Abstract

SCHEDULING DISTRIBUTION AND MOTOR LEARNING GUIDED TREATMENT WITH CHILDHOOD APRAXIA OF SPEECH

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The purpose of this study was to examine the use of motor learning guided (MLG) treatment with different treatment schedules in the treatment of participants with a diagnosis of childhood apraxia of speech (CAS). Five participants, chronological ages 4;6 to 5;11 years, received MLG treatment for diagnosed CAS in two different treatment schedules, mass and distributed. The mass schedule consisted of four weekly 60-minute treatment sessions for a total of 240 minutes of intervention. The distributed schedule consisted of 16 15-minute treatment sessions provided four days a week for a total of 240 minutes of intervention. With the mass treatment schedule, participants demonstrated an increase in performance accuracy by an average of 9.1%. With the mass treatment schedule, participants demonstrated an increase in probe accuracy by an average of 5%. With the distributed treatment schedule, participants demonstrated an increase in performance accuracy by an average of 21.4%. With the distributed treatment schedule, participants demonstrated an increase in probe accuracy by an average of 17%. Both treatment schedules produced positive outcomes with the distributed treatment schedule resulting in the highest improvement in speech production accuracy. The results of this study suggest that children with CAS may benefit from shorter and more frequent intervention

sessions to yield motor learning of speech skills and to increase accuracy of speech production performance.

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SCHEDULE DISTRIBUTION AND MOTOR LEARNING GUIDED TREATEMENT

WITH CHILDHOOD APRAXIA OF SPEECH

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. Review of Literature

Introduction

Childhood apraxia of speech (CAS) is a motor speech disorder that occurs in a small percentage of the general population, between 1-10 in 1000. The majority of these cases are male (Souza, Payã, & Costa, 2009; The Childhood Apraxia of Speech Association of North America, 2005). It has been suggested that there has been a substantial increase in occurrence during the past decade, but measurable population data is limited (American Speech-Language and Hearing Association [ASHA], 2007a).

CAS has been a focus of research in the past few decades due to the controversy over its origin and characteristics and its increasing prevalence (Shriberg, Aram, & Kwiatkowski, 1997). This resulted in a call for research on CAS by ASHA to explore a variety of questions about the diagnosis and various treatment techniques (ASHA 2007a).

Various diagnostic labels have been applied to children who have exhibited specific speech production behaviors, and these labels have historically been based on varying views of etiology (i.e., developmental apraxia of speech, developmental verbal dyspraxia, and the general term typically used for adults, apraxia of speech). In the past, developmental apraxia of speech identified deficits considered related to motor planning, whereas developmental verbal dyspraxia referred to phonological and language deficits co-occurring with motor deficits (Velleman, 2003). In 2007, the ASHA Ad Hoc Committee on Childhood Apraxia of Speech recommended the use of the label CAS and provided a formal definition. They described CAS as "a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits" (ASHA, 2007b).

Etiology

The etiology of idiopathic CAS remains in question; however, CAS has also been associated with known conditions. These include genetically based impairments, neurological disorders, developmental delays, prenatal or perinatal insults, and differences in the rate of development/quality of myelination (Cumley, Ball, Skinder, 2001).

CAS can also co-occur with other neurological disorders such as Autism, Down Syndrome, and Fragile X (Flipsen & Gildersleeve-Neumann, 2009) and with other disorders such as otitis media, hypotonia, and sensory integration disorder (Teverovsky, Bickel, & Feldman, 2009), making it difficult to isolate a single etiology. Pre- and perinatal difficulties that have been connected to severe speech sound disorders (including CAS) include infections during pregnancy, preterm birth and low birth weight (Fox, Dodd, & Howard, 2002). However, there is a continued need for further investigation on the etiology of CAS and its co-existence with other disorders.

Genetic research with the "KE" family, in which half of its members have orofacial apraxia, has identified a point of mutation on the FOXP2 gene. The FOXP2 gene was the first gene that researchers have been able to link to speech and language behavior. Located at chromosome 7q31, it has been implicated in "development of brain networks involved in orofacial learning, planning, and execution, particularly in motor sequences for speech, as well as conducting manual and other motor sequences" (Souza et al., 2009).

Diagnosis

Marrs (2010) reported that up to 75% of children diagnosed with CAS are actually misdiagnosed. There is an obvious need for consensus among clinicians with respect to appropriate diagnostic criteria and efficacious intervention.

Although such hypotheses exist, there are currently no validated diagnostic criteria for CAS that differentiate it from other speech sound production disorders (ASHA, 2007a). Three main characteristics have been identified as being indicative of CAS. These include: errors on consonants and vowels that are characterized by their inconsistency when syllables or words are produced multiple times, expanded transition times between sounds/syllables, and inappropriate prosody (ASHA, 2007b). However, these characteristics are also commonly seen in other motor speech disorders (i.e., dysarthria) and may have contributed to an overdiagnosis of CAS (ASHA, 2007a). In an attempt to identify areas of research need, Crary (1993) discussed five areas hypothesized to be critical for differential diagnosis: the nonspeech motor skills, motor speech production, articulation and phonological skills, language performance, and an "other" category (e.g., attention and behavior).

A comprehensive assessment for CAS includes speech intelligibility rating, receptive and expressive language skills, diadochokinetic performance, and speech consistency scores (ASHA 2007a; Velleman, 2003). Children with CAS may exhibit one or more of the following speech production errors: "non-diminished phonotactic (how sounds can be organized) errors beyond 3 years of age, regression, and variability in word usage and individual sounds" (ASHA, 2007a). Children with a motor speech disorder, often have co-occurring language deficits, often with higher receptive than expressive abilities (Crary, 1993).

Treatment

To be able to definitively report the effectiveness of CAS intervention, it is imperative for researchers to report "exactly what was treated (i.e. primary and secondary treatment targets) and how (i.e. nature, duration, and intensity), as well as what outcomes were measured and their results" (Morgan & Vogel, 2009). Treatment techniques, including various motor and

phonological approaches, have been studied but almost all studies lack information on how intervention was delivered.

Current practice suggests intensive services for CAS, particularly when the disorder is severe (ASHA, 2007; Hula et al., 2008; McCauley & Strand, 2008;). Indeed, it may be difficult to "dissociate motor and linguistic features of verbal dyspraxia because lexical, phonological, and articulation deficits co-occur" (Morgan & Vogel, 2009). Although, intensive services are needed, clinicians struggle to determine the appropriate amount (e.g., scheduling, collaboration, service delivery models, placements) (Cirrin et al., 2010). While providing intensive treatment can be challenging, some variables can be manipulated. These include quality and quantity of service, which includes the number of hours spent in therapy, child's participation in therapy, proportion of adults to children during treatment (e.g., one-on-one, group), and the number of therapy sessions (Warren, Fey, & Yoder, 2007). However, because there are insufficient empirical data to support specific interventions, clinicians must rely on professional judgment and experience to determine the treatment approach.

Treatment approaches reflect the broad scope of speech-language pathology, from linguistic to motoric, and some even employ non-speech oral movements. While each of these strategies approach CAS according to differently assumed etiology, they typically include similar aspects such as drill, remediation, self-monitoring, and feedback (Maas et al., 2008).

Linguistic approaches. Clinicians who consider CAS a linguistic disorder often treat using a phonological, or linguistic-based approach (Velleman, 2003). The most common phonological intervention, Cycles Approach, aims to stimulate the entire phonological system (Hodson & Paden, 1991; Kamhi 2006; Velleman, 2006). Hodson (2006) states that targets are selected based on a normative perspective with consideration given to each child's specific

sound inventory since multiple sounds are developed at one time. This is conducted via traditional speech therapy (focused on motor production) in combination with a perceptual component (Kamhi, 2006). During each session, error sounds are targeted through review, auditory bombardment, word cards, production practice, and stimulability practice and probes (Garcia & Bauman-Waengler, 2009). Kamhi (2006) indicates that this approach has proven effective for children with CAS in some case studies, but additional evidence is needed for specific treatment and results on this particular population.

Another phonologically based treatment, Phonotactic Therapy (Velleman, 2002), uses goal sets to focus on only one phonetic, phonotactic, and literacy goal at a time (Velleman, 2006). Phonotactic therapy addresses word structure by increasing syllable length in a step-by-step process using (1) modeling, adjacency, and fading; and (2) altering syllables by manipulating stress, harmony, and patterns. Phonotactic features affect speech movement patterns and the ability to vary the complexity of syllable structures (Velleman, 2006). This approach practices exaggerated vowels in syllables although vowel production is commonly impaired with CAS. This and the limited amount of phonotactic variability result in limited gains (Velleman, 2006).

Prosodic approaches, which focus on production of varied stress and rhythm in speech, are another form of treatment used with CAS. The most common formalized prosodic therapy is melodic intonation therapy. Melodic intonation therapy was originally developed for and used with participants with apraxia of speech who also had aphasia. These participants have the acquired form of apraxia of speech, thus have had normal language in the past, unlike children with CAS who have a disorder in development (ASHA, 2007a). Also, participants with both apraxia of speech and aphasia have some level of language difficulty. As melodic intonation

therapy implies, it is based on intonation, rhythm, and the use of gestures to help disordered individuals stay in time with their speech (McCauley & Strand, 2008). Square (1994) notes that this treatment assumes that a major component of Apraxia of Speech is related to the disruption of "the oscillating rhythmic substrate that underlies speech and the entire motor circuit" and this therapy aims to make a person's speech more cyclic in nature. However, this approach can be difficult because as speakers, we automatically segment speech, making it difficult to work on problematic vowel productions. While this approach is considered to be linguistic based, it does have a motor component, with aspects that include arm swinging/leg tapping, finger counting, and vibro-tactile stimulation (Square, 1994).

Motor learning theory. An intensive motor approach is considered the optimal treatment program (ASHA, 2007) for CAS. Two primary goals for motor approaches are to increase automatic speech oral motor flexibility (Velleman, 2006). These treatments are time-intensive, drill based, structured, and have an emphasis on self-monitoring (Stein, Harvey, & Macko, 2009). They are based on the assumption that motor programs are "road maps" that help speakers achieve speech targets that are perceived as normal (Square, 1994). Schmidt & Lee (2005) define motor learning as "a set of processes that produces a relatively permanent acquired capability for movement that is not directly observable". Pre-practice activities are completed prior to each therapy session to motivate the person and gain selective attention to the task through setting goals, emphasizing the importance of the tasks, and ensuring the client understands the instructions (Caruso & Strand, 1999; Schmidt & Lee, 2005). Practice is not begun until the participant is engaged in the specific motor activity. It is important that repetitive practice is paired with focused, selective attention to ensure the person learns the movements and remembers them for future productions (Caruso & Strand, 1999). To increase awareness of

learned behaviors, motor learning theory manipulates various aspects of learning, such as cueing, feedback, and distribution of practice (Schmidt & Lee, 2005).

Cueing. Cueing is used to increase motor learning and can be provided through tactile, auditory, visual, or verbal modes (McCauley & Strand, 2008). Verbal imitation is a commonly used cue for motor learning but is often used in conjunction with other modalities (Caruso & Strand, 1999). However, research has shown that using imitation alone with children with CAS does not yield the improvement seen with typically developing peers (Moriarty & Gillon, 2006).

Feedback. Feedback is another method used to increase motor learning. Feedback is defined in a variety of ways based on the type, monitoring, timing, and/or frequency provided. *Feedback type* refers to the differences between giving knowledge of the results (e.g., correct or incorrect) versus knowledge of performance (e.g., "I heard you say…") and *feedback frequency* refers to how often feedback should be given, frequently or infrequently (Maas et al., 2008). Moriarty and Gillon (2006) noted that children with CAS showed the greatest improvement when given information about phonological and phonetic makeup of the targets (i.e., knowledge of their performance), rather than simply correct or incorrect. Similar to feedback frequency, *feedback timing* considers the effects of providing immediate feedback after each utterance versus delayed feedback after a set or variable number of utterances. *Monitoring* refers to the use of intrinsic (self-monitoring) or extrinisic (clinician-provided) feedback (Maas et al., 2008). Intrinsic, when the person determines whether their own productions are correct or incorrect, and extrinsic feedback, when the person is given feedback (i.e., accuracy of performance) by the clinician, are both considered to potentially change the acquisition of skills because they may shape current behaviors (Sheppard, 2008). However, research suggests that when doing motor activities, either speech or nonspeech, excess feedback provided too quickly interrupts a person's

self-monitoring abilities and inhibits the ability to gauge success (Swinnen, Schmidt, Nicholson, & Shapiro, 1990).

Practice distribution. Distribution of practice is based on the time spent in actual practice compared to the time spent at rest. Motor learning theory provides the principle that the most effective distribution of practice can enhance performance, as well as the retention of skills (Caruso & Strand, 1999). Practice can be distributed by two categories: distributed, defined as many sessions that last a short period of time; and mass, defined as the same amount of practice but in fewer but longer sessions (Caruso & Strand, 1999). In motor learning studies not involving speech tasks, performance (accuracy within a session) and learning (retention over time) were greater when longer rest periods (i.e., mass practice) were provided (Schmidt & Lee, 2005). It is expected that the most effective distribution of practice can enhance performance during speech treatment sessions as well as the retention rate of those skills; however, a lack of evidence is available to examine the effects of motor learning for speech production using these different schedules (Caruso & Strand, 1999).

Mass practice schedule. Use of a mass practice schedule has been found to be the most effective distribution of practice in some speech studies (Hall, Jordan, & Robin, 1993). Evidence suggests that when utilizing a phonological approach, such as language and literacy training, a mass practice schedule produces the highest results (Kamhi, 2006).

In terms of CAS, high intensity services are considered to produce the best results among clinicians; however, little evidence supports this claim and there is lack of a true definition of what characterizes high intensity. When a university language-literacy camp for children aged four to five years old was conducted and each child received approximately two hours a day of

intensive therapy, minimal progress was noted in the children diagnosed with CAS (Edwards & McDonald, 2009).

Distributed practice schedule. Motor learning evidence consistently suggests that distributed practice results in greater learning than mass practice, and that it helps with both immediate performance and retention for various motor tasks, lasting up to nine months. This is opposed to mass practice, which typically shows a loss of performance gains shortly after therapy ends (Maas et al., 2008). In a study done using Motor Learning Guided Treatment (MLGT) with swallowing and feeding disorders, it was determined that distributing practice was most efficient, gave more opportunities for feeding, and allowed optimal brain plasticity (Sheppard, 2008). In 2000, Shea, Lai, Black & Park looked at memory consolidation between massed and distributed practice based on the theory that "two associations are of equal strength but of a different age, a new repetition has a greater value to the older one" (McGeogh, 1943). In two experiments, Shea et al. (2000) examined a person's balance and performance on a numeric keyboard task to show generalization. Results for both experiments indicated that memory consolidation and increased participant performance occurred through distributed practice (Shea et al., 2000).

Motor learning evidence for speech is limited but many clinicians base their distribution of practice on the text of Caruso and Strand (1999). They recommend distributed practice as most efficacious for serial motor learning tasks and producing the greatest gain in performance and learning because it is a continuous skill (i.e., has no beginning or end and can be stopped at any moment such as swimming) (Caruso & Strand, 1999). Another possible reason for benefit of distributed practice is the fact that children, especially younger ones, can maintain attention to a task for a maximum of 30 minutes, limiting the amount of quality intervention per session

(ASHA, 2007a). In a study on the effects of treatment scheduling on phonemic awareness skills, distributed practice was found to be more effective for maintenance of knowledge (i.e., learning), but this was not proven true for immediate knowledge (i.e., performance) and over the course of the school semester, the advantage appeared to be minimal (Ukrainetz et al., 2009).

A motor programming approach requires the clinician to use a more distributed practice schedule in order to give the client the most effective prognosis. It is important to note that research has not determined whether "impaired motor systems are sensitive to the same principle of learning as intact motor systems" (Maas et al., 2008). Some researchers say that there is no difference between the amount of gains for the two types of practice. One study looked specifically at the difference between a three-week summer camp and a typical speech therapy period of 12 months for children with cleft palate who had articulation disorders. While both treatment schedules showed significant decreases in the children's misarticulations, there were no significant differences between the two groups (Pamplona, Ysunza, Patino, Ramirez, Drucker, & Mazon, 2004). Another study looked at a traditional Lee Silverman Voice Treatment program, a voice treatment for people with Parkinson's, which involves a massed practice schedule and compared it to an extended version of the program. In this study, distributed practice did not enhance voice abilities in comparison to the traditional program (Maas et al., 2008).

Stimulus distribution. Distribution of stimuli is another consideration of motor learning and can be organized in a blocked or random pattern, or a combination of the two (Schmidt & Lee, 2005).

A blocked distribution in motor learning is completed when one task, with multiple trials, is completed before another stimulus is practiced. Caruso and Strand (1999) report that in

speech therapy this leads to better performance as one target sound/word is practiced multiple times. Blocked distribution is used when targeting new goals and for children who have limited verbalizations (Gildersleeve-Neumann, 2007). During the earliest stages of learning, evidence suggests that this form of distribution provides the most success (Caruso & Strand, 1999).

Random distribution, on the other hand, is used when multiple stimuli are being used and the same task is never repeated in consecutive trials (Schmidt & Lee, 2005). The order of the presentation of the stimuli is randomized throughout the session and it is suggested that this distribution results in better retention of skills for motor learning (Caruso & Strand, 1999). However, random practice requires increased motor planning and cognitive involvement of the individual (Gildersleeve-Neumann, 2007).

Both forms of stimulus distribution require further investigation before a definitive recommendation can be made for speech tasks (Caruso & Strand, 1999). Schmidt and Lee (2005) suggest that using a combined randomized-block schedule (i.e., a combination of random and blocked distribution) allows the clinician to combine many of the positive features from both forms of stimulus distribution.

Motor treatment approaches. Common motor approaches used for CAS treatment include (a) non-speech oral motor exercises, (b) Prompts for Restructuring Oral Muscular Phonetic Targets (Hayden, 2009), and (c) motor learning (e.g., integral stimulation, Nuffield Centre Dyspraxia Programme, and Motor Learning Guided Treatment) (Caruso & Strand, 1999; Williams, McLeod, & McCauley, 2010).

Nonspeech oral motor exercises. Although commonly used, nonspeech oral motor exercises are typically associated with therapy of dysarthria. McCauley & Strand (2008) stated that non-speech oral motor exercises could be used to help increase coordination and strength of

the muscles involved in speech. To achieve this, clinicians use sensory stimulation (i.e., pressing under jaw, practicing sucking, biting, blowing, and moving tongue) and manipulation to increase strength, stability, range of motion, and respiratory support (McCauley & Strand, 2008). McCauley & Strand (2008) note that this approach is most often used in conjunction with articulation practice, but not always. It is essential to note that CAS is not a disorder of muscle weakness and there is a lack of evidence on the effectiveness of oral motor therapies for CAS (Kamhi, 2006). It has also been noted that "no speech sound requires the tongue tip to be elevated towards the nose and that no sound is produced by puffing out the cheeks, …oral movements that are irrelevant to speech movements will not be effective as speech therapy techniques" (Lof, 2009).

PROMPT. Hayden (2009) described PROMPT as an approach in which the clinician manually guides the various speech structures (e.g., tongue, lips, cheeks) in an attempt to manipulate muscles and structures of speech, ranging from the mouth to the larynx. It uses tactile and kinesthetic cues and also addresses the posture of the head, neck, and trunk (Hayden, 2009). Adults with acquired AOS used the PROMPT system, and experienced a gain in skills at the end of therapy but lacked retention of those skills over time (Square, Chumpelik, Morningstar, & Adams, 1986).

Integral Stimulation. Integral stimulation is another motor approach that has been used to treat CAS (Caruso & Strand, 1999). Integral Stimulation is geared towards matching the cognitive motor learning to the current skill level (Gildersleeve-Neumann, 2007). It aims to achieve an adequate speech signal by focusing on oral movement patterns. Integral Stimulation uses auditory, visual, and tactile cues to enhance the success of the concept, "listen to me, watch me, and do as I do" (McCauley & Strand, 2008). A hierarchical approach is followed, moving

from simple to complex productions; subsequently, as more complex productions are achieved, the clinician support (e.g., feedback, frequency) is gradually decreased. For example, at stage one, a child watches and listens while simultaneously producing the stimulus with the clinician. Once simultaneous production accuracy is mastered, the clinician next models the stimulus and the child repeats the model while the clinician silently mouths it, and gradually fades the "mouthing" cue. In considering motor learning theory and the need for repetitive practice, Integral Stimulation uses multimodal cues, which may detract from the number of potential productions in a session. Also, integral stimulation does not take into account the time required for the articulatory system to "reset" to produce consistently accurate productions. This delay is needed to allow time for sensory and motor signals to be converted and transported prior to another action can being accurately produced (Wolpert, Ghahramani, & Flanagan 2001).

Motor Learning Guided Treatment. Considering that CAS is a motor speech disorder, it is most appropriate to use a treatment that engages the oral motor system. Motor Learning Guided Treatment (MLGT) includes components from Integral Stimulation and adds features from motor learning theory. MLGT focuses on motor learning as a "set of internal processes associated with practice or experience leading to relatively permanent changes in the capability for movement" (Schmidt & Lee, 2005). The basis of this approach considers four main motor learning principles: background information (e.g., motivation, family involvement), conditions of practice, rate, and feedback (Maas et al., 2008).

MLGT applies a hierarchical approach in which practice starts with randomized stimuli. Once sufficient practice (i.e., person is motivated and expectations are clear) has been completed, stimuli are introduced in a random-block distribution. Stimuli are selected based on similar error patterns to target behaviors. A delay follows each attempt to allow time for internal

processing. The amount (high or low frequency) of feedback given is also restricted (Fountain, Lasker, & Stierwalt, 2007). MLGT has been used in both the treatment of speech and non-speech tasks.

Although MLGT has been used with adults diagnosed with apraxia of speech, it has not been used with children diagnosed with CAS. While MLGT is believed to be beneficial in treating motor speech disorders, including hypothetically CAS, there are few studies published examining its effectiveness in disorders other than AOS (Maas et al, 2008).

Summary and Rationale

Based on the current literature, specific aspects of motor learning have proven to be more successful with remediating CAS. Imitation should be combined with other cueing strategies, including verbal, visual, & auditory cues, to increase speech (Moriarty & Gillon, 2006). This cueing system should be paired with providing feedback on knowledge of performance based on Moriarty & Gillon's (2006) findings that children with CAS experience greater improvement when information is given about the phonological and phonetic makeup of their productions and not just correct/incorrect. Another aspect of motor learning that has proven successful is using a combined randomized-block schedule. Using a combination of a random and blocked stimuli distribution allows the clinician to provide the positive features from both distribution types, allowing enough practice for a new skill to be learned and increasing overall skill abilities (Schmidt & Lee, 2005).

While certain aspects of motor learning have been recognized as being the most beneficial with children with CAS, there continues to be a lack of evidence on the effectiveness of various practice schedules using the MLGT with children diagnosed with CAS (ASHA, 2007a). Research is needed to definitively report the distribution of therapy that is used with

children with CAS and what outcomes were measured while using the distribution schedules (Morgan & Vogel, 2009). Motor learning studies involving nonspeech tasks suggest that a mass schedule will provide greater performance and learning (Schmidt & Lee, 2005); however, there is a lack of evidence to examine if these findings can also apply to speech production tasks and with the growing population of children with CAS (Caruso & Strand, 1999).

This project addresses one aspect of treatment for children with CAS. The various structures of practice, distributed and massed, using MLGT with children with CAS were studied and analyzed. The performance and learning rates of these sessions will be examined. As a benefit, this research provides information on intervention techniques used to support children with CAS and to identify differences in various structures of practice. This project enhances the knowledge regarding CAS and its clinical intervention. It also aims to provide an effective intervention strategy for clinicians by determining the most successful distribution of practice with children with CAS.

Research Question

When treatment time is held constant (e.g., 300 minutes) among typically used treatment schedules [distributed: 1 or 2 times a week sessions and massed: 5 times a week sessions], do children with CAS show greater response to one schedule?

II. Methods

Participants

Five children chronological ages ranging from 4;6 to 5;11 years were recruited from the clients of East Carolina University Speech-Language and Hearing Clinic and the surrounding area through advertisement. Approval was obtained from the ECU Institutional Review Board and consent forms (Appendix A) were signed prior to testing. Participants were excluded if they had any known neurological/organic conditions or scored below average receptive language testing. Inclusion criteria for participation was based on: (a) passing an audiometric screening; (b) corrected visual acuity to interact sufficiently with stimuli; (c) native American English (range of cultural/racial backgrounds) to reduce potential variability resulting from production of non-English words; and (d) characteristics of CAS as defined in the ASHA Technical Report (ASHA, 2007a).

To determine whether participants met the CAS characteristic inclusion criteria, a series of assessments were completed and results are displayed in Table 1. A hearing screening was administered at 25 dB HL for 1000 Hz, 2000 Hz, and 4000 Hz, adjusted from the recommended 20 dB HL for children due to the participants being tested in a noisy clinic room, in order to confirm probable normal hearing (ASHA, 1997). An oral mechanism screening was administered to rule out craniofacial abnormalities that could interfere with task performance. The *Primary Test of Nonverbal Intelligence* (PTONI) (Ehrler & McGhee, 2008) was administered to screen for cognitive ability necessary to complete the tasks in the study and determine inclusion criteria. The *Test of Auditory Comprehension of Language, 3rd Edition* (TACL-3) (Carrow-Woolfolk, 1998) was administered to assess receptive language abilities and establish inclusion factors. The *Clinical Assessment of Articulation and Phonology* (CAAP)

Table 1

Standardized Test Scores of Participants

	1	2	3	4	5
Age	5;11	5;3	5;9	4;11	4;6
Gender	Male	Male	Female	Male	Male
Hearing & Vision	Pass	Pass	Pass	Pass	Pass
PTONI	132 (Very Superior)	77 (Low)	99 (Average)	103 (Average)	113 (Above Average)
TACL-3	115 (Above Average)	115 (Above Average)	126 (Superior)	106 (Average)	102 (Average)
CAAP	41	48	12	20	46
KSPT					
SS					
Oral	108	63	108	106	106
Simple	17	<3	<17	<49	<49
Complex	<3	<2	64	55	9
DDK					
# per sec					
/pʌ/	2.67	2.7	2.7	3	3
/tʌ/	2.67	3.3	3	3	2.67
/kʌ/	2.33	3	3.3	3.33	2.3
Patticake	1	1.3	1.3	.83	1.3

(Secord, Donohue, & Johnson, 2002) measured the child's speech production skills of single words. Results of this assessment also were used to determine the participant's phonetic inventory and single word intelligibility and were the basis of stimulus creation. The *Kaufman Speech Praxis Test for Children* (Kaufman, 1995) provided information for a vowel inventory, consistency of vowel production, complexity of syllables produced, phoneme prolongations, and accuracy of nonsense word repetition. Diadochokinesis (DDK) tasks were completed to determine syllable repetitions (e.g., maximum repetition rate, alternating repetition rate, and diadochokinesis).

Participants were between the ages of 4;6 and 5;11 at the beginning of the study. Participants 1, 2, and 3 had finished Kindergarten prior to participating in the study and the remaining two participants were enrolled in preschool. Each participant completed all testing during a single 1-hour session. Scores on the PTONI ranged from 77-132. Participant 2, who scored a standard score of 77 on the PTONI, was the only participant who did not fall under the "average" to "very superior" range. Due to the discrepancy between his receptive language score on the TACL-3 (SS- 115, above average) and his score on the PTONI, he was included in the study. His low score on the PTONI was considered to be a reflection of attention and not of actual ability and that his receptive language score was more likely a closer measure of performance. Receptive language was in the average to superior range for all participants, with standard scores ranging from 102-126. Standard scores on the CAAP ranged from <55-75, indicating profound to moderate speech delays, with the participants' total number of errors on mono- & multisyllabic words and cluster words ranging between 12-48. Standard scores on the KSPT included: 63-108 for oral tasks, <49- <3 for simple tasks, and 64- <2 for complex tasks. As tasks increased in motoric difficulty on the KSPT, scores decreased. DDK tasks were slow

and inaccurate for all participants (Mean of pΛ= 2.67-3, tΛ= 2.67-3.3, kΛ= 2.3-3.33) compared with normative scores of pΛ (4.00-4.03), tΛ (4.07-4.14), and kΛ (4.56-4.58) (Flecther, 1972).

For inclusion in this study, children were diagnosed with CAS if they exhibited one or more features from categories including nonspeech motor behavior, motor speech behavior, speech sound and structure, and prosody (Table 2). Nonspeech motor behaviors included impaired oral volitional movement, and/or articulatory groping obtained from DDK and KSPT tasks. Motor speech behaviors included impaired prolongation of fricatives, difficulty with monosyllabic and trisyllabic DDK sequences, and an inability to do nonword and multisyllabic word repetitions. Speech sound and structure features were obtained from the KSPT and CAAP and included vowel errors, inconsistency in speech errors, errors in production order of sounds, morphemes, and words, articulatory regression, improved performance on automatic productions in comparison to volitional productions. Prosody errors obtained from the CAAP and KSPT included syllable segregation and excessive-equal stress patterns.

Stimuli

An error analysis was completed based on speech sound errors made on the CAAP and KSPT. This error analysis was used to identify errors as consistent or inconsistent, and then further distinguished by place within syllables (initial, medial, and final). Phonemic combinations that the participant never produced accurately in syllables/words were not included. Targets were selected such that the participant (1) produced a maximum of one phoneme in error at baseline, and (2) had inconsistent error production in that word position. Once 80-100 stimuli were created for each child, a random number generator (Stat Trek, 2011), was used to select 60 stimuli for use in practice. From the group of 60, 20 stimuli were randomly selected for use as untreated probes. These probes were used at the beginning of the session to

Table 2

CAS Inclusion Parameters for Study

	S1	S2	S3	S4	S5
Nonspeech Motor Behavior (1 or more)					
Impaired oral volitional movement		x		x	x
Lingual/mandibular articulatory groping	x	x	x		x
Motor Speech Behavior (1 or more)					
Impaired prolongation of fricatives	x	x	x		x
Impaired production of monosyllabic & trisyllabic DDK sequences	x	x			x
Impaired nonword repetition	x	x			x
Impaired multisyllabic word repetition	x	x	x	x	x
Speech Sound & Structure (1 or more)					
Vowel errors	x	x	x	x	x
Inconsistent speech errors	x	x	x	x	x
Errors in production order					
Sounds	x	x	x	x	x
Morphemes	x	x	x	x	x
Words			x		
Prosody (1 or more)					
Syllable segregation (Staccato Speech)		x		x	x
Excessive-equal stress	x	x	x	x	x

Note: Items from this checklist were selected from the literature and in particular the ASHA Technical Report (2007)

estimate generalization of skills to untreated probes. The remaining 40 stimuli were randomly assigned to two groups of 20 stimuli for practice (see Appendix B).

Stimuli were of varied complexity, from simple 1-word productions (e.g., key, pig, cheek, lemon) to sentences with more complex movement patterns (e.g., "I am five", "That toy is too expensive"), based on the participant's abilities.

Procedure

The five participants were randomly assigned to two groups. Treatment schedule order was counterbalanced for each group to reduce order effects in performance and ensure each group completed both schedules. Table 3 illustrates group assignments. Group 1 included two participants (Ss 2, 3); this group was assigned to the Mass schedule for treatment first, during which they participated once a week for 60-minutes for 240 minutes of total treatment. During these 60-minutes sessions, the 20 stimuli were randomized for practice and after completing all stimuli they were re-randomized 3-5 times for practice. When all four sessions of the Mass schedule was completed, Group 1 began the Distributed schedule, during which they received 4 weeks of intervention four times a week (M-TH) for 15-minutes (16 sessions) for 240 minutes of total treatment. Group 2 consisted of participants 1, 4, and 5 and was assigned the Distributed schedule initially, followed by the Mass schedule. During each session, participants produced the 20 probe items to establish an initial baseline and evaluate potential generalization of treatment to untreated targets. Twenty treated stimuli randomized prior to each session.

During data collection, participants were in quiet clinical treatment rooms as free from distraction as possible. They were seated in child-sized chairs at a small table with stimuli

Table 3

Group Distribution and Treatment Schedule

Group	Schedule 1	Schedule 2
1	Mass	Distributed
Participants: 2 & 3	(1x/week for 60 min)	(4x/week for 15 min)
2	Distributed	Mass
Participants: 1, 4, & 5	(4x/week for 15 min)	(1x/week for 60 min)

presented via a PowerPoint presentation using words and clip-art pictures. The stimulus words and sentences were individualized for each participant and no two sets of targets were the same.

Each session was structured in a similar manner, varying only in amount of practice time per session. The researcher started the session by presenting each probe given a stimulus picture and no verbal model to the participant. The participant named the word or sentence and each response was judged as correct or incorrect.

After completion of all 20 probes, the 20 treated stimuli were introduced. The researcher began treatment by presenting a stimulus with a verbal model and stimulus picture. The participant imitated the stimulus utterance without assistance, followed by a delay interval of 3 seconds. After the delay, the researcher continued therapy by cueing (pointing) the participant to produce the same stimulus item again but provided no additional verbal cue. The participant then produced the stimulus utterance a second time, without feedback. This point-no verbal cue procedure was 3 additional times, with a 3 second delay interval between each production. Feedback was provided once all 5 productions were complete. This procedure was followed for all 20 treated stimuli and each production judged as correct or incorrect.

As further illustrated in Table 4, each schedule is broken down into the number of stimuli produced and the procedure for all stimuli with imitation of verbal model beginning followed by a 3 second delay & 4 productions with no verbal model and delay between each production prior to feedback being given. The number of stimulus sets practiced varied depending on the treatment schedule (mass vs. distributed). During the mass schedule, the 20 stimuli were practiced five times, for a total of 100 utterances produced in a 60-minute session. In the distributed schedule, the 20 stimuli were practiced one time, for a total of 20 utterances practiced in a 15-minute session.

Table 4

Presentation of Stimuli by Treatment

Schedule	Distribution of Stimuli
Mass	100x – M-(3 sec delay)-Imitation$_1$-(3)-I$_2$-(3)-I$_3$-(3)-I$_4$-(3)-I$_5$-Feedback
Distributed	20x – M-(3 sec delay)-Imitation$_1$-(3)-I$_2$-(3)-I$_3$-(3)-I$_4$-(3)-I$_5$-Feedback

Note: M= Model and I= Imitation. Each stimulus word/sentence began with a model and then participant was required to imitate stimuli 5 times.

Each session was digitally audio and video recorded using ceiling mounted Canon VC-C50i cameras fitted with Crown PZM-10 microphones for later scoring of responses and analysis.

III. Results and Discussion

Descriptive statistics were used to analyze data, as the goal of this exploratory research was to evaluate whether altering treatment distribution could effectively alter the speech of children with CAS. The following analyses involved direct comparisons among participants on learning and generalization of stimuli.

Articulation Accuracy

Each participant's productions of treated targets were used to calculate overall accuracy. For mass practice, accuracy was determined by calculating the mean performance of all repetitions, approximately 500 total for each participant, of the treated targets (i.e., Accuracy = Accurate Productions/Total Productions). For distributed practice, accuracy was determined by calculating the mean performance of all utterances, approximately 100 total for each participant, (i.e., Accuracy = Accurate Productions/Total Productions). These data were used to investigate and compare change and consistency across treatment for all participants. Data from the mass schedule and distributed schedule for all participants is shown in Tables 5 & 6. Figures 1 & 2 illustrate the pattern of change for both schedules.

Each participant's production accuracy increased from the baseline to the final session in both the mass and distributed schedules. Percent of change was calculated by subtracting the final session accuracy from the baseline accuracy for both schedules (i.e., Change in Accuracy = Percent Accuracy in Final Session – Percent Accuracy in Baseline). Participant 3 showed the greatest percentage of change with the mass schedule versus the distributed schedule. As illustrated by Figures 3 & 4, the remaining four participants experienced greater improvement with the distributed schedule. Data from each schedule, mass and distributed, for all participants is shown in Table 7.

Table 5

Accuracy of Treated Stimuli of Mass Schedule

Participant	Session 1	Session 2	Session 3	Session 4
1	60.2	51.6	69.8	64.6
2	45.5	39.5	38.2	57.5
3	N/A	57.1	59.39	75.17
4	73.2	84.8	77.2	77
5	60.8	63.8	89.8	68

Table 6

Accuracy of Treated Stimuli of Distributed Schedule

Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	41	47	50	62	50	45.3	54	56	48	49	52	58	62	62	61	64
2	40	47	68	44	47	57	59	47	43	39	49	36	40	45	36	72
3	65	50	48	52	59	52	58	62	66	60	61	60	63	77	83	78
4	80	92	94	87	64	81	82	82	85	96	87	95	83	79	84	89
5	45	47	40	40	43	29	53	57	51	43	76	45	45	79	43	75

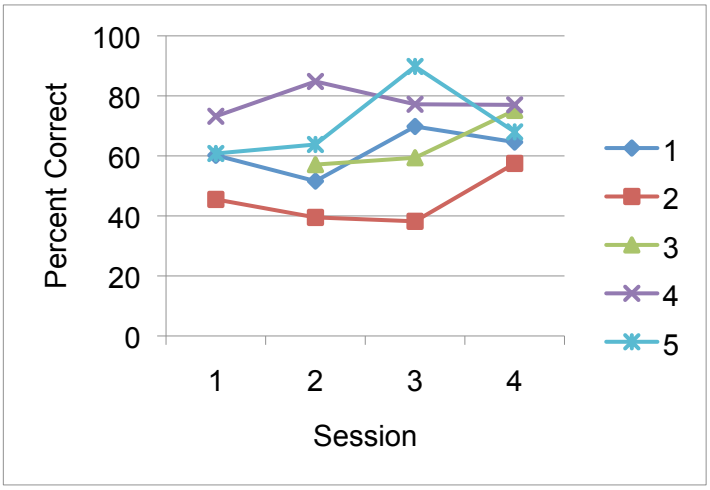

Figure 1. Mass Schedule Mean Accuracy of Stimuli by Session

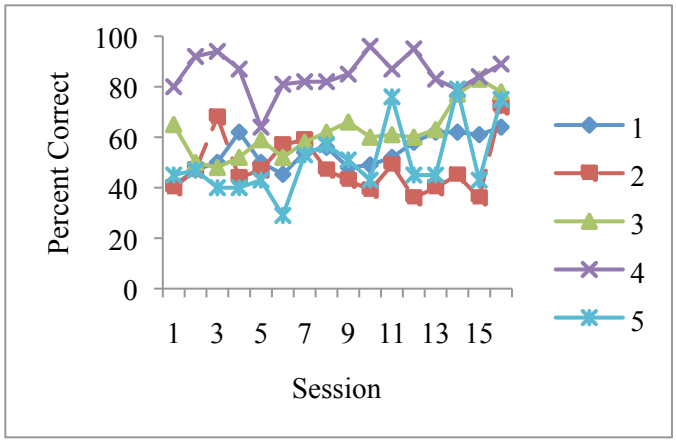

Figure 2. Distributed Schedule Mean Accuracy of Stimuli by Session

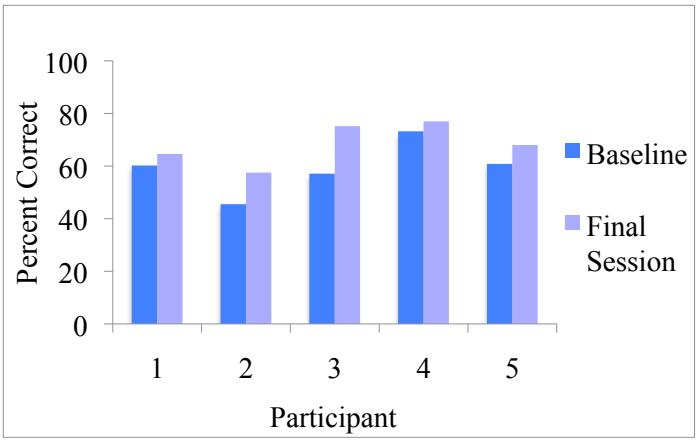

Figure 3. Mass Schedule Baseline and Final Session Accuracy of Treated Stimuli

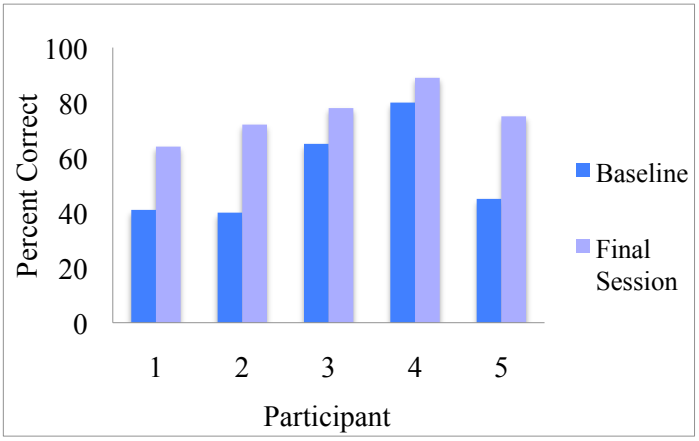

Figure 4. Distributed Schedule Baseline and Final Session Accuracy of Treated Stimuli

Table 7

Baseline/Final Session Results of Treated Stimuli by Schedule

	Mass Schedule			Distributed Schedule		
Participant	Baseline	Final	% Change	Baseline	Final	% Change
1	60.2	64.6	+4.4	41	64	+23
2	45.5	57.5	+12	40	72	+32
3	57.1	75.17	+18.1	65	78	+13
4	73.2	77	+3.8	80	89	+9
5	60.8	68	+7.2	45	75	+30
Mean Change:			+9.1			+21.4

As illustrated in Figure 5, no participant experienced more than 18.1% improvement with mass schedule from baseline to the final session (n=4). Participants experienced greater levels of improvement from baseline to the final session (n=16) during the distributed schedule, with the highest percent of increase at 32%. Overall, the amount of change seen from the mass schedule ranged from 3.8-18.1% (M=9.1%) versus the distributed schedule range of 9.0-32% (M=21.4%) (Figure 6). Mean accuracy of participants by severity of CAS (i.e., severe, moderate, mild) can be seen in Figure 7. Percent change data from each schedule, mass and distributed, for all participants is shown in Table 7.

The mass schedule yielded a significant difference between baseline and final session accuracy ($t(4) = 3.40$, $p = .03$, 95% CI [-16.53, -1.67]). The distributed schedule also resulted in a significant difference between baseline and final session accuracy ($t(4) = 4.71$, $p = .009$, 95% CI [-34.02, -8.78]). While significant differences between baseline and final session accuracy were identified, interpretation of these statistical findings should be guarded due to the small sample size.

Probe Accuracy

Each participant produced 20 probes, or untreated words/phrases, at the beginning of each session. These probes were used to determine impact of treatment on untreated stimuli. For both schedules, accuracy was determined by calculating the mean performance accuracy (i.e., Accuracy = Accurate Productions/Total Productions). Figures 8 & 9 illustrate the trends toward improvement for the mass and distributed practice schedules. Data from each session for the mass and distributed schedules for all participants is shown in Tables 8 & 9.

With the exception of Participant 4, all participants experienced some improvement during each treatment schedule (i.e., mass & distributed). No increase in accuracy was observed

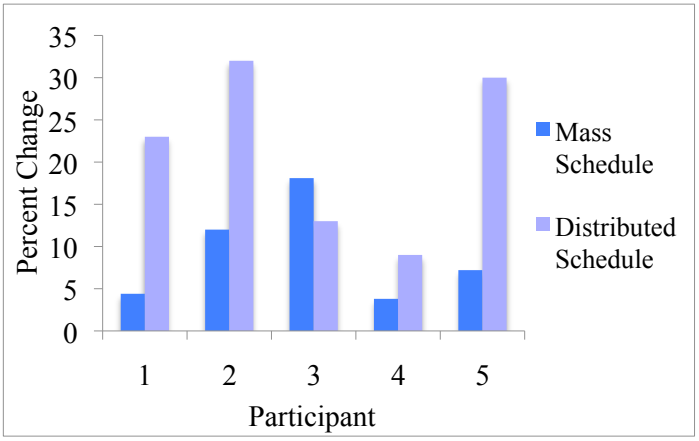

Figure 5. Change in Accuracy between Mass and Distributed Schedules

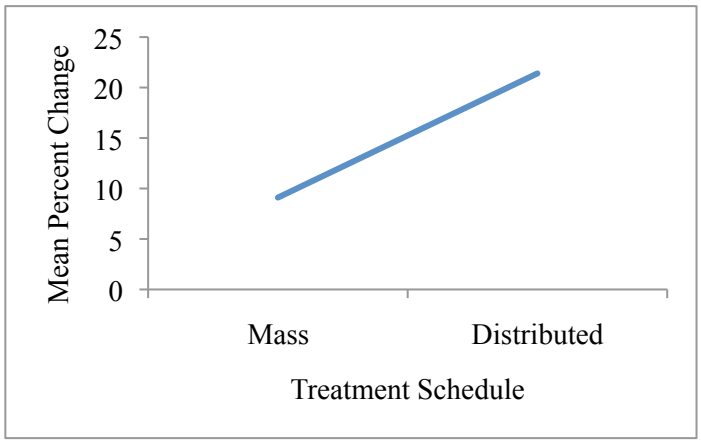

Figure 6. Overall Mean Change in Accuracy of Stimuli in Mass and Distributed Schedules

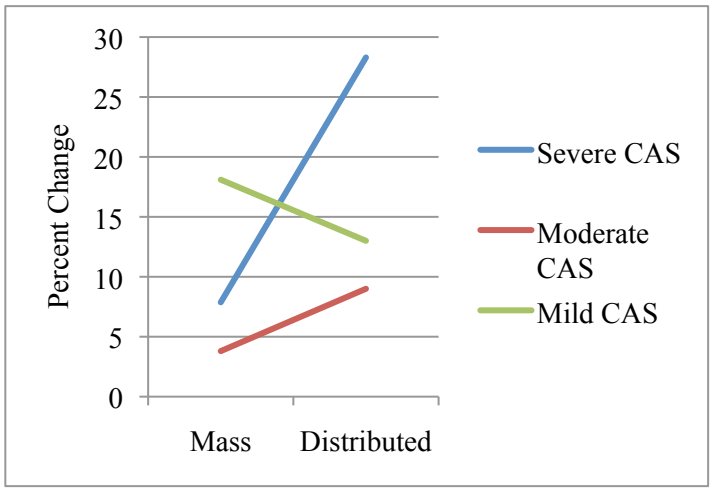

Figure 7. Mean Percent Change by CAS Severity Grouping

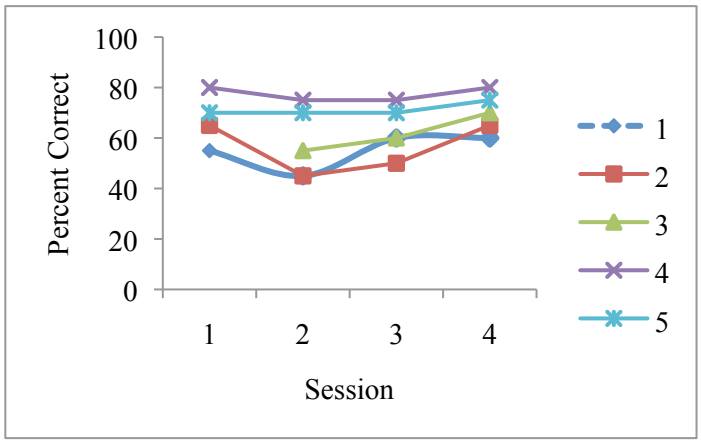

Figure 8. Mass Schedule Mean Accuracy of Probes by Session

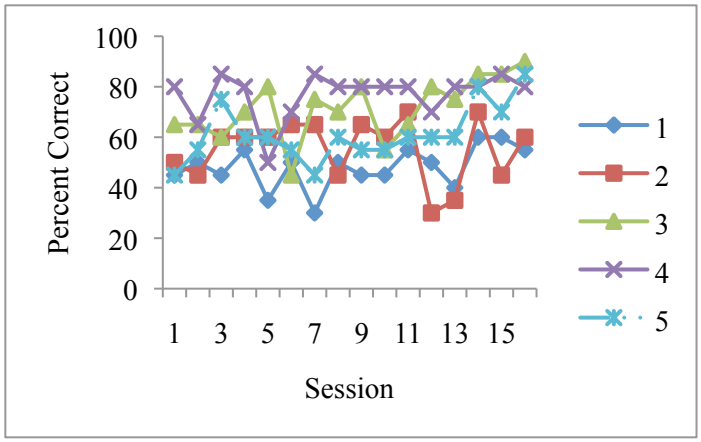

Figure 9. Distributed Schedule Mean Accuracy of Probes by Session

Table 8

Accuracy of Probes during Mass Schedule

Participant	Session 1	Session 2	Session 3	Session 4
1	55	45	60	60
2	65	45	50	65
3	N/A	55	60	70
4	80	75	75	80
5	70	70	70	75

Table 9

Accuracy of Probes during Distributed Schedule

Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	45	50	45	55	35	50	30	50	45	45	55	50	40	60	60	55
2	50	45	60	60	60	65	65	45	65	60	70	30	35	70	45	60
3	65	65	60	70	80	45	75	70	80	55	65	80	75	85	85	90
4	80	65	85	80	50	70	85	80	80	80	80	70	80	80	85	80
5	45	55	75	60	60	55	45	60	55	55	60	60	60	80	70	85

on probes during the mass schedule for Participants 2 and 4, nor during the distributed schedule for Participant 4. However, during the distributed schedule, Participant 2 demonstrated a 10% gain on probe accuracy. Data from each schedule, mass and distributed, for all participants is shown in Table 10. These findings are illustrated in Figures 10 & 11.

Percent of change in accuracy on probes was calculated by subtracting the final session accuracy from baseline accuracy for both schedules (i.e., Change in Accuracy on Probes = Percent Accuracy in Final Session – Percent Accuracy at Baseline). As shown in Figure 12, the range of accuracy on probes varied among participants. Probe accuracy during the mass schedule ranged from a 0%-15% improvement (M=5%). Probe accuracy during the distributed schedule ranged from 0%-40% improvement (M= 17%), as shown in Figure 13. Data from each schedule, mass and distributed, for all participants is shown in Table 10. The smallest degree of change as measured by accuracy on probes was achieved during the mass schedule. While overall a greater increase in accuracy on probes was seen during the distributed schedule, the percent of change are smaller than those of the treated stimuli.

No significant difference between baseline and final session on probes was found with the mass schedule ($t(4) = 1.83$, $p = 1.4$, 95% CI [-12.60, 2.60]). The distributed schedule also did not demonstrate a significant difference between baseline and final session probes ($t(4) = 1.94$, $p = 1.3$, 95% CI [-36.51, 6.51]). It is noted that these statistical findings are interpreted guardedly due to the small sample size in the study.

Discussion

All participants included in the study were diagnosed with CAS of diverse degrees of severity, from mild to severe. Additionally, research has shown that children with CAS make limited progress in treatment. Nonetheless, the participants demonstrated improvement on

Table 10

Baseline/Final Session Results of Probed Stimuli by Schedule

	Mass Schedule			Distributed Schedule		
Participant	Baseline	Final	% Change	Baseline	Final	% Change
1	55	60	+5	45	55	+10
2	65	65	0	50	60	+10
3	55	70	+15	65	90	+25
4	80	80	0	80	80	0
5	70	75	+5	45	85	+40
Mean Change:			+5			+17

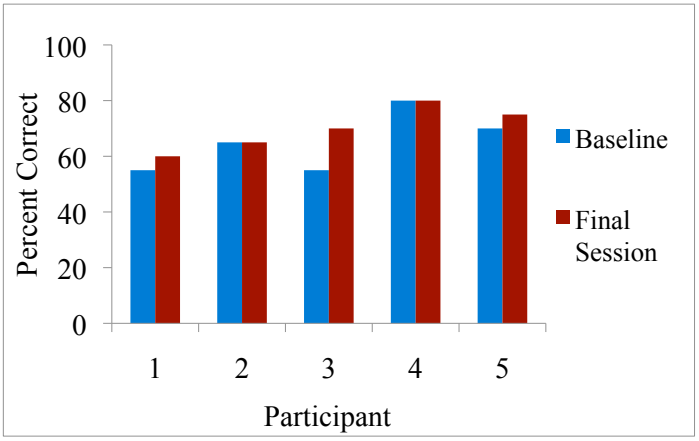

Figure 10. Mass Schedule Baseline and Final Session Accuracy of Probes

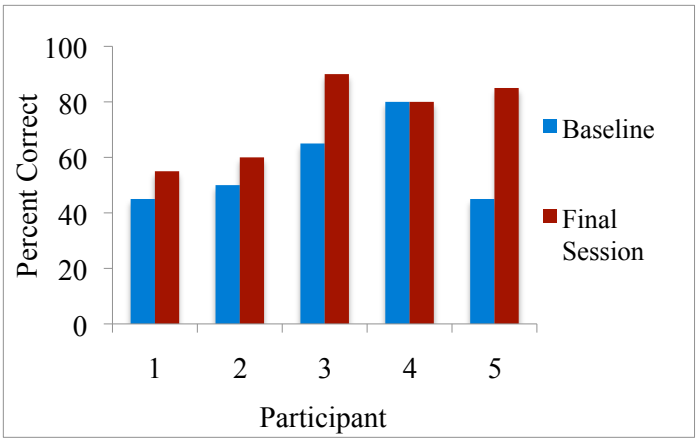

Figure 11. Distributed Schedule Baseline and Final Session Accuracy of Probes

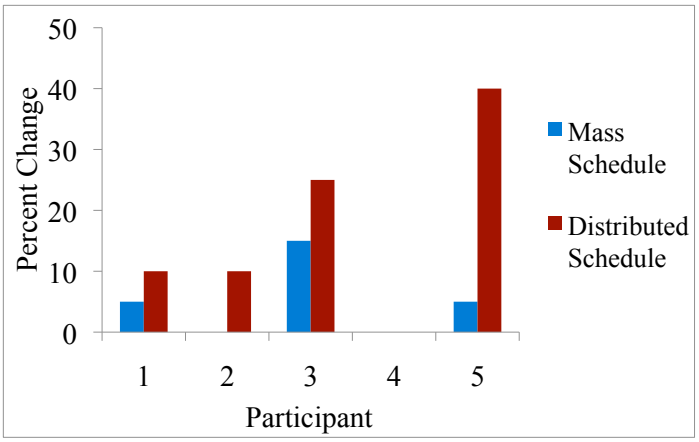

Figure 12. Change in Probe Accuracy between Mass and Distributed Schedules

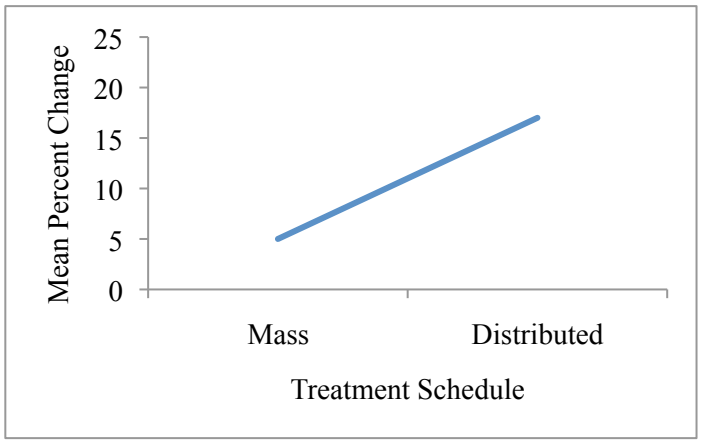

Figure 13. Mean Change in Probe Accuracy between Mass and Distributed Schedules

treated targets during both treatment schedules (i.e., mass & distributed). However, participants demonstrated a greater response to distributed treatment than mass treatment.

MLG Treatment with Severe CAS. Participants 1, 2, and 5 were all diagnosed with severe CAS. During the distributed schedule, these participant's accuracy levels increased to a greater degree than those participants with less severe CAS. These three participants all experienced more than a 20% change in overall accuracy. Accuracy on probes varied widely within this severe group during the distributed schedule. Participant 5 experienced the greatest change in accuracy at 40%, while participants 1 & 2 experienced only a 10% increase. The high increase experience by Participant 5 may have been related to increased and more focused attention during the shorter sessions associated with the distributed practice, allowing him to better monitor his own speech productions.

During the mass schedule, Participants 1 & 5 experienced no more than a 5% change in overall accuracy while Participant 2 experienced no change at all. Overall accuracy of probes during the mass schedule was identical to accuracy on treated stimuli, with participants 1 & 5 experiencing a 5% increase and Participant 2 showing no change.

MLG Treatment with Moderate CAS. Participant 4 was diagnosed with moderate CAS. Participant 4 demonstrated increased accuracy of treated stimuli during both treatments schedules. However, during the distributed schedule, a 9% increase in accuracy was obtained. Whereas, during the mass schedule, accuracy was limited to a 3.8% increase. This participant experienced no change in accuracy on probes during either treatment.

MLG Treatment with Mild CAS. Participant 3 was diagnosed with mild CAS. An increase in accuracy on treated stimuli during both treatments was attained. During the distributed schedule, an improvement of 13% accuracy was achieved. During the mass schedule,

an improvement of 18.1% was achieved. Unlike the other participants, greater improvement on treated stimuli was observed during the mass schedule. Although it's difficult to provide a rationale for why this participant was different, it was noted that she had difficulty removing herself from a camp environment to participate in the distributed sessions, which may have impacted her overall progress during that schedule. Similarly, she was the only female and least severe; therefore, this may reflect gender and/or severity based differences in response to treatment. Increased accuracy on probes was seen for both treatments. However, greater improvement was observed during the distributed schedule, with a 25% increase compared to a 15% increase during the mass schedule.

Potential Limitation of the Study. Overall the participants had significantly greater difficulty maintaining attention during the mass schedule due to the lengthy sessions involved. Distractors, such as tokens & prizes, were used in order to maintain motivation throughout these sessions. Attention fluctuated and made a clear impact on accuracy of treated stimuli. For participant's short attention span consistent with their ages, the distributed schedule may have reduced the requirement for prolonged attention.

Clinical Implications. Based on the findings of this study, additional research is warranted to further evaluate the response of children with CAS to MLG interventions. Future research should focus on examining more participants and distributing gender so that comparisons between male and females regarding response to treatment can be completed. Additional analyses may also be completed to evaluate CAS response to MLGT based on age, severity, length of treatment and sessions, and type of stimuli.

Anecdotally, clinicians often report difficulty providing drill-based practice to young children. However, this research illustrated a successful approach to providing drill-based

treatment in an enjoyable environment. Participants with limited attention showed greater benefit from the distributed treatment schedule than the mass treatment schedule. While the participants produced 120 utterances per session, the distributed sessions lasted only 15 minutes at a time. In a typical clinical setting this may be difficult to schedule, as traditional therapy sessions last between 30 minutes to 1 hour (i.e., a mass treatment schedule). However, by having shorter, more intense sessions (i.e., distributed treatment schedule), the child can engage for a larger portion of the session and perhaps experience progress towards performance and learning at a faster rate than in a traditional session.

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Appendix A: IRB Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
1L-09 Brody Medical Sciences Building• 600 Moye Boulevard • Greenville, NC 27834
Office **252-744-2914** • Fax **252-744-2284** • **www.ecu.edu/irb**

TO: Caitlin Webb, Master's Student, Dept of CSDI, ECU—Mailstop 668

FROM: UMCIRB

DATE: April 13, 2010

RE: Expedited Category Research Study

TITLE: "Scheduling Distribution and Motor Learning Guided Treatment with Childhood Apraxia of Speech"

UMCIRB #10-0147

This research study has undergone review and approval using expedited review on 4.1.10. This research study is eligible for review under an expedited category number 6 & 7. The Chairperson (or designee) deemed this **unfunded** study **no more than minimal risk** requiring a continuing review in **12 months**. Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The investigator must adhere to all reporting requirements for this study.

The above referenced research study has been given approval for the period of **4.1.10** to **3.31.11**. The approval includes the following items:

- Internal Processing Form (dated 12.1.09)
- Informed Consent, Version B (dated 2.19.10) (received 4.1.10)
- Minor assent (dated 3.25.10)
- Flyer

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

The UMCIRB applies 45 CFR 46, Subparts A-D, to all research reviewed by the UMCIRB regardless of the funding source. 21 CFR 50 and 21 CFR 56 are applied to all research studies under the Food and Drug Administration regulation. The UMCIRB follows applicable International Conference on Harmonisation Good Clinical Practice guidelines.

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East Carolina University

University Health Systems of Eastern Carolina

Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Title of Research Study: Scheduling Distribution and Motor Learning Guided Treatment with Childhood Apraxia of Speech

Principal Investigator: Caitlin L. Webb, B.S., Master's Student
Institution/Department or Division: Communication Sciences & Disorders/College of Allied Health
Address: 3310U Allied Health Sciences, Mail Stop 668, Greenville, NC 27834
Telephone #: (252) 744-6147

Researchers at East Carolina University (ECU) study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of people who are willing to take part in research.

The person who is in charge of this research is called the Principal Investigator. The Principal Investigator may have other research staff members who will perform some of the procedures. The person explaining the research to you may be someone other than the Principal Investigator. Martha Smith, Skye Lewis, or Caitlin Webb may be asking you and your child to take part in this study.

You may have questions that this form does not answer. If you do, feel free to ask the person explaining the study, as you go along. You may have questions later and you should ask those questions, as you think of them. There is no time limit for asking questions about this research.

You do not have to consent to your child taking part in this research. Take your time and think about the information that is provided. If you want, have a friend or family member go over this form with you before you decide. It is up to you. If you choose to allow your child to be in the study, then you should sign the form when you are comfortable that you understand the information provided. If you do not want your child to take part in the study, you should not sign this form. That decision is yours and it is okay to decide not to volunteer your child.

Why is this research being done?
The purpose of this research is to determine whether one treatment schedule provides better outcomes than another with childhood Apraxia of Speech (CAS). The decision for your child to take part in this research is yours to make. By doing this research, we hope to learn how to better treat CAS.

Why is my child being invited to take part in this research?
Your child is being invited to take part in this research because he/she has persistent sound substitutions errors consistent with a speech diagnosis of CAS. If you volunteer your child to take part in this research, he/she will be one of about 6 children to do so.

UMCIRB
APPROVED
FROM 4.1.10
TO 3.31.11

Title of Study: Scheduling Distribution and Motor Learning Guided Treatment with Childhood Apraxia of Speech

Are there reasons my child should not take part in this research?
I understand that if I will not be able to keep scheduled testing or treatment sessions, I should not volunteer my child for this research study.

What other choices do I have if my child does not take part in this research?
You have the choice of not permitting your child to part in this research study.

Where is the research going to take place and how long will it last?
The research procedures will be conducted in the Health Sciences Building at the East Carolina University Speech-Language and Hearing Clinic. You will need to bring your child to the ECU Speech-Language and Hearing Clinic 21 times during the study. Each of those visits will take from 10 minutes to 1 hour. The total amount of time you will be asked to volunteer your child for this study is approximately 1 hours of testing, and 600 minutes of treatment over the next 3 months.

What will my child be asked to do?
Your child is being asked to do the following:

- Pre-experimental testing will be completed and will include a speech and language battery (i.e., oral mechanism examination, Test of Auditory Comprehension of Language, conversational speech sample, an articulation test, as well as a test of nonverbal intelligence). This will be done to measure your child's language and cognition. We will ensure that your child's speech mechanism is within functional limits. We will also determine whether your child's speech qualifies as CAS. The entire battery of tests will take approximately 1 hour to complete, not including breaks for your child.
- We will screen your child's hearing acuity throughout the speech frequencies at 1000, 2000, and 4000 Hz HL. This screening will take 5-10 minutes. This will ensure that your child's hearing is within limits appropriate for completing the study.
- We will screen your child's vision. This screening will take 5 minutes. It will ensure that your child's vision is within limits appropriate for completing this study.
- Your child will attend a total of 600 minutes of therapy over the course of the study. The therapy will be divided into two treatments schedules:
    - 1: Your child will attend 6 50-minute sessions, once weekly.
    - 2: Your child will attend 30 10-minute sessions, 3 per day, five times per week for two weeks.

In addition, each session will be digitally audio- and video recorded. This procedure is integral for collection of data for the research study. Only the named researchers will have access to the audio/video data. The recordings will be kept for 5 years from the conclusion of the study. They will be kept on a hard drive in the Principal Investigator's locked lab.

What possible harms/discomforts might my child experience if he/she takes part in the research?
There are always risks (the chance of harm) when taking part in research. It has been determined that the risks associated with this research are no more than what you would experience in a normal life. However, some people react to things differently so it is important for you and your child to tell us as quickly as possible if he/she experiences any negative feelings, or feels sick.

Are there any reasons you might take my child out of the research?
During the study, information about this research may become available that would be important to you. This includes information that, once learned, might cause you to change your mind about wanting your child to be in the study. We will tell you as soon as we can.

There may be reasons we will need to take your child out of the study, even if you want him/her to stay in. We may find that you are not or cannot come for your child's study visits as scheduled. If this is found to be true, we will need to take your child out of the study.

What are the possible benefits my child and I may experience from taking part in this research?
We do not know if you will get any benefits by taking part in this study. This research might help us learn more about CAS and how to best treat it. Besides free speech therapy services, there may be no personal benefit from your child's participation but the information gained by doing this research may help others in the future.

Will my child be paid for taking part in this research?
We not pay your child for the time he/she volunteers while being in this study.

Who will know that my child took part in this research and learn personal information about him/her?
To do this research, ECU and the people and organizations listed below may know that your child took part in this research and may see information about him/her that is normally kept private. With your permission, these people may use your private information to do this research:

- Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the Food and Drug Administration (FDA), the North Carolina Department of Health, and the Office for Human Research Protections.
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.

How will you keep the information you collect about my child secure? How long will you keep it?
All data will be kept for 5 years from the completion of the research study. Digital audio and video recordings, as well as physical data (e.g., test protocols) will be kept in the Principal Investigator's locked lab.

What if I decide I do not want my child to continue in this research?
If you decide you no longer want your child to be in this research after it has already started, he/she may stop at any time. He/she will not be penalized or criticized for stopping. He/she will not lose any benefits that your child should normally receive.

What if my child gets sick or hurt while he/she is in this research?
This study does not involve any risk greater than what your child experiences in everyday life. Therefore, we do not expect your child to become sick or hurt as a result of being part of this research. However, people respond differently to things and sometimes accidents do happen. Therefore, if you need emergency care, call 911 for help. If possible, take a copy of this consent form with you when you go.

Call the principal investigator as soon as you can. She needs to know that your child is hurt or ill. Call Dr. Laura J. Ball at (252) 744-6147, Dr. Martha Smith at (252) 744-6094, or Ms. Skye Lewis at (252) 744-6119.

If you believe you have been hurt or if you get sick because of something that is done during the study, you should call Dr. Laura J. Ball at (252) 744-6147 immediately. There are procedures in place to help provide care for your child. Costs associated with this care will be billed in the ordinary manner, to you or your insurance company. However, some insurance companies will not pay bills that are related to research costs. You should check with your insurance about this. Costs that result from research-related harm may also not qualify for payments through Medicare, or Medicaid. You should talk to the Principal Investigator about this, if you have concerns.

Research Participant Authorization to Use and Disclose Protected Health Information

The purpose of the information to be gathered for this research study is to better understand effects of treatment scheduling in children with childhood apraxia of speech. The individuals who will use or disclose your identifiable health information for research purposes include Ms. Caitlin Webb, Ms. Skye Lewis, Dr. Laura Ball, and Dr. Martha Smith. Individuals who will receive your identifiable health information for research purposes include Ms. Caitlin Webb, Ms. Skye Lewis, Dr. Martha Smith, and Dr. Laura Ball. The type of information accessed for this research study includes videotaped recordings. The information will be used and disclosed in such a way as to protect your identity as much as possible; however, confidentiality cannot be absolutely guaranteed. Someone receiving information collected under this Authorization could potentially re-disclose it, and therefore it would no longer be protected under the HIPAA privacy rules (federal rules that govern the use and disclosure of your health information). There is not an expiration date for this Authorization.

You may not participate in this study if you do not sign this Authorization form. You may revoke (withdraw) this Authorization by submitting a request in writing to Dr. Laura Ball. However, the research team will be able to use any and all of the information collected prior to your request to withdraw your Authorization.

To authorize the use and disclosure of your health information for this study in the way that has been described in this form, please sign below and date when you signed this form. A signed copy of this Authorization will be given to you for your records.

Who should I contact if I have questions?
The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator, Dr. Laura J. Ball, at (252) 744-6147 (days, between 8:00 am-5:00 pm).

If you have questions about your rights as someone taking part in research, you may call the UMCIRB Office at phone number (252) 744-2914 (days, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of UMCIRB Office, at (252) 744-1971.

I have decided I want my child to take part in this research. What should I do now?
The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.

Title of Study: Scheduling Distribution and Motor Learning Guided Treatment with Childhood Apraxia of Speech

- I understand that I can stop my child from taking part in this study at any time.
- By signing this informed consent form, I am not giving up any of my rights.
- I have been given a copy of this consent document, and it is mine to keep.
- I understand that the researchers may contact me about future research opportunities.

Participant's Name (PRINT)	Signature	Date

Person Obtaining Informed Consent: I have conducted the initial informed consent process. I have orally reviewed the contents of the consent document with the person who has signed above, and answered all of the person's questions about the research.

Person Obtaining Consent (PRINT)	Signature	Date

Principal Investigator (PRINT) (If other than person obtaining informed consent)	Signature	Date

Minor Assent Document

Title of Research Study: Scheduling Distribution and Motor Learning Guided Treatment with Childhood Apraxia of Speech
Principal Investigator: Caitlin Webb
Telephone #: (252) 744-6104

You should ask the study doctor or the study coordinator to explain any words or information that you do not understand.

What is the research study about?

Our research study will try to figure out why some kids have trouble with their sounds and how we can best help them talk better.

Who will be in the research study?

Sometimes when kids talk, their sounds don't come out perfectly. It isn't because they don't know what they are talking about, but it might make it hard for some kids to say what they want to say. We need kids like these in our research study.

What will I be asked to do?

We will make sure your ears can hear. We will make sure that everything looks good in your mouth. You will say some words, point to pictures, and answer questions. You will come to the clinic every day for two weeks, then once a week for six weeks.

Where will the research study take place?

We will see you at the East Carolina University Speech-Language and Hearing Clinic.

How can I participate?

All you need to do is sign or write your name on the back of this page. If you have any questions, please ask them at any time.

What happens if I change my mind about participating?

Participating in this study is your choice. You may stop at any time during the study. No one will be upset with you if you decide not to participate.

Who can answer any questions that I might have later on?

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TO 3·31·11

You can talk to Ms. Webb, Dr. Ball, Dr. Smith, or Ms. Lewis at (252) 744-6104 if you have more questions at any time during the study. You can also call the university office at (252) 744-2914 if you are concerned about how you have been treated in the study.

If I put my name at the end of this form it means I agree to be in this study. I will be given a copy of this form to keep after I sign it and so will my parents.

Print your name _____

Sign your name_____

Date _____

UMCIRB HIPAA Authorization Checklist/Approval Form

UMCIRB #: 10 - 0147 PI: Caitlin Webb

Title of study (full or abbreviated): " Scheduling Distributions and Motor Learning ----- Apraxia of Speech."

Check one of the boxes below:

- ☐ Use of ECU "Research Participant Authorization to Use and Disclose Information for Research"
- ☐ Use of a sponsor/granting agency or other alternative HIPAA Patient Authorization
- ☑ Use of research informed consent document form with required elements of the HIPAA Patient Authorization

Designated UMCIRB reviewer has reviewed the substitute HIPAA Patient Authorization for Research or proposed research consent form and found that it is written in plain language and contains:

Yes	No	
☑	☐	A specific and meaningful description of the information to be used or disclosed
☑	☐	The name or identification of persons or class of persons authorized to make requested use/disclosure of PHI
☑	☐	The name or identification of persons or class or persons who will use PHI for research-related purposes
☑	☐	A description of each purpose of the use or disclosure
☑	☐	The individual's signature (or that of his/her authorized representative) and the date.
☑	☐	An expiration date or event, or a statement "end of research study" or "none" when appropriate
☑	☐	A statement that the individual may revoke the authorization in writing;
☑	☐	Any exceptions to the right to revoke (e.g. researcher may continue to use and disclose, for research integrity and reporting purposes any PHI collected from the individual pursuant to such Authorization before it was revoked).
☑	☐	A statement that information disclosed under the Authorization could potentially be re-disclosed by the recipient and would no longer be protected under HIPAA.
☑	☐	A statement of the ability or inability to condition treatment, payment, enrollment or eligibility for benefits on the authorization by stating either stating the applicable conditions or the consequences to the individual for refusal to sign the authorization.

☑ **All the above elements are present, HIPAA AUTHORIZATION document is APPROVED**

☐ **All the above elements are not present; HIPPA AUTHORIZATION document is NOT APPROVED**

Susan McCammon 4-7-10

Designated UMCIRB Reviewer **Date**

Principal Investigator: Present this signed form at the time PHI is requested from custodians of records. ***By signing this document, I acknowledge and affirm that all enrolled subjects have signed a valid HIPAA Authorization Form.***

Principal Investigator **Date**

Version 08-04-03

UMCIRB APPROVED
FROM 4-7-10
TO no expiration

**********IMPORTANT INFORMATION**********

Continuing Review/Closure Obligation

As a investigator you are required to submit a continuing review/closure form to the UMCIRB office in order to have your study renewed or closed before the date of expiration as noted on your approval letter. This information is required to outline the research activities since it was last approved. You must submit this research form even if you there has been no activity, no participant s enrolled, or you do not wish to continue the activity any longer. The regulations do not permit any research activity outside of the IRB approval period. Additionally, the regulations do not permit the UMCIRB to provide a retrospective approval during a period of lapse. Research studies that are allowed to be expired will be reported to the Vice Chancellor for Research and Graduate Studies, along with relevant other administration within the institution. The continuing review/closure form is located on our website at www.ecu.edu/irb under forms and documents. The meeting dates and submission deadlines are also posted on our web site under meeting information. Please contact the UMCIRB office at 252-744-2914 if you have any questions regarding your role or requirements with continuing review.
http://www.hhs.gov/ohrp/humansubjects/guidance/contrev0107.htm

Required Approval for Any Changes to the IRB Approved Research

As a research investigator you are required to obtain IRB approval prior to making any changes in your research study. Changes may not be initiated without IRB review and approval, except when necessary to eliminate an immediate apparent hazard to the participant. In the case when changes must be immediately undertaken to prevent a hazard to the participant and there was no opportunity to obtain prior IRB approval, the IRB must be informed of the change as soon as possible via a protocol deviation form.
http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm#46.103

Reporting of Unanticipated Problems to Participants or Others

As a research investigator you are required to report unanticipated problems to participants or others involving your research as soon as possible. Serious adverse events as defined by the FDA regulations may be a subset of unanticipated problems. The reporting times as specified within the research protocol, applicable regulations and policies should be followed.
http://www.hhs.gov/ohrp/policy/AdvEvntGuid.htm

Version 02-26-07

Appendix B: Stimuli for Participants

Table B1

Participant 1 Stimuli List

Untreated Stimuli	Mass Schedule	Distributed Schedule
1. Toys	1. Good	1. Boat
2. Wand	2. Dog	2. Lid
3. Geek	3. Lock	3. Tea
4. Base	4. Hedge	4. Feed
5. Cap	5. Guide	5. Vein
6. Cone	6. Top	6. Cough
7. Fight	7. Lemon	7. Toe
8. Guard	8. Ride	8. Teeth
9. Rack	9. Ramp	9. Roof
10. Hive	10. Wood	10. Rip
11. Peas	11. Loop	11. Mud
12. Lip	12. Coin	12. Net
13. Guess	13. Duck	13. Bake
14. Rib	14. Kiss	14. Beet
15. Line	15. Penny	15. Tongue
16. Key	16. Day	16. Go
17. Pen	17. Guy	17. Lime
18. Wedding	18. Move	18. Zit
19. Lamb	19. Path	19. Taxi
20. Gas	20. Pony	20. Comb

Table B2

Participant 2 Stimuli List

Untreated Stimuli	Mass Schedule	Distributed Schedule
1. Deep	1. Duck	1. Pup
2. Hit	2. Moon	2. Duck
3. Badge	3. Locket	3. Hoop
4. Peak	4. Map	4. Beak
5. Beg	5. Hot	5. Look
6. Bone	6. Cook	6. Dog
7. Bag	7. Beak	7. Tent
8. Toad	8. Music	8. Deck
9. Funnel	9. Whip	9. Up
10. Move	10. Lemonade	10. Lie
11. Fell	11. Bathe	11. Tail
12. Hay	12. Glove	12. Balloon
13. Yawn	13. Lake	13. Photo
14. Mitt	14. Hip	14. Foot
15. Dot	15. Pickle	15. Edge
16. Hug	16. Kitten	16. Peel
17. Black	17. Clown	17. Good
18. Two	18. Five	18. Light
19. Hide	19. Day	19. Tool
20. Lap	20. Puzzle	20. Wag

Table B3

Participant 3 Stimuli List

Untreated Stimuli	Mass Schedule	Distributed Schedule
1. We went to the lake	1. I want to vacation at the beach	1. My spine is on my back
2. Pack a lunch	2. Don't believe the gossip	2. Jen had a headache
3. The baby is asleep	3. A pentagon has five sides	3. Pillow fights at night
4. Seal the envelope	4. My zip code is 27832	4. I like school
5. The bunny has a pink nose	5. The panda is black and white	5. I have a cousin in Maine
6. I'd like soup and a sandwich	6. Lock the van	6. A daisy has white petals
7. I need a map	7. The ketchup is on the table	7. Let's play in the sun
8. The fan is going fast	8. The beach is fun	8. Bees like pollen
9. Sit on my lap	9. Let's have pizza	9. Ben had a vanilla shake
10. The ham is in the oven	10. Get the phone	10. I need a nap
11. Look at those kids	11. They went to a magjc show	11. That toy is too expensive
12. I swim in the ocean	12. Caitlin made a mistake	12. Put on the baseball cap
13. Don't peek	13. We found a sunken ship	13. Let's have a picnic
14. She was too sick to go	14. She has a white dove	14. An animal was in the cave
15. I put seventeen violets in the vase	15. That was a big wave	15. I am five
16. I want to talk to you	16. We won the basketball game	16. I don't want the olive
17. The boy is nine	17. I'm good at addition	17. Bees make hone in a hive
18. I saw a snake	18. I take a vitamin at night	18. The moon is full tonight
19. Have some pie	19. A diamond is a shape	19. Beauty is only skin deep
20. Hop like a bunny	20. I want a bun	20. Give the baby a bottle

Table B4

Participant 4 Stimuli List

Untreated Stimuli	Mass Schedule	Distributed Schedule
1. Base	1. Knee	1. Balloon
2. House	2. Toss	2. Dove
3. Lace	3. Net	3. Keys
4. Check	4. Sheep	4. Eyes
5. Pies	5. Pitch	5. Shop
6. Cane	6. Bit	6. Lies
7. Type	7. Mitt	7. Wave
8. Dive	8. Fish	8. Knock
9. Chew	9. Vet	9. Bus
10. Peas	10. Cello	10. Map
11. Hive	11. Leave	11. Shoes
12. Face	12. Dig	12. Knife
13. Bone	13. Seal	13. Choke
14. Five	14. Night	14. Cup
15. Cheek	15. Goose	15. Mop
16. Big	16. Cone	16. Gill
17. Pave	17. Move	17. Love
18. Lion	18. Sun	18. Cape
19. Kneel	19. Chat	19. Neck
20. Yes	20. Nut	20. Toys

Table B5

Participant 5 Stimuli List

Untreated Stimuli	Mass Schedule	Distributed Schedule
1. Puff	1. Comb	1. Sack
2. China	2. Tide	2. Fight
3. Game	3. Cheat	3. Teach
4. Wood	4. Pool	4. Pad
5. Hoof	5. Moon	5. Tail
6. Duck	6. Bike	6. Match
7. Back	7. Cheetah	7. Gate
8. Pull	8. Say	8. Boot
9. Wave	9. Bee	9. Mall
10. Man	10. Key	10. Watch
11. Bag	11. Fat	11. Tape
12. Kit	12. Mood	12. Same
13. Day	13. Go	13. Cheek
14. Kiss	14. Paid	14. Knife
15. Bat	15. Map	15. Jeep
16. Type	16. See	16. Guy
17. Duke	17. Pave	17. Hood
18. Choke	18. Seat	18. Mad
19. Chat	19. Loop	19. Beak
20. Feet	20. Add	20. Cat