EXPLORING THE FEASIBILITY OF GROUP MUSICAL DUAL-TASK TRAINING IN COMMUNITY-DWELLING OLDER ADULTS WHO HAVE CONCERNS ABOUT FALLS

By

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Abstract

The purpose of this study was to evaluate the feasibility and limited efficacy of Group Musical Dual-Task Training (G-MDTT) for community-dwelling older adults who had concerns about falls. G-MDTT asked the participants to practice performing two music-related tasks at the same time and was designed to reduce fall risk factors including impairment of executive function, dual-task cost, and balance, and concerns about falls. Six participants with a mean age of 79 volunteered for the study. They were requested to attend a 40-minute group session, two times a week, across one month, for a total of eight sessions. Overall results support the feasibility of G-MDTT to community-dwelling older adults who have concerns about falls and revealed the potential of G-MDTT to reduce the dual-task cost on walking speed in task-specific trained tasks such as "Subtraction 3" task and "Auditory Stroop" task, with some modifications. Recommendations for modifications were discussed and included in the G-MDTT Intervention Manual for clinical application.

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Chapter 1: Introduction

Falls and concerns about falls are common among community-dwelling older adults and pose a significant threat to the health of these individuals. About one in three older adults over 65 fall at least once per year (Masud & Morris, 2001). Approximately one fifth to one third of all fall victims suffer injuries of varying severity, ranging from cuts and scrapes to hip fractures and head traumas. These injuries can result in loss of independence in daily living and can even lead to early death in extreme cases (Alexander, Rivara, & Wolf, 1992; Sterling, O'Connor, & Bonadies, 2001). In addition, two out of three individuals report concerns related to falls, (Arfken, Lach, Birge, & Miller, 1994) regardless of whether or not they have actually experienced a fall in the past (Yardley & Smith, 2002). These concerns may result in avoidance of activities, decline in physical and mental performance, decrease in health-related quality of life, and an increased risk of falling (Delbaere, Sturnieks, Crombez, & Lord, 2009; Scheffer, Schuurmans, Van Dijk, Van der Hooft, & De Rooij, 2008; Zijlstra, Van Haastregt, Van Eijk, van Rossum, Stalenhoef, & Kempen, 2007b).

Previous studies have identified factors that increase the risk of falling in community-dwelling older adults (Fabre, Ellis, Kosma, & Wood, 2010; Stevens, 2005). Muscle weakness, gait deficits, balance impairment, and visual impairment are important physiological risk factors for falls (Rubenstein, 2006). Hazards around the living area such as lack of stair railings, uneven or slippery surfaces, and inadequate lighting are environmental risk factors (Gill, Williams, Robison, & Tinetti, 1999). Additionally, impaired executive function has received attention in recent studies as another risk factor (Mirelman et al., 2012; Rubenstein, 2006). Executive function in those studies usually covered a set of cognitive processes including attention, memory, and mental flexibility, which is the ability to switch tasks and respond to a target while inhibiting response to a non-target (Buracchio et al., 2011; Mirelman et al., 2012). Individuals who experience frequent falls exhibited decreased performance on executive function measurement when compared with their non-falling counterparts (Hausdorff et al., 2006). Executive function deficits also predicted future falls. Older adults with lower executive function were more likely to fall than those with better executive function during the 2-year follow-up period (Herman, Mirelman, Giladi, Schweiger, & Hausdorff, 2010).

Executive function also controls the regulation of gait, especially in everyday situations when the individuals are required to walk and process another cognitive task at the same time such as walking while talking (Mirelman et. al., 2012). Walking while talking is an example of a dual-task activity. Such dual- task activities demand effectively allocating attention among concurrent tasks (Yogev-Seligmann, Hausdorff, & Giladi, 2008). Compared to those with intact cognition, older adults with cognitive impairment or dementia exhibited exacerbated gait slowing and gait variability when performing dual-tasks (Lamonth et al., 2011; Tseng, Cullum, & Zhang, 2014)**.** More specifically, older adults with lower executive function walked slower during the performance of dual-task than individuals with better executive function (Coppin et al., 2006). Executive function impacts the gait performance under dual-task and links dual-task gait disturbance and balance disorder to fall risks (Herman, 2010; Mirelman et al., 2012; Springer et al., 2006).

The inter-relationship among impaired executive function, gait changes, and increased fall risk suggests adopting a complementary approach to remediation that targets executive function (Montero-Odasso, Verghese, Beauchet, & Hausdorff, 2012). Accordingly, dual-task interventions may have more benefits than an exercise intervention alone in fall prevention since dual-task requires executive function. Studies have shown that dual-task interventions where the older adults are trained to perform a physical task and a cognitive task at the same time, thus requiring executive function, improve gait velocity and balance (Dorfman et al., 2014; Plummer-D'Amato et al., 2012; Silsupadol et al., 2009). This improvement may potentially reduce the risks of falls (Schwenk, zieschang, Oster, & Hauer, 2010; Silsupadol et al., 2009). Similarly, dual-task programs that involved pairing common activities (e.g., walking and calculating; music-based movement and multitasking programs) improved gait, balance, and reduced incidences of falls in older adults (Hamburg & Clair, 2003; Trombetti et al., 2011).

The promising training effects from the dual-task studies (Dorfman et al., 2014; Plummer-D'Amato et al., 2012; Schwenk, zieschang, Oster, & Hauer, 2010; Silsupadol et al., 2009) and the music-based multitasking study (Hamburg & Clair, 2003; Trombetti et al., 2011). lend support for the present study, which examined the effect of Group Musical Dual-Task Training (G-MDTT) on fall risk reduction. G-MDTT adapted the protocol of the Musical Dual-Task Training (MDTT), which was implemented in a one-on-one session format (Chen, 2014) while maintaining the same goal of enhancing the executive function and related dual-task performance in adults with dementia. Trombetti and colleagues' (2011) music-based multitasking intervention was adopted from Jaques-Dalcroze eurhythmics. Jaques-Dalcroze eurhythmics is originally a music education method using movement representation to help students learn the concept of rhythm, structure, and music expression. The participants changed their movements, walking, or ways of handling objects according to change in the music (Trombetti et al., 2011). In contrast, MDTT (Chen, 2014) was specifically designed to simulate everyday situations, such as responding to traffic signs, avoiding obstacles (visual stimuli), or talking to a companion (auditory stimuli) while walking. The idea of MDTT is to translate a non-musical everyday task into a musical exercise. In MDTT, the participants are instructed to process a physical task and a cognitive task at the same time and within the structure of a musical context. The physical task in MDTT was walking and the cognitive task consisted of active music making including singing and playing rhythm on percussive instruments such as tambourines, paddle drums, maracas, and woodblocks while following cues. In the present study, the cognitive task was the same as that which was designed in MDTT. However, the physical tasks in G-MDTT included walking and the movements of toe tapping and heel lifting, through playing the bass drum, high-hat cymbal, and foot tambourines. Music performed live by the therapist provided cues for the participants to respond to a cognitive challenge and to facilitate the movements of the physical task.

G-MDTT may have added value over a regular dual-task program since music making places significant demands on attention and memory, which might elicit experience-dependent plasticity in the brain by strengthening the attention network (Strait & Kraus, 2011; Wan & Schlaug, 2010). Trained musicians demonstrated greater activation in brain areas that control top-down attention processing, such as the frontal cortex, parietal cortex, and anterior cingulate (Pallesen et al., 2010; Strait, Kraus, Parbery-Clark, & Ashley, 2010). This consistent and extensive recruitment of the musicians' attention networks may explain their enhancement in many forms of visual and auditory attention abilities, executive function tasks, task switching and dual-task performance compared to non-musicians (Bialystok & Depape, 2009; Moradzadeh, Blumenthal, Wiseheart, 2014; Rodrigues, Loureiro, & Caramelli, 2013; Strait et al., 2010). Even short-term piano practice has improved executive function in older adults (Bugos, Perlstein, McCrae, Brophy & Bedenbaugh, 2007; Seinfeld, Figueroa, Ortiz-Gil, & Sanchez-Vives, 2013).

In addition to the impact of music making on the brain, music stimuli were applied in G-MDTT for the functions of motivation, adherence, and entrainment. Besides the cognitive and physical components of a dual-task, music-based intervention increased participant motivation and adherence to the program (Hamburg & Clair, 2003; Trombetti et al., 2011). Music also supports the repetitive gait movements with rhythm. The synchronization of the gait with musical rhythm may free up attentional resources from the gait by making the gait more automatic (Maclean, Brown, & Astell, 2014). This facilitation would allow older adults to perform the everyday act of concurrently walking and carrying out another task more successfully.

While MDTT has had positive results (Chen, 2014), the present study was interested in knowing whether it could be executed as effectively in a group format, because a group session might be more efficient for treatment delivery as the therapists could treat multiple persons at the same time. In addition, the present study targeted community dwelling older adults, who would not need one-on-one supervision, making a group session applicable.

The purpose of this study was two-fold. It was designed to 1) determine the feasibility of a G-MDTT protocol for community-dwelling older adults who have concerns about falls, and 2) obtain preliminary data of intervention effects on immediate outcomes related to fall risks. Results of this study may contribute to the development of a motivating music therapy intervention aimed to alleviate the impact of reduced executive function on fall risks in community-dwelling older adults during dual-task performance. Outcomes may also have implications for a fall-prevention program that enhances quality of life.

Chapter 2: Literature Review

This chapter provides a discussion of the research literature related to the feasibility of group musical dual-task training in community-dwelling older adults who have concerns about falls. Topics examined in this chapter include (a) falls; (b) factors which increase fall risks; (c) interventions to prevent falls; and (d) music based interventions which relate to fall risks. In conclusion, the chapter outlines the purpose of this study and addresses the research questions.

Significance of Falls in Older Adults

According to the World Health Organization Ageing and Life Course Unit's global report on falls prevention in older age (2007), falls are commonly defined as "inadvertently coming to rest on the ground, floor, or other lower level, excluding intentional change in position to rest in furniture, wall, or other objects (p.1)." For older adults, falls are a major hazard due to their high incidence and associated injuries that adversely influence independence and quality of life. One-third of older adults living in the United States, age 65 and above will fall each year (Tromp et al., 2001). Twenty to thirty percent of individuals who fall suffer from a limitation of daily living due to fall-related injuries. Common injuries include lacerations, hip fractures, and head traumas ("Falls among older adults," 2013; Sterling, O'Connor, & Bonadies, 2001). As a primary reason for non-fatal hospitalization, falls are also the leading cause for injuries that lead to mortality ("Falls prevention: Fact sheet," n.d.). The cost for necessary health care for falls also represents a serious public health concern as the older population continues to expand ("The older population," n.d.). In 2010, older adult patients and insurance companies spent 30 billion dollars treating fall-related injuries ("Costs of falls among older adults," 2014).

Risk Factors of Falls

Many factors increase the risk of falling among older adults. These factors can be categorized into environmental and individual aspects. Environmental factors concern the hazards around the living area such as lack of stair railings, uneven or slippery surfaces, and inadequate lighting (Gill, Williams, Robison, & Tinetti, 1999). Occupational therapists could perform a home safety assessment and recommend modifications to remedy some of these environmental issues (Lord, Menz, & Sherrington, 2006).

Individual risk factors are associated with personal features. Personal features yielding higher fall risks include: older age, female gender, lower physical functions, visual impairment, postural hypotension, a history of falling, and a fear of falling. Statistics showed older adults fall more often than younger adults and among the older adults, females fall more often than males (Campbell, Spears, & Borrie, 1990). Individuals taking four or more medications and those with chronic diseases such as Parkinson's disease, stroke, and dementia also experience an increased risk of falling (STEADI, 2014; Stevens, 2005). Many older adults take medications with the side effects of drowsiness and dizziness such as benzodiazepines, antidepressants, and sedatives, which make them more susceptible to falls (Leipzig, Cumming, & Tinetti, 1999). Cognitive decline commonly observed in older adults was considered unrelated to fall risks in the past, but recent studies clearly pointed out that impaired executive function is associated with increased risk (Buracchio et al., 2011; Mirelman et al., 2012; Woollocott & Shumway-Cook, 2002). Impaired executive function also worsens the dual-task performance, where the individual is processing a mental task in addition to walking at the same time. Deficits in dual-task performance thus become a risk factor (Buracchio et al., 2011).

Proper interventions could potentially modify some of these individual risk factors such as physical problems with balance and gait, declining executive functions, exacerbated performance under a dual-task condition, and excessive fear of falling (Gillespie et al., 2012; Montero-Odasso, Verghese, Beauchet, & Hausdorff, 2012; Zijlstra et al., 2007b). These modifiable individual factors, including balance, gait, executive function, dual-task performance, and fear of falling, are discussed in greater detail as follows.

Balance

The ability to keep balance, while standing, walking, and doing daily activities, is a complex motor skill that involves interaction with multiple sensorimotor resources. Individuals may have impaired balance because the muscle weakness of feet and ankles limits the range they can move their body's center of mass without moving their feet. They may lose balance because of an impaired ability to evaluate the somatosensory, vision and vestibular information in response to the environment; they may be prone to falls due to a decline in cognition because postural control requires cognitive processing (Horak, 2006). At this point, no single assessment addresses all of the factors causing balance impairment (Mancini & Horak, 2010). Accordingly, although balance impairment has been acknowledged as one of the major risk factors of falls (Delbaere et al., 2010, Overstall, Exton-Smith, Imms, & Johnson, 1977; Rubenstein, 2006), the ability to identify individuals who fell (fallers) and who did not fall (non-fallers) or predict future falls varies among different balance assessment tools (Muir, Berg, Chesworth, Klar, & Speechley, 2010).

Common balance measures for evaluating community-dwelling older adults include the Timed Up and Go Test (TUG) (Podsiadlo & Richardson, 1991; Shumway-Cook, Brauer, Woollacot, 2000), one-leg stand (Vellas et al., 1997), functional reach (Duncan, Weiner, Chandler, & Studenski, 1990), Tinetti Balance Assessment Tool (TB) (Tinetti, Williams, & Mayewski, 1986), and Berg Balance Scale (BBS) (Berg, Wood-Dauphinee, Williams, & Maki, 1991) (Lin et al., 2004). TUG measures the time needed for an individual to stand up from an armed chair, walk three meters, turn, walk back, and sit down. The amount of time required to complete the task determines the functional mobility in terms of the balance in performing daily activities (Podsiadlo & Richardson, 1991). The one-leg stand balance test instructs individuals to raise one leg and stand without assistance while keeping their arms to theirs sides and their eyes open. The number of seconds that pass from when the individuals raise their leg until they touch the floor or their other leg is measured. Longer times are seen as a sign of better balance (Vellas et al., 1997). The functional reach balance test asks the individuals raise one arm with a closed fist until it is parallel to the floor while standing close to, but not touching the wall. The individual is then instructed to reach as far as possible forward without losing balance or raising either foot. The distance between the starting point and the end point the arm can reach determines balance ability with longer reach corresponding to greater balance ability (Duncan et al., 1990). TB assesses an individual’s ability to perform eight tasks such as sitting balance, sit to stand, and sitting down. Each task is rated as 0, 1, or 2 depending on the steadiness and successfulness of the performance. The maximum score is 16 and a higher score indicates better balance ability (Tinetti et al., 1986). BBS is a clinician rated performance measure that includes 14 functional activities of varying difficulties such as sitting, standing, and change of position. Level of function is scored from 0 to 4 points with “0” indicating the lowest level and “4” indicating the highest. A cutoff point of 45 is originally determined for balance impairment (Berg et al., 1991).

The present study chose TUG as a measure for balance for its ability in identifying fallers and predicting future falls. Older adults who fell two or more times in the previous 6 months took significantly more time to complete the test than those who did not fall in the previous 6 months. Poorer TUG performance was associated with higher risks of falling during a 12-month follow-up (Shumway-Cook, Brauer, & Woollacott, 2000). Another advantage of applying TUG is older adults, including those with lower function, were more receptive to TUG when compared to one-leg stance and functional reach, leading to higher participation rates. The relatively low refusal rate for TUG may indicate older people were not afraid of the possibility of losing balance or did not believe themselves likely to fall while taking TUG (Lin et al., 2004).

Gait

Gait alteration is commonly observed in older adults. Compared to younger adults, older adults walk slower and exhibit stride length reduction with greater variability and decreased motion of ankle plantar flexion and knee extension while walking (Elble, Thomas, Higgins, & Colliver, 1991; Kim, & Kim, 2014; Ostrosky, VanSwearingen, Burdett, & Gee, 1994). Montero-Odasso et al. (2005) found that slowing gait velocity was strongly associated with more incidences of adverse events such as hospitalization and falls in community-dwelling older adults.

In addition to walking speed, studies found that the fluctuation between strides creates instability, which increases the risk of falls in older adults (Hausdorff, 2007; Hausdorff, Rios, & Edelberg, 2001; Maki, 1997). Barak, Wagenaar, and Holt (2006) compared these gait characteristics between groups of elderly with and without a history of falls. The results indicated that the elderly who previously fell exhibited greater gait variability. Moreover, a prospective cohort study conducted by Callisaya et al. (2011) revealed that greater stride length variability was associated with increased risk of multiple falls. In their study, older adults were randomly selected from the population in Tasmania, Australia and their gait performances were assessed at baseline. Falls occurring after baseline measurements were recorded during the one-year follow-up period.

Studies have speculated that the greater gait variability is a result of loss of muscle strength and flexibility, as well as the impairment of executive function in regulation of gait (Hausdorff, 2007; Kang & Dingwell, 2008). Thus, Salzman (2010) suggested that gait disturbance should not be considered as a natural consequence of aging. Instead, one or more underlying causes of gait alternation, including a cautious gait pattern associated with fear of falling, should be considered when older adults undergo a functional assessment to identify individuals at risk of falling.

Executive Function

Recent studies revealed that a decline in executive function is related to an increase in fall risks (Hausdorff et al., 2006; Holtzer et al., 2007). Hausdorff et al. (2006) examined the cognitive profiles of elderly fallers who reported falling at least two times in the past year and at least one time in the previous 6 months. This group was compared to a control group who reported no falls in the past year. The results demonstrated that elderly fallers performed worse in the executive function and attention test while their global cognition was comparable to the non-fallers as indicated by identical Mini Mental State Exam scores (Folstein, Folstein, & McHugh, 1975). A correlational study by Holtzer et al. (2007) found that executive function and attention were related to both single falls and recurrent falls among a cohort of community dwelling elderly without cognitive impairment. If an elderly individual scored one standard deviation higher in executive function tests, including the Trail Making Test (TMT; Army Individual Test Battery, 1944), Digit Symbol, and Block Design sub-tests of the Wechsler Adult Intelligence Scale-revised (WAIS-R; Wechsler, 1981), he or she reduced fall risk by approximately 50%.

In addition to examining the retrospective data in the above studies, some prospective cohort studies examined whether executive function served as a baseline for predicting falls (Buracchio, 2011; Herman et al., 2010; Mirelman et al., 2012). Herman et al. (2010) found that the executive function index was able to predict future falls during the 2 years of follow-up. In Herman et al.'s study, participants who reported no previous falls and were in the bottom quartile of executive function index were three times more likely to fall. These individuals were also more prone to transition from a non-faller to a faller at an earlier point in time. Similarly, a study conducted by Buracchio (2011) indicated that lower executive function scores were associated with higher numbers of falls during the 13 months follow up in elderly without balance impairment. In a 5-year follow up study, Mirelman et al. (2012) also found that executive function and attention were predictors of future falls among community-living older adults.

Dual-Task Performance

A dual-task paradigm is a process in which an individual is required to perform a single-task and a dual-task. The comparison between how an individual performs the two tasks simultaneously can reveal whether there is interference from the second task. The extent of interference suggests that these two tasks share or compete for the same processing mechanism in the brain, potentially the higher executive control (Sala, Baddeley, Papagno, & Spinnler, 1995; Pashler, 1994). In order to understand how processing a second task while walking relates to fall risks, three findings from the dual-task research are discussed as follows: 1) walking is an attention-demanding task rather than a purely automatic physical movement; 2) lower executive function is associated with greater gait disturbance caused by performing a dual-task exercise; 3) exacerbated difficulty while performing dual-task performance is a predictor for increased risk of falls.

Walking requiring additional attention control is observed in a phenomenon of “stop walking when talking,” which commonly occurs within the geriatric population. Lundin-Olsson, Nyberg, and Lars (1997) described a clinical observation in which some older adults stopped walking upon entering conversations, even if the other person was walking with them. This is presumably because, for them, walking represents a greater drain on attention than what the average person experiences and the addition of a second task would require a split focus. This split in attention is likely perceived by them to be beyond their abilities and hence could potentially cause them to fail in one task or the other. In other words, if walking does not require attention, the older adults do not need to stop walking in order to devote all the attention capacity to conversation. Individuals likely stopped walking because they prioritized the talking task over the walking task and stopping might also serve as a mechanism to avoid falling. Lundin-Olsson and her colleague also found that among 58 residents in a nursing facility, the older adults who stopped walking while talking were more likely to fall during the 6-month follow-up compared to those who continued walking during the baseline assessment. Not only did older adults display these tendencies, but younger adults also exhibited gait change during dual-task performance. Beauchet, Dubost, Hermnn, and Kressig (2005) found when a group of 49 healthy young adults were required to walk while counting backward, their walking speed was significantly lower than walking alone. They also counted significantly fewer numbers during walking than when seated. This difference induced by dual-task represents a dual-task cost, which confirmed walking is not merely an automatic physical movement. Certain aspects of walking demand attention resources.

The study by Beauchet et al. (2005) also found the dual-task cost was greater on the cognitive task than the walking task in the young adult participants. Greater interference on the cognitive task in the young adults may indicate that younger individuals tend to prioritize the walking task over the cognitive task. Meanwhile, older adults and/or adults with cognitive impairment tend to prioritize the cognitive task over the walking task (exhibited by the tendency to stop walking while talking). Research indicates that individuals with a history of falls, who have poor executive function, or those with Parkinson's, were at increased risk of falls and were more likely to employ a "posture second" strategy, meaning they put a greater priority on the cognitive task and a lesser priority on maintaining the balance of walking (Beauchet et al., 2007; Bloem, Valkenburg, Slabbekoom, & van Dijk, 2001; Hobert et al., 2011). The employment of "posture second" strategy by older adults with declining executive function was observed in Hobert et al.'s study (2011). Hobert et al. indicated that, when challenged by walking while subtracting serial 7s, the elderly with inferior executive function walked significantly slower than those with superior executive function. The two groups did not exhibit any difference in terms of the dual-task cost on the amount of subtractions performed during the exercise. However, the percentage of group members who made one subtraction error was higher during the dual-task condition than during the single-task condition among the better performers. Among the weaker performers, the performance was reversed; the percentage of group members who made one subtraction error was higher during the single condition than during the dual-task condition. The altered prioritization to the cognitive task during dual-task condition in the individuals with poor executive function might make them more vulnerable to falls.

If we assume walking requires attention, the dual-task paradigm illustrates the fact that an individual's ability to successfully perform a dual-task is dependent upon whether or not the individual can effectively and efficiently allocate attention resources between two tasks. This ability is recognized as an example of executive function called divided attention (Pettersson, Olsson, & Wahlund, 2007; Sheridan, Solomont, Kowall, & Hausdorff, 2003). A review article by Yogev-Seligmann, Hausdorff, and Giladi (2008) listed three theories to explain why divided attention impacts dual-task performance: the capacity-sharing theory, the bottleneck theory, and the multiple resources model. The capacity-sharing theory claims individuals possess a finite amount of attention and contends that, when simultaneously performing two more attention-demanding tasks, individuals will experience a decreased capacity to perform one or more of the tasks. The bottleneck theory claims that individual neural processors or networks within the brain can only perform one task at a time and must complete one task, or one component of a larger task, before moving on to the next task. Under this theory, humans can only accomplish one task at a time. While the brain works on one task, the other task requiring the same parts of the brain is delayed until the first task or subtask is completed. The multiple resources model proposes processing tasks requires a specific resource or resources. If two simultaneous tasks require a common resource, the resource is split between them and neither task receives as much of the resource as it would separately. Conversely, if two simultaneous tasks require different resources, the attention is not divided.

In fact, research findings suggest executive function is a contributing factor to dual-task performance and, as a result, older adults perform worse than younger adults during a dual-task condition; additionally, older adults with reduced executive function perform worse than their cognitively intact counterparts (Hollman, Kovash, Kubik, & Linbo, 2007; Priest, Salamon, & Hollman, 2008). In the study by Hollman et al., the researchers asked young, middle age, and older adults to walk and verbally spell a five-letter word backward. They found differences in gait velocity and stride-to-stride variability between walking only and dual-task walking were greater in older adults than in younger adults. As aging has been associated with the decline of executive function and attentional systems (Glisky, 2007), this study supported the idea that age-related dual-task gait disturbance is related to executive function.

Studies that compared the dual-task performance of healthy older adults and older adults with declining executive function reinforced the importance of executive function in dual-task (Allali et al., 2008; IJmker & Lamoth, 2012; Lamoth et al., 2011). Lamoth et al. asked elderly participants with and without dementia to walk and name as many words starting with a predefined letter. Participants with dementia showed significantly more changes in stride-to-stride variability between walking only and dual-task walking than cognitively intact elderly controls. Their findings support the concept that changes in cognitive functions likely contribute to changes in the variability and stability of the gait pattern, which was more visible during a dual-task condition. It would appear that dual tasking has a greater effect upon elderly individuals with cognitive impairments than those without.

In additional to comparison studies, correlational studies have examined the relationship between executive function and dual-task performance (Van Iersel, Kessels, Bloem, Verbeek, & Rikkert, 2008; Coppin et al., 2006). Springer et al. (2006) discovered a correlation between executive function and dual-task performance in the entire group of older adults regardless of having a history of falling; the correlation became stronger when the dual-task complexity increased. Springer and his colleagues also found executive function performance was significantly lower and the variability of time spent on the swing phase (during which the foot is off the ground) during dual-task was significantly higher in older fallers than non-fallers. Correspondingly, Van Iersel et al., (2008) discovered lower executive function was associated with higher stride length variability in community-living elderly individuals when asked to walk and name as many animals as possible at the same time.

Given that impaired executive function impacts dual-task performance, the next question is: could the exaggerated slowing and variability of gait during a dual-task condition predict falls? A study by Toulotte, Thevenon, Watelain, and Fabre (2006) only found significant differences in the gaits of those with a history of falls and those without such a history when performing dual-tasks and not during single-tasks. Their study suggested the poor performance on a dual-task might be an indicator to identify fallers. Furthermore, Herman, Mirelman, Giladi, Schweiger, and Hausdorff (2010) conducted a study to exam if executive function and dual task performance, a demand on executive control, could predict future falls in a cohort of community-dwelling older adults with intact cognition. During the 2-year follow up, lower executive function in participants was significant associated with future falls. The higher the gait variability exhibited during the dual-task condition, the more likely the patient was to fall.

Fear of Falling/Concerns about Falls/Falls Efficacy

Concerns about falls are considered equivalent to fears of falling, which reflect the psychological aspects related to falls in older adults (Zijlstra, 2007). According to Tinetti and Powell (1993), fear of falling is defined as "a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing" (p. 36). Yet other authors have attributed fear of falling to a patient's low confidence in keeping balance and avoiding falls (Cumming, Salkeld, Thomas, & Szonyi, 2000; Maki, Holliday, & Topper, 1991; Tinetti, Speechley, & Ginter, 1988). This latter view conceptualized fear of falling as influenced by low perceived self-efficacy about balance. If individuals believe they will fall (low perceived self-efficacy), they will more likely develop a fear of falling. Based on this conceptualization, Tinetti, Richman, and Powell (1990) constructed the Falls Efficacy Scale (FES) that measures fear of falling by asking how confident individuals are regarding fall avoidance while performing every day activities.

In contrast, Hadjistavropoulos, Delbaere, and Fitzgerald (2011) argued that fear of falling and falls efficacy are related but distinct in construct. Falls efficacy, which concerns the cognitive component of fear of falling (subjective evaluation of one's ability to avoid falls), mediates the relationship between fear of falling and falls. As Li, Fisher, Harmer, and McAuley (2005) found, balance-training programs such as Tai Chi raised the level of fall efficacy, and the enhanced fall self-efficacy in turn reduced fear of falling. In their study, fear of falling was measured by the Survey of Activities and Fear of Falling in the Elderly (SAFFE) (Lachman et al., 1998). In addition to asking the individuals how worried they are when they perform daily activities such as taking a shower or walking for exercise, SAFFE also asks the individuals if they avoid doing certain activities due to worry about falls. Because of the proposed difference between falls efficacy and fear of falling, this present study applied both the extended FES and SAFFE as outcome measurements for concerns about falls.

Fear of falling has long been believed to develop after one has fallen as a post-fall syndrome (Bhala, O'Donnell, & Thoppil, 1982; Murphy & Isaacs, 1982). However, later research indicates a comparable fall rate reported between fallers and non-fallers (Lawrence et al., 1998). Fear of falling could develop from firsthand experience from falling in the past, or secondhand experience from witnessing falls of others (Hadjistavropoulos, Delbaere, & Fitzgerald, 2011).

Fear of falling may result in activity restriction and gait change and is associated with a decline in physical and mental performance, health-related quality of life, and an increased risk of falling (Delbaere, Sturnieks, Crombez, & Lord, 2009; Scheffer et al., 2008; Zijlstra et al., 2007a). Older adults who avoid activity due to severe fear of falling also commonly exhibit anxiety and symptoms of depression (van Haastregt, Zijlstra, van Rossum, van Eijk, & Kempen, 2008). Cumming, Salkeld, Thomas, and Szonyi (2000) discovered that older adults with a greater fear of falling as indicated by lower scores on the Fall Efficacy Scale (FES) had an increased risk of falling during the 12-month follow-up. Similarly, Friedman, Munoz, West, Rubin, and Fried (2002) found that older adults who did not fall at the baseline but indicated fear of falling were more likely to report falls at the 20-month follow-up than those who did not fall at baseline and did not indicate fear of falling. A systematic review concluded that home-based exercise, fall-related multifactorial programs, and community-based Tai Chi training are effective in explicitly or indirectly reducing fear of falling in community-living older adults (Zijlstra et al., 2007b).

Fall Prevention Interventions

Falls lead to serious consequences, but some of the factors contributing to increased risks of falls are not inevitable. Evidence-based strategies, including exercise, Tai Chi, dual-task training, and multifactorial assessment and management (Schubert, 2011) are discussed in this section.

Exercise

Systematic reviews of literature revealed that the risk and rate of falls in older adults could be reduced by well-designed exercise interventions (Gillespie et al., 2009; Sherrington et al., 2008; Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011). Exercises commonly applied in the trials included balance training, strength building, aerobic, and stretching exercise (Barnet, Smith, Lord, Williams, & Baumand, 2003; Robertson, Campbell, Gardner, & Devlin, 2002; Skelton, Dinan, Campbell, & Rutherford, 2005). The meta-analysis by Sherrington et al. (2011)

indicated that only exercise aimed at challenging balance control of adequate frequency (at least 2 hours per week ongoing) was effective. A balance targeted exercise program could be delivered in a group setting where community living older adults were invited to attend an exercise class instructed by professionals (Barnett et al., 2003; Skelton et al., 2005). Individuals also benefited from a home-based program where they practiced learned exercises at home while periodically supervised and monitored by the professionals (Robertson et al., 2002)

A randomized control trial by Barnett et al. (2003) indicated that a year-long community based group exercise program improved balance and decreased fall rate in older adults aged 65 and older identified as at-risk of falling. Participants in the experimental group attended a 60-minute group exercise practice once a week for a year with a median of 23 sessions. The program was designed by a physical therapist to address the fall-related physical functions of balance, coordination, aerobic capacity, and muscle strength. Specific exercises aimed at balance and coordination included weight-shifting and reaching exercises in the form of modified Tai Chi, stepping and dancing practices, and ball catching and throwing. Exercise to improve aerobic capacity included fast walking with varied pace and direction. Exercises to build up muscle strength comprised of sit-to-stand practice, wall press-ups, and arm and leg exercises using a resistance band. Although Barnett et al.'s study examined primarily the effects of a community-based exercise program; the participants in the study were provided class content to aid at home practice.

Another study that also encouraged home practice required participants to attend a 60-minute supervised exercise class once a week and exercise 30-minutes twice a week at home for 36 weeks. Among a total number of 81 female participants aged 65 and above with a history of frequent falls, 50 attended the exercise intervention. The intervention was an individually tailored group exercise, Falls Management Exercise (FaME), which focused on balance and muscle strengths as well as the ability to get down and up from the floor to increase falls efficacy. In addition to exercises such as weight lifting, standing squats, marching, sidestepping, side and backward walking, the participants also practiced ways to avoid falling such as compensatory stepping and functional floor exercises including crawling, rolling, back extensions, and side leg lifts. The results indicated that the 36-week group combined with home-based exercise program lowered the rate of falls by one-third (Skelton, Dinan, Campbell, & Rutherford, 2005).

The exercise program used in the study conducted by Skelton et al. (2005) was adopted from the Otago exercise program developed from a series of studies by Campbell, Robertson, and their colleagues. Campbell et al. (1997) designed a home-based exercise for community-dwelling women aged 80 and older. They found this easily implemented program lowered the rate of falls in the exercise group compared to the control group during the one-year follow-up. Balance in the exercise group also improved after 6 months compared to the control group. This physical therapist prescribed exercise program aimed to increase strength and balance by developing the lower leg muscles. Examples of exercises included weight lifting, standing with one foot in front of the other, as well as walking outside of the house. Each routine of the exercise program lasted 30 minutes and was to be practiced at least 3 times a week.

Researchers recommend that an effective exercise program should have medium to high intensity (Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011). Weerdesteyn et al. (2006), however, found that a 5-week low intensity exercise program, the Nijmegen Falls Prevention Program, reduced fall numbers during the 7-month follow-up in community-dwelling older adults with a history of falls. The authors attributed the effectiveness of the program to the unique design of the exercise in the study. Unlike many studies where balance and gait were practiced as individual exercises, Weerdesteyn et al.'s study required the participants to practice walking around obstacles such as over uneven pavement and doorsteps while carrying a tray of cups or memorizing a story, which they were told while walking. These activities represent potentially challenging activities that people may perform everyday. This study may provide the implication for incorporating dual-task and obstacle negotiation into exercise programs for future study.

Tai Chi

Since balance is the essential component of an effective fall prevention exercise program, researchers began to introduce a specific exercise, Tai Chi, into programs. A martial arts form in Chinese culture, Tai Chi, focuses on lower-limb strength and postural stability (Li et al, 2005). Wolf et al.'s study (1996) stated that "(in learning Tai Chi), balance was stressed under conditions that continuously invoked body rotational movements under a progressively diminishing base of support" (p. 490). Correspondingly, Sherrington, Tiedemann, Fairhall, Close, and Lord (2011) recommended that the best practice of a balance exercise should include the components of reducing the base of support, controlling of the body position while standing, and reducing the support from the arms while exercising in a standing position. All three of these balance challenges are the core of Tai Chi practice.

Studies have shown that practicing Tai Chi improves functional balance, reduces the rate of falls, and further prevents potential falls at follow up (Li et al., 2005; Voukelatos, Cumming, Lord, & Rissel, 2007; Wolf et al.). Wolf et al. (1996) examined the effects of a simplified version of Tai Chi on community-dwelling older adults and found the risk of multiple falls was reduced after a comparatively short intervention period of 15 weeks. Two hundred participants were recruited and randomly assigned to a Tai Chi group, a balance-training group, and an education group. The Tai Chi program advanced in difficulty, gradually promoting single limb stance, increasing body and trunk rotation, and circular arm movements. Participants met twice a week for group sessions, received one-on-one instruction once a week, and practiced daily at home on their own.

Similarly, the study by Li et al. (2005) indicated that 6-months of Tai Chi practice reduced the number of falls, risk of falling, and fear of falling in the elderly who live in the community but are not physically active. A sample of 256 elderly individuals aged 70 or older were recruited and randomly assigned to a Tai Chi intervention group and a stretching exercise group. The Tai Chi group attended a 60-minute practice three times a week for a total of 26 weeks. The classical Yang style Tai Chi was taught by an experienced instructor, which included the essential components of Tai Chi practice, including multidirectional weight shifting, body alignment awareness, and body movement coordination with synchronized breathing integrated into each movement. In addition to its effect on fall reduction, this Tai Chi program also improved the participants' balance and physical performance.

Dual-task Training

Studies have shown that impaired dual-task performance in gait speed and balance could be improved through dual-task training (Dorfman et al., 2014; Pedroso et al., 2012; Peirone, Goria, & Anselmino, 2014; Plummer, Villalobos, Vayda, Moser, & Johnson, 2014; Plummer-D'Amato et al., 2012; Schwenk, Zieschang, Oster, & Hauer, 2010; Silsupadol et al., 2009; Yang, Wang, Chen, & Kao, 2007; Yogev-Seligmann, Giladi, Brozqol, & Hausdorff, 2012; You et al., 2009). While there is lack of direct link between the improvement of dual-task and the actual reduction of fall risks, these dual-task training studies contribute to the development of an intervention aimed at fall related dual-task deficits. Such studies investigated the training effects of performing a dual-task on a variety of populations including healthy, community-dwelling, older adults (Plummer-D'Amato et al., 2012), older adults with balance impairments (Silsupadol et al., 2009), older adults with a history of falls (Dorfman et al., 2014; You et al., 2009), patients who have suffered a stroke (Plummer et al., 2014; Yang et al., 2007), patients with brain injury (Peirone et al., 2014), individuals with Parkinson's disease (Yogev-Seligmann et al., 2012), and those with mild to moderate dementia (Pedroso et al., 2013; Schwenk et al., 2010). This next section will review the literature through: 1) describing 10 dual-task training studies in terms of their content of the training protocol and outcomes; and 2) identifying several questions that warrant further consideration in designing a dual-task training protocol.

Plummer-D'Amato et al. (2012) compared the effect of single-task and dual-task training on 17 community-dwelling healthy older adults and found that both trainings increased the walking speed and improved balance measured by the Timed Up and Go test (TUG). The single-task intervention consisted of a physical task focused on balance, gait, and agility while the dual-task intervention added a variety of simultaneous cognitive tasks on top of the same physical single-task. Each weekly session was 45-minutes in length. Both training interventions progressed in difficulty over the 4 weeks of treatment period. Examples of dual-task activities included standing on a narrow base while words in a category such as animal or fruit and walking while spelling words backwards. Despite the improved gait and balance, both trainings failed to improve the performance when the participants needed to walk while negotiating around the obstacles on a 6-meter route. The authors attributed the lack of effect on obstacle negotiation task to a potential ceiling performance of the healthy participants, the relatively lower intensity and duration of the program, and the possibility that the dual-task training effects during the treatment did not translate into the untrained dual-task assessed at the pre and posttest.

Dual-task studies have included individuals who had experienced falls, or who were at risk of falling due to impaired balance without known diagnoses (Dorfman et al., 2014; Silsupadol et al., 2009; You et al., 2009). In the study by Dorfman et al. (2014), researchers recruited 10 older adults with a history of multiple falls. The participants were instructed to walk on a treadmill while processing one of the three different cognitive tasks, including answering questions after listening to a story, naming words starting with a particular letter, and doing multiplication table exercises. Both the treadmill walking exercise and the cognitive exercise increased in difficulty over time. For example, the therapist increased the speed on the treadmill and raised the difficulty of the questions. Following treatment that occurred three times a week for at least 6 weeks, the participants improved their balance control as evaluated by the Borg Balance Scale (BBS) and Dynamic Gait Index, their gait speed during single and dual-task walking, their executive function as measured by the Trails Making Test B (TMT-B), and their quality of life, and physical activity. In order to test if the treadmill training would transfer to the untrained over-ground walking task, the participants walked on the ground while performing a serial threes subtraction test in which they counted down by threes from a random 3-digit number at the pre and posttest assessment.

You et al. (2009) also investigated the effects of dual-task training on older adults with a history of falls. Thirteen participants attended 30-minute sessions over 6 weeks for a total of 18 sessions. In addition to evaluating the motor performance, You et al. were interested in knowing whether the participants' working memory performance improved after task-specific training. The same dual-task routine was assessed at the pre and posttest and also trained during the intervention. This dual-task required the participants to memorize seven words and carry out three simple calculations while walking. In contrast to other studies showing improvements in gait performances You et al.'s study did not find changes in walking speed and stability but instead observed an improvement in memory performance. The dual-task group indicated greater memory recall than the control group who practiced walking while listening to the same piece of classical music as a placebo treatment. You et al. speculated that the lack of enhancement in gait was a result of ceiling performance of the participants in terms of their walking functions. The authors further suggested the participants' better memory without compromising their gait during dual tasking was of clinical importance. The participants may enhance their ability to effectively allocate attention between tasks throughout the training process.

Instead of the examination on individuals with a history of falls, Silsupadol et al. (2009) compared the effect of single-task and dual-task balance training on 23 older adults with balance impairment. The participants attended a 45-minute individual training session 3 times a week for 4 weeks. The participants were randomly assigned to one of three groups. The single-task group received balance practice only. The fixed-priority dual-task group received balance practice and cognitive task dual-task training, paying equal attention to both tasks. The variable-priority dual-task group received the same dual-task training, but prioritized the attention to balance half of the time, and shifted focus to the cognitive task for the other half. Examples of balance practice included standing with closed eyes, standing on foam while handling a ball, walking on a narrow surface, and walking backward while manipulating an object in hand. The participants in the dual-task groups simultaneously processed another cognitive task such as counting numbers backward and spelling words backward. To test if there was a transfer of dual-task processing skills from a trained dual-task to a novel dual-task, the participants were evaluated under two dual-task conditions at the pre and posttest: walking on a narrow surface while performing the serial threes subtraction test (trained) and walking around the obstacles while performing a auditory Stroop test (untrained). The auditory Stroop test is a test to evaluate the mental flexibility. In the test, the researcher asks individuals to respond to auditory stimuli where the meaning of the words and the pitch used to present the words are potentially in conflict. For example, the individuals may hear the word "low" presented at a "high" pitch, and they have to report "high," ignoring the meaning of the word, "low." The results showed that both single-task and dual-task trainings improved balance under the single-task narrow walking and obstacle negotiation conditions regardless of priority. Dual-task training, especially with the variable priority instruction, was more effective in improving the single-task cognitive task performance in serial threes subtraction task and the auditory Stroop test. Moreover, dual-task training with the variable priority instruction indicated greater improvement in balance under the trained dual-task condition than the dual-task training with fixed priority instruction as well as single-task training. However, the dual-task training effects did not transfer to the untrained dual-task where the participants responded to auditory Stroop test while walking.

Dual-task studies have also included individuals with cognitive impairment (Pedroso et al., 2012; Schwenk, Zieschang, Oster, & Hauer, 2010). Schwenk, Zieschang, Oster, and Hauer (2010) conducted a study to examine whether the dual-task performance of patients with dementia would improve after dual-task training. This randomized controlled study included 61 participants who attended a 2-hour session twice a week for 12 weeks. The intervention group spent at least an hour doing progressive resistance training and progressive functional-balance training. While the participants were performing the balance task, they also practiced processing a second task at the same time such as throwing and catching a ball or calculation. In addition, the participants practiced a specific dual-task in which they walked while carrying out serial twos addition calculation or serial threes subtraction calculation if able. The control group attended sessions where they practiced exercise addressing the goals of body fitness and flexibility. Results indicated that dual-task training increased gait speed, reduced dual-task cost, and improved gait stability under dual-task. However, the improvement was only observed under a more complex dual-task condition, the serial threes subtraction calculation, but not under the less challenging condition, the serial twos addition calculations. This finding indicated that in order to detect a difference in dual-task training effects, the attention demand from the dual-task assessment needed to reach a certain threshold of difficulty. In this study, participants were trained on the pre and posttest dual-task tasks as part of the intervention. The authors suggested that future studies should test whether the effects of trained tasks could transfer to untrained conditions.

Pedroso et al. (2012) also conducted a study exploring the effects of dual-task on patients with cognitive impairment. Instead of measuring the dual-task performance as Schwenk et al. (2010) did in their study, Pedro et al.'s study examined whether practicing dual-task improved executive function, balance, and reduced the number of falls in 21 patients with Alzheimer's disease. Participants received a 60-minute training 3 times a week for 4 months. The intervention group practiced dual-task activities such as walking while verbalizing names of animals or fruits. Moreover, the participants stopped or resumed their motor task according to a musical cue or a verbal command. The control group did not receive any treatment. Results showed that the intervention group exhibited significantly greater improvement in their balance evaluated by the BBS and in executive function measured by the Frontal Assessment Battery (FAB) and the Clock Drawing Test (CDT) compared to the control group. The dual-task intervention group also showed a reduction in the number of falls, although this change was not statistically different when compared to the control group.

The effects of dual-task training have also been examined for individuals with physical limitations who are vulnerable to falls due to neurological disease such as Parkinson's disease, stroke, and brain injury. Yogeve-Seligmann, Giladi, Brozgol, and Hausdorff (2012) conducted a pilot study on seven patients with Parkinson's disease and found that their walking speed and stability under dual-task condition improved after a 4-week individual dual-task training. Sessions were 25-minutes long and occurred 3 times per week. Based on the task-specific training principle, three dual-task combinations trained as interventions were also evaluated at the pre- and posttest. These trained combinations included: 1) walking while naming words beginning with a certain letter, 2) walking while doing a serial threes subtraction calculation, and 3) walking while performing simple calculations. Instead of reporting the answers as numbers, the participants indicated the numbers being larger or smaller than four. An untrained task was also tested at the pre- and posttest to see if the effects transferred to an untrained task. The results indicated that gait speed and variability improved not only in trained, but also in untrained, tasks.

Yang, Wang, Chen, and Kao (2007) conducted a dual-task training study to test the effects on walking in 25 individuals with chronic stroke. Different from the common dual-task regime that involved a physical task and a concurrent cognitive task, the two tasks applied in Yang et al.'s study were both motor-oriented. During the intervention, the participants were instructed to walk while handling a ball. They held one or two balls in hands, bounced the balls, or kicked the balls within a net. After 4 weeks of training, which lasted 30-minutes per session and took place 3 times a week, the intervention group showed significant improvement in gait speed and stability under both single-task and dual-task conditions compared to the control group who did not receive any training. The dual-task tested at the pre and post was walking while carrying a tray and glasses. Since this task was not specifically trained during the intervention, the result indicated that the dual-task effects were transferred to untrained tasks in patients with chronic stroke.

Plummer, Villalobos, Vayda, Moser and Johnson (2014) also conducted a study on stroke patients. Unlike Yang et al's study (2007), which recruited patients with chronic stroke, patients involved in Plummer et al.'s study had suffered a stroke within the previous year. The dual-task intervention was a gait training combined with cognitive tasks. This case series study included seven patients. The participants attended a 30-minute session 3 times a week for 4 weeks. The gait training covered various aspects of abilities in walking. For instance, the participants not only practiced walking around fixed obstacles, they also practiced walking around moving obstacles or in a crowed area where the conditions were not predictable. The cognitive tasks included a variety of cognitive activities with different levels of difficulty ranging from recalling a grocery list than varied in length from three items to five items and from naming words in a category to naming words beginning with a specific letter. To test whether the training effects transferred to untrained tasks, the pre and posttest included three untrained tasks in addition to the auditory Stroop task, which was considered a trained task since the dual-task intervention and auditory Stroop task both required executive function. The results showed that five out of the seven participants reduced their dual-task cost in walking speed in at least one of the four dual-task assessment conditions.

Peirone, Goria, and Anselmino (2014) examined the effects of dual-task training in 16 patients who sustained brain injury 12 to 18 months before the study. They found that patients who participated in additional home-based dual-task training demonstrated significantly greater improvement in balance control measured by the Balance Evaluation System Test than those who attended traditional physical therapy alone. The traditional physical therapy was individualized addressing goals such as dressing while standing and walking in a crowded environment. Both intervention and control groups received this traditional 50-minute physical therapy 3 days a week for 7 weeks. Additionally, the intervention group also practiced dual-task 30 minutes a day, 6 days a week at home. While they practiced balance exercises at home, they counted, held a tray of glasses, or wrote a phone message at the same time. No instruction on task priority was given.

The previously discussed studies support the use of dual-task training in the present study for individuals with concerns about falls. The following list of questions addresses several concerns that impact the design of a dual-task study based on the literature review of the 10 studies described in detail, as well as others focused on dual-task training (Agmon, Belza, Nguyen, Logsdon, & Kelly, 2014; Yogeve-Seligmann, Giladi, Brozgol, and Hausdorff, 2012):

Should the intervention be task-specific? Task-specific intervention required from the participants to practice during the intervention the activities that would be tested later at the evaluation stage. Bayona, Bitensky, Salter, and Teasell (2005) and Yogeve-Seligmann et al. (2012) indicated that task-specific intervention yielded the best outcomes and elicited experience-dependent plasticity in the brain. In contrast, the advantage of using an untrained task during assessment was to test if the trained dual-task managing skill could transfer to untrained tasks. It might be beneficial to include both trained and untrained dual-task opportunities during assessment for comparison. Therefore, in the present study, both trained and untrained dual-tasks were included for assessment.

Should priority instruction be given to the participants? The variable-priority approach allowed the participants to shift attention between the physical task and the cognitive task. The fixed-priority asked the patients to pay equal attention to both tasks. Plummer-D'Amato et al. (2012) and Silsupadol et al. (2009) indicated that the variable-priority dual-task approach was more effective than fixed-priority. However, Silsupadol et al. was the only study included in this 10-study in-depth literature examination that actually compared the effects of two different instructions. The remaining studies either did not give instructions on priority or did not address whether instructions were given. Accordingly, more studies are needed to determine if a priority instruction is necessary and whether a variable-priority is more effective. It was not the interest of the present study to determine the effectiveness between a variable-priority approach and a fixed-priority. Participants were instructed to pay both tasks an equal amount of attention.

Should the dual-task progress in difficulty during the training? At least seven studies indicated that the dual-task activities presented to the participants increased in difficulty (Dorfman et al., 2014; Plummer, Villalobos, Vayda, Moser & Johnson, 2014; Peirone, Goria, & Anselmino, 2014; Plummer-D'Amato et al., 2012; Schwenk, Zieschang, Oster, & Hauer, 2010; Yang, Wang, Chen, & Kao, 2007; Yogeve-Seligmann, Giladi, Brozgol, & Hausdorff, 2012). Two studies did not specify but implied increased levels of difficulty since their programs were individualized and potentially tailored to individual progress (Silsupadol et al., 2009; You et al., 2009). Yogeve-Seligmann et al. suggested that increasing the level of difficulty over the training period promoted improvement and motivation. Accordingly, this present study raised the difficulty level of the dual-task activities assigned to the participants over time.

What is the appropriate intensity and duration of the treatment? The intensity and duration in the 10 dual-task studies ranged from 25-minutes, 3 times a week across 4 weeks (Yogeve-Seligmann et al., 2012) to 120-minutes, twice a week, for 12 weeks (Schwenk et al., 2010). The common practice was 30-45 minutes, 3 times a week, for 4-6 weeks, which yielded immediate improvement after training. For the purpose of examining the feasibility of the present study, treatment periods were set twice a week, for 4 weeks, for a total of 8 sessions.

What is the appropriate format of the training, group sessions or individual sessions? According to the American Geriatrics Society's clinical practice guideline for fall prevention in older persons ("AGS/BGS Clinical Practice Guideline," 2015), group exercise programs and individual exercise sessions are equally effective. For dual-task paradigms, there is no indication that group programs were more effective than one-on-one programs and vice versa (Agmon, Belza, Nguyen, Logsdon, & Kelly, 2014). Among the 10 studies, some were performed at group settings, some were performed individually or at home, and the others did not clearly address whether a group or individual format was applied. Since the previous studies did not indicate a significant advantage to group sessions or individual sessions, the present study decided to evaluate the feasibility of a group session format.

What is the content of the physical tasks? Balance exercise and walking are the two main physical tasks. Variations on walking tasks include walking on a treadmill (Dorfman et al., 2014), walking with foot-related steps like dancing (Schwenk, Zieschang, Oster, & Hauer, 2010), and walking under various conditions such as around obstacles, on an uneven surface, and in a crowded environment (Plummer, Villalobos, Vayda, Moser, & Johnson, 2014). Balance exercise usually includes a practice on transferring, such as standing up from a seated position, and standing on a reduced base. In Pedroso et al.'s study (2012), not only walking and balance was included, the participants also practiced coordination, aerobic resistance, flexibility, and agility, such as a weight-lifting exercise and ball bouncing activity.

What is the content of the cognitive tasks? Common cognitive tasks include 1) serial twos/threes subtraction or simple calculation; 2) verbal fluency tasks, such as naming as many objects within a category or as many as words as possible starting from a specific letter; 3) memory tasks such as recalling items or answering questions after listening to a story; and 4) backward counting or spelling words. Yogeve-Seligmann, Giladi, Brozgol, and Hausdorff (2012) suggested that patients would benefit from training in a variety of tasks since task variety enhances learning and encourages the transfer of learning from one experience to another. In addition, some tasks may be easier for some individuals than others and vice versa. A variety of tasks would also help participants transfer the skills learned to daily life where people face a variety of challenges.

How challenging should the dual-task assessment be? Two studies hypothesized that the ceiling performances from the participants might be responsible for non-significant effects of the dual-task training (Plummer-D'Amato et al., 2012; You et al., 2009). In the study of Schwenk, Zieschang, Oster, and Hauer (2010), training effects were only prominent under a more complex dual-task condition. There was no standard dual-task assessment to date. A better approach might be to include dual-task assessments with different levels of difficulty. Taking into account the potential ceiling effects for the present study, because the participants were community-dwelling older adults and taking into account individual differences which may make certain tasks more difficult or easier when comparing an individual to his or her peers, the researcher chose to have a variety of tasks in the hopes of representing different levels of difficulty for participants. Among the tasks were calculation, verbal fluency, reasoning, mental flexibility.

Should the participants walk at their comfortable, preferred speed or as fast as possible during the assessment? Among the 10 cited studies, five sets of researchers asked the participants to walk at their comfortable, normal, or preferred speed (Dorfman et al., 2014; Plummer-D'Amato et al., 2012; Silsupadol et al., 2009; Yang, Wang, Chen, & Kao, 2007; Yogev-

Seligmann, Giladi, Brozqol, & Hausdorff, 2012); two asked the participants to walk as fast as possible (Schwenk et al., 2010; You et al., 2009); one did not specify (Plummer, Villalobos, Vayda, Moser, & Johnson, 2014); and two did not include walking speed in the assessment (Pedroso et al., 2011; Peirone, Goria, & Anselmino, 2014). Researchers have indicated that comfortable and maximum walking speeds are both valid and highly reliable measurements (Bohannon 1997; Kollen, Kwakkel, & Lindeman, 2006). The present study decided to ask the participants to walk at their comfortable speed during the assessment.

Multifactorial Assessment and Management

Systematic reviews of literature indicated that a multifactorial intervention successfully reduces the numbers of falls in community living older adults (Feder, Cryer, Donovan, & Carter, 2000; Gates, Fisher, Cooke, Carter, & Lamb, 2008; Gillespie et al., 2012). A multifactorial intervention usually involves an individual assessment of fall risk by health professionals and a provision of information, referral, and/or direct service for appropriate interventions based upon the assessment. Because of the individual differences with varying risk factors, older adults may receive different combinations of interventions. A multifactorial program having intensive interventions to manage the risk factors may be more effective than assessment alone (Gates et al.; Weatherall, 2004).

Tinetti et al. (1994) examined the effectiveness of a multifactorial intervention in reducing fall risk in community living elderly people 70 years of age and above. The assessment included a variety of risk factors such as postural hypertension, medications, muscle strengths, balance, gait, home hazard, visual acuity and cognition. Corresponding interventions, including medications adjustment, behavioral recommendation, home safety, and exercise training, were provided through home visits for the intervention group. Results indicated that fewer people fell in the intervention group during the one-year experiment period compared to those in the control group. A multifactorial intervention also benefits older adults at high risk of falls. In the study of Close et al. (1999), they recruited older adults admitted to the emergency room with a diagnosis of a fall. Older adults who received interventions based on the assessment reported fewer falls during the one-year follow-up than those who did not.

Music-Based Interventions

Few music-based intervention studies directly addressed the issue of falls in older adults. Based upon the previous literature review, which suggests that improved gait, balance, executive function, and dual-task performance reduce fall risk, a discussion of the effects of music-based intervention on gait, balance, executive function, and dual-task performance in older adults will be presented in the following paragraphs.

Music for Balance and Gait

Music has been used to facilitate exercise focusing on balance and gait. A series of research studies on the effects of a specific movement with music was carried out by Hamburg and Clair (2003) in healthy older adults and further extended to patients with Parkinson's disease by Clair, Lyons, and Hamburg (2012). In these studies, a Laban Movement analyst designed movement sequences that specifically sought to enhance physical flexibility, balance, breathing, and coordination for older adults with various levels of physical function. Participants' balance performance improved after training. According to the authors, the enhancement of music on movement could be explained in at least three different ways. First, music-enhanced exercise has demonstrated the ability to motivate greater adherence to the program than exercise without music (Johnson, Otto, & Clair, 2001). Exercise usually became more pleasurable when music was involved because of music's influences on the limbic system (Wan & Schlaug, 2010). Music listening, especially the preferred music, activates the activity of limbic system including the nucleus accumbens, area that associates with dopamine release, which explains why listening to music is rewarding and pleasurable (Menon & Levitin, 2005). Secondly, the music in this program was specifically designed to support the principles outlined by two Neurologic Music Therapy techniques: Rhythmic Auditory Stimulation (RAS) and Patterned Sensory Enhancement (PSE). RAS uses a steady beat to elicit coupling between intrinsically rhythmic movement, such as gait, and auditory stimulation, which improves gait performance. PSE applies all musical elements including melody, rhythm, and dynamics, to provide spatial cues, timing cues, and force cues for motor planning. Both techniques enhance the efficiency and effectiveness of the exercise. Third, studies that support the positive effect of dancing, a form of movement to music, on gait and balance further reinforce the applicability of music cuing in exercise (Hackney & Earhart, 2009; Hackney & Earhart, 2010).

Just as Clair et al. (2012) observed the benefits of music in motivation and rhythmic facilitation, Shimizu et al. (2012) found that a movement music exercise program incorporating a traditional Japanese musical instrument, the Naruko clapper, improved balance in older adults under 75 years old. The main exercise included strengthening of the leg and abdominal muscles and improving balance and flexibility. The participants shook the clapper on their hands while performing the physical exercises.

Music for Executive Function and Attention Control

Studies that compared the performance of musicians and non-musicians on executive function tests provided insights for the potential of using music as an intervention for cognitive rehabilitation (Moradzadeh, Blumenthal, & Wiseheart, 2014). Bialystok and DePape (2009) revealed that young musicians who studied an instrument or voice at least half of their lives outperformed non-musicians on a modified auditory Stroop Test. The Stroop Test assesses individuals' abilities to solve the conflict between stimuli, inhibit response to irrelevant information, and attend to the target stimuli with congruent and incongruent trials where selective attention is required. Faster reaction times in musicians were found in both congruent and incongruent trials, indicating musicians' enhanced cognitive control in selective attention, inhibition, monitoring, and switching.

Musicians not only demonstrated enhanced auditory selective attention but also showed superior visual attention in detecting targets. In the experiments of Brochard, Dufour, and Despres (2004), young musicians with at least eight years of formal training and non-musicians were asked to detect on which side of a horizontal or a vertical line a target dot was flashed. Reaction times in musicians were significantly shorter under both experimental conditions where a reference line was presented and where the participants needed to keep a mental image since the reference line would be removed before the target was presented. Although it is debatable whether this visual-spatial discrimination test is associated with top-down attention control, this visual-spatial ability seems to give musicians an advantage in processing a top-down attention control task, such as the Trail Making Test.

As speculated in Brochard et al.'s study, Hanna-Pladdy and MacKay (2011) confirmed that high activity musicians performed significantly better on Trail Making Test both parts A and B where musicians showed better selective and shifting attention with faster processing speed in visual-motor searching and sequencing. Those high activity musicians were older healthy individuals who had at least 10 years of formal musical training and engagement in actively playing musical instruments throughout their life. In addition to attention control, they displayed significant cognitive differences in the measures of nonverbal memory, naming, and executive processes compared to those who had never received formal musical training.

Rodrigues, Loureiro, and Caramelli (2013) indicated that musicians' superior performance in selective, divided, and sustained attention could not be supported by enhanced sensorimotor integration. In their study, the sensorimotor performances between musicians and non-musicians were comparable. Instead, studies suggested that music training might augment the executive control brain network for auditory and visual processing (Strait & Kraus, 2011; Strait, Kraus, Parbery-Clark, & Ashley, 2010). The executive control network involves brain regions including the parietal cortex (Schmithorst & Holland, 2003), frontal cortex (Strait & Kraus), and other brain areas such as the anterior cingulate cortex (Pallesen et al., 2010), which underlines the attention process. Musicians demonstrated greater activation in these brain areas when performing attention tasks and this strengthened, extensive recruitment of the attention network may explain why they better direct their attention resources to target stimuli (Haslinger et al., 2005; Luo et al., 2014).

The effects of music making are not only revealed in long-term training but also in short-term engagement (Bugos, Perlstein, McCrae, Brophy & Bedenbaugh, 2007; Seinfeld, Figueroa, Ortiz-Gil, & Sanchez-Vives, 2013). Bugos et al. found that community-dwelling older adults between ages 60 and 85 benefited from short-term music-training programs. After 6 months of individualized piano instruction and practice, participants significantly improved their performance on the Trail Making Test, and Digit Symbol score of the Weschler Adult Intelligence Scale III compared to controls who did not receive the training. Correspondingly, the study by Seinfeld et al. indicated that four months of group piano lessons and daily practice improved executive function, as measured by the Stroop Test and Trail Making Test in older adults age 60 to 84 compared to the controls who participated in other leisure activities such as exercise and computer lessons. These studies support the idea that brain plasticity is possible even in adulthood. The findings also suggest that actively learning and playing an instrument and reading music have the potential to improve executive function in older adults as practicing music is a complex activity that demands attention control and integration of motor, auditory, visual, and somatosensory systems.

In addition to learning and practicing a musical instrument, Thaut and his colleagues developed Musical Executive Function Training (MEFT), a specific technique in Neurologic Music Therapy that uses musical exercise to train executive function (Thaut, 2005). Executive function includes a variety of cognitive processes that relate to goal-directed behaviors such as planning, reasoning, decision-making, and problem solving. When individuals compose, improvise, and perform music, the creative process demands executive function. Accordingly, MEFT allows individuals to practice executive function skills within the engagement in musical experiences (Thaut, 2005).Thaut et al. (2009) examined the immediate effects of a 30-minute MEFT treatment on patients suffering from traumatic brain injury and found that MEFT improved Trail Making Test B performance.

Musical Attentional Control Training (MACT) is another Neurologic Music Therapy technique. This technique uses musical exercise to train focused attention, sustained, and divided attention (Thaut, 2005). Individuals practice attention control by following a changing musical cue or responding to alternating musical cues modulated by musical elements such as tempo, loudness, rhythmic patterns, and pitch. Clair, Chen, and Nakamura (2011) applied MACT to a small group of patients with dementia in a group living care environment. They found that the patients were more alert and aware of their surroundings by increasing verbal expression with relative information, social interaction, and engagement in the rhythmic music making.

Music for Dual-task Paradigms

Music-based multitask physical exercise program. To date, only one line of research has examined the effects of multitask physical exercise programs which involved the musical component on gait, balance, and fall risks in community-living elderly who were at increased risk of falling (Hars, Herrmann, Gold, Rizzoli, & Trombetti, 2014; Trombetti et al., 2011). The music-based multitask physical exercise intervention in the study of Trombetti et al. was a Jaques-Dalcroze eurhythmics program. Jaques-Dalcroze Eurhythmics is an approach that teaches young students to understand music through body movement to music. In the study, the elderly participants were instructed to move to the rhythm of improvised piano music. A variety of exercise movements was introduced. They walked to music in time and responded to changes, and they might have played instruments or manipulated balls at the same time. Results showed that participating in a 60-minute music-based multitask exercise class once a week over a 6-month period could improve gait, balance, and reduce incidences of falls. The researchers suggested that this program changed the physical patterns of the elderly participants while music motivated participation and increased adherence to the program. They further speculated that improved attention and executive function might contribute to improved gait performance.

Musical Dual-task Training. Chen (2014) developed a Musical Dual-task Training (MDTT) technique for patients with mild to moderate dementia. The concept of MDTT was to train dual-task performance in a musical context. The MDTT protocol required participants to sing or play simple percussive instruments while walking; at the same time they also paid attention and changed their ways of singing or playing according to visual or auditory cues provided by the music therapist. Chen conducted a randomized, pretest/posttest with control group study on 25 older adults age 55 and above and found that those who received MDTT improved executive function measured by Trail Making Test after eight weekly individual 60-minute sessions.

Purpose of This Study

The summary of the proceeding review of the literature established that a) reduced executive function as evidenced by poor dual-task performance is an important fall risk factor; b) dual-task performance can be improved after training; and c) music based dual-task intervention has the potential to improve dual-task performance because music making strengthens the attention network and is motivating. Thus, the purpose of this study was two-fold and was designed to 1) determine the feasibility of a G-MDTT protocol for community dwelling older adults who have concerns about falls, 2) obtain preliminary data of intervention effects on immediate outcomes related to fall risks. Inherent within each of these two purposes were research questions. The research questions regarding feasibility included 1) What were the participants' perceived levels of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment for each session (demand)? 2) Did any falls occur during the study period for participants (safety)? 3) What was the attendance for the participants (implementation)? 4) To what extent did the participants perceive the protocol beneficial and satisfactory (acceptability)? 5) To what extent were the participants /willing to continue the program if the program continues (acceptability)? 6) To what extent would the participants recommend the program to others (acceptability)? The research question regarding testing the limited-efficacy of the G-MDTT was: Did participants exhibit reduced fall risks as evidenced by improved executive function, reduced dual-task cost on gait speed, improved balance, and less concerns about falls?

Chapter 3: Method

Participants, Recruitment, and Informed Consent

Participants were recruited in a college town within the Southwest region of the United States. Recruitment flyers were posted at a physical therapy clinic in the city hospital, local churches, a senior center, and were included in emails sent to the researcher's colleagues and friends. Interested participants were invited to contact the researcher by phone or email to ask questions or schedule a meeting for a detailed description of the study (See Appendix A for a sample recruitment flyer).

This study set a target to recruit one group of 6 individuals. Participants were included if they were: 1) age 55 or older, 2) able to walk 10 meters independently without the use of a walker, cane, or assistance of another person, and 3) could answer, "yes," to the question: Do you have concerns about falling? Participants were excluded if they had musculoskeletal or neurological disorders such as acute stroke or Parkinson's disease, visual impairment that hinders ambulation, or hearing loss that would have prevented them from hearing the musical cues.

The Human Subjects Committee at a large Midwestern university and a small regional Southwestern university approved this study. All participants were asked to sign an informed consent form prior to participating in the study (see Appendix B for a sample informed consent).

Research Design, Procedure, and Setting

This study was a feasibility study with a single group, survey, and pre and posttest design. This study employed a feasibility design because there are few previously published studies using the music-based dual-task intervention to address the issue of fall risks. In addition, although MDTT had positive outcomes in patients with dementia, the applicability of a group MDTT for individuals with concerns about falls is not yet known. A feasibility study is a small-scale study designed by a researcher to help determine the requirements, practicality and likelihood of success before performing a full-scale or larger-scale study. A feasibility study can potentially help the researcher to refine methods or protocols (Bowen et al., 2009). In this present study, the use of the survey helped the researcher to understand how accessible G-MDTT to the target population and their reactions. Pre and posttest helped the researcher to evaluate the limited efficacy G-MDTT might yield in this small-scale experiment.

One week before the study commenced, each participant attended an individual Pretest session administered by the researcher for approximately 60 minutes, where executive function, dual-task performance, balance, and concerns about falls were assessed using a standardized protocol, as detailed in the following Outcome Measurements section. During the Pretest, participants were also asked to provide demographic information concerning their age, gender, history of falls, years of education, musical background, and music familiarity and preferences on a questionnaire (See Appendix C for a sample questionnaire for demographic information and song preferences). Participants indicated their music preference by noting familiar songs and liked songs from a provided song list (See Appendix C; the song list was included in the questionnaire). This list of 20 songs was selected based upon a survey study on the music preferences of geriatric clients (Sikora, 2013) and the researcher's clinical experience working with the senior residents at an assisted living facility in the Southwest region of the United States. A write-in option allowed them to name preferred songs not included on the list. Detailed information of the songs actually used in the sessions was presented in the following Music in G-MDTT section.

Beginning the following week, one group of six participants attended a 40-minute group session, two times a week, for four weeks. A total of eight sessions were conducted by the researcher, a board certified music therapist. In the week after the last treatment session, each participant attended an individual Posttest session administered by the researcher for approximately 60 minutes where the same assessments of executive function, dual-task performance, balance, and concerns about falls were conducted to compare with the Pretest session data. As part of the individual Posttest session, the participants filled out a questionnaire that surveyed their opinions toward the treatment intervention (See Appendix E for a sample questionnaire for program feedback). The content of the questionnaire is detailed in the following Outcome Measurements section.

The Pretest, Posttest, and training sessions took place in a well-lit multi-function space with moveable chairs and two pianos at a university. This space is 50 X 35 square feet with adequate room for six individuals to walk and turn without bumping into each other.

Intervention

G-MDTT Protocol Description

The protocol of G-MDTT consists of the simultaneous performance of a motor task and a cognitive task. Both components progressively grow in difficulty over time. This protocol is adapted from the individual MDTT program, which was originally designed to improve the executive function and dual-task performance in patients with mild to moderate dementia (Chen, 2014). Deficits in executive function and dual-task performance both increase the likelihood of falls. MDTT has been shown to improve both executive function and dual-task performance, thereby legitimizing the application of MDTT for fall prevention. Counter to MDTT, G-MDTT is conducted in groups of 4 to 6 participants. Since G-MDTT participants did not suffer from musculoskeletal or neurological disorders or visual or hearing impairments, the participants did not need one-on-one attention or supervision as would be necessary for patients with dementia.

The motor task that targets gait training involves the exercises of toe tapping, heel lifting, and walking. The exercises of toe tapping and heel lifting are realized by performing on the bass drum, high-hat cymbal, and foot tambourine. Bass drum and high-hat cymbal are pedal-operated instruments. The two basic techniques required to play these two instruments are: heel down and heel up. The heel down technique requires the entire foot be in contact with the footboard of the pedal and the use of the calf muscles and ankle joint to trigger the stroking, like toe taps. The heel up technique requires the heel be lifted up and for only the toes be in contact with the footboard, combining ankle movement with the weight of the leg to activate the pedal, like heel lifts. The foot tambourine is a small tambourine mounted on the foot near the toe with an elastic band. Playing the foot tambourine requires the motion of toe taps to make the jingle. Toe tapping and heel lifting can help strengthen the supporting muscles that allow for ankle movement through a calf raise, which contributes to fall prevention because ankle weakness is related to impaired balance (Horlings, van Engelen, Allum, Bloem, 2008; Orr, 2010; Spink et al., 2011).

In order to simulate everyday situations where individuals respond to obstacles (visual stimuli) and engage in conversation (auditory stimuli) while walking, the cognitive task requires participants to sing or play simple percussive instruments while paying attention and responding to the visual or auditory cues given by the music therapist, such as lyrics written in different colors or sections of music with contrasting styles. The simple percussive instruments include tambourines, paddle drums, maracas, and woodblocks. These instruments are easy to play without additional physical challenge. At the same time, this category of instruments covers a variety of timbres to add uniqueness and interest to the musical ensemble. The participants take turns in playing each kind of the instrument during the sessions. Participants have the opportunity to play all the instruments.

The motor task includes four practices:

1. Seated toe tapping and heel lifting with a steady beat (less complex) (Figure 1): Participants take turns playing the bass drum, high-hat cymbal, and foot tambourine, circulating through the different positions as they play together as an ensemble.

Figure 1. Notation of a steady beat.

2. Seated toe tapping and heel lifting with specific rhythmic patterns (more complex) (Figure 2): Participants play a simple, four-beat long rhythm, or a combination of two four-beat long rhythm on the bass drum, high-hat cymbal, and foot tambourine. The bass drum, high-hat drum, and foot tambourine each play unique and independent rhythms. The participants play simultaneously and continuously as an ensemble.

Figure 2. Examples of the more complex rhythmic patterns.

3. Walking forward with a steady beat (less complex) (Figure 1): The participants walk forward with necessary turns, stepping in time with a given beat while negotiating drums

placed around the room as obstacles. The participants also avoid contact with moving individuals as they walk at the same time.

4. Walking forward and backward with specific rhythmic patterns (more complex) (Figure 2): The participants walk continuously with a specific pattern, such as forward for three steps then backward for three steps, stepping in time with a beat.

The cognitive task included four practices:

1. Singing (less complex): The participants sing familiar songs.
2. Singing in response to visual cues (more complex): The participants are provided a lyrics sheet with lines of lyrics written in two to three colors, such as black, red, and green. Each participant is assigned a color and instructed to only sing lines of the respective color and to not sing when shown lines in another color. Colors are randomly assigned to the lyrics lines to keep the participants engaged and encourage active thinking.
3. Instrument playing with a steady beat (less complex) (Figure 1): The participants play a steady beat on simple percussive instruments such as tambourine, maracas, woodblocks, and pedal drum. Participants take turns playing the tambourine, maracas, woodblocks, and pedal drum, circulating through the different positions as they play together as an ensemble.
4. Instrument playing in response to auditory cues (more complex): The therapist plays music in a binary form which includes two distinct sections or music in a rondo form which includes up to two episodes in addition to the reoccurring theme, making three distinct sections. The participants are instructed to only play their instruments continuously when they hear one particular musical section. They need to stop playing when they hear the other musical sections presented.

Implementation of G-MDTT Protocol

In each of the 40-minute training sessions, participants completed eight blocks of 5 minutes of dual-task practices. A specific combination of a motor task and a cognitive task was practiced in each block. The motor task alternated between a seated practice and a walking practice to avoid fatigue. The participants were challenged by increased complexity of the dual-task every week. Participants were instructed to pay equal attention to both tasks. The researcher, a board certified music therapist who has had five years of clinical experience working with older adults, facilitated the sessions.

During Week 1, participants practiced combinations of a less complex cognitive task and a less complex motor task as well as combinations of a less complex cognitive task and a more complex motor task. The order of the eight blocks of dual-task practice were as follows:

1. Seated toe tapping and heel lifting with a steady beat while singing familiar songs
2. Seated toe tapping and heel lifting with specific rhythmic patterns while singing familiar songs
3. Walking forward with a steady beat while singing familiar songs
4. Walking forward and backward with specific rhythmic patterns while singing familiar songs
5. Seated toe tapping and heel lifting with a steady beat while playing a simple percussive instrument with a steady beat
6. Seated toe tapping and heel lifting with specific rhythmic patterns while playing a simple percussive instrument with a steady beat
7. Walking forward with a steady beat while playing a simple percussive instrument with a steady beat

8. Walking forward and backward with specific rhythmic patterns while playing a simple percussive instrument with a steady beat

During Week 2, participants practiced combinations of a less complex motor task and a less complex cognitive task as well as combinations of a less complex motor task and a more complex cognitive task. The order of the eight blocks of dual-task practice were as follows:

1. Seated toe tapping and heel lifting with a steady beat while singing familiar songs
2. Seated toe tapping and heel lifting with a steady beat while singing in response to visual cues (sing contingently based on the color of the lyrics lines)
3. Walking forward with a steady beat while singing familiar songs
4. Walking forward with a steady beat while singing in response to visual cues
5. Seated toe tapping and heel lifting with a steady beat while playing a simple percussive instrument with a steady beat
6. Seated toe tapping and heel lifting with a steady beat while playing a simple percussive instrument in response to auditory cues (playing contingently based on the different musical sections)
7. Walking forward with a steady beat while playing a simple percussive instrument with a steady beat
8. Walking forward with a steady beat while playing a simple percussive instrument in response to auditory cues

During Week 3, participants practiced combinations of a more complex motor task and a less complex cognitive task as well as combinations of a more complex motor task and a more complex cognitive task. The order of the eight blocks of dual-task practice was as follows:

1. Seated toe tapping and heel lifting with specific rhythmic patterns while singing familiar songs
2. Seated toe tapping and heel lifting with specific rhythmic patterns while singing in response to visual cues
3. Walking forward and backward with specific rhythmic patterns while singing familiar songs
4. Walking forward and backward with specific rhythmic patterns while singing in response to visual cues
5. Seated toe tapping and heel lifting with specific rhythmic patterns while playing a simple percussive instrument with a steady beat
6. Seated toe tapping and heel lifting with specific rhythmic patterns while playing a simple percussive instrument in response to auditory cues
7. Walking forward and backward with specific rhythmic patterns while playing a simple percussive instrument with a steady beat
8. Walking forward and backward with specific rhythmic patterns while playing a simple percussive instrument in response to auditory cues

During Week 4, participants practiced combinations of a more complex cognitive task and a less complex motor task as well as combinations of a more complex cognitive task and a more complex motor task. The order of the eight blocks of dual-task practice were as follows:

1. Seated toe tapping and heel lifting with a steady beat while singing in response to visual cues
2. Seated toe tapping and heel lifting with specific rhythmic patterns while singing in response to visual cues

3. Walking forward with a steady beat while singing in response to visual cues
4. Walking forward and backward with specific rhythmic patterns while singing in response to visual cues
5. Seated toe tapping and heel lifting with a steady beat while playing a simple percussive instrument in response to auditory cues
6. Seated toe tapping and heel lifting with specific rhythmic patterns while playing a simple percussive instrument in response to auditory cues
7. Walking forward with a steady beat while playing a simple percussive instrument in response to auditory cues
8. Walking forward and backward with specific rhythmic patterns while playing a simple percussive instrument in response to auditory cues

Within every session, between block two and block three and between block six and block seven, there were transitions of sit-to-stand. The following instruction was given to help the participants to stand up (Smith, 2005):

1. Grasp the armrests near the front
2. Place your feet on the floor approximately the same length apart as your hips
3. Lean forward
4. Slide or shuffle to the edge of your seat
5. Adjust one foot so that it is slightly closer to the chair than the other
6. Begin shifting your weight onto your feet with nose over toes
7. Look straight ahead
8. Straighten your legs while pushing up on the armrests until upright

Within ever session, between block four and block five, there were transitions of stand-to-sit. The following instruction was given to help the participants to sit down (Smith, 2005):

1. Stand and make sure you feel your backs of your legs touching the font of the chair
2. Balance your weight evenly on both feet
3. Begin bending your knees to lower yourself onto the seat while reaching back for

the armrests until you feel the seat supporting you

Music in G-MDTT

After reviewing the participants' responses to the song list at the Pretest, the researcher determined the 16 songs that were most frequently selected by the participants and used these in the sessions. Sixteen songs were included because two songs were practiced in one session and there were 8 sessions in total. Within a session, one song was sung while the participants were seated and the other song was sung while the participants were walking. Participants were introduced to different songs each session in order to minimize the practice effects and boredom which could be caused by singing the same songs throughout the intervention period. The researcher prioritized the songs which were both familiar and liked. Higher priority was given to familiar songs than liked songs, because the focus was on participants responding to cues and learning an unfamiliar song, even if it is well-liked, may complicate the performance. A song was determined to be familiar to the participants if they acknowledged on the song preference questionnaire at Pretest that "I know the song. I can sing along at least the first verse and chorus if lyrics are provided." The 16 songs, which were chosen, were in duple meter such as 2/4 or 4/4 with moderate to fast tempo, 108 to 112 beats per minute, which is appropriate for gait movement. Older adults are capable of walking at a cadence more than 100 steps per minute (Tudor-Locke, Barreira, Brouillette, Foil, & Keller, 2013) and a cadence more than 100 is recommended for moderate-intensity physical activity for the older adults (Marshall et al., 2009). There were no songs in triple meter on the proposed list presented to the participants at Pretest. The participants might write in to suggest their preferred songs which could be in a triple meter. However, the researcher would advise against using these songs because a triple meter was not suitable for an intrinsically symmetric gait movement such as walking. During the session, the board certified music therapist sang the songs with the participants a cappella or accompanied by the piano. The therapist may have sung a cappella if she needed to model or conduct the participants. Two songs were sung in one session. Two different songs were sung the following session and this practice continued across the eight sessions The list of songs was played in alphabetical order of the song titles as a default with the possibility of changing order for any or no reason, as song order was considered irrelevant to the study (See Table 1 for the tiles of the songs tentatively listed in the anticipated session order). Songs actually used in the sessions are presented in the results chapter.

Table 1

Songs Used for Singing in the Sessions

Session	Songs for Singing
1	America the Beautiful, Don't Fence Me In
2	Don't Sit Under the Apple Tree, Five Foot Two, Eyes of Blue
3	Hey, Good Lookin', How much is That Doggie in the Window
4	I'll Fly Away, I've Been Working on the Railroad
5	Love Me Tender, Oh Susanna
6	Oklahoma, Ring of Fire
7	Side By Side, Sugar Time
8	Take Me Home Country Road, This Land is Your Land

Well-known classical music selections were arranged by the researcher to use for the instrument-playing task. The music may originally be an orchestra piece and the researcher improvised a piano reduction version to play on the piano. Repertoires in binary form, or with distinct sections, were selected since these types of organization offered participants the opportunity to respond to changes. During the sessions, the board certified music therapist played the music on the piano. These arrangements were performed with moderate to fast tempo, 108 to 112 beats per minute, appropriate for gait movement. Eight arrangements were used over the course of eight weeks. One arrangement was played for each week. The list of songs was assigned to the sessions in alphabetical order of the composers' last names as a default with the possibility of changing order for any or no reason, as tune order was considered irrelevant to the study (See Table 2 for the tiles of the repertoires by session order).

Table 2

Repertoire Used for Instrument Playing in the Sessions

Session	Tune for Instrument Playing
1	Bizet, L'Arlesiennne Suite no. 2 Farandole
2	Bizet, March of the Toreadors
3	Brahms, Hungarian dance no. 5
4	Mozart, Piano Sonata Turkish March
5	Offenbach, Overture Orpheus in the Underworld
6	Schubert, Marche Militaire op. 51 no.1
7	Sousa, The Stars and Stripes Forever
8	Sr. Johan Strauss, Radetzky Marsch, Op.228

Outcome Measurements

Feasibility

The feasibility of the G-MDTT program was assessed 1) after each session for reflection and safety of the intervention, 2) throughout the study period for attendance adherence to the 8-week training program, and 3) at the Posttest for program feedback. Immediately after each session, each participant rated his or her perception of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment on four different 10 cm visual analogue scales (Miller & Ferris, 1993; Plummer, Villalobos, Vayda, Moser, & Johnson, 2014). Testing four separate categories, the left end of each 10-cm horizontal line represented no fatigue/difficulty/anxiety/enjoyment respectively and the right end of each line represented the maximum possible fatigue/difficulty/anxiety/enjoyment respectively. Participants marked their levels of fatigue/difficulty/anxiety/enjoyment on the corresponding position of the lines. Individual scores were determined by measuring the distance (millimeter) between the participants' mark and the left end of the line using a ruler. Time to complete these four scales was no more than 2 minutes (See Appendix D for a sample visual analogue scale for feasibility). Participants also reported if they had any falls between the previous and the present session on the same sheet where they indicated their levels of fatigue/difficulty/anxiety/enjoyment. Throughout the study, the researcher recorded the attendance and reason for absence of each participant.

Additionally, during the Posttest, each participant filled out a paper-based survey. Participants were asked to take the survey once and the survey took 5 to 10 minutes to complete. The survey asked the participants to rate their perceived benefits from the treatment, level of satisfaction, their motivation for continuous participation, and their willingness to recommend the program to others on a 5-point symmetric agree-disagree scale (De Bruin et al., 2010). Participants rated their level of agreement on survey question statements such as “The program is beneficial,” and “I will continue attending the program if the program continues.” Response options ranged from 1, “strongly disagree,” to 5, “strongly agree.” The survey also asked the participants to list any benefits and/or unfavorable effects (if any) experienced in the program (See Appendix E for a sample questionnaire for program feedback).

Effectiveness

Executive function. The Trail Making Test was used to evaluate executive function (TMT; Army Individual Test Battery, 1944). The TMT test is comprised of two parts. In part A of the test, participants were instructed to connect a series of 25 encircled numbers in numerical order by drawing lines with a pencil as fast as possible. Part A of the TMT test measures the participants’ ability to search visually and their motor speed skills. The more complicated part B section of the test asks participants to connect 25 encircled numbers and letters in numerical and alphabetical order, alternating between the numbers and letters to produce an order of “1,” “A,” “2,” “B,” “3,” “C,” etc. Part B of the TMT test measures executive function and mental flexibility, in addition to process speed. In both sections of the test, numbers and letters are scattered across the page with order introduced only to prevent overlapping lines, which might cause confusion irrelevant to the test. The test's primary variable of interest is to determine the time a participant needed to complete parts A and B (Bowie & Harvey, 2006). Longer completion time indicates greater impairment of executive function. Results for TMT test were reported as the number of seconds required to complete part A and part B at the Pretest and Posttest. A ratio score, determined by dividing the time to complete part B with time to complete part A, may show greater sensitivity in measuring executive function by controlling the part A performance (Arbuthnott & Frank, 2000). This present study also reported the part B/part A ratio score at the Pretest and the Posttest in the Results section. TMT requires 5 to 10 minutes to administer (Bowie & Harvey, 2006).

Dual-task performance. Participants' dual-task performance was determined by dual-task cost on the walking speed task (Schwenk, Zieschang, Oster, & Hauer, 2010) because the goal of G-MDTT was to reduce the impact of a concurrent cognitive task on walking. Dual-task cost refers to the ratio of change of performance from a single-task to a dual-task condition. Dual-task cost on walking speed is calculated as follows: (Walking speed single task − walking speed dual-task) ⁄ walking speed single task × 100. Lower percentage represents less dual-task interference (Abernethy, 1988; Plummer-D'Amato et al., 2012).

In order to determine the dual-task cost, participants were asked to perform under one single-task walking condition and four dual-task walking conditions. During these five walking conditions, participants' walking speeds were assessed through a 10-meter walk test where participants were instructed to walk 10 meters at their preferred walking speed. These five walking conditions were:

1. Single-task walking (walking while not doing any other task)
2. "Verbal fluency": Walking while performing a verbal fluency task in which the participants came up with as many words as possible within a category such as animal, fruit, vegetable, and sports (Plummer, Villalobos, Vayda, Moser, & Johnson, 2014; Plummer-D'Amato et al., 2012; Yogev-Seligmann, Giladi, Brozgol, & Hausdorff, 2012)
3. "Subtraction 3": Walking while performing serial 3 subtractions starting from a random 3-digit number. For example, if the participant is given a number of 365, then he/she will say 362, 359, 356, 353, and continue reducing the number by three (Yogev-Seligmann et al., 2012)
4. "Auditory Stroop": Walking while performing an auditory Stroop test. Participants were asked to respond to a recording of the words "high" and "low" spoken in either a high or a low pitch. Every word stimulus was presented one and half second apart. Participants must accurately report the pitch of the word in a timely manner while ignoring the meaning of the spoken word (Plummer et al., 2014; Silsupadol et al., 2009).
5. "Spontaneous response": Walking while answering open-ended questions such as "Give three reasons explaining why you prefer dogs, cats, both, or neither," "Name three qualities you look for when purchasing a new pair of shoes," "List three advantages or disadvantages of living in a small town compared to a big city (Yogev-Seligmann et al., 2012)"

The dual-task conditions in this present study were selected from tasks frequently/commonly used in previous dual-task studies and intended to cover a variety of cognitive functions (Plummer et al., 2014; Plummer-D'Amato et al., 2012; Silsupadol et al., 2009; Yogev-Seligmann et al., 2012). The verbal fluency task involves sematic memory; the serial 3 subtraction focuses on working memory; Auditory Stroop task demonstrates executive function; the spontaneous response task requires participants to think about the question by drawing on life experience and reasoning skills as they would have to do in real world conversations (Patel, Lamar, & Bhatt, 2014; Yogev-Seligmann et al., 2012)

Each participant performed three trials for each of the five conditions. The average of the three trials was used for analysis. The assessment always started with the single-task. The sequence of the four dual-task conditions was fixed for every participant. In addition, the sequence an individual participant was tested on during the Pretest was repeated for the Posttest. During each trial, participants were asked to walk 10 meters. The participants started walking immediately after the researcher presented the additional cognitive task and said, "Go." As the researcher delivered the instruction, she also used a stopwatch to time participants and recorded results on a data-collecting sheet. A trained research assistant, who was a graduate student with a bachelor degree in music therapy, helped video the process, so the participants' performance in the cognitive tasks could be analyzed. The walking speed (m/s) was calculated as 10 meters divided by the time (second) it took the individual to walk that distance. It typically took 5 minutes to complete all three trials in each walking condition; thus participants were asked to expect the study would require 25 minutes to finish the five-walking-conditions assessment. The assessment was videotaped to assist in data analysis. When the results were reported, both the absolute speeds and the dual-task costs at the Pretest and Posttest were presented.

Balance. The Timed Up-and-Go test (TUG) was used to determine relative level of balance (Podsiadlo & Richardson, 1991; Shumway-Cook, Brauer, Woollacot, 2000). Beginning from a seated position in a standard armchair, participants were asked to stand up and walk three meters away from the chair before walking back and returning to their initial seated position. Participants were asked to complete the TUG test as quickly as possible. Longer than average completion times were considered an indication of impaired balance, with the longer times indicating greater impairment. The TUG test has proven to be highly reliable with excellent discriminant validity. There is a strong correlation between longer completion scores and each of the following: balance impairments, past falls, disabilities in activities of daily living, and the need for walking aids (Beauchet et al., 2011; Lin et al., 2004).

During the testing, the researcher began to time the participant using a stopwatch when she said, “Go” and stopped timing when the participant’s returned to seated position, beginning when the participant’s back touched the chair. Each participant performed a practice run of the test before the official testing, which was not timed. Time was recorded in units of one one-hundredth of a second. Administration of the TUG required less than 5 minutes per participant (Podsiadlo & Richardson, 1991).

Concerns about falls. Concerns about falls were measured by the Falls Efficacy Scale International (FES-I). FES-I assesses fear of falling by asking the participants to indicate how concerned they are that they might fall while performing everyday activities (Tinetti, Richman, & Powell, 1990; Yardley et al, 2005).

FES-I is an expanded version of the Falls Efficacy Scale (FES) (Tinetti et al., 1990). Expanding upon the original FES, which has 10 activities, FES-I was developed to include social and physical activities considered more challenging and considered to potentially increase concerns about falls in individuals with higher physical function (Yardley et al., 2005). Items in FES-I include 16 activities such as getting dressed or undressed, taking a bath or shower, going up or down stairs, reaching for something, and going out to a social event. Participants indicated their level of concern about falls in doing each listed activity on a 4-point Likert scale with 1 being not at all concerned and 4 being very concerned. A FES-I score is calculated as the sum of the 16 item scores. The FES-I had excellent internal validity (Cronbach's alpha = 0.96) and test-retest reliability (Intraclass Correlation = 0.96) (Yardley et al., 2005).

The researcher administered the FES-I during a face-to-face interview, in which the participants filled out the survey by themselves with the researcher available to answer questions. FES with 10 items takes 10 to 15 minutes to administer (Hussey, 2013). FES-I, which has 16 items, was expected to be completed in 15 to 20 minutes based on the time required for FES and the relative number of items in the tests.

Data Analysis

Feasibility

Demand. Each participant had 8 data points (8 sessions) on the visual analogue scales for each of the factors that determined the demand for the protocol including fatigue (physical and mental), difficulty, anxiety, and enjoyment (RQ1). The researcher first plotted the data into line charts and visually analyzed the data. The researcher then computed the mean scores for each factor for each participant in order to compare the data among participants. Additionally, mean scores were computed for each factor using data collected from all participants.

Safety. The researcher reviewed the participants' reports on falls throughout the study and calculated the numbers of falls that occurred for each participant (RQ2).

Implementation/Attendance. Each participant's attendance was converted to a percentage by dividing the number of sessions the participant attended by the total number of sessions (N =8) and then multiplying that number by 100. The average attendance was computed as the mean of all participants' percentage of sessions attended (RQ3).

Acceptability/Program feedback. The researcher reviewed the ratings on the Posttest questionnaires. Average ratings across participants were computed for each item including perceived benefits from the treatment, level of satisfaction, their motivation for continuous participation, and their willingness to recommend the program to others (RQ5, RQ6).

Effectiveness

The researcher first compared the differences between Pretest and Posttest data for executive function, dual-task performance, balance, and concerns about falls for each participant. The researcher then conducted a series of paired sample t-tests for each of the outcome measures. De Winter (2013) stated that a paired t-test is feasible for a small sample size especially when the within-pair correlation is high. The researcher would first examine the correlation between the pretest data and posttest data to determine if a t-test would be appropriate. However, results needed to be interpreted with caution as statistics with small sample sizes increase the risk of false positives, and because behavioral research usually does not yield large effect size, hence there is lack of power to detect a meaningful difference. The researcher did not suggest causation between the treatment and outcomes through the statistics testing but intended to examine the trends in outcome measurements.

Chapter 4: Results

Results were presented in this chapter to address the research questions regarding the feasibility and the limited-efficacy of the G-MDTT. The research questions regarding feasibility included 1) What were the participants' perceived levels of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment for each session (demand)? 2) Did any falls occur during the study period for participants (safety)? 3) What was the attendance for the participants (implementation)? 4) To what extent did the participants perceive the protocol beneficial and satisfactory (acceptability)? 5) To what extent were the participants willing to continue the program if the program were to continue (acceptability)? 6) To what extent would the participants recommend the program to others (acceptability)? The research question regarding testing the limited-efficacy of the G-MDTT was: Did participants exhibit reduced fall risks as evidenced by improved executive function, reduced dual-task cost on gait speed, improved balance, and less concerns about falls?

In this chapter, the researcher describes the recruitment process and how participants' demographic information and song preferences were gathered at the Pretest. Following this, the researcher presents the results of the self-rated visual analogue scales the participants filled out during each session and data reporting the number of falls and attendance, and results of a program feedback questionnaire that participants filled out at the Posttest to determine intervention feasibility. The researcher also presents clinical observations of each participant's performance in the dual-task activates during the sessions to better evaluate the feasibility and use in tandem with participants' self-ratings. Next, the data from the Trail Making Test (TMT), dual-task performance, Timed Up-and-Go (TUG), and Falls Efficacy Scale International (FES-I) at Pretest and Posttest are presented to determine protocol efficacy. Another purpose of the feasibility study was to test if a protocol/program could be successfully executed to the intended participants and whether it needed to be refined. As a result, the researcher includes an evaluation of the execution of G-MDTT protocol, presenting what worked, what did not work, and what was adapted in the study. After recommendations for changes were made, the protocol was revised and the researcher presents the revised protocol as a G-MDTT manual. The G-MDTT manual is included as Appendix F.

Recruitment Process

The participant flow chart is presented in Figure 3. Six participants were originally contacted and all six signed consents. Four of these participants attended the Pretest while two participants withdrew due to schedule conflicts. Two more participants were then contacted and both participants signed the consent and attended the Pretest. All six participants attended the Posttest.

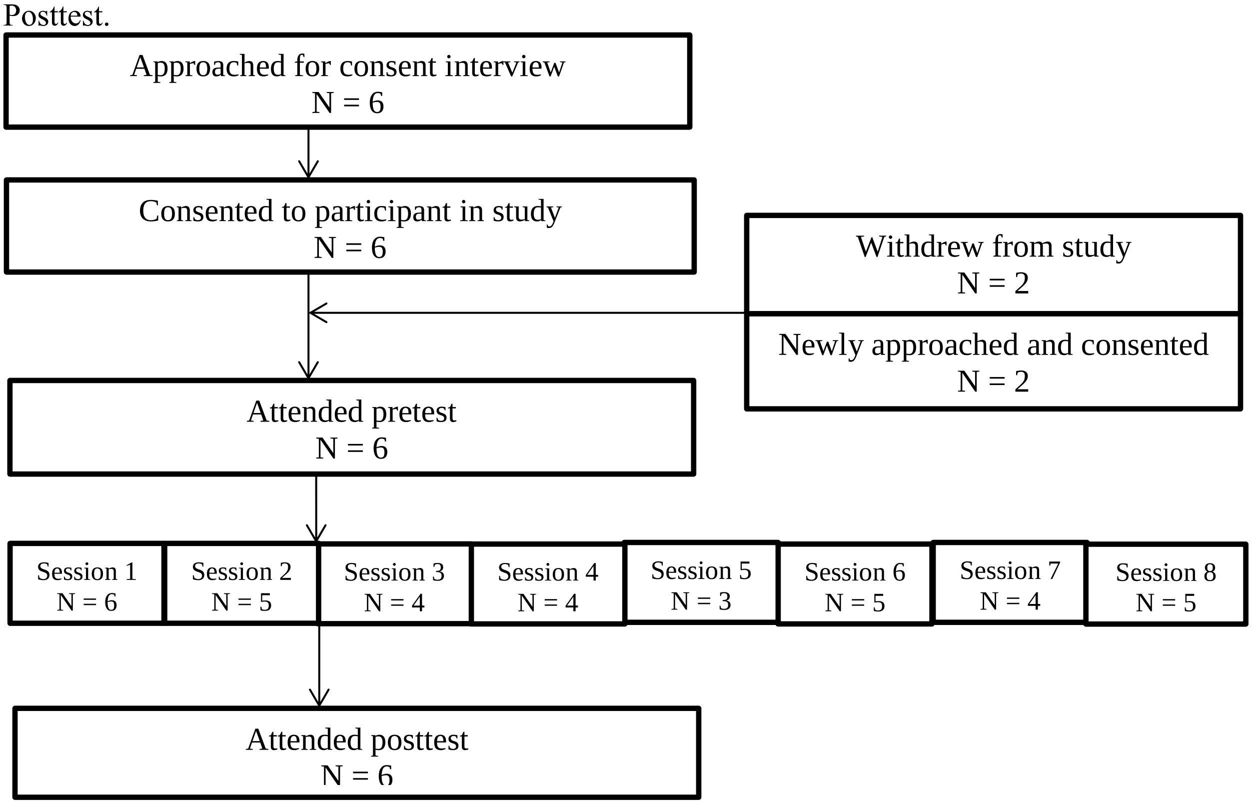

Figure 3. Flow chart of participants through study.

Demographic Information

Participants' demographic information is presented in Table 3. Among the six participants were four females and two males. Participant CR and participant DR were wife and husband. Participant DD and participant MD were wife and husband. The average age of the participants was 79. Four of them had at least one fall during the 12 months prior to the start of the study. They were all well-educated, having at least two years of schooling after high school. Four of them had regular involvement in music during their adult lives. Participant R used to be a piano instructor, owned a music store and sang in a church choir. Participant DD had a bachelor's degree in public school music and continued to sing in a church choir. The couple CR and DR used to sing in a church choir until DR had difficulties reading the music due to vision loss as a result of diabetes. The two participants, C and MD, who were not actively involved in music making during their adult lives were both avid music listeners.

Table 3

Participants' Demographic Information

Participant	Gender	Age	Fall/No fall during the last 12 months	Education (year)	Musical background
C	F	79	Y	16	Listening to music
R	F	74	Y	20	Playing instruments Singing Attending concerts Listening to music
CR	F	75	Y	14	Playing instruments Singing Attending concerts Listening to music
DR	M	77	Y	16	Singing Attending concerts Listening to music
DD	F	82	N	18	Playing instruments Singing Attending concerts Listening to music
MD	M	87	N	14	Listening to music
Mean		79		16.3	

Note. Years of education counted every year of schooling starting from the first grade onward.

Song Preference and Song Selections

Table 4 shows the rankings of the groups of songs based on the familiarity and preference the participants indicated at the Pretest. The first ranked group has four songs, which are known to all the participants and liked by all the participants; the second ranked group has another four songs, which are known to all the participants and liked by all the participants except for participant MD. The researcher originally intended to select 16 songs to be used in the sessions; however, only eight songs were familiar to all six participants. As a result, the researcher used only the eight songs from the first and second ranked groups. The impact of participant MD's dislike of the second ranked group was eventually irrelevant as he stopped participating after the first session. During session five, it turned out that the participants were only familiar with the chorus of "Take Me Home Country Road" but not the verses, although they thought they knew the song when they filled out the survey. The researcher substituted "Take Me Home Country Road" with "I've Been Working on the Railroad" for its strong rhythm, variety of lyrics and sections.

Table 4

Rankings of the Songs based on Participants' Familiarity and Preference

Ranking	Song title	Number of participants who knew the song	Number of participants who did not like the song
1	America the Beautiful	6	0
	He's Got the Whole World in His Hands	6	0
	Hey, Good Lookin'	6	0
	I'll Fly Away	6	0
2	Oklahoma	6	1
	Take Me Home Country Road	6	1
	This Land Is Your Land	6	1
	You Are My Sunshine	6	1
3	Don't Sit Under the Apple Tree	5	1
	How much is That Doggie in the Window	5	1
	I've Been Working on the Railroad	5	1
	Love Me Tender	5	1
	This Little Light of Mine	5	1
	Walk the Line	5	1
4	Don't Fence Me In	5	2
	Oh Susanna	5	2
5	Five Foot Two, Eyes of Blue	4	2
	Ring of Fire	4	2
	Sugar Time	4	2
6	Side By Side	3	2

Table 5 shows the songs actually used in the sessions in alphabetical order with the exceptions that “Take Me Home Country Road” was removed after session five, pushing “This Land Is Your Land” forward into session six, and “I’ve Been Working on the Railroad” was added to the end. All songs were well received by the participants judging by the fact they all sang along and provided verbal feedback such as saying, “I hope we will sing those old songs again,” and “I like to sing the old songs.” Even though they were not familiar with the verse of “Take Me Home Country Road,” they were instructed to sing only the chorus in session five and they did.

Table 5

Songs Actually Used in Sessions

Session Number	Seated/Walking Task	Song Title
1 & 2	Seated	America the Beautiful
	Walking	He's Got the Whole World in His Hand
3 & 4	Seated	Hey Good Lookin'
	Walking	I'll Fly Away
5	Seated	Oklahoma
	Walking	Take Me Home Country Road
6	Seated	Oklahoma
	Walking	This Land Is Your Land
7 & 8	Seated	You Are My Sunshine
	Walking	I've Been Working on the Railroad

Feasibility

Research Question #1: What were the participants' perceived levels of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment for each session (demand)?

Demand. (RQ1). The demand for the protocol was determined by each participant's ratings in each of the eight sessions using visual analogue scales, measured from 0 to 100 mm, with the left end of the scale representing the minimum amount of the given variable and the right end of the scale representing the maximum. These scales were used to measure the variables of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment. Following narrative descriptions, line graphs are presented to portray the trajectories of each participant's ratings across eight sessions for physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment respectively. The mean scores of all participants in each session are presented in the same graphs as the individual ratings for each given variable.

Physical fatigue. Figure 4 shows the ratings of perceived physical fatigue across eight sessions for each of the six participants, including the mean scores of all participants in each session. An overall increasing trend of fatigue was observed for participants C, CR, and DR.

Participant DR had a rather gradual increase. In contrast, participant C had a large increase from session one to session two, stayed stable at a moderate-to-high fatigue level from session two to session six, and gradually increased across the last two sessions. A similar pattern was observed in participant CR's ratings. Participant CR had a larger increase from session one to session two compared to participant C but also stayed stable at a moderate-to-high level from session three to session six. After missing the seventh session, her rating went up again during the last session. Participant DD's ratings stayed low and stable. After missing three sessions, participant R's ratings increased dramatically for two sessions yet dropped to below the beginning ratings in the last session. Participant MD only participated in session one and his level of physical fatigue was 38, the second highest among the six participants.

The mean ratings of all the participants gradually increased at the beginning, had a peak in session five, and decreased slightly at the end. The absence of participant DD in session five may have contributed to the higher mean rating of session five because participant DD tended to rate her fatigue level very low based on information from her other sessions. If one adds participant DD's average rating of 5 into the overall calculation, the mean rating of session five would be 43.75. If this were the case, the mean ratings would have a gradual increasing trend to session seven, instead of a steep increase to session five. In addition, the mean ratings might have the potential to increase in the last session if participant R's ratings had not dropped so dramatically in the final session. The mean rating in session eight would have been 56 (instead of 48), slightly lower than the highest rating in session five, 57, without including R's rating in the calculation.

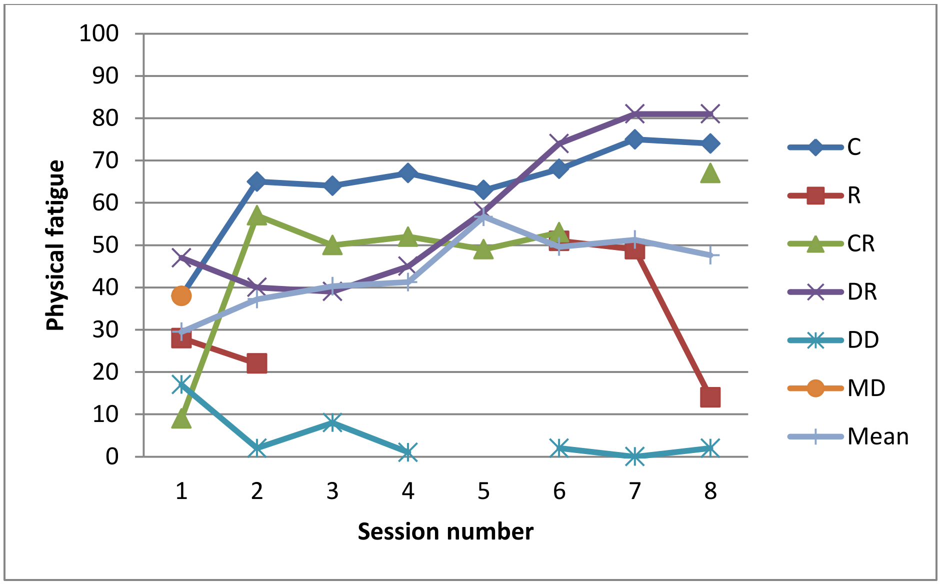

Figure 4. Ratings of physical fatigue across sessions.

Mental fatigue. The ratings of perceived mental fatigue across eight sessions for each of the six participants, including the mean scores of all participants in each session, are presented in Figure 5. The ratings of mental fatigue of participants CR, R, and DD revealed similar patterns when compared to their ratings of physical fatigue. Participant CR had a very large increase in mental fatigue ratings from session one to session two and then stayed stable in the moderate-to-high range from session three to session six. She then had an increase during the last session following her absence in session seven. Participant R started with very low levels of mental fatigue for two sessions. Her ratings increased dramatically for two sessions after missing three sessions yet dropped in the last session. Participant DD's ratings of mental fatigue stayed low and stable across sessions. Participant C had an increase from session one to session two and then a decrease in session three. Her ratings gradually increased to session six and then gradually decreased in sessions seven and eight. Participant DR's ratings of mental fatigue alternated between a lower and higher rating with a general trend toward increasing. His ratings corresponded to the proposed protocol, which increased its difficulty every two sessions.

However, within the same level of protocol difficulty, which lasted two sessions, participant DR experienced a lower level of mental fatigue during the first session than the second session. Participant MD only participated in session one and his level of mental fatigue was the highest of all participants. The high mental demands he experienced in session one might be a factor that discouraged him from returning.

The mean ratings of perceived mental fatigue of all the participants displayed a similar pattern when compared to the mean rating of perceived physical fatigue, gradually increasing at the beginning, reaching a peak in session five, and decreasing slightly at the end. Participants' ratings of physical fatigue and mental fatigue were highly correlated (r = .92) (see Table 6). The same factor affecting the mean rating of physical fatigue in session five, the absence of participant DD, might also have contributed to the high mean rating of mental fatigue in session five because participant DD was likely to rate her mental fatigue level very low based on her other sessions. Hypothetically, therefore, the mean ratings of mental fatigue would have likely still increased to session five, but to a lesser extreme, and would not increase much more toward the end. Two other factors might contribute to the peak ratings in session five for mental fatigue. First, only three participants were present in session five so they might have felt more stressed because there was the potential they were more closely watched by each other and by the researcher. Also, because they were each performing independently, it may have been different from the other sessions in that there was no one to compare to as they played, which may have facilitated less self-correction than in the other sessions. Second, the songs sung in session five were "Oklahoma" and "Take Me Home Country Road." Participants in this session had some disagreement on the opening rhythm of the song "Oklahoma" and they were not familiar with the verse of the song: "Take Me Home Country Road." These factors might have caused additional mental stress for participants.

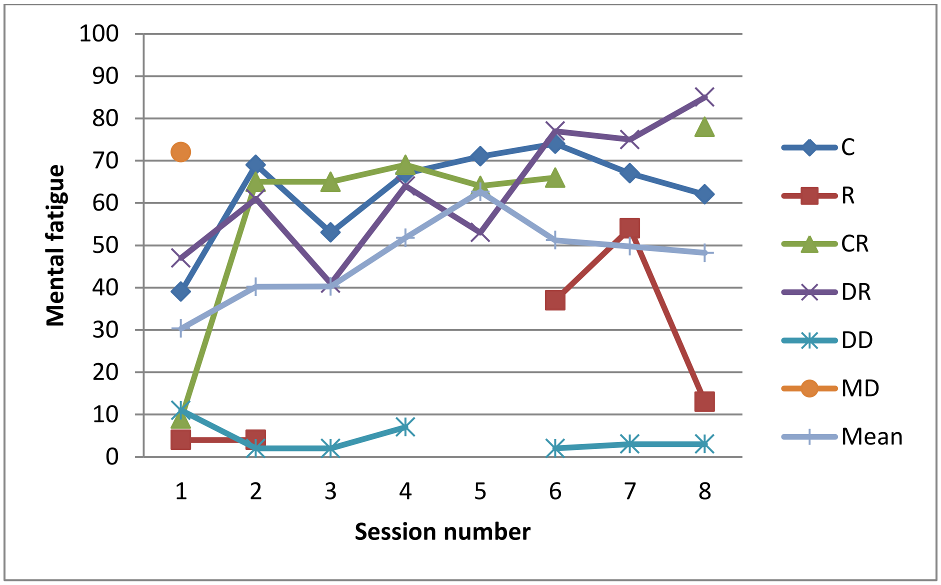

Figure 5. Ratings of mental fatigue across sessions.

Table 6

Correlation Matrix of the Five Factors of Demand

	Physical fatigue	Mental fatigue	Task difficulty	Anxiety	Enjoyment
Physical fatigue	____				
Mental fatigue	.92	____			
Task difficulty	.76	.90	____		
Anxiety	.95	.94	.88	____	
Enjoyment	-.05	.14	.29	.11	____

Task difficulty. Figure 6 provides the individual ratings of task difficulty from each participant across the eight sessions, as well as a line showing the mean ratings of all participants for each session. Except for participant DD, all participants experienced an increase of perceived task difficulty from session one to session two. From session two to session five, participant DR's ratings of task difficulty stayed stable while participant CR's ratings kept increasing. After session five, participant DR experienced an increase in task difficulty while participant CR experienced a decrease. Participant R also experienced a decrease in task difficulty after she came back from three absences. For participant C, her ratings of task difficulty dropped from session two to session three, slightly increased in session four, and kept decreasing until session six. Participant C then experienced an increase for the last two sessions. Participant DD's ratings of task difficulty, like her other ratings for physical fatigue and mental fatigue stayed low and did not change throughout. Participants DD's and R's ratings of task difficulty were relatively low when compared to the rest of the participants. Participant MD's rating of task difficulty in session one, in contrast to his high rating of mental fatigue, was low and comparable to participants R, CR, and DD,

The mean ratings of task difficulty increased until session five and then decreased. Mean ratings of task difficulty were highly correlated with the mean ratings of physical fatigue ($r = .76$) and mental fatigue ($r = .90$) (see Table 6). The same factors that influenced the peak ratings of physical fatigue and mental fatigue in session five might also apply to the peak ratings of task difficulty, which included the absence of participant DD, overall low attendance, and the songs chosen for that session. The intervention was proposed to increase its difficulty every two sessions and results revealed that the participants experienced an increase of perceived difficulty until session five and considered the rest of the sessions to have similar levels of difficulty. One factor that may have contributed to this potential trend toward non-increase was that the researcher found that the most difficult dual-task combination was "seated toe tapping with specific rhythmic patterns while singing in response to visual cues" and it was first introduced in session five and continued to be practiced across the remaining sessions. As a result, the researcher introduced more cues/prompts to the participants, such as modeling (walking with the participants), providing rhythmic cues on the left-hand accompaniment on the piano, and allowing the research assistant to play the rhythmic patterns on the instrument for walking or conducting the rhythmic patterns with hand gestures for playing the foot tambourines and drum sets. The researcher also adjusted the complexity of the rhythmic patterns for playing the foot tambourines and drum sets based on the participants' performance. For example, if one rhythmic pattern seemed difficult for the participants, the researcher would shorten or simplify the rhythm in the following session. These clinical adjustments may have altered the participants' perception of task difficulty and kept them motivated.

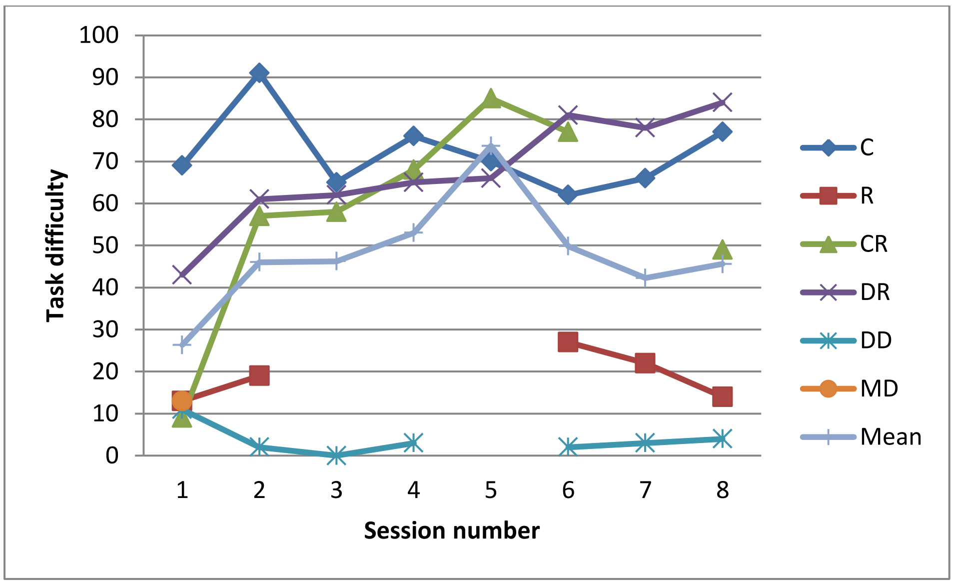

Figure 6. Ratings of task difficulty across sessions.

Anxiety. Individual participants' anxiety ratings across eight sessions, and the mean scores of all participants in each session, are presented in Figure 7. Except for participant MD, all participants started with low levels of anxiety. Participants C, CR, and DR had an overall trend toward increased anxiety levels with some periods of reduced and elevated anxiety levels between the beginning and end of the study. Participant C had two drops in anxiety level in sessions four and eight. Participant CR had a larger increase in session two and a smaller increase in session five. Participant DR also had a large increase in session two but a small increase in session six. Participant DD's and participant R's ratings of anxiety levels stayed relatively low and stable compared to the other participants, similar to their perceived task difficulty ratings. Participant MD only participated in session one and his rating of anxiety was the highest among the six participants, 43, more than double the second highest rating, made by participant C, 20. This high level of anxiety might be a factor in why he stopped attending.

The mean ratings of anxiety, like the mean ratings of physical fatigue, mental fatigue, and task difficulty, showed an increase toward session five and a decrease in following sessions. The mean anxiety ratings were highly correlated with the mean ratings of physical fatigue (*r* = .95), mental fatigue (*r* = .94), and task difficulty (*r* = .88) (see Table 6). Once again, the same factors that contributed to the peaks in physical fatigue, mental fatigue, and task difficulty ratings in session five might also have contributed to the peak ratings of anxiety. Additionally, being in a small ensemble and the unfamiliarity of the songs might have been anxiety provoking.

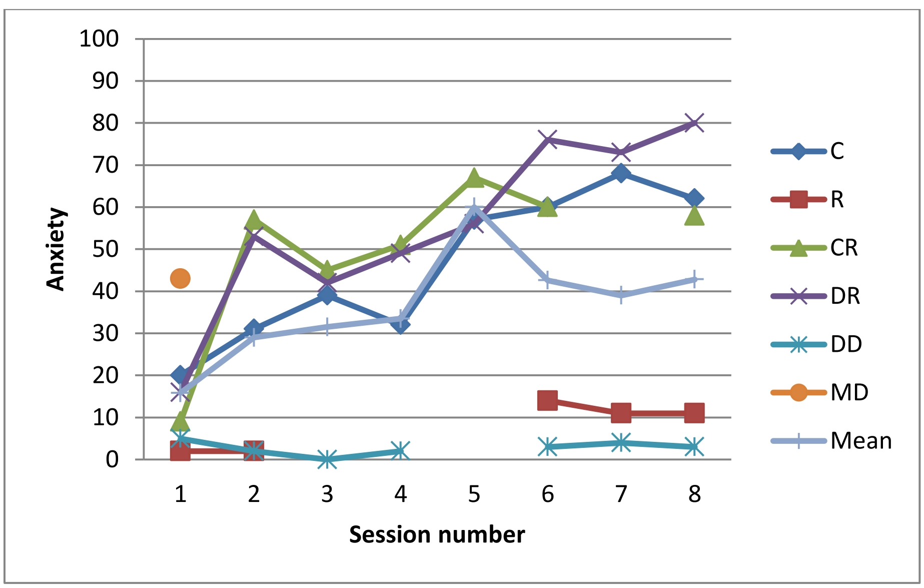

Figure 7. Ratings of anxiety across sessions.

Enjoyment. Individual participants' ratings of enjoyment over the eight sessions are presented in Figure 8. A line showing the mean enjoyment ratings of all participants across sessions is included. Results showed that Participant CR and DD had overall high and stable ratings of enjoyment. Participant C began with high enjoyment for two sessions but her enjoyment level dropped in session three. Starting in session four, her ratings returned to higher levels and remained stable, although slightly lower than her initial ratings. Participant R also started with high levels of enjoyment for two sessions. However, after three absences, her enjoyment rating dropped to only half of what it had previously been. Her enjoyment was back to the initial high level during the final session. Participant R's ratings of enjoyment showed an exact reversion of her ratings of mental fatigue. Participant DR's level of enjoyment exhibited a gradual increase over time with a dip in session five. There were only three participants in session five. This change in group dynamic might have influenced his feeling of enjoyment. Participant MD's rating of enjoyment in session one was extremely low, 11, compared to the other participants, whose ratings in session one ranged from 67 to 89 with a mean of 87. His low rating revealed that he did not enjoy the session, and this might have factored into his decision not to return for the following sessions.

Mean enjoyment ratings of all participants rose from session one to two, dropped slightly in session three, showed a gradual trend toward decreasing from session three to session seven, yet rose again in session eight. The mean ratings of enjoyment had little correlation with the mean ratings of physical fatigue (r = -.05), mental fatigue (r = .14), task difficulty (r = .29), or anxiety (r = .11) (see Table 6). However, while there was no significant correlation as a group, there were varied correlations for individuals, with positive and negative correlations.

For example, participant R's and DD's enjoyment was highly and negatively correlated with their perceptions of how difficult the task was (r = - .98) (r = - .80), how fatigued they were physically (r = - .93) (r = - .78), how fatigued they were mentally (r = - .98) (r = - .68), and how anxious they were (r = - .76) (r = - .51). Inversely, participant DR's enjoyment level was positively and highly correlated with his perception of physical fatigue (r = .62), mental fatigue (r = .62), task difficulty (r = .75), and anxiety (r = .69).

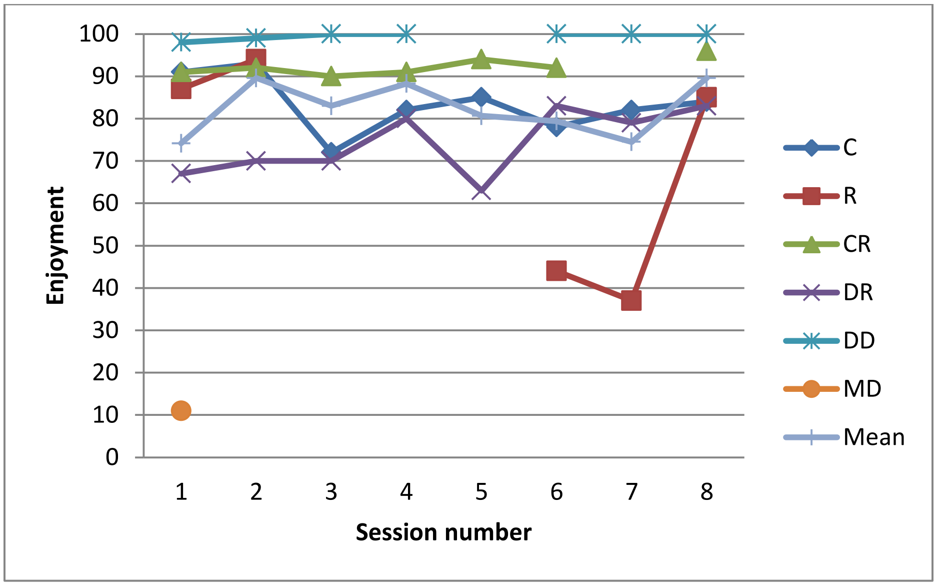

Figure 8. Ratings of enjoyment across sessions.

Clinical observations of each participant's performance. Participant C was one of the two participants who had the least musical background. Although she seemed a little intimidated by the instruments and musical tasks at first, she had perfect attendance and was always on time. The researcher found that she sometimes used her hands to help lift her feet up half way through the sessions that might be due to physical fatigue. When performing the combination of seated toe-tapping while singing in response to visual cues, she sometimes did not sing. Her ability to respond to cues while performing another physical task did improve over time. Figure 9 shows participant C's ratings of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across eight sessions all on one graph. Her perceived task difficulty and enjoyment had a large positive correlation (r = .68). The more difficulty she experienced, the more enjoyment she felt.

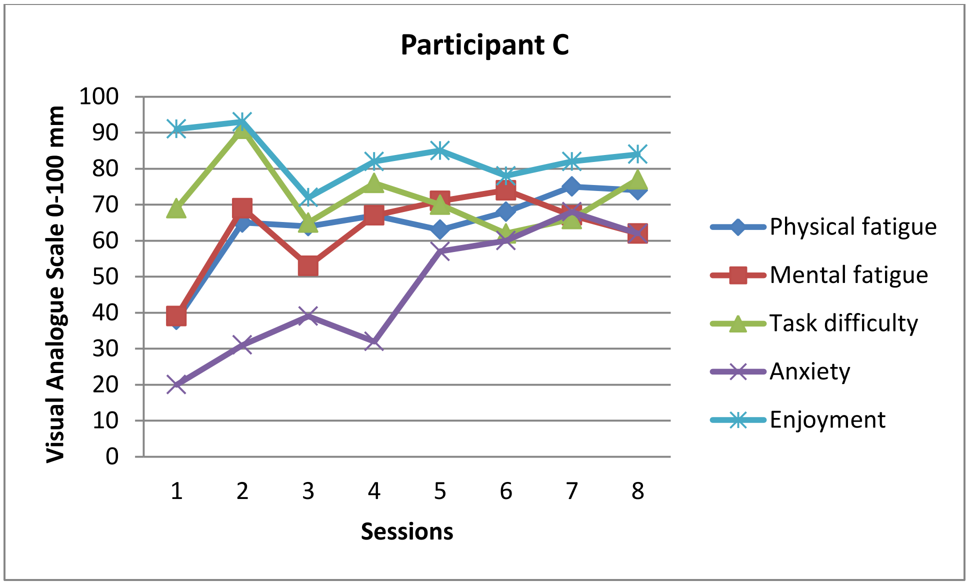

Figure 9. Participant C's ratings of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across sessions.

Being a former piano instructor, participant R had no hesitation in trying the foot tambourine and drum set. She could keep her rhythm on her feet while singing and playing instruments for the majority of the time in the first two sessions. However, after missing three consecutive sessions, she was not able to perform the dual-task as successfully as she did initially. She frequently relied on modeling, watching the footsteps of the research assistant all the time. She would keep playing her instruments when it was not her turn. Her higher self-ratings on the physical demands, mental demands, task difficulty, and anxiety in session six and seven reflected her poor performances. (see Figure 10).

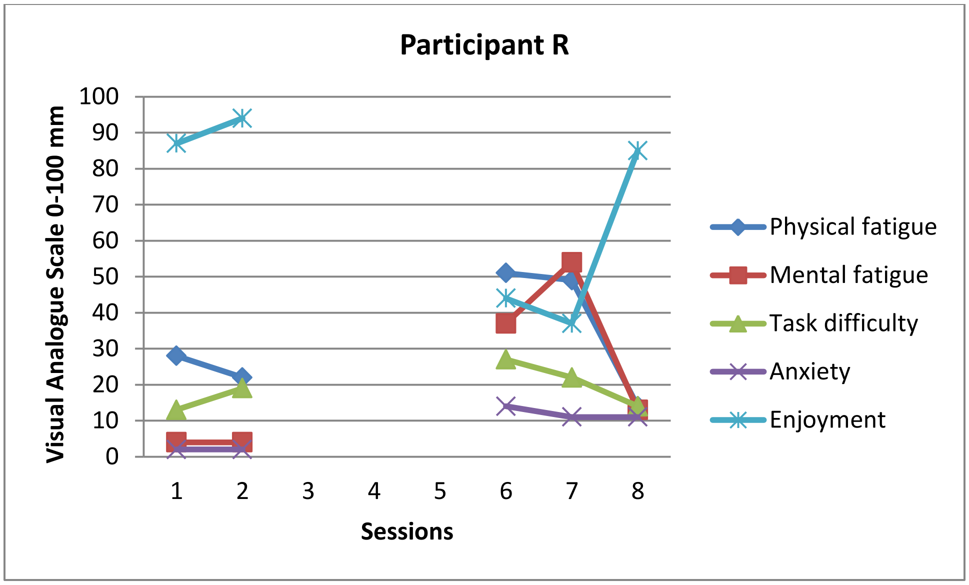

Figure 10. Participant R's physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across sessions.

Participant CR started out following the rhythmic patterns well. At times she was able to prompt her husband, participant DR, to follow visual or auditory cues. However, during session six, she appeared distracted and tired and missed more cues than normal. She was late for session six due to an emergency room visit and trying to schedule a shoulder surgery. She then missed session seven due to the minor shoulder surgery, and when she came back in session eight, one of her arms was in a sling. During the final session, she missed many cues and kept playing even during several moments when it was not her turn. Even though she missed the cues, she was aware of her mistakes, and when the music stopped she would acknowledge she played for the whole time. Her physical discomfort may have negatively affected her ability to focus. This was reflected by her elevated physical fatigue and mental fatigue ratings in session eight (see Figure 11).

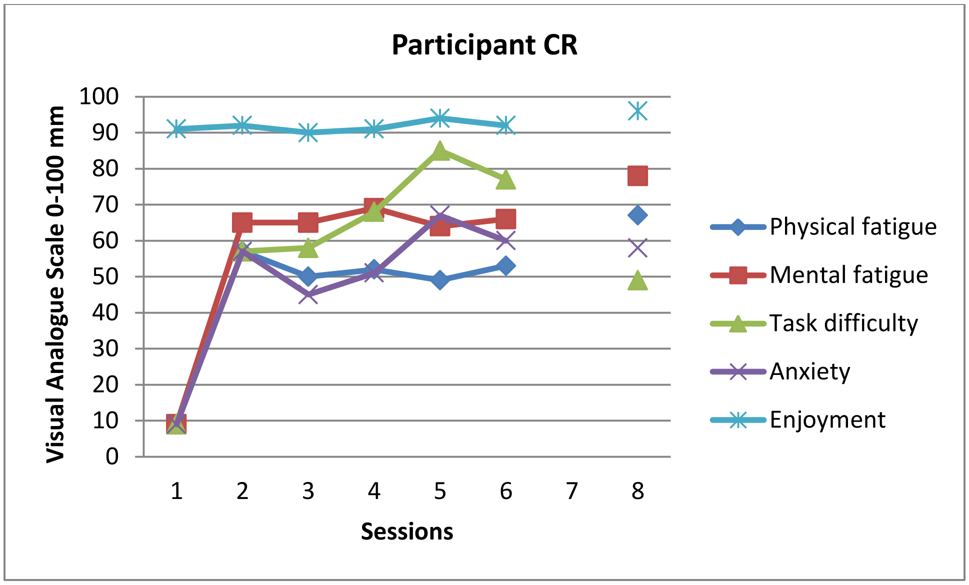

Figure 11. Participant CR's physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across sessions.

Participant DR's right ankle was rigid. As a result, when he tapped his toes or played bass drum, he had to lift his whole foot up rather than just his toe, which made it more difficult for him to keep the beats. He exhibited signs of muscle weakness in his lower limbs and balance concerns. When he walked, he would not always raise his feet, would drop his raised foot back down quicker than other participants, sway forward and back more than other participants, keep his upper body stiff, and seem to have more trouble staying in one place than other participants when marching in place. He needed two arms to help him get up from a seated position and spent considerable time looking down to watch his steps when he walked forward and backward with specific rhythmic patterns. He sometimes added extra steps that were not part of the rhythm. For dual-task performance, he performed better in response to auditory cues than visual cues; a vision loss might have contributed to him responding less successfully to visual cues. Furthermore, he required lyrics written in red so he could read them and sometimes stopped walking when it was his turn to sing. His performance improved over time and pointed out participant CR's (his wife) mistake in later sessions. Figure 12 shows participant DR's ratings of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across eight sessions all on one graph.

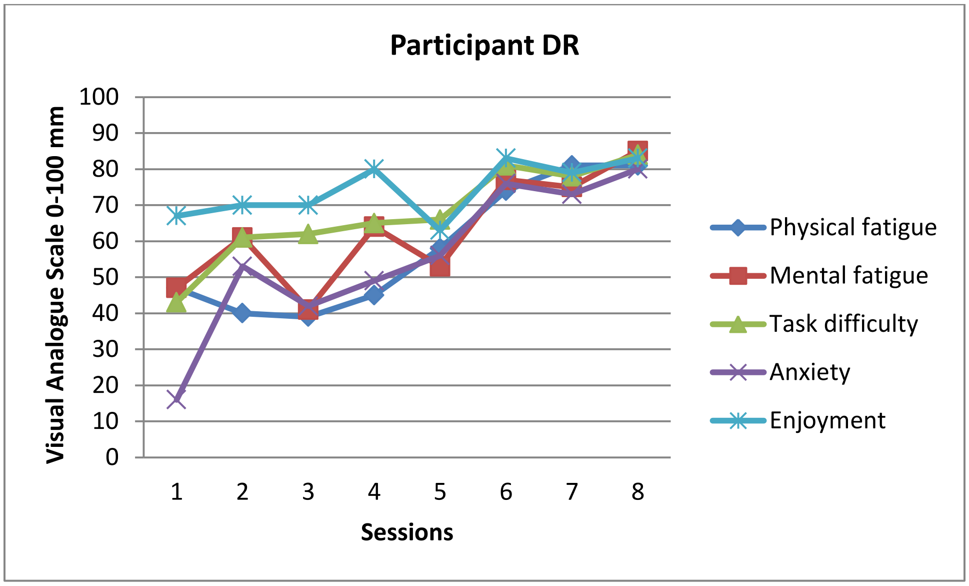

Figure 12. Participant DR's ratings of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across sessions.

Participant DD performed the best among all the participants. She was able to successfully perform the dual-task at any level of difficulty without additional prompts. She would keep chanting the rhythmic patterns on her own during the dual-task so she could keep the beats while responding to auditory cues. She was also able to keep her rhythmic pattern on feet and improvised another complicated rhythmic pattern with hands at the same time. Her subjective ratings reflected her superior performance as she had consistently low ratings of physical fatigue, mental fatigue, task difficulty, and anxiety, and high ratings of enjoyment (see Figure 13). She attended many exercise groups in addition to G-MDTT including water aerobics and walking, which might have contributed to her physical fitness.

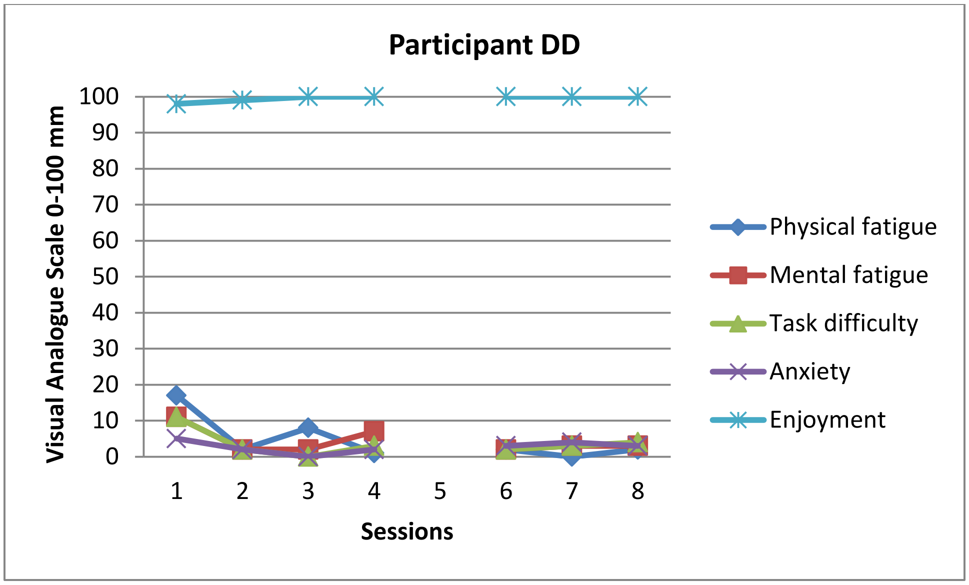

Figure 13. Participant DD's ratings of physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across sessions.

Participant MD had a mild stroke several years ago. It affected his balance and some physical coordination. Although he only attended the session once and did not enjoy the experience, he followed the directions and was engaged in every dual-task for the entirety of session one. He kept a steady beat with his feet, sang along, and played along. When instructed to play a specific rhythmic pattern on feet, he instead kept playing a steady beat. Since he only showed up for one session, it was not clear that this was because he had difficulty playing the specific pattern or because he did not want to and/or did not try. Although he indicated he did not consider the task difficult, he experienced high mental fatigue (see Figure 14).

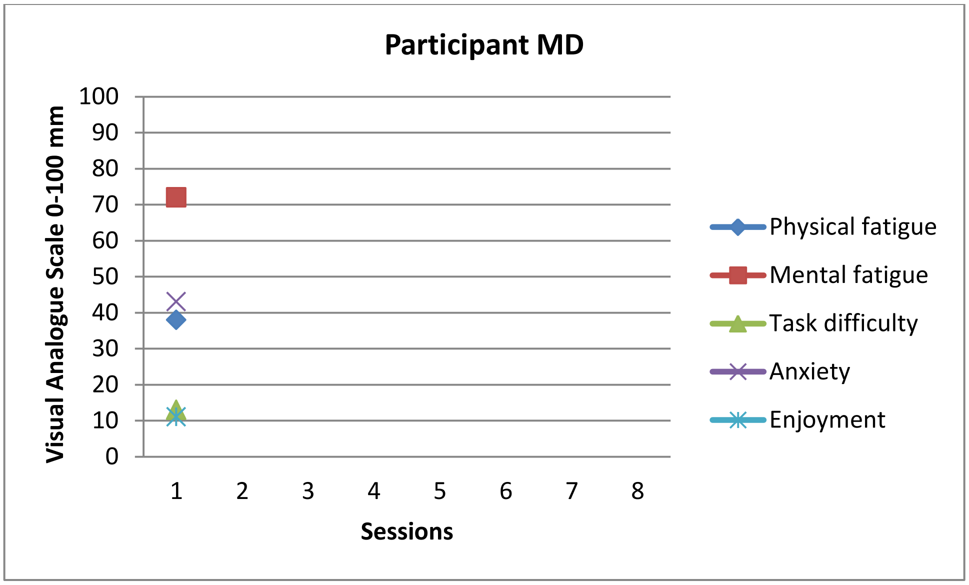

Figure 14. Participant MD's physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment across sessions.

Research Questions #2: Did any falls occur during the study period for participants (safety)?

Safety. (RQ2). Participant MD experienced one fall between the sixth and seventh sessions. None of the other participants experienced any falls throughout the study.

Research Questions #3: What was the attendance for the participants (implementation)?

Implementation/Attendance. (RQ3). Participant C and DR attended all eight sessions. Their attendance rate was 100%. Participant CR missed the seventh session due to a minor shoulder surgery. Her attendance rate was 87.5%. Participant DD was absent in session five because of feeling tired. Her attendance rate was also 87.5%. Participant R missed sessions three, four, and five for an out-of-town trip. Her attendance rate was 62.5%. Participant MD quit attending after the first session. He showed up for the last session but did not engage in any tasks. He came because his wife, participant DD persuaded him to do the Posttest following the last session. His attendance rate was 12.5%. The average attendance rate of all participants was 75% when including MD and 87.5% when not including participant MD.

Research Question #4: To what extent did the participants perceive the protocol beneficial and satisfactory (acceptability)?

Research Question #5: To what extent were the participants willing to continue the program if the program were to continue (acceptability)?

Research Question #6: To what extent would the participants recommend the program to others (acceptability)?

Acceptability/Program feedback. (RQ4, RQ5, RQ6). The program questionnaire was based on a 5-point symmetric agree-disagree scale with an answer of 1 representing the participant strongly disagreeing and an answer of 5 representing the participant strongly agreeing with the statement. The statements in the questionnaire addressed the perceived benefits from the treatment, level of satisfaction, their motivation for continuous participation, and their willingness to recommend the program to others. The higher number the participants indicated, the more strongly the participants agreed that the treatment was beneficial, the more they were satisfied with the program, continue if the program continued, and recommend the program to others. The average perceived benefits of all participants was 4.2, satisfaction was 4.33, and motivation for continuous participation was 3.5. The average willingness to recommend the program to others was 4.33. Participants also listed benefits they experienced during their participation, which included: 1) "playing different instruments" (participant C), 2) "thinking about more than one thing at a time" (participant R), 3) "coordination, listening, paying attention" (participant CR), 4) "I got to sing and I love to sing" (participant DR), and 5) "enjoy the singing and playing of the instruments, the interaction with other individuals" (participant DD). Participant MD wrote "NOT MY THING!" as the unfavorable effect he experienced during his participation. No other unfavorable effects were reported.

Research Question #7: Did participants exhibit reduced fall risks as evidenced by improved executive function, reduced dual-task cost on gait speed, improved balance, and less concerns about falls?

Effectiveness

Executive function. Executive function was determined by the time required for the participants to complete the Trail Making Test (TMT) part A, part B, and a ratio score calculated by dividing the competition time of part B with the competition time of part A. Individual participant's TMT part A, part B, and B/A at Pretest and Posttest are shown in Figures 15, 16, and 17 respectively. A reduced time to complete part A and part B and reduced B/A ratio indicated improved executive function. Participants DR, DD, and MD reduced their time in completing part A at Posttest. The other participants' times at Posttest were somewhat comparable to their times at Pretest. The average time of all participants in completing part A was reduced but not significantly (see Table 7). Participants C and DD reduced their times in completing part B after intervention while the other participants increased their times, especially MD, whose time more than doubled at Posttest. Participant MD was the individual who only participated in the first session and audited the eighth session. The average of time for all participants in completing part B was increased but not significantly (see Table 7). Except for participant C, all participants' B/A ratios increased at Posttest. The average B/A of all participants increased but not significantly (see Table 7). The reduction in part A and increase in part B made the increase of ration B/A score even prominent, as evidenced in both participants DR and MD.

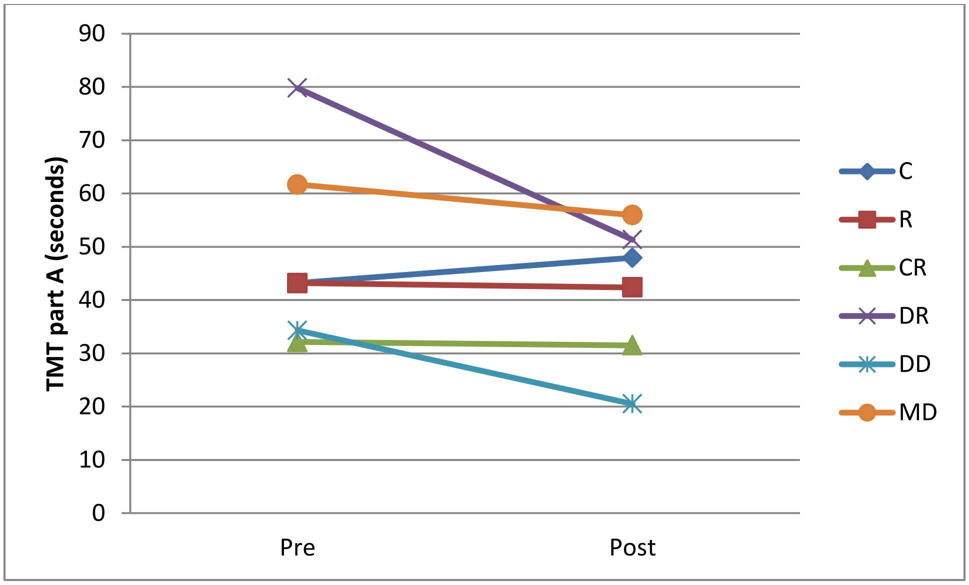

Figure 15. TMT Part A at Pre and Posttest.

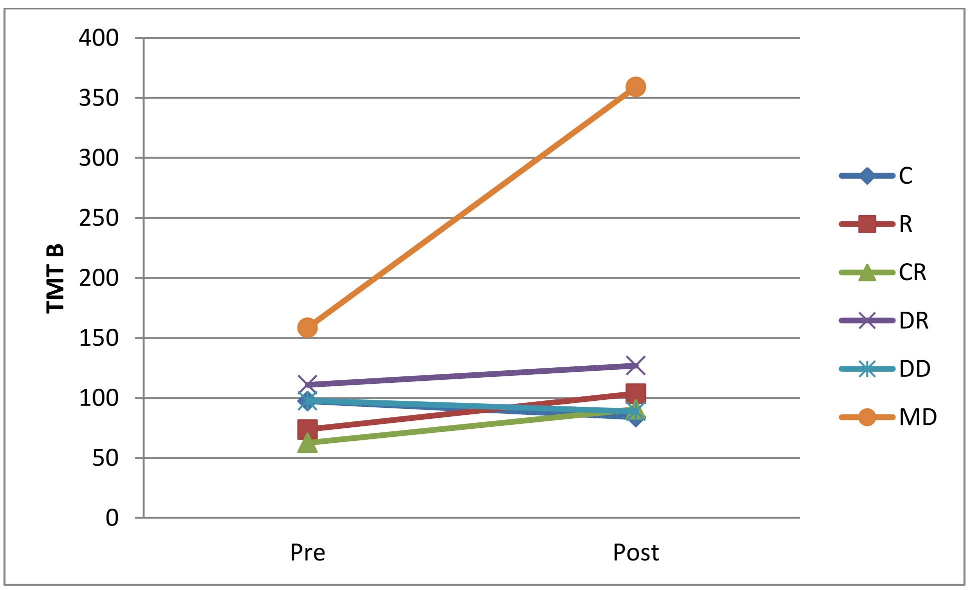

Figure 16. TMT part B at Pre and Posttest.

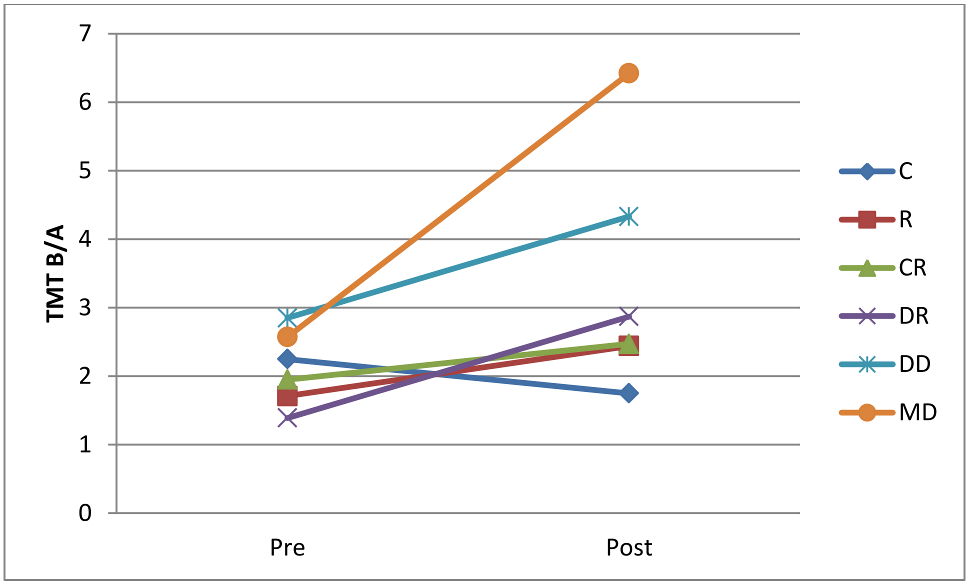

Figure 17. TMT B/A at Pre and Posttest.

Table 7

Means and Standard Deviations for TMT

	Pre	Post	
	M (SD)	*M (SD)*	*p*
Part A	49.04 (18.32)	41.59 (13.33)	.19
Part B	100.13 (33.61)	142.14 (107.40)	.25
B/A	2.12 (.54)	3.38 (1.72)	.09

Dual-task performance. The dual-task performance was determined by calculating the dual-task cost on walking speed during four tasks: "Verbal fluency," "Subtraction 3," "Auditory Stroop," and "Spontaneous response." In the "Verbal fluency" task, participants were asked to name as many as items as they could from a category, such as naming as many fruits or sports as they were able. In the "Subtraction 3" task, participants were given a 3-digit number and asked to subtract units of 3 from it. In the "Auditory Stroop" task, participants were presented with a sequence of words consisting of the words "high" and "low" spoken in either a high or low pitch and asked to ignore the meaning of the words instead only describing the pitch as high or low. In the "Spontaneous response" task, participants were asked their opinions on subjective questions and to list reasons for their opinions. Dual-task cost refers to the ratio of change of performance from a single-task to a dual-task condition. Dual-task cost on walking speed is calculated as follows: (Walking speed single task − walking speed dual-task) ⁄ walking speed single task × 100. Lower percentage represents less dual-task interference (Abernethy, 1988; Plummer-D'Amato et al., 2012). A decreased dual-task cost is indicated by a reduction in the differences of walking speed between when a participant is only walking and walking while performing one of the four tasks. A reduction in dual-task cost indicates an improvement. The raw data of absolute walking speed in single walking task and four dual-task walking tasks at Pretest and Posttest are presented in Appendix G. The raw data of dual-task cost on walking speed in four tasks are also included in Appendix G.

Verbal fluency. Individual participant's dual-task cost in the "Verbal fluency" task as measured by walking speed at Pretest and Posttest is shown in Figure 18. A large decrease in dual-task cost on walking speed during "Verbal fluency" task from Pretest to Posttest was observed in participant R and a small decrease was found in participant MD. The other four participants' dual-task costs in the "Verbal fluency" task stayed unchanged from Pretest to Posttest. No significant differences were found after intervention with outlier R ($p = .25$) and without ($p = .34$) (see Table 8).

Table 8

Means and Standard Deviations for Dual-task Cost on Walking Speed

	Pre	Post	
	M (SD)	*M (SD)*	*p*
Verbal fluency	28.00 (26.74)	21.83 (16.35)	.25
Subtraction 3	55.50 (36.94)	34.50 (18.90)	.04*
Auditory Stroop	42.83 (27.30)	25.83 (9.39)	.10
Spontaneous response	39.83 (25.13)	36.50 (23.18)	.51

*$p < .05$

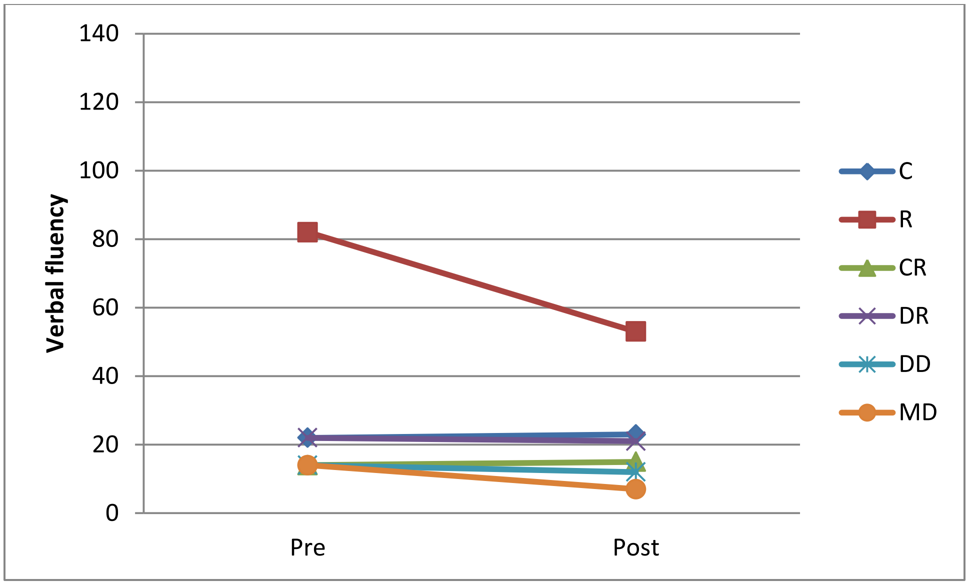

Figure 18. Dual-task cost in the "Verbal fluency" task at Pre and Posttest

Subtraction 3. Figure 19 displays the changes from Pretest to Posttest for dual-task cost in the "Subtraction" task, as measured by walking speed. All six participants reduced their dual-task cost in the "Subtraction 3" task from Pretest to Posttest. This reduction was significant ($p < .05$) (see Table 8). The researcher further reported the average number of subtractions the participants were able to make during the walks and the average accuracy of subtraction 3 task (see Table 9). Both the average number of subtractions ($p = .85$) and accuracy ($p = .68$) of all participants at Posttest were comparable with those at Pretest. Results showed that the participants were able to reduce the impact from the "Subtraction 3" task on their walking speed without sacrificing the quality of the "Subtraction 3" task performances. The raw data of the four cognitive tasks during the dual-task walking are included in Appendix H.

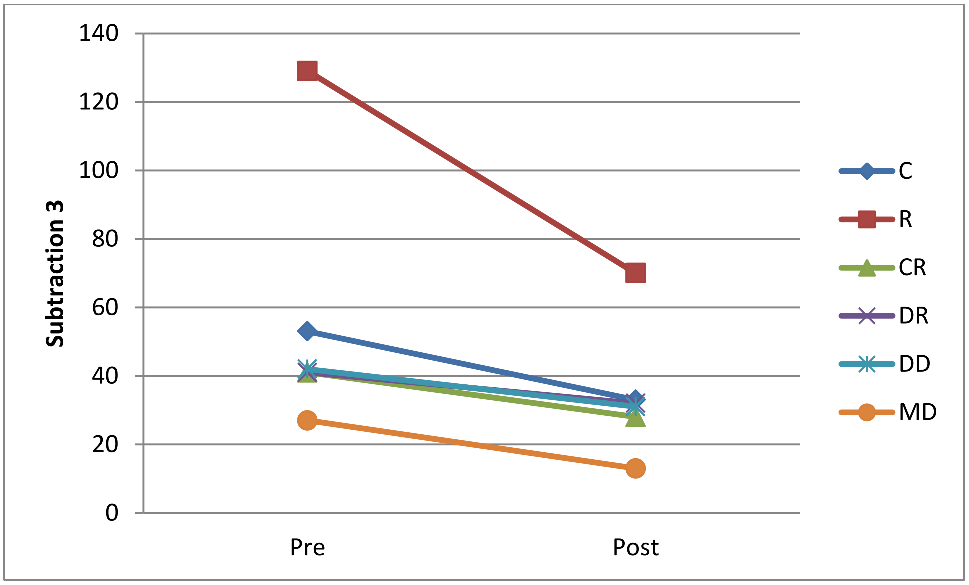

Figure 19. Dual-task cost in the "Subtraction 3" task at Pre and Posttest.

Table 9

Means and Standard Deviations for Subtraction 3

	Pre	Post	
	M (SD)	*M (SD)*	*p*
Number of Subtractions	4.64 (1.77)	4.72 (1.63)	.85
Accuracy	75.33 (18.38)	73.17 (17.93)	.68

Auditory Stroop. Individual participant's dual-task cost in the "Auditory Stroop" task as measured by walking speed at Pretest and Posttest is presented in Figure 20. All six participants' dual-task cost reduced in the "Auditory Stroop" task after intervention. Participant R and participant MD had a larger reduction than the other four participants. A two-tailed paired t-test indicated that this reduction was not significant (p = .10) (see Table 8). The average numbers of responses the participants were able to make during the walks and the average accuracy of "Auditory Stroop" task of all participants are further illustrated in Table 10. Results revealed that although the participants' average reduction of dual-task cost in the "Auditory Stroop" task on walking speed was not significant, their average accuracy in the "Auditory Stroop" improved significantly at Posttest (p < .05) (see Table 10).

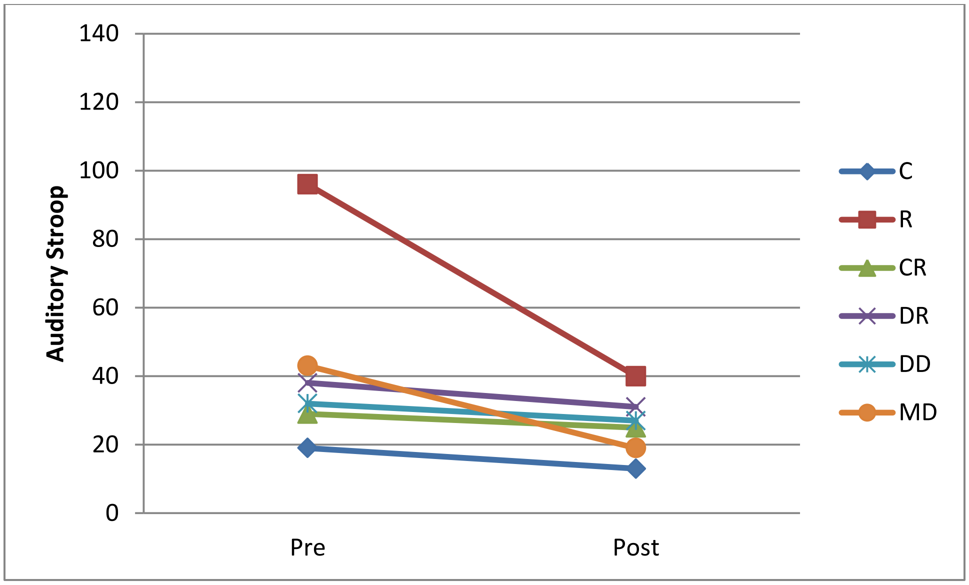

Figure 20. Dual-task cost in the "Auditory Stroop" task at Pre and Posttest.

Table 10

Means and Standard Deviations for Auditory Stroop Test

	Pre	Post	
	M (SD)	*M (SD)*	*p*
Number of responses	7.11 (1.61)	6.95 (1.32)	.65
Accuracy	74.83 (23.19)	87.67 (19.00)	.00*
*$P < .05$			

Spontaneous response. Figure 21 demonstrates the changes from Pretest to Posttest for dual-task cost in the "Spontaneous response" task, as measured by walking speed. Participants C, R, DR, and MD had a reduction in their dual-task cost at Posttest while participant DD had an increase. Participant CR's dual-task cost stayed unchanged. No significant differences of average changes of all participants were found after intervention (p = .51) (see Table 8).

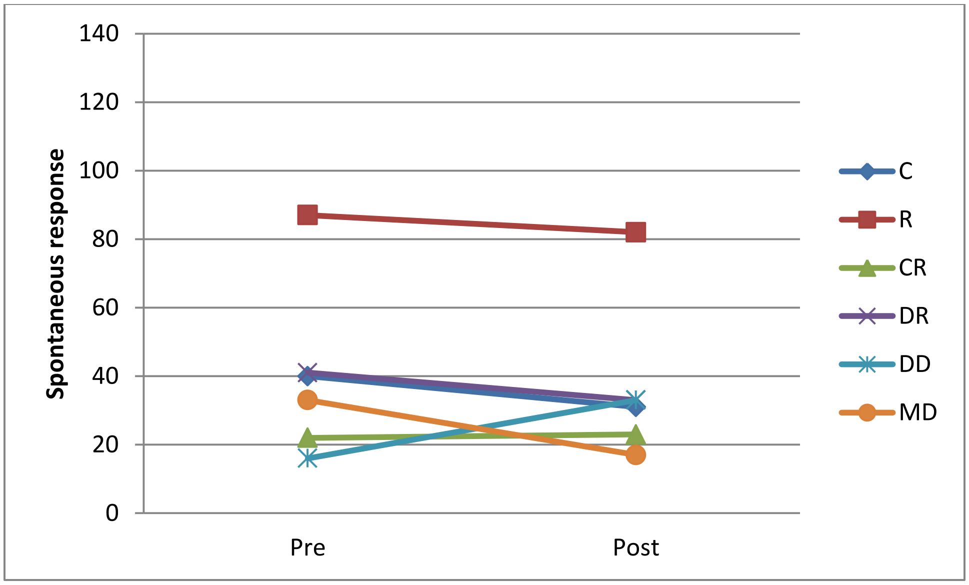

Figure 21. Dual-task cost in the "Spontaneous" task at Pre and Posttest.

Balance. Balance was determined by the time required for the participants to complete the Timed Up-and-Go (TUG) test. Individual participants' completion times of TUG at Pretest and Posttest are displayed in Figure 22. The time required for participants C, R, and DD to complete the TUG test in Posttest was approximately a second or more longer than what they required in the Pretest. Participants CR, DR, and MD's times at Posttest were all comparable to their scores at the Pretest. There was no significant difference in the average degree of change of all participants after intervention (p = .25) (see Table 11).

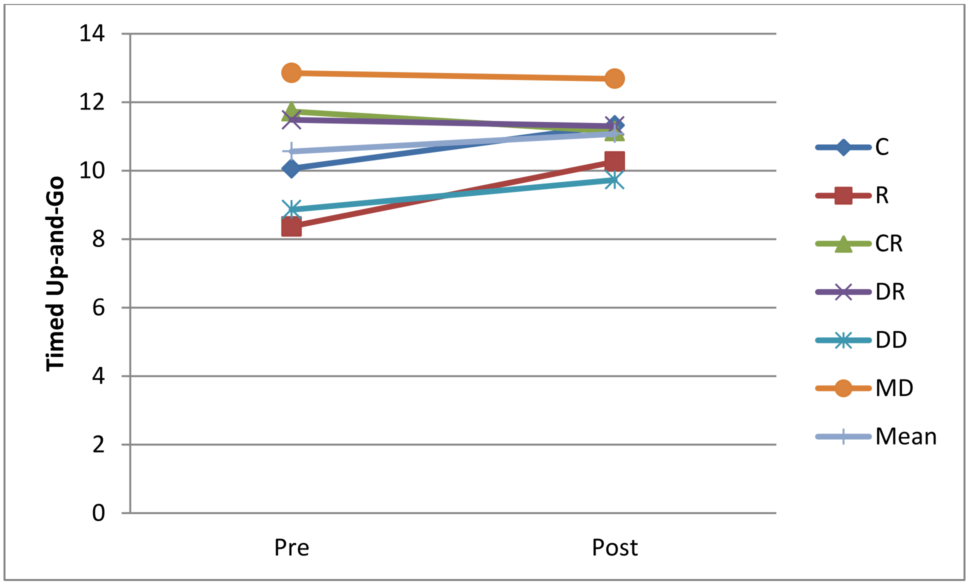

Figure 22. TUG at Pre and Posttest.

Table 11

Means and Standard Deviations for TUG

	Pre	Post	
	M (SD)	*M (SD)*	*p*
TUG	10.56 (1.75)	11.07 (1.02)	.25

Concerns about falls. Concerns about falls were determined by the participants' self-ratings on Falls Efficacy Scale International (FES-I). Figure 23 shows individual participants' score of FES-I at Pretest and Posttest. Participant MD was excluded in this analysis because there were missing data. He marked two checks on one item at Pretest and missed answering one item at Posttest. Participants R and DR lowered their ratings on concerns about falls after intervention while participant C raised her rating. Participants CR's and DR's ratings remained unchanged. No significant changes in the average ratings of all participants were observed between Pretest and Posttest (*p* = .52) (see Table 12).

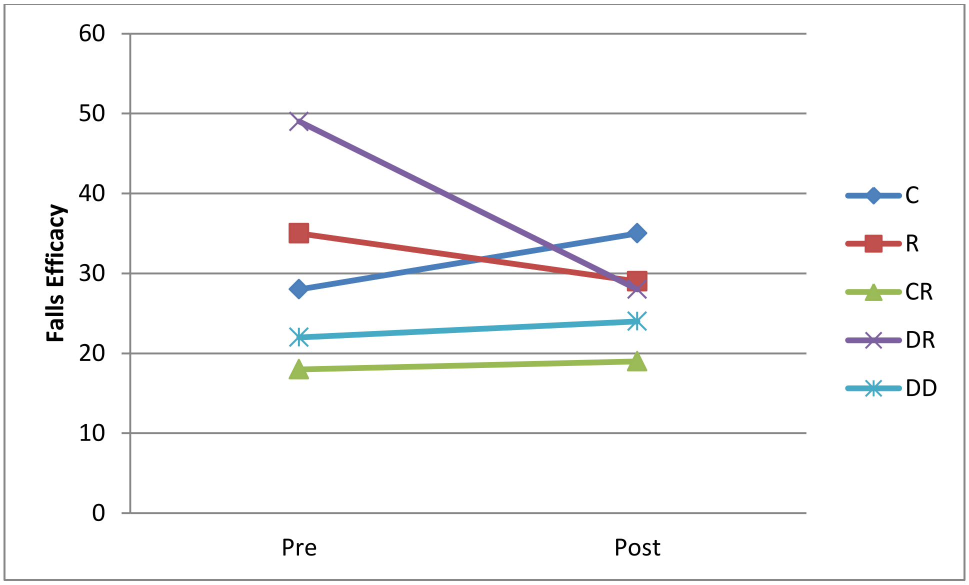

Figure 23. FES-I at Pre and Posttest.

Table 12

Means and Standard Deviations for FES-I

	Pre	Post	
	M (SD)	*M (SD)*	*p*
FES-I	30.40 (12.22)	27.00 (5.96)	.52

Evaluation of the Protocol

Music. The songs selected by the participants were sung in session in alphabetical order. No objections were made to the song choices or the order of the songs used in each session. The researcher did observe that it was more difficult to keep up with the beat if the songs started on the up-beat, such as "You Are My Sunshine," and "This land is your land." The songs that started on a down-beat in 4/4 meter were the easiest to follow, such as "I'll fly away" and "I've been working on the railroad." Among all the songs they sang during the sessions, their favorite songs were "I'll Fly Away," "Hey Good Lookin'" and "I've Been Working on the Railroad." This was indicated by comments such as "I sang it in church," and "I like these old songs." The participants tried to teach the entire song to the researcher as she only presented two verses of "I've Been Working on the Railroad."

Well-known classical music selected by the researcher to use for instrument playing was effective in serving the cues for participants to respond (see Table 2). The repositories were well received by the participants, based on the facts that at times, they would spontaneously praise the pieces, discuss the pieces and ask what the pieces' titles were. If the changes between the sections were not clear to the participants, the researcher played the different sections in different registers or different dynamics to make the differences between sections more noticeable.

For the rhythmic patterns performed with foot tambourine and drum sets, participants were able to do simple and short rhythms composed of only quarter notes and half notes. Participants lost count when there was syncopation or multiple eighth notes, especially when adding singing. Table 13 displayed the various rhythmic patterns used in the sessions. These patterns were printed on papers placed on a music stand in front of the participants so they had a visual representation of the rhythms to follow throughout. To accommodate those who might not be able to read musical notes, the researcher introduced lyrics whose syllables corresponded with the rhythm such as the three syllables of the word "beautiful" being used to represent two eighth notes and one quarter note. Examples are shown in Table 13. Table 14 demonstrates the difficulty levels of these rhythmic patterns the researcher found in this present study based on the participants' performances. The participants relied on the cues from piano accompaniment or modeling to perform the more challenging rhythmic patterns during the sessions. Figure 24 and 25 showed the examples of how the researcher prompted the rhythmic patterns with the piano accompaniment. For the movement patterns, the participants were able to alternate feet when performing the rhythm. They could also alternate between tapping feet together and tapping one foot. However, they had difficulty if asked to repeat on one foot. They were either not able to perform it or reported soreness after performing it. The movement patterns associated with each rhythmic pattern used in the sessions are also included in Table 13.

Table 13

Rhythmic Patterns for Drum Set and Foot Tambourine

Session	Drum set	Foot tambourine
1	 Right Right Left	 Together Right Left
2	 Right Left	 Right-Left Right Left (Beau-ti-ful land)
3 & 4	Steady beat	Steady beat
5	 Right Left (O K)	 (Sweeping down the plain)
6		 (In the sky)
7	 (My sun—shine)	 (Sun—shine a way)
8	 Right Left (Sun-shine)	 Right Left Together

Table 14

Difficulty levels of Rhythmic Patterns for Playing with the Foot Tambourines and the Drum Set

Level of difficulty	Rhythmic Patterns
Simple	
	
Moderate	
Challenging	
	
	
	
	

Figure 24. Example of the song “America the Beautiful” with piano accompaniment in a specific rhythmic pattern.

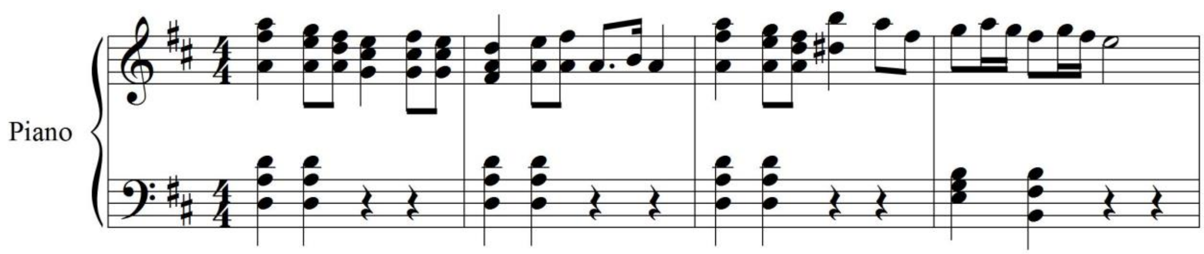

Figure 25. Example of music “Schubert, Marche Militaire op.51 no. 1” with piano accompaniment in a specific rhythmic pattern.

For the rhythmic patterns that the participants followed as they walked forward and backward, the researcher also found that some patterns were more challenging than others. First of all, it was easier if the forward and backward patterns were the same. Second, a pause was helpful in transition between the forward and backward patterns. Third, rhythms that were slower than natural walking speed were typically more difficult than rhythms closer to natural walking speed (see Table 15).

Table 15

Difficulty Levels of Rhythmic patterns for Forward and Backward Walking

Level of difficulty	Rhythmic Patterns
Simple	 Forward 3 steps Backward 3 steps
Moderate	 Forward 2 steps Backward 2 steps
	 Forward 5 steps Backward 5 steps
Challenging	 Forward 4 steps Backward 4 steps
	 Forward 2 steps Backward 2 steps
	 Forward 3 steps Backward 2 steps

Protocol Modification. The researcher made some adjustments during the sessions based on clinical judgment in the best interest of the participants.

1. The "actual" sessions mainly focused on toe taps rather than both toe taps and heel lifts: Two reasons affected the decision of the researcher during the sessions to not

practice the motion of heel lifts. The first reason was the researcher expected heel-up (heel lift) to be a more difficult technique than heel-down (toe taps) for the participants when playing the drum sets, since the heel-up required only the toes resting on the pedal and the heel lifting up at all time, which caused fatigue more easily than heel down on the pedal pressing the toes. The participants might feel the pedal easier when resting their entire foot on the pedal. The second reason was time constraint. The plan was for each dual-task combination to be practiced for five minutes. Within the five minutes, participants had to take on and off their foot tambourines, rotate between the foot tambourines and drum sets, and transfer between seats. As a result, the researcher decided to focus on the practice of toe taps in the sessions. Nevertheless, the researcher believed the heel lifts should also be practiced in a future study or future clinical applications of this study. Future applications should dedicate time for participants to master the heel-up and heel-down skills for playing the bass drum and high-hat cymbal before a dual-task combination is introduced.

2. The “walking forward” task had been modified to the “marching in place” task: Due to the size of the room, the participants were not able to keep walking forward without turns. As a result, the participants were spontaneously walking in a circle when asked to walk forward which caused dizziness. Moreover, when the participants walked in a circle, they could not always read the lyrics written in colors on the poster board in front of the room, so they were not able to perform the task of singing in response to visual cues. Therefore, the participants were instructed to march in place, instead of walking forward. To avoid dizziness during the session where the

participants did walk in a circle, the researcher asked them to change directions of walking when they heard the music change. Changing walking patterns in response to auditory cues was not originally in the proposed protocol, but it could potentially be another dual-task combination.

3. The "playing a simple percussive instrument with a steady beat" task was modified to "playing a simple percussive instrument freely:" The researcher observed the participants struggled with keeping a specific rhythmic pattern while playing foot tambourines and drum sets. As a result, the researcher instructed them to play the simple percussive instruments with their hands freely instead of keeping a steady beat. Some participants, including DD, CR, and DR, greatly enjoyed playing freely. On the other hand, participants were frequently unable to play another rhythm with hands due to the natural tendency to synchronize with the rhythm played by feet and the difficulty in keeping two separate rhythms. Playing the same rhythm with hands also served a self-directed cue to help keep the rhythm of the feet.
4. The practice of a "less complex motor task and a less complex cognitive task" combination was added before the participants practiced the planned combination from session five to session eight: The participants were supposed to begin practicing the moderate level of dual-task, in which either motor task or cognitive task should have been more complex from session five to session eight. However, the researcher observed it was helpful to incorporate a simple combination as a warm-up, so the participants would exhibit less frustration.
5. To consider tailoring the protocol for various levels of capability within the group context, the therapist in the future may allow the participants to perform different

tasks of different difficulty levels at the same time. For example, one participant may start to work on practicing a specific rhythmic pattern while another may continue to focus on keeping a steady beat.

Chapter 5: Discussion

G-MDTT was designed to reduce the risks of falling through practice performing two music-related tasks at the same time including singing, toe tapping and heel lifting, marching in place, walking in rhythmic patterns, operating a drum set with feet, and playing instruments with hands. The purpose of this study was to determine if G-MDTT was feasible for a group of six participants who had concerns about falls and to see if G-MDTT could change or improve the performances on the fall risk factors including executive function, dual-task cost, balance, and concerns about falls.

When analyzing the data of all the participants as a whole, the results from the visual analogue scales indicated participants had a trend toward reporting an increase in their levels of perceived physical fatigue, mental fatigue, task difficulty, and anxiety starting from the beginning of sessions until a peak in session five and then decreasing until the end. Results were different from the originally proposed progression of task difficulty, which would have increased task difficulty every week. Participant DD's absence might have contributed to the peak in session five since she was likely to give low ratings based on her other sessions. The increases in fatigue, task difficulty, and anxiety in session five might have been more gradual and less steep if participant DD was present and her data were added into the analyses. Nevertheless, the results revealed session five was still the highest point and participants did not feel the tasks increased in difficulty and/or caused more fatigue after session five. In addition, this peak in session five could be explained by the fact session five was the first time participants were introduced to the most difficult combination of dual-task, toe taps with a specific rhythmic pattern and singing in response to specific visual clues. This combination was continually practiced in sessions six, seven, and eight. As a result, the perceptions of the participants indicated that there was no combination in the sessions following session five that was more difficult than the combination first introduced in session five. Moreover, the researcher originally anticipated that a more complex cognitive task would be more difficult than a more complex motor task, that is, singing in response to visual cues would be more difficult than seated toe tapping with specific rhythmic patterns. Therefore, the combination of seated toe tapping with a steady beat while singing in response to visual cues, practiced in sessions seven and eight, would be more difficult than the combination of seated toe tapping with specific rhythmic patterns while singing familiar songs, practiced in session five and six. However, based on the subjective ratings reported by the participants, seated toe tapping with specific rhythmic patterns was more difficult than singing in response to visual cues, which also explained why the participants did not give increased ratings of task difficulty for the last two sessions.

On the other hand, participant's individual ratings varied. One factor correlated with atypical results was musical background. Participant DD, who possesses a degree in public school music, consistently gave low ratings in physical fatigue, mental fatigue, task difficulty, and anxiety. Participant R, a former piano instructor, gave relatively lower ratings on these four ratings as well when compared to the rest of the participants, although she did not give ratings as low as DD. Another factor was absences. After missing a session or sessions, participants tended to perform worse than they did in the last session they attended and tended to rate more physical and mental fatigue.

One positive worth mentioning was that the average perceptions of physical fatigue, mental fatigue, task difficulty, and anxiety were unrelated to enjoyment. Individually, participant R's and participant DD's perceptions of physical fatigue, mental fatigue, task difficulty, and anxiety were negatively correlated with enjoyment. On the other hand, participant DR's enjoyment level was positively and highly correlated with his perception of physical fatigue, mental fatigue, task difficulty, and anxiety. This indicated that some participants might be motivated by the challenges and the participants could potentially enjoy the sessions even though they considered the task difficult and anxiety provoking.

No one fell during the sessions or during the experiment period except for participant MD. However, he quit attending after the first session and he fell, while he engaged in activities unrelated to the session. Therefore, the G-MDTT was considered safe to the participants and did not increase additional risks of falling. The average attendance was 75%. Participant MD's reason for absence was related to the intervention as he wrote in the questionnaire saying "(the intervention was) NOT MY THING." This was reflected in his ratings of session one which indicated high mental fatigue, high anxiety, and low enjoyment. The main reason participant MD originally agreed to attend was because his wife would participate, although he was actually the one who needed this intervention the most as he had a stroke several years ago and had some balance concern. The reason the other participants who missed sessions was not related to the intervention. Participant CR had to miss attending sessions because of a shoulder surgery not because of a fall. Participant R had a scheduled trip. In general, participants were satisfied with the program and considered the program beneficial. Although they were relatively neutral about continuing the program, they indicated they would recommend the program to others. Their comments on the questionnaires suggested that this intervention was more appealing to individuals who had a musical background or at least who liked to sing. They mentioned they enjoyed playing a variety of instruments and singing in the questionnaires regarding the benefits of participating in G-MDTT.

Results demonstrated the eight individual sessions of the G-MDTT, each 40-minute in length, were feasible and the intensity and duration of the treatment were appropriate for community-dwelling older adults who have concerns about falls. Participant DD mentioned the interaction with other individuals was beneficial, suggesting being in favor of the group format. A group of six participants was a feasible ensemble size, allowing for three sections to simultaneously play the drum sets and the foot tambourines while also allowing for two participants in each section to play the same instrument at once, creating the opportunity for those participants to learn from watching each other.

The results of the limited efficacy analysis revealed that G-MDTT had the potential to reduce the dual-task cost on walking speed in “Subtraction 3” task and “Auditory Stroop” task, but not in the “Verbal fluency” and “Spontaneous response” tasks and other fall risk factors including executive function, balance, and concerns about falls. The reduction of dual-task cost in “Subtraction 3” was significant in that participants were able to reduce the impact on walking speed from the “Subtraction 3” without their performance in the “Subtraction 3” task suffering. Even though the dual-task cost in “Auditory Stroop” task did not have a significant reduction after intervention, the participants performed significantly better on the “Auditory Stroop” test itself. Participants R and CR even had 100 % accuracy at Posttest. The “Subtraction 3” task and “Auditory Stroop” task were considered task-specific tasks in this present study as the “Subtraction 3” task tested working memory, and the “Auditory Stroop” task tested executive function. While G-MDTT did not directly ask the participants to perform “Subtraction 3” and “Auditory Stroop” tasks during the sessions, the abilities required to perform those tasks, working memory and executive function, were embedded in the core of G-MDTT. For example, keeping rhythm with the feet while singing required working memory. Additionally, responding to cues while singing demonstrated mental flexibility that was also tested in the "Auditory Stroop" task. Participant C indicated G-MDTT helped her perform the "Auditory Stroop" task at Posttest. The findings were consistent with the studies of Bayona, Bitensky, Salter, and Teasell (2005) and Yogeve-Seligmann et al. (2012) that indicated the best outcomes came from task-specific interventions because it stimulated experience-dependent plasticity in the brain.

In this present study, the gains from G-MDTT were not able to transfer to the untrained dual-tasks including "Verbal fluency" and "Spontaneous responses." "Verbal fluency" involved sematic memory and "Spontaneous response" assimilated daily conversation in which the participants answered questions based on their life experiences and reasoning skills. "Verbal fluency" and "Spontaneous response" examined different skill set than what was examined through "Subtraction 3" and "Auditory Stroop." In addition, the type of responses in the tasks was different. In "Verbal fluency" task, one participant might list "apple" and "banana" in the category of fruits while another might list "grape" and "orange," and all of these answers were correct. In "Spontaneous response," one might provide reasons for their personal preference, for example they might choose "cat" and one might provide reasons for the preference over "dog," while another participant did the opposite and they were both correct. Inversely, there were right and wrong answers in "Subtraction 3" and "Auditory Stroop" and participants needed to keep responding during the "Auditory Stroop," because the stimuli of "Auditory Stroop" were presented every one and half seconds. G-MDTT might not be able to improve the type of tasks that required sematic memory and spontaneous response.

Individual Musical Dual Task Training was able to significantly improve the executive function in a group of individuals who had mild to moderate dementia, as evidenced by the fact they shortened their times to complete the TMT part A at Posttest (Chen, 2014). However, this enhancement was not observed in this present study for a group of older adults who had concerns about falls. Not only were the results of part A not improved, but both the results of part B and B/A ratio, which are supposedly more representative of executive function than part A, were not improved. The enlarged TMT B/A ratio at Posttest could be explained by the mean reduction time in part A and mean increase time in part B. For example, both participant DR and MD shortened time for completion in part A but lengthened the time for completion of part B making the ratio at Posttest even more prominent. In addition, for participant DD, her part A and part B both improved, however, the fact that she improved more in A than B made the ratio score at Posttest seem worse than at Pretest because the difference between them became greater. Except for participants DR and MD, the participants' performances were comparable to normative data stratified by age and education according to the study by Tombaugh (2004). Although most participants' performances did not improve, they did fall into the normal range. It might be that it was difficult to improve upon patients who were already in the normal range.

Comparable to Chen's earlier study (2014), this present study failed to improve balance, as measured by the TUG test, suggesting that Musical Dual-Task Training, whether it was delivered in an individual or group format, was not able to target balance. TUG might be able to identify the relative severity of balance concerns in the participants, as participant MD took the longest time. However, TUG might not be sensitive enough to detect intervention-induced changes in this present study.

Also like Chen's original study (2014), this present study did not find a difference between participants' self-ratings of concerns about falls at the Pretest and Posttest, as measured by FES-I. Two participants, R and DR, reduced their concerns after intervention. However, the increased concerns in participant C cancelled the effect of their reduced concerns. Nevertheless, the reduction of R and DR was still impressive given they both started out with the highest levels of concern. The potential floor effects observed in higher functioning older adults might explain the lack of differences between Pretest and Posttest for participants CR and DR (Hauer et al., 2011).

Limitations and Recommendations

The main limitation of the present study was the difficulty of interpreting the results due to small sample size. For example, there might be evidence of an effect on dual-task cost in the "Auditory Stroop" test, but the result came just short of being statistically significant. Second, the present study applied an intention-to-treat analysis so although participant MD only participated in the first session, his Posttest data was included in the analysis. Participant MD showed improvement in some outcome measures even though he did not receive the same dosage of intervention. As a result, it was difficult to determine whether his improvements were because high dosage and low dosage of G-MDTT were both effective or there was a maturation effect. A future larger scale study with a randomized control group will help better determine the efficacy of G-MDTT. Third, the study seemed more appealing to participants who had background and/or involvement with music. It may be beneficial for a future study to compare the feasibility and effects of G-MDTT between a group of individuals who have musical backgrounds and another whose members do not. Lastly, future study may begin exploring the effects of G-MDTT with different populations at risk of falling, other than community-dwelling older adults, such as older adults living in a nursing facility, older adults with Parkinson's, or older adults with mild dementia.

Conclusion

Overall results support the clinical application of G-MDTT to community-dwelling older adults who have concerns about falls, with some modifications. Rather than adhering to a fixed schedule, the pace at which task difficulty increases should be more tailored to individuals' capability and relative level of progress. More time should be specifically dedicated to teaching participants the technique for playing the bass drum and high hat cymbal as most participants will be first-time players and proper technique may help prevent soreness and fatigue. Break time between tasks should be provided. Because participants are required to walk forward and backward while adhering to a specific rhythmic pattern in G-MDTT, this walking may be more energy consuming than taking a walk outside with a comparably number of steps.

Although this feasibility study was only able to examine the limited-efficacy of G-MDTT, results indicated a trend toward reducing dual-task cost on walking speed in tasks that focused on working memory and executive function. To the researcher's knowledge, the present study is the first music-based dual-task study that targeted fall prevention by reducing fall risk factors. This study contributed to the protocol development of a group musical dual-task training program. Older adults who have concerns about falls may benefit from this innovative intervention.

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Appendices

Appendix A

Sample Recruitment Flyer

<u>Volunteers Needed for Research:</u>

"Exploring the feasibility of group musical dual-task training in community-dwelling older adults who have concerns about falls"

Hi! I am a music therapy instructor at SWOSU and also a doctoral candidate at the University of Kansas. Research has shown that music making improves mental flexibility which may enhance your ability to perform two tasks at the same time. I believe this can be used to aid in fall prevention because people are more likely to fall while walking and carrying on a conversation.

For this reason, as a music therapist, I have designed a musical dual-task training protocol, in which people practice performing two things at the same time, such as singing while walking, to train mental flexibility. I am inviting you, if you are above age 55 and have concerns about falls, to participate in this study for 8 weeks, twice a week, 40-minutes per session. Your participation will help us understand how this training can help people in preventing falls and how to apply this training to further study. Participating in this program is voluntary.

If you are interested, or having any questions, please contact me via email at yuling@ku.edu, yu-ling.chen@swosu.edu, or phone at 785-727-8896.

Thank you!

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This study has been reviewed and approved by the Human Subjects Committee - Lawrence Campus (HSC-L) University of Kansas and Protection of Human Subjects Committee at Southwestern Oklahoma State University

Appendix B

Sample Informed Consent

INFORMED CONSENT STATEMENT

Exploring the feasibility of group musical dual-task training in community-dwelling older adults who have concerns about falls

INTRODUCTION

The Department of Music Education and Music Therapy at the University of Kansas and the Department of Music at Southwestern Oklahoma State University support the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with the University of Kansas and/or Southwestern Oklahoma State University.

PURPOSE OF THE STUDY

To determine if a music training program is feasible and has measurable influences on attention, walking ability, balance, and concerns about falls. The following measurements will be taken: 1) speed on the Trail Making Test, 2) walking speed, 3) the amount of time needed to complete the Timed Up-and-Go test, 4) scoring on the Falls Efficacy Scale International.

PROCEDURES

You will participate in a 40-minute group session, two times a week, across one months, for a total of eight sessions conducted by the researcher, a board certified music therapist. Within the music training session, you will be asked to sing familiar songs, play simple percussive musical instruments such as paddle drums, maracas, bass drum, high-hat cymbal, and foot tambourine, sing while walking, and play instruments while walking.

To determine the feasibility of the training you will be asked to rate your physical fatigue, mental fatigue, task difficulty, anxiety, and enjoyment immediately after each session. You will also be asked to fill out a paper-based survey concerning your satisfaction and feedback for the program.

To evaluate the outcomes of the training you will be asked to complete four measures described below on two separate ocassions, 1) once before the study begins, and 2) once after the eight training sessions are completed. It may take 60 minutes each time for you to finish these four measures.

1) The Trail Making Test has two parts each of which is timed using a stop watch. In Part 1 you will use a pencil to connect a series of dots numbered from 1 to 25. In Part 2 you

will connect dots again this time alternating between numbers and letters (1, A , 2, B , etc.).

2) Walking speed will be assessed by asking you to walk at your preferred pace for 10 meters. Then, you will walk the same distance four times. Each time you will walk while doing one of the following four tasks. The first task asks you to walk while stating as many words as possible within a category such as animal, fruit, vegetable, or sports. The second task asks you to walk while listening to the researcher give you a number and you count down by three from that number. For example, if you hear a number of 365, you will say 362, 359, 356, 353, and continue reducing the number by three. The third task asks you to walk while listening to a recording of the words "high" and "low" spoken in either a high or a low pitch and reporting the pitch of the word in a timely manner while ignoring the meaning of the spoken word. The fourth task asks you to walk while answering open-ended questions such as "Give three reasons explaining why you prefer dogs, cats, both, or neither."
3) The Timed Up-and-Go test is done by timing the number of seconds it takes for you to rise from a chair with arms, walk 3 meters, turn around, walk back to the chair, and sit down again.
4) The Falls Efficacy Scale International will require you to rate your level of concern that you might fall while doing 16 daily activities such as getting dressed or undressed, taking a bath or shower, and going up or down stairs. You will rate each activity on a scale from 1 to 4; 1 being not at all concerned and 4 being very concerned.

Your training sessions will be video recorded to facilitate data anylysis. These videos will provide important information concerning your progress during the training. Videos from the study will be held in the music therapy archives at the Southwestern Oklahoma State University. They will be used by the researchers only and stored in a locked cabinet.

We ask your permission to edit these videos to use in student training, and in the education of other professionals and the general public. Yet, it is possible to participate in the study without granting permission to use the videos for educational purposes. Without permission, the videos will be used only for data collection/verification.

RISKS

No risks are anticipated with your participation beyond those you experiences in your everyday life.

BENEFITS

It is possible that you will experience some changes in your physical and cognitive functioning as a result of your participation in the study. You may have improvements in gait stability, balance, and attention. You may have less concern about falling. Furthermore, your participation will help verify the specific benefits individuals with concerns about falls can experience as a result of their participation in the music training program.

PAYMENT TO PARTICIPANTS

You will not be paid for participating in the study.

INFORMATION TO BE COLLECTED

To perform this study, researchers will collect information about you. This information will be obtained from a brief interview concerning educational and musical background/preference conducted by the researcher. Also, information will be collected from the study activities that are listed in the procedures section of this consent form.

Your name will not be associated in any way with the information collected about you or with the research findings from this study. The researcher(s) will use a study number or a pseudonym instead of your name to represent him/her in the study.

The information collected about you will be used by: Yu-Ling Chen and Dr. Cynthia Colwell and the class of other persons or groups authorized to use and/or disclose the information internal to the University, Lawrence Campus, including KU's Center for Research and officials at KU that oversee research, including committees and offices that review and monitor research studies.

In addition, Yu-Ling Chen will share the information gathered in this study, including your information, with Yi-Wei Huang, the research assistant at the Southwestern Oklahoma State University. Again, your name would not be associated with the information disclosed to this individual.

The researchers will not share information about you with anyone not specified above unless required by law or unless you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your information for purposes of this study at any time in the future.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas and/or Southwestern Oklahoma State University, or to participate in any programs or events of the University of Kansas and/or Southwestern Oklahoma State University. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose further information collected about you, in writing, at any time, by sending your written request to: Yu-Ling Chen, 1530 Naismith Drive, Room 448, Murphy Hall, Division of Music Education and Music Therapy, The University of Kansas, Lawrence, KS 66045-3103. Or. Yu-Ling Chen, 100 Campus Dr., Department of Music, Southwestern Oklahoma State University, Weatherford, OK 73096.

If you cancel permission to use your information, the researchers will stop collecting additional information about you. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher(s) listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study and the use and disclosure of information about myself for the study. I understand that if I have any additional questions about my rights as a research participant, I may call +1 (785) 864-7429 or write the Human Subjects Committee Lawrence Campus (HSCL), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7563, email irb@ku.edu. Or, I may contact the chair of the Southwestern Oklahoma State University Institutional Review Board-Protection of Human Subjects Committee (IRB-PHSC), Dr. Michael Wolff, Associate Professor for the Department of Psychology. He may be contacted at 580-774-3720.

[Please check one of the boxes below:]

☐ I agree to take part in this study as a research participant and to be video recorded during the sessions. I also authorize the release of photographs, video mages, or other likenesses of me for educational purposes.

☐ I agree to take part in this study as a research participant and to be video recorded during the sessions, but I **do not** agree to authorize the release of photographs, video mages, or other likenesses of me for educational purposes.

By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

____________________________ ____________________

Type/Print Participant's Name Date

____

Signature

Researcher Contact Information

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Appendix C

Sample Questionnaire for Participants' Demographic Information and Song Preferences

- **Name: ________________________**
- **Gender:** ☐Male ☐Female
- **Age: _______________**
- **Has at least one fall during the last 12 months:** ☐Yes ☐No
- **How many years of education do you have? _________________**
- **Please describe your musical background (play(ed) instrument(s), sing (sang) in a choir, attend(ed) concerts, listen(ed) to music, etc.):**

  ____

  ____
- **Song preferences:**

Song title	I know the song. I can sing along at least the first verse and the chorus if lyrics are provided.	I like the song. I will enjoy singing the song during the sessions.
1. America the Beautiful	☐Yes ☐No	☐Yes ☐No
2. Don't Fence Me In	☐Yes ☐No	☐Yes ☐No
3. Don't Sit Under the Apple Tree	☐Yes ☐No	☐Yes ☐No
4. Five Foot Two, Eyes of Blue	☐Yes ☐No	☐Yes ☐No
5. He's Got the Whole World in His Hands	☐Yes ☐No	☐Yes ☐No
6. Hey, Good Lookin'	☐Yes ☐No	☐Yes ☐No
7. How much is That Doggie in the Window	☐Yes ☐No	☐Yes ☐No
8. I'll Fly Away	☐Yes ☐No	☐Yes ☐No
9. I've Been Working on the Railroad	☐Yes ☐No	☐Yes ☐No
10. Love Me Tender	☐Yes ☐No	☐Yes ☐No
11. Oh Susanna	☐Yes ☐No	☐Yes ☐No
12. Oklahoma	☐Yes ☐No	☐Yes ☐No
13. Ring of Fire	☐Yes ☐No	☐Yes ☐No
14. Side By Side	☐Yes ☐No	☐Yes ☐No
15. Sugar Time	☐Yes ☐No	☐Yes ☐No
16. Take Me Home Country Road	☐Yes ☐No	☐Yes ☐No
17. This Land is Your Land	☐Yes ☐No	☐Yes ☐No
18. This Little Light of Mine	☐Yes ☐No	☐Yes ☐No
19. Walk the Line	☐Yes ☐No	☐Yes ☐No
20. You Are My Sunshine	☐Yes ☐No	☐Yes ☐No
Please name songs not included above but you would like to sing during the sessions:		

Appendix D

Sample Visual Analogue Scale for Feasibility

- Session No. _______________
- Please mark on the line below indicating your perceived levels of fatigue/difficulty/anxiety/enjoyment during today's session:

	Minimum	Maximum
Physical Fatigue	______________________________	
Mental Fatigue	______________________________	
Task Difficulty	______________________________	
Anxiety	______________________________	
Enjoyment	______________________________	

- Please write down how many falls you have experienced between the last session and today's session. Also specify if you have an injury due to the fall(s):

  ____

(Falls are defined as "inadvertently coming to rest on the ground, floor, or other lower level, excluding intentional change in position to rest in furniture, wall, or other objects (p.1)." (Department of Aging and Life Course, 2007)

Appendix E

Sample Questionnaire for Musical Dual-Task Training Program Feedback

- Please indicate your level of agreement for the following statements:

	1 strongly disagree	2	3	4	5 strongly agree
1. The program is beneficial					
2. I am satisfied with the program					
3. I will continue if the program to continues					
4. I am willing to recommend this program to others					

- Please list any benefits (if any) you experienced during your participation in the program:

____

- Please list any unfavorable effects (if any) you experienced during your participation in the program:

____

Appendix F

Group Musical Dual-task Training (G-MDTT) Manual

A: Intervention Theory

Group Musical Dual-task Training (G-MDTT) is designed to train executive function and the ability to dual task, which refers to performing a motor task and a cognitive task at the same time. Poor executive function and impaired dual-task performance are two of the risk factors of falls. Accordingly, the goal of G-MDTT is to help prevent falls through reducing these risk factors. G-MDTT targets community-dwelling adults who have concerns about falls.

G-MDTT involves the practice of seated toe tapping/heel lifting while simultaneously singing or playing simple percussive instruments as well as walking while simultaneously singing or playing simple percussive instruments. In addition, participants have to respond to sensory cues that simulate every day activities, such as responding to traffic signs, avoiding obstacles (visual stimuli), or talking to a companion (auditory stimuli) while toe tapping, heel lifting, and walking. The movements of toe tapping and heel lifting are realized by operating a drum set including a bass drum and a high-hat cymbal, and a pair of foot tambourines. Dual-task is structured as a musical experience because making music is demand-intensive, specifically for memory and attention, potentially enhancing the attention network. (Strait & Kraus, 2011; Wan & Schlaug, 2010). Being able to effectively and efficiently allocate attention between the motor task and the cognitive task is the key to the success of dual-task. Music is also used to motivate and entrain participants in the G-MDTT sessions, and increase their level of adherence to the program. (Hamburg & Clair, 2003; Trombetti et al., 2011). Music may also reduce the amount of attention required to perform repetitive movements, such as walking, as gait often become synchronized with the music's rhythm. This may allow the participants to focus more of their attention resources on other tasks, by allowing them to focus less on gait movements, due to the potential automation of gait movements (Maclean, Brown, & Astell, 2014). By freeing up these attention resources, older adults may be better able to perform a dual-task activity.

B: Intervention Content

B.1: Person Selecting the Music

Participants selected the songs they sing in the sessions from a limited set. A limited set of songs is provided because the therapist likes to make sure the songs are in duple meters such as 2/4 or 4/4, which is appropriate for gait movement. The songs are also appropriate if they are at a moderate-to-fast tempo in nature, 108 to 112 beats per minute. A moderate-to-fast tempo is recommended because older adults are capable of walking with this cadence and the walking will provide them an exercise at a moderate level of intensity (Marshall et al., 2009; Tudor-Locke, Barreira, Brouillette, Foil, & Keller, 2013). Participants' selections are based on familiarity and preference. One of the tasks in the G-MDTT intervention is paying attention to the lyrics and only singing the lyrics lines written in a specific color. This task focuses on the ability to respond to the target stimuli while inhibiting the response to the non-target stimuli. Therefore, it is better for the participants to know the melody and lyrics of the songs. If the participants are not familiar with the songs, it will be difficult to know if their potential struggles of performing this task are due to the inability to respond to the target and inhibit response to the non-target or because they are still learning how to sing the songs. Preference is also important as participants may be more motivated if they like the songs they are singing. When the therapist composes a song list, he or she should also consider the participants' age and cultural background. For example, "Side by Side" may not be known to a group with a mean age of 79 in this present study but it may be known by a group of younger adults. In addition, "Oklahoma" might not be as familiar to the participants outside of state of Oklahoma. Participants may suggest their song choices. The therapist just has to make sure the songs they suggested are in duple meter, at a moderate-to-fast tempo, familiar to all group members, and liked by majority of the members. Table displays the list of songs used in the present study. This list is to be used as a reference and the therapist should feel free to move beyond the list.

Table 16

Recommend Song List

	Song Titles
1	America the Beautiful
2	He's Got the Whole World in His Hand
3	Hey Good Lookin'
4	I'll Fly Away
5	I've Been Working on the Railroad
6	Oklahoma
7	This Land Is Your Land
8	You Are My Sunshine

The music played by the therapist for playing instruments in the sessions is selected by the therapist. The therapist selects well-known classical music in binary form, or with distinct sections, since these types of organization offered participants the opportunity to respond to changes. A recommended list is presented in Table 2.

B.2: Music

The songs used for singing are usually folk songs or old popular songs for which the lyrics and sheet music are easily resourced. The music used for instrument playing is classical music whose piano transcription (if originally an orchestra arrangement) may be obtained from IMSLP website. IMSLP stands for International Music Score Library Project, providing free downloadable sheet music or recorded music in public domains. During the session, the therapist has to improvise the accompaniment in order to give cues for rhythmic patterns. Examples of the piano accompaniment with rhythmic patterns are shown in Figure 18 and 19.

B.3. Music Delivery Method (Live or Recorded)

Music is provided live by the music therapist. The participants will also play foot tambourines, bass drum, high-hat cymbal, and other simple percussive instruments with the therapists as a small ensemble. The music therapist and the participants also sing songs together. Piano is used as an accompaniment instrument for the therapist for the reasons of it having a full range and being loud enough for the participants to hear even when they are playing along with the drum sets. Guitar or other accompaniment instruments would be possible if the therapist could create clear musical cues for the participants to follow accordingly. Recorded music has potential especially when the participants are well trained in the process and can be implemented as a home program. Recorded music needs to be used with caution because the tempo will not be able to accommodate the condition of walking at various situations.

B.4: Intervention Materials

The music and non-music materials include 1 piano, 4 music stands, 4 lyric sheets, 4 rhythmic patterns sheets, 2 drum sets including a bass drum and a high-hat cymbal, 6 pairs of foot tambourines, 6 chairs, 1 poster, and 1 poster stand.

B.5: Intervention Strategies

Description of motor task and cognitive task:

The motor task includes four practices. Toe tapping/heel lifting and marching in place are considered simple tasks. Walking forward and backward with specific rhythmic patterns is a moderate task. Seated toe tapping/heel lifting with specific rhythmic patterns is a difficult task. These four practices are detailed as follows:

1. Seated toe tapping/heel lifting with a steady beat (simple) (See Figure 1): Participants take turns playing the bass drum, high-hat cymbal, and foot tambourine, circulating through the different positions as they play together as an ensemble.
2. Marching in place with a steady beat (simple): Participants march in place, stepping in time with a beat.
3. Walking forward and backward with specific rhythmic patterns (moderate): The participants walk continuously with a specific pattern, such as forward for three steps then backward for three steps, stepping in time with a beat.
4. Seated toe tapping and heel lifting with specific rhythmic patterns (difficult): Participants play a simple, four-beat long rhythm, or a combination of two four-beat long rhythms on the bass drum, high-hat cymbal, and foot tambourine. The bass drum, high-hat drum, and foot tambourine each play unique and independent rhythms. The participants play simultaneously and continuously as an ensemble. For example, the therapist may assign to participants who play the foot tambourines a rhythm and assign to participants who plays the drum sets another rhythm. The therapist first teaches the rhythm by modeling. The participants are also provided a rhythm sheet presented on the stands in front of them. Figure 26 shows rhythm sheets used in the task on a stand. Examples of rhythmic patterns of different difficulty levels are presented in Table 14. Some rhythm patterns are more difficult than the others. The therapist should make the selections based on participants' capabilities.

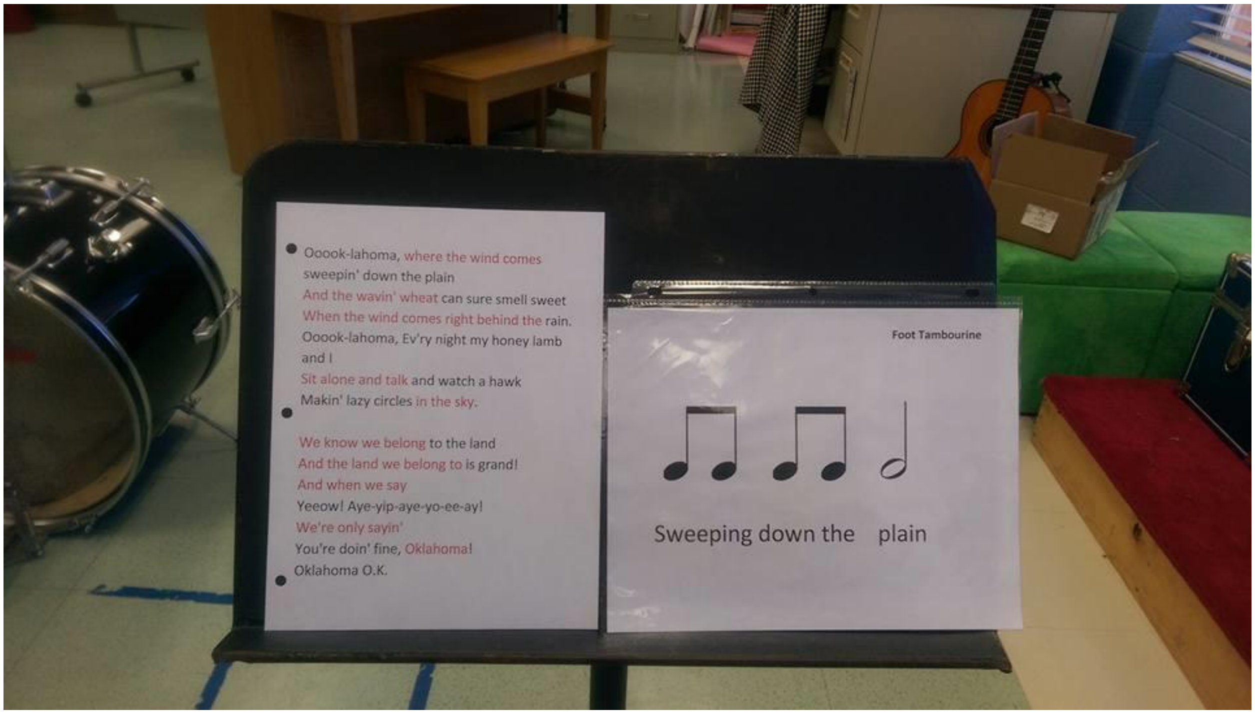

Figure 26. Rhythm sheet and lyrics sheet on a music stand.

The cognitive task includes four practices. Singing familiar songs and playing simple percussive instruments freely are considered simple tasks. Singing in response to visual cues and Instrument playing in response to auditory cues are difficult tasks. These four practices are detailed as follows:

1. Singing (simple): The participants sing familiar songs.
2. Instrument playing freely (simple): The participants play freely on a variety of simple percussive instruments such as tambourine, maracas, woodblocks, and pedal drum. They may also play on the cymbal and tom-tom mounted on the bass drum if they are playing the drum set. Participants take turns playing the tambourine, maracas, woodblocks, and pedal drum, circulating through the different positions as they play together as an ensemble.

3. Singing in response to visual cues (difficult): The participants are provided a lyrics sheet with lines of lyrics written in two to three colors, such as black, red, and green. Each participant is assigned a color and instructed to only sing lines of the respective color and to not sing when shown lines in another color. Colors are randomly assigned to the lyrics lines to keep the participants engaged and encourage active thinking. The lyrics sheet is presented on a music stand in front of the participants (see Figure 26)
4. Instrument playing in response to auditory cues (difficult): The therapist plays music in a binary form which includes two distinct sections or music in a rondo form which includes up to two episodes in addition to the reoccurring theme, making three distinct sections. The participants are instructed to only play their instruments continuously when they hear one particular musical section. They need to stop playing when they hear the other musical sections presented.

Motor task and cognitive task combination:

Table 17 illustrated a dual-task combination matrix displaying all the possible dual-task combinations, which can be arranged into a session schedule based on the types of tasks (seated, walking, singing, walking) and difficulty levels. There are five levels of difficulty: The level 1 combination is at the least level of difficulty and includes 4 combinations; the level 5 combination is the most difficult and includes two combinations.

Table 17

Dual-task Combination Matrix

		1a Simple	1 b Simple	3a Difficult	3b Difficult	
	Cognitive Task / Motor Task	Singing familiar songs	Playing a simple percussive instrument freely	Singing in response to visual cues	Playing a simple percussive instrument in response to auditory cues	
1A Simple	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set	1A + 1a Level 1	1A + 1b Level 1	1A + 3a Level 3	1A + 3b Level 3	Unit 1 or 3
1B Simple	Marching in place	1B + 1a Level 1	1B + 1b Level 1	1B + 3a Level 3	1B + 3b Level 3	Unit 2 or 4
2 Moderate	Walking forward and backward with specific rhythmic patterns	2 + 1a Level 2	2 + 1b Level 2	2 + 3a Level 4	2 + 3b Level 4	Unit 2 or 4
3 Difficult	Seated toe tapping/heel lifting with specific rhythmic patterns with foot tambourines or on a drum set	3 + 1a Level 3	3 + 1b Level 3	3 + 3a Level 5	3 + 3b Level 5	Unit 1 or 3
		Unit 1 or 3	Unit 2 or 4	Unit 1 or 3	Unit 2 or 4	

Single session schedule:

Individual session follows a schedule shown in Table 18, which begins with a 5-minute of preparation followed by 40 minutes of dual-task practice and concluded with a 5-minute of stretch exercise and relaxation. An entire session is 50 minutes in length.

The purpose of the preparation unit is to warm up and learn or review the techniques of heel-up and heel-down for playing the bass drum and high-hat cymbal. The following is the instructions for playing the drum set:

1. Put a carpet under the bass drum and the high-hat cymbal so they do not move while the participants are playing.
2. Position the bass drum on the right and the high-hat cymbal on the left. Arrange the bass drum pedal and high-hat cymbal pedal so that with the participants' feet on the pedals, their two legs form a V shape.
3. Adjust the seat's height. Let the participants sit slightly higher so that their thighs and legs are at slightly more than the right angles to each other. Place the heels a couple inches in front of the knees with their feet on the pedals. Remind the participants to sit up avoiding leaning forward or backward.
4. Instruct the participants to practice the heel-down technique. Ask the participants to place their entire feet on the pedals and have the balls of the feet pressed down on the pedal to activate the beaters. Their heels act as a pivot point for the feet allowing the participant to play with his or her whole foot, instead of the legs.
5. Let the participants play heel-down alternating between right leg and left leg operating between bass drum and high-hat cymbal until they feel comfortable.
6. Instruct the participants to practice the heel-up technique. Ask the participants to place only their toes on the pedals with their heels lifted up without touching the pedals. To activate the beaters, instruct the participants to use the weight of their entire feet to press down on the pedals

7. Let the participants play heel-up alternating between right leg and left leg operating between bass drum and high-hat cymbal until they feel comfortable.

The following dual-task practice main course is divided into four units, alternating between seated dual-task combinations and walking combinations. The first two units should consist of singing. The last two units should consist of instrument playing. Each unit involves 8 minutes of practice and 2 minutes of breaks for transitioning between positions. The instructions given to participants for stand-up and sit-down are presented on page 53 and 54. An armed chair is recommended especially if a participant or participants exhibits balance issues. However, sometimes the armrests might interfere with hand movements. Also, the participant may not be able to adjust the height of a regular armchair chair so they have to sit on a drum stool, which has no armrest, so the therapist should make sure to provide a table or chair by the participants' side when they transition between positions so they have something stable to hold onto. If the space is big enough, the room can be divided as a place for drum sets, chairs, a place for seated dual-tasks and another as a place for walking dual-tasks free of obstruction. This is ideal since the participants can move to another side of room without the hassles of moving the chairs. If chairs do have to be removed, make sure to help move the chairs after the participants have already moved, or make sure the participants are standing up straight for at least five seconds before the chairs are removed.

Let the participants know they can rest whenever they need, especially for those participants who may have a knee or hip problem. Although the standard practice of the drum set is right foot for bass drum and left foot for high-hat, it can be switched if the right foot is not their dominant leg or is weaker.

The last unit of a session concludes the session through performing some simple stretches and relaxation exercises. The stretching exercises include knee extension, ankle circles, arm extensions, and shoulder rolls and are to be performed seated. These exercises are selected from the study of Johnson, Otto, and Clair (2001). The following is the instructions for the exercises:

1. Knee extension: Instruct the participants to raise one foot by straightening the leg until leg is almost parallel to the floor. Point the toes upward for 3 seconds and slowly lower the leg back down. Switch legs and perform the same movements. Alternate legs, until the participants perform four repetitions with each leg.
2. Ankle circles: Instruct the participants to lift up one foot off the ground and use the toes of that foot to draw clockwise and counter-clockwise circles in the air. Switch feet and perform the same movements. Alternate feet, until the participants perform four repetitions with each foot.
3. Arm extensions: Place one hand on the back of the head with the elbow of that arm raised above the shoulder and then straighten the arm up above the head, like waving hi to people. Alternate arms, until the participants perform four repetitions with each arm.
4. Shoulder rolls: Instruct the participants to raise the shoulders up to the ears and then slowly roll them back down so the shoulders create a circular motion. Repeat doing the circles five times and then do the circles in the other direction for another five times.

Table 18

Individual Session Schedule

Unit	Time (minute)	Task
Preparation	5	Warm up/Review the techniques of heel-up and heel-down for playing the bass drum and high-hat
1	8	Seated and singing combination
	2	Break/Transition
2	8	Walking and singing combination
	2	Break/Transition
3	8	Seated and instrument playing combination
	2	Break/Transition
4	8	Walking and instrument playing combination
	2	Break/Transition
Wrap up	5	Stretch exercise/Relaxation

Treatment schedule:

A course of G-MDTT consists of eight 50-minute sessions. The two fundamental principles for planning out the eight sessions are 1) the sessions are to increase in difficulty, and 2) the therapist is to tailor the program to the participants' progress and capabilities. The pace at which more difficult combinations are introduced should be determined based on close observation of the participants' performances.

Table 19 illustrates a beginner-level first session schedule where the participants only practice dual-task combinations of level 1 task difficulty. The same session schedule should be repeated at least two times, possibly more, until all the participants are comfortable with performing these dual-task combinations. After the participants master the beginner-level, an intermediate level session plan can be introduced. Table 19 shows an example of this. Combinations of up to level 3 can be arranged into intermediate levels. Please refer to the Dual-task Combination Matrix for possible combinations. Notice that even though the difficulty increases, participants should always start with level 1 within a unit, so they can warm up and feel more prepared. The advanced level of session, which is exemplified in Table 21, can be introduced after the participants complete the intermediate levels.

Table 19

Session Schedule at Beginner Level

Unit	Time (m)	Level of Difficulty	Task
Preparation	5		Warm up/Review the techniques of heel-up and heel-down for playing the bass drum and high-hat
1	8	1	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Singing familiar songs
	2		Break/Transition
2	8	1	Marching in place + Singing familiar songs
	2		Break/Transition
3	8	1	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Playing a simple percussive instrument freely
	2		Break/Transition
4	8	1	Marching in place + Playing a simple percussive instrument freely
	2		Break/Transition
Wrap up	5		Stretch exercise/Relaxation

Table 20

Session Schedule at Intermediate Level

Unit	Time (m)	Level of Difficulty	Task
Preparation	5		Warm up/Review the techniques of heel-up and heel-down for playing the bass drum and high-hat
1	8	1	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Singing familiar songs
		3	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Singing in response to visual cues
	2		Break/Transition
2	8	1	Marching in place + Singing familiar songs
		2	Walking forward and backward with specific rhythmic patterns + Singing familiar songs
	2		Break/Transition
3	8	1	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Playing a simple percussive instrument freely
		3	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Playing a simple percussive instrument in response to auditory cues
	2		Break/Transition
4	8	1	Marching in place + Playing a simple percussive instrument freely
		2	Walking forward and backward with specific rhythmic patterns + Playing a simple percussive instrument freely
	2		Break/Transition
Wrap up	5		Stretch exercise/Relaxation

Table 21

Session at Advanced level

Unit	Time (m)	Level of Difficulty	Task
Preparation	5		Warm up/Review the techniques of heel-up and heel-down for playing the bass drum and high-hat
1	8	1	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Singing familiar songs
		3	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Singing in response to visual cues
		5	Seated toe tapping/heel lifting with specific rhythmic patterns with foot tambourines or on a drum set+ Singing in response to visual cues
	2		Break/Transition
2	8	1	Marching in place + Singing familiar songs
		2	Walking forward and backward with specific rhythmic patterns + Singing familiar songs
		4	Walking forward and backward with specific rhythmic patterns + Singing in response to visual cues
	2		Break/Transition
3	8	1	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Playing a simple percussive instrument freely
		3	Seated toe tapping/heel lifting with a steady beat with foot tambourines or on a drum set + Playing a simple percussive instrument in response to auditory cues
		5	Seated toe tapping/heel lifting with specific rhythmic patterns with foot tambourines or on a drum set + Playing a simple percussive instrument in response to auditory cues
	2		Break/Transition
4	8	1	Marching in place + Playing a simple percussive instrument freely
		2	Walking forward and backward with specific rhythmic patterns + Playing a simple percussive instrument freely
		4	Walking forward and backward with specific rhythmic patterns + Playing a simple percussive instrument in response to auditory cues
	2		Break/Transition
Wrap up	5		Stretch exercise/Relaxation

C: Intervention Delivery Schedule

One course of G-MDTT is 50 minutes long, twice a week, for four weeks, for a total of eight sessions. However, the therapist does not have to conclude after the eight sessions, and the program can continue if the therapist believes it is appropriate.

D: Interventionist

The interventionist should be a board-certified music therapist. One therapist is able to deliver the intervention. It is beneficial to have an intervention assistant, such as a music therapy student, intern, or other health professional to model the dual-task for the participants while the interventionist is accompanying or providing musical cues on the piano.

E: Treatment Fidelity

The therapist is provided a G-MDTT protocol manual. The manual is composed following the reporting guideline by Robb (2011).

F: Setting

The interventions can be delivered in any open space that is accessible to the individuals in the community, such as a choir room or fellowship hall at a church, an activity room in a retirement center, or a classroom at a school.

G: Unit of Delivery

G-MDTT is to be delivered in a small group of six.

Appendix G

Raw Data of Absolute Walking Speed and Dual-task Cost at Pre and Posttest

Participant	Pretest		Posttest	
	Walking speed (s/m)		Walking speed (s/m)	
Single				
C	12.75		14.07	
R	9.46		9.13	
CR	9.33		9.16	
DR	9.62		10.01	
DD	7.14		7.65	
MD	10.06		10.95	
	Walking speed (s/m)		Walking speed (s/m)	Dual-task cost (%)
Verbal fluency				
C	15.54	22	17.33	23
R	17.21	82	13.93	53
CR	10.66	14	10.57	15
DR	11.71	22	12.14	21
DD	8.16	14	8.60	12
MD	11.42	14	11.67	7
Subtraction 3				
C	19.50	53	18.74	33
R	21.62	129	15.52	70
CR	13.12	41	11.71	28
DR	13.56	41	13.21	32
DD	10.14	42	9.99	31
MD	12.73	27	12.38	13
Auditory Stroop				
C	15.13	19	15.83	13
R	18.50	96	12.75	40
CR	12.00	29	11.44	25
DR	13.26	38	13.08	31
DD	9.39	32	9.70	27
MD	14.36	43	13.80	19
Question				
C	17.83	40	18.42	31
R	17.66	87	16.61	82
CR	11.38	22	11.25	23
DR	13.57	41	13.36	33
DD	8.29	16	10.15	33
MD	13.43	33	12.83	17

Appendix H

Raw Data of Cognitive Task Performance in Dual-task Walking

Participant	Pretest	Posttest
Number of items named in "Verbal fluency" task		
C	8	7
R	6	7.67
CR	7.67	7
DR	6.67	7
DD	7.67	7.33
MD	5.67	6.67
Number of subtractions calculated in "Subtraction 3" task		
C	6.67	4.67
R	4.33	4.33
CR	4.67	4.67
DR	6.67	7.67
DD	2	2.67
MD	3.67	4.33
Accuracy of "Subtraction 3" task (%)		
C	46	46
R	70	60
CR	93	85
DR	95	91
DD	67	88
MD	81	69
Number of responses in "Auditory Stroop" test		
C	9	9
R	8.67	8
CR	5.67	6
DR	6.67	7
DD	5	5.67
MD	7.67	6
Accuracy of "Auditory Stroop" test (%)		
C	72	93
R	88	100
CR	94	100
DR	85	95
DD	80	88
MD	30	50