The Effect of a Music-Movement Intervention on Arousal and Cognitive Flexibility in Older Adults With and Without Mild Neurocognitive Disorder

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THE EFFECT OF A MUSIC-MOVEMENT INTERVENTION ON AROUSAL AND COGNITIVE FLEXIBILITY IN OLDER ADULTS WITH AND WITHOUT MILD NEUROCOGNITIVE DISORDER

By

Carolyn Dana Dachinger

A DISSERTATION

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THE EFFECT OF A MUSIC-MOVEMENT INTERVENTION ON AROUSAL AND COGNITIVE FLEXIBILITY IN OLDER ADULTS WITH AND WITHOUT MILD NEUROCOGNITIVE DISORDER

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The purpose of this study was to examine the effect of a music-movement intervention (MMI) on cognitive flexibility and arousal in older adults with typical cognitive aging (TCA) or with symptoms of mild neurocognitive disorder (MND). This study also examined the relationships among participants’ demographics, including age, exercise frequency, and years of music participation, and the dependent variables of cognitive flexibility, perceived arousal, physiological arousal, and perceived exertion.

Previous research and current theory suggest that multimodal interventions combining simultaneous physical activity and cognitive training may be an effective avenue for enhancing older adults’ cognition. Moreover, theory suggests that participation in such interventions can have an immediate effect on cognition via an arousal mechanism. As far as can be determined, no research exists exploring the cognitive outcomes associated with music-facilitated multimodal interventions, such as those that might be implemented by a board-certified music therapist.

Forty-eight older adults with and without MND completed a series of assessments and then took part in either the MMI or an identical intervention without music (i.e., the Movement-Only Intervention [MOI]). The MMI is a researcher-developed, single session, combined cognitive-movement intervention consisting of playing musical instruments that
simulate functional, everyday movements in time with familiar, recorded music. Assessments included a demographics questionnaire; heart rate measured at pre-test, mid-test, and post-test; perceived arousal measured at pre-test and post-test; perceived exertion measured at pre-test, mid-test, and post-test; and cognitive flexibility measured at pre-test and post-test.

Results indicated that regardless of cognitive status, participants assigned to the MMI significantly improved their cognitive flexibility from pre-test to post-test, as indicated by a decrease in the time necessary to complete the cognitive flexibility measure. By contrast, changes in cognitive flexibility over time for MOI participants were not significant. This result suggests that the addition of music listening and simple music instrument playing tasks to the movement intervention was more effective in improving cognition than the multimodal intervention without the music components. Moreover, these results suggest that older adults both with and without MND can immediately benefit from participation in the MMI.

Results also indicated that changes in perceived arousal, physiological arousal, and perceived exertion were not significantly different over time according to cognitive status and/or intervention assignment. This finding suggests that the MMI and MOI were comparable in terms of arousal potential. Moreover, changes in perceived arousal, physiological arousal, and perceived exertion did not significantly correlate with changes in cognitive flexibility. These results imply that the significant changes in cognitive flexibility observed in MMI participants were not due to alterations in arousal.

Researcher observations and participants’ feedback suggest that the interventions differed in terms of their ability to affect changes in state mood. Specifically, MMI
participants seemed to enjoy the combination of familiar music and novel instrument playing tasks, which led to improved mood and greater attention to task completion. By contrast, MOI participants shared that they felt bored, unmotivated by, and disengaged from the movement intervention. Thus, MMI participants’ improved mood and enhanced attention appeared to temporarily enhance their cognitive flexibility. Overall, while both the MMI and MOI included completing an identical series of functional movements and engaged the same cognitive skills, the MMI appeared to do so to a greater extent.

This study’s findings may be useful in conceptualizing how music perception and performance can be integrated into multimodal training to improve older adults’ cognition. If older adults are offered the opportunity to participate in interventions such as the MMI and enjoy doing so, they may be more likely to regularly take part in the training and potentially experience lasting benefits. For this reason, music therapists and related professionals may utilize information from this study to design, implement, and research the effects of similar functional training protocols.
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Chapter 1

Introduction

Between 2003 and 2013, the number of Americans aged 65 and older increased by close to 25% and this population is expected to double to close to 100 million people by 2060 (United States Department of Health and Human Services, 2014). Moreover, life expectancy predictions also continue to increase over time. For example, individuals who reach their 65th birthday can expect to live approximately 19 more years, close to 5 years longer than observed in 1960 (Federal Interagency Forum on Aging-Related Statistics, 2016). These population growth and life expectancy increases have been primarily attributed to higher per-person health care spending (Organization for Economic Co-operation and Development, 2015) along with overall health care advances (Federal Interagency Forum on Aging-Related Statistics, 2016).

Older adults’ health is characterized by unique, age-related changes in multiple body systems involved in cognitive, musculoskeletal, sensory, digestive and metabolic, urogenital, dental, skin, and functional health (National Institutes of Health, 2007). While significant intra-individual variability exists in regard to the aging process, cognitive decline is observed in nearly all individuals as they age (American Psychiatric Association [APA], 2013; Zelinski, Dalton, & Hindin, 2011). Thus, age-related cognitive changes can be considered a standard phenomenon of the aging process. For this reason, researchers across disciplines have increasingly stressed the need to have a greater understanding of cognitive aging, including structural and functional changes in the brain, potential associated cognitive declines, and effective interventions (Glisky, 2007; Harada, Love, & Triebel, 2013; Zelinski et al., 2011).
Age-Related Cognitive Changes

During aging, changes occur in a wide variety of cognitive processes, including attention, memory, speech and language, visuospatial abilities, and executive functioning. Some aspects of these functions may be preserved or actually improve as one ages, while others show gradual decline (Glisky, 2007; Harada et al., 2013). Accordingly, individuals in different periods of life may experience both positive and negative cognitive changes. Moreover, certain cognitive skills remain relatively stable throughout the lifespan (Park & Reuter-Lorenz, 2009). For these reasons, cognitive aging is considered a standard, but highly variable phenomenon (Glisky, 2007).

The variable changes in cognitive skills can be explained by examining the constructs of crystallized and fluid intelligence. Crystallized intelligence refers to knowledge and skills accumulated and stored over time, reflecting life experiences and learned procedures (Nisbett et al., 2012). In general, crystallized intelligence is observed to stabilize as one moves through older adulthood (Salthouse, 2012). By contrast, fluid intelligence involves the ability to effectively and flexibly manage novel situations and/or abstract problems independently of overlearned knowledge (Harada et al., 2013; Nisbett et al., 2012). Declines in perception, attention, memory, speech and language, decision making, and executive functioning are all associated with aging (Zelinski et al., 2011). These cognitive skills are considered components of fluid intelligence, and skills in this area begin to decline gradually over time after one turns 30 years old (Salthouse, 2012).

**Declines in cognitive flexibility.** While a normal part of the typical aging process, cognitive decline is also prevalent in abnormal aging processes associated with clinical disorders like dementia (APA, 2013). Typical aging is characterized by
negligible, gradual changes in cognition that may or may not affect daily functioning (Harada et al., 2013; Petersen, 2011). By contrast, pathology associated with clinical syndromes such as mild neurocognitive disorder (MND) includes at least a modest deterioration in cognitive functioning from prior abilities (APA, 2013).

This cognitive decline is considered clinically significant when individuals, and frequently other people around them, notice the deterioration. Additionally, individuals with MND must also exert increased effort, utilize compensatory strategies, and/or receive accommodations in order to live and complete daily activities with the highest possible levels of independence (APA, 2013). The disorder is frequently, but not always, a precursor to the development of major neurocognitive disorders, such as dementia or Alzheimer’s disease (Rosenberg, Johnson, & Lyketsos, 2006).

Deficits in cognitive flexibility, the complex ability to switch one’s previously used thoughts and behavior processes to adapt to environmental changes, are frequently observed during the aging process (Braver, Paxton, Locke, & Barch, 2009; Ionescu, 2012; Wecker, Kramer, Hallam, & Delis, 2005). Cognitive flexibility is an aspect of executive functioning, a multi-faceted cognitive characteristic consisting of the ability to plan, inhibit, select, shift, monitor, and update behavior based on internal and/or external environmental stimuli (Bari & Robbins, 2013). Cognitive flexibility changes are primarily associated with structural and/or functional alterations in the prefrontal cortex (Kim, Johnson, Cilles, & Gold, 2011). In older adults, declines in cognitive flexibility can impact a number of functional abilities, such as independent activities of daily living, driving, and managing one’s finances (Glisky, 2007; Gutchess & Park, 2000; Harada et al., 2013; Higginson, Lanni, Sigvardt, & Disbrow, 2013; McDowd & Shaw, 2000; Peres
et al., 2008). At the same time, cognitive skills requiring the ability to shift between sets appear to be especially responsive to training (Glisky, 2007).

**Interventions to support older adults’ cognitive health.** Researchers have investigated the impact of a number of cognitively engaging activities as a way to support healthy cognitive aging in older adults (Harada et al., 2013). Participating in activities and interventions that activate different types and levels of cognitive skills may help to strengthen the brain’s ability to develop compensatory mechanisms and strategies for utilizing cognitive skills at necessary times (Park & Reuter-Lorenz, 2009). Both physical exercise and music training have been proposed as forms of cognitively engaging methods of enhancing cognitive functioning in older adults, with some overlap in proposed neural mechanisms (Glisky, 2007; Harada et al., 2013).

Long-term participation in either diverse forms of exercise or music activities calls upon different levels and types of cognitive skills, resulting in extended, repetitive activation of neural areas involved in cognitive functions, such as the prefrontal cortex (Park & Reuter-Lorenz, 2009). By contrast, short-term cognitive enhancement brought about by participation in either of these activity types is likely mediated through increased arousal in brain structures such as the reticular formation and frontal lobe (Berlyne, 1971; Brisswalter, Collardeau, & René, 2002).

In addition to the positive contributions of single-mode activities, recent theory and research has emphasized the potential of multimodal interventions, such as ones combining exercise and cognitive training, to more effectively strengthen cognition in older adults (Kraft, 2012). In particular, a body of research has examined a combined functional movement-cognitive training program (Law, Barnett, Yau, & Gray, 2013;
Law, Barnett, Yau, & Gray, 2014) as a promising intervention to use with this population. Functional training involves practicing movements and movement sequences associated with cognitively demanding activities of daily living, such as reaching and lifting, which are inherently cognitive demanding.

Functional training that includes movement and cognitive components closely aligns with aspects of several Neurologic Music Therapy (NMT) interventions used in sensorimotor rehabilitation and cognitive rehabilitation, respectively: Patterned Sensory Enhancement (PSE)/Therapeutic Instrumental Music Playing (TIMP) and Musical Executive Function Training (MEFT). Both PSE and TIMP involve repetitive practice of music-facilitated movement patterns that mimic functional movements performed in everyday life (Thaut, 2005). MEFT is a technique that utilizes music exercises, such as improvisation and composition, to practice and strengthen executive function skills (Gardiner & Thaut, 2014). Accordingly, functional-cognitive training involves movements typically practiced in PSE and TIMP, but the goal of such training programs aligns with that of MEFT.

The addition of music to structured exercise may enhance the overall cognitive stimulation of a multimodal intervention. Music perception and production are both associated with increases in physiological and psychological arousal, which helps to activate cortical areas associated with high-level cognitive skills such as executive functions (Berlyne, 1971; Levitin & Tirovolas, 2009). When exercise is performed at a lower intensity, such as movements completed while sitting in a chair, the addition of music may help to increase and maintain an optimum level of arousal. Both music perception and production (i.e., instrument playing) also stimulate the prefrontal cortex, a
key neural area involved in cognitive flexibility (Levitin & Tirovolas, 2009). Moreover, practicing functional movement patterns in the context of instrument playing (i.e., during TIMP) closely mimics the use and manipulation of objects associated with activities of daily living. Thus, playing instruments provides an isomorphic opportunity to practice cognitively demanding functional movements associated with everyday life that call upon executive attention, performance monitoring, updating, planning, and action selection (Bari & Robbins, 2013; Yoo, 2009).

Statement of the Problem

While a standard part of the aging process, cognitive declines that impact cognitive flexibility, can impair older adults’ abilities to function independently. For this reason, designing and evaluating effective intervention strategies to address age-related cognitive decline is considered a research priority across disciplines serving this population. Recently, multimodal interventions combining aspects of exercise and cognitive training have been proposed as a potential approach for addressing older adults’ cognition. Music training is inherently multimodal because it can be structured to combine movement and cognitively complex tasks involving cognitive flexibility, planning, switching, monitoring, and other executive functions. Despite the potential of music training as an effective intervention for mitigating age-related cognitive decline, a paucity of research exists exploring the outcomes of such interventions.

Need for the Study

This study’s purpose is both theoretically and practically relevant. Theoretically, it will describe what, if any, differences exist between multimodal movement programs facilitated either with music or without music. While related theory suggests that both
music and exercise can enhance cognition in older adults, the effects of a combined intervention specifically implemented to address cognition have yet to be determined. Thus, the current study will address a current gap in the literature. Moreover, this basic research will explore the role of arousal as a potential mediating mechanism in cognitive changes arising from participating in two different interventions.

Uncovering the potential mediating mechanisms underlying music’s ability to affect changes in nonmusical domains, such as cognition, is congruent with the Rational-Scientific Mediating Model (R-SMM) for scientific research in Neurologic Music Therapy (Thaut, 2000). The R-SMM is a research model with a primary goal of uncovering the role of music as a mediator of nonmusical behavior. In turn, uncovering the music’s role in affecting change in nonmusical behavior becomes the impetus for developing and examining the effects of music therapy treatment protocols with clinical populations (Thaut, 2000). Research at the mediation level of this model provides a theoretical framework for conceptualizing and conducting practical, applied research implemented during the clinical practice development level of the R-SMM.

Practically, this study will add to the growing body of literature focused on music therapy as an effective and viable intervention strategy to address cognitive rehabilitation. The results of this study will inform future applied best practice research and intervention development with older adults. Music therapists and other professionals may be able to use the study’s methodology as a template for designing clinical interventions that use music-facilitated, multimodal training activities to enhance older adults’ cognitive functioning.
By comparing intervention-facilitated cognitive changes in older adults with and without symptoms of MND, this study will also help music therapists determine which of these populations will most benefit from this type of intervention. Thus, the results may inform music therapists’ clinical decision-making processes when selecting appropriate interventions for their older adult clients. Finally, if arousal is implicated as a mediating mechanism in the music-movement intervention, interventionists may be motivated to assess clients’ arousal states before and after such interventions to better conceptualize their potential functional outcomes.

**Purpose of the Study**

The primary purpose of this study was to examine the effect of a multimodal, combined music-movement intervention (MMI) on arousal, exertion, and cognitive flexibility in older adults with and without symptoms of mild neurocognitive disorder (MND). This study compared differences in cognitive flexibility following participation in the music-movement intervention, and an identical movement-only intervention without music. Additionally, the research explored differences in cognitive changes observed in older adults with and without symptoms of MND. Finally, the study examined the potential role of arousal as a mediating mechanism in any observed changes in cognitive flexibility.
Chapter 2

Review of Literature

This chapter presents research relevant to understanding how a cognitively demanding music-movement intervention may affect short-term arousal and cognitive flexibility in older adults with and without cognitive impairments. The first section describes literature focused on cognitive decline in older adults, specifically as it relates to cognitive flexibility. The proposed neural changes thought to underlie age-related cognitive deficits are discussed, and the concept of cognitively engaging activities as an approach to alleviating the functional impact of age related cognitive declines, is reviewed.

The third and fourth sections present research supporting exercise, and music, respectively, as examples of cognitively engaging activities appropriate for older adults, and describe the potential neurophysiological and neurobiological mechanisms that underlie their effectiveness. The final section explores the concept of multimodal interventions combining multiple forms of cognitive engaging activities, such as music, exercise/movement, and cognitive training, as an effective means of mitigating age related cognitive changes in typical older adults and those with clinical cognitive decline. Listed in this chapter are the research questions.

Cognitive Flexibility

Cognitive flexibility refers to the complex, fluid ability to quickly re-direct or switch one’s previous thought- and behavior processes to adapt to fluctuating internal or environmental demands (Braver et al., 2009; Ionescu, 2012; Wecker, Kramer, Hallam, & Delis, 2005). This ability is considered a component of executive
functioning, or a multi-faceted, broad collection of cognitive skills involved in the ability to plan, inhibit, select, shift, monitor, and update behavior based on internal and/or external environmental stimuli (Baddeley, Chincotta, & Adlam, 2001; Bari & Robbins, 2013).

Executive functions play a significant role in the regulation of lower-level, automatic cognitive processes in order to facilitate goal-directed behavior, and thus can be considered “top down” cognitive mechanisms (Bari & Robbins, 2013; Miller & Cohen, 2001). For these reasons, the ability to exert cognitive flexibility and other executive functions is essential in all situations where effortful, adaptive, controlled behavior is necessary, such as when one is operating a vehicle or performing a musical instrument.

Cognitive flexibility is conceptualized as a complex cognitive characteristic involving the dynamic interaction of various other cognitive functions and situational or task demands over time (Ionescu, 2012). For example, the ability to exert adaptive, flexible behavior involves the ability to coordinate perceptual and attentional resources, manage conflicts as they arise, and call upon previous knowledge as appropriate. Activation of these cognitive mechanisms is dependent on the task demands and context, as well as the sensorimotor components of the task itself. Thus, flexible cognition should be viewed not as a fixed ability, but rather a trait sensitive to cognitive resources and changing task requirements (Ionescu, 2012).

**Neuroanatomical evidence of cognitive flexibility.** Both cognitive flexibility theory and neuroimaging research indicate that cognitive flexibility is a primary function of the prefrontal cortex and that functional deficits in this skill observed in typical and
clinical populations are thought to originate in this brain area (Kim et al., 2011; Wecker et al., 2005). In their integrative theory of prefrontal cortex function, Miller and Cohen (2001) describe that this neural structure has several distinct properties that help it to promote flexible behavioral control. For example, the prefrontal cortex demonstrates a propensity for changing based on experiences (i.e., neuroplasticity). This structure contains multiple and wide-reaching connections to other brain regions, and is able to maintain, update, and integrate information it receives from them to guide behavior. The prefrontal cortex is able to exert cognitive control in the face of interference and exert bias to other brain structures to promote goal-directed behavior (Miller & Cohen, 2001).

Functional magnetic resonance imaging (fMRI) studies establish that well-defined activation of the prefrontal cortex, most notably in the dorsolateral and medial prefrontal regions, occurs while exerting cognitive flexibility (Leber, Turk-Browne, & Chun, 2008; Moll, Oliveira-Souza, Moll, Bramati, & Andreiuolo, 2002; Ravizza & Carter, 2008; Zakzanis, Mraz, & Graham, 2005). Across different tasks, cognitive flexibility also reliably activates distributed cortical and subcortical brain structures such the basal ganglia, anterior cingulate cortex, and posterior parietal cortex (Leber et al., 2008). Given that the prefrontal cortex has significant connections with sensory, motor, limbic structures and systems (Miller & Cohen, 2001), interaction of task characteristics, cognitive resources, and behavior over time may also differentially activate additional, widespread brain regions.
Cognitive Flexibility and Aging

Declines in cognitive flexibility are commonly observed in older adults both with and without pathological patterns of cognitive decline, such as those associated with dementia. Deficits in the ability to exert cognitive flexibility are associated with changes in the ability to perform instrumental activities of daily living (ADLs) and other functional tasks at necessary levels (Higginson et al., 2013). ADLs that may be affected by cognitive flexibility impairment include those that require several sequential steps to be completed and/or those that require multitasking (APA, 2013). For example, a number of researchers note that switching and flexible use of attention is a key component of driving, and that deterioration of these skills significantly contributes to automobile accidents involving older adults, including those with relatively normal cognitive aging (Gilsky, 2007; Harada et al., 2013; McDowd & Shaw, 2000). Another cognitively complex activity frequently affected by cognitive aging, considered to be one of the earliest abilities to be affected by cognitive decline, is the ability to manage one’s finances (Peres et al., 2008). Thus, declines in cognitive flexibility can limit older adults’ independence.

Neuroanatomical evidence of age-related changes in cognitive flexibility. As previously described, the prefrontal cortex is the primary neural structure involved in flexible cognitive control (Kim et al., 2011; Wecker et al., 2005). Among brain regions, this structure is one of the most susceptible to age-related changes (Gunning-Dixon, Brickman, Cheng, & Alexopoulos, 2009; Raz & Rodrigue, 2006). These changes are associated with specific patterns of structural, functional, and chemical environment brain alterations.
With regard to brain volume, magnetic resonance imaging (MRI) data collected over five years in a longitudinal study of cognitively and physically healthy older adults indicated that significant decreases in prefrontal white matter volume were observed as participants aged (Raz et al., 2005). Prefrontal white matter contains tracts that connect the structure to other sensory, motor, and subcortical structures (Miller & Cohen, 2001). Thus, changes in white matter volume during the aging process may lead to a state of ‘disconnection’ between the prefrontal cortex and these other structures, contributing to cognitive deficits in the ability to exert top-down control (Bennett & Madden, 2014; Gunning-Dixon et al., 2009).

Changes in the prefrontal cortex neurotransmitter environment, specifically in regard to dopamine, have also been implicated in the aging process and its associated cognitive changes. Along with the ventral tegmental area, the prefrontal cortex is part of the mesocortical dopaminergic pathway. In this pathway, dopamine stored in neurons located in the ventral tegmental area is projected to and released in the prefrontal cortex, where the neurotransmitter binds to receptors (Blumenfeld, 2011). Dopaminergic receptors in this pathway play a critical role in cognition, particularly in situations that call upon attention regulation and changing responses in the face of fluctuating environmental stimuli and demands (Cools, 2008; Reuter & Park-Lorenz, 2009). As one ages, the number of dopamine receptors in the brain are depleted, and may account for many of the cognitive deficits associated with aging (Kaasinen & Rinne, 2002; Park-Lorenz & Reuter, 2009), including difficulties exerting cognitive flexibility (Klanker, Feenstra, & Denys, 2013).
In addition to structural changes in the brain during aging, functional alterations in prefrontal neural activation patterns are also apparent. Neuroimaging studies have confirmed that aging is associated with reliable increases in bilateral prefrontal activation during tasks requiring cognitive control (Cabeza, Anderson, Locantore, & McIntosh, 2002). However, unlike age-related structural changes, these alterations or shifts in brain activation associated with aging may actually enhance the ability of older adults to exert cognitive control despite general cognitive decline.

In their scaffolding theory of aging and cognition, Park and Reuter-Lorenz (2009) suggest that changes in activation patterns typically observed during the aging process are compensatory, rather than cognitively damaging, in nature. In particular, bilateral prefrontal cortex activation observed during the aging process may be an adaptive mechanism to help account for decreased neural activity in other areas, including the hippocampus, the visual and sensory cortices, and the default network (i.e., a collection of brain areas active when a person is actively thinking about something without begin disturbed) (Park & Reuter-Lorenz, 2009). In their view, the process of scaffolding occurs when the brain, in the face of cognitive challenges, introduces increased bilateral activation in frontal circuits as a way to compensate, supplement, or provide an alternative method for meeting cognitive and/or behavioral objectives. Thus, scaffolding indicates that the brain is adapting to increased cognitive demands (Park & Reuter-Lorenz, 2009).

The brain’s ability to scaffold is enhanced by increased exposure to cognitively engaging activities, such as learning a new skill, exercise, or participating in cognitive training programs (Park & Reuter-Lorenz, 2009). Additionally, one paradoxical benefit
of improved scaffolding is the promotion of more efficient use of the original neural networks in need of compensatory assistance. Thus, effective cognitive training for older adults that promotes scaffolding actually lessens the brain’s reliance on the scaffolded, compensatory neural circuitry (e.g., involving increased activation/bilateral activation). The outcome is better overall neural efficiency of already-established neural networks (Park & Reuter-Lorenz, 2009).

**Aging and Cognitively Engaging Activities**

While cognitive skills involving the frontal lobe, such as those requiring cognitive flexibility, are particularly prone to age-related cognitive decline, they are also observed to be responsive to training (Glisky, 2007). For this reason, a number of cognitively engaging activities have been proposed to help mitigate the effects of cognitive decline (Harada et al., 2013), such as exercise, cognitive training, social engagement, playing musical instruments, reading, and playing games/puzzles (Glisky, 2007; Harada et al., 2013). Participation in cognitively engaging activities is hypothesized to help mitigate or delay the onset of age-related cognitive decline, thus enhancing older adults’ quality of life and maintaining independence.

**Exercise and cognition.** A number of positive cognitive effects have been documented in older adults following participation in various forms of short-term and long-term exercise protocols. Several meta-analytic studies have investigated the relationship(s) between fitness training interventions and cognitive functioning in older adults (Colcombe & Kramer, 2003; Etnier, Nowell, Landers, & Sibley, 2006; Heyn, Abreu, & Ottenbacher, 2004). Results of the meta-analyses revealed significant effect
sizes, ranging from small to moderate, for cognitive outcomes in both typical older adults and those showing early symptoms of Alzheimer’s disease.

Colcombe and Kramer’s meta-analysis (2003) examined fitness effects on discrete cognitive task processes, including cognitive speed, global cognitive processing, and visuospatial abilities, cognitive control, and executive functioning. While all processes significantly improved following exercise training, executive functioning received the most robust effects. The authors also explored a variety of moderating variables, with the largest cognitive improvements observed for training that combined both cardiovascular and strength exercises and included sessions of moderate length (i.e., 31-45 minutes).

Clearly, exercise has the potential to enhance cognitive function (Kashihara, Maruyama, Murota, & Nakahara, 2009). The potential of exercise to affect immediate changes in cognitive functioning is hypothesized to occur through arousal modulation (Brisswalter et al., 2002). These authors describe research supporting the hypothesis that exercise intensity, duration, and task complexity interact to modify central nervous system arousal during physical activity, which, in turn, enhances attention to relevant cues. The modulation of arousal facilitated by exercise was first explained by Yerkes and Dodson (1908), who posited that the relationship could be visualized as an inverted U shape with a medium level of arousal facilitating the highest level of performance. In the case of exercise, optimum cognitive and physical performance occurs when arousal is maintained at moderate level, while arousal at low or high levels can impair performance (Brisswalter et al., 2002).
Exercise immediately affects arousal by improving regional cerebral blood flow circulation and increasing neurotransmitter levels, such as dopamine and serotonin, throughout the brain (Kashihara et al., 2009). These exercise-induced changes in the brain environment appear to maintain a heightened arousal level for a short period of time following exercise completion (Tomporoski, 2003; Audiffren, Tomporowski, & Zagrodnik, 2008). Specifically, the arousal potential of short-term exercise may lead to improvements in various cognitive processes, including information processing, attentional resource allocation, problem solving (Tomporowski, 2003). Thus, individuals engaging in short bouts of exercise may experience temporary improved cognition.

The relationship between consistent participation in ongoing exercise interventions and improved cognition is hypothesized to occur by altering brain function over time. Specifically, participating in regular exercise supports stimulation of genes and brain growth factors that set into motion and coordinate a series of brain changes (Cotman, Berchtold, & Christie, 2007). Exercise enhances neuroplasticity by inducing neurogenesis and decreasing the risk of brain injury, such as stroke, via improved vascular functioning (Cotman et al., 2007). Moreover, regular exercise decreases inflammation in the brain and body, and helps reduce the risk of developing other health conditions associated with cognitive decline, such as high blood pressure or diabetes. Together, exercise-induced brain and body changes converge to impact cognitive functioning.

Music and cognition. Involvement in active music experiences positively impacts various facets of older adults’ well-being by promoting socialization with peers, instilling a sense of personal accomplishment, and facilitating feelings of enrichment.
(Coffman & Adamek, 1999; Coffman, 2002). Along with these indicators of improved quality of life, the beneficial cognitive effects of music in older adults’ lives have been documented in music training and music therapy literature. Executive functioning, of which cognitive flexibility is a component, appears to especially benefit from musical instrument learning and practice later in life.

Bugos, Perstein, McCrae, Brophy, and Bedenbaugh (2007) explored the cognitive outcomes associated with older adults’ participation in individualized piano instruction. The treatment group participated in one, 30-minute piano training session per week with three hours of independent practice for six consecutive months. The treatment sessions consisted of basic music theory training; practice of scales, triads, and dexterity exercises; and learning piano repertoire. Results indicated that individuals participating in piano training showed significant improvement over time on select tests measuring memory and executive functioning.

Of particular interest to the present study is the treatment group’s significant improvement on a measure of cognitive flexibility, the Trail Making Test B (Reitan & Wolfson, 1985), following participation in piano training. The researchers believe that the training’s ability to exercise both cognitive and motor domains through high-level, concurrent spatial and temporal processing contributed to an overall improvement in cognitive abilities in older adults. Additionally, consistent music practice is necessary to maintain maximum cognitive benefits over time in older adults experiencing typical, age-related cognitive decline.

In a follow-up study, Bugos (2010) compared the cognitive effects of 16 weeks of 1) once-weekly group piano instruction with daily individual practice; and 2) music
listening instruction (i.e., music appreciation) with daily individual listening in healthy older adults. Participants in both groups had improvements in verbal fluency, cognitive control, and processing speed, but only the piano instruction group’s outcomes were statistically significant from pre-test to post-test. The researcher suggests that while both types of music interventions call upon cognitive processes, the active music-making involved in piano playing intervention was novel, required bimanual motor coordination, and utilized a step-wise progression from simple to more challenging tasks. Together, these intervention characteristics engaged participants in cognitively complex tasks that appeared to be beneficial in affecting healthy older adults’ cognition.

**Music therapy, aging, and cognition.** In addition to research exploring music training, music therapy literature has also examined cognitive outcomes in older adults. However, most of the research in this area has focused almost exclusively on individuals diagnosed with dementia or Alzheimer’s disease rather than older adults with typical cognitive aging.

Brotons, Koger, and Pickett-Cooper (1997) noted that the first music therapy journal publications describing music-based interventions with these populations were written in the mid-1980s. Despite the fact that cognitive decline is one of the most prominent features of Alzheimer’s disease and related disorders (APA, 2013), the authors describe that between 1985 and 1996, very few music therapy studies with these populations specifically explored the cognitive effects of music (Brotons et al., 1997). Furthermore, many of this era’s “music therapy” studies involving older adults with cognitive decline such as dementia were conducted by non-music therapy clinicians, such
as occupational therapists, registered nurses, or individuals with non-specified professional statuses (Koger, Chapin, & Brontons, 1999).

Some of the research conducted with this population by both music therapists and related professionals involves examining only passive listening (e.g., with headphones) (e.g., Gregory, 2002, Li, 2015). While listening can be a component of music therapy sessions, listening is typically utilized within the larger context of a specific, goal-oriented intervention, such as relaxation, song discussion, or reminiscence (Grocke & Wigram, 2006). Thus, research on isolated music listening may have limited applicability to music therapy, and particularly so when the research is conducted by non-music therapists.

In one early music therapy study focused on active interventions, older adults with Alzheimer’s disease participated in six, 30-minute music sessions consisting of playing instruments along to recorded big band music (Lord & Garner, 1993). These participants had significant improvements in mood, social interaction, and the ability to recall their personal history, while no changes were observed for participants in a puzzle or art activity groups. Later, Sambandham and Schirm (1995) found that listening to preferred music in a group setting significantly improved memory and reminiscence abilities in older adults with very severe cognitive impairments. Taken together, these results suggest that group music listening and performance may temporarily enhance memory in older adults with cognitive impairments.

Older adults often remain musically responsive even when experiencing cognitive decline. For this reason, a number of researchers have developed and piloted music-based assessment tools specifically designed to measure older adults’ residual music skills
(York, 1994), cognitive status/skills singly (Lipe, 1995) or as a part of a global assessment of functioning (Adler, 2001; Hintz, 2000; Norman, 2012), and clinical response to music therapy (McDermott, Orrell, & Ridder, 2014). Both York’s (1994) Residual Music Skills Test (RMST) and Lipe’s (1995) Music-Based Evaluation of Cognitive Functioning (MBECF) involve verbal response questions and observation of music-making tasks such as listening, singing, and rhythm playing. Significant correlations exist between RMST and MBECF scores and a commonly-used cognitive functioning measure, the Mini-Mental Status Exam (MMSE), suggesting that these music-based measurement tools are appropriate for measuring cognition in older adults with cognitive decline (Lipe, York, & Jensen, 2007).

A number of global music therapy assessment tools for older adults contain components meant to measure cognitive status, and provide suggestions for assessment administration and/or interventions (Adler, 2001; Hintz, 2000; Norman, 2012). Noting that music-based assessment tools previously designed for this population are time-consuming to complete, Norman (2012) published a protocol and assessment tool that can be implemented fully within an individual or group music therapy session. Within these three global assessment tools, and the previously described cognitive assessment, the authors’ recommended music therapy interventions include tasks such as singing, rhythm recall, movement, and instrument playing.

Measuring older adults’ responses to music therapy interventions is useful for individualizing therapy to address the clients’ priority needs as their cognitive status or health changes. McDermott et al. (2015) developed and validated the Music in Dementia Assessment Scales (MiDAS) as a method for evaluating ongoing responses to music
therapy. The assessment tool contains five items -- measuring interest, response, initiation, involvement, and enjoyment – meant to be completed by a non-music therapy staff memory before and after the music therapy session, and by the music therapist at the beginning and middle of the music therapy session. The authors suggest that the MiDAS is appropriate for observing subtle benefits from music therapy that neuropsychiatric measurement tools may not assess or pick up on, such as improved social engagement (McDermott et al., 2015). Mover, the MiDAS demonstrates adequate-to-good psychometric properties and thus may be an appropriate tool for clinical use.

In addition to research exploring uses of music in older adults’ cognitive assessment, a small body of literature exists examining music therapy’s effectiveness in addressing this population’s cognitive needs. Hanson, Gfeller, Woodworth, Swanson, & Gerand (1996) compared low-demand and high-demand movement, rhythm, and singing exercises included in a biweekly music therapy program facilitated for 12 weeks with older adults with Alzheimer’s disease and related disorders (ADRD).

The authors examined participants’ active and passive involvement and disruption in all three activity types, and determined that participants were most actively engaged during movement activities regardless of cognitive functioning level (i.e., low, medium, and high cognitive impairment). By contrast, the greatest amount of passive engagement, such as simply sitting and listening, occurred during singing activities. Live singing provided by a music therapist can increase alertness in older adults in the late stages of dementia, especially when the music intervention is repeated over time (Clair, 1996). Thus, individuals in more advanced stages of cognitive decline may be responsive to low-demand singing exercises. In music therapy groups consisting of individuals with varying
cognitive functioning levels, movement interventions may be an appropriate way to involve all participants.

Bruer, Spitznagel, and Cloninger (2007) examined the sustainability of cognitive improvements resulting from music therapy in older adults with dementia and related syndromes. Participants took part in an 8-week program consisting of once-weekly, 45-minute sessions alternating between music therapy and a control condition involving watching a movie. In other words, participants received music therapy one week, a video the second week, music therapy the third week, and so on. The researchers measured participants’ cognition using the MMSE the morning of the intervention, and hour after the intervention was finished, and the morning after the intervention took place.

Results indicated that MMSE scores were significantly improved immediately following music therapy participation, while these scores decreased immediately after watching the video. The researchers observed similar results for MMSE scores compiled the morning after intervention participation: music therapy participation significantly improved MMSE scores from baseline, while control scores decreased. However, the groups’ MMSE scores were comparable a week following the study’s conclusion. These results suggest that music therapy can immediately affect older adults’ cognition, but that such results may not persist once treatment is discontinued.

More recently, researchers explored how music therapy provides longer-term cognitive enhancement in older adults with dementia. Chu et al. (2013) also utilized the MMSE to measure older adults’ cognition over 12 weeks of group music therapy participation delivered twice weekly or treatment as usual. Results indicated that participants who received music therapy has significant improvements in one MMSE
component, recall, at halfway through study, at the end of the study, and at one month after the study interventions had been completed.

These results indicate that frequent participation in music therapy can affect cognition such that improvements endure even after individuals stop attending sessions. Specifically, the researchers suggest that music stimuli, and in particular its rhythm qualities, provides structure that can help organize memory recall and enhance reality orientation (Chu et al., 2013). Additionally, they describe that music therapists who want to enhance cognition can design and implement sessions to specifically stimuli different cognitive functions, which will likely enhance cognition in these areas (Chu et al., 2013).

A recent systematic review and meta-analysis of 11 studies explored the short-term effects of receptive (i.e., music listening) and active music therapy (i.e., singing and instrument playing) on Mini-Mental State Examination (MMSE) scores reflective of general cognition (Li, Wang, Chou, & Chen, 2015). The review indicated that receptive music therapy produced significantly improved MMSE scores across studies, while no significant cognitive effects were observed for singing-only interventions. When results across studies were pooled in the meta-analysis, no significant short-term effects on cognition emerged.

The authors suggest caution in interpreting this result, as the MMSE may not be sensitive enough to detect short-term cognitive changes. Moreover, previous research (Chu et al., 2014) suggests that music therapy may be more effective with less severe forms of cognitive impairment, while the studies included in the present meta-analysis primarily involved neurocognitive disorders such as dementia and Alzheimer’s disease.
Finally, the majority of the included studies did not provide enough information to determine if the interventionist(s) was a trained and certified music therapist.

**Music, arousal, and cognition.** Music-based interventions may lead to a temporary state of increased arousal, characterized as a state of alertness and reactivity toward stimuli which can impact one’s present level of cognitive functioning (Berlyne, 1971; Posner, 1980). Using a psychobiological framework, Berlyne (1971) described how art’s various stimulus properties modify arousal states. In his view, perceiving music’s psychophysical, collative, and ecological properties can stimulate heightened arousal states by activating areas of the brain, such as the reticular activating system (Berlyne, 1971).

This brain system plays a key role in modulating attention by filtering out irrelevant stimuli so that one can attend to relevant and meaningful information. An optimum level of arousal is reached when a moderate amount of information is present during music perception, leading to the experience of pleasure. The brain is more likely to focus on environmental stimuli, such as music, that is perceived as pleasurable (Berlyne, 1971). Thus, music experienced as pleasurable has the potential to engage attentional processes over time.

A more contemporary view of arousal and attention mechanisms proposed by Posner (1980) explains how arousal modulated by stimuli such as music can activate attention processes. Specifically, three attention networks involved in alerting, orienting, and executive attention control facilitate complementary aspects of attention. At the earliest stages of attention, alerting helps maintain an attentive set toward the environment (Posner & Rothbart, 2007). Maintaining a level of alertness toward the
environment plays a necessary role in detecting changes in sensory stimuli and allowing the brain to assign priority processing to the most important sensory events (Posner & Petersen, 1990). Alerting is facilitated by several neural structures, including the superior parietal lobe, temporal parietal junction, frontal eye fields, and superior colliculus (Posner & Fan, 2008).

Once significant sensory information has been selected, orienting occurs through the process of directing attention to that information via overt (e.g., eye movement) or covert (i.e., physical) behavioral responses (Posner & Rothbart, 2007). The locus coeruleus and right frontal and parietal cortices make up the orienting network (Posner & Fan, 2008). Once attention has been directed, executive attention is engaged to facilitate executive functioning, or higher-level cognitive skills involved in successfully integrating and managing behavioral responses (Posner & Rothbart, 2007).

In addition to triggering arousal and attention processes, prefrontal cortex activation plays a primary role in exerting the executive functions necessary to perceive and attend to various aspects of musical experiences (Levitin & Tirovolas, 2009). Brain imaging studies have established that prefrontal cortex activation is required and occurs during music perceptual processes such as generating expectations and detecting violations of these expectations (Tramo, 2001) and distinguishing major versus minor tonality in music (Green et al., 2008). Processes involved in perceiving culturally familiar, native melodies also rely on prefrontal cortex activation (Nan et al., 2007). Prefrontal cortex activation occurs while one is detecting phrase boundaries in music by maintaining attention and updating working memory during music listening (Sridharan, Levitin, Chafe, Berger, & Menon, 2007). Additionally, the prefrontal cortex contains
connections to brain regions responsible for emotion regulation (i.e., the amygdala) and memory (i.e., the hippocampus), and thus impacts emotion evocation during music listening (Bigliassi, Leon-Dominguez, & Altimari, 2015).

Music performance necessarily entails executive function processes including attention, cognitive flexibility, and working memory (Zuk, Bejanmin, Kenyon, & Gaab, 2014). Thus, prefrontal cortex activation is necessary during active music making to facilitate the goal-directed, controlled behavior necessary for performance (i.e., the executive functions of music). However, level of prefrontal cortex activation during active music making depends on the cognitive and motor demands required by the task.

For example, a recent brain imaging study found that areas of the lateral prefrontal cortex were deactivated in trained jazz musicians during piano improvisation, suggesting that musicians may engage in aspects of improvisation without the significant influence of certain higher-level executive processes (Limb & Braun, 2008). In other words, different improvisation components may become automated. By contrast, concurrent medial prefrontal cortex activation occurred during the same task, suggesting that this neural region regulates executive functions such as attention, inhibitory control, and other behaviors that require active self-monitoring during improvised music performance (Kringelbach & Rolls, 2004).

The results of these studies involving music perception and production provide support that music arouses and activates the prefrontal cortex leading to stimulation of higher-level cognitive skills involved in attention and executive functioning.
Multimodal Training Programs for Older Adults

Recent research and theory suggests that training programs combining multiple forms of stimuli and activities, known as multimodal training, may have particularly beneficial cognitive effects for healthy older adults and those with known cognitive impairment. Exercise directly impacts both brain and physical health and helps to mediate improvements in cognitive functioning (Cotman, Berchtold, & Christie, 2007). Moreover, exercises and training interventions structured to be cognitively demanding, such as those that include complex sequences of movements, object manipulation, or performance monitoring, involve activation of various higher-level cognitive skills, such as planning and behavioral flexibility (Law et al., 2013).

Kraft (2012) proposes that multimodal training programs combining simultaneous cognitive and exercise components may be more effective in mitigating age-related cognitive changes than unimodal cognitive or exercise interventions. Specifically, Kraft (2012) hypothesizes that because cognitive and exercise training both positively influence age-related cognitive changes, the combination of both together may produce greater cognitive benefits than participating in both separately. Multimodal training may enhance older adults’ cognition by increasing frontal bilateral activation, facilitating neurogenesis, or neuron growth and development, and stimulating distributed neural networks (Kraft, 2012). These neural mechanisms are proposed to help the aging brain scaffold, or compensate, for age-related cognitive declines (Park & Reuter-Lorenz, 2009).

Kraft (2012) acknowledges that a paucity of research exists examining the effect of combined cognitive-exercise training programs on cognition in older adults. In one study, healthy older adults who received two months of combined aerobic exercise and
mental training showed significantly greater improvements in memory than did individuals who received either aerobic exercise or mental training alone (Fabre, Chamari, Mucci, Massé, & Préfaut, 2002). Compared to participants receiving physical training, psychosocial training, cognitive training, or a combination of physical and psychosocial training, healthy older adults receiving one year of a combined cognitive-physical intervention showed significant improvements in cognitive functioning. Participants’ improvements were still observed, at a significant level, at a five-year study follow-up (Oswald, Gunzelmann, Rupprech, & Hagen, 2006).

Combined cognitive-exercise interventions have also been examined in older adults with cognitive impairments. Older adults with mild cognitive impairments, mild Alzheimer’s disease, or moderate Alzheimer’s disease maintained their cognitive status after receiving six months of combined psychosocial support and an intensive cognitive-motor intervention, while participants only receiving psychosocial support showed declines (Olazarán et al., 2004). Other multimodal interventions that have shown positive cognitive outcomes include amateur dancing (Kattenstroth, Kolankowska, Kalisch, & Dinese, 2010) and a combined cardiovascular exercise and coordination training program (Voelcker-Rehage, Godde, & Staudinger, 2011). These results lend preliminary support that multimodal cognitive-exercise interventions for mitigating cognitive decline in older adults are worthy of further study in order to confirm Kraft’s (2012) hypothesis.

The current study emphasizes a combined music and movement intervention using exercises based on training functional movement patterns that require strength, endurance, and range of motion. This type of program most closely aligns with a type of exercise known as functional training. Functional training refers to structured exercise
specifically focused on training body movements and sequences typically associated with
everyday tasks and activities of daily living (Whitehurst, Johnson, Parker, Brown, &
Ford, 2005). As activities of daily living require cognitive and physical control,
functional training programs integrate aspects of typical exercise, such as strength and
endurance, with opportunities to exert cognitive skills associated with the completion of
daily activities. Thus, functional training is not merely exercise, but rather combines
characteristics of cognitive and physical exercise training programs into a single
intervention (Law et al., 2013).

Functional training can be considered a task-oriented approach to physical activity
because of its emphasis on enhancing movement patterns specific to activities of daily
living. In their review of literature, Bayona, Bitensky, Salter, and Teasell (2005)
identified several principles underlying successful task-oriented rehabilitation strategies
applied to the physical and perceptual domains. First and foremost, training tasks that are
personally meaningful to the individual leads to better functional outcomes and produces
important cortical changes. Cortical changes associated with task-oriented training
require repetition and practice, but functional tasks need not be practiced at a high
intensity to be effective. Finally, long-term cortical changes associated with task-oriented
training occur in the specific neural areas that are activated during the exercises being
performed (Bayona, Bitensky, Salter, & Teasell, 2005). In other words, repeated brain
activation that occurs during functional training can facilitate neural changes that enhance
future task completion.

The above principles can be applied to research examining the cognitive benefits
associated with older adults’ participation in functional training programs that focus on
task-specific movement patterns. Vreugdenhil, Cannell, Davies, and Razay (2010) examined the influence of participation in a four-month, community-based home exercise program on cognitive functioning in individuals diagnosed with Alzheimer’s disease. The daily exercise routine consisted of a series of ten simple exercises practiced at three progressively more challenging levels coupled with a minimum of 30 minutes of brisk walking. While not multimodal in nature, this exercise intervention includes movement patterns associated with everyday living, such as weight shifting and reaching, and thus can be considered a form a functional training.

Cognitive outcomes were measured using the Alzheimer’s disease Assessment Scale (ADAS) cognitive sub-scale and the Mini-Mental State Examination (MMSE). The results indicated that participants who completed the exercise program showed a statistically significant improvement in cognitive functioning compared to the control group as indicated by increases on the MMSE and decreases on the ADAS subscale. Among the participants who exercised, cognitive improvements were also accompanied by improved physical outcomes in areas such as balance, mobility, and lower body strength, as well as enhanced independence in completing activities of daily living. These findings indicate that participation in a functional training program may simultaneously enhance cognitive, physical, and independent functioning in individuals diagnosed with Alzheimer’s disease (Vreugdenhil et al., 2011).

Law et al. (2013) developed and examined the cognitive benefits associated with a functional task exercise program, the FcTSim (i.e., simulated [Sim] functional tasks [FcT]). The FcTSim protocol consists of placing and collecting a set of dining utensils according to five specific movement patterns from least- to most-physically and
cognitively challenging, including: 1) simple placement/collection; 2) clockwise placement and counterclockwise collection; 3) placement and collection alternating left and right hands; 4) place and collect with a point of repetition; and 5) place and collect with both hands in opposite directions. An interference task was performed between each table task movement to add an additional level cognitive and physical demand to the training. The exercises included in the FcTSim were designed to involve different types and levels of cognitive demand, including attention, working memory, and executive functioning. Because the FcTSim involves both physical activity and cognitive training, it is an example of a multimodal training program.

Participants, all of whom were diagnosed with mild cognitive impairment (MCI), completed three training sessions a week for ten weeks. Each one-hour training session included five-to-ten minutes each of warm-up and cool-down light stretching along with approximately 30 minutes of the FcTSim exercises, practiced at a pace determined by each participant’s success in learning and completing the different movement tasks (Law, Barnett, Yau, & Gray, 2013). No control group was included in the study.

Outcome measures included tests of general cognitive functions, specific functions in the executive function and memory domains, functional ADL abilities, and everyday problem solving skills. Results indicated that participants had statistically significant increases on all measures from pre-test to post-test, and these changes were maintained at three months post-treatment. Moreover, effect sizes at post-intervention ranged from small to very large, with the largest effect sizes observed for problem solving, general cognitive functioning, and one aspect of memory, total free recall (Cohen’s $d = 0.76$). Thus, participation in the FcTSim program appears to be of great
cognitive and functional benefit to individuals with MCI. The simultaneous cognitive and motor processes involved in the practice of functional tasks appear to be an important aspect of this intervention’s success (Law, et al., 2013).

In a follow up to their 2013 study, Law et al., (2014) conducted a randomized control trial to compare the effects of the FcTSim with that of a cognitive training program on cognitive functioning in older adults with MCI. Participants received either 10 weeks of FcTSim or cognitive training. The cognitive training involved computer exercises, cognitive strategy training, and take-home exercises.

Results indicated that both FcTSim and the cognitive training interventions improved cognition. However, FcTSim participants displayed significantly greater increases in general cognitive functioning, memory, executive functioning, functional ADL abilities, and everyday problem solving abilities, and effects on general cognitive functioning and everyday problem solving abilities were maintained at 6 months post-intervention. Thus, practicing functional exercises that include demanding cognitive requirements, such as those included in the FcTSim, appears to provide greater cognitive benefits than does cognitive training alone, and several benefits are maintained over time (Law et al., 2014).

In summary, the results observed in these studies suggest that both simple and more complex training programs focused on functional movement patterns positively impact cognition in older adults experiencing cognitive impairments, such as those associated with MCI or Alzheimer’s disease (Vreugdenhil et al., 2011; Law et al., 2013; Law et al., 2014). Moreover, these studies support the notion that an interaction of motor and cognitive processes occurs when one performs functional tasks, and that structured,
repetitive practice of such tasks can lead to the maintenance, or improvement, of important cognitive skills. Cognitive skills observed to improve following functional training include attention, memory, and higher-level executive processes, all of which are associated with age-related declines (Zelinski et al., 2011). Thus, functional training may be an effective intervention for mitigating age-related cognitive declines. Moreover, functional training does not necessarily require specific tools or equipment (Law et al., 2013; Law et al., 2014; Whitehurst et al., 2005) making it both practical training modality for older adults.

**Music-facilitated functional training.** Music-facilitated movement interventions can be considered multimodal because this type of training combines the cognitively demanding characteristics of both functional movement and music training programs. As previously described, research indicates that perceiving music can modulate arousal to an optimum level necessary to facilitate higher-level attention and executive functions (Berlyne, 1971; Posner & Rothbart, 2007) known to be modulated by the prefrontal cortex. Maintaining a moderate arousal level during physical and/or cognitive tasks is associated with high performance (Brisswalter et al., 2002, Yerkes & Dodson, 1908). Thus, the addition of music to a functional training program may help to facilitate and maintain an optimum arousal level leading to improved cognitive performance. When the functional training is of low intensity, such as seated movement sequences, performing movements using the music to pace the movements may help to increase its arousal potential to an ideal level.

Arousal arising from structuring functional movements to music inherently relies on basic cognitive functions, such as patterned information processing (Thaut, 2005). In
the context of music perception and movement, patterned information processing involves perceptual recognition of the various patterns and groupings embedded in music and using these organizational structures to develop a template for regulating motor performance of functional movements (Thaut, 2005). Humans automatically organize music into these structural units, known as auditory gestalts, in order to more efficiently filter, select, and categorize information, which, in turn, leads to enriched information processing and action selection (Lipscomb, 1996). Thus, including music in a functional training program enhances neural organization of the auditory stimuli for further processing and use.

In music-facilitated functional training, such as Patterned Sensory Enhancement (PSE) or Therapeutic Instrumental Music Performance (TIMP), the music is used to cue simple or complex movements, or movement sequences, rather than serving as an accompaniment or background stimuli (Thaut, 2005). Music therapists who implement PSE and/or TIMP improvise or design music stimuli to structure motor patterns associated with functional movements (Thaut, 2005). The live music provides a template for completing the movements by cueing the appropriate spatial, temporal, and force parameters.

For example, a music therapist may use music elements such as pitch, volume, duration, and/or harmony to cue the movements as they occur in space. Temporal aspects of music, such as tempo and meter, provide clients with information that facilitates appropriate timing of movements. Movement force can also be indicated through the use of harmony, which can signify when muscle tension or relaxation is required (Thaut, 2005). TIMP extends PSE by including instrument playing to replicate functional
movement patterns. The instrument is utilized as a target for the movement’s end point and provides auditory feedback that the movement has been completed.

In order to successfully practice sequences of functional movements being cued by the music, such as a series of arm movements involving reaching, grasping, and lifting, different aspects of higher-level cognitive processes, known as executive functions, must be integrated. Bari and Robbins’s (2013) hypothesized model of integrated brain function, which describes how different aspects of executive function relate to each other, can serve as a framework for conceptualizing the relationship of higher-level cognitive processes to music-facilitated functional training.

In this model the ability to exert attention to the internal and/or external environment is necessary in order to recognize if and when changes in stimuli occur. Individuals must constantly monitor their own behavioral performance in order to determine if their current behavioral set is effectively meeting task demands (Bari & Robbins, 2013). When the current behavior is no longer effective, the behavioral goal is updated and a new plan of action must be selected. Behavior and attention then shift to the new goal-oriented behavioral plan until attention processes recognize new task demands that require beginning this cognitive cycle anew (Bari & Robbins, 2013).

Participating in music-facilitated functional training interventions such as PSE and TIMP engages the cognitive processes described by Bari and Robbins (2013). Specifically, during these interventions, individuals must attend to the dynamic, changing sensory cues provided by the therapist, the individual’s body, and/or the musical instrument (i.e., during TIMP) in order to plan, execute, and monitor their own performance while completing the movement pattern(s) in time and with the appropriate
amount of force (Yoo, 2009). Attention to these sensory cues promotes self-correction and self-assessment of progress. Thus, both PSE and TIMP continuously engage executive functions. By contrast, functional movements performed without a sensory template or auditory feedback may become automatic as participants complete movements without paying conscious attention. Participants may experience low levels of arousal, leading to disengaged attention and cognitive processes.

While PSE and TIMP involve the practice of functional movement patterns that require different levels of cognitive control, music therapists design and implement these interventions to address sensorimotor goals, such as improved strength, endurance, balance, and posture (Thaut, 2005). By contrast, Musical Executive Function Training (MEFT) is a Neurologic Music Therapy technique meant to strengthen executive functioning skills such as decision-making and problem solving (Gardiner & Thaut, 2014). Thus, music therapists who utilize music-facilitated functional training programs with a goal of enhancing cognition are actually conducting MEFT. While designing the MEFT exercises, the music therapist will utilize knowledge of the types of cognitive tasks (e.g., sequencing) necessary to strengthen executive functioning and incorporate knowledge of PSE and TIMP principles to design and implement the appropriate music and movement experiences.

In the present study, the music-facilitated movements can be understood to be an intervention belonging to MEFT. However, throughout this manuscript, the term Music-Movement intervention (MMI) will be used instead of MEFT to emphasize this intervention’s unique combination of both movement and cognition training.
Summary of the Literature Review

The theoretical and research literature supports an examination of the effect of a multimodal, music-facilitated, exercise-cognition intervention on cognitive flexibility in older adults with and without symptoms of mild neurocognitive disorder (MND). Cognitive flexibility declines during both typical and pathological aging processes, yet is also responsive to cognitively engaging activities, such as exercise and music, which call upon top-down cognitive processes. Long-term participation in these activities can slow down or mitigate the functional impact of cognitive declines by activating and the strengthening the prefrontal cortex. Moreover, cognitively engaging activities are hypothesized to produce immediate, reliable increases in arousal, which may account for acute increases in cognitive functioning for a short time after participation.

Multimodal training interventions are proposed to be more effective than unimodal interventions to address cognitive decline in older adults. In particular, a small but growing body of research has begun to investigate functional training programs that combine movement sequences that mimic activities of daily living with high-level cognitive tasks. The addition of music training to functional movement programs may help facilitate optimum levels of arousal and provide unique opportunities to strengthen executive functions via extended prefrontal cortex activation through structured practice of cognitively complex functional movement patterns. Music therapists utilize movement interventions with properties similar to functional training programs, yet research in this area has primarily focused on sensorimotor, rather than cognitive, outcomes. Thus, research is necessary to ascertain if music-facilitated functional training interventions
have a reliable effect on cognition in older adults, both short-term and long-term, and identify the mediating mechanism for observed changes.

**Research Questions**

This study addressed the following research questions:

1. What are the interaction and main effects of cognitive status (typical cognitive aging [TCA] versus mild neurocognitive disorder [MND]), intervention type (MMI versus MOI), and time (pre-test/post-test) on cognitive flexibility in older adults?
   a. Null hypothesis: Cognitive status, intervention type, and time will not interact to affect, and will not exert main effects on, cognitive flexibility in older adults.

2. What are the interaction and main effects of cognitive status, intervention type, and time (pre-test/post-test), on self-perceived arousal in older adults?
   a. Null hypothesis: Cognitive status, intervention type, and time will not interact to affect, and will not exert main effects on, perceived arousal in older adults.

3. What are the interaction and main effects of cognitive status, intervention type, and time (pre-test/mid-test/post-test) on changes in physiological arousal in older adults?
   a. Null hypothesis: Cognitive status, intervention type, and time will not interact to affect, and will not exert main effects on, physiological arousal in older adults.
4. What are the interaction and main effects of cognitive status, intervention type, and time (pre-test/mid-test/post-test) on perceived exertion in older adults?
   a. Null hypothesis: Cognitive status, intervention type, and time will not interact to affect, and will not exert main effects on, perceived exertion in older adults.

5. What relationships exist between participant demographic variables (i.e., age, days of the week participant exercises, and number of years of music participation) and the study’s dependent variables (i.e., cognitive flexibility, perceived arousal, physiological arousal, and perceived exertion).
   a. Null hypothesis: No significant relationships will emerge between participant demographic variables and the study’s dependent variables.
Chapter Three

Method

In this chapter, this study’s methodological details are presented, including information regarding participants, study components, and measurement tools. Data collection and statistical analysis procedures are also included.

Participants

The researcher pre-screened a total of 124 individuals for potential study participation using the Revised Physical Activity Readiness Questionnaire (rPARQ) (Cardinal, Esters, & Cardinal, 1996). This assessment tool contains questions that helped the researcher determine potential participants’ readiness for safely engaging in physical activity. Of those individuals who were pre-screened, 70 answered “yes” to one or more of the rPARQ questions, indicating that they may not have been able to safely engage in the interventions. These individuals were excluded from participating in the study. The most common reasons for study exclusion included individuals having bone or joint problems that could be made worse by participating in physical activity or individuals taking prescription drugs for blood pressure or a heart condition. Individuals who answered “no” to all rPARQ questions ($n = 54$), indicating that they were likely able to safely engage in the interventions, were invited to participate.

The final participant pool included 48 older adults that presented with symptoms of either mild neurocognitive disorder (MND) ($n = 24$) or typical cognitive aging (TCA) ($n = 24$), as indicated by the St. Louis University Mental Status (SLUMS) examination (Tariq, Tumosa, Chibnall, Perry III, & Morley, 2006). Prior to data collection, the researcher conducted a power analysis, using G*Power software (version 3.1.9.2)
(Faul, Erdfelder, Buchner, & Lang, 2009) to determine the number of participants necessary to detect an effect. Utilizing information about this study’s primary statistical analysis procedures to guide the power analysis (see the “Data Analysis” section in this chapter for more information), results indicated that a minimum sample size range of 28 to 32 participants would be have 80% power to detect a study effect size of .25 (Cohen’s \( f \)), which is a medium effect size for an analysis of variance (ANOVA) (Cohen, 1988).

All participants were fluent in spoken and written English, were able to follow simple directions, and could move different parts of their body (i.e., upper extremities, lower extremities, and the trunk/torso) independently. Any participant whose score on the SLUMS assessment indicated symptoms of dementia was excluded from this study. Additional exclusion criteria included the following: psychotic disorders; acute physical disorders or conditions that limit or interfere with the ability to move the body such as broken bones; and/or sensory impairment that could interfere with the ability to understand and follow directions and respond to the visual and auditory stimuli presented during assessment and interventions.

**Age range.** Participants in this study ranged from 65 to 84 years of age. A number of previous studies exploring cognitive outcomes associated with older adults’ participation in functional exercise interventions and other low- or no-impact physical activities have utilized participants whose ages fall within this range (Vreugdenhil et al., 2011; Law et al., 2013). Moreover, adults over the age of 85 are more likely than those between 65 to 84 years old to experience chronic physical, cognitive, and/or medical conditions that may interfere with the ability to participate in physical activities independently (United States Department of Health and Human Services, 2014). For this
reason, the researcher assumed that participants between 65 and 84 years old would be most likely to meet the study’s inclusion criteria and safely participate and benefit from the interventions.

**Participant recruitment.** Prior to participant recruitment, the study was reviewed and approved by both Sam Houston State University’s Protection of Human Subjects Committee (study #26003) and the University of Miami’s Human Subjects Research Committee (study #20151132). Participants were recruited from in and around the Huntsville, TX area and in south Florida. In Texas, the researcher primarily recruited participants by conducting short presentations about the study to organizations such as church groups, philanthropic organizations, senior centers, retirement communities, and community activity centers. Also in Texas, flyers were posted around the community and on the Sam Houston State University campus, inviting potential participants to contact the researcher for more information (see Appendix G). In Florida, participants were recruited primary via word-of-mouth through the researcher’s direct contact with colleagues and peers.

As a token of appreciation, facilities and organizations that allowed the researcher to utilize their location for recruitment were offered a complimentary 30-minute music therapy in-service, consultation, or presentation to take place once the study was completed. Participants were offered $15 to compensate for their time participating in the study, which was researcher-funded.

**Measures**

**Revised Physical Activity Readiness Questionnaire (rPARQ).** The rPARQ (Cardinal, Esters, & Cardinal, 1996) is a self-assessment that includes seven questions
used to evaluate an individual’s readiness for safely engaging in physical activity (see Appendix A). The rPARQ’s questions focus on indications that a person may not be ready to participate in physical activity without a doctor’s supervision, such as presence of a heart condition, feeling chest pain while doing or not doing physical activity, bone or joint problems, or taking prescription medication for blood pressure or heart conditions.

In the present study, the researcher utilized the rPARQ as a screening tool to ensure that potential participants \( n = 124 \) were physically healthy enough to safely take part in the study’s movement-based interventions. Potential participants who answered “no” to all of the rPARQ questions \( n = 54 \) were invited to participate in the study. Potential participants who answered “yes” to any of the rPARQ questions \( n = 70 \) were excluded from participating in the study.

**Demographic questionnaire.** A researcher-created demographics questionnaire (see Appendix B) was used to collect basic information about each participant, such as age, gender, ethnicity, current exercise routine, and previous musical experiences.

**The Saint Louis Mental Status Examination (SLUMS).** The SLUMS (Tariq, Tumosa et al., 2006) is an 11-item neuropsychological measure used to detect mild neurocognitive disorder and/or dementia (see Appendix C). The researcher utilized the SLUMS assessment to determine if the participant’s cognitive status was typical, indicative of mild neurocognitive disorder, or indicative of dementia (which would exclude the participant from continuing with additional study activities). Additionally, participants’ SLUMS scores were used to assign participants to the different intervention types as described in this chapter in the “Procedures” section.
The SLUMS is a 30-point, 7-minute assessment tool that measures a number of important cognitive skills implicated in mild neurocognitive disorder and dementia, such as problems with attention, immediate and delayed memory, executive functioning, item naming and recognition, and numeric calculation (Cummings-Vaughn et al., 2014; Tariq et al., 2006). During administration, the assessor asks the individual to complete a number of different tasks with different point values, such as remember a list of words, recall overlearned information, complete simple math calculations, draw numbers on a clock face, and answer questions about a short story.

To account for cognitive differences associated with examinees’ education levels, the SLUMS includes two scoring interpretations to identify normal cognitive functioning, mild neurocognitive disorder, or dementia in individuals who have or have not previously completed high school. For example, individuals without a high school education are scored utilizing the following scale: 1-20 dementia; 21-26 mild neurocognitive disorder; 27-30 typical. By contrast, individuals without a high school education are scored utilizing the following scale: 1-19 dementia; 20-24 mild neurocognitive disorder; 25-30 typical. In the present study, all participants had a minimum of a high school education.

Cummings-Vaughn et al. (2014) indicate that the SLUMS is a valid measure for detecting and differentiating between typical cognitive functioning, mild neurocognitive disorder, and dementia. The SLUMS has similar or better validity than other commonly utilized mild neurocognitive disorder/dementia screening tools, including the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA) (Cummings-Vaughn et al., 2014). Moreover, the SLUMS is appropriate for individuals with different levels of education, while the MMSE may not be appropriate for
examinees with higher educational profiles (Tariq et al., 2006). The SLUMS also takes less time to administer than the MMSE and the MoCA, making it easier to utilize in research and clinical settings (Cummings-Vaughn et al., 2014). Thus, for purposes of this study, the SLUMS was an appropriate tool to distinguish and categorize participants based on functional cognitive status.

Perceived Arousal Scale (PAS). In the present study, the PAS was utilized as a pre-test and post-test measure of participants’ perceived arousal immediately prior to, and following participation in, their assigned intervention. The PAS (Anderson, Deuser, DeNeve, 1995; Ansderson, Anderson, & Deuser, 1996) is a 24-item self-report assessment tool used to measure perceived state arousal (see Appendix D). State arousal refers to one’s temporary or transient degree of general activation or alertness (van Zomeren & Brouwer, 1994) existing along a continuum from low to high (Eysenck, 2012). Individuals typically perceive arousal as a combination of physiological and psychological activity ranging from tiredness (low) to energetic (high), and calmness (low) to tension (high), respectively (Thayer, 1989). The underlying neurophysiological mechanisms that modulate these periods of low or high activation include alterations in brain wave activity and/or peripheral physiological measures (e.g., in muscle tone, heart/respiration rate, respiration rate, or hormone release) (Foote, 2000).

The PAS includes descriptive words indicative of either high (10 items) or low (14 items) arousal states scored using a 5-point Likert-type scale (e.g., 1 = not at all; 5 = extremely). For each given word, examinees select a number between 1 and 5 to indicate the extent to which they feel that way right now, rather than how they typically feel. Because higher scores on the PAS indicate higher arousal levels, descriptive words
indicative of low arousal states (e.g., drowsy, sleepy, depressed) are reverse scored. For example, a score of 5 on the word “sleepy”, indicating a high level of fatigue (i.e., low arousal), would be reverse-scored as a 1.

Previous studies utilizing the PAS indicate that the tool demonstrates high internal consistency ($\alpha = 0.92$ to 0.95) (Anderson et al., 1995, 1996; Anderson, Carnagey, Eubanks, 2003). Moreover, the PAS demonstrates adequate face and content validity (Streiner, Norman, & Cairney, 1995), as it appears to address physiological, psychological, and affective components associated with perceived arousal.

**Heart rate.** Physiological responses to exercise typically involve fluctuations in heart rate that increase as exercise becomes more intense (Kashihara et al., 2009). In the present study, heart rate measurements assessed participants’ physiological arousal. Using a pulse oximeter, heart rate measurements were collected and were taken prior to, halfway through, and following participants’ completion of assigned interventions. Pulse oximeters are small devices that clip over one’s first finger and shine two light beams into the finger, helping the device to detect changes in blood flow that correlate to heart rate (World Health Organization, 2011).

**Borg Rating of Perceived Exertion scale (RPE).** Perceived exertion is a psychophysical measurement of subjective feelings about the amount of physical effort one puts into an activity and its associated physical fatigue (Karageorghis & Priest, 2012). The RPE scale (Borg, 1982) was utilized to measure participants’ perceptions of their physical effort and intensity (not included in appendix due to copyright limitations). The scale ranges from 6 to 20, with 6 corresponding to “no exertion at all” and 20 corresponding to “maximal exertion.” A person’s RPE rating strongly correlates with his
or her heart rate such that the rating can be multiplied by 10 to calculate approximate heart rate (Borg, 1998). For example, if a participants’ rating of perceived exertion is 7, their heart rate would be approximately 70 beats per minute ($7 \times 10 = 70$). Thus, the RPE scale can be considered a subjective measure of physiological arousal (i.e., perceived physiological arousal). Participants’ ratings of perceived exertion were collected prior to, halfway through, and following participants’ completion of assigned interventions.

**Trail Making Test Part B (TMT-B).** The TMT-B (Reitan & Wolfson, 1985) was used to assess cognitive flexibility (see Appendix E). The researcher utilized a stopwatch to time how long, in seconds, it took each participant to complete the trail prior to, and after participating in, their assigned intervention.

The TMT-B is considered one of the most popular, well-established, and clinically sensitive neuropsychological measurement tools presently available (Kortte, Horner, & Windham, 2010). The TMT-B is a paper-and-pencil assessment that includes 25 circles containing letters (A to L) and numbers (1 to 13). Participants are required to connect letters and numbers in an alternating, number-letter pattern (i.e., 1-A, 2-B, 3-C, 4-D, etc.).

The test is timed, and the administrator instructs the participant to complete the TMT-B as quickly and accurately as possible. Moreover, the administrator must quickly point out when or if any errors are made so that the participant has the opportunity to correct them. The TMT-B score is equal to the number of seconds the participant takes to successfully complete the trail. Total number of errors is not accounted for in the TMT-B scoring process, and instead is assumed to factor in to the length of time needed to complete the assessment (Bowie & Howie, 2006).
The TMT-B is a measure of cognitive flexibility (Kortte et al., 2010), a cognitive characteristic that promotes complex, adaptive behaviors necessary to meet changing environmental demands (Ionescu, 2012). In older adults, cognitive flexibility often declines with age, and at the same time, has the potential for improvement through training interventions (Glisky, 2007). In the present study, both interventions designed to require cognitive flexibility with the intention of strengthening participant abilities in this area. Thus, the TMT-B was utilized as a pre-test and post-test to examine acute changes in cognitive flexibility following intervention participation.

The TMT-B is endorsed as an appropriate assessment tool for measuring alternating attention (e.g., the ability to flexibly shift between two stimuli) in the context of clinical music therapy treatment (Gardiner, 2005). Moreover, previous research studies with characteristics similar to the present study have utilized the TMT-B as a pre-test and post-test. For example, the TMT-B was selected by Thaut et al. (2009) to measure changes in cognitive flexibility in individuals with brain injury following one, 30-minute Neurologic Music Therapy session addressing executive functioning through participation in Musical Executive Function Training. Additionally, the TMT-B has been used in studies exploring the acute effects of exercise on cognition in a variety of populations, including older adults with and without cognitive impairment (Baker et al., 2010; Córdova, Silva, Moraes, Simões, & Nóbrega, 2009).

The TMT-B’s psychometric properties have been validated in previous studies. Test-retest reliability for short-term administrations given to individuals with and without cognitive impairment is acceptable-to-excellent ($r = .68$ to $.94$) (Bornstein, Baker, & Douglass, 1987; Temkin, Heaton, Grant, & Dikmen, 1999; Eckhardt & Matarazzo, 1981).
Moreover, the magnitude of practice effects for this measure is small (i.e., standardized effect size < 0.10) as retesting decreases the time complete the assessment by an average of four seconds in a non-clinical sample (Temkin et al., 1999). Further, a positive correlation of .59 between TMT-B scores and the percentage of perseveration errors made on the Wisconsin Card Sorting Test (WCST) has been reported (Heaton, Chelune, Talley, Kay, & Curtiss, 1993). The WCST is another well-established and reliable measure of cognitive flexibility used in research and clinical settings. Thus, the TBT-B demonstrates moderate convergence validity and is an appropriate tool for exploring changes in cognitive flexibility following participation in this study’s interventions.

**Interventions**

**Music-movement intervention (MMI).** The MMI is a researcher-developed, single session, combined cognitive-movement intervention consisting of playing musical instruments that simulate functional, everyday movements in time with recorded music. A single-session intervention was designed specifically to explore the immediate effects of the multimodal, music-facilitated cognitive-exercise intervention, and to explore the relationships among perceived arousal, physiological arousal, perceived exertion, and cognitive flexibility.

The examination of arousal and exertion, through music and movement, as potential mediators of cognitive response in older adults, reflects the aims of the Rational-Scientific Mediating Model for conducting scientific research in music therapy (Thaut, 2005). The study’s short-term intervention design and use of older adults with and without cognitive impairment are criteria representing the mediating level of the research model. Recent research in music therapy (Thaut et al. 2009) and exercise
(Hogan, Mata, & Carstensen, 2013) suggests that short-term interventions in each of these areas are effective in enhancing cognition in older adults with various degrees of cognitive impairment. However, the effects of a combined intervention have yet to be determined.

The MMI is proposed to enhance short-term cognition via an arousal mechanism. In addition to physiological arousal alterations brought about by participating in physical activity, the music’s stimulus properties are thought to stimulate and involve brain areas involved in arousal, such as the reticular activating system (Berlyne, 1971). Heightened arousal brought about by the music activates attention processes involved in alerting and orienting oneself to salient environmental stimuli (Posner, 1980). In turn, executive cognitive functions, mediated by the prefrontal cortex, are initiated in order to effectively manage appropriate behavioral responses to the music.

In the present study, heightened arousal facilitating an attentive set was hypothesized help the participant to plan, execute, and monitor each movement sequence according the temporal, spatial, and force information present in the music stimuli (Yoo, 2009). Cognitive processes involving arousal, planning, and monitoring engaged throughout the intervention were hypothesized to produce short-term improvement in cognitive flexibility. Additionally, the researcher hypothesized that the attentive set facilitated in the MMI would lead to feelings of decrease exertion, or perceived physiological arousal.

The MMI’s eight exercises and their corresponding musical instrument performance tasks were selected and modified from those described by in the Therapeutic Instrumental Music Performance (TIMP) chapter (Mertel, 2014) of Handbook of
Neurologic Music Therapy (Thaut & Hoemberg, 2014) (see Table 1). In order to provide a whole-body exercise experience, movements included in the intervention address the upper extremities (3), lower extremities (3), and trunk/torso (2) and, to avoid participant fatigue, are completed in an alternating fashion (i.e., the first exercise involves upper extremities, the second exercise involves lower extremities, the third exercise involves the trunk/torso, and so on).

To increase the cognitive complexity associated with the MMI movements, each movement was designed for performance at three movement levels that progress from low-to-high cognitive demand (see Table 1). Movement levels utilized in the MMI were selected and modified from a published functional movement program intended to address cognition (Law et al., 2013) and consist of alternating extremities or movement directions, bimanual movements (i.e., right and left extremities moving at the same time), midline crossing, and/or sequences that combine these movements.

Moreover, the MMI’s cognitively demanding movement progressions and their associated musical instrument playing tasks reflect the aims of Musical Executive Function Training (MEFT). MEFT typically involves improvisatory or compositional interventions that directly involve executive functioning skills, such as impulse control, problem solving, and goal setting (Gardiner & Thaut, 2014). More broadly, MEFT is an appropriate term for describing any Neurologic Music Therapy techniques implemented specifically for improving executive functioning skills, of which cognitive flexibility is a part of.

For upper extremity movements such as bicep curls, movements are performed first with alternating arms, followed by arms together; and finally, a sequence of both
alternating arms and arms together. Lower extremity movements such as toe taps/heel raises are performed first with alternating legs, followed by their legs together or by a sequence of alternating legs (e.g., right, right, left, left), and finally with a sequence of legs together and/or separate. Finally, trunk/torso exercises are performed first by alternating moving to the right and left, followed by alternating moving to the right and left with midline crossing (e.g., participant moves body to one side while simultaneously crossing the midline with the opposite arm). Table 1 describes the movements and movement levels included in both interventions.

A musical instrument playing task was created for each movement following guidelines for designing clinical TIMP protocols and utilizing principles of Patterned Sensory Enhancement (PSE), which involves designing music stimuli to facilitate and guide movements (Thaut, 2005). Each movement pattern was conceptualized and a parallel, traditional or adapted instrument playing opportunity fitting the movement pattern was selected. For some of the instrument playing tasks, the participant held the instrument while completing the movement. For example, participants held and played maracas to practice elbow flexion/extension (i.e., bicep curls). By contrast, some of the instrument playing tasks required the researcher to hold the instruments so that the participant could play them while completing the movement. For example, the researcher held tambourines over participants’ knees during the hip flexion/extension exercise so that participants could tap the tambourines with their knees while completing the movement. Table 2 describes the movements, their associated musical instrument playing tasks, and the music stimuli characteristics included in the MMI.
### Table 1

**Functional Movements and Movement Levels Included in the Music-Movement Intervention and Movement-Only Intervention**

<table>
<thead>
<tr>
<th>Functional Movement</th>
<th>Movement Levels</th>
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| Lateral shoulder abduction/adduction        | 1. Alternate right and left arms  
                                           | 2. Arms together  
                                           | 3. Sequence (right, left, together, together) |
| Toe dorsiflexion/plantar flexion            | 1. Alternate right and left feet  
                                           | 2. Feet together  
                                           | 3. Sequence (together, right, left, together) |
| Trunk rotation with midline crossing        | 1. Alternate right and left directions  
                                           | 2. Midline crossing  
                                           | 3. Sequence (right, left, right with left arm crossing midline, left with right arm crossing midline) |
| Elbow flexion/extension                     | 1. Alternate left and right arms  
                                           | 2. Arms together  
                                           | 3. Sequence (together, right, together, left) |
| Knee flexion                                | 1. Alternate right and left legs  
                                           | 2. Sequence (right, right, left, left)  
                                           | 3. Sequence (right, right, left, left) |
| Lateral weight shifting with midline crossing| 1. Alternating right and left directions  
                                             | 2. Midline crossing  
                                             | 3. Sequence (right, left, right with left arm crossing midline, left with right arm crossing midline) |
| Rear shoulder extension                     | 1. Alternate right and left arms  
                                           | 2. Arms together  
                                           | 3. Sequence (right, left, together, rest) |
| Hip flexion/extension                        | 1. Alternate right and left legs  
                                           | 2. Sequence (right, left, left, right)  
                                           | 3. Sequence (right, left, left, right) |

*Note.* Functional movements adapted from Mertel, 2014. Movement levels modified from Law et al., 2013.

To follow PSE guidelines, musical selections familiar to older adults with appropriate temporal structures were selected to fit each movement. Familiar, preferred music used to facilitate movement is motivating and at the same time, is unlikely to be
distracting to older adults if it contains simple musical structures (Mertel, 2014). For this reason, familiar songs representing music categories preferred and recognized by older adults, including popular, patriotic, hymns, folk, and musicals, were chosen (Vanweelden & Cevasco, 2007, 2009) (see Table 2). Accompaniment was selected to utilize simple harmonic structures and rhythmic patterns. For example, “Cielito Lindo” was selected to facilitate elbow flexion/extension movement because its temporal characteristics match those required of the movement pattern (i.e., \( \frac{3}{4} \) time signature). The accompaniment includes major chords with emphasis placed on the first beat of each measure.

Table 2

*Functional Movements, Musical Instrument Playing Tasks, and Music Stimuli Characteristics Included in the Music-Movement Intervention*

<table>
<thead>
<tr>
<th>Functional Movement</th>
<th>Musical Instrument Playing Task</th>
<th>Music Stimuli Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral shoulder raise/lower</td>
<td>Tambourine tapping*</td>
<td>“Take Me Out to the Ballgame” in ( \frac{3}{4} )</td>
</tr>
<tr>
<td>Toe dorsiflexion/plantar flexion</td>
<td>Ankle bells**</td>
<td>“Just a Closer Walk with Thee” in 4/4</td>
</tr>
<tr>
<td>Trunk rotation with midline crossing</td>
<td>Tambourine tapping*</td>
<td>“Sentimental Journey” in 4/4</td>
</tr>
<tr>
<td>Elbow flexion/extension</td>
<td>Maraca playing**</td>
<td>“Cielito Lindo” in 3/4</td>
</tr>
<tr>
<td>Knee flexion</td>
<td>Tambourine playing (tap with toes)*</td>
<td>“Yankee Doodle Boy” in 2/4</td>
</tr>
<tr>
<td>Lateral weight shifting with midline crossing</td>
<td>Tambourine playing*</td>
<td>“My Favorite Things” in ( \frac{3}{4} )</td>
</tr>
<tr>
<td>Rear shoulder extension</td>
<td>Maraca playing**</td>
<td>“Deep in the Heart of Texas” in 2/4</td>
</tr>
<tr>
<td>Hip flexion/extension</td>
<td>Tambourine playing (tap with knees)*</td>
<td>“When Johnny Comes Marching Home” in 6/8</td>
</tr>
</tbody>
</table>

* indicates researcher holds the instrument, ** indicates participant holds the instrument
To select suitable music, the research considered both musical structure and appropriate number of repetitions for each movement. The selected musical pieces were arranged to cue the desired number of repetitions for each movement level. For example, each movement level of elbow flexion/extension was designed to include 16 repetitions that can be completed over two entire repetitions of “Take Me Out to the Ballgame.” Appendix F provides information about the music stimuli included in the MMI.

In order to promote intervention consistency, music used to facilitate the MMI was recorded utilizing GarageBand software. Prerecorded music was necessary because it allowed the researcher to facilitate participant instrument playing by holding instruments in specific spatial arrangements. Melody lines were presented on flute, while harmonic accompaniment was provided by guitar. Guitar was selected as the accompaniment instrument based on feedback received during the vetting process (see “Intervention Vetting” heading below). Specifically, both the older adults and music therapists involved in the vetting process agreed that the recorded guitar produced the clearest rhythmic cues, while piano and autoharp accompaniment tended to sound “muddy.”

To further emphasize the temporal cues necessary to properly complete each movement, music tracks also contained background metronome clicks, presented as a wood block sound, set at the appropriate tempo. The entire MMI protocol took approximately 30 minutes to facilitate, depending on the amount of time each participant needed to observe and practice each movement prior to completing each movement level with the appropriate music stimuli.

**Intervention vetting.** The MMI was developed and vetted over two stages with input from older adults and seasoned music therapy professionals. During the first
stage, older adults with a personal relationship to the researcher who self-identified as having no cognitive impairment ($n = 4$) or cognitive impairments described as “mild” ($n = 2$) informally reviewed the MMI components with the researcher and provided feedback about the included movements, movement levels, number of repetitions, and music selections. This feedback was utilized to further develop the intervention to its current state, which is described in the Appendix F.

The MMI was vetted by a panel of experts comprised of board-certified music therapists ($n = 3$) with an average of 12 years of clinical experience working with older adults with and without cognitive impairment. One of the panelists was trained in Neurologic Music Therapy. The panel was asked to provide informal feedback about the intervention’s suitability for the intended population, its cognitive demand, and its arousal potential. The panel’s feedback indicated that the intervention is appropriate for the population. Moreover, the music therapists described that the intervention appears to require moderate cognitive demand relative to participants’ cognitive status. Moreover, their feedback suggested that the intervention would likely induce a moderate arousal level, again depending on participant cognitive status.

All panelists agreed that cognitive demand and arousal potential would be higher for participants with cognitive impairment than those without. The panel provided feedback about the intervention, and made suggestions for improving instructions to ensure that the intervention is replicable by other researchers or clinicians. Finally, they reviewed musical selections for familiarity and appropriateness for use with older adults.

**Movement-only intervention (MOI).** The MOI utilized the same movements and simple-to-complex movement levels as the MMI, but did not include the music
components (i.e., instrument playing and pre-recorded musical stimuli). While facilitating the MOI, the researcher utilized a visual metronome without sound to pace verbal cues given to the participant. The visual metronome was placed on a stand out of participants’ visual fields (i.e., only the researcher could see the metronome). The entire MOI protocol took approximately 30 minutes to facilitate, depending on the amount of time each participant needed to observe and practice each movement prior to completing each movement level with verbal cueing from the researcher.

**Materials.** The researcher provided movement video clips via a laptop computer, and the MMI’s music stimuli via a tablet computer. For the MMI, the following instruments were utilized: two Remo Fiberskyn 8” single row tambourines, two West Music 3.75” round hand-decorated wood maracas, and two West Music Ankle Bells. Heart rate measurements were taken using a pulse oximeter. Pre-recorded movement demonstrations were shown to participants on a laptop computer, and pre-recorded music stimuli were presented to participants through a computer tablet’s internal speakers. The researcher also used paper copies of all measures and paperwork utilized in the study.

**Procedure**

The primary research location was the Sam Houston State University Huntsville campus. Additional research locations included the Senior Center of Walker County, Assistance League of Montgomery County, and in participants’ community clubhouses or homes. Potential participants learned about the study either through personal contact with the researcher or through flyers posted throughout the community.

Potential participations that contacted the researcher were pre-screened, either over the phone or in person, using the rPARQ. Individuals who answered “no” to all of
the rPARQ questions were invited to take part in the study. During their appointment with the researcher, participants read and signed the approved informed consent form. Following completion of the informed consent form (see Appendix H), the participant took part in the study, which lasted approximately an hour and fifteen minutes.

Following informed consent, the researcher interviewed the participant using the questions contained on the demographics form. After completing the demographics questions, the researcher administered the SLUMS assessment to determine if the participant’s score indicated either typical cognitive functioning or symptoms of mild neurocognitive disorder. If participants’ scores indicated dementia, they did not complete any additional portions of the study.

The SLUMS assessment results helped the researcher to determine intervention group assignment. Participants’ assignment to intervention groups occurred by alternating interventions between participants within each cognitive status group. For example, the first participant with typical cognitive aging received the MMI, the second participant with typical cognitive aging received the MOI, and so on. The researcher utilized the same procedure to assign participants in the mild neurocognitive disorder group to interventions.

Once the participant completed the SLUMS, the researcher administered the TMT-B. The researcher followed published administration instructions for the testing procedure, which included providing verbal instructions and completing a sample version of the TMT-B while the participant observed before instructing the participant to complete the assessment independently (Bowie & Howie, 2006). Next, the researcher explained the PAS instructions and participant was given the PAS to complete
independently. Finally, the researcher measured the participant’s heart rate and asked the participant to rate his or her perceived exertion using the RPE scale. After completing these pre-test measures, the participant completed his or her assigned intervention.

The researcher facilitated the MMI and MOI using comparable directions and cueing. Prior to completing each level of a particular movement, participants watched a short video clip, presented on a laptop computer, of a male performing the movement in time to verbal counts provided by the researcher the appropriate tempo. Next, the researcher asked the participant to demonstrate the movement to ensure full understanding, and corrected the participant if necessary. During this step, the researcher also described to the MMI participants what the instrument playing tasks was, and these participants practiced the movement with the musical instruments/equipment. If participants expressed confusion or uncertainty regarding a movement, or did not demonstrate understanding of the movement, the researcher presented the video clip again and/or verbally corrected the participant.

Once participants demonstrated understanding of the movement sequence, the researcher facilitated their participation in the movement. For the MMI, the researcher played the appropriate, pre-recorded music track, which included a recorded verbal count-in (e.g., “One, two, three, four, five, six, one, two, three, one, ready, move!”) on a tablet computer. For the MOI, the researcher provided a verbal count-in for the participant using identical cues as provided for the parallel MMI exercise and utilized a visual metronome (i.e., a metronome with visual, not auditory, rhythmic cues) to ensure that the presented tempi were consistent with those presented in the MMI music stimuli.
The participant did not see or otherwise follow the visual cues provided by the metronome.

For both the MMI and MOI, the researcher verbally cued the participants as necessary (e.g., periodically counted aloud or reminded them which direction to move in) to ensure they were completing the movements correctly and at the appropriate pace. If participants made errors, such as moving in the wrong direction, the researcher verbally corrected the error and encouraged the participant to keep moving. This process was repeated for each movement at all three associated movement levels. In other words, each participant viewed a separate short video clip prior to each of the 24 movement levels and demonstrated the movement prior to completing the repetition with or without music.

Halfway through the assigned intervention (i.e., after four of the eight movements were completed), the researcher measured the participant’s heart rate and asked him or her to rate perceived exertion using the RPE scale.

At the end of the intervention, the researcher measured the participant’s heart rate and asked the participant to rate his or her perceived exertion using the RPE scale. Next, the participant was given the PAS to complete for the second time. Finally, the researcher administered the TMT-B. The researcher then asked the participant to discuss his or her experience completing the intervention, 

Data analysis. Statistical analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) version 22. This study included two between-subjects independent variables, intervention type (music-movement intervention [MMI] and movement only intervention [MOI]) and cognitive status (typical cognitive aging [TCA] and mild neurocognitive disorder [MND]). Additionally, the study included one within-
subjects independent variable, time (i.e., repeated measures). The study had four
dependent variables: cognitive flexibility, as measured by the TMT-B; perceived arousal,
as measured by the PAS; physiological arousal, as measured by heart rate; and perceived
exertion, as measured by the RPE scale. Because this study included both between- and
within-subjects variables, it utilized a mixed factorial design including repeated measures
(Tabachnick & Fidell, 2013). The researcher conducted four analyses of variance
(ANOVAS) to analyze the data.

To analyze data for cognitive flexibility, the researcher conducted a 2 x 2 x 2
analysis of variance (ANOVA) to compare mean differences on cognitive flexibility for
the different intervention groups (MMI/MOI) and cognitive status groups (TCA/MND)
over time (pre-test/post-test). For self-perceived arousal, the researcher conducted a
second 2 x 2 x 2 ANOVA to compare mean differences on self-perceived arousal for the
different intervention groups and cognitive status groups over time (pre-test/post-test).
For physiological arousal, a 2 x 2 x 3 ANOVA was conducted to compare mean
differences of heart rate for the different intervention groups and cognitive status groups
over time (pre-test/mid-test/post-test). For perceived exertion, a 2 x 2 x 3 ANOVA was
conducted to compare mean differences on the RPE for the different intervention groups
and cognitive status groups over time (pre-test/mid-test/post-test).

Each ANOVA examined three main effects (intervention, cognitive status, and
time); three, 2-way interaction effects (intervention x time, cognitive status x time, and
intervention x cognitive status); and one, 3-way interaction effect (intervention x
cognitive status x time).
For each ANOVA, the alpha level for determining statistical significance was set at 0.05, which is customary for most disciplines when only one analysis is being performed on a data set for a specific dependent variable (Gamst, Meyers, & Guarino, 2008). Effect sizes for ANOVAs, reported as partial eta squared (partial $\eta^2$) values, were calculated and interpreted as being small (0.01), medium (0.06), or large (0.14) (Cohen, 1988).
Chapter Four

Results

The purpose of this study was to examine the effect of a music-movement intervention (MMI) on cognitive flexibility and arousal in older adults with typical cognitive functioning (TCA) or symptoms of mild neurocognitive disorder (MND). Forty-eight participants with or without MND completed a series of pre-test assessments to measure their cognitive flexibility and arousal, including the Trail Making Test Part-B (TMT-B), Perceived Arousal Scale (PAS), heart rate measurement (i.e., physiological arousal), and the Borg Rating of Perceived Exertion (RPE). These participants then completed either the MMI or a movement-only intervention (MOI), which included the same movements as the MMI but did not utilize music. Halfway through their assigned interventions, participants’ heart rate and RPE were re-assessed. After completing their assigned intervention, participants were re-assessed with the TMT-B, PAS, heart rate, and RPE.

In this study, the independent variables included intervention type (MMI/MOI), cognitive status (TCA/MND) and time (pre-test/post-test or pre-test/mid-test/post-test). The dependent variables included cognitive flexibility as measured by seconds to complete the TMT-B, perceived arousal, physiological arousal, and perceived exertion.

In this chapter, the researcher will interpret the statistical analyses, organized by research question. These results will be discussed in detail and compared with previous research findings and the study’s theoretical framework. The researcher will discuss the study limitations and identify recommendations for future research. Finally, the study’s theoretical and practical implications will be presented.
**Demographic Results**

Older adults between 64 and 85 years ($M = 74.85$, range = 21) of age participated in this study. A total of 118 potential participants were initially screened with the Physical Activity Readiness Scale (rPARQ) (Cardinal, Esters, & Cardinal, 1996) to determine if they were in good enough physical health to safely take part in the study activities. Fifty-four of these potential participants answered “no” to all questions on the rPARQ and were invited to set up a time to take part in the study. The final participant sample included 48 of the individuals from this group.

Participants were grouped according to cognitive status, as determined by results on the St. Louis University Mental Status (SLUMS) examination (Tariq et al., 2006). Participants were identified as having typical cognitive aging (TCA) or symptoms of mild neurocognitive disorder (MND). The SLUMS assessment results helped the researcher to determine intervention group assignment.

The TCA group included participants whose SLUMS score was between 27 and 30 points. For individuals who completed high school, scores in this range is indicate that typical cognitive functioning. The TCA group consisted of 20 females and four males, with a mean age of 72.83 years. This group included two Asian, 19 Caucasian, and three African American participants. Of the 24 participants with TCA, 12 were assigned to the Music-Movement Intervention (MMI) and 12 were assigned to the Movement-Only Intervention (MOI).

Participants in the MND group included participants whose SLUMS score was between 21 and 26 points. For individual who completed high school, this score range suggests symptoms of mild neurocognitive disorder (MND). The MND consisted of 20
females and four males, with a mean age of 76.88 years. This group included 21 Caucasian and three African American participants. Of the 24 participants with symptoms of MND, twelve were assigned to the Music-Movement Intervention (MMI) and twelve were assigned to the Movement-Only Intervention (MOI). Table 3 includes detailed information regarding all participants’ demographics.

Participants’ assignment to intervention groups occurred by alternating interventions between participants within each cognitive status group. For example, the first participant with TCA received the MMI, the second participant with TCA received the MOI, and so on. The researcher utilized the same procedure to assign participants in the MND group to interventions.

The majority of participants (77.1%), regardless of cognitive status, endorsed current participation in a regular exercise routine. With regard to exercise type, 24 participants endorsed participating in cardiovascular exercise, such as walking or running. Ten participants endorsed participating in strength training, such as weight lifting. Eleven participants endorsed participating in flexibility training, such as yoga or pilates. Twelve participants endorsed participating in low-impact exercise, such as water aerobics or chair exercises. Finally, seven participants endorsed participating in other types of exercise, such as playing golf, dancing, and doing yard work or gardening.

Eleven participants described not currently participating in a regular exercise routine. When asked for the reasons they don’t currently engage in exercise, six participants endorsed that they have low motivation to do so. Two participants described that physical limitations are the reason for their lack of regular exercise, while two participants stated that they don’t have enough time. No participants endorsed cognitive
limitations or lack of resources as the reasons for their lack of regular exercise. Table 4 contains detailed information regarding participants’ current exercise habits.

Table 3

*Frequency of Participant Demographics*

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Frequency</th>
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<td>Intervention Assignment</td>
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<td>MMI</td>
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<tr>
<td>MOI</td>
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</table>
### Table 4

**Frequency of Participant Exercise Behaviors**

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<th>Frequency</th>
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<td>Currently participates in exercise</td>
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<td>Frequency of exercise participation (days/week)</td>
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<td>Types of exercise</td>
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</table>

Questions regarding participants’ previous and current music experiences were included in the demographic questionnaire. Most participants (81.3%) did not endorse current participation in any type of formal music activities. By contrast, many participants (83.3%) endorsed previous experience participating in formal music activities, such as playing an instrument. Overall, participants had an average of 19.42
years of music participation over their lifetime. Information regarding participants’ music experiences is listed in Table 5.

Table 5

*Frequency of Participant Music Participation*

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<td>20</td>
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<table>
<thead>
<tr>
<th>Frequency of total music participation (years)</th>
<th>Typical</th>
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**Research Question #1**

The first research question investigated the interaction and main effects of cognitive status (TCA versus MND), intervention type (MMI versus MOI), and time (pre-test/post-test) on cognitive flexibility. The descriptive and inferential results are presented below.
**Descriptive analysis.** With data from all participants pooled, the average cognitive flexibility pre-test score was 82.38 seconds ($SD = 17.26$) and the average cognitive flexibility post-test score was 77.06 seconds ($SD = 18.16$). Table 6 summarizes the cognitive flexibility pre-test and post-test scores for participants in the four group intervention/cognitive status combinations. These groupings include: 1) individuals with TCA assigned to the MMI; 2) individuals with symptoms of MND assigned to the MMI; 3) individuals with TCA assigned to the MOI; and 4) individuals with symptoms of MND assigned to the MOI. All participants’ Trail Making Test Part B (TMT-B) scores, as measured in seconds to complete the test, decreased over time, indicating participants completed the cognitive flexibility measure faster at post-test than at pre-test.

**Table 6**

*Means and Standard Deviations of TMT-B Scores Over Time by Cognitive Status and Intervention Assignment*

<table>
<thead>
<tr>
<th></th>
<th>TCA ($n = 24$)</th>
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<th>MND ($n = 24$)</th>
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<td></td>
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<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
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<td>MMI</td>
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<tr>
<td>MOI</td>
<td>78.42</td>
<td>20.24</td>
<td>77.83</td>
<td>22.63</td>
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</table>

*Note.* Numbers are reported in seconds. A decrease in the number of seconds from pre-test to post-test indicates improvement in cognitive flexibility over time.

**Inferential analysis.** Prior to conducting the cognitive flexibility analysis, the researcher compiled histograms and stem-and-leaf plots to check the data for outliers (e.g., participants whose scores appeared to be disconnected from the overall group trends) (Tabachnick & Fidell, 2013). The researcher did not detect any outliers. Thus, the following analysis contained data from all 48 participants.
A 2 x 2 x 2 mixed factorial analysis of variance (ANOVA) was conducted to explore the interaction and main effects of cognitive status, intervention type, and time on cognitive flexibility. Prior to conducting the analysis, the researcher checked for three assumptions of mixed ANOVA, including the assumptions of normality, sphericity, and homogeneity of variance, respectively. Regarding normality, the researcher examined Q-Q plots and determined that the dependent variable’s errors were normally distributed. Because the independent variables only contained two levels each, the assumption of sphericity was automatically met (Tabachnick & Fidell, 2013). Finally, results of Levene’s test of error variance equality for pre-test and post-test cognitive flexibility scores were not statistically significant, indicating that the groups had equal variance ($F(3, 44) = .450, p = .718$) ($F(3, 44) = 1.01, p = .398$).

Results indicated that the three-way interaction effect of cognitive status, intervention type, and time was not significant, $F(1, 44) = .001, p = .973$, partial $\eta^2 = .001$. In other words, the two-way interaction of intervention and time did not vary across levels of cognitive status. Conversely, the two-way interaction of cognitive status and time did not vary across levels of intervention. The effect size was small (partial $\eta^2 = .001$).

Because the three-way interaction effect was not significant, the researcher explored the two-way interaction effects produced during the mixed ANOVA analysis. The two-way interaction effect of intervention and time was statistically significant, $F(1, 44) = 4.64, p < .05$, partial $\eta^2 = .095$. This result indicates that changes in cognitive flexibility scores from pre-test to post-test were significantly different between the two intervention groups. The effect size was medium-to-large (partial $\eta^2 = .095$). A
Bonferroni post hoc analysis indicated that MMI participants’ significantly decreased the amount of time necessary to complete the cognitive flexibility measure by 9.21 seconds ($p < .01$). By contrast, while MOI participants’ decreased the amount of time necessary to complete the cognitive flexibility measure by 1.42 seconds, the difference over time was not significantly different ($p = .583$). Figure 1 displays the significant two-way interaction of intervention and time.

![Graph](image)

*Figure 1.* Significant two-way interaction effect of intervention and time on cognitive flexibility scores of all participants ($p < .05$).

The two-way interaction effect of cognitive status and time was not significant, $F(1, 44) = 14.260, p = .672$, partial $\eta^2 = .004$. Thus, changes in cognitive flexibility from pre-test to post-test were not significantly different between the two cognitive status groups. The effect size was small (partial $\eta^2 = .004$). Additionally, the two-way interaction effect of intervention type and cognitive status was not significant, $(F(1, 44) = .048, p = .827$, partial $\eta^2 = .001$). This result indicates that average cognitive flexibility scores were not significantly different between participants according to the combination
of intervention type and cognitive status (e.g., individuals with TCA assigned to the MMI/MOI or individuals with symptoms of MND assigned to the MMI/MOI). The effect size was small (partial $\eta^2 = .001$).

Finally, two significant main effects emerged. The main effect of time was statistically significant, $F(1, 44) = 8.62, p = .01$, partial $\eta^2 = .164$. This result indicates that when data for all participants were combined across intervention types and cognitive statuses, significant differences existed ($p = .01$) between their pre-test and post-test scores. Specifically, participants significantly decreased the time necessary to complete the cognitive flexibility measure by 5.31 seconds from pre-test to post test. The effect size was large (partial $\eta^2 = .164$). This significant main effect of time is depicted in Figure 2.

Additionally, the main effect of cognitive status was statistically significant, $F(1, 44) = 6.81, p = .012$, partial $\eta^2 = .134$. The average score on the cognitive flexibility measure (i.e., number of seconds to complete the assessment) for participants with TCA was 73.90, while participants with symptoms of MND scored an average of 85.54. This significant main effect of cognitive status is depicted in Figure 3.

The main effect of intervention was not significant, $F(1, 44) = 2.81, p = .101$, partial $\eta^2 = .060$, indicating that average cognitive flexibility scores were not significantly different between participants in the two intervention types. The effect size was medium (partial $\eta^2 = .060$). Results of the ANOVA appear in Table 7.
Figure 2. Significant main effect of time on cognitive flexibility scores ($p = .01$).

Figure 3. Significant main effect of cognitive status on cognitive flexibility scores ($p = .012$).
Table 7

2 x 2 x 2 Mixed Design Analysis of Variance (ANOVA) for the Effect of Intervention, Cognitive Status, and Time on Cognitive Flexibility

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
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<th>MS</th>
<th>F</th>
<th>p</th>
<th>η²</th>
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<tbody>
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</tr>
<tr>
<td>Cognitive status</td>
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<td>3255.010</td>
<td>6.805</td>
<td>.012</td>
<td>.134</td>
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<tr>
<td>Intervention</td>
<td>1342.510</td>
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<td>2.807</td>
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<tr>
<td><strong>Within-subjects</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>677.344</td>
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<td>644.344</td>
<td>8.622</td>
<td>.005</td>
<td>.164</td>
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<tr>
<td>Cognitive status * time</td>
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<td>14.260</td>
<td>.182</td>
<td>.672</td>
<td>.004</td>
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<tr>
<td>Intervention * time</td>
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<td>364.260</td>
<td>4.637</td>
<td>.037</td>
<td>.095</td>
</tr>
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<td>Cognitive status * intervention * time</td>
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<td>1</td>
<td>.094</td>
<td>.001</td>
<td>.973</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
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<td>44</td>
<td>78.558</td>
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</table>

*Note. Alpha level = .05.*

Research Question #2

The second research question investigated the interaction effect of cognitive status (TCA versus MND), intervention type (MMI versus MOI), and time (pre-test/post-test) on perceived arousal. The descriptive and inferential results are presented below.

**Descriptive analysis.** With data from all participants pooled, the average perceived arousal pre-test score was 90.10 ($SD = 13.66$) and the average perceived arousal post-test score was 94.73 ($SD = 10.82$). Table 8 summarizes the perceived arousal
pre-test and post-test scores for participants in the four group intervention/cognitive status combinations. These groupings include: 1) individuals with TCA assigned to the MMI; 2) individuals with symptoms of MND assigned to the MMI; 3) individuals with TCA assigned to the MOI; and 4) individuals with symptoms of MND assigned to the MOI. All participants’ Perceived Arousal Scale (PAS) scores increased over time, indicating participants experienced increased arousal from the beginning to the end of their assigned interventions.

Table 8

*Means and Standard Deviations of PAS Scores Over Time by Cognitive Status and Intervention Assignment*

<table>
<thead>
<tr>
<th></th>
<th>Typical (n = 24)</th>
<th>MND (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>MMI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>91.50</td>
<td>13.01</td>
</tr>
<tr>
<td>MOI</td>
<td>90.58</td>
<td>16.06</td>
</tr>
</tbody>
</table>

**Inferential analysis.** Prior to conducting the perceived arousal analysis, the researcher compiled histograms and stem-and-leaf plots to check the data for outliers (e.g., participants whose scores appeared to be disconnected from the overall group trends) (Tabachnick & Fidell, 2013). The researcher did not detect any outliers. Thus, the following analysis contained data from all 48 participants.

A 2 x 2 x 2 mixed factorial analysis of variance (ANOVA) was conducted to explore the main and interaction effects of cognitive status, intervention type, and time on perceived arousal. Prior to conducting the analysis, the researcher checked for three
assumptions of mixed ANOVA, including the assumptions of normality, sphericity, and homogeneity of variance, respectively. Regarding normality, the researcher examined Q-Q plots and determined that the dependent variable’s errors were normally distributed. Because the independent variables only contained two levels each, the assumption of sphericity was automatically met (Tabachnick & Fidel, 2013). Finally, results of Levene’s test of error variance equality were not statistically significant for pre-test or post-test perceived arousal scores, indicating that the groups had equal variance ($F(3, 44) = 1.19, p = .326$) ($F(3, 44) = .489, p = .692$).

Results indicated that the three-way interaction effect of cognitive status, intervention type, and time was not significant, $F(1, 44) = 1.83, p = .183$, partial $\eta^2 = .04$. In other words, the two-way interaction of intervention and time did not vary across levels of cognitive status. Conversely, the two-way interaction of cognitive status and time did not vary across levels of intervention. The effect size was small (partial $\eta^2 = .04$).

Because the three-way interaction effect was not significant, the researcher explored the two-way interaction effects produced during the mixed ANOVA analysis. The two-way interaction effect of intervention and time was not statistically significant, $F(1, 44) = .320, p = .574$, partial $\eta^2 = .007$. This result indicates that changes in cognitive flexibility scores from pre-test to post-test were not significantly different between the two intervention groups. The effect size was small (partial $\eta^2 = .007$). The two-way interaction effect of cognitive status and time was not significant, $F(1, 44) = .668, p = .418$, partial $\eta^2 = .015$. Thus, changes in cognitive flexibility from pre-test to post-test
were not significantly different between the two cognitive status groups. The effect size was small (partial $\eta^2 = .015$).

The two-way interaction effect of cognitive status and intervention was not statistically significant, $F(1, 44) = 1.01, p = .320$, partial $\eta^2 = .023$. This result indicates that average perceived arousal scores were not significantly different between participants according to their combination of intervention type and cognitive status (e.g., individuals with TCA assigned to the MMI/MOI or individuals with symptoms of MND assigned to the MMI/MOI). The effect size was small (partial $\eta^2 = .023$).

Finally, one significant main effect emerged. The main effect of time was statistically significant, $F(1, 44) = 12.18, p < .01$, partial $\eta^2 = .217$. This result indicates that when data for all participants were combined across intervention types and cognitive statuses, significant differences existed ($p = .01$) between their perceived arousal pre-test and post-test scores. Specifically, participants’ perceived arousal increased an average of 4.625 points from pre-test to post test. The effect size was large (partial $\eta^2 = .217$). This significant main effect of time on perceived arousal is depicted in Figure 4.

![Figure 4. Significant main effect of time on perceived arousal scores ($p < .01$).](image)
The main effect of cognitive status was not statistically significant, $F(1, 44) = .798, p = .376$, partial $\eta^2 = .018$, indicating that average perceived arousal scores were not significantly different between participants in the two different cognitive status groups. The effect size was small (partial $\eta^2 = .018$). The main effect of intervention was not significant, $F(1, 44) = .939, p = .338$, partial $\eta^2 = .021$, indicating that average perceived arousal scores were not significantly different between participants in the two intervention types. The effect size was small (partial $\eta^2 = .021$). Results of the ANOVA appear in Table 9 below.

Table 9

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
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<td><strong>Between-subjects</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive status</td>
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<td>210.042</td>
<td>.789</td>
<td>.376</td>
<td>.018</td>
</tr>
<tr>
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<td>247.042</td>
<td>.939</td>
<td>.338</td>
<td>.021</td>
</tr>
<tr>
<td><strong>Within-subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>513.375</td>
<td>1</td>
<td>513.375</td>
<td>12.178</td>
<td>.001</td>
<td>.217</td>
</tr>
<tr>
<td>Cognitive status * time</td>
<td>28.167</td>
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<td>28.167</td>
<td>.668</td>
<td>.418</td>
<td>.015</td>
</tr>
<tr>
<td>Intervention * time</td>
<td>13.500</td>
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<td>13.500</td>
<td>.320</td>
<td>.574</td>
<td>.007</td>
</tr>
<tr>
<td>Cognitive status * intervention * time</td>
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<td>77.042</td>
<td>1.827</td>
<td>.183</td>
<td>.040</td>
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<td>Error</td>
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</tr>
<tr>
<td>Total</td>
<td>2944.085</td>
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</tr>
</tbody>
</table>

*Note. Alpha level = .05.*
Research Question #3

The third research question investigated the interaction effect of cognitive status (TCA versus MND), intervention type (MMI versus MOI), and time (pre-test/mid-test/post-test) on physiological arousal. The descriptive and inferential results are presented below.

Descriptive analysis. With data from all participants pooled, the average physiological arousal pre-test score (i.e., heart rate) was 72.33 beats per minute ($SD = 10.422$), mid-test score was 72.58 beats per minute ($SD = 15.383$) and post-test score was 77.98 beats per minute ($SD = 11.746$).

Table 10 summarizes the physiological arousal pre-test, mid-test, and post-test scores for participants in the four group intervention/cognitive status combinations. These groupings include: 1) individuals with TCA assigned to the MMI; 2) individuals with symptoms of MND assigned to the MMI; 3) individuals with TCA assigned to the MOI; and 4) individuals with symptoms of MND assigned to the MOI. All participants’ heart rate (HR) measurements, with the exception of the participants with symptoms of MND assigned to the MOI, increased from pre-test to mid-test to post-test, indicating participants experienced increased physiological arousal from the beginning to the end of their assigned interventions. Participants with symptoms of MND who were assigned to the MOI showed decreased heart rate from pre-test to mid-test. However, they had an overall increase from pre-test to post-test, and from mid-test to post test.
Table 10

Means and Standard Deviations of Heart Rate Over Time by Cognitive Status and Intervention Assignment

<table>
<thead>
<tr>
<th></th>
<th>Typical (n = 24)</th>
<th></th>
<th>MND (n = 24)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>MMI</td>
<td>70.25</td>
<td>71.00</td>
<td>76.00</td>
<td>72.58</td>
</tr>
<tr>
<td></td>
<td>8.31</td>
<td>7.274</td>
<td>5.66</td>
<td>10.80</td>
</tr>
<tr>
<td>MOI</td>
<td>74.75</td>
<td>76.17</td>
<td>79.50</td>
<td>71.75</td>
</tr>
<tr>
<td></td>
<td>16.68</td>
<td>10.69</td>
<td>9.80</td>
<td>12.36</td>
</tr>
</tbody>
</table>

*Note.* Numbers indicate heart beats per minute.
**Inferential analysis.** Prior to conducting the physiological arousal analysis, the researcher compiled histograms and stem-and-leaf plots to check the data for outliers (e.g., participants whose scores appeared to be disconnected from the overall group trends) (Tabachnick & Fidell, 2013). The researcher did not detect any outliers. Thus, the following analysis contained data from all 48 participants.

A 2 x 2 x 3 mixed factorial analysis of variance (ANOVA) was conducted to explore the main and interaction effects of cognitive status, intervention type, and time on physiological arousal. Prior to conducting the analysis, the researcher checked for three assumptions of mixed ANOVA, including the assumptions of normality, sphericity, and homogeneity of variance, respectively. Regarding normality, the researcher examined Q-Q plots and determined that the dependent variable’s errors were normally distributed. The data violated the assumption of sphericity, as indicated by Mauchly’s test, χ²(2) = 22.409, p < .01. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε = .711). Finally, results of Levene’s test of error variance equality were not statistically significant for pre-test, mid-test, or post-test physiological arousal, indicating that the groups had equal variance (F(3, 44) = .973, p = .414) (F(3, 44) = 1.96, p = .134) (F(3, 44) = 2.22, p = .099).

Results indicated that the three-way interaction effect of cognitive status, intervention type, and time was not significant, F(1.422, 88) = 1.67, p = .202, partial η² = .037. In other words, the two-way interaction of intervention and time did not vary across levels of cognitive status. Conversely, the two-way interaction of cognitive status and time did not vary across levels of intervention. The effect size was small (partial η² = .037).
Because the three-way interaction effect was not significant, the researcher explored the two-way interaction effects produced during the mixed ANOVA analysis. The two-way interaction effect of intervention and time was not statistically significant, $F(1.422, 88) = 1.069$, $p = .329$, partial $\eta^2 = .024$. This result indicates that changes in physiological arousal measurements between any pairings were not significantly different between the two intervention groups. The effect size was small (partial $\eta^2 = .024$). The two-way interaction effect of cognitive status and time was not significant, $F(1.422, 88) = .400$, $p = .602$, partial $\eta^2 = .009$. Thus, changes in physiological arousal from pre-test to mid-test to post-test were not significantly different between the two cognitive status groups. The effect size was small (partial $\eta^2 = .009$).

The two-way interaction effect of cognitive status and intervention was not significant, $F(1, 44) = 1.819$, $p = .184$, partial $\eta^2 = .040$. This result indicates that average physiological arousal scores were not significantly different between participants according to the combination of intervention type and cognitive status (e.g., individuals with TCA assigned to the MMI/ MOI or individuals with symptoms of MND assigned to the MMI/MOI). The effect size was small (partial $\eta^2 = .040$).

Finally, one significant main effect emerged. The main effect of time was statistically significant, $F(1.422, 88) = 10.35$, $p < .01$, partial $\eta^2 = .190$. This result indicates that when data for all participants were combined across intervention types and cognitive statuses, significant differences existed ($p = .01$) between their physiological arousal over time. The effect size was large (partial $\eta^2 = .190$). A Bonferroni post hoc analysis indicated that physiological arousal significantly increased by an average of
5.396 beats per minute from mid-test \((M = 72.58, \ SD = 15.383)\) to post-test \((M = 77.98, \ SD = 11.746)\) \((p = .01)\), and by an average of 5.646 beats per minute from pre-test \((M = 72.33, \ SD = 10.422)\) to post-test \((M = 77.98, \ SD = 11.746)\) \((p < .01)\). This significant main effect of time on physiological arousal is depicted in Figure 5.

![Figure 5](image)

**Figure 5.** Significant main effect of time on physiological arousal (i.e., heart rate measurements) \((p = .001)\). Heart rate significantly increased from pre-test to post-test \((p = .01)\), and from mid-test to post-test. \((p < .01)\).

The main effect of cognitive status was not statistically significant, \(F(1, 44) = .035, p = .852, \) partial \(\eta^2 = .001\), indicating that average physiological arousal scores were not significantly different between participants in the two different cognitive status groups. The effect size was small (partial \(\eta^2 = .001\)). The main effect of intervention was not significant, \(F(1, 44) = .001, p = .977, \) partial \(\eta^2 = .000\), indicating that average physiological arousal scores were not significantly different between participants in the two intervention types. The effect size was small (partial \(\eta^2 = .001\)). Results of the ANOVA appear in Table 11 below.
Table 11

2 x 2 x 3 Mixed Design Analysis of Variance (ANOVA) for the Effect of Intervention, Cognitive Status, and Time on Physiological Arousal

<table>
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<tr>
<th>Source</th>
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<th>MS</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
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<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td>.001</td>
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<td>Intervention</td>
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<td>.340</td>
<td>.001</td>
<td>.977</td>
<td>.000</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>376.847</td>
<td>1.422</td>
<td>686.801</td>
<td>10.350</td>
<td>.001</td>
<td>.190</td>
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<td>Cognitive status * time</td>
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<td>1.422</td>
<td>26.571</td>
<td>.400</td>
<td>.671</td>
<td>.009</td>
</tr>
<tr>
<td>Intervention * time</td>
<td>10.931</td>
<td>1.422</td>
<td>70.962</td>
<td>1.069</td>
<td>.329</td>
<td>.024</td>
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<td>Cognitive status * intervention * time</td>
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<td>110.803</td>
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<td>.202</td>
<td>.037</td>
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*Note.* Alpha level = .05.

**Research Question #4**

The fourth research question investigated the interaction effect of cognitive status (typical versus MND), intervention type (MMI versus MOI), and time (pre-test/mid-test/post-test) on perceived exertion. The descriptive and inferential results are presented below.

**Descriptive analysis.** With data from all participants pooled, the average perceived exertion pre-test score was 6.865 (SD = 1.959), mid-test score was 9.125 (SD =
1.953) and post-test score was 10.240 (SD = 2.279). Table 12 summarizes the perceived exertion pre-test, mid-test, and post-test scores for participants in the four group intervention/cognitive status combinations. These groupings include: 1) individuals with TCA assigned to the MMI; 2) individuals with symptoms of MND assigned to the MMI; 3) individuals with TCA assigned to the MOI; and 4) individuals with symptoms of MND assigned to the MOI. All participants’ perceived exertion measurements increased from pre-test to mid-test to post-test, indicating participants experienced increased perceived exertion from the beginning to the end of their assigned interventions.

**Inferential analysis.** Prior to conducting the perceived exertion analysis, the researcher compiled histograms and stem-and-leaf plots to check the data for outliers (e.g., participants whose scores appeared to be disconnected from the overall group trends) (Tabachnick & Fidell, 2013). The researcher did not detect any outliers. Thus, the following analysis contained data from all 48 participants.

A 2 x 2 x 3 mixed factorial analysis of variance (ANOVA) was conducted to explore the main and interaction effects of cognitive status, intervention type, and time on perceived exertion. Prior to conducting the analysis, the researcher checked for three assumptions of mixed ANOVA, including the assumptions of normality, sphericity, and homogeneity of variance, respectively. Regarding normality, the researcher examined Q-Q plots and determined that the dependent variable’s errors were normally distributed. The data violated the assumption of sphericity, as indicated by Mauchly’s test, $\chi^2(2) = 25.424, p < .01$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .691$). Finally, results of Levene’s test of error variance equality were not statistically significant for pre-test, mid-test, or post-test perceived
exertion scores, indicating that the groups had equal variance ($F(3, 44) = 1.14, p = .343$) ($F(3, 44) = .911, p = .444$) ($F(3, 44) = 2.40, p = .080$).

Results indicated that the three-way interaction effect of cognitive status, intervention type, and time was not significant, $F(1.383, 60.842) = .697, p = .452$, partial $\eta^2 = .016$. In other words, the two-way interaction of intervention and time did not vary across levels of cognitive status. Conversely, the two-way interaction of cognitive status and time did not vary across levels of intervention. The effect size was small (partial $\eta^2 = .016$).

Because the three-way interaction effect was not significant, the researcher explored the two-way interaction effects produced during the mixed ANOVA analysis. The two-way interaction effect of intervention and time was not statistically significant, $F(1.383, 60.84) = .988, p = .351$, partial $\eta^2 = .022$. This result indicates that changes in perceived exertion measurements from pre-test to mid-test to post-test were not significantly different between the two intervention groups. The effect size was small (partial $\eta^2 = .022$). The two-way interaction effect of cognitive status and time was not significant, $F(1.383, 60.84) = .853, p = .394$, partial $\eta^2 = .019$. Thus, changes in perceived exertion from pre-test to mid-test to post-test were not significantly different between the two cognitive status groups. The effect size was small (partial $\eta^2 = .019$).
Table 12

*Means and Standard Deviations of Perceived Exertion Over Time by Cognitive Status and Intervention Assignment*

<table>
<thead>
<tr>
<th></th>
<th>Typical (n = 24)</th>
<th></th>
<th></th>
<th></th>
<th>MND (n = 24)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>M</em></td>
<td><em>SD</em></td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
<td>Mid</td>
</tr>
<tr>
<td>MMI</td>
<td>6.50</td>
<td>1.45</td>
<td>8.63</td>
<td>1.63</td>
<td>9.30</td>
<td>2.17</td>
<td>7.38</td>
<td>2.38</td>
</tr>
<tr>
<td>MOI</td>
<td>6.75</td>
<td>1.22</td>
<td>9.88</td>
<td>1.88</td>
<td>10.96</td>
<td>1.63</td>
<td>6.83</td>
<td>2.59</td>
</tr>
</tbody>
</table>

*Note.* The perceived exertion scale ranges from 6 to 20, with 6 indicating “no exertion” and 20 indicating “maximal exertion.”
The two-way interaction effect of cognitive status and intervention was not significant, \( F(1, 44) = 2.41, \ p = .128, \) partial \( \eta^2 = .052. \) This result indicates that average perceived exertion scores were not significantly different between participants according to their combination of intervention type and cognitive status (e.g., individuals with TCA assigned to the MMI/MOI or individuals with symptoms of MND assigned to the MMI/MOI). The effect size was small-to-medium (partial \( \eta^2 = .052. \))

Finally, one significant main effect emerged. The main effect of time was statistically significant, \( F(1.383, 60.842) = 73.480, \ p < .01, \) partial \( \eta^2 = .625. \) This result indicates that when data for all participants were combined across intervention types and cognitive statuses, significant differences existed (\( p = .01 \)) between their perceived exertion over time. A Bonferroni post hoc analysis indicated that perceived exertion significantly increased by an average of 2.26 points from pre-test (\( M = 6.865, \ SD = 1.96 \)) to mid-test (\( M = 9.125, \ SD = 1.93 \)), an average of 1.12 points from mid-test (\( M = 9.125, \ SD = 1.93 \)) to post-test (\( M = 10.24, \ SD = 2.28 \)), and an average of 3.375 points from pre-test (\( M = 6.865, \ SD = 1.96 \)) to post-test (\( M = 10.24, \ SD = 2.28 \)) (all \( p < .01 \)). This significant main effect of time on perceived exertion is depicted in Figure 6.
Figure 6. Significant main effect of time on perceived exertion. The perceived exertion scale ranges from 6 to 20, with 6 indicating “no exertion” and 20 indicating “maximal exertion”. Perceived exertion significantly increased from pre-test to post-test ($p = .01$), and from mid-test to post-test ($p < .01$).

The main effect of cognitive status was not statistically significant, $F(1, 44) = .93$, $p = .762$, partial $\eta^2 = .002$, indicating that average perceived exertion scores were not significantly different between participants in the two different cognitive status groups. The effect size was small (partial $\eta^2 = .002$). The main effect of intervention was not significant, $F(1, 44) = .307, p = .582$, partial $\eta^2 = .007$, indicating that average perceived exertion scores were not significantly different between participants in the two intervention types. The effect size was small (partial $\eta^2 = .007$). Results of the ANOVA appear in Table 13 below.
Table 13

2 x 2 x 3 Mixed Design Analysis of Variance (ANOVA) for the Effect of Intervention, Cognitive Status, and Time on Perceived Exertion

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between-subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive status</td>
<td>.840</td>
<td>1</td>
<td>.840</td>
<td>.093</td>
<td>.762</td>
<td>.002</td>
</tr>
<tr>
<td>Intervention</td>
<td>2.778</td>
<td>1</td>
<td>2.778</td>
<td>.307</td>
<td>.582</td>
<td>.007</td>
</tr>
<tr>
<td><strong>Within-subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>283.878</td>
<td>1.383</td>
<td>205.297</td>
<td>73.480</td>
<td>.001</td>
<td>.625</td>
</tr>
<tr>
<td>Cognitive status * time</td>
<td>3.295</td>
<td>1.383</td>
<td>2.383</td>
<td>.853</td>
<td>.394</td>
<td>.019</td>
</tr>
<tr>
<td>Intervention * time</td>
<td>3.816</td>
<td>1.383</td>
<td>2.760</td>
<td>.988</td>
<td>.351</td>
<td>.022</td>
</tr>
<tr>
<td>Cognitive status * intervention * time</td>
<td>2.691</td>
<td>1.383</td>
<td>1.946</td>
<td>.697</td>
<td>.452</td>
<td>.016</td>
</tr>
<tr>
<td>Error</td>
<td>169.986</td>
<td>60.842</td>
<td>2.794</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>467.284</td>
<td>68.374</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note. Alpha level = .05.*

**Research Question #5**

The fifth research question investigated the relationships among participant demographic variables (i.e., age, days per week participant exercises, and years of music experience) and the study’s dependent variables (i.e., cognitive flexibility, perceived arousal, physiological arousal, and perceived exertion) pre-test scores and change scores.

**Inferential analysis.** Pearson’s product moment correlations were calculated to examine the relationships between participant demographic variables and the study’s
dependent variables. For the dependent variables, pre-test scores and change scores were included in the analysis. Change scores (also known as gain scores or difference scores) were calculated by subtracting the pre-test score from the post-test score (Knapp & Shafer, 2009). Table 14 displays the correlation matrix for the relationships between participant demographic variables and the dependent variables.

As displayed in the correlation matrix (see Table 14), a number of significant correlations exist between participant demographic variables and the dependent variables. A significant small, negative correlation \( r = -.332, p < .05 \) emerged between age and number of days per week participants exercise, indicating that higher age was associated with less-frequent exercise. A significant small, negative correlation \( r = -.440, p < .01 \) emerged between age and pre-test heart rate, indicating that higher age was associated with lower heart rate prior to participating in the assigned intervention.

A significant, small, negative correlation \( r = -.320, p < .05 \) emerged between cognitive flexibility pre-test scores and cognitive flexibility change scores, indicating that taking less time to complete the cognitive flexibility pre-test was associated with larger change scores. Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase in the time necessary to complete the cognitive flexibility measure from pre-test to post-test. Thus, completing the measure quicker at pre-test was associated with completing the measure slower at post-test. Conversely, completing the measure slower at pre-test was associated with completing the measure faster at post-test.

A significant, moderate, negative correlation \( r = -.462, p < .01 \) emerged between perceived arousal pre-test scores and perceived arousal change scores, indicating that
lower arousal scores at pre-test were associated with larger change scores. Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase in arousal from pre-test to post-test. Thus, lower pre-test arousal scores were associated with higher levels of arousal as post-test. Conversely, higher arousal at pre-test were associated with lower levels of arousal at post-test.

A significant, small, positive correlation ($r = .335, p < .05$) emerged between perceived arousal change scores and heart rate change scores. Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase in perceived arousal or heart rate from pre-test to post-test. Thus, this result indicates that increased heart rate over time was associated with increased perceived arousal over time.

A significant, very small, negative correlation ($r = -.288, p < .05$) emerged between perceived arousal pre-test scores and heart rate change scores. Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase heart rate from pre-test to post-test. Thus, this result indicates that lower arousal at pre-test was associated with increased heart rate over time. Conversely, higher arousal at pre-test were associated with decreased heart rate over time.

A significant small, negative correlation ($r = -.315, p < .05$) emerged between perceived arousal pre-test scores and perceived exertion pre-test scores. This result indicates that lower arousal at pre-test was associated with higher perceived exertion at
pre-test time. Conversely, higher arousal at pre-test was associated with lower perceived exertion over time.

Finally, a significant, moderate, negative correlation ($r = -.461, p < .05$) emerged between perceived exertion pre-test scores and perceived exertion change scores. Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase in perceived exertion from pre-test to post-test. Thus, this result indicates that lower perceived exertion at pre-test was associated with increased perceived exertion over time. Conversely, higher perceived exertion at pre-test was associated with decrease perceived exertion over time.
Table 14

Correlations Between Participant Demographic Variables and Dependent Variable Pre-Test and Change Scores

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Exercise</th>
<th>Music</th>
<th>CF Pre</th>
<th>CF Ch.</th>
<th>PA Pre</th>
<th>PA Ch.</th>
<th>HR Pre</th>
<th>HR Ch.</th>
<th>PE Pre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td>-.332*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Music</td>
<td>.221</td>
<td>-.174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF Pre</td>
<td>-.013</td>
<td>-.069</td>
<td>-.221</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF Change</td>
<td>-.148</td>
<td>-.056</td>
<td>.207</td>
<td>-.320*</td>
<td>-.127</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA Pre</td>
<td>-.142</td>
<td>-.040</td>
<td>-.116</td>
<td>-.127</td>
<td>-.027</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA Change</td>
<td>.094</td>
<td>.022</td>
<td>.145</td>
<td>-.138</td>
<td>-.228</td>
<td>-.462**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR Pre</td>
<td>-.440**</td>
<td>.078</td>
<td>-.049</td>
<td>.003</td>
<td>.205</td>
<td>.023</td>
<td>.049</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR Change</td>
<td>.132</td>
<td>-.055</td>
<td>.108</td>
<td>-.282</td>
<td>-.004</td>
<td>-.288*</td>
<td>.335*</td>
<td>-.032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE Pre</td>
<td>.098</td>
<td>-.155</td>
<td>.125</td>
<td>.045</td>
<td>-.049</td>
<td>-.315*</td>
<td>.005</td>
<td>-.049</td>
<td>.108</td>
<td></td>
</tr>
<tr>
<td>PE Change</td>
<td>-.106</td>
<td>-.053</td>
<td>-.075</td>
<td>.056</td>
<td>.199</td>
<td>.109</td>
<td>.075</td>
<td>.197</td>
<td>.112</td>
<td>-.461**</td>
</tr>
</tbody>
</table>

Note. * indicates p < .05, ** indicates p < .01. Exercise = number of days per week participant exercises; Music = number of years participant has engaged in music activities; CF Pre = cognitive flexibility pre-test; CF Ch. = cognitive flexibility change score. PA Pre = perceived arousal pre-test; PA Ch. = perceived arousal change score; HR Pre = heart rate at pre-test; HR Ch. = heart rate change score; PE Pre = perceived exertion pre-test; PE Ch. = perceived exertion change score.
Chapter Five

Discussion

The purpose of this study was to examine the effect of a music-movement intervention (MMI) on cognitive flexibility and arousal in older adults with typical cognitive aging (TCA) or symptoms of mild neurocognitive disorder (MND). Forty-eight participants with or without MND completed a series of pre-test assessments to measure their cognitive flexibility and arousal, including the Trail Making Test Part-B (TMT-B), Perceived Arousal Scale (PAS), heart rate measurement (i.e., physiological arousal), and the Borg Rating of Perceived Exertion (RPE). These participants then completed either the MMI or a movement-only intervention (MOI), which included the same movements as the MMI but did not utilize music. Halfway through their assigned interventions, participants’ heart rate and RPE were re-assessed. After completing their assigned intervention, participants were re-assessed with the TMT-B, PAS, heart rate, and RPE.

In this study, the independent variables included intervention type (MMI/MOI), cognitive status (TCA/MND) and time (pre-test/post-test or pre-test/mid-test/post-test). The dependent variables included cognitive flexibility as measured by seconds to complete the TMT-B, perceived arousal, physiological arousal, and perceived exertion.

In this chapter, the researcher will interpret the statistical analyses, organized by research question. These results will be discussed in detail and compared with previous research findings and the study’s theoretical framework. The researcher will discuss the study limitations and identify recommendations for future research. Finally, the study’s theoretical and practical implications will be presented.
Discussion of the Research Questions

The interaction and main effects of intervention type, cognitive status, and time on cognitive flexibility. The first research question examined the interaction and main effects of intervention (MMI/MOI), cognitive status (typical/MND), and time (pre-test/post-test) on cognitive flexibility. Cognitive flexibility was measured with the TMT-B, which was a timed test requiring participants to draw lines connecting letters and numbers in an alternating, number-letter pattern (i.e., 1-A, 2-B, 3-C, 4-D, etc.). The TMT-B score is equal to the number of seconds the participant takes to successfully complete the trail.

Results indicated the three-way interaction effect of intervention, cognitive status, and time was not statistically significant. Thus, the interaction between time and intervention did not vary by cognitive status, and the interaction between time and cognitive status did not vary by intervention. However, the two-way interaction effect of intervention type and time was statistically significant, illustrating that differences in cognitive flexibility over time differed by intervention. Specifically, results showed that participants assigned to the MMI had significant improvement in cognitive flexibility from pre-test to post-test, while participant assigned to the MOI did not. Because the two-way interaction effect of cognitive status and time was not significant, this result indicates that changes in cognitive flexibility over time occurred due to differences between the interventions and/or extraneous variables not accounted for in the present study, but not differences related to participants’ cognitive status.

These findings support the study’s theoretical framework focused on 1) the potential effectiveness of multimodal interventions (Kraft, 2012) to strengthen older
adults’ cognitive functioning; and 2) the researcher’s hypothesis that adding music to a multimodal intervention increases its cognitive demand. Specifically, the present study was based on principles of functional training, a type of multimodal intervention focused on training body movements and sequences typically associated with everyday tasks and activities of daily living (Whitehurst et al. 2005).

The current study’s findings are convergent with those from previous research findings illustrating the beneficial effects of functional training on older adults’ cognition, including executive functioning (Law et al., 2013, 2014). However, these previous studies explored long-term participation in functional training, while the current study focused on a single-session intervention. Thus, the current study’s results indicate that functional training that involves music listening and simple instrument playing can facilitate immediate changes in older adults’ cognition.

In addition to the previous studies’ length, these studies did not include music playing/listening components as a way to structure the body movements and sequences. In the present study, participants assigned to the MMI had significantly greater improvement in cognitive flexibility from pre-test to post-test than did participants assigned to the MOI. This result indicates that the addition of music to a functional training program may uniquely benefit participants’ cognitive flexibility when compared to similar programs that do not utilize music.

A number of explanations may account for the MMI’s significant effect on cognitive flexibility. First, theory suggests that music listening can facilitate an optimum level of arousal which can enhance attention and executive functioning (Berlyne, 1971; Posner & Rothbart, 2007). For this reason, the researcher proposed that the addition of
music to a functional training program may help to facilitate and maintain an optimum arousal level leading to improved cognitive performance. However, the statistical analyses revealed that both the MMI and MOI produced comparable changes in perceived arousal, physiological arousal, and perceived exertion over time (see specific research question discussions, below, for detailed information). Additionally, no significant correlations were found between changes in cognitive flexibility and changes in perceived arousal, physiological arousal, and perceived exertion over time. These results indicate that participants’ changes in arousal were not differentially affected by the presence of music, and that changes in cognitive flexibility were not associated with changes in arousal.

An alternative explanation for the MMI’s effectiveness in improving cognitive flexibility over time may lie in its ability to more effectively engage and integrate executive functions than the MOI. While playing musical instruments (a key component of the MMI), participants were engaging multiple cognitive skills simultaneously, including attention, planning, behavior execution, self-monitoring, and sensorimotor timing (e.g., hand-eye coordination) (Yoo, 2009). Additionally, the MMI was paced by familiar, recorded music tracks that required participants to attend to in order to perform their movements at the appropriate tempo.

The researcher’s observations and participants’ feedback support the hypothesis that the MMI was more cognitively engaging than the MOI. The researcher observed that the MMI participants appeared to actively refer to the recorded music tracks to complete their movements in time. In other words, the music provided a structure for pacing the movements, and the participants consciously attended to the music in order to complete
their movements at the appropriate tempo. Consequently, MMI participants had less difficulty performing movements at the appropriate tempo than the MOI participants, who frequently sped up their pace, even if they counted aloud or when given verbal cues.

These observations indicate that the MMI provided appropriate, external auditory cues for participants to utilize as a template for the movements, comparable to the type of music designed to facilitate Patterned Sensory Enhancement (PSE). Participants had to continuously attend to and refer to these cues to successfully perform movement sequences at the appropriate tempo. Moreover, participants were able to use these cues to self-correct their pace as necessary, for example if they found themselves speeding up or slowing down. Following their participation in the study, many of the MMI participants endorsed utilizing the music recordings to pace themselves, either by counting aloud or internally. Additionally, many of these participations felt that the tasks were mentally challenging when following the music and maintaining the appropriate pace, particularly when their instinct was to complete the movements faster than the provided tempo.

Attending to both the music and their bodies in time, participants actively engaged alternating attention, which requires cognitive flexibility.

In contrast to the MMI participants, many participants in the MOI appeared to perform movements in more of an automatic, less attentive manner. For example, many MOI participants had significant difficulty maintaining the appropriate movement pace, as most participants sped up. Many participants would attempt to end the movement sequence before, or kept going after, the appropriate number of repetitions were completed, suggesting lack of conscious attention to the task at hand. When interviewed following study participation, many of these participants described being cognitively
disengaged from the tempo unless being cued by the researcher. For example, one participant stated, “I just kept doing the movement until you told me to stop and I kind of tried to keep the right tempo, but I knew you’d cue me now and then so I didn’t pay too much attention.” This comment echoed the sentiment of many comments provided by MOI participants.

The instrument playing as required by the MMI also enhanced the intervention’s cognitive demand. A number of previous studies support the notion that active music making, such as instrument playing in educational or therapy settings, can enhance older adults’ cognitive functioning (Bugos et al., 2007; Bugos, 2010; Li et al., 2015; Lord & Garner, 1993). Bugos et al. (2007) suggest that the concurrent engagement of cognitive and motor systems during instrument playing involves simultaneous spatial and temporal processing which in turn, leads to cognitive improvement. Thus, music playing tasks involves high levels of cognitive engagement, comparable to functional movements in everyday life that involve object manipulation/use (Thaut, 2005). In other words, instrument playing in the context of a functional training program improves the training program’s usefulness and relevance in improving cognitive skills.

To summarize, completing the MOI, which included functional movement sequences without music listening and instrument playing components, engaged many of the same cognitive skills as the MMI, but likely to a lesser extent. Specifically, the music listening provided a template that participants consciously attended to in order to complete the movements in time. At the same time, the instrument playing tasks provided an isomorphic opportunity to practice functional movement patterns while manipulating instruments, thus increasing the functional movements’ cognitive demand.
The interaction and main effects of intervention type, cognitive status, and time on perceived arousal. The second research question examined the interaction and main effects of intervention (MMI/MOI), cognitive status (TCA/MND), and time (pre-test/post-test) on perceived arousal. Perceived arousal was measured with the Perceived Arousal Scale (PAS), a 24-item self-report assessment tool used to measure perceived state arousal. The PAS included 24 descriptive words indicative of either high (10 items) or low (14 items) arousal states that participants scored using a 5-point Likert-type scale (e.g., 1 = not at all; 5 = extremely). Because higher scores on the PAS indicate higher arousal levels, descriptive words indicative of low arousal states (e.g., drowsy, sleepy, depressed) were reverse scored.

Results indicated that perceived arousal significantly increased from pre-test to post-test regardless of intervention type and cognitive status. In other words, the addition of music to the functional training program, as presented in the MMI, did not enhance or enrich participants’ arousal differently than did the MOI. This result, along with evidence that no significant correlations were found between changes in cognitive flexibility and changes in perceived arousal, challenges the researcher’s original hypothesis. Specifically, the researcher proposed that the combination of music perception and production included in the MMI could facilitate an optimum level of arousal, leading to enhanced cognition (Berlyne, 1971; Posner & Rothbart, 2007). However, the results indicated MMI and the MOI were comparable in terms of perceived arousal potential. Arousal is a highly-complex concept that does not have one agreed-upon definition, measure, or model in the literature. However, arousal is generally characterized by alterations in brain activity, physiological responses, and psychological
states (Foote, 2002). These arousal components are reflected in the descriptive words contained in the PAS, including those that indicate changes in cognition (e.g., “alert”), physiology (e.g., “energetic”), and affect (i.e., “depressed”). However, this measure may not have been sensitive enough to detect and differentiate subtle, complex changes in arousal over time. Additionally, as will be discussed (see specific research question discussions, below, for detailed information), changes in physiological arousal over time, as detected objectively via heart rate measurement, were also similar in the MMI and MOI. Taken together, these results indicate that neither perceived nor physiological arousal was differentially affected by the addition of music to the training program.

While changes in physiological arousal were not different between MMI and MOI participants, the researcher’s observations and participants’ feedback suggest that differences in state mood (i.e., emotional experiences brought about during participation) may have affected cognitive flexibility. While affective change is a component of arousal modulation (Foote, 2002), the researcher did not include any assessments to specifically measure participants’ affective responses to their intervention. However, participants’ feedback was very telling in terms of differences in mood brought about by the different interventions.

MMI participants’ feedback largely contained positive comments. For example, MMI participants described their intervention as “fun”, “motivating”, “pleasant”, “invigorating”, “stimulating”, etc. Along with these positive comments, MMI participants described that the music was familiar and enjoyable, and that the instrument playing task was new and different for them. Thus, participants appeared to enjoy both hearing music that was familiar and the novelty involved in the instrument playing tasks. By contrast,
MOI participants’ feedback was significantly less positive; MOI participants used words such as “boring”, “tedious”, “uninteresting”, and “dry”.

Emotional or affective experiences involve a combination of valence (i.e., degree of pleasantness/unpleasantness) and arousal (i.e., degree of activation/deactivation) (Posner, Russell, & Peterson, 2005). Given the discrepancy in participants’ feedback, exploring valence or specific emotions may be a more precise and accurate way of conceptualizing differences in participants’ experiences rather than simply considering the broad construct of arousal. For example, participants may not have experienced noticeable changes in arousal, but could have experienced pleasurable emotions or a decrease in negative emotions, which the PAS was not intended to capture.

The increase in pleasurable emotions brought about by the music may partially be due to the intervention’s novelty. Weierich, Wright, Negreira, Dickerson, and Barrett (2010) described that affective responses to novel stimuli produce neural activation in brain areas shared with arousal, such as the amygdala. The authors used functional magnetic imaging (fMRI) to explore amygdala activation to novel and familiar stimuli. Amygdala response was more intense, and lasted longer, for novel stimuli compared to familiar stimuli. Additionally, positive stimuli also engaged the prefrontal cortex regions responsible for regulating affective behavioral responses, including dorsolateral and ventrolateral cortices. Participants also subjectively rated novel stimuli as more arousing than familiar stimuli.

With regard to novelty, Shomaker and Meeter (2015) provide a framework for conceptualizing how novel stimuli impacts brain activity and cognition. Specifically, they propose that novelty can produce immediate, short-term, and/or relatively longer-term
changes to various cognitive processes and subsequently, behavior. First, they contend that exposure to novel stimuli immediately enhances perceptual processes via altering and orienting attention mechanisms, a view also shared by Posner and colleagues (Posner, 1980, Posner & Peterson, 1990; Posner & Fan, 2008, Posner & Rothbart, 2007). Shomaker and Meeter suggest that activation of the amygdala facilitates this process, and this assumption aligns with results of Weierich et al.’s study (2009).

In addition to immediate effects on perception, Shoemaker and Meeter (2015) explain that novel stimuli activate the brain stem, leading to increased arousal and immediate, short-term effects on behavior, particularly in relation to cognitive processes requiring pre-frontal cortex activation. Finally, they argue that dopamine release that occurs due to spatial novelty (i.e., environmental novelty versus specific stimulus-based novelty) can produce relatively long-lasting (e.g., 10+ minutes) changes in affective and cognitive processes including motivation, reward, learning, and memory.

In the present study, the combination of both familiar, overlearned music and novel musical instrument playing tasks may have facilitated an increased sense of arousal and pleasure in MMI participants. Neurobiologically, this increased arousal and pleasure may have enhanced perceptual and cognitive processing via increased amygdala and prefrontal cortex stimulation. However, the measures utilized in the study may not be sensitive enough to detect arousal changes over time in a meaningful and practical manner. Moreover, no formal mood assessment was included in the methodology.

Using a combination of precise brain imaging techniques (such as fMRI), physiological assessment tools (e.g., heart rate, temperature, skin conductance), and self-report questionnaires may be a more appropriate and accurate way to conceptualize the
unique contributions of music to the functional training program. Additionally, a combination of indices may be the most appropriate way to conceptualize if, and how, music-modulated arousal affects cognitive flexibility in older adults. In other words, music may alter arousal such that a complex mixture of cognitive, affective, and physiological changes occurs and interact to enhance the functional training’s cognitive outcomes.

To recap, changes in perceived arousal were not significantly different in MMI and MOI participants; both groups experienced significant increases in arousal from pre-test to post-test. Thus, the addition of music to the functional training program (i.e., the MMI) did not appear to uniquely affect arousal in this group of participants. Rather, as per narrative feedback, the addition of music to the functional training program appeared to differentially impact participant’s affective experiences, which may have led to improved perceptual processes and cognitive engagement.

**The interaction and main effects of intervention type, cognitive status, and time on physiological arousal.** The third research question examined the interaction and main effects of intervention (MMI/MOI), cognitive status (TCA/MND), and time (pre-test/post-test) on physiological arousal. Physiological arousal was assessed at pre-test, mid-test, and post-test using heart rate measurements collected using a pulse oximeter.

Results indicated that physiological arousal significantly increased from pre-test to post-test, and from mid-test to post-test, regardless of intervention type and cognitive status. In other words, the addition of music to the functional training program, as presented in the MMI, did not enhance or enrich participants’ physiological arousal.
differently than did the MOI. Thus, both the MMI and MOI were comparable in terms of physiological arousal potential.

As a physiological arousal indicator, heart rate is an objective proxy for exercise intensity; increased heart rate correlates with more intense exercise (Mayo Clinic, 2016). Given that the MMI and MOI had identical exercise/movement characteristics, it follows that no significant differences should exist regarding changes in physiological arousal arising from both interventions. Additionally, the movements were performed at relatively slow-to-moderate tempi (i.e., 76-124 beats per minute), which would likely not induce high levels of physiological arousal in most individuals. Average heart rate measurements taken over time ranged from approximately 70-80 beats per minute, indicating that in terms of exercise intensity, the interventions were both extremely light to very light in nature (Borg, 1982).

Additionally, a significant, positive correlation emerged between changes in perceived arousal and changes in physiological arousal, illustrating that a relationship emerged between these two dependent variables. Average heart rate ranged from 70-80 beats per minute and average perceived arousal scores ranged from 87 to 97 points over time. Thus, both perceived and physiological arousal only covered a maximum range of approximately 10 units over time. While changes over time were statistically significant, this relatively small change in physiological arousal has several important clinical implications. For example, individuals who have medical conditions and/or physical limitations that preclude them from participating in strenuous exercise could still benefit from a participating in a low-impact, low-intensity functional training program.
Older adults who frequently practice and take part in cognitively-engaging activities, such as multimodal training programs, will receive long-term cognitive benefits from doing so (Park & Reuter-Lorenz, 2009). When multimodal training includes task-oriented components, such as the functional movements associated with activities of daily living in the MMI, the functional tasks can still be practiced at a low intensity and be effective (Bayona et al., 2005). Rather, it is prolonged and frequent activation of neural areas involved in cognitive functions during the exercise, such as the prefrontal cortex, which leads to these areas being strengthened over time, not exercise intensity itself (Park & Reuter-Lorenz, 2009).

The addition of music listening and instrument playing tasks to a low-intensity functional training program, such as the MMI, may encourage older adults to make the training program a regular occurrence in their weekly schedules. As previously described, the combination of familiar music and novel instrument playing tasks could impact affect in terms of motivation to participate and pleasure from the experience of exercising. This motivation and pleasure could lead to regular participation in the program, contributing to long-term strengthening of cognitive skills over time. Thus, music therapists and other professionals involved in facility and/or community therapeutic programming should consider making such sessions available to older adults. Additionally, music therapists facilitating functional training programs should be knowledgeable of Neurologic Music Therapy (NMT) principles and techniques, particularly PSE, Therapeutic Instrumental Music Performance (TIMP), and Musical Executive Function Training (MEFT).

To review findings regarding physiological arousal, both the MMI and MOI were comparable in terms of physiological arousal potential; participation in both interventions
produced only small changes in heart rate over time. Both low-intensity functional training programs may be especially appropriate for older adults experiencing medical or physical barriers to participating in more strenuous forms of exercise. The addition of music listening and instrument playing could motivate older adults to participate in the exercise program on a regular basis, leading to maintenance or improvement of cognitive skills.

**The interaction and main effects of intervention type, cognitive status, and time on perceived exertion.** The fourth research question examined the interaction and main effects of intervention (MMI/MOI), cognitive status (TCA/MND), and time (pre-test/post-test) on perceived exertion. Perceived exertion was measured with the Borg Rating of Perceived Exertion (RPE) rating scale, a subjective measure of physical activity level as observed by physiological activity such as heart rate (Centers for Disease Control and Prevention, 2015). Participants rated their perceived exertion by identifying a number between 6 and 20 that corresponded with their perceived level of physical effort and activity. The RPE scale is anchored by the number 6 and the description of “no exertion at all” and increases to the number 20 with the description of “maximal exertion”. Participants rated their perceived exertion before participating in their intervention, halfway through each intervention, and following participation in the intervention.

Results indicated that perceived exertion significantly increased from pre-test to mid-test, mid-test to post-test, and pre-test to post-test regardless of intervention type and cognitive status. In other words, the addition of music to the functional training program, as presented in the MMI, did not significantly influence perceived exertion differently than did the MOI.
A wide body of literature has examined the music’s effects on perceived exertion during different types of exercise with varying degrees of intensity levels. However, this research is primarily focused on asynchronous uses of music, that is music that is played during the exercise task but that the individual does not purposefully attempt to synchronize to (i.e., background music) (Karageorghis & Priest, 2012). Moreover, most of these studies examined inherently rhythmic forms of exercise, such as running or cycling. The present study utilized synchronous music, specifically designed for participants to move in time with, and included functional movements that are not inherently rhythmic. Despite these differences, studies involving asynchronous music and inherently rhythmic exercises may provide a starting point for conceptualizing the present study’s results.

Karageorghis and Priest (2012) point out that in studies utilizing asynchronous music during exercise with low-to-moderate intensity levels, perceived exertion is reduced by approximately 10%, but this reduction does not seem to persist in higher-intensity exercises. They propose that this effect is modulated by the central nervous system’s limited capacity for sensory stimuli and its tendency to focus on stimuli with the strongest attentional cues. At low and moderate exercise intensities, music and other pleasant stimuli is interpreted as more salient that the physiological effects of the exercise, and thus, can mask perceptions of physical exertion in favor of attending to the stimuli. By contrast, the physiological effects of higher intensity exercise may be too strong for music to compete with. Thus, music appears to be more effective at reducing perceived exertion when the exercise is done at lower intensity levels (Karageorghis and Priest, 2012).
In the present study, the average mid-test and post-test perceived exertion scores ranged between “very light” to “light” on the RPE (i.e., approximately 9-to-10.5) and thus the interventions can both be considered relatively low intensity. Overall, MMI participants’ perceived exertion was approximately 4% less than MOI participants at mid-test, and approximately 6% lower than MOI participants at post-test. From pre-test to post-test, MOI participants’ perceived exertion change was approximately 20% larger than MMI participants. While this interaction effect of intervention and time was not significant, these results did illustrate that small differences existed in perceived exertion between the two groups.

Rhythmic synchronization, or entrainment, to music occurs automatically when movements are inherently rhythmic, such as walking or running. This entrainment effect of music occurs unconsciously because external rhythm serves as a timekeeper that attracts the motor system (Thaut, 2005). With the exception of seated marching, the functional movements in the MMI and MOI are not inherently rhythmic in nature. Thus, while the music was used to facilitate and time the MMI, it provided a structure for participants to consciously attend to and organize their bodies in time and space. In other words, the music served as an established template for completing the movements at the appropriate tempo, but this cuing did not occur automatically and required attention.

In addition to proving a rhythmic structure for completing movements, the MMI also included instrument playing tasks. These tasks served as a way to practice the functional movements in a manner that simulates how these movements might be performed outside of the intervention (e.g., while manipulating objects). Furthermore, the
instrument playing tasks provided additional auditory cues to help the participant plan and alter movements to ensure they occurred at the appropriate time.

Together, the recorded music tracks and the instrument playing tasks provided salient stimuli for participants to focus on during the MMI. This increased attention to the recorded music and the instrument playing tasks may have led to the small differences in perceived exertion between the MMI and MOI participants.

Interestingly, participants’ average RPE scores and heart rate scores did not appear to be related, as indicated by non-significant correlations between these measurements. Previous research indicates that RPE ratings typically significantly correlate with heart rates such that RPE rating can be multiplied by 10 to calculate approximate heart rate (Borg, 1998). For example, if a participants’ rating of perceived exertion is 7, their heart rate would be approximately 70 beats per minute (7 x 10 = 70). At pre-test, participants’ average heart rates ranged between approximately 70-75 beats per minute, and their RPE scores ranged from approximately 6.5 to 7. At mid-test, the average heart rates ranged from between approximately 71 to 76 beats per minute, but RPE scores increased to approximately 9. At post-test, average heart rates ranged from approximately 76 to 80 beats per minute, yet RPE scores ranged from approximately 10 to 10.5.

These results indicate that participants’ perceived exertion at mid-test and post-test was higher than their actual physiological arousal levels as measured by heart rate. In other words, participants described that they were contributing more physical effort than what their heart rates indicated. The discrepancies between physiological arousal and perceived exertion could indicate that participants did not report their RPE truthfully for
any number of reasons, a phenomenon known as response bias (Furnham, 1986). For example, participants may have inflated their ratings of perceived exertion because they believed that the researcher expected or wanted such a response (i.e., social desirability).

Alternatively, despite the researcher explaining perceived exertion before administering the measurement tool, participants may not have fully understood the concept and thus did not answer accurately. For example, since the functional movements involved a simple-to-complex hierarchy where movements were performed with different levels of cognitive difficulty, participants may have confused the idea of perceived physical exertion, as measured by the RPE, with that of perceived mental exertion.

Overall, these results indicate that the addition of music to a functional training program may decrease the perceived exertion of completing the exercises. This decreased perceived exertion may be due to the music components capturing participants’ attention and thus distracting them from attending to the amount of physical effort they were using.

**The relationships among participant demographic variables and the study’s dependent variables.** The fifth research question investigated the relationships among participant demographic variables (i.e., age, days per week participant exercises, and years of music experience) and the study’s dependent variables (i.e., cognitive flexibility, perceived arousal, physiological arousal, and perceived exertion) pre-test scores and change scores.

With regard to participant demographic variables, the significant small, negative correlation between age and number of days per week participants endorsed exercising indicated that higher age was associated with less-frequent exercise. This relationship is likely due to a number of factors. For example, older adults may feel that they are not
young or strong enough to exercise, do not believe it is necessary to do so, or may experience changes in health that decrease the desire or ability to exercise (Schutzer & Graves, 2004; United States Department of Health and Human Services, 2014). While older adults can experience a host of benefits from regular exercise, they are among the least likely to do so (Schutzer & Graves, 2004). As previously discussed, music-facilitated physical activity may be more motivating for this population, which may encourage more frequent participation in exercise.

A significant small, negative correlation emerged between age and pre-test heart rate, indicating that higher age was associated with lower heart rate prior to participating in the assigned intervention. Resting heart rate can vary significantly – from approximately 60 to 100 beats per minute in adults – and is influenced by a number of factors, such as current activity level, medication, and affect (Laskowski, 2015). In the context of this study, this relationship among age and pre-test heart rate likely emerged due to the nature of heart rate being a highly variable measurement.

Several of the study’s significant correlations can likely be attributed to the fact that individuals who score on the low or high end on a particular measure are likely to score closer to mean on subsequent measurements (i.e., regression to the mean) (Chiolero, Paradis, Rich, & Hanley, 2013). For example, a significant, small, negative correlation emerged between cognitive flexibility pre-test scores and cognitive flexibility change scores, indicating that taking less time to complete the cognitive flexibility pre-test was associated with larger change scores, and vice versa.

Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase in the time necessary to
complete the cognitive flexibility measure from pre-test to post-test. Thus, completing the measure quicker at pre-test was associated with completing the measure slower at post-test. Conversely, completing the measure slower at pre-test was associated with completing the measure faster at post-test. Similar relationships emerged between perceived arousal pre-test scores and perceived arousal change scores, and perceived exertion pre-test-scores and perceived exertion change scores, respectively. These correlations indicate a regression to the mean for individuals who had relatively low or high cognitive flexibility, high perceived arousal, or perceived exertion scores at pre-test.

A significant, small, positive correlation emerged between perceived arousal change scores and heart rate change scores. Thus, this result indicates that increased heart rate over time was associated with increased perceived arousal over time. Because PAS scores were significantly correlated with heart rate, an objective measure of arousal, the relationship provides evidence of the PAS’s criterion validity (Fraenkel, Wallen, & Hyun, 2015) as an appropriate tool for measuring arousal.

A significant, very small, negative correlation emerged between perceived arousal pre-test scores and heart rate change scores. Because change scores are calculated by subtracting the pre-test score from the post-test score, positive change scores indicate an increase in heart rate from pre-test to post-test. Thus, this result indicates that lower perceived arousal at pre-test was associated with increased heart rate over time. Conversely, higher perceived arousal at pre-test was associated with decreased heart rate over time.

Given that perceived arousal and heart rate change scores were significantly, positively correlated, these results may indicate that individuals who indicated low
perceived arousal at pre-test would be more likely to experience increased heart rates over time, and vice versa. In other words, one might expect that as individuals with extreme perceived arousal scores would regress to the mean perceived arousal score, they might also regress to the mean heart rate measurement.

A small, negative correlation emerged between perceived arousal pre-test scores and perceived exertion pre-test scores. This result indicates that lower arousal at pre-test was associated with higher perceived exertion at pre-test. Conversely, higher arousal at pre-test was associated with lower perceived exertion at pre-test. This result could indicate that individuals who started at low perceived arousal levels were experiencing low levels of physical energy. By contrast, individuals with higher levels of perceived arousal may have had higher levels of physical energy.

**Study Limitations and Recommendations for Future Research**

The current study’s results indicate that a short-term, music-facilitated functional movement training program is more effective in enhancing cognitive flexibility than an identical program without music. However, the study has several important limitations that should be considered when interpreting and applying results, such as the short-term nature of the intervention, data collection with individuals versus groups, lack of control for medication or time-of-day effects, sample size and participant characteristics, lack of control for certain individual differences, and practical transfer of results to non-research, everyday functioning.

The study’s first limitation pertained to the single-session design, which was, in essence, a proof-of-concept or pilot study. The pilot study’s aim was to establish if the music-facilitated functional movement intervention (i.e., the MMI) could produce
immediate changes in cognitive flexibility that were different from an identical intervention without music, and to identify potential underlying reasons for these changes.

These aims reflect the objectives of the Rational-Scientific Mediating Model for conducting scientific research in music therapy (Thaut, 2000). Additionally, the study’s short-term intervention design and use of older adults with and without cognitive impairment are criteria representing the mediating level of the research model. However, a single-session intervention cannot elucidate how long-term participation in the interventions affects cognitive flexibility and the other variables, which are both important considerations for clinical decision-making in music therapy settings. Moreover, asking participants to complete the intervention multiple times would help to clarify if the observed results were simply due to involvement in research or trying something new, rather than actually a result of the intervention.

Another limitation was that participants took part in the study individually, rather than in a group. While working with participants individually allows for greater control of extraneous variables, many music therapists work with older adults in group settings, and the social aspect of a group session may be motivating to participants. Thus, group data collection would help to increase generalizability of results to clinical settings. Additionally, music therapists often provide live music, which could impact arousal and attention. For this reason, future research could also implement the MMI with live music to see if doing so affects cognitive functioning and arousal differently than does recorded music.
Although various medications can impact arousal and cognition, the researcher did not collect specific information about participants’ medication regimens. Moreover, while arousal and cognitive levels can vary greatly over the course of a day, the researcher did not control for potential time-of-day effects. Future research should attempt to control for the influence of medication and time of day on arousal and cognition.

While groups were balanced in terms of cognitive status and assignment to the two different interventions, some inconsistencies in participant demographic variables, such as ethnicity, sex, and potentially socioeconomic status existed. Specifically, the majority of participants were White females, which limits the study’s generalizability. Additionally, individuals of different ethnicities may experience symptoms of cognitive aging in varied and unique ways. For example, a recent, large-scale study found that Hispanic and non-Hispanic Black older adults demonstrate lower cognitive functioning than non-Hispanic White older adults, which was mediated by educational status (Díaz-Venegas, Downer, Langa, & Wong, 2016). In the present study, all participants had a minimum of a high school education, but the researcher did not collect data about specific education levels. Future related research could compare if or how outcomes differ by education level.

With regard to socioeconomic levels, the researcher observed that potential health disparities may have existed among participants from different recruiting sites. For example, participants appeared to have differing amounts resources in terms of access to quality healthcare, social opportunities, and means to participate in cognitively-engaging activities, which may have been due in part to their socioeconomic statuses. Future
research could examine intervention outcomes among participants of various socioeconomic statuses.

Given the lack of participants’ ethnic diversity in the current study, additional research in this area should attempt to recruit participants representing more varied ethnic backgrounds. In doing so, researchers could better conceptualize how individuals of different ethnicities respond to the functional training program. Moreover, obtaining feedback from these individuals regarding music familiarity and preference could provide important information about adjustments that could be made to the MMI to ensure that it is culturally relevant.

In terms of this study’s outcomes, the measurement tools utilized in the study included those used in neuropsychological (i.e., TMT-B, PAS) or exercise science-based assessment and research (i.e., RPE). While these assessments are appropriate for capturing data in empirical research, their results may not provide meaningful information about how the measured behaviors transfer to clinical settings. For example, while MMI participant’s TMT-B scores decreased from pre-test to post-test, indicating improved cognitive flexibility, the practical outcomes of this change outside of the research setting are not obvious. In other words, how or if the changes in cognitive flexibility manifest in everyday situations has not been uncovered. Future studies should attempt to utilize additional measures that help to provide more practical information about skill transfer.

Given that the MMI’s affective-motivational qualities appear to have impacted the intervention’s cognitive engagement potential, future research could explore the role of music in motivating older adults’ exercise participation. Because this population can
greatly benefit from regular physical activity, exploring ways that intentional music selection and use during exercise impacts older adults’ commitment to regular physical activity may help generate best practices for encouraging exercise and enhancing exercise regimen retention.

**Study Implications**

The current study’s findings contribute both theoretical and practical implications regarding the effect of a music-based functional movement training program on cognitive flexibility and arousal in older adults with and without symptoms of mild neurocognitive disorder. Theoretically, the result provides information regarding the unique contributions of music, when paired with functional movement sequences, to enhance cognition in older adults. Additionally, practical implications extracted from the study can assist music therapists and those who music therapists collaborate with to design and implement similar interventions in clinical settings.

**Theoretical implications.** This study involved two interventions that were identical in nature with the exception of music in one condition. Its results highlight the potential unique ways in which music can enhance physical activity when combined into a multimodal, cognitive-exercise intervention. The researcher originally hypothesized that the addition of music to the functional training program would help facilitate an optimum arousal level and also engage executive functioning skills to a greater extent than would the functional training program without music. The findings suggest that the second hypothesis was true, and that improved cognitive flexibility may have also been facilitated by music’s motivational-affective qualities.
These findings provide a starting point for understanding how the intentional use of synchronous music paired with cognitively demanding, movement-based interventions can enhance older adults’ cognition. Additionally, these findings provide evidence that a single-session multimodal training intervention can produce immediate changes in cognitive flexibility. To date, research in this area has examined long-term intervention participation, and has not included music components. Thus, the present study fills a gap in the literature.

**Practical implications.** This study involved a novel music therapy intervention, the MMI, that the researcher developed by integrating research evidence and best practice suggestions, clinical expertise, and music therapists’ and older adults’ feedback. Music therapists can use the MMI as a framework for designing and implementing similar functional training programs for older adults. When using the MMI as a template, music therapists can alter aspects of the intervention, such as musical selections, movements and complexity of movement levels, and instrument playing tasks, to best meet their clients’ needs.

With regard to altering the MMI’s movements and movement levels, music therapists may also enhance their MMI implementation by collaborating with other professionals that facilitate movement-based interventions, such as physical therapists, occupational therapists, and dance/movement therapists. For example, older adults’ occupational therapists could help music therapists identify appropriate MMI movements based on their clients’ need to practice certain cognitively-demanding activities of daily living. Following movement selection, the music therapist could then design appropriate
musical stimuli to facilitate repetitive practice of these movements at differing levels of cognitive demand.

In addition to practical applications of the MMI intervention, clinicians may also benefit from the study’s description of and information provided about the different measurement tools utilized to collect data. In clinical settings, music therapists should utilize standardized, reliable, and valid assessment tools that can help to conceptualize the client’s functioning in everyday life (Thaut, 2014). The measurement tools included in the current study, including the TMT-B, PAS, heart rate using a pulse oximeter, and RPE, demonstrated adequate reliability and validity, were not music-based, did not cost money to acquire, and did not require extensive practice or training to administer. For this reason, music therapists can consider selecting these assessments for use in clinical settings as appropriate.

Summary and Conclusions

The purpose of this study was to examine the effect of a music-movement intervention on arousal and cognitive flexibility in older adults with and without symptoms of mild neurocognitive disorder. Additionally, the study explored relationships among cognitive flexibility and the arousal measures (i.e., perceived arousal, physiological arousal, and perceived exertion). Forty-eight older adults with and without symptoms of mild neurocognitive disorder participated in the study; half of these participants completed the Music-Movement Intervention (MMI) and the other half completed the Music-Only Intervention (MOI).

Results indicated that participants who completed the MMI had significantly improved cognitive flexibility from pre-test to post-test. By contrast, MOI participants
did not experience significant changes in cognitive flexibility over time. This finding suggests that the addition of music listening and instrument playing to a functional training program is more effective at enhancing cognitive flexibility than an identical training program without music.

The researcher’s original hypothesis posited that changes in cognitive flexibility brought about by the MMI could be due to changes in arousal that facilitated engaged cognitive processing. However, results revealed that no significant differences emerged between MMI and MOI participants’ in terms of perceived arousal, physiological arousal, and perceived exertion. Moreover, arousal measure scores did not significantly correlate with cognitive flexibility pre-test scores or change scores. Thus, arousal did not appear to be a potential mediator of cognitive flexibility. Rather, the MMI appeared to possess affective-motivational qualities that facilitated focused attention during the intervention. Moreover, the MMI’s music listening and instrument playing tasks appeared to engage higher-level cognitive skills to a greater extent than did the MOI.
References


Appendix A

Revised Physical Activity Readiness Questionnaire (rPARQ)*

1. Has your doctor ever said that you should only perform physical activity recommended by a doctor?

2. Do you feel pain in your chest when you perform physical activity?

3. In the past month, have you had chest pains when you were not performing any physical activity?

4. Do you lose your balance because of dizziness or do you ever lose consciousness?

5. Do you have a bone or joint problem that could be made worse by participating in physical activity?

6. Do you know of any other reason why you should not engage in physical activity?

7. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

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Appendix B

Participant Demographic Questionnaire

Section I: Personal Information

1. Age: ___

2. Sex: Male ____ Female ____

3. Ethnicity (check all that apply):
   a. Hispanic or Latino (regardless of race) ____
   b. Not Hispanic or Latino:
      i. American Indian or Alaska Native
      ii. Asian
      iii. Black or African-American
      iv. Native Hawaiian or Pacific Islander
      v. White

Section II: Current Exercise Routine

4. Do you currently engage in a regular exercise routine (check one)?
   a. Yes ___ (go to questions 5, 6)       b. No ___ (skip to question 7)

5. How many times a week do you exercise? ___

6. What kinds of exercise do you engage in (check all that apply)?
   a. Cardiovascular, such as walking or running ___
   b. Strength training, such as lifting weights ___
   c. Flexibility training, such as yoga or pilates
   d. Low-impact exercise, such as water aerobics or chair exercises ___
   e. Other: ____________________________________
7. What are the reasons why you don’t currently engage in exercise (check all that apply)?
   a. Low motivation ___
   b. Physical limitations ___
   c. Cognitive limitations ___
   d. Not enough time ___
   e. Lack of resources, such as access to equipment ___
   f. Other: ________________________________________________

Part III: Previous Music Experience

8. Are you currently involved in formal music activities, such as playing an instrument, performing with a music ensemble, or taking private lessons?
   a. Yes ___
      i. Describe: __________________________________________
   b. No ___

9. If applicable, list any formal music activities you have participated in previously, such as playing an instrument, performing with a music ensemble, or taking private lessons:

   ______________________________________________________
   ______________________________________________________

10. How many years of formal music training/participation do you have? _____
Appendix C

St. Louis University Mental Status (SLUMS) Examination*

Saint Louis University
Mental Status (SLUMS) Examination

Name ____________________________ Age ________

Is patient alert? __________

Level of education ________________________

1. What day of the week is it?
2. What is the year?
3. What state are we in?
4. Please remember these five objects. I will ask you what they are later.
   Apple  Pen  Tie  House  Car
5. You have $100 and you go to the store and buy a dozen apples for $3 and a tricycle for $20.
   How much did you spend?
   How much do you have left?
6. Please name as many animals as you can in one minute:
   0-4 animals  5-9 animals  10-14 animals  15+ animals
7. What were the five objects I asked you to remember? 1 point for each one correct.
8. I am going to give you a series of numbers and I would like you to give them to me backwards. For example, if I say 42, you would say 24.
   87  649  8537
9. This is a clock face. Please put in the hour markers and the time at ten minutes to eleven o'clock.
   Hour markers okay
   Time correct
10. Please place an X in the triangle.
    Which of the above figures is largest?
11. I am going to tell you a story. Please listen carefully because afterwards, I'm going to ask you some questions about it. Jill was a very successful stockbroker. She made a lot of money on the stock market. She then met Jack, a devastatingly handsome man. She married him and had three children. They lived in Chicago. She then stopped work and stayed at home to bring up her children. When they were teenagers, she went back to work. She and Jack lived happily ever after.
   What was the female's name?
   When did she go back to work?
   What work did she do?
   What state did she live in?

TOTAL SCORE __________

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Appendix D

Perceived Arousal Scale (PAS)**

Different people react very differently to the same situations. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following 5-point rating scale. Write the number corresponding to your rating on the blank line next to each word.

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<td></td>
<td>very slightly or not at all</td>
<td>a little</td>
<td>moderately</td>
<td>quite a bit</td>
<td>extremely</td>
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*Item needs to be reverse scored. The asterisks are not present in the scale when presented to research participants

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Appendix E

Trail Making Test*

*The Trail Making Test is in the public domain.
Appendix F

Intervention Characteristics

Functional Exercise 1

**Exercise Name:** Lateral shoulder flexion

**Exercise Description:** seated side arm raise/lower

**Performance:** Holding arms straight down at the sides with elbows slightly bent, raise right arm in a “clock-like” motion, bringing it straight above the head (e.g., in a 12 o’clock position). Slowly lower arm, bringing it back to rest in the original position.

**Tempo:** Metronome marking (MM) = 112 beats per minute (BPM)

**Procedure:** One repetition consists of a full movement sequence of shoulder flexion, either with one or both arms. One full repetition occurs over 12 beats.

1) Alternating right and left arms: 16 repetitions (8 right, 8 left) (for example, see Figure E1)

2) Arms together: 16 repetitions (for example, see Figure E2)

3) Sequence (right, left, together, together): 16 repetitions (i.e., sequence completed 4 times)

![Figure E1](image1.png)

*Figure E1.* Image depicting the first movement sequence for lateral shoulder flexion with the right arm.

![Figure E2](image2.png)

*Figure E2.* Image depicting the second movement sequence for lateral shoulder flexion with arms together
**Music Instrument Playing Task:** Researcher holds two tambourines over the participant’s head placed back-to-back with drum heads facing left and right. Participant will make contact with the tambourine as hands reach the overhead position.

**Music Stimuli:** “Take Me Out to the Ballgame” in ¾ time signature with accompaniment emphasis on beat 1 (see Figure E3)

**Guitar accompaniment:** Fingerpicked, bass-chord-chord pattern as indicated below

(> = accent/emphasis; p = thumb, i = 1st finger, m = middle finger, a = ring finger)

```
>  
1  2  3  
   i  i  
  m  m  
 a  a  
```

```
Take Me Out to the Ballgame
Norworth/Von Tinzer (Arr. Dachinger)
```

```
\[\text{Flute}\]
\frac{1}{3} \text{C} \quad \text{G} \quad \text{C} \quad \text{G} \quad \text{G} \quad 7
\frac{9}{112} \text{A} \quad \text{Dm} \quad \text{D7} \quad \text{G} \quad \text{G7}
\frac{17}{15} \text{C} \quad \text{G} \quad \text{C} \quad \text{F}
\frac{25}{17} \text{C} \quad \text{D7} \quad \text{G7} \quad \text{C}
```

*Figure E3. Music stimuli for side shoulder flexion.*
Functional Exercise 2

Exercise Name: Toe/heel dorsiflexion/plantarflexion

Exercise Description: seated toe/heel lifting and lowering

Performance: With seat flat on the floor, flex ankle and point toes toward the ceiling, keeping heel on the ground. Bring toes down, returning feet to a flat position on the floor. Raise heels, keeping balls of the feel on the floor. Bring heels down, returning feet to a flat position on the floor.

Tempo: MM = 96 BPM

Procedure: One repetition consists of the full movement sequence that begins with the start of the toe tap and ends when the heel raise is completed. One full repetition occurs over 4 beats.

1) Alternating right and left feet: 16 repetitions (for example, see Figure E4)
2) Feet together: 16 repetitions (for example, see Figure E5)
3) Sequence (together, right left, together): 16 repetitions (i.e., sequence completed 4 times)

Figure E4. Image depicting the first movement sequence for toe/heel dorsiflexion/plantarflexion with the right foot.

Figure E5. Image depicting the second movement sequence for toe/heel dorsiflexion/plantarflexion with feet together.
**Music Instrument Playing Task:** Prior to beginning this exercise, the researcher ties ankle bells on participant’s ankles. Participant jingles ankle bells as he or she completes the movements.

**Music Stimuli:** “Just a Closer Walk with Thee” in 4/4 time signature with accompaniment emphasis on beats 2 and 4 (printed notation not included due to copyright limitations; please contact the researcher for information about this song)

**Guitar accompaniment:** Swung, strummed pattern as indicated below
(> = accent/emphasis; D = down strum, U = up strum)

```
> >
1 2 + 3 4 +
D D U D D U
```
Functional Exercise 3

Exercise Name: Trunk rotation with midline crossing

Exercise Description: seated torso twisting

Performance: With elbows bent at 90° angles and held close to the rib cage, rotate torso and arms to the right and then back to the center. For midline crossing, bring left arm across body as body rotates right and then back to center; bring right arm across body as body rotates left and then back to center.

Tempo: MM = 72 BPM

Procedure: One repetition consists of full trunk rotation movement that begins with the participant initiates the movement and ends when the participant brings arms/torso back to center. One full repetition occurs over 2 beats.

1) Alternating right and left rotations: 16 repetitions (for example, see Figure E6)

2) Midline crossing with right and left arms: 16 repetitions (for example, see Figure E7)

3) Sequence (right, left, cross midline with right, cross midline with left): 16 repetitions (i.e., sequence completed 4 times)

Figure E6. Image depicting the first movement sequence for trunk rotation.

Figure E7. Image depicting the second movement sequence for trunk rotation with midline crossing.
**Music Instrument Playing Task:** Researcher holds two tambourines on either side of the participant’s body within the hands’ trajectories. Participant makes contact with the tambourines with his or her hands as the trunk is rotated to either side.

**Music Stimuli:** “Sentimental Journey” in 4/4 time signature with accompaniment emphasis on beats 1 and 3 (printed notation not included due to copyright limitations; please contact the researcher for information about this song)

**Guitar accompaniment:** Swung, strummed pattern as indicated below

(> = accent/emphasis; D = down strum, U = up strum)

```
>   >
1  2  +  3 4  +
D  D  U  D  D  U
```
Functional Exercise 4

**Exercise Name:** Elbow flexion/extension

**Exercise Description:** Seat bicep curls

**Performance:** With elbows bent at 90° angles and held close to the rib cage, bend elbows, moving hands up to the shoulders. Extend elbows back to original position.

**Tempo:** MM = 124 BPM

**Procedure:** One repetition consists of one bicep curl that begins and ends with elbows bent at 90° angles. One full repetition occurs over 6 beats.

1) Alternating right and left arms: 16 repetitions (for example, see Figure E8)

2) Arms together: 16 repetitions (for example, see Figure E9)

3) Sequence (together, right, together left): 16 repetitions (i.e., sequence completed 4 times)

*Figure E8.* Image depicting the first movement sequence for elbow flexion/extension for the right arm.

*Figure E9.* Image depicting the second movement sequence for elbow flexion/extension for arms together.
**Music Instrument Playing Task:** The participant holds maracas while completing the exercise, which provide auditory feedback during movement.

**Music Stimuli:** “Cielito Lindo” in 3/4 time signature with accompaniment emphasis on beat 1 (see Figure E10)

**Guitar accompaniment:** Fingerpicked, bass-chord-chord pattern as indicated below (> = accent/emphasis; p = thumb, i = 1st finger, m = middle finger, a = ring finger)

\[
\begin{array}{ccc}
> & 1 & 2 \\
& i & i \\
& m & m \\
& a & a \\
\end{array}
\]

\[ p \]

---

Cielito Lindo

Mendoza (Arr. Dachinger)

Flute

\[
\begin{align*}
\text{G} & \quad \text{D7} \\
9 & \quad \text{G} \quad \text{C} \\
17 & \quad \text{G} \quad \text{Am} \quad \text{D7} \\
26 & \quad \text{D7} \quad \text{G}
\end{align*}
\]

*Figure E10. Music stimuli for elbow flexion/extension.*
Functional Exercise 5

**Exercise Name:** Knee flexion

**Exercise Description:** Seat leg stretching

**Performance:** Seated with good posture, knees bent at 90° angles, and feet flat on the floor, extend leg at the knee. Lower leg, returning to starting position. Hold onto the sides of chair for stability, if necessary.

**Tempo:** MM = 76 BPM

**Procedure:** One repetition consists of one full knee extension that begins and ends with feet flat on the floor. One full repetition occurs over 4 beats.

1) Alternating right and left legs: 16 repetitions (for example, see Figure E11).

2) Sequence (right, right, left, left): 16 repetitions (i.e., sequence completed 4 times)

3) Sequence (same as described in #2 above): 16 repetitions (i.e, sequence completed 4 times)

*Figure E11.* Image depicting the first movement sequence for knee flexion.
**Music Instrument Playing Task:** The researcher holds two tambourines in front of the participant at slightly below hip level with heads facing down. Participant makes contact with the tambourine(s) with feet as knees reach the extended position.

**Music Stimuli:** “Yankee Doodle Boy” in 2/4 time signature with accompaniment emphasis on beat 1 (see Figure E12)

**Guitar accompaniment:** Fingerpicked, bass-chord pattern as indicated below
(> = accent/emphasis; p = thumb, i = 1st finger, m = middle finger, a = ring finger)

```
> 1 2
  \ i
  \ m
  \ a
p
```

**Yankee Doodle Boy**

\[\text{Cohan (Arr. Dachinger)}\]

![Yankee Doodle Boy Sheet Music](image)

*Figure E12. Music stimuli for knee flexion.*
Functional Exercise 6

Exercise Name: Lateral weight shifting with midline crossing

Exercise Description: Seated swaying/reaching

Performance: With good posture and arms held at the sides of the body, lift up left buttoc and shift weight to the right, reaching arm out. Return to center, and repeat on the left. For midline crossing, cross and reach left arm across the body when shifting weight to the right, and cross and reach right arm across the body when shifting weight to the left.

Tempo: MM = 120 BPM

Procedure: One repetition consists of the full movement sequence that begins and ends with the body at center and buttocks flat on the chair. One full repetition occurs over 6 beats.

1) Alternating right and left shifts: 16 repetitions (for example, see Figure E13)

2) Midline crossing with right and left arms (i.e., shift left with right arm crossing midline, shift right with left arm crossing midline): 16 repetitions (for example, see Figure E14)

3) Sequence (right, left, right arm crosses midline, left arm crosses midline): 16 repetitions (i.e., sequence completed 4 times)

Figure E13. Image depicting the first movement sequence for lateral weight shifting.

Figure E14. Image depicting the second movement level for lateral weight shifting with midline crossing.
**Music Instrument Playing Task:** The researcher holds two tambourines to the participant’s side. As participant shifts weight with arms out or crossing midline, her or she makes contact with the tambourines with hands.

**Music Stimuli:** “My Favorite Things” in 3/4 time signature with accompaniment emphasis on beat 1 (printed notation not included due to copyright limitations; please contact the researcher for information about this song)

**Guitar accompaniment:** Fingerpicked, bass-chord-chord pattern as indicated below (> = accent/emphasis; p = thumb, i = 1st finger, m = middle finger, a = ring finger)

```
>  
1  2  3
i  i
m  m
a  a
p
```
Functional Exercise 7

Exercise Name: Seated rear shoulder extension

Exercise Description: Move arms back

Performance: With good posture and holding the arms at the sides, move arms straight back one at a time or together. Return arm(s) to starting position.

Tempo: MM = 72 BPM

Procedure: One repetition consists of the full movement sequence that begins with arms moving back and ends with the arm back at the side of the body (or, for movement level 3, one count of rest). One full repetition occurs over 4 beats.

1) Alternating right and left arms: 32 repetitions (for example, see Figure E15)

2) Arms together: 8 repetitions, rest 8, 8 repetitions, rest 8 (For example, see Figure E16)

3) Sequence (right, left, together, rest): 32 repetitions (i.e., sequence completed 8 times)

Figure E15. Image depicting the first movement sequence for rear shoulder extension.

Figure E16. Image depicting the second movement level for rear shoulder extension.
**Music Instrument Playing Task:** The participant holds maracas while completing the exercise, which provide auditory feedback during movement.

**Music Stimuli:** “Deep in the Heart of Texas” in 2/4 time signature with accompaniment emphasis on beat 1 (printed notation not included due to copyright limitations; please contact the researcher for information about this song)

**Guitar accompaniment:** Fingerpicked, bass-chord pattern as indicated below
(> = accent/emphasis; p = thumb, i = 1st finger, m = middle finger, a = ring finger)

```
> 1
 2
 p
```

i
m
a
Functional Exercise 8

Exercise Name: Seated hip flexion/extension

Exercise Description: Seated marching

Performance: With good posture and feet flat on the ground, raise and lower knees.

Tempo: MM = 82 BPM

Procedure: One repetition consists of the full movement sequence that begins and ends with the feet flat on the ground. One full repetition occurs over 2 beats. Participant rests for 8 beats between each movement level:

1) Alternating right and left: 32 repetitions (for example, see Figure E17)

2) Sequence (right, left, left, right): 32 repetitions (i.e., sequence completed 8 times)

3) Same as #2 above: 32 repetitions (i.e., sequence completed 8 times)

Figure E17. Image depicting the first movement sequence for hip flexion/extension

Music Instrument Playing Task: The researcher holds two tambourines, head down, over the participant’s knee trajectories. Participant makes contact with tambourines and he or she raises knees.

Music Stimuli: “When Johnny Comes Marching Home” in 6/8 time signature (with duple feel) with accompaniment emphasis beats 1, 3, and 4 (see Figure E22)

Guitar accompaniment: Strummed pattern as indicated below

(> = accent/emphasis; D = down strum, U = up strum)

\[
\begin{array}{ccccccc}
> & > & > \\
1 & 2 & 3 & 4 & 5 & 6 \\
D & U & D
\end{array}
\]
When Johnny Comes Marching Home

Flute

Gilmore (Arr. Dachinger)

\[ \text{Figure E22. Music stimuli for hip flexion/extension.} \]
Appendix G

Recruitment Flyer

- Study #: 20151132  Approval Date: 1/28/2016

Sam Houston State University / University of Miami Research Study

Movement and Music Interventions for Older Adults

Are you…

• …a male or female between 65 and 84 years of age?
• …interested in helping researchers develop effective, cognitively engaging interventions for adults over the age of 65?

Participation this study includes completing a series of assessments and taking part in a 30-minute seated movement session with or without music.

Participants will be compensated for their time!

For more information, contact principal investigator Carolyn Dachinger, MM, MT-BC, Assistant Professor of Music Therapy at Sam Houston State University and doctoral student at the University of Miami at (936) 294-1366 or cdachinger@shsu.edu
Appendix H

Informed Consent Form

Consent to Participate in a Research Study

TITLE: “The Effect of Movement Interventions on Cognition”

The following describes a research study in which you are being asked to participate. Please read the information carefully. At the end, you will be asked to sign if you agree to participate.

PURPOSE OF STUDY:
You are being asked to participate in a research study. The purpose of this study is to investigate the effect of a movement-based activity on cognitive functioning.

PROCEDURES:
If you agree to participate, the following steps will take place:

Step One: Eligibility Screening. This step will be completed prior to the start of any interventions and should take about 10 minutes to complete.
1. The investigator will administer two assessments to determine your eligibility to participate in the research activities. During the assessments, the investigator will ask you a series of questions and ask you to complete a series of activities using pencil and paper.
2. The investigator will review your assessments and determine if you are eligible to participate in the research activities. If you are eligible to participate, you will complete the procedures listed below. If you are not eligible to participate, you will not complete the procedures listed below.

Step Two: Pretest measures. This step will take will be completed prior to the start of the research conditions and should take about 20 minutes to complete.
1. You will be asked to complete a short “Participant Information” form. This form asks you for information such as your age, health status, and description of exercise routine and previous musical experiences.
2. You will complete a short assessment using pencil and paper.
3. You will rest for five minutes.
4. You will complete a self-evaluation form using pencil and paper.
5. The investigator will measure your heart rate using a small, battery-operated device that fits on the first finger of your hand.
Step Three: Music-Movement Condition or Movement-Only Condition. This portion of the research study will take approximately 30 minutes to complete.

1. You will be randomly assigned (like the flip of a coin) to either a music-movement condition or a movement-only condition.
2. If you are assigned to the music-movement condition, you will participate in an individual session with the investigator. During the session, you will be taught a series of either seated movements. You will then complete a series of eight seated movements in time with recorded music and using musical instruments. The movements involve your arms, legs, and trunk/torso. Your heart rate will be measured after you complete half of the movements, and when you are finished completing all of the movements.
3. If you are assigned to the movement-only condition, you will participate in an individual session with the investigator. During the session, you will be taught a series of either seated movements. You will then complete a series of eight seated movements. The movements involve your arms, legs, and trunk/torso. Your heart rate will be measured after you complete half of the movements, and when you are finished completing all of the movements.

Step Four: Posttest measures. This step will take will be completed following your participation in your assigned research condition and should take about 15 minutes to complete.

1. You will be asked to rate your experience completing your assigned research condition.
2. You will complete a self-evaluation form using paper and pencil.
3. You will rest for five minutes.
4. You will complete a short assessment using pencil and paper.
5. You will complete a self-evaluation form using pencil and paper.

RISKS AND/OR DISCOMFORTS
You may feel discomfort answering some personal questions on the “Participation Information” form. You may decline to answer any question or questions that make you feel uncomfortable.

You may feel physical discomfort while completing the movements included in your assigned research condition. If you feel any physical discomfort while completing the movements included in your assigned research condition, please discontinue the movements and alert the investigator immediately.

In the event of injury related to this research study, you should contact your physician or the University Health Center. However, you or your third party payer, if any, will be responsible for payment of this treatment. There is no compensation and/or payment for medical treatment from Sam Houston State University or the University of Miami for any injury you have from participating in this research, except as may be required of the University by law.
BENEFITS:
No benefit can be promised to you for participating in this study. You may enjoy participating in the research condition with the investigator. The information gained in this study may be useful in developing future music therapy interventions.

CONFIDENTIALITY:
Records related to this study will be kept in a locked filing cabinet within an office environment and on a password-protected desktop computer. Only the Primary Investigators and other approved research personnel will have access to this information. Identification Codes will be used in place of your name on all forms or files. When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity.

The investigators and their assistants will consider your records confidential to the extent permitted by law. The U.S. Department of Health and Human Services (DHHS) may request to review and obtain copies of your records. Authorized University or other agents who will be bound by the same provisions of confidentiality may also review your records for audit purposes.

COSTS:
There are no costs associated with your participation in this study.

COMPENSATION:
You will receive $15 to compensate you for the time you take to participate in this study. The compensation will be provided to you once you have completed your participation in the study.

RIGHT TO DECLINE OR WITHDRAW:
Your participation in this study is voluntary. You are free to refuse to participate in the study or withdraw your consent at any time during the study. Your withdrawal or lack of participation will not affect your relationship with the universities sponsoring this research. The investigators reserve the right to remove you from participation without your consent at such time they feel it is in the best interest for you.

CONTACT INFORMATION:
• Carolyn Dachinger, Assistant Professor of Music Therapy at Sam Houston State University, serves as the Principal Investigator. This research is being completed in partial fulfillment of the requirements for the Doctor of Philosophy (Ph.D.) in Music Education with Emphasis in Music Therapy degree at the University of Miami. Carolyn can be reached at cdachinger@shsu.edu or by phone at (936) 294 - 1366.
• Teresa Lesiuk, Ph.D., MT-BC, serves as the Principal Investigator at the University of Miami. She may be contacted at tlesiuk@miami.edu or by phone at (305) 284 – 3650.
• If you have any questions about your rights as a research subject you may contact Sharla Miles at the Office of Research and Sponsored Programs at Sam Houston.
State University at sharla_miles@shsu.edu or by phone at (936) 294-4875 or e-mail ORSP. Alternatively, you may contact the Human Subjects Research Office at the University of Miami at (305) 243 – 3195.

PARTICIPANT AGREEMENT:
I have read the information in this consent form and agree to participate in this study. I have had the chance to ask any questions I have about this study, and they have been answered for me. I am entitled to a copy of this form after it has been read and signed.

______________________________  _________________
Signature of Participant                  Date

______________________________  _________________
Signature of Person Obtaining Consent     Date

Study #: 20151132  Approval Date: 1/28/2016  Expiration Date: 1/27/2017