

Spring 5-18-2019

# Patterned Sensory Enhancement-Based Interventions in an Acute Rehabilitation Setting: Development of a Method

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## Recommended Citation

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Patterned Sensory Enhancement-Based Interventions in an Acute Rehabilitation Setting:

Development of a Method

Capstone Thesis

Lesley University

May 5, 2019

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Music Therapy

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### Abstract

Constraint-induced therapy (CIT) or Constraint-induced movement therapy (CIMT) is used in rehabilitation to improve upper extremity function in patients who suffer from brain injuries, such as stroke or cerebral palsy. By engaging in repetitive exercises and increasing the use of the affect area of the upper extremity, the brain develops a change in neural pathways that helps recover the use of limbs by these patients. Unfortunately, one of the main limitations of CIT is the low compliance with patients involved in CIT, due to the stopping of use of compensation strategies, and the intensity and duration of the treatment, especially with the pediatrics population. However, the Neurologic Music Therapy (NMT) technique, Patterned Sensory Enhancement (PSE), was developed to address those same goals through the therapeutic use of music and rhythm as a driving force to facilitate better movement quality. The auditory cues in the music help facilitate movement exercises that are not rhythmic in nature, which in turn improve strength, endurance, balance and posture of the patient participating in recurring sessions involving PSE. The goal of this study was to design, develop and facilitate movement exercises and facilitating music for an intervention based on the knowledge of PSE to target both upper and lower extremities of patients hospitalized in an acute rehab setting. The intervention was facilitated in a group session consisting of 5 patients, who were recovering from various forms of brain injury. Prior to this study, a portion of the group session usually consisted of movement exercises facilitated by an occupational therapist or physical therapist.

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**Introduction**

Through shaping techniques and repetitive practice, CIT movement exercises have a positive impact on rehabilitation and are supported with valid research of its effectiveness as presented in the review by Huange et al. (2009). The review states that behaviors can be progressively modified toward a goal through successive approximation and reinforcement. This plays a huge role during rehabilitation, when patients must often learn cognitive and physical skills from scratch once again.

The five patients in this Capstone Thesis Project utilized wheelchairs as their ambulation device, and often had to be assisted during ambulation or with their activities of daily living, due to their physical constraints. Occupational Therapists (OTs) and Physical Therapists (PTs) assessed these five patients and patients were selected as suitable participants for the group session. Once per week, patients participated in the group session for a total duration of one hour. Typically, the first 30 minutes were movement exercises facilitated by an OT or PT, followed by 30 minutes of NMT interventions targeting similar goals. For this study, it is proposed that the first 30 minutes of movement exercises were replaced by the newly designed intervention proposed by this project, hence making the entire session 60 minutes of music therapy-based interventions, while the OT or PT would assist with modelling the movements as a visual cue for the patients to follow. Before implementing the new changes in the group session, observations of the older sessions were made in order to compare and contrast with the changes later on.

During the movement exercises, patients often presented fatigue after 15 minutes and became decreasingly motivated to participate in the session, hence negatively impacting the effectiveness of the group session. Common feedback amongst participants indicated that regular movement exercises may not have been stimulating enough, and due to their physical limitations, some exercises were difficult for particular patients to follow and keep up with, discouraging them from following through with the session. This was one of the motivations for wanting to develop and change the format of the older sessions. The biggest change, however, would be the implementation of music and rhythm into the music and movement exercises. A PSE-based intervention was selected because in this NMT technique, “rhythmic, melodic, harmonic, dynamic-acoustical elements of music are used 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), making this technique most suitable for addressing the goals of the group session. There is a lot of similarity between PSE and regular movement exercises, with PSE being more polished due to the addition of the nature of neural entrainment of the patients’ movements with the rhythm and music.

Thaut et al. (2015) states that entrainment is defined by a temporal locking process, where one system’s motion or signal frequency entrains to the frequency of another system. This process is universal, and can be observed in physical systems such as pendulum clocks and biological systems such as fire flies, and that entrainment can also be observed between human and sensory motor systems as evidenced by studies by Paltsev and Elnor (1967) and Rossignol and Jones (1976), demonstrating how rhythm and sound can “prime and time muscle activation via reticulospinal pathways” (Thaut, 2015). The brain can access rhythmic entrainment

mechanisms despite being injured, and music and rhythm can act as a driving force for the repetition of motor movement, thus benefiting the rehabilitation process of a brain injury patient.

An electronic keyboard was the primary choice of instrument for this project intervention, due to its wide rhythmic and melodic versatility. It was also selected due to its portability, making it a viable instrument regardless of the location of the sessions. When utilized in the sessions, a sustain pedal is attached to the keyboard to allow greater melodic expression of the music being played, which plays a key role in facilitating the music for its desired purpose. With PSE, only the facilitator plays an instrument, not the participants. Prior to implementing PSE into the group sessions, the music and movement for the technique were designed over a duration of two weeks. The movements were designed to target both upper and lower extremities, starting with the neck, then to the shoulders, arms and wrists, followed by trunk and lastly, quads and ankles.

A PSE study was conducted by Altenmüller et al. (2009), in which either piano or electronic drum pads programmed to emit piano tones were used to support therapy for motor impaired stroke patients. The study showed that patients who utilized the music instruments in therapy yielded significant improvement in fine and gross motor skills in terms of speed, precision and smoothness of movements, when compared to the patients who did not utilize music instruments. Another study by Luft et al. (2004) demonstrates that rhythmic auditory cueing in rehabilitation therapy increased hemispheric activation as changes in activation were observed in the contralesional cerebrum and ipsilesion cerebellum, providing biological plausibility for rhythmic auditory cueing in rehabilitation. Hence, it was hypothesized that the introduction of a PSE-based intervention into group sessions as a replacement for regular movement exercises would present greater success and benefits, such as improvement in mood,

motivation to participate and increase in intensity and number of reps of the exercises. Reiss et al. (2012) states that efforts by researchers to improve the methodology and standardization of protocols can assist practicing clinicians in analyzing evidenced based practice (EBP), and incorporating best practices into clinical practice. Being able to establish a standardized best-model alternative CIMT protocol would also allow stroke guidelines to make a much clearer, and more defined recommendations regarding CIMT. Thus, highlighting the importance of the development of PSE as an alternative to treating patients with brain injury, not just as an intervention or technique, but also as a method of informing the clinical practice of others.

### **Literature Review**

The development of a method was chosen as the capstone option for this project. This section discusses the history and related themes regarding the implementation of a PSE-based intervention for rehabilitation. In NMT, there exists another technique called Rhythmic Auditory Stimulation (RAS), which is used to facilitate the rehabilitation of movements that are intrinsically biologically rhythmical. However, despite the similarity in the goals addressed between RAS and PSE, RAS is mostly used to target gait training. PSE, on the other hand, is used to target non-gait, upper extremity and lower extremity functional movement. It is “broader in application than RAS, because it is applied to movements that are not rhythmical by nature (e.g., most arm and hand movements, functional movement sequences such as dressing or sit-to-stand transfers) and (b) it provides more than just temporal cues.” (The Academy of Neurologic Music Therapy, 2005). There is an importance in developing an intervention that could be used as an alternative to CIT or CIMT in rehabilitation settings. As demonstrated in a survey conducted by Daniel et al. (2012), 92 therapists with one year of clinical experience working in clinical neurorehabilitation were surveyed. Survey results demonstrated that 75% of participants

reported that they found difficulty in administering CIMT in their clinics, while 83% felt that they would have insufficient resources to do so. Other CIMT limitations mentioned included the unlikely reimbursement for CIMT, and restrictive device durations.

A prior study by Tze-Hsuan et al. (2013) has shown that the implementation of PSE techniques in group sessions induced greater improvements in gross motor capacity. In this case, the study was conducted with children with spastic diplegia, a form of cerebral palsy. The children ranged from 5 to 13 years of age and were assigned to two different groups, one group with PSE exercises implemented and the other group with no music implemented. Both groups had sessions over 6 weeks, however, the PSE group only exercised with prerecorded music. The results of the study concluded that the PSE group improved significantly greater than the non-music group in terms of functional skills and 1-repetition sit-to-stand. The improvement lasted for approximately 6 or 12 weeks though, no significant improvements in the rest PEDI (Pediatric Evaluation of Disability Inventory) scales and walking speeds were found (Tze-Hsuan et al., 2013). Study findings further supports that the implementation PSE focuses on the functional use of upper and lower extremities, rather than gait training or walking speeds, making PSE a more viably adapted NMT technique than RAS for the Capstone Thesis Project when functional motor skills are addressed. Even though the study by Tze-Hsuan et al. (2013) was successful despite utilizing pre-recorded music, the method for facilitating PSE for the Capstone Thesis Project will utilize live music on an electric keyboard instead.

There are multiple benefits to playing live music as opposed to playing pre-recorded music. A study conducted by Bailey (1983) compares the effects of singing and playing guitar music to using tape-recorded music of the same material with 50 hospitalized cancer patients ranging from 17 to 69 years of age. Each participant was randomly selected and placed into one

of two groups. One group had live music played for them, while the other group had recorded music played for them. Mood states before and after the trial were recorded using a Profile of Mood States (POMS) questionnaire. The results of the study concluded that patients with live music reported significantly less tension and anxiety and presented more vigor than patients with recorded music. Bailey (1983) states that there exists a vital part in live music which consists of a human element. Part of the development of PSE-based music and movement exercises for the Capstone Thesis Project consists of taking the patients' physical limitations into consideration. Each patient had a different level of physical limitation, making it more difficult for some to follow through with the intervention if pre-recorded music at a set tempo was played. Also, some patients also have some days when they are more fatigued than others, making it important for the facilitator to have the ability and musical competency to adjust the music or tempo to suit the group's needs in the moment. Being flexible with the musicality of a PSE-based intervention enables the participants to feel like they can go at their own pace if they want to, despite having the music to direct and cue their motor movements. Similar to Bailey's (1983) study, it was hypothesized that the existence of a human element in the music and it interacted with the patients also changes how receptive the patients are towards the activity, likely because it enabled them to find it recreational as well despite the physical intensity of working on their functional motor movements over a duration of 30 minutes. The proposed duration of 30 mins was hypothesized to be the most suitable duration based on previous observations of the music and exercise groups which were used to gauge the participants' level of tolerance of the activity. The duration of the intervention was a factor to consider when developing it, as patients expressed their concerns with how time consuming therapy can be, hence limiting their willingness to participate in sessions as mentioned in an article by Sterr and Saunders (2006).

However, there have also been instances where PSE have been utilized and little or no benefits have been presented while utilizing recorded music. In a prior study by O’Konski et al. (2010), long-term care residents participated in two groups which were videotaped. The first group consisted of PSE exercises with recorded pre-composed music while the second group consisted of regular motor exercises with big band recorded music playing in the background instead. The variables of the same patients in both groups were measured in order to maintain reliability. The variables measured were the number of repetitions, adherence to the modeled movements, range of motion and form. Observers would watch videotape recordings of the sessions to code how well the patients would fare PSE with pre-composed music against similar motor exercises with big band music instead. The sound was removed from the videotapes so that the observers would not know which group the tapes were from, in order to maintain reliability. Based on their findings, PSE exercise groups were found to have insignificant benefits compared to exercise groups using big band background music. The specifics of the music utilized in this study were not stated. Rhythm plays a considerable role in driving motor movement, however the difference between the rhythm and tempo of the pre-composed music and big band music in this study was unknown. It was also noted that the utilization of recorded music would make it difficult for the exercises to suit the participants’ pace as it was not possible to control the rhythm or tempo of recorded music in a session.

Another study with a similar population to the Capstone Thesis Project was conducted by Clark et al. (2012), where live PSE was implemented instead of recorded music, in exercise groups with older adults in rehabilitation. Two exercise groups ran per week, with one group utilizing live PSE and the other did not. Live PSE in this study consisted of live piano or guitar with no vocal accompaniment and was timed to match the movements and pace of the group.

One to two minutes of rest were given in between each exercise set, and the exercises were aimed to improve the strength and endurance of the major muscle groups in the arms and legs, while resistance for each exercise was provided either by body weight, weighted cuffs, or dumbbells. The results revealed that there were no significant differences between number of repetitions and amount of weight lifted for exercises involving upper and lower extremities. However, despite the results, the Capstone Thesis Project consisted of several differences in order to observe if these changes can facilitate an improvement in results. Firstly, all the sessions of the Capstone Thesis Project consisted solely of live PSE-based music played only by an electric keyboard. It was hypothesized using only one instrument throughout the project would better familiarize the participants with the music. Weighted devices were not utilized, as some of the PSE-based movement exercises were designed to be slightly more complicated and go beyond one-step movements. This was done to ensure that the participants were not simply just “following through” with the movement but were actually sustaining their attention to the music and task while being mindful of the directives of the particular set of movements, such as carrying out a single movement exercise consisting of movement in multiple directions of various speeds and durations. It was also hypothesized that implementing some movements that were slightly more complicated or did not “come as naturally” to the participants would encourage them to use the music as auditory cues to build familiarity via task repetition.

The intervention used in the Capstone Thesis Project would focus more on building neuroplasticity through music without inducing fatigue, rather than using facilitating music to improve the number of repetitions of an exercise or improving the weight of a device being lifted in the exercise, as demonstrated in Clark’s et al. (2012) study. Participants would not be pushed to the limit to assess if their physical abilities were improved. With this in mind, the exercises

themselves and the facilitating music would be designed solely by the facilitator, unlike in Clark's et al. (2012) study where a physical therapist demonstrated the exercises and the music therapist followed the physical therapist's lead instead. Takeuchi and Izumi (2015) states that within the human motor system, it had been well described that activity-dependent plasticity can be artificially induced by brain stimulation in a manner dependent on strict temporal relationships in central or peripheral voluntary activity. The artificially induced brain stimulation plays a vital part in building plasticity and in the rehabilitation of the motor system, while the music in PSE can act as a strong auditory cue for the stimulation to build plasticity. Takeuchi and Izumi (2015) also states that CIMT combines a rehabilitative training regime for the paretic limb with non-paretic limb restraint and can overcome learned nonuse of the paretic limb. The training regime has been shown to improve motor function in patients with stroke, and is similar to the intervention facilitated in the group setting for this Capstone Thesis Project. Even though each participant had different, specific extremities that were being worked on, a combination of repetitive, standardized exercises in a group setting could target affected and non-affected areas of the body, which could be trained together to improve motor function.

Also, participants of any form of music therapy did not require any former music training or experience to experience the benefits of the sessions. A study by Schneider (2010) demonstrated that in addition to conventional physiotherapy and functional motor training, 32 stroke patients with no previous music experience received fifteen 30-minute music-supported training (MST) sessions over three weeks. The patients participated in sessions where they would either play an electronic piano or electronic drum set emitting piano tones. Each session was documented, and later analysis showed that groups that participated in music sessions had significant improvements in fine motor movement while the group that participated in

conventional therapy such as occupational and physical therapy, did not produce any improvement in most of the parameters assessed. These results demonstrated that music can be used as a driving auditory cue for the rehabilitation of fine motor skills as well. The Capstone Thesis Project exercises, however, had a greater focus on range of motion, fluidity and endurance of upper and lower extremities instead. This focus was one of the main objectives for the facilitation of group music and movement sessions, primarily to combat muscle spasticity and muscle tone that are present in patients. Muscle spasticity in brain injury patients was observed to be prevalent in this acute rehabilitation hospital setting. Spasticity is defined as the uncontrolled tightening (increased muscle tone) caused by disrupted signals from the brain. It is common in persons with severe brain injuries (TBI) (Model Systems Knowledge Translation Center, 2015). These patients who suffer from spasticity from brain injury may feel as if their muscles are unable to stretch or relax and it greatly affects their functional motor skills and negatively impacts them due to the struggle with activities of daily living.

Muscle spasticity is reported to affect more than an estimated 12 million people worldwide as about 80 percent of people with cerebral palsy (CP) have varying degrees of spasticity. An estimated 500,000 people in the United States with some form of CP. Notably, about 400,000 people with some degree of CP-related spasticity and about 80 percent of people with multiple sclerosis (MS) have varying degrees of spasticity. An estimated 400,000 people in the United States are diagnosed with MS, with about 320,000 people having some degree of MS-related spasticity (American Association of Neurological Surgeons, 2019). Some other conditions that cause spasticity include Traumatic brain injury (TBI), Spinal cord injury (SCI), Brain damage due to a lack of oxygen, Stroke, Encephalitis, Meningitis, Adrenoleukodystrophy, Amyotrophic lateral sclerosis (Lou Gehrig's disease) and Phenylketonuria (American

Association of Neurological Surgeons, 2019). These common diagnoses were similar to the ones observed in the setting where the Capstone Project was facilitated. A prior study by Cheng et al. (2015) demonstrated that whole body vibration (WBV) interventions targeting lower extremity muscle tone and function in children with cerebral palsy resulted in improved active joint range and enhanced ambulatory performance lasting at least three days. The vibration from WBV interventions utilized mechanical stimulus characterized by oscillatory motion (Cardinale & Wakeling, 2005), and was considered a “safe and effective way to exercise musculoskeletal structures” (Cardinale & Wakeling, 2005), further supporting the need for safe, effective and non-invasive exercises among patients with muscle spasticity. The lessening of muscle spasticity will no doubt be advantageous in helping patients regain motor functions and skills that they may have lost due to brain injury.

### **Methods**

**Intervention Development.** Development for the PSE-based intervention began 3 weeks prior to its first implementation in the group session. Motor exercises were designed to target areas of the neck, shoulders, arms and wrists, followed by trunk, quads and ankles. Some of the exercises included several simple exercises taken from observation sessions with PTs and OTs. During the intervention development phase, a weekly meeting with a neurologic music therapist who worked at the rehab hospital took place in order to brainstorm ideas for the motor exercises, music and to give feedback regarding existing exercises and the facilitating music. Much thought was given to designing the movement exercises to go beyond one-step directions in order to ensure that participants would be challenged in attending to verbal directions and auditory cues in the music. For example, for one of the exercises, instead of simply repeating the motion of moving both arms up and down repetitively to the music, participants would instead have to

move their arms up as high as possible, followed by lowering their arms down, and finally bending forward and touching their toes before returning to the sitting position. The exercise movements were also designed to have as much carryover as possible, enabling the patients to maximize functional benefits in their day to day activities after the sessions. For example, a combination of wrist rotation and arm exercises enable patients to work on the ability to rotate door knobs and pull or push a door. Reaching arms up as high possible and bending forward and touching their toes enable them to work on the ability to reach for an item on a high shelf or bend down and tie their shoelaces respectively. Each of the five patients utilized wheelchairs as their ambulatory device, and they remained seated in their wheelchairs for the duration of the group session. Hence, all the exercise movements were designed to be carried out while patients remained in a seated position.

Original music was also composed to facilitate these movements. The piano was the sole choice of instrument for this intervention, due to its wide rhythmic and melodic versatility and range. With the intention to build familiarity with the music, only one instrument was chosen for the project as it was hypothesized that the participants would build familiarity faster with a single instrument rather than a few. Following Thaut's (2014) principles on PSE, a consistent underlying timing structure was one of the biggest priorities taken into consideration when designing the motor movements and the music as the consistency "results in coupling of the motor system with the auditory system through rhythmic entrainment, and therefore drives the movement pattern" (p. 108). Other musical properties such as pitch, dynamics, sound duration, harmony, temporal cues, tempo, meter, rhythmic pattern and form were also taken into consideration during their composition. For example, when the movement moves in an upward direction, the pitch of the music goes higher, however when the movement moves in a downward

direction, the pitch of the music goes lower instead. As another example, if the movement consists of a marching exercise using bilateral lower extremities, the music would sound sharply detached rather than in a smooth flowing manner, in order to emphasize the powerful, deliberate uniformity of the marching motion. At the end of the three-week intervention development phase, a total of 20 exercises with facilitative music spanning across approximately 30 minutes was developed and ready for the music group.

**Participants.** Inpatients at the acute rehabilitation hospital were assessed and selected for the group sessions in this Capstone Thesis Project. Based on how well they were doing in individual sessions with OT and PT, the respective therapists made recommendations that these patients would be suitable individuals for the music and exercise group. Patients were invited to participate in the group sessions based on the following criteria: (a) patient could follow simple commands, (b) patient could sustain their attention to tasks for a period of time, (c) patient did not have conflicts in scheduling with other therapy sessions or medical appointments, (d) patient did not have profound auditory or visual problems that could greatly hinder their ability to participate, and (e) patient had motor function goals they needed to address. Although the age of the patient was not a criterion that was taken into consideration, the patients' ages ranged from 60 to 95 years of age. The five patients selected for the music therapy group presented a variety of health issues; however, they were cognitively high functioning despite their physical constraints. Due to this, all five patients required some level of assistance with their activities of daily living, as they also ambulated in wheelchairs. Due to brain injury, the range of motor impairment among them included problems with grip strength, weakness in either one or both upper extremities, weakness in either one or both lower extremities, muscle tone and spasticity, ataxic movement in upper extremity, limited range of motion of either one or both upper and/or lower

extremities, and regular instances of fatigue. All patients also required assistance from time to time from a PT, OT or rehab aide during the group sessions, such as positioning themselves in suitable positions to sit, taking instruments for the activities, and handing back instruments after the activities. As the group sessions were conducted once per week, each session had an OT or PT as a co-facilitator that rotates every session. There were, however, no problems with familiarity between facilitators and participants as each patient was being seen for three hours of individual sessions each day by the same OTs and PTs that co-facilitate the group sessions.

**Materials.** As wheelchairs serve as the ambulatory devices for each of all five patients, they remained seated in their wheelchairs for the duration of the group music session. Essential medical devices required by particular individuals, such as feeding pumps, or IV bags remained within close proximity of the patients during the sessions. A vital sign monitor also remained close by and could be utilized by PTs, OTs or rehab aides in case any of the participants started to feel unwell. One PT or OT, and one rehab aide was present to co-facilitate the group sessions by modeling the exercise movements and by providing verbal cues. They also occasionally provided hand-over-hand assistance, to participants who had difficulty carrying out the exercises. Hand-over-hand assistance is provided as minimally as possible in order to encourage the participants to perform to the best of their abilities. Since all the participants were already seated in wheelchairs, chairs were required for the facilitator and co-facilitators.

A battery-powered, non-weighted electronic keyboard with 61 keys was the most important piece of equipment of all as it was used to play the music needed to facilitate the PSE-based intervention live. A sustain pedal was utilized in conjunction with the electronic keyboard as it allowed for greater musical expression. A spare set of batteries were also kept readily available in case the electronic keyboard ran out of power. The lack of an acoustic piano at the

acute rehabilitation hospital was also one of the reasons why an electronic keyboard was used instead, however its volume at its maximum proved to be audibly sufficient for the activity. A bottle of liquid hand sanitizer was also used to sanitize everyone's hands before and after the group sessions, while observations and feedback regarding the interventions were noted down in a journal after every session.

**Project Intervention Procedure.** The PSE-based sessions were held once per week for four weeks at the common area of the neurology floor at the acute rehabilitation hospital. After the three-week period of intervention development, the OTs and PTs who previously facilitated exercise movements during group sessions were given notice that the PSE-based intervention was ready to be implemented. Participants were also notified prior to the first music therapy session that there would be a change in how the group would be facilitated and a brief explanation of PSE was given to them. Everyone promptly agreed to participate in the newly designed session. The first change the participants noticed was the electronic keyboard that was brought to the group. Everyone in the group sat in a circle so that they could have a good view of each person present at the session.

Every group session began with introductions as a warmup activity to build familiarity and rapport among group participants and facilitators. Everyone would introduce their name and state where they were from to the group. When introductions finished, each of the music and movement PSE exercises were facilitated one by one. Each exercise was modeled first, then the participants were encouraged to follow along to the visual, auditory, and verbal cues given by the OT or PT and rehab aide. Due to the difficulty of modeling a movement exercise while playing the electronic keyboard as the facilitator, sometimes one hand was used to model while the other was used to play a simplified version of the melody once through, to give the participants a

rough idea of how they were supposed to move. Once the participants initiated their movements, the music reverted to its intended form, with both hands playing the electronic keyboard. Short two-minute breaks were given to participants after every three or four intervention-based movements. During the breaks, facilitators and participants engaged in small-talk, such as asking the participants how they were feeling, and what they thought of the movements or music.

Due to the time it took to set up the equipment required for the group, and to assist each of the participants ambulate to the location of the session, the PSE group would always stretch over the anticipated 30 minutes. At the end of each group session, participants and co-facilitators were verbally and informally questioned regarding how they felt physically, and in terms of their mood. They were also asked if they had any other thoughts on how they would like the facilitation to be improved. After the session, the patients were assisted to their desired location on the hospital floor. Once all equipment was accounted for, an approximately 15-minute supervision session was held with the in-house neurologic music therapist (NMT) regarding topics such as observations that came up within the session, details that may have been missed during the intervention's design phase, and how improvements regarding facilitation could be made.

## **Results**

**First Post-Session Feedback.** The session was implemented successfully with the overall feedback given by both the participants and co-facilitators that the music was very enjoyable, and they preferred doing the exercises with music rather than without. They also found the music to be soothing, which was said to help with cueing the movements they were supposed to carry out, despite of the complexity of several of the exercises. One of the participants mentioned that the activity reminded her of ballet dancing, where dancers would

choreograph their movements elaborately and gracefully to piano music. For the first group music therapy session, the PSE-based movements targeted specific areas of the body and were facilitated from head to toe, starting from the neck, then to the shoulders, arms, and lastly the legs. The main concern given as feedback that session from co-facilitators and participants, was that it was exhausting to finish all exercises focusing on one part of the body before moving on to the next, and they would rather have alternated the focus of each part of the body. This consideration was noted and implemented from the second PSE-based session onwards.

One detail that was initially not taken into consideration during the intervention development, was that some of the participants were not able to move either their upper or lower extremities due to their physical limitations in some of the exercises. For example, when the participants were tasked for an exercise that required them to do long arc quads, one of the participants was unable to carry out the exercises due to a transtibial amputation of the lower extremity. In such instances, the participant would be asked to do an alternative exercise while the rest of group would carry on per usual. For example, this patient was asked to stretch and extend his shoulders to the music instead of extending his quads. There were also several instances where one or two patients had to carry out alternative exercises from the group due to extreme weakness or fatigue with that particular part of their body, or if the session simply did not have enough co-facilitators to assist that patient. The movements for the alternative exercises would usually consist of similar motion speed and intensity as the intended exercise, so that the music would suit the movements for all participants regardless of whether they were doing the intended exercise or an alternative one.

Feedback from the NMT included suggested alterations to the music for specific exercises, such as changing the tempo or the music altogether. Some exercises required better

musical cueing due to the lack of rhythmic aspects of the music, particularly with the more complicated movement exercises that go beyond one-step directions. It was suggested that some of the music required more elaborate chords and melodies in order for the various exercises to sound much more melodically different. This proved to be a slightly challenging due to the similarity between the direction and intensity between the simpler, one-step exercises. For example, the movement of the dorsiflexion and plantar flexion of the foot would sound melodically similar to the movement of bicep curls utilized in the upper extremity. Hence, the current music for the exercises was developed further to accommodate these suggestions and eventually implemented on the second group session.

**Second Post-Session Feedback.** With the change in music, participants still needed more time to build familiarity with the new music, however the new material was just as effective in directing the participants to the cues and movements. As all five participants required wheelchairs as ambulatory exercises due to limited functions with their lower extremities, it is observed that the participants often had difficulty with lower extremity exercises in terms of range of motion and endurance. With only one OT or PT, and one rehab aide as co-facilitators, participants had to be re-directed to carry out alternative exercises instead when three or more participants required assistance with moving their lower extremities to the music. If alternative exercises were required to be carried out by participants due to insufficient manpower for hand-over-hand assistance, or a complete inability of utilizing a part of their body, it was noted that the music for the alternative exercises had to be prepared as well. In this session, the alternative exercises consisted of exercises that had already been carried out earlier in the session. For example, a patient who had a transtibial amputation was asked to carry out bicep curls instead of doing dorsiflexion and plantar flexion of the feet, even though bicep curls had already been done

by the group earlier in the session. Feedback from the NMT for this session included the suggestion of verbally counting down during the last few repetitions of a set of the PSE-based exercises, so that the participants would know when to anticipate the end of the set of the particular exercise. This suggestion was further implemented in the third and final sessions.

**Third Post-Session Feedback.** When counting down the last few repetitions of a set during each exercise, some exercises required a countdown not to end the set, but to change the direction of the movement of the exercise itself. For example, when carrying out wrist rotations in a clockwise motion, a verbal count down of the repetitions would eventually signal the change in direction to an anti-clockwise motion instead. The feedback for this session suggested that the transition from one set of exercise in one direction, to another set of the same exercise in the opposite direction was not smooth enough. There were moments in the session when the participants were slightly confused as to whether they should stop because it was the end of a PSE exercise set, or if they should keep on moving in the opposite direction instead. The suggested remedy for this was to also verbally remind the participants just before the end of the countdowns, that the exercise was going to continue in the opposite direction. It is noted that the implementation of alternative exercises for patients who were unable to carry out certain exercises went much more smoothly compared to previous sessions. Alternative exercises were tasked to fit the music of the current PSE-based exercise well, which ensured that everyone was rhythmically well cued to carry out the exercises.

**Final Post-session Feedback.** The previously mentioned changes were implemented in the final session successfully. Feedback from the OTs and PTs confirmed that the PSE-based intervention was an excellent and safe way of allowing patients to exercise a wide range of areas

of their bodies. At the end of the session, the co-facilitators recommended that the group music therapy sessions should carry on beyond the final session due to the benefits.

### **Summary**

The overall consensus from PT and OT who have participated in the sessions, are that the participants have become more fluid with their motor movement and their range of motion. The participants found the exercise group session more enjoyable with music than without. The preference for music shows how music can be a great motivator for group participation. Feedback was given that the music has regulated and cued their movements well, as they built their familiarity with the music over the several sessions, while becoming accustomed to the intensity and duration of the sessions. It is noted that the exercises developed in the PSE-based intervention of the Capstone Thesis Project were overall more physically demanding than the usual non-music exercises, hence showing an improvement in the strength and endurance of the patients when they are able to participate from start to end with demonstrating little or no signs of fatigue. The variety of the parts of the body the exercises addressed was greater than the exercises implemented without music prior to the Capstone Thesis Project, which was also one of the reasons which made PSE preferable as a group intervention, partly also because the group exercises were limited, as the sets would repeat once one set of the exercises were facilitated. Feedback from the OTs and PTs confirmed that PSE was an excellent and safe way of allowing patients to exercise a wide range of areas of their bodies, and it was highly recommended that the PSE sessions should carry on beyond the final session if possible, due to the benefits observed.

The Capstone Thesis Project was a success and a suitable alternative to CIT. The feedback received played a huge role in the design and constant development of how the NMT intervention would be facilitated in a group setting. Prior to facilitating the first group music

therapy session for the Capstone Thesis Project, it was also hypothesized that implementing some movements that were slightly more complicated or did not “come as naturally” to the participants would encourage them to use the music as auditory cues to build familiarity via task repetition. It was observed that during these complicated PSE-based movements, patients and co-facilitators could be seen mouthing or verbalizing the directions dictated by the movement and rhythm of the music even when verbal facilitation had stopped. With each “complicated” exercise, the participants would often start moving slower than dictated, or moving to inaccurate directions. However, through task repetition, it was observed that the participants would demonstrate an improvement in accuracy to the overall task. This shows the building of neuroplasticity in action, hence fulfilling one of the goals of the Capstone Thesis Project.

One future possibility to explore would be to facilitate the same intervention in a group setting with other populations that would similarly benefit from PSE such as pediatric patients (Tze-Hsuan et al., 2013) or with patients who suffer from dementia and require strength and endurance training as a form of physical habilitation. It was hypothesized that the music composed for PSE-based interventions might be changed with each new, due to the difference in the challenges each population may present. For example, children who suffer from ADHD may find it difficult to participate in an instruction-based 30-minute intervention due to deficits in attention. PSE-based exercises for such a population would then have to be reconfigured, including redesigning the exercises, facilitating music or number of repetitions to have a greater emphasis on engaging the participants.

It was noted that after the first two sessions, participants indicated that they were already mostly familiar with the movement exercises and the facilitating music. Another future possibility to explore would be the implementation of recorded PSE music in this group setting

to examine if recorded music would have a similar effectiveness after building familiarization with live music, because if no differences in the implementation of live and recorded music is found, it would mean that the utilization of recorded music would then have greater logistical convenience in future group music therapy sessions that would be facilitated in the long run. When contrasting between the facilitation of live and recorded PSE music, it is recommended that a few sessions of live-PSE be facilitated first, in order to build familiarity with the music and exercises. Implementing recorded music without a way of controlling the tempo for a PSE-based exercise when participants are unfamiliar with the music and exercises, would make it challenging for participants to follow through accurately to the task, hypothesizing that the results obtained from such an observation would yield inaccurate results for the comparison. So far, there have been no studies comparing and contrasting the difference between utilizing live pre-composed music for PSE and using recorded versions of the same pre-composed music for PSE.

Feedback suggests that increasing the overall tempo of the PSE-based movement could be explored to observe if the participants could feel any significant difference in their performance during the session. An increase in 5% of the tempo could be implemented with each session in order to observe any carryover effects of previous sessions. The increasing difficulty could prove to be challenging even for groups who have been doing well for a couple of sessions. Facilitating the group with weighted props such as dumbbells and weighted bars could also be explored, so that PSE-based exercises could have a greater focus on building strength, rather than focusing on the range of motion and habilitation, for appropriate participants who do continuously well in regular group music therapy groups. One study regarding strength training showed that postoperative rehabilitation programs that incorporate strength training, enabled

patients who underwent lumbar spine fusion to enable earlier function recovery than standard rehabilitation protocol (Kernc, et al., 2018). PSE is hence also suitable for postoperative patients or patients with spinal injury, as PSE addresses strength, endurance, balance and posture at the same time. (Thaut, 2014).

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