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The Effects of Melodic Intonation Therapy (MIT) on People with Communication Impairments: A Primary Focus on People with Broca's Aphasia

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THE EFFECTS OF MELODIC INTONATION THERAPY (MIT) ON PEOPLE WITH
COMMUNICATION IMPAIRMENTS: A PRIMARY FOCUS ON PEOPLE WITH BROCA'S
APHASIA

by

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B.A., Indiana University, 2012

A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
Master of Science Degree

Rehabilitation Institute
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in the field of Communication Disorders and Sciences

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Melodic intonation therapy (MIT) has been found to be a very efficacious intervention for people with Broca's aphasia. MIT is a hierarchal system that works on adding melody and prosodic features to speech to increase verbal output. The theory behind MIT is that the right hemisphere takes over speech production, because the right hemisphere is responsible for more musical components such as melodic contour, meter, and musical phrasing. MIT can be a useful intervention program because the melodic and prosodic features will lead to a general reduction in the vocalization rate as syllables are lengthened and chunked into larger structures (Schlaug, 2008). MIT has been found to be an effective intervention in increasing verbal output of words, phrases, and syllables (Wilson, 2006). Also, investigations of MIT have found measurable brain activity and measurable brain plasticity in the right hemisphere (Zipse, 2012). There are many promising effects of MIT on people with Broca's aphasia such as increasing verbal output, increasing measurable brain activity, and increasing measurable brain plasticity.

Increased Verbal Output

Melodic Intonation Therapy (MIT) has been found to be an effective treatment to increase verbal output in people with Broca's aphasia. Verbal output is indicated by words, syllables, sentences, standardized test scores, and social rating scales. Research by Hough (2010), supports that MIT increases verbal output indicated by phrases, standardized test scores, and social rating scales. The participant in this investigation was a male with Broca's aphasia and was given a modified version of MIT without the tapping component. MIT was given for three to four hours a week for eight weeks. The MIT intervention measured verbal output by measuring automatic and self-generated phrases. Also, standardized tests and social validation measures were given pre and post treatment. The standardized test used was the Western Aphasia Battery-Revised (WABR). The social rating scales used were the ASHA FACS Communication

Independence Scales, ASHA Quality of Life Communication Scale, and the CETI. The criterion for increased verbal output for the automatic phrases was set at 75% accuracy over two consecutive sessions. The client reached the set criterion four weeks into the program which was maintained throughout the MIT intervention and at the follow-up sessions. There were t-tests used to analyze the phrase data and the results indicated highly significant treatment effects. There were also improvements on the social rating scales and standardized tests. The WABR indicated that most improvement occurred in the areas of auditory comprehension, reading, writing, naming, and spontaneous speech. Also, increased communicative effectiveness were noted by the client from the social rating scales (Hough, 2010).

This investigation supports the efficacy of MIT, however there were a few limitations to this investigation. This was a case investigation so the generalization of the research to the entire population of people with Broca's aphasia is weak. Also, the investigation needs to look at generalization to other natural and environmental contexts not just increased verbal output in the therapy room. Future research can look more into the treatment, length, and intensity of the MIT intervention to see if there is variation. Another limitation is that maintenance of verbal output was only gathered in follow-up sessions. There needs to be more data collected on the verbal output over longer periods of time.

This investigation shows that MIT can be an effective treatment for some people with Broca's aphasia because the client increased his ability to produce short phrases and increased other language areas such as auditory comprehension, reading, writing, and naming. Also, this investigation is useful because it shows that the procedures in MIT can be modified; the tapping part of MIT was removed from this investigation and it was still shown to be effective (Hough, 2010).

Research by Breier, Randle, Maher, and Papanicolaou (2010) also supports MIT increasing verbal output. This investigation supports that MIT increases verbal output indicated by words, which was measured by naming line drawings in an action naming test. The participants received MIT in two blocks consisting of two 30-minute treatment sessions per day for two weeks during which they were asked to produce a set of phrases before and after each treatment block. The words in the phrases were measured as correct information units (CIUs) to indicate measures of change. There was a significant increase in CIUs after the first block of treatment for the first participant. However, the second participant did not demonstrate substantial changes in verbal output from either block of MIT (Breier et al., 2010). This investigation did not follow the criterion for participants unlike the previous investigation by Hough. Both participants exhibited aphasia, however the second participant in the investigation exhibited a mixed expressive and receptive aphasia. The first participant in the investigation had much better comprehension than the second participant. MIT is aimed for individuals with Broca's aphasia and the treatment may not have been as effective for the second participant due to poor auditory comprehension. However, since verbal output was increased with the participant who met the criterion for MIT this is very promising that words can be increased from MIT. Additionally, this is a promising investigation because there was measurable functional brain activity in the left hemisphere for the participant with Broca's aphasia treated with MIT.

Measurable Brain Activity in the Left Hemisphere

Another area that supports the efficacy of MIT is that brain activity can be measured before and after intervention. MIT has been found to increase measurable functional brain activity in the right and left hemispheres (Breier et al., 2010). The investigation by Breier et al., 2010, suggested that MIT promotes left hemisphere activation and that right hemisphere

activation may have a detrimental effect on verbal output. The participants were tested before and after two blocks of MIT with magnetoencephalography (MEG). The first participant who responded with increased verbal output had decreased activation in the right hemisphere and a strong left hemisphere lateralization of MEG activity. The second participant who did not increase verbal output after MIT had a right hemisphere lateralization of MEG activity. The participant who had success with MIT showed increased left hemisphere activation in Broca's area and a decreased activation in the right hemisphere homotopic to Wernicke's area. These findings could indicate that the increased verbal output was associated with an activation in the language areas and that decreased verbal output and persistence of aphasia was indicated by the right hemisphere activation (Breier et al., 2010).

This investigation is very promising for the efficacy of MIT in treating Broca's aphasia. However there were some problems with the investigation. There were only two participants which is a very limited population to generalize this investigation to the entire population of people with Broca's aphasia. Also, MIT has a set criterion of only being used for people with severe Broca's aphasia who have moderately preserved auditory comprehension (Hough, 2010). The second participant in this investigation had signs of Wernicke's aphasia and poor auditory comprehension which could be why there was not an increase in verbal output. Also, the participant without success from MIT could have had more damage in language areas than the other participant, which could affect the ability to recover from aphasia and affect the brain plasticity in the left hemisphere. Also, this MIT intervention was very task specific and only involved the action naming task (Breier et al., 2010). Other protocols of MIT involve phrases, standardized tests, and social rating scales as measures of increased verbal output (Hough, 2010). This investigation is very promising for MIT intervention with people with Broca's aphasia

because there was measurable functional brain activity in the left hemisphere. Also, this investigation continues to support the criterion that MIT should mainly be used with people with Broca's aphasia.

Brain activity was also measured by looking at changes in cerebral blood flow (CBF) with positron emission tomography (PET) during an investigation by Belin, Eeckhout, Zilbovicius, Remy, Francois, Guillaume, Chain, Rancurel, & Samson, (1996). This investigation included seven participants with aphasia between the ages of 40 and 58 years. The participants all had severe non-fluent aphasia. There were word activation tasks that measured the CBF. Participants were asked to listen to words and then they had to repeat the words with and without MIT-like intonation. Words were bi-syllabic and concrete. The verbal output was then measured with and without MIT. The words that were repeated without MIT resulted in abnormal activation of the right hemisphere. Words that were repeated with MIT reactivated Broca's area and the adjacent left prefrontal cortex. Significantly more words were repeated with MIT, which continues to support that MIT increases verbal output as determined by words (Belin et al., 1996). Also, this investigation supports the findings by Breier et al. (2010) that MIT is associated with measurable functional brain activity in the left hemisphere. A limitation of this investigation was that there could be some internal validity depending on the size and severity of the lesion. The abnormal activation patterns in the right hemisphere might be due to the degree of language lateralization before the stroke. Also, the investigation suggests that the regions abnormally activated in the right hemisphere could be associated with the persistence of aphasia. The activation patterns may not be associated with recovery from aphasia. Despite the limitations, the abnormal activation can mean that there is brain plasticity in the left hemisphere. The words without MIT were activated in the right hemisphere, but the MIT-loaded words were activated in

the left hemisphere (Belin et al., 1996). MIT might actually be able to change brain plasticity (Zipse, Norton, Marchina, & Schlaug, 2012).

Measurable Brain Activity in the Right Hemisphere

Belin et al. (1996) supported that MIT-loaded words activated the left hemisphere; however most of the existing research refutes this claim. Zipse et al. (2012) supports that activation does not occur in the left hemisphere, but in fact there is activation in the right hemisphere. Zipse et al. (2012) investigated the effects of MIT on an 11-year old girl who exhibited measurable brain plasticity in the right hemisphere; an adapted version of MIT was used on her. The participant experienced a very large left-hemisphere lesion and severe non-fluent aphasia from a stroke and completed 80 sessions of MIT. Verbal output was measured as the number of correct words in trained and untrained phrases, using intoned sentences with left hand tapping. The participant increased verbal output on the trained and untrained phrases, but showed more improvement on the trained phrases using MIT. Also, there was improvement in connected speech in conversation. The relative degree to which the cerebral hemispheres were activated was indicated with fMRI. During therapy the participant showed an increase in activation of right middle frontal and inferior frontal areas. The fMRI revealed that there were structural white matter increases in the right hemisphere, as well as increases in the arcuate fasciculus (AF) volume in the right hemisphere; this finding may suggest that speech can be mapped to motor commands when the left hemisphere is impaired. This investigation shows that the right hemisphere may have plasticity and take over some language functions. While only trace amounts of left-hemisphere tissue remained in this participant, her right hemisphere was apparently able to develop the speech and language function. The young age of this participant could be an important factor in the recovery and brain plasticity. This investigation has strong

clinical implications because it shows that brain plasticity could be possible into late childhood. Previous research found that the critical period for language acquisition ends at age six, but this investigation shows that the critical period could go into late childhood with MIT training. Also, this investigation is clinically significant in that it shows that MIT can be used with younger participants with aphasia (Zipse et al., 2012).

This is not the only study indicating that MIT can result in measurable brain plasticity in the right hemisphere. Schlaug, Marchina, & Norton (2009) found that MIT can increase brain plasticity in the right hemisphere as well. Increases in white matter of the arcuate fasciculus in the right hemisphere were found in six participants with moderate non-fluent aphasia. Six participants with Broca's aphasia underwent 75 sessions of MIT. Increased verbal output was measured by CIUs during spontaneous speech, syllables per phrase, and word naming on picture description tasks. MRI studies were given using diffusion tensor imaging (DTI) before and after MIT intervention. After the MIT intervention, all six participants increased the number and volume of AF fibers in the right hemisphere; one participant even showed an increase in length of fibers in the AF after intervention. This investigation supports that MIT intervention could result in measurable brain plasticity. This study is clinically relevant because it suggests that intense long term MIT intervention can lead to plasticity of the right hemisphere. Also, the investigation suggests that there is plasticity in the AF because more connections between speech relevant brain regions in right hemisphere are required. This could cause changes in myelination and axons that could add to the increased number of fibers detected after therapy. This investigation has many strengths, however there is a limitation. The AF fibers could only be seen in the right hemisphere tracts because the left hemisphere had too much damage from the strokes,

so while there may have been structural changes in the left hemisphere, the damage was too great for structural changes to be detected (Schlaug et al., 2009).

Schlaug et al. (2009) completed another investigation that supports that right hemisphere activation is an important component to MIT, specifically that melodic and prosodic features of the right hemisphere will lead to a general reduction in the vocalization rate as syllables are lengthened and chunked into larger structures. The slower vocalization rate and chunking of syllables can reduce the difficulty of speech production for people with Broca's aphasia (Schlaug et al., 2009). One investigation found that left hand tapping was an important component to increasing measurable brain activity in the right hemisphere (Schlaug, Marchina, & Norton, 2008). Schlaug et al. (2008) investigated two participants with severe Broca's aphasia. A modified version of MIT intervention was used with and without hand tapping. The participants underwent 40 sessions of MIT; verbal output was measured by syllables per phrase, and the percentage of words correct on picture naming tasks. Increased verbal output was measured in one participant with the left hand tapping. The fMRI studies revealed that the one participant who used tapping showed significant fMRI changes in a right-hemisphere network involving the premotor, inferior frontal, and temporal lobes. The participant who did not use tapping had changes in the left hemisphere pre-central gyrus and the superior temporal gyrus, but did not show as much improvement in increased verbal output as the participant who used tapping. This investigation is clinically significant in that it supports the bi-hemispheric role in vocal production for speaking and singing. Also, the investigation showed that sustained vocalization and left hand tapping seemed to have an effect on measurable right hemisphere activation. The investigation showed that the left hand tapping can serve as a pacemaker or metronome in MIT and can facilitate speech production through rhythmic anticipation (Schlaug et al., 2008).

Speech-language pathologists may want to consider the importance of the tapping component of MIT when implementing the intervention.

Brain stimulation has also been found to augment the effects of MIT in the inferior frontal gyrus (IFG) of the right hemisphere (Vines, Norton, & Schlaug, 2011). The brain stimulation was found to have a positive effect on speech recovery. Transcranial direct current stimulation (tDCS) was used as a noninvasive approach to modulate neural activity during the treatment of MIT. Anodal-tDCS was used to increase excitability in the IFG of the right hemisphere; this area is the region responsible for singing through mapping of articulatory actions. Six participants with moderate to severe Broca's aphasia underwent three consecutive days of anodal-tDCS, followed by three days of sham-tDCS. The sham-tDCS decreased excitability in the right IFG and the anodal-tDCS increased excitability in the right IFG. The participants received MIT with the brain stimulation for 20 minutes a day. There was one week between the sham and anodal tDCS sessions. Verbal output was measured with the BDAE before and after each MIT session by measuring automatic production of sequences, picture naming, and line drawings. MIT with anodal-tDCS resulted in significant improvements in verbal fluency, while verbal fluency in sham-tDCS had no significant changes. The improvements in fluency supported the possibility of brain plasticity in the right hemisphere. It is possible that the anodal-tDCS increased synaptic plasticity in brain areas engaged by MIT. The brain may have reorganized and compensated for damage to the left hemisphere by activating the right hemisphere. MIT combined with anodal-tDCS may further recovery from aphasia by enhancing right hemisphere activity with a sensorimotor network for articulation. This investigation supports that anodal-tDCS to the right IFG during MIT treatment can augment the effects of MIT by increasing excitability in the right IFG. Future research may look at the placement of the

electrodes on other areas of the right temporal cortex. Also, this investigation is clinically significant in that brain stimulation may augment effects on other types of behavior therapy. It is possible that cortical excitability with non-invasive brain stimulation may facilitate neural connections and brain plasticity in other types of treatment. This investigation looked at MIT combined with the brain stimulation, but it is possible that the brain stimulation by itself, without MIT, could activate neural connections that increase verbal output. A limitation of this investigation is that there was not data on the longevity of MIT beyond the treatment period. The verbal output was only measured after three sessions of MIT. It is possible that brain stimulation with MIT can lead to stronger effects of therapy with fewer sessions of MIT. More research is needed in this area, but it is a very promising area for increasing verbal output in people with aphasia (Vines et al., 2011).

Melodic and Rhythmic Components to MIT

Rehearsal of familiar song lyrics with the melody has also been found to increase verbal output. Increased verbal output from MIT intervention was found in a single case study of a singer with Broca's aphasia who could sing familiar songs with lyrics, but could not speak (Wilson, Parsons, & Reutens, 2006). Verbal output was measured with a pre and post-test Boston Diagnostic Assessment Exam (BDAE). Also, 30 trained and untrained phrases were measured along with line drawings from the Boston Naming Test. The MIT phrases consisted of words with three to six syllables that had rhythm and prosody similar to conversational speech. After five weeks of MIT there was an increase in verbal output with the syllables and trained phrases. The MIT phrases showed the highest correct response rate without prompting, the lowest number of errors, and lowest number of paraphasias. The melodic rehearsal seemed to be key for long term increases in verbal output. This investigation is clinically significant in that it supports

previous literature that familiar songs are able to be sung but not unrehearsed songs. Rehearsal seemed to be the most important component to this particular investigation. The unrehearsed phrases showed no significant results and had many errors and paraphasias (Wilson et al., 2006). Speech-language pathologists should consider that rehearsal is an important component to increasing verbal output. A limitation of this study is that the participant's background as a singer may have given him a high level of motivation because of his arousal in response to music. This investigation may not be as successful with persons who have no interest in music. MIT may be an effective intervention if individuals with Broca's aphasia show strong interest in music or can sing familiar songs.

Much of the research supports that melody and singing are important components to increasing verbal output with MIT. However, there have been arguments about which components of MIT are the most effective in therapy. Although there is support from the previous investigation that singing and melody increase verbal output, an investigation by Stahl, Kotz, Henseler, Turner, & Geyer (2011) found that singing and melody may not hold the key to recovery in aphasia. Seventeen people with Broca's aphasia between the ages of 27 and 80, who were German speakers, were tested with MIT. Three experimental modalities were applied: melodic intoning, rhythmic speech, and a spoken arrhythmic control. The three modalities were assessed to investigate which factor of MIT was the most important for increasing verbal output. The results indicated that singing may not be a critical component of MIT. The acoustic settings, insufficient control of syllable durations, and specific stress patterns were found to be more important components than melody. Rhythm was found to be the contributing factor to increasing verbal output; it was found to be crucial especially for lesions in the basal ganglia. This investigation has clinical implications in that long term memory and preserved motor

automaticity appeared related to speech production. The melodic component used in repeating words was seen as less significant than the rhythmic components. Rhythmic components involved in long term memory and automaticity were found to be the most significant. Automatized formulaic expressions are found to be lateralized in the right hemisphere; this shows that the right hemisphere might be activated from the automaticity of phrases more than the melodic components. Future research needs to look at each separate component of MIT to draw conclusive evidence, but this investigation points out that melody should not be assumed to be the most important factor in increasing verbal output in MIT (Stahl et al., 2011).

Boucher, Garcia, Fleurant, and Paradis (2001) supported the previous investigation that rhythm is more important than the melody in MIT intervention. Boucher et al. (2001) examined the effects of tonal and rhythmic components of MIT on the repetition abilities of two individuals with non-fluent aphasia. The investigators included target phrases to measure either tonal or rhythmic attributes. The phrases that measured rhythmic attributes used verbal pacing and hand tapping; the phrases that measured tonal attributes used melodic intonation and tone contour. Both participants had a higher number of immediate and deferred repetitions in the phrases with rhythmic attributes. The phrases that emphasized rhythm corresponded to substantial gains in the participant's ability to repeat phrases. The phrases that emphasized tonal attributes had no effect on the participant's repetition of phrases. This investigation further supports that rhythm may be a critical feature of MIT (Boucher et al., 2001). This investigation helps to clarify which components of MIT may be increasing verbal output. Rhythm seems to be a very important feature in MIT. The tapping component and rhythmic anticipation seem to be critical features (Schlaug et al., 2008). However, there is limited research separating each

component of MIT. Melodic features should not be ignored, and researchers should continue to investigate the effects of MIT with and without melodic and rhythmic components.

MIT in Other Clinical Populations

MIT has been found to increase verbal output in people with Broca's aphasia. However, MIT has been found to be an effective treatment in other populations as well. MIT can be modified to fit individualistic needs of people based on their impairment. Modified versions of MIT have been successful in case studies of people with childhood apraxia of speech (CAS), autism, and traumatic brain injury (TBI).

Shifra & Toca (1979) found that MIT increased verbal output in a male participant with autism; they hypothesized that the increased use of right hemisphere dominance for the melodic aspect of speech increased the role of the right hemisphere, in interhemispheric control of language in children with autism. They based this belief on the observation that many children with autism could sing commercials and tunes, but were unable to speak about those same television commercials. They investigated a three year old nonverbal male with autism with a modified adapted version of MIT. The modified version consisted of signing and an intoned verbal stimulus. This investigation was a case study of a boy who did not respond to speech; he responded to musical features, such as volume distortions, pitch, rhythm, and stress. The modified version of MIT used simple melodic patterns for short phrases and sentences, with signing gestures added to the intoned speech model. The participant had severe receptive and expressive language deficits. After 25 MIT sessions of simultaneous signs and intoned verbalizations, the participant responded without physical assistance to requests. The signing was used for word approximations to answer requests, and eventually spontaneous signing in response to verbalizations outside of therapy sessions was being used. After 35 sessions of MIT,

the participant could say two word sentences without intervening prompts, and started using echolalia with family members. After some follow up sessions of MIT, the participant had many new words that appeared in the same melody as the original experimental model. This investigation is promising that a modified version of MIT can be used with persons who are on the autism spectrum. One limitation to this version of MIT is that the participant was only able to answer questions that were intoned; the therapy did not generalize to spoken language. Also, all of the answers to questions continued to be melodic. MIT was clinically significant in this investigation because it showed that a modified version could help children with autism have some form of verbal output (Shifra et al., 1979).

MIT has also been used on participants with childhood apraxia of speech (CAS). CAS is a deficit in the level of motor planning and programming. People with CAS have difficulty with sequencing and planning sound movements. During motor planning spatial and temporal specifications of articulatory movements are needed. The motoric component of CAS is presumed to take place in the part of the brain similar to Broca's aphasia; the lesion location in CAS can only be presumed. A modified version of MIT has been shown to increase verbal output in a participant with CAS. Martikainen and Korpilahti (2011) looked at the effectiveness of a combination of two motor intervention methods: MIT and Touch-Cue Method (TCM). These two methods were used on a four year old female who fulfilled the criterion for CAS. The participant received a six week treatment with MIT, followed by a six week treatment free period, then had a six week treatment period with TCM. MIT was used to work on the melodic line, tempo, rhythm, and stress in speech; TCM was used to give touch cues on syllables, utterances, and spontaneous speech. Verbal output was measured with bi-syllabic words in two to three word sentences, a picture naming task using nouns and verbs, and percentage of correct vowels

and consonants. The results of this investigation indicated that speech sound errors decreased and sequencing abilities increased after the MIT treatment period. The progression of increased verbal output continued through the TCM period. The combination of MIT and TCM seemed to be an effective intervention approach. Improvement was maintained in a 12-week follow up session as well. This investigation is clinically significant in that verbal output was increased, and accuracy of vowel and consonant production improved. The results further support the hypothesis that participants with CAS may have a motoric planning deficit similar to participants with Broca's aphasia. The increased speech production may reflect more precise motor planning and programming in the participant (Martikainen et al., 2011). Future research can look at MIT and TCM separately in intervention to determine the relative influence of each. This case study adds to the previous study by Shifra et al. (1979) that a modified version of MIT can be an effective intervention tool in other clinical populations.

MIT has also been tested on participants with TBI. Schaefer, Murrey, Magee, and Wheeler (2006) used MIT in four case studies of the effectiveness of MIT on people with TBI. The first case study involved a 30 year old male who had a TBI in a traffic accident that resulted in expressive and receptive aphasia. The participant's comprehension was poor, but MIT was used because the participant was able to respond to familiar songs. When the participant was asked to sing the last word in each phrase of a familiar song he produced words when singing but not in regular speaking. Melodic, rhythmic, structural, and verbal elements were needed to prompt verbalizations. The main focus of the MIT for this participant was on communication and emotional expressions by maximizing vocalization on familiar songs. First the participant was encouraged to sing the final words in phrases; then he was encouraged to sing as many words in each phrase as he could. He attended MIT for three months; at the end of MIT treatment he was

inconsistently able to produce a few short functional verbal phrases that had been practiced. Also, songs were used to express a range of emotional states. The music helped motivate him and explore emotions as an expressive outlet. The approach was a combination of MIT and music therapy to express sadness and other emotions. A second case study was completed on a 36 year old woman with attentional deficits and no spontaneous speech. An interdisciplinary team of occupational therapists (OT), physical therapists (PT), and speech-language pathologists (SLP) used MIT. Repetition of phrases was sung in rhythm, unison repetitions were initiated on simple sentences, and hand tapping was used. Upon discharge, the participant was able to say one to two word answers to moderately demanding questions and state basic needs 75% of the time. MIT provided a means to communicate basic needs to caregivers, and the participant was able to return home and live with family.

A third case involved a person who had a TBI from a car accident. Music was introduced at specific times during the day, and therapy at other times. During the 1-2 months of therapy the participant exhibited simple commands with specific rhythm patterns. The participant began to turn her head to the rhythm pattern and attempted purposeful responses, although her responses were unintelligible. Eventually, the participant was able to answer simple questions with yes or no responses, if a rhythmic tone was used in those questions. Family was able to communicate basic needs. A fourth case study involved a 57 year old participant who sustained a TBI and CVA. The participant had Broca's aphasia co-morbidly with the TBI. Traditional MIT was used, and after one week the participant began to hum independently. There were improvements in rote sentences, and the participant responded to stimuli that required one to four words to complete. The participant was able to respond to open ended questions using carrier phrases at the end of therapy to state basic needs. Spontaneous phrases using rhythm occurred 14 to 25

times per day by medical staff and family members. MIT has a range of levels and techniques. Modifications are important for the participants' individualistic needs. Also, modifications are important for participants who do not meet the typical criterion for MIT. Functional communication increased in all four participants with the appropriate modifications; this suggests that MIT is useful for individuals without Broca's aphasia. Therapy should always focus on the best approach, modification, or combination of approaches to increase verbal output in functional communication (Schaefer et al., 2006).

MIT in Other Languages

MIT may also increase verbal output in participants who speak other languages (Bonakdarpour, Eftekhazadeh, & Ashayeri, 2003). Bonakdarpour et al. (2003) implemented MIT intervention with seven Persian speaking participants with non-fluent aphasia in four males and three females, five of whom had Broca's aphasia and two of whom had subcortical aphasia. MIT was presented to the participants for one month for three to four days a week; each participant had 15 MIT sessions total. The investigators measured verbal output by using the Farfsi Aphasia Test (FAT), an aphasia battery available in Iran. The Mahour scale of Persian music was used for intoning stimuli. All seven participants had increased verbal output when items were intoned. There were significant improvement in oral expression subtest scores for phrase length, confrontation naming, repetition, responsive naming, and word discrimination. Also, phrase length of sentences increased significantly after the 15 sessions of MIT. This investigation is clinically significant in that it showed that MIT can be adapted for Persian speaking individuals with aphasia. This investigation is promising for the efficacy of MIT in individuals who speak other languages (Bonakdarpour et al., 2003). Although verbal output was increased based on the Persian test battery, the FAT, there is not much research available on the

reliability and validity of the FAT. The results should be looked at closely because of the lack of research on the subtests. However, phrase length did increase which is evidence that MIT worked to some extent. Also, follow up measurements are needed because there were only 15 sessions measured. Caution should be used when implementing MIT to speakers of other languages because syntactic patterns of English and Persian might not be similar; there needs to be more evidence that MIT can be generalized to other languages. Also, there are different musical scales in other cultures that might influence how therapy is implemented. Caution should be used when implementing MIT to people who speak other languages.

Conclusion

MIT has been found to increase verbal output in a multitude of ways in people with Broca's aphasia. Automatic and self-generated phrases, standardized test scores, and social rating scales have all shown significant improvements in people with Broca's aphasia (Hough, 2010). Also, verbal output increased in participants using words and phrases in line drawing naming tasks (Brier et al., 2010). Besides increasing verbal output, MIT has been found to increase measurable functional brain activity in the left and right hemispheres. Measurable functional brain activity has been measured with MEG's, fMRI's, PET's, and electrodes in brain stimulation tasks. Brier et al. and Belin et al., found that the left hemisphere was activated in participants following MIT treatment; these investigations support that language areas are able to be reactivated in participants with Broca's aphasia. However, left hemisphere activation was not the only brain activation found. Right hemisphere activation was also found in individuals after MIT (Zipse et al., 2012). The melodic and prosodic features of MIT were hypothesized to show measurable brain plasticity in the right hemisphere; brain plasticity in the right hemisphere was supported with an increase in volume of the AF fibers in the right hemisphere (Schlaug et al.,

2009). The brain plasticity and hemisphere activation varied depending on the participants' severity of the lesion, but all of the investigations support that there could be measurable activation in language areas after MIT. As long as there is some language area activated, the future of using MIT to treat participants with Broca's aphasia looks promising. Also, brain stimulation in the right hemisphere was a promising finding because electrodes were shown to augment the effects of therapy (Vines et al., 2011). Future research needs to look more into which features of MIT are the most effective in therapy. Rhythm has been found to be more effective in MIT than melodic features (Stahl, 2011). However, modified versions of MIT have been effective as well. As of now, no feature of MIT should be discounted because the best type of intervention uses an individualistic approach, including many different factors. A variety of features can be used in MIT to tailor the intervention to individual participants; this is shown in investigations that used modified versions of MIT to increase verbal output in populations other than Broca's aphasia. Modified versions of MIT have been successful in people with autism, apraxia, and TBI. There is future research that still needs to occur. However, the future of MIT looks promising due to the existing evidence that supports structural and functional changes in the brain.

Future Research

Many investigations show promising effects on verbal output of MIT, however, there are limitations in the investigations. There is a need for further research in the area of MIT with regards to the level of auditory comprehension in the participants, the severity of lesions in the participants, MIT in other languages, brain hemisphere activation, and the timing of MIT intervention.

Future research needs to have investigations with similar linguistic profiles of participants. The level of auditory comprehension in each participant and the severity of the lesion itself are important areas for future research. The current research supports that auditory comprehension should be moderately intact for MIT to be effective (Hough, 2010). However, several studies used MIT on participants who did not have intact auditory comprehension. Brier et al. (2010) used MIT on a participant who did not have intact auditory comprehension, and the intervention was not effective. There is a need for more investigations that look specifically at individuals with and without intact auditory comprehension in order to clarify the type of participant with whom MIT should be used. Also, the lesion severity varied greatly in the various investigations. Brain activity measurements may be inaccurate if one area of the brain is completely damaged. In order to have more efficacious research, participants need to have the same level of brain damage. There is a need for a uniform linguistic profile, because there are misleading investigations that use participants with different levels of auditory comprehension and severity levels of lesions.

MIT should be investigated in languages other than English. There are few investigations of the effects of MIT on people who speak other languages. It is important to know if MIT can be implemented with people who speak languages other than English. MIT will be a greater intervention method if it can be expanded to culturally and linguistically diverse populations. Future research needs to compare the various syntactic and tonal patterns of other languages to determine whether MIT can be generalized to languages other than English.

Future research needs to separate the individual components of MIT to explore evidence on the relative effectiveness of the various components. There is debate on whether the rhythmic component, synchronicity, or melody is the most crucial for the success of MIT. There is

variability in the investigations on which component is most effective to increase verbal output. Future studies should compare each component separately in intervention; this will help future clinicians focus on specific elements of MIT. Intervention may be more effective if one component is the focus. Until then, SLP's may be wasting valuable treatment time focusing on ineffective features of MIT. Future investigators may also discover that MIT is most effective when components are used in particular combinations or in particular sequences that are yet to be discovered.

The timing of MIT is another area that needs more research. Most studies examined the effects of MIT for a time period of six months or longer post stroke. There is not clear research on whether the sub-acute or chronic phases after stroke are more effective (Meulen et al., 2012). Future research that looks specifically at the timing of intervention can help clinicians implement treatment at the most effective time. The timing of intervention may be altered in a way to have greater increases in verbal output.

Brain hemisphere activation needs to continue to be investigated as well. The evidence is contradictory on whether the right or left hemisphere activation plays a role in increasing verbal output. Some investigations supported that the right hemisphere is activated (Zipse et al., 2012), while other investigations supported that activation occurred in the left hemisphere (Belin et al., 1996). More research needs to be conducted to find out if there are specific areas that can be activated to increase verbal output. If a specific area in the brain is found to be consistent in increasing verbal output, then electrode brain stimulation may be an effective intervention approach in the future.

Rhythmic and melodic elements of MIT, timing of intervention, severity and size of lesions, level of auditory comprehension, and brain hemisphere activation are all areas that could

be limitations to the investigations on MIT. Separating all of these areas is not an easy task because there is such a variety in the participants treated with MIT. Each participant is slightly different, and it is very difficult to control the difference in linguistic profiles. Although there is still a need for more research in this area, the results of the existing research are still promising. The measurable changes in brain plasticity, regardless of the contradictory results in hemisphere activation, are a significant finding. Language is a difficult area to treat because its inherent complexity, and MIT could be an effective treatment for language impairments. Regardless of the limitations, MIT can be used to activate brain hemispheres and increase verbal output in participants with Broca's aphasia.

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