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A Combination of Therapeutic Techniques: Severe Broca's Aphasia

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Severe Broca's Aphasia

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Abstract

The effects of Modified Melodic Intonation Therapy for a fifty-nine year old adult with severe Broca's aphasia were examined. Intervention included inner rehearsal and first sound practice to potentially increase initiation abilities. Pre and post self-assessments were used to evaluate self-awareness. Six target phrases (four three-syllable phrases and two two-syllable phrases) were treated over the course of fifteen weeks with two one-hour sessions per week. Results showed an increase in the participant's ability to produce the target phrase. Inner rehearsal proved to be an initiation strategy that met functional needs of the participant in a timelier manner; on the other hand, first sound practice allowed the initiation of a phrase with perfect accuracy through 60 days post treatment. The two syllable phrases within each condition proved to be most successful and varying degrees of accuracy were observed for the three syllable phrases. Additional research needs to be conducted to further distinguish the impact of syllable length for ideal candidates and initiation strategies.

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Introduction

According to the National Aphasia Association (NAA), at least one million individuals in America have aphasia (n.d.). When one is diagnosed with aphasia, areas of comprehension and/or production are impaired within one's language processing abilities; however, an individual's intelligence in not affected (NAA, n.d.). According to Brookeshire (2008), Broca's aphasia is when one's output of words may be very limited, but comprehension is mainly intact. Often speech is reduced to short, limited utterances. Speech production may be labored, effortful and halting. Comprehension of speech is often present and the ability to read may be spared. However, writing is often impaired. The damage to the brain may immediately result in Broca's aphasia or an individual may show signs of a more severe, global aphasia that gradually improve until the persistent characteristics resemble Broca's aphasia. The lesion location is typically in the inferior-posterior portion of the frontal lobe, and severity varies from individual to individual. The person may or may not experience apraxia of speech which is illustrated by the difficulty in producing speech due to a motor planning deficit (Brookeshire, 2008).

Melodic Intonation Therapy

Melodic Intonation Therapy (MIT; Helm-Estabrooks & Albert, 2004) is a technique with evidence of effectiveness in aiding individuals' production of rehearsed phrases (Sparks, Helm, & Albert, 1974; Sparks & Holland, 1976). MIT was developed for individuals with aphasia to use the skills one has retained in order "to close the gap between the virtual inability to produce propositional speech and the need and desire to communicate through speech" (Helm-Estabrooks & Albert, 2004, p. 221). MIT was developed based upon the hypothesis that the right cerebral hemisphere, known to be

involved in music, may help individuals with left hemisphere damage (Sparks, et al., 1974; Sparks & Holland, 1976). When MIT was being created, the developers spent much time establishing evidence for the ideal type of candidates. Their research led them to a description of candidates that have survived a unilateral, left-hemisphere stroke and have severe difficulties with the verbal production of speech. Ideal candidates are described as non-fluent with some ability to sing words from familiar songs but struggle with repetition. Comprehension is at least moderately retained in ideal candidates, and therefore, they may have the diagnosis of Broca's aphasia. Finally, ideal candidates have the ability to attend, are motivated, and considered emotionally stable (Helm-Estabrooks & Albert, 2004; Sparks, et al., 1974). MIT builds and transitions the intact abilities of an individual with severe Broca's aphasia, including the ability to sing some phrases and display relatively good receptive abilities, to more typical verbal speech in order to meet communication needs.

The MIT protocol (Helm-Estabrooks & Albert, 2004) consists of three levels: elementary, intermediate, and advanced. In the elementary and advanced levels, there are five steps in each while there are four levels in the intermediate. A target word or phrase is selected at the appropriate level determined by the complexity of the target word or phrase. At the beginning of each level the client listens to the target phrase or word with a corresponding tonal sequence. The tonal sequence is developed to reflect one's natural speech intonation. Each time the target word/phrase is presented, the clinician presents the word slowly (about one syllable per second) and smoothly, with appropriate picture stimuli, and with the tapping the client's left hand to each syllable produced. As the client learns each target word/phrase, space is added between the presentation of the stimuli and

production of the target word/phrase along with decreased prompting. In the second step of the third level, the target word/phrase is moved from melodic intonation to more typical speech production (Helm-Estabrooks, & Albert, 2004).

Effectiveness of MIT. Several discussions have occurred about how MIT impacts specific neuronal action pathways in order to be an effective therapy for the selected population. The amount of right and left hemisphere involvement during MIT and modified forms of MIT has been researched. One explanation is that the right hemisphere is activated during MIT and compensates for the damaged area in the left hemisphere (Wilson, Parsons, & Reutens, 2006; Schlaug, Marchina, & Norton, 2008). Other researchers believe the left hemisphere is activated during MIT and then the left hemisphere is able to control the speech skills needed (Belin, et al., 1996; Breier, Randle, Maher, & Papanicolaou, 2010).

Researchers integrated melodic components into MIT based upon the theory and knowledge that music skills and melodic aspects are processed using the right hemisphere. Wilson, Parsons, and Reutens (2006) conducted a single participant design with melodic intonation as the isolated variable. The participant presented with severe Broca's aphasia and had a history of being an amateur musician. Three groups consisting of ten phrases were targeted in a 52-year-old male, four years post stroke. The phrases ranged from one syllable to four syllables. The first words were used within a traditional MIT protocol, while the second group was presented with a rhythmic emphasis. The third group of words was not targeted in therapy. The participant had therapy twice a week for four weeks with equal time spent on the melodic phrases and rhythmic phrases. Data were also collected at two post therapy points. The participant had greater success in

accessing and using the melodic phrases with less prompts than the non-melodic phrases. The findings indicated that the ability to encode phrases or initiate a phrase using melodic components relies on right hemisphere involvement, which supports the understanding of different music and speech processing systems. However, successful spontaneous productions of even the melodic phrases were limited. All phrases needed supports and varying levels of cues. The limited four-week time span may not have allowed enough time for the production of phrases to be instilled as independently initiated.

Schlaug, Marchina, and Norton (2008) also supported the concept of increasing an individual's ability to volitionally produce speech given right hemisphere activation. The study compared brain activation using functional magnetic resonance imaging (fMRI) of bisyllablic words/phrases with two participants after completion of a randomly assigned MIT protocol or speech repetition therapy. The fMRI images revealed an increased activation of the right hemisphere following 40 sessions and then after 35 additional sessions of MIT for their first participant. An improvement was also measured in spontaneous speech. The second participant who received speech repetition therapy, which did not include melodic components, showed increased left hemisphere activation after 40 sessions but had decreased speech production outcomes compared to the participant who received MIT therapy. The second participant then received 40 sessions of MIT and showed gains in speech output but his skills in picture naming remained the same.

Schlaug, Marchina, and Norton (2008) acknowledged there is bihemisphere involvement in speech production within individuals without brain injuries. However, they identified four components of MIT that may greater engage the right hemisphere and

decrease the dependence on the left hemisphere in order for individuals with left hemisphere brain damage to produce spontaneous speech. The components included reduction of speed, syllable lengthening, and syllable "chunking" as melodic intonation allows for additional time to process the required movement of the articulators. Furthermore, hand tapping was considered valuable in MIT to initiate articulators with the understanding that once the body is engaged in movement, the articulators needed for speech may also become stimulated and ease the transition to the production of speech.

Also using imaging studies, other researchers have found support for higher activation of left hemisphere involvement. In 1996, Belin et al. conducted a positron emission tomography (PET) study to further examine the activated areas of the brain while using MIT. Cerebral blood flow was measured in nine regions of the brain over four conditions in seven individuals with persistent, severe non-fluent aphasia. The conditions were being at rest, listening to a set of words, repeating words, and repeating words given with an MIT intonation. Bisyllabic words were used for each condition and consistent for frequency between each condition. The study found that the conditions not using the MIT component had an abnormal section of the right hemisphere activated for language that was homotopic to typical areas activated in the left hemisphere for language. When participants repeated the words presented using MIT, imaging showed left hemisphere activation. Results supported the understanding that the persistence of aphasia may be due to abnormal activation of right hemisphere structures during language tasks, and subsequently, MIT encourages activation of left hemisphere language centers. Belin et al. (1996) suspected the exaggerated prosody and rhythmic aspects of the melodic intonation involved in MIT engage the language centers of the left

hemisphere: It is not the musical tones initiating the right hemisphere but rather the prosody is slowed down and emphasized, so therefore the left hemisphere has more time to process and initiate movements.

In addition, Breier et al.(2010) discovered supportive results for left hemisphere activation following MIT treatment in their study using magnetoencephalography (MEG). Two participants with severe aphasia with expressive deficits received two three-week treatments of MIT resulting in a total of twelve hours of therapy. MEG images were taken while the participants named activities when presented pictures of drawings prior to treatment, after the first set of MIT, and after the second set of MIT. The first participant responded more favorably to the MIT treatment and showed an increase in expressive language after the first set of MIT. Subsequently, the MEG depicted an increase and more consistent activation of the left hemisphere. On the other hand, the second participant, whose receptive abilities were greatly lower than the first participant's, did not show an increase in expressive language following both sets of MIT. Initially, a slight increase in left hemisphere activity was observed following the first set of MIT, but overall, a greater right hemisphere lateralization was noted for the second participant. The severity of damage in the second participant may have contributed to the participant's lack of ability to engage centers of his left hemisphere and subsequently, limiting his ability to improve his expressive language using MIT. The authors recognized the limitations of MEG sensitivity and the narrowness of a covert naming task. However, their findings are consistent with those of Belin et al. (1996).

While at this time the level of hemisphere involvement may be individualized due to conflicting imaging studies, our modified form of MIT appeals to both reasoning of

speech production initiation following left hemisphere damage through the use of inner rehearsal and first sound practice.

Modified Forms of Melodic Intonation Therapy

Modified forms of MIT have successfully improved speech production in individuals with aphasia. Baker (2000) capitalized on the musical components of MIT with two participants who suffered traumatic brain injuries resulting in left hemisphere damage. Two participants in their 30s received the modified form of MIT. One participated for a year and a half while the other participated for three months. The modified version emphasized melodic components versus using speech prosody as in the traditional MIT. The pitch ranges were greater than four notes for the selected phrases as each word and phrase were completely unique in intonation. Target phrases and words were added throughout treatment as progress was shown. Instead of counting phrases for accuracy, independence of using words was counted along with words that required musical cueing. In addition, the playing of musical instruments accompanied treatment. At the end of treatment, one participant could independently initiate 124 words and phrases while the other could generate 30 words and phrases.

While Baker (2000) stressed an individualized melodic intonation for each word in her modified form of MIT, Hough (2010) implemented a modified form of MIT with the exclusion of hand tapping. Reportedly, the participant had previously engaged in traditional MIT within therapy but showed little success. The hand tapping was removed in order to streamline the sensory stimuli to the phrases being introduced. Significant differences were noted between baseline data and data taken through a maintenance phase.

While Baker (2000) and Hough (2010) demonstrated the functional improvement for a total of three participants using modified forms of MIT, Conklyn, Novak, Boissy, Bethoux, and Chemali (2012) provided evidence of an effective modified melodic intonation therapy through a randomized group study. The participants were recently diagnosed with mild to severe aphasia resulting from left middle cerebral artery damage and proved to be aware of their speech deficits. Individuals with dysarthria and/or apraxia of speech were not included. Fourteen participants were assigned to the control group of no treatment, and sixteen participants were assigned to the modified form of MIT. Conklyn et al. (2012) defined their modification of MIT by two distinctions a) the treating therapist developed individualized melodic intonation patterns ranging greater in pitch and rhythm than traditional MIT phrases, and b) entire phrases were used throughout all sessions. The authors also emphasized the importance of implementation of treatment within the first 90 days of an expressive aphasia diagnosis. The participants in the treatment group demonstrated greater overall success in verbal speech production following even one session. While this study did not directly compare a modified form of MIT to the traditional MIT, the results provided evidence for the successful impact a modified form of MIT can have for an individual with non-fluent aphasia.

The studies of Baker (2000), Hough (2010), and Conklyn et al. (2012) accentuated the positive aspects of modifying the MIT procedure; however, further investigation needs to transpire to determine ways to improve one's ability to self-generate speech. Studies need to be conducted to examine ways to increase the ability for an individual with Broca's aphasia to independently initiate speech.

Inner Rehearsal

Inner rehearsal, also referred to as inner voice or inner speech, has been defined many ways by various researchers depending upon the context. The relationship between inner rehearsal and speech production is still under investigation, but one of the most well-known, and first individuals to describe inner voice was Vygotsky in 1934. De Bleser and Marshall (2005) reported that Vygotsky described the behaviorism definition as "spoken language minus the overt vocalization (and hence sound)" (p. 250). Therefore, one's inner voice can produce language internally without the verbal output. Research from the mid-1960s to 1970s by Sokolov determined that individuals with aphasia have varying levels of disruption in the multidimensional inner speech process. During the same time period as Sokolov, researches Luria and Tsvetkova worked with electromyographic recordings to determine the relationship of inner voice and the production challenges of those with (non-fluent) aphasia. They determined that impairment in one's inner voice affected one's ability to have verbal output (De Bleser & Marshall, 2005).

The location of brain involvement during inner rehearsal was conducted within a study by McGuire et al. (1996) using positron emission tomography (PET) scans. They determined that when participants silently articulated phrases, their brains were activated in the inferior frontal area of the left hemisphere. The study focused on differentiating inner rehearsal and auditory visual rehearsal and also the implications for individuals who have schizophrenia. While the participants were not of the same demographic as individuals with non-fluent aphasia, the anatomical location of brain activity of inner rehearsal supports a connectedness between one's ability to think about articulation and to initiate it (McGuire et al., 1996).

An individual with Broca's aphasia's ability to monitor speech either internally or depending on auditory feedback was assessed by Oomen, Postma, and Kolk (2005) by using noise-masking to differentiate the conditions. The 71-year-old male participant described the path of a red dot while it moved between objects. Two raters transcribed semantic and phonological errors while the participant spoke with the ability hear himself audibly and another time with the introduction of white noise to encourage monitoring before speech production. Eleven healthy control participants were used for comparisons in both conditions. The results revealed that healthy participants minimized errors more with normal auditory feedback, hence they relied more on monitoring speech production by listening to themselves auditorially. On the other hand, the participant with Broca's aphasia had similar results within both conditions which indicated monitoring internally, possibly through inner rehearsal. While the results of this study cannot be generalized to the general population due to the limited numbers, it demonstrates the potential importance and connectedness of using inner rehearsal to produce accurate and desired speech production results within individuals with Broca's aphasia.

In direct relation to MIT, Norton et al. (2009) suggested that the clinician modeling and describing one's inner voice may lead to better generalization of target phrases. The practicing and mastery of the covert production of a phrase may help with overall initiation of other expressive phrases, particularly for individuals with apraxia of speech (Norton, Zipse, Marchina, & Schlaug, 2009). However, a suggested protocol to implement the strategy was not given.

First Sound Practice

Word finding and initiation difficulties are often associated with individuals that have aphasia (Brookeshire, 2008). Pease and Goodglass (1978) conducted a study where twenty individuals with either Wernicke's, Broca's, or anomic aphasia were presented with a total of 173 pictures of low and high frequency words. Six cueing levels were used including the clinician saying the first sounds, superordinate cues, location with environmental context, presenting a rhyming noun, describing the function, or completing an open ended sentence. Each participant proved to have different needs depending on factors such as severity and lesion location, but it was determined that providing the first sound of a word and giving a sentence completion cue were the most beneficial for the majority (Pease & Goodglass, 1978). While the participants did not produce the first sound in the study, the usefulness of being provided the initial sounds of a word demonstrated the importance of an individual needing to know and be confident in the first sound of a word in order to find and produce it.

Another study that emphasizes the importance of an individual becoming confident in associating the first sound of a word with each word was completed by Lenard, Rochon, and Laird (2008). The researchers implemented a word finding treatment called the phonological components analysis (PCA) where the participants identified six phonological factors of the target word, including the first sound. Cues were given if the participant was unable to come up with a characteristic. The results showed that PCA treatment was effective for the ten participants in the study. The authors commented that maintenance of the skills may be improved by having "more active engagement on the part of the participant," which includes practicing the initial

sound of the word (Lenard et al., 2008, p. 16). More research needs to be completed in order to determine the particular significance of practicing the initial sound of a word to help with initiation and word finding.

Self-Awareness

An individual's level of awareness may also impact or reflect an individual's brain injury and potential ability to learn over time. Hunt, Turner, Polatajko, Bottari, and Dawson (2013) conducted a scoping review study of executive function, self-regulation, and attribution in relation to individuals with brain injuries. In regards to self-regulation, the authors discuss the support for three phases of self-evaluation. In an initial phase, a plan for initiation is made with consideration of beliefs and previous experience. Implementation of initiation occurs in the second phrase along with self-monitoring, and the third phase involves self-reflection. The information gleamed from self-reflection is then taken into consideration for an upcoming initial phase (Hunt et al., 2013). The ability to self-monitor, in particular speech production, through the phrases listed implies a level of cognitive connectedness to initiation, whether through mental preparation, inner rehearsal, motoric capacities, or first sound practice.

Kennedy and Coelho (2005) have studied self-awareness in individuals with traumatic brain injuries. Even though traumatic brain injuries do not always result in aphasia, the concept of how self-awareness can be affected by a brain lesion is consistently applicable. Kennedy and Coelho believe that one's self-awareness is necessary in the self-regulation process. An individual must self-monitor and be aware of one's surroundings and performance in order to develop effective inner feedback. Inner feedback allows one to take the information about the situation and decide if adjustments

need to be made and subsequently implement the appropriate adjustments. It has been found that a person has a higher chance of learning and re-learning concepts in therapy when that individual has retained most of his or her self-regulation and self-awareness (Kennedy & Coelho, 2005). More studies must be completed to look at the self-regulation process and how that process affects learning and other executive functioning tasks for individuals that have a brain injury.

Purpose of the Study

The purpose of the conducted study was to examine the effects of a newly modified MIT as means to increase verbal output in an older adult with severe Broca's aphasia. Three research questions were addressed: 1) Does the participant's production of speech increase after completing the Modified Melodic Intonation Therapy (MMIT)? 2) Does the participant have a higher accuracy in speech production using an inner rehearsal technique or by practicing the first sound of a phrase? 3) Does the participant's pre and post self-rating reflect treatment performance?

Hypotheses

It was hypothesized that the MMIT would result in an increase in the participant's verbal production of speech. In regards to the two techniques being addressed, it was expected that the phrases practiced with inner rehearsal would result in higher accuracy in speech production due to the growing interest, understanding, and importance of inner rehearsal and cognitive concepts within individuals with brain injuries. When examining the participant's cognitive connection involving self-reflection of skills, it was anticipated that the participant's self-rating would become more reflective of the participant's treatment performance with succeeding sessions.

Method

Participant

The participant was a fifty-nine year old right-handed Caucasian woman with severe Broca's aphasia. She survived a left middle cerebral artery ischemic infarction and began the study 28 months post stroke. The participant lived independently at home with the support of her husband. She presented with severe Broca's aphasia using the Western Battery Aphasia-Revised (WAB-R, Kertesz, 2006) aphasia classification criteria. Observations revealed minimal spontaneous speech; she produced "yes," "no," and a few family names. Difficulties with naming and word finding were measured through a categorical naming and word finding score of 1.2 out of 10 on the WAB-R, and the participant achieved a repetition score of 1.6 out of 10 (raw score of 16) indicating limits in verbal production. An auditory verbal comprehension score of 6.25 out of 10 (raw score of 125) demonstrated good auditory comprehension. In addition, her overall aphasia quotient score was 28.1 indicating severe impairment according to the WAB-R Aphasia Classification Criteria. Her attention and memory were considered severely low according to the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001) with scores of 42 and 56 respectively. She showed limited improvement on speech intelligibility and production during previous speech therapy as reported by the participant and her family, indicating the need for a modified treatment procedure (Conklyn et al., 2012).

General Procedure

The study was a simultaneous treatment single case design with an A-B-A format. Data was collected over two pre-treatment sessions, twenty treatment sessions, one post-

treatment session, and two maintenance sessions. Sessions lasted approximately 60 minutes. Maintenance sessions were taken at 30 days post-treatment and 60 days post-treatment. All procedures were approved by the Minnesota State University Mankato Institutional Review Board for human participants.

The participant's baseline ability to produce the target and probe phrases was initially collected and phonetically transcribed during the two pre-treatment sessions. However, during the second baseline pre-treatment session, the graduate student researchers noticed that the participant attempted to repeat what the graduate student researchers said before the researchers completed producing the target phrase. The graduate student researchers decided to implement a two-second wait time. The graduate student researcher explained to the participant to refrain from speaking when the graduate student researcher's hand was in a vertical, stop position. The participant could speak once the graduate student researcher turned her hand horizontal with the palm up. Two seconds passed between the time the probe was presented and when the participant could speak. The indicated hand gesture was used during implementation of wait time throughout treatment sessions. Therefore, baseline data was collected directly prior to the first treatment session (since the two pre-treatment sessions had already expired) in order to accurately measure her independent ability to produce the target and probe phrases.

During the first of twenty treatment sessions, MMIT and the reason for using it was explained to the participant:

> The left side of your brain controls language. When you had your brain injury, the language center of your brain was impaired. Music and rhythm stimulate both hemispheres of the brain. Using this procedure, new connections bridge the left

and right sides of your brain to compensate for the damaged area. Tapping your hand while we sing and hum maximizes the benefits of melodic intonation therapy.

The research project was conducted at a university clinic and within the participant's home. At the clinic, a designated therapy room with two graduate student researchers was set aside. The two graduate student researchers and the participant sat at the participant's kitchen table when sessions were off campus. Distractions were minimized by selecting times when the participant's spouse was gone or already home. Other distractions such as the phone ringing or needs of the participant's dog were addressed by the graduate student researcher not administrating the treatment. Within both facilities, the participant and one graduate student researcher sat adjacent to each other with access to the participant's left hand. The other student researcher sat directly across from the participant. A camcorder was used to video-record each session. The pre-treatment assessments, two treatment sessions, and follow-up testing were conducted at the clinic. Eighteen treatment sessions and the post-treatment assessments were conducted in the participant's home. Once treatment sessions began, the participant was seen for two one-hour sessions each week over the course of fifteen weeks.

Phrase Selection

Six target phrases and six probe phrases were used in the study. Initially, the researchers determined fourteen phrases with two or three syllables that appeared applicable to the participant's daily life needs. The participant and her spouse rated the participant's ability and need for each of the fourteen words/phrases compiled by circling "no need," "sometimes," "often," or "all the time" next to each phrase. The researchers

used the information provided by the participant and her spouse to designate six, functional target phrases that were used in the treatment and six probe phrases that were assessed weekly. The three target phrases including “My Pills,” “I Love You,” and “Someone Came,” were used with one condition, while “Help Me,” “I’m XXX (participant’s name),” and “Good Morning,” were used with a secondary condition. The three phrases contained different phonemes per condition. Twenty-nine percent (29%) of the phonemes overlapped between the two conditions while 71% of the phonemes were different. Overlapping phonemes between the two conditions consisted of /l, m, n, p, s, aɪ, ɪ/. The probe phrases consisted of three phrases that had similar phonemic components to the target phrases (“Give More,” “I Like Cake,” and “Hug a Lot”) while three phrases had different phonemic components from the target phrases (“Tie the Shoe,” “Bake That,” and “Just be Quiet”). Table 1 depicts the phoneme similarities and differences between the probe and target phrases.

Each target phrase was assigned an intonation that reflected the prosody of speech. Unique patterns were created in order to differentiate the phrases for the participant (Baker, 2000).

Modified Melodic Intonation Therapy (MMIT)

Melodic Intonation Therapy (MIT; Helm-Estabrooks & Albert, 2004) was designed to enhance verbal output in individuals with severe non-fluent aphasia. The beginning level of MIT has five steps. No response is required from the participant in the first step as the phrase is hummed twice while incorporating hand tapping of one hand tap per syllable. The second step involves unison singing where the research and participant hum twice and then intone the targeted phrase twice while the researcher taps the

participant's left hand. The research fades out the intonation on the third step while continuing to tap the participant's hand for each syllable. In the fourth step, the researcher intones and taps the participant's left hand. Then the participant repeats the intoned target phrase while the researcher continues to tap the participant's left hand. A question is then asked to elicit the appropriate target phrase independently for the fifth step. Hand tapping may or may not be included in this step.

The Modified Melodic Intonation Therapy (MMIT) used the five steps of the MIT procedure as the framework with two *back-step* conditions: inner rehearsal and first sound practice. Of the six phrases identified, three were used with the inner rehearsal condition and administered by one graduate student researcher while the other graduate student researcher directed the MMIT treatment with the other three phrases using the first sound practice condition. All six target phrases were addressed each session for a maximum of ten minutes per phrase. The inner rehearsal condition phrases and first sound practice condition phrases were administered alternatively between treatment sessions. The inner rehearsal condition phrases were targeted first during the first treatment session followed by the first sound practice condition phrases. The second treatment session began with first sound practice condition phrases and then followed with the protocol for condition one phrases. The sessions continued to alternate between the administrations of inner rehearsal and first sound practice phrases for the continuation of treatment sessions.

Inner Rehearsal. The inner rehearsal condition focused on using an inner visualization of production to initiate phrases. For steps two through five, a score of one was awarded for accurate completion of the target phrase and a zero for an incomplete

response. Accurate completion of a phrase required the participant to verbally produce 100% of the phonemes in the phrase accurately. If she omitted or substituted a sound, the phrase was considered incomplete and a zero was given. If a score of one was documented, the administration of the next step occurred. For example, on step two, if the participant successfully intoned all of the phonemes within the target phrase in unison with the researcher, a one would be scored and step three, unison singing with fading would be introduced. If a zero was scored for a step, the appropriate back-step condition was implemented. For example, on step two, if the participant did not intone in unison with the researcher by either not producing any phonemes or only partial phonemes of the phrase, the condition of inner rehearsal would be applied.

The graduate student researcher initially explained the use of one's inner voice to internally hear the phrase that was being targeted by stating, "When I sing this phrase, I want you to sing this phrase inside. Imagine hearing someone sing 'Happy Birthday' to you right now. That is your inside voice."

Once the participant acknowledged the concept, the graduate student researcher referred to inner rehearsal by saying, "I want you to hear this inside your head while I sing." The graduate student researcher tapped the participant's hand while intoning the target phrase twice. If the participant acknowledged "hearing" the phrase inside her head, then a one was scored and the participant continued on with the same step of the MMIT. As an example, if the participant failed to produce all the phonemes of an inner rehearsal condition phrase during step three of singing with fading, as previously noted, inner rehearsal would be used. If the participant nodded her head vertically up and down, indicating an acknowledgement of hearing the phrase inside her head after the graduate

student researcher had intoned the phrase, a one would be documented. The protocol for step three would be reinstated and assessed again for completion of phrase production. If inner rehearsal was not acknowledged after implementation of inner rehearsal, a zero was scored and the participant moved to the previous MMIT step. Again using step three as an example, if the participant did not respond or shook her head horizontally side to side indicating she did not hear or understand, a zero was scored and instructions for step two (unison singing) was continued. If the graduate student researchers noticed the participant's mouth move while the graduate student researcher was intoning the target phrase during the inner rehearsal back-step, the participant was given a reminder. The reminder emphasized the participant focusing on hearing the phrase inside her head instead of trying to move her mouth.

First Sound Practice. The first sound practice condition emphasized the practice of the initial phoneme of the target phrases to encourage independent initiation. If a zero was scored on one of the five steps of MIT, the graduate student researcher guided the participant through the production of the first sound of the target phrase. A combination of an iPad articulation placement app (University of Iowa Research Foundation, 2014), mirror, and modeling were used to help demonstrate the correct articulation placement. A trial began once the participant correctly demonstrated the ability to produce the first sound of the target phrase either in isolation, the initial position of a word, or consonant-vowel combination. If the participant was able to correctly produce the desired sound in an initial position four out of five times, a one was scored and the participant returned to the current step. If the participant was unable to accurately produce the first sound of the target phrase, a zero was marked and the previous step was addressed. For example, if the

participant successfully completed steps one and two on the phrase “Good Morning” but did not successfully complete the requirements (producing the phrase with 100% accuracy) to continue past step three, the first sound practice was implemented as stated previously. If she accurately produced the sound in a minimum of four out of five opportunities after demonstration, the protocol for step three of unison singing with fading was assessed again. If she did not produce the phoneme correctly, the step two protocol, unison singing, was introduced.

The flow chart in Figure 1 depicts the incorporation of the inner rehearsal and first sound practice conditions with the MIT protocol, creating the MMIT.

Self-Ratings. The participant rated her performance using a rating scale. The scale range was on five increments with zero representing “ poor,” twenty-five representing “fair,” fifty representing “so-so,” seventy-five representing “good,” and 100 representing “excellent.” The scale was used every treatment session for each phrase. Before the treatment of each phrase, the graduate student researcher directed the participant to rate herself by stating, “How well will you perform on this phrase? Poor, fair, so-so, good, or excellent?” The participant indicated her choice on the rating scale by pointing to number or phrase. After the treatment of each phrase, the participant was asked how well she thought she did after the phrase of focus was completed by asking, “How well did you perform on this phrase? Poor, fair, so-so, good, or excellent?” An answer was indicted by the participant pointing to one of the marks on a visual continuum.

Homework. To encourage daily practice, each week a homework sheet was sent home to elicit the practice of each target phrase three times each day. For each of the six

target phrases, the student graduate researchers came up with three questions that would elicit a desired target response. For example, in order to hopefully elicit "My Pills," the spouse would ask "What does the doctor give you?" (while having a prescription bottle in sight), "What's in the bottle?" (while pointing to a prescription bottle), and "What do you need to take in the morning?" The spouse ideally asked the participant the eighteen designated questions (three for each of the six target phrases) each day and recorded her response on a homework form (Appendix A). The spouse circled "yes" or "no" based upon if the participant responded by saying the desired phrase, in this case "My Pills." The requirements to indicate a "yes" on the form were simply if the participant responded with the correct target phrase; cueing on any level was deemed as appropriate. If the spouse did not ask the participant any questions on a given day, then the page was left unmarked. The researchers gave a blank homework sheet to the spouse each week and collected the previous week's homework sheet.

Modified Melodic Intonation Therapy Data Collection. Each treatment session began with data collection of phonetically transcribing each of the target and probe phrases by asking the participant to "Please say [target or probe phrase]." A two-second-wait time with gesture was used before the participant responded. After target and probe phrase data were collected, treatment on the target phrases began. For each phrase, the participant was asked to first rate herself on how she expected herself to perform. Then the graduate student researcher prompted, "Please say [target phrase]" with two-seconds of wait time using visual hand gestures indicated previously. If the participant produced the target phrase with 100% accuracy, then a one was scored and the post self-assessment was given. If the participant was not able to produce the target phrase with 100%

accuracy, the MMIT was administered. The participant moved throughout the five steps of the MMIT with each target phrase for ten minutes or until the participant completed the five steps consecutively three times. A flowchart documentation form was used for each phrase within the inner rehearsal condition (Appendix B) and first sound practice condition (Appendix C). After the ten minutes or completion of the protocol three times, the participant was asked to rate how well she did on the phrase. The process then began again for the next target phrase. The completion of levels was also recorded for each phrase. So if the participant successfully completed the protocol three times for the phrase, "Good Morning," then it was noted the participant reached step five, three times. If the participant made it through the protocol once and ended on step two within the ten minute of allotted time, the graduate student researchers noted the participant reached step five, once and finished on step two.

Accuracy of each phrase was recorded by documenting her verbal production using the International Phonetic Alphabet (IPA) and calculating the percent correct. Her accuracy was documented for each probe phrase once and twice for each target phrase during the treatment sessions. As noted, the probe phrases were asked at the start of every treatment session along with each target phrase. The second time the target phrase accuracy was recorded occurred directly prior to the individual practice of each target phrase. For example, "My Pills," a target phrase practiced with the inner rehearsal condition, was phonetically transcribed and percent accuracy reported during the initial prompt of all target and probe phrases and also before the specified treatment began on the phrase.

Initial and Final Assessment Measures

The participant's initial language and cognitive abilities were measured through the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2006), American Speech Language Hearing Association Functional Assessment of Communication Skills for Adults (ASHA FACS; Frattali, Holland, Thompson, Wohl, & Ferketic, 1995), Quality of Communication Life Scale (QCL; Paul et al., 2005), and Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001). Administration of the WAB results in an aphasia quotient, severity rating, and type of aphasia. Strengths and challenges in areas of content, fluency, repetition, auditory comprehension, naming, reading, writing, and language function are also identified. The CLQT assesses the participant's cognitive abilities in memory, executive functions, language, attention, and visuospatial skills. In order to determine the operative adeptness of the participant's communication skills, the ASHA FACS was given to the participant's spouse. The previous graduate clinician who worked with the participant also reported the ASHA FACS pre-treatment. While the ASHA FACS provided a picture of how others perceive the participant's communication abilities, administration of the QCL allowed the researchers to recognize the participant's personal reflection on her own communication skills. On the ASHA FACS, her spouse initially rated a mean score of 5.71 in the participant's ability of communication of basic needs. Her QCL initial rating was a mean of 4.3 out of a possible 5. All tests were given again after completion of treatment in order to monitor change in linguistic and cognitive areas.

Results

Probe and Target Phrase Performance

The first research question explored if the participant's production of speech increased after completion of the MMIT. The changes of average percent phoneme accuracy of probe and target phrases over the course of treatment, 30 days post treatment, and 60 days post treatment can be seen in Figure 2. The average percent phrase accuracy was determined by calculating the average of the phrases given the phonemes correctly produced within the phrase. Any phoneme produced was transcribed and considered for calculation as the graduate student researchers did not deem it appropriate to interpret if certain productions were fillers or an attempt at word production.

The average phrase percent accuracy for the baseline of target phrases of both inner rehearsal and first sound practice conditions ("My Pills," "I Love You," "Someone Came," "Good Morning," "I'm XXX," and "Good Morning") was 4.6% based upon the single baseline point. The participant produced the /s/ phoneme correctly within attempts of the phrases "I'm XXX," and "Someone Came." Initially, baseline data was collected during two pre-treatment assessment sessions. However, wait time was not incorporated, so that data was not considered to be an accurate representation of her level. Therefore, the baseline was collected directly before the first treatment session began. As previously noted, the average phrase percent accuracy for baseline was 4.6% of phonemes correct and treatment effect can be noted by comparing the baseline average percent accuracy across treatment and maintenance sessions.

The graduate student researchers defined the presence of the treatment effect as when the average percent accuracy of phonemes within the target phrases rose above the

baseline measurement in Figure 2. Treatment effect was observed at treatment session three when there was a sudden increase in average percent accuracy for target phrases from treatment session two (2.8%) to treatment session three (17.1%) as the accuracy increased above the baseline collection of 4.6%. Due to the nature of the baseline collection occurring directly before treatment session one, treatment session two served as the first data collection point depicting the impact of treatment. There was an additional increase in average percent accuracy of target phonemes from treatment session three (17.1%) to treatment session four (32.4%). While there was a decrease from treatment session four to treatment session five (15.7%), the average phoneme percent accuracy was maintained above the treatment effect line. The average phoneme percent accuracy of target phonemes fluctuated between 38% and 53% from treatment session seven through 30 days post treatment. Even with a decrease in accuracy to 19.7% measured at 60 days post treatment, the average phoneme percent accuracy of target phrases remained higher than the baseline measurement of 4.6% for target phrases. The participant produced the two syllable phrase "Help Me" with 100% accuracy at 60 days post treatment as compared to the production of /jɛs/ for all of the six target phrases during baseline.

The average percent accuracy of phonemes in probe phrases fluctuated between treatment sessions with a range of 23.4%. The lowest percent accuracy was 0.0% measured in treatment session four and the high was documented as 23.4% in treatment session eighteen where she produced /kek/ for the probe phrase "I Like Cake" (/aɪ laɪk kek/), /k/ for "Hug a Lot" (/hʌg ʌ lɒt/), and / b ʃu/ for "Tie the Shoe" (/taɪ ðʌ ʃu/). The participant did not respond for the remaining probe phrases. There was consistently a

difference between the accuracy level of probe and target phrases throughout the course of treatment and maintenance. The only incidence where the participant had a higher average percent accuracy of probe phrases than target phrases was in treatment session two with a difference of 9.9%. The remainder of the treatment and maintenance data collections revealed a consistently higher performance of target phrases rather than probe phrases with the greatest difference measured in treatment session ten with a difference of 46.4% in accuracy of average phonemes produced between the target and probe phrases. Table 2 depicts the average percent accuracy of phonemes within probe and target phrases as well as the difference between the probe and target phrases.

Statistical effect size was unable to be calculated due to the limits of the one baseline collection, and while the treatment effect is arguably small, an effect size remains clearly present. It is anticipated that the data may have been higher if data were collected at the end of each treatment session and at the end of treatment for each individual target phrase. Instead, the ability to maintain learning from the previous treatment session was emphasized with the collection points occurring at the beginning of each session and directly prior to the individual implementation of treatment for each target phrase. The intent of phoneme production was not assessed which may have impacted calculation measures. However, determining a protocol for phonemic production intent may also have excluded productions that were intended as target or probe phrase productions.

No generalization was noted as the average percent accuracy of all six probe phrases remained lower than the target phrases in all measurements except for one data collection. Generalization was still not observed when the probe phrases were separated

into the average percent accuracy of the three probe phrases with similar phonemes as the target phrases and three probe phrases with different phonemes as the target phrases. Please refer to Table 3. In comparison to the target phrases, the probe phrases with similar phonemes and probe phrase with different phonemes depicted a low and inconsistent average accuracy of phrases. The highest average phoneme percent accuracy of the probe phrases with similar phonemes with the target phrases was 25.7% at treatment 17, while the highest average percent accuracy was 27.8% for probe phrases with different phonemes at treatment 18. There was no clear rise and fall pattern of average phoneme percent accuracy in comparison to the average phoneme percent accuracy of the target phrases.

The method of probe data collection may explain for the lack of generalization results. All probes were consistently asked sequentially with no break. If the participant did not respond or responded quickly with a minimal attempt (often by responding /no/) to the initial phrase or phrases, then subsequent phrases appeared to have similar responses. In addition, the graduate student researchers used calculated average phoneme percent accuracy by considering all phonemes produced as there is no definite way to determine intent of production. Therefore, when the participant perseverated “yes” (/jɛs/) for all probe phrases at the baseline, a 0% accuracy was calculated for the probe phrases “Give More,” “I Like Cake,” “Hug a Lot,” “Tie the Shoe,” and “Bake That,” while an 8% accuracy was calculated for the phrase “Just Be Quiet” as one of the twelve phonemes (/s/) was present in the probe phrase and the verbal production of the participant. A formula to determine intent of production may have impacted the calculated results of average phoneme percent accuracy.

Inner Rehearsal Condition

Inner rehearsal phrases and first sound practice phrases were analyzed in order to determine the results of the second research question determining if the participant had higher accuracy in speech production using the inner rehearsal technique or by practicing the first sound of a phrase. The phrases treated with the inner rehearsal back-step condition were "My Pills," "I Love You," and "Someone Came." The calculation for the phrases included the average of the phonemes produced correctly for each phrase within two points during each session. Data were collected for each target phrase at the beginning of each session with the probe phrases and again individually directly prior to the implementation of the treatment of each phrase. The baseline and maintenance calculations were devised using the participant's one opportunity for production. For example, the average phoneme percent accuracy for "My Pills" during session nine was calculated by averaging the participant's production /ʌm pɪlz/ and /pɪlz/ for an average accuracy of 66.7%. In comparison, the 30 days post treatment phoneme percent accuracy used the participant's production /pɪlz/. The two-syllable phrase "My Pills" reached the highest average phoneme percent with an 83.3% average phoneme percent accuracy during treatment eleven by saying /ʌm pɪlz/ and /sp ʌm hɪlz/ as well as treatment session eighteen by saying /ʌm ʌ pɪlz/ and /ʌm pɪlz/. While some variability occurred within the accuracy of "My Pills," the participant's production remained at 66.7% accuracy or above from treatment session three through 30 days post treatment but fell back to baseline at 60 days post treatment. Please refer to Figure 3.

The two additional inner rehearsal condition phrases presented with some variability. The participant produced "Someone Came" with higher average phoneme percent

accuracy than “I Love You” at baseline, in sixteen of the nineteen treatment sessions, and at 30 days post treatment. Both phrases were produced with 0.0% accuracy at treatment session two and 60 days post treatment. Within these opportunities, the participant shook her head in a no response manner and did not vocalize. “I Love You” remained below 30% accuracy except for treatment session 17 when a dramatic increase of 58.35% accuracy was observed. However, her accuracy fell again at treatment session eighteen and remained below 20% for the remainder of the study.

First Sound Practice Condition

The phrases treated with the first sound practice back-step condition were “Help Me,” “I’m XXX,” and “Good Morning.” The procedure for the calculation of the phoneme percent accuracy was identical to the phoneme percent accuracy of inner rehearsal condition phrases; two productions were averaged during the consideration of treatment session two through twenty while one production of the phrase was used for the calculation during baseline and maintenance. Figure 4 depicts the results in a graph.

Initially, it appeared that the participant’s accuracy of “Good Morning” would be the highest percent accuracy as she produced a 93.75% accuracy by saying /gʊd mɔrnɪŋ/ and /krʊd mɔrnɪŋ/ during treatment session four. However, her accuracy of “Good Morning” dropped to 31.25% the following session and fluctuated for the remainder of the study and falling to a baseline of 0% at 60 days post treatment. The highest percent accuracy the participant produced for the phrase “I’m XXX” was 50% during treatment session seventeen, but she remained consistent in the phonemes she produced through the maintenance phase.

The participant demonstrated the greatest success with the two syllable phrase "Help Me." Initially, her production of "Help Me" was at 0.0% percent for the baseline and treatment session one and two. Her accuracy increased to 50% at treatment session four and then decreased to 8.35% for treatment sessions five and six. Once she produced "Help Me" with 100% accuracy at treatment session seven, she maintained that accuracy through the 60 days post treatment.

Self –Awareness

In order to answer the question of if the participant's pre and post self-rating reflected treatment performance, the participant's pre and post treatment ratings were compared to her achievement of levels within the MMIT protocol for each phrase. Table 4 and Table 5 depict the participant's pre- and post-treatment ratings along with the levels of MMMIT she reached during the treatment of each target phrase within inner rehearsal condition and first sound practice conditions, respectively. The pre and post self-ratings were on a 25 increment scale from 0 to 100. The highest achievable level of MMIT that could be achieved is indicated by "5, 5, 5" which would show the participant reached level 5 of the protocol three times within the ten minutes of allotted time for each phrase. The last level listed indicates she was working on that level when the ten minutes for each phrase expired.

The participant chose 75 as a pre-rating for treatment session 1 and 5 through 20 for the phrase "My Pills." She selected 100 as a pre-rating for treatment sessions 2, 3, and 4. However, she selected 75 as a post-rating for all of the treatment sessions regardless of the inconsistent achievement of levels with the MMIT protocol. For the phrase "I Love You," the participant selected a pre-rating of 50 for the first treatment session and then

selected 75 for subsequent pre-ratings. She achieved the level 5 twice or higher in sixteen out of the 20 treatment sessions. The participant increased her post-rating in 14 out of 15 of those opportunities where she achieved the level five twice or higher. Similarly, the participant showed an increase in pre to post rating in 12 out of 12 treatments sessions where she achieved a level 5 two times or higher. She increased her pre to post self-rating in one session where she achieved the level 5 and then made it to level 4 before time ran out. While it was not defined what level of achievement deserved an "excellent" or 100 rating, it was disclosed that there was a maximum achievement of reaching level 5 of the protocol three times per phrase.

The participant's self-ratings for first sound practice condition phrases appeared to be more inconsistent in relation to the reached levels of MMIT. The participant increased her self-rating in 18 out of 20 treatment sessions while either achieving the level 5 three times or not needing to go through the protocol due to producing 100% accuracy of the phrase after the pre self-rating was documented. Treatment session 1 and treatment session 15 were the two sessions where she did not increase her self-rating score. She maintained a 75 during treatment 1 and reached level 5 of the MMIT two times. In treatment 15, she began with a self-assessment phrase of 100 and maintained that self-assessment rating after producing "Help Me" with 100% accuracy. There were no indications noted as to why she may have initially rated herself 100 during the treatment session 15 as she gave a pre-rating of 75 for all other phrases that session.

Her level of achievement within the MMIT protocol for "I'm XXX" fluctuated and never reached a level 5, similar to the production of "My Pills." She maintained her self-rating of 75 in 19 out of the 20 treatment sessions. In treatment session 4, her self-

rating increased from pre to post and she achieved a level 2 of the MMIT protocol as she had the previous three treatment sessions.

During the treatment of "Good Morning," the participant increased her self-rating from 75 to 100 in six treatment sessions. In five of those six treatment sessions, she reached level 5 of the MMIT protocol at least once; however, she did not increase her self-ratings in four other treatment sessions where she achieved a level of 5.

Initial and Final Assessments

Assessments were conducted prior to treatment and after completion of treatment using the WAB-R (Kertesz, 2006), ASHA FACS (Frattali et al., 1995), QCL (Paul et al., 2005), and CLQT (Helm-Estabrooks, 2001). Table 6 depicts the results of the initial and final assessment of the WAB-R, QCL, and CLQT.

The participant's scores decreased on the WAB-R and CLQT from the initial pre-treatment assessment to the final post-treatment assessment. However, the testing environment and length were different between the two assessment periods which may attribute to the amount of fatigue and distractions. The first assessments were given at the university clinic over the course of two sessions while the final assessment was given in the client's home within one session. The participant's mean overall quality of life did increase by 0.1 from an already high score of 4.3 to a score of 4.4. The participant's spouse rated the same number of items in the areas of social communication and communication of basic needs on the ASHA FACS, and the spouse indicated an increase in the participant's abilities within these two sections. While the participant's spouse may be a biased reporter, the spouse is the individual with daily and functional interaction with the participant, so the values reported by the spouse should be valued.

Discussion

Support for Modified Melodic Intonation Therapy

The results support the hypothesis of the effectiveness of the MMIT protocol. Both inner rehearsal and first sound practice were incorporated into the protocol with which the participant had a clear increase in production of target phrases from baseline to treatment and post treatment. In conjunction with previous researchers, these findings support the understanding that modifying the MIT protocol can prove beneficial for participants (Baker, 2000; Hough, 2010; Conklyn et al., 2012). Baker (2000) and Hough (2010) both had participants that struggled with the independence of producing phrases without external cues following other therapies or a traditional MIT protocol. Even though Baker emphasized more melodic components of MIT in her modification while Hough streamlined the sensory stimuli by removing hand tapping, both had participants achieve greater output in verbal production. However, there were still limitations in independent production abilities. The modification of MIT through inner rehearsal and first sound practice back steps allowed for the exploration of further independence in initiation as the participant also had limited success with previous therapies.

There are conflicting image studies between Belin et al. (1996), Breier et al. (2010), and Schlaugh et al. (2008) about the involvement of hemisphere during traditional MIT. Schlaugh et al. found greater right hemisphere activation through an fMRI following MIT treatment sessions. They identified components including syllable lengthening that may allow extra time for the right hemisphere to process information so as not to depend so heavily on the left hemisphere for language production. Conversely, Belin et al. used a PET study while Breier et al. used a MEG study to agree that the left

hemisphere is more activated than the right within the traditional MIT technique. Belin et al. identified components of the MIT protocol that initially appear to be favorable for right hemisphere activation but really allow the left hemisphere to be stimulated. One such component was that the exaggerated prosody allows additional processing time for the left hemisphere rather than increased activation of the musical driven right hemisphere.

With the MMIT study, no imaging data were obtained but the participant was able to experience some success in speech initiation by using inner rehearsal and first sound practice back step modifications. Whether the right or left hemisphere is more activated through the modifications cannot be determined in this study. While the extent of each hemisphere involvement is debated, researchers (Schlaugh et al., 2008; Belin et al., 1996; Breier et al., 2010) agree that traditional MIT allows for additional processing time that proves beneficial for ideal candidates previously described. Therefore, the implementation of the traditional MIT should have been proved beneficial for this ideal participant, but she did not experience ideal gains from previous treatments, including traditional MIT. The participant's gains in the MMIT protocol demonstrate the need for her brain, and potentially others, to have additional initiation learning strategies within the protocol. Inner rehearsal and first sound practice expand on the already beneficial components of MIT to allow for potentially even more control over speech productions. Inner rehearsal may rely on greater cognitive awareness and visualization skills preferred by right hemisphere processing, while first sound practice may rely more on segmental and attention to details associated with the left hemisphere. Either way, the back step modifications to the MIT allowed the participant to reap the known brain activation

benefits of MIT and potentially acquire additional initiation strengths as her overall speech production output increased following MMIT treatment.

Initiation through Inner Rehearsal and First Sound Practice

The hypothesis that inner rehearsal phrases would have more success than first sound practice phrases remains to be true when considering functional clinical situations. Initially, it may appear that first sound practice would be the more desired option to consistently implement in a modified form of MIT as the participant maintained perfect accuracy, once reached, through 60 days post treatment. Researchers also recognize the power initial phoneme cues can have in word finding and production (Pease & Goodglass, 1978); however, first sound practice phrase required four additional sessions to reach a functional production. The participant achieved a functional accuracy of the inner rehearsal phrase "My Pills" at session three as compared to the seven sessions needed for functional production of the first sound practice phrase "Help Me." The functional accuracy of a phrase can be thought of as not necessarily reaching the perfect production of phonemes but producing enough that the client's message is able to be clearly understood. The participant responded with "Pills" in most cases to achieve a high accuracy of the inner rehearsal phrase, and even though it is one syllable, the participant's request could still be identified if used; the production was maintained 30 days post treatment. As previously mentioned, Oomen et al. (2005) found that an individual with Broca's aphasia relied more on internal monitoring of speech in comparison to individuals without brain injuries who relied more on auditory feedback. It may be that due to the brain damage in individuals with aphasia, they are more dependent on internal

monitoring of speech or inner rehearsal. Therefore, practicing and refining the inner control of speech may lead to functional speech productions in a timelier manner.

Clinical use of inner rehearsal or first sound practice within a modified MIT format may depend upon the time and desired outcome. If the need is to develop functional communication phrases in a short amount of time, then inner rehearsal may be implemented. On the other hand, first sound practice may be included if the desire is to develop more complete, typical productions of phrases and time is not a concern.

It is unknown the exact reason why the participant maintained the first sound practice phrase "Help Me" 60 days post treatment and the inner rehearsal phrase "My Pills" only 30 days post treatment. There may have been various circumstances in the participant's day during the time of 60 days post treatment collection or there could be further need to examine the initial phoneme of a phrase, no matter the strategy of initiation.

The placement of the initial phoneme may also hold greater significance for initiation. Within both conditions, the phrases that began with phonemes that could be more readily seen or easily produced had greater success. "My Pills" was the inner rehearsal phrase with the greatest success and while the participant often omitted the "my" of the phrase, both /p/ and /m/ are visually seen and movements can be more gross in comparison to the /s/ and /aɪ/ that begin the other phrases. "Help Me" had the highest success of the first sound practice phrases. It was a two syllable phrase, but also started with /h/ which required very little cuing for the participant to produce as compared to /aɪ/ and /g/ in the other phrases. While /h/ does not allow for a visual cue, /h/ is a sound that requires minimal effort and coordination as the sound is not voiced and can be made with a relaxed exhale. The participant had lower accuracy with the two phrases that began

with “I.” While varying phonemes were divided between conditions, the inner rehearsal phrase “I Love You” and first sound practice phrase “I’m XXX” both shared the same initial phoneme. The limited improvement on these phrases indicate the potential that the “I” or /aɪ/ may be a more challenging phoneme to initiate whether relying on inner rehearsal or first sound practice.

Phrase Length

The study revealed the importance of selecting phrases with the appropriate syllable length which leads to the need for further evaluation of the inner rehearsal condition phrases compared to the first sound practice conditions. Overall, both of the treatment phrases in each condition improved at different degrees. However, the length of the phrases in syllables revealed a difference in average percent accuracy between two syllable phrases and three syllable phrases without consideration of the treatment back-step conditions.

Appropriate candidates have been identified based upon general descriptions including severe verbal production challenges but with comprehension as a strength (Helm-Estabrooks & Albert, 2004; Sparks et al., 1974). The participant met the requirements for an ideal candidate for MIT, so the information gathered about the participant’s phrase length performance could enhance further research in treating individuals with Broca’s aphasia at the appropriate phrase level using MIT or a modification of MIT.

The three syllable phrases within the inner rehearsal condition, “Someone Came” and “I Love You,” presented with lower accuracy than the two syllable phrase, “My Pills.” Similarly, the two syllable first sound practice phrase, “Help Me,” had greater overall

accuracy than the three syllable first sound practice phrases, “I’m XXX” and “Good Morning.”

Self-Awareness

Self-awareness allows an individual the ability to self-evaluate in order to implement necessary changes to complete a desired action (Hunt et al., 2013). Including a self-awareness component through the self-rating task was important in order to identify if the participant could utilize her self-awareness to learn how to best initiate speech. The participant’s self-ratings, overall, appeared to accurately reflect her treatment performance when she achieved the higher levels of the MMIT protocol. Her self-ratings indicate a sense of self-awareness in her abilities; it could also be her ability to identify feedback from the graduate student researchers in their enthusiasm. If the participant was more aware of the responses or reactions of the graduate student researchers, the self-ratings that did not appear to follow a pattern may be explained. Her self-ratings may also have been determined by the completion length of the protocol. Kennedy and Coelho (2005) and Hunt et al. (2013) acknowledge that individuals collect feedback in order to self-evaluate and then make the necessary changes in an upcoming activity. Therefore, no matter the form of feedback, the participant would be able to make appropriate self-ratings if she had a high level of self-awareness. There is potential that the participant more accurately rated herself when higher levels of MMIT were achieved because there is a need to process more prominent feedback, rather than subtle, due to her injury.

In therapy, clinicians may be able to help patients heighten their sense of self-awareness by discussing the role of self-awareness in making adjustments to complete a desired action such as speaking. Initially, the clinician may have to bring external

attention to specific skills and observations if the patient's self-awareness ability is developing. The increase in self-awareness may allow patients to use necessary cognitive abilities in order to master a desired skill.

Limitations

As with each study, there are limitations which require acknowledgement. The single case study design limits the ability to generalize findings to a larger population of individuals with Broca's aphasia. Since the extent of the data relied on transcribing the participant's speech, developing inter-rater reliability checks using research students outside of the study would also have been beneficial. Although having two graduate research students transcribing and agreeing on phrases in time provides more benefit than having only one graduate research student recording.

In regards to the methodology, data was collected prior to the initiation of treatment each session rather than directly following treatment of each phrase. If data were collected in the latter manner, then more immediate effects of treatment may have been noticed rather than analyzing the learned skills from the previous session. However, the manner of collection allowed for more analysis of carry over and functional aspect of the treatment. The inner rehearsal and first sound practice condition phrases also could have been administered randomly versus alternatively in order to diminish order effect. In addition, implantation of a detailed post treatment homework program could have aided the retention of phrases through maintenance.

As previously mentioned, the design allowed for two baseline measurements to be attained but was limited to one due to the need to implement wait time to adequately reflect the participant's current ability. Having two baselines would have allowed

opportunities to implement further statistical measures during analysis. Also, it was determined that the participant may have been at more of a two syllable phrase level rather than three. Identifying the underlying reasons for the participant's change in self-rating is also a limitation. It is not known, only speculated, if the participant changed her self-rating scores due to feedback from the graduate student researchers, length of protocol, or an increasing sense of cognition and self-awareness.

Future Research

The findings of this research ignite further avenues of research. The connection between appropriate syllable level and ideal candidates for the MIT protocol can be explored. There is also a need to determine if including an inner rehearsal back-step with MIT, in comparison to a traditional MIT protocol, is beneficial for a larger population of individuals with Broca's aphasia in successfully initiating functional communication in a timely manner. Further refining phrase selection in regards to the accessibility and complexity of the initial phoneme would also prove beneficial.

References

Baker, F.A. (2000). Modifying the melodic intonation therapy program for adults with severe non-fluent aphasia. *Music Therapy Perspectives, 18,* 110-114.

Belin, P., Van Eeckhout, P., Zilbovicius, M., Remy, P., Francois, C., Guillaume, S., et al. (1996). Recovery from nonfluent aphasia after melodic intonation therapy: A PET study. *Neurology, 47,* 1504-1511.

Brier, J. I., Randle, S., Maher, L. M., & Papanicolaou, A. C. (2010). Changes in maps of language activity activation following melodic intonation therapy using magnetoencephalography: Two case studies. *Journal of Clinical and Experimental Neuropsychology, 32*(3), 309-14.

Brookeshire, R.H. (2008). *Introduction to neurogenic communication disorders* (7th ed.). St. Louis: Mosby.

Conklyn, D., Novak, E., Boissy, A., Bethoux, F., & Chemali, K. (2012). The effects of modified melodic intonation therapy on nonfluent aphasia: A pilot study. *Journal of Speech, Language, and Hearing Research, 55,* 1463-71.

De Bleser, R., & Marshall, J. C. (2005). Egon weigl and the concept of inner speech. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 41* (2), 249-257.

Frattali, C., Holland, A., Thompson, C., Wohl, C., & Ferketic, M. (1995). Functional assessment of communication skills for adults. American Speech-Language Hearing Association.

Helm-Estabrooks, N. (2001). Cognitive linguistic quick test. New Jersey: Pearson.

Helm-Estabrooks, N., & Albert, M. (2004). *Manual of aphasia and aphasia therapy (*2nd ed). Autisn, Texas: PRO-ED.

Hough, M. (2010). Melodic intonation therapy and aphasia: Another variation on theme. *Aphasiology, 24* (6-8), 775-786.

Hunt, A., Turner, G., Polatajko, H., Bottari, C., & Dawson, D. (2013). Executive functions, self-regulation and attribution in acquired brain injuring: A scoping review. *Neuropsychological Rehabilitation: An International Journal, 23*: 6, 914.

Kennedy, M. R. T., & Coelho, C. (2005). Self-regulation after traumatic brain injury: A framework for intervention of memory and problem solving. *Seminars in Speech and Language, 26*(4), 242-255.932.

Kertesz, Andrew. (2006). Western aphasia battery-revised. New Jersey: Pearson.

Leonard, C., Rochon, E., & Laird, L. (2008). Treating naming impairments in aphasia: Findings from a phonological components analysis treatment. *Aphasiology, 22*(9), 923-947.

McGuire, P., Silbergsweig, D., Murray, R., David, A., Frackowiak, R., & Frith, C. (1996). Functional anatomy of inner speech and auditory verbal imagery. *Psychological Medicine, 26*, 29-38.

National Aphasia Association. (n.d.). Aphasia fact sheet. Retrieved from http://www.aphasia.org/aphasia-resources/aphasia-factsheet/

Norton, A., Zipse, L., Marchina, S., & Schlaug, G. (2009). Melodic intonation therapy: Shared insights on how it is done and why it might help. *Annals of the New York Academy of Sciences, 1169*, 431-436.

Oomen, C., Postma, A., & Kolk, H. (2005). Speech monitoring in aphasia: Error detection and repair behaviour in a patient with broca's aphasia. (209-225). *Psychology Press*, New York, NY.

Paul, D., Frattali, C., Holland, A., Thompson, C., Caperton, C., & Slater, S. (2005). Quality of communication life scale. American Speech-Language Hearing Association.

Pease, D. M., & Goodglass, H. (1978). The effects of cuing on picture naming in aphasia. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior, 14*(2), 178-189.

Schlaug, G., Marchina, S., & Norton, A. (2008). From singing to speaking: Why singing may lead to recovery of expressive language function in patients with broca's aphasia. *Music Perception, 25*, 315-323.

Sparks, R.W., Helm, N. A., & Albert, M. L. (1974). Aphasia rehabilitation resulting from melodic intonation therapy. *Cortex, 10*, 303-16.

Sparks, R.W., & Holland, A. L. (1976). Method: Melodic intonation therapy for aphasia. *Journal of Speech and Hearing Disorders, 41*, 287-95.

University of Iowa Research Foundation. (2014). Sounds of speech. (Version 1.6.5) [Mobile application Software]. Retrieved from http://itunes.apple.com

Wilson, S. J., Parsons, K., & Reutens, D.C. (2006). Preserved singing in aphasia: A case study of the efficacy of melodic intonation therapy. *Music Perception, 24*, 23-36.

Appendix A

Homework for _____ (date) to _____ (date)
XXX will work on six target utterances this semester. Three questions are designed to elicit each target utterance. Please ask XXX each question (a total of 18 questions) every day. Circle "Yes" if XXX correctly produces the target utterance, or "No" if she cannot produce the target utterance. Please return the homework sheets to us next Tuesday. Thank you!

Questions	Target Utterance: "My pills"	
1 What do you need to take in the morning?	Yes	No
2 What's in that bottle? (point to prescription bottle)	Yes	No
3 What does the doctor give you? (have prescription bottle in sight)	Yes	No

Questions	Target Utterance: "I love you"	
1 What would you say to your family to show affection?	Yes	No
2 What do you say to your husband on Valentine's Day?	Yes	No
3 What do you say to your son to show you care?	Yes	No

Questions (assuming someone came to the house today)	Target Utterance: "Someone came"	
1 Did anyone come to the house today?	Yes	No
2 Was anyone here? (Using the house as a cue if needed)	Yes	No
3 If the mailman brought you mail, you could say…?	Yes	No

Questions	Target Utterance: "Help me"	
1 What do you say if you've fallen down and someone walks by you?	Yes	No
2 What do you say if you're hurt?	Yes	No
3 What do you say if you're in need of assistance?	Yes	No

Questions	Target Utterance: "I'm XXX"	
1 Who are you?	Yes	No
2 What do you say when you introduce yourself to someone?	Yes	No
3 What is your name?	Yes	No

Questions	Target Utterance: "Good morning"	
1 What do you say when you greet people at breakfast?	Yes	No
2 What do you say when you see your husband after you wake up?	Yes	No
3 What do you say when you greet people early in the day?	Yes	No

Appendix B

MIT Scoring Sheet - Condition 1: Inner RehearsalCode:_____ Date: _____ Session #: _____
Word/phrase:

Pre-Rating Scale:	0	25	50	75	100

Correct Speech:	1	0
1 – Humming	-	- hum 2x
2—Unison Singing	1 → Step 3	0 → Inner Rehearsal
Inner Rehearsal Criterion= subject acknowledges Inner Voice	1 → Step 2	0 → Step 1
3—Unison Singing with Fading	1 → Step 4	0 → Inner Rehearsal
Inner Rehearsal Criterion= subject acknowledges Inner Voice	1 → Step 3	0 → Step 2
4—Immediate Repetition	1 → Step 5	0 → Inner Rehearsal
Inner Rehearsal Criterion= subject acknowledges Inner Voice	1 → Step 4	0 → Step 3
5—Response to a Probe Question	1 → next target word (if 3 times successful)	0 → Inner Rehearsal
Inner Rehearsal Criterion= subject acknowledges Inner Voice	1 → Step 5	0 → Step 4

**If subject successfully complete step 5 on a target word/phrase THREE times, this target word/phrase will become probe words.

Post-Rating Scale:	0	25	50	75	100

Appendix C

MIT Scoring Sheet – CONDITION 2 First Sound Practice Code:_____ Date: _____ Session #: _____
Word/phrase:

Pre-Rating Scale:	0	25	50	75	100

Correct Speech:	1 0	
1 – Humming	- -	hum 2x
2—Unison Singing	1 → Step 3	0 → First sound practice
First sound practice Criterion= 4/5	1 → Step 2	0 → Step 1
3—Unison Singing with Fading	1 → Step 4	0 → First sound practice
First sound practice Criterion=4/5	1 → Step 3	0 → Step 2
4—Immediate Repetition	1 → Step 5	0 → First sound practice
First sound practice Criterion=4/5	1 → Step 4	0 → Step 3
5—Response to a Probe Question	1 → next target word (if 3 times successful)	0 → First sound practice
First sound practice Criterion=4/5	1 → Step 5	0 → Step 4

**If subject successfully complete step 5 on a target word/phrase <u>THREE</u> times, this target word/phrase will become probe words.

Post-Rating Scale:	0	25	50	75	100

Table 1.

Comparison of Probe and Target Phonemes

Target phrases	Probe phrases	
	Similar	Different
d, **g**, **h**, **j**, **k**, **l**, **m**, n, p, **s**, ŋ, v, **w**, z,	**g**, **h**, **k**, **l**, **m**, t, v	b, **j**, **k**, **s**, t, **w**, ð, ʃ, ʤ,
aɪ, **ɪ**, **ʌ**, u, ɔ, **e**, ɛ, o, **ɔr**, ʊ	**aɪ**, **ɪ**, **ʌ**, **e**, ɒ, **ɔr**	**aɪ**, **ɪ**, **ʌ**, **e**, u, æ, i

Note. Bolded phonemes indicate representation in both target phrases and probe phrases.

Table 2.

Probe and Target Average Percent Accuracy and Difference

	Average % accuracy		Difference
Session	Probe	Target	
Baseline	1.4	4.6	3.2
Treatment			
2	12.7	2.8	-9.9
3	13.6	17.1	3.5
4	0.0	32.4	32.4
5	2.4	15.7	13.4
6	3.3	20.6	17.3
7	6.7	41.0	34.3
8	9.9	39.1	29.2
9	12.3	41.0	28.7
10	7.5	53.9	46.4
11	15.1	50.5	35.4
12	5.7	41.0	35.3
13	9.9	46.8	36.8
14	5.2	38.2	33.0
15	12.1	43.8	31.6
16	12.3	45.1	32.8
17	15.6	46.5	30.9
18	23.4	46.5	23.1
19	17.9	38.2	20.3
20	13.7	48.4	34.7
30 Days Post	5.6	38.2	32.6
60 Days Post	0.0	19.4	19.4

Note. Treatment 10 depicted the greatest difference at 46.4%. Range of 23.4% within the differences of average phoneme percent accuracy of probe and target phrases.

Table 3.

Average Percent Accuracy of Similar and Different Phonemes of Probe Phrases

	Target	Probe	
Session		Similar	Different
Baseline	4.6	0.0	2.8
Treatment			
2	2.8	14.3	11.1
3	17.1	13.3	13.9
4	2.1	0.0	0.0
5	15.7	4.8	0.0
6	20.6	6.7	0.0
7	41.0	13.3	0.0
8	39.1	14.3	5.6
9	41.0	19.0	5.6
10	51.2	6.7	8.3
11	50.5	19.0	11.1
12	41.0	11.4	0.0
13	46.8	14.3	5.6
14	38.2	4.8	5.6
15	43.8	4.8	19.4
16	45.1	19.0	5.6
17	46.5	25.7	5.6
18	46.5	19.0	27.8
19	38.2	19.0	16.7
20	48.4	19.0	8.3
30 Days Post	38.2	0.0	11.1
60 Days Post	16.7	0.0	0.0

Note. Average phoneme percent accuracy was calculated with the three probe phrases with similar phonemes as the six target phrases and the three probe phrases with different phonemes in comparison to the six target phrases. The probe phrase calculations were separated into phrases with similar and different phonemes as the target phrases.

Table 4.

Self-Ratings and MMIT Achievement Levels within Inner Rehearsal Phrases

		Treatment session																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
My Pills	Pre-rating	75	100	100	100	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Post-rating	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Level	4	4	4	4	2	3	4	2	5	4	2	2	3	4	4	2	2	2	5	2
I Love You	Pre-rating	50	**75**	75	75	75	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**
	Post-rating	50	**100**	75	75	75	**75**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	Level	5	**5,5,2**	3	5,3	3	**5, 5**	**5,5, 5**	**5,5, 3**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**
Someone Came	Pre-rating	50	75	75	75	75	75	75	75	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**
	Post-rating	50	75	75	75	75	75	100	75	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	Level	5,2	2	5	4	5, 1	3	5,4	5,2	**5,5, 5**	**5,5, 1**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**	**5,5, 5**

Note. The bolded treatment sessions indicate when the participant's self-rating increased from pre- to post- rating and she achieved a level of 5 two times or higher. The participant had the opportunity to achieve level 5 of the MMIT three times within ten minutes.

Table 5.

Self-Ratings and MMIT Achievement Levels within First Sound Practice Phrases

		Treatment session																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Help Me	Pre-rating	75	**75**	**75**	75	**75**	**75**	75	75	75	75	75	75	75	75	100	75	75	75	75	**75**
	Post-rating	75	**100**	**100**	100	**100**	**100**	100	100	100	100	100	100	100	100	100	100	100	100	100	**100**
	Level	5, 5	**5,5, 5**	**5,5, 5**	-	**5,5, 5**	**5,5, 5**	-	-	-	-	-	-	-	-	-	-	-	-	-	**5,5, 5**
I'm XXX	Pre-rating	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Post-rating	75	75	75	100	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Level	2	2	2	2	2	2	2	2	3	4	3	3	4	2	2	4	2	3	2	4
Good Morning	Pre-rating	50	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	**75**	75	75
	Post-rating	75	75	100	75	75	75	75	75	75	75	75	75	100	100	100	75	100	**100**	75	75
	Level	2	2	2	2	3	4	4	4	4	4	4	5,5	5,1	5	5,1	5	5	**5,5, 5**	5	5

Note. The bolded treatment sessions indicate when the participant's self-rating increased from pre- to post- rating and she achieved a level of 5 two times or higher. "-" indicates the MMIT protocol did not need to be initiated because she was able to produce the phrase with 100% accuracy when prompted with the phrase. The participant had the opportunity to achieve level 5 of the MMIT three times within ten minutes.

Table 6.

Initial and Final Assessments

	Initial	Final
Western Aphasia Battery		
Spontaneous speech	5	4
Auditory verbal comprehension	6.25	4.65
Repetition	1.6	0.2
Naming and word finding	1.2	2.2*
Aphasia quotient	28.1	22.1
Cognitive Linguistic Quick Test		
Attention	42	36
Memory	56	37
Executive Function	8	6
Language	5	4
Visuospatial skills	42	28
Clock drawing	6	6
Composite severity rating	1.2 (Severe)	1 (Severe)
Quality of Communication Life Scale		
Mean overall score	4.3	4.4*
In general, "my quality of life is good" score	5	5
ASHA FACS-Spouse Rating		
Social communication items rated	21	21
Social communication mean	3	5.47*
Communication of basic needs items rated	7	7
Communication of basic needs mean	5.71	7*
Reading, writing, number concepts items rated	10	28
Reading, writing, number concepts mean	2.8	3.5*
Daily planning items rated	5	18
Daily planning mean	4	6*

Note. * indicates an increase in score

Figure 1.

Modified MIT Procedure Flow Chart

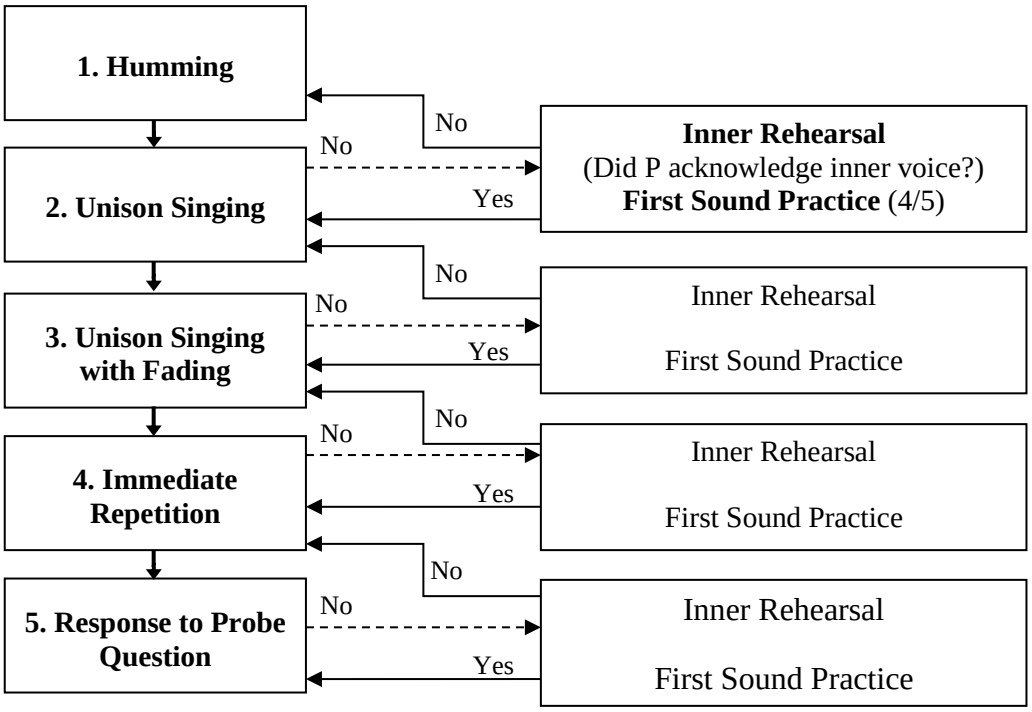

Figure 2.

Probe versus Target Average Phrase Percent Accuracy

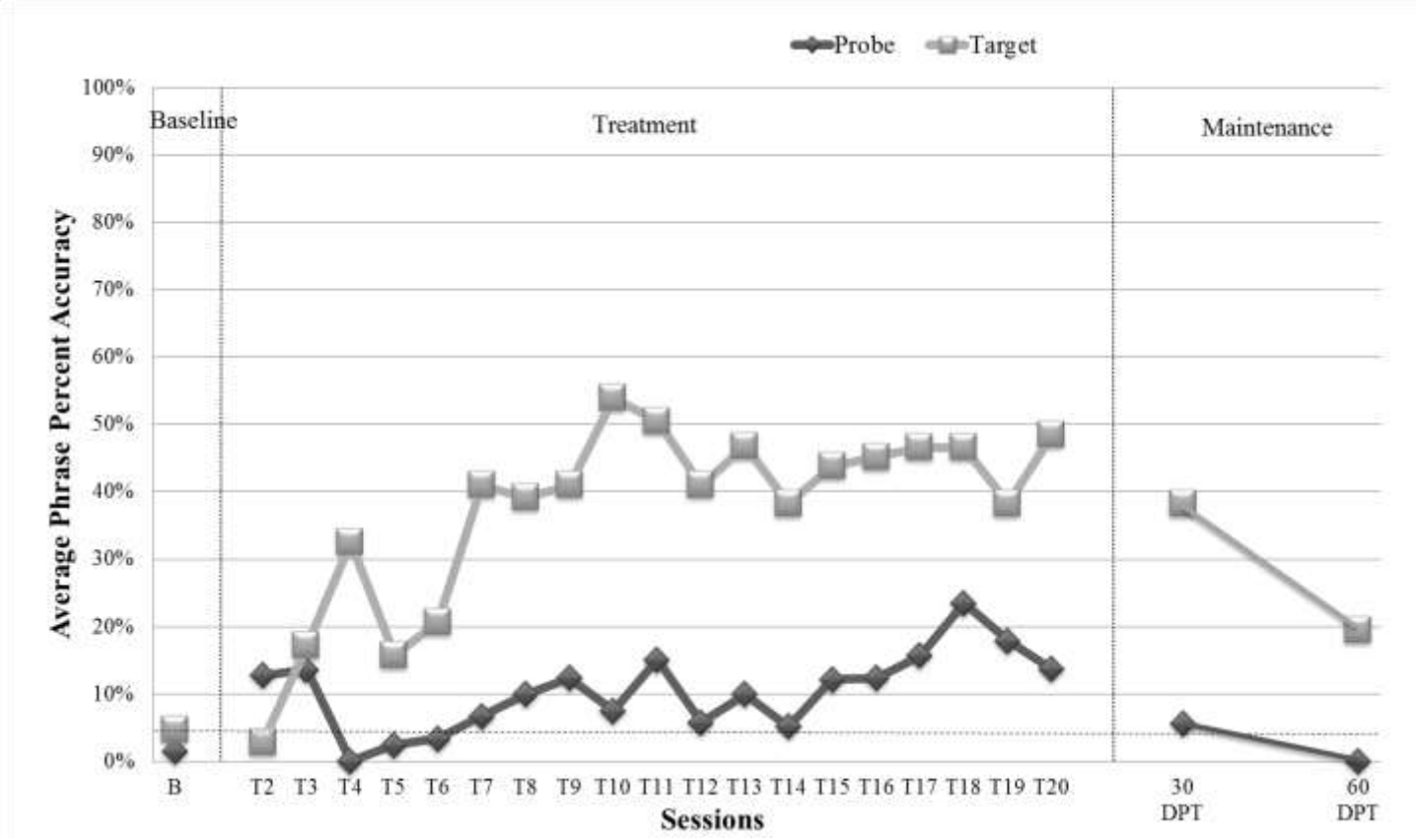

Figure 2. Average phrase percent accuracy of probe versus target phrases. An effect line is drawn at 4.6% across the time intervals from the baseline measurement of target phrases. DPT stands for "days post treatment."

Figure 3.

Average Percent Phoneme Accuracy within Inner Rehearsal Condition

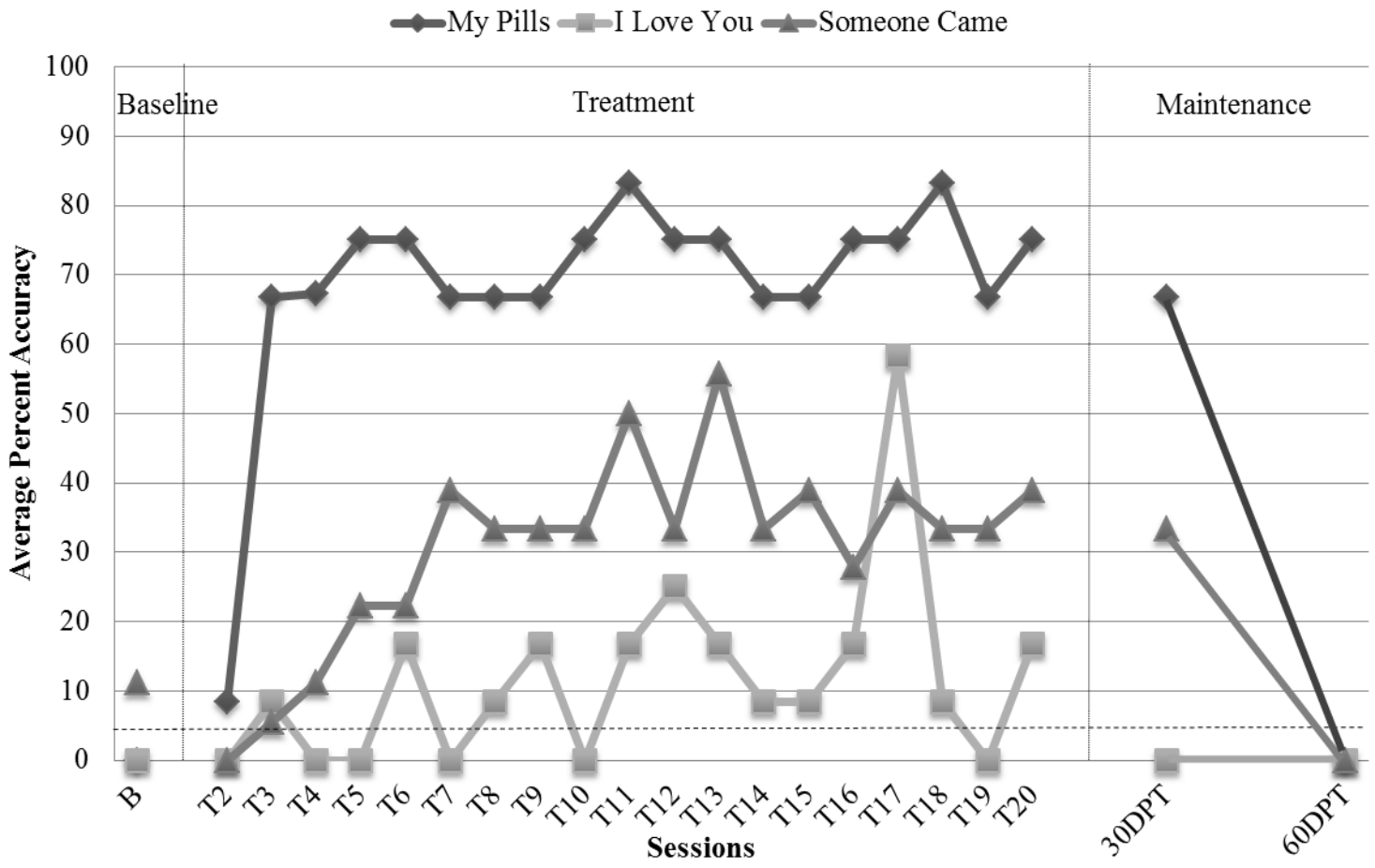

Figure 4.

Average Percent Phoneme Accuracy within First Sound Practice Condition