

THESIS

TRAINING ENDOGENOUS TASK SHIFTING USING NEUROLOGIC MUSIC THERAPY

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## ABSTRACT

### TRAINING ENDOGENOUS TASK SHIFTING USING NEUROLOGIC MUSIC THERAPY

People with acquired brain injury (ABI) are highly susceptible to disturbances in executive functioning (EF) and these effects are pervasive. Research studies using music therapy for cognitive improvement in this population are limited. Scientific research regarding the proposed neural correlates of executive functions abound. Additionally, scientific music research is gaining momentum. The presence of shared neural correlates and extended pathways between certain kinds of music and executive functions is clear. Further, the capacity of music training to induce neural plasticity has significant support, but interventions on a clinical level are sparse. The current randomized control trial (n=14) sought to uncover whether using a specific neurologic music therapy approach to train endogenous task shifting would create positive results in standard measures of executive functioning (the Trail Making Test and the PASAT). In this pilot study, participants were randomly assigned to one of three groups: a neurologic music therapy group (NMT), a placebo, singing group and a control group. Both music groups met for one hour a day for five days. One-way ANOVA of the pre- and posttest group differences revealed a statistically significant difference between the NMT group and the placebo group ( $p = .3189$ ; LSM  $p = .0315$ ;  $F = 4.44$ ;  $\eta^2 = .446$ ;  $\omega^2 = .329$ ;  $d = 1.79$ ;  $MSE = .3189$ ; C.I. -1.6661, -.0939). However, a statistically significant difference was not found between the NMT group and the control group. Further, a statistically significant effect was also found between the control group and the placebo group, leading to inconclusive results ( $p = .3189$ ; LSM  $p = .0230$ , C.I. -1.8343,

-0.1667;  $F=4.44$ ;  $\eta^2 = .446$ ;  $\omega^2 = .329$ ;  $d= 1.79$ ;  $MSE=.3189$ ). The novelty of meeting in a group to sing songs did not show a difference, providing preliminary support for the importance of therapeutically applied music. Treatment feasibility and future considerations are discussed.

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## CHAPTER I: INTRODUCTION

### Purpose

The purpose of this study was to determine whether targeting a subcomponent of executive functioning with musical executive functioning training would improve overall executive functioning in individuals with an acquired brain injury. Specifically, training internal preparation for a shift in task was examined.

### Significance/Need for the Study

Although executive dysfunction is a common result of acquired brain injury, controlled group research studies of effective rehabilitation techniques are limited. The majority of these research studies focus on compensatory techniques. However, these approaches are complex and therefore difficult to replicate. Additionally, compensatory techniques seek to work around a problem rather than to fix it. Growing support for neural plasticity, or the brain's ability to rewire and regain function, is encouraging and has indicated music as a medium to positively change the brain. Consequently, precise methods to achieve this rewiring need further investigation. Unfortunately, research supporting the therapeutic use of music to address executive dysfunction is nearly nonexistent. Bradt, Magee, Dileo, Wheeler, and McGilloway (2010) conducted a comprehensive Cochrane review of music therapy research studies addressing acquired brain injuries. The review yielded no results in the area of executive functioning or cognition. Given this vast hole in the research literature, studies examining the use of standardized music therapy techniques to address executive functioning are sorely needed. Further insight into the elements

of successful, replicable interventions would be beneficial to any clinician working with this population.

## Background

Executive functioning (EF) refers to a psychological construct, or concept. It seeks to describe a multitude of interacting abilities necessary for navigating our everyday lives. Therefore, like any concept, it can be difficult to define. When people talk about executive functioning, they are typically referring to an individual's ability to complete goal-related activity. Subcomponents necessary for goal accomplishment include the capacity to sequence, manage time, set priorities, make decisions, sustain and shift attention, synthesize and evaluate information and utilize working memory. Other common skills thought to necessitate EF include the capacity to inhibit a response and display flexibility of thinking. Prospective remembering (PR) has also been identified as an important aspect of EF (Gouveia, Brucki, Malheiros, & Bueno, 2007; Kopp & Thöne-Otto, 2003). This form of memory entails not only *knowing* information (retrospective memory) but remembering to use the information *at the correct time* and then actually *act* on it. Many researchers include emotional regulation, motivation and self-initiation within their EF definition. The facilitation and orchestration of all of these skills are the essence of executive functioning.

Orchestrating all of these subcomponents is what makes executive functioning so elusive. When examined separately, a person may have normal functioning of many or all of these skills. It is when the individual is on their own, usually attempting to complete something new, that the problem of orchestration becomes evident. To complicate the issue, the circumstances under which problems occur are unique for each person. Schutz and Wanlass (2009) propose several

necessary characteristics to evoke executive functions. They believe these conditions include a novel situation, deemed by the individual to be challenging and important enough to require special attention but not so difficult that failure is imminent. These individualized circumstances create a challenge for assessing executive functioning. Further challenges lie within the set-up of standardized assessments and tests. Burgess and Simons (2005) outline the cardinal caveats of traditional neuropsychological tasks beautifully:

[Traditional neuropsychological tests] do not typically require the following: the creation, maintenance and execution of delayed intentions; the ability to recognize the need for, self-initiate and carry out complex meta-strategies; dovetailing of tasks to be time-effective; prioritization of tasks; and deciding for oneself in the absence of feedback whether a result is satisfactory. In other words, traditional executive tests do not measure many of the abilities that make a person effective in the real world. (p. 227-228)

Naturally, creating the circumstances conducive to all of these elements is not simple.

The structured environment of traditional tests is what ensures standardization and strict adherence to protocol; the necessary elements for reliable replication. Unfortunately, it appears to remove the exact elements necessary to capture EF in action. Among these elements, self-initiation of response and novelty are perhaps the most difficult elements to include. To overcome these obstacles, a handful of researchers have begun creating ecological assessments. Pioneered by Wilson and colleagues in 1996, these assessments create situations that aim to accurately reflect functioning in everyday life. The tests typically include hands-on, unstructured projects that are to be *attempted* within a given amount of time, guided by a set of simple rules. The projects are designed so that completion of each task is often not possible within the allotted time. Intervention from the administrator is not provided. Oftentimes these assessments are administered in busy, uncontrolled environments to ensure the presence of novelty and distraction, such as a shopping mall or a hospital. Although time-consuming and somewhat

complicated to conduct, ecological assessments have gained interest for their unique capacity to identify individual problems and also predict functioning within everyday life.

Historically, the term “executive dysfunction” and “frontal lobe syndrome” were used interchangeably. This was because the vast majority of people who exhibited clear signs of executive dysfunction had sustained damage to the frontal lobe. With the advent of advanced neuroimaging techniques, the development of new assessments, and better understanding of executive dysfunction, this is no longer believed to be the case. Although the frontal lobes (especially the prefrontal cortex) are clearly involved in executive functioning, the pathways that send and receive information to this area are just as important. The anterior cingulate gyrus, some parietal areas, basal ganglia and cerebellum all have research supporting their importance in executive functioning (Aron, 2008; Banich, 2009; Elliot, 2003; Schweizer et al., 2008). Dorsolateral prefrontal, orbital frontal and anterior cingulate circuits have also been identified (Vataja et al., 2005).

The wide network of areas involved in executive functioning supports the myriad of populations believed to be affected by its dysfunction. In addition to acquired brain injuries (of a non-degenerative nature), the range of disorders affected by executive dysfunction includes: Alzheimer’s disorder, Parkinson’s disease, Huntington’s disease, multiple sclerosis, schizophrenia, bipolar disorder, autism, HIV, major depressive disorder, substance use disorders and attention deficit hyperactivity disorder (Banich, 2009; Elliot, 2003). Additionally, scientists believe that optimal executive functioning does not occur until full development of the connections to the frontal lobes, around the age of 25. Further, executive dysfunction appears to occur as a result of the normal aging process. In sum, executive dysfunction is a problem for a multitude of people seeking therapeutic care.

Effective rehabilitation is imperative for executive dysfunction because not only is the disorder widespread, its effects can be pervasive. To illustrate, people with acquired brain injury exhibiting executive dysfunction show poorer recovery from post-stroke depression (Vataja et al., 2005), are less likely to return to work (Ownsworth & Shum, 2007), require higher levels of care and support for basic activities of daily living (Leśniak, Bak, Czepiel, Seniów, & Członkowska, 2008), and are more likely to have an earlier onset of Alzheimer's (Espinosa et al., 2009). These consequences compel those working in rehabilitation to discover and implement reliable techniques that create positive, long-lasting change.

To summarize, executive functioning (EF) refers to a multitude of abilities that must be coordinated in order to reach goals. This coordination must be initiated and maintained by the *individual*, during new situations that contain personal significance. Traditional testing provides too much structure and tasks that may appear arbitrary, does not elicit emotional responses, and does not require extensive coordination of skills. However, the use of ecological tests that reflect everyday functioning is gaining momentum. Historically, EF was believed to “reside” in the frontal lobes, but current viewpoints place EF within distributed networks throughout the brain. Therefore, people experiencing executive dysfunction may have a multitude of diagnoses. Those with acquired brain injury are particularly susceptible to the widespread effects of executive dysfunction.

### Rationale for Treatment

People with acquired brain injury (ABI), either from a stroke, traumatic brain injury or removal of a tumor, have a high rate of executive dysfunction. This makes sense, due to the diffuse pattern of injury often seen in these populations. The use of music as therapy for people

with traumatic brain injury has been in wide use since World War I (Davis, Gfeller & Thaut, 2008; Ilsen, 1926; Seymour, 1920). At that time, treatment goals were typically aimed at restoring the mental health of an individual, though some physical deficits were also addressed. In the last twenty years, neuroimaging techniques have been developed and refined. Neuroscientists have used these techniques to quantitatively show music's capacity to stimulate and change the brain. Informed and guided by these neurological findings, Neurologic Music Therapy (NMT) was developed. While substantial research exists that evaluates the use of motor and language NMT techniques with clinical populations, research with clients in the cognitive domain is still in the preliminary stages.

One study in the cognitive domain was conducted by Thaut et al. (2009). Thaut and colleagues researched the use of NMT techniques to affect attention, emotional adjustment, memory and executive functioning in a group of participants with acquired brain injury. Four different treatment days included a pretest, a 30-minute neurologic music therapy intervention and a post-test. Regarding executive functions, the researchers focused on mental flexibility, as measured by the Trail Making Test, part B. Although both the treatment and the control group showed improvement, the change in the treatment group reached statistical significance and yielded a significant effect size compared to the control group.<sup>1</sup> Although the study's results are preliminary, the large effect size indicates excellent potential for the use of music to affect mental flexibility, a subcomponent of executive functioning. Therefore, further studies examining the use of neurologic music therapy techniques to improve executive functioning are warranted and sorely needed.

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<sup>1</sup> Effect sizes help distinguish true differences in the scores within a study, because they incorporate the standard deviations of both groups. Thus, these give a better picture of actual clinical significance (Gold, 2004).

In 2007, Stablum, Umiltà, Mazzoldi, Pastore, & Magon successfully trained people with ABI to internally prepare for a shift in task. Their previous research had shown that some people with ABI show significant difficulties implementing a shift in task, even when internal preparation to do so was possible. Ironically, these individuals performed similarly to controls when internal preparation was not possible. It could be argued that mental flexibility is internally driven; Thaut et al.'s study (2009) already indicates the use of music therapy to improve mental flexibility. Within the context of music therapy and aided by a salient beat, perhaps the attributes of music production would further facilitate and optimize internal preparation and execution of a shift in task.

#### Research Questions/Hypothesis

The following research questions will be addressed:

- Will training in independent task switching, within the context of a song, increase independent shifting in a non-musical task?
- Will this training transfer to increases in working memory performance?

For each of these questions, the following sub-questions apply:

- Will the scores of the treatment group, compared to the scores of a placebo group (who are provided musical novelty, therapist contact and a social context), show a difference that is statistically significant?
- Will the scores of the treatment group, compared to the scores of a no-treatment group, show a difference that is statistically significant?

The following null hypothesis is proposed: Individuals within the neurologic music therapy group will perform equally on measures of executive functioning as those individuals in a singing group and in a no treatment group.

## CHAPTER II: LITERATURE REVIEW

### Theories of the Frontal Lobes

Just as defining executive functioning is complex, so are the theories of the frontal lobes. There have been a number of theories over the years, starting in the sixties with the Soviet psychologist Alexander R. Luria. Boelen et al. (2011) credits two main, current theories of frontal lobe functioning; that described by Shallice and Burgess (1996) (many symptoms but a common cause) and one described by Stuss (2009) (many parts with different levels of impairment). Shallice and Burgess' theory is an update to the theory of Norman and Shallice (1980). The theory basically states that the executive function is a kind of "supervisory attentional system" (SAS) that activates when we encounter situations we have never dealt with before.

Contrary to the idea of one system in charge of many functions, Stuss questions the use of the term "executive dysfunction". He cautions its over-use, particularly when the deficit is contained to one or two areas. Stuss (2007; 2009) suggests considering different areas of the prefrontal lobe as being interdependently involved in four categories of behavior. These categories include (a) executive cognitive (lateral prefrontal cortex); (b) behavioral/emotional self-regulatory (ventral medial prefrontal cortex, emerging from the orbitofrontal cortex); (c) energization (frontal-subcortical pathways and superior medial regions, including the ACC); (d) metacognitive behaviors (frontal polar region, BA 10). "Executive cognitive" includes at least two subcomponents; *task setting* or identifying a cause and effect relationship and then making a plan of response (left ventrolateral PFC) and *monitoring* or reviewing the plan and making necessary changes (right ventrolateral PFC). "Behavioral/emotional self-regulatory" refers to emotional processing as well as reward-response. "Energization" can be thought of as the seat of



motivation and drive. This would include initiating and continuing (or sustaining) a response. “Metacognitive behaviors” refer to higher functions such as self-awareness, memory of things that we have experienced and which make us who we are today, humor and the capacity to see things from the perspective of someone else (or theory of mind). Stuss postulates that the metacognitive functions serve as a bridge between our cognitive abilities and the capacity to self-regulate. Therefore, lesions or abnormalities in one network could cause problems in another network. However, it is also possible that the functions of one or more categories will remain preserved.

Although both theories allow a myriad of symptoms to be inter-related, treatment approaches might differ. Clinicians that lean towards the idea of one system might prefer treating executive dysfunction as a whole. On the other hand, if several areas contribute to the clinical expression of what we call executive functioning, identifying and specifically training the affected areas would seem more efficient if it lead to overall improvement. More importantly, this would save resources and make rehabilitation more efficient and cost-effective. At this point in time, neither theory has been proven or disproven. However, studies are mounting that appear to fall into two categories: compensatory or restorative. Compensatory techniques seem to be based upon Shallice and Burgess’s theory; Restorative techniques appear more in line with Stuss’s theory.

#### Rehabilitation of Executive Functioning: Compensatory Approaches

The majority of available treatment techniques are compensatory in nature (Worthington, 2005; Boelen, Spikman & Fasotti, 2011). These include what Boelen, Spikman & Fasotti (2011) referred to as internal and external strategies. Internal strategies are interventions taught to the

individual with the aim of helping them change their approach to planning and problem solving. Popular examples include Goal Management Training (GMT, Levine et al., 2000) and Problem Solving Training (PST, von Cramon & Matthes, 1994) or alterations of both. External strategies are interventions that provide support by using external reminders to help individuals stay on-task. These include auditory alerts such as the NeuroPage system (Wilson, Emslie, Quirk & Evans, 2001) or the use of diaries, checklists and schedules. Some treatments focus on training your thoughts to stay on task, such as Self-Monitoring Training (SMT, Alderman, 1995) or additionally include mindfulness training along with using elements of GMT and PST (Novakovic-Agopian et al., 2011).

Spikman, Boelen, Lamberts, Brouwer & Fasotti (2010), document one very thorough example of using a compensatory approach. These researchers conducted a three month, one-hour, bi-weekly intervention that demonstrated that executive dysfunction could be treated using a multifaceted treatment program. More importantly, this treatment carried over into functional aspects of everyday life. They based their treatment program upon Ylvisaker's eight aspects of EF (1998). These include the capacity of a person to demonstrate the following: 1. *Self-awareness* of one's capacities and limitations, 2. *Goal-setting* which is specific and set in regard to personal capacity levels, 3. *Planning* the steps to acquire the goal, 4. *Self-initiation* of the plan, 5. *Self-monitoring* to determine progress in relation to both the plan and the goal, 6. *Self-inhibition* to avoid off-task behavior, 7. *Flexibility* and *problem solving* to adapt the plan when needed, 8. *Strategic behavior* to apply learned skills in a variety of situations (Spikman et al, 2010). Due to the varying levels of impairment to EF, the authors suggested comprehensive treatment and constructed their program accordingly.

In addition to using Goal Management Training (GMT, Levine et al., 2000) and Problem Solving Training (PST, von Cramon & Matthes, 1994), the authors also included external compensatory devices, such as an alarm, extensive training of self-awareness, self-initiation and transfer to daily life. The control group received training on a computerized program, Cogpak, which provided direct feedback regarding performance but no guiding questions or help with strategy. Clear connections to daily life were also not provided. Both groups improved significantly from baseline in measures of daily life functioning and well-being as well as attaining specific goals that were set by the participants themselves. However, the experimental group improved significantly more than the control group on the Role Resumption List (RRL) and the Treatment Goal Attainment (TGA). Perhaps most importantly, the experimental group showed even greater increases according to the RRL (which measures the return to roles related to work, social and leisure skills as well as mobility) at the six-month follow-up. Though the control group had also improved on the RRL, this improvement remained constant (between post-treatment and the six-month follow-up).

This could have been due to an overall change in the participants' implementation of reacquired skills. That is, both groups showed improvement in EF but six months later, the experimental group utilized these skills at a higher frequency. The study did not report effect sizes or confidence intervals, which makes these assertions difficult to fully evaluate. However, several aspects of the study should be given note. Providing education about what executive dysfunction looks like might increase patient self-awareness. Feedback regarding realistic goals and steps to reach those goals could also attribute to this self-awareness. Self-efficacy can improve by pointing out progress and positive feedback throughout treatment. Repeatedly talking

about specific examples of EF within everyday life, as well as examples of behaving differently, could lead to better transference and generalization of skills.

The external guidance provided by the therapists appears to mirror the “supervisory attentional system” of Shallice and Burgess’ theory. Questioning the client throughout the process seems to reactivate the capacity of the client to do this for themselves. However, some clients would be very quickly overwhelmed and discouraged by such a process. This would especially be true if metacognitive functions described by Stuss were damaged. One way to sidestep the necessity of self-reflection is to train areas directly, using restorative techniques.

#### Rehabilitation of Executive Functioning: Restorative Approaches

Boelen, Spikman and Fasotti (2011) reviewed several restorative approaches. Restorative approaches appear to support Stuss’s theory of four interdependent yet separable areas of the frontal lobes. These interventions seek to regain functional use of underlying components of executive function; they aim to engage brain plasticity through isolated, repeated therapy.

Stablum, Umiltà, Mogentale, Carlan & Guerrini (2000) provide support for neuroplasticity of one executive functioning component, the coordination of two tasks. Pashler & Johnston (1989) describe a “bottleneck notion”, whereby two tasks presented simultaneously will compete for attention. The decision to attend to one over the other creates a lag in response time (while the brain decides), referred to as “dual-task cost”. If this lag becomes too large, coordination falls apart and several activities of basic daily living become extremely difficult or even impossible. In their paper, which actually described two separate studies with the same treatment protocol, two distinct groups, people with closed head injury and those post-stroke (anterior communicating artery aneurysm), showed a decrease in dual-task cost after five

sessions that took place once a week. Computerized training included two parts; first subjects had to indicate on a keyboard if the letter was on the left or the right of the screen, then they had to say if the two letters presented were the same or not. Response time was recorded for the first response and accuracy of the second response (but not timing).

As suspected, at baseline both controls and subjects showed a slower response time to the first task when the additional, verbal identification task was added. The subjects, however, were significantly slower. By the end of the treatment phase, both the CHI and the stroke group demonstrated dual-task costs that were no longer significantly different from that of controls. Improvement remained at the 3-month follow-up (taken for those with CHI) and at 3 and 12 month follow-up in the stroke group. More importantly, both groups showed improvements in an un-trained test, suggesting generalization of results. This test was the Paced Auditory Serial Addition Task (PASAT), which measures different aspects of executive functioning (monitoring, inhibiting and processing speed). Further, the stroke group showed gains in the modified Continuous Performance Task (CPT; Braver, Barch and Cohen; 1999), a measure of response inhibition.

The CPT presents a letter (A or B), two different lengths to wait (150 or 5000 ms) and then another letter (X or Y). The combination A followed by X required a specific button to be pressed; all other combinations required activation of the other button (A-Y, B-X, B-Y). Both response time and accuracy of their responses are tracked. There was no difference between controls and those with stroke when responding to combinations B-X or B-Y. This makes sense, because the letter B already tells the subjects which button to press, so there is no need to inhibit. However, this also indicates that the subjects maintained working memory of the rules (to

respond differently to the A-X condition) and the sustained attention necessary to maintain vigilance.

While working memory and sustained attention are oft cited as components of EF, such deficits were not seen in these particular subjects (those with post- anterior communicating artery aneurysms). This adds further support to the idea that executive functions can be fractionated. However, monitoring (as measured by the PASAT) also improved after the intervention. Monitoring naturally requires working memory (you cannot check to see if your performance is in line with your goal if you cannot remember what you are supposed to be doing). Several of these capacities are interconnected; training on one (the coordination of two tasks) resulted in improvements in several (not only the coordination of two tasks, but also working memory, inhibition, and processing speed). Although measures of everyday functioning were not administered, this study provides encouraging support for the capacity to train deficits directly, rather than simply relying on compensation strategies.

As mentioned briefly in the introduction, Stablum et al. (2007) expanded upon this research, including a task-shift paradigm and the Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996), an ecological battery that correlates strongly with everyday functioning. The task shift paradigm is based on the idea that there is a loss of time when switching between two different tasks. The switch cost is determined by measuring response times; achieved by comparing this value when the task is the same to the value when the task is different. Across many trials, in both controls and patients, the mean reaction time is always greater when the task changes. However, this amount normally decreases when we know that a change is about to occur, thus allowing internal preparation of the switch (endogenous task). Likewise, unanticipated changes result in larger switch costs.

Contrarily, the participants with severe closed-head injury (severity determined by admission Glasgow Coma Scale) only showed deficits in trials of 2- or 4- item sequences, which should have allowed for internal preparation. Those with mild closed-head injury and controls performed typically. That is, their switch costs were far lower when the items were fewer, due to the capacity to anticipate the shift. All groups performed similarly when the items presented were great enough that internal preparation was no longer possible (exogenous task). This was seen at sequences of 10 items (Stablum et al, 2007).

This distinction is very important and often overlooked. The deficit did not necessarily have to do with reaction time, rather anticipation and implementation of a new reaction. With 5 days of training completed in one week, all groups improved. In fact, statistically significant differences among the three groups were no longer present on the third training day and these results remained significant four months later. Further, improvement generalized to other tests of executive functioning: dual tasks (previously described), the PASAT and the BADS. Extremely interesting was what occurred with the mild CHI group; although they did not show differences from controls for endogenous tasks at baseline, they did show improvement across all related measures after treatment. That is, they no longer could be distinguished from controls, whereas before treatment, they could (on dual task, the PASAT and the BADS).

In addition to the 2000 study, these results provide important information regarding executive functioning. If a subcomponent of EF can be specifically trained and if this training results in improvement on other, separable components of EF, then this would imply that subcomponents, though separable, are also interconnected. The study also adds valuable support for the notion that individual skills of EF can be rehabilitated through isolated training and that this training has widespread effects. As the authors point out, one major benefit of this

restorative approach is that the subjects do not need to be self-aware. This is a common problem with people suffering from executive dysfunction and a main component of compensatory approaches (Bertisch, Rath, Langenbahn, Sherr, & Diller, 2012).

Both studies by Stablum et al. (2000, 2007) indicate the use of restorative techniques to improve a subcomponent of executive functioning. Coordinating two tasks and internally preparing for a switch in task were both improved through repetitive training. To further understand how decision-making, inhibiting, internal preparation and task switching are inter-related (all related to a change in behavior), investigation into their neural correlates is required.

### Neural Correlates to a Change in Behavior

The abilities to stop, inhibit, and switch what one is doing are pivotal to everyday tasks such as decision-making, multi-tasking, and reaction time. As skills that fall under the umbrella of executive function, understanding the areas involved in typical functioning should also lend valuable insight into which areas require rehabilitation, should parts thereof become damaged. Aron (2008) focused on “stopping” and described activation of a network connecting the right, inferior frontal cortex (rIFC) to the presupplementary motor area (preSMA) and the subthalamic nucleus (STN) of the basal ganglia. His research suggests that the interplay among these three neural correlates is responsible for evaluating two competing options and for deciding to stop an action already in progress (e.g. pausing midstride to avoid tripping over a previously unseen object). Further, switching between two actions (and thus stopping one action to start another) also appears to involve this network.

In addition to the IFC, the dorsal lateral prefrontal cortex (dlPFC) and the anterior cingulate cortex (ACC) are neural correlates identified in many executive functions. Working



memory, such as the capacity to hear what a professor has said and write it down in your notes, is often attributed to the dlPFC (BA 9, 46). Some research also suggests its involvement in ignoring off-task information and using relevant information, such as hearing a peer in class whispering to another peer and still having the capacity to attend to the professor (which would also require inhibition). The ACC increases activation when a choice must be made and the possibility of making an incorrect choice is present (Banich, 2009). This makes sense, as the cingulate cortex is part of the limbic system, responsible for our emotions (Nolte, 2009) The cingulum bundle, which consists of the white matter tracts just under the cingulate cortex, connects the inferior parietal lobule (IPL), the ACC and the dlPFC bilaterally (Makris et al., 2007). Therefore, activation in one area will affect activation in another. This is just one of many networks that appears to activate during decision-making, working memory and inhibition.

Sakagami, Pan and Uttl (2006) also concentrated on cortical pathways in the brain, with a focus on decision-making. Although not specifically shifting or inhibiting, when making a decision, one must inhibit the urge to continue one task (or the urge to try a different option) and shift attention to a new action. Their research tracked the ventral and dorsal pathways. Both pathways begin in the visual cortex, but then split off into two different directions; the dorsal pathway carries information about *location* to the parietal cortex and ends in the dorsolateral prefrontal cortex, and the ventral pathway carries information about *identification* to the inferior temporal cortex and on to the ventrolateral prefrontal cortex. The ventrolateral prefrontal cortex is also believed to integrate *emotional* and *sensory* content. Consequently, our emotions influence decision-making. It then relays this information to the dorsolateral prefrontal cortex, where it is then sent to the motor cortex and an action occurs. The researchers hypothesize that this complex exchange is how we make deliberate decisions about our behavior.

Hedden & Babrieli (2010) sought to determine the neural correlates of inhibition and shifting, both thought to be important components in executive control. Using functional magnetic resonance imaging (fMRI), they determined that several areas overlapped between the two tasks. These included the dlPFC, vlPFC, and anterior cingulate cortex (ACC) of the prefrontal cortex as well as parietal and basal ganglia regions. The authors postulated that a network of regions, as opposed to individual neural correlates, is responsible for inhibiting and shifting responses. Upon setting high levels of neural activation to signal significance, a strong right lateralization was seen for inhibition. These areas included parts of the right PFC (BA 6/8, 9 and 10), right inferior parietal lobule (BA 40) and the left cerebellum (which is connected to the right cortex). The right inferior frontal gyrus and striatum were also present but to a lesser degree. Interestingly, the only area that showed stronger activation for shifting (as opposed to inhibiting) was the left inferior parietal lobule (BA 7).

According to the authors, their results suggest that shifting and inhibiting are the same process. The “shift cost” of reaction time, seen behaviorally, is more likely due to the “bottleneck” theory. When two or more processes share the same system or network, a time processing lag will occur as processes attempt to occur simultaneously (Hedden, 2010; Hunt & Kingstone, 2004; Stablum, Umiltà, Mogentale, Carlan & Guerrini, 2000; Stablum, Umiltà, Mazzoldi, Pastore, & Magon, 2007). It is important to note that the shifting task within this study was attentional (respond to the *form* of a letter or to the *smaller letters that comprised the form* of a larger letter) and not related to a new rule for action. Internal preparation, inherent to endogenous tasks, was not discussed.

Ravizza & Carter (2008) found differences between attentional (or perceptual switching) and rule switching. The rule condition involved pressing a previously assigned keystroke that

corresponded to the item in the sequence that was different (e.g. if the letter x was the unique symbol, the keystroke was not necessarily placed directly under that stimulus; they had to recall which key represented “x”). In the perceptual condition, letters encased within shapes were simultaneously presented. The unique symbol was identified but the keystroke was directly below the presented item; this could be either a letter or a shape.

In their study, only the rule shift condition activated the dlPFC (BA 9 and 46). Additionally, participants who had shorter shift costs in the rule condition also showed greater dlPFC activation. The right superior parietal cortex appeared to show increased activation due to perceptual shifts; the authors infer that this is due to difficulty inhibiting irrelevant information. Noteworthy was their lack of finding concerning shared regions for both tasks. This would suggest the presence of separable networks for attending to perceptual and rule shifts. Clinically, this would indicate the necessity of identifying which type of task requires rehabilitation and then ensuring fidelity to this information throughout treatment. Also, though not discussed within the study, it appeared as though the demand on working memory was higher in the rule shift condition, as the assignment of symbols to keystrokes had to be remembered and not simply noticed. This might have also accounted for the greater activation seen in the dlPFC.

Working memory and the activation of the dlPFC was also discussed in a study by Slagter et al., (2006). They sought to determine whether the brain can truly prepare for set shifting and which neural correlates would be responsible. Their findings confirmed that it is possible to endogenously prepare for a shift in task and that the frontoparietal control network subserves this function. Contrary to other studies, however, they did not see much activation in the PFC other than the pre-SMA and dorsal premotor cortex (dPMC.) The authors attributed the lack of dlPFC activation to the short intervals between cues and targets (1500 ms); other studies

that show dlPFC activation had intervals ranging from 2500-8000 ms in length. As mentioned, they hypothesized that as the interval between cue and target increases, the need for working memory (dlPFC) also increases. The same was said for task complexity, which they described as rather simple in their study design (i.e. indicate if the stimulus was a certain color or placed in a certain direction). However, the presence of dlPFC activity does not indicate a lack of preparation. Rather, the authors argue that determining factors for internal preparation include the global task set (how many tasks are presented within a block) and how the stimuli are presented. Clinically, this would affect how an intervention is set up (e.g. show the cue ahead of time or repeat the cue in a predictable fashion) and keep the variety of stimuli to a minimum. If activation of the dlPFC is a clinical goal, response complexity should be considered and the interval between the cue and the target set to a minimum of 2500 milliseconds.

Understanding the circumstances under which particular neural correlates activate is pivotal to the creation of targeted clinical interventions. Outward expressions of decision-making, inhibiting and switching appear to activate similar brain regions across a variety of studies. These include the right, inferior frontal cortex (rIFC), the presupplementary motor area (preSMA) and the subthalamic nucleus (STN) of the basal ganglia; the dorsolateral prefrontal cortex (dlPFC) and the anterior cingulate cortex (ACC); the dorsal premotor cortex (dPMC), ventrolateral prefrontal cortex (vlPFC) and the right and left inferior parietal lobules. However, the extent to which an area becomes involved seems to be largely influenced by the type of stimulus presented. Although identified areas are many, several are interconnected via pathways throughout the brain. Listening to and producing music activates many of these pathways and neural correlates. Therefore, the therapeutic application of music could theoretically access and

expand these same pathways responsible for inhibiting, shifting and internal preparation, resulting in an overall change in executive functioning.

### Neural Correlates of Music

In order for music to be a reasonable tool for the rehabilitation of task switching, shared neural correlates should be established (Thaut, 2005). A multitude of studies exists examining what happens in the brain under different musical conditions. Many of these areas overlap with the previously named correlates involved in task switching, inhibiting, and internal preparation.

Zatorre, Chen & Penhune (2007) sought to pinpoint which parts of the brain, or neural correlates, are responsible for the orchestration that is required within musical performance. They argued the importance of studying the motor components together, rather than as separate units, which they deduced to three fundamental functions: “timing, sequencing and spatial organization of movement” (p.547). The first of these units, timing, was attributed to several neural regions; the supplementary motor area (SMA; responsible for planning of movements), basal ganglia, and the cerebellum. However, when the rhythm became more complex, the prefrontal cortex (PFC) and the dorsal premotor cortex (dPMC) became involved, as well as further regions within the cerebellum. Therefore, the authors contend that a network controls motor timing, rather than one particular region. The dPMC’s role in musical processing and production was further explained regarding sensory-motor transformations; namely, the decision to choose a specific action. As rhythmic complexity increased, so did the activity of the dPMC, particularly the rostral dPMC. They felt that the dPMC served as a sort of mediator between “higher order features of a sound” and a timed response.

Zatorre et al. (2007) also examined music perception. Their research found that simply listening to a rhythm also activated motor regions (the basal ganglia, cerebellum, dPMC and SMA). Naturally, the temporal lobes (auditory regions) showed involvement as well. Therefore, the perception of rhythm may rest on the coordination between the motor and auditory systems; rhythm primes the motor system. The authors described two separate systems that depend on this coordination: the feedforward and feedback systems. The feedforward system activated when the input was of a predictive nature. In this system, what was heard influenced the movements. Further, when the beat presented was more prominent, both the motoric response and the neural connectivity increased. However, they described how certain interactions relied on a feedback system (e.g. singing or playing the violin). In the case of a feedback system, what was heard altered the motor response in a continuous fashion. The need for constant alterations when playing such instruments, mainly perceived only at the neural level, make predictive movements difficult. In summary, this study by Zatorre et al. (2007) identified interconnections among the cerebellum, basal ganglia, dPMC, SMA and PFC in the production and perception of music. A prominent beat increased neural connectivity. When rhythm was complex, the PFC and dPMC showed greater activation. These areas are all involved in decision-making, inhibiting, switching and internal preparation.

Ramnani & Passingham's 2001 study provides additional support for the significant activation of the cerebellum, PFC, PMC, and SMA during conditions involving rhythm. Instead of focusing on music performance or listening to music, this study sought to identify what happens when a new rhythm is learned. The dPFC activated when participants were aware that they were learning something or when they attended to previously learned movements. As the rhythm was learned and attention could go elsewhere, activation of the dPFC decreased.

Contrarily, the dPMC and cerebellum, as parts of the cortico-cerebellar loop, increased activation as the sequences were learned, thus signaling increased movement preparation. Learning a rhythm of a predictive nature activated neural correlates related to timing, attention and internal preparation.

Koelsch (2009) further reported on a variety of brain regions that activate in the presence of music. His focus included music's capacity to activate the limbic system, mirror neuron system and neural correlates for theory of mind. Neural activation included the ventromedial PFC (vmPFC), orbitofrontal cortex and cingulate cortex. The nucleus accumbens (implicated in reward processing), insula, temporal poles, hippocampus, parahippocampal gyrus and amygdala were also profusely discussed, all regarding the emotional responses to both positive and dissonant music. Therefore, music not only accesses the neural correlates of inhibiting, switching, internal preparation and timing, it also activates the emotional and metacognitive areas described by Stuss in his four-part theory of the frontal lobes.

These studies by Zatorre et al. (2007), Ramnani and Passingham (2001), and Koelsch (2009) all sought to identify what areas of the brain are activated under different music conditions. Several of these areas are regularly indicated for their involvement in the EF subcomponents, decision-making, inhibiting, switching and internal preparation. Most cited are the ventral and lateral PFC, orbitofrontal cortex, cingulate cortex, cortico-cerebellar loop, SMA and the dPMC. The shared neural correlates between areas activated by music and areas required in executive functions indicate the logical use of music to rehabilitate executive dysfunction. Though few in number, studies have been done that show this idea is valid.

## Music as a Tool for Non-Musical Changes

Simply listening to music illustrates the point that activating shared neural networks leads to improvements in brain functioning. Särkämö et al. (2008) studied individuals who had sustained a middle cerebral artery stroke and were in the acute recovery stage (between 3 and 6 months post-stroke). Participants either listened to music, audio books or received treatment as usual (no intervention). As assessed by the Rivermead Behavioural Memory Test (RBMT; Wilson et al., 1985), the music condition showed significant gains in verbal memory and focused attention. Though not described as working memory within the study, it could be argued that this test does in fact tap working memory, a subset of executive functioning. A list of ten words was read aloud and participants were to rename as many of the words as possible. This was repeated 3 times and the total score is used. Focused attention was assessed by the Stroop test. Although spontaneous recovery may have contributed to some of the success, all groups (n=18 per group) were randomly assigned and showed no significant differences at baseline. Therefore, it is likely that the unique characteristics of the music did account for the changes in nonmusical functions. The capacity for music to mediate nonmusical changes (verbal memory, focused attention and therefore working memory) indicates the therapeutic application of music.

Not all interventions that involve music can be classified as therapy. A therapeutic technique uses a protocol or detailed plan, a clinical population and seeks to induce functional, lasting changes (Thaut, 2000). As mentioned, music therapy techniques as an intervention for executive dysfunction have not been thoroughly explored in a clinical population. Aside from the Thaut et al. 2009 study, research using music therapeutically with adult populations is sparse. One exception is a study by Bugos, Perlstein, McCrae, Brophy and Bedenbaugh (2007). These researchers specifically sought to combat cognitive decline associated with aging. In their



randomized control trial of healthy, older adults (ages 60-85), the authors endeavored to enhance executive functioning through Individualized Piano Instruction (IPI).

Their six-month intervention progressively increased in difficulty, per progress of the individual. This was based upon the premise that task complexity and novelty is vital to the engagement of multiple cognitive systems, and that this engagement maintains and improves executive functioning. All participants were “musically naïve” (had less than 5 years of musical training in their background). Within weekly, half-hour lessons, the instruction included learning basic elements of music theory, musical scales and song selections that incorporated the theory and scales of that week. Additionally, participants practiced independently, approximately half an hour per day, and these practice sessions were recorded.

Post-test results showed significant changes in scores of both of the *Trail Making Tests* (TMT Parts A and B; Reitan & Wolfson, 1985). Not only is the TMT a fairly typical neuropsychological measure of executive functioning, positive changes in the test scores indicate a transfer of skills not specifically trained within their intervention. Though measures of everyday functioning were not included, this randomized controlled study suggests the systematic use of active music playing as a valid tool to improve executive functioning. Although one might argue that older adults are not a clinical population, cognitive decline is a natural occurrence in this age bracket. Mild cognitive impairment is a precursor to dementia, a risk factor for late-stage depression, and the loss of independence (Espinosa et al., 2009). Consequently, interventions that combat cognitive decline in this population are, in fact, clinically significant.

The capacity for elements of music to create non-musical, cognitive changes is reasonable when shared neural correlates are present (Thaut, 2005). This is based on the idea that

“a training task that stimulates and influences the functioning of specific brain areas (or processes) results in improvement in the related cognitive activities” (Moreno, Bialystok, Barac, Schellenberg, Cepeda & Chau, 2011, p.1425). Extended networks are another way to access and strengthen neural correlates. Neurologically speaking, extended networks refer to different parts of the brain (neural correlates) that are connected via axonal pathways. Some of these pathways are very robust and easily detected, like the corpus callosum (which connects the two sides of the brain) or the superior longitudinal fasciculus (the largest association bundle, which connects cortical areas on the same side of the brain) (Nolte, 2009). These pathways explain why damage to the cerebellum can cause problems with cognition (mediated by the cerebral cortex); the extended networks are affected (Schweizer et al., 2008). While music processing is found in both shared neural correlates and the extended networks of cognitive processes, so are movement and some aspects of language. The difference between using movement or language alone or combined with elements of music lies in music’s capacity to optimize neural functioning.

### Music for Optimization

Optimization, in the strictest of terms, refers to a mathematical procedure for finding the maximum of a function. However, it can also refer to the combined elements that create the most efficient, *optimal* circumstances possible. The effects of musical elements on the brain are arguably an excellent example of optimization.

Rhythm is one element of music that induces several phenomena, the first of which is neural resonance. Neural resonance describes how, when presented with a salient rhythmic stimulus, neurons begin to fire stronger and in concert with the presented stimulus (Fujioka, Ween, Jamali, Stuss & Ross, 2012; Large & Snyder, 2009; Trainor, Shahin & Roberts, 2009). It

is important to note that the significance of stronger firing is not entirely clear. Stronger firing could mean the brain is working harder to inhibit a response; however, stronger firing could also indicate increased excitation. Nevertheless, large activations, resulting from enriched stimulation, cause dendritic sprouting (Thaut et al., 2009). It is generally believed that new dendrites (extensions of the cell body that receive information) and dendritic spines may indicate specialized changes of the synapse due to learning (Nolte, 2009). The presence of a strong, external beat synchronizes the firing of neurons; this synchronization creates changes at the cellular level conducive to learning. Therefore, neural resonance, induced by an element of music, optimizes cognitive processes. Another level of neuronal activity induced by music is neural oscillation.

Neural oscillations also synchronize to external musical rhythms. Oscillations (or loops) occur because of the interplay between excitatory and inhibitory neurons (Large & Snyder, 2009). These oscillations can be measured via EEG and MEG and correlated to the activity in which the subject engages. These measurements are oft described in terms of hertz (Hz), which refers to the number of recorded oscillations or cycles per second. Studies examining the EEG and MEG activity during music conditions have reported both gamma- and beta-band responses (Fujioka et al., 2012; Large & Snyder, 2009; Trainor et al., 2009). Beta-band generally refers to activity in the 15-30 Hz range (Fujioka et al., 2012); gamma-band activity lies in the 30-100 Hz range. Gamma-band activity has been correlated with musical training. Both beta- and gamma-band activity have been associated with anticipation of when a sound will occur, changes in the loudness and intensity of a beat (accent) and removal of an expected sound or stimulus (Large & Snyder, 2009).

Trainor et al. (2009) found that the level of gamma-band activity in response to a musical tone increases in relation to how long a person has been musically trained. Further, non-musicians produce gamma-band activity when they hear a sound, but the number of cycles per second is also less than that of trained musicians. In both musicians and non-musicians, they found higher responses to piano or violin tones than to pure tones. Additionally, they noted that processing what we hear and see simultaneously (intrinsic to musical note reading or even seeing pictures connected to music) creates beta-band activity. Wang (2010) correlates such sensory integration to gamma-band activation.

Though unclear whether one or the other (beta- or gamma- band activity) is preferred, both have been associated with optimized brain functioning. Beta-band activity has been associated with increased motor-coordination (Large & Snyder, 2009; Fujioka et al., 2012); Gamma-band activity has been associated with conditions requiring attention and anticipation (Trainor et al., 2009; Wang, 2010) as well as working memory (Wang, 2010). Thus, though the exact significance and conditions related to beta- and gamma-band activity is not known, current research relates both to increased levels of performance. Music conditions not only evoke neural oscillations, they do so at a rate conducive to enhanced cognitive performance. Therefore inducing beta- and gamma-band activity is yet another way that music optimizes cognitive rehabilitation. These oscillations can create communication between neural correlates, such as that seen in auditory-motor coupling.

Auditory-motor coupling is based on the premise that after the brain learns the association between a motor act and an auditory act, the onset of one will instigate neural activation of the other, even in its absence. For example, playing a muted piano will actually present neural activity as if the notes could be heard. Vice versa is also true. If a trained piece is

merely heard and not played, the same areas responsible for its motor output activate (Rodriguez-Fornellis, Rojo, Amengual, Ripollés, Altenmüller & Münte, 2012). These responses can even be evoked in non-musicians who have had a stroke. The areas that show increased functional activity after music supported therapy include the IFG, SMA and ACC. Though activated due to motor memory, these are the same areas necessary for making a cognitive decision to shift tasks. Therefore, it is possible that coordination of motor movement to a strong beat will also create robust connections, and thus increased optimization, on a cognitive level. In order for cognition to be optimal, other factors come into play.

Cognition is not an isolated state. Just as being physically tired will affect motor output (and cognition, for that matter), there are several conditions that affect cognitive processes. Music also helps create these additional conditions. First, music increases our arousal level. This is mainly subserved by activation of the reticular formation in the brain stem. The reticular formation is responsible for alerting the cortex when sensory processing or attention is required. Rhythm activates this system via the reticulospinal tract (Thaut, 2005).

Immediate auditory and sensory feedback is another way that music affects cognition. As mentioned, the capacity for decision-making in the absence of feedback is one function attributed to the executive functioning system. When engaged in music making, we hear and feel the results of our actions in real time. This element of music could support activation of self-awareness (one of Stuss' metacognitive behaviors allocated to the frontal polar region). Music engages emotional arousal, also known to affect cognition. This arousal can be both positive (enjoyment, group cohesion, self-esteem) and negative (high expectations of performance, difficult memory associations, fear of being heard making a mistake). Modulated and monitored by the presence of the music therapist, this emotional arousal can be used to induce real-life

feelings and a safe context in which to practice navigation of them. Emotional and behavioral regulation, mediated by the ventral medial prefrontal cortex, is also known to affect autonomic functions such as heart rate and blood pressure. These can also create changes in cognitive functioning. To summarize, attentional arousal, auditory and sensory feedback, and emotional responses all contribute to cognitive functioning and these conditions can be created by musical elements. Thus, music further optimizes cognitive rehabilitation.

The unique properties of music, when critically applied, can create an ideal environment for the rehabilitation of inhibiting and shifting. The human brain naturally identifies transitions and expectancies when listening to music (Chen et al., 2009; Levitin & Tirovalas, 2009; Sridharan et al, 2007; Zatorre et al., 2007). Therefore, internal preparation should be enhanced with the addition of a musical structure. The presence of shared neural correlates and extended networks between music and executive functioning has been established. Optimization via neural resonance, induced beta-and gamma band activations, auditory-motor coupling, increased attention, tangible feedback and emotional arousal has also been described. Hence, the therapeutic application of music to rehabilitate internal preparation for a shift in task in individuals with acquired brain injury is indicated. For review, the following research questions will be addressed:

- Will training in independent task switching, within the context of a song, increase independent shifting in a non-musical task?
- Will this training transfer to increases in working memory performance?

For each of these questions, the following sub-questions apply:

1. Will the scores of the treatment group, compared to the scores of a placebo group (who are provided musical novelty, therapist contact and a social context), show a difference that is statistically significant?

2. Will the scores of the treatment group, compared to the scores of a no-treatment group, show a difference that is statistically significant?

The following null hypothesis is proposed: Individuals within the neurologic music therapy group will perform equally on measures of executive functioning as those individuals in a singing group and in a no treatment group.

## CHAPTER III: METHODOLOGY

### Research Design

To control for selectivity bias, three randomly assigned groups were created, using a placebo control group design (Rubin, 2005). Random assignment was accomplished by assigning numbers to each participant using the online program RANDOM.org. The numbers were then randomly sorted into three groups using the online randomization program, Research Randomizer. Glasgow Coma Scale scores (at the time of hospital admission when the injury occurred) were not incorporated into the random assignment, as the official numbers were unavailable to the researcher. Treatment technique was the independent variable. Group 1 participated in sessions training endogenous shifting, within the context of music and led by a board-certified music therapist. Group 2, the placebo group, participated in group sing-a-long sessions, led by the same music therapist. Group 3 received no intervention outside of their current regular schedule (treatment as usual).

### Participants

Participants for this study included adults who had sustained an acquired brain injury of non-degenerative etiology. This included survivors of a cerebral vascular accident (n=1) and traumatic brain injury (n=14). Participants were between the ages of 25 and 65 (to limit maturational effects on the frontal lobes and to exclude participants that may be experiencing significant loss of executive functioning due to age). Capacity to understand all directions in English and functional use of at least one hand was additionally required. To estimate whether an issue with executive functioning affected their daily life, participants and someone close to them



completed separate versions of the Dysexecutive Questionnaire (DEX; Wilson, Alderman, Burgess, Emslie, & Evans, 1996). Participants were aware of the design and purpose of the study and written informed consent was obtained prior to group assignment (Appendix I). Elements that resulted in exclusion from participation included the presence of seizures, degenerative brain conditions (e.g. multiple sclerosis or dementia), and history of alcohol or substance abuse (n=1). Participants were recruited at QLI in Omaha, Nebraska by flyer and direct contact by the QLI treatment team and the researcher. Raw data for the participants are summarized in Table 1 (found at the section end) Two other participants expressed interest but did not receive consent from their guardian before the start of treatment. One participant dropped out due to scheduling conflicts. The study was approved by the Human Research Committee of Colorado State University (Appendix II).

Table 1

*Raw Data of Participant Baseline Demographics, Per Group*

<i>Group</i> Participant Number	Age	Gender	Years of Education	Years Since Injury
<i>NMT Group</i>				
1	39	M	12	25
6	32	M	14.5	17
8	39	M	14.5	11
10	48	F	16	27
15	57	M	13	40
<i>Placebo Group</i>				
3	57	M	12	35
4	40	M	12	24
7	30	M	12	26
12	43	M	12	21
14	59	F	16	7
<i>Control Group</i>				
2	28	F	13	8
9	40	F	12	25
11	56	F	14	33
13	47	M	21	8

*Note:* Participant #5 withdrew from the study after random assignment was completed.

### Procedure

The treatment group met for five sessions, once a day for 60 minutes. The room had a closed door and blinds on all windows, which were kept closed to reduce both distraction and visual glare. Participants sat around a typical, oval-shaped dining room table with the instruments placed in front of them. Approximately 1 seat was left empty between participants, on either side. During the first five minutes, the music therapist (MT) welcomed participants, introduced the new song and ensured that each participant had a new instrument to play. 40 minutes of training followed, with a five-minute water and stretch break midway. The MT used the last 10 minutes for session closure.

During training, participants followed color-coded music, playing corresponding notes on a musical instrument. The participants played the base note of the appropriate chord, which they could hear from a pre-recorded CD. The MT sang and played the guitar on both the recording and live (whenever possible). The MT created the song recording and salient drumbeat using GarageBand by Apple Computers. Vocals were recorded using an Audix f5 instrument microphone. Guitar parts were recorded using a Dean Markley ProMag Plus™ acoustic guitar pick-up. Both guitar and vocals ran through a PreSonus AudioBox USB interface to a Power Mac computer. To ensure strict adherence to a metronome (for both timing and duration of the beat), the NMT used type and click placement to create the drum track. The GarageBand recording was converted to an mp3 recording using iTunes, which was then burned to a CD. A Bose Wave II audio system played the CD.

This set up allowed the neurologic music therapist to focus on giving positive encouragement and emotional feel to the song, without sacrificing consistency of the musical template. The metronome encouraged feed-forward responses of both cognition and motor output. Songs were in 4/4 time signature. Pattern of play consisted of 4 steps or less, over a duration of at least 2500 milliseconds (2.5 seconds) before rule switching occurred. The importance of this duration influenced the tempo at which the songs were played. The pattern naturally repeated within the context of the song and the entire musical pattern was visually present; these essential factors allowed for internal preparation of when to switch responses. The color-coded music was created on Microsoft Word and printed on 8.5”x 14” paper, in landscape orientation. The font color changed from black (Calibri 16 point) to the corresponding note color when it was time for said note to be played. Because the difference between blue and light blue was difficult to distinguish when printed, the song that incorporated both colors used

highlighting instead of a font color change. This problem also occurred with orange and yellow, as was discovered on the first day with “I Walk the Line”. Therefore, “Me and Julio Down by the Schoolyard” used a highlighted yellow instead of a font change (Appendix III). The colors chosen corresponded to the standard colors used on many brands of hand bells, such as Kids Play. The other instruments were color-coded using Avery® Removable Round Color-Coding Labels, 3/4” diameter. Table 2 describes the stimulus materials in further detail.

Table 2

*Detail of Stimulus Materials*

<b>Song Used</b>	<b>Beats Per Minute</b>	<b>Song Key</b>	<b>Notes and Corresponding Font Colors Used</b>
“I Walk the Line” (written by Johnny Cash)	110	A	B: Standard Purple, A: Blue (accent 1, darker 25%), D: Orange (red 255, green 153, blue 0), E : Yellow (red 255, green 204, blue 0).
“Grandma’s Feather Bed” (written by John Denver)	100	C	C: Standard Red, F: Standard Green, G: Standard Light Blue, D: Orange.
“Ob-La-Di, Ob-La-Da” (written by Paul McCartney)	98	C	C: Standard Red, G: Standard Light Blue, F: Standard Green
“Happy Together” (written by Garry Bonner and Alan Gordon)	100	Am	(All highlighter colors, with black font) A: Blue, G: Turquoise, F: Bright Green, E: Yellow (with gray font), C: Red.
“Me and Julio Down by the Schoolyard” (written by Paul Simon)	135	A	A: Blue, D: Orange, E: Yellow (highlighter).

*Note:* Unless noted, all colors used the same formula as in “I Walk the Line” except for “Happy Together”

The color-coded music was laminated at a school supply store. Each participant had their own music, clipped to a clear, bent, acrylic plastic picture frame. When necessary, a small box was placed below the frame to raise the music to a comfortable height. The only exception to this was when a participant played the keyboard, then the music stand attached to the keyboard was used. Neither visual nor specific verbal prompts to switch were provided, once it was clear the participant understood the expectations. However, elements of music and sensory enhancement were employed (e.g. stressing the sung word directly before a switch should occur).

The auditory feedback of the instrument, within the context of the song, provided immediate cues as to their progress. By playing in a group context, a more natural environment of distraction and social pressure was present, similar to functioning in daily life. However, a non-competitive environment with an emphasis on cognitive training, as opposed to musical performance, was fostered. An mp3 recording of each trial was taken on a handheld mp3 recorder placed in the center of the table and immediately listened to after live playing (in order to further highlight their success and problem areas). The mp3 player was attached to the Bose unit for playback, using an aux cable. Problem areas were practiced before trying the entire song within the context of the recorded music again. Session closure was provided at the end of each session. Stimulus reflection (Davis, Gfeller & Thaut, 1992, p.280) was used to remind the participants that we were training the capacity to attend to and respond to environmental factors, using internal preparation. Participants had the chance to talk about the experience and reflect on similar, non-musical situations within their week (e.g. I turned on the stove to heat butter in a pan and had to remember to turn off the water that was running, then return to the pan). Reminders to think about times when they noticed themselves attending, preparing and switching were also

given. Mention of the next day's session was included, double-checking that all would attend, as well as mention of the remaining number of sessions.

These steps are included as basic components of many music therapy sessions. All sessions were videotaped to ensure treatment fidelity. Videos were uploaded to a secure Dropbox folder each evening. Independent reviewers trained in neurologic music therapy watched excerpts of the videos (a minimum of three, five-minute excerpts) to determine that the actual implementation of therapy matched the procedure described. This occurred before the subsequent session and feedback (via a checklist with room for comments) was provided to the music therapist leading the group so that errors could be corrected (Appendix IV). Two different reviewers watched the videos from Monday and Tuesday (one watched Monday, another watched Tuesday). A third reviewer watched the videos for Wednesday through Friday.

Each session consisted of a new song to learn and a new instrument on which to play. This ensured continued novelty and a subtle increase in task demand. The following instruments were used: desk bells (required tapping a button on top to activate; only bells within the song were present); a Yamaha, full-sized keyboard (required pressing one key, with multiple unused keys present); desk bells without a finger tap (required picking up with one hand to activate and place back down; only bells within the song were present); resonator bells (required hitting a chime with one mallet; only chimes within the song were present); and an alto xylophone (required one mallet, with several unused bars present). Participants rotated to a new instrument each day.

The placebo group also gathered daily with the same neurologic music therapist to sing preferred songs, including the same songs provided to the treatment group. These sessions started by welcoming individuals and passing out songbooks. The first song was the song of the

day from the treatment group. Subsequently, participants chose songs out of the songbooks to sing. After approximately 30 minutes, 10 minutes of a water and stretch break was provided. More singing ensued for the remaining 20 minutes.

The MT did not discourage natural social interactions (e.g. talking about the songs) but also did not facilitate them. The session ended by asking for song suggestions for the following day, double-checking that all would attend and stating how many gatherings were left. The MT provided novelty via group participation, the presence of music and contact with the same therapist as the treatment group. No further intervention was included and these groups were not referred to as music therapy. These sessions were also videotaped and excerpts were reviewed by the same reviewer as the treatment sessions day. The reviewer ensured that elements of therapy used in the treatment group were not inadvertently employed and feedback via a checklist was e-mailed to the neurologic music therapist before the next gathering.

The control group did not meet with the therapist to play or sing music. Further, they did not receive any form of engagement outside of their normal schedule. The MT coordinated pre- and post- testing sessions, which the psychometrist administered. This was the only time the control group had individual contact with the MT. On the other hand, those in the control group were offered the treatment after posttests were completed.

### Instrumentation

The psychometrist at QLI, who remained blind to group membership, performed data collection on the Trail Making Test parts A & B scores (time and errors), and scores on the Paced Auditory Serial Addition Test (3 second and 2 second delivery rate). The researcher (neurologic music therapist) collected the data for the AMMA and also distributed and collected

the DEX questionnaires. Testing sessions were randomly videotaped to ensure adherence to protocol. Testing took place in the same room as both the therapy and placebo group.

### Pretest and Posttest

Pretest and posttest measurements were made with the following instruments: The DEX of the Behavioral Assessment of Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996), the Trail Making Test parts A & B, and the Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977).

The Trail Making Test, parts A& B were included as a measure of mental flexibility. This test is so widely used as a measure of executive functioning that it made sense to include it for comparison across studies. Specifically, both studies that used music to affect executive functioning (Bugos, Perlstein, McCrae, Brophy & Bedenbaugh, 2007; Thaut et al., 2009) used the TMT. All three of the studies seeking remediation of executive functioning (Stablum, Umiltà, Mazzoldi, Pastore, & Magon, 2007; Stablum, Umiltà, Mogentale, Carlan & Guerrini, 2000; Westerberg et al., 2007) used the PASAT in their pre and post assessments. The PASAT measured monitoring and working memory.

### Pretest Only

Taking cues from Bugos et al. (2007), the Advanced Measures of Music Audiation (AMMA; Gordon, 1989) were included at pre-test to establish initial music aptitude. This was to ensure that all participants had a similar baseline of response to musical cues. The AMMA was administered in a room adjacent to the testing and therapy room on a Bose Wave II system. The administration of the test was slightly modified; after each excerpt was played, the music



therapist paused the disk to hear their answer and mark it on the form. This was done to isolate musical aptitude rather than processing and response speed. However, the modification was given across all subjects and repeated listening to a given track was not allowed.

### Statistical Measures

All statistical measures were computed using SAS<sup>®</sup> Enterprise Guide<sup>®</sup>. Normal distribution of the test scores was established using Q-Q plots, a plot of residuals (the individual's observed value minus the group mean). Due to the small sample sizes, the Shapiro-Wilk calculation was also considered to determine equal variance. If the Shapiro-Wilk probability was higher than 0.05 (assigned level of statistical significance), the data was considered normally distributed and parametric tests were used (One-way ANOVA). The Kruskal-Wallis test, a non-parametric alternative, was used if the residuals of the group statistics were not normally distributed. Baseline demographic characteristics were also analyzed (age, years of education, time from onset of ABI, and musical aptitude scores) using one-way ANOVA and the Kruskal-Wallis tests. Changes in baseline and post-test scores were analyzed using one-way or repeated measures analyses of variance (ANOVA). Within-subjects factors were baseline and post-test. The between-subjects factor were group (neurologic music therapy group, placebo group, and control group). Level of significance was set at  $p < 0.05$ . Effect sizes were calculated using eta squared and omega squared. Cohen's D was calculated from eta squared and included for cross-comparison to other studies.

Power was calculated using Lenth's online calculator. Data from Thaut et al.'s 2009 study provided the standard deviation (Sd=20; calculated backwards from the t-test scores to find the standard deviations of the differences) and detectable contrast (D=15; comparing the pre- and

post-test differences between the treatment and control group). Using ANOVA with a one-sided alternative, 80% power would have been achieved if there were 23 subjects per treatment group. The current study had 5 subjects per treatment group and one subject dropped out (total N=14).

## IV: RESULTS

### Baseline Demographic Characteristics

To determine if the groups differed from one another, baseline demographic characteristics were analyzed using one-way ANOVA in SAS<sup>®</sup> Enterprise Guide<sup>®</sup>. The data for both age and years since injury showed normal distribution, but not years of education. Table 3 summarizes these results.

Table 3

*Analyzed ANOVA Data of Group Baseline Demographics*

Group/ Mean and SD	Age	Years of Education	Years Since Injury
<i>Across Groups</i>	F=0.11 Pr>F=.8978	Shapiro Wilk=.032 Kruskal- Wallis=.306	F= .44 Pr>F= .6574
<i>NMT Group</i>			
Mean	43	14.0	24
SD	(9.66)	(4.08)	(11)
<i>Placebo Group</i>			
Mean	45.8	12.8	22.6
SD	(12.15)	(1.78)	(10.16)
<i>Control Group</i>			
Mean	42.75	15	18.5
SD	(11.81)	(4.08)	(12.56)

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*Note:* NMT=Neurologic Music Therapy Group/Treatment Group; SD=Standard Deviation; NMT (N=5), Placebo (N=5), Control (N=4); Statistical significance=\*  $p < 0.05$

As can be seen in Table 3, none of the demographic differences reached statistical significance. Group differences were also examined using one-way ANOVA for the pre-test measures of executive functioning (DEX, TMT, and the PASAT) and the pre-test for musical aptitude (AMMA). The DEX-self assessment showed abnormal distribution (Shapiro-Wilk,  $p=0.0125$ ) but no group difference (Kruskal-Wallis,  $p=0.6218$ ). All other tests of normality were satisfied.

No significant differences were found amongst measures except the pretest TMT B ( $F=4.23$ ,  $p=.04$ ) and the pretest TMT B-A ( $F=4.74$ ,  $p=.03$ ). Group inequalities for both of these measures were found between the NMT group and placebo group; the control group and the placebo group showed the same group inequalities. There was no difference found between the NMT and control groups. Table 4 provides further detail on the analysis of these measures of cognitive functioning.

Table 4

*Means and Standard Deviations on Tests of Cognitive Functioning*

<b>Measures of Cognition</b>	<b>NMT</b>	<b>Placebo</b>	<b>Control</b>
<i>Pretest Only</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>
DEX-self <sup>a</sup>	19.8 (20.69)	12.75 (4.66)	8.4 (12.97)
DEX-other <sup>b</sup>	29.2 (21.31)	21.4 (10.21)	16.0 (15.98)
AMMA <sup>c</sup>	50.8 (5.718)	35.6 (21.916)	47.5 (7.55)
<i>Pretest</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>
TMT B/A <sup>d</sup>	2.996 (.789)	3.548 (.815)	2.367 (.655)
TMT B-A <sup>e</sup> *	119.2 (39.81)	199.2 (29.09)	103.25 (80.01)
TMT B <sup>f</sup> *	180.6 (35.49)	284 (35.78)	175.75 (110.25)
PASAT 3'' <sup>g</sup>	24.2 (10.49)	11.4 (8.73)	12.0(10.29)
PASAT 2''	16.6 (3.13)	8.8 (6.379)	10.5 (14.177)

*NOTE:* a= Dysexecutive Questionnaire, self-report; b= Dysexecutive Questionnaire, report by assisted living staff; c= Advanced Measures of Music Audiation; d= Trail Making Test B time it took to complete B divided by time it took to complete A; e= Trail Making Test B time minus A time; f= Trail Making Test B used in the Thaut et al. (2009) study and thought to measure mental flexibility; g= Paced Auditory Serial Addition Test, 3'' and 2'' refer to the amount of seconds between stimuli; SD= standard deviation. \*p-value = 0.05, indicating a difference in group means.

## Analysis of Pre- and Posttest Differences

Analysis of the *differences* between post- and pre-test measures were done using one-way ANOVA, as the QQ-plots and Shapiro-Wilk scores all supported normal distribution. Only one of the neuropsychological measures (TMT B/A) showed a significant difference between the groups in the pre and posttest scores ( $F = 4.44$ ,  $p = .038$ ,  $\eta^2 = .446$ ,  $\omega^2 = .329$ ,  $d = 1.79$ , Mean Square Error = 0.3189). Table 5 summarizes the differences between post- and pretest measures.

Table 5

ANOVA changes in cognitive functioning for the NMT, placebo and control groups

Measures	Treatment Condition	Raw Scores		F	P < 0.05	$\eta^2$ ( $\omega^2$ ) d	MSE
		Pretest M(SD)	Posttest M(SD)				
PASAT 3''	NMT	24.2 (10.49)	23.0 (13.6)	0.02	.9784	.011 <sup>a</sup> (-.04) .21	81.85
	Placebo	11.4 (8.73)	14.2 (15.09)				
	Control	12.0 (10.29)	18.25 (16.7)				
PASAT 2''	NMT	16.6 (3.13)	15.8 (10.8)	0.36	.7030	.06 <sup>b</sup> (-.099) .51	61.69
	Placebo	8.8 (6.379)	5 (5.75)				
	Control	10.5 (14.177)	11 (10.42)				
TMT B	NMT	180.6 (35.49)	141 (30.04)	0.81	.4717	.128 <sup>b-c</sup> (-.028) .77	1363.43
	Placebo	284 (35.78)	257 (64.58)				
	Control	175.75 (110.25)	161.5 (109.68)				
TMT B-A	NMT	119.2 (39.81)	84.40 (30.8)	0.53	.6044	.087 <sup>b</sup> (-.07) .62	1359.45
	Placebo	199.2 (29.09)	192.2 (54.17)				
	Control	103.25 (80.01)	72.75 (55.02)				
TMT B/A	NMT	2.996 (.789)	2.54 (.661)	4.44	.038*	.446 <sup>c</sup> (.329) <sup>d</sup> 1.79	.3189
	Placebo	3.548 (.815)	3.97 (.609)				
	Control	2.367 (.655)	1.78 (.193)				

NOTE: M=group mean; SD= group standard deviation; MSE= Mean Square Error; NMT=Neurologic Music Therapy or Treatment Group, Placebo= Singing or Novelty group, Control= Treatment as Usual;  $\eta^2$ = ANOVA effect size where small = .01<sup>a</sup>, medium = .059<sup>b</sup> and large = .138<sup>c</sup>;  $\omega^2$ =ANOVA effect size controlling for MSE, where small = numbers between .0099- .0588 , medium = .0588-.1379, large<sup>d</sup> = .1379< ; Cohen's d effect size where small = 0.2, medium = 0.5 and large = 0.8 to infinity; \*p-value = 0.05

In order to determine in what direction the significant change took place, pair-wise group comparisons for ANOVA (LSD =Least Significant Difference) were examined. The average group difference and standard deviation for the NMT group was -.462 and .586; the placebo group was .418 and .606; the control group was -.582 and .470. Both the NMT group and the control group scored significantly better than the placebo group. The comparison between the treatment group and the control group did not reach significance. These comparisons for the TMT B/A are described in Table 6.

Table 6

*ANOVA LSD Pair- wise Comparisons for the Trail Making Test: Average Ratios of the Time on Part B divided by Time on Part A*

Comparison	Difference Between the Means	95% Confidence Interval <sup>a</sup>	Least Squares Mean Significance level
NMT – Placebo	-0.88*	-1.6661, -.0939	0.0315*
NMT – Control	0.1205	-0.7133, 0.9543	0.7564
Control - Placebo	-1.0005*	-1.8343, -0.1667	0.0230*

*Note:* NMT= Neurologic Music Therapy Group or treatment group, \* $p < 0.05$  indicates statistical significance; 95% Confidence Interval<sup>a</sup> = We can be 95% confident that the true population mean is contained within the interval; therefore, any number outside of the interval is rejected. The interval should not contain 0. LSD= least significant difference; does not control for multiple comparisons.

In summary, the analysis of demographic characteristics showed normal distribution and group equality upon statistical comparison of the group means. Pretest measures of cognition also showed group equality except for the TMT B and the TMT B-A scores; at baseline, both the NMT and control groups showed a statistically significant difference from the novelty group but not from one another. There was no significant difference found between pre- and posttest measures of cognition except for the TMT B/A. Once again, differences were found between

both the NMT and control groups and the novelty group but not between the NMT and control group.



## CHAPTER V: DISCUSSION

### Research Questions

The researcher first wanted to know if training in independent task switching, within the context of a song, would increase independent shifting in a non-musical task. The second question posed whether or not this training would transfer to increases in working memory performance. For both of these questions, the researcher aimed to uncover if the scores of the treatment group, compared to the scores of a placebo group (who were provided musical novelty, therapist contact and a social context), would show a difference that was statistically significant. Further, the researcher sought to answer if the scores of the treatment group, compared to the scores of the no-treatment group, would show a difference that was statistically significant. Finally, the null hypothesis was proposed that individuals within the neurologic music therapy group would perform equally on measures of executive functioning as those individuals in a singing group and in a no treatment group.

To answer the first research question, let us examine results from the Trail Making Test, parts A and B. The TMT captured flexibility of thinking (which somewhat required independent shifting) in a non-musical task. Part B involved switching between two rule-sets (Find 1 then A, 2-B, 3-C etc), whereas Part A mainly measured processing speed, as the rule never changed (find 1-2-3-4 etc). By taking the ratio of time it took to show mental flexibility to the time it took to process, the added challenge of the second rule could be observed in a new way. Salthouse (2011) suggests that the B/A ratio identifies problems with flexibility, even amongst individuals who process very quickly (p. 227). Referring to Table 4, pretest scores did not show group differences on the TMT B/A. Therefore, the difference could be due to the treatment intervention. However, although there was a significant group difference between the NMT and

placebo group (LSM  $p = .0315$ ), there was not a significant group difference between the NMT and control groups (LSM  $p = .7564$ ). Additionally, the control group also scored significantly better than the placebo group (LSM  $p = .0230$ ). Therefore, yes, the treatment group scored significantly better on independent task switching than the placebo group. However, no, the treatment group score did not score significantly better than the control group on independent task switching, as measured by the TMT.

To answer the second research question regarding working memory, let us examine results on the PASAT. There were no significant differences between the pre- and posttest change scores on any of the pair-wise comparisons. Training independent task shifting within the context of a song did not transfer to an increase in working memory performance, compared neither to the placebo nor to the control group.

In order to determine whether the null hypothesis was rejected, the NMT group only needed to show a group difference from one of the groups, not both. Because the NMT group showed a statistically significant group difference from the placebo group on the TMT B/A, the null hypothesis was rejected. However, because a statistically significant difference between the NMT group and the control group was not found (and the control group performed better than the placebo group) caution must be made when interpreting the results.

In order to interpret the results, it helps to examine what factors contribute to statistical significance; namely, the size of the effect and the size of the sample (Coe, 2002). In the present study, the size of the sample was small ( $N=14$ ). Therefore, the statistical results alone might not be the best way to determine treatment effectiveness. Another value to consider is the effect size.

As mentioned in the introduction, effect sizes help distinguish true differences in the scores within a study, because they incorporate the standard deviations of each group being

compared (Gold, 2004). In addition to statistically significant group differences on the TMT B/A, these differences also had relatively robust effect sizes ( $\eta^2=.446$  and  $\omega^2= .329$ ,  $d= 1.79$ ). The reporting of all three values for effect size is important because if we just looked at the  $\eta^2$  values, it would appear that all measures indicated a clinically significant treatment effect (Table 5). For the TMT B/A, the eta squared effect size ( $\eta^2=.446$ ) posits that the treatment accounts for 44.6% of the variance. However, eta squared looks at variance alone. Though rarely reported,  $\omega^2$  takes into account the mean square error ( $MS_E$ ), or the variance *and* its bias. Looking at the  $\omega^2$  values, the other measures all have negative values, or zero predicted effect. This is not to say that  $\eta^2$  values are not important; their value lies in the comparison of differences within the same research study. In this case, the TMT B/A measure showed a much larger effect size than the other measures. In order to predict the effect size for the population (and not just the sample population),  $\omega^2$  (Omega squared) is pivotal, especially if the sample size is small (Fritz, Morris, & Richler, 2012). The TMT B/A effect size for the population was also robust ( $\omega^2= .329$ , where values greater than .1379 are considered large). Cohen's  $d$  was reported for cross-comparison with other studies. The formulas to calculate both omega squared and eta squared are found in Figure 1.

$$\frac{\omega^2 = SS_{Effect} - (\alpha - 1)MS_{Error}}{SS_{Total} + MS_{Error}} \quad \text{or} \quad \omega^2 = \frac{(\alpha - 1) \times (F_A - 1)}{(\alpha - 1) \times (F_A - 1) + N}$$

$$\eta^2 = \frac{SS_{Effect/Model}}{SS_{Total}}$$

Figure 1. Formulas for ANOVA effect sizes. Eta squared ( $\eta^2$ ) and omega squared ( $\omega^2$ ) are used to calculate the effect sizes when there are more than two groups.

Therefore, based on the effect size for one-way ANOVA and small sample sizes, differences on the TMT B/A indicate the treatment had a significant effect.

### Feasibility

Although the current investigation yielded mixed results, several important elements regarding the feasibility of the NMT intervention were uncovered. Feasibility measures provide valuable information regarding whether or not an intervention is worth pursuing on a larger scale (Bowen et al., 2009). In other music therapy studies, rate of consent, rate of completed sessions and rate of completed instruments were three principle criteria used to indicate feasibility (Burns, Robb, & Haase, 2009).

The researcher approached twenty-six people with an acquired brain injury to participate in the current study. The psychometrist at QLI approached four more. The initial seven people lived in Fort Collins; two were outside of the age-limit. The remaining five did not provide enough participants for three groups, therefore the study was relocated to Omaha, Nebraska. Of the 19 people approached at QLI, only one refused due to the presence of pre- and posttest measures. Of the remaining 18, one had a history of drug abuse and two did not receive guardian assent before the start of the treatment. 15 remaining participants were randomly assigned to three groups; one withdrew after random assignment due to time-conflicts with the group meeting time. Therefore, of the original 26 interested participants, 18 gave consent, resulting in a 69% consent rate. According to Burns, Robb and Haase (2009) a 69% consent rate would be considered good and this rate would imply the feasibility of obtaining larger numbers in future studies (p.14).

The number of completed sessions varied for the NMT group and the placebo or novelty group. The NMT group had two participants who attended the entire five sessions. One participant missed the first session because he forgot about the appointment and was off-campus. Another participant missed the first session because of a previously scheduled doctor's appointment; this same participant missed half of the last session due to an intense migraine. A third participant of the NMT group missed session 4, due to an off-campus job interview that ran late. Of the 25 possible complete sessions, participants attended 21.5, resulting in an 86% NMT group completion rate.

Three participants completed all five sessions in the placebo, singing group. One participant slept through the second session, due to having a bad head cold. Another participant left half-way through the third session, due to a previously scheduled therapeutic horseback riding appointment. Of the 25 possible complete sessions, the placebo group attended 23.5, resulting in a 94% completion rate. Session completion rates support feasibility but indicate a need for clearer communication of session times for better scheduling of outside appointments. Instrumentation composed of five pretest measures and three posttest measures; broken down into test subcomponents, there were eleven measures. The 14 participants attempted 100% of these measures. One participant in the control group reached the discontinue time for the TMT B (both pre- and posttest), as well as the discontinue rule for the PASAT (both pre-and posttest). Another member of the control group did not complete the pretest PASAT, 2-second delivery. Four participants in the placebo, singing group reached the discontinue time for the TMT B pretest; three of those four discontinued in the posttest as well. Two of these met the discontinue rule for the PASAT; one did not complete any of the pre- or posttest PASAT measures and one met the discontinue rule for the posttest PASAT, 2-second delivery. Only one participant of the

NMT group met a discontinue rule; this was on the posttest PASAT, 2-second delivery. This NMT group member was the same participant who missed the last session, due to a migraine (and the migraine was still present during post testing). A summary of unique data points are provided in Figure 2.

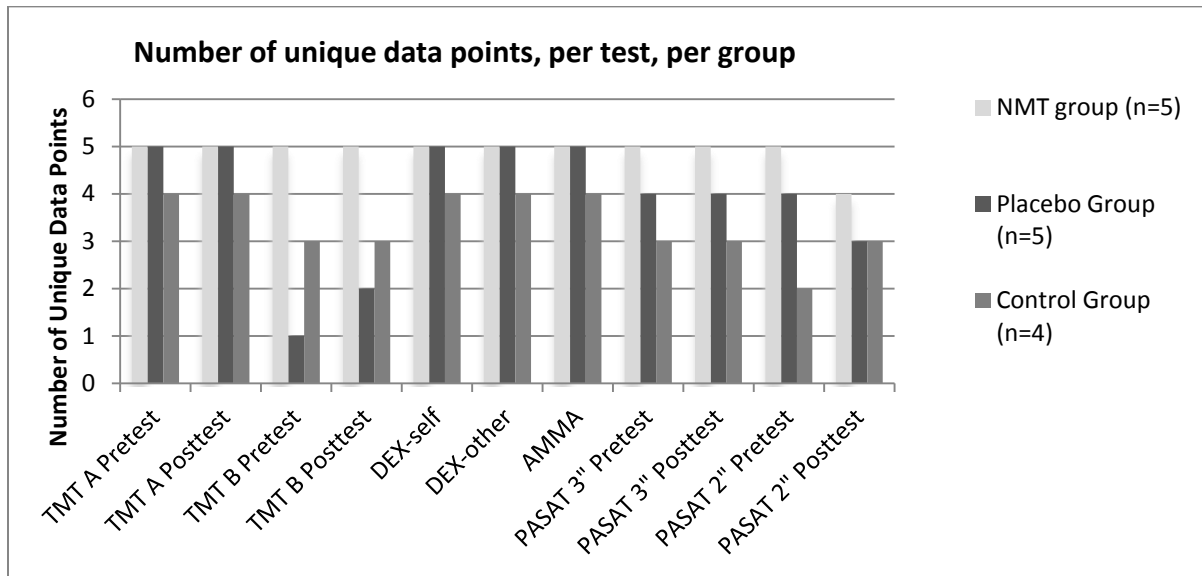


Figure 2. Number of unique data points. This figure illustrates the number of unique data points per treatment group, per cognitive test.

As can be seen in Figure 2, both the TMT B and the PASAT had fewer unique data points than other measures. The placebo group performed worse than both the NMT and control groups. Therefore, although all participants attempted to complete the instruments, not all of the data points were unique. The NMT group produced 54 unique scores out of a possible 55 (98%), the placebo group produced 43 unique scores out of a possible 55(78%), and the control group produced 37 unique scores out of a possible 44 (84%). For feasibility, different measures of cognitive functioning are suggested in order to capture a more accurate level of group differences. However, the rate of attempted instruments supports feasibility (100%). It is important to mention that the researcher offered the NMT treatment intervention to both the

control and placebo groups, after completion of post testing. This incentive most likely supported the high rate of instrument completion.

To summarize, rate of consent, session completion and instrument completion rates support feasibility of the NMT treatment intervention. Due to two of the groups showing difficulty with the TMT B and the PASAT, future studies might consider replacing these measures for more accessible tests. However, since 9 of the 14 (64%) participants provided unique data points, replacing the measures would be up to the researcher. Overall, the current NMT intervention appears feasible for implementation in a larger study.

### Limitations

The small sample size was the first limitation of the current study. The music studies detailed in the literature review that showed statistical significance had much larger participant pools (Bugos et al, N=31; Thaut et al, N=54). In addition to the small sample size, several other limitations may have significantly influenced the result of this study. These limitations include not having access to severity or location of injury, lack of ecological measures for executive dysfunction and endogenous task shifting, testing difficulty, length of treatment and specificity of audio feedback.

As previously discussed, the researcher planned to use the Glasgow Coma Scale scores as an index of injury severity in order to ensure equal distribution of groups. This had been a limitation in the Thaut et al 2009 study, upon which the power for this study was based. While the researcher obtained permission to access these scores, actually retrieving them proved beyond the resources of the facility. Therefore, it is possible the groups were not evenly

distributed. Figures 3 through 6 demonstrate how each participant performed, per standard measurement.

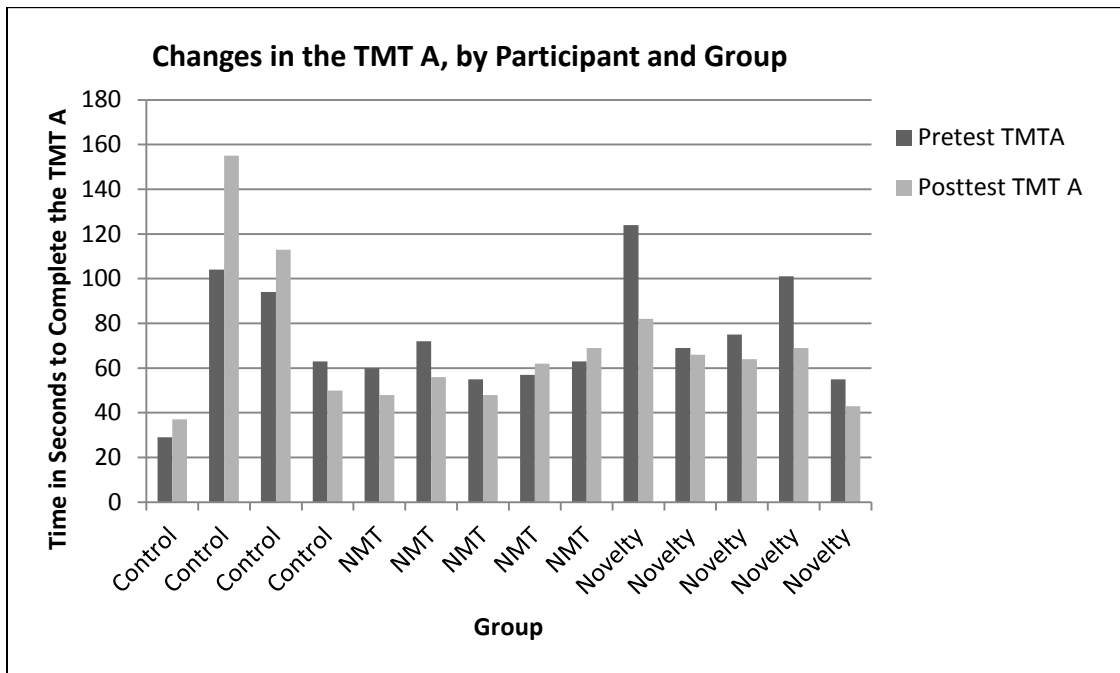


Figure 3. Changes in the Trail Making Test, Part A, by participant and group.

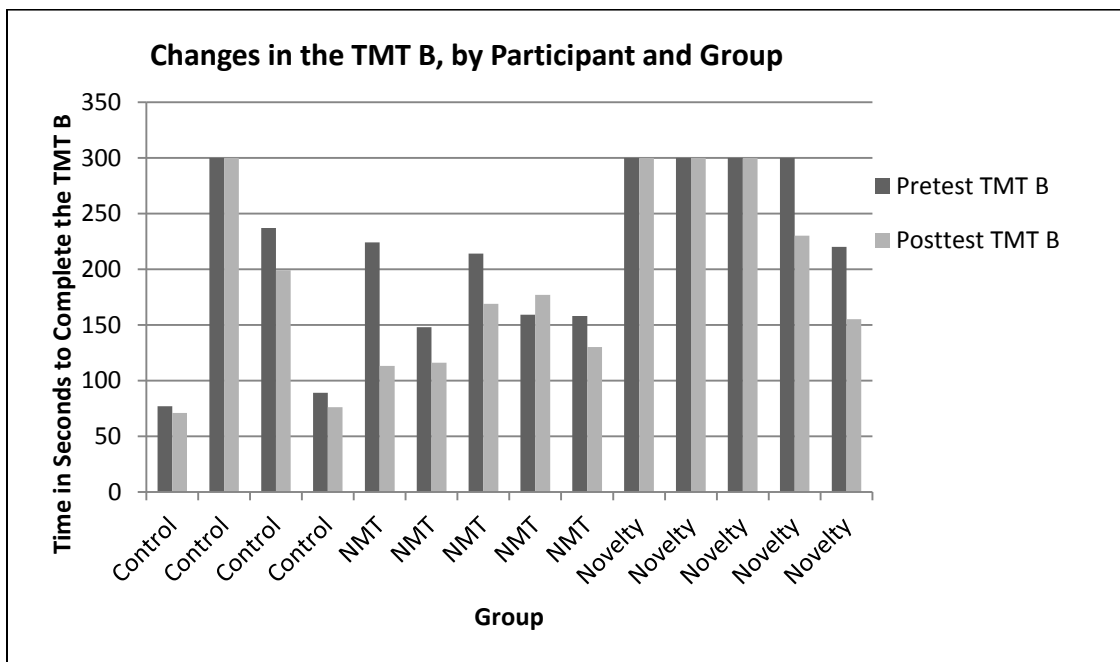


Figure 4. Changes in the Trail Making Test, Part B, by participant and group.



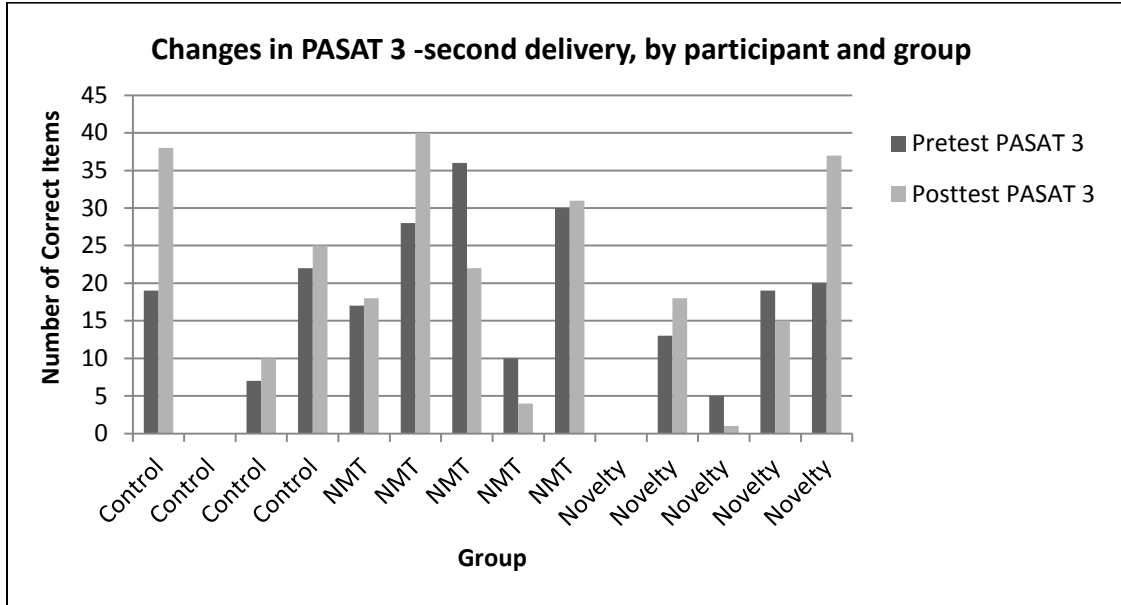


Figure 5. Changes in the PASAT 3-second delivery, by participant and group.

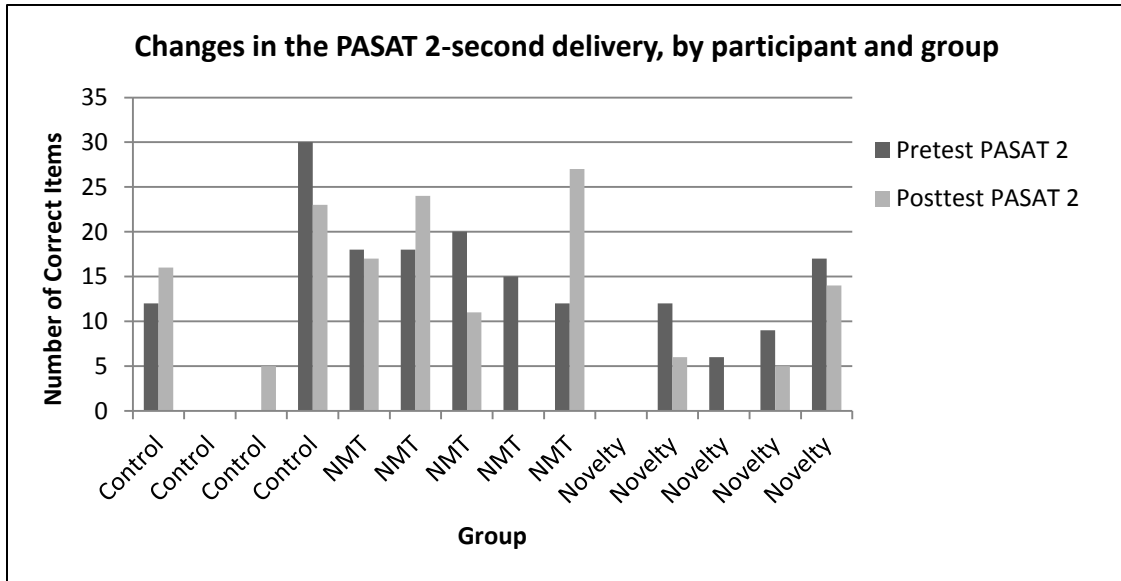


Figure 6. Changes in the PASAT 2-second delivery, by participant and group.

Additionally, the researcher did not obtain information regarding the location of injuries.

As previously mentioned, this can also contribute to the severity of executive dysfunction. The

researcher included the DEX to estimate the presence of executive dysfunction, but not as a measure on its own.

The DEX has a maximum score of 80, with higher numbers indicating greater difficulty with executive function in a participant's daily life. The DEX does not report norms for determining the presence of a dysexecutive syndrome, though its interpretation is widely described in the research (Bennett, Ong, & Ponsford, 2005; Boelen, Spikman, Rietveld, & Fasotti, 2009; Norris & Tate, 2000). Most often, the self-report scores and those completed by an independent observer produce a discrepancy. In the present study, correlations between the participant self-report and other report for the NMT, placebo and control groups were  $r = .79$ ,  $r = .38$ , and  $r = .18$  respectively. Wilson et al. attribute discrepancies to a lack of personal insight into the severity of injury (1996); however, at least one study found very low discrepancy between DEX-other and DEX-self scores, especially when the frontal poles were not affected (Boelen et al., 2009; Cicerone et al. 2006; Stuss, 2007). Because the current study did not have information regarding location of injury and the research is mixed regarding its interpretation, these scores were included for anecdotal evidence only. Therefore, the DEX scores could not be used as a substitute for the Glasgow Coma Scale scores; it is possible that participants without executive dysfunction were inadvertently included.

Similarly, specific measures for endogenous task shifting were unavailable. Although the neuropsychological measures used in this study were based upon previous research studies, they are not designed to capture the capacity to *endogenously* switch attention. The TMT purports to measure flexibility of thinking, which would require the capacity to switch attention. However, when the TMT is administered, errors are corrected. This real-time error correction takes away from the necessity to decide internally (endogenously) when to switch attention. Independent

switching would have been present in both the Modified Elements of the BADS and the Executive Secretarial Test, where the test administrator withholds intervention. Due to the relocation of the study from Fort Collins to Omaha, these tests were no longer available and thus removed from the original study design. The measurements that remained were for cross-comparison, and not originally intended to measure the aimed area of treatment. Also, as demonstrated under treatment feasibility, not all of the participants were able to complete the TMT B or the PASAT according to test administration rules. This limitation resulted in fewer unique data points for analysis and may be the culprit behind the inconclusive results.

Moreover, actual length of treatment may have limited the results of the current study. While the Stablum studies (2000, 2007) both implemented treatment over five hours, they did not administer treatment within a group. The current investigation purposely used a group setting to evoke conditions where executive functioning (EF) may arise. While valuable for creating emergence of EF, treatment in a group setting limits the amount of individual feedback. What is more, processing specific feedback with five individuals requires more time than feedback to one. Hence, the added time it took to provide and process feedback with five participants reduced the amount of actual time spent training.

Under the current protocol, the group setting also affected specificity of audio feedback. While the mp3 recording captured the overall performance of the group, certain instruments were more difficult to tease out (e.g. the xylophone). In both the Stablum studies and the Bugos study, the participants received regular, specific instruction of what to correct (e.g. go faster or go slower). Lack of resources therefore affected specificity of feedback, which could have negatively affected participants' progress.

To summarize, the current investigation presented several limitations. These included small sample size, limited information regarding severity and location of injury, lack of specific, ecological measures of endogenous task shifting, difficulty for some participants to accurately complete all measures, length of treatment, and quality of individual audio feedback. Although beyond the scope of the current study, in future studies, steps to ameliorate these limitations are encouraged.

### Observations

Aside from the limitations, the researcher observed several elements that may have affected the study outcome. These include group size, emotional support, and fidelity to the purpose statement.

Although power calculations suggested much larger group sizes ( $n=23$ ), it would have been difficult to train more than 5 participants at a time, given the size of the room and the number of instruments available. With five treatment days and five different instruments, the current study ensured that each participant used the same types of response activation, for the same amount of time.

Additionally, the participants required a high level of therapeutic counseling and encouragement to stay with the task. As mentioned in the introduction, executive dysfunction often affects the capacity to regulate emotions. This was clinically apparent in the majority of the treatment group. A large portion of time was given toward redirecting their focus to what they were doing well and away from what they believed was going wrong. As previously discussed, executive functioning worsens if we believe a task is beyond our capacity to successfully complete. Therefore, addressing the self-defeating talk appeared imperative (Addressing self-

reflection will be discussed further). By the third treatment session, replacement of self-defeating statements began to take effect and the amount of actual playing surpassed the amount of discussion.

While self-defeating talk hinders executive functioning, addressing the issue may have turned the treatment away from the initial purpose of the study. The original purpose of the current study was to investigate whether targeting a subcomponent of EF, using the neurologic music therapy technique musical executive functioning training (MEFT), would improve overall EF in individuals with acquired brain injury. The idea was based on Stuss' theory of separable, yet interconnected categories of behavior (as discussed in the literature review). The researcher aimed to use music as a restorative, rather than a compensatory technique.

However, upon reflection for this section it became clear that the procedure evolved into a hybrid of the two categories of therapy. While focus was placed on activating specific neural areas (the prefrontal cortex, dorsal premotor cortex and supplementary motor areas), attention to self-defeating statements activates the frontal poles.

As mentioned in the literature review, if the acquired brain injury damaged the frontal polar region (BA 10), self-awareness is affected. Surpassing this requirement is one of the main advantages of the restorative technique. However, many elements of the Spikman et al (2010) study, testing a compensatory approach, were unintentionally included in the approved procedure. Namely, talking about the experience of the intervention, addressing self-defeating thoughts, and drawing connections to the participants' daily lives all required self-reflection. While Spikman's study showed significant effects, it took place over three months, two hours per week, and it required the participants to be self-reflective. Therefore, it is possible that fidelity to

the purpose statement was inadvertently lost, as the protocol did not really match the research upon which it was based.

Part of this error was most likely due to the research therapist's familiarity using musical executive functioning training (MEFT) in one particular way, which involves a lot of probing on the part of the therapist. Upon reflection, this models the therapist attempt to mirror the supervisory attentional system described by Shallice and Burgess (also discussed in the Spikman et al 2010 study). That is *not* to say that MEFT is restricted to this technique; NMT's interventions are based upon the Rational Scientific Mediating Model (RSMM; Thaut) and the transformational design model (TDM; Thaut) and do not always follow predetermined techniques.

The TDM is the formulation of the specific details of a clinical application. Creating an isomorphic transformation of a nonmusical intervention into a musical intervention is an imperative element of the success of the TDM. Had the procedure minimized self-reflective processing while still providing positive feedback, it would have more closely followed the restorative method while remaining MEFT. Although the researcher followed the protocol diligently, the initial planned conversion of the nonmusical intervention to the musical intervention was not isomorphic. These observations on group size, emotional support, and fidelity to the purpose statement all contribute to the limitations of the study.

### Fidelity to Treatment

As mentioned, the researcher attempted to follow the protocol with strict adherence. The use of fidelity measures supported this attempt. Fidelity measures have been used successfully in occupational therapy research (Parham, Cohn, Spitzer, Koomar, Miller, Burke, et al. 2007). In

the current research study, professional training (the researcher is a fellow member of the academy of neurologic music therapists), video recording for collegial review and a protocol checklist were three of the fidelity measures used.

Due to the dynamic nature of live music making, developing a set protocol for interaction is difficult. However, keeping interventions consistent and specific is imperative in order for replicable studies to be possible. In the current study, the music therapist kept a fidelity checklist visible while leading both the NMT and placebo groups. Additionally, the sessions were video recorded and reviewed by an independent observer before the proceeding session. The reviewer feedback included the fidelity checklist and any observations they felt were important to include. This method allowed the therapist to make changes before the next session (such as tapping along with the beat with one's foot rather than one's hand to avoid inadvertently cuing a time to shift). The reviewers were also trained in neurologic music therapy.

### Considerations

Future studies might consider recruiting more reviewers so that cross comparisons of their ratings could be made. Revisal of the current study's checklist to avoid elements of compensatory techniques would also be suggested. Administering the treatment in groups of five done over several months could be an alternative way to achieve power. Naturally, this would require resources beyond the scope of the current study. One possibility for specificity of audio feedback would be to connect each instrument individually to an iPad via MIDI or use an acoustic pick up. This way, they could hear their own contributions on the playback (individually with headphones). Also, a program could be used that visually records their playing and compares it with the musical stimulus. Statistical data could be gathered and offer an objective

measure of their daily, individual progress. Although there are programs like Guitar Hero that have similar capacity, the manipulation of real instruments provides immediate vibrotactile, audio feedback not present in video games. Further, the real instruments provided natural, novel changes to the task, also a necessary component to the activation of executive functioning. Another element to consider is age of injury. Although the study required participants to be at least 25 years of age, it did not control for those whose injury occurred long before maturation of the frontal lobes.

What is more, given the emphasis on shared and extended neural networks, it would be ideal to include neuroimaging as an additional measure. fMRI could be used to determine if the specific musical condition described in the protocol actually evoked increased responses in the areas believed to control endogenous task-shifting. Combined with electroencephalography (EEG) or magnetoencephalography (MEG), timing of activation could be more precise and the level of neural oscillations could be explored. As mentioned in the literature review, the presence of salient rhythms optimizes neural oscillations (Fujioka et al., 2012; Large & Snyder, 2009; Trainor et al., 2012). Although the current study did not explore the feasibility of such measures, it would be interesting to see if an EEG or MEG would confirm the increased presence of gamma- and beta-band oscillations in areas of EF during music-based interventions.

Finally, the presence of the novelty group provided preliminary evidence of two important elements to consider. First, the novelty of the intervention could not account for the increases in test scores. Contact with the same therapist, meeting in a group and exposure to live music controlled for these potentially novel effects. Second, and perhaps most important, simply being exposed to music did not produce noticeable effects. When leading the placebo group, the therapist took careful steps to avoid any use of music in a therapeutic (e.g., discussion was not



facilitated, songs were not selected based on the mood of the participants, and videos of the sessions were reviewed for fidelity to protocol). Therefore, the critical application of music, as provided by a board-certified music therapist, made a difference. Future studies that involve the use of music might consider the continued presence of a novelty or placebo group.

In summary, more reviewers, the avoidance of compensatory techniques, small group sizes, individual recordings of each music instrument, age of injury, and inclusion of neuroimaging devices as well as a placebo group are all areas to consider for future studies.

### Conclusion

The current pilot study did not conclusively suggest that using neurologic music therapy to train endogenous task shifting was successful. However, this randomized control trial does lay the groundwork for future investigations. Feasibility of the intervention was established via high rate of consent, low rate of withdrawal, completion of sessions and rate of attempted instrument completion. The shared and extended network between specific elements of music and subcomponents of executive functioning has been established. The conditions under which certain pathways activate were provided (a short pattern that repeats but over a minimum duration and using an observable rule-switch, awareness of learning and repetition of skills). Elements that provide optimization of brain functioning were included (a salient drum beat, coordination of motor movement to said beat, controlled execution of the accompaniment, and the need for sensory integration via visual, auditory and motor responses). Characteristics for executive function activation were present (novelty, emotional arousal, an attainable challenge, self-initiation of response, a need for delayed intention, sequencing, shifting, inhibiting, and timing responses). The critical application of music, by a board-certified music therapist, created significant advances over the simple presence of music. Limitations included sample size,

availability of psychometric tests and participant information, incapacity of all participants to complete the measures, length of treatment, and specificity of audio feedback. The continued use of fidelity measures is highly recommended. Neurologic music therapy creates a safe environment to practice executive functioning while still arousing emotions and adding an element of positive stress. Discovering the exact mechanisms necessary to harness the untapped power of musical elements remains an exciting area for future studies in the cognitive realm.

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## APPENDIX I

## CONSENT TO PARTICIPATE IN A RESEARCH STUDY

### AUTHORIZATION TO RELEASE PROTECTED HEALTH INFORMATION

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**TITLE OF THE STUDY:** *Training Endogenous Task-Shifting Using Neurologic Music Therapy*

**PRINCIPAL INVESTIGATOR:** Blythe LaGasse, Ph.D., Assistant Professor, Department of Music, Theatre and Dance, Colorado State University, Fort Collins, CO 80523; TEL: (970) 491-4042 or EMAIL: [Blythe.Lagasse@colostate.edu](mailto:Blythe.Lagasse@colostate.edu)

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#### WHAT YOU SHOULD KNOW ABOUT THIS STUDY:

You are being asked to join a research study. This consent form explains the research study and your part in the study. Please read it carefully. Take as much time as you need. Please ask the study staff questions about anything you do not understand. You can ask questions now or anytime during the study. If you join the study, you can change your mind later. You can quit the study at any time.

You will be randomly assigned to one of the 3 study treatments. This means that whichever treatment you get will be decided by chance, like drawing names out of a hat. You will have a 1 in 3 chance of getting any one of the study treatments. This will be done by a computer and the researcher does not have any control over the group in which you are placed.

Your participation in this research requires your authorization to release information from your medical record: the measurement of the severity of your injury, called the *Glascow Coma Scale score*. This is protected health information which will also be linked to your random assignment. For example, if there are 3 people with a score of 20 on the Glasgow Coma Scale, they will be randomly placed in each group first. Then all people with scores of 15 will be randomly placed and so on, until all participants are assigned to a group. This helps to ensure that the level of injury of the participants is as equal as possible across all three groups. This method is called stratified random sampling. *The Glasgow Coma Scale score* is the only protected health information from your medical record that we are asking your permission to access.

1 of the groups will not meet to make music during the study.

#### WHAT DO I GET FOR BEING IN THE STUDY?

We do not know if you will benefit from being in this study. However, we hope to use the information from this study to develop new programs for treating changes in how people respond to the environment because of an acquired brain injury. We hope to show that music therapy makes a positive difference. We hope this research will help insurance companies decide to pay for future music therapy services. You will not receive payment for being in the study.

#### DO I HAVE TO BE IN THIS STUDY?

No, being in this study is up to you and you can withdraw your permission to allow your health information to be used in the research. You can say no now or leave the study at any time later.

## **WHAT WILL I BE ASKED TO DO?**

In the first meeting, you will take several tests that help us see your level of cognition (for example, problem-solving ability and memory) before participating in the group. You will take these tests even if you are not assigned to one of the groups that will meet weekly. The tests usually take about half an hour to complete. All testing will be videotaped. This is to make sure each participant is asked questions and given directions in the same way, each time. The videos will be kept indefinitely. The videos are kept in a secure place and used for research purposes only. Your name will not be attached to any of the video files.

If you are assigned to one of the music groups, you will meet in the Assisted Living of QLI to participate in group music-making. Each day of the treatment week:

**Group 1** will meet for one hour, for five days, to play songs on instruments by following a simple notation system. You will not need to read music or have any musical training. These sessions will also be videoed and the recordings will be kept indefinitely in a secure and locked computer file. The recordings will be used for research purposes only. Your name will not be attached to any video files. An mp3 audio recording of the playing may also be made. There may be times when we will listen to the recording as a group. The mp3 recordings will be kept in a locked computer file and all recordings will be deleted at the end of the 5 sessions.

**Group 2** will also meet for one hour, for five days, and they will sing songs together, led by the music therapist. These groups will also be videoed and the recordings will be kept indefinitely in a secure and locked computer file. The recordings will be used for research purposes only.

**Group 3** will not attend any groups and will therefore not be videoed except during testing. After the five days, all groups will take the tests again.

If you are randomly assigned to be in one of the music groups, your approximate total time commitment is 6 hours (no more than one hour per day). If you are not randomly placed in one of the music groups, your total time commitment will be approximately 1 hour total. Testing usually takes about a half an hour, done on one day. The tests will be repeated at the end of the treatment period. Total testing time will be approximately 1 hour.

## **WHO WILL SEE INFORMATION THAT I GIVE?**

Your confidentiality is one of our main concerns. We will store all of your research records in locked cabinets and secure computer files. We will not place your name on any research data. Instead, we will label your information with a code number. The master list that links your name to your code number will be stored in a locked cabinet. We will keep all the information you give us confidential as provided by law. The only exception is any risk of possible harm to you or others and the CSU IRB has the authority to audit the research files. We won't share your study results with anyone unless you ask us to. Your name won't appear in any reports about this study.

Only the researchers, Colleen Mueller and Blythe Lagasse, Ph.D., will have access to your data and the symptom severity score you received from the hospital right after your injury (your Glasgow Coma Scale score). Once your Glasgow Coma Scale score is linked to your assigned number, your name will be deleted. As mentioned in the first paragraph, this information will help us determine that the treatment groups are equally distributed.

## **WILL I GET TO SEE THE RESULTS OF MY TESTING AND PARTICIPATION?**

Yes. If you wish to know how you have done, we will go over the results with you and explain what they mean. You are also welcome to see the video if you are interested. Copies of the mp3 recordings will not

be provided. However, if all members in the group say it is okay, copies of the audio recordings can be arranged. You are welcome to ask questions at any time.

### **WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?**

You may feel some stress during research procedures due to an unfamiliar environment, involvement with people you do not know, or feeling uncomfortable in testing situations. The researchers will try to reduce possible stress with fun group activities. If you become tired or feel any discomfort during the groups, you may take a break at any time. Video recording will be used in this study and will be kept on a password-protected computer in a locked office. Your name will not be used on any data files; rather, an assigned study number will be used to protect your identity. It is not possible to identify all potential risks in research procedures, but the researcher(s) have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

### **WHAT HAPPENS IF I AM INJURED BECAUSE OF THE RESEARCH?**

It is not anticipated that you will become injured because of the research. However, the Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

### **WHAT ELSE DO I NEED TO KNOW?**

Information regarding the release of your Glasgow Coma Scale Score:

- This is protected health information (PHI). The research team will take precautions that no one other than the researchers have access to this information. The CSU IRB may also audit the research files. Federal and state laws also protect your privacy.
- We will use and disclose your information only as described in this form. We will take measures to be sure that everyone who needs to see your information keeps it confidential – but we cannot guarantee this.
- Signing this consent form replaces the need to sign a separate Health Insurance Portability and Accountability (HIPAA) Authorization form to release this information to our research team.
- We cannot do this study without your permission to use this information. You do not have to give us permission. If you do not, then you may not join this study.
- The use and disclosure of your information has no time limit. You can cancel your permission to use and disclose your information at any time by notifying the Co-Principal Investigator of this study in writing. The Co-Principal Investigator's name and contact information is on page one of this consent form.
- If you cancel your permission to use and disclose your information, your part in this study will end. Your cancellation would not affect information already collected in the study.

**WHAT IF I HAVE QUESTIONS?** Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the co-principal investigator, Colleen Mueller at (402) 953-7719. You are also welcome to contact either the principal investigator, Dr. Blythe LaGasse, at (970) 491-4042, or Dr. Jeffrey Snell of QLI, at (402) 573-2162. If you have any questions about your rights as a volunteer in this



research, contact Janell Barker, Human Research Administrator at 970-491-1655. We will give you a copy of this consent form to take with you.

This consent form was approved by the CSU Institutional Review Board for the protection of human subjects in research on February 12, 2013.

I have read this form and the research study has been explained to me by \_\_\_\_\_.  
I have been given the chance to ask questions, and my questions have been answered. If I have more questions, I have been told who to call. I agree to be in the research study described above. I agree to have my injury severity score released to the researchers and have been informed that this authorization has no expiration date. I will receive a copy of this consent form after I sign it.

Your signature acknowledges that you have read the information stated and willingly sign this consent form. Your signature also acknowledges that you have received, on the date signed, a copy of this document containing 4 pages.

\_\_\_\_\_  
Signature of person agreeing to take part in the study

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of person agreeing to take part in the study

\_\_\_\_\_  
Signature of Legally Authorized Representative

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of Legally Authorized Representative

\_\_\_\_\_  
Name of person providing information to participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Research Staff

## APPENDIX II

**NOTICE OF APPROVAL FOR HUMAN RESEARCH**

**DATE:** June 10, 2013  
**TO:** Lagasse, Blythe, Music, Theatre & Dance  
Mueller, Colleen, Music, Theatre & Dance, Queen, Todd, Music, Theatre & Dance  
**FROM:** Barker, Janell, Coordinator, CSU IRB 2  
**PROTOCOL TITLE:** Training Endogenous Task-Shifting Using Neurologic Music Therapy (this is a change from the Protocol Title, Task Shifting to Repair Executive Functioning)  
**FUNDING SOURCE:** NONE  
**PROTOCOL NUMBER:** 12-3566H  
**APPROVAL PERIOD:** Approval Date: June 26, 2013 Expiration Date: June 25, 2014

The CSU Institutional Review Board (IRB) for the protection of human subjects has reviewed the protocol entitled: Training Endogenous Task-Shifting Using Neurologic Music Therapy (this is a change from the Protocol Title, Task Shifting to Repair Executive Functioning). The project has been approved for the procedures and subjects described in the protocol. This protocol must be reviewed for renewal on a yearly basis for as long as the research remains active. Should the protocol not be renewed before expiration, all activities must cease until the protocol has been re-reviewed.

If approval did not accompany a proposal when it was submitted to a sponsor, it is the PI's responsibility to provide the sponsor with the approval notice.

This approval is issued under Colorado State University's Federal Wide Assurance 00000647 with the Office for Human Research Protections (OHRP). If you have any questions regarding your obligations under CSU's Assurance, please do not hesitate to contact us.

Please direct any questions about the IRB's actions on this project to:

Janell Barker, Senior IRB Coordinator - (970) 491-1655 [Janell.Barker@Colostate.edu](mailto:Janell.Barker@Colostate.edu)  
Evelyn Swiss, IRB Coordinator - (970) 491-1381 [Evelyn.Swiss@Colostate.edu](mailto:Evelyn.Swiss@Colostate.edu)

Barker, Janell



Barker, Janell

Approval is to recruit 30 participants with the approved recruitment and consent. The above-referenced project was approved by the Institutional Review Board with the condition that the approved consent form is signed by the subjects and each subject is given a copy of the form. NO changes may be made to this document without first obtaining the approval of the IRB.

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**Approval Period:** June 26, 2013 through June 25, 2014  
**Review Type:** EXPEDITED  
**IRB Number:** 00000202

## APPENDIX III

## I Walk the Line Johnny Cash

I keep a close watch on this heart of mine, I keep my eyes wide open all the time. I keep the ends out for  
the tie that binds because you're mine, I walk the line.

I find it very, very easy to be true. I find myself alone when each day is through. Yes I'll admit that I'm a  
fool for you, because you're mine, I walk the line.

As sure as night is dark and day is light, I keep you on my mind both day and night and happiness I've  
known proves that it's right, because you're mine, I walk the line.

You've got a way to keep me on your side, You give me cause for love that I can't hide. For you I know  
I'd even try to turn the tide, because you're mine, I walk the line.

I keep a close watch on this heart of mine, I keep my eyes wide open all the time. I keep the ends out for  
the tie that binds because you're mine, I walk the line.

### Grandma's Feather Bed – John Denver

**When** I was a **little** bitty boy, **Just** up off the **floor**, **We** used to go down to **Grandma's** house, **Every** month end or **so**  
We had **chicken** pie and **country** ham, and **homemade** butter on the **bread**, But the **best** darn thing about **Grandma's** house  
was her **great** big feather **bed**.

It was **nine** feet tall and six feet wide, Soft as a **downy chick**, It was **made** from the feathers of forty 'leven geese,  
took a **whole** bolt of cloth for the **tick**. It'd **hold** eight kids, and four hound dogs, and a **piggy** we stole from the **shed**,  
We didn't **get** much sleep but we **had** a lot of fun on **Grandma's** feather **bed**.

**After** supper we'd **sit** around the fire The **old** folks'd spit and **chew**, **Pa** would talk about the **farm** and the war,  
And **Granny'd** sing a ballad or **two**. I'd **sit** and listen and **watch** the fire, Till the **cobwebs** filled my **head**,  
Next **thing** I know I'd **wake** up in the morning In the **middle** of the old feather **bed**.

It was **nine** feet tall and six feet wide, Soft as a **downy chick**, It was **made** from the feathers of forty 'leven geese,  
took a **whole** bolt of cloth for the **tick**. It'd **hold** eight kids, and four hound dogs, and a **piggy** we stole from the **shed**,  
We didn't **get** much sleep but we **had** a lot of fun on **Grandma's** feather **bed**.

Well I **love** my Ma, I **love** my Pa, I love **Granny** and Grandpa **too**, I've been **fishing** with my uncle, I **wrassled** with my cousin  
I **even** kissed old Aunt **Lou**. But **if** ever had to **make** a choice, I **guess** it ought to be **said**  
That I'd **trade** them all plus the **gal** down the road, For **Grandma's** feather **bed**.

It was **nine** feet tall and six feet wide, Soft as a **downy chick**, It was **made** from the feathers of forty 'leven geese,  
took a **whole** bolt of cloth for the **tick**. It'd **hold** eight kids, and four hound dogs, and a **piggy** we stole from the **shed**,  
We didn't **get** much sleep but we **had** a lot of fun on **Grandma's** feather **bed**. We didn't **get** much sleep but we **had** a  
lot of fun.....  
on **Grandma's** feather **bed**.

## Happy Together – The Turtles

Imagine **me** and you, I do                      I think about you **day** and night                      It's only right  
To think about the **girl** you love                      And hold her tight                      So happy to **gether**

If I should **call** you up                      Invest a dime                      And you say you be **long** to me                      And ease my  
mind  
Imagine how the **world** could be                      So very fine                      So happy to **gether**

**I** can see me **loving** nobody but **you**                      For all my **life**                      **When** you're with me  
**Baby** the skies will be **blue**                      For all my **life**

**Me** and you                      And you and me                      No matter how they **tossed** the dice                      It had to be  
The only one for **me** is you                      And you for me                      So happy **together**

**I** can see me **loving** nobody but **you**                      For all my **life**                      **When** you're with me  
**Baby** the skies will be **blue**                      For all my **life**

**Me** and you                      And you and me                      No matter how they **tossed** the dice                      It had to be  
The only one for **me** is you                      And you for me                      So happy **together**

**So** happy **together**                      **How** is the **weather**                      **So** happy **together**                      **We're** happy  
**together**  
**So** happy **together**

## Ob-la-di Ob-la-da – Lennon/McCartney

Desmond has a barrow in the market place, Molly is a singer in a band, Desmond says to Molly „Girl I like your face“, and Molly says this as she takes him by the hand.

Ob-la-di ob-la-da, life goes on, bro, la la how the life goes on.

Ob-la-di ob-la-da , life goes on, bro, la la how the life goes on.

Desmond takes a trolley to the jeweller's store, buys a twenty carat golden ring, Takes it back to Molly waiting at the door, and as he gives it to her she begins to sing:

Ob-la-di ob-la-da, life goes on, bro, la la how the life goes on.

Ob-la-di ob-la-da , life goes on, bro, la la how the life goes on.

In a couple of years they have built a home sweet home. With a couple of kids running in the yard of Desmond and Molly Jones.

Happy ever after in the market place, Desmond lets the children lend a hand Molly stays at home and does her pretty face and in the evening she still sings it with the band:

Ob-la-di ob-la-da, life goes on, bro, la la how the life goes on.

Ob-la-di ob-la-da , life goes on, bro, la la how the life goes on.



## Me and Julio Down By the Schoolyard- Paul Simon

The mama pajama rolled out of bed, she ran to the police station,  
When the papa found out he began to shout, And he started the investigation

It's against the law, It was against the law, What the mama saw, It was against the law

Mama looked down and spit on the ground every time my name gets mentioned,  
The papa said oy if I get that boy I'm gonna stick him in the house of detention

Well I'm on my way, I don't know where I'm going, I'm on my way I'm taking my time,  
But I don't know where Goodbye to Rosie the queen of Corona,  
Seeing me you and Julio down by the schoolyard Seein' me you and Julio down by the schoolyard

Well, in a couple of days they gonna take me away cause the press let the story leak  
And when the radical priest come to get me released We was all on the cover of Newsweek Oh

I'm on my way, I don't know where I'm going, I'm on my way I'm taking my time,  
But I don't know where Goodbye to Rosie the queen of Corona,  
Seeing me you and Julio down by the schoolyard Seein' me you and Julio down by the schoolyard

## APPENDIX IV

Fidelity Measures for Colleen Mueller's Thesis:

**Here is the pertinent part of the methods section. Highlighted sections indicate what you should look for when reviewing the video. A checklist and portion for feedback will follow.**

Neither visual nor specific verbal prompts to switch will be provided, once it is clear the participant understands the expectations. However, elements of music and sensory enhancement may be employed (e.g. stressing the sung word when a switch should occur).

The auditory feedback of the instrument, within the context of the song, will provide immediate cues as to their progress. By playing in a group context, a more natural environment of distraction and social pressure will be present, similar to functioning in daily life. However, a non-competitive environment with an emphasis on cognitive training, as opposed to musical performance, will be fostered. An mp3 recording of each trial will be taken and immediately listened to after live playing in order to further highlight their success and problem areas.

Problem areas will be practiced before trying the entire song within the context of the music again. Session closure will be provided at the end of each session. Stimulus reflection (Davis, Gfeller & Thaut, 1992, p.280) will be used to remind the participants that we are training the capacity to attend to and respond to environmental factors. Participants will have the chance to talk about the experience and reflect on similar, non-musical situations within their week (e.g. I turned on the stove to heat butter in a pan and had to remember to turn off the water that was running, then return to the pan). Reminders to think about times when they notice themselves attending and switching will be incorporated. Mention of the next day's session will be included, double-checking that all will attend, as well as stating how many sessions are left. These steps are included as basic components of many music therapy sessions. All sessions will also be videotaped to ensure treatment fidelity. An independent reviewer trained in neurologic music

therapy will watch excerpts of the videos to determine that the actual implementation of therapy matches the procedure described. This will occur before the subsequent session and feedback will be provided to the neurologic music therapist leading the group so that errors may be corrected.

Each day will consist of a new instrument on which to play and a new song to learn and “perform”. This is to ensure continued novelty and a subtle increase in task demand. Proposed order of instruments is as follows: desk bells (requires tapping a button on top to activate), keyboards (requires pressing one key, with multiple unused keys present), hand chimes (requires picking up with one hand to activate and also silence before placing back down), tone chimes (requires hitting a chime with one mallet; only chimes within the song are present) and xylophones (requires one mallet, with several unused bars present).

The placebo group will also gather daily with the same neurologic music therapist to sing preferred songs together, including the same songs provided to the treatment group. These sessions will start by welcoming individuals and passing out songbooks. The first song suggested will be the song of the day from the treatment group. Subsequently, participants may choose songs out of the songbooks to sing. After approximately 30 minutes, 10 minutes of a water and stretch break will be provided. More singing will ensue for the remaining 20 minutes. Natural social interactions (e.g. talking about the songs) will not be discouraged but they will also not be facilitated. The session will end by asking for song suggestions for the following day, double-checking that all will attend and stating how many gatherings are left. Novelty via group participation, the presence of music and contact with the same therapist as the treatment group will be provided. No further intervention will be included and these groups will not be referred to as music therapy. These sessions will also be videotaped and excerpts will be reviewed by the

same reviewer as the treatment sessions. The reviewer will ensure that elements of therapy used in the treatment group are not inadvertently employed.

## Checklist for Reviewers

Name:

- I have read the excerpted methods section carefully and in its entirety.
- I am familiar with Neurologic Music Therapy
- I have watched at least 3 five-minute excerpts of the **treatment group** on this time and date: \_\_\_\_\_

(Please document start and stop times; they may be more than 5 minutes but not less)

- 1.
- 2.
- 3.

### **In the treatment group:**

- neither visual nor specific verbal prompts to switch were provided  
(If there was, please indicate the time during the excerpt and briefly state what you saw the therapist doing:)
- A non-competitive environment with an emphasis on cognitive training, as

opposed to musical performance, was fostered.

(If this was not seen, please remind the therapist to do this.)

- An mp3 recording of each trial was taken and immediately listened to after live playing in order to further highlight their success and problem areas.

Comments:

- Problem areas were practiced before trying the entire song within the context of the music again

Comments:

### **During stimulus reflection:**

- Participants were reminded that they were training the capacity to attend to and respond to environmental factors (wording may vary)
- Specific examples were discussed, allowing participants to give their own examples
- Participants were given the chance to talk about the experience

- Reminders to think about times when they notice themselves attending and switching were incorporated.
- The therapist mentioned the next day's session
- The therapist double-checked that all will attend
- The therapist stated how many sessions are left

Name:

- I have watched at least 3 five-minute excerpts of the **novelty group** on this time and date: \_\_\_\_\_

(Please document start and stop times; they may be more than 5 minutes but not less)

- 1.
- 2.
- 3.

**The novelty group:**

- Was led by the same neurologic music therapist as the treatment group
- Took place in the same room as the treatment group
- Did not play instruments with notation
- Started with a welcome and receiving the song books
- Sang the same song first as the one the treatment group used.

- Used songs that the group appeared to prefer or enjoy (If they weren't preferred, the leader stated that different songs would be available the next day OR an attempt to incorporate preferred songs was made immediately)
  - Had natural social interactions and song discussion but these were not facilitated.
  - Was asked for song suggestions for the following day
  - Was reminded of the time of the next group
  - Was reminded how many sessions were left
  - Was asked if all would be available to attend the following day
- Any comments or feedback?