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The Effect of Patterned Sensory Enhancement on Balance and Ambulation in Persons Diagnosed with Parkinson's Disease

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THE EFFECT OF PATTERNED SENSORY ENHANCEMENT ON BALANCEAND AMBULATION IN PERSONS DIAGNOSED WITH PARKINSON'S DISEASE

by

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One rehabilitation protocol effective in delaying the symptoms of Parkinson's Disease (PD) is Lee Silverman Voice Training BIG (LSVT BIG), comprising pre-gait exercises and gait training. This study seeks to determine if combining Patterned Sensory Enhancement (PSE), a music therapy intervention, with LSVT BIG will improve quality of movement. During physical therapy sessions with three participants, a music therapist adapted the PSE stimuli to support each patient's motor needs, which were then recorded on CD and sent with patients to exercise with at home. Results showed improved balance and ambulation comparing pre- and post-measures of the BERG balance scale and timed up and go test (TUG), however they were not statistically significant. Participants also completed subjective anonymous exit surveys which communicated overall positive experiences incorporating PSE into LSVT BIG.

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CHAPTER I

INTRODUCTION

Problem

According to the Parkinson's Disease Foundation (2014), there are approximately 60,000 newly diagnosed cases of Parkinson's Disease (PD) in the United States each year, meaning roughly one million Americans are currently living with PD. Medical and technological advances have contributed to a longer average life span for the general population, but with no cure for PD, its prevalence rate is predicted to rise due to its progressive nature. PD is a progressive neurodegenerative disease with an average age of onset around 60, with symptoms including "rigidity, muscle tremors, slow movements, and difficulty initiating physical and mental activity" (Kalat, 2009, p. 249). This is due to a loss of neurons in a midbrain area, called the substantia nigra, which releases the neurotransmitter dopamine through a pathway of brain structures that through simultaneous activation generate motor movement. As neurons in the substantia nigra decrease, dopamine levels decrease in the basal ganglia, which are a group of brain structures responsible for initiation of movement, that leads to slower onset or ceasing of movements (Kalat, 2009; Morris, 2006).

The cause of PD remains unknown, and there is no specific diagnostic test. However a neurologist, movement disorder specialist, or family physician can provide an accurate diagnosis using specific criteria. According to the UK Parkinson's Disease Society, bradykinesia must be present along with at least one of the following: muscular rigidity, 4-6 Hz rest tremor, or postural instability not caused by primary visual, vestibular, cerebellar, or proprioceptive dysfunction. Bradykinesia, meaning "slow movement," manifests in short, shuffling steps, difficulty with repetitive movements, or a decrease in facial expression. A combination of these symptoms may lead to freezing of gait, increased fall risk, and difficulties with oral motor planning (Bish-Ziegelhofer, 2014; Hughes, 1992, Parkinson's Disease Foundation, 2014).

Treatment for the motor symptoms of PD includes pharmacologic interventions, surgical procedures, and various rehabilitative therapies.

> The combined direct and indirect cost of Parkinson's, including treatment, social security payments and lost income from inability to work, is estimated to be nearly $25 billion per year in the United States alone. Medication costs for an individual person with PD average $2,500 a year, and therapeutic surgery can cost up to $100,000 dollars per patient. (Parkinson's Disease Foundation, 2014)

Rationale for Research

The most widely used pharmaceutical treatment for PD is the drug L-Dopa, intended not to cure the disease but to decrease presence of symptoms. L-dopa is a precursor to the catecholamine neurotransmitters dopamine, norepinephrine, and epinephrine by crossing the blood-brain barrier and converting into dopamine. However, it has proven only moderately effective due to its side effects and the disease's several contributing factors. Side effects in the early stages include nausea, vomiting, drowsiness, confusion, and headaches. In later stages, side effects may include hallucinations, delusions, and psychosis (Kalat, 2009; Sperry, 2015). Motor symptoms which may not respond satisfactorily to dopaminergic medication include freezing of gait during turns or initiation, festination (i.e., quick shuffling steps), or postural disturbances like camptocormia (i.e., "bent spine") or antecollis (i.e., "dropped head") (Ebersbach, 2014). While L-Dopa can substitute for dopamine, it cannot replace lost neurons, and for individuals in the late stages of the disease, and increased dosages have not proven effective in decreasing symptoms (de Dreu, Kwakkel, & van Wegen, 2014; Kalat, 2009; Morris, 2006; Neiuwboer, 2008). This progressive neurologic disease manifests not only in physical deficits but also in non-motor symptoms like memory loss, anosmia (decreased sense of smell), hypophonia (low vocal volume), decreased speech intelligibility, sleep disturbance, painful foot cramps, autonomic dysfunction like postural lightheadedness, disordered sphincter control, sexual dysfunction, and abnormal sweating (Parashos, 2012; Sperry, 2015). As a result of these debilitating factors and as additional side effects from medication, psychiatric symptoms may emerge such as depression, anxiety, emotional lability, psychotic phenomena, and loss of motivation (Ebersbach, 2014; Parashos, 2012; Sperry, 2015).

In many cases, it appears that the numerous side effects of dopamine replacement therapy outweigh the benefits. In search for successful alternatives, mounting evidence has accumulated for the role of exercise in the improvement of motor performance, facilitating both cognitive and automatic control of movement. This has initiated a plethora of PD-specific physical therapy exercise programs, for individuals and groups, focused on functional mobility, gait training, and vestibular exercises (Ebersbach, 2010; Ebersbach, 2014, Farley, 2002, Lima, 2013, Petzinger et. al, 2013)

Furthermore, physical therapy has been found to significantly overcome the ceiling effects of pharmaceutical interventions when paired with auditory cueing (O'Konski, 2010; Pachetti et. al, 2000; Thaut, 2005, Yamada, 2011). One such treatment modality is music therapy as it applies to neurorehabilitation. For decades, neuroscientific research has examined the ways in which the components of music are perceived, processed, and generated throughout the human brain. Neurologic Music Therapy (NMT) is a codified system of 20 "biomedical interventions of music within therapy, rehabilitation and medicine" generated from such collaboration of neurology and music research (Thaut, 2005, p. 126). While some interventions employ components of rhythm to address gait, other techniques use the social and performance aspects of music when applied to psychosocial goals. One intervention that utilizes both rhythmic and melodic components in its application to neurorehabilitation is Patterned Sensory Enhancement (PSE), further explained in the review of literature. Thus a more multidisciplinary approach to PD treatment has presented as most effective in improving overall quality of life across studies of different disciplines.

Research Questions and Hypothesis

The current study sought to determine if the integration of Patterned Sensory Enhancement (PSE), into a PD-specific physical therapy regimen, commonly known as Lee Silverman Voice Training BIG (LSVT BIG), would promote greater quality of movement for individuals with Parkinson's disease. The study also sought to gauge participants' subjective perceptions of using PSE. The proposed hypothesis: Participants who incorporate PSE into their LSVT BIG exercise regimen will yield improved balance and ambulation, as evidenced by a statistically significant difference between mean pre-test scores and mean post-test scores for both the BERG and the TUG assessments. Null hypothesis: There will be no significant difference between each of the pre- and post-scores of the BERG and TUG.

CHAPTER II

LITERATURE REVIEW

Exercise and Parkinson's Disease

It was once believed that the human brain reaches full maturation around the age of 21 years, where it remained static for the remainder of the lifespan. However, decades of neuroscience research has demonstrated how the brain's ability to change continues throughout the lifespan due to neuroplasticity. "Neuroplasticity is a process by which the brain encodes experiences and learns new behaviours, and is defined as the modification of existing neural networks by addition or modification of synapses" (Petzinger et. al, 2014, p.723). "Neuroplasticity includes a wide range of structural and physiological mechanisms including synaptogenesis, neurogenesis, neuronal sprouting, and potentiation of synaptic strength, all of which can lead to the strengthening, repair, or formation of neuronal circuitry" (Petzinger et. al, 2014, p.716) Exercise physiology has discovered that exercise in the treatment of PD heavily facilitates neuroplasticity, slows disease progression, and overrides the confounds of pharmaceutical and surgical intervention as evidenced by neurobiological and behavioral evidence (Fini, 2011). Lima, Scianni, and Rodrigues-de-Paula (2013) completed a systematic review with meta-analysis of two randomized trials and two quasi-randomized controlled trials of individuals with PD to determine if progressive resistance exercise improved muscle strength and physical performance. Progressive resistance exercise was defined as "movement against progressively increased resistance… involv[ing] repetitive, strong, or effortful muscle contractions,…and intensity was progressed as ability changed" (p. 8). All four trials averaged 15 weeks of exercise and presented a clinically worthwhile effect on walking capacity, as evidenced by the 6-minute walking test, but physical performance outcomes did not demonstrate clinically worthwhile. Two of the trials demonstrated high levels of participants' perceived exertion, according to their Borg ratings of perceived exertion, a subjective measure of exertion rated on a 6-20 Likert scale. Through goal-based physical therapy and aerobic exercise mediums, individuals with varying levels of PD strengthen and improve motor circuitry through mechanisms that include increased synaptic strength, generalized brain health, increased blood flow, altered immune response, and altered metabolism (Fini, 2011; Lima et. al, 2013; Petzinger et. al, 2014).

LSVT BIG Training

When clinicians recognized this need for PD patients to have more rigorous exercise, several programs emerged. LSVT BIG is among one of the most recognized exercise protocols throughout physical therapy best practices. BIG is modeled after the Lee Silverman Voice Treatment speech therapy program developed by Lorraine Ramig, PhD. CCC-SLP in 1987, abbreviated LSVT LOUD. Ramig created LOUD as a standardized, research-based protocol using intensive and high effort speech and vocalization exercises to target speech deficits commonly encountered in the PD population, including vocal loudness or amplitude, respiratory, laryngeal and articulatory function, and speech intelligibility (LSVT Global, 2017). Then in 2004, Becky Farley, PT, PhD and Cynthia Fox, PhD, CCC-SLP used the LOUD protocol as a template to create LSVT BIG. Like LOUD, the BIG program emphasizes high-amplitude movements to target a global motor control parameter, train a self-cueing strategy, and allow for maximal repetition in everyday living (Fini, 2011). This exercise protocol emphasizes the use of visual modeling and tactile cues to target bradykinesia and hypokinesia and encourage kinesthetic awareness.

The treatment concepts of LSVT BIG are: emphasis on amplitude, sensory calibration, high effort, intensive delivery, and quantification. A single focus on amplitude directly targets the disease- specific pathophysiology of PD, impaired internally cued amplitude regulation. Emphasizing amplitude trains a self-cueing strategy that can be used anywhere and anytime and provides an internal focus, allowing for maximum repetition in everyday living. Calibration is the ability for the patient to recognize and accept the relationship between increased movement *effort* and normal motor output. Many patients who begin LSVT BIG training comment that if they were to move in public how the PT instructs in therapy, their movements would seem overdone and ridiculous. Re-calibration refers to the process of teaching the patient to self-monitor and accept that what feels too big is actually within normal limits. The amount of effort needed for an individual with PD to reach a normal movement level feels similar to the amount of effort a healthy individual would feel to perform a “big” movement. When a patient is “re-calibrated” he/she would use bigger movements “automatically” in daily living. Furthermore, LSVT BIG requires high physical and mental effort to enforce active engagement to scale motor output. Clinical studies found that patients with PD walk with increased cadence and stride length when concentrating on performance, but both decrease when attention is distracted from movement execution. As the patient progresses, LSVT BIG clinic sessions increase in intensity, including more complex and challenging gait exercises (e.g. practicing on uneven surfaces, walking on inclines or declines, or doing several start-stop tasks, as one would experience in a public setting). This maintains motivation and accountability while practicing necessary skills for activities of daily living. Lastly the quantification component stipulates 16 one-hour sessions be delivered 1:1 by an LSVT BIG-certified physical or occupational therapist, which ensures that the protocol is standardized, increases feedback opportunities for the patient, and provides objective methods to document improvement (Bish-Ziegelhofer, 2014; Fini, 2011; LSVT Global, Inc., 2013).

This program's most notable clinical study was conducted in 2010, comparing LSVT BIG to a group training called Nordic Walking and a group assigned non-supervised home exercises for 58 individuals with PD. The primary outcome measure was motor performance as assessed by blind video rating using the Unified Parkinson's Disease Rating Scale (UPDRS) motor section. Criteria such as tremors, rigidity, finger taps, hand movements, leg agility, posture, and gait were scored on a Likert scale. All interventions were delivered by the same physiotherapist certified in both LSVT BIG and Nordic walking. ANCOVA analysis indicated that the LSVT group showed the greatest improvement after 16 weeks of therapy, Nordic walking showed a moderate change, and the home exercise showed slight improvement. LSVT was also superior to the other two programs in secondary outcome measures of a timed up-and-go (TUG) and a 10-meter gait assessment. All analyses were controlled for age, disease duration, and antiparkinsonian medication (Ebersbach et. al, 2010).

Sonification of Movement

Effenberg (2005) defines *movement sonification* as "transforming data into sound" (p. 53). Utilized primarily in motor performance domains of sports and physical rehabilitation, movement sonification considers kinematic and dynamic sound parameters to facilitate more efficient motor patterns associated with a particular exercise. Effenberg investigated whether perception and reproduction of complex gross-motor movement patterns were enhanced by visual, auditory, or audiovisual stimuli. When subjects were prompted to assess movements with each of the three conditions, they were most accurate when presented with audiovisual stimuli. When prompted to replicate complex movement patterns, audiovisual stimuli again produced the most efficient results (Effenberg, 2005). Effenberg, Fehse, and Weber (2011) continued this research by comparing effects of unimodal versus multimodal stimuli on motor performance of indoor rowing. Forty-eight participants randomly assigned to three groups were instructed to observe the rowing technique of a model and physically replicate it as close as possible. Group one was shown a video only model, group two was shown a video model with audio recordings of the rowing machine, and group three was presented a video model along with movement sonification. Participants trained two times a week for three weeks. Consistent with previous results, group three with visual and movement sonification demonstrated "faster and more precise learning" compared to the other two groups (Effenberg, Fehse, & Weber, 2011). These findings support the research hypothesis that sonification cues may act as a supportive supplement to the LSVT model which provides primarily visual cues.

Several studies have examined how the brain's auditory processes influence motor processes. Bidet-Caulet, Voisin, Bertrand, and Fonlupt (2005) examined how the brain perceives the sound of footsteps. Ten participants were given headphones to listen to 6-second sound clips of two sets of pre-recorded footsteps, randomized for speed, shoe type, ground/floor type, and sound intensity. Randomly within the clip, one set of footsteps would cross from one side of the listener to the other. The participant was to attend to when this cross occurred and click a response box as soon as they believed it occurred. This was implemented to ensure that participants placed fixed attention on the sound of the footsteps. Using fMRI imaging, results showed that not only were auditory areas of the brain activated but also motor areas involved in planning the corresponding motion, referred to in the article as the supplemental motor area (SMA) (Bidet-Caulet, Voisin, Bertrand, & Fonlupt, 2005). Friberg, Sundberg, and Frydén (2000) conducted a study that used the sound of footsteps to determine whether listeners could associate the sound with the movement that created it. Using adjectives such as "stamping," "springy," "graceful," "stumbling," "jumping" as they related to gait patterns, participants easily identified an auditory stimulus with its corresponding motor qualities. Such results indicate that if individuals are able to match a sound with a corresponding motion, they are likely able to execute (or attempt to execute) that same motion (Bidet-Caulet et al., 2005; Friberg et al., 2000; Yamada, 2009).

Lahav, Saltzman, and Schlaug (2007) applied the principles tested in Bidet-Caudet et al.'s and Friberg et al.'s studies to a music stimulus instead of footsteps. Lahav's researchers trained nine non-musicians to play a fifteen-note melody on the keyboard that consisted of five notes in a fixed-finger hand position. Participant practiced this melody until they were able to play it with minimal errors. Participants were then analyzed under fMRI while listening to three pieces of music: one was the piece they had learned to play, a second was a piece that included the same notes but in different order, and a third piece that included completely different notes. Results showed that among all participants, listening to the sample they learned to play generated significantly more activity in the frontoparietal motor-related network (including Broca's area, the premotor region, the intraparietal sulcus, and the inferior parietal region) compared to the other two samples (Lahav, Saltzman, & Schlaug, 2007). This provides implications that if physical rehabilitation patients are presented and practice a motor pattern paired with sonification in therapy, they would be likely to create motor memory for that sonified phrase. Then if that sonification was recorded and sent home with a patient, additional repetitions of similar quality would be completed outside of therapy due to the patient's motor association with the auditory stimuli.

Neurologic Music Therapy

In conjunction with the evidence that auditory stimuli generate activation of the motor cortex, neuroscience research has examined ways in which the components of music are perceived, processed, and generated throughout the human brain. Neurologic Music Therapy (NMT) is a codified system of “biomedical interventions of music within therapy, rehabilitation and medicine” generated from collaboration of neurology and music research (Thaut, 2005, p. 126). The neurological and physiological theory for the efficacy of NMT in neurologic rehabilitation is that not only does sound excite the central nervous system, but in fact, “rhythmically structured sound patterns…entrain the timing of muscle activation patterns” (Thaut et al., 1999 p.101). The nervous system responds to external stimuli and shares the sensory information from the stimuli with the motor system, which then initiates and shapes motor tasks, also known as entrainment.

Research suggests that auditory cues create faster physical responses than visual or tactile cues due to the proximity of the auditory and motor cortices (Thaut et al., 1999). Studies have found that entrainment of motor movements occurs on a subcortical level to an auditory stimulus (Effenberg, 2005; Thaut et al., 1996; Thaut et al., 1999). Motor entrainment to an auditory stimulus is seen particularly in intrinsically rhythmic central patterned generators (CPGs). Central pattern generators (CPGs) are neuronal circuits that carry specific timing information and when activated can produce rhythmic motor patterns such as walking and breathing in the absence of sensory or descending inputs (Marder & Bucher, 2001). CPGs are mediated subcortically and can be influenced cortically to create “meaningful movement patterns” (Marder & Bucher, 2001, p. R986). Because walking is a CPG movement, it can entrain to and be regulated by an auditory stimulus. “The presence of rhythmic cues adds stability in motor control immediately” (Thaut et al., 1999, p. 102).

A 1993 study by Thaut et. al demonstrated a correlation between auditory rhythmic cues and motor entrainment. Ten participants, all who displayed gait deficits due to stroke, were instructed to walk eight meters, first with no auditory stimulus at their own pace, and a second time with a musical composition designed for the intervention that matched the patient's initial walking speed. The music stimulus was an original composition that incorporated woodwinds, harpsichord, and percussion on a synthesizer. Using EMG signals, Thaut et al. sought to determine if this external auditory stimulus would improve temporal stride and/or increase muscular control in gait. Trials that included the auditory stimulus resulted in a statistically significant increase in weightbearing on the affected side, decrease in stride variation, and decrease in stride symmetry (Thaut, McIntosh, Prassas, & Rice, 1993). Rice and Johnson (2013) add:

> Cuing of the movement period is another important concept as we incorporate auditory rhythm into neurological rehabilitation. Research results indicate that the interval of time between rhythmic cues provides timing information for the completion of a movement cycle (such as the time to extend the arm), not just the end points of the movement (Thaut & Kenyon, 2003). Therefore, the rhythmic cue provides a continuous time reference for planning and execution, entraining timing across the entire movement (p. 59).

Multiple experiments have used these procedures to demonstrate motor response synchronicity to rhythmic music, the most persistent conclusion has been the idea that a steady and consistent beat results in entrainment of the motor response within one or two pulses of the rhythmic cue (Meill, 2005). Therefore, the neural-muscular circuitry involved in consciously hearing a rhythmic stimulus and motor-mapping the meter behind it is virtually immediate, demonstrating the hard-wired relationship between two distinct cortical agendas (audition and motion). The second piece of crucial information found in these behavioral studies is the discovery that when experimenters randomly changed the tempo of specific rhythmic sequences (alterations of only a fraction of a beat per second) the auditory differences were below the level of conscious perception (Thaut, 2005).

In further studies, researchers have been able to map both distinct cortical regions and neuronal interconnections related to the perception of music and subsequent motor action. Researchers used positron emission tomography (PET) to identify a basic neural network, one anatomical example of a CPG, consisting of a simple array of “auditory, opercular premotor areas, basal ganglia, and cerebellar areas” that work together to map the temporal coding and processing of a musical rhythm (Thaut et al, 2009, p. 49). Specific musical tasks such as mapping irregular rhythms and changes in key and pitch have provided topographical evidence that indicate the cerebellum has multiple and differentiated functions in the central motor region of the brain related to musical motor responsiveness. Thus, this neuroanatomical research demonstrates how both the cerebellum and auditory-motor circuitry of the brain are not uniform in structure or function, and motor entrainment relies on a combination of auditory and motor neuron interactions, thereby positing the mechanism’s flux and ability to change (Thaut et al, 2009). This adaptability speaks to the success of how auditory cues enhance motor function in those with PD. While those with PD often display deficits in basal ganglia function, other components in the auditory-motor circuitry can compensate to execute normal motor patterns.

Patterned Sensory Enhancement

One way to further optimize the building of neural networks and the efficiency of a motor task is to introduce multi-faceted auditory input-- an isomorphic representation of the movement in regards to space, time, and force. This creates a map for the brain to plan and coordinate the movement enhancing the efficiency and fluidity of the movement. Specific musical elements and patterns provide explicit input to the brain regarding the position of the limb in space and time, and contribute to enhanced motor coordination (Thaut, 2005). As Thaut (2005) suggested, the auditory representation may help improve proprioceptive and visual feedback when planning and executing the movement.

> Patterned Sensory Enhancement (PSE) is a technique that uses the rhythmic, melodic, harmonic, and dynamic-acoustical elements of music to provide temporal, spatial, and force cues for movements which reflect functional movements of activities of daily living, or the fundamental motor patterns underlying these activities (Thaut, 2014, p. 106).

Whether a patient is working on physical rehabilitation through bicep curls, knee extension, or trunk strengthening exercises, a patterned sensory enhancement intervention is composed to match the patient's specific rehabilitation goal(s). During PSE, a neurologic music therapist presents movement sonification using a music instrument(s). Due to the vast variations of exercises, clinicians have found that the piano/keyboard and autoharp, which naturally possess wide pitch ranges, are the most functional instruments to structure for PSE interventions (Thaut, 2014). Thaut emphasizes that the music's role in PSE does not accompany the movement, but rather to facilitate it. When music dictates the duration, speed, and/or intensity of the movement, it will encourage the patient to better entrain to that auditory stimulus, most likely promoting a larger range of motion, more systematic repetitions, and/or longer endurance (2014). Thaut (2005) explains the auditory stimulus is rhythmically stable to provide an anticipatory motor planning reference and uses frequency and intensity aspects of music/sound to indicate spatial and dynamic movement components.

Clinical Practice and Research of PSE

As with most NMT interventions, PSE has been implemented most frequently with neurorehabilitation populations, including traumatic brain injury, stroke, and Parkinson's Disease. Whitall and Waller (2013) were interested in how Thaut's components of Rhythmic Auditory Stimulation (RAS), used in gait rehabilitation, would apply to upper-extremity motor tasks. Using an intervention called Bilateral Arm Training and Rhythmic Auditory Cueing (BATRAC), individuals with upper-extremity hemiparesis (weakness on one side of the body) due to stroke were instructed on operation of a reach and return movement apparatus (using shoulder flexion/protraction and elbow extension) and encouraged to complete 5-minute intervals of this repetitive movement. A metronome simultaneously played at the participant's preferred speed. The measured dependent variables of movement impairments, functional task limitations, and impact on use of the arm in daily living, resulted in statistically significant improvement was shown for all fourteen participants and improvements were retained after nine weeks (Whitall & Waller, 2013). While the BATRAC intervention did not fall within the parameters of PSE since it only used a rhythmic auditory cue without any melodic components, thought it simulated the spatial components of PSE through the use of the metronome.

Rice and Johnson (2013) implemented PSE-specific interventions when working with patients with similar diagnoses (i.e., stroke, PD) and found similar results. A music therapist used the back-and-forth motion of the autoharp to facilitate the patient's shifting weight from side to side as a pre-gait exercise for a patient who had right-side stroke. While the patient stood up with assistance and a physical therapist behind him, the music therapist provided a 6/8 rhythmic pattern on the autoharp while mirroring the movements in front of the patient, using dynamics to communicate force cues and utilizing the high-low range of the autoharp to communicate spatial cues. In a second case, the music therapist paired the heel strike with a downbeat in a musical phrase and the initiation of the swing phase with a pickup beat as a pre-gait exercise for a patient who displayed "freezing" symptoms of PD. The tempo of the music communicated the speed of the repetitions and dynamics (i.e., variations in volume) represented the amount of force or energy required throughout the different phases of the exercise. These motions were then transferred to begin RAS training. In both cases, the patients were able to strengthen and maintain more functional gait patterns after prolonged therapy and eventual fading of the music stimuli. This was due in part to the utilization of mp3 recordings of the PSE music outside of therapy sessions. As suggested by Lahav et. al's research, perhaps the music reminder allowed these two patients to consistently access the motor planning learned in PSE training outside of therapy, due to the music reminder.

When a patient is participating in the repetitious exercises involved in PSE, not only is he/she exerting physical effort to complete the task, but also a high level of cognitive awareness. If one's arm cannot reach as far forward as it once did due to neurological impairment, one must devote additional attention to completing the motor task, which can quickly result in mental fatigue. However, if one is completing a task with an auditory cue, he/she can instead focus on synchronizing to the beat. It has also been hypothesized that using music during physical exercises would create a more enjoyable experience, increasing motivation, thus resulting in increased physical endurance and decreased perceived exertion. Studies have showed mixed results for this hypothesis. While some demonstrated that exercise sessions including music increased mood and performance parameters, others showed that music acted as a distraction to exercise (Clark, Baker, & Taylor, 2012, Karageorghis, C. I., & Terry, 1997). Such variation in outcomes may be attributed to the time of day the sessions were conducted, participants' music preferences, participants' hearing levels, length of sessions, or other confounding clinical variables.

While PSE interventions are most commonly used with stroke and traumatic brain injury populations, they have also been effective in sensorimotor rehabilitation for children with cerebral palsy. Cerebral palsy is a group of disorders that result in movement and posture disabilities. The most common type is called spastic diplegia (SD), whose symptoms include motor weakness and lack of control in the lower extremities. Goals for children with SD may include increased walking speed, motor capacity, range of motion, movement fluidity, or extension. In studies that compared a PSE group to a control, all PSE groups produced greater outcomes than the non-PSE groups in one or more of the above mentioned goals. Movements addressed through PSE included sit-to-stand tasks, warm-up extension exercises, and balance activities (Kwak, 2007; Peng et al., 2011; Wang, et al., 2013).

One clinical study with similar components of the current study compared the effectiveness of pre-recorded PSE or background music on exercise performance for 45 older adults in a long-term care facility over four weeks. O'Konski, Bane, Hettinga, and Krull (2010) used a CD with 19 pre-recorded PSE compositions for the PSE group and a CD of big band music for the "background music group" to gauge participants' effort and satisfaction ratings. Results indicated no significant difference in satisfaction between groups, and participants performed significantly more repetitions in synchrony with the facilitator during PSE sessions for three out of the nineteen exercises, as rated by two trained observers who were blind to which condition they were coding. The majority of other PSE clinical studies compare live-PSE to non-PSE groups, not individual sessions. To the researcher's knowledge, no published clinical studies exist that examine the combination of LSVT BIG and PSE for individuals with PD. The current study sought to pair the evidence of exercise’s positive reduction of PD symptoms and PSE’s ability to facilitate efficient movement for those with neurologic impairment to supplement the LSVT BIG program in regard to balance and ambulation outcomes.

CHAPTER III

METHODS

Design

A single-subjects research design with a basic AB method is most appropriate for the current study since target behaviors being measured are irreversible. “Single-subject research designs provide a quasi-experimental approach to evaluating treatment effectiveness in a single subject or small group of subjects, in which subjects serve as their own controls” (Backman & Harris, 1999).

Participants

The study stipulated the following inclusion criteria: physician’s diagnosis of Parkinson’s Disease, no more than age-related hearing loss, and no physical impairments beyond PD that could exacerbate heterogeneity in the sample. Participants were recruited through physicians’ referrals or Parkinson’s Partners in Erie, PA. Parkinson’s Partners is a local community organization that provides resources, informational meetings, and health-related liaisons to individuals with PD and their families, and encourages those with a recent diagnosis to begin physical therapy to delay disease progression. Six participants met inclusion criteria and were recruited, five of those recruited consented to participate in the study, and three participants completed the entire treatment period. Participants were male, ages 66, 77, and 61 and had ICD10 primary diagnosis G20: Parkinson’s disease and secondary diagnosis R26.2: Difficulty in walking, not elsewhere classified. One participant had an additional diagnosis of R29.3: abnormal posture.

Procedures

After receiving approval from the Human Subjects Institutional Review Board (HSIRB) (See Appendix A), all treatment sessions occurred at the Hertel & Brown Sterrettania office in Erie, Pennsylvania, administered by one LSVT-certified physical therapist (PT) and one board-certified music therapist (MT). Prior to recruitment, the MT met with the PT to coordinate treatment schedules and model how the PSE tracks coincide with each exercise, taking comments and suggestions from the PT and modifying as necessary. Music tracks to be used as stimuli in the PSE condition were recorded and edited within the iPad app *GarageBand*. The compositional components of these tracks are described in the subsequent section, using piano and multiple percussion instruments within the app.

Participants attended 2-3 sessions a week over 2-3 months depending on schedule availability and financial affordability. During session one, the PT obtained the participants' pertinent demographic and medical information and explained the principles of LSVT BIG. Then the MT initiated informed consent, giving each patient a consent form to take home and read and requested a final decision regarding participation by session two. The PT and patient then completed initial assessments. As with any physical therapy treatment, there is a risk of falling, which was explained in the consent form. To reduce the risk of falling during in-clinic exercise, the PT remained in close proximity to the patient and utilized a gait belt on the patient if clinically implicated. Afterwards the PT modeled each of the seven LSVT BIG maximal daily (pre-gait) exercises, requiring the participant to mimic the PT. The MT joined the participant and PT during pre-gait exercises for those who consented to participate in the study by session two.

First, the PT and participant completed exercises in silence while MT recorded the participant's preferred speed for each exercise. Second, the MT instructed and modeled how to exercise with the PSE tracks modified to the first set's speeds, where PT and participant were instructed to mimic. PSE tracks were played via the *GarageBand* iPad app and amplified by a Bluetooth speaker. *GarageBand* enables modification of tempo (speed) in real time, essential for patient-specific PSE. For instance, if a participant presented with severe arm tremors, he/she may have required more time to complete an exercise sequence than higher functioning participant. In this instance, the music therapist may adapt the tempo so he/she could receive tracks at a slower speed (e.g., 60 beats per minute (bpm)), compared the higher-functioning counterpart who would receive tracks at a faster speed (e.g., 80 bpm). The presence of a music therapist was necessary during clinic appointments as each PSE track was adapted in *GarageBand* by the MT to meet each participant's individual physical and motivational needs when performing exercises.

The second half of the LSVT BIG protocol consists of hierarchy tasks, such as gait training and practice of Activities of Daily Living (ADLs) (e.g., picking up objects from the floor or fine motor tasks). While the PT administered the hierarchy tasks with the participant, the MT generated a CD via laptop of the seven audio files used during session two and presented the CD to the participant at the end of session two. Participants were also given worksheets from the PT that explained each exercise in words and through picture models (LSVT Global, Inc., 2013).

Participants were encouraged to complete exercises two times at home on non-treatment days and one time at home on treatment days, as stipulated by the LSVT BIG protocol. Home exercise was not supervised by MT or PT. All participants declined the offer to borrow a CD player, stating they would use their own. Participants were encouraged to play the CD through a CD player with adequate volume and not to use headphones, as headphones and their attached cord could obstruct certain upper body movements during exercise. All participants were trained by the MT to *always* exercise with PSE, both in and out of the clinic. The rationale being, even if the music supplement was taken away from them halfway through the treatment period, they could not simply unlearn the motor patterns they associate with the music. Ideally, memory of each exercise should be paired with memory of its respective PSE-track, so that in time a participant could hear the song “in his/her head” in order to facilitate exercise. For example, when one learns choreography to a particular piece of music, it is learned by modeling others’ movements while the music plays. After several repetitions, one could perform the movement sequence without a visual model as long as the music continued. If this person was asked to perform the movement sequence without the music playing, he will most likely recall the song in his head, which contains rhythmic cues for movement speed and melodic cues for transitions, in order to initiate the movement sequence.

During subsequent sessions, the PT and MT monitored each participant’s progress and modified exercises and music tracks as needed. For instance, if a participant’s flexibility improved from a previous session, he may was encouraged to perform the Maximal Daily Exercises at a faster pace, and the MT would provide a new CD with faster PSE tracks. Each session was approximately 60 minutes, where the first 30 minutes comprised the seven pre-gait exercises and the experimental treatment (PT and MT) and the latter 30 minutes comprised the hierarchy tasks (no experimental treatment or MT). On session ten, the PT conducted post-test assessments of the BERG and TUG for all participants, administered the FES and MFES for two participants, and conducted the 9-hole peg test for two participants.

Measures

After receiving informed consent (See Appendix B), the PT administered the BERG and TUG assessments for all participants and additional assessments as clinically indicated for each participant. The BERG balance scale (See Appendix C) measures one’s balance in a clinical setting with a numeric score based on a sum of several sitting, standing, and transfer tasks, scored on a Likert scale with a maximum score of 56 (American Academy of Health and Fitness, 2017). A score of 41 or above is categorized as a low fall risk. The timed up and go test (TUG) (See Appendix D) assesses the amount of time for one to stand up from an armchair, walk 10 feet forward at a "normal pace," walk back to chair, and sit back down (Centers for Disease Control and Prevention, n.d.a). A score of 12 or more seconds is considered a high fall risk. The Falls Efficacy Scale (FES) (See Appendix E) and the Modified Falls Efficacy Scale (MFES) (See Appendix F) gauge the participant's subjective perception of balance and motor coordination as they relate to activities of daily living where participants rate ease/difficulty of a task on Likert scales (Edwards, N., & Lockett, D., 2008; Tinetti, M., D. Richman, et al.,1990) . The Nine-hole peg test (See Appendix G) assesses fine motor coordination recording the time it takes for the subject to place nine pegs in a peg board and take them out, one hand at a time (Mathiowetz, Weber, Kashman, & Volland , 1985). A score within 20-30 seconds with either the dominant or non-dominant hand is considered within functional limits. These assessments and the LSVT pre-gait exercises required three chairs for the participant and PT, with at least one with arms and one without arms. Materials for the nine-hole peg test include: board with nine holes, container for pegs, nine pegs, and a stopwatch. The PSE intervention required an iPad with the *GarageBand* app installed, a portable Bluetooth speaker (Phillips BT2200), portable CD players (Sony CFD-E75) with output speakers for participants to borrow if they did not already own one, a laptop computer (Gateway T-6345u) to create CDs for participants, and approximately 10 blank CDs (Memorex CD-R 700MB).

Patterned Sensory Enhancement Compositional Components

PSE can be adapted to facilitate most any upper- or lower-body exercise through careful visual observation of several repetitions of the exercise and the methodical incorporation of three types of movement cues: spatial, temporal, and force cues. Spatial cues refer to how much physical space the exercise requires, whether from one side of the body to the other, above the head or towards the floor, away from or towards the body. The size and direction of a movement can be facilitated through particular music elements (i.e., pitch/melody, rhythm, dynamics). For instance, the second exercise of the LSVT protocol is a side-to-side sustained movement. A PSE composition for this exercise should include spatial cues to abduct the arm from (1) resting to perpendicular position, (2) horizontal arm adduction and trunk rotation to sweep across the body, and (3) horizontal abduction and vertical adduction to bring arm back to the starting side. Since cue 1 exists on a vertical plane, this can be musically cued with five to eight pitches that ascend in direction. When the pitch goes up, the arm goes up. Cue 2 requires a wide stretch across the body, which can be musically cued with 16-32 pitches that span a wide range from low to high (e.g., 55Hz to 880Hz). Cue 3 could use the same wide range of pitches but in the opposite direction, high to low.

In watching the PT perform the BIG exercises, the researcher subdivided each motor sequence into a particular number of beats using a tap metronome. A tap metronome allows the user to tap a rhythmic stimulus for multiple beats and the metronome then produces output for what average tempo that input reads in beats per minute (bpm). Use of this project's PSE tracks with future participants would require clinicians to receive in-person training or a tutorial to visually match a participant's motor speed with a tap metronome speed. This would allow the clinician to assign a correct PSE track speed for each exercise. For instance, in Exercise 2 the clinician should tap the metronome twice evenly in the time it takes the participant to bring his/his arm from his side to perpendicular (cue 1) and twice evenly in the time it takes the participant to swing arm across body (cue 2).

Temporal cues refer to the duration of each movement and timing from one movement to the next, which can be musically emulated with the tempo (i.e., speed) of the music, duration of sound, and the overall structure, or form, of the music. Cue 1 takes relatively less time than others in the exercise, so the PSE for cue 1 should last for two beats, followed by a different two-beat cue to facilitate trunk rotation and arm sweep across the body. Then a section with ten repetitions of a distinct sound would coincide with the instruction to “hold ten counts.” Next, a two-beat cue as the arm moves back to the left thigh (cue 3) and a five-count phrase that cues a resting period before the next repetition begins. Each exercise requires 10 repetitions on both sides of the body, so the form of the PSE track would require the sequence [2 beats arm out, 2 beat rotate, 10 count hold, 2 beat return, 5 beat rest] repeated ten times, a melodic cue to switch sides/limbs, then the sequence repeated another ten times.

Force cues refer to the amount of physical exertion required to execute each movement pattern, most noticeably facilitated by music changes in volume and complexity. Taking entire exercise into account, the portion that requires the most physical exertion and endurance is holding the arm up in the air. Therefore the loudest and most musically complex phrase should be reserved for the ten-beat hold. In cue 1 as the arm abducts, volume would start at a moderate level, cue 2 where the arm sweeps would be a suddenly loud phrase, the ten-beat hold would start soft and gradually increase in volume with each beat, cue 3 return would be the same volume as cue 1 (i.e., moderate level), and the five-beat rest would be softest to indicate muscle relaxation.

CHAPTER IV

RESULTS

All three participants completed ten sessions within a two to three month window and demonstrated improved quality of movement as evidenced by scores on the BERG and TUG. Participants scored higher balance scores on the BERG Balance Scale, where Participant 01 increased by 4 points, Participant 02 increased by 2 points, and Participant 03 increased by 2 points. However, the assessment tool states that a change of 8 points is required to reveal a genuine change in function between two assessments. Two of the three participants demonstrated lower completion times on the TUG (improved ambulation), where Participant 01 showed no change, Participant 02 decreased by 1.2 seconds, and Participant 03 decreased by 8 seconds. The assessment tool reads that a score of 12 seconds or more indicates a high risk for falling, and it does not suggest a minimum score that would be considered within functional limits. Also, Participant 01 and Participant 02 had lower post-test scores for fall risk, indicating a decreased risk for fall. Participant 01 used the Falls Efficacy Scale (FES), where the output is a total of subjective scores of "confidence of not falling" of 10 various activities of daily living, where 1 is very confident and 10 is not confident at all. Participant 01 demonstrated increased efficacy rating by one point (12 to 11), from pre- to post-test. A total score of 70 or more indicates a fear of falling. Participant 02 completed the Modified Falls Efficacy Scale (MFES), which uses a different rating scale for "confidence of not falling" for 14 activities of daily living where 0 is "not confident" and 10 is "completely confident." The final score for the MFES reports the average of all 14 scores. The higher the score (maximum of 10), the greater fear of falling. Participant 02 rated average fear of falling 1.43 points lower on post-test (0.07) than pre-test (1.5), both indicating a minimal fear of falling. For the Nine-Hole Peg Test, a timed fine motor task, Participant 02 scored higher on post-test (right hand 2 seconds, left hand 3 seconds). Participant 03 had lower post test scores (right hand 1.4 seconds, left hand 0.8 seconds). A score within 20-30 seconds with either the dominant or non-dominant hand is considered within functional limits. (see Table 1).

Table 1

Balance, Ambulation, and Motor Coordination Measures

Participant	BERG [a] (score)		TUG [b] (seconds)		FES [c] (score)		Modified FES [d] (score)		9-hole peg test [e] (seconds)			
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre		Post	
01	46	50	7	7	12	11	N/A		N/A			
02	52	54	9.5	8.3	N/A		1.5	0.07	R 25	L 20	R 27	L 23
03	54	56	16	8	N/A		N/A		R 17	L 19.7	R 15.6	L 18.9

[a] The BERG Balance Scale (BERG) rates various balance tasks on a Likert scale by PT, with a max score of 56. A score of 41 or above is considered a low fall risk.
[b] The Timed Up and Go test (TUG) measures time (seconds) to stand up from an armchair, walk 10 feet forward and return at a "normal pace," and sit back down. A score of 12 or above is considered high fall risk.
[c] The Falls Efficacy Scale (FES) is a subjective Likert scale rating (1 confident- 10 not confident) of ease/difficulty of various activities of daily living, where the score is the sum of all ratings. Score of 70 or more indicates fear of falling.
[d] The Modified Falls Efficacy Scale (Modified FES) is a subjective Likert scale rating (0 not confident-10 completely confident) of ease/difficulty of various activities of daily living, where the final score is the average of 14 ratings. The higher the score (maximum score of 10), the greater the participant's fear of falling.
[e] The 9-hole peg test measures time (seconds) to place 9 pegs in a peg board and take them out, one hand at a time. R and L stand for right and left hand. A score within 20-30 seconds with either the dominant or non-dominant hand is considered within functional limits.

While the small sample size did not warrant the use of statistical analyses, the student researcher conducted paired sample t-tests on pre- and post- BERG and TUG scores to demonstrate the ability to perform statistical analyses had the sample size been appropriate to do so. Participants on average demonstrated improved balance as evidenced by higher post-test BERG score s (M=53.33, SE=1.76) than pre-test BERG scores (M=50.67, SE=2.40), t (2)= -

4.00, $p>.05$, $r=.67$. Participants on average demonstrated improved ambulation as evidenced by lower post-test TUG score s ($M=7.77$, $SE=0.39$) than pre-test TUG scores ($M=10.83$, $SE=2.68$), $t(2)= 1.23$, $p>.05$, $r=2.49$. Results are displayed in Tables 2 and 3.

Table 2

Paired Sample Descriptive Statistics- BERG and TUG

Test	Mean	N	Std. Deviation
BERG_Pre	50.6667	3	4.16333
BERG_Post	53.3333	3	3.05505
TUG_Pre	10.8333	3	4.64579
TUG_Post	7.7667	3	.68069

Table 3

BERG and TUG Pre to Post Test Scores

	Paired Differences		
	Mean Difference	Std. Deviation	Sig. (2-tailed)
BERG_Pre - BERG_Post	-2.66667[a]	1.15470	.057
TUG_Pre - TUG_Post	3.06667[b]	4.31432	.343

a. Mean difference shows that on average, participants scored higher on post-test BERG than pre-test, indicating improved balance scores.
b. Mean difference shows that on average, participants scored lower on post-test TUG than pre-test, indicating improved ambulation scores.

Participants completed anonymous exit surveys (See Appendix H) to express perceptions of treatment both in and out of the clinic, particularly how the PSE impacted their therapy experiences. All participants reported that the PSE was not a source of distraction to exercises (i.e., questions 8 and 9). For the two participants who used PSE at home, both rated the PSE “highly effective” in completing home exercise (i.e., question 7). Lastly, all participants stated they would recommend that future LSVT patients use PSE (i.e., question 10). (See Table 4)

Table 4

Exit Survey Responses

Question	Participant 01	Participant 02	Participant 03
1. Do you feel in better physical shape after your physical therapy sessions than before?	No	Yes	Yes
2. During the treatment period, were there circumstances that prevented you from completing the LSVT exercises at home?	Yes “every other day”	No	Yes “illness”
3. During the treatment period, did you exercise outside of the clinic other than the LSVT exercises? If yes, how often?	No	No	Yes (50-80%)
4. During the treatment period, circle the approximate number of days you completed the LSVT exercises at home each week.	4	4	6
5. During the treatment period, were there circumstances that prevented you from using your CD when completing the exercises at home?	No	Yes (CD player issues)	No
6. How often did you use your CD during in-home exercise?	Consistently (81-100%)	Never (0%)	Consistently (81-100%)
7. Rate the effectiveness of the PSE tracks on the CD to complete exercises at home (0-4)	4	not rated	4
8. Rate the level of distraction the PSE tracks provided during your exercises in the clinic (0-4)	0	0	0
9. Rate the level of distraction the PSE tracks provided during your exercises at home (0-4)	0	not rated	0
10. Would you recommend other LSVT patients use the PSE tracks on CD during exercise? Why/why not?	Yes “helps timing of exercise”	Yes “gives an opportunity to hear what I am doing”	Yes “helps with rhythm and timing”
11. Additional Feedback	N/A	“If it were possible to introduce each track with the exercise it may be more helpful.”	“Enjoyable experience. Working with Brittany was enjoyable--she is enthusiastic and fun!”

CHAPTER V

DISCUSSION

Summary of Research Findings

While there are no academic studies known to the researcher specifically analyzing the effects of PSE on LSVT BIG outcomes, this shares similarities with the Effenberg, Fehse, and Weber (2011) study. Both used visual and auditory stimuli to influence motor performance. Effenberg, Fehse, and Weber found that the group who received audiovisual stimuli produced "faster and more precise learning" compared to the audio-only or visual-only groups. While this LSVT BIG project did not allow for a control group, the exit survey demonstrated that participants appreciated having auditory cues when exercising, especially during home exercise where visual cues from a therapist were absent. Home exercise during outpatient physical therapy is paramount for ongoing functional improvement. And while it cannot be determined whether the utilization of PSE during home exercise influenced the frequency of home exercise, the exit survey displays that participants who consistently (81-100%) used their PSE CDs during home exercise reported exercising an average of 5 days each week throughout the treatment period. It is likely that the high frequency of home exercise positively influenced outcome measures for Participants 01 and 03.

Furthermore, Rice and Johnson (2013) demonstrated how PSE interventions influenced PD patients to strengthen and maintain more functional gait patterns through the use of live and recorded music. Rice and Johnson highlighted that recorded music sent home with participants mirrored the live music used in clinic sessions, using specific spatial, temporal, and force cues for each patient. This LSVT BIG project incorporated that principle with a slight modification of using recorded music for both in-clinic and in-home exercises. However, this recorded music was adaptable via the *GarageBand* app similar to how a music therapist would adapt live music within a session. Using the same music for both settings eliminated the chance of the PSE stimulus from changing between in-clinic and in-home exercise, as it is nearly impossible for live music to be exactly replicated for each repetition.

Strengths

An added benefit to using recorded music amplified via Bluetooth speaker was that the MT had her hands free to visually model each exercise for the participants. While the PT was present for each session and provided visual cues when needed, the PT was unfamiliar with the PSE before the experiment and lacked information regarding how the exercises coincided with the PSE. Recorded music allowed for the MT to explain what cues to listen for, demonstrate how specific auditory cues facilitated specific motor patterns, and allowed the MT to exercise along with the participant through all seven exercises every session, simply pressing a play/pause button in between each track and modifying speeds (i.e., tempo) as indicated by the participant's motor performance as necessary.

Limitations

Multiple confounding factors influenced the design, participation, and generalizability of this study. Over seven months, the Hertel & Brown facility received six patients presenting with PD, where they typically receive one to two new patients per month. Recruitment was likely affected by harsh winter weather, as well. It is likely that individuals with a mobility deficit may not have chosen to begin outpatient therapy in such conditions. Subsequently, the small *n* necessitated that all consenting participants receive the experimental treatment, rather than including a control group as well. Also, there was also a confounding variable of dosage, where by the time Participant 02 remembered to use his CD player at home, the treatment period was over. Therefore, it is impossible in this project to determine whether outcomes could be attributed solely to the PSE treatment, the physical therapy regimen alone, or to natural recovery, let alone any medications or additional exercise. Also, initial diagnosis date for each participant was unknown, making the sample likely less heterogeneous. Furthermore, external validity of any single-subject research design is limited, because each participant acted as his own control.

Clinical Implications

Duration of outpatient rehabilitation therapy is frequently limited by insurance coverage and consequently, many patients have not met their maximal physical ability at discharge. This impacted this study, as the LSVT protocol suggests 16 in-clinic sessions over four weeks, but participants completed ten sessions over two-three months due to insurance coverage, illness, and scheduling conflicts. Since PD symptoms are progressive, it is imperative that exercise continue beyond an outpatient rehabilitation program to encourage delay of symptoms and maintain therapeutic progress. Having a tool like the PSE CD served as not only a resource for exercise during outpatient treatment but can be used after outpatient treatment is complete. As previously discussed, if one learns choreography to a recorded song, eventually movement patterns become paired with musical cues. Related to the LSVT BIG literature, BIG participants perform better when concentrating on performance but declines when attention is distracted from movement execution, (e.g., trying to remember a particular movement sequence after therapy discharge). PSE serves as an auditory reminder to execute high amplitude, consistent repetition of exercise, where according to questions seven through nine of the exit survey, participants consistently rated the PSE as “0, not distracting” and “4, highly effective.” The PSE CD can be used as a carryover tool, after outpatient therapy is complete, as it can provide/reinforce specific principles of rhythmic entrainment and priming of the auditory-motor pathways, to cue the motor patterns demonstrated during therapy sessions This allows the PSE CD to serve as a continuous foundation to solidify and maintain the learned sensorimotor techniques.

Recommendations for Future Research

Replications of this study would allow for a larger sample size, where the researcher could arrange a control group and data could be controlled for age, gender, multiple diagnoses, etc. One barrier to replication would be the researcher's choice to use the same PSE tracks used in this study or use newly created PSE tracks by another music therapist.

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Appendix A

HSIRB Approval Form

WESTERN MICHIGAN UNIVERSITY

Institutional Review Board
FWA00007042
IRB00000254

Date: December 5, 2017

To: Edward Roth, Principal Investigator
Brittany Barko, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number 17-11-08

This letter will serve as confirmation that your research project titled "The Effect of Patterned Sensory Enhancement on Balance, Sit-to-Stand, and Ambulation in Persons Diagnosed with Parkinson's Disease" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: **December 4, 2018**

Office of the Vice President for Research
Research Compliance Office
1903 W. Michigan Ave., Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276
WEBSITE: wmich.edu/research/compliance/hsirb

CAMPUS SITE: 251 W. Walwood Hall

Appendix B

Consent Form

Western Michigan University
School of Music

Principal Investigator: Edward Roth, MM, MT-BC

Student Investigator: Brittany Barko, MT-BC

Title of Study: The Effect of Patterned Sensory Enhancement on Balance and Ambulation in Persons diagnosed with Parkinson's Disease

You have been invited to participate in a research project titled "The Effect of Patterned Sensory Enhancement on Balance and Ambulation in Persons diagnosed with Parkinson's Disease." This project will serve as Brittany Barko's thesis project for the requirements of the Masters of Music in Music Therapy program. This consent document will explain the purpose of this research project and will go over all of the time commitments, the procedures used in the study, and the risks and benefits of participating in this research project. Please read this consent form carefully and completely and please ask any questions if you need more clarification.

What are we trying to find out in this study?
This study seeks to determine if incorporating music-therapy informed music tracks into the LSVT BIG physical therapy training will improve participants' quality of movement as compared to those without the music supplement.

Who can participate in this study?
Individuals with Parkinson's Disease eligible for outpatient physical therapy, with no more than age-related hearing loss, and no physical impairments beyond PD.

Where will this study take place?
This study will take place during physical therapy appointments at the Hertel & Brown Sterrettania office.

What is the time commitment for participating in this study?
There is no additional time commitment beyond attendance at physical therapy appointments and performing and tracking exercises at home (2 times per day), as stipulated by the LSVT BIG protocol.

What will you be asked to do if you choose to participate in this study?
Participants will be randomly assigned to a control group or an experimental group. Those in the control group will complete LSVT BIG training as stipulated by the standard protocol.

Appendix B (continued)

Participants in the experimental group must be willing to undergo instruction on how to incorporate music into Maximal Daily Exercises in the clinic, as modeled by music and physical therapists. Participants are then provided a CD to take home to use during daily exercise. If they do not have access to a CD player at home, one will be provided by the researcher.

What information is being measured during the study?
Outcome measures include the BERG balance scale, timed up and go test (TUG), and the sit-to-stand (STS) test. Participants will also be given a survey regarding perceptions of their treatment experiences.

What are the risks of participating in this study and how will these risks be minimized?
As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or additional treatment will be made available to you except as otherwise stated in this consent form. To reduce the risk of falling during treatment, the physical therapist will remain in close proximity to the participant.

What are the benefits of participating in this study?
Through participation in the study, it is anticipated that participants will improve their movement patterns, walk with larger, more predictable strides, and execute larger range of motion in upper and lower extremities. These physical gains commonly transfer to greater confidence in motor ability and feasibility of activities of daily living.

Are there any costs associated with participating in this study?
Aside from the costs of physical therapy treatment, whether or not you are paying out-of-pocket or submitting to insurance, there are no additional costs to participate in the study.

Is there any compensation for participating in this study?
There is no compensation for participating in this study.

Who will have access to the information collected during this study?
Only the researcher, Brittany Barko, and the participant's physical therapist will have access to information during the study.

What if you want to stop participating in this study?
You can choose to stop participating in the study at anytime for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience NO consequences either clinically or personally if you choose to withdraw from this study. The investigator can also decide to stop your participation in the study without your consent.

Should you have any questions prior to or during the study, you can contact the student investigator, **Brittany Barko** at **814-746-5427** or **brittany.a.barko@wmich.edu** or the principal investigator, Edward Roth at 269-397-5415. You may also contact the Chair, Human Subjects

Appendix B (continued)

Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board

chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

____
Please Print Your Name

____________________________________ _______________________________
Participant’s Signature Date

Appendix C

Berg Balance Scale

Berg Balance Scale

The Berg Balance Scale (BBS) was developed to measure balance among older people with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluation of the effectiveness of interventions and for quantitative descriptions of function in clinical practice and research. The BBS has been evaluated in several reliability studies. A recent study of the BBS, which was completed in Finland, indicates that a change of eight (8) BBS points is required to reveal a genuine change in function between two assessments among older people who are dependent in ADL and living in residential care facilities.

Description:
14-item scale designed to measure balance of the older adult in a clinical setting.

Equipment needed: Ruler, two standard chairs (one with arm rests, one without), footstool or step, stopwatch or wristwatch, 15 ft walkway

Completion:
Time: 15-20 minutes
Scoring: A five-point scale, ranging from 0-4. "0" indicates the lowest level of function and "4" the highest level of function. Total Score = 56

Interpretation:
41-56 = low fall risk
21-40 = medium fall risk
0 –20 = high fall risk

A change of 8 points is required to reveal a genuine change in function between 2 assessments.

Appendix C (continued)

Berg Balance Scale

Name: ___________________________ Date: ____________________

Location: _________________________ Rater: ____________________

ITEM DESCRIPTION	SCORE (0-4)
Sitting to standing	________
Standing unsupported	________
Sitting unsupported	________
Standing to sitting	________
Transfers	________
Standing with eyes closed	________
Standing with feet together	________
Reaching forward with outstretched arm	________
Retrieving object from floor	________
Turning to look behind	________
Turning 360 degrees	________
Placing alternate foot on stool	________
Standing with one foot in front	________
Standing on one foot	_______
Total	________

GENERAL INSTRUCTIONS

Please document each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item.

In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if:

- the time or distance requirements are not met
- the subject's performance warrants supervision
- the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.

Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 1.

Appendix C (continued)

Berg Balance Scale

SITTING TO STANDING
INSTRUCTIONS: Please stand up. Try not to use your hand for support.
( ) 4 able to stand without using hands and stabilize independently
( ) 3 able to stand independently using hands
( ) 2 able to stand using hands after several tries
( ) 1 needs minimal aid to stand or stabilize
( ) 0 needs moderate or maximal assist to stand

STANDING UNSUPPORTED
INSTRUCTIONS: Please stand for two minutes without holding on.
( ) 4 able to stand safely for 2 minutes
( ) 3 able to stand 2 minutes with supervision
( ) 2 able to stand 30 seconds unsupported
( ) 1 needs several tries to stand 30 seconds unsupported
( ) 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL
INSTRUCTIONS: Please sit with arms folded for 2 minutes.
( ) 4 able to sit safely and securely for 2 minutes
( ) 3 able to sit 2 minutes under supervision
( ) 2 able to able to sit 30 seconds
( ) 1 able to sit 10 seconds
( ) 0 unable to sit without support 10 seconds

STANDING TO SITTING
INSTRUCTIONS: Please sit down.
( ) 4 sits safely with minimal use of hands
( ) 3 controls descent by using hands
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently but has uncontrolled descent
( ) 0 needs assist to sit

TRANSFERS
INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
( ) 4 able to transfer safely with minor use of hands
( ) 3 able to transfer safely definite need of hands
( ) 2 able to transfer with verbal cuing and/or supervision
( ) 1 needs one person to assist

Appendix C (continued)

(   ) 0   needs two people to assist or supervise to be safe

STANDING UNSUPPORTED WITH EYES CLOSED
INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
(   ) 4   able to stand 10 seconds safely
(   ) 3   able to stand 10 seconds with supervision
(   ) 2   able to stand 3 seconds
(   ) 1   unable to keep eyes closed 3 seconds but stays safely
(   ) 0   needs help to keep from falling

STANDING UNSUPPORTED WITH FEET TOGETHER
INSTRUCTIONS: Place your feet together and stand without holding on.
(   ) 4   able to place feet together independently and stand 1 minute safely
(   ) 3   able to place feet together independently and stand 1 minute with supervision
(   ) 2   able to place feet together independently but unable to hold for 30 seconds
(   ) 1   needs help to attain position but able to stand 15 seconds feet together
(   ) 0   needs help to attain position and unable to hold for 15 seconds

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)
(   ) 4   can reach forward confidently 25 cm (10 inches)
(   ) 3   can reach forward 12 cm (5 inches)
(   ) 2   can reach forward 5 cm (2 inches)
(   ) 1   reaches forward but needs supervision
(   ) 0   loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.
(   ) 4   able to pick up slipper safely and easily
(   ) 3   able to pick up slipper but needs supervision
(   ) 2   unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
(   ) 1   unable to pick up and needs supervision while trying
(   ) 0   unable to try/needs assist to keep from losing balance or falling

TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING
INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. (Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.)
(   ) 4   looks behind from both sides and weight shifts well

Appendix C (continued)

(   ) 3   looks behind one side only other side shows less weight shift
(   ) 2   turns sideways only but maintains balance
(   ) 1   needs supervision when turning
(   ) 0   needs assist to keep from losing balance or falling

TURN 360 DEGREES
INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.
(   ) 4   able to turn 360 degrees safely in 4 seconds or less
(   ) 3   able to turn 360 degrees safely one side only 4 seconds or less
(   ) 2   able to turn 360 degrees safely but slowly
(   ) 1   needs close supervision or verbal cuing
(   ) 0   needs assistance while turning

PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED
INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.
(   ) 4   able to stand independently and safely and complete 8 steps in 20 seconds
(   ) 3   able to stand independently and complete 8 steps in > 20 seconds
(   ) 2   able to complete 4 steps without aid with supervision
(   ) 1   able to complete > 2 steps needs minimal assist
(   ) 0   needs assistance to keep from falling/unable to try

STANDING UNSUPPORTED ONE FOOT IN FRONT
INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width.)
(   ) 4   able to place foot tandem independently and hold 30 seconds
(   ) 3   able to place foot ahead independently and hold 30 seconds
(   ) 2   able to take small step independently and hold 30 seconds
(   ) 1   needs help to step but can hold 15 seconds
(   ) 0   loses balance while stepping or standing

STANDING ON ONE LEG
INSTRUCTIONS: Stand on one leg as long as you can without holding on.
(   ) 4   able to lift leg independently and hold > 10 seconds
(   ) 3   able to lift leg independently and hold 5-10 seconds
(   ) 2   able to lift leg independently and hold ≥ 3 seconds
(   ) 1   tries to lift leg unable to hold 3 seconds but remains standing independently.
(   ) 0   unable to try of needs assist to prevent fall

(   )   TOTAL SCORE (Maximum = 56)

Appendix D

The Timed Up and Go (TUG) Test

Purpose: To assess mobility

Equipment: A stopwatch

Directions: Patients wear their regular footwear and can use a walking aid if needed. Begin by having the patient sit back in a standard arm chair and identify a line 3 meters or 10 feet away on the floor.

Instructions to the patient: When I say **"Go,"** I want you to:

1. Stand up from the chair
2. Walk to the line on the floor at your normal pace
3. Turn
4. Walk back to the chair at your normal pace
5. Sit down again

On the word **"Go"** begin timing. Stop timing after patient has sat back down and record.

Time: _________ seconds

An older adult who takes ≥12 seconds to complete the TUG is at high risk for falling.

Appendix E

Falls Efficacy Scale

Name:___________________________________ Date:_________________

On a scale from 1 to 10, with 1 being very confident and 10 being not confident at all, how confident are you that you do the following activities without falling?

Activity:	**Score:** 1 = very confident 10 = not confident at all
Take a bath or shower	
Reach into cabinets or closets	
Walk around the house	
Prepare meals not requiring carrying heavy or hot objects	
Get in and out of bed	
Answer the door or telephone	
Get in and out of a chair	
Getting dressed and undressed	
Personal grooming (i.e. washing your face)	
Getting on and off of the toilet	
Total Score	

A total score of greater than 70 indicates that the person has a fear of falling

Adapted from Tinetti et al (1990

References:

Tinetti, M., D. Richman, et al. (1990). "Falls efficacy as a measure of fear of falling." Journal of gerontology **45**(6): P239.

Appendix F

The Modified Falls Efficacy Scale

Name_____________________________ Date______________

On a scale of 0 to 10, please rate how confident you are that you can do each of these activities without falling, with 0 meaning "not confident/not sure at all", 5 being "fairly confident/fairly sure", and 10 being "completely confident/completely sure".

Note:

*If you have stopped doing the activity at least partly because of being afraid of falling, score a 0

* If you have stopped an activity purely because of a physical problem, leave that item blank (these items are not included in the calculation of the average MFES score).

* If you do not currently do the activity for other reasons, please rate that item based on how you perceive you would rate it if you had to do the activity today.

		Not Confident					Fairly Confident					Completely Confident
	Activity	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1.	Get dressed and undressed											
2.	Prepare a simple meal											
3.	Take a bath or a shower											
4.	Get in/out of a chair											
5.	Get in/out of bed											
6.	Answer the door or telephone											
7.	Walk around the inside of your house											
8.	Reach into cabinets or closet											
9.	Light housekeeping											
10.	Simple shopping											
11.	Using public transport											
12.	Crossing roads											
13.	Light gardening or hanging out the washing *											
14.	Using front or rear steps at home											

* Rate most commonly performed of these activities

Score/Item Rated=

Average= _____

Appendix G

Nine Hole Peg Test

General Information:

- The Nine Hole Peg Test should be conducted with the dominant arm first.
- One practice trial (per arm) should be provided prior to timing the test.
- Timing should be performed with a stopwatch and recorded in seconds.
- The stop watch is started when the patient touches the first peg.
- The stop watch is stopped when the patient places the last peg in the container.

Set-up (Mathiowetz et al, 1985):

- A square board with 9 holes,
    - holes are spaced 3.2 cm (1.25 inches) apart o each hole is 1.3 cm (.5 inches) deep
- 9 wooden pegs should be .64 cm (.25 inches) in diameter and 3.2 cm (1.25 inches) long
- A container that is constructed from .7 cm (.25 inches) of plywood, sides are attached (13 cm x 13 cm) using nails and glue
- The peg board should have a mechanism to decrease slippage. Self-adhesive bathtub appliqués were used in the study.
- The pegboard should be placed in front of the patient, with the container holding the pegs on the side of the dominant hand.

Patient Instructions (Mathiowetz et al, 1985):

- The instructions should be provided while the activity is demonstrated.
- The patient's dominant arm is tested first.
- Instruct the patient to:
    - "Pick up the pegs one at a time, using your right (or left) hand only and put them into the holes in any order until the holes are all filled. Then remove the pegs one at a time and return them to the container. Stabilize the peg board with your left (or right) hand. This is a practice test. See how fast you can put all the pegs in and take them out again. Are you ready? Go!"
-
    - "This will be the actual test. The instructions are the same. Work as quickly as you can. Are you ready? Go!" (Start the stop watch when the patient touches the first peg.)
    - While the patient is performing the test say "Faster"
    - When the patient places the last peg on the board, instruct the patient "Out again…faster."
    - Stop the stop watch when the last peg hits the container.
- Place the container on the opposite side of the pegboard and repeat the instructions with the non-dominant hand.

Appendix G (continued)

Nine Hole Peg Test

Name:____

Dominant Hand (circle one): Right Left

Time to complete the test in seconds:

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Downloaded from www.rehabmeasures.org
Test instructions derived from Mathiowetz et al, 1985
The NHPT is provided courtesy of Virgil Mathiowetz, PhD, OTR/L, FAOTA

References:

Mathiowetz V, Weber K, Kashman N, Volland G. Adult Norms for the Nine Hole Peg Test of Finger Dexterity. *The Occupational Therapy Journal of Research.* 1985;5:24-33.

Appendix H

LSVT BIG + PSE Exit Survey

Please answer the following questions honestly and to the best of your knowledge.

1. Do you feel in better physical shape after your physical therapy sessions than before?

Yes No

2. During the treatment period, were there circumstances that prevented you from completing the LSVT exercises at home?

Yes No

If yes, please explain:

____

3. During the treatment period, did you exercise outside of the clinic other than the LSVT exercises? (running, yoga, dance, strength training, etc.)

Yes No

If yes, approximately how often?

Never	Rarely	Inconsistently	Consistently
(0%)	(1-49%)	(50-80%)	(81-100%)

4. During the treatment period, circle the approximate number of days you completed the LSVT exercises at home each week. (you may circle more than one number)

0 1 2 3 4 5 6 7

5. During the treatment period, were there circumstances that prevented you from using your CD when completing exercises at home?

Yes No

If yes, please explain:

____

6. How often did you use your CD during *in-home* exercise?

Never	Rarely	Inconsistently	Consistently
(0%)	(1-49%)	(50-80%)	(81-100%)

Appendix H (continued)

7. Rate the effectiveness of the PSE tracks on the CD to complete exercises *at home*:

N/A	0	1	2	3	4
	Not Motivating				Highly Motivating

8. Rate the level of distraction the PSE tracks provided during your exercises *in the clinic*:

N/A	0	1	2	3	4
	No distraction				Highly Distracting

9. Rate the level of distraction the PSE tracks provided during your exercises *at home*:

N/A	0	1	2	3	4
	No distraction				Highly Distracting

10. Would you recommend other LSVT patients use the PSE tracks on CD during exercise?

Yes No

Why/why not?

____

____

11. Any additional feedback?

____

____

____