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Exploring the effects of piano study on cognitive function in senior adults

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EXPLORING THE EFFECTS OF PIANO STUDY ON COGNITIVE FUNCTION IN SENIOR ADULTS

by

BARBARA D. PERRY-DEEGAN

B. Music Education, SUNY Potsdam, 1983
M.S., Lesley University, 1988
M.M., Missouri State University, 2006

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Approved by

First Reader _____

Kirsten Mitak, Ph.D.
Artist/Teacher in Music Education
University of Rhode Island

Second Reader _____

Diana R. Dansereau, Ph.D.
Assistant Professor of Music, Music Education

Third Reader _____

Karin S. Hendricks, Ph.D.
Assistant Professor of Music, Music Education

DEDICATION

I dedicate both my DMA and this paper to my Mother, Patricia M. Henry. She never gave up until she instilled a love for reading and writing in a wild haired, stubborn little girl who preferred going outside. Fifty-three years later, going outside is still preferred, but the places I have gone due to her dedication cannot be measured in mere words.

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BARBARA D. PERRY-DEEGAN

Boston University College of Fine Arts, 2018

Major Professor: Kirsten Mitak, Ph.D., University of Rhode Island, Artist/Teacher in Music Education

ABSTRACT

The purpose of this study was to examine whether exposure to a 6-week piano class would have an impact on specific cognitive functions (attention, short-term memory, and planning) in senior adults. In addition, I aimed to determine whether the cognitive function of participants who studied piano as children would differ from those who did not. Twelve 30-minute sessions were offered to residents of a rural, southern Missouri county using the Yamaha Music in Education (MIE) piano laboratory in a local elementary school. The on-line version of the Cambridge Neurological Test Automated Battery (CANTAB) was used to measure attention, short-term memory and planning. Thirty-six ($N = 36$) older adults completed the study. Four groups of 8 to 10 participants were randomly assigned. One treatment (Group A) and one control (Group C) received the CANTAB pretest, and posttest, and one treatment (Group B) and one control (Group D) received only the CANTAB posttest. I performed an ANCOVA and discovered no significant difference between CANTAB posttest scores for treatment groups and control groups. Additionally, no significant difference was found between CANTAB scores for those who had piano lessons as a child and those who did not. Evidence from the CANTAB scores support the null hypothesis that there was no evidence of a relationship

between twelve 30-minute piano lessons and improved cognitive function in senior adult students. There was also no evidence of a relationship between studying piano before the age of 18 and improved cognitive function as measured by CANTAB.

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Abbreviations

CANTAB……..….. Cambridge Neurological Test Automated Battery

MIE……..…..Yamaha Music in Education Piano System

NDM…….…..Naturalistic Decision Making

CHAPTER ONE

PROLOGUE-MUSIC AND THE BRAIN

Do not go gentle into that good night,
Old age should burn and rave at close of day;
Rage, rage against the dying of the light (Dylan Thomas, 1914-1953).

I conducted a small volunteer orchestra from 2002 to 2012. The group was an eclectic mix of students, retirees, music teachers, and people in other professions who just loved to play orchestral music. Among the retirees was a retired professional bassoon player I'll call Dave.

Dave was retired from playing in a large symphony and had also been a career bassoonist and music educator. In addition to leading the bassoon section in a symphony orchestra, Dave was a founding member of a woodwind quintet, a department head at the local school of music, and a bassoon instructor for a generation of young players. Upon retirement, he and his wife moved to the small town where I was beginning my tenure as a volunteer orchestra conductor. Dave played principal bassoon for 8 of the 10 years that I served as the conductor. During that time, Dave slowly succumbed to dementia. I watched the progression in sadness and awe. As Dave lost memory, social skills, and other cognitive functions, his musicianship was still present. Orchestra members marveled at his great tone, melodic expression and accuracy. Toward the end of his participation, his musical facility remained in intact; however, he had some mini-strokes that interfered with his embouchure, so he had to stop playing the bassoon. His piano skills remained until shortly before his death.

In 2014, I wrote to Dave's wife and obtained her permission to share his story.

Dave's experience is not an isolated example. There are documented cases of trained musicians retaining their musical skills well into the onset of dementia (Halpern, 2012; Sacks, 2008).

Like Dave, some senior adult players in the orchestra I conducted, like Dave, were retired professional musicians. Other participants were retirees who had played in ensembles during their high school years but had not played since. Still other musicians had played in amateur groups periodically throughout their working lives and continued to perform music in retirement. There were also players in the orchestra who had started learning an instrument as an adult. Park (1995) reported on the various levels of musicianship involved in community music participants: "1) The adult novices, 2) the retired professional musicians, 3) professional dropouts, 4) music as a second career, 5) music teachers, 6) amateurs who play as well, if not better than, the professionals" (p. 154-158). The orchestra I conducted included all the above, in addition to some high school musicians and some gifted young string players who took private lessons.

Adult novices, often people in retirement, choose to learn an instrument as part of their set of goals for an active post-employment lifestyle (Bowles, 1991, 2010; Bugos, 2010; Hallam et al., 2014; Jutras, 2006). Carol Echols (2014), a fellow teacher and musician, shared an experience she had as an instrumental festival judge:

> Several years ago, I was adjudicating for the National Piano Teachers Guild. My assignment was St. Louis, MO. One morning, as I was looking at my schedule for the day, I noticed the age of one of the piano students: 67 years old! He was going to perform a ten-piece college level program. When he came into the room, he

> was visibly nervous. I chatted with him for a few minutes hoping to help him calm a bit. He told me he had retired at age 65 after his life as a medical doctor. His retirement gift to himself was a 7' Steinway and piano lessons. He had never played before. He looked for the best teacher and found Jennifer Lim. She had one opening−8:00 on Saturday mornings. He took it and began his studies. He told her he was too old to memorize. She had him play three notes on the piano without a score in front of him. He did. Then she asked him to play the same three notes. He did. "There," she said, "you can memorize." This student practiced four hours a day and in one year had progressed through beginning, intermediate and was now playing advanced material. I encouraged him to publish his experiences. I don't know if he did. (Echols, 2014, p. 1)

In the example above, Echols shared the story of a senior who started as a novice player after a complete career in a different field. Many adults participate in what David Elliott (2005) referred to as *musicing*. Taking lessons or participating in a musical group provides the "playing-and-listening and performing-and-listening" (p. 7) elements of musicing. As I observed the community orchestra members from rehearsal to performance, I had many opportunities to wonder what unseen and undocumented benefits they derived from their participation. At the heart of this investigation was inquiry into music and cognition in senior adults. There is evidence to support the physical, emotional, and cognitive benefits of learning new skills throughout adulthood (Bugos, 2010; Clément, Tonini, Khatir, Schiaratura, & Samson, 2012; Coffman, 2002; Jutras, 2006). I wanted to focus on the cognitive benefits of playing piano, so I

concentrated on adult novices and the possible cognitive consequences of playing piano.

Benefits of Music Participation

There are well-documented mental, physical, and cognitive benefits resulting from participation in music as a senior adult. These benefits can be derived from something as passive as concert attendance (Bygren, Konlaan & Johansson, 1996), or more involved when individuals join in rudimentary music activities (Clément, 2012); learn to play an instrument (Bugos, 2010; Mitak, 2012, Parr, 1985); or participate in a community organization (Coffman, 2002; Deegan, 2006; Hall, 2001; Higgins, 2006). Identified benefits have ranged from simple enjoyment (Hallam et al. 2014), to measurable changes in brain structure (Gaser and Schlaug, 2003a, 2003b; Hudziak et al., 2014; Jensen, 2000; Pantev et al., 1998; Schlaug, Jancke, & Pratt, 1995; Schlaug et al., 1995; Wang, Xei, Zhu, Liu, & Dong, 2013).

Although benefits can be derived from each type of music participation, Elliott (2005) asserted that productive participation was much more significant than passive listening and said, "A person can be active and still get nothing done. Doing implies intention; the word activity alone does not" (p. 50). What is clear from the literature is that both researchers and participants believe active involvement in music has a positive effect on physical health (Tims, 1999); mental health (Hallam et al, 3013); life satisfaction (Mitak, 2012, Deegan, 2007); and cognition (Bugos, 2010).

Life satisfaction and comprehensive cognitive function are significant concerns for the older adult population. The isolation caused by retirement, and a sedentary lifestyle can accelerate age-related brain decline (Chen & Feeley, 2013; Chimene, 1987).

Music participation has been identified as a powerful tool for senior adults wishing to maintain an active and healthy lifestyle (Jutras, 2006; Mitak, 2012; Parr, 1985; Thaut & Abiru, 2010; Vinkers, Jacobin, Stek, Westendorp, & Vander Mast, 2004). Music participation can also encourage social connections, increase cognitive activity, and promote physical movement, and these three elements are associated with life satisfaction in seniors (Jutras, 2006). Creating opportunities for social and mental stimulation could possibly benefit seniors both cognitively and emotionally. Because music study and music participation are being used to help people who show signs of physical and cognitive decline, I wondered if musical activity could improve or stimulate brain function in senior adults who are not yet experiencing a severe cognitive decline.

Although adult novices are the main focus of this study, there are adults who studied piano as a child and ceased piano lessons as they get older. In an examination of cognitive function and piano playing, this could be a moderator variable. Researchers have identified brain structure changes in children who study music before the age of 18 (Hudziak et al., 2014, Schlaug, Jancke, Huang, Steiger & Steinmetz, 1995; Wang, Xei, Zhu, Liu &, Dong, 2013). Examining the study results, researchers discovered increased connections between the brain's right and left hemisphere, and increased development of the cortex. Hudziak et al. (2014) identified changes in the brain's emotional regulatory regions when students were exposed to music study. If the earlier brain development is different for a child who participates in musical studies, then there is a question as to whether those changes will impact the same subjects as older adults.

Chang, Wray, and Lin (2014) proposed a model that involved social relationships and leisure activities as contributors to physical health and psychological well-being. This study was not specific to music leisure activities. Music as a leisure activity is only one part of a broad spectrum of approaches to music. Park (1995) defined six levels of adult amateur musicians ranging from adult novices to amateurs who played at the professional level. It should be noted that the former is a leisure activity, and the latter is not. Stebbins (1997) classified music as a serious leisure activity while Juniu, Tedrick, and Boyd compared and contrasted music as profession and music as leisure. Bugos (2010) and Seinfeld, Figueroa, Ortiz-Gil & Sanchez-Vives (2013) reported that music participants experienced larger increases in cognitive function when compared with participants in other leisure activities.

Chang, Wray and Lin examined data on 2,965 older participants to determine if leisure activities mediated the link between social relationships and health. The researchers concluded that leisure activities do strengthen the link between social relationships and health in these age groups. Chen and Feeley (2013) also examined the relationship between social support and health in senior citizens. In both studies, the researchers identified support for strong ties between social connections, leisure activities, mental health and physical health. Specific to the piano, the focus of this study, Taylor (2011) cited amateur keyboard playing as a means for personal growth, self-fulfillment and life satisfaction in senior adults. In documenting interviews with 21 older novice musicians, Taylor reported that amateur musicians who played piano keyboard reported a sense of "choice and control," a "musical identity" and ongoing support (p.

352). These elements are linked to physical and mental health and positive quality of life in senior adults.

Evaluating Brain Function

Sahakian & Owen (1992) and Owen (1993) collaborated with university computer specialists at the MRC Cognition and Brain Sciences Unit, Cambridge UK in order to create an evaluation system for four key cognitive functions: attention, short-term memory, planning, and verbal reasoning. Because specific parts of the brain control attention, memory, planning and verbal reasoning (McDonald, 2014), Sahakian and Owen designed the CANTAB to evaluate cognitive function in those specific four areas. Researchers have reported that there is evidence that music study alters brain anatomy (Hudziak et al., 2014, Schlaug, Jancke, Huang, Steiger & Steinmetz, 1995; Wang, Xei, Zhu, Liu &, Dong, 2013). Therefore, I wanted to determine whether piano study would affect three of the four areas evaluated in the CANTAB: Attention, Memory, and Planning.

What Is Cognition?

Brandimonte, Bruno, and Collina, (2006) pointed out that the word cognition is historically used in two ways. The first way is a "process: cognition as something that humans do. The second is a product: cognitions as mental representations that surface to consciousness when we perceive, reason, or form mental images" (p. 2). I will use the first definition in this paper. The process of cognition has two main parts. The first part is the way in which individuals understands and look at the world. The second part is how individuals respond to the world based on their understanding. Cognition is responsible

for nearly every human action and interaction.

What is Cognitive Ability?

Cognitive ability refers to how well we learn, remember, problem-solve, and pay attention. Cognitive ability is not knowledge, but instead is a response or action based on prior knowledge and present stimulus. For example, playing the piano involves perception (seeing the piano), decision making (deciding to play and selecting what to play), motor skill (playing), language skills (interpreting music aurally or through markings), and social skills (performing for others or playing with others). Cognitive ability and cognitive skills are supported by specific regions of the brain and the connecting neuro and muscle networks (Flohr & Hodges, 2006, Hodges, 1999).

In a report about music study and cognition, Flohr and Hodges (2006) pointed out that cognition involves much more than the brain. True cognition involves all the "nerve fibers and receptors sending information to the brain and the muscles and fibers which take messages from the brain" (p. 8). Studying and playing a musical instrument requires interactions between the mind, brain, and body (p. 10).

Conceptual Framework

There are connections between piano playing and three of the cognitive functions that decline as a result of aging: attention, short-term memory, and planning (Palmer, 2005; Altenmüller & Gruhn, 2002). Multiple areas within the brain are affected by piano playing. The motor cortex controlling the fingers enlarges in response to piano finger exercises (Flohr & Hodges, 2006; Pascual-Leone et al., 1995). A pianist's brain is focused intently on the motions necessary to execute a piece of music. In addition,

pianists are busy planning how to use their fingers to play the notes in front of them most effectively (planning). As a pianist begins to notice subtle differences in note patterns (attention), cognitive action takes place in the frontal lobe (Flohr & Hodges, 2006; Altenmüller & Gruhn, 2002). Piano playing also requires motor and executive memory functions as players recall short phrases (memory) (Flohr and Hodges, 2006; Altenmüller & Gruhn, 2002; Tramo, 2001).

Even when the music is in front of the player, memory is involved so that finger placement becomes instinctual (Lehmann, Sloboda, & Woody, 2007). During all the previously-mentioned activities, the pianist's occipital lobe is involved in interpreting musical symbols and directions. The occipital lobe is connected with interpreting language symbols and verbal reasoning because it connects the optic nerve to the cerebellum (Loritz, 2002). With piano playing, music participation is embellished by using both the right and left hands and reading two lines of music. Coordinating symbol interpretation with right and left hand motion stimulates both halves of the brain (Jensen, 2000; Pallesen et al, 2010; Tramo, 2001).

Playing the piano stimulates the brain as various cognitive processes perform together and separately (Tramo, 2001). Although the cognitive filtering for melody, rhythm, harmony, form, dynamics, and timbre occur separately, neurological communication between all areas of the brain enable a person who is learning music to process all the musical information simultaneously (Tramo, 2001). Researchers are aware that changes in the brain take place as a musician practices and performs. The motor cortex controlling the fingers enlarges in response to piano finger exercises (Flohr and

Hodges, 2006; Pascual-Leone et al., 1995).

"Doing music" (Elliott, 1995) is the sheer embodiment of cognition. Recall the two parts in the definition of cognition above: the way in which an individual understands and looks upon the world and how individuals respond to the world based on their understanding. When a student or professional musician "does music," then the body of their personal experience is imposed on the process. Elliott said "to perform music is to act thoughtfully and knowingly" (p. 50). As a student pianist progresses, their focus moves from hand placement, to rhythm, to expression, and finally extrinsic and intrinsic meaning. Their attention changes, they begin to plan how they will perform the piece of music, their short-term memory is influenced by previous musical experiences and patterns, and they interpret musical symbols in a way that is meaningful to them.

Attention or **focus** is the ability to filter outside distractions and focus on the details of a task or conversation until it is completed. Normally a person cooking dinner while the TV is on or the phone rings would only be momentarily distracted and then resume the task without confusion once the interruption ceased. Another example of focus is reading a road map and choosing the visual information that is important for answering a specific question (such as, how do I get from my parents' house in Catskill, NY to Innesfree Garden in Millbrook, NY?). A map contains much more information than a person needs in order to find a location. Attention means sorting out visual or auditory information and focusing on what is pertinent to a particular situation.

When people play music, their focus changes often (Chaffin et al., 2002). Attention frequently shifts back and forth between general artistic decisions (such as

phrasing and dynamics) to specific actions, (such as how to touch the keyboard and what finger sequence will be used). A novice will spend more focus time on individual actions, such as finger patterns. A professional who is more familiar with patterns, will likely devote more attention to artistic decisions (Lehmann, Sloboda & Woody, 2007). The more experienced the piano student/player, the more easily the individual can manipulate their focus in order to successfully perform a musical work.

Short-term memory is memory that is concerned with immediate conscious perceptual and linguistic processing. An example of short-term memory would be to look at a sequence of numbers and then a short time later to remember them well enough to write them down. Lehman, Sloboda, and Woody (2007) called this "chunking" and pointed out that short-term memory relied on previously stored information to apply learned patterns to new situations (p. 112). In daily life, this might mean remembering a phone number (such as the last four digits being 4416…four times four is 16). In music, this can be done aurally or visually by breaking music down into recognizable fragments (such as part of a scale) or even finger patterns that have been used in another piece. Information that is organized in a pattern that is recognizable to the individual will be easier to retain in short-term memory (Halpern & Bower, 1982).

Planning is the process of thinking about and organizing the activities required to achieve a desired goal. For instance, when a person fries zucchini, there is a sequence that must be followed precisely. If the cook fries the zucchini first, then the batter is pointless. Newell and Simon (1982) stated that cognitive planning involved thinking forwards from the given information on a problem and backwards from the goal. In short, cognitive

planning is a series of connected problems. In music, particularly piano music, there are many things to consider when planning an approach to a musical work. For the novice piano player, appropriate finger placement (and even starting on the correct finger so the player does not run out of fingers in a crucial place: for example, a pianist who needs to play G, A, B, C and D with the right hand will need to start with the right thumb so they have five fingers for the five notes) is essential. However, playing music involves a lot more than correct notes. Included in the planning process are essential questions about rhythm, tempo, dynamics, articulation, and how strict the tempo will be. These are segments of the process a player goes through when planning to play a piece of music (Chaffin, Imreh, & Crawford, 2002).

Need for the Study

It is estimated that, by 2030, one in five Americans will be over 65 (Coffman, 2002; He, Sengupta, Velkoff, & DeBarros, 2005; West, Cole, Goodkind & He, 2010). Currently, senior adults in the United States have more years of education and are more culturally and ethnically diverse than previous generations (Coffman, 2002; He, Sengupta, Velkoff, & DeBarros, 2005; West, Cole, Goodkind & He, 2010). Seniors are healthier and living longer, so they are looking beyond the basics such as physical survival, nutrition, and financial and personal security (Mitak, 2012).

In addition to having educational background, financial resources and personal time to spend on new activities, seniors are concerned about the quality of their extended lives (Coffman, 2002; He, Sengupta, Velkoff, & DeBarros, 2005; Slater, 1995). Coffman (2002) reported that there was increased focus “on improving the quality of life for older

adults instead of merely trying to extend the quantity or length of life" (p. 76). Slater (1995) admonished that stereotypes about what seniors are capable of often hinder programs designed to engage seniors in activities that will enhance their quality of life (social contact, educational experiences, playing music) (p. 97).

Many senior adults really want to play music (Bowles, 1991; Coffman, 2002; Cooper, 2001; Hallam et al, 2013). Further, a large number of those seniors who want to play music express interest in playing the piano (Bowles, 1991; Cooper, 2001; Hallam et al, 2013; Hanna-Pladdy & MacKay, 2011). Detailing their reasons for playing piano, seniors reported improved personal skills and aesthetic pleasure (Cooper, 2001). Cooper also reported that 78% expressed that they enjoyed practicing because it was relaxing and promoted a feeling of accomplishment.

Although there is a growing body of research focused on music as an intervention for those with cognitive deficits and for seniors in cognitive decline (Hodges, 1999; McIntosh, Brown, Rice, & Thaut, 1997; Thaut, 2010; Whitall, McCombe, Silver, & Macko, 2000), there is little information published regarding the effect of piano study on brain function in senior adults who are not in serious cognitive decline. Measuring specific cognitive functions such as attention, short-term memory, and planning could provide detailed insights into possible cognitive changes older adults experience from playing the piano. A study focusing on seniors who play piano could provide useful information to those who work with senior adults and also to those who study cognitive changes that are a result of normal aging.

Purpose

The purpose of this study was to examine whether exposure to a 6-week piano class would have an impact on specific cognitive functions (attention, planning, and short-term memory) in senior adults. In addition, I aimed to determine whether the cognitive function of participants who studied piano as children would differ from those who did not.

Research Questions

I focused on two research questions:

- Is there a significant difference between the CANTAB scores of senior adults who participated in six weeks of piano class and those who did not?
- Is there a significant difference between the CANTAB scores of senior adults who studied piano before the age of 18 and those who did not?

CHAPTER TWO

RELATED LITERATURE

Although there are many studies focused on music and brain function, it is a relatively new research area. The studies mentioned in this chapter represent diverse research communities with a common curiosity about music and brain function. I will first discuss studies concerning music and brain development. I will then describe research focused on the aging brain: what discoveries have been made about music and cognitive function, what scientists are concluding based upon these studies, and how a study of aging adults engaged in piano playing can contribute to the dialogue. Finally, I will discuss the four cognitive areas evaluated by CANTAB and explore their possible relationships to piano study.

It is important to recognize that there has not been a causal relationship established between music study and altered brain anatomy or enhanced cognition. Gruhn and Rauscher (2006) pointed out that researchers have at best discovered a correlation between music study, brain anatomy and cognitive function:

> It is also not clear in these studies whether the morphological effects were caused by the music instruction. Studies that compare musicians to non-musicians are correlational, not causal. They therefore do not address whether differences in brain structure between these two groups of subjects are a function of the music exposure or of inborn atypicalities in the brains of musicians that may attract them to music making in the first place. Clearly, longitudinal causal studies are needed to investigate the maturation of cognitive abilities and brain regions before and

during early versus later onset music instruction. It is important to note that no scientific studies have directly investigated the effects of music instruction on the adult brain. We must be careful not to ignore the fact that brain development continues until death (p. 53).

Music and Cognition

There are many studies concerning possible links between music learning and improved cognitive function. There have also been several discoveries related to music study and brain structure (Hudziak et al., 2014; Jensen, 2000; Pantev et al., 1998; Schlaug, Jancke, & Pratt, 1995; Schlaug et al., 1995; Wang, Xei, Zhu, Liu, & Dong, 2013). One purpose of the current study was to examine the possibility of a relationship between piano study before the age of 18 and cognitive function in older adults; therefore, I will begin by discussing the effects music study has on the development of the young brain. Additionally, the differences between the brain structures of musicians and non-musicians will be addressed. Because the primary focus of this study was to discover if there is a link between piano study and cognition in senior adults, I will share research related to the impact of music exposure and study on the adult brain. I will then highlight some studies that identified piano playing as a means of improving cognitive function.

Music and brain development. Researchers identified unique brain changes in children who studied instrumental music (Hudziak et al., 2014; Jensen, 2000; Pantev et al., 1998; Schlaug, Jancke, & Pratt, 1995; Schlaug et al., 1995; Wang, Xei, Zhu, Liu, & Dong, 2013). More specifically, the musician's youth and frequency of practice affected

how extensive the changes in the brain's structure were (Jensen, 2000; Schlaug, Jancke, & Pratt, 1995).

In collaborative work examining the size of the cerebellum, Schlaug, Thangaraj, Edelman, and Warach (1998) compared the brains of musicians and non-musicians. Musicians' cerebellums were five percent larger than those of non-musicians. Schlaug et al. concluded that the many years of finger exercises contributed to additional nerve growth. In other studies associated with brain development and music, researchers (Elbert, Pantev, Weinbruch, Rockstroh & Taub, 1995; Schlaug et al., 1995) discovered that the corpus callosum in musicians who played instruments requiring the use of both the right and left hand was up to 15 percent larger than non-musicians. Both research teams pointed out that the degree of difference in the corpus callosum size appeared to be directly related to how young the individual was when musical instruction started. The younger the student was when music instruction started, the lager the corpus callosum (if the student continued to study music).

Another skill that appears to be more easily acquired at a young age is perfect pitch. Perfect pitch is the ability to identify or recreate a musical tone without the benefit of a reference tone. Jordain (1997) discovered that 95 percent of students who studied music from the age of four or younger had perfect pitch, but only five percent of students who began music study after the age of twelve had perfect pitch. This indicated, as with many educational stimuli, that early kinesthetic, aural, and visual training had a lasting impact. There is a possible correlation between early music study and perfect pitch, but causality would be difficult to establish because it is not known whether the students in

Jourdain's study had perfect pitch before they began music instruction (Gruhn & Rauscher, 2006). In addition, how this preliminary development affects the brain later in life is still in question. Granted, I attempted to show causality when I designed a study that links piano playing and improved cognition; however, causality is virtually impossible to prove given all of the unaccounted for variables inherent in human behavior.

Music and the aging brain. When it comes to overcoming the physical and mental challenges inherent with learning an instrument as an adult, the desire to learn an instrument often takes precedence over the age of the individual participating in instrumental lessons. Although adults generally do not learn musical tasks as quickly as children do, researchers have reported positive results with respect to seniors' abilities to learn new musical tasks (Bee, 1996; Cavanaugh, 1997). Additionally, the brain changes that happen as a result of playing an instrument at a young age may not be a strong factor affecting an adult student's ability to learn piano. (Belgrave, 2014; Bygren, Konlaan, & Johansson, 1996; Gibbons, 1993; Hall, 2002; Jutrus, 2006; Mitak, 2012; Parr, 1985) Previous experience playing the piano can be helpful as adult students began to play again, but those who have never studied piano are able to learn as an adult (Belgrave, 2014).

Benefits. Musical activities, including instrumental study, have been explored by researchers as possible interventions for cognitive decline. Bugos, Perlstein, McCrae, Brophy and Bedenbaugh (2007) employed "individualized piano instruction as a potential cognitive intervention to mitigate normal age-related cognitive decline in older adults" (p.

465). In the study, Bugos et al. concluded that there was evidence to support the use of music as an effective intervention for age-related cognitive decline in the areas of attention and concentration, which aid short-term memory (p. 469). The authors emphasized that the cognitive benefits were not sustained when practice and lessons were discontinued.

In a later study, Bugos (2010) identified word fluency as an area that was helped by piano instruction and music listening. Comparing the effects of piano instruction with the effects of music listening instruction, Bugos discovered that both piano students and active listening students experienced significant gains with regard to scores for executive function. Bugos expressed surprise because the posttest results for executive function were similar for participants who played piano and for those who listened to and studied music. Bugos theorized that more training might have widened the cognitive gap between listeners and players, and that the limited sample along with the short practice time may have affected the results. Bugos further discovered that participants in the piano study group showed significantly higher posttest scores for verbal fluency while the music listening group did not. Bugos speculated that auditory "chunking strategies reflected in sequences and repetitions inherent to musical training may have contributed to these results" (p. 6). This is a good incentive for additional research with longer and more frequent instruction (Bugos, 2010).

Seinfeld, Figueroa, Ortiz-Gil and Sanchez-Vives (2013) reported that the relationship between piano study and cognitive function was not as clear as Bugos (2010) found. In a study comparing piano study to other forms of leisure activity (cooking,

reading, museum attendance), the researchers found that the hypothesis that the piano learners would increase their performance in cognitive domains was "partially supported," and that the hypothesis that there would be an improvement in "mood, subjective well-being, and quality of life was also partially supported" (p. 8). The authors used the term "partially supported" because posttest scores for one type of tests were significantly higher, while posttest scores for a second type of test measuring similar cognitive function were either not significantly different or were significantly lower than the pretest. An example of this is the "digit span" test. Participants in the piano group remembered fewer digits in the posttest when compared with their score for the pretest (p. 1). Comparison between piano participation and other forms of leisure determined a slightly stronger connection between piano playing and cognitive function than there was between other leisure activities and cognitive function.

In an extensive study called the *Music for Life Project*, Hallam et al. (2014) explored the benefits older adult amateur musicians derived from participating in musical learning. In a study with 398 participants who took music classes for nine months, Hallam et al. collected data through surveys, individual participant interviews, focus groups, and class video observations. The participants reported that they enjoyed being challenged, felt the positive effects from the mental and physical stimulation, and expressed that their emotional and physical well-being improved (Hallam et al., 2014, p. 3).

Three cognitive areas

In this section I will discuss the cognitive skills evaluated by the CANTAB and how they relate to piano playing. The three cognitive areas I focused on in this study were attention, short-term memory, and planning. All three of these areas are related to piano playing (Flohr & Hodges, 2006). It is important to point out that each of the three cognitive areas can be controlled by more than one section of the brain (Flohr & Hodges, 2002).

Attention. Styles (2005) defined attention as "the selection of a subset of information for further processing by another part of the information-processing system" (p. 5). Researchers often use attention, focus and cognitive control to mean the same thing. Attention is a "pool of resources" (p. 6) that can be focused on one thing or "divided between cognitive tasks" (p. 6). Styles concluded that the many kinds of attention could be broken into two sub sets. The first is attention for perception and the second is attention for action (p. 5). In this section I will first discuss attention for perception and attention for action. I will then discuss studies involving music and attention.

Attention for perception is focusing on an object, symbol, or sound to determine what it is and what its function might be (Styles, 2005). Attention for perception requires no action. It is simply a means of identifying something. For example, last night I heard a clunking sound as I lay in bed. I began to pay attention to the sound and realized that it was my cat climbing onto the window sill behind the wood blinds covering the window. The clunking was the wood binds bumping against the wall as the cat got behind them.

My attention went from a broad, subliminal awareness of my surroundings as I read a book to a narrow focus as I became aware of a sound I didn't recognize.

Attention for action first requires perception and then an action related to that perception (Styles, 2005). Imagine sitting in an orchestra horn section. During rests, a player perceives the beat by paying attention to the conductor and listening to the other instruments play. The player also perceives that there are eight measures of rest in common time, so counting is required in order to begin playing at precisely the right spot.

The complexity of cognitive focus and also the intricacy of the brain cause an interesting phenomenon once we have learned how to do something. The more advanced an individual becomes at a particular task, the less cognitive resources it takes this person to perform a task (Chaffin & Imreh, 2002; Lehman & Davidson, 2006). Beginning piano players focus on hand placement, fingers playing each note, and basic rhythm. A more advanced student or professional pianist no longer focuses on details that are so important to a beginner. An advanced player concentrates on musical interpretation and style. The details that take most of the perception and attention resources for a beginning pianist will take very little resources from a more advanced player, who has unconsciously placed those fundamentals into procedural and motor memory. Advanced players do not play everything automatically, however. Lehman and Davidson (2006) discussed the variable attention advanced players use in their approach to performing a piece of music:

> The performer cannot at all times be aware of every performance aspect—this would overload human information-processing capacity. However, the mental representation of the piece should be such that the performer can switch between

> levels of consciousness, going from an unfocused and quasi-automatic "letting the music flow" to a conscious attention to specific expression or note sequences. Being able to step back but also zoom in on detail if necessary is a desired state of mastery that differs from the novice's possibilities (Lehman & Davidson, 2006, p. 233).

Attention, according to researchers, requires perception and memory in order to be successful (Styles, 2005; Lehman &Davidson, 2006). It also requires discernment so that an individual can decide which visual and auditory information is important (Lehman & Davidson, 2006). However, the primary question about attention for the present study is whether or not learning to play piano improves attention in senior adult learners.

Research concerning music study and attention. There is growing evidence that there is a correlation between studying music and elevated cognitive focus (Patston, Hogg, & Tippett, 2007; Pallesen et al, 2010). In studies comparing focus and reaction time between musicians and non-musicians, musicians displayed a clear advantage, even in tasks that were not related to musical skill. In this section I will review some of those studies.

Bugos (2010) reported that individuals who studied music had a significant improvement in cognitive control (attention) between pretest and posttest tasks. Treatment subjects were divided into three groups. One group participated in a music appreciation class; a second group participated in piano lessons, and a third group was the control group with no treatment administered. The three groups were matched in intelligence and aptitude, and there were no significant difference among the pretest

scores of all three participant groups. The groups that took piano lessons and music appreciation class both had significantly higher cognitive control (attention) posttest scores when compared with the control group (p. 5).

The BOLD response. During tasks that require attention, the brain directs more oxygen and to the area of the brain needed for the action. This is called that blood oxygenation-level dependent (BOLD) response (Ogawa, Lee, Kay, & Tank, 1990). The BOLD response is measured by fMRI. In a musical study measuring working memory and attention in musicians and non-musicians, Pallesen et al (2010) determined that musicians had a "clear advantage" (p. 1). Pallesen et al discovered that musicians had a significantly larger blood oxygenation-level dependent BOLD response than non-musicians when asked to do the same attention or working memory task. In addition, musicians had significantly faster reaction times and accuracy than non-musicians.

Bilateral. In tasks related to visual attention, right-handed people tend to perform more accurately on activities located on the left side of their visual field (Patston, Hogg, and Tippett, 2007). Error rates elevated as the focus approached the mid-line and became even higher as the focus is located in the right portion of the visual field. There is evidence that music study improves bilateral attention. The authors determined that musicians performed attention tasks more accurately on right-sided stimuli than non-musicians. There were 20 musicians and 20 non-musicians in the study, and participants were all right handed. The musician participants all had been studying music at least eight years, and the majority of them played piano. Participants were asked to perform attention tasks on the left side, mid-line and right side of their visual field. Because piano

playing involves reading two lines of music and playing with both the right and left hand, dominant and non-dominant areas controlling hand movement in the brain are more symmetrical in musicians who use both hands equally (piano players). In non-musicians, the dominant side is larger (Schlaug et al., 1995). Musicians had faster reaction time and performed more accurately on mid-line and right side tasks than non-musicians. Patston, Hogg, and Tippett (2007) asserted that this was evidence that previous research regarding brain anatomical changes related to musical study (Schlaug et al, 1995; Gaser and Schlaug, 2003a, 2003b) was supported by changes in neurological and cognitive performance.

Cognitive control (focus/attention) and memory are linked (Ward & Patrick, 2007). Pianists discover that, once a finger pattern, such as a scale, sequence, or arpeggio is learned, then the pattern becomes one unit. This act links attention and memory because when a pattern is committed to memory, then the player's focus can be directed elsewhere:

> Larger perceptual spans point to larger chunks in memory, which means that the players can devote more attention to the solution of other performance problems, for example, reassuring themselves of unclear passages or planning fingerings and jumps (Lehman &McArthur, 2002, p. 139).

Memory

Modern memory theorists break memory down into three parts: encoding, storage, and retrieval. Encoding memory is turning information into mental representation that can be stored. Storage is maintaining the mental representation for a period of time.

Retrieval is accessing stored information for use in a new situation (Miller, 2014, p.92). Discussing memory by itself in this section is not meant to mislead the reader into thinking that memory is disconnected from other cognitive processes. Both long-term and short-term memory work together to form cognitive architecture that focus and planning are connected to. Gaining insight into short-term memory requires an awareness of active thought. Whatever an individual is thinking about in a given moment requires short-term memory (Martinez, 2010). In the following section I will discuss a historical model for memory and then focus on short-term memory and how it is beneficial for the piano student.

Modal Model. Although the modal model, also called the Multi-store concept (Atkinson & Shiffrin, 1968) is an older theory and isn't used any more, it is beneficial to start a discussion about memory with the modal model because many contemporary memory theorists use components derived from it (Miller, 2014). In the modal model, memory was divided into what was described as three different "work stations" (Miller, 2014, p. 91). Information is obtained either visually or aurally and encoded in a process called sensory memory. This information is then stored in short-term memory (often called working memory) where "small amounts of information are stored in a highly available state" (p. 91)). Short-term memory can be enhanced by rehearsal (such as repeating internally what is needed in a particular instance). Some information in short-term memory is used and then forgotten (such as needing a pencil from the next room and getting a pencil), and some are then stored in long-term memory for future use (such as directions to school from your residence). Information stored in long-term memory can

then be retrieved and sent to short-term memory in order to be easily accessed during a time of need (such as while driving to school).

Multi-store Model

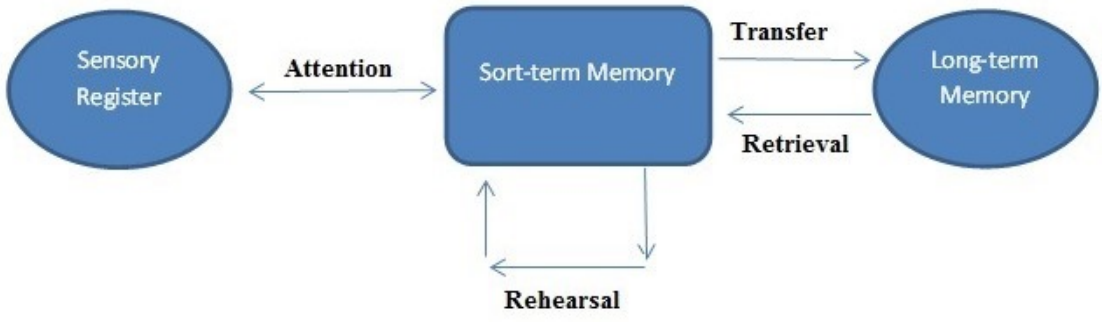

Figure 1. In the Multi-store model, sensory information is gathered and sent to the short-term memory. The information may be kept in short-term memory and rehearsed for immediate retrieval, it may be lost, or it may be directed to long-term memory for future use (Illustration based on information from Atkinson & Shiffrin, 1968, p. 37).

There is evidence that long-term and short-term memory are different cognitive systems that rely on separate areas within the brain. Researchers who studied subjects with damage to the parietal and temporal lobe discovered that those subjects had impaired short-term memory; however, their long-term memory function remained intact (Vallar & Popagno, 2002). Observing that the systems are separate is helpful in studying memory; however, Miller (2014) pointed out that the modal model is not used by the contemporary memory theorist because there are too many memory characteristics that fall outside of the rigid structure of the modal model. For example, "meaningful events are more memorable," and new information containing patterns that have been committed to long-term memory are also more easily retrieved from short-term memory (p. 91).

Consequently, theorist began to realize that Atkinson and Shiffrin's model was not comprehensive enough.

A word about short-term memory and working memory. Many theorists use the terms short-term memory and working memory and don't distinguish between them (Inglis, 2014; Baddeley, 2012). Some theorists use short-term memory and working memory as different words with the same definition while others identify working memory as a component of short-term memory (Inglis, 2014, p. 48). Inglis identified short-term memory as "storage without manipulation" and working memory as "storage with manipulation" (2014, p. 48). Baddeley (2012) reiterated this definition. An example of this distinction is playing a line in music for the second time (short-term memory), and then experimenting on the passage with varied dynamics, articulation, and rhythm (working memory). Using these definitions as a blueprint, what the CANTAB memory test actually evaluates is short-term memory, or memory without manipulation.

Contemporary Theories. Contemporary memory theorists have attempted to create a lasting model for memory; however, Miller (2014) concluded that a universally accepted memory theory does not exist. Miller further pointed out that events and impressions with mundane qualities versus those with meaningful qualities have an effect upon memory because individuals are more likely to remember events with meaning. In addition, not every individual remembers things in the same way, and the linear fashion outlined in Atkinson & Shiffrin's (1968) modal model no longer fits with what researchers know about memory. Baddeley and Hitch (1974, 1994) expanded the modal model and outlined the multi- store concept to elaborate on short-term memory function.

The multi store concept has been used as a foundation for many contemporary memory theorists.

Baddeley and Hitch's Memory Model. Baddeley and Hitch expanded Atkinson & Shiffrin's (1968) ideas about short-term memory and proposed the three component system (1974) to describe short-term memory function in more detail. Expanding on what Atkinson & Shiffrin (1968) called sensory memory, Baddeley and Hitch (1974) theorized that, rather than short-term memory being a single "holding tank," the information in short-term memory was "a system of sub components geared to handling specialized information, including (but probably not limited to) word sounds and visual-spatial information" (Miller, 2014, p. 92). Baddeley and Hitch determined that short-term memory was different from long-term memory, there were different short-term memory functions based upon the type of information that was being committed to memory, and that short-term memory storage was distinct from short-term memory retrieval (Baddeley and Hitch, 1974).

Baddeley and Hitch referred to the visual component of short-term memory as the *visuo-spatial sketch pad* and the auditory component of short-term memory as the *phonological loop* (1974). Baddeley and Hitch found that auditory memory was stored and retrieved differently than visual memory. Specialized components are governed by another mechanism called the central executive (Baddeley & Hitch, 1974; Baddeley, 1983). Baddeley and Hitch believed that the central executive was responsible for coordinating the information in the visuo-spatial sketch pad and the phonological loop.

The visuo-spatial sketch pad. Baddeley (1983) asserted that short-term memory relies on coding and characteristics, not meaning (p. 316). Baddeley described it as the formation of a picture in the "mind's eye" (p. 318). In addition, the mind looks for patterns that are familiar. In this way, short-term memory and long-term memory are linked.

Baddeley and Hitch's Model for Short-term Memory

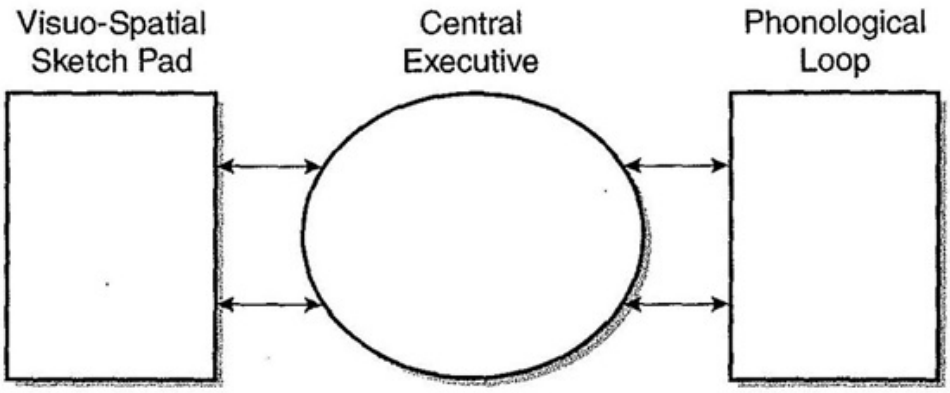

Figure 2. In Baddeley and Hitch's short-term memory model, the central executive governs what information is either stored or retrieved from the visuo-spatial sketch pad and the phonological loop. It also determines what is sent to long-term memory (Baddeley, 1992, p. 557).

Another discovery about the visuo-spatial sketch pad is that brain regions associated with sight are activated along with memory regions of the prefrontal cortex when short-term memory is accessed (D'Esposito, 2007). In a very real way, the individual is actually seeing a coded picture of the object or symbol to be remembered and utilized.

The phonological loop. In a way that is similar to the visuo-spatial sketch pad, the phonological loop stores information as patterns (Baddeley, 1983). Baddeley and Hitch

described the phonological loop as a "modular system comprising a brief store together with a means of maintaining information by vocal or sub-vocal rehearsal" (Baddeley, 2012, p. 7). Rehearsal is the repetition of a word or phrase with the goal of remembering it. An example would be repeating driving directions to your-self either out loud (vocal) or silently (sub-vocal). The auditory regions within the brain are activated along with areas of the prefrontal cortex associated with short-term memory. An individual can "hear" a song or a voice in their head.

The central executive. The central executive is the most complex and also the most difficult to conceptualize (Baddeley, 1983; Baddeley & Hitch, 1974, 1994; Miller, 2014). Baddeley (1983) described the central executive as a "limited capacity attentional system" (p. 315). This system sorts through the information temporarily stored in the visuo-spatial sketch pad and the phonological loop in order to organize and recall information as it is needed. It is capable of "selection and control" (p. 315) and is a means of making sense of the coded information stored in the short-term memory. Baddeley himself was reluctant to discuss the central executive in depth, saying, "my reluctance to tackle the executive stemmed from two sources: first, its probable complexity, and second, because of the crucial importance of its attentional capacity" (Baddeley, 2012, p. 6). In this way, Baddeley conceded that the central executive involved focus and discernment in addition to being part of short-term memory processing. Baddeley (2012) asserted that the three component system model for short-term memory was a work in progress when it was presented and that it "is still not complete nearly 40 years and many publications later" (Baddeley, 2012, p. 6).

Nairne's Feature Model of Immediate Memory. Another theory of short-term memory was presented by Nairne (1988). Like Baddeley and Hitch, Nairne asserted that short-term memory was broken into different processes. In the Feature Model of Immediate Memory, Nairne proposed that there were two types of memory processing for short-term memory. The first was modality independent, or intrinsic. The second was modality dependent, or extrinsic. I introduce each of these types below.

Modality independent. Modality independent memory is memory stimulated by an "inner voice" (Nairne, 1988, p. 344). Nairne asserted that using the words inner voice could be misleading because the coding was nothing like speech. An example of modality independent short-term memory is recalling a feeling. This feeling isn't dependent upon speech, language, or movement.

Modality dependent. Modality dependent memory is dependent upon aural or visual coding, such as speech, written words, or demonstrated movement. Examples could be spoken directions, a written list of words, or a short section of a dance that a peer has demonstrated to a subject.

Nairne's Feature Model of Immediate Memory

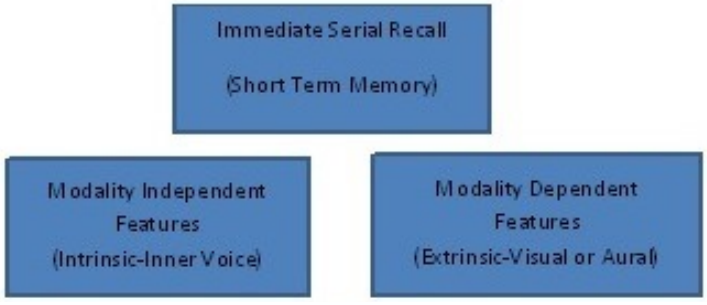

Figure 3. Rather than distinguishing between aural and visual, Nairne split sensory input into external and internal sources (Illustration based on information from Nairne, 1998, p. 344).

Short-Term Memory and Music Study

There is limited research associated with music and short-term memory. Research exists identifying music listening as a distractor when subjects are trying to perform a memory game (Baddeley & Hitch, 1994; Hjortsberg, 2009) or taking a reading comprehension test (Fogelson, 1973). Contrasting researchers' observations that music hinders performance when participants listen to music as they do a task (Baddeley & Hitch, 1994; Fogelson, 1973; Hjortsberg, 2009), Deems (2009) reported that participants who habitually listened to music while they studied scored higher on reading comprehension tests. Listening to music did not inhibit practice on a task, but when the additional pressure of evaluation was added, then music listening had a negative effect. This is different than focusing exclusively on music as an intervention that might produce added extra-musical benefits.

Chaffin and Imreh (2002) asserted that short-term memory is enhanced in those who study piano in a similar way to those who can remember letters more easily if those letters are arranged into words that they can read (p. 67). *Chunking* (Chaffin & Imreh, 2002), also called *clustering* (Woll, 2001) happens when letters are arranged into meaningful patterns such as words. The same thing happens when a more experienced musician recognizes a scale or arpeggio in music. Instead of treating each note as an individual unit, a musician treats the scale or arpeggio as a unit and thus that section is easier to recall in short-term memory (p. 68). In this way, long-term, motor and procedural memory can enhance short-term memory (p. 69). Conway (1991) argued that research on everyday memory "start[s] from the premise of prior, personally meaningful

knowledge on the part of the subject and attempt[s] to understand the nature of this knowledge" (p. 20). Things are easier to relegate to short-term memory when they are arranged into a pattern that has previous meaning as opposed to random arrangements of numbers or pitches (Chaffin & Imreh, 2002; Woll, 2001).

There is conflicting information about a link between verbal cognitive processes and musical cognitive processes (Patel, 1998; Williamson, Baddeley & Hitch, 2010). Patel (1998) suggested that "some aspect of syntactic processing is shared between [verbal and musical] domains" (p. i). Williamson, Baddeley, and Hitch (2010) stated that "findings support[ed] a limited degree of correspondence in the way that verbal and musical sounds are processed in auditory short-term memory"; however, there is also support for the converse argument that the two processes belong to separate domains (Deliège & Sloboda, 1997, p. 201). Because my inquiry was focused on whether music study could improve short-term memory, I sought literature related to music and short-term memory.

Pallesen et al. (2010) studied auditory working (short-term) memory by comparing brain function in non-musicians and musicians. The researchers recruited 10 participants with minimal musical training and 11 participants who were classical musicians. Both participant groups were presented with working memory tasks that were increasingly difficult. Although both the non-musicians and musicians rated the difficulty of the working memory tasks similarly, "the behavioral data revealed that musicians performed better than non-musicians in the auditory working memory tasks" (p. 5), indicating a correlation between music study and stronger memory performance. We

know, however, that correlation doesn't equal causality (see Gruhn and Rauscher, 2006).

Bugos et al. (2007) reported improved short-term memory in "musically naïve senior adults" when the treatment group received six months of piano instruction. The researchers administered neurological assessments as a pretest, then after six months of piano lessons, and then again three months after the lessons had ended. The research group determined that piano instruction improved short-term (working) memory and that the improvement was sustained three months after the classes ended. This study is similar to my current research; however, as is evident in this section, I wanted to locate a stronger definition of short-term memory. I approached this section with some questions concerning the nature of short-term memory, the relationship between short-term memory and working memory, and research concerning the relationship between short-term memory and long-term memory.

George and Coch (2011) "investigated a possible association between music training and improvements in working memory at both the behavioral and neural levels" (p. 1085). Using standardized behavioral tests and Electrophysiological (ERP) testing, the researchers determined that musicians performed better on the standardized tests for working memory and musicians also displayed more neural activity based upon the results from the ERP test.

The research is far from conclusive. Hutka (2015) studied musicians and tone-language (Cantonese) speakers and determined that "neither musicianship nor speaking a tone language was associated with a benefit to 'visual working memory'" (p. 101). It will be useful at this point to recall that Baddeley and Hitch (1974), in a model that

contemporary memory theorists use as a foundation (Miller, 2014), considered auditory short-term memory and visual short-term memory to be two different processes. It may be that music study improves auditory short-term memory and not visual short-term memory. The research in this area is still new.

Planning

Cognitive planning, as stated in the introduction in this paper, is the process of thinking about and organizing the activities required to achieve a desired goal. There are several theories about cognitive planning and the approaches that humans take to achieve individual goals. Schank and Abelson (1977, 1981) described planning as "a series of projected actions to realize a goal" (p. 70–71) and asserted that cognitive planning grew from memory and pre-determined scripts based upon an individual's previous experiences. Newell (Newell, Steier & Mitchell, 1996) defined planning as "thinking forwards from the statement about a problem and backwards from the goal of a problem." The name of the system and the theory was SOAR (State, Operator, And Result) (Newell, 1990). Some cognitive planning theorists (Orasanu & Connolly,1993; Zsambok & Klein, 1997) described *Naturalistic Decision Making* (NDM) and argued that individuals with successful cognitive planning skills had specific characteristics "(flexibility, speed, resilience, adaptability, boldness, and accuracy)" (Zsambok & Klein, 1997, p. 101). In this section I will discuss cognitive planning theories and how each could possibly relate to studying piano.

Schank and Abelson (1977, 1981) theorized that humans progressed towards goals using pre-determined scripts from past experience. The scripts used in daily life

were “highly structured and predictable sequences of actions” (Woll, 2001, p. 133). For example, if I am going to start my car, then I will put the keys in the ignition and then turn the key. Schank and Abelson (1981) said that scripts are “bundles of inferences about the potential occurrence of a set of events and may be structurally similar” and “involves expectations about the order as well as the occurrence of events” (p. 717). Thus, when I walk to my car, climb in, put the key in the ignition, and turn the key, I expect the car to start. Scripts can be flexible (maybe I opened my purse and put on my sun glasses before I put the keys in the ignition) or completely ritualized, such as a Japanese tea ceremony or a Catholic Mass (p. 717).

Scripts can lead to other scripts when the flow is disrupted (Abelson, 1981). For example, if I am driving to work I may have to take another route because of construction or an accident. I take a new route that I am aware of because of previous experience, or I look at a map for an alternative route, the map consultation in itself being a script that I have experienced in similar circumstances.

A piano student both creates and uses scripts during the process of learning to play. The scripts can be as simple as finding middle C (find the cluster of two black keys in the middle of the piano/keyboard. The white key to the left is middle C). The script will become more complex as a student advances. For example, when a student uses a previously learned finger pattern for a passage, they don’t have to think about each finger and each note. The passage is “structurally similar” (Abelson, 1981) to previously learned material, so the student relies on an order and finger pattern with an expectation of success.

Naturalistic Decision Making (NDM). Proponents of NDM (Orasanu & Connolly, 1993; Zsambok & Klein, 1997) argued that it was difficult to replicate real-life scenarios in the laboratory setting. Researchers in laboratory settings did not provide opportunities for real-life problem detection or for realistic job and organizational settings. Cognitive field research methods are the cornerstone of NDM so researchers can use task analysis to observe and study skilled planners. NDM and controlled experimentation are complementary approaches. NDM researchers provide the observations and models, and controlled experimentation provides the testing and formalization. NDM researchers identified four defining markers (Zsambok and Klein, 1997). The first was "an array of task and setting markers: flexibility, speed, resilience, adaptability, boldness, and accuracy" (p. 4).

The other three markers concerned the use of experienced decision makers (not naive subjects), the purpose of the research (real-life life context), and relevance of the setting, planning and decision making to the participant (not a random problem with only one solution (P. 4). The NDM process can be symbolized by a series of steps called recognition primed decision making (Lipshitz & Ben-Shaul, 1997):

The steps and evaluations in figure 4 take place very fast. Most NDM researchers focus on high stakes military and flight operation, so its relationship to piano study might appear tenuous at first; however, musicians must make split-second decisions more and more as they progress through their lessons. When presented with a piece of music, a student has much different goals playing it the first time in contrast with playing it at a performance. The characteristics of flexibility, speed, resilience, adaptability, boldness,

and accuracy are necessary for a student to successfully learn to play and perform at the piano.

Model of Recognition-primed Decision Making

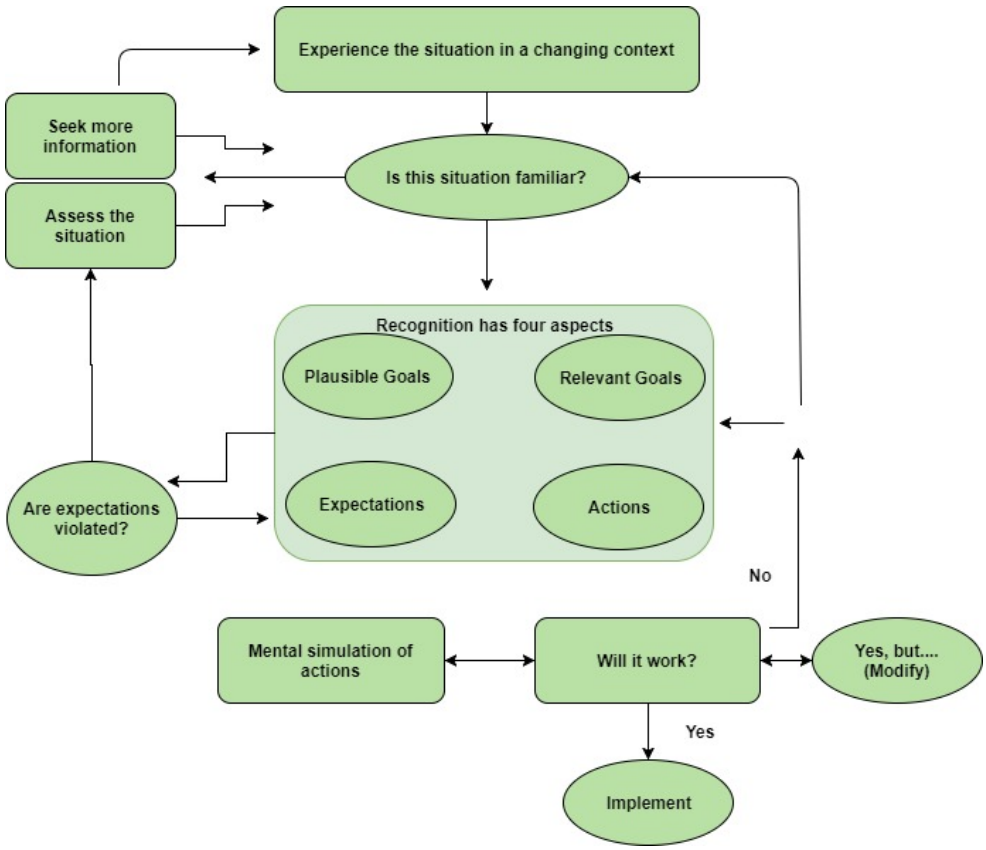

Figure 4. Recognition-primed decision making uses short-term memory, working memory, long-term memory, and focus in the process of formulating a logical sequence of thought and action (Lipshitz & Ben-Shaul, 1997)

Not all piano players take an analytical approach (Chaffin, Imreh, & Crawford, 2002) but some do sit and analyze the piece before playing it. One participant in a study conducted by Hallam (1995) said, "You spend most of your time delving into the reasons of it...I find I spend far more time in dealing with construction and analysis, and I learn quite a lot of my works without actually playing them" (p. 120). Other pianists use a

more “intuitive approach” (Chaffin, Imreh, & Crawford, 2002, p. 83) and work out issues as they play. Applying NDM theory to the contrasting planning styles pianists display, it may be that the intuitive players are faster at planning and making musical decisions. On the other hand, it may simply be a different means to the same end.

Summary. After researching short attention, term memory, and planning, it is apparent how interconnected these cognitive functions are. Planning is dependent on reasoning and is closely connected to memory. Memory is directly affected my attention and focus for determining what is important. Like music itself, dividing out the parts of cognition serves only to help understand the relationships that make each part the whole. Moving forward with a study on music and cognition is daunting because, despite what we know about cognition, we do not know very much.

CHAPTER THREE

METHOD

Study Setting

The study setting was a rural county in south-central Missouri. Government census indicated that there were 16.8 people per square mile in comparison with the state of Missouri, which averages 87.1 people per square mile. The study results cannot be generalized to the population over aged 65 in the United States, in part because there was a larger percentage of people aged 65 and older in the target county, and because the target population was over 90% white. According to the 2014 estimated census, the total United States population was 318,857,056. Seniors aged 65 and older comprised 15.5 percent of the total population, or 49,422,844. Almost 22 percent (21.8) of the target county's population for this study was aged 65 or older. This was a larger ratio of senior adults when compared to the national average as well as with the state of Missouri, which had a senior population of 15 percent. In addition, 24.1 percent of the target county residents had income below the poverty level.

Sampling

I sought volunteers using a newspaper article, a newspaper advertisement, a radio advertisement, a letter of invitation at the local senior center, and flyers distributed among the community banks, library, and stores. I asked for volunteers who wanted to learn beginning piano and who were not active musicians, although they could have taken music lessons as a child under 18 years of age. I also looked for participants who were aged 65 or older.

I held an informational meeting for those interested in participating in the study in my school district's elementary music room where the piano lab was located, and 19 people attended. I distributed an introductory letter describing the research. Because I am employed by the district, the letter also expressed that I had support from the school district administrators. I noted in the letter that a $10.00 concert ticket to a local event was available to study participants. Finally, I provided a telephone number for anyone with questions. During the informational meeting, I read the consent script (appendix C) and answered questions. Names were written on numbered pieces of paper (Numbered 1-40) and placed within a box. The numbers were used in place of participants' names in the study in order to retain anonymity. A colleague randomly drew names from the box for each treatment and control group. Unused numbers were set aside.

Because there were only 19 potential participants at the first meeting, I kept the start date flexible in order to have more time to recruit volunteers. After the initial meeting, unused numbers had an A, B, C, or D added to them and the papers were placed in individual envelopes. As more participants joined the study, they were read the consent script, and then they drew an envelope from the box and were assigned to the group letter (A, B, C, or D) in the envelope. This kept the groups A, B, C, and D as random as possible.

Instrument

The Cambridge Neuropsychological Test Automated Battery. "The Cambridge Neuropsychological Test Automated Battery (CANTAB)" tests (Sahakian & Owen, 1992; Owen, 1993) were a series of computer-based tests developed by

Hampshire and Owen during their time at the MRC Cognition and Brain Sciences Unit, Cambridge UK. The CANTAB tests are variants on paradigms that have been used for functional neuroimaging studies. These images show how cognitive processes such as short-term memory, planning, and attention are mediated by specific regions within the brain (a field known as 'brain mapping')" (McDonald, 2014, p2). CANTAB tests have also been used to investigate why some brain functions become impaired as a result of disorders such as Alzheimer's disease, Parkinson's disease, schizophrenia, and traumatic brain injury (Sahakian and Coull, 1993; Summers & Saunders, 2012).

Three brain function areas evaluated by CANTAB. CANTAB tests were designed to evaluate four areas of brain function: attention, short-term memory, planning, and verbal reasoning. Because my search of literature did not reveal a link between music study and verbal reasoning, I chose only to use the attention, planning, and short-term memory tests in this study (Sahakian & Owen, 1992; Owen, 1993). Each of these is described below.

Attention. In the CANTAB attention task, the participant views a series of pictures with slight differences where the sequence may not be obvious. For example, the participant may be presented with three pictures that are almost identical; however, each time the picture is presented, it is rotated clockwise a quarter turn and an additional small dot may be added to one square. The distraction is provided by the rotation and the variety of shapes and colors. Participants must decide if the answer provided is the next in the sequence (Sahakian & Owen, 1992; Owen, 1993).

Short-term memory. The CANTAB cognitive test for short-term memory is called the *Monkey ladder.* In the *Monkey ladder* test, the participant is shown boxes with sequential numbers (starting with 1, 2 and 3) that are not in order. After a brief moment, the numbers disappear, and the participant is asked to click on the boxes in numerical order (Sahakian & Owen, 1992; Owen, 1993).

Planning. The CANTAB cognitive test for planning is called the *Hampshire Tree Task*. This test measures the brain's ability to plan ahead. A tree-shaped frame will appear on the screen with nine numbered balls slotted onto the branches. Participants are asked to rearrange the balls so that they are slotted onto the branches in numerical order making as few moves as possible. Some balls are already in the correct spot, and some are not (Sahakian & Owen, 1992; Owen, 1993).

Challenges researching senior adults. Obstacles inherent to research with senior adults take many forms. First, attrition is often an issue with older participants. Transportation, health issues, family issues, death, and inclement weather all served as possible deterrents to successful completion of a study (Hofer, 2002; Rhodes, 2014; Davies et al., 2014). I planned a flexible schedule and allowed for opportunities to make up missed practice times. I also ascertained that everyone had reliable transportation.

Research Design

The study was a randomized Solomon pretest-posttest design (Dimitrov & Rumrill, 2003; Isaac & Michael, 1981). I chose to use the randomized Solomon design to check for practice effect; that is, to evaluate whether taking the CANTAB test two times (as in the pretest and posttest) would cause participants to have a higher score than

participants who only took the CANTAB once (as in posttest). The randomized Solomon design allows the researcher to evaluate separately the magnitude of effects due to treatment, maturation, history, and pretesting (Dimitrov & Rumrill, 2003, p. 160). I also tested for any effect that piano before the age of 18 might have on cognition.

Three tests from Cambridge Brain Trials were administered during this study. The CANTAB tests utilized measured four areas that have been linked to cognitive decline in seniors: Attention (Att), memory (Monkey Ladder: ML), and planning (Hampshire tree: HT) (Sahakian & Owen, 1992; Owen; 1993). Treatment Group A and control Group C completed the CANTAB pretest and posttest, while treatment Group B and control Group D received the posttest-only. Data were analyzed using SPSS © statistics software.

The independent variable in this study was six weeks of piano lessons. Participants in the treatment groups A and B received 12 half-hour lessons over a 6-week treatment period. The dependent variables were the CANTAB pretest and posttest scores. I performed an ANCOVA with the pretest as a covariate, and the posttest scores for treatment groups A and B were compared with control groups C and D in order to discover if there were any significant differences between the treatment and control groups posttest scores.

In this study, the moderator variable was piano lessons before the age of 18. Participants were asked if they studied piano before the age of 18, and verbally responded with “yes” or “no.” I performed an ANCOVA with experience as a covariate to determine if there was a significant difference between the CANTAB scores of senior adults who studied piano before the age of 18 and those who did not.

Class design and materials

Participants in treatment groups A and B were given piano lessons during the treatment period. Participants in control groups C and D were not given piano lessons during the treatment period, but were offered piano lessons after the treatment period was over.

Knowles (1990) expressed that adults preferred to be self-directing, so the study plan involved creating a piano class in which students had choices: the choice as to what degree the teacher was involved in the learning, and the choice of how they defined success. None of the students wanted to perform a recital at the end of the class, but three expressed an interest in playing a song at church. Most wanted to learn something new, and two expressed that their doctor had recommended piano playing as an intervention for arthritis in their hands.

In addition to using a self-directed approach, it was necessary to keep the whole-brain nature of musical study in mind. Whole brain study involves vocalization, kinesthetic motion, verbal connection, physical connection, and mental awareness (Battle, 2010). Individuals who study piano use both left and right brain as they approach piano playing. In addition to the skills related to reading symbols, touching the correct key, and finger motion, I also expected all students to advance to a point where they could play two separate lines of music at the same time. Participants also learned about basic musical interpretation. I guided students' musical interpretation with leading questions about melody, rhythm, harmony, form, dynamics, and timbre. Some sample questions are listed below.

- What do you notice about the first and second line? Are they the same or different?
- Look at the second measure. Are the notes right next to each other or do you have to skip a note?
- Why not explore different keyboard sounds? What sound do you like best for this song?

Because of the range of backgrounds and experiences of the piano students, I deemed it important to allow each participant the opportunity for self-discovery. Every student could put on headphones and moved at their own pace. It also meant that I was more of a consultant than a teacher. The Yamaha MIE keyboard laboratory was well suited to this type of instruction because there were two sets of headphones for every keyboard. The individual participants could play for me without anyone else hearing them, and they reported that this eased their stress. Each student was introduced to the piano in the same way. They were given a copy of Thompson's *Teaching Little Fingers to Play* (1936) and told that this was a starting point. Other materials were available, including the Thompson's *Modern Course for the Piano: First-Grade book* (1937), Bastien's *Piano Method Level A* (1985) and Bastien's *Piano Method Level 1*(1985). Additionally, Tornquist's *Music in Me: A Piano Method for Young Christian Students: Level 1* (2006) was provided. This was a book of simple church tune arrangements with finger numbers similar to the Thompson method. Students chose from these materials, and were also welcome to bring in music that they wanted to explore.

Based upon the principles set forth in Knowles andragogy (1970), I was available

as a facilitator and my involvement with the participants' learning adjusted in accordance with their personal preferences. I listened and gave suggestions. I was also available to answer any questions that they might have. All students in treatment groups A and B were introduced to the piano in the same way:

1. Students were shown how to locate middle C, middle D, and middle E (the first three notes in the first song).
2. Students were told that the thumb was 1, the pointer finger was 2, and the middle finger was 3.
3. Students were introduced to quarter notes and half notes, which were used in the first song (using "ta" and "too" as pneumonic devices for counting).
4. Students were told that performance was not the primary goal. The first goal was learning to play.
5. Students in participant groups A and B were informed that I would be available in the piano lab Monday through Thursday from 5pm to 7pm. Their responsibility was to come into the piano laboratory and practice for one hour on two separate days during the week. Flexibility was important, and I am certain that my availability attracted the number of participants I needed.

Procedures

In order to establish anonymity, a colleague administered the CANTAB pretests and posttests, so I was unable to match scores with participant names. Each participant was listed by an assigned number in place of their name. All participants took the CANTAB in the school district computer lab with the help of a computer technology

specialist. Pretests were administered to participants in treatment Group A and Control Group C in the computer lab by appointment with the computer specialist prior to beginning piano practice. Descriptive information regarding participants' previous musical experience was collected by asking participants if they played piano for at least two years before they were 18 years old. Their response was recorded with their identifying number.

I gave the participants in treatment Groups A and B six weeks of piano class, two sessions per week for a total of 12, half-hour classes. All participants would sign in as they entered the piano lab so that there was a record of their participation. The lessons occurred simultaneously because the students could put the headphones on to play and practice. Each keyboard had two sets of headphones, so I could walk around and listen to each student through headphones as they played. All adult students were given options concerning how involved they wanted the teacher to be, and they chose their personal goals. After the six weeks of class, the CANTAB was administered to all participants in all groups. Following the study, piano classes were offered to the participants in control Groups C and D.

The specific hypotheses tested are shown below in null form:

- There is no significant difference between the cognitive function scores of senior citizens who received 12 piano lessons and those who did not.
- There is no significant difference between the cognitive function scores of senior citizens who studied music as a child and those who did not.

All hypotheses were tested for significance.

Research Questions

This study focused on two questions:

- Is there a significant difference between the CANTAB scores of senior adults who participated in six weeks of piano class and those who did not?
- Is there a significant difference between the CANTAB scores of senior adults who studied piano before the age of 18 and those who did not?"

Hypothesis

Based upon the review of literature, two major hypothesis areas were used to guide data analysis. First, I hypothesized that piano study would have a positive effect on cognitive function of senior adults. In short, treatment Group A and B participants' CANTAB posttest scores would be significantly higher than control Groups C and D participants' CANTAB posttest scores. Variables from previous studies such as improved short-term memory and attention (Bugos et al., 2007; Seinfeld, Figueroa, Ortiz-Gil and Sanchez-Vives, 2013) and planning (Palmer, 2005; Altenmüller & Gruhn, 2002) provided support for this hypothesis. Secondly, researchers have discovered that studying music before the age of 7 (Hudziak et al., 2014, Schlaug, 1995; Wang, Xei, Zhu, Liu, & Dong, 2013) increased connections between the brain's right and left hemisphere, and causes increased development of the cortex. The brains of students who study music at an early age look different than the brains of students who do not study music. In addition students who study music at a young age have more connections between their right and left brain (Hudziak et al., 2014, Schlaug, 1995; Wang, Xei, Zhu, Liu, & Dong, 2013). Consequently, it was predicted that the CANTAB pretest and posttest scores would be

significantly higher for participants who had previously studied music as a child when compared with participants who did not have piano lessons before they were 18 years old.

CHAPTER FOUR

RESULTS

The purpose of this study was to examine whether exposure to a 6-week piano class would have an impact on specific cognitive functions in senior adults. This chapter is a report on the data collected from participant responses to the Cambridge Neuropsychological Test Automated Battery (CANTAB). Statistical data from the CANTAB were analyzed with the goal of answering the following questions:

- *Is there a significant difference between the CANTAB scores of senior adults who participated in six weeks of piano class and those who did not?* I compared CANTAB posttest scores in order to discern if there was a significant difference between the scores of treatment and control groups.
- *Is there a significant difference between the CANTAB scores of senior adults who studied piano before the age of 18 and those who did not?* I compared the CANTAB scores of participants with previous piano study to the CANTAB scores of participants who had no previous piano study.

What follows is a description of the participants and responses to the research questions based upon data from the CANTAB.

The Participants

Initially, there were 38 participants in the study (N =38) with seven male students (n = 7) and 31 female students (n = 31). One female participant dropped out of the study after the first class, and one female participant passed away after 10 classes. This left 36 students completing the study (N = 36). Table 1 shows the participants within each group.

Table 1

Pretest and Posttest Treatment and Control Groups

	Treatment Group A $n = 9$	Treatment Group B $n = 8$	Control Group C $n = 9$	Control Group D $n = 10$
CANTAB pretest	Yes	No	Yes	No
Piano lessons	6-week treatment period	6-week treatment period	After study was over	After study was over
CANTAB posttest	Yes	Yes	Yes	Yes

CANTAB- Cambridge Neuropsychological Test Automated Battery.

The Data

I organized the data and calculated the mean score for pretest-posttest groups A and C, and the mean difference in the scores for pretest-posttest groups A and C using SPSS version 22 (Table 2). I also calculated the mean scores for posttest only groups B and D (Table 3). The reader will note that some score in the attention task are negative numbers. This is because the attention task scores were calculated as the difference between correct and incorrect scores. For example, a participant who got 5 answers correct and 5 answers incorrect received a score of 0. Hence, it was possible to get more incorrect answers than correct answers and receive a score that was a negative number.

Table 2

Scores for Treatment Group A and Control Group C

Group	Att-Pre	Att-Post	ML-Pre	ML-Post	HT-Pre	HT-Post
A	-3	3	4	6	19	3
A	-5	-7	6	2	12	19
A	-7	6	5	8	0	14
A	-2	7	4	5	0	6
A	6	-2	6	6	6	1
A	2	-12	4	7	14	0
A	24	11	8	8	28	23
A	-12	1	6	7	3	17
A	15	3	6	7	15	23
Mean	2	1.11	5.4	6.22	10.77	11.77
C	5	5	5	4	14	10
C	0	11	3	6	11	19
C	-8	-5	5	5	16	10
C	-5	-5	6	7	19	10
C	-4	-8	6	5	14	16
C	-7	6	6	7	11	11
C	1	0	6	7	19	14
C	3	0	7	8	12	13
Mean	-1.87	0.5	5.5	6.12	14.5	12.87

Note: Att-Attention; ML-Monkey ladder (Memory); HT- Hampshire tree task (Planning)

I further analyzed the CANTAB scores using SPSS version 22. I first performed an ANOVA on the pretest scores for treatment Group A and control Group C to determine if the scores prior to treatment were similar See Table 4). Orcher (2005) pointed out that it is "random assignment from an random sample that makes the experiment a 'true experiment' because random assignment to groups forms two groups that are equivalent" (p. 183). Nevertheless, it is wise to explore whether the scores for the two pretest groups are similar in order to ascertain any significant differences in the

posttest scores. There was not a significant difference between the pretest scores for treatment Group A and control Group C.

Table 3

CANTAB Scores for Treatment Group B and Control Group D.

Att-TB	Att-CD	ML-TB	ML-CD	HT-TB	HT-CD
9	-5	7	7	14	3
4	-20	8	2	14	0
0	-1	6	3	0	3
10	5	8	6	0	14
-3	-17	5	4	0	0
-4	7	7	7	22	13
9	4	8	7	13	6
1	-3	7	7	14	0
	9		6		11
	-1		3		3
3.25	-2.20	7.00	5.20	9.62	5.30

Note: Att-Attention; ML-Monkey ladder (Memory);
HT- Hampshire tree task (Planning)
TB-Treatment Group B; CD-Control Group D.

Table 4

Pretest Comparison for Groups A and C

	Mean		Variance		Significance
CANTAB	Group A	Group C	Group A	Group C	P value
Attention	2.00	-1.88	129.50	22.98	.39
Memory	5.40	5.50	1.77	1.43	.93
Planning	10.78	14.50	88.69	10.77	.31

I examined the results of an ANCOVA with the control group and the experimental group as independent variables (See table 5). The covariates were piano experience before the age of 18 and the pretest (The pretest was administered to treatment

Group A and control Group C). Because the covariate piano before the age of 18 was a yes or no question, it was binary; therefore, I assigned the number 1 for yes answer and 0 no. There was not a significant difference between the CANTAB adjusted scores when comparing treatment groups A and B to control groups C and D (Attention: F (1, 30) = .04, p < .93; Memory: F (1, 30) = 2.49, $p < .83$; Planning: $F\ (1, 30) = .05, p < .39$). The results were evidence that there was no practice effect for participants who took the pretest, and that there was not a significant difference between the CANTAB scores for participants who played piano before the age of 18 and those who did not.

Table 5

Posttest Comparison: Treatment Groups (A and B) and Control Groups (C and D)

	Mean		Variance		Significance
CANTAB	Group A, B	Group C, D	Group A, B	Group C, D	P value
Attention	2.12	2.92	40.61	23.73	.93
Memory	6.65	6.61	2.49	31.55	.83
Planning	11.47	9.28	89.63	30.80	.39

I performed an ANCOVA comparing the posttest results for pretest-posttest groups A and C and posttest only groups B and D. (ATT*: $F\ (1, 30) = .40, p < .53$*; ML: $F\ (1, 30) = .104, p < .85$; HT: $F\ (1, 30) = 2.68, p = .11$; VR: $F\ (1, 30) = 1.96, p < .17$). There was not a significant difference between the CANTAB scores for pretest-posttest groups A and C and posttest only groups B and D, further indicating that taking the pretest did not cause a practice effect.

Research Questions

Based upon the SPSS analysis of the CANTAB scores for treatment groups A and B and control groups C and D, I arrived at the following conclusions:

- *Is there a significant difference between the CANTAB scores of senior adults who participated in six weeks of piano class and those who did not?* Based upon the CANTAB scores in this study, there is no evidence to support a relationship between piano study and improved cognitive function in senior adults.
- *Is there a significant difference between the CANTAB scores of senior adults who studied piano before the age of 18 and those who did not?* Based upon the CANTAB scores for this study, there is no evidence to support a relationship between previous piano study and improved cognitive function in senior adults.

CHAPTER FIVE

DISCUSSION

> Wild men who caught and sang the sun in flight,
> And learn, too late, they grieved it on its way,
> Do not go gentle into that good night (Dylan Thomas, 1914-1953)

I expected this study to provide insight into the areas of adult education, music and the brain, and cognitive health. Previous researchers have found a connection between music and physical and emotional well-being in senior adults (Belgrave, 2014; Coffman, 2002; Jutras, 2006, Vinkers et al., 2004). There is also evidence to support music's positive effect on physical health (Parr, 1985; Puhan et al., 2006; Sacks, 2008; Thaut, 2010). Connections exist between music and improved brain function (Elbert et al., 1995; Hudziak et al., 2014; Jensen, 2000; Pantev et al., 1998; Schlaug, Jancke, & Pratt, 1995; Schlaug et al., 1995; Wang, Xei, Zhu, Liu, & Dong, 2013); therefore, in the present research study I sought to connect measurable changes in cognitive function to piano instruction. The results for this research project support the null hypothesis for the first research question: There was no evidence that six weeks of piano study affected cognitive function for Attention, Memory, and Planning as measured by The Cambridge Neuropsychological Test Automated Battery (CANTAB). In addition, there was no evidence that studying piano before the age of 18 affects cognitive function as measured by the CANTAB.

Attention, Memory, and Planning

What follows is a brief recap discussion about attention, memory, and planning in which I offer additional insight into the complexity I encountered while studying these

three areas. I will raise questions about measuring each of the cognitive areas in this study and also point out some thoughts for future study. The questions that I raise are not meant to diminish my results or to refute the validity in the CANTAB test results. My discussion is only meant to bring up future questions and to outline the complexity inherent in studying cognitive function. Following the discussion about attention, memory, and planning, I will describe the class setting and things that I observed about participants in my study which could possibly be applied to music education for adult learners, and for learners at all levels.

Attention

Every day as we go about our lives, we make conscious and unconscious decisions about where our focus should be. Styles (2005) identified "attention for perception" and "attention for action" *(p. 5)* as the two main parts of cognitive attention. To review, attention for perception is noticing something while attention for action requires an individual to produce an action in response to what is perceived. The CANTAB test for attention was designed to evaluate attention for perception. The participant was instructed to look at a series of patterns and either to decide which picture didn't fit the series or to select the picture that continued a perceived sequence. Participants in the piano class were required to use both attention for perception and attention for action. Granted, the study participants needed to act in order to answer questions on the CANTAB test; however, an individual looking at music and then playing the piano in response to what notes are seen, how loud or soft those notes should be played, and how fast or slow the music needs to be requires much more extensive

perception for action. There was not a significant change in the CANTAB test scores for attention as attention for perception. The test did not evaluate attention for action.

Memory

As outlined in my related literature section, there are numerous cognitive actions that fall under the general heading called memory. In addition, memory is intricately connected to focus and planning as well as other cognitive functions such as the senses (touch, taste, smell, hearing, vision), and emotions (Woll, 2001). This complex array of relationships makes evaluating changes in a single aspect of memory difficult. One aspect of memory that researchers agreed was important was the process of Chunking (Chaffin & Imreh, 2002), also called clustering (Woll, 2001). Chunking occurs when a participant can discern patterns that enable them to store chunks of information that are saved as one unit as opposed to a series of smaller units.

Even though both numbers and boxes were used in the CANTAB test for memory, the numbers and boxes were not displayed in any immediately discernible patterns; consequently, it was probably as pure a memory test as it could possibly be. Numbers appeared in the boxes for a few seconds and then disappeared. Because the process of chunking requires detecting a pattern, it would have been difficult in this situation. The participants were instructed to click on the randomized boxes in numerical order from lowest to highest. In hindsight, I realized that the CANTAB test for memory did not involve several of the cognitive actions that the participants used for the piano classes every time they attended. These cognitive actions included, but were not limited to kinesthetic memory, chunking, hearing, and seeing. Perhaps the treatment group

participants' memory was not affected by piano playing. There were no significant changes in the CANTAB scores; however, the CANTAB memory test designers isolated limited parts of memory. If memory is inextricably linked to other cognitive functions, it will be a challenge to isolate individual parts of the cognitive processes we call memory in order to evaluate them.

Planning

Playing music requires planning, but the way musicians plan is as individual as the musician (Chaffin, Imreh & Crawford, 2002). Newell and Simon (1982) stated that cognitive planning involved thinking forwards from the given information about a problem and backwards from the goal. Chaffin, Imreh, and Crawford (2002) pointed out that musicians have various ways that they learn a piece of music: some look carefully at the whole piece, while others begin by playing the piece on their instrument, stopping to explore and mark as they go. Still others look for the more complicated areas in the piece and start working on those sections first. Chaffin, Imreh, and Crawford suggested that there was not one approach that was "better" than others; rather, it was the individual preference of each musician. If we apply the idea that there is more than one way to successfully approach planning, then the CANTAB test for planning values two qualities over other approaches: speed and limited number of steps. This suggests that a plan that is conceptualized and implemented quickly is superior to a plan that is conceptualized and implemented slowly, and I am not sure this is accurate. Is a bridge that was planned and built in a short time better than a bridge that was planned and built over a longer period? The challenge in research, as Zsambok and Klein (1997) pointed out, is to find

the balance between research and realistic situations.

The Classroom Experience

Strategies for this study were planned with the awareness that adults learn differently and tend to be more self-directed and independent than young learners (Guglielmino, 1977; Knowles, 1990; Zmeyov, 1998). Knowles (1978), borrowing the word "andragogy" from his European colleagues, identified differences in mature learning styles and asserted that, "self-direction is the point at which (the learner) psychologically becomes adult. A very critical thing happens when this occurs: the individual develops a deep psychological need to be perceived by others as being self-directing" (p. 56). It was important, therefore, to consider unique elements of adult learning when designing the piano classes. In the following section, I will address the need for time flexibility when working with adult students. Next, I will discuss how the participants in this study were self-directed learners, their need for emotional safety and how that relates to adult learning theory. Finally, I will describe some of the challenges participants faced when learning piano, and what their ultimate progress was through the classes.

Flexibility in Scheduling and Learning Approach

Teaching adult students presents a new approach to scheduling, and this is important to both researchers and educators (Bowles, 2010; Guglielmino, 1997; Knowles, 1990). Elementary students arrive and leave school in a set and generally predictable pattern each day. Adult students have lives and schedules that vary not only from day to day, but from week to week. To this end, it may be important for educators to be flexible

and make a variety of times available for students to be in contact with the teacher/facilitator (Guglielmino, 1977; Knowles, 1990; Mezirow, 1990).

Adult learning theorists (Bowles; 2010; Guglielmino, 1977; Knowles, 1990; Mezirow, 1990) concur that adult learners need independence and self-direction while still having access to a teacher/facilitator when needed. The flexibility and allowance for independent exploration elicited a positive reaction from all participants. Initially, students were anxious about playing for me, and expressed that they felt awkward performing a task that they were not "good at." Participants quickly fell into a routine, however, and almost all were relaxed and overcame their anxiety by session number three.

Attendance was consistent throughout the study. There was a sign-in sheet so I could keep track of attendance, and I only had to contact two people concerning their attendance. One participant had to be contacted regularly because she felt she was not "good enough," and her attendance suffered accordingly. This participant did ultimately finish the study. The second participant missed classes due to illness. Sadly, the latter participant passed away and was removed from the study.

Emotional Safety and Adult Learning Theory

The participants expressed a high degree of emotional safety because they alone could hear their practice sessions, and because I was more a human resource than a teacher. It is important for researchers to recognize the need for emotional safety when planning for adult learning (Higgins & Shehan-Campbell, 2010; Bowles, 2010; Thornton, Mattocks, & Thornton, 2001). Thornton, Mattocks, and Thornton (2001) suggested that

emotional safety was linked to personal empowerment. Short and Reinhart (1992) asserted that empowerment had "six empirical dimensions: impact, self-efficacy, autonomy, involvement in decision-making, opportunities for professional growth and (professional) status" (p. 951). These six dimensions are similar to the theories outlined by Guglielmino (1977), Knowles (1990), and Mezirow (1990) as they discuss adult learning. Specifically, the learning theories connect to empowerment via impact (does what is being learned relate to the student's personal experience?), self-efficacy (confidence that the student can learn the task), autonomy (the student can learn the task using the teacher primarily as a resource), and involvement in decision making (student decides how to approach learning). Empowerment involves a willingness on the student's part to take risks trying something new while that student is aware of the teacher's accepting and supportive presence. Higgins and Shehan-Campbell (2010) called this "safety-without-safety" (p. 13).

There was a high level of comfort during the piano classes. Participants reported having fun and they appeared motivated to finish the practice sessions. They lingered after sessions to chat with each other. All reported improved mobility in their hands. In terms of quality of life for senior adults, this is notable. Both being motivated to do a particular task and having the opportunity to do it, presented a good combination for physical and mental health (Parr, 1985; Tims, 1999; Wristen, 2005). My class design was not complex. In fact, other than the presentation of a rose to participants at the halfway point (after six classes) and celebrating with a pizza party at the end of the six weeks, most of the good feelings the students experienced were from my casual encouragement

when they were successful. They all expressed pleasure at playing the piano.

Independent

The participants' independence was evident in the variety of approaches to playing the piano that they exhibited during the classes. Some participants wanted to use the fingering numbers provided by the method book authors; others insisted on learning all of the note names right away. Adult learning theorists (Bowles; 2010; Guglielmino, 1977; Knowles, 1990; Mezirow, 1990) concur that it is important for adults to be active decision makers concerning how and what they are learning. A few participants learned only the notes that they would need to accomplish each lesson, so they learned the notes gradually.

Challenges

There were individual learning differences between the participants. For instance, some had challenges with coordinating the correct hand with bass and treble clef and would accidentally play the right hand with the bass clef or the left hand with the treble clef. Further, participants who had previously typed for a living had difficulty remembering to use their thumbs because whereas the thumbs are kept well below the other fingers and only used on the space bar when typing, the thumbs are even with the other fingers and have a much more significant role in piano playing.

Progress

Every student completed most or all of *Teaching Little Fingers to Play* (1936), and six of the participants were in Thompson's *Modern Course for the Piano: First Grade Book* (1937) at the end of the six weeks. One subject chose to explore Tornquist's

Music in Me: A Piano Method for Young Christian Students: Level 1 (2006), which was formatted similar to Thompson's *Teaching Little Fingers to Play* (1936). Participants who had played piano when they were young quickly played through the beginning books up to the point where they had been when they quit playing, particularly the participants who had used the Thompson books as children. I did not find any literature relating to this phenomenon; however, it is significant to researchers and music educators. Some of the participants had not played the music in over 50 years, yet they still recognized and accurately played the pieces.

Adult Learners and Music

Hallam et al (2014) asserted that many adults have a strong desire to participate in music making and that a large percentage of those seeking music making want to play piano. Knowles (1990), Guglielmino (1977) and Mezirow (1990) asserted that adult learners prefer to be self-directed. In creating this opportunity for learning piano and for self-direction, I observed adults actively engaged in music and piano without fear or reservation. Music educators, researchers, and other individuals working with seniors could find it beneficial to provide music making experiences senior adults while acting as a resource in an environment that is less structured and provides opportunities for adults to design their own approach to learning.

Limitations

Lord Denman (1779–1854) asserted that, "The mere repetition of the *Cantilena* of lawyers cannot make it law, unless it can be traced to some competent authority; and if it be irreconcilable, to some clear legal principle" (Bartlett, 2000, p. 1). A similar statement

can be made concerning studies about music and cognition, because even the slightest evidence of music having extra-artistic powers has the potential to create a media storm of limited and often misleading information. This information is then reiterated as a resounding truth until the initial study and findings get lost in the rhetoric.

An example of media misuse of information from a peer-reviewed study is the so-called "Mozart Effect." In the original study (Rauscher, Shaw, & Ky, 1993), researchers reported a momentary increase in spatial intelligence scores after college students listened to a Mozart sonata for 10 minutes. In subsequent news stories, the words "temporary" and "college student" were left out, and the "Mozart Effect" was born (Bangerter, & Heath, 2004). Bangerter and Heath (2004) defined this as a "scientific legend" and discussed how the legend evolved during media presentation (p. 617). The "Mozart Effect" was so prevalent in the media because it tapped into social anxiety about the United States falling behind other countries academically (p. 614). With this in mind, I emphasize that this study was an exploration about whether music study influenced the scores of elder adults on the Cambridge Neuropsychological Test Automated Battery (CANTAB). No all-encompassing statements about the relationship between senior adults and music study are intended.

Study location. Jorgensen (2001) said that creating and declaring resolutions about education, specifically music education, impairs the work of combining theory and practice. Putting Knowles' (1990) theory into practice by designing classes for adults with self-directed learning in mind validates prior research and elevates participant comfort. Resolutions are developed for a specific time and situation, and one solution for

every music education situation is not realistic. Such resolutions are not only "time bound" but they are also "place bound," and Jorgensen (2001) suggested a "doing" philosophy rather than "mandating a particular world view or theory" (p. 344). In this study, I wanted my participants to act (do something) and leave with a sense of having accomplished something.

This study was also time and place bound. The time was fall, 2015, and the place was a rural area in south-central Missouri. In terms of participating in this study, the time and place were not convenient for the participants. The classes were in the evening, and the site location was rural. Most participants lived outside of town. Everyone except one participant had to be able to drive. As fall changed to winter, and it got darker earlier, motivation to stay at home could have been a possible variable preventing participation; however, participation stayed high throughout the study, with most students having perfect attendance.

Generalizability. It is important to stress that the results from this study cannot be generalized to the entire older adult population in the United States. Contrasting with the heterogeneous nature of senior adults in the United States, the county in Missouri where this study took place was 95.9% white. The study was not designed to make sweeping statements about cognitive health, but to pull on a thread of curiosity about senior adults as beginning music students and about music and brain function.

Computers. When any instrument is used to measure results, no matter how reliable and valid that instrument is, there are many unmeasured effects that influence the study outcome. There were variables that were not given enough consideration during the

planning of this study. Several participants lacked experience with computers, specifically the mouse, and despite assistance in this area, it may have impacted their CANTAB results. The researchers creating the CANTAB tests' on-line format have recently updated the site (2018) in order to provide practice using the computers and taking the tests before the actual evaluation proceeds. "Each test is now accompanied by an interactive tutorial that allows your participants to learn about the test in an engaging and intuitive practice run" (Zukier, 2018, p. 1). The tutorials help to familiarize the test taker with the format before the actual evaluation. I believe this is a positive step towards a more senior-friendly research tool.

The time of day may also have been a contributing factor affecting test results. Most treatment group participants took the CANTAB posttest immediately after their last hour-long practice session, so fatigue may have affected test performance (Lorist, Boksem, & Ridderinkof, 2005). It is impossible to measure what impact fatigue and lack of computer experience had on participant performance; however, future researchers will need to take these into consideration.

Suggestions for further research

As with any research project, there are possible revisions that could improve the project should someone choose to replicate it. It is possible that the results could have been different if I had planned to do 12 weeks and 24 lessons instead of six weeks and 12 lessons, or even longer. For example, Bugos (2010) reported positive gains in executive function scores after adult participants were administered 16 weeks of piano lessons. Bugos used Advanced Measures of Music Audiation (AMMA) (Gordon, 1989), Wechsler

Abbreviated Scale of Intelligence (WASI) (Wechsler, 1999), and Paced Serial Addition Task (PASAT) (Gronwall, 1977). A researcher might have participants do 16 weeks of piano study and compare Bugos' (2010) results to scores obtained from the CANTAB tests. Perhaps a more extended instructional period would have demonstrated a measurable effect on cognitive function as measured by the CANTAB tests. It might be difficult to compare test results because two of the three tests in Bugos' study measured what would be considered music skills (audiation and steady beat) while the CANTAB specifically measures cognitive skills. Another possibility would be to administer 12 piano lessons over a six-week period and use the tests that Bugos used in order to see if similar results would happen over a shorter time period.

I also have considered what might have happened with the CANTAB scores if I had provided a rest period of at least 24 hours between the last practice session and the posttest instead of administering the posttest immediately after the final class. It is important to determine what caused the scores of several participants to drop significantly. Fatigue was a variable that could have affected performance (van der Linden, Frese, & Meijman, 2003), so taking the posttest at least 24 hours after the last class may yield different results.

Additionally, the participants who had previous piano experience were accessing memory when they were able to retrieve the physical and musical skills necessary to tackle songs that they have already played. Researchers (Crystal, Grober, & Masur, 1989; Hodges, 1996; Sacks, 2007) also assert that musical memory lingers long after other brain functions fade. How can researchers identify the characteristics that make music

and memory interact with each other?

There was no significant difference between CANTAB scores for participants who had previously studied piano before the age of 18 and CANTAB scores for participants who had not studied piano; however, I observed that those participants who had piano experience presented an interesting trait. They could access physical and musical memory to progress fairly quickly back to the level they were at when they stopped playing as a youth. This presents researchers with questions about where that memory is stored, because it did not cause a change in memory as measured by the CANTAB. Of course, this does not mean that cognitive changes didn't happen—it just means that if changes happened, then they were not measured by the CANTAB.

Implications for the practice of teaching piano. This study has already affected my teaching. This past spring (2017) I designed and taught a ten-week-long piano class for 17 sixth graders in my school district. The students were given a goal sheet, and they set their own goals from week to week. They were in control of goal setting and how they approached meeting those goals. In addition, they were permitted to consult with classmates as they worked towards those goals. At the culmination of the ten weeks, my students presented a recital to their parents. All of the students chose which piece they would perform. The students were also told that they did not have to perform, and it was their choice. As Knowles (1990) pointed out, andragogy is not limited to adults. Many younger students also benefit from a more self-directed approach to learning.

For educators who work with adult music students, the implications are broader. Although I did not find conclusive evidence for a relationship between piano playing and

cognitive function in older adults, there is evidence that interacting with others and learning new skills keeps the aging brain alert and combats depression (Jutras, 2006; Mitak, 2012; Parr, 1985; Thaut & Abiru, 2010; Vinkers, Jacobin, Stek, Westendorp, & Vander Mast, 2004). This, coupled with personal control over what is learned and how it is learned could contribute to a more informed approach to teaching older adults. Additionally, goals that are not performance-oriented might suit older adults who want to learn but who also prefer to keep piano playing as a fun diversion rather than a performance activity. Stebbins (1992, see also 2001) called this “serious leisure.” Stebbins defined serious leisure as "the systematic pursuit of an amateur, hobbyist, or volunteer activity sufficiently substantial and interesting for the participant to find a career there in the acquisition and expression of a combination of its special skills, knowledge, and experience" (1992, p. 3). The key word in the latter definition is “could.” Leisure implies the pursuit of relaxation and pleasure in contrast to work, which would be a means of survival or a career.

Although there was no significant difference between the majority of the CANTAB pretest and posttest scores, it is hoped that this report could stimulate more in-depth investigations utilizing more sophisticated evaluation tools to find out if studying piano will slow cognitive decline. Finally, this investigation was instigated by my curiosity about whether or not music study can improve quality of life. Previous researchers have discussed how studying music has decreased depression and increased life satisfaction in senior adults, and how their participants stressed extra-musical benefits as their primary motivation. What remains is to discover how and why.

Conclusion

Leonardo DaVinci believed that the human soul was composed of harmony, and Pythagoras believed that music's purpose was to connect the soul to divine nature. A common theme between these two great artist/philosopher/mathematicians is the mention of the soul. There is research suggesting musical memory is stored in a different part of the brain than other types of memory (Bartlett, 1996; Crystal, Grober, & Masur, 1989). What significance this has still remains a musical mystery. Musical awareness remains long after many other cognitive functions have faded in individuals with diseases such as Alzheimer's. Addressing music's connection to the human soul is beyond the scope of this paper, but the idea that music remains after all but the most ancient vestiges of the human brain grow silent stimulates the imagination.

The best part of the study for me had nothing to do with numbers. I watched as a group of people, who were randomly brought together through a common interest, grew as individuals, and we appeared to be transformed. It was inspiring to witness the excitement when the playing "came back" to those who had taken piano lessons as children. Three participants purchased their own keyboards after the study was over and are continuing to play. Others, although they enjoyed it, felt that the 12 lessons were enough. Several participants remarked that the experience had made a difference in their concentration, and that they enjoyed having the opportunity and time to explore something new. I personally enjoyed collaborating with a different age level than I have worked with in the past, and liked the challenge of attempting to quantify something that is difficult to measure. Also, musicians generally have performance in mind when

learning a piece of music. It was a new feeling to approach music instruction in a way not related to a performance, but simply for the player's personal growth and pleasure. It has caused me to re-evaluate how I approach young players.

This study design started because I saw music lingering in a senior musician as other aspects to his personality faded, and I wondered about it. My experience with a small community orchestra was transformative for me, because I had walked away from music and teaching for ten years. Joining the group inspired me to pick up my instrument, return to teaching, get a master's degree in music, and ultimately work on a doctorate. This piano study was transformative yet again because it enabled me to share music with a community of people who really wanted to be part of a meaningful experience.

The volunteer symphony I played in and conducted was a place of discovery for new players both young and old, and it was also a final performance outlet for aging devoted musicians. I can think of no better way to honor a group that shared my musical life and growth for 20 years than to share music with a fresh community of people. Adults seek learning experiences. They desire personal choices, enjoyment, growth, and new encounters. We should not expect that the drive to learn and succeed will fade just because an individual matures and retires. Perhaps DaVinci and Pythagoras were not far off in describing music's ability to connect with the soul. A life allowed to decline in usefulness causes a spirit to decline. Music is one avenue for keeping that inner spirit alive.

APPENDIX A

PARTICIPANT RECRUITMENT MATERIALS

Adult Piano Students Wanted!

Are you interested in taking 12 piano lessons at no charge? Looking for some interested seniors to help with a doctoral dissertation on music and the brain. All participants will be given a ticket to a local string concert. Participants must be:

Attention! Minimum age has been lowered to 60 or older!

- Not a professional or amateur active musician
- Living independently and Have reliable transportation
- Call **Barbara Deegan at 417-543-5696** if you are interested

Article for Paper and Radio

Seniors Aged 65 or older wanted!

Would you like 12 piano lessons at no charge? My name is Barbara Deegan. I am the elementary music teacher at the Ava school district, and I am currently working on my Doctorate in Music Education through Boston University's on-line program.

I would like to let you know about a research study that may be of interest to seniors (male and female) aged 65 and older, and ask you to consider taking piano lessons and participating in the study. The purpose of the study is to explore whether six weeks of piano class will affect individuals' scores on a series of tests evaluating brain function.

For my dissertation I am offering six weeks of piano lessons at no charge to seniors who are

- Aged 65 or older
- Not a professional or amateur musician
- Living independently
- Have reliable transportation

Unfortunately, this study cannot include

- Active professional or amateur musicians.
- Seniors in a care facility.
- Seniors under a physician's care for age-related dementia.

The 30 minute piano classes will take place two evenings a week for six weeks. Seniors who decide to participate in the study will be offered basic piano materials, and be supported in learning a new musical skill. In addition, participants will be given a ticket to a local string concert in appreciation for their help.

I look forward to speaking with seniors who may be interested in participating in this study. Please feel free to contact me with questions.

I will be holding an informational meeting on August 30 at 7PM in the Ava Elementary Music room. If you are interested in participating, please call me at 417-543-5696 or email me at conn8dartist@yahoo.com. I am looking forward to meeting you and I am confident we will have a great time!

Barbara Deegan
PO Box 1084
Ava, Missouri 65608
417-543-5696
Conn8dartist@yahoo.com

Mrs. Bonnie Evans
109 2nd St
Ava, MO 65608

Dear Mrs. Evans

My name is Barbara Deegan. I am the elementary music teacher, and I am currently working on my Doctorate in Music Education through Boston University's on-line program. I would like to let you know about a research study that may be of interest to senior center members and ask you to consider referring seniors for possible participation in my dissertation study.

For my dissertation I am offering six weeks of piano lessons at no cost to seniors who are

- Aged 65 or older
- Not a professional or amateur active musician
- Living independently
- Have reliable transportation

People excluded from this study.

- Active professional or amateur musicians.
- Seniors in a care facility.
- Seniors under a physician's care for age-related dementia.

The 30-minute piano classes will take place two evenings a week for six weeks. Seniors who decide to participate in the study will be offered a variety of basic piano materials, and be supported in learning a new musical skill. In addition, participants will be given a ticket to a local concert in appreciation for their help, even if they aren't chosen for the study. The purpose of this study is to explore whether six weeks of piano class will affect individuals' scores on a series of tests evaluating brain function.

I look forward to speaking with seniors who may be interested in participating in this study. Please feel free to contact me with questions, or have seniors who would like to participate contact me themselves, using the contact information provided below. I will be holding an informational meeting on August 30 at 7PM in the Ava Elementary Music room. Thank you for your time and consideration.

Sincerely, Barbara Deegan Conn8dartist@yahoo.com

417-543-5696

APPENDIX B

PERMISSION TO USE SCHOOL DISTRICT PIANO LABORATORY AND COMPUTER LABORATORY

August 1, 2014

Barbara Deegan
PO Box 1084
Ava, Missouri 65608
(417)543-5696
Conn8dartist@yahoo.com

Mrs. Premer and Dr. Lawler,

I am giving you a copy of my study Music and the Brain: Exploring the cognitive effects of piano study on elderly adult students because, as we discussed last spring, I would like to use the piano lab and some computers in the elementary music room for the study. I am hopeful that I will be performing the study during either spring or summer of 2015, but it may be fall of 2015 before I receive approval. I assure you that I will plan for times that will not conflict with the student lessons or the school day.

Please feel free to call me with any questions or concerns you might have.

Sincerely,

[redacted]

Barbara Deegan

[redacted] Date 10-1-2014 Ava Bears Den Coordinator

[redacted] Date 10-2-14 Ava Superintendent

APPENDIX C

CONSENT SCRIPT

Consent Script

My Name is Barbara Deegan. I am an elementary teacher at the Ava R-I School District and I am working on my Doctorate in music education through Boston University's on=line program. I would like to invite you to participate in a research project involving people aged 65 and older who would like to learn to play the piano. The research focus is the cognitive function of senior adults who play piano.

If you agree to participate, you will be randomly divided into four groups. Everyone in all four groups will take a twenty-minute survey called the Self-Directed Learning Readiness Survey. Following this, two groups will be asked to take a computer test that require about an hour. Mrs. Wendy Thompson will be on hand to help everyone with any computer concerns, and the directions on the test are clear, so if you are concerned about using the computer, we will help you. After this, two groups will take six weeks of piano classes at no cost. At the end of the six weeks of piano class, everyone in all four groups will take an hour-long computer test. In this study, there will be a control group that will not receive lessons during the study. These people will be offered piano lessons at no charge for six weeks after the study is over, so if you are not in the initial study group, you will still be able to receive piano lessons. In addition, if you are not chosen for the study, you will be offered six weeks of piano lessons after the study is over at no charge to you.

We do not anticipate any risks to study participants, and the benefits to you personally will be the chance to play piano, and the chance to see a free concert; however, we hope to learn more about piano playing and brain cognition in senor adults. There will be no charge for the classes and there is no other cost to participate in the study.

The greatest risk to research subjects in research in the social and behavioral sciences is an inadvertent disclosure of private identifiable information. With this in mind, Mrs. Wendy Thompson will administer the tests and assign each person a number. As soon as the last test is taken, the list that identifies each person with their number will be shredded. The list will be locked up. The scores will be visible, but not which of you has been assigned what number.

The greatest priority is that you will have a comfortable and fun experience during this study. You will be asked often how your experience is, and if there are any concerns, you might have. It is completely up to you whether to participate. You may withdraw at any time, and you may skip questions on the tests that you would prefer not to answer. You will receive a concert ticket upon completion of this study.

Do you have any questions about me or our interview before we begin? Please feel free to contact me at any time by phone 417-543-5696 or email conn8dartist@yahoo.com. You may also contact my advisor Dr. Kirsten Mitak at (401) 338-1674 or kmitak@uri.edu In addition, you may contact the Boston University Institutional Review Board at 617-358-6115.

APPENDIX D

IRB APPROVAL

Boston University Charles River Campus Institutional Review Board

25 Buick Street
Room 157
Boston, Massachusetts 02215
T 617-358-6115
www.bu.edu/irb

BOSTON UNIVERSITY

Notification of IRB Review: Exemption Request

August 13, 2015

Barbara Deegan
College of Fine Arts
School of Music Education

Protocol Title: Music and the Brain: Exploring the Cognitive Effects of Piano Study on Elderly Adult Students
Protocol #: 3857X
Funding Agency: Unfunded
IRB Review Type: Exempt

Dear Ms. Deegan:

On August 13, 2015, the IRB determined that the above-referenced protocol meets the criteria for exemption in accordance with CFR 46.101(b) (2). Per the protocol, this study will examine whether six weeks of piano study will affect the cognitive function of a group of senior adults. The study will use a randomized Solomon pretest-posttest design. Subjects assigned to the control group will be offered six weeks of piano lessons after data collection is complete. The exempt determination includes the use of a consent statement, two questionnaires – Cambridge Neuropsychological Test Automated Battery (CANTAB) and the Self Directed Learning Readiness Survey (SDLRS), recruitment flyer, article, and letter to senior center coordinator.

Additional review of this study is not needed unless changes are made to the current version of the study.. Any changes to the current protocol must be reported and reviewed by the IRB. If you have any changes, please submit the ***Clarification Form*** located at http://www.bu.edu/irb/. No changes can be implemented until they have been reviewed by the IRB.

In approximately six months, you will receive an inquiry from the IRB to ascertain whether your study still meets the requirements for exempt review.

If you have any questions, please contact me at 617-358-6117.

Sincerely,

[redacted]

Ed Szkutak
Senior IRB Analyst
Charles River Campus IRB

cc: Professor Kirsten Mitak, PhD

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