THE EFFECTS OF VARYING MELODIC INTERVALS IN MELODIC INTONATION THERAPY FOR PERSONS WITH APHASIA

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The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Arts, with a major in Communication Sciences and Disorders.

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DEDICATION

To my mom, Keri, who got me started in this field, and my mother-in-law, Shari, who wouldn't let me quit.

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ABSTRACT

Melodic Intonation Therapy (MIT) long has been a popular, evidence-based treatment for persons with non-fluent aphasia. While the contribution of rhythm within MIT has been frequently studied, little research has been completed to determine the role that melodic intervals (pitch) play in this therapy. The purpose of this study was to evaluate the effects of using two different melodic intervals in MIT: the minor third (m3) and tritone. Participants were exposed to both intervals while participating in MIT across eight weeks. Spoken probe phrases were scored prior to, during, and after treatment to monitor progress for phrases intoned on each interval. An effect size was calculated for each interval using a formula created for single-subject, multiple baseline aphasia research studies. It was determined that the effect size for the tritone was greater than the effect size of the minor third for both participants. Due to COVID-19, treatment was completed via teletherapy, the first time such a method has been used to conduct an MIT treatment study. It was determined that MIT in this format did result in significant improvement in trained phrases, though no control group was used. Further research should be done to further evaluate the effects of various intervals within MIT, and the complex interaction between rhythm and pitch.

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CHAPTER 1

INTRODUCTION

1.1 Overview of Aphasia

Aphasia is defined by the American Speech-Language Hearing Association as "an acquired neurogenic language disorder resulting from an injury to the brain – most typically, the left hemisphere" (American Speech-Language Hearing Association, n.d.). It is characterized by deficits in both expressive and receptive language, although the type and degree of impairment varies depending on the location of the lesion in the brain. While many types of aphasias exist, they often are organized into two main categories: fluent and non-fluent (Davis, 2007).

Non-fluent aphasia (commonly referred to as "Broca's aphasia") generally results from damage to Broca's area located in the left frontal lobe of the brain. This region corresponds to Brodmann's areas 44 and 45. A primary characteristic of Broca's aphasia is telegraphic speech lacking function words. In other words, individuals with Broca's aphasia may be able to produce the correct word or words to indicate the main idea of their message, but fail to include conjunctions, articles, prepositions, and other parts of speech that are necessary for their sentences to be grammatically correct. Persons with this type of aphasia also may exhibit mild auditory comprehension problems and significant word finding difficulties. These individuals generally are aware of their deficits and express frustration with their inability to generate even the most basic language (Chapey, 2008; Hallowell, 2017).

In contrast, fluent aphasia results from damage to Wernicke's area in the superior temporal lobe of the brain, or Brodmann's area 22. The language of persons with this type of aphasia often consists of jargon containing neologisms or made up, nonsensical words. While their speech may

be fluent, it generally is void of any meaningful content. Individuals with fluent aphasia commonly are unaware of their deficits (Chapey, 2008; Hallowell, 2017).

1.2 Introduction to Melodic Intonation Therapy

Melodic Intonation Therapy (MIT) is one of many evidence-based approaches to the treatment of aphasia. However, it is unique in that it involves manipulation of the musical components of speech and language to facilitate recovery. Although historically many researchers have noted that persons with aphasia often retain their ability to sing despite speaking difficulties, MIT was not formally published as a therapy until 1974 by Robert Sparks and colleagues (Sparks et al., 1974). By emphasizing melodic elements such as tempo, rhythm, and intonation, this therapy engages the preserved right hemisphere of the brain historically thought to be responsible for processing music. Left hand-tapping also is considered an essential part of MIT, as it helps activate the right hemisphere, and emphasizes the rhythmic component of the therapy (Helm-Estabrooks et al., n.d.; Sparks et al., 1974).

MIT is designed for persons with Broca's aphasia with lesions only in the left hemisphere of the brain, as it relies on an undamaged right hemisphere to stimulate recovery of speech and language through music. The ideal candidate also displays acceptable auditory comprehension skills and determination to make progress through an intensive therapy program. It is not recommended for persons with any type of fluent aphasia, or with lesions in the right cerebral hemisphere (Chapey, 2008; Hallowell, 2017; Helm-Estabrooks et al., n.d.; Norton et al., 2009).

1.3 MIT Procedures

MIT is a hierarchical therapy program organized into three levels: Elementary Linguistic Level, Intermediate Linguistic Level, and Advanced Linguistic Level. The phrases used in therapy increase in both phonemic complexity and number of syllables with each subsequent

level. Phrases included in the Elementary Linguistic Level generally contain only one to two words amounting to two to four syllables. Complex phonemic processes, such as consonant blends and liquids should be avoided. The Elementary Linguistic Level consists of five steps, beginning with the clinician humming a simple melody while tapping the left hand of the client in rhythm. The client is invited to join in humming in unison with the clinician. Once the intonation pattern is established via humming, step two begins with the clinician intoning (or singing) the first phrase to be taught using the same melody that was hummed. The clinician continues to repeat the phrase until the client joins in singing in unison. The client receives a score of one during this step if he or she successfully sings the phrase in unison with the clinician. (If at any point the client is unable to finish a step, the current phrase is discontinued, and a new phrase is begun at step one.) In step three the clinician and client again sing the target phrase in unison, however the clinician fades out as the client begins to sing the phrase independently. Once the client does this successfully, he or she is ready for step four. Here, the client listens as the clinician again intones the target phrase. The client then repeats the phrase independently. The clinician may provide a phonemic cue for the first word of the phrase if the client is unable to begin independently. Two points are given if the client intones the phrase without cueing, and one point is given if the client intones the phrase with no more than one cue. If the client is unable to repeat the phrase even with a phonemic cue, the phrase is discontinued. In the last step of the Elementary Linguistic Level, the clinician intones a question that requires the client to answer with the target phrase. Scoring for this step is identical to the previous one (Helm-Estabrooks et al., n.d.).

Once the client reaches approximately 90% accuracy across several sessions at the Elementary Linguistic Level, he or she advances to the Intermediate Linguistic Level. Phrases

used at this level increase in both phonemic complexity and number of syllables. This level consists of three steps; hand-tapping continues throughout the first two. In step one the clinician again intones the target phrase and signals the client to join in. The clinician slowly fades out until the client is singing the phrase independently. One point is given if the client successfully completes this step. Step two involves delayed repetition. The clinician intones the sentence, pauses for several seconds, then signals the client to repeat the phrase independently twice in a row with a brief pause in between. The client is awarded two points if the step is completed on the first try. One retrial is allowed. The clinician discontinues the utterance if the client is unable to complete step two after the retrial. In step three, hand-tapping is discontinued. Here the clinician intones a question which is relative to the target sentence, but which cannot be directly answered by the target sentence alone. For example, if the target is "I need a drink" the clinician might ask "what would you like to drink?". The client scores two points for giving an appropriate answer. Failure to answer results in regression to step two followed by a retrial. Again, the utterance is discontinued if the retrial is unsuccessful (Helm-Estabrooks et al., n.d.).

The Advanced Linguistic Level involves four steps. Hand-tapping is reestablished through step two. The clinician begins by intoning the sentence as he or she did in previous levels. The clinician then pauses and presents the same phrase using a technique known as "*sprechgesang.*" This is described as a vocal expression in between speech and song; melody and rhythm are still emphasized, however there is no definable pitch. The client is invited to join in unison. Two points are awarded if the client is successful, and one point is given if a retrial is needed. Failure to succeed in this step after a retrial results in the discontinuation of the target phrase. Step two begins with the clinician presenting the phrase again using *sprechgesang*. The clinician then pauses for several seconds before signaling the patient to repeat the utterance.

Scoring for this step is the same as in step one. Hand-tapping is discontinued in step three, as the clinician says the target phrase using normal speech. There is a brief pause before the client is asked to repeat the phrase in the same manner. This step is scored the same way as the previous two. In the fourth and final step, the clinician asks the client both specific and more generalized questions related to the target sentence. The client scores two points if he or she can answer a specific question, or one point if backup to step three is needed to do so. The client also can earn a single score of three points if able to answer one or more of the less specific questions. The generalized questions are scored on a pass-fail basis, and no backup is allowed (Helm-Estabrooks et al., n.d.).

It is recommended by the authors of MIT that the therapy be administered in an "intense" manner, with sessions occurring as frequently as possible (Helm-Estabrooks et al., n.d.). The selected target phrases should be useful to the client and carefully thought out by the clinician together with the client and other caretakers or family members. Progression from one level to the next should happen only after an average score of 90% across ten consecutive sessions has been achieved (Chapey, 2008; Hallowell, 2017; Norton et al., 2009).

CHAPTER 2

LITERATURE REVIEW

2.1.1 Precautions for Evaluating Research Surrounding MIT

While many studies have evaluated the effects of music-based therapy for persons with aphasia, several factors have made it difficult to objectively determine the efficacy of MIT. First, few research studies have adhered strictly to the guidelines described by the original MIT handbook (Benson et al., 1994). Zumbansen et al. (2014) examined 14 research studies and found that only five followed the original protocol. The authors hypothesize modifications are made frequently to individualize therapy for each client's particular needs. One major inconsistency in this arena is the use of pitch, which is the focus of this project. The authors of MIT suggest intoning phrases on only two pitches separated by a minor third or perfect fourth and avoiding melodies which correspond to familiar songs. However, many research articles do not specify the melodic intervals used, or the researchers use familiar melodies despite research showing the ineffectiveness of this technique (e.g., Zumbansen et al., 2014; Racette et al., 2006; Yamadori et al., 1977; Weidema et al., 2016). Further problems surrounding the inconsistent use of pitch in MIT will be addressed later in this thesis.

Second, withholding treatment from research participants to create a control group poses an ethical issue. This dilemma often forces researchers to sacrifice the quality of their research to maintain ethical expectations. A literature review done by Hurkmans et al. (2012) found that, while all the articles evaluated reported positive findings regarding MIT, the methodological quality of the articles was rated as low. The most common compensatory strategy for this issue is withholding treatment from a control group for only a short period of time before offering the participants in this group the same treatment given to the experimental group (Haro-Martinez et

al., 2019; Meulen et al., 2016). Other researchers have implemented methods that allow subjects to serve as their own controls (e.g., Sparks et al.,1974; Parsons, 2006).

A third common issue in the research is the use of very few participants, or participants who do not meet the suggested criteria for candidacy for MIT (Schlaug, 2008; Bard et al., 2014; Parsons, 2006). Haro-Martinez et al. (2019) determined that a sample size of 27 participants would be needed in order to conclusively determine the effects of MIT through a randomized control trial, though few studies have actually included that many participants. Many current articles are case studies or single subject design including only one to two subjects (e.g., Schlaug, 2008; Parsons, 2006). It is with these three considerations in mind that one must evaluate the research surrounding MIT.

2.1.2 Efficacy Studies

The first study of the efficacy of MIT was done in 1974 by the original authors of the therapy (Sparks et al.,1974). In this study, MIT was administered to eight persons with severe non-fluent aphasia who had previously made no progress using other therapy approaches. Six of the eight participants made some significant recovery as a result of MIT. Schlaug (2008) contrasted the effects of MIT with Speech Repetition Therapy (another approach to the treatment of Broca's aphasia that does not entail intonation). While both participants made progress, significantly more improvement was made by the one who received MIT. A case study done by Parsons (2006) found that MIT resulted in better articulation and the production of more complete utterances than rehearsed or unrehearsed verbal repetition therapies for one patient with Broca's aphasia. Conklyn et al. (2012) conducted a study with 30 participants using a modified version of MIT. The researchers found that this therapy led to significant improvements in speech output. A recent study done by Haro-Martinez et al., (2019) involved administration of

MIT to 20 persons with non-fluent aphasia who were six months post-stroke. While Boston Diagnostic Aphasia Examination scores did not improve as a result of therapy, scores on the Communicative Activity Log did. Notably, progress was reported to have been maintained three months post-treatment.

While most studies have found MIT to yield positive results, Muelen et al. (2016) found that MIT improved only the repetition of trained items. Otherwise, the therapy resulted in no generalized effect to untrained material and progress was not maintained six weeks post-treatment. The authors concluded that MIT was unsuccessful at recovering any functional language abilities. The researchers do caution, however, not to underestimate the effects of seemingly infinitesimal progress, as the ability to produce even single word utterances may tremendously improve one's quality of life.

Aside from evaluating the effects of MIT, other studies have examined the general music abilities of persons with aphasia. Racette and Peretz (2006) evaluated the preserved singing abilities of eight persons with non-fluent aphasia. The study found that, while singing by oneself did not improve word production or recall, singing in unison with a partner or group did facilitate improvement in language as compared to speaking. Yamadori et al. (1977) found that, out of 24 participants with Broca's aphasia, 90% were able to sing satisfactorily. Interestingly, the researchers found no correlation between the severity of aphasia and the number of prompts needed to begin singing.

2.2.1 Explanations for the Efficacy of MIT: Neural Processing

Exactly why singing is an effective treatment for Broca's aphasia has long been debated by researchers. Most agree, however, that the way in which music is processed by the brain contributes significantly to the success of music-based therapies such as MIT. While neural

processing of music is not yet fully understood, it was thought traditionally that the right hemisphere plays a dominant role. More recent studies, however, have posed evidence against this domain-specific theory (Menon 2016).

The first question to consider regarding the role of neural processing in the efficacy of MIT is how music is processed differently than speech, thus giving MIT an advantage over other therapies that do not use pitched speech. A literature review done by Peretz et al. (2015) concluded that there is significant overlap in the neural processing of language and music (further discrediting domain-specific theories of music and language processing). This may be accounted for by the fact that music and language share many of the same elements, such as pitch, rhythm, and syntax (Merrett et al., 2014). However, using magnetoencephalography, Bergelson et al. (2013) determined that there are at least *some* detectable differences in early cortical responses to the processing of music and language.

The authors of MIT propose that the right hemisphere is responsible for processing the melodic elements of speech, such as rhythm and melody, which are directly targeted in this therapy. They further hypothesize that it is the left hemisphere which integrates these elements with the encoding and decoding of speech (Sparks et al., 1974). Schlaug et al. (2009) used a form of MRI called diffusion tensor imaging (DTI) to view changes in the arcuate fasciculus of the right hemisphere following intense MIT treatment. The arcuate fasciculus plays a major role in the processing of speech and serves as a connection between the temporal and frontal lobe. As a result of therapy, the number of fibers in the arcuate fasciculus increased in all participants. A 2014 study by Merrett et al. suggests that MIT may increase neuroplasticity, as it involves intense practice of the production of language. Norton et al. (2009) believe that perhaps slowly-modulated signals are processed in the right hemisphere, whereas rapidly-modulated signals are

processed in the left hemisphere. Therefore, reducing the rate of articulation during MIT may lend itself to right hemisphere processing.

Schlaug (2008) comments that left-hand tapping also contributes to the stimulation of the right hemisphere during MIT. Schlaug proposes that hand-tapping in combination with the exaggeration of the musical elements of speech accounts for the success of MIT. In another study Schlaug et al. (2009) further reason that left hand-tapping may prime the sensorimotor network of the right-hemisphere which contributes to articulatory tasks. It also may be that the metronomic element of rhythmic hand-tapping facilitates speech through "rhythmic anticipation." Researchers agree that much more experimentation is needed to better understand the differences and commonalities in the neural processing of music and language stimuli.

2.2.2: Explanations for the Efficacy of MIT: Rhythm Versus Pitch

Perhaps the most debated topic amongst researchers is the individual contribution each musical element makes to the efficacy of MIT. Most often, rhythm is credited as playing a greater role than pitch in the success of MIT (Zumbansen et al., 2014; Zumbansen et al., 2014; Day-O'Connell, 2013; Conkly et al., 2012). Pitch is the perceptual characterization of a tone or note. For example, individual tones can be described as sounding "high-pitched" or "low-pitched." Objectively speaking, pitch can be measured as the frequency of a soundwave in Hertz. Rhythm is "the placement of sounds in time" (Crossley-Holland, 2020). The rhythm of a song dictates what beats are emphasized and the duration of this emphasis. One explanation as to why rhythm is so important in the recovery of language post-stroke is that speech (like rhythm) possesses a temporal nature and can be divided into a series of rhythmic intervals (Ravignani et al., 2017) .

Stahl et al. (2011) designed a study to directly compare the effects of rhythm versus pitch in 17 individuals with aphasia. The study found no advantage of therapy requiring singing over therapy that targeted rhythmic speech with no intonation or other melodic components. It is important to note that this study used well-known song lyrics and melodies in the intoned therapy, which the authors of MIT advise against. This may account for the insignificant progress made with this method. Boucher et al. (2001) found that exercises emphasizing rhythm were just as successful as singing-based exercises at generating a response from two participants with non-fluent aphasia. Stahl et al. (2013) conducted a study with 15 subjects who were divided into three treatment groups receiving either singing, rhythmic, or standard therapy. These researchers also found that singing therapy had no advantage over rhythmic therapy. However, they too used familiar melodies to teach phrases in the sung therapy. Laughlin et al. (1979) examined the effects of using different syllable durations during MIT. Using three different syllable durations, they found that longer syllables were associated with the best production of utterances, contributing further evidence to the proposal that rhythm plays a major role in the success of MIT.

Few studies have sought to determine the importance of pitch and melodic intervals in MIT. In a review of current literature, Stahl and Kotz (2014) point out that even though most studies have found rhythm to be the most important factor, they do not control for the individual melodic components of MIT. Therefore, it cannot yet be said definitively which element makes the most significant contribution. Zumbansen et al. (2014) conducted a study in which they evaluated the claim that rhythm is the key contributor to the success of MIT. The researchers used three modes of speech to teach phrases to participants: intoned, rhythmically spoken, and normally spoken. In contrast to most others, this study found that the treatment using intoned

phrases led to more significant recovery than the therapies involving rhythmically and regularly spoken phrases. The researchers believe that pitch plays an invaluable role in recovery, as it adds another cue in addition to rhythm that is necessary for reactivation of the areas of the brain responsible for processing music. Another study found that MIT led to longer-lasting recovery and better articulation than did therapy using non-intoned rhythmic phrases, suggesting that melodic therapy has an added effect over rhythmic therapy alone (Parsons, 2006).

2.3.1: Importance of Pitch

To understand the importance of pitch in MIT, one first must have a basic understanding of what constitutes a melodic interval. Put simply, a melodic interval is the distance in frequency (Hz) from one musical tone to another. Intervals can be defined in various ways. Terms such as *major*, *minor*, *perfect*, *augmented*, or *diminished* often are used to characterize various melodic intervals. Mathematical ratios can also be used to proportionally define frequency differences. For example, the distance from C4 (middle C) to G4 on the piano is seven semitones. This interval is called a perfect fifth (P5) but also can be described by its mathematical ratio of 3:2 (as the frequency of C4 is 262 Hz and frequency of G4 is 392 Hz). Perceptually, this interval is heard at the beginning of the traditional alphabet song melody: the ascending interval from the letter ‘B’ to ‘C’ is a perfect fifth. Melodic intervals also seem to carry emotional connotations positively correlated with their perceived pleasantness. For example, novice musicians often are taught that minor chords or intervals can be distinguished from major chords by their “sad” quality. Intervals can also be described as “consonant,” meaning the two pitches sound agreeable and harmonious, or “dissonant” meaning the two pitches sound discordant or incongruous (Musical U Team, 2017).

The researchers of the present study believe there are several reasons as to why pitch is an important factor in MIT. First, there seem to be certain melodic intervals that occur more frequently in regular speech than others. One study asked two groups of participants to rate their familiarity with or the frequency of specific intervals. Among the most common intervals were the ascending and descending minor third, ascending perfect fourth, ascending major second, and ascending major sixth (Jeffries, 1972). Realizing that precisely tuned intervals are difficult to detect in speech, Ross et al. (2007) sought to determine how the *formants* of human speech influence preference for certain melodic intervals. Interestingly, the researchers found that the first two formants of the targeted phonemes shared the same ratio as notes on the chromatic scale in 68% of trials for both English and Mandarin speakers. Day-O'Connell (2013) studied the prosodic interval of the stylized interjection and found that it is most often spoken using an interval ranging from a major second to minor third. This study also found that intervals greater than four semitones require greater vocal effort and are less natural to sing or speak. Because there seem to be intervals that occur more frequently in speech, the degree to which intoned phrases mimic the natural prosody of speech may have an impact on the success of therapy.

Another reason pitch is important is because it is the element of MIT most closely related to prosody. Prosody is imperative to language, as vocal inflection can change the meaning of a message, and assists in communicating emotions (McKelvey & Weissling, 2013; Robledo et al., 2016; Hammerschmidt & Jurgens, 2007). In a study by Hammerschmidt and Jurgens (2007), participants repeatedly said one word using six different emotions. The researchers found that specific acoustic profiles could be attributed to each emotion. Curtis and Bharucha (2010) found that the directionality of intervals in speech is influenced by the emotion of the speaker. For example, words implying sadness were spoken more frequently using a descending pitch,

whereas words implying anger were spoken with an ascending pitch. Therefore, recovery of prosody may be just as important as the recovery of speech for persons with aphasia.

2.3.2 Purpose of Present Study

The researchers of the present study believe the importance of pitch in MIT (specifically regarding melodic intervals) has been overlooked. It is evident that melodic intervals often are used inconsistently or not controlled for in research studies. The purpose of the present study is to further evaluate the role of melodic intervals in MIT by studying the effects of intoning phrases using two different intervals: a minor third (m3) and tritone.

Although the authors of MIT suggest using common melodic intervals (such as a minor third or perfect fourth) to intone phrases, it is unlikely that most speech-language pathologists who employ MIT are aware of the intervals they are using. They also likely lack consistency (Norton et al., 2009).

2.3.3: Hypothesis

Prior to initiating treatment, the researchers of the present study predicted that using a more common and perceptually pleasant or "consonant" interval (i.e., m3) to intone phrases in MIT will result in more significant and longer-lasting recovery of language function than intoning phrases on a less common and perceptually unpleasant or "dissonant" interval (i.e., tritone). This prediction rests on the assumption that because the m3 is both more familiar and pleasant than the tritone, it is easier to sing and would facilitate a more efficient and engaging therapeutic process.

CHAPTER 3

METHODS

3.1.1 Participants: Recruitment

The research proposal for this study was approved by Wichita State University's Institutional Review Board (IRB) on May 29, 2020 (IRB Number: 4720). The following methods are consistent with those described in the IRB application. Participants for this study were recruited through Wichita State University's Evelyn Hendren Cassat Speech-Language Hearing Clinic. Due to a temporary university-wide shut down precipitated by COVID-19, in-person recruitment was not possible. Alternatively, an electronic flyer was sent out via email to all members of the clinic's two aphasia groups whose most recent *Western Aphasia Battery-Revised* (WAB-R) scores met the study's inclusion criteria. The flyer invited clients to participate in a research study evaluating the effects of using pitched speech to facilitate language recovery for persons with aphasia. The term Melodic Intonation Therapy was not stated in order to prevent potential participants from researching the therapy and subsequently affecting the results of the study. No financial compensation was offered; however, free individual therapy served as an incentive for participation.

3.1.2 Participants: Inclusion Criteria

The following WAB-R subtest scores served as inclusion criteria for this study: score <5 on word fluency, score >4 on auditory verbal comprehension, and score <8 on verbal repetition. These scores reflect the candidacy requirements described in the MIT manual (Helm-Estabrooks et al., n.d.). To remain in accord with CDC guidelines for COVID-19, it was determined that all sessions would take place via teletherapy. Therefore, all participants were required to have access to Zoom along with a working microphone and speakers.

3.1.3 Participants: Demographics

Two participants responded to the initial invitation to participate in the study and were deemed eligible based on the inclusion criteria and access to the required technology. Pseudonyms were assigned to each participant and will be used henceforth. The first participant, Lee, was a 51-year-old male. At the time of treatment Lee was nine years post-stroke. WAB-R scores indicated a diagnosis of Broca's aphasia with an Aphasia Quotient of 46.7. This was consistent with his observed deficits which included non-fluent, telegraphic speech, as well as deficits in naming, repetition, and word finding. Lee had received both individual and group therapy continuously since the CVA occurred, however this study was the first time he had participated in treatment involving music. Lee did have some music education and formerly played several instruments; however, right hemiparesis made playing instruments impossible post-stroke.

The second participant, Karla, was a 54-year-old female who was seven years post-stroke at the time the study took place. Though originally diagnosed with Broca's aphasia, her most recent WAB-R scores indicated a diagnosis of conduction aphasia with an Aphasia Quotient of 74.6. Karla also presented with symptoms characteristic of apraxia of speech; however, this had not been formally diagnosed at the time this study occurred. She had received speech-language therapy services since her CVA occurred; however, she had not participated in music-based therapy before this study. Unlike Lee, Karla did not have an educational background in music.

3.2 Selection of Intervals

The two intervals chosen for comparison in this study were the minor third and tritone. These intervals vary both mathematically and perceptually. Three semitones separate the two notes in a minor third. This corresponds to a pitch ratio of 6:5. The notes comprising a tritone are

six semitones or three whole tones apart, thus the prefix “tri.” It corresponds to a pitch ratio of 10:7. The minor third is used regularly in Western music and generally is perceived to be pleasant. Conversely, the tritone is rarely used. Historically it has been perceived to be so abhorrent that it earned the nickname “the devil’s tone.”

As aforementioned, these starkly contrastive intervals were chosen as a means of determining if participants respond more favorably to a common, consonant, and pleasant interval or unfamiliar, dissonant, and unpleasant interval within Melodic Intonation Therapy.

3.3 Probe Phrases

Sixteen probe phrases were selected for use within each of the three MIT levels. This amounts to a total of 48 phrases used in this study. The majority of phrases came directly from the MIT handbook, which provides sample phrases for each level along with a recommended intonation pattern. The remaining phrases were generated by the researchers. These phrases were determined to be functional phrases applicable to everyday life. It is important to note that, when spoken, the stress pattern of each phrase may vary depending on the context in which the phrase was used. The syllabic stress of individual words also differs depending on whether they are spoken in isolation versus within a sentence or phrase. Therefore, the selected intonation pattern for each phrase is one of several possibilities. Figure 1 lists each pair of phrases at all three levels.

FIGURE 1

	Elementary Linguistic Level		Intermediate Linguistic Level		Advanced Linguistic Level	
Pair 1	Open up	Make my bed	My name is _____	Answer the phone	It is raining	It is cold out
Pair 2	I am fine	Pay the bill	Do the dishes	I am thirsty	I can't find it	Help me clean it
Pair 3	Watch TV	Lock the door	Ring the bell	Shut the door	I don't want that	Do the laundry
Pair 4	Hungry	Water	Wait for me	Tie my shoe	Ready to order	Go to the restaurant
Pair 5	Thankyou	Help me	Pick it up	Hurry up	Give me the remote	Turn on the TV
Pair 6	My pill	I am hot	I feel sick	Go to bed	I need my keys	A cup of coffee
Pair 7	Wake up	Lie down	I am tired	I am hungry	Don't understand	Come over here
Pair 8	Bathroom	Money	Turn it off	Turn it down	Call the doctor	Change the channel

3.4 Randomization and Assignment of Intervals

Each probe phrase was paired with another probe phrase within the same level that had an identical intonation pattern. Most paired phrases also had the same number of syllables, however the few that did not differed by only one syllable and the number of ascending and descending intervals remained the same as its pair.

During treatment, each participant heard one phrase from each pair intoned on a m3 and the other participant heard the same phrase intoned on the tritone. The interval assigned to each of the phrases within the pair was reversed for the two participants. For example, one pair included the phrases “ring the bell” and “shut the door.” Lee always heard the phrase “ring the bell” intoned on a tritone and “shut the door” intoned using the m3. Conversely, Karla only heard “ring the bell” intoned on the m3 and “shut the door” on the tritone. A randomization feature within Microsoft Excel was used to determine which interval was assigned to each phrase for the two participants.

This mechanism of assigning intervals mimics a Latin square design, which is “a method of placing treatments so that they appear in a balanced fashion within a square block or field. Treatments appear once in each row and column” (Gao, 2005). Traditionally, the Latin square design has been used to offset an order effect, though it is frequently used for balancing other factors as well. In this study the design served as a control factor by counterbalancing the potential impact of phonemic and linguistic differences within the pairs of phrases. Table 1 illustrates how the conditions of each pair were distributed using the Latin square design.

TABLE 1

LATIN SQUARE DISTRIBUTION

	Participant 1	**Participant 2**
Phrase 1	A	B
Phrase 2	B	A

A traditional Latin square design requires an equal number of rows and columns to fully counterbalance the conditions. In this design: A=minor 3; B=tritone. Each pair of phrases can be represented by its own square grid.

3.5.1 Pre-Treatment

Both participants attended three pre-treatment sessions lasting approximately fifteen minutes prior to beginning MIT to gather baseline data. At each of the three pre-treatment sessions, the participants were given a probe phrase assessment. The probe phrase assessment was created by the researchers to monitor progress made on each phrase. The assessment consisted of the client repeating each of the 48 probe phrases after hearing them spoken by the lead researcher. Three pre-treatment probe assessment scores were needed to calculate an effect size using the formula proposed by Beeson and Robey (2006), which requires the standard deviation of pre-treatment scores to be computed (see **4.1 Analysis of Data)**.

These probe assessments were scored in the following manner: participants could receive a maximum of one point per syllable. Syllables that were judged to be intelligible received one point. Zero points were given for syllables that were unintelligible or deleted. Half of a point was earned for each intelligible syllable the participant used that was different from the original phrase but did not change the meaning. For example, if substituting “a” for “the” did not change the meaning of the phrase, the client still received half of a point. An exception to this rule was that the participants still received a full point if the only change they made to a syllable was

adding “s” to the end of a word. One example of this is changing “bill” to “bills.” The participants could ask for multiple repetitions of a probe phrase; however, only the best of the participants’ first two attempts at each phrase was scored.

The number of points earned was divided by the number of points possible to determine a percentage score for the probe phrases at each individual MIT level, as well as an overall score for each of the three pre-treatment sessions. Additionally, an overall and level-specific score was calculated for all phrases that were to be intoned on a m3 and all that were to be intoned on a tritone.

3.5.2 Treatment Sessions

Participants were asked to attend two individual thirty-minute treatment sessions per week across eight weeks. Due to scheduling conflicts, Lee attended twelve sessions and Karla attended ten. Because the present study has a single-subject design and each client served as his or her own control, the difference in the number of treatment sessions did not impact the validity of the results or ability to compute an effect size.

As aforementioned, all sessions took place via teletherapy due to COVID-19. This prevented the clinician from facilitating the left hand-tapping which is considered a crucial element of MIT. To compensate, the participants were given instructions to tap their left hand in rhythm with each word of the phrase as they sang. Participants were told this was necessary for neural stimulation of the right hemisphere. Frequent reminders were provided throughout each session to continue hand-tapping.

Prior to each session, the order in which the phrases would be presented was randomized using the randomization function in Microsoft Excel. Again, the interval upon which each phrase was intoned remained the same for the participants at every session. The participants cycled

through every phrase of the level before any phrase was repeated. For example, if they did not complete each of the sixteen phrases for the level they were on in one session, then treatment at the following session treatment began with the phrase they left off with before beginning the next cycle of randomized phrases. This ensured that participants practiced each phrase an equal number of times.

The MIT handbook was followed intently during treatment sessions regarding cueing, scoring, and discontinuation of phrases when warranted by the participant's score. Of note, the optional pictorial cue cards were not used during this study. Session scores were recorded as described in the handbook, however these were not used in any statistical analysis. Rather, they were used to help determine when participants were ready to advance to consequent levels and were presented to the participants through graphs upon completion of treatment to allow the participants to visualize their progress.

The clinician used an electric piano to maintain pitch accuracy throughout each session. The piano was not visible on camera and the volume was turned down low enough to not be heard by the participant. This was done intentionally to not draw the participants' attention to the emphasis being placed on pitch. Additionally, having the clinician serve as the primary instigator and manipulator of pitch kept treatment analogous with traditional MIT sessions. Participants were encouraged to sing with the clinician. However, as expected in MIT, they often struggled to match the presented pitches or spoke the phrases in unison with the clinician using an exaggerated form of speech which closely mimicked *sprechgesang*.

As recommended by the authors of MIT, a comfortable vocal range was determined by the clinician in conjunction with each participant. The lower note remained the same for both intervals for each participant. For example, Lee always began on G below middle C. Therefore,

the m3 interval was G to B-flat (Bb) and the tritone interval was G to C-sharp (C#). Karla began on B below middle C, meaning the m3 was intoned using the notes B and D, and the tritone B to F. It is important to note that one melodic interval can begin on any note and maintain the same perceptual quality, as it is the *distance between* the two notes that defines the interval (not the notes themselves). In other words, intervals are relative whereas pitch is absolute.

Treatment began at level one of MIT, otherwise known as the Elementary Linguistic Level. Advancement to subsequent levels was permitted when participants reached a score of approximately 90% at the current level and were perceived by the clinician's judgement to be ready for advancement. Lee completed four cycles through level one phrases, three cycles through level two, and one cycle through level three. Karla completed three cycles through level one, three cycles through level two, and one cycle through level three. Only one cycle through level three words was completed for each participant for this study. Neither received a passing score of 90% or above at the final level.

Upon completion of each level the participants again completed a probe phrase assessment. These were administered and scored in the same way as the pre-treatment assessments. Scores were calculated for phrases intoned on a m3 and tritone at each level, as well as an interval-specific overall score and combined overall score.

3.5.3 Post-Treatment

A follow-up session was conducted four weeks post-treatment to gather maintenance data. The purpose of the maintenance session was to determine how much progress was retained after a period of recession from therapy. At this session the participants again were asked to repeat all probe phrases after hearing them read by the clinician. This probe assessment was

scored in the same manner as the previous ones. Only one probe assessment score was required during the maintenance period to calculate the effect (see **4.2 Analysis of Data**).

CHAPTER 4

RESULTS

4.1 Analysis of Data

Two quantitative data measures were collected within this study: session scores and the probe assessments. Session scores were recorded at each session using the scoring protocol outlined in the MIT handbook. These scores were not used in any statistical analyses; however, they were used to determine when participants were ready to advance to the next level. Additionally, a graph of overall session scores (i.e., not interval specific) for each level was presented to participants post-treatment to allow them to see their progress throughout treatment.

The probe assessments were used to calculate an effect size (*d*) using the formula proposed by Beeson and Robey (2006) for single-subject aphasia treatment research: $d = \frac{\bar{X}_{A2} - \bar{X}_{A1}}{\sigma_{A1}}$. (Refer to **3.5.1 Pretreatment** for an explanation of probe assessment administration and scoring.) In this formula, A_1 is the mean of the pre-treatment probe assessment scores, A_2 is the maintenance score, and σ_{A1} is the standard deviation of the three pre-treatment probe assessment scores. In other words, the average of the baseline data points is subtracted from the maintenance data point and the difference is divided by the standard deviation. An effect size in a single-subject research study is designed to "measure change in performance on a variable (or variables) of interest in response to the described treatment" (Beeson & Robey 2006). The independent variables in the present study are the melodic intervals used during MIT treatment. This formula requires a minimum of three baseline data points and a maintenance data point. For this study, the pre-treatment probe assessments served as baseline data, and the four-week post-treatment probe assessment was used as a maintenance data point. An effect size was calculated for the m3 and tritone for each participant. Additionally, an overall effect size was calculated to

determine the efficacy of MIT in general regardless of pitch. Effect sizes are listed below in Table 2.

TABLE 2

EFFECT SIZES

	Minor 3 Effect Size	**Tritone Effect Size**	**Overall Effect Size**
Participant 1 ("Lee")	6.4	7.1	6.5
Participant 2 ("Karla")	1.3	4.7	2.8
Average	3.9	5.9	4.7

A first-year graduate student in the speech-language pathology program at Wichita State University served as a blind scorer by watching recorded videos of the spoken probe phrase assessments and scoring them using the same guidelines developed by the primary researcher. The student was untrained in MIT, blind to the purpose of the study, and did not hear any phrases intoned on an interval (since the probe phrases were spoken). Table 3 lists the blind scorer's results.

TABLE 3

BLIND SCORER'S RESULTS

	Minor 3 Effect Size	**Tritone Effect Size**	**Overall Effect Size**
Participant 1 ("Lee")	6.3	6.4	5.5
Participant 2 ("Karla")	1.5	2.6	3.2
Average	3.9	4.5	4.4

An inter-rater reliability analysis was completed through the IBM SPSS Statistics Software using Cronbach's alpha. The inter-rater reliability correlation was .891, or 89.1%.

4.2 Interpretation

Beeson and Robey (2006) acknowledge that, while calculating an effect size for single-subject design studies is possible, interpreting the magnitude of the effect size is complicated. Several factors, including a sheer lack in number of studies and a wide variety of the variables in question, contribute to the complexity of this task. Robey et al. (1999) offer the following benchmarks for effect size in single-subject aphasia research: 2.6 (small), 3.9 (medium), 5.8 (large). Based on these benchmarks, the overall MIT effect size for Lee is considered large and the overall MIT effect size for Karla is small to medium. The effect size for the tritone was larger than the m3 effect size for both participants. The blind scorer's results validate this finding. The tritone resulted in a medium to large effect size for Karla and large effect size for Lee. The m3 resulted in a large effect size for Lee and small effect size for Karla. The researchers of the present study believe this is sufficient to state there is a meaningful difference in the effect sizes for the tritone versus the m3, with the tritone resulting in a greater treatment effect within MIT than the m3. However, because of the small number of participants, no statistical analyses could be done to determine if the difference was statistically significant. Nevertheless, these results are contrary to the researcher's hypothesis, which predicted the reverse effect. Aside from interval specificity, this study also contributes to the significant amount of research that shows MIT is efficacious for persons with aphasia.

CHAPTER 5

DISCUSSION

5.1 Explanation of Effect Size

Several explanations may account for the results of this study. First, the researchers predicted the m3 would produce a greater effect size because generally it is considered a pleasant-sounding, consonant interval and is easier to sing than the tritone. However, the *novelty* of the tritone may have resulted in it having a larger effect size by drawing more attention to the unorthodox interval than the trite m3. In accord with this theory, participants may have been captivated by the oddity and dissonance of the tritone and therefore more attentive to the phrases intoned on this interval. It likely required more effort and concentration for the clients to sing this interval accurately. Perhaps singing this unfamiliar interval forced the client to build new neural pathways, whereas singing the m3 failed to promote neuroplasticity since the interval is not unorthodox by any means.

In further support of the novelty argument is the fact that the m3 is a remarkably common interval in Western music and may rouse thoughts of familiar songs with parallel melodies or intervals. The authors of MIT discourage use of familiar melodies precisely because these affinities may hamper the effectiveness of therapy if the client is unable to disassociate the melody with the notorious lyrics.

Another explanation of these results may be the sheer distance between notes for each of these intervals. The distance between the notes that comprise a m3 is three semitones, whereas the notes comprising a tritone are six semitones. Like the previous rationale, more emphasis may have been placed on phrases intoned on the tritone because of the more drastic distance between notes. Essentially, both the novelty and distance theories allude to accentuation as being

responsible for the results. In contrast, however, the novelty theory provides a qualitative or perceptual description, whereas the distance theory evidences a quantitative explanation.

5.2 Efficacy of Melodic Intonation Therapy

Regardless of pitch, this study further contributes to the literature evidencing the efficacy of MIT for teaching *trained phrases*. Though not directly measured, MIT was not noted to improve untrained phrases unless they contained words that had been practiced. For example, some improvement was noted on the untrained level two phrase “I am hungry” after level one likely because the word “hungry” was one of the rehearsed probe phrases during level one.

To the best of the researchers’ knowledge, this is the first study using MIT that was conducted via teletherapy. The results indicate that MIT *is* efficacious in this format, though no control group existed to compare in-person to virtual therapy. Several technology-related barriers also complicated therapy in this format. Internet glitches and delays made singing in unison difficult. Additionally, the clinician was unable to facilitate left hand-tapping, which is required throughout the majority of MIT. The participants were reminded to tap their hand in rhythm while they listened and sang. However, because the participants were in control of hand-tapping instead of the clinician, the rhythm often was dictated by their speech fluency rather than vice versa.

Despite a few technological drawbacks, there were definite advantages to conducting MIT via teletherapy. First, the clinician was able to access a digital keyboard to ensure accuracy of pitch. Computer sound could be easily muted to allow for reference to the instrument. Second, the participants were able to partake in therapy in their natural environment. This is typically considered advantageous and associated with greater generalization of skills learned in therapy to

real-life contexts. The Zoom platform also allowed sessions to easily be recorded with permission from the participants as cited in the IRB proposal.

5.3 Generalization

The results of this study indicate that use of the tritone within MIT may yield more auspicious results than the m3. This is contrary to what is currently suggested by the authors of MIT, who recommend intoning phrases on familiar intervals such as the m3. However, because this study cannot conclude whether the distance between or novelty of the tritone led to superior results, this information should be implemented with caution. Furthermore, it may not be practical to expect speech-language pathologists to intone phrases using a tritone since it can be assumed that most are not experienced musicians. Even seasoned musicians, including the researchers, find it difficult to sing a tritone with perfect intonation. It perhaps would be more conceivable to implement different tonal recommendations if further research were to indicate that the larger distance between notes was responsible for the better outcome. In other words, it would be more feasible to teach non-musical SLPs to sing larger intervals than to sing strange intervals perfectly in tune.

A second consideration regarding generalization is client predilection. Both participants in this study commented at various times that phrases intoned on the tritone sounded “strange,” “sounded off,” and were “hard to sing.” This occasionally resulted in the participants preferring to speak along with the clinician rather than sing along. Speaking the phrases is clearly antithetical to the purpose of MIT, which is to stimulate language recovery through music. Still it should be noted that training with the tritone *did* result in significant improvement in phrase production.

5.4 Limitations of Study

The researchers acknowledge there were several limitations to this study. First, COVID-19 resulted in administering MIT via teletherapy. Clearly this was not ideal, as it led to an inability of the clinician to facilitate hand-tapping and resulted in intermittent technological glitches that interrupted the flow of therapy. Despite the researchers' best efforts, this format also limited the number of participants since in-person recruitment was not possible and not all eligible clientele had access to the equipment needed for teletherapy. While it is not uncommon for aphasia research studies to include only one to two participants, the researchers had hoped to recruit more to increase statistical power, reliability, validity, and generalizability of the study. Arguably, another disadvantage of this study regarding demographics is that both participants were several years post-stroke. Larger effect sizes may have been collected had the participants been less than a year post-stroke, as that is when the most progress regarding language is typically seen. However, the researchers believe this actually may strengthen the study since progress cannot be credited to spontaneous recovery.

Scoring done by the researcher is another limitation of this study, as bias could have been present. However, results contradictory to the proposed hypothesis provide evidence against such bias. Additionally, an untrained blind observer also scored the probe assessments and similarly concluded that the tritone had a more significant impact than the m3 with few discrepancies in scores despite a tedious and complex scoring process.

Human error associated with pitch also presents a potential flaw with this study. The primary researcher who administered the therapy is an experienced musician with training at the collegiate level in keyboard, aural skills, and music theory. Intervals also were intoned on the keyboard before presenting each phrase in order to substantiate accurate pitch. This does not

preclude the chance that intervals periodically were sung out of tune, however. Conversely, this actually may enhance the generalizability of the study, as MIT most often rests on clinician-instigated pitch in the absence of instrumentation.

A final limitation to this study is the lack of absolute balance of paired phrases regarding function versus content words and phonemic complexity. Difficulty with function words is a hallmark of telegraphic speech associated with non-fluent aphasia. Furthermore, each participant seemed to have specific function words and phonemes that were challenging for him or her to produce. Karla also has apraxia of speech, making motor planning for certain phonemic patterns increasingly difficult. Selecting phrases directly from the MIT handbook was elected to combat this, as the suggested words and phrases are purportedly of equal phonemic complexity at each level. Randomization of phrases also attributed to prevention of bias of this nature.

5.5 Future Research

This study, being the first of which to manipulate pitch within MIT, incites multitudinous potential to further evaluate the role of pitch in this therapy. First, future research should seek to determine if it was the novelty of the tritone or larger distance that led to greater improvements in phrase production. To test this, a future study may compare the effects of using several small intervals such as a major and minor second and third with the effects of using larger intervals, such as the perfect fifth and major sixth.

Furthermore, while previous studies have concluded that rhythm is more impactful than pitch in MIT, this study has provided evidence that pitch *does* impact the efficacy of therapy. In fact, a myriad of expendable melodic intervals may actually give yet unfound advantage to pitch manipulation in this therapy. It would be appropriate, therefore, to continue investigating the complex interaction of pitch and rhythm within MIT.

The efficacy of teletherapy also should be assessed compared to a control group receiving in-person therapy. This is especially pertinent with the increasing demand for and access to teletherapy precipitated by COVID-19. Lastly, future studies should strive to include more participants in order to increase the validity and generalizability of this realm of research.

CHAPTER 6

CONCLUSION

The researchers of the present study believe the results supply revolutionary evidence of the role that melodic intervals play in MIT. Though previous evidence has suggested that rhythm plays a more important role than pitch, this study shows that the intervals used may impact the efficacy of therapy. Additionally, our research provides evidence that MIT conducted via teletherapy is efficacious, although the degree to which it compares to in-person therapy is yet unknown due to lack of a control group. The researchers believe this study lays the foundation for future research to further investigate the significant and perhaps surprising contribution that pitch makes to MIT.

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