Effects of the Interactive Metronome® on Older Adults: Does Use Improve Cognitive and Motor Abilities?

by

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September 2016

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The purpose of this pre-test, post-test, quasi-experimental study was to examine the relationship between the Interactive Metronome® (IM) protocol and cognitive plasticity, cognitive retention, and motor skills of older adults in southeastern North Carolina. The IM protocol was carried out in various settings with an occupational therapist and/or graduate occupational therapy students present for motivation and guidance. All participants underwent pre- and post-test assessments in order to track cognitive and motor function as they moved through the protocol. Cognitive assessments included the Woodcock-Johnson III (WJ III) and the d2 Test of Attention (d2). Motor assessments included the Four Step Square Test (FSST) and the Nine Hole Peg Test (NHPT). The participants' scoring and progress within the IM program was also tracked and examined for trends and indicators. This pre-test, post-test, quasi-experimental design was used to compare the differences between the assessment scores before and after intervention with the IM protocol. In all, a relationship was delineated between positive percentage of change on IM performance and positive percentage of change on the cognitive and motor assessments.

Effects of the Interactive Metronome® on Older Adults: Does Use Improve Cognitive and Motor Abilities?

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by

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CHAPTER I

Introduction

Our aging population, the Silver Tsunami, otherwise known as adults 65 years and older, is growing rapidly. In fact, in 2050, the population aged 65 and over is projected to be 83.7 million, almost double its estimated population of 43.1 million in 2012 (Barry, 2008; Mynatt, Essa, & Rogers, 2000; National Institutes of Health [NIH], 2014; Ortman, Velkoff, & Hogan, 2014). In addition, the population of individuals under the age of 65 is in a state of decline, which means that soon the older population will outnumber the younger population (Dishman, 2004; NIH, 2014).

One of the main goals of the aging population is to maintain an independent lifestyle; thus, maintaining the quality of their lives. An independent lifestyle is supported through an individual's continued mastery of activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (Mynatt et al., 2000; Willis, 1996). As stated by Kempen and Suurmeijer (1990), the ability to perform essential ADL functions are indicative of an individual's self-care performance, while IADL functions are indicative of an individual's ability to be independent in certain environments. In order to live independently, it is necessary for individuals to be able to continue to provide their own direct self-care, as well as to remain self-reliant in their functions, such as feeding/eating, bathing, dressing, toileting, and transferring, across different environments. This allows individuals to take part in what has been termed "aging in place," or remaining in the home environment throughout the lifespan, which is something that occupational therapy can aid individuals in accomplishing (Borell, 2006; Iwarsson & Isacsson, 1996).

The increasing body of knowledge about cognitive changes that are part of the natural aging process has shown there is general decline, but some individuals' abilities remain intact as they enter their 70s and 80s (Mynatt et al., 2000). Aging leads to an increased difference between individual change in cognitive skills in task performance, and cognitive aging also has the potential to negatively affect performance of ADLs and IADLs and, in turn, independence and self esteem (Albert, Duffy, & Naeser, 1987; Baudouin, Vanneste, Isingrini, & Pouthas 2005; Hultsch, MacDonald, & Dixon, 2002; Morse, 1993). However, the brain contains properties of plasticity; that is, the brain can undergo continuous changes, given certain stimuli (Classen, Liepert, Wise, Hallett, & Cohen, 1998; Donoghue, 1995; Ungerleider, 1995). This cognitive plasticity lends itself to the idea that with practice and repetitive input, the brain can undergo changes in structure and functioning, possibly leading to both cognitive and motor benefits throughout the lifespan and/or in the event of neuro-impairment.

Also linked with cognition are the concepts of executive functioning and internal rhythms. Executive functioning allows individuals to make and perform multi-step plans (Allain et al., 2004). Internal rhythms, more commonly referred to as circadian rhythms, contribute to an individual's metabolic and behavioral systems, as well as cognition and motor control and are regulated by the suprachiasmatic nucleus (SCN) of the hypothalamus (Bradshaw & Szabadi, 1997; Buhusi & Meck, 2005; Pastor & Artieda, 1996). Since an individual's ability to carry out ADLs and IADLs depends heavily upon planning, motor functions, and cognition, executive functions and internal rhythms are intriguing areas for occupational therapists to explore through the lens of maintaining independence in self-care and self-reliant functioning throughout the lifespan.

This study aims to explore cognitive and motor skills retention; specifically, to see if the study's participants will both attain and retain therapeutic effects from the recommended 12 Interactive Metronome® (IM) sessions with an additional regimen of six more sessions after a six week break. The IM is a computer-based training tool that seeks to improve the brain's timing, build efficient, synchronized connections in the brain, and increase the brain's ability to perform efficiently and better benefit from other interventions (Interactive Metronome, 2015). Hill, Dunn, Dunning, and Page (2011) conducted a study in which the participants reported gains in sensorimotor processing, cognition, and ADL speed after IM treatment. Furthermore, IM (2015) claims that through implementation, the IM can improve timing, rhythm, and synchronization in the brain. It is the aim of this study to provide evidence to either support or disprove these claims in order to bolster the literature. Then, the literature may provide guidance to occupational therapists in their quest to provide clients with the continued ability to perform functions, and thus, quality of life, as they age.

Statement of the Problem

A study to examine the relationship between the IM program and cognitive plasticity, cognitive retention, and motor skills of older adults in southeastern North Carolina is important for several reasons. First, as the aging population rapidly expands, the necessity for quality of life of this cohort remains an important health care concern occupational therapists are often called to address. Cognitive and motor skills provide a solid base on which individuals develop the various activities that build the perception of quality of life. Secondly, occupational therapists, along with other healthcare professionals, are called to seek out possible treatment or intervention options that could aid individuals in maintaining independence in ambulation, ADLs, and IADLs for as long as is safe for individuals and those around them. If the IM program has a positive relationship with cognitive plasticity, cognitive retention, and motor skills, then it must be communicated to the profession as a whole that this intervention tool is a viable option for practitioners' treatment plans. Third, as new intervention tools are being developed, it is important for the literature to reflect both the positive and negative aspects of pre-existing tools. Since this research seeks to determine what works and what does not, we can pave the way for more successful, efficient intervention tools in the future.

Purpose of the Study

The purpose of this pre-test, post-test, quasi-experimental study is to examine the relationship between the IM program and cognitive plasticity, cognitive retention, and motor skills of older adults in southeastern North Carolina. The IM program will be carried out in various settings with an occupational therapist and/or graduate occupational therapy students present for motivation and guidance. All participants will undergo pre- and post-assessments in order to track their cognitive and motor function as they move through the program. Cognitive assessments include the Woodcock-Johnson III (WJ III) and the d2 Test of Attention (d2). Motor assessments include the Four Step Square Test (FSST) and the Nine Hole Peg Test (NHPT). The participants' scoring and progress within the IM program will also be tracked and examined for trends and indicators. This pre-test, post-test quasi-experimental design will be used to compare the differences between the assessment scores before and after intervention with the IM program.

Research Questions

1. At what point in the IM short form assessment do significant predictors of percentage of change within the IM long form assessment arise?
2. After completing a full regimen of the IM protocols, how do the initial long form assessment scores compare to the post-four-to-six-week control period long form assessment scores?
3. Is there a correlation between change in scores on the full IM regimen and scores on the WJ III, the d2, the FSST, and the NHPT?
4. At what point do individuals saturate their level of performance within the full IM protocol, and can the IM short form assessment be an indicator of where that saturation level exists?

Limitations

Possible limitations of this study included the following: participants were acquired through volunteering and convenience sampling and the study's population was comprised of the aging population. Due to the participants being acquired through volunteering/convenience sampling/networking/snowballing, it was impossible to attain a truly random sample. Since the prospective participants were likely to come from similar backgrounds, communities, and history, the sample may be too heterogeneous to be considered generalizable to the diverse worldly population.

Due to the fact that the study's participants were comprised of the aging population, a possible limitation of this study could lie in participant drop out. Higher rates of participant drop out could have resulted due to aging adults losing interest in participating in the study or because of scheduling conflicts due to activities or doctor appointments. For the same reasons, multiple missed IM sessions could also have been a limitation.

Furthermore, since some of the participants were seen by the principle investigator, some were seen by an additional member of the occupational therapy department faculty, and some were seen by the two occupational therapy student researchers, some elements of consistency were challenged (i.e., the students did not have an equivalent level of experience with interaction with participants). Furthermore, some sessions needed to be modified to match the endurance and skill level of some participants. This affects consistency and was considered when statistical analysis was done.

Future studies should seek to eliminate limitations in the following ways: in order to compensate for the limitations resulting from the volunteer/convenience sampling, further efforts to seek out a truly random sample could be instituted in future studies. This would provide more generalizable results. Retention of study participants could be improved by providing participation incentives. Measures could also be put in place to ensure more consistency between the participants' treatment sessions.

CHAPTER II

Review of the Literature

A review of the literature supports the need for this study focusing on how using the IM affects cognitive and motor skills of healthy, older adults. The following topics support the need for further research in this area: aging in place, cognitive plasticity and retention, executive functions, internal rhythms, the IM's role in improving these functions, and the IM's role and success with populations other than healthy, older adults.

Aging in Place

According to Mynatt et al. (2000), the United States is encountering a social problem in supporting the aging population, who collectively want to continue inhabiting independent homes instead of moving into institutional care settings, a concept otherwise known as aging in place. The researchers go on to list the ways in which older adults can demonstrate their ability to continue living independently: performance of ADLs, such as bathing, toileting, and eating; performance of IADLs, such as managing medications, maintaining the household, and preparing nutritionally-adequate meals; and the ability to adapt to changing environments. Furthermore, the researchers state, since nursing homes have been instituted to support those with physical disabilities, an emphasis has now been placed on also supporting those with cognitive deficits (Czaja, 1990; Lawton, 1990; Mynatt et al. 2000).

Borell (2006) credits occupational therapy as a viable option for guiding older adults in the quest to remain independent and age in place. She states that occupational therapists have a role in helping individuals remain in their homes, despite activity limitations and participation restrictions. Additionally, she supports the idea that an individual's environment – both physical and social – can contribute to and support continuity of functioning of these individuals (Borell, 2006). Bernard (2014) supports this idea, citing nutrition, transportation, city design, mobile care clinics, social networks, and family monitoring as opportunities for enhancing the possibilities of aging in place. This gives way to the idea that occupational therapists must take ownership of the responsibility to seek out resources both within the community environment, as well as technology and other such interventions, to aid older adults in the quest to retain independence.

Cognitive Plasticity/Retention

Classen et al. (1998) found that a reorganization of the neuronal network mediating thumb movements takes place with the simplest repetitive movement and it encodes, in the short term, certain kinematic aspects of the practiced action. They go on to state that their results suggest the motor cortex appears to undergo continuous plastic modifications and frequently repeated movements reinforce connectional patterns, but that, in the absence of practice, the skills wane (Butefisch, Hummelsheim, Denzler, & Mauritz, 1995; Classen et al., 1998). The brain's ability to modify itself over time allows individuals a unique opportunity to take control over their mental capacities. If one wants to improve cognitive retention abilities, memory, or critical thinking and attention skills, it appears they need only practice, giving the brain the tools and time necessary to rebuild itself around the desired abilities. Similarly, computerized brain plasticity-based cognitive training has been found to have a positive effect on individuals with mild cognitive impairment, schizophrenia, and traumatic brain injury in regard to attention, memory, and information processing (Barnes et al., 2009; Fisher, Holland, Merzenich, &

Vinogradov, 2009; Fisher, Holland, Subramaniam, & Vinogradov, 2010; Keefe et al., 2010; Lebowitz, Dams-O'Connor, & Cantor, 2012).

Kluge and Frank (2014) found that decay of skill elements not used frequently during routine operations quickly occurs. Furthermore, the researchers concluded that a refresher intervention is effective in preparing individuals for non-routine tasks, but perhaps not so much for routine tasks, unless individuals continue the intervention without stopping. Jarus and Ratzon (2000), however, concluded mental practice in both childhood and old age held benefits, but that especially in old age, mental practice was beneficial for the retention process. There is support for the idea that repetitive practice of skills desired has the potential to produce those very skills and abilities individuals might be seeking in the quest to improve cognitive and motor function (Classen et al., 1998; Jarus & Ratzon, 2000). Thus, the prospect of cognitive plasticity and retention suggests that, even if an individual has experienced losses in these areas of the brain responsible for cognition, motor, and executive function, performance of repetitive activities and training could repair these areas of the brain, and thus, restore function.

Executive Function and Internal Rhythms

Allain et al. (2004) defined executive function as many different functions, such as inhibition, mental shifting, and abstract thinking, which require higher-level cognitive function to facilitate performance on both complex and everyday tasks. They also found changes in executive functions, due to aging, occur earlier and are more pronounced, noting the frontal area deteriorates earlier and more severely than other cerebral areas in healthy adult aging. The frontal lobe of the brain is responsible for executive functions such as planning, sequencing, organizing, and problem solving, as well as for personality and behavioral regulation. Researchers also stated that many neuropsychological models proposed that decline of the frontal lobe is responsible for many age-related cognitive changes (Allain et al., 2004; Daigneault, Braun, & Whitaker, 1992; Tisserand & Jolles, 2003). Levine et al., (1999) proposed that the fact that deficits in executive functions have a negative effect on individuals' lives and require those working in rehabilitation to formulate creative, effective interventions is a broadly-accepted reality. They go on to say that disruption of these functions lead to everyday dysfunction, especially when the frontal lobe is involved.

Buhusi and Meck (2005) proposed that accurate temporal processing is required for individuals to reach goals as well as survive, and that an assortment of biological mechanisms is necessary to track time in multiple settings. Additionally, they state that activation of certain brain areas, such as the basal ganglia, the supplementary motor area (SMA), the prefrontal cortex (PFC), and the posterior parietal cortex (PPC) are controlled flexibly and cognitively by a seconds-to-minutes range timer. The SMA, the PFC, and the PPC are related to sequences of movements, planning of cognitive behavior (executive function), and production of planned movements, respectively. Thus, parts of the brain associated with motor and cognitive planning operate under a system of timing, an internal rhythm. In addition, Baudouin et al. (2005) found that with regard to memory, production is related to motor tempo, and reproduction is related to working memory measures. Furthermore, Janata and Grafton (2003) found connections between music and attention, indicating that sensory input supports attending rhythms in a dynamic systems framework and connected that this framework is used to model characteristics of other types of neural timing and mechanisms that underlie coordinated actions.

Interactive Metronome®

The IM program is comprised of computer software, the IM station, wireless button triggers, a wireless tap mat trigger, USB cable, headphones, large hand glove, and small hand glove. There are three assessments to choose from when administering the IM protocol: the Short Form Assessment (SFA), the Long Form Assessment (LFA) and Attend Over Time.

According to Interactive Metronome® (2015), the IM is an assessment and training tool backed by evidence that improves timing, rhythm, and synchronization in the brain. The three goals of the tool that the company lists include the following: (1) improve neural timing and decrease neural timing variability (jitter) that impacts speech, language, cognitive, motor, and academic performance; (2) build more efficient and synchronized connections between neural networks; and (3) increase the brain's efficiency, performance, and ability to benefit more from other rehabilitation and academic interventions. Engaging in the IM system includes the participant hitting a trigger to correspond to an auditory beat elicited by the program and provides early cognitive engagement, repetitive practice, practice of specific functional motor skills, and feedback for millisecond timing to facilitate motor learning (Interactive Metronome 2015). Interactive Metronome® (2015) states that it has been supported that the ability to tap consistently to an auditory beat is correlated to the following: consistency of auditory brainstem response to sound, ability to read, and phonological awareness; as well as less trouble synchronizing and thus, less neural jitter.

Interactive Metronome® Used on Other Populations

Koomar et al. (2001) have noted benefits in the use of the IM in a clinical occupational therapy setting. They found it might be useful when used in concert with other occupational therapy interventions, such as sensory integration and cognitive rehabilitation training, in order to organize movement patterns through time and space. According to existing literature on the IM, this treatment modality has been used in the treatment of individuals with attention and motor disorders, stroke, and cerebral palsy (Bartscherer & Dole, 2005; Cosper, Lee, Peters, & Bishop, 2009; Johansson, Domellof, & Ronnqvist, 2012; Koomar et al., 2001; Rosenblum & Regev, 2013; Shaffer et al., 2001).

Several IM studies demonstrate positive effects when used with children with attention and coordination disorders in the areas of motor, cognition, and attention (Bartscherer & Dole, 2005; Rosenblum & Regev, 2013; Shaffer et al., 2001). Cosper, Lee, Peters, and Bishop (2009) called the IM a reasonably effective treatment for children with motor functioning deficits, and Shaffer et al. (2001) reported improved attention. Johansson, Domellof, and Ronnqvist (2012) noted improvements in spatio-temporal organization in two children with hemiplegic cerebral palsy when incorporating the IM into their treatment. Due to the positive results gleaned from IM studies with children with varying diagnoses, the idea of a host of similar benefits within the aging population seems possible.

With regard to stroke, Hill et al. (2011) showed that using the IM with patients who had a stroke was feasible and improved both motor abilities and function. It was also noted that quality of life was improved through use of the IM, as measured and demonstrated by scores on the Stroke Impact Scale; in all, their results support usage of the IM as a supplement to occupational therapy treatment that could maximize individuals' potential to respond to rehabilitation (Hill et al., 2011).

Summary

Thus, connections between aging in place, cognitive plasticity and retention, executive functions, internal rhythms, the IM's role in improving these functions, and the IM's role and success with other populations support the need for further research on the IM's impact on the cognitive and motor functions of healthy, older adults. Since it appears the motor cortex undergoes continuous plastic modifications, and that repetition is paramount in retaining those modifications (Classen et al., 1998; Kluge & Frank, 2014), and because the IM is based off of repetitive exercises, it could follow that the IM may be closely tied with practice-induced plasticity of the brain. Additionally, upon ceasing the exercises, all progress may be lost. It is the aim of this study to examine that very aspect of IM training: whether or not LFA and SFA scores will be the same or different after a period of no training, and thus, examining if the positive effects of the IM are retained or lost if the IM intervention is not continued on a long-term basis.

When considering the positive effects the IM has contributed to in regard to people with diagnoses such as attention and coordination disorders, cerebral palsy, and stroke, it would appear that research regarding IM's effects on healthy, aging adults is currently needed. Perhaps if positive effects are noted on healthy, aging adults when using the IM as a treatment modality, the IM could be integrated into the occupational therapy regimens of healthy, aging adults in the future to improve quality of life, cognitive and motor function, and retention of skills. This could, in turn, aid in the effort for older adults to age in place. Ultimately, the IM could foster benefits that support preventative health care for healthy, aging adults. For all of these reasons, this study is necessary and relevant.

CHAPTER III

Methodology

Design

This study will follow a pre-test, post-test, quasi-experimental design. The independent variable is the intervention with the IM as a treatment. The dependent variables include the participants' scores on the Woodcock Johnson III (WJ III), the d2 Test of Attention (d2), the Four Step Square Test (FSST), and the Nine Hole Peg Test (NHPT), and performance scores that are recorded within the IM software. The assessments will track the possible changes in the participants' scores, which represent both the cognitive and motor categories. The study design is appropriate, in this instance, because the researchers will be measuring if participants' scores on the cognitive and motor assessments remain the same, improve, or decline during and after the two treatment phases. In order to assess possible positive or negative changes, there will be a pre-test before they begin treatment, re-assessment after the initial 12-session treatment block has ended, before treatment starts up again after the 6-week rest period, and one final time after the second 6-session treatment block has ended.

Participants

A convenience sample, which was obtained through networking and snowballing, included 30 healthy, aging adults who are age 60 or older. The subjects were recruited through information sessions given by the principle investigator; the distribution of educational materials; and word-of-mouth spreading through other participants who have already been recruited (snowballing). The inclusion criteria are (1) age 60 and older; (2) ability to read and understand English; and (3) demonstrates intact visual and auditory abilities (determined through participant report and clinical observation). The exclusion criteria are (1) diagnosed with a cognitive disability (e.g., dementia, Alzheimer's, late-stage Parkinson's); (2) diagnosed with a motor disability (e.g. Parkinson's, Huntington's, Cerebral Palsy, missing limbs, paralysis of upper or lower extremities); (3) traumatic brain injury; (4) diagnosed with testing disabilities (i.e., testing or assessment anxiety, dyslexia).

Instrumentation

Both the WJ III and the d2 have been chosen as a means to assess the participants' cognitive abilities. Both the FSST and the NHPT have been chosen as a means to assess the participants' motor abilities. The four assessments have been chosen so that participants could be tested at the beginning of the study period (pre-treatment with the IM), after IM treatment, after the 6-week break period, and after the second 6-week round of treatment sessions.

The Woodcock-Johnson III Tests of Cognitive Abilities (WJ III COG) and the Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities (DS) include 31 tests for measuring general intellectual ability, broad and narrow cognitive abilities, and aspects of executive functioning. The COG includes 20 tests, and the DS includes 11 tests (Schrank & Wendling, 2009). The Woodcock-Johnson III Tests of Achievement (WJ III ACH) includes 22 tests for measuring skills in reading, mathematics, and writing, as well as important oral language abilities and academic knowledge (Wendling, Schrank, & Schmitt, 2007). Participants will be given the following tests within the WJ III COG/DS: Visual Matching (Test 6) and Decision Speed (Test 16) (See Appendix C). Participants will be given the following tests within the WJ

III ACH: Reading Fluency (Test 2), and Math Fluency (Test 6) (See Appendix D). The Visual Matching test assesses speeded visual perception and matching. The Decision Speed test assesses the following cognitive processes: object recognition and speeded symbolic/semantic comparisons (Schrank & Wendling, 2009). The Reading Fluency test assesses the following cognitive processes: speeded (automatic) semantic decision making requiring reading ability and generic knowledge. The Math Fluency test assesses the following cognitive processes: speeded (automatic) access to and application of digit-symbol arithmetic procedures (verbal associations between numbers represented as strings of words) (Wendling et al., 2007).

The WJ III has been standardized on over 8,000 participants, from the ages of 2 to over 80 (Hale & Fiorello, 2004). This assessment is often used to assess school children in order to ensure they are on track for their age group and school grade. Since the WJ III assesses cognitive function, it is a valid form of measure for this study, as one of the aims is to assess cognitive retention and if that retention is increased in those participants who are treated with the IM. In terms of reliability, Hale and Fiorello (2004) found that the General Intellectual Ability (GIA) score had a median reliability score of .97 across all ages.

The d2 is a test that requires participants to use attention and concentration to discriminate and cancel certain images (Bates & Lemay, 2003). According to Zillmer (2008), the d2 consists of the following: the letters d and p, with one to four dashes that are arranged either individually or in pairs above or below the letter. The participant scans each line of characters and identifies and crosses out each d with two dashes. The test consists of 14 lines, each with 47 characters, for a total of 658 items. The subject is allowed 20 seconds per line (Zillmer, 2008).

The d2 has been found to have internal consistency as a valid tool to measure accuracy of visual scanning and speed. An excellent internal consistency was found within the subscales, with coefficients within the typical range of .80 to .95. Construct validity was supported for the test, and "results of the factor analysis also suggested the discriminant validity of d2 performance measures relative to intelligence, abstraction abilities, and immediate memory." Thus, the d2 is supported as being internally consistent and valid, and it possesses potential utility as an assessment of attention in the United States (Bates & Lemay, 2002).

The FSST (See Appendix E) requires subjects to rapidly change direction while stepping forward, backward, and sideways, over a low obstacle, while time to complete the test is measured. Test equipment includes a stopwatch and 4 canes (Dite & Temple, 2002). According to the Rehabilitation Measures Database (2014), it tests dynamic balance and assesses a participant's ability to step over objects forward, sideways, and backwards. The test is also used to assess ADLs, vestibular balance, and non-vestibular balance.

The FSST was found to have high interrater reliability, with n = 30 and an intraclass correlation coefficient (ICC) of .99; high retest reliability, with n = 20 and ICC = .98. In addition, validity was supported because the FSST showed significantly better performance scores ($p<.01$) for each of the healthier and less impaired groups; a sensitivity of 85%, a specificity of 88% to 100%, and a positive predictive value of 86% were found (Dite & Temple, 2002).

The NHPT is an assessment commonly used by occupational therapists to quickly assess finger dexterity (Grice et al., 2003). According to the Rehabilitation Measures Database (2014), the NHPT is administered by carrying out the following steps and standards: (1) the client is asked to take the pegs from a container, one by one, and place them into the holes on the board, as quickly as possible; (2) participants must then remove the pegs from the holes, one by one, and replace them back into the container; (3) the board should be placed at the client's midline, with the container holding the pegs oriented toward the hand being tested; (4) only the hand being evaluated should perform the test; (5) the hand not being evaluated is permitted to hold the edge of the board in order to provide stability; (6) scores are based on the time taken to complete the test activity, recorded in seconds; (7) alternate scoring occurs when the number of pegs placed in 50 or 100 seconds can be recorded. In this case, the results are expressed as the number of pegs placed per second; and (8) stopwatch should be started from the moment the participant touches the first peg until the moment the last peg hits the container.

The NHPT was found to have a high interrater reliability, right $r = 0.984$ and left $r = 0.993$. The test-retest reliability "showed a moderate correlation in the scores of the subjects, which demonstrates poor reliability" (Grice et al., 2003).

These assessments were conducted in a quiet, secluded area free from distractions. In some cases, the assessments were conducted in the participant's homes, and in other cases, the assessments were conducted at the participants' respective assisted living facilities or community centers. Only one researcher (the principle investigator) was present when the assessments are administered.

The IM is a computer-based technology that uses rhythm-training exercises in the effort to promote motor and cognitive functioning (See Appendix F). Tools used include the following: Master Control Unit, Installation CD-ROM, Hand Gloves, Junction Box and Cable, Serial Cable, USB Cable, Foot and Hand Triggers, and Headphones. The Master Control Unit provides sounds and records the repetitions (Beckelhimer, Dalton, Richter, Hermann, & Page, 2011). The SFA of the IM is given at the beginning of each regular training session in order to establish a baseline; it is given at the start and end of each session to measure progress within the treatment periods. The SFA consists of two separate performances of the clapping exercise, during which the participant wears a trigger on their dominant hand and claps to engage the trigger, while attempting to match their clap with the auditory cue from the program. Comparison of task average, variability average, and super right on percentage can be calculated between different test dates. The task average is the comparison of the participant's trigger hits to the reference tone, or how many milliseconds they may be off the beat. The variability average is the comparison of one trigger hit to the next trigger hit, or within how many milliseconds the participants varies from one hit to the next. The super right on percentage is the percentage of time the participant hits the trigger in sync with the reference tone. The goal is for scores to progress downward on the graphs to indicate that task averages are decreasing (Interactive Metronome, 2015).

The LFA of the IM is given at each of the four points of measure of this study. It consists of 14 tasks, including the clapping task described above, as well as a variety of other tasks, such as hitting a trigger on the wireless tap mat in various combinations, as well as tapping the wireless tap mat with the feet. The LFA serves to show participants' performance progression as they move through their IM sessions (Interactive Metronome, 2015).

Procedure

To begin, IRB approval was attained for the research protocol. Next, the two occupational therapy student researchers were trained and certified in IM protocols and procedures by attending a certification course; additionally, they practiced to the point of confidence.

In order to attain research subjects, participants were recruited through the following measures: an information session given by the principle investigator and the distribution of educational materials (i.e., flyers – See Appendix G) at Cypress Glen, a continued care retirement center in Greenville, North Carolina; and word-of-mouth spreading through other participants who had already been recruited (snowballing).

After recruitment, interested participants were checked for eligibility against the inclusion and exclusion criteria. Any interested participants who did not meet the inclusion criteria, or met the exclusion criteria, were not accepted into the study. Those participants deemed eligible through the inclusion and exclusion criteria were assigned to the study group, and informed consent was obtained from each participant. All 30 of the participants were given the LFA, the WJ III, the d2, the FSST, and the NHPT, which provided the initial point of measure (T1).

After the pre-test assessments were completed, the participants began IM treatment. The first treatment period included 12 sessions completed over a period of six weeks. Sessions included the SFA and the regular training protocol, as determined by the principle investigator. Participants were able to reschedule 2 of their IM sessions within the 12-week period. If the total time necessary to complete the sessions exceeded eight weeks, participants' data were withdrawn from consideration in the analysis to preserve consistency of treatment periods. In addition, since the participants of this study involved the aging population, participant dropout was expected, due to sessions conflicting with doctor appointments or other prior engagements. Participant dropout was considered when the statistical analysis was performed.

Treatment program protocols were developed by the principle investigator prior to the start of the first IM treatment sessions, which determined the specific IM activities carried out in each session. Activity duration, number of repetitions, and selection of exercises varied from session to session, but all participants followed the same progression of session content (See Appendix H). This served to ensure consistency among the sessions with the different participants. In another effort to promote consistency, the two occupational therapy student researchers conducted IM sessions with their participants together. The principle investigator, as well as an additional occupational therapy faculty member, separately conducted IM treatment sessions with other qualified participants.

After the first treatment period ended, the participants underwent the post-test re-assessment, which served as the second point of measure (T2). In the re-assessment period, the participants were again given the LFA, the WJ III, the d2, the FSST, and the NHPT. The principle investigator conducted the assessments independently.

After a 6-week rest period, the participants were given a follow-up round of the same four assessments and the LFA, which served as the third point of measure (T3). The participants then embarked on a second round of IM treatment sessions, six total over a three-week period. Participants could reschedule two of their IM sessions within the three-week period. If the total time necessary to complete the sessions exceeded four weeks, their data were withdrawn from consideration in the analysis in an effort to preserve consistency.

After the second round of IM treatment sessions, the participants underwent the same four post-test assessments and the LFA for the fourth and final time, providing the fourth point of measure (T4). After the data from all four points of measure had been collected, it was then analyzed to see if any significant differences are noted between T1-T4.

Analysis of data collected through the IM software was conducted through a review of the tables, charts, and graphs generated. Comparison of performance on both the SFA and LFA across the four different points of measure, as well as during the two different treatment blocks, were conducted for all participants. These data were used to visually analyze differences in performance of the participants.

Data Analysis

This study used parametric statistics, as the data is at the ratio level, since a score of zero was possible on the assessments. Inferential statistics were used, with the confidence p level being set at .05 and .001. This way, the researchers could be 95% sure that the independent variable had an effect on the dependent variable if indicated by the data. Raw scores were recorded in a Microsoft Excel Spreadsheet for the following components: LFA Task 1 and Task 14; SFA for Treatment Period 1; SFA for Treatment Period 2; and d2, FSST, NHPT and WJ III across the four different points of measure. Percentage of change was calculated across the four different points of measure, and paired t tests were calculated for each assessment at each point of measure as well. Through these varying forms of analysis, effects of the IM were determined.

Tables and other figures depicting the individual participants' performance on both the SFA and the LFA were generated through Microsoft Excel. These graphs were analyzed for the emergence of patterns, such as the following: the point in the SFA at which significant predictors of percentage of change arose; how initial LFA scores compared to post-six-week-break-period scores; the possible correlation between improvement in scores on the full IM regimen and scores in the four assessments; and at what point individuals saturated their level of performance within the full IM protocols, and if the SFA can be an indicator of where that saturation level occurs.

CHAPTER IV

Analysis of Data

Data were analyzed for the following study components: SFA in the first treatment period for sessions 1-12 (Table 1 Short Form Assessment); SFA in the second treatment period (Sessions 1-6); SFA Percentage of Change First Treatment Period; SFA Percentage of Change Second Treatment Period; LFA Task 1 (for points of measure T1-T4); LFA Task 14 (T1-T4); LFA Percentage of Change Task 1 (T1-T4); LFA Percentage of Change Task 14 (T1-T4); d2 Percentage of Change (T1-T4); and NHPT Percentage of Change (T1-T4). Thirteen total participants completed the protocol for these points of measure. The SFA was administered throughout the two treatment periods, and the LFA, d2, and NHPT were administered at the T1, T2, T3, and T4 points of measure.

Neither the WJ III nor the FSST was included in the data analysis. Use of the WJ III assessments was a request by the funding body of this research; however, this set of cognitive assessments is not sensitive enough to show variance within the healthy, older adult population. As such, most of the participants scored in the 99^{th} percentile, and their scores remained the same. The funding body has used these instruments in studies with children and individuals with traumatic brain injury, in whom changes may be detected by the WJ-III. The FSST was omitted for similar reasons; namely, this research study followed participants already competent in balance. Thus, at their level of function, the test was not sensitive enough to detect any significant changes.

IM Short Form Assessment

Table 1

Short Form Assessment Results First Treatment Period

P	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
1	65	62	85	80	43	42	38	46	44	30	25	23
2	120	85	190	65	52	39	35	45	32	28	25	21
3	36	84	88	62	45	40	38	42	28	32	25	19
4	195	65	235	55	40	42	38	30	35	26	21	18
5	160	58	58	70	50	50	40	30	38	41	40	48
6	66	78	87	43	56	55	55	50	45	41	48	40
7	60	142	40	60	70	45	41	32	28	30	31	28
8	50	22	19	26	26	22	22	21	16	18	20	15
9	160	50	40	110	60	58	40	32	33	29	28	25
10	68	43	82	44	36	55	40	35	28	34	25	30
11	40	25	70	71	40	30	26	26	30	28	19	22
12	40	25	70	71	40	30	26	26	30	28	19	22
13	50	22	19	26	26	22	22	21	16	18	20	15

Notes. The P column indicates the participant number. The S columns indicate the session numbers.

The scores in Table 1 *Short Form Assessment Results First Treatment Period* represent the task average for each of the 13 participants throughout the first treatment period, or the first 12 sessions, on the SFA. Task average numbers represent the comparison of the participant's trigger hits to the reference tone, indicating how many milliseconds the participant is off. Thus, the lower the task average, the better the participant's performance.

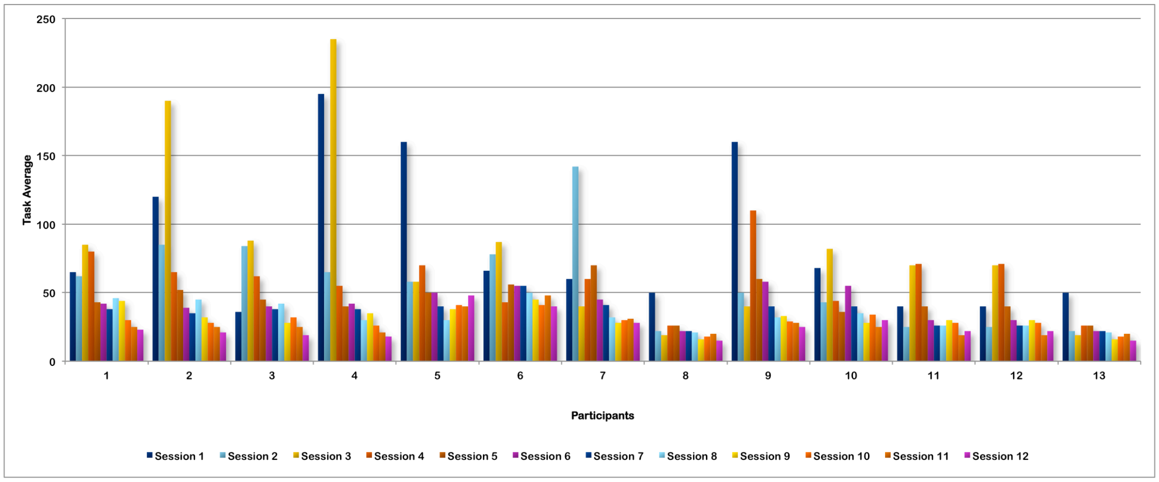

Figure 1. Short form assessment results first treatment period.

As depicted in Figure 1 *Short Form Assessment Results First Treatment Period*, a general trend emerged for the participants as they moved through the 12 sessions in the first treatment period. Task average scores generally started out higher and declined as the participants moved through the subsequent sessions, indicating an overall increase in performance across the sessions. As indicated by the bar graph clusters representing each participant, although there was variability of scoring between the different participants, they followed the same trend and decreased over time, indicating an overall improvement in performance over time.

Table 2

Short Form Assessment Results Second Treatment Period

P	S1	S2	S3	S4	S5	S6
1	42	30	25	23	43	42
2	75	128	62	61	40	51
3	25	28	27	18	21	24
4	55	30	28	25	20	21
5	50	30	22	40	30	25
6	46	56	87	43	56	55
7	45	38	25	32	28	24
8	25	28	27	18	21	24
9	80	95	45	35	30	33
10	25	28	27	18	21	24
11	40	20	38	32	23	25
12	40	20	38	32	23	25
13	25	28	27	18	21	24

Notes. The P column indicates the participant number. The S columns indicate the session numbers.

The scores in Table 2 *Short Form Assessment Results Second Treatment Period* represent the task average for each of the 13 participants throughout the second treatment period, or the six sessions following the break period, on the SFA. Task average numbers represent the comparison of the participant's trigger hits to the reference tone, indicating how many milliseconds the participant is off. Thus, the lower the task average, the better the participant's performance.

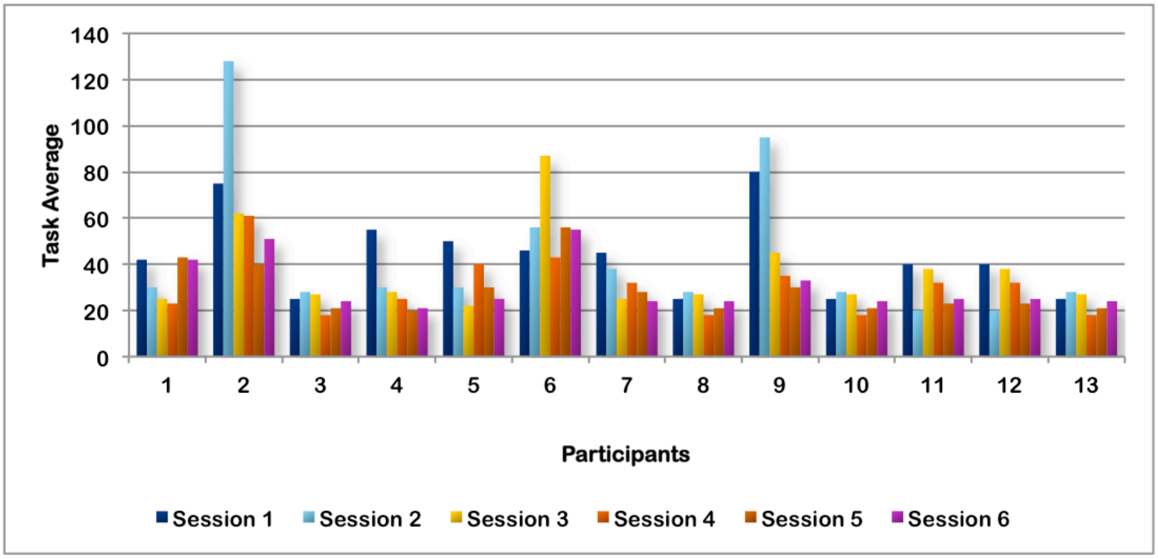

Figure 2. Short form assessment results second treatment period.

Figure 2 *Short Form Assessment Results Second Treatment Period* depicts the trend of task average scores among participants in sessions one through six of the second treatment period, which occurred after the break period. Generally, the scores follow a similar trend to the first treatment period, with the scores starting out higher and declining over time, indicating an overall improvement in performance.

Table 3

Short Form Assessment Percentage of Change First Treatment Period

P	S1-2	S1-3	S1-4	S1-5	S1-6	S1-7	S1-8	S1-9	S1-10	S1-11	S1-12
1	4.62	-30.77	-23.08	33.85	35.38	41.54	29.23	32.31	53.85	61.54	64.62
2	29.17	-58.33	45.83	56.67	67.50	70.83	62.50	73.33	76.67	79.17	82.50
3	-133.33	-144.44	-72.22	-25.00	-11.11	-5.56	-16.67	22.22	11.11	30.56	47.22
4	66.67	-20.51	71.79	79.49	78.46	80.51	84.62	82.05	86.67	89.23	90.77
5	63.75	63.75	56.25	68.75	68.75	75.00	81.25	76.25	74.38	75.00	70.00
6	-18.18	-31.82	34.85	15.15	16.67	16.67	24.24	31.82	37.88	27.27	39.39
7	-136.67	33.33	0.00	-16.67	25.00	31.67	46.67	53.33	50.00	48.33	53.33
8	56.00	62.00	48.00	48.00	56.00	56.00	58.00	68.00	64.00	60.00	70.00
9	68.75	75.00	31.25	62.50	63.75	75.00	80.00	79.38	81.88	82.50	84.38
10	36.76	-20.59	35.29	47.06	19.12	41.18	48.53	58.82	50.00	63.24	55.88
11	37.50	-75.00	-77.50	0.00	25.00	35.00	35.00	25.00	30.00	52.50	45.00
12	37.50	-75.00	-77.50	0.00	25.00	35.00	35.00	25.00	30.00	52.50	45.00
13	56.00	62.00	48.00	48.00	56.00	56.00	58.00	68.00	64.00	60.00	70.00
Avg.	12.96	-12.34	9.31	32.14	40.42	46.83	46.83	53.50	54.65	60.14	62.93

Notes. The P column indicates the participant number. The S columns indicate the session numbers. All numbers in the table are percentages.

Table 3 *Short Form Assessment Percentage of Change First Treatment Period* includes the percentage of change between session one and each subsequent session in treatment period one, including the average percentage of change between session one and each subsequent session in treatment period one. A decrease in task average between two sessions indicates an improvement in performance; additionally, a decrease in task average scores corresponds to a positive percentage of change and an increase in performance.

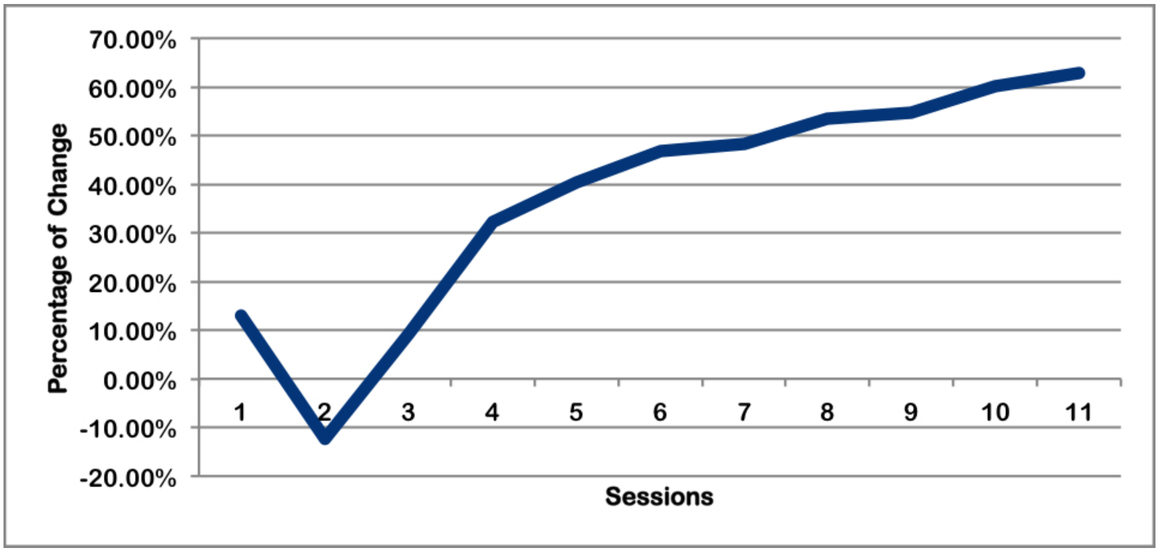

Figure 3. Short form assessment average percentage of change first treatment period.

As indicated in Figure 3 *Short Form Assessment Average Percentage of Change First Treatment Period*, the average percentage of change between session one and the 11 subsequent sessions increased after a dip at the second session. This indicates an increase in average percentage of change over time, and thus, an improvement in performance over time.

Table 4

Short Form Assessment Percentage of Change Second Treatment Period

P	S1-2	S1-3	S1-4	S1-5	S1-6
1	28.57	40.48	45.24	-2.38	0.00
2	-70.67	17.33	18.67	46.67	32.00
3	-12.00	-8.00	28.00	16.00	4.00
4	45.45	49.09	54.55	63.64	61.82
5	40.00	56.00	20.00	40.00	50.00
6	-21.74	-89.13	6.52	-21.74	-19.57
7	15.56	44.44	28.89	37.78	46.67
8	-12.00	-8.00	28.00	16.00	4.00
9	-18.75	43.75	56.25	62.50	58.75
10	-12.00	-8.00	28.00	16.00	4.00
11	50.00	5.00	20.00	42.50	37.50
12	50.00	5.00	20.00	42.50	37.50
13	-12.00	-8.00	28.00	16.00	4.00
Avg.	5.42	10.77	29.39	28.88	24.67

Notes. The P column indicates the participant number. The S columns indicate the session numbers. All numbers in the table are percentages.

Table 4 *Short Form Assessment Percentage of Change Second Treatment Period* includes the percentage of change between session one and each subsequent session in treatment period two, including the average percentage of change between session one and each subsequent session in treatment period two. A decrease in task average between two sessions indicates an improvement in performance; additionally, a decrease in task average scores corresponds to a positive percentage of change and an increase in performance.

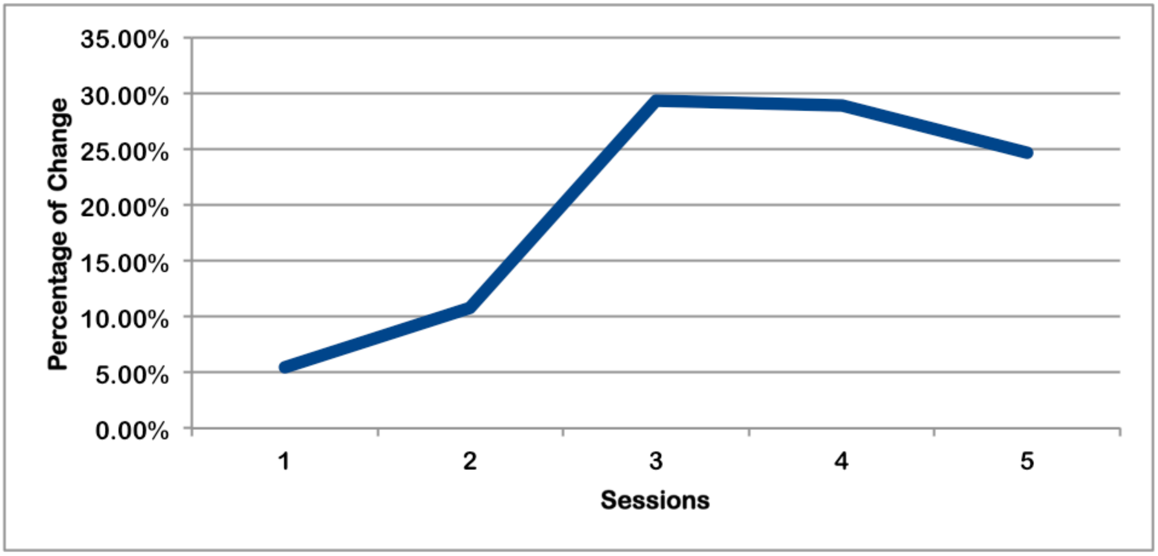

Figure 4. Short form assessment average percentage of change second treatment period.

As indicated in Figure 4 *Short Form Assessment Average Percentage of Change Second Treatment Period*, the average percentage of change between session one and session three steadily increased, with a plateau period and small decrease between session three and session four, and a steady decrease between session four and session five. Overall, there is an increase in average percentage of change over time, and thus, an improvement in performance over time; however, the plateau and dip in performance indicated between session three and session five may indicate a saturation point.

IM Long Form Assessment

Table 5

Long Form Assessment Results Task 1

P	T1	T2	T3	T4
1	41	26	36	21
2	62	37	75	21
3	40	22	26	18
4	229	21	30	26
5	51	28	33	29
6	37	48	35	33
7	174	21	67	20
8	19	17	62	37
9	37	35	37	38
10	67	18	26	21
11	92	25	26	21
12	229	21	19	17
13	67	20	25	18

Notes. The P column indicates the participant number. The T columns indicate the four points of measure.

Table 6

Long Form Assessment Results Task 14

P	T1	T2	T3	T4
1	219	26	42	18
2	84	58	68	19
3	32	28	21	19
4	175	18	38	35
5	213	22	33	25
6	64	44	44	31
7	166	28	54	12
8	51	14	84	58
9	58	31	35	34
10	76	19	26	19
11	65	27	26	19
12	175	18	51	14
13	54	12	32	21

Notes. The P column indicates the participant number. The T columns indicate the four points of measure.

The scores in Table 5 *Long Form Assessment Results Task 1* and Table 6 *Long Form Assessment Results Task 14* represent the task average for each of the 13 participants throughout the four points of measure (T1-T4) on two different tasks within the LFA. Task 1 includes clapping with the trigger attached to the dominant hand; task 14 includes clapping with the addition of the guide sounds. Task average numbers represent the comparison of the participant's trigger hits to the reference tone, indicating how many milliseconds the participant is off. Thus, the lower the task average, the better the participant's performance.

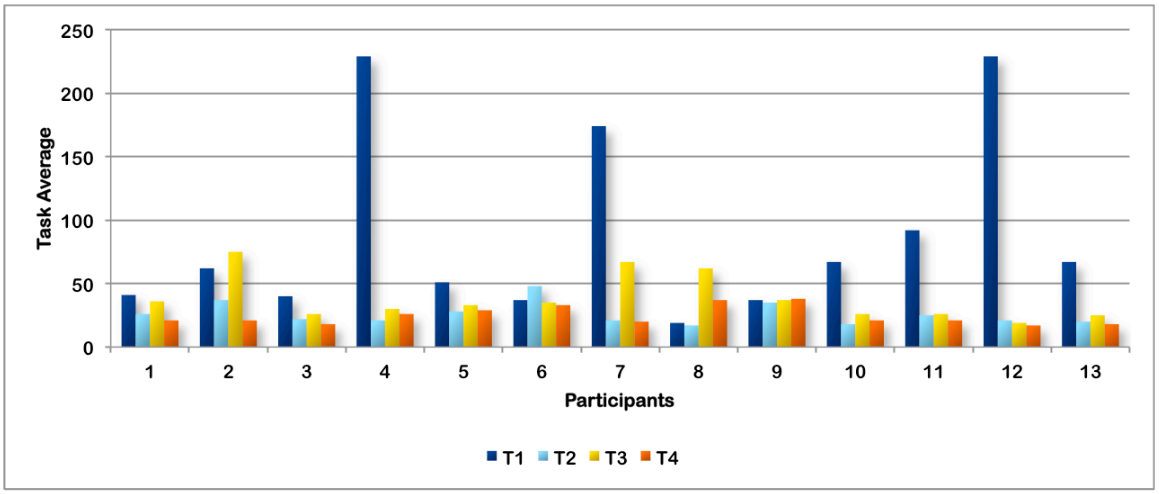

Figure 5. Long form assessment results task 1.

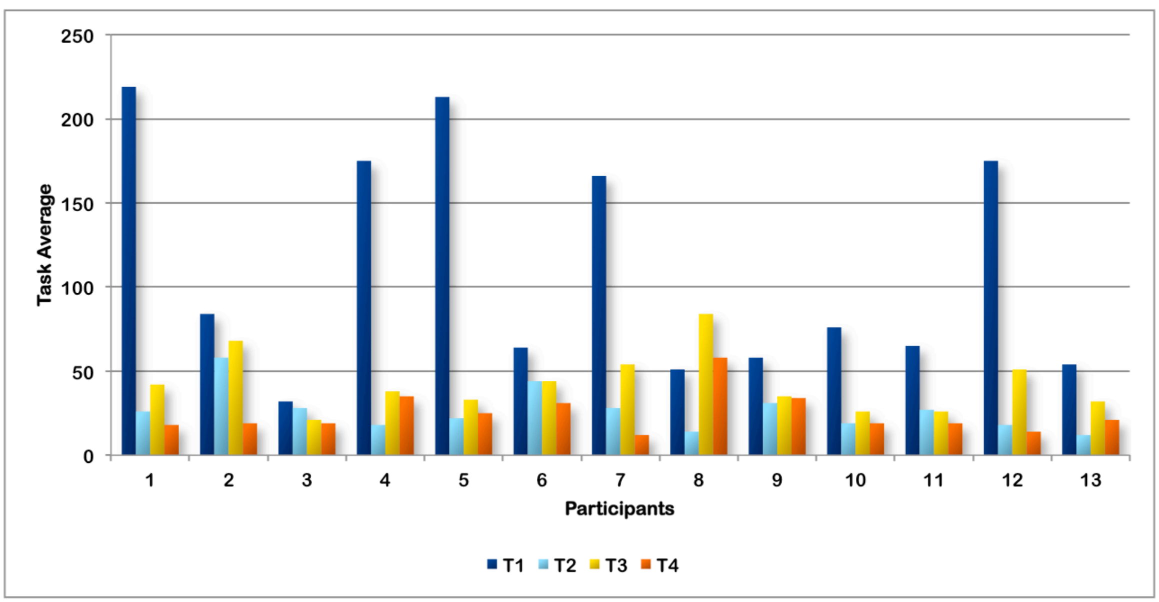

Figure 6. Long form assessment results task 14.

Figure 5 *Long Form Assessment Results Task 1* and Figure 6 *Long Form Assessment Results Task 14* represent the trends of task average scores among the participants across the four points of measure (T1-T4). T1 represents the pre-test period; T2 represents the post-test period, which occurred after the 12 sessions in the first treatment period; T3 represents the pre-test period after the six-week break; and T4 represents the post-test period, which occurred at the end of the second treatment period. In general, task averages in T1 were higher for Task 14 than Task 1, indicating participants' dislike of the guide sounds, which many described as distracting. The scores for T3 in both Task 1 and Task 14 were generally higher, indicating a decrease in performance on the IM after the six-week break; this follows an expected clinical outcome given the break from IM treatment. At T4, the scores generally drop back off, indicating an increase in performance after another six sessions of treatment with the IM.

Table 7

Long Form Assessment Percentage of Change Task 1

P	T1-T2	T1-T3	T1-T4	T2-T3	T2-T4	T3-T4
1	36.59	12.20	48.78	-38.46	19.23	41.67
2	40.32	-20.97	66.13	-102.70	43.24	72.00
3	45.00	35.00	55.00	-18.18	18.18	30.77
4	90.83	86.90	88.65	-42.86	-23.81	13.33
5	45.10	35.29	43.14	-17.86	-3.57	12.12
6	-29.73	5.41	10.81	27.08	31.25	5.71
7	87.93	61.49	88.51	-219.05	4.76	70.15
8	10.53	-226.32	-94.74	-264.71	-117.65	40.32
9	5.41	0.00	-2.70	-5.71	-8.57	-2.70
10	73.13	61.19	68.66	-44.44	-16.67	19.23
11	72.83	71.74	77.17	-4.00	16.00	19.23
12	90.83	91.70	92.58	9.52	19.05	10.53
13	70.15	62.69	73.13	-25.00	10.00	28.00
Avg.	49.15	21.26	47.32	-57.41	-0.66	27.72

Notes. The P column indicates the participant number. The T columns indicate the four points of measure. All numbers in the table are percentages.

Table 7 *Long Form Assessment Percentage of Change Task 1* includes the percentage of change between T1-T2, T1-T3, T1-T4, T2-T3, T2-T4, and T3-T4 on the IM LFA Task 1. The average percentage of change between the same combinations of points of measure is also included. A decrease in task average between two sessions indicates an improvement in performance; additionally, a decrease in task average scores corresponds to a positive percentage of change and an increase in performance.

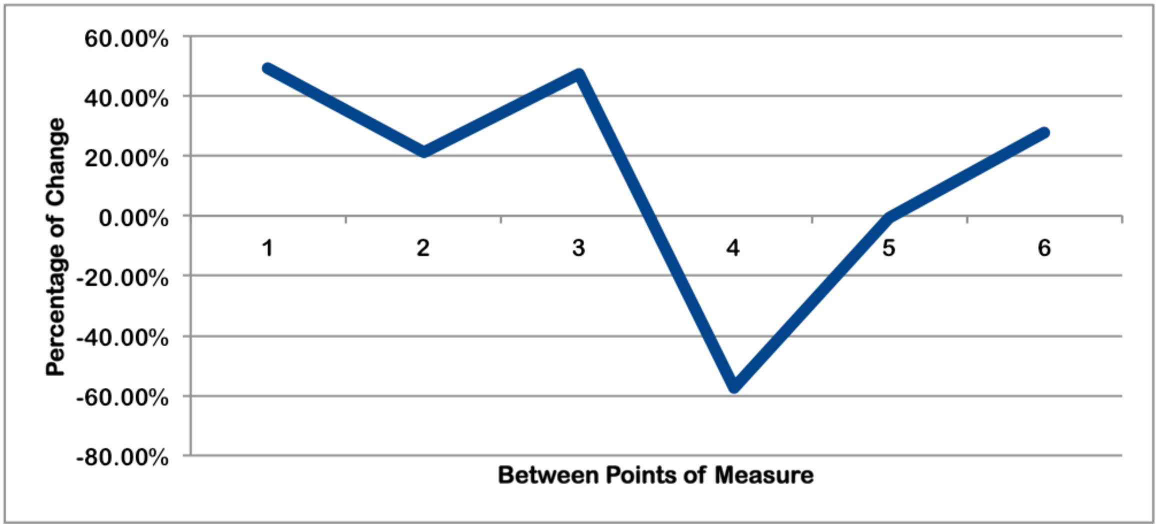

Figure 7. Long form assessment average percentage of change task 1.

As indicated in Figure 7 *Long Form Assessment Average Percentage of Change Task 1,* the average percentage of change is greatest between T1 and T2, decreases between T1 and T3, increases between T1 and T4, dips quite low between T2 and T3, and increases both between T2 and T4 and T3 and T4. This indicates that on average, participants increased performance from the initial pre-test and the post-test after the first 12 sessions of treatment; from the initial pre-test and the post-test at the end of the IM protocol; from the post-test after the first 12 sessions of treatment and the post-test at the end of the IM protocol; and from the pre-test after the six-week break and the post-test at the end of the IM protocol. The participants' performance decreased between the initial pre-test and the pre-test after the six-week break and from the post-test after the initial 12 sessions and the pre-test after the six-week break. This loss of performance is an anticipated change in most clinical deliveries of service. Just as it has been found that in order to reap the benefits from an exercise program, an individual must keep exercising or benefits will be lost (Bloomfield & Coyle, 1993; Clark & White, 2009; Hall & Brody, 2005), the IM system seems to follow the same trend with its cognitive and motor benefits. The participants would benefit from continued IM system use in order to maintain any cognitive and motor benefits gained through its use.

Table 8

Long Form Assessment Percentage of Change Task 14

P	T1-T2	T1-T3	T1-T4	T2-T3	T2-T4	T3-T4
1	88.13	80.82	91.78	-61.54	30.77	57.14
2	30.95	19.05	77.38	-17.24	67.24	72.06
3	12.50	34.38	40.63	25.00	32.14	9.52
4	89.71	78.29	80.00	-111.11	-94.44	7.89
5	89.67	84.51	88.26	-50.00	-13.64	24.24
6	31.25	31.25	51.56	0.00	29.55	29.55
7	83.13	67.47	92.77	-92.86	57.14	77.78
8	72.55	-64.71	-13.73	-500.00	-314.29	30.95
9	46.55	39.66	41.38	-12.90	-9.68	2.86
10	75.00	65.79	75.00	-36.84	0.00	26.92
11	58.46	60.00	70.77	3.70	29.63	26.92
12	89.71	70.86	92.00	-183.33	22.22	72.55
13	77.78	40.74	61.11	-166.67	-75.00	34.38
Avg.	65.03	46.78	65.30	-92.60	-18.33	36.37

Notes. The P column indicates the participant number. The T columns indicate the four points of measure. All numbers in the table are percentages.

Table 8 *Long Form Assessment Percentage of Change Task 14* includes the percentage of change between T1-T2, T1-T3, T1-T4, T2-T3, T2-T4, and T3-T4 on the IM LFA Task 14. The average percentage of change between the same combinations of points of measure is also included. A decrease in task average between two sessions indicates an improvement in performance; additionally, a decrease in task average scores corresponds to a positive percentage of change and an increase in performance.

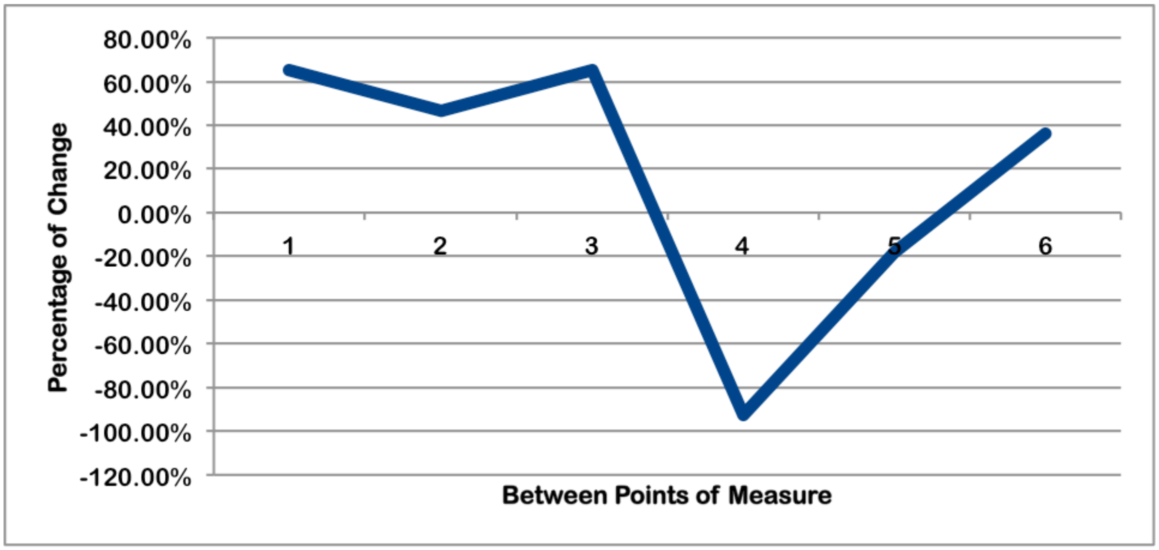

Figure 8. Long form assessment percentage of change task 14.

The average percentage of change between the same combinations of points of measure is also included in Figure 8 *Long Form Assessment Average Percentage of Change Task 14*. A decrease in task average between two sessions indicates an improvement in performance; additionally, a decrease in task average scores corresponds to a positive percentage of change and an increase in performance. The average percentage of change in Task 14 follows the same pattern as the average percentage of change in Task 1, supporting the researchers' prediction of a decrease in performance after the six-week break.

d2 Test of Attention

The d2 is a test that requires participants to use attention and concentration to discriminate and cancel certain images (Bates & Lemay, 2003). The d2 consists of the following: the letters d and p, with one to four dashes that are arranged either individually or in pairs above or below the letter. The participant scans each line of characters and identifies and crosses out each d with two dashes. The test consists of 14 lines, each with

47 characters, for a total of 658 items. The subject is allowed 20 seconds per line (Zillmer, 2008).

Table 9

d2 Test of Attention Percentage of Change

P	T1-T2	T1-T3	T1-T4	T2-T3	T2-T4	T3-T4
1	20.90	17.16	67.91	-3.09	38.89	43.31
2	-5.93	-2.54	5.93	3.60	12.61	8.70
3	18.42	13.16	34.21	-4.44	13.33	18.60
4	18.24	11.49	27.03	-5.71	7.43	13.94
5	14.17	3.94	23.62	-8.97	8.28	18.94
6	19.19	16.86	31.98	-1.95	10.73	12.94
7	19.51	15.85	32.93	-3.06	11.22	14.74
8	9.77	4.51	31.58	-4.79	19.86	25.90
9	17.12	11.71	37.84	-4.62	17.69	23.39
10	20.13	11.69	30.52	-7.03	8.65	16.86
11	15.10	11.98	18.23	-2.71	2.71	5.58
12	20.00	13.94	33.33	-5.05	11.11	17.02
13	10.83	12.50	32.50	1.50	19.55	17.78
Avg.	15.19	10.94	31.35	-3.56	14.01	18.28

Notes. The P column indicates the participant number. The T columns indicate the four points of measure. All numbers in the table are percentages.

Table 9 *d2 Test of Attention Percentage of Change* includes the percentage of change between T1-T2, T1-T3, T1-T4, T2-T3, T2-T4, and T3-T4 for the d2 Test of Attention. Raw scores measured outcomes and were used in this analysis. The rationale behind using raw score measures is that the participants percentile scores on the d2 were in the 98-100th percentile ranges and did not indicate progression of change, whereas the raw scores allowed for change to be measured. The average percentage of change between the same combinations of points of measure is also included. An increase in scores between two sessions indicates an improvement in performance; additionally, an increase in scores corresponds to a positive percentage of change and an increase in performance.

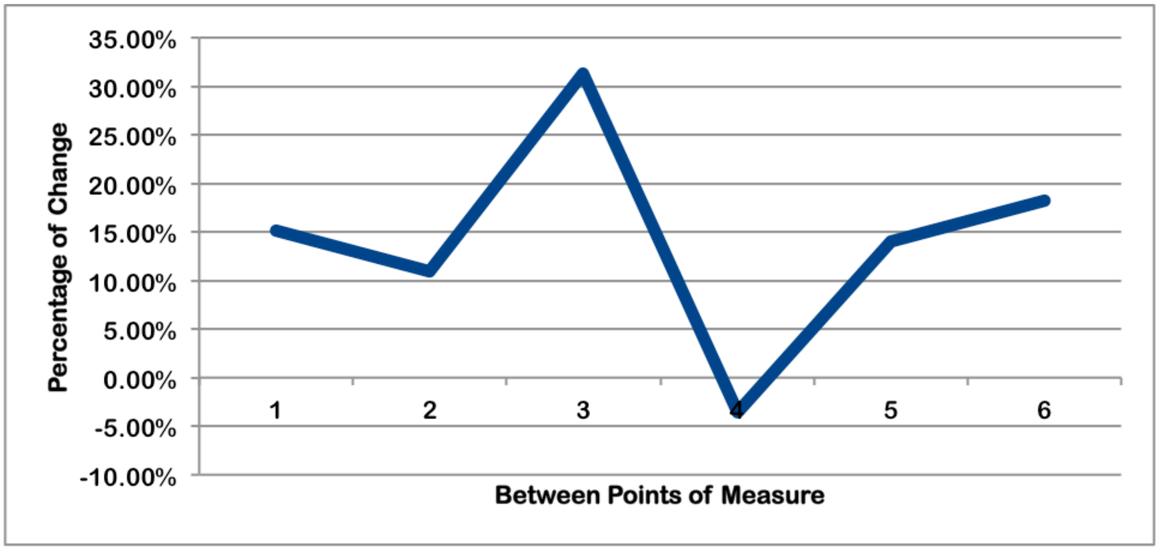

Figure 9. d2 Test of Attention average percentage of change.

Thus, since Figure 9 *d2 Test of Attention Average Percentage of Change* mirrors the pattern in both Figure 7 *Long Form Assessment Average Percentage of Change Task 1* and Figure 8 *Long Form Assessment Average Percentage of Change Task 14*, the average percentage of change throughout the compared points of measure follows a similar trend.

Nine Hole Peg Test

The NHPT is administered by carrying out the following steps and standards: (1) the client is asked to take the pegs from a container, one by one, and place them into the holes on the board, as quickly as possible; (2) participants must then remove the pegs from the holes, one by one, and replace them back into the container; (3) the board should be placed at the client's midline, with the container holding the pegs oriented towards the hand being tested; (4) only the hand being evaluated should perform the test; (5) the hand not being evaluated is permitted to hold the edge of the board in order to provide stability; (6) scores are based on the time taken to complete the test activity, recorded in seconds; (7) alternate scoring occurs when the number of pegs placed in 50 or 100 seconds can be recorded. In this case, the results are expressed as the number of pegs placed per second; and (8) stopwatch should be started from the moment the participant touches the first peg until the moment the last peg hits the container (Rehabilitation Measures Database, 2014).

Table 10

Nine Hole Peg Test Percentage of Change

P	T1-T2	T1-T3	T1-T4	T2-T3	T2-T4	T3-T4
1	0.00	-4.76	4.76	-4.76	4.76	9.09
2	4.76	4.76	4.76	0.00	0.00	0.00
3	7.69	15.38	7.69	8.33	0.00	-9.09
4	4.17	8.33	12.50	4.35	8.70	4.55
5	4.35	8.70	21.74	4.55	18.18	14.29
6	14.71	11.76	17.65	-3.45	3.45	6.67
7	7.69	23.08	26.92	16.67	20.83	5.00
8	25.00	0.00	8.33	-33.33	-22.22	8.33
9	8.33	-4.17	4.17	-13.64	-4.55	8.00
10	17.24	13.79	24.14	-4.17	8.33	12.00
11	0.00	0.00	5.00	0.00	5.00	5.00
12	25.00	0.00	8.33	-33.33	-22.22	8.33
13	0.00	0.00	5.00	0.00	5.00	5.00
Avg.	9.15	5.91	11.62	-4.52	1.94	5.94

Notes. The P column indicates the participant number. The T columns indicate the four points of measure. All numbers in the table are percentages.

Table 10 *Nine Hole Peg Test Percentage of Change* includes the percentage of change between T1-T2, T1-T3, T1-T4, T2-T3, T2-T4, and T3-T4 for the NHPT. The average percentage of change between the same combinations of points of measure is also included. A decrease in scores between two sessions indicates an improvement in performance; additionally, a decrease in scores corresponds to a positive percentage of change and an increase in performance.

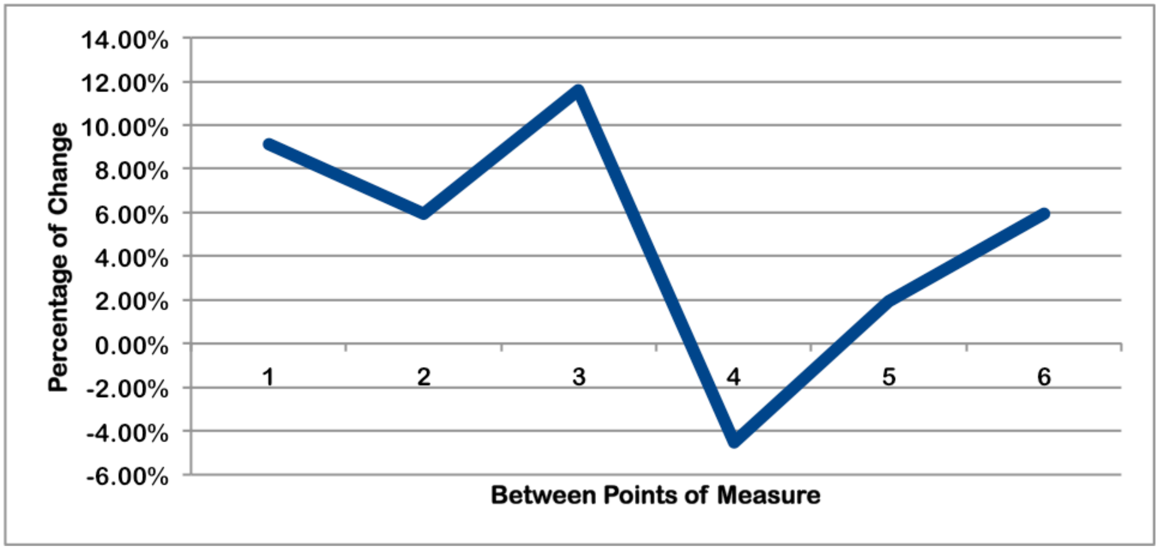

Figure 10. Nine Hole Peg Test average percentage of change.

Figure 10 *Nine Hole Peg Test Average Percentage of Change* depicts a similar pattern to that shown in both Figure 7 *Long Form Assessment Average Percentage of Change Task 1* and Figure 8 *Long Form Assessment Average Percentage of Change Task 14*. Thus, the average percentage of change throughout the compared points of measure follows a similar trend for performance on the NHPT, as it did in the d2.

Significance of IM Short Form Assessment

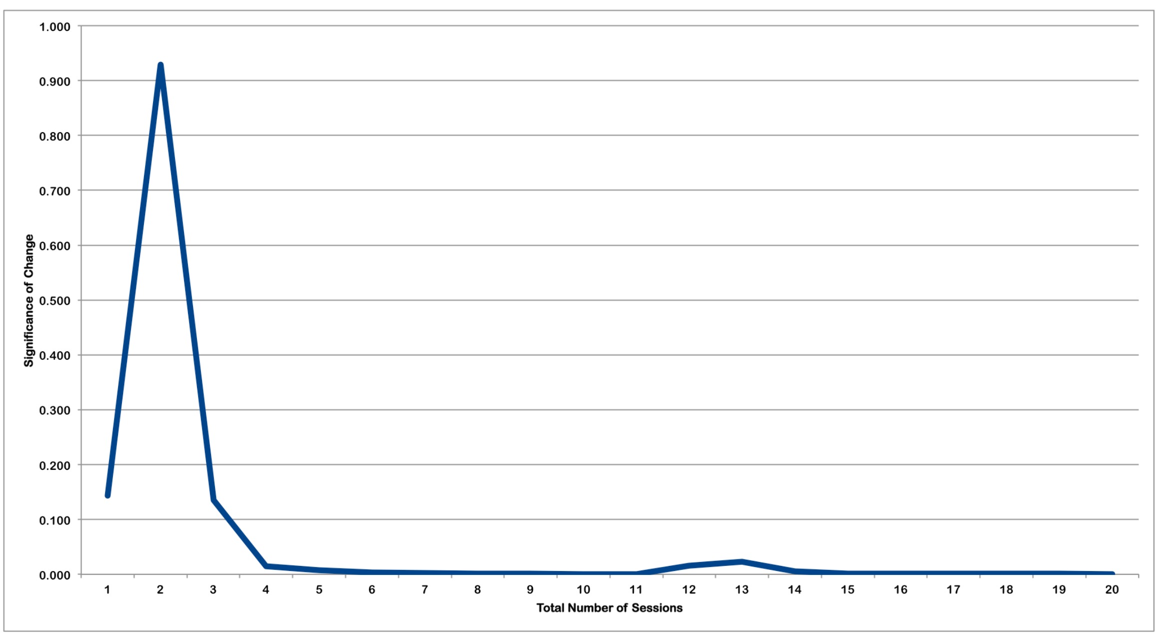

Figure 11. Significance of change in scores for short form assessment.

Figure 11 *Significance of Change in Scores for Short Form Assessment* depicts the significance of change in scores for the SFA throughout all 18 sessions. These results were analyzed using a repeated measures t-test, with the significance level set at .001. Significance indicates that the relationship between the variables is due to something other than random chance. The trend includes a dip in significance of change between sessions one and two, followed by a steep incline of significance of change between sessions two and three. A steady decline continues until the time between sessions 11 and 12, mirroring the decline in performance seen after the six-week break period in the LFA graphs, as well as the d2 and NHPT graphs. Significance again increases between treatment sessions 13 and 14, and the change in scores remains significant for the remainder of the sessions.

CHAPTER V

Conclusions & Recommendations

Summary

This was a pre-test, post-test, quasi-experimental study to examine the treatment of the IM on healthy, older adults in southeastern North Carolina. Thirteen participants successfully completed a total of 18 SFAs, four LFAs, four d2s, and four NHPTs. A discussion of the results follows.

Results

Performance on the SFA demonstrated significance of change in scores for the majority of the treatment sessions. Results were insignificant at times that correspond to the beginning of the IM protocol, as well as the point of measure after the six-week break in treatment. General trends on the SFA data indicated a decrease in task averages over time, or an increase in performance, supporting that treatment with the IM protocol leads to an increase in performance on the IM.

Performance on the LFA showed a general trend toward improvement in performance between the initial pre-test period and the post-test after the first treatment period of 12 sessions (T1-T2); a decline in performance between the post-test after the first treatment period of 12 sessions and the pre-test after the six-week break (T2-T3); and an improvement in performance between the pre-test after the six-week break and the post-test at the end of the IM treatment protocol (T3-T4). These results add to the current IM research and support that treatment with the IM protocol leads to an increase in performance on the IM; however, the results also indicate that discontinuing the IM protocol may lead to a slight decrease in performance on the IM, which was not significant. This could mean that benefits of the IM are lost over time, but not at a significant level of loss. As with most physical and mental routines that support wellness, continued participation in these activities is warranted, and thus the continued use of the IM protocol is recommended at some level.

Performance on both the d2 and the NHPT followed a similar general pattern as performance on the LFA, indicating that participation in the IM protocol could be linked with increased performance on the d2 and the NHPT. If participation with the IM program can promote cognitive and motor performance, then participation with the IM could promote aging in place through cognitive plasticity and supporting executive function.

Conclusions

Research Question 1. At what point in the IM short form assessment do significant predictors of percentage of change within the IM long form assessment arise?

Given the measurement indicators in Figure 11 *Significance of Change in Scores for Short Form Assessment*, there was significant change at week 5 that consistently held throughout the treatment sessions. This improved level was reached during the second phase of the treatment sessions within one treatment session and remained until the conclusion of the study. In practice, this means that occupational therapists could integrate the IM into their treatment programs and could expect to see positive changes within a few weeks that would continue throughout the duration of the IM treatment period.

Research Question 2. After completing a full regimen of the IM protocols, how do the initial long form assessment scores compare to the post-six-week control period long form assessment scores?

The post-six-week control period LFA scores showed a decrease, on average, from the initial LFA scores. This demonstrates that continued use of the IM improves people's cognitive and motor skills and could possibly serve as an instrument to maintain these skills in daily life. These findings support the use of the IM in occupational therapy treatment protocols, and serve as an indication that the IM system could be used to aid participants in aging in place, and, thus, overall quality of life throughout the lifespan. Periodic IM sessions interspersed throughout the course of treatment would serve to benefit clients in maintaining the benefits gained.

Research Question 3. Is there a correlation between change in scores on the full IM regimen and scores on the WJ III, the d2, the FSST, and the NHPT?

Because of the lack of sensitivity and measurement outcomes, the WJ III and the FSST were not included in this analysis. Some changes were noted, but because of the lack sensitivity and ability to depict true change, they were omitted from inclusion in this section of the study. In general, as performance on the full IM regimen increased, scores on both the d2 and the NHPT increased as well. This indicates that the IM could be the impetus for changes in executive function in the aging population. Change or improvement in both cognitive and motor performance is evident in each of the participants, exhibiting a positive dual outcome result that few if any interventions or treatments are currently providing. This implies that occupational therapists could add the

IM in as a supplement to their treatment protocols and reap the cognitive and motor benefits for their patients.

Research Question 4. At what point do individuals saturate their level of performance within the full IM protocol, and can the IM short form assessment be an indicator of where that saturation level exists?

Given the outcome in comparing the results of treatment session one and treatment session two, one can continue to measure change or improvement in each of the participants. The change no longer remains significant over time, but is reflective of maintenance of the participant's ability to remain at peak levels of both cognitive and motor skill performance. Thus, since it appears that a positive percentage of change, or overall improvement in performance, is lost over time, the results support the need to continue with the IM protocol in order to maintain the results gained when beginning treatment. This supports the idea of using the IM system for cognitive and motor performance maintenance with the aging population, and thus, extending and improving aging in place and continued quality of life.

Recommendations

Methods to Improve the Study. Seeking out a truly random sample, as well as a larger sample, could compensate for the limitations resulting from the volunteer/convenience sampling. This would provide more generalizable results. Retention of study participants could be improved by providing participation incentives. Measures should also be put in place to ensure more consistency between the participants' treatment sessions. Small study samples, as this study presents, often lead to criticism of generalizability. A control group of the same size may lead to acceptance of the findings, regardless of study population and size.

Final Implications. Though further research is needed to examine the link between participation in the IM protocol and possible changes in cognitive and motor abilities, the researchers were successful in delineating a relationship between positive percentage of change in scores on the IM protocol and positive percentage of change on both a cognitive and motor assessment. Future studies should seek to more closely examine this relationship to determine if the IM can be used as a tool to improve cognitive and motor abilities in healthy, older adults, namely by integrating it into a maintenance program to promote aging in place.

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Appendix A

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **www.ecu.edu/irb**

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: Leonard Trujillo
CC:

Date: 6/18/2014
Re: UMCIRB 14-001065
The Effectiveness of the IM with Healthy Aging Adults

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 6/11/2014 to 6/10/2015. The research study is eligible for review under expedited category #4, 7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
Cyprus glenn IM Info.docx	Clinical Investigators Brochure
Cyprus glenn IM Info.docx	Recruitment Documents/Scripts
IM No More thant minimal risk - LGT-June.doc	Consent Forms
IM Protocols for Aging Adults.pdf	Study Protocol or Grant Application

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

Appendix B

East Carolina University

Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Title of Research Study: The Effectiveness of the Interactive Metronome with Healthy Aging Adults: a Longitudinal Study
Principal Investigator: Leonard G Trujillo (Leo)
Institution/Department or Division: Occupational Therapy
Address:600 Moye Blvd HSB RM#3305, Greenville, NC 27858
Telephone #: 252-477-6195 - Cell 252-258-0363

Study Sponsor/Funding Source: Cypress Glen, St. Peter's Catholic Church, Pitt County Council on Aging and Interactive Metronome

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Researchers at East Carolina University (ECU) as well as the Interactive Metronome Corporation along with Directors from Cypress Glen participate in and study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of volunteers who are willing to take part in research.

Why is this research being done?
The purpose of this research is to make a stronger case of using the Interactive Metronome as an effective tool to help improve the aging individual's daily lives. Some specific areas that we hope to make a difference in a person's balance, improving organization skills, and what we refer to as cognitive processing skills. Cognitive processing includes such things as being able to pay attention to tasks with less distraction and for longer periods of time; being able to remember the most recent event or what was just being discussed in a conversation as well as being able to formulate complex tasks or make plans. The decision to take part in this research is yours to make. By doing this research, we hope to learn how effective the Interactive Metronome is on the motor and mental skills, and if these expected positive improvements last over a month – to 3 months period of time.

Why am I being invited to take part in this research?
You are being invited to take part in this research because we consider you to be a healthy adult that is at least 60 years old and you may be interested in improving or sustaining your current motor and mental skills. By agreeing to be a participant you see yourself in good health and would possibly refer to yourself as a healthy aging adult. If you volunteer to take part in this research, you will be one of about 30 people to do so.

Are there reasons I should not take part in this research?
During this study the treatment time will progress from approximately 20 min of time to 30 min of time. It would be preferred if you can stand during that time, but could sit if needed. The actual time spent takes about 45 min. It is preferred that you have hearing in both ears. Hearing aids are acceptable, but you should be aware that you will be asked to wear headphones that go over one's ears during the treatment time. If you need to we will be able to adjust the volume. We will be using computer screens which will give you feedback, if you have difficulty with your visual acuity to distinguish what is being shown on the screen you will need to inform the researcher so they can make adjustments accordingly. It is important that you be willing to inform the researcher of your needs so we can make the adjustments accordingly.

 Initial:_________

The Effectiveness of the Interactive Metronome with Healthy Aging Adults: a Longitudinal Study

What other choices do I have if I do not take part in this research?
You can choose not to participate. This is just an additional activity being supported by your agency to offer you more opportunities to remain active and live your life to its fullest.

Where is the research going to take place and how long will it last?
The research procedures will be conducted in an area provided by your sponsoring agency such as the activities center room. We will establish times in the afternoons to bring the Interactive Metronome to you directly. You will need to come to the designated area room during the times we agree on, a minimum of two times a week and possibly 3 times if you agree to the time available. The total amount of time you will be asked to volunteer for this study is two one and a half hour evaluations sessions and then 12 additional treatment sessions that will last 20 to 35 min of treatment time but usually last 45 min each. Because this is a longitudinal study, one that lasts over a specifi period of time we will ask you to return between 1 month and 3 months from completing this first round and complete the process again. We plan to start this in mid June and end the by the end of July returning in September for the second round, with hopes of completing this before the Holiday seasons come in November. So the first part of the study should take around 8 to 9 hours total time, there will be a short period of time where no sessions will be conducted and then we will repeat the sessions, but only doing half the first training for another 6 hour time for a compiled 16 – 18 hours of time involved.

What will I be asked to do?
You are being asked to do the following: The Interactive Metronome requires that you listen to rhythmic sounds and attempt to tap a switch to the timing of the sound trying to match the time you hit the switch to the timing of the rhythmic sound. Some of the switches will be on the floor and you will tap them with your heel or toe. If balance is a problem for you, you may ask or it be recommended that you sit during any of the activities. The total time will progress from 20 min per session in the beginning, to that of just fewer than 30 minutes for the last three sessions. The real time is closer to 45 min. There are different activities that will run from 2 minutes to almost 5 min by the final sessions in the total process. During this time you will be wearing headphones that you will take on and off and receive instructions from the researcher. These are the same activities that are being used in clinics across America in many out patient programs.

What are the possible benefits I may experience from taking part in this research?
We do not know if you will get any benefits by taking part in this study. This research might help us learn more about how older adults respond to the Interactive Metronome and if its affects last over time. There may be no personal benefit from your participation but the information gained by doing this research may help others in the future. Most often there are measureable changes made, but it is sometimes difficult for the individual to make notice of these changes as they become the new norm for most of us. The IM is designed to addresses: Brain timing, Rhythmicity , Synchronicity , Increasing the speed and coordination of informational signals within the brain , Improving the processing abilities that affect attention, motor planning, and sequencing and Coordination. By participating in this research study, you may also experience these benefits.

Will I be paid for taking part in this research?
We will not be able to pay you for the time you volunteer while being in this study. Exception: If you are part of the St Peter's Group because of travel expenses you will be compensated with a $50.00 gift card. Other groups will not because of the expectation of providing community service. If you have questions in this regard please ask Dr Trujillo about this option. However, if you were receiving this treatment in a for profit private clinic each session you would be asked to pay approximately $120 per session $1,440 is therapy costs.

What will it cost me to take part in this research?

Initial: _________

The Effectiveness of the Interactive Metronome with Healthy Aging Adults: a Longitudinal Study

It will not cost you any money to be part of the research. The sponsor of this research will pay the costs of: the IM equipment and computers used along with the leased time used in providing the sessions. The cost to you is your time and effort to participate.

Who will know that I took part in this research and learn personal information about me?
To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:

- The sponsors of this study.
- Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the North Carolina Department of Health, and the Office for Human Research Protections
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.
- Additionally, the following people and/or organizations may be given access to your personal health information and they are: Activities Director at Cypress Glen, Greenville, NC.

How will you keep the information you collect about me secure? How long will you keep it?
The data that we are collecting will be protected at several levels and we want you to know we strongly understand your need to have your privacy protected and all means possible to maintain it using the best options available. To begin with this consent form will be the only printed document that has your full name written on it. This document will be stored in a locked file drawer, in Dr. Trujillo's university office that is locked during times he is not in the office suite. His door has very limited access to only those who have sub Masters Keys or Masters key for the College. At the end of this document we will identify an identification code that will be used on all future documents in conjunction with your first name. That same identification code will be the one used with registering you with the IM computer program that will be accessed via a password-protected computer. In addition to the password protected PC the IM program encrypts your data and information and only the program can decrypt the data collected. In order to access your data one would have to know your IM Identity, only your direct researcher and Dr. Trujillo will know your identification codes. Very little sensitive data if being collected, Name, age/ Birthdate, gender, handedness and statement of general health. In addition the test evaluation forms from the evaluation will be kept in the same file folder where this consent form will be kept to maintain security and privacy of this data collected. If translated into electronic data it would be stored in an encrypted password protected data storage system similar to pirate drive provided by ECU. Because this study is identified to take place for approximately one year for data collection and then a 2nd year for data analysis these files will be maintained for a 2 year length of time. After that time any information that could be pointed back to you as an individual who participated in the study will be stripped of the data for possible future research process. The data when it is reported will be done so in aggregate format – which means report as a group of individuals who live in a residence in Eastern North Carolina and not specific to a group of older adults at your agency. We hope to publish studies in this regard to include a possible Graduate Student Thesis.

What if I decide I do not want to continue in this research?
If you decide you no longer want to be in this research after it has already started, you may stop at any time. You will not be penalized or criticized for stopping. If you find your schedule needs to be adjusted to better continue that can be arranged. You will not lose any benefits that you should normally receive.

Who should I contact if I have questions?
The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator Leo Trujillo at 252-744-6195 (Monday through Friday during the day between 8:00 AM and 5:00 PM. You can leave a message if you wish to or if you want to use the staff at Cypress Glen you may do so by contacting Allison Terzain who is your Life enrichment coordinator at the facility. She will serve as your conduit and contact Leo Trujillo. For those at Pitt County Council on Aging you would contact Diane

Initial: _________

The Effectiveness of the Interactive Metronome with Healthy Aging Adults: a Longitudinal Study

Skalko, Executive director 252-752-1717/3 or email her at dsklako@pittcoa.com . Those associated with St Peter's can voice your concerns with the St Peter's Office 252-757-3259 extension 201 and the office staff will direct your question to the appropriate person. As the principle investigator Leo Trujillo is available at anytime via his cell phone at 252-268-0363. You may also voice any concerns or feedback directly to the researcher you are working with and they are training to make accommodations or respond to most of your needs directly,

If you have questions about your rights as someone taking part in research, you may call the Office of Research Integrity & Compliance (ORIC) at phone number 252-744-2914 (days, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the ORIC, at 252-744-1971.

Is there anything else I should know?

We think this covers most any question that you may have had in order to make a decision about being a participant in this study. Remember it will have two parts each lasting a total of 14 sessions the first and last being evaluations and the middle 12 being the treatment sessions that will last around 30 min of your time.

I have decided I want to take part in this research. What should I do now?

The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I know that I can stop taking part in this study at any time.
- By signing this informed consent form, I am not giving up any of my rights.
- I have been given a copy of this consent document, and it is mine to keep.

____

Participant's Name (PRINT) **Signature** **Date**

Person Obtaining Informed Consent: I have conducted the initial informed consent process. I have orally reviewed the contents of the consent document with the person who has signed above, and answered all of the person's questions about the research.

____

Person Obtaining Consent (PRINT) **Signature** **Date**

Personal Identification IM ID:

Name: ________________ ____ ______________
First MI Last

Initials: __ __ __ (If no middle name or initial place a "Z" in its place)
F M L

Year of Birthdate: __ __ __ __

IM ID: ___ ___ ___ __ __ __ __

Initial: _________

Appendix C

Table 1, continued

Organizational Schema Relating WJ III COG and Diagnostic Supplement Tests, CHC Broad Factors and Narrow Abilities, Cognitive Processes, and Related Educational Interventions

Test 5: Concept Formation	Fluid Reasoning (*Gf*) *Induction*	Rule-based categorization; rule switching; induction/inference	Categorize using real objects; develop skills in drawing conclusions; hands-on problem-solving tasks; make meaningful associations; concrete examples of grouping objects
Test 6: Visual Matching	Processing Speed (*Gs*) *Perceptual speed*	Speeded visual perception and matching	Emphasize speediness; build cognitive speed via repetition, speed drills; use of technology
Test 7: Numbers Reversed	Short-Term Memory (*Gsm*) *Working memory*	Span of apprehension and recoding in working memory	Chunking strategies; rehearsal; mnemonics
Test 8: Incomplete Words	Auditory Processing (*Ga*) *Phonetic coding*	Analysis of a sequence of acoustic, phonological elements in immediate awareness; activation of a stored representation of the word from an incomplete set of phonological features	Promote phonological awareness; read aloud; games that focus on sounds and words
Test 9: Auditory Working Memory	Short-Term Memory (*Gsm*) *Working memory*	Recoding of acoustic, verbalizable stimuli held in immediate awareness	Rehearsal; mnemonics; active learning
Test 10: Visual-Auditory Learning–Delayed	Long-Term Retrieval (*Glr*) *Associative memory*	Retrieval and reidentification; associative encoding (for relearning)	Active, successful learning experiences; rehearsal; overlearning; organizational strategies; mnemonics; illustrate or visualize content
Test 11: General Information	Comprehension-Knowledge (*Gc*) *General (verbal) information*	Semantic activation and access to declarative generic knowledge	Text talks; semantic maps
Test 12: Retrieval Fluency	Long-Term Retrieval (*Glr*) *Ideational fluency* *Naming facility*	Recognition, fluent retrieval, and oral production of examples of a semantic category	Oral elaboration
Test 13: Picture Recognition	Visual-Spatial Thinking (*Gv*) *Visual memory*	Formation of iconic memories and matching of visual stimuli to stored representations	Activities designed to discriminate/match visual features and recall visual information
Test 14: Auditory Attention	Auditory Processing (*Ga*) *Speech-sound discrimination* *Resistance to auditory-stimulus distortion*	Selective auditory attention	Reduce distracting noise; modifications to listening environment
Test 15: Analysis-Synthesis	Fluid Reasoning (*Gf*) *General sequential reasoning* *Quantitative reasoning*	Algorithmic reasoning; deduction	Deductive reasoning using concrete objects; hands-on problem solving tasks; metacognitive strategies
Test 16: Decision Speed	Processing Speed (*Gs*) *Semantic processing speed*	Object recognition and speeded symbolic/semantic comparisons	Emphasize speediness; build cognitive speed via repetition
Test 17: Memory for Words	Short-Term Memory (*Gsm*) *Auditory memory span*	Formation of echoic memories and verbalizable span of echoic store	Mnemonics; rehearsal; provide visual cues
Test 18: Rapid Picture Naming	Processing Speed (*Gs*) *Naming facility*	Speed/fluency of retrieval and oral production of recognized objects	Increase fluency through self-competition

Image Source: Schrank and Wendling (2009)

Appendix D

Table 1.
WJ III ACH Tests, CHC Narrow Abilities (within primary curricular area), Cognitive Processes, and Related Educational Interventions

Test	Area/Narrow Abilities	Cognitive Process(es)	Related Educational Interventions
Test 1: Letter-Word Identification	Reading *Reading decoding*	Feature detection and analysis (for letters) and recognition of visual word forms and/ or phonological access to pronunciations associated with visual word forms (i.e., words may or may not be familiar)	Explicit, systematic; synthetic phonics instruction; word-recognition strategies (word walls, flow lists, word banks, flash cards); repeated readings, teaching high-frequency words, spelling-based decoding strategies; Fernald method
Test 2: Reading Fluency	Reading *Reading speed* *Semantic processing speed*	Speeded (automatic) semantic decision making requiring reading ability and generic knowledge	Repeated reading; passage previewing; assisted reading; practicing words in isolation
Test 3: Story Recall	Oral Expression *Meaningful memory* *Listening ability*	Construction of propositional representations and recoding	Opportunities to hear and practice language; direct instruction in semantics, syntax, and pragmatics; role-playing; games; compensatory skills; use of strategies
Test 4: Understanding Directions	Listening Comprehension *Working memory* *Listening ability*	Construction of a mental structure in immediate awareness and modification of the mental structure via mapping	Opportunities to practice listening and following directions; echo activities; auditory skill tapes; modifying the listening environment
Test 5: Calculation	Mathematics *Math achievement*	Access to and application of knowledge of numbers and calculation procedures; verbal associations between numbers represented as strings of words	Use of manipulatives; sequential direct instruction; development of number sense; cover-copy-compare method; demonstration with verbalization; mnemonic strategies; peer-assisted tutoring; concrete-representational-abstract teaching techniques; computer-assisted instruction
Test 6: Math Fluency	Mathematics *Math achievement* *Numerical facility*	Speeded (automatic) access to and application of digit-symbol arithmetic procedures (verbal associations between numbers represented as strings of words)	Development of number sense; math facts charts; explicit timings; computer-assisted instruction

Image Source: Wendling, Schrank, and Schmitt (2007)

Appendix E

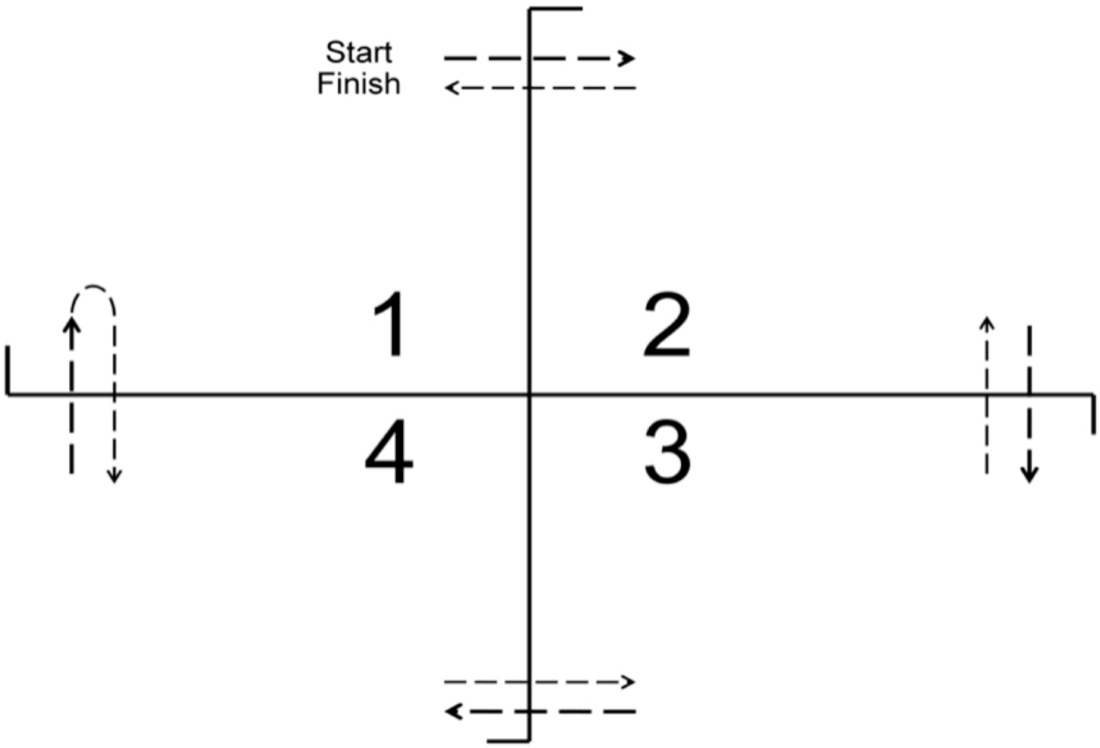


Image retrieved from the Rehabilitation Measures Database: http://www.rehabmeasures.org/PDF%20Library/Four%20Step%20Square%20Test%20Instructions.pdf

Appendix F

Figure 1. The Interactive Metronome.

Image Source: Beckelhimer et al. (2011)

Appendix G

What is the Interactive Metronome™ ?

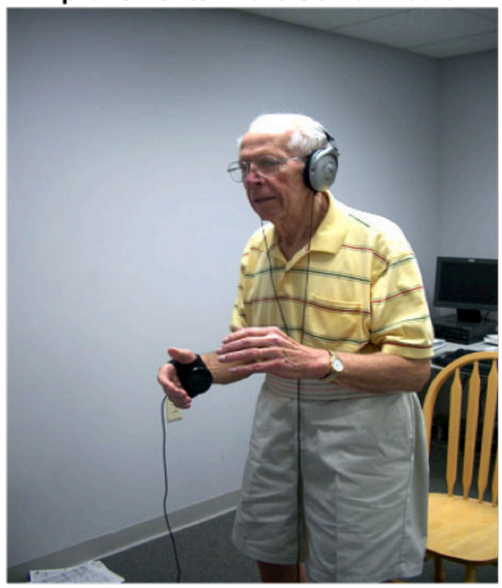
The Interactive Metronome (IM) combines the concept of a musical metronome with a patented technology program that accurately measures, assesses and improves a person's rhythm and timing. It is an advanced assessment & treatment program developed to improve the processing abilities that affect motor planning and sequencing, which are central to human activity. This improvement, we hope, is extended in one's daily activities in self care, and cognitive alertness.

IM addresses:

1. Brain timing
2. Rhythmicity
3. Synchronicity
4. Increasing the speed and coordination of informational signals within the brain
5. Improving the processing abilities that affect attention, motor planning, and sequencing
6. Coordination

interactive metronome.

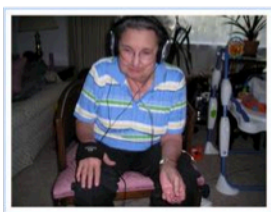
The Interactive Metronome™ Movement and Cognitive Improvements in the Senior Adult



What do we hope to learn?
The purpose of this research study is to understand if participating in an occupational therapy intervention using the IM treatment protocol as a modality has a positive effect on one's motor and cognitive processing abilities. The information from this study will help therapists better develop effective treatment plans for individuals who are changing along their life span, but hope to remain physically and mentally active.

What do we need from you?

As a participant in the study, you will complete a short series of standard rehabilitation evaluations used to determine how effectively you use your arms and hands; along with setting a base line for cognitive processing skills. These evaluations take about 30-45 minutes and ask you to move your arm and pick up and move simple objects; or perform other simple tasks. These are simple short cognitive processing tests and attention tests that will be asked of you as well. The evaluations will help the researchers measure the amount of movement you have in your arms, fingers, and hand, and the scores from these evaluations will serve as a baseline, which will be used to determine if there are improvements in arm/hand functioning after participation in the research treatment sessions. The same goes for setting baselines for the cognitive and attention tests. You will then be asked to participate in the Interactive Metronome treatment sessions. These will take between 30- and 45 min with short tasks lasting 2-3 min each. Upon completing these sessions, you will be asked to take the same tests that were given in the beginning to determine the changes you have made. We hope that any change in scores will be due to the beneficial effects of the IM treatment sessions. Most people start to see changes after 5 – 6 sessions, but part of this study will help us determine when these changes start to occur.



A second part to this study is to ask if you would be willing to come back after 2-3 months of time has passed and repeat the process again. This will help us determine how long the and how effective the sessions last with each person.

How Can I participate? And When is this going to happen?

This study needs volunteersyou're your help. We are hoping to start the sessions in **June and July this summer**. Please contact Allison Terzian to sign up and participate in the study, and for information on how to get involved. If you have questions you can contact the primary investigator.

Primary Investigator

Leo Trujillo, PhD, OTR/L, FAOTA
Occupational Therapy Department
East Carolina University
(252) 744-6195

Associate Investigator

Jane Painter-Patton, EdD, OTR/L, FAOTA
Occupational Therapy Department
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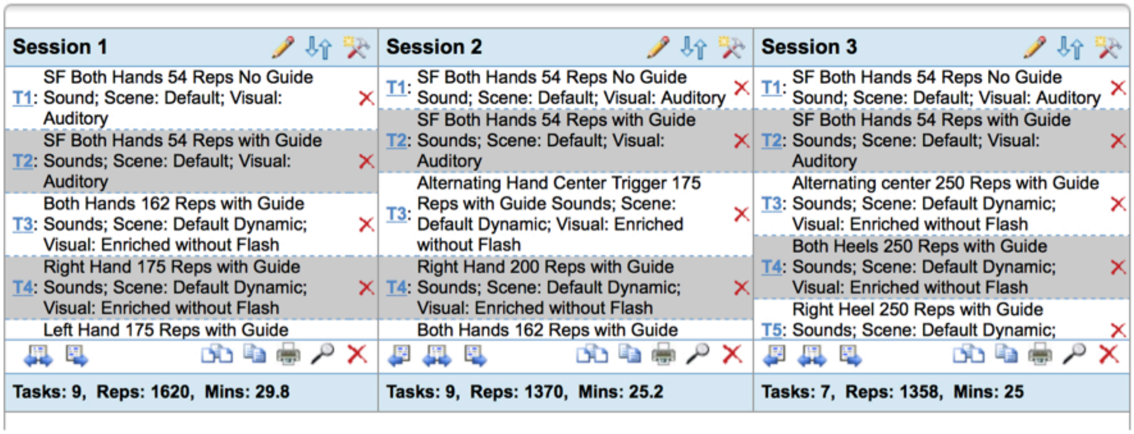
Cypress Glenn Point of Contact

Allison Terzian
Life Enrichment Director
Cypress Glen Retirement Community
Community Phone: 252.830.0036
Direct Line: 252.830.7078
E-mail: aterzian@umrh.org

Appendix H



Session 1	Session 2	Session 3
T1: SF Both Hands 54 Reps No Guide Sound; Scene: Default; Visual: Auditory	T1: SF Both Hands 54 Reps No Guide Sound; Scene: Default; Visual: Auditory	T1: SF Both Hands 54 Reps No Guide Sound; Scene: Default; Visual: Auditory
T2: SF Both Hands 54 Reps with Guide Sounds; Scene: Default; Visual: Auditory	T2: SF Both Hands 54 Reps with Guide Sounds; Scene: Default; Visual: Auditory	T2: SF Both Hands 54 Reps with Guide Sounds; Scene: Default; Visual: Auditory
T3: Both Hands 162 Reps with Guide Sounds; Scene: Default Dynamic; Visual: Enriched without Flash	T3: Alternating Hand Center Trigger 175 Reps with Guide Sounds; Scene: Default Dynamic; Visual: Enriched without Flash	T3: Alternating center 250 Reps with Guide Sounds; Scene: Default Dynamic; Visual: Enriched without Flash
T4: Right Hand 175 Reps with Guide Sounds; Scene: Default Dynamic; Visual: Enriched without Flash	T4: Right Hand 200 Reps with Guide Sounds; Scene: Default Dynamic; Visual: Enriched without Flash	T4: Both Heels 250 Reps with Guide Sounds; Scene: Default Dynamic; Visual: Enriched without Flash
Left Hand 175 Reps with Guide	Both Hands 162 Reps with Guide	T5: Right Heel 250 Reps with Guide Sounds; Scene: Default Dynamic;
Tasks: 9, Reps: 1620, Mins: 29.8	Tasks: 9, Reps: 1370, Mins: 25.2	Tasks: 7, Reps: 1358, Mins: 25