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Music and Language Playing the Same Tune: How Melodic Intonation Therapy Can Help in the
Recovery from Aphasia

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Resumen

La Terapia de Entonación Melódica (Melodic Intonation Therapy, MIT por sus siglas en inglés) es un programa de tratamiento diseñado específicamente para individuos con afasia no fluente. Al ser uno de los únicos tratamientos disponibles para la afasia no fluente con suficiente uniformidad, se perfila como un tratamiento prometedor cuya eficacia puede estudiarse y evaluarse para dicha población (“Assessment: Melodic Intonation Therapy,” 1994). El tono y el ritmo son los dos componentes centrales del MIT. Estudios previos han intentado determinar el papel de cada uno en la naturaleza rehabilitativa de MIT como tratamiento (Stahl et al., 2011, 2013). El presente estudio, sin embargo, da un paso más no solo al comparar MIT con la terapia regular del habla, sino también al comparar los efectos del tono y el ritmo mientras se controla adecuadamente para el componente de MIT que no se usa en cada método particular de tratamiento. Diez participantes fueron asignados a tres grupos de tratamiento: uno enfocado en los aspectos rítmicos de MIT (RET), uno enfocado en los aspectos tonales de MIT (TET)—cada uno con una duración de 20 sesiones—y uno en que los participantes solo recibían terapia regular del habla (grupo control). Los resultados exhibieron que los dos grupos que recibieron una forma modificada de MIT (MMIT) mostraron mayores mejorías que el grupo que solo recibió terapia del habla. Asimismo, mientras los dos grupos de MMIT tuvieron un mejor desempeño que el grupo control, cada grupo de MIT se desempeñó de forma diferente, lo que sugiere que los elementos de ritmo y tono contribuyen de manera distinta al tratamiento de la afasia. No obstante, aunque los componentes de MIT se utilicen de forma separada, MIT todavía muestra ser más efectivo que terapia regular del habla.

Palabras clave: afasia, afasia de Broca, afasia no fluente, Terapia de Entonación Melódica, ritmo, tono

Abstract

Melodic Intonation Therapy (MIT) is a specifically designed treatment program for individuals with non-fluent aphasia. As one of the only sufficiently uniform treatments available for non-fluent aphasia, it presents promise as a treatment whose efficacy can be studied and evaluated for this population (“Assessment: Melodic Intonation Therapy,” 1994). Tone and rhythm are the two central components that make up MIT. Previous studies have tried to determine the role each plays in the rehabilitative nature of MIT as a treatment (Stahl et al., 2011, 2013). This study, however, goes a step further not only by comparing MIT to regular speech therapy but also by comparing the effects of tone and rhythm while adequately controlling for the component of MIT that is not used in a particular treatment method. Ten adult, English-speaking participants were assigned to three treatment groups: one focusing on the rhythmic aspects of MIT (RET), one focusing on the tone aspects of MIT (TET)—each lasting 20 sessions—, and one in which participants only received regular speech therapy (control group). The results displayed that both the groups that received a modified form of MIT (MMIT) showed greater improvement than the group that only received speech therapy. Additionally, while both MMIT groups performed better overall than the control group, the MIT groups performed differently, suggesting the rhythmic and tone elements do have different contributions to aphasia treatment. Nevertheless, even when the components of MIT are utilized individually, MIT still proves to be more effective than regular speech therapy.

Keywords: aphasia, Broca’s aphasia, non-fluent aphasia, Melodic Intonation Therapy, rhythm, tone

Introduction

Throughout history much thought has been given to the relationship between music and language. After all, both are present in every culture, society, human group, and they are both deeply embedded with identity and tradition (Davis et al., 2008). There has been speculation about the evolutionary role music plays because, unlike language, it does not seem necessary for survival. This has sparked much research into what music contributes to society, to individuals, and to those who actively learn how to make music – musicians. From this research, a profession has emerged called music therapy that uses music to accomplish non-musical goals, because there is a great amount of empirical clinical data showing that music can aid in many facets of life (Davis et al., 2008). One growing field is the use of music therapy in helping individuals with aphasia recover their language abilities. Melodic Intonation Therapy (MIT) is a specific technique that has been developed to help individuals with non-fluent aphasia (otherwise known as Broca's aphasia).

A growing topic of study regards the relationship that music and language have in the brain. Many studies have shown a positive correlation between musical training and development of language abilities, math abilities, problem solving, and so on. However, the results of many of those studies have been limited to correlations, which means it was unknown whether individuals who got involved in music had higher aptitude for all the other skills as well or if music actually helped them develop those skills. In her dissertation, Musacchia (2008) discusses just this issue. While it was not the goal of her study, by collecting background data asking how many years her participants had been studying music, she was able to find strong evidence for musical training shaping and developing the brainstem and other subcortical regions of the brain. In her study, the main topic was learning-related neural plasticity. This is a type of

neural plasticity that “can be induced at any stage of development and is evident throughout adulthood” (Musacchia, 2008, p. 9). This is the type of neural plasticity on which musical training capitalizes. In her study, Musacchia found that

protracted musical practice, and not innate musical disposition promotes neural plasticity...Even without knowing which aspects of musical training specifically contribute to enhance neural activity, we can conclude that it is beneficial to the [Central Auditory Nervous System]. This may be useful in designing training paradigms for people with communication difficulties and, in particular, implies that musical training may be an effective remediation tool for those with auditory or multi-sensory encoding deficits. (2008, pp. 66–67)

Without meaning to, Musacchia (2008) discovered evidence that music induces learning-related neural plasticity, which means music can be used at any age in life to increase neural development, which is exactly what aphasia patients need.

Non-fluent Aphasia

Aphasia is “a disorder caused by a brain injury...[and] can be subdivided into fluent and non-fluent categories. Non-fluent aphasia generally results from lesions in the frontal lobe including the portion of the left frontal lobe known as Broca’s region” (Schlaug et al., 2008, p. 315). Damage to this area leaves individuals able to comprehend language, but they have a difficult time speaking. While aphasia is a known condition that has been named and classified since the 19th century, “surprisingly, there are no universally accepted methods for the treatment of non-fluent aphasia” (Schlaug et al., 2008, p. 315). In fact, “of the many variations of language therapy currently in use, very few are sufficiently precise to allow evaluation across different

subjects, therapists, and institutions” (“Assessment: Melodic Intonation Therapy,” 1994, p. 566). This makes it difficult because Music Therapists (MT) have nothing to compare their techniques against in order to prove their efficacy (Merrett et al., 2019; Schlaug et al., 2008). However, there is a technique that has been developed for the treatment of non-fluent aphasia called Melodic Intonation Therapy (MIT). This therapy was developed specifically for use with non-fluent aphasiac individuals to work on developing speech. This technique is built upon the observation that individuals with non-fluent aphasia are still often able to sing (“Assessment: Melodic Intonation Therapy,” 1994; Sparks et al., 1974; Stahl et al., 2013). Because of this, it was theorized that the right hemisphere of the brain that was still intact with non-fluent aphasia must be the area of the brain involved in singing. Thus, MIT was developed with the idea that the right side of the brain could be trained to do some of the language functions that were lost due to the damage in the left hemisphere (“Assessment: Melodic Intonation Therapy,” 1994; Sparks et al., 1974; Van Der Meulen et al., 2012). The singing and the tapping specifically with the left hand both aim to activate the right hemisphere as the patient goes through the MIT treatment (“Assessment: Melodic Intonation Therapy,” 1994; Stahl et al., 2011). While there are some studies that have seemed to back up this theory (Conklyn & Rung Meehan, 2018; Di Pietro et al., 2004; Schlaug et al., 2009; Stahl et al., 2013), there are others that question it (Bhogal et al., 2003; Zumbansen et al., 2014a). At this time there is not enough known about the brain, and even more specifically about the brain of individuals with non-fluent aphasia to be able to pinpoint specific areas that are responsible for recovering language (Bennett & Hacker, 2003; Schlaug et al., 2009). In fact, in 40 years of research there were only 12 patients for which there was “brain imaging data acquired pre- and post- MIT” (Zumbansen et al., 2014a, p. 7). Even though there is not enough information to know if the speculated neural effects do take place

with MIT, the technique is built upon that idea and has specific principles that aim to apply that theory.

Melodic Intonation Therapy

According to Curtis et al. (2020), “[t]he core elements [of MIT] typically include two musical components: (1) melodic intoning of spoken phrases, with a higher pitch for stressed syllables and a lower pitch for unstressed syllables, and (2) rhythmic hand-tapping while intoning the phrase” (Curtis et al., 2020, p. 581). MIT, therefore, combines melody and rhythm to help an individual begin to speak again. This is based on much research showing that even individuals with non-fluent aphasia who cannot speak at all can sing fluently (“Assessment: Melodic Intonation Therapy,” 1994; Sparks et al., 1974). Originally, therapists tried to utilize these songs that individuals could still sing as the melodies for new phrases. However, early studies found that individuals instead reverted back to the lyrics they already knew instead of the new ones with key phrases in it (Sparks et al., 1974).

This prompted the development of a method which avoids any distinct melody even reminiscent of a popular song or jingle. The resulting method, now referred to as Melodic Intonation Therapy, has a limited range of pitch variation. Each sentence-item is “composed” so that the inflection pattern, rhythm, and stress are similar to the speech prosody of that sentence. (Sparks et al., 1974, p. 304)

While more recent studies have reported that “familiarity with the melody did not constrain the patients’ sung production of lyrics that differed from the original ones” (Stahl et al., 2013, p. 5), traditional MIT still sets phrases to two pitches – one high and one low. Stressed syllables are sung on the higher pitch, and unstressed syllables on the lower pitch to mimic the natural

prosody of speech. The pitches are sung, typically in time with natural speech prosody. The nature of MIT is such that it can be adapted to precisely fit the needs of the individual receiving it and, therefore, adapts to each new participant; however, there are some common ways of putting it in practice. Most frequently, it is set in a multi-layered, hierarchical process beginning with the Board-Certified Music Therapist humming the pitches to which the words have been set. Then the MT will have the patient join in on the humming. Once they are both humming the sequence, the MT will gradually fade out until the patient is humming on their own. Next, they will sing the pitches with the words, following the same sequence of steps as before. Once the patient is successfully singing the sentence, they will move to *Sprechstimme* or *Sprechgesang* (Goldfarb, 2015), which is a cross between singing and speaking, while still following the same steps as the previous stage. Finally, they will speak the words, MT and patient together at first, then the MT will fade out, and the MT will end by asking the patient what the word or phrase was, and the patient will speak their answer. This entire time the MT will ensure that the patient is tapping their left hand as they are humming/singing/saying each syllable (if the individual cannot tap on their own, the MT will use the hand-over-hand helping technique). This is a general outline of MIT, however, the nature of it is such that it will be adapted by the MT as they go through it to best suit the needs of the individual with whom they are working. Thus, for an individual who has more severe aphasia, they might never get to the speaking, but for someone who can catch on quickly, they might only do the singing and the speaking, skipping the other steps. As mentioned before, this therapy is meant to fit the exact needs of each patient.

MIT has proven to be a successful technique in treating non-fluent aphasia, but due to the nature of its field and its medium, there is not sufficient empirical research about it. As noted before, the field of aphasia has no standard treatment. It is common for individuals with aphasia

to see a speech therapist, but even among speech therapists, there is no common intervention or technique that they use (Bhogal et al., 2003). This makes it hard for MIT to prove its efficacy because there is no other technique against which to compare it. The other factor that can make it hard to gather research on MIT is the nature of the clinical setting. In a clinical setting, every session is different, even two sessions helping the same person, because the session aims to meet the person where they are at that day and help them toward accomplishing their long-term and short-term goals. As the sessions progress, the change of mood, potential setbacks, etc., can all lead to the technique being altered even from what the MT planned when starting the session, so that they can adapt to the situation at hand. Add to this the incredible, varying nature of aphasia patients (Curtis et al., 2020; Merrett et al., 2019; Schlaug et al., 2008), and it can seem like it would be nearly impossible to gather any sort of generalizable data.

However, despite its adaptability, MIT still remains more precise and uniform than the other treatments, such that it, out of all the language therapies for non-fluent aphasia, “can fulfill consistency for research-level studies” (“Assessment: Melodic Intonation Therapy,” 1994, p. 566). Thus, much research has aimed to evaluate MIT in the treatment of aphasia. Early studies focused mainly on patients with chronic aphasia, so that the patients themselves acted as their own control (Sparks et al., 1974; Zumbansen et al., 2014b). Other studies sought to examine the effects of MIT compared to generic speech therapy (Zumbansen et al., 2014b). And still others sought to examine the ways in which the melodic and the rhythmic components each contributed to the efficacy of the therapy (Conklyn & Rung Meehan, 2018; Stahl et al., 2011, 2013). Despite the studies that have been conducted, very few comparisons can be made between the studies for overall efficacy of MIT (Goldfarb, 2015; Van Der Meulen et al., 2012, 2016; Zumbansen et al., 2014a). A major factor in this is that every study uses a different version of MIT. Many studies

are conducted by speech therapists who lack the proper training in MIT, so even the modifications they seek to make do not provide comparable groups. Stahl and colleagues tried twice to prove that singing and melody were not necessary parts of the treatment (Stahl et al., 2011, 2013). However, both studies they conducted failed to account for the natural melodic elements in the speech they used for the non-singing group. Hence, while their results could have been used to confirm the efficacy of MIT, their interpretations do not allow for comparisons to be made since they presented only groups of MIT (one with only melody components and one with rhythm and the natural melodic components of speech). Similarly, other studies have sought to find ways to modify MIT, but since the researchers were not properly trained in the method itself, their modifications and application of the technique involved different steps, progressions, and even goals (Bonakdarpour et al., 2003; Van Der Meulen et al., 2012, 2016; Zumbansen et al., 2014a, 2014b). Notably, even with the incredible variation among researchers as to what they thought MIT was, how to do it, and its targeted outcomes, studies have still found that it helps individuals with non-fluent aphasia regain some speech abilities (“Assessment: Melodic Intonation Therapy,” 1994; Bonakdarpour et al., 2003; Stahl et al., 2011, 2013; Zumbansen et al., 2014a, 2014b) and there are some studies that have contributed greatly to the understanding of MIT and how it can be applied and its varying levels of success.

In 2008, Schlaug et al. wanted to see if MIT really did provide some sort of benefit that regular speech therapy did not. They compared two patients with “left hemisphere ischemic stroke involving mainly the superior division of the middle cerebral artery” (Schlaug et al., 2008, p. 317). These two individuals were given tests to evaluate their ability to speak, they completed fMRI scans to determine that the damage was of comparable size, depth, and location, and they were both comparable lengths of time out from the stroke. Across the board, they were

comparable in every measure. So, Schlaug et al. (2008) enrolled one of the participants in MIT and one of them in Speech Repetition Therapy (SRT). These two therapies are the same in every way, except MIT has the added component of musical pitches. The two participants were then tested after 40 sessions and the one who had been in MIT showed significantly greater improvement over the other participant. The second participant was then enrolled in 40 sessions of MIT working on new phrases and his improvement was also greater than his own previous improvement in SRT.

Factors That Contribute to the Efficacy of MIT

In another study conducted by Merrett et al. (2019), another two patients with aphasia were observed. This study sought to examine a possible way that MIT could be standardized. Merrett et al. (2019) wanted to examine the efficacy of MIT in a research setting, to eliminate the variations that arise in the clinical setting. For this study, they recorded three DVDs each with sessions of MIT. Each DVD was watched 10 times over two weeks. In this study, one participant improved greatly using this method (although the original assessments he was given did not reflect this change). However, the second participant, who had more severe aphasia and apraxia, did not show any improvement during the six weeks of this study. Nonetheless, after the study, the second participant enrolled himself in MIT and started showing incredible improvement with the specialized MIT he was receiving. One reason for this could be that with apraxia, he was unable to perform the tapping, but once he was meeting with a MT, he could get hand-over-hand help with the tapping and reap the entrainment benefits from it. This study aimed to find a way to provide a standardized method of implementing MIT, so that their findings could be generalized more broadly. Their findings suggest instead that part of the effectiveness of MIT relies on its

customizability. By standardizing the MIT provided, it was only able to help the participant with less severe aphasia.

As seen in the previous study, the ability of MIT to be personalized is one of the aspects that makes it effective, so Curtis et al. (2020) sought to find out if there were general customizations that could be prescribed early on in MIT that would help it to be more effective. To do this, they conducted three single-subject studies with three individuals who had varying levels of aphasia. In this study, Curtis et al. (2020) wanted to determine if the left hand tapping, which is normally part of MIT, is effective for anyone with aphasia or if there are individuals who should do MIT without the tapping. There are two prevailing ideas behind the inclusion of the left-hand tapping in the MIT technique.

[First], tapping the left hand may engage a right-hemisphere sensorimotor network that coordinates not only hand movements but orofacial and articulatory movements as well. There is some evidence in the literature that such super ordinate centers exist in the premotor cortex and share neural substrates for hand and orofacial movements...[therefore] it is conceivable that the role of the left hand-tapping could be the activation and priming of a right-hemispheric sensorimotor network for articulation. An additional or alternative explanation is that the left hand tapping may serve the same function as a pacemaker, and in so doing, may facilitate speech production through rhythmic anticipation, rhythmic entrainment, or auditory-motor coupling. (Schlaug et al., 2009, pp. 5–6).

Based on these proposals, it is possible that there could be different levels of damage that could counter the effects of the left hand tapping. To examine this, Curtis et al. (2020) had two groups to which individuals were randomly assigned. One group had MIT with tapping first, then MIT

without tapping, and the other group had the opposite. There were five weeks of each type of MIT, with a one-week washout period in between during which the participants were tested. The target phrases were not the same between types of MIT. The results of this study revealed that hand tapping is not beneficial for everyone. The findings “suggest that the ability to entrain to a musical beat may be indicative of whether tapping should be included in MIT for a given individual” (Curtis et al., 2020, p. 595). The participant who did not improve with tapping was unable to entrain the beat, which means the tapping might have been taking too much conscious effort for it to be a helpful scaffolding tool.

Finally, there are many studies that have sought to determine the best inclusion criteria for someone with non-fluent aphasia to qualify for MIT (Curtis et al., 2020; Van Der Meulen et al., 2016). Originally MIT was designed to be an intensive treatment, and research still shows that the higher the intensity of treatment, the better the outcomes (Bhogal et al., 2003; Schlaug et al., 2009). Additionally, there has been debate as to which type and severity of brain damage qualifies or disqualifies an individual for MIT. Shi and Zhang (2020) reviewed recent literature on the involvement of the basal ganglia in the ability of music to help with aphasia recovery. Shi and Zhang state that

the theoretically proposed function of the basal ganglia is domain-general in music and language, which is to transfer hierarchical structures into temporally linearized strings. Empirical evidence suggests that the functions of the basal ganglia include the rhythm/beat procession, temporal prediction, motor programming, and execution. Such functions are proposed to be the mechanism underlying the efficacy of MIT treatment in the cases of non-fluent aphasia with basal ganglia lesions. (2020, p. 6)

Thus, this review found that there was significant correlation between basal ganglia damage, non-fluent aphasia, and the efficacy of MIT as a treatment for aphasia across the current literature. Other research speculates that “recovery from aphasia can be achieved through recruitment of either peri-lesional brain regions in the affected hemisphere or homologous language regions in the non-lesional hemisphere” (Schlaug et al., 2009, p. 1). These researchers posit that the severity of the lesion is what determines the path of recovery.

In patients with small lesions, there tends to be more activation of left-hemisphere peri-lesional cortex and variable right-hemisphere activation either during the recovery process or after recovery. In patients with large left-hemisphere lesions involving most, if not all of the language-capable regions in the left frontotemporal lobes, there tends to be more activation of homologous right-hemisphere language regions. (Schlaug et al., 2009, p. 2)

While these theories would suggest that individuals with small to severe lesions in the left hemisphere could benefit from MIT equally, there has not been research done that measured pre- and post- therapy improvements both verbally and in pathways in the brain to know if that is truly the case (Schlaug et al., 2009; Zumbansen et al., 2014a). Thus, more research is needed into this area to know if the inclusion criteria should be more specific to the type and severity of lesions (Van Der Meulen et al., 2012; Zumbansen et al., 2014a).

In summary, though aphasia treatment is not necessarily new, there are no standardizations among the way it is practiced. Therefore MIT, though effective, has nothing against which to compare itself to determine its efficacy. However, despite that, MIT has proven effective as a treatment for aphasia. Additionally, it is the only aphasia treatment consistent enough to be studied and researched at this level (“Assessment: Melodic Intonation Therapy,”

1994). It is a uniform treatment that utilizes two basic principles (intonation and rhythm), with the goal being to activate the remaining intact areas of the left hemisphere or the homologous language areas of the right hemisphere (Schlaug et al., 2009; Van Der Meulen et al., 2012; Zumbansen et al., 2014a), but it is also highly specialized because there is room for modification to meet the needs of each aphasic patient (Bonakdarpour et al., 2003; Curtis et al., 2020; Stahl et al., 2011, 2013). Research has shown that one of the reasons that MIT helps is because of the connection music and language share with the basal ganglia. Research displays that “[t]he percentage of aphasia after damage to the basal ganglia can reach around 39.25%” (Shi & Zhang, 2020, p. 4). Hence, many people who have aphasia have damage to the basal ganglia, which is a part of the brain crucially involved in the processing of rhythm, a feature integral to both language and music. The hand-tapping of MIT (for patients who can entrain the beat) is also beneficial because it is inducing neural plasticity in the area that was damaged. Therefore, “[f]or those who can entrain, the beat can act as a timing scaffold, functioning as a timing aid without competing much for working memory or other cognitive resources” (Curtis et al., 2020, p. 596). Additionally, the melodic components involve the right hemisphere of the brain, allowing for further scaffolding and activation as the individual relearns language expression (Schlaug et al., 2009). Although MIT can be customized for each patient, the studies examined here exhibit that, even in more uniform settings, it is an effective treatment for aphasia and leads to improvement. As seen in Merret et al. (2019) and Curtis et al. (2020), however, its customizable nature is what makes it most effective, and completely standardizing MIT reduces its effectiveness for some people. It has been proposed that to mitigate the hours that the patient needs with the MT in MIT, but still keep the customizability that allows for the best progress, a patient’s caregiver could be trained during the initial sessions of MIT to help the patient through the exercises. Then, the

caregiver can replace the MT for a few days a week to allow the patient to receive intensive MIT daily, without the burden of having to meet with the MT daily (Goldfarb, 2015). Though this would help mitigate the cost and the necessity of seeing the therapist daily, there is not yet any research showing this would still produce the results seen when MIT is utilized in daily sessions with a MT (Goldfarb, 2015). By nature, MIT is a specialized technique that utilizes several general principles to meet the patient right at the point where they are and provide the means for which they can improve, working towards their specific short- and long-term goals. The interaction of music and language in the basal ganglia, brain stem, cortical and subcortical layers are just some of the reasons why MIT is a useful therapy for non-fluent aphasia (Bhogal et al., 2003; Schlaug et al., 2009; Shi & Zhang, 2020).

The Present Study

While it seems apparent in the literature that MIT makes a difference when used as a rehabilitation technique for aphasiac individuals (Schlaug et al., 2009; Stahl et al., 2011, 2013; Van Der Meulen et al., 2012, 2016; Zumbansen et al., 2014a, 2014b), MIT is part of a field that is still working hard to prove itself as a viable means of treatment. Many patients, health care providers, and insurance companies do not view music therapy as a feasible treatment option. In many cases, this can be said because there are other treatment options out there, whether they are pharmaceutical treatments or just other types of therapy (i.e., speech or occupational therapy), that have been thoroughly researched and proven to meet the needs of patients. In the case of aphasia patients, however, this is not the case. There is no specified treatment for aphasia. Thus, MIT provides a unique opportunity for both the field of music therapy and aphasia, as it is a treatment developed specifically for non-fluent aphasia and it is the only specific treatment there

is for non-fluent aphasia. Nonetheless, the research regarding MIT must be compiled and conducted in a way that allows it to prove its efficacy, but also be generalizable. Much research has been done in this field, but it has yet to be conducted in any systematic way, that allows for comparable claims to be made about its efficacy (Bonakdarpour et al., 2003; Zumbansen et al., 2014a). Given this background, the present study seeks to answer the following question: does MIT exhibit its efficacy based on the performance of participants before and after receiving MIT? The hypothesis, based on preliminary research, is that MIT will, in fact, prove to be effective. While the premise of this study is the work of the principal investigator, the data utilized in this study were collected by Dr. Hayoung A. Lim from Oral Roberts University in a previous study (Lim, 2019), before the principal investigator joined the research team. The following section outlines Dr. Hayoung A. Lim's methodology for collecting the data.

Method

Participants

Participants for the study were selected based on a speech-language pathologist's assessment of their language capacity and scores from the National Institute of Health Stroke Scale (NIHSS). They were all patients in an inpatient neurological rehabilitation hospital who had nonfluent aphasia. To qualify for this study patients had to meet the following inclusion criteria: (1) be aged 18 or older, (2) be Native English speakers, (3) have a diagnosis of nonfluent aphasia as noted in the medical records, (4) have documented damage to the left middle cerebral artery region, (5) have no pre-morbid history of speech-language impairments or neurological impairments, (6) have no hearing loss, and (7) report having had a stroke no more than three

months prior to the time of data collection. For participant recruitment, a board-certified MT notified all qualifying patients regarding the nature of the study. Patients who then desired to participate were given the opportunity to provide informed consent. In addition to obtaining informed consent from the participants who met the criteria and voluntarily chose to participate, informed consent was obtained from the family members of the participants.

Study Design

Twelve patients with non-fluent aphasia consented to participate in the study. The study was comprised of three different treatment groups, so the participants were randomly selected in sequence for each of the three groups (four participants in each group). The method used for this assignment process ensured that participants were distributed evenly and were not aware of the different types of treatment until they had been assigned to a group. After all the participants had been distributed, two dropped out of the study, one from each of the two groups receiving MIT.

The three groups of participants were designed to best examine the efficacy of Modified Melodic Intonation Therapy (MMIT), thus a single factor design was used with a between-subjects factor of treatment in these three groups. Two of the groups were each presented a different form of MMIT, with one, called Rhythm-emphasized treatment (RET), focusing on the rhythmic elements of MIT, and the other, called Tone-emphasized treatment (TET), focusing on melodic elements of MIT. The third group was a control group, receiving only the standard rehabilitation program, which included speech therapy with no music elements. This provided a baseline group for comparison. Because this group did not receive any MIT treatment they were called No-MIT treatment (NMIT). For data analysis, the RET and TET groups both had three participants (owing to the two participants that dropped out of the study) and the NMIT group had four participants.

Measurement

Both groups receiving MIT went through a four-week program of treatment, with sessions five days out of the week. This totaled 20 sessions, though not all participants attended the full 20 sessions (average = 18, range = 14-20). In each session, a MT gave participants tasks of speaking target phrases (see Stimuli). Every session of music treatment was video recorded, and the video recordings were viewed by two independent raters, blinded to the purpose and protocol of the study. These raters measured the success of each participant on four outcomes: (1) speaking attempts (i.e., practicing target phrases), (2) competency of repeating target phrases given a MT's prompt, (3) articulation of target phrases during practice, and (4) pragmatic use of target phrases upon situational cueing questions at the end of each training phrase. Practiced target phrases were elicited using situational cues. Ability to respond to the situational cue with the practiced target phrase was used to measure appropriate use of trained utterances. Due to the practical importance of production both without achieving accuracy and while achieving accuracy of practiced phrases, all four of these measures were considered in order to test the efficacy of the MMIT.

In addition to examining the production of speech, this study also evaluated other domains of language before and after completion of the treatment programs. The other domains were auditory verbal comprehension and use of vocabularies. These domains were assessed using two subscales including Auditory Recognition and Object Naming of the Western Aphasia Battery (WAB). These measured language domains other than speech by asking participants to perform certain other language-related tasks. The auditory word recognition task (maximum 60 points) asked participants to identify the word that was presented auditorily to them by pointing to the item on the page that they heard named. The object naming task (maximum 60 points)

asked participants to name objects that were presented in various categories on a sheet of paper. These two tasks measured the auditory verbal comprehension and the vocabulary usage of the participants before and after going through the treatment programs.

Stimuli

The target utterances used for the music therapy treatment programs were comprised of thirty non-formulaic phrases. Before the treatment an independent MT musically notated these phrases for consistency. The phrases were then grouped into different difficulty levels according to the number of syllables ranging from three to five syllables. There were 10 utterances in each level. The participants began the treatment program with the lower-level utterances and progressed through utterances of the higher levels as the treatment program progressed and the participant successfully produced the target phrases at the previous level (measured at an accuracy of 80% or above).

Due to the nature of the study being to examine the efficacy of MMIT and to evaluate the differences noted between the influence of the rhythmic elements versus the tone elements, the standard practice of MIT was modified in each of the two MMIT groups. In an effort to isolate these factors, other elements of MIT that are normally separate steps were combined for this MMIT. The MMIT used in the treatment program included the steps of introducing a recorded non-verbal musical pattern (rhythmic figure only for RET group or tone figure only for TET group) with the hand-tapping of the pulse (i.e., underlying beats), repeating unison singing (speech rhythm for RET group or intoning for TET group) of a stimulus phrase, and the music therapist's gradual fading in singing at the first level. A fading technique of singing in unison was also used in the treatment program. This was implemented because it is known to enhance word production for individuals with non-fluent aphasia (Stahl et al., 2013; Zumbansen et al.,

2014). Typically, MIT uses a *Sprechgesang* or *Sprechstimme* (Goldfarb, 2015) technique as well to transition from singing to speaking a target phrase. However, due to the comparative nature of the study (in order to examine the difference between melodic and rhythmic influence in MIT), this technique was eliminated. At the second level, the MT provided a cueing question for the practiced phrase (e.g., “What do you say when you want to eat?”) to elicit verbal production of the practiced phrase as a response (e.g., “I am hungry”). The match between the participant’s answer to the question and the trained target phrase was evaluated as the competency of utterance use after practices.

For the differences between the RET and TET groups of the MMIT treatments, the music therapists emphasized the corresponding components (rhythm or tone) by providing a control for the other component (tone or rhythm) during the course of the treatment program. Given the nature of music itself as well as that of MIT (even MMIT), tone and rhythm cannot be entirely separated from each other. Thus, the MTs minimized the impact of the controlled component of music in each group, which then allowed for the non-controlled component to be emphasized so that differences in efficacy—if any were to emerge—between RET and TET could be observed. In RET, tones and intervals mimicking speech prosody were disconnected to minimize the effect of tonal contour in speech production and syllables were presented in monotone. This then emphasized the rhythmic elements of the MMIT, allowing it to be the salient component for the RET treatment group. Similarly, exposure to natural speech rhythms was minimized by pairing a syllable with a note of equal length (i.e., one syllable per second) in TET. By doing this, the tone was emphasized as the salient component for the TET treatment group.

Procedure

Each participant was assigned to one of three groups: RET, TET, or NMIT. MTs were not informed of the participant's treatment condition until the first session of treatment. While none of the participants had previously received any speech rehabilitation incorporating music, they all received the standard inpatient therapy. This standard inpatient therapy included physical and occupational therapies and implemented music as part of activities in the neurological rehabilitation program. In combination with these therapies, the participants also received traditional speech-language therapy as part of the inpatient program. Standard days of speech therapy treatment involved two 30-minute sessions centered on oral exercises that encouraged the production of proper sound and speech. The speech therapy was led by a speech-language pathologist and included oral motor exercises, swallowing treatment, silent mouth modeling, constraint-induced therapy, a categorical vocabulary exercise, speech games, and role play.

In addition to the above therapies, the RET and TET groups received a 20-minute session of MMIT per day with a board-certified MT. During RET, participants completed the following steps: (1) they listened to a monotone rhythmic phrase (one pitch) superimposed over a metronome beat, (2) they worked with the therapist who tapped the beat on the participant's left hand or physically assisted the participant in tapping with the left hand, (3) they verbalized a target phrase with the therapist, (4) they repeated the rhythmically emphasized, monotone phrases while the therapist faded out verbalizations, but continued to physically tap the rhythm, and (5) they responded to the situational cue question corresponding to the trained target phrase. These five steps were repeated for each target phrase.

During TET, participants' tasks were to (1) listen to the tones (a series of pitches) of a phrase superimposed over a metronome beat, (2) to work with the therapist who tapped the beat on the participant's left hand or physically assisted the participant in tapping with the left hand,

(3) to sing the tones embedding the target phrase with the therapist, at a rate of one syllable per second, (4) to repeat the tonally emphasized phrases while the therapist faded out singing, but to continue to tap the beat, avoiding the natural rhythmic pattern of the phrase, and (5) to respond to the corresponding situational questions with the target phrase.

The goal of the two MMIT groups was to have a similarly paced 5-step procedure, with the difference in program being only the emphasis on rhythm (RET) or tone (TET). The protocol outlined for the RET and TET groups was followed by the MTs to train the target phrases for each participant. Successful production was determined to be 80% or above. Once the participant met this level of successful production at a particular level of target phrase, they were advanced to the next level of target phrases. Every session of MMIT was video recorded for subsequent revision to assess the efficacy of music-embedded language programs in the field setting.

The NMIT group did not receive any additional therapy in this study, but only received the standard inpatient therapies given to all participants. Therefore, they provided merely a baseline. The participants in all three groups were individually administered the auditory word recognition and object naming tasks before and after the treatment program. While the present modified MIT protocols focused on investigating the usefulness of MMIT on speech recovery in individuals with nonfluent aphasia, it was embedded in the inpatient neurological rehabilitation program in order to minimize any interference towards the existing rehabilitation program for patients.

The predicted result of this study is that there will be a difference between the participants who receive MIT versus the individuals who do not receive MIT. Specifically, the participants who receive MIT will show more improvement when compared to those who do not receive MIT.

Results

There were 10 stroke patients who participated in the study (age: 48.1 ± 11.95 years, five males). All participants had the diagnosis of nonfluent aphasia, which was caused by a stroke, and all were right-handed English speakers. Owing to the limited samples size, non-parametric statistical tests were performed. All measures, except for the WAB, were converted to the percent of possible maximum scores (POMP) for comparisons among conditions. A Kruskal-Wallis H test was performed to examine the main difference between the three groups (RET, TET, and NMIT). A Mann-Whitney test was performed for post-hoc comparisons if there was any significant difference in the main effect. A Mann-Whitney test was also used for comparison between the two MIT conditions. The threshold of significance was set to $p < .05$ for all analyses.

The RET and TET group results for production frequency and accuracy are displayed in Table 1. Observation of video recordings revealed that the frequency of participants repeating target phrases with prompting after receiving RET and TET were the same, $p = .51$. Similarly, there was no difference found between these two groups in the areas of accuracy of target phrase production, $p = .12$, the level of articulation, $p = .27$, nor use of practiced phrases, $p = .13$. Thus, it is seen that both the RET and TET groups had the same performance in practicing, articulation, and successfully repeating target phrases during treatment.

Table 1. Frequency and accuracy production results by MIT group and by measure

Measure	RET	TET	Mann-Whitney test of difference between groups
Repetition of target phrases with prompting	298.6	104	$p = .51$
Accuracy of target phrase production	187	54.6	$p = .12$
Articulation score	16.3	17.3	$p = .27$
Use of practiced phrases	11.33	4	$p = .13$

While the performance on the above tasks was similar between the two music therapy groups, other WAB measures and measure of speech production showed both that the MIT groups performed differently than each other on certain categories of tasks, and that the individuals who received MIT did, in fact, improve more on practiced phrases (see Table 2), $\chi^2(2) = 7.44, p = .02, \eta^2 = .51$. Compared to the NMIT control group who received no training on the target phrases, both MIT groups showed improvement, $Z = -2.12, p = .03, r = .86$. The WAB measures of Auditory Recognition and Object Naming were chosen to measure progress between the three groups. Prior to treatment, there was not a difference between the groups as to the scores on these measures, $\chi^2(2) = 2.20, p = .33, \eta^2 = .3$ for Object Naming, or $\chi^2(2) = 2.94, p = .23, \eta^2 = .46$ for Auditory Recognition. After treatment, there was also no group difference found, $\chi^2(2) = 2.34, p = .31, \eta^2 = .40$ for Auditory Recognition, nor $\chi^2(2) = 3.97, p = .13, \eta^2 = .53$ for Object Naming. These group results for the measures of WAB, Auditory Recognition and Object Naming tasks and for speech production are displayed in Table 2.

Table 2. Mean pre- and post-treatment WAB categories Auditory Recognition/Object Naming and speech production scores by group

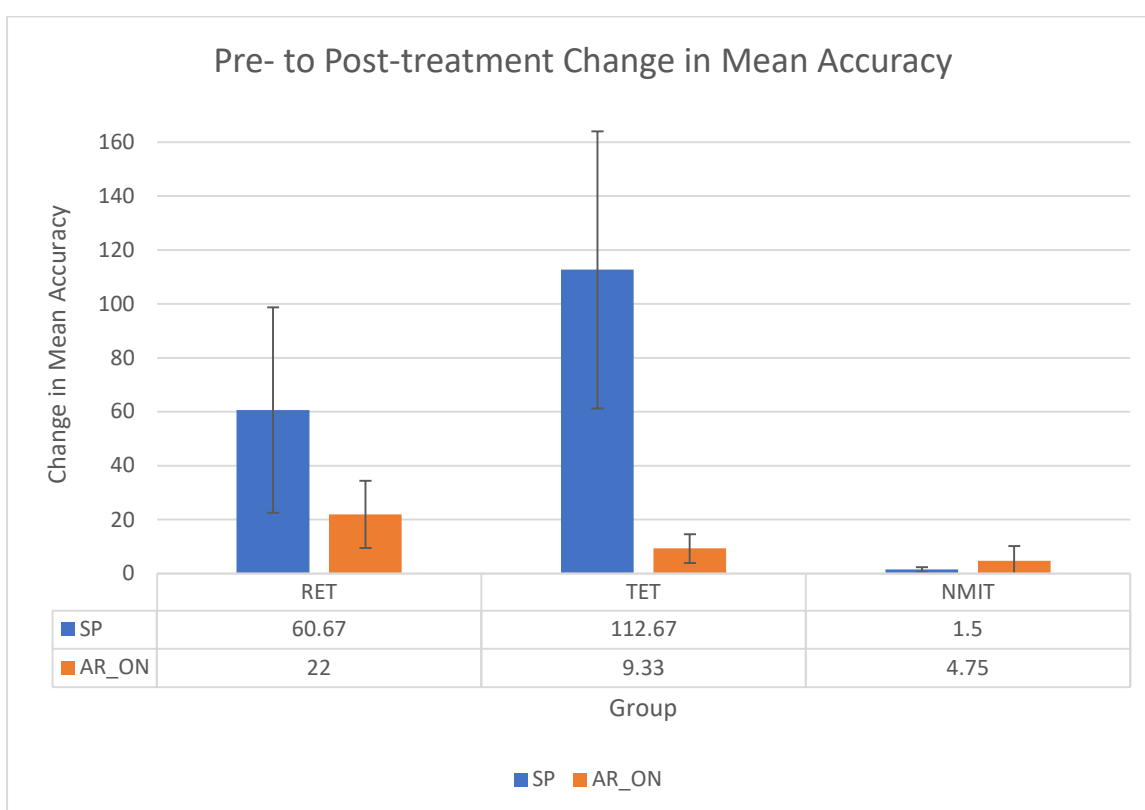
Measure	Pre-treatment		Post-treatment		Change	
	AR	ON	AR	ON	AR	ON
NMIT	59.65	4.25	64.40	5.75	4.75	1.50
RET	87.66	107.33	107.00	169.00	22.00	60.67
TET	42.33	21.33	51.67	134.00	9.33	112.67

Note: WAB = Western Aphasia Battery / AR = Auditory Recognition/ ON = Object Naming SP = Speech Production

Despite there being no significant difference between the two MIT groups in their pre- and post-treatment scores on the WAB measures, there was surprisingly a difference between the two MIT groups in the change between the pre- and post-scores on each of the measures. The change in mean accuracy for verbal production between pre- and post-treatment was 60.67 for

the RET group, 112.67 for the TET group, and 1.50 for the NMIT group with the standard error of the means being 38.10, 51.4, and .96 respectively. The change in mean accuracy for Auditory Recognition and Object Naming between pre- and post-treatment was 22.00 for the RET group, 9.33 for the TET group, and 4.75 for the NMIT group, with the standard error of the means being 12.49, 5.36, and 5.48 respectively. These results are represented graphically in Figure 1.

Figure 1. Mean pre- and post-treatment verbal production (WAB), Auditory Recognition and Object Naming (AR_ON) scores by group



Discussion

These results demonstrate that MIT for participants in both the RET and TET groups led to greater improvement than seen for the participants in the NMIT group. This supports the prediction that MIT is effective as a treatment for non-fluent aphasia. It also suggests that MIT is more effective than just receiving regular speech therapy as the patients who received MIT in

addition to the speech therapy showed greater improvement than those who only received speech therapy. Additionally, it was seen that both the types of MIT that were utilized in this study, while helpful on the trained phrases, did not generalize to overall language skills. It has been proposed by other authors that MIT can generate a new way of producing language such that it is generalizable to all of a speaker's utterances. In order to do that, however, it is necessary for the MIT to be at a very high intensity level and there needs to be a huge variation of utterances worked on by the individual (Schlaug et al., 2009; Zumbansen et al., 2014b). In that type of MIT there is less work on target phrases as each utterance is only reviewed a few times, but, by going over so many types of utterances, it is proposed that the person learns a new way to produce language altogether. While the MIT provided in this study was closer to the intensity level suggested for best MIT results, this study focused on specific phrases as target phrases to determine if MIT showed greater improvement over regular speech therapy in learning specific utterances. Thus, while the results did show that patients who received MIT improved more, there was no significant improvement seen in overall language production measures, further supporting that the way in which MIT is practiced can lead to different end results (Van Der Meulen et al., 2012; Zumbansen et al., 2014a).

While this study certainly shows that MIT is effective for improving verbal production and auditory recognition/naming objects, it did have a few limitations that impact its generalizability. The biggest limitation is that the RET and TET groups received 20 minutes more therapy per day than the NMIT group. Thus, the differences between the NMIT group and the other two groups could be due more to the extra time than the MIT technique itself. Future replication studies could provide an extra 20 minutes of speech therapy per day to rule out any effects that extra time might have had in the improvement seen for the individuals in the MIT

groups. Additionally, though the Auditory Recognition and Object Naming measures of the WAB were chosen because of their frequent usage to measure language abilities for individuals with non-fluent aphasia, these measures were not the ones most suited to evaluate the efficacy of the MIT treatment protocol. They test language skills that differ from those that MIT aims to work on, as the Auditory Recognition task relies on language comprehension and the Object Naming task relies on recall of semantic knowledge. Studies have shown that short term memory loss can be common among individuals with non-fluent aphasia (Knibb et al., 2009), however, MIT itself does not target either of those language skills. Given that research in the field of MIT is not consistent and that different measures have been used in different studies, it has been hard to make generalizations and overall claims about MIT because the different measures used do not allow for direct comparisons (“Assessment: Melodic Intonation Therapy,” 1994; Van Der Meulen et al., 2012; Zumbansen et al., 2014a). Thus, by choosing the specific measures of the WAB that are most commonly tested in evaluation of patients with non-fluent aphasia, this study helps to provide consistent measures which can be compared not just among MIT studies, but among other current research in the field of non-fluent aphasia. Nonetheless, future studies could include some additional measures that are targeted at the areas of speech production that MIT seeks to improve.

Despite the limitations, this study provides a strong case for the efficacy of MIT. With the sample size of 10 participants who completed the study it also makes it a larger sample size than many other studies that have been conducted in this field (Bonakdarpour et al., 2003; Conklyn & Rung Meehan, 2018; Curtis et al., 2020; Merrett et al., 2019; Schlaug et al., 2008, 2009; Shi & Zhang, 2020; Stahl et al., 2011, 2013; Zumbansen et al., 2014a, 2014b). The two separate groups focusing on the two component elements of MIT – rhythm and tone – also

provide the basis for future studies to begin to examine the role that each of those elements plays in the overall efficacy of MIT. Past studies that have looked into this matter have failed to take into consideration the tone inherent to language when it is spoken (Stahl et al., 2011, 2013). Thus, their results were not able to determine the individual impact of tone and rhythm on language rehabilitation from MIT. This study, however, took the tone inherent to spoken language into account and controlled for that factor in the RET group by having the words of the target phrases set to a monotone. Therefore, this study is the first to look at the effect of a solely rhythm-focused MIT treatment method. Upcoming research can examine this further and dig deeper into the difference between rhythm and tone, and the outcomes for patients in each group. It could be, like noted in previous research, that certain rhythmic elements are only beneficial for certain types of participants, and, thus, an adapted MIT, like seen in the TET group, could be a more effective treatment. Creating these individual groups also allows for the customizability of MIT to begin to be studied in a way that can be generalized by having established accommodations to MIT. This can also lead to better inclusion criteria for MIT as the roles of each of its components will be clearer.

Conclusion

The goal of this study was to evaluate the efficacy of MIT in the recovery of propositional speech for individuals with non-fluent aphasia. While MIT is over 40 years old, research in this field still lacks the data to determine the preferred practice of MIT to obtain the best results, the impact each of the elements has on the overall treatment protocol, and the most adequate inclusion criteria to obtain the best recovery outcomes. This study sought to examine the influence of each MIT element in the overall treatment efficacy by comparing two MIT treatment groups against a control group who only received speech therapy. As MIT is composed

of two main elements – rhythm and tone – the two MIT groups sought to examine the role of each element in the treatment, hence, there was a group that singled out the rhythm aspects of MIT (RET) and a group that singled out the tone aspects of MIT (TET). Since the RET group was focused only on the rhythmic elements, the MTs made sure to sing and say all words on a monotone syllable to control for the normal tone elements present in signing and in speech. Likewise, in the tone-focused modification, the MTs made sure to present each word at the same tempo, to control for the rhythm aspects inherent to singing and speech..

The results displayed that, in fact, MIT was effective as the participants who had either the RET or TET forms of MMIT showed more improvement than the participants in the NMIT control group who received only regular speech therapy. The findings also show that there was a difference between how the participants in the MMIT groups improved, which suggests that rhythm and tone each affect different aspects of language. Further study into the specific differences and why those differences arose could shed light for future application of MMIT. This could allow MTs to modify MIT at the outset of treatment depending on the areas in which the patient can benefit the most from the technique. As seen in (Curtis et al., 2020) study, it seems that not all patients can benefit from the left hand tapping, but only those who can entrain a beat. Further study into the influence of tone and rhythm elements individually in MIT could lead to even more predictable customizations, leading to treatments that can better serve the unique needs of each aphasia patient from the very beginning of treatment.

It is also important to note that as research is able to figure out the influence of each component in MIT, this treatment can be better adapted cross-linguistically. Bonakdarpour et al. (2003) examined how MIT could be used for Persian-speaking individuals. In order to do this, not only did the rhythmic structure of the technique have to change because Persian is a syllable-

timed, not stress-timed, language, but even the two-pitch concept of MIT had to change because that is rooted in the Western major scale, which does not exist in Persian music. Thus, for this technique to not only be measured in terms of efficacy, but also to be utilized with patients who speak languages other than English and who are from areas of the world that do not utilize the Western major scale, it is important to know how the components interact and each contribute to redevelopment of language skills.

This study examined the ways that tone and rhythm each play a part in the process of language rehabilitation for individuals with non-fluent aphasia. As predicted, both MIT conditions saw an improvement over the control group that received only speech therapy. Thus, this study lends support to MIT being an effective treatment in regaining language production abilities. Further study in this area can lead to better ways that MIT can be implemented according to inclusion criteria, better knowledge of ways to adapt MIT to different cognitive abilities post-stroke (e.g., ability to entrain a beat), as well as better strategies for adapting this technique cross-linguistically and cross-musically so that it can remain as effective as possible. It should be noted in the context of future research, that many languages such as Spanish are syllable timed while others like Persian and French are not. Moreover, it would also be helpful if future studies take into account speakers of tonal languages, such as Mandarin and Yoruba. Though research has shown that songs in tonal languages do often change tonal patterns of words without disrupting the meaning of the words (Schellenberg, 2012), future study should take into consideration how tone contributes when the goal is speech rehabilitation of a tonal language.

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