

Running head: REVIEW OF CURRENT NMT RESEARCH

Neurologic Music Therapy Techniques: A Systematic Review of Current Research

By:

Brianna Cowen

A Thesis

Submitted in Partial Fulfillment

Of the Requirements for the Degree of

Master of Music

Music Therapy

At the State University of New York University at Fredonia

Fredonia, New York

August 2014



Dr. Joni Milgram-Luterman

Thesis Advisor, Discipline Chairperson

Music Therapy



Dr. Teresa Brown

Provost and Vice-President

for Academic Affairs

## REVIEW OF CURRENT NMT RESEARCH

### Abstract

The purpose of this systematic review was to identify clinical research studying neurologic music therapy (NMT) and non-NMT techniques and identify which techniques are more commonly researched. Thaut (2008) describes NMT as the use of standardized treatment techniques as interventions that are founded on scientific research. The success of NMT is evidenced by clinical research. The techniques of NMT provide the therapeutic application of music to cognitive, sensory, and motor dysfunctions used as a method to treat neurologic disease. This systematic review identifies studies related to music therapy to support the various NMT techniques. For the purposes of this study, non-NMT music therapy articles follow similar protocol to NMT with no mention of NMT. Study questions are: (1) Which techniques are more commonly researched? (2) Is there a difference between NMT research and non-NMT research that studies the clinical effects of NMT techniques? (3) Which NMT techniques are more researched and developed after NMT was founded? And, (4) Which studies predate NMT?

Conclusions revealed that several NMT techniques are minimally researched, and the author could find no clinical research using Symbolic Communication Training through Music (SYCOM). Also identified were several studies that predate the founding year (1999) of NMT. Recommendations include ongoing NMT research to further justify its effectiveness in medical settings, with attention to the least researched techniques.

Table of Contents

CHAPTER I  
Introduction.....Page 1

CHAPTER II  
Methods.....Page 4

CHAPTER III  
Sensorimotor Rehabilitation Techniques.....Page 7  
Rhythmic Auditory Stimulation.....Page 8  
Patterned Sensory Enhancement.....Page 18  
Therapeutic Instrument Playing.....Page 24  
Table I .....Page 31

CHAPTER IV  
Speech and Language Rehabilitation Techniques.....Page 33  
Melodic Intonation Therapy.....Page 33  
Musical Speech Stimulation.....Page 40  
Rhythmic Speech Cueing.....Page 43  
Vocal Intonation Therapy.....Page 45  
Therapeutic Singing.....Page 48  
Oral Motor and Respiratory Exercises.....Page 51  
Developmental Speech and Language Training Through Music.....Page 54  
Symbolic Communication Training through Music.....Page 57  
Table.....Page 59

CHAPTER V  
Cognitive Rehabilitation Techniques.....Page 62  
Musical Sensory Orientation Training.....Page 62  
Musical Neglect Training.....Page 65  
Auditory Perception Training.....Page 68  
Musical Attention Control Training.....Page 69  
Musical Mnemonics Training.....Page 73  
Associative Mood and Memory Training.....Page 76  
Musical Executive Function Training.....Page 81  
Table .....Page 85

CHAPTER VI  
Discussion and Implications.....Page 88  
References.....Page 90  
Appendix A: Sample Data Extraction Form.....Page 100

## CHAPTER I:

## Introduction

For centuries, music has been used as means for healing as part of therapeutic practice. The use of music in healing is a powerful way to facilitate improvement in many different areas (Meyer, 1956; Dowling & Harwood, 1986; Snyder, 2000). Music therapy is the clinical use of music to help individuals improve or maintain different facets of their health (i.e. physical, emotional, cognitive, physiological, and spiritual). Music as an art form has existed in every culture throughout human history. Music may not be considered a basic need, but it is interesting how the pervasiveness of music may imply that there is a biological and neurological basis of music in the human brain that plays a role in shaping brain and behavior function considerably beyond broad notions of musically induced well-being (Thaut, 2008). Historically, music therapy was first used with veterans with post-traumatic stress disorder (PTSD) following World War II. Within the past two decades, the impact of music has become a research focus in the brain sciences creating a wide range of clinical research as an avenue to investigate the effectiveness of treatment procedures (Thaut, 2008).

Neurologic Music Therapy (NMT), as a model of music therapy identifies techniques that have been incorporated into medical settings. Thaut (2008) describes NMT as the use of standardized treatment techniques as interventions that are founded on scientific research. The techniques of NMT provide the therapeutic application of music to cognitive, sensory, and motor dysfunctions used as a method to treat neurologic disease. A significant aspect of the creation of NMT techniques is that it provides a reference base for music therapists to develop personalized interventions for clients in rehabilitation settings. NMT techniques are broken down into three

treatment areas including: sensorimotor rehabilitation, speech and language rehabilitation, and cognitive rehabilitation (Hodges & Sebald, 2011; Thaut, 2008).

While several therapeutic strategies predate the use of the term ‘neurologic music therapy’ to describe them, this designation seemed to emerge around the turn of the 21<sup>st</sup> century. The creation of this concept served as an umbrella under which this specialized field within music therapy could be formally organized. The earliest mention of a formal program of study that was found during the research for this systematic review was the Robert F. Unkefer Academy of Neurologic Music Therapy at Colorado State University (CSU) that was established in 2002. However, there was a previous training program that began in 1999 at CSU.

NMT practitioners attend education workshops and supervised training toward understanding the NMT paradigm of the Transformational Design Model (TDM). According to Thaut (2005) TDM has five steps that include: “(1) Diagnostic and functional assessment of the patient, (2) Development of therapeutic goals/objectives, (3) Design of functional, nonmusical therapeutic exercises and stimuli, (4) Translation of step 3 into functional therapeutic music exercises, and (5) Transfer of therapeutic learning to functional, nonmusical real-world applications” (2008, p. 131). This scientific model helps to teach NMT candidates the fundamental methods for creating efficient therapeutic music applications and applying them into their practice.

The author had an interest in investigating clinical studies conducted using interventions similar to NMT techniques, and to better understand how effective and commonly researched each NMT technique is with various populations. The author hypothesized that more clinical research existed using techniques used for sensorimotor and speech and language rehabilitation, but that limited research would be found using cognitive rehabilitation NMT techniques. Therefore, the

purpose of this systematic review was to identify clinical research of NMT and non-NMT techniques and examine which techniques are more commonly researched. For the purposes of this study non-NMT articles follow similar protocols as NMT with no mention of NMT terms. Research questions include: (1) Which NMT techniques are more commonly found in clinical research literature? (2) Is there a difference between NMT research, non-NMT music therapy research and non-NMT research that studies the clinical effects of NMT techniques? (3) Which NMT techniques are more researched and developed after NMT was founded? And, (4) Which studies predate the founding year of NMT?

All NMT techniques identified in the research literature from the bodies of research of both NMT and non-NMT sources are reviewed. The following four chapters provide definitions, descriptions and review of literature of each of the three NMT rehabilitation settings including their identified strategies. Charts provide comparison and percentages that address the research questions. Chapter II provides a description of methods used in conducting this systematic review. Chapter III includes descriptions of several sensorimotor rehabilitation studies and a chart for literature comparison. Chapter IV identifies speech and language rehabilitation literature including a literature comparison chart. Chapter V includes descriptions of several cognitive rehabilitation studies and a chart for literature comparison. The final chapter provides discussion and implications.

## CHAPTER II:

## Methods

Conducting this systematic review consisted of completing three steps: (1) Selection of studies, (2) Data extraction, and (3) Data synthesis. Identification of studies was conducted using various electronic databases on the SUNY Fredonia website, rabbit searching, and manual searches in several books. Electronic databases used to locate research were PubMed, Medline, Music Index, PsycArticles, PsycINFO, RILM Abstracts of Music Literature, JSTOR, ScienceDirect (Elsevier), and Google Scholar. The search was conducted between June 2013 and January 2014 to identify clinical research literature published using NMT techniques and literature that uses NMT-like strategies.

Previous to this study the author completed NMT training from the Robert F. Unkefer Academy of Neurologic Music Therapy to better understand NMT strategies and to be able to recognize these strategies in the research. Before beginning the selection of studies, the author selected several keywords to use in database searches. The search terms include: music therapy, neurologic music therapy, NMT, cognitive rehabilitation, speech and language rehabilitation, musical mnemonics training, gait rehabilitation, physical deficits, visual neglect, mood and memory training, rhythmic auditory entrainment, instruments, therapeutic instrument playing, gait training, sonification, melodic intonation therapy, music and speech, singing, mood and memory, rhythmic cueing, vocal intonation, oral motor and respiratory, speech motor control, dysarthria, stroke, dementia, arousal orientation, attention maintenance, inattention, sensory integration, integrating movement to music, and executive function and music.

## Selection of Studies

Finding literature on every NMT technique proved to be challenging. The author then contacted an NMT fellow in order to gain insight on locating appropriate source material for review. This was extremely helpful in locating both NMT and non-NMT research, and shed insight and increased likelihood for including appropriate material for this review. The author used an extraction method to eliminate literature used for two strategies due to the vast amount of research found. Extraction method used was completed by selecting the literature by fives. The extraction method was used for Melodic Intonation Therapy (MIT) and Rhythmic Auditory Stimulation (RAS). The electronic databases led to the author finding 33 studies. Upon review of the 33 studies, two were eliminated because the study methods did not following NMT protocol. In the remaining 31 studies, the author conducted rabbit checking to locate more literature. Rabbit checking led to the author finding 12 more studies. The researcher also examined the NMT code manual (Oliver, Thaut & Sena, 2005) and a NMT textbook (Thaut, 2008) for further literature. From this, eight more were identified, totaling 51 studies.

#### Data Extraction

Each study was evaluated individually for methodological quality. The author completed a data extraction form for each study to prepare for data synthesis (See Appendix A). It was determined that every study had merit for inclusion in this systematic review, even if a study yielded negative results.

#### Data Synthesis

Upon preparing data for synthesis, the author decided to use direct quotes from the Medical Coding and Records Manual: Neurologic Music Therapy handbook (Oliver, Thaut & Sena, 2005) for all techniques, because the author wanted to use official technique definitions as a matter of respect and to assure thoroughness. The author created a chart of all 51 studies to aid

in data synthesis. Using the data extraction forms for each study, the author inputted and described information from the various studies. Finally, the author synthesized research findings. Conclusions and implications for future research were then discussed.

## CHAPTER III:

## Sensorimotor Rehabilitation Techniques

NMT has been used in a variety of populations for rehabilitative purposes including individuals with Parkinson's disease, Multiple Sclerosis (MS), orthopedic conditions (total knee or hip replacement or other joint problems), traumatic brain injury (TBI) or individuals who have had a stroke. Sensorimotor rehabilitation is a method to improve gait. According to Thaut (2008) the three sensorimotor rehabilitation techniques in neurologic music therapy are Rhythmic Auditory Stimulation (RAS), Patterned Sensory Enhancement (PSE), and Therapeutic Instrumental Music Performance (TIMP). Sensorimotor rehabilitation is typically used with individuals with motor dysfunctions. Initial NMT research appeared to focus on motor-control in rehabilitation settings. Currently, the use of NMT is widely used in both cognitive, speech and language, and sensorimotor rehabilitation and also non-rehabilitation settings. The findings demonstrate a new way of understanding the purpose and function of music therapy and reflect the concept of rhythmic entrainment to facilitate control of movement. Phillips-Silver, Aktipis, and Bryant (2010) define entrainment as the synchronization of individuals to an auditory stimulus. Music therapists use musical entrainment to help individuals to time-lock their movements by integrating information across different sensory modalities. An interesting area of focus is examining motor neuroscience and how it has determined that rhythmic auditory stimuli can stimulate and improve motor responses in individuals with gait deficits. For example, a therapist could use rhythmic entrainment as a therapeutic intervention to facilitate targeted physical outcomes in the client's movements. Studies found using NMT and non-NMT techniques in sensorimotor rehabilitation are explored.

Rhythmic Auditory Stimulation

As defined in the Medical Coding and Records Manual on neurologic music therapy, RAS is:

A neurologic technique of rhythmic motor cueing to facilitate training of movements that is intrinsically and biologically rhythmical. In humans, the most important type of these movements is gait. Therefore, RAS is used almost exclusively for gait rehabilitation. It uses rhythmic cues in 2/4 and 4/4 meter, presented either as pure metronome beats or as strongly accentuated beats in complete musical patterns, to cue gait parameters such as step cadence, stride length, velocity, symmetry of stride length and stride duration, and double and single support time of leg stance. (Oliver et al., 2005, p. 1)

Generally, RAS is used to facilitate recovery for clients with substantial gait deficits due to Parkinson's disease, Multiple Sclerosis (MS), Cerebral Palsy (CP), orthopedic conditions, stroke, traumatic brain injury (TBI), aging or similar causes.

#### NMT RAS Studies

Kim, Kwak, Park and Cho (2012) demonstrated the effects of RAS on gait patterns in individuals with CP. Participants were twenty-eight individuals with CP with bilateral spasticity. They were randomly assigned to either the RAS group (n=15) or the neurodevelopmental treatment group (n=13). For three weeks both groups participated in three sessions for thirty minutes at a time. Physical therapists collected the data from the neurodevelopmental treatment group. RAS was delivered using rhythmic cueing from a live keyboard and a metronome set to each individual's internal cadence. The procedure for the RAS group included: 1.) identifying each individual's internal cadence (steps/minute) by having them walk ten meters three times, 2.)

The metronome was set to the individuals' internal cadence, and 3.) RAS was incorporated by music therapists using keyboards who played a rhythm pattern to match the metronome pace. Participants in the neurodevelopmental group received a traditional method of gait training by physical therapists. Researchers failed to describe what the participants of the neurodevelopmental group did. Data was collected on both the temporal and kinematic identifying features of each individual including the hip, pelvis, knee, foot and ankle. Data was collected before and after both the RAS and neurodevelopmental treatment groups using a motion analysis system. The authors of this study did not mention the reliability and validity of the motion analysis system. However, the methods and procedures are well described otherwise.

Results indicated that the RAS treatment group had significant increase in temporal gait parameters including stride length, walking velocity, step length, and cadence after three weeks of training. However, these results were not statistically significant. The neurodevelopmental treatment group saw significant decrease in all areas other than stride time, which increased slightly. Some significant results were found among the kinematic parameters of the hip joint showing an aggravation of the hip movement in those who were treated with RAS. On the other hand, the neurodevelopment treatment group showed an improvement of external and internal rotations of the hip joint. The researchers site the aggravation of the hip joint in the RAS treatment group due to an increase of cadence. According to the researchers, this suggests that using RAS may have some limitations when used with individuals with CP. Overall, this quantitative research study indicates a significant improvement of gait parameters of the individuals in the RAS treatment group; however some limitations did occur with aggravation of the hip joint.

Kim, Kwak, Park, Lee, Kim, Song and Cho (2011) demonstrated the effects that RAS has on adults with CP. Participants were fourteen individuals with CP (9 male, 5 female) with bilateral spasticity. The control group participants were thirty healthy individuals (15 women, 15 men). The participants with CP were split into two groups: household ambulators (can walk minimum of 50 feet) and community ambulators (can walk minimum of 150 feet). The procedures included the following stages: 1.) Each participant walked three times for ten meters without RAS, 2.) Music therapist calculated each participants internal cadence (steps/minute), 3.) A metronome was set to each participants cadence, 4.) RAS was provided by music therapists using a keyboard that was set to the specific metronome beat specific to each participant, 5.) The same pattern was repeated to help participants adjust to RAS, and 6.) Each participant walked ten meters three times with RAS. Data was collected using a six-camera motion-analysis system to record gait analysis and a gait deviation index (GDI) was used to measure overall gait pathology. A formula was used to calculate the percentage of each participant's irregularities between the left and right limb with and without RAS. The Statistical Package for Social Sciences (SPSS) software was used to evaluate comparisons between gait measurements with and without RAS conditions.

Findings of this study varied. There was an improvement in the kinematics of pelvis and hip joint instead of distal movements in participants with CP when using RAS. Gait pathology of these individuals also improved with RAS. There was more improvement in the household ambulators than community ambulators when adding RAS. The authors believe that RAS could produce improved kinematic gait pattern and temporospatial asymmetry in patients with CP.

Staum (1983) sought to explore the use of RAS to increase independent ambulation in individuals with uneven gait patterns. The study participants were sixteen adults (52-87 years of

age) and nine children (5-19 years of age) all with gait abnormalities due to CP, scoliosis, cerebrovascular accident (CVA), hemiplegia due to brain trauma, Parkinson's disease, or osteoarthritis. The adult participants were chosen from a long-term care facility in a medical hospital and the children were selected from special education programs in two different public schools. Five different marches were selected based on clear beat patterns helping participants to match their steps with the beat easier. The marches selected included "Stars and Stripes Forever," "Colonel Bogey," "Grand March" from Verdi's Aida, "76 Trombones," and "Semper Fidelis." The selected marches were then recorded at eight different tempos. Also recorded were rhythmic pulses to the same eight tempi as the music selections. To determine each participant's abilities and capabilities the researcher walked with the participants to identify their internal cadence (number of steps per minute). Researchers completed this for three consecutive days while also ascertaining motor functioning in other body parts. On the following day, the subjects were asked to walk for a minute, rest for a minute, and then continue this for six more cycles.

Videotape recordings were used to collect data of these six walking trials for each participant and recordings were analyzed for walking cadence, differences in left/right footfall, irregular gait, and variations of speed. Each participant listened to three different tunes with different rhythms. Subjects first listened to music through headphones, while they were asked to tap a selected body part along with the music for one minute, and then asked to verbalize to the music. Next, subjects were asked to walk with the music for a minute. This process was then repeated with a different music selection. After the researcher determined that a subject had an adequate change or control in walking, both music and pulse sounds were progressively faded. By the end of the experiment, auditory cues were completely removed for all subjects.

Results indicated an improvement in gait characteristics of all subjects involved. As Staum (1983) states, “The most impressive gain was a 66-year-old male stroke patient who decreased his gait arrhythmia from a deviation of 29.56 seconds between feet in baseline to .61 seconds by the end of treatment” (p. 78). This man’s walking pattern had become smoother after RAS treatment. Most participants achieved a “normal rhythmic evenness” in their walking. Improvements in arrhythmic walking slightly decreased after fading music and rhythmic pulse. The author of this systematic review believes that this could be attributed to the short training period. Staum concluded that the subjects may have benefited from a prolonged treatment period. Consistency in walking speed improved for 68 % of the subjects, whereas the results were variable and inconsistent for the remaining subjects. Other gross motor functions that improved after treatment were decreased unnecessary mid-line crossing in spastic and ataxic disorders, and an elimination of identifiable differences in stepping with the affected side of the body in stroke patients. Researchers concluded that all subjects made improvements in rhythmic walking and they did not show any aggravation in hip joints like the previous study. This study is particularly interesting due to the lack of discrimination and variety of populations and age groups, allowing for generalization.

Clair and O’Konski (2006) explored two different forms of RAS with persons with late-stage dementia. The study sought to examine whether using RAS would show changes on gait characteristics of the participants. The two forms of RAS being used in this experiment included using metronome beats alone, and music imbedded with metronome beats. Researchers explored whether these subjects would show changes in gait characteristics of cadence, velocity, and stride length, when they walk with music, a metronome or with silence. Before beginning treatment, researchers used The Functional Independence Measure (FIM) assessment to

determine locomotion condition. In order to be included in the study, the residents needed to have the ability to walk a distance of 50 feet or less with minimal assistance. Study subjects were 4 males and 24 females with ages ranging from 70 to 92 years. The three walking conditions in the experimental sessions include: (1) walking to music with clear beats, (2) walking to a metronome pulse, and (3) walking to no auditory stimulus. Each subject had a total of nine sessions with each condition. Individual cadence (steps per minute) was identified for each participant before the study began. Next, researchers created recordings of improvised music on a keyboard to match each participant's cadence. They were then given two recordings of individually created music, one recording with music and audible rhythmic beats, and one recording with metronome beats alone.

Authors concluded that the subjects did not show changes in their gait characteristics of cadence, velocity, and stride length when walking in the three different conditions. However, upon inquiry, researchers found that participants perceived that they could ambulate better with the music stimulus. They concluded that this result could be attributed to the music functioning as an entraining mechanism for these individuals. RAS could also help persons providing care to the individuals with late stage dementia. RAS could help decrease strain of physical support for ambulation of the client, possibly eliminate the need for a second staff person, and RAS could possibly help extend ambulation later into the disease process. Overall, results of this study show RAS not having any significant effects on ambulation of persons with late stage dementia; however the perceptions of the participants show otherwise. The author of this systematic review believes that further research into the perceptions of individuals with late stage dementia using RAS to improve gait may be of importance to better understand the influence of music on gait and the effects of cognitive rehabilitation.

Hurt, Rice, McIntosh, and Thaut (1998) studied the effects of RAS on gait patterns of individuals with TBI. The researchers sought to investigate if there was an immediate effect of RAS on gait patterns and if RAS would improve gait patterns of participants with TBI. The study subjects were eight individuals (3 female/ 5 male) with TBI between the ages of 25 and 35. All individuals participated in physical therapy and were no longer showing observable improvements. Their physical therapists sought out alternative therapies to further aid their physical deficits.

The researchers conducted two experiments applying RAS both in a lab and at home. First the researchers asked the subjects to walk on a ten meter walkway four times. During the first walk, researchers had subjects walk at their normal pace to identify individual cadences. For the second walk, researchers had subjects walk on beat to the music that was set to their cadence identified in the previous walk. During the third walk, researchers instructed subjects to walk as fast as they could safely without RAS. And finally during the fourth walk, subjects were asked to walk on beat to music set at 5% faster than third walk. To collect data a computerized stride analysis system was used.

The second experiment of the study had five subjects (2 female/ 3 male) with the same requirements as the first experiment. After identifying individual cadences, each subject began a five week home-based therapy program. They were provided with recordings of RAS music they walked to each day for fifteen minutes. Each week the participants' level of endurance was re-assessed and an additional minute was added to both the normal and fast walks of their gait training. The recordings included music at a normal tempo and then an accelerated version of the same songs. Subjects could choose between a tape of the blues version of "Back in the saddle" or the instrumental version for their individual home-based RAS program. After the five weeks

were completed, subjects returned to the Biomedical Research Center for a posttest of their normal and fast walk without music. Both pretest and posttest data was collected without RAS.

In the normal walking condition of the first experiment results showed that all parameters increased when RAS was present. For example, average velocity increased by 18%, cadence increased 8%, stride length increased 7%, and swing symmetry increased 18%. However, during the fast walk condition, results varied; velocity decreased 6%, stride length decreased 2%, step cadence increased .39 steps per minute, and swing symmetry increased 28%. Interestingly, when the RAS frequency had been set 5% faster than the subject's fast walk, the average identified the subjects walking 3% slower than cued by RAS.

The purpose of the second experiment was to determine if there were any significant differences between pretest to posttest in stride length, velocity, symmetry, and cadence. As concluded by the authors, results indicated statistically significant increases in all gait parameters ( $p < 0.05$ ). These findings indicate that RAS can strongly alter gait parameters of TBI patients over time. Results of the first experiment provide verification that TBI patients can synchronize their gait to RAS with some variability. Results of the second experiment presents verification that over time, training with RAS can yield statistically significant increases in cadence, velocity, stride length, and symmetry as consequence. Overall, the researchers offer evidence of the benefits of using RAS when treating individuals with TBI's.

#### Non-NMT RAS Study

Thaut (1985) demonstrated the use of auditory rhythm and rhythmic speech to aid the temporal muscular control of a gross motor movement sequence. This study is not RAS because the researcher used a variation of RAS by incorporating speech and movement into the protocol that is not typical of RAS. Also, NMT was not fully developed in 1985. The study participants

were eight male children between the ages of 6 years to 6 years and 11 months, eight male children between ages 7 to 7 years and 11 months, and eight male children between the ages of 8 years to 8 years and 11 months from two remedial motor programs in the Department of Health and Physical Education at Michigan State University. These twenty-four subjects were randomly selected to either the control or treatment conditions in an even number for each age levels. A referral from an outside source such as a teacher, therapist, or physician was necessary to be involved in the study. Each control and experimental subject was seen for three treatment sessions for thirty minutes. Baseline measures for each participant were recorded during initial assessments. The researcher demonstrated the movement to the participants, and then asked them to repeat the model. If the motions were correct, sensors were attached to the participant's body to record time duration of each movement. After sensors were attached, the participants were asked to complete the model five more times. All participants, both in the treatment and control groups underwent 10 movement cycles. The first cycle was not used to record data because it was used as a warm-up and adjustment period. Even though the control group completed all ten cycles, only 2-5 were measured. For the treatment group, cycles 2-5 were recorded, cycle 6 RAS was faded, and cycles 7-10 were recorded for treatment under faded conditions.

No significant interaction effects were found comparing results of motor rhythm accuracy for both treatment and control groups. Also, age level of the participants did not affect the motor rhythm accuracy recorded. However, when comparing the treatment effects between the treatment and control groups, the researcher found significant performance differences. Results indicate increased accuracy in the gross motor pattern when using both auditory rhythm and rhythmic speech. Interestingly, the researcher also found that visual modeling of the gross motor

planning, when used alone to guide the participants, did not show as much improvement as the repeated rhythmic rehearsal strategy. Over time, both groups significantly improved their combined performance profile. When adding the fading condition, results changed somewhat. Treatment effects indicate that the treatment group did not perform better than the control group when the fading condition was used. The researchers suggest that there was no difference in motor rhythm accuracy due to differences in age. Overall, the study indicates that auditory rhythm and rhythmic speech were successful in assisting the participants' motor control in an intricate gross motor sequence.

### Conclusions

All of these articles used similar sample size and research methods. Various populations were used including TBI, dementia, and CP. A common gap in the studies includes sparse demographic data. Articles written by Kim et al. (2011) and Kim et al. (2012) include only gender, age, weight and height (Kim et al. 2012; Kim et al. 2011). The remaining articles only identified gender and age (Hurt et al., 1998; Staum, 1983; Clair & O'Konski, 2006; Thaut, 1985). In addition, all the studies had small sample sizes that decrease generalizability. A strength noted in the Kim et al. (2011) article is the reliability and validity of the measures used to evaluate activities of daily living (ADL). Kim et al. (2012) also uses the same measures. However, they do not mention the reliability and validity. Another strength mentioned in Kim et al. (2011) is the mention of an Institutional Review Board (IRB) for approval of the experimental procedure. A weakness in Hurt et al. (1998), Clair and O'Konski (2006), Staum (1993) and Thaut (1985) is the lack of mentioned reliability and validity. One interesting aspect found was the comparison of people to themselves in the experimental design in the study conducted by Hurt et al. This makes the research more valid due to not using control samples which are

extremely difficult to match in a heterogenous TBI population. Ultimately, these studies provide useful information regarding rhythmic auditory stimulation and its use with individuals with CP, TBI and dementia.

### Patterned Sensory Enhancement

Oliver et al. (2005) define Patterned Sensory Enhancement (PSE) as:

A technique, which uses the rhythmic, melodic, harmonic and dynamic-acoustical elements of music to provide temporal, spatial, and force cues to structure and regulate functional movements.

PSE can be used to structure, in time, space, and force, any functional movement patterns and sequences, regardless of whether they are intrinsically rhythmic or discrete of the upper trunk, arms, hands, or whole body (e.g. reaching, grasping, and lifting motions; sit-to-stand transfers, etc.). (p. 2)

Although there are several similarities between RAS and PSE, there is one major difference. PSE uses all musical elements in a multidimensional structure to use sound patterns to prompt movement patterns, whereas RAS operates solely on time cueing. PSE provides for a more multifaceted assimilation process in the brain than RAS. No non-NMT research was found that uses the strategies similar to PSE.

### NMT PSE Studies

O’Konski, Bane, Hettinga, and Krull (2010) examined whether participants would demonstrate improved performance during the PSE condition as opposed to the background music condition. Researchers also perceived emotions towards PSE versus background music sessions. The study participants were forty-five individuals (3 male/ 42 female) all recruited from

five different long-term care facilities in the Midwest. In order to be included in the study, there had to be a need for exercise as determined by a nurse or aide, and participants needed to have a minimum score of 18 on the Mental Status Examination. The participants presented with a variety of medical diagnoses, such as early stage Alzheimer's disease, arthritic conditions, asthma, history of cerebrovascular accident, chronic obstructive pulmonary disease, chronic urinary tract infection, coronary artery disease, congestive heart failure, depression, diabetes, gastro esophageal reflux, hypertension, irritable bowel syndrome, myasthenia gravis, osteoporosis, and recent transient ischemic episodes. A music therapist and neurologic music therapy fellow recorded 19 keyboard compositions to a compact disc for the PSE condition. To provide validity for the created PSE compositions, the researchers sought other neurologic music therapy professionals to evaluate the compositions that met criteria for PSE. A compact disc (CD) of big band music was used for the background music condition. After each exercise session a questionnaire was given to each participant to evaluate exertion, enjoyment, and exercise quality levels. They were also asked to indicate whether the exercise leader was easy or difficult to follow.

The participants received both the PSE condition and background music condition once a week for twenty minutes for four weeks. Every exercise session was conducted the same way including the same order of movements by the same facilitator. The exercise facilitator even wore the same clothes week to week to increase the participants' familiarity with her. Exercises included both upper and lower body movements.

Post-session questionnaires indicated high enjoyment levels in the PSE and background music conditions. Results of the questionnaire also revealed how effective and easy the exercise program was in both these conditions. However, as far as exercise performance, the only

significant difference between conditions was the increased amount of hand grip repetitions that occurred during the PSE condition versus the background music condition. Overall, the authors concluded that PSE facilitated better devotion to completing movements, but no other significant differences between PSE and background music conditions were found. Author of this systematic review believes continued research on this topic may include a no-music control group to determine effect size differences.

Clark, Baker and Taylor (2012) sought to observe the effects of PSE on exercise output and mood, as well as to examine ratings of perceived exertion during PSE exercise. The study participants were twenty-four (8 men/ 16 women) older adult inpatients in a rehabilitation center attending a group exercise program. The individuals were between the ages of 65 and 101 years of age and presented with multiple physical and psychosocial deficits. The group exercise program took place twice weekly for 60 minutes each time. A music therapist with neurologic music therapy training conducted sessions incorporating live-PSE once weekly while a physical therapist conducted sessions without using live-PSE once weekly. Data was collected over eighteen weeks.

During the live-PSE sessions, the music therapist played pre-composed music on piano or guitar. Compositions were selected based on previous use by neurologic music therapists when conducting PSE sessions. Exercises used in the study included lower and upper body movements. Exercise outcome measures were observed using the Sport Injury Rehabilitation Adherence Scale (SIRAS) during the first two sessions each participant attended. Also during the initial two sessions, researchers examined feelings of effort using the Rating of Perceived Exertion CR 10 (RPE) scale. For the initial and last two sessions researchers measured mood scores using the Visual Analogue Mood Scale (VAMS).

Analysis of VAMS, RPE, and SIRAS indicated no significant differences in live-PSE or physical therapy conditions. Hypotheses made by researchers indicating a greater output in exercise during the live-PSE condition was not supported. One participant indicated how much fun he had using music to exercise. He stated wanting to move with the music, even when he was tired. After the session was complete, the physical therapist involved in the study also mentioned wanting to continue live-PSE as an exercise program because the participants were disappointed when music therapy was not included in the sessions. The researchers indicate that having music as part of an exercise program provided a set rhythmic pace for the group. This made it helpful for the physical therapist to observe them. A possible avenue of research on this topic could incorporate perceptions of the value of music during exercise, especially because outcomes were not supported by the hypothesis.

Wang, Peng, Chen, Lu, Liao, Tang and Shieh (2013) evaluated the effects of a 6-week, home-based PSE program on gross motor function, physical strength, mobility, and walking speed for children with spastic diplegia. Participants in the study were 33 children with spastic diplegia between the ages of 5-13. In order to be considered to participate in the study, children needed to be able to walk independently without falling, follow verbal directions, and have parental consent to supervise the home-base PSE training program. Children were randomly assigned into either the experimental (PSE exercise program) or control (no-music exercise program) group. The study was performed over a six week period, three times per week. Before the study began, the sit-to-stand exercises were introduced and demonstrated during the first home visit. At this time, each child was given a rope, chair, weighted body vest, and weights that were prepared for exercise sessions. Caregivers were given an exercise log to keep track of repetitions of exercise, duration of exercise, and any unpleasant events that occurred during or

after exercise programs. The exercise program included a gentle ten-minute muscle warm-up, three sit-to stand sets, ending with cool down stretching. During the first and third sets, the researchers used weighted vest at 20% with one repetition maximum (1-RM) of sit-to-stand exercises for 10 repetitions. The second set was increased to 50% of 1-RM and repeated until the child became tired. PSE music samples were created by a music therapist using a keyboard and GarageBand based on PSE principles. According to each child's progress, the music therapist adjusted tempo of PSE samples every two weeks to reassess individual needs. Measures used to identify gross motor capacity and daily mobility and self-care functions included the Gross Motor Function Measure (GMFM) and the Chinese version of Pediatric Evaluation of Disability Inventory (PEDI).

Results revealed that children who participated in the PSE group had statistically significant improvements in gross motor capacity than those who participated in the no-music group. Interestingly, the no-music group had statistically significant improvements in the children's daily functioning, strength, and walking speed (PEDI scores) whereas the PSE group did not yield these results. To the researcher's surprise, the no-music group had more improvement on the Caregiver Assistance Scale than the PSE group after three months. Important to mention, researchers state that PSE group children tended to be more obliging and achieved more repetitions during the exercise. Overall, the research suggests the feasibility of using PSE for children with spastic diplegia during sit-to-stand exercise programs.

Peng, Lu, Wang, Chen, Liao, Lin, and Tang (2011) sought to explore the effects of PSE on loaded sit-to-stand movement in children with spastic diplegia. The participants consisted of 23 children (13 female/10 male) between the ages of five and twelve years old. The researchers randomly selected the participants into either the control or PSE groups. Each child was given a

weighted vest and a chair at the height of the knee joint. One loaded sit-to-stand cycle required participants to stand up and touch a rope at their body height, to then sit down and stand up again. The PSE music condition included two trials of loaded sit-to-stand exercises for which the two trials had eight exercise repetitions using a 50% 1-RM. To aid participants in exercise, researchers provided live PSE using an electric keyboard in an ascending and descending manner during movements. Researchers also incorporated musical accents and volume changes to emphasize up and down movement. In the control condition, participants were asked to complete the same trials and repetitions of exercises. Data was collected and analyzed using video recording of sessions. In both conditions, researchers gradually increased vest weights until participants were no longer able to complete both exercise cycles.

Study results indicate that the PSE music condition was found statistically significant improvements the instant the loaded sit-to-stand movement began. Interestingly, the participants in the PSE music condition were able to continue the exercise at the same rate after the music had ceased. Participants also showed more even center of mass motion during the loaded sit-to-stand movement with a significantly smaller mean in normalized jerk index values in the PSE condition than the control condition. Overall, researchers found that the individualized PSE music condition yielded improvements in loaded sit-to-stand movements versus the control condition in children with spastic diplegia.

## Conclusions

These four PSE articles discussed different populations, age groups, study locations (Taiwan, Australia, and United States) and similar sample sizes. Clark et al. (2012) was the only study that did not yield statistically significant results. Interestingly, this technique was used with

individuals with children with CP and older adults with dementia. This indicates a wide range of possible uses for this technique.

### Therapeutic Instrumental Music Performance

Oliver et al. (2005) defines Therapeutic Instrumental Music Performance (TIMP) as:

The playing of musical instruments to exercise and simulate functional movement patterns in motor therapy. Musical instruments and spatial configuration of instruments and motor patterns for playing are selected on the basis of functional considerations to train appropriate ranges of motion, endurance, strength, limb coordination, and functional movements entailing finger dexterity, grasp, flexion/extension, adduction/abduction, rotation, supination/pronation, etc. (p. 3)

Playing an instrument entails the use of fine and gross motor skills, attention skills, and the ability to process sensory information. Therefore, this technique could benefit several aspects of sensorimotor functioning in individuals with physical deficits.

### NMT TIMP Study

Lim and Fabian (2011) conducted research investigating the effects of TIMP as compared to traditional occupational therapy (TOT) on fatigue, endurance and exertion on thirty-five individuals. Study participants consisted of individuals with physical deficits due to orthopedic surgeries or neurologic disorders. Rhythmic auditory entrainment of each participant was determined by researchers prior to beginning study. Study measurements included a Patient Perceived Fatigue Level Scale (PFL) and a measurement of exertion (RPE-Ratings of Perceived Exertion). Each participant was randomly assigned to either participate in a single session of

Traditional Occupational Therapy (TOT) or TIMP on the first day of the study. On the second day of the study, those who participated in TOT were then assigned to complete a TIMP session, and vice versa.

The first TIMP session contained a target movement of a complete elbow extension/flexion with a 90 degree flexed shoulder. This target movement was conducted using a light mallet with a one pound weight placed on the participant's wrist aiming towards a paddle drum held by the investigator. Familiar recorded music was selected to be used for the study. Participants were instructed to tap the investigators shoulder, extend to strike the paddle drum, and then repeat the sequence. While participants practiced the sequence, the investigators identified individual optimal tempo (number of sequences per 10 second interval). When this was identified, investigators set music to the tempo of each participant's optimal tempo and began the music. Participants then continued the sequence while music was playing until they were no longer able to continue due to pain or fatigue. Investigators recorded duration of exercise and frequency of sequences for each participant.

The second TIMP session contained target movements including: (1) "bicep curls with arm in neutral, flexing to shoulder and back" using a jingle stick, (2) "shoulder flexion with elbow extended across mid-line, back to neutral, to opposite side, then back to neutral" using a mallet, conga drums, and one pound wrist weight, and (3) "elbow flexion/extension with shoulder fully flexed" using a mallet aiming towards a tambourine (p. 136). The investigator demonstrated target movements, and while participants practiced sequences, investigator again calculated optimal tempo for each individual. Music was then set to individual optimal tempo and turned on while participants completed sequence until becoming fatigued. When one folk song ended, participants were instructed to begin the next movement sequence along with

another song. This was repeated until all movement sequences were completed. At the completion of all exercises, participants completed exertion and fatigue scales.

The first TOT session contained the identical target movement as the first TIMP session. However, no musical instruments were used and the only instrument used was a hand held weight during exercise. The investigator demonstrated the exercise and requested that the participant repeat the sequence at a comfortable pace. The investigator then instructed the participant to repeat the sequence as long as he or she could before becoming fatigued, uncomfortable or in pain. Duration and frequency of exercise were measured.

The second TOT session contained identical target movements as the second TIMP session, again without musical instruments and with a one pound hand held weight. The investigator demonstrated all movement sequences. Participants were given 20 seconds to practice exercises. The investigator instructed the participants to complete 32 repetitions of the first movement while investigator counted and provided visual cues. Participants then proceeded to complete 16 repetitions for the second movement sequence and 32 repetitions of the third movement sequence. Upon completion of all exercises, participants were asked to complete perceived fatigue and exertion scales.

During the TIMP condition the mean frequency was 65 repetitions of the target movement and the mean duration of exercise was 89 seconds. However, during the TOT condition the mean frequency was 58 repetitions of the target movement and the mean duration of exercise was 92 seconds. Authors conclude that the participants were able to produce more target movements within a shorter time using TIMP, and fewer target movements within a longer time period in the TOT condition. Participants reported lower fatigue levels during both conditions, and indicated not being as tired during TIMP compared to TOT. Participants also

indicated that the TIMP session was easier than the TOT session. Overall, the researchers found that the TIMP sessions may be more effective than TOT sessions when assessing patient perception, frequency and duration of target movements. Future research using these strategies may further verify efficacy.

#### Non-NMT TIMP Studies

Schneider, Schonle, Altenmuller, and Munte (2007) conducted research to observe if using musical instruments would improve motor functions for individuals following a stroke. This study is particularly interesting because the researchers followed the NMT protocol when using TIMP in rehabilitation, but it is not clear that they were aware that they were using the technique or that NMT research existed. The researchers did use music therapy as a keyword for their study, but there was no mention or description in the body of the article. Study participants consisted of forty individuals (13 female, 27 male) between the ages of 54 and 58 with moderate impairment of motor function of upper extremities. Prior to beginning the study, each participant was evaluated for motor function capabilities using an Action Research Arm Test, Computerized Movement Analysis System, Arm Paresis Score, Nine Hole Pegboard Test, and a Box and Block Test. First, participants were randomly assigned to either the conventional therapy group (n=20) or the music-supported training plus conventional therapy group (n=20). Participants in the music supported training group received twenty-seven sessions of conventional therapy and fifteen sessions of music training for thirty minutes over a three week study period. Participants in the conventional therapy group received twenty-seven treatment sessions for thirty minutes over a span of three weeks. Conventional therapy sessions incorporated individual physical therapy, occupational therapy, and some group therapy. Music-supported training used two different instruments including a MIDI-piano, and an electric drum set with eight pads.

Interestingly, the drum set pads were set to produce piano sounds, not drum sounds. Researchers did this to facilitate both fine and gross motor functions. All exercises were demonstrated first by the researcher and mimicked by the participants. Results showed that the music-supported training group showed improvements in velocity, range of motion, and the quality of movement whereas the conventional therapy group did not yield these improvements. However, the results were not statistically significant.

Cofrancesco (1985) examined the effect of music therapy interventions on improving hand grasp in stroke patients. Methods used in this study were similar to TIMP, but the researcher did not refer to NMT due to the study predating the founding year of NMT. Participants consisted of three stroke patients (ages 50-75) with partial paralysis, specifically left hemiplegia due to a CVA. The procedure for the study included 15-20 music therapy sessions over a five week period. Each session took place for 30-35 minutes each time. Data collection included the use of the Jamar Adjustable Dynamometer to measure hand grasp strength. Several tests were administered as pretest/posttest measures to identify possible treatment effects, such as the nine-hole peg test, 15-hole peg test, stacking graduated boxes, a Diagnostic Assessment of Music Related Expression and Behavior, and the "Classification and Progress Record" form (Brunnstrom, 1970, chap. 2; Cofrancesco, 1985). All participants received a 3-minute warm-up massage and were then individually assessed by an occupational therapist or music therapist using the identified tests before and after the treatment program. The treatment protocol incorporated three phases: The first phase included concentration skills, bilateral movement, and grasp and coordination techniques using a tambourine, cymbal, drum, and claves. The second phase incorporated the use of the piano to increase finger dexterity, muscular strength, and joint

motion, and the third phase introduced the autoharp to improve coordination skills and finger dexterity. After each music therapy treatment, Dynamometer readings were recorded.

Results indicated slight improvements during music therapy treatment. All three participants had less substantial gains in their left side functioning due to damage to the right side of their brain. Future research in this area may include the use of Musical Neglect Training (MNT) along with TIMP to improve outcomes on the patients affected side due to stroke.

Zelazny (2001) examined the effects of keyboard playing on fine motor skills of hand osteoarthritis in older adults. This is also another study that follows the protocol for using TIMP without mentioning its use. Participants consisted of four females between the ages of 84 and 88 who were diagnosed with hand osteoarthritis. The study was conducted over the course of four weeks to measure finger pinch ability. A visual Likert scale was used to measure participants' arthritic discomfort. Before and after each session researchers measured keynote finger velocity by using a Yamaha keyboard connected to a computer. To establish a baseline for each participant, a finger pinch measurement was taken two days prior to the start of keyboard sessions. The Likert discomfort scale was given to each participant before and after each session. During the initial keyboard session, the investigator guided each participant through a series of folk tunes using both hands. After assessing individual abilities and capabilities, the researcher adapted each session to meet their individual learning style. The researcher took each song and typed in the correct finger numbers on a sheet of paper. Each song was within the five finger C position for both hands. At the conclusion of the study, finger pinch measurements were again assessed.

Pinch meter measurements indicated varied results for each participant. Participant I and II remained fairly consistent from pre to post study. Participant III only had a slight improvement

of the left lateral. Participant IV had improvements across all pinch meter measurements. The Likert discomfort scale revealed that participant I reported an increase in discomfort after playing the keyboard, whereas participant II and IV reported decreases in discomfort. Participant III did not experience any significant changes in discomfort after playing the keyboard. Measurements for keynote finger velocity indicate that finger velocity increased significantly from pre to posttest for participants I, II and IV. However, results for participant III indicate decreased velocity from pre to posttest. Overall, results indicate three of the four participants made significant improvements in finger agility and strength. The author concluded that playing the keyboard may be effective to help manage hand osteoarthritis in older adults.

### Conclusions

One main weakness was found throughout the TIMP and TIMP-like studies. Researchers did not mention validity or reliability of their studies. Cofrancesco (1985) and Zelanzy et al. (2001) used very small sample sizes limiting generalizability, whereas, both Schneider et al. (2007) and Lim and Fabian (2011) conducted research with larger sample sizes, allowing for more reliability of the outcome and making the studies more generalizable. On the whole, results show a consistency of positive outcomes after using TIMP for rehabilitation. One limitation worth noting is demonstrated in Schneider et al. where the researchers should have exposed their control group with the same amount of therapy sessions, making the results more comparable. In this study, the music group received fifteen extra sessions of therapy which allowed more improvements to occur. TIMP appears to be an effective intervention for individuals with osteoarthritis, paralysis due to stroke, and physical deficits due to orthopedic surgery.

Sensorimotor Rehabilitation Techniques

	Year	Journal	Participants	Population	Country	Results	NMT	Non-NMT
<b>Therapeutic Instrument Music Performance (TIMP)</b>								
Title: The effects of therapeutic instrumental music performance on endurance level, self-perceived fatigue level, and self-perceived exertion of inpatients in physical rehabilitation Authors: Lim et. al.	2011	Journal of Music Therapy	n=35, mean age=79 9 male/26 female	Individuals with physical deficits due to orthopedic surgery or neurologic disorder	United States	Positive	X	
Title: Therapeutic instrumental music playing in hand rehabilitation for older adults with osteoarthritis: Four case studies. Author: Zelanzky	2001	Journal of Music Therapy	n=4 (female) 84-88 y/o	Older adults with hand osteoarthritis	United States	Positive		X
Title: The effect of music therapy on hand grasp strength and functional task performance in stroke patients Author: Cofrancesco	Predates NMT 1985	Journal of Music Therapy	n=3 50-75 y/o	Stroke pt's with partial paralysis	United States	Positive		X
Title: Using musical instruments to improve motor skill recovery following a stroke Authors: Schneider et. al.	2007	Journal of Neurology	n=40, 13 females/ 27 males, 54-58 y/o	Individuals with a moderate impairment of motor function of upper extremities following a stroke	Germany	Positive		X
Percentages: 75% non-NMT, 25% NMT								
<b>Patterned Sensory Enhancement (PSE)</b>								
Title: A home-based program using patterned sensory enhancement improves resistance exercise effects for children with cerebral palsy: A randomized controlled trial Authors: Wang et. al.	2013	Journal of Neurorehabilitation and Neural Repair	n=33, 5-13y/o	Children with spastic diplegia	Taiwan	Positive	X	
Title: The effects of live patterned sensory enhancement on group exercise participation and mood in older adults in rehabilitation Authors: Clark et. al.	2012	Journal of Music Therapy	n=24, 8 male/16 female 65-101 y/o	Older adult inpatients in a rehabilitation center with physical and psychosocial deficits	Australia	Negative	X	

Title: Comparative effectiveness of exercise with patterned sensory enhanced music and background music for long-term care residents Authors: O'Konski et. al.	2010	Journal of Music Therapy	n=45, 3 male/42 female 53-94 y/o	Dementia and Alzheimer's disease	United States	Positive and Negative	X	
Title: Immediate effects of therapeutic music on loaded sit-to-stand movement in children with spastic diplegia Authors: Peng et al.	2011	Journal of Gait and Posture	n= 23, 5-12 y/o 13 male/10 female	Children with spastic diplegia due to CP	Taiwan	Positive	X	
Percentages: 100% NMT								
<b>Rhythmic Auditory Stimulation (RAS)</b>								
Title: The use of auditory rhythm and rhythmic speech to aid temporal muscular control in children with gross motor dysfunction Author: Thaut	Predates NMT 1985	Journal of Music Therapy	n=24, all male, 6-9 y/o	Children with gross motor dysfunction	United States	Positive		X
Title: Rhythmic auditory stimulation in gait training for patients with traumatic brain injury Authors: Hurt et. al.	Predates NMT 1998	Journal of Music Therapy	Study 1: n=8 (5 male/3 female) 25-35 y/o Study 2: n=5 (3 male/2 female) 25-35 y/o	Individuals with TBI	United States	Positive	X	
Title: Differential effects of rhythmic auditory stimulation and neurodevelopmental treatment/bobath on gait patterns in adults with cerebral palsy: A randomized controlled trial Authors: Kim et. al.	2012	Clinical Rehabilitation	n=28, 18 male/10 female mean age=27 y/o	Individuals with CP	South Korea	Positive and Negative	X	
Title: Changes in gait patterns with rhythmic auditory stimulation in adults with cerebral palsy Authors: Kim et. al.	2011	Neurorehabilitation	n=44 (24 male/20 female) 21-26 y/o	Individuals with CP and healthy individuals	South Korea	Positive	X	
Title: Music and rhythmic stimuli in the rehabilitation of gait disorders Author: Staum	Predates NMT 1983	Journal of Music Therapy	n=16 (52-87 y/o) n=9 (5-19 y/o) 15 female/10 male	Individuals with gait abnormalities due to CP, scoliosis, CVA, PD or TBI	United States	Positive	X	
Title: The effect of rhythmic auditory stimulation (RAS) on gait characteristics of cadence, velocity, and stride length in persons with late stage dementia Authors: Clair & O'Konski	2006	Journal of Music Therapy	n=28 (24 female/4 male) 70-92 y/o	Older adults with dementia	United States	Negative	X	
Percentages: 16.7 % non-NMT, 83.3% NMT								

Table I

## CHAPTER IV:

## Speech and Language Rehabilitation Techniques

There are many individuals who are struck by an unexpected loss of speech from different neurologic injuries or disorders that are able to regain speech through music. “With many similarities between music and speech, it has often been assumed that music, and especially singing, is a valuable tool for the treatment of speech disorders” (Thaut, 2008, p. 166).

Techniques used for speech and language rehabilitation in neurologic music therapy include, Melodic Intonation Therapy (MIT), Music Speech Stimulation (MUSTIM), Rhythmic Speech Cueing (RSC), Vocal Intonation Therapy (VIT), Therapeutic Singing (TS), Oral Motor and Respiratory Exercises (OMREX), Developmental Speech and Language Training through Music (DSLTM), and Symbolic Communication Training through Music (SYCOM) (Thaut, 2008).

Melodic Intonation Therapy

Oliver et al. (2005) defines melodic intonation therapy (MIT) as:

A treatment technique developed for the rehabilitation of expressive (Broca’s) aphasia; there is also some evidence for its use with apraxia conditions. MIT utilizes a patient’s unimpaired ability to sing to facilitate speech production. Functional sentences or brief statements/utterances are translated into song (or more accurately melodic intonations) by translating the speech inflection patterns into musical prosody. In later stages, the singing is reduced to ‘speech singing’ and finally retranslated into normal speech. (p. 4)

MIT predates NMT, and was created in 1973 by Sparks, Helm and Albert. MIT is typically used with individuals with left-side lesions in the Broca's area that is accountable for speech production. Individuals with Broca's aphasia generally have the ability to sing familiar songs. However, they cannot produce meaningful statements. As Thaut (2008) states, "the rationale for MIT is based on a hemispheric transfer of speech functions from the left-hemisphere to its right-hemisphere homologue during encoding of speech into singing" (p. 166). Purposeful sentences or statements are transformed into song by transferring the speech intonation pattern into musical poetic rhythm. First, the music therapist presents a specific utterance by humming the melody and tapping the client's hand (some individuals have difficulty allowing the therapist to touch them, adaptation may be necessary). Next, there is an interchange of therapist singing alone, the client and therapist singing in unison, and then possibly a singing conversation involving the therapist and client. This is followed by a fading stage where the client continues the utterance while the therapist fades out. To aid the client to initiate verbal output the therapist and client alternate in singing the phrase. This also helps the client create the intended outcome of producing the statement independently. The final step involves the therapist questioning the client to practice the statement. This can be accomplished first by singing the practiced statement and eventually doing so verbally, without the singing (Thaut, 2008).

#### NMT MIT Studies

LaGasse (2012) conducted research to evaluate MIT for individuals with developmental apraxia of speech (DAS). The purpose of this research was to look at the use of MIT in creating functional speech production for a child with DAS. This experiment involved two children with developmental apraxia of speech. Both participants completed four MIT sessions and five speech

language pathology (SLP) sessions each week for four weeks. LaGasse (2012) used a pre-test/post-test design to establish the differences in “speech sounds (phonemes), sequencing, blending, and production” (p. 49). Each participant received both SLP and MIT treatments. Researchers used the Goldman-Fristoe Test of Articulation, and the Khan-Lewis Phonological Analysis that tests articulation and speech production.

Both participants had minimal improvement in their speech when engaged in MIT per evaluation from testing measures. The noted improvements were that one had fewer substitution errors, and had more sequenced movements. Participant two also showed improvement in sequencing; however his speech production was more inconsistent. The author concluded that a weakness of MIT is using it with children due to the difficulty in maintaining interest. Some possible adaptations may include the use of American Sign Language (ASL) and pictures. Making alterations to the technique to make it more fun for children may increase improvement and participation.

Krauss and Galloway (1982) explored the use of MIT with children with apraxia and delayed speech. Interestingly, this study also sought to establish if MIT is generalizable to children. Researchers acknowledged it was necessary to modify the strict MIT procedures when working with children. This is interesting because this study was conducted thirty years prior to LaGasse (2012) and she mentioned needing modifications to typical MIT procedures to better suit use with children. Some thirty years later, there remains limited research regarding the use of MIT with children. A pre/post-test design was used with two male children participants. Both boys had expressive language below normal age level and diagnosed as suffering from verbal apraxia. Participants underwent two pre-tests using two different types of speech/language assessments including the Porch Index of Communicative Ability in Children, and Language

Sampling Analysis, and Training, and one post-test including the same assessments. Prior to beginning MIT, both participants had 2 months of traditional therapy to serve as a control condition. Following the control condition, the children received two months of traditional therapy with MIT as a warm-up consisting of 20% of each session. During the experimental condition, the therapist implemented several new phrases or sentences with each successive session.

Results revealed significant improvements in verbal naming articulation skills, and phrase length response. Interestingly, the authors found that the results of this study are equivalent to those of adult studies who receive MIT for treatment of apraxia. Adaptations to the MIT technique aided to elicit verbal output with the use of visual cues. Overall, this study found that MIT assisted in word retrieval in individuals with delayed language apraxia.

Schlaug, Marchina, and Norton (2008) conducted a study to evaluate components of MIT and the effects of the treatment using speech repetition therapy (SRT), a strategy that was designed to use elements of MIT without using melodic intonation and hand tapping. Both participants received language assessments and brain imaging throughout the study. The study participants consisted of two adult individuals diagnosed with severe non-fluent aphasia who had received speech therapy prior to receiving MIT. Patient one was randomly selected to receive MIT for treatment and patient two was randomly selected to receive SRT and MIT. Both participants received seventy-five sessions for 1.5 hours per day, five days a week.

After 40 sessions of MIT, patient one had improvements on speech and item naming, and after 75 sessions of MIT, those improvements were even more distinct. After SRT, patient two had improvements in speech output and picture identification and further improvements after switching to MIT treatment. Overall, the MIT patient showed more improvement than that of the

SRT/MIT treated patient across all outcomes and both patients had positive changes in left/right brain hemisphere activation as per evaluation of their fMRI.

Zipse, Norton, Marchina, and Schlaug (2012) conducted an experiment to investigate the efficacy of an adaptation of MIT and also to examine what changes to the MIT protocol might facilitate improvements in an individual with no feasible functioning left hemisphere areas to assist in the process of speech function recuperation. This study participant was an 11-year-old girl who had a stroke that left her with a large left hemisphere lesion. She underwent a multiple baseline design which was used to assess the trained versus untrained production of phrases. The participant participated in five 1.5 hours of treatment per week for 16 weeks. The sessions continued for 16 weeks (totaling 80 hours of treatment). MIT followed typical protocol with the addition of pictures used to cue each phrase. Research included two phases (sessions 1-40 and 41-80). The first phase introduced MIT to the client and the second phase added an emphasis on syntax.

Findings showed an improvement on both trained and untrained phases, and an improved communicative fluency. The participant easily mastered phase one, but was still having difficulties with fluency. Subsequently, when the client completed MIT sessions, her fMRI reflected an increased activation of the frontal areas of the brain. The authors stated, “This could reflect an increased efficacy of a right hemisphere front temporal system” (Zipse et al., 2012, p. 244). This finding could be the result of the brain compensating for the damaged regions of the brain. This study provides additional evidence for the efficacy of MIT therapy with individuals with left hemisphere lesions.

Baker (2000) demonstrated the differences and similarities between MIT and an adapted version of MIT. The aim of the study was to observe how using an adapted version of MIT

helped two adults reclaim a significant and purposeful communication system. Both participants have severe damage to the left-hemisphere of the brain and had been working with a speech pathologist to help regain speech. However, the speech pathologist was not seeing progress so the participants were referred to receive MIT. The modified MIT consisted of three steps including, “(1) engaging the client in singing of familiar, well-known songs, (2) introducing a small number of meaningful phrases, set to simple melodies (repeated several times), and lastly (3) the therapist incorporates target words in normal conversation to test independent word generation” (pp. 111-112). One participant received MIT five times weekly for thirty minutes and throughout this period, the collaboration by the music therapist and speech pathologist aided in increased positive outcomes. The other participant received MIT three to four times weekly for thirty minutes.

On final assessment, the first participant gained functional communication of 148 words/phrases of which she could recall 124 independently and the remaining 124 with a musical cue. On the other hand, the second participant could independently produce 30 words and the names of all his family members. Although the second participant had fewer improvements, these results were significant to him and significant to the severity of his brain injury. This emphasizes the prospective importance of making adaptations to MIT protocols that may facilitate persons with severe non-fluent aphasia to salvage their ability to verbally communicate. The strength of this study was that the authors incorporated phrases and names that were important to the clients into their therapy that could also demonstrate motivation due to MIT.

Brier, Randle, Maher, and Papanicolaou (2010) examined a possible association between the improvement of language functions and activation in the language portions of the left-hemisphere when using MIT. The study included two male adults between the ages of forty-nine

and fifty-five years old with chronic expressive aphasia. They underwent MIT for thirty minutes, twice a week for three weeks (block one) and then again for another three weeks (block two), totaling 12 hours of treatment. Data was collected through a magnetoencephalography (MEG) after MIT to illustrate brain changes. Results showed signs of activation in the left hemisphere of both participants' brains after MIT indicating a significantly positive result in reactivating portions of the brain after a stroke.

Laughlin and Naeser (1979) studied the possibility of prolonged syllable duration to improve communicative presentation using MIT. Participants consisted of five adult stroke patients, four of whom had left hemisphere lesions and one who had bilateral lesions. All participants were identified as having either Broca's aphasia, mixed aphasia, or Global aphasia. For each participant a baseline for "phrase repetition level (number of syllables per phrase which could be reliably repeated)" was determined (p. 315). Sparks and Holland (1976) created the five MIT steps that are used in the procedure of this experiment and are listed as follows: (1) Unison humming, (2) unison intoned phrase production, (3) clinician fades as patient attempts intoned production alone, (4) patient repeats intoned production alone, (5) patient intones appropriate response to clinician's intoned question (Laughlin & Naeser, 1979, Sparks & Holland, 1976, p. 316). Each subject had 12 sessions, three times per week for 30 minutes. During the sessions, 60 different stimulus idioms with different syllable durations were administered.

Results indicate a significant improvement in correct phrase productions when using 1.5 and 2.0 second per syllable with intoned conditions only during step 4 (phrase production by participant only) and 5 (phrase production by participant only in response to question from therapist). The findings also suggested that as the MIT steps became more difficult for the participants, the amount of accurate phrase productions decreased. In light of the minimal

amount of research on syllable durations using MIT since 1979, it may be beneficial to continue studies such as this.

### Conclusions

In reviewing these articles, this author found that the majority of the studies contained extremely small sample sizes. This makes it difficult to generalize the positive or negative effects of MIT treatment to the general population.

The majority of the studies found that MIT seems to be an effective technique for individuals with left hemisphere lesions to regain speech. Also, when working with children, a modified version of MIT is necessary to facilitate engagement in the technique to increase improvement. MIT was initially developed for individuals with Global aphasia, expressive aphasia, general aphasia and apraxia. This research has provided music therapists an opportunity to better understand neurologic disorders and has also aided in understanding the means to facilitate improved individualized plans for our clients. More research on neurologic music therapy techniques are imperative not only to increase awareness to other healthcare professionals, but also to families and friends of those who have been struck by a neurologic disorder. MIT cannot help those who have never heard of it.

### Musical Speech Stimulation

Oliver et al. (2005) define Melodic Speech Stimulation (MUSTIM) as:

A technique used in aphasia therapy that utilizes musical and music-related materials, such as songs, rhymes, chants, musical phrases, simulating prosodic speech gestures, in order to stimulate non-propositional speech. These therapeutic musical exercises are directed to trigger non-propositional speech through, for example,

completion or initiation of over learned familiar song lyrics during singing, spontaneous production of words via their association with familiar song tunes, or using musical phrases to elicit and shape functional speech responses. (p. 5)

For example, spontaneous completion of familiar sentences is stimulated through familiar tunes or obvious melodic phrases (i.e. “You are my ...” or “How are ...?”) (Thaut, 2008). Though MUSTIM is typically used with individuals with aphasia, this technique may be used with other populations. It may also be used to model speech gestures. For example, a music therapist may play an instrument to mimic a statement or by accenting dynamics to emphasize a statement (Thaut, 2008). Modeling speech gestures to trigger an automatic fill-in of an intended statement by the client can also lead to other positive outcomes (i.e. improved quality of life). The following research studies demonstrate examples of MUSTIM being used in speech and communication rehabilitation. No NMT MUSTIM studies were found.

#### Non-NMT Studies

Yamaguchi, Akanuma, Hatayama, Otera and Meguro (2012) examined the effects of singing different melodies to improve speech in people with severe aphasia. The study participant was one seventy-nine year old woman. In the first music intervention, the participant was asked to sing sixteen songs including folk, nursery and popular songs. She practiced songs with a therapist to improve lyric production. For the second music intervention, the participant was asked to repeat singing a new familiar simple melody. She then repeated singing this melody to memorize and utter the lyrics over a three month period (weekly sessions for thirty minutes). And lastly, two songs used during the first intervention were selected and used as a cue to elicit spontaneous speech. The therapist began by bowing to the client as the lyrics from the song said,

“hello.” The client then sang the word, “hello.” The therapist then began singing the other selected song and as the word, “goodbye” was sung, the therapist waved goodbye. After this cue, the client sang the word “goodbye.” The client practiced this thirty-eight times for ten minutes.

In the initial intervention, the client was able to spontaneously sing the first verse of eight different songs just by hearing the name of the song. Initially, at the beginning of the second intervention, the client could not understand directions and was not able to sing the familiar melody. Over time, she was able to repeat the lyrics, but only after receiving a cue to sing from the therapist. The third intervention yielded significant results as the client was able to say “hello” and “goodbye” on cue. Ultimately, using music semantic recall facilitated activation in the left hemisphere of the brain, thereby improving the ability of an individual with severe aphasia to sing/speak.

Ozdemir, Norton, and Schlaug (2006) examined the possibility of shared neural substrates of singing and speaking in persons who do not have neurological, psychiatric or hearing problems. Participants consisted of ten people (5 female, 5 male) with an average age of twenty-four years old. Before beginning the study, researchers made recordings of 20 bi-syllabic words and phrases both spoken and melodically intoned on two different pitches (Ozdemir et al., 2006). The study included two experimental conditions; intoned (singing) and non-intoned (speaking) of bi-syllabic words and three control conditions; humming, silence, and vowel production. During the speaking condition, participants heard bi-syllabic words or phrases and after hearing a cue (a ding), they were asked to repeat what they heard. When the participants were administered the singing condition, they heard recorded melodic words and phrases and were asked to repeat as many as they could. In the silence condition, participants did not hear any stimuli. During the humming control condition, participants heard the same two pitches that

were used in the singing condition but hummed, and they were asked to repeat what they heard after hearing the auditory cue (a ding). In the vowel production control condition, a spoken vowel pair was presented and after the auditory cue, participants were asked to repeat what they heard. Each individual in the study received an fMRI pre and post treatment. The results indicate that the singing condition showed more brain activation compared to the speaking condition, as reflected on fMRI's. In particular, this study showed the use of MUSTIM in a non-conventional way, providing validity in using this technique to stimulate brain activation.

### Conclusions

Both studies had several differences including sample populations (healthy individuals and individuals with non-fluent aphasia), sample sizes, methodology, and results. Yamaguchi et al. (2012) only studied one individual, while Ozdemir et al. (2006) studied ten individuals. Interestingly, both studies did not indicate using the term MUSTIM. However, they followed the protocol. Limitations for both studies could be the limited sample sizes used allowing for minimal generalizability to the general population. However, facilitating an fMRI to participants in both studies does increase validity and reliability of results. Though the studies vary in many aspects the outcomes indicate positive changes in participants.

### Rhythmic Speech Cueing

Oliver et al. (2005) define Rhythmic Speech Cuing (RSC) as:

a rate-control technique that uses auditory rhythm (metronome form or embedded in music) to cue speech. The impelling and anticipatory action of a rhythmic stimulus sequence can also help to initiate speech. RSC has been shown to be effective in fluency disorder rehabilitation for stuttering and cluttering, in rate control

to enhance intelligibility in dysarthric patients, and in facilitating rhythm sequencing in apraxia. (p. 6)

RSC can be divided into two groupings including, “metric and patterned cuing” (p. 170). Patterned cuing involves the use of beat patterns to rouse normal speech inflection. Metric cuing is when beats are equivalent to syllables, allowing for speech inflection. The following research study is non-NMT. However it follows protocol for RSC.

#### Non-NMT Study

Max and Yudman (2003) examined the speech and non-speech rhythmic timing capabilities of persons who stutter and do not stutter. Participants consisted of ten (7 male, 3 female) people who stutter and ten (7 male, 3 female) who do not stutter between the ages of twenty-six and forty-six. All participants completed the Lateral Preference Inventory (LPI) and three rhythmic timing tasks. Researchers stated, “The timing tasks required isochronous rhythmic movements of (a) orofacial structures for speech production, (b) orofacial structures for non-speech production, and (c) index finger and thumb” (p. 148). Auditory stimuli used for the study included sine wave beeps set at 50ms and 500Hz and were offered through headphones. While listening to stimuli, participants were asked to begin movements when they felt they were able to synchronize with the stimuli. After individuals completed ten movements, auditory stimuli ceased, and they were asked to continue movements at the same rate for ten more movements. For both the speech and non-speech tasks, participants were asked to synchronize the correct response with the auditory stimuli. The speech task required a response of the syllable “pa” and the non-speech task required a popping sound created by pushing lips together and releasing. Instrumentation used for data collection included a custom designed electrogoniometer to measure finger-movement and a head-mounted strain gauge to determine movements of the

lips and jaw. Results indicate that both individuals who stutter and who do not stutter performed equally well when timing isochronous speech, non-speech and finger movements.

Currently there is a paucity of research conducted using RSC. Therefore there is not enough evidence to demonstrate effectiveness.

### Vocal Intonation Therapy

Oliver et al. (2005) defines Vocal Intonation Therapy (VIT) as:

A technique used to address issues in the rehabilitation of voice disorders. Musical vocalization, e.g. through singing, breathing, and other vocal control exercises, is directed at training all aspects of voice control, including inflection, pitch, breath control, timbre, loudness, phonation, and resonance. (p. 7)

Some different therapeutic approaches could include relaxation, phonation or intoned voicing exercises. The following three research studies include different approaches to using VIT in speech and language rehabilitation.

### NMT VIT Study

Tamplin (2008) conducted a pilot study to examine the effect of vocal exercises and singing on persons with dysarthric speech. Participants were three females, and one male between the ages of 19 and 51 with dysarthria due to cerebralvascular accident. Each participant received three music therapy sessions per week for eight weeks. Sessions were thirty minutes long and contained vocal exercises and singing three familiar tunes. Reasoning for interventions were to strengthen muscles and mechanisms involved in speech, to model articulation, and to cue rate of speech. The Sentence Intelligibility Test (SIT) was used to assess rate of speech, communication efficiency, and to calculate intelligibility scores. Also used in the study was a

Picture Description Test (PDT) to evaluate unprompted speech. Pre, mid and post assessments were conducted for each participant. The SIT assessment required recording the participants as they completed 5-15 word sentences. The PDT required the participants to describe a photo within 3 to 4 sentences.

Results showed several improvements over the duration of the study. This included increased speech intelligibility on the PDT test between pre and post assessments. The author concluded that the mean intelligibility and mean rate of speech on both the PDT and SIT assessments. Post-treatment sentences were assessed as being more natural than pre-treatment 85% of the time. Also, results showed a decrease in pause length between words from pre to post assessment. On the whole, all four participants attained improvements in functional intelligibility following music therapy intervention.

#### Non-NMT VIT Study

Yinger and Lapointe (2012) examined the effects of the Haneishi's (2011) Group Music Therapy Voice Protocol (G-MTVP) on individuals with Parkinson's disease. The study evaluated the intensity, fundamental frequency, and fundamental frequency variability of speech in the participants. Ten individuals with Parkinson's disease (7 men/ 3 women) ranging in age from 59 to 85 years of age were included in the study. Each participant attended weekly rehearsals for a choir of individuals with PD which followed the procedure of a G-MTVP. Each participant received G-MTVP one to two times weekly for six weeks. At the mid-point of the study, a probe test was given to the participants. The researcher recorded each participant reading three sentences aloud from the Rainbow Passage. The researcher then recorded 30 seconds of each participant's conversational speech. Choir rehearsal followed a fifty minute G-MTVP which consisted of the following: (1) Opening conversation (5 minutes), (2) physical warm-ups (5

minutes), (3) breathing exercises (5 minutes), (4) speech exercises (5 minutes), (5) vocal warm-ups (5 minutes), (6) singing exercises (20 minutes), and (7) closing conversation (5 minutes).

Researchers examined voice recordings using Praat Software. The G-MTVP appears similar to VIT as they both use vocal exercises to produce similar speech and language outcomes. The only difference is that the G-MTVP uses facial warm-ups and conversation at both the beginning and end of procedures.

Pretest, probe and posttest measures indicate a significant difference in the intensity of the reading passage. Results also showed a significant increase of intensity of conversational speech from pretest to posttest. As the researchers state, even if the participants were only able to maintain functions of speech after the G-MTVP this is still seen as progress. Researchers indicate that this may be due to the participants having a degenerative disease where the ability to maintain function over time is unlikely. In any case, it is difficult to know if the vocal functioning would have improved without using the G-MTVP protocol, as there was no control group. Overall, the study showed evidence for using G-MTVP in improving speech for individuals with Parkinson's disease.

### Conclusions

In summary, these two studies are extremely different. Tamplin (2008) is the only article where VIT is specifically used, whereas Linger and LaPointe (2012) do not specify the use of VIT. These studies have small sample sizes (reducing generalizability), different methodologies, different locations (United States, Australia, and Sweden), and different sample populations. Both Tamplin and Yinger and LaPointe found statistically significant results when using VIT in speech and language rehabilitation.

### Therapeutic Singing

Oliver et al. (2005) define Therapeutic Singing (TS) as:

A technique which involves the unspecified use of singing activities to facilitate initiation, development, and articulation in speech and language as well as to increase functions of the respiratory apparatus, used with a variety of neurological or developmental speech and language dysfunctions. TS addresses a wide spectrum of functions in a more general and undifferentiated way and can incorporate and support the goals of other, more specific therapeutic techniques. (p. 8)

Singing techniques include the formation of sound, articulation, breath control, and more specifically the movement of the speech motor apparatus. Many different functions occur simultaneously when producing vocalizations. Therefore, singing can facilitate several improvements in speech and language. Other NMT techniques like OMREX or VIT could be reinforced by using TS in rehabilitation settings. The following research studies use TS to improve speech and language in several different sample populations. There were no NMT studies found for VIT.

#### Non-NMT TS Studies

Cohen and Masse (1993) explored the effects of singing and rhythmic instruction on the rate and intelligibility of persons with neurologic impairments. They also wanted to establish if age, musical experience, and type of neurologic impairment influenced participants' speech production. The participants consisted of thirty-two adults with multiple sclerosis, cerebral palsy, Parkinson's disease, or cerebral vascular accident. Participants were randomly assigned to one of three groups: the control group (n=14), the singing group (n=9), or the rhythm group (n=9).

Study test included the Computerized Assessment of Intelligibility of Dysarthric Speech (CAIDS). This assessment was conducted pre and post test (after the 6<sup>th</sup> and 12<sup>th</sup> sessions). Participants were separated into two treatment groups: the rhythmic instruction and singing instruction groups. Both treatment groups incorporated the same speech material including vowels, words, and functional sentences. Treatment groups met twice weekly for thirty minutes each time. The singing instruction group incorporated several different exercises including breathing exercises, vocal exercises, and group singing. The rhythmic instruction group focused on rhythmic imitation, vowel production, functional sentences, “automatized material” (i.e., lyrics, sayings), and monosyllabic and polysyllabic word formation (Cohen & Masse, 1993).

The results showed an increase in produced words per minute by 21 words after rhythmic instruction, and 23 words after singing instruction. The control group increased in produced words per minute by two words. The findings revealed a decrease of percentages of verbal intelligibility by 5% in both the control and rhythmic groups, yet increased by 21% in the singing group. The authors concluded that there was an increase in vocal intensity for both treatment groups and also an increase in vocal range in the singing group. In general, the present study effectively examines the effects of rhythmic and singing instruction on the rate of intelligibility of speech in persons with neurologic impairments.

Cohen (1992) sought to evaluate the effects of singing instruction on the speech of individuals with neurologic impairments. Participants consisted of eight individuals who volunteered for the study, six of whom were placed into the treatment group and two who were placed in the control group. Sessions occurred three times weekly in thirty minute intervals for a three week period. On the first day of the study, participants were asked to describe two photos. Photo descriptions were recorded for each subject. Treatment sessions included vocal, rhythmic

and physical exercises and singing familiar tunes. Instruments consist of a Kay Elemetrics Corporation DSP Sono-graph to determine vocal intensity and mean duration of speech.

Five out of the six treatment subjects had improvements in speaking fundamental frequency, rate of speech, vocal intensity, and verbal intelligibility. The one treatment subject that did not show improvements only attended four treatment sessions due to medical complications. The control subjects showed improvements in vocal intensity, verbal intelligibility, and rate of speech. Results also showed that the mean percentage of speech pause time decreased 25% from pre to post test. Cohen (1992) stated, “The results reinforced the possibility that neurologically impaired persons with expressive speech disorders can benefit from singing instruction, especially in the areas of speaking fundamental frequency variability, speech rate, and verbal intelligibility” (p. 100).

Baker, Wigram, and Gold (2005) examined the effects of a singing intervention on speaking intonation of individuals with TBI. Participants consisted of four 24 to 29 year old males. The study lasted five to eight weeks, totaling fifteen sessions for forty-five minutes each session. Participants selected three songs to sing and researchers provided lyric sheets and guitar accompaniment. Data was collected pre and post session in which participants were asked to complete three tasks. These tasks included; singing the lowest and highest note they could produce to identify voice range, to read four sentences aloud to assess ability to emote, and to complete a visual analog mood scale (VAMS). For data analysis, all sessions were recorded.

The results of the study illustrated that partaking in singing seemed to have a long-term effect on improving expressive speech, mood and voice range of persons who have a TBI. The author of this systematic review believes that future research on this topic may consider using

different songs over the course of the study to increase vocal flexibility and variation in musical mood expression.

### Conclusions

Studies using TS used several different sample sizes, sample populations, methodology, and results. Both Cohen (1992) and Baker et al. (2005) only used a few participants in their studies, limiting reliability and generalization. Overall, the studies listed contained positive outcomes where TS had improvements in speech and language. This indicates that even though the researchers did not specifically mention the use of TS, they still succeeded in using the protocol.

### Oral Motor and Respiratory Exercises

Oliver et al. (2005) define Oral Motor and Respiratory Exercises (OMREX) as:

The use of musical materials and exercises, mainly through sound vocalization and wind instrument playing, to enhance articulatory control and respiratory strength and function of the speech apparatus. These techniques may be applied in development disorders, dysarthria, muscular dystrophy, and other disorders affecting speech motor control and respiratory function. (p. 9)

OMREX was specifically intended to work on articulation control rather than voice quality (Thaut, 2008). The use of wind instruments such as kazoos, whistles, and flutes help patients to improve speech muscle functioning and improve respiratory control and cardiopulmonary functions (Thaut, 2008).

### NMT OMREX Studies

Kim (2010) sought to determine if music assisted treatment would affect the swallowing function of stroke patients with dysphagia. Participants consisted of eight individuals between the ages of 50-70 years. The study began with an initial interview where the researcher asked participants about their musical background, musical preferences, and music education background. The researcher identified preferred songs as Korean folk music, religious music, and Korean popular music. Following the interview, each participant was scheduled for twelve individual music therapy sessions that took place three times per week for four weeks lasting about fifteen minutes per session. The study incorporated an assessment called the Frenchay Dysarthria Assessment (Enderby, 1983) to assess swallowing. Measurements using this assessment were taken three times during the course of the study; once before the first music therapy session, at the conclusion of the sixth session, and at the completion of the study. For purposes of this study only three sections of the assessment were used: (1) reflex (cough, swallow, and dribble), (2) respiration (respiration at rest and in speech), and (3) laryngeal categories (time, pitch, volume, and in speech). Music therapy protocol consisted of the investigator playing the keyboard as accompaniment to the participants singing selected familiar Korean tunes. All sessions were videotaped for observation purposes.

Results showed significant improvements from the initial evaluation to the mid-evaluation for respiration at rest, pitch, volume, laryngeal time, and speech outcomes. Over the duration of the study, improvements were noted on reflex, respiration, and laryngeal categories. This study indicates ways in which oral motor and respiratory exercises (OMREX) can be used to effect swallowing for individuals with dysphagia.

LaGasse (2013) sought to determine the viability of using motor entrainment procedures for oral motor entrainment to help understand how to facilitate speech output. The participants

consisted of twelve children between the ages of 7 and 14 and twelve adults between the ages of 18 and 35 years old. Data was collected using a three-camera system that were placed on the upper lip, lower lip, and slightly inferior to the mental protuberance of the mandible. A metronome was used to generate an external auditory stimulus. The researcher used three conditions comprised of two with external cueing and one without external cueing and began the study with the “no external rhythm” condition. Participants were asked to repeat syllables at their own pace, and each person’s individual tempo was then averaged and used for the second condition. The participants were asked to manufacture the same syllable at the tempo set to each individual’s pace identified in the previous condition. This condition was called the “self-paced rhythm” condition. For the final (“faster rhythm”) condition, the researcher increased the external cue (metronome) 10% faster than each individual’s preferred tempo.

Findings suggest there was a significant difference in the motor variability of the upper lip, lower lip, and the mental protuberance of the mandible, which helped overall speech. The authors concluded that there was a significant difference between the self-paced rhythm and no external rhythm conditions. This indicates that motor stability decreased within the self-paced rhythmic entrainment condition, but interestingly not during the fast paced rhythmic entrainment condition. No significant differences were found between varying ages of participants or conditions, leading the author of this systematic review to interpret that there may be potential for increased generalization. The purpose of this study was to determine feasibility of participants adhering to a research protocol for all conditions and to determine the degree to which the research protocol would measure oral motor synchronization. The results indicate that 96% of participants were successful in completing the research protocol which indicates minimal

attrition. In conclusion, synchronization may encourage steadiness and organization of the oral musculature during oral motor repetitions, aiding individuals in attaining the sequence.

### Conclusions

Both studies have similar sample populations; however Kim (2010) used a much smaller sample size, decreasing generalizability. LaGasse (2013) sought to identify the feasibility of using a limb motor response procedure with both children and adults. Kim was specifically looking to improve the swallowing mechanism in adults with dysphagia. This indicates a vast difference in sample populations using OMREX. Research was particularly difficult to locate using this technique because it has many similarities to VIT. Author of this systematic review believes that further research using this technique may be considered to solidify effectiveness.

### Developmental Speech and Language Training Through Music

Oliver et al. (2005) define Developmental Speech and Language Training through Music (DSLTM) as “the specific use of developmentally appropriate musical materials and experiences to enhance speech and language development through singing, chanting, playing musical instruments, and combining music, speech and movement” (p. 10). DSLTM experiences could include singing or playing music to a child with developmental disabilities, writing songs, initiating vocalizations through singing or using musical instruments to teach numbers and shapes (Thaut, 2008). All DSLTM experiences are adapted to facilitate the client at a suitable level and aid them to move to the next developmental stage. The following research articles show ways in which DSLTM can be used to improve aspects of speech and language.

### NMT DSLTM Study

Lim (2010) examined the effects of DSLTM on children with Autism Spectrum Disorders (ASD). Participants consisted of 50 children diagnosed with ASD from various treatment

facilities between the ages of 3 and 5 years old. Prior to the study, level of functioning, language age and echolalia was determined. Twenty-five of the children were at a high functioning level and twenty-five children were at a low functioning level, at different levels of language development. To establish language age and functioning level, the Childhood Autism Rating Scale (CARS), Autism Diagnostic Interview Revised (ADI-R), and the Preschool Language Scale were used. In the study 32 out of the 50 participants had identified echolalia. Thirty-six target words were selected for the study based on vocabulary of a typically developing three-year-old. Pre and posttest measures used the 36 target words in a fill-in-the-blank form. The neurologic music therapy technique, DSLM was used to address acquisition of the intended target words. Six songs were composed including the 36 target words. All songs were videotaped and presented to participants using a television. For the speech condition, the same 36 target words were placed in stories (6 target words per story), recorded onto a videotape, and presented on a television. Each participant was randomly assigned to either the music, speech or no training conditions. The music condition was nine minutes long, and the speech condition was six minutes long. Each participant watched the same video two times per day for three days. Data was collected using a Verbal Production Evaluation Scale (VPES) including components such as semantics, phonology, pragmatics, and prosody (Lim, 2010).

The results show that both the music and speech conditions had a significant impact on speech production compared to the no training condition. There was also a significant difference between high and low functioning participants on improved verbal production. Results determined that the individuals with a higher level of functioning had improved verbal production to a greater degree. Interestingly, the researcher saw more improvements in participants with echolalia, than those without echolalia. According to Lim, the low-functioning

participants produced greater improvements in verbal production during music versus speech training, whereas the high-functioning participants produced improvements in both trainings. Overall, the findings suggest that speech and music training can positively affect verbal production in children with autism. The findings also suggest that lower-functioning children with autism saw more improvements during the music training condition.

#### Non- NMT DSLM Study

Saylor, Sidener, Reeve, Fetherston and Progar (2012) determine the effects of auditory simulation on vocal stereotypy in children with autism. Two children between the ages of 5 and 6 years of age (one female, one male) were included in the study. Sessions were conducted four to ten times per week for ten minutes each time. Three different conditions were administered including, music, white noise and a “self” condition. During the music condition, participants listened to a recording of four to five children’s tunes. In the “self” condition, participants listened to a recording of his or her personal verbal stereotypy. During the white noise condition, participants listened to a recording of several frequencies with identical volume. The children wore headphones to receive all conditions. In order to identify baseline measures, children wore headphones for ten minutes without listening to anything. Interestingly, after the treatment conditions, researchers conducted treatment extension sessions to evaluate typical settings where participants had high levels of vocal stereotypy (i.e. grocery store, playground, kitchen, etc.). The results showed a significant decrease in vocal stereotypy in the music and self conditions, and only a minimal decrease in the white noise condition. On the whole, this study identified DSLM as an effective way to minimize vocal stereotypy in children with autism.

#### Conclusions

Both articles showed several differences including, sample size, methodology and results and both conducted their research on children with ASD. The study implemented by Lim (2010) included 50 children which made that study more generalizable compared to having only two participants in the study implemented by Saylor et al. (2012). Interestingly, Saylor et al. sought to determine if music stimuli could help decrease vocal stereotypy, whereas, Lim was looking to identify speech production during a music stimulus. The studies demonstrated improvements in speech production (Lim) and a decrease in vocal stereotypy during music stimuli (Saylor et al.).

#### Symbolic Communication Training through Music

Oliver et al. (2005) define Symbolic Communication Training through Music (SYCOM) as:

The use of musical performance exercises to simulate and train communication behaviors, language pragmatics, appropriate speech gestures, and emotional communication in a nonverbal 'language' system for patients with a severe loss of expressive language or a dysfunctional or absent functional language development. SYCOM can effectively be used to train structural communication behaviors such as dialoguing, using questions and answers, listening and responding, appropriate speech gestures, appropriate timing of initiation and responding, initiating and terminating communication, appropriate recognition of the other communicant's message, and other communication structures in social integration patterns in real time. (p. 11)

SYCOM can be used to communicate effectively and express emotions. Upon reviewing several databases and the NMT code manual (Oliver et al., 2005), no research was found, perhaps indicating that it may not be used. No analysis was possible due to paucity of research.

Speech and Language Rehabilitation

	Year	Journal	Participants	Population	Country	Results	NMT	Non-NMT
<b>Melodic Intonation Therapy (MIT)</b>								
Title: Evaluation of melodic intonation therapy for developmental apraxia of speech Author: LaGasse	2012	Journal of Music Therapy	n=2, (males), 5-6 y/o	Children with developmental apraxia of speech (DAS)	United States	Positive	X	
Title: intonation therapy with language delayed apraxic children Authors: Krauss & Galloway	Predates NMT 1982	Journal of Music Therapy	n=2 (male)	Apraxic children with delayed speech	United States	Positive	X	
Title: From singing to speaking: Why singing may lead to recovery of expressive language function in patients with broca's aphasia Authors: Schlaug et. al.	2008	Music Perception	n=2, (male), 47-58 y/o	Individuals with non-fluent aphasia	United States	Positive	X	
Title: When right is all that is left: Plasticity of right-hemisphere tracts in a young aphasic patient Authors: Zipse et. al.	2012	Annals New York Academy of Sciences	n=1 (female) 11 y/o	Individual who had a stroke and was left with a severe left hemisphere lesion	United States	Positive	X	
Title: Modifying the melodic intonation therapy program for adults with severe non-fluent aphasia Author: Baker	2000	Journal of Music Therapy	n=2 (1 female/1 male) 30-32 y/o	Individuals with severe left hemisphere brain damage	Norway	Positive	X	
Title: Changes in maps of language activity activation following melodic intonation therapy using magnetoencephalography Authors: Brier et. al.	2010	Journal of Clinical and Experimental Neuropsychology	n=2 (both male) 49-55 y/o	Adults with chronic expressive aphasia	United States	Positive	X	
Title: Effects of three syllable durations using the melodic intonation therapy technique Authors: Laughlin & Naeser	Predates NMT 1979	Journal of Speech and Hearing Research	n=5, 47-67 y/o	Adult stroke pt's with aphasia	United States	Positive	X	
Percentages: 100% NMT								
<b>Musical Speech Stimulation (MUSTIM)</b>								
Title: Shared and distinct neural correlates of singing and speaking Authors: Ozdemir et al.	2006	Neuroimage	n=10, mean age= 24.2 (5 female/5 male)	Individuals who do not have neurological, psychiatric, or hearing problems	United States	Positive		X
Title: Singing therapy can be effective for a patient with severe nonfluent aphasia Authors: Yamaguchi et. al.	2012	International Journal of Rehabilitation Research	n=1 (female) 79 y/o	Individual with severe non-fluent aphasia	Japan	Positive		X
Percentages: 100% non-NMT								
<b>Rhythmic Speech Cueing (RSC)</b>								

Title: Accuracy and variability of isochronous rhythmic timing across motor systems in stuttering versus nonstuttering individuals Authors: Max & Yudman	2003	Journal of Speech and Hearing Research	n=10, 27-45 y/o 7 male/ 3 female n= 10 26-46 y/o 7 male/ 3 female	Individuals who stutter and individuals who do not stutter	United States	Positive		X
Percentages: 100% non-NMT								
<b>Vocal Intonation Therapy (VIT)</b>								
Title: The effects of participation in a group music therapy voice protocol (G-MTVP) on the speech of individuals with Parkinson's disease Authors: Yinger & LaPointe	2012	Journal of Music Therapy	n=10 (7 male/ 3 female) 59-85 y/o	Individuals with PD	United States	Positive		X
Title: A pilot study into the effect of vocal exercises and singing on dysarthric speech Author: Tamplin	2008	Journal of Neurorehabilitation	n=4 (3 female/1 male) 19-51 y/o	Individuals with dysarthric speech due to CVA	Australia	Positive	X	
Percentages: 33.3% NMT, 66.7% non-NMT								
<b>Therapeutic Singing (TS)</b>								
Title: The effect of singing instruction on the speech production of neurologically impaired persons Author: Cohen	Predates NMT 1992	Journal of Music Therapy	n=8, 3male/5 female	neurologically impaired individuals	United States	Positive		X
Title: The application of singing and rhythmic instruction as a therapeutic intervention for persons with neurogenic communication disorders Authors: Cohen & Masse	Predates NMT 1993	Journal of Music Therapy	n=32, 26-76 y/o	MS, CP, CVA, and Parkinson's Disease	United States	Positive		X
Title: The effects of a song-singing program on the affective speaking intonation of people with traumatic brain injury Authors: Baker et. al.	2005	Brain Injury	n=4 (all male) 24-29 y/o	Individuals with TBI	Australia	Positive		X
Title: Songs as an aid for language acquisition Authors: Schon et al.	2008	Cognition	Experiment 1: n=26 mean age= 23 Experiment 2: n=26 mean age= 23 Experiment 3: n=23 mean age= 23.5	Native French speaking individuals	France	Experiment 1: Negative Experiment 2: Positive Experiment 3: Positive		X
Percentages: 100% non-NMT								
<b>Symbolic Communication Training Through Music (SYCOM)</b>								
<b>Developmental Speech and Language Training Through Music (DSLTM)</b>								

Title: Effect of “Developmental speech and language training through music” on speech production in children with autism spectrum disorder Author: Lim	2010	Journal of Music Therapy	n=50, 3-5 y/o	Autism Spectrum Disorders	United States	Positive	X	
Title: Effects of three types of noncontingent auditory stimulation on vocal stereotypy in children with autism Authors: Saylor et al.	2012	Journal of Applied Behavior Analysis	n=2, 1 female/1 male 5-6 y/o	Children diagnosed with autism	United States	Positive		X
Percentages: 50% non-NMT, 50% NMT								
<b>Oral Motor and Respiratory Exercises (OMREX)</b>								
Title: Influence of an external rhythm on oral motor control in children and adults Author: LaGasse	2013	Journal of Music Therapy	n=24, 7-35 y/o	All individuals have no history of speech, language, or hearing impairments and are all native english speakers	United States	Positive	X	
Title: Music therapy protocol development to enhance swallowing training for stroke patients with dysphagia Author: Kim	2010	Journal of Music therapy	n=8, 50-70 y/o	Stoke with Dysphagia	South Korea	Positive	X	
Percentages: 50% non-NMT, 50% NMT								

Table II

## CHAPTER V:

## Cognitive Rehabilitation Techniques

Rimmel and Hester (1987) define cognitive rehabilitation as “procedures designed to provide patients with the cognitive and perceptual skills necessary to perform tasks or solve problems which are currently difficult, but which were within their capabilities before injury” (Thaut, 2008, p.179; Rimmel & Hester, 1987, p. 353). Prior to the beginning of cognitive rehabilitation in the 1900’s, most neurological injuries resulted in death either due to the head injury itself or an infection resulting from the injury (Thaut, 2008). As technology improved and more individuals survived neurologic injuries it was noted that brain plasticity can occur over time. Brain plasticity allows for a reorganization of the brain to complete tasks by using new neural pathways (Goodwin, 1989; Loring, 1999), allowing for possible results in improving remediation of attention, visual-spatial skills, memory, language, and executive functioning. Neurologic music therapy techniques used for cognitive rehabilitation include, Musical Sensory Orientation Training (MSOT), Musical Neglect Training (MNT), Auditory Perception Training (APT), Musical Attention Control Training (MACT), Musical Mnemonics Training (MMT), Associative Mood and Memory Training (AMMT), and Musical Executive Function Training (MEFT).

Musical Sensory Orientation Training

Oliver et al. (2005) defines Musical Sensory Orientation Training (MSOT) as:

The use of music presented live or recorded, to stimulate arousal and recovery of wake states and facilitate meaningful responsiveness and orientation to time, place, and person. In more advanced recovery of developmental stages, training would

involve active engagement in simple musical exercises to increase vigilance and train basic attention maintenance with emphasis on quality of response. It includes sensory stimulation, arousal orientation, and vigilance and attention maintenance. (p. 12)

This technique incorporates arousal orientation, sensory stimulation, and attention maintenance. The following studies explore the use of MSOT with individuals with dementia. Both are non-NMT or music therapy articles, but they do use protocols similar to MSOT.

#### Non-NMT MSOT Studies

Cooke, Moyle, Shum, Harrison and Murfield (2010) explored the effect music has on agitated behaviors and anxiety in people with dementia. Participants consisted of forty-six people (70% female) aged 75 to 94 years old with mild to moderate dementia. All participants took part in both the music intervention and reading group sessions. They received eight weeks of music for forty minutes, three times a week, a five week washout period and then eight weeks of reading sessions for forty minutes, three times a week. The researchers assessed the participants' anxiety and agitation three times using the Cohen-Mansfield Agitation Inventory-Short Form (CMAI-SF) and the Rating Anxiety in Dementia Scale (RAID). Music sessions comprised of singing familiar tunes for thirty minutes and ten minutes of pre-recorded instrumental music. Reading sessions contained reading and social activities including reading short stories, newspaper articles, and telling jokes. Results for both the music and reading sessions suggested low levels of anxiety and agitated behavior according to the RAID and CMAI-SF. However, verbal aggression frequency increased over time. Overall, there were not significant findings to show the therapeutic importance of the music program in improving agitation and anxiety for individuals with dementia.

Hammar, Emami, Engstrom and Gotell (2010) studied how music therapy caregiving (MTC) affects persons with dementia and their caregivers to convey verbal and non-verbal communication during morning care. Participants consisted of six caregivers between the ages of 31 and 54 years old and ten persons with dementia (4 male/ 6 female). Prior to beginning the study, all caregivers were trained in MTC. The caregivers were trained to understand and recreate music appreciation during morning care. Caregivers learned songs from the early twentieth century and body movements to go along with singing. The normal morning care condition (without music) was used as a baseline. All sessions were video recorded to collect and analyze data. Participants were observed once a week for two months. Typical morning duties for the caregiver included; helping patient from bed into the bathroom, help remove patient's night clothing, and help the patient to bathe and get dressed.

It was noted during the ordinary morning care condition that persons with dementia had trouble communicating and the caregivers seldom sought eye contact. Caregivers were very focused on duties rather than building a relationship with the patient. The music therapeutic caregiving yielded much different results. While singing, the caregivers were more focused on communicating with the patient and they showed a willingness to build a relationship. Through this new found verbal and non-verbal communication system, patients were more active in getting dressed and were more responsive to cues. The study identified the possible positive outcomes of using MSOT to develop better relationships between caregiver and patient with dementia leading to an increased quality of care.

### Conclusions

These two articles have similar sample populations and research outcomes. Cooke et al. (2010) found decreased agitation and aggression, whereas, Hammar et al. (2010) found that

when the caregivers used MTC, the dementia patients were more engaging and the verbal and non-verbal communication improved. A common gap in the studies includes limited demographic data. Cooke et al. only include the total of participants, ages and a percentage of female participants. Hammar et al. include a small sample size which decreases generalizability. A weakness in both Hammar et al. and Cooke et al. was not mentioning the use of an Institutional Review Board (IRB) for approval of the experimental procedure. Also there was a lack of discussion related to reliability and validity in the text. On the whole, these studies provide useful information regarding MSOT and its use on individuals with dementia.

### Musical Neglect Training

Oliver et al. (2005) define Musical Neglect Training (MNT) as:

The active performance exercises on musical instruments, which are structured in time, tempo, and rhythm and is in appropriate spatial configurations to focus attention to a neglected visual field. A second application type consists of receptive music listening to stimulate hemispheric brain arousal while engaging in exercises addressing visual neglect or inattention. (p. 13)

This technique typically goes hand in hand with neglect assessments to identify level of neglect either visually or physically. MNT is usually used with individuals who have had a stroke. The following three articles are examples of research that follows MNT protocol with no mention of NMT or MNT. Both Hommel et al. (1990) and Chen et al. (2013) did not mention music therapy, whereas Tsai et al. (2013) did.

### Non-NMT MNT Studies

Hommel, Peres, Pollak, Memin, Besson, Gaio, and Perret (1990) determined the outcome of passive tactile and auditory stimuli on left visual neglect following a stroke. The participants consisted of fourteen individuals (8 men/ 6 women) between the ages of 29 and 81. A test was administered that required participants to copy six drawings including: a cube, a flower, a bicycle, a house, a clock, and two men. A sheet of paper with pictures was placed directly in front of the participants. During the drawing test, passive stimulation was administered and included tactile stimulation (repetitive taps with smooth part of a pencil on the cheek) and auditory simulation (either female voice of encouragement, white noise or classical music). Study results show that music and white noise stimulation improved visual neglect of the participants. Tactile stimulation showed a boost in blood flow. The study shows how the use of auditory stimulation may improve left visual neglect on individuals following a stroke.

Tsai, Chen, M., Huang, Lin, Chen, K., and Hsu (2013) examined the effects of listening to classical music on unilateral neglect following a stroke. Participants consisted of sixteen individuals (6 male/ 10 female) who have all suffered from a stroke. The study used a baseline condition (silence) and two auditory stimuli conditions (classical music and white noise). First, participants were asked to complete a Visual Analog Scale (VAS) to evaluate mood and arousal. After one minute of either experimental condition, participants were asked to complete VAS again. After the scale was completed, conditions were started again and participants completed three neglect assessments that included the Star Cancellation Test (SCT), Line Bisection Test (LBT), and a Picture Scanning Test (PST). Results indicate that participants have higher scores on neglect tests when listening to white noise and music versus silence. The mean enjoyment levels were the highest during classical music condition. Ultimately, this study demonstrates that

classical music may improve visual attention performance in individuals with unilateral visual neglect due to stroke.

Chen, Tsai, Huang and Lin (2013) also sought to examine the effects of music on visual attention in persons with unilateral neglect due to stroke. Participants consisted of nineteen people (10 male/ 9 female) with a mean age of 66.1 years old. Each participant chose three pieces of music that they perceived as pleasant to listen to and three that were unpleasant to listen to. Overall, the majority of pleasant music selected was well-known Taiwanese songs. Unpleasant music chosen by the participants included rap, military songs, and heavy metal. Assessments used included the SCT, LBT, PST and VAS. Researchers also examined heart rate and galvanic skin response (GSR) of participants. Individually, participants were tested in three conditions including unpleasant music, pleasant music and white noise. One minute into each experimental condition, the VAS was administered to indicate any change in arousal or mood. While continuing to listen to experimental condition, participants completed all clinical tests, lasting about fifteen minutes. As in the previous study, results indicated that the pleasant music condition recorded better moods, and increased arousal than the other conditions leading to a decrease in neglect behaviors.

### Conclusions

These three studies used similar sample sizes, methodology, research outcomes and sample populations. Chen et al. (2013), Tsai et al. (2013) and Hommel et al. (1990) all used between 16 and 19 participants with unilateral neglect due to stroke. Since the sample sizes are relatively small, the ability for the results to be generalized to the general stroke population is limited. Interestingly, the researchers from these studies used the same neglect assessments. It would be interesting to replicate these studies with larger sample sizes to validate preliminary

findings. Research outcomes for these studies found that listening to pleasant music increased arousal and attention (Chen et al.), passive music stimulation may slightly improve neglect (Hommel et al.), and visual neglect may improve when listening to classical music (Tsai et al.).

### Auditory Perception Training

Oliver et al. (2005) define Auditory Perception Training (APT) as:

The use of musical exercises to discriminate and identify different components of sound, such as time, tempo, duration, pitch, timbre, rhythmic patterns, as well as speech sounds. It involves integration of different sensory modalities such as visual, tactile, and kinesthetic input are used during active musical exercises such as playing from symbolic or graphic notation, using tactile sound transmission, or integrating movement to music. (p. 14)

APT incorporates both sensory integration and auditory perception (Thaut, 2008). The following research study is an example of how APT can be used with individual with Wernicke's aphasia. This article is not specifically APT, but it follows the procedures.

### Non-NMT APT Study

Midorikawa, Kawamura and Kezuka (2003) investigated individuals' disruption in musical reading and writing abilities due to having Wernicke's aphasia. This study is particularly interesting because it could be used in cognitive, sensorimotor and speech and language rehabilitation settings. Researchers unknowingly used an adaptation to APT technique. Subjects consisted of one sixty-two year old female who had a stroke and two healthy female control individuals between fifty-nine and sixty years old – all who are or were piano teachers. First, participants were asked to read single notes, and then asked to read musical signs (i.e. eighth

notes and dynamic marks). Using the piano, researchers played a tune and requested the subjects to select the accurate musical notation presented. Next, subjects were asked to sight-read two unknown melodies and two well-known melodies. Subjects were then asked to write out specific music notes and two well-known melodies. Finally, the subjects were asked to copy a melody.

The study results indicated that the control subjects correctly completed all experimental conditions. The subject with the stroke was able to read individual music notes twelve out of twelve times on the treble clef and ten out of twelve times on the bass clef. However, when reading musical signs, the subject with the stroke was not able to correctly identify any (0/24). When reading unknown melodies, the subject with the stroke performed well on pitch reading (100% correct), 62% correct on melody reading, and 50% correct on rhythm reading. Surprisingly, the subject with the stroke had more difficulty reading the first well-known melody than the second well-known melody in which she played the piano with both hands and did not exhibit any difficulties in reading the music. The subject with the stroke scored 83% correct on treble clef writing and 92% correct on bass clef writing. The subject did not write out the melody from the well-known melodies. Lastly, the subject correctly copied 75% of a melody. These results indicate that the subject had musical alexia, but only with unfamiliar melodies. Musical alexia is when an individual loses the ability to read musical notation. Interestingly, the disturbance of the subject's abilities was limited to rhythm reading, which implies the autonomy of pitch reading and rhythm reading. It would be interesting to replicate this study with a larger sample size to validate preliminary findings and further validate the use of the NMT technique.

#### Musical Attention Control Training

Oliver et al. (2005) define Musical Attention Control Training (MACT) as a “structured active or receptive musical exercises involving pre-composed performance or improvisation in

which musical elements cue different musical responses in order to practice sustained, selective, divided, and alternating attention functions” (p. 15). Music incorporates several layers of information which can arouse multiple levels of attention (Thaut, 2008). Using MACT is an efficient way to arouse attention and thereby activate memory systems. The following research includes three articles that use MACT unknowingly.

#### Non-NMT MACT Studies

Gregory (2002) explored how long elderly individuals with cognitive impairments could maintain attention to a music intervention and how the results compared with younger adults. Gregory also sought to determine if there were any short-term effects of attention training with the elderly participants. Participants consisted of twelve elderly individuals with cognitive impairments. Six women aged 70 to 95 years, and six men aged 72 to 87 years old. Other participants were six college students (four female/two male) between the ages of 22 to 48 who volunteered for the study. Three instrumental pieces were selected including, “Yankee Doodle,” “Battle Hymn of the Republic,” and “America the Beautiful.” Several excerpts for each piece were presented in the present study for content variation. All music was presented on a cassette tape for each participant. The Continuous Response Digital Interface (CRDI) device was used to record, “non-verbal, simultaneous, real-time focus-of-attention responses of individuals and small groups” (Gregory, 2002, p. 248). Results suggest that the elderly participants could recognize melodies in different frequencies, both simple and complex melodies, and when the melodies began from different starting points. This study showed that age does not impair perception or motor abilities involved in playing a listening game.

Jeong and Lesiuk (2011) explored the initial use of an attention assessment called the Music-based Attention Assessment (MAA). The participants consisted of fifteen individuals with

a diagnosis of traumatic brain injury (TBI) between 29 and 59 years of age. A demographic questionnaire was given to each participant prior to beginning the study to gather information including ethnicity, age, gender, date of TBI, level of education, and years of music education. “The 48-item Music-based Attention Assessment (MAA) for patients with TBI is a melodic contour identification test with three subtests consisting of sustained attention, selective attention, and divided attention” (Jeong & Lesiuk, 2011, p. 557). The sustained attention portion of the assessment requires participants to identify the contour of a short series of tones by stating whether the contour goes up, down, or stays stationary. Music is presented using a guitar, piano, or flute. The selective attention portion of the assessment requires participants to identify the contour of a series of tones representing a melody while a competing sound is also played. The divided attention portion of the assessment requires participants to identify the contours of two different series of tones. For each assessment portion there were 16 points allotted, with a total assessment score of 48. The assessment required the participants to select a melodic contour by circling an answer on a multiple choice test. The assessment took a total of thirty minutes to complete for each participant.

This study was an attempt to determine the feasibility of a new attention assessment called the Music-based Attention Assessment (MAA). Study results indicate that further exploration of the MAA be conducted to determine efficacy. Researchers indicate, “The assessment has potential to provide diagnostic information in regards to auditory attention of patients with TBI” (Jeong & Lesiuk, 2011, p. 567). Also indicated in the results was that the assessment progressively became more difficult from the sustained attention portion to the divided attention portion. Further research with a much larger sample size would be recommended to confirm validity and consistency of the MAA.

Sarkamo and Soto (2012) investigated the benefits of music listening on cognitive functioning in individuals who had sustained a stroke. Participants consisted of fifty-four persons between the ages of thirty-five and seventy-five. They were randomly assigned to one of three groups: audio book group, control group, or a music group. Sessions lasted one hour every day for two months. In the audio-book group, participants were given portable players with pre-selected audio-books by each participant. Participants in the control group did not receive any listening material. The music group participants received compact discs filled with their preferred music. All participants underwent cognitive tests after one week, three months, and six months to measure memory, executive function, attention, and mood. Study results indicated that the music group showed less depression and confusion than the control group. Participants also reported that listening to music helped them relax, improve their mood, and increase motor movement. Results from MRI and MEG assessments showed that the volume of grey matter changed music-induced group over time allowing for enhanced cognitive recovery.

### Conclusions

These three studies have varying sample sizes, methodology, and location of research, research outcomes and sample populations. Both Gregory (2002) and Jeong and Lesiuk (2011) used between 12 and 15 participants which is relatively small, limiting the ability for the results to be generalized to the general cognitive rehabilitation population and reduces the studies' reliability. Sarkamo and Soto (2012) uses a larger sample size (n=54), making the study more reliable. Replication of the studies with smaller sample sizes may help validate preliminary findings. Locations of studies were in the United States and Finland. Research outcomes for these studies found that the assessment used showed potential for use (Jeong & Lesiuk), that age does not impair the perception or motor abilities required to play a listening game (Gregory), and

that music can facilitate decreased feelings of depression and confusion (Sarkamo & Soto).

These studies show effectiveness in using MACT with individuals who had a stroke, people with cognitive impairments, and TBI.

### Musical Mnemonics Training

Oliver et al. (2005) define Musical Mnemonics Training (MMT) as:

the use of musical exercises to address various memory encoding and decoding/recall functions. Immediate recall of sounds or sung words using musical stimuli may be used to address echoic functions. Musical stimuli may be used as a mnemonic device or memory template in a song, rhyme, chant to facilitate learning of nonmusical information by sequencing and organizing the information into temporally structured patterns or chunks. (p. 16)

Research conducted on music mnemonics gives sufficient verification that music plays a strong role in memory functioning (Tomaino, 1998; Carruth, 1997).

### NMT MMT Study

Moore, Peterson, O'Shea, McIntosh, and Thaut (2008) investigated the effectiveness of music as a mnemonic device to assist in learning and memory in persons with multiple sclerosis. Study participants included a total of thirty-eight individuals who were randomly assigned to either the "spoken group" (14 females/4 males) or the "music group" (16 females/4 males). To be included in the study, participants had to be measured for disability level using the Extended Disability Status Scale (EDSS). All participants had to have scored between a 3.5 and a 7 on the scale. To be included, the participants also had to be right-handed, non-smokers, they had to have at least five brain lesions, and could not have been treated with pulse-cortical steroids

within three months prior to the study beginning. For baseline measures, all participants were given four neuropsychological tests including: the Buschke's Selective Reminding Task (SRT), Logical Memory I, the Wisconsin Card Scoring Test (WCST), and the Seashore Rhythm Test. These assessments measured verbal learning and memory, executive functioning, and sustained attention. In the beginning of the study, demographic information was attained. Researchers then connected each participant to an electroencephalogram (EEG) and administered the Auditory-Verbal Learning Test (AVLT). First, participants were given a fifteen word list to learn. They were then given an interference trial and a twenty minute distracter task which was unrelated to the learning and memory task. Finally, participants listened to a fifty word list. After each word was presented, participants had four seconds to determine if the word was on the original word list. Individuals randomly selected for the music group were presented with the word lists in a song format and were asked to sing back as much as they could remember. Individuals assigned to the spoken group heard the word lists in a spoken format and were asked to say as many words as they could remember, but in the order presented, as much as possible. Word recall was recorded for analysis.

Results indicate that the individuals in the spoken group performed slightly better by having more correct recognitions than those in the music group. According to Moore et al. (2008), results show that "The AVLT response bias index beta showed no statistically significant correlations and no strong relationships to any of the baseline measures in either of the two experimental conditions" (p. 319). Results of this study indicate no significant differences on the recognition memory test between both learning conditions. Perhaps this study could be replicated and conducted on individuals in the earlier stages of their disease to possibly yield better results.

Non-NMT MMT Study

Schon, Boyer, Moreno, Besson, Peretz, and Kolinsky (2008) examined the use of singing to assist language acquisition. The first experiment consisted of twenty-six native French-speaking people as participants with a mean age of twenty-three years old. Researchers created a language of four consonants and three vowels and combined them into a set of eleven syllables. The syllables were then combined and separated every three syllables to create a total of six tri-syllabic words (mimosi, gimysy, pymiso, pogysi, sipygy, and sysipi). For seven minutes, participants were asked to listen to a continuous speech stream of the six tri-syllabic nonsense words (learning phase). Using a computer keyboard, participants were asked to identify one of the two words on the screen as being a word from the language created (testing phase). Researchers created ‘part-words’ to pair with the “words” from the nonsense language for the testing phase. Part-words were created by combining the last syllable of a word and the first syllable of another, or vice versa. Results indicate the participant’s level of performance was not significantly different from chance (48% correct) and they were not able to differentiate words from part-words.

The second experiment had twenty-six native French-speaking individuals as participants with a mean age of twenty-three years old. This experiment was identical to the initial experiment. However, the words were sung instead of spoken all on the same melodic contour and each word began on a different pitch. Results of this experiment indicated that the participants did learn the words (64% correct). By simply changing the spoken words to singing words, participants were more able to differentiate words from part-words.

The third experiment consisted of a group of twenty-three French speaking individuals with a mean age of twenty-three. All aspects of this experiment were identical to experiment two. However, researchers used variable starting pitches (first syllable), while the second and

third syllables remained the same. Participants were 56% correct in identifying words from part-words, indicating a higher level of performance compared to the initial experiment. Overall, the series of experiments show how musical mnemonics training may facilitate memory for language acquisition.

### Conclusions

Both of these studies use similar sample sizes and differing methodology, research outcomes and sample populations. Moore et al. (2008) and Schon et al. (2008) both used between 54 and 75 participants, which increases reliability and generalizability. Interestingly, Schon et al. used healthy native French speaking individuals as participants, whereas, Moore et al. conducted research on MS participants. Schon et al. conducted several experiments to examine if music could enhance learning. Moore et al. studied the effects of music as a mnemonic device on learning and memory. These studies are two very different approaches to using MMT in cognitive therapy. Schon et al. facilitated positive outcomes in memory after incorporating musical information. Even though these studies did not specifically mention the use of MMT, their use of a similar protocol allowed for analysis in this section. Further research in this area may demonstrate the possible effectiveness of MMT in cognitive rehabilitation.

### Associative Mood and Memory Training

Oliver et al. (2005) defines Associative Mood and Memory Training (AMMT) as a “musical mood induction technique to instate a) a mood congruent mood states to facilitate memory recall, or b) to access associative mood and memory function through inducing a positive emotional state in the learning and recall process” (p. 18). Similar to MMT, AMMT is heavily involved in improving the memory function. The following four research studies are examples of both AMMT and articles that use AMMT without referring to it as such.

### NMT AMMT Studies

Thaut and De l'Etoile (1993) compared the use of music to produce a mood-state dependent recall effect to no music during a cognitive learning task. Fifty undergraduate female individuals participated in the study. All participants were asked to complete a cognitive incidental learning task over a two day period. On the first day of the cognitive learning task, participants were given forty adjectives and asked to write down an opposite adjective for each (encoding). On the second day, participants were asked to write down as many antonyms that they could remember from the previous day (recall). Each participant was randomly assigned to one of five experimental conditions. Conditions included, "Condition A, background music during encoding, no background music during recall; Condition B, no music during encoding, background music during recall; Condition C, background music during encoding, background music during recall; Condition D, no music during encoding, no music during recall; and Condition Cx, mood induction through music (MMI) prior to encoding, mood induction through music prior to recall" (Thaut & De l'Etoile, 1993, p. 75). All recorded music used in the study was identical across all conditions. In Condition Cx, participants were asked to listen to music prior to working on the task. After completing the listening task, they were asked to identify the mood of the piece. No music was added during encoding or recall in this condition.

Most successful results in recalling adjectives were found in the music and mood induction (Condition Cx), and the lowest average of recalled adjectives occurred during condition D (no music in either encoding or recall). The authors concluded that music as a mood induction technique produced the best overall recall performance among experimental conditions.

De l'Etoile (2002) decided to replicate and expand upon the previous study. The purpose of the study was to examine the "effect of a musical mood induction on mood state dependent word retrieval" (p. 145). The study consisted of forty-five participants (13 males/ 32 females) from a mid-Western university. Similar to the study conducted by Thaut and De l'Etoile (1993), on the first day of the study participants were asked to create antonyms for forty words, and on the second day, they were asked to recall as many as possible. Participants were only given ten minutes to complete encoding and recall tasks. To assess mood-state dependent word retrieval participants were randomly assigned to one of four conditions. Conditions included, "(a) musical mood induction prior to encoding only, (b) musical mood induction prior to recall only, (c) no musical mood induction prior to encoding or recall, and (d) musical mood induction prior to both encoding and recall" (De l'Etoile, 2002, p. 151). Musical mood induction included three steps. First participants were asked to indicate mood. Participants then listened to music for five minutes and asked to determine mood of music and to move themselves into the mood of the music. And finally after listening to the music, participants were again asked to indicate mood.

Twenty-nine out of the thirty-four participants had ample mood changes after the musical mood induction procedure which led to an 85% success rate. Male participants met the mood change criterion 87.5% of the time, and the female participants came in slightly behind them with 84.6%. Group four (received mood induction prior to encoding and recall) had the greatest mean number of recalled words (15.3). Group one, who received no musical mood induction had retrieved the least amount of recalled antonyms. This study provides evidence for the use of musical mood inductions on the encoding and free recall of words.

Non-NMT AMMT Studies

Magee and Davidson (2002) sought to determine if music therapy sessions could positively affect mood states in individuals with acquired neurological disabilities. Fourteen individuals with acquired neurological disabilities participated in the study. Participants were divided into three diagnostic groups including: Multiple Sclerosis (MS=5), traumatic brain injury (TBI=5), and a combined group of individuals with brain damage from stroke or anoxia (CVA/An=4). To gauge memory functions and orientation, participants were given a mental state questionnaire. The Bipolar form of the Profile of Mood States (POMS-BI; Lorr & McNair, 1988) was administered pre and post treatment sessions. Each participant attended one music therapy session per week for two weeks. Each session contained both an 'opening' and 'closing' musical activities to structure the session. Sessions also included the use of either improvisation methods or pre-composed music.

Researchers indicated that the results showed noteworthy positive differences for composed-anxious, energetic-tired and agreeable-hostile mood states after music therapy. The authors concluded that the mean scores pre and post session showed a change in mood in a positive direction. This suggests that music therapy can facilitate positive feelings. Overall, the present study shows that music therapy may be an effective clinical intervention assisting in positive mood changes in adults with neurologic disabilities.

Millard and Smith (1989) sought to determine if there was a change in behavior after music therapy sessions. Researchers investigated the possibility of singing to enhance "quality of care" for individuals with Alzheimer's disease. Subjects consisted of ten individuals (3 men/ 7 women) between the ages of 71 and 98 diagnosed with Alzheimer's disease. Group sessions were held for thirty minutes, twice weekly over a period of five weeks. Subjects attended both a baseline condition and a treatment condition. The baseline condition lasted thirty minutes and it

incorporated visual prompts for discussion. The treatment condition also lasted thirty minutes. However, it incorporated a music therapy singing session. Data were obtained through the use of a behavior checklist called “behavior mapping.” According to researchers, “Behavior mapping is one of the few feasible ways to measure changes objectively in Alzheimer’s disease (AD) patients as verbal information from demented patients is not reliable” (Bell & Smith, 1986; Millard & Smith, 1989, p. 62). This behavior checklist was given both in the music and non-music conditions. Subjects were observed for a one minute interval four times per session, where their behaviors were recorded as occurring or not occurring. For thirty minutes following the sessions, researchers observed the subjects behaviors.

Results showed significantly higher vocal/verbal participation from subjects during the group singing sessions, than the discussion sessions. Interestingly, results also indicated that in both the music session and non-music session there was a significant effect on frequencies of physical and social behaviors. This indicates the vital need for activities in general as important for maintenance of quality of life for persons with Alzheimer’s disease. Limitations of this study include the limited number of subjects used due to the limited room in the dining area (where the sessions took place). This study led to an increased amount of empirical support confirming the use of music with Alzheimer’s disease victims.

### Conclusions

Comparing these articles was difficult due to the vast differences in sample sizes, sample populations, and research outcomes. De l’Etoile (2002) and Thaut and De l’Etoile (1993) both used similar sample sizes (45-50 participants), sample population (undergraduate students), and they used almost identical methods to conduct their research. In both of these studies, the results indicated that the most successful results in recalling adjectives happened while in the music and

mood induction condition. Since the sample populations were a decent size for these two studies, their studies seemed more reliable and generalizable. However, Magee and Davidson (2001) and Millard and Smith (1989) both only used between 10 and 14 participants. If these studies are replicated in the future, they may consider expanding the sample size in order to validate the preliminary findings. Overall, this research provides clinical support for AMMT in cognitive rehabilitation.

### Musical Executive Function Training

Oliver et al. (2005) defines Musical Executive Function Training (MEFT) as:

The use of improvisation and composition exercises in a group or individually to practice executive function skills such as organization, problem solving, decision making, reasoning, and comprehension. The musical context provides important therapeutic elements, such as performance products in real time, temporal structural, creative process, affective content, sensory structure, or social interaction patterns. (p. 19)

When in a group setting, this technique can encourage clients to evaluate their own performance, and receive feedback from peers. This is an efficient way for clients to become more self-aware of abilities and limitations. The following two articles are examples of how MEFT can be used to assess executive functions and memory.

#### NMT MEFT Study

Thaut, Gardiner, Holmberg, Horwitz, Kent, Andrews, Donelan, and McIntosh (2009) sought to examine the immediate effectiveness of the framework of neurologic music therapy techniques on executive function. Twenty-three participants with acquired brain injuries were

randomly assigned to the control group and thirty-one individuals into the treatment group. Individuals assigned to the treatment group participated in four different sessions including an emotional adjustment session, executive function session, attention session, and memory session (in this order) on four different days. At the beginning of each session, the cognitive function for that day was administered individually. Each participant was then individually given a 30-minute neurologic music therapy session including vocal and instrumental warm-up exercises. At the conclusion of each session, the appropriate cognitive or emotional test was given to each participant. Measurements used in this study included: (1) Wechsler Adult Intelligence Scale III to measure attention, (2) Auditory Verbal Learning Test (AVLT) to assess memory, and (3) Global Severity Index (BSI-18) and the Multiple Affect Adjective Check List (MAACL) assessed executive function. The neurologic music therapy session incorporated group improvisations and addressed the clinical rehabilitation goals.

The study results included several statistically significant outcomes in most areas of assessment. The treatment group showed improvements in mental flexibility, emotional adjustment (i.e. anxiety and depression), and confidence in their executive function ability. Although the control group did show improvements in emotional adjustment, they did not show improvements for anxiety or depression. The control group also did not show improvements in executive functioning. Interestingly, the control group the participants' positive affect changed in a negative direction while the NMT group did not change significantly. Results also indicate that neither group showed improvement in memory or attention. Overall, this study indicates that neurologic music therapy sessions may improve aspects of executive function, and emotional adjustment in individuals with brain injuries.

Non-NMT MEFT Study

Bialystok and DePape (2009) sought to determine if musical experience has an effect on executive function. Participants consisted of ninety-five people between the ages of eighteen and thirty-five years old who were monolingual, bilingual and some who were instrumentalists or vocalists. Before beginning the study, participants were given a Language and Musical Background Questionnaire, Lattell Culture Fair Intellectual Test, Spatial Span Subtest, Trail Making test, and two experimental tasks including the 'simon task' and the 'stroop task.' Tests and tasks were conducted to: (1) record background and demographic information, (2) measure general intelligence, (3) test short-term visual-spatial memory, (4) test executive function, (5) evaluate response time and accuracy, and (6) evaluate ability to judge pitches as high or low. Overall results indicated that musicians and bilinguals performed better than monolinguals on response speed, cognitive processing, and pitch differentiation. This research demonstrates the effectiveness of musical training on enhancing executive control and could be useful in studies conducted on individuals with frontal lobe injuries.

### Conclusions

The only similarity between Thaut et al. (2009) and Bialystok and DePape (2009) are that they both had large sample sizes (between 54 and 95 participants). This increased reliability and generalizability. Otherwise, they had different populations, research outcomes and methodologies. Thaut et al. looked at the effect of using MEFT with individuals with TBI, whereas; Bialystok and DePape studied the effect of using MEFT protocol to evaluate executive function control of bilinguals, monolinguals, instrumentalists and vocalists. Both articles had extensive descriptions for research methods, indicating well-thought out processes. The treatment group in Thaut et al. showed improvements in mental flexibility, confidence in executive function capabilities, and emotional adjustment. In Bialystok and DePape research,

their outcomes suggest that the musicians and bilinguals performed better than the monolinguals on executive function tasks. On the whole, these two studies presented different strategies in using MEFT.

Cognitive Rehabilitation

	Year	Journal	Participants	Population	Country	Results	NMT	Non-NMT
<b>Musical Sensory Orientation Training (MSOT)</b>								
Title: Communicating through caregiver singing during morning care situations in dementia care Authors: Hammar et al.	2010	Scandinavian Journal of Caring Sciences	n=10 4 male/6 female n=6 caregivers 31-54 y/o	Individuals with dementia and caregivers who take care of them	Sweden	Positive		X
Title: A randomized controlled trial exploring the effect of music on agitated behaviors and anxiety in older people with dementia Authors: Cooke et al.	2010	Journal of Aging and Health	n=46, 70.2% female, 75-94 y/o	Individuals with dementia with a history of behavioral aggression or agitation	Australia	Positive and Negative		X
Percentages: 100% non-NMT								
<b>Musical Neglect Training (MNT)</b>								
Title: Pleasant music improves visual attention in patients with unilateral neglect after stroke Authors: Chen et. al.	2013	Brain Injury	n=19, mean age=66.1 y/o 10 male/9 female	Individuals following a right-hemisphere stroke with unilateral neglect	Taiwan	Positive		X
Title: Effects of passive tactile and auditory stimuli on left visual neglect Authors: Hommel et. al.	Predates NMT 1990	Archives of Neurology	n=14 (8 male, 6 female) 29-81 y/o (mean age= 57 y/o)	Individuals with left-sided visual neglect due to stroke	France	Positive		X
Title: Listening to classical music ameliorates unilateral neglect after stroke Authors: Tsai et. al.	2013	The American Journal of Occupational Therapy	n=16 (6 male/10 female) mean age= 64.4 y/o	Individuals with unilateral neglect due to stroke	Taiwan	Positive		X
Percentages: 100% non-NMT								
<b>Auditory Perception Training (APT)</b>								
Title: Musical alexia for rhythm notation: A discrepancy between pitch and rhythm Authors: Midorikawa et. al.	2003	Neurocase	n=3 (all female), 59-60 y/o	Individuals with Wernicke's aphasia	Japan	Positive and Negative		X
Percentages: 100% non-NMT								
<b>Musical Attention Control Training (MACT)</b>								
Title: Development and preliminary evaluation of a music-based attention assessment for patients with traumatic brain injury Authors: Jeong & Lesiuk	2011	Journal of Music Therapy	n=15, 29-59 y/o	TBI	United States	Positive		X

Title: Music listening for maintaining attention of older adults with cognitive impairments Author: Gregory	2002	Journal of Music Therapy	n=12 6 female, 70-95 y/o 6 male, 72-87 y/o	Individuals with cognitive impairments	United States	Positive		X
Title: Music listening after stroke: beneficial effects and potential neural mechanisms Authors: Sarkamo & Soto	2012	Annals New York Academy of Sciences	n=54, 35-75 y/o (mean age= 58.9 y/o)	Individuals who had an acute ischemic stroke	Finland	Positive		X
Percentages: 100% non-NMT								
<b>Musical Mnemonics Training (MMT)</b>								
Title: The effectiveness of music as a mnemonic device on recognition memory for people with multiple sclerosis Authors: Moore et al.	2008	Journal of Music Therapy	n=38 (8 male/30 female) mean age= 36 y/o	MS	United States	Negative		X
Percentages: 100% non-NMT								
<b>Associative Mood and Memory Training (AMMT)</b>								
Title: The effect of music therapy on mood states in neurological patients: A pilot study Authors: Magee & Davidson	2002	Journal of Music Therapy	n=14	MS, TBI, and CVA	London	Positive		X
Title: The effect of a musical mood induction procedure on mood state-dependent word retrieval. Author: De l'Etoile	2002	Journal of Music Therapy	n=45 (13 male/32 females)	Students at a mid-Western university, and none were music majors	United States	Positive	X	
Title: The influence of group singing therapy on the behavior of alzheimer's disease patients Authors: Millard & Smith	Predates NMT 1989	Journal of Music Therapy	n=10 (3 male/7 female) 71-98 y/o	Individuals with Alzheimer's disease	United States	Positive		X
Title: The effects of music on mood state-dependent recall Authors: Thaut & De l'Etoile	Predates NMT 1993	Journal of Music Therapy	n=50, all female	Undergraduate students at Colorado State University who are receiving degrees in anything but music	United States	Positive	X	
Percentages: 50% non-NMT, 50% NMT								
<b>Musical Executive Function Training (MEFT)</b>								
Title: Neurologic music therapy improves executive function and emotional adjustment in traumatic brain injury rehabilitation Authors: Thaut et. al.	2009	Journal of Neurosciences and Music III	n=54, 47-52 y/o, 83% male	Individuals with acquired brain injuries	United States	Positive	X	

Title: Musical expertise, bilingualism, and executive functioning Authors: Bialystok & DePape	2009	Journal of Experimental Psychology: Human Perception and Performance	n= 95, 18-35 y/o	Individuals who were monolingual, bilingual, instrumentalists and vocalists	Canada	Positive		X
Percentages: 50% non-NMT, 50% NMT								

Table III

## CHAPTER VI:

### Conclusions and Implications for Future Research

This systematic review identified several clinical studies that demonstrated how music can be facilitated in rehabilitation settings. These studies show how the power of music may improve many different aspects of rehabilitation. NMT techniques help to facilitate improvements in cognitive, sensorimotor and speech and language functions. The purpose of this systematic review was to identify clinical research using neurologic music therapy (NMT) and non-NMT techniques that follow NMT protocol and do not refer to the title “NMT.” This systematic review sought to determine which NMT and NMT-like techniques are more commonly researched and which techniques reflect NMT research, and which do not. The author also sought to determine if there were NMT techniques that were more researched and developed pre and post NMT’s creation. Locating research on various strategies proved to be difficult. Many studies that were found had abstracts in English, but the study content was in a different language. This eliminated several possible studies for this systematic review.

Results identified that studies using MSOT, MNT, APT, MACT, MMT, MUSTIM, and RSC were 100% non-NMT. All studies found using MIT and PSE were 100% NMT, demonstrating that PSE and MIT are most commonly researched by neurologic music therapists. Interestingly, the researcher did not find any research conducted using SYCOM. This could be due to a lack of understanding of the technique or a problem with the technique itself. The techniques that have research both using NMT and non-NMT are AMMT, MEFT, VIT, DSLM, OMREX and RAS. Also, RAS is another technique that was identified as being the most commonly researched. Interestingly, the author found that 15/27 non-NMT articles mentioned

the concept of music therapy. This suggests that the majority of these researchers demonstrate an understanding of music therapy.

The author found several studies that predate NMT. Twelve studies were found to predate the founding year (1999) of NMT. Three RAS studies predate NMT indicating an equal amount of research both before and after NMT was created. The author was not surprised to find several research studies using MIT that predated NMT, because MIT was created in 1973, prior to NMT. All studies found using PSE, VIT, OMREX, DSLM, MUSTIM, RSC, MMT, MEFT, MACT, MSOT, and APT were more researched and developed after NMT was founded. This outcome could indicate that these techniques were created around the same time as NMT. The author also found studies using TS, RAS, MIT, TIMP, MNT, and AMMT that were all being researched prior to the development of NMT.

All 51 studies were conducted in various locations including the United States, Sweden, Australia, Taiwan, France, Japan, Finland, London, Norway, South Korea, and Germany. This shows the expansion of music therapy in rehabilitation settings has spread into many different places.

Ongoing NMT research is recommended to further justify its effectiveness in medical settings. It was disappointing to discover that many of the NMT techniques lack research, particularly SYCOM that did not have any related research. It would be helpful to research the effectiveness and/or scientific evidence of SYCOM in rehabilitation settings. The majority of the literature used in this systematic review yielded positive results (43/51). This signifies that NMT techniques may be effective when used in rehabilitation settings. Overall, this systematic review provided information that demonstrates the lack of research in several areas of NMT. Implying that either these techniques have no merit or rehabilitation patients who could benefit from these

techniques are not being served. NMT has positively influenced the practice of music therapy and has continued to give scientific support to the field of music therapy.

## References

- Baker, F. A. (2000). Modifying the melodic intonation therapy program for adults with severe non-fluent aphasia. *American Music Therapy Association: Music Therapy Perspectives*, 18, 110-114.
- Baker, F., Wigram, T., & Gold, C. (2005). The effects of a song-singing programme on the affective speaking intonation of people with traumatic brain injury. *Brain Injury*, 19(7), 519-528.
- Basso, A., Capitani, E., & Vignolo, L. A. (1979). Influence of rehabilitation on language skills in aphasic patients. *Archives of Neurology*, 36, 190-196.
- Bettison, S. (1996). The long-term effects of auditory training on children with autism. *Journal of Autism and Developmental Disorders*, 26, 361-375.
- Bialystok, E., & DePape, A. (2009). Musical expertise, bilingualism, and executive functioning. *Journal of Experimental Psychology: Human Perception and Performance*, 35(2), 565-574.
- Bower, G. H. (1981). Mood and memory. *American Psychologist*, 36(2), 129-148.
- Breir, J. I., Randle, S. Maher, L. M., & Papanicolaou, A. C. (2010). Changes in maps of language activity activation following melodic intonation therapy using magnetoencephalography: Two case studies. *Journal of Clinical and Experimental Neuropsychology*, 32(3), 309-314. doi: 10.1080/13803390903029293
- Carruth, E. K. (1997). The effects of singing and the spaced retrieval technique on improving face-name recognition in nursing home residents with memory loss. *Journal of Music Therapy*, 34, 165-186.
- Chen, M., Tsai, P., Huang, Y., & Lin, K. (2013). Pleasant music improves visual attention in

- patients with unilateral neglect after stroke. *Brain Injury*, 27(1), 75-82.
- Clair, A. A., & O’Konski, M. (2006). The effect of rhythmic auditory stimulation (RAS) on gait characteristics of cadence, velocity, and stride length in persons with late stage dementia. *American Music Therapy Association: Journal of Music Therapy*, 43(2), 154-163.
- Clark, I. N., Baker, F., & Taylor, N. F. (2012). The effects of live patterned sensory enhancement on group exercise participation and mood in older adults in rehabilitation. *American Music Therapy Association: Journal of Music Therapy*, 49(2), 180-204.
- Clark, I. N., & Harding, K. (2012). Psychosocial outcomes of active singing interventions for therapeutic purposes: A systematic review of the literature. *Nordic Journal of Music Therapy*, 21(1), 80-98.
- Claussen, D., & Thaut, M. H. (1997). Music as a mnemonic device for children with learning disabilities. *Canadian Journal of Music Therapy*, 5, 55-66.
- Cofrancesco, E. M. (1985). The effect of music therapy on hand grasp strength and functional task performance in stroke patients. *National Association for Music Therapy: Journal of Music Therapy*, 22(3), 129-145.
- Cohen, N. S. (1992). The effect of singing instruction on the speech production of neurologically impaired persons. *National Association for Music Therapy: Journal of Music Therapy*, 49(2), 87-102.
- Cohen, N. S., & Masse, R. (1993). The application of singing and rhythmic instruction as a therapeutic intervention for persons with neurogenic communication disorders. *National Association for Music Therapy: Journal of Music Therapy*, 30(2), 81-99.
- Cooke, M. L., Moyle, W., Shum, D., Harrison, S. D., & Murfield, J. E. (2010). A randomized controlled trial exploring the effect of music on agitated behaviours and anxiety in older

- people with dementia. *Journal of Aging and Mental Health*, 14(8), 905-916.
- De l'Etoile, S. K. (2002). The effect of a musical mood induction procedure on mood state-dependent word retrieval. *American Music Therapy Association: Journal of Music Therapy*, 39(2), 145-160.
- De l'Etoile, S. K. & Thaut, M. H. (1993). The effects of music on mood state-dependent recall. *National Association for Music Therapy: Journal of Music Therapy*, 30(2), 70-80.
- Deutsch, D. (1982). Organizational processes in music. In M. Clynes (Ed.), *Music, Mind and Brain*, 119-131. New York: Plenum Press.
- Dowling, W. J., & Harwood, D. L. (1986). *Music Cognition*. Orlando, FL: Academic Press.
- Frassinetti, F., Bolognini, N., & Ladavos, E. (2002a). Enhancement of visual perception by cross-modal visual-auditory interaction. *Experimental Brain Research*, 147, 332-343.
- Frassinetti, F., Pavani, F., & Ladavos, E. (2002b). Acoustal vision of neglected stimuli: Interaction among spatially convergent audio- visual inputs in neglect patients. *Journal of Cognitive Neuroscience*, 14, 62-69.
- Geist, K., & Geist, E. A. (2012). Bridging music neuroscience evidence to music therapy best practice in the early education classroom: Implications for using rhythm to increase attention and learning. *American Music Therapy Association: Journal of Music Therapy*, 30, 141-150.
- Gfeller, K. E. (1983). Musical mnemonics as an aid to retention with normal and learning disabled students. *Journal of Music Therapy*, 20, 179-189.
- Gfeller, K. E., Woodworth, G., & Robin, D. A. (1997). Perception of rhythmic and sequential pitch patterns by normally hearing adults and adult cochlear implant users. *Ear and Hearing*, 18, 252- 260.

- Glover, H., Kalinowski, J., & Rastatter, M. (1996). Effect of instruction to sing on stuttering frequency at normal and fast rates. *Perceptual and Motor Skills*, 83, 511-522.
- Gregory, D. (2002). Music listening for maintaining attention of older adults with cognitive impairments. *American Music Therapy Association: Journal of Music Therapy*, 59(4), 244-264.
- Haas, F., Distenfield, S., & Axen, K. (1986). Effects of perceived music rhythm on respiratory patterns. *Journal of Applied Physiology*, 61, 1185-1191.
- Hammar, L. M., Emami, A., Engstrom, G., & Gotell, E. (2010). Communicating through caregiver singing during morning care situations in dementia care. *Scandinavian Journal of Caring Sciences*, 25, 160-168.
- Heaton, P., Hermelin, B., & Pring, L. (1988). Autism and pitch processing: A precursor for savant musical ability? *Music Perception*, 15, 291-305.
- Hommel, M., Peres, B., & Pollak, P., Memin, B., Besson, G., Gaio, J., & Perret, J. (1990). Effects of passive tactile and auditory stimuli on left visual neglect. *Archives of Neurology*, 47, 573-576.
- Hurt, C. P., Rice, R. R., McIntosh, G. C., & Thaut, M.H. (1998). Rhythmic auditory stimulation in gait training for patients with traumatic brain injury. *American Music Therapy Association: Journal of Music Therapy*, 35(4), 228-241.
- Hallam, S., Cross, I., & Thaut, M. (2009). *Oxford handbook of music psychology*.
- Hodges, D. A. & Sebald, D. C. (2011). *Music in the human experience: An introduction to music psychology*. New York, NY: Routledge.
- Jackson, S. A., Treharne, D. A. & Boucher, J. (1997). Rhythm and language in children with moderate learning disabilities. *European Journal of Disorders of Communications*, 32,

99-108.

- Jeong, E., & Lesiuk, T. L. (2011). Development and preliminary evaluation of a music-based attention assessment for patients with traumatic brain injury. *American Music Therapy Association: Journal of Music Therapy*, 48(4), 551-572.
- Kim, S. J. (2010). Music therapy protocol development to enhance swallowing training for stroke patients with dysphagia. *American Music Therapy Association: Journal of Music Therapy*, 67(2), 102-119.
- Kim, S. J., Kwak, E. E., Park, E. S., & Cho, S. R. (2012). Differential effects of rhythmic auditory stimulation and neurodevelopmental treatment/bobath on gait patterns in adults with cerebral palsy: A randomized controlled trial. *Clinical Rehabilitation*, 26(10), 904-914.
- Kim, S. J., Kwak, E. E., Park, E. S., Lee, D. S., Kim, K. J., Song, J. E., & Cho, S. R. (2011). Changes in gait patterns with rhythmic auditory stimulation in adults with cerebral palsy. *NeuroRehabilitation*, 29, 233-241.
- Krauss, T. & Galloway, H. (1982). Melodic intonation therapy with language delayed apraxic children. *Journal of Music Therapy*, 19(2), 102-113.
- Kwak, E. E. (2007). Effect of rhythmic auditory stimulation on gait performance in children with spastic cerebral palsy. *American Music Therapy Association: Journal of Music Therapy*, 44(3), 198-216.
- LaGasse, B. (2012). Evaluation of melodic intonation therapy for developmental apraxia of speech. *American Music Therapy Association: Music Therapy Perspectives*, 30(1), 49-55.
- LaGasse, B. (2013). Influence of an external rhythm on oral motor control in children and adults. *American Music Therapy Association: Journal of Music Therapy*, 50(1), 6-24.

- Laughlin, S. A. & Naeser, M. A. (1979). Effects of three syllable durations using the melodic intonation therapy technique. *Journal of Speech and Hearing Research*, 22, 311-320.
- Lim, H. A. (2010). Effect of “Developmental speech and language training through music” on speech production in children with autism spectrum disorder. *American Music Therapy Association: Journal of Music Therapy*, 67(1), 2-26.
- Lim, H. A., Miller, K., & Fabian, C. (2011). The effects of therapeutic instrumental music performance on endurance level, self-perceived fatigue level, and self-perceived exertion of inpatients in physical rehabilitation. *American Music Therapy Association: Journal of Music Therapy*, 48(2), 124-148.
- Maeller, D. H. (1996). Rehearsal strategies and verbal working memory in multiple sclerosis. Unpublished Master’s thesis, Colorado State University.
- Magee, W. L. & Davidson, J. W. (2002). The effect of music therapy on mood states in neurological patients: A pilot study. *American Music Therapy Association: Journal of Music Therapy*, 59(1), 20-29.
- Max, L. & Yudman, E. M. (2003). Accuracy and variability of isochronous rhythmic timing across motor systems in stuttering versus nonstuttering individuals. *Journal of Speech, Language, and Hearing Research*, 46, 146-163.
- Meyer, L. B. (1956). *Emotion and Meaning in Music*. Chicago: University of Chicago Press.
- Midorikawa, A., Kawamura, M., & Kezuka, M. (2003). Musical alexia for rhythm notation: A discrepancy between pitch and rhythm. *Neurocase*, 9(3), 232-238.
- Millard, K. A., & Smith, J. M. (1989). The influence of group singing therapy on the behavior of alzheimer’s disease patients. *National Association for Music Therapy: Journal of Music Therapy*, 46(2), 58-70.

- Moore, K. S., Peterson, D. A., O'Shea, G., McIntosh, G. C., & Thaut, M. H. (2008). The effectiveness of music as a mnemonic device on recognition memory for people with multiple sclerosis. *American Music Therapy Association: Journal of Music Therapy*, 45(3), 307-329.
- Ogata, S. (1995). Human EEG responses to classical music and simulated white noise: Effects of a musical loudness component on consciousness. *Perceptual and Motor Skills*, 80, 779-790.
- O'Konski, M., Bane, C., Hettinga, J., & Krull, K. (2010). Comparative effectiveness of exercise with patterned sensory enhanced music and background music for long-term care residents. *American Music Therapy Association: Journal of Music Therapy*, 47(2), 120-136.
- Oliver, S., Thaut, M., & Sena, K. (2005). Medical coding and records manual: Neurologic music therapy.
- Ozdemir, E., Norton, A., & Schlaug, G. (2006). Shared and distinct neural correlates of singing and speaking. *Neuroimage*, 33, 628-635.
- Peng, Y., Lu, T., Wang, T., Chen, Y., Liao, H., Lin, K., & Tang, P. (2011). Immediate effects of therapeutic music on loaded sit-to-stand movement in children with spastic diplegia. *Journal of Gait and Posture*, 33, 274-278.
- Phillips-Silver, J., Aktipis, A., & Bryant, G. A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception*, 28(1), 3-14.
- Rimmele, C. T., & Hester, R. K. (1987). Cognitive rehabilitation after traumatic head injury. *Archives of Clinical Neuropsychology*, 2, 353-384.
- Sarkamo, T., & Soto, D. (2012). Music listening after stroke: beneficial effects and potential

- neural mechanisms. *Annals of the New York Academy of Sciences*, 1252, 266-281.
- Saylor, S., Sidener, T. M., Reeve, S. A., Fetherston, A., & Progar, P. (2012). Effects of three types of noncontingent auditory stimulation on vocal stereotypy in children with autism. *Journal of Applied Behavior Analysis*, 45, 185-190.
- Schlaug, G., Marchina, S., & Norton, A. (2008). From singing to speaking: Why singing may lead to recovery of expressive language function in patients with broca's aphasia. *Music Perception*, 25(4), 315-323. doi: 10.1525/MP.2008.25.4.315
- Schneider, S., Schonle, P., Altenmuller, E., & Munte, T. (2007). Using musical instruments to improve motor skill recovery following a stroke. *Neurology*, 254, 1339-1346.
- Schon, D., Boyer, M., Moreno, S., Besson, M., Peretz, I., & Kolinsky, R. (2008). Songs as an aid for language acquisition. *Journal of Cognition*, 106, 975-983.
- Snyder, B. (2000) *Music and Memory*. Cambridge, MA: MIT Press.
- Sparks, R. W., Helm, N. A., & Albert, M. L. (1973). Melodic intonation therapy for aphasia. *Archives of Neurology*, 29(2), 130-131.
- Sparks, R.W. & Holland, A. L. (1976). Method: Melodic intonation therapy for aphasia. *Journal of Hearing and Speech Disorders*, 11, 287-297.
- Staum, M. J. (1983). Music and rhythmic stimuli in the rehabilitation of gait disorders. *National Association for Music Therapy: Journal of Music Therapy*, 20(2), 69-87.
- Tamplin, J. (2008). A pilot study into the effect of vocal exercises and singing on dysarthric speech. *NeuroRehabilitation*, 23, 207-216.
- Thaut, M. H. (2003) Neural basis of rhythmic timing networks in the human brain. *Annals of the New York Academy of Sciences*, 999, 364-373.
- Thaut, M. H. (2008). *Rhythm, music, and the brain: Scientific foundations and clinical*

- applications*. New York, NY: Taylor & Francis.
- Thaut, M. H. (1985). The use of auditory rhythm and rhythmic speech to aid temporal muscular control in children with gross motor dysfunction. *National Association for Music Therapy: Journal of Music Therapy*, 22(3), 108-128.
- Thaut, M. H., Gardiner, J. C., Holmberg, D., Horwitz, J., Kent, L., Andrews, B. D., & McIntosh, G. R. (2009). Neurologic music therapy improves executive function and emotional adjustment in traumatic brain injury rehabilitation. *The Neurosciences and Music III: Disorders and Plasticity*, 1169, 406-416.
- Thaut, M. H., Peterson, D. A., & McIntosh, G. C. (2005). Temporal entrainment of cognitive functions: Musical mnemonics induce brain plasticity and oscillatory synchrony in neural networks underlying memory. *Annals New York Academy of Sciences*, 1060, 243-254.
- Tomaino, C. M. (1998). Music and memory: Accessing residual function. *Clinical Applications of Music in Neurologic Rehabilitation*, 19-27.
- Tsai, P., Chen, M., Huang, Y., Lin, K., Chen, K., & Hsu, Y. (2013). Listening to classical music ameliorates unilateral neglect after stroke. *The American Journal of Occupational Therapy*, 67(3), 328-335.
- Wallace, W. T. (1994). Memory for music: Effect of melody on recall of text. *Journal of Experimental Psychology: Learning, Memory, Cognition*, 20, 1471-1485.
- Wang, T. H., Peng, Y. C., Chen, Y. L., Lu, T. W., Liao, H. F., Tang, P. F., & Shieh, J. Y. (2013). A home-based program using patterned sensory enhancement improves resistance exercise effects for children with cerebral palsy: A randomized controlled trial. *Neurorehabilitation and Neural Repair*, 20(10), 1-11.
- Yamaguchi, S., Akanuma, K., Hatayama, Y., Otera, M., & Meguro, K. (2012). Singing therapy

can be effective for a patient with severe nonfluent aphasia. *International Journal of Rehabilitation Research*, 78-81.

Yinger, O. S., & Lapointe, L. L. (2012). The effects of participation in a group music therapy voice protocol (G-MTVP) on the speech of individuals with parkinson's disease. *American Music Therapy Association: Journal of Music Therapy*, 30, 25-31.

Zelazny, C. M. (2001). Therapeutic instrumental music playing in hand rehabilitation for older adults with osteoarthritis: Four case studies. *American Music Therapy Association: Journal of Music Therapy*, 38(2), 97-113.

Zipse, L., Norton, A., Marchina, S., & Schlaug, G. (2012). When right is all that is left: Plasticity of right-hemisphere tracts in a young aphasic patient. *Annals of New York Academy of Sciences: The Neurosciences and Music IV: Learning and Memory*, 1252, 237-245. doi: 10.1111/j.1749-6632.2012.06454.x

Appendix A:  
Sample Data Extraction Form

Study title: \_\_\_\_\_

Author(s): \_\_\_\_\_

Year: \_\_\_\_\_

Journal found in: \_\_\_\_\_

Study location: \_\_\_\_\_

NMT or Non-NMT: \_\_\_\_\_

NMT technique used: \_\_\_\_\_

Participants: \_\_\_\_\_

Methods: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Results: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Strengths/Weaknesses: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Implications: \_\_\_\_\_

\_\_\_\_\_