SHAW, CATHERYN R., Ph.D. An Assessment Tool for Participant Groupings for Human Neuroimaging Research: Measuring Musical Training. (2018)
Directed by Dr. Jennifer S. Walter. 163 pp.

The purpose of this study was to develop an assessment tool to measure musical training and experiences for grouping participants in human neuroimaging research studies. To fulfill the purpose of this study, the researcher:

1. Completed a comprehensive review of the research literature to establish the essential content of the assessment tool;
2. Developed an assessment tool to survey subjects about their musical training and experiences;
3. Pilot tested the assessment tool, and revised the tool according to the preliminary analyses of the validity, reliability, and usefulness of the assessment tool;
4. Established the content validity and reliability of the assessment tool with subjects participating in a neuroimaging study designed to analyze the influences of musical training and experiences on brain structures and functions, and
5. Determined if the assessment tool functioned effectively in the selection and grouping of musically trained and musically untrained subjects for neuroimaging studies.

The assessment tool was administered to a purposive sample ($N = 42$) in the southeastern region of the United States. Participants were recruited on the basis of musical training, both the existence and lack thereof. The assessment was completed via

the web-based platform, Qualtrics. Coding of survey responses indicated differences in the participant pool that resulted in two groups: Musicians and Non-musicians. Further investigation yielded two subgroups within the Musician participant group: Moderate and Advanced.

Validity of the assessment tool was established using a three-step construction process, (a) development of a draft based on the existing literature and the musical training knowledge of the researcher, (b) a review of the assessment tool by five music educators and performers, and (c) administration to a pilot group of five additional people with varying levels of musicianship. Additional content validity was completed by external reviewers by rating each assessment item using a Likert-type scale: 1 – *Not important*, 2 – *Slightly important*, 3 – *Fairly important*, 4 – *Important*, and 5 – *Very important*. Reliability was established using interrater reliability and was determined to be 88.9%.

A discussion was presented that included the differences among participants that made their musical training and experiences unique compared with other participants. Implications were discussed regarding the usage possibilities for the survey, as well as the potential effects of the survey on human neuroimaging research.

AN ASSESSMENT TOOL FOR PARTICIPANT GROUPINGS FOR HUMAN NEUROIMAGING RESEARCH: MEASURING MUSICAL TRAINING

by

Catheryn R. Shaw

A Dissertation Submitted to
the Faculty of The Graduate School of
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
2018

Approved by

Jennifer S. Walter
Committee Chair

This work is dedicated to the memory of

Frank Butenschon, III

and

Joseph A. David, III

APPROVAL PAGE

This dissertation, written by Catheryn R. Shaw, has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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ACKNOWLEDGMENTS

There are so many people to thank who have helped me through this process; not only the dissertation document, but the degree program as well. It is impossible to acknowledge each individual, but know that I am thankful for so many people.

To Dr. Jennifer Walter, or just "Walter"; you have served as an incredible role model for me. You are an advocate for your students, a brilliant teacher, and an amazing mentor. Thank you for believing in me and my ideas. Most of all, thank you for listening to me over the past 3 years.

To Dr. Don Hodges, your Psychology of Music course changed my life and the trajectory of my career. You have always pushed me to be better—a better student, a better writer, and a better teacher. You have encouraged me and spent countless hours reading and editing my work. The world needs more people like you.

To Dr. Patti Sink, thank you for meeting with me on November 17, 2014. You opened the door for this journey to begin for me. Your passion for music education is infectious, and your leadership and knowledge are inspiring.

To Dr. Bret Nolker, your enthusiasm for my research has inspired and encouraged me on days when I really needed it. You are a true music educator, and it has been my honor to work with you and learn from you.

To Dr. Robin Wilkins, thank you for the encouragement to pursue the development of this assessment tool and the assistance in its creation.

To Dr. Tami Draves, in one semester, you challenged my beliefs as a music educator more than any other course in my graduate work. You helped me become a better writer, and ultimately, a better teacher. To Dr. Connie McKoy, your caring nature and kind spirit have gotten me through some tough days; thank you for your encouragement. To Dr. Rebecca MacLeod, thank you for making me a "string person." Your advice has always been spot on, and I greatly admire you.

To my colleagues in the PhD program, past and present: Dr. Chris Hansen, Dr. Christen Mack, Dr. Jackie Secoy, Dr. Karen Thomas, Mark Dillon, and William Southerland—thank you for your support, your advice, and your friendship. To Melody Causby, thank you for the inside jokes, the willing ear, and your honest opinion. You are the best. To my friends and extended family, thank you for your encouragement, love, and support. You may not have known what I was talking about, but you listened, and that is what matters.

To my family—there is no getting away from music in our family. To Granny, thank you for always checking on me. To my siblings Claire, Jim, and Jeremy, thank you for sending me funny text messages and making me laugh when I needed it the most. To my mama, thank you for your support and for your willingness to listen. I have a brilliant mother, and I have learned so much from you. I am glad that you were there to remind me that I always find a way to make things happen. To my daddy, I mostly did this for me, but a lot of it was for you. You told me this is what I needed to do, and you have

promised me through the tough times that I could and would get through this. You were right. As always.

To Marc—thank you for giving me this crazy idea. I am almost positive that the visit to the UNCG campus in the summer of 2014, specifically to the School of Music just to pick up a brochure, was very strategic. You have believed in me even when I did not, and you are my rock. Thank you for loving me through this. You and the boys are my life, and I look forward to our many adventures together.

Finally, to the incredible educators that I have had the privilege of working with in my career: Dr. Lynn Corbin, Dr. Derald Jones, Gary Bradley, and Nancy Rohlfs, as well as my Perry, Lowndes, and High Point University students, thank you for making me a better teacher. You are the reason I do what I do.

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CHAPTER I

INTRODUCTION

Background of the Problem

Assessment tools that measure both the quantity and quality of musicians' experiences for the purposes of brain-imaging are rare. The assessment tools used in brain-imaging studies vary widely and generally request information from participants in order to classify participants as "musicians" or "non-musicians" based on years of experience, age of onset, and/or how often participants practiced (self-reported). Although important information is gained by asking these questions (years of experience, age of onset, practice frequency), brain-imaging researchers often fail to grasp the breadth and depth of musicians' skills and experiences. Therefore, the purpose of this study was to develop, pilot test, and determine reliability and validity for a researcher-designed assessment tool for future use in brain-imaging studies. Further testing was completed relative to reliability and validity in order to determine the effectiveness of the assessment tool.

A cursory examination of the literature involving brain-imaging studies that include musician participants indicates that sustained intensive musical training may serve as a powerful tool in changing the structure and function of the human brain. Although these findings are intriguing, differences began to emerge in the manner in which musicians were characterized within or selected for research studies. For example,

Bailey et al. (2014) defined musician groups by the age of onset of training. Out of 30 participants who were musicians, 15 participants were categorized in the "Early Training" group, meaning they started musical training before the age of 7. The other 15 participants were in a "Late Training" group, meaning they started musical training after the age of 7. Bangert et al. (2006), on the other hand, compared musicians and non-musicians and classified musicians by the number of years of training they had received, with the average being 20 years for this specific sample. Furthermore, Baumann et al. (2007) combined the ideas of age of onset of training and number of years of training with the average number of practice hours per day. In summary, these grouping and selection discrepancies exist across the research, focused on human brain behaviors, and cause problems in replication and interpretation of the research studies and results.

To understand this problem, it must be acknowledged that musical training involves much more than how many years a subject or participant has studied, how old subjects were when they began training, and/or how often participants practiced. Musical training is a multidimensional phenomenon or experience. For students who participate in school music programs, there are numerous opportunities for learning and performing. Typically, instrumental and vocal music students are involved in multiple ensemble rehearsals per week, with the possibility of additional private vocal and/or instrumental music lessons. Most secondary school music programs offered multiple performing ensembles, such as concert band, chamber orchestra, marching band, chorale, jazz band, show choir, and small chamber ensembles. Through participation in school music programs, other opportunities often include auditioned honor ensembles at the county,

district, region, and state levels, solo and ensemble performance opportunities, and community ensemble participation.

For many research participants who engage in music performance, it becomes a source of joy and entertainment, a hobby, or an activity that filled free time, aside from their everyday activities. For a small percentage of people, music becomes a career. Whether music training has taken place formally or informally, music is a path to earning a living. Formal music training at the university level involves earning a degree in either music performance or music education, the arts, music therapy, or music business. This training involves courses in music theory, aural skills, and music history in addition to private lessons on a primary instrument and often an additional secondary instrument, large-ensemble participation, and numerous other pedagogical courses. University degrees in music exist at the bachelors, masters, and doctoral college levels and require extensive years of dedicated training.

Since music training involves multidimensional practices that contribute to growing a musician, training cannot be captured adequately by the number of years that a person studies a particular musical instrument, by the age a person starts taking private lessons, or by the number of practice hours a person practice during a given time period. When examining the number of years of musical training a person has received, numerous questions emerge: “What was the quality of instruction?” “What was accomplished during that time?” and “Was the instruction large group, small group, or one-on-one?” For example, in comparing two pianists who both competed 7 years of musical training, at the conclusion of the seventh year of training, one pianist has

mastered “Für Elise” (Beethoven, 1810), while the other pianist has mastered “Un Sospiro” (Liszt, 1848). Clearly, there was inequality somewhere due to the nature of the musical experiences, the teachers, and/or the music students themselves.

Similar questions and examples also emerge as related to age of onset of training, such as “What was the quality of instruction?” “How long did this person continue to study music?” “How mature was the student when they began music study?” and “How quickly were they able to move through common musical tasks?”

In addition to the multidimensionality associated with musical training and age of onset, the reliability of reporting practice hours was questionable. “How accurate was the count?” “What was the quality of the practice time?” These questions are linked to accurately reporting the number of cumulative practice hours in order to determine musicianship.

Research on the human brain using fMRI has expanded the potential to acquire increased knowledge and understanding of how music instruction and training changes the human brain. A seminal fMRI study by Schlaug, Jäncke, Huang, Staiger, and Steinmetz (1995) compared structural differences in the corpus callosum of musicians and non-musicians. Results from this study generated interest in the investigation of neural differences in people who were musically trained and those who were not. The focus of fMRI-based studies, however, has gradually shifted from structural to functional differences in the brains of non-musicians as compared to musicians. Various fMRI methods of analysis have been used in research to make these discoveries including voxel-based morphometry (Sato, Kirino, & Tanaka, 2016), the process of measuring

differences in gray and white matter in the brain (Schlaug et al., 1995), and a network science approach (Wilkins, Hodges, Laurienti, Steen, & Burdette, 2012). The researcher selected to confine the focus of the present research to fMRI primarily because the assessment tool is being developed as part of a brain-imaging study which uses fMRI as its data source.

Functional MRI has been in existence since 1991 and is considered a non-invasive method of measuring human brain activation (Bandettini, 2009). A substantial body of research literature exists where fMRI was used to investigate the brains of musicians. For example, Halpern, Zatorre, Bouffard, and Johnson (2003) conducted research regarding the brain responses of perceived and imagined timbres of various musical instruments with a participant population that had a minimum of 5 years of musical training. Additionally, Dick, Lee, Nusbaum, and Price (2011) selected a participant pool of only trained musicians and actors when studying the effects of fine arts training and sensitivity to speech, such as spoken language and other complex sounds.

There have been portions of the literature in which researchers used a comparative approach with non-musicians as a control group and musicians as an experimental group. For example, Angulo-Perkins et al. (2014) explored music listening differences among musicians and non-musicians as it related to specific cortical regions within the temporal lobe. Another example can be found in Li et al. (2014), where researchers suggested that differences existed in functional connectivity in white matter structural networks among musicians and non-musicians. Previous research has shown that there are differences between musicians and non-musicians in multiple regions of the brain, including the

premotor cortex, an area associated with movement (Bailey, Zatorre, & Penhune, 2014; Bangert et al., 2006; Baumann et al., 2007).

Need for the Study

There has been a broad idea of what encompasses musical training and experience presented in the extant literature; however, a review of the literature suggests that each individual's musical training experience was likely more unique and varied than reported. Although the field of music and brain research is replete with diverse research questions, often it is difficult to generalize results and to compare results among research studies because of the discrepancies in the ways subject characteristics are measured and categorized. A uniform measure has been needed for some time to most accurately select and group subjects based on their musical training and experience.

Purpose of the Study

The purpose of this study was to develop an assessment tool to measure musical training and experiences for grouping participants in human neuroimaging research studies. To fulfill the purpose of this study, the researcher:

1. Completed a comprehensive review of the research literature to establish the essential content of the assessment tool;
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CHAPTER II

RELATED LITERATURE

The use of functional Magnetic Resonance Imaging (fMRI) in conjunction with studying the effects of music and musical training on the brain has been in existence for approximately 20 years. A seminal study by Schlaug et al. (1995) focused on differences in the corpus callosum, the fiber tract that connects one hemisphere of the brain to the other (Banich, 2004), between professional musicians and a control group of non-musicians. While the two groups were matched for variables such as sex, age, and handedness, the main difference between them was the presence of musical training. In the musician group, Schlaug et al. chose to investigate keyboard and string players who were either enrolled in a music school or had just completed training. Out of this pool, the researchers divided the participants into two subsections: (a) participants who had begun musical training before the age of 7, and (b) participants who had begun musical training after the age of seven. Differences were found in the size of the corpus callosum between musicians who began their studies before the age of 7 and non-musicians, with the musically trained group having an increased anterior portion. However, there were no significant differences found in the anterior portion of the corpus callosum between controls and musicians who began training after the age of seven. Researchers speculated that this difference in size of the corpus callosum between musician and non-musicians was because of the presence of musical training, specifically at an early age. This

groundbreaking study was pivotal in shaping the future of brain research when comparing musicians to non-musicians using fMRI.

In general, researchers have suggested that musical training affects brain structure and function, but there were inconsistencies in how the research was conducted. The most glaring inconsistency has been the method by which the characteristics of musicians were quantified. In this review, I will examine how researchers have classified musicians and non-musicians in fMRI studies to date.

There were two broad topics that researchers have used to quantify musicians. The first was training/experience background (Bailey & Penhune, 2010), and within this topic numerous subsets were found. Those subsets included years of training, age of onset of training, and practice hours. The second broad topic used by researchers to quantify musicians was performance area (e.g., instrument, voice). Subsets of performance area included keyboard, string, wind (woodwind and brass), percussion, and voice, among others.

Most researchers utilized self-reports from the participants to obtain this information. In order to gain a deeper understanding of these areas, this review will focus on each subset individually.

Training/Experience Background

When discussing the training and experiences of musician participants, researchers generally employed three grouping mechanisms commonly found in the literature: (a) years of training, (b) age of onset of training, and (c) cumulative practice

hours. These grouping mechanisms were found as standalone factors or were often combined with other factors to ascribe levels of musicianship.

Years of Training

The years of training a participant received was reported in a variety of ways, including using a minimum number ("participants studied music for a minimum of 7 years"), an average number ("participants received musical training for an average of 12.2. years"), or a range of years of training ("participants received training for 6–20 years"). The following studies applied these methods of reporting years of training either singularly or in combination with another grouping mechanism as a defining factor for musician participants.

Minimum number of years. Among the studies reviewed, 11 utilized a minimum number of years of training to define musician participants (see Figure 1). The minimum number of years of musical training ranged from 3 to 15 years, with a mean of 9.18 years. The lowest number of minimum years of training was 3 years (Angulo-Perkins et al., 2014), in which researchers investigated musician and non-musician responses to stimuli including instrumental sounds, human vocal sounds, and non-vocal sounds (e.g., a car starting, a toilet flushing). Musicians revealed greater bilateral activation in the planum polare, which has been implicated in language functions. Researchers suggested that the results could mean that music processing took place in specific regions of the auditory cortex.

Figure 1. Minimum Years of Training. This Figure Represents the Required Minimum Years of Musical Training for Participants in fMRI Studies.

A minimum of 5 years of training was a common grouping mechanism for two studies. For example, participants were considered musicians if they possessed at least 5 years of musical training in a beat perception study (Grahn & Rowe, 2009). The researchers required participants to determine differences in rhythmic patterns with accented and unaccented beats. Researchers suggested a significant neuron interaction between the bilateral supplementary motor area and the superior temporal gyrus in musicians when compared to non-musicians, leading to the conclusion that different areas of the brain were used in beat perception for musicians. Similarly, a minimum of 5 years of musical training was employed as a grouping mechanism in a task-based study that required participants to compare instrument timbres (Halpern et al., 2003). Researchers suggested that participants with at least 5 years of musical training had similar activation

in the brain when they imagined instrument timbres and when they heard the actual instrument timbre.

Researchers also examined participants with a minimum of 8 years of musical training who were asked to complete a memory retrieval task (Huang et al., 2010). Musicians in this study were found to have better memory retrieval skills related to pitches than non-musicians, possibly because of functional reorganization in multiple sensory areas as a result of musical training. An increase to 9 years as a minimum of training was required in a study that involved a finger-tapping rhythmic task (Ono, Nakamura, & Maess, 2015). Participants were asked to tap perceived rhythmic segments from a video of a conductor. Undoubtedly, the musician participants were able to complete this task with more ease than the non-musicians. The musicians also, however, demonstrated greater activation in the left superior frontal gyrus, thus leading to the conclusion that musicians possessed better timing prediction than non-musicians because of extended time in a group ensemble setting with a conductor.

Another study to note in this area separated its musician participants into two subgroups: Music Expert and Music Hobby (Sato et al., 2016). The Music Expert group possessed a minimum of 9 years of musical training, while the Music Hobby group possessed a maximum of 7 years of musical training. When compared with each other, the Music Expert group exhibited greater gray matter volume in the following areas: inferior frontal gyrus, left middle occipital gyrus, and bilateral lingual gyrus. Researchers suggested that these results could be attributed to the cognitive demand in musical training and processing, as well as the visual attention needed for music performance.

Additionally, participants in a task-based study (with a minimum of 10 years of training) were required to execute finger movements during a listening selection (Baumann et al., 2007). Results suggested that trans-modal activity, the act of multiple sensory areas interacting, was stronger in musicians than non-musicians, likely due to plasticity incurred as a result of intensive training. Bermudez and Zatorre (2005) explored gray matter volume and white matter structure in musicians and non-musicians, where 10 years was the minimum number of years of musical training expected in order to be labeled a musician participant. The authors reported that musicians with a minimum of 10 years of training showed greater gray matter volume in the right lateral surface of the superior temporal gyrus than non-musicians as a result of musical training. Even though the musicians were separated into those with absolute pitch and those with relative pitch, the only differences were found between musicians and non-musicians. Participants with a minimum of 10 years of musical training also showed greater white matter architecture in the genu, or frontal area of the corpus callosum as a result of the cognitive and motor effects of musical training (Schmithorst & Wilke, 2002).

In two articles, a minimum number of years of training higher than ten was required. In a study that included a passive listening task, researchers determined that musicians had greater neural activity in auditory areas as well as the prefrontal cortex because of sustained musical training of a minimum of 12 years (Ohnishi et al., 2001). This was important because it lead to the conclusion that the onset of training may also affect functional reorganization. In a rhythmic perception study by Limb, Kemeny, Ortigoza, Rouhani, and Braun (2006), participants with a minimum of 15 years of

musical playing experience displayed greater activity in the left frontal operculum, the superior temporal gyrus, and the inferior parietal lobule—all areas implicated in language function due to musical training.

In summary, eleven studies reported a minimum number of years of training received in order to be classified as a musician. The minimum number of years of training ranged from 3 to 15 years, with an average of 9.18 across all of the studies. The most commonly used minimum number was 10 years of musical training (Baumann et al., 2007; Bermudez and Zatorre, 2005; Schmithorst and Wilke, 2002).

Average number of years. Sixteen articles utilized average number of years of training and/or experience to define musician participants (see Figure 2). Hyde et al. (2009) analyzed gray matter volume between two separate scanning sessions. One scan was taken prior to musical training, and one scan followed an estimated 15 months of musical training. Results from the first scanning did not reveal any differences between participant groups, both without musical training. In comparing results from the second scanning session (following the musical training) the researchers found increased gray matter voxel size in motor areas, the corpus callosum, and the right primary auditory regions of participants who received musical training.

Although it was common for most neuroimaging studies to focus on either gray matter volumes or white matter integrity, Han et al. (2009) reported findings in both areas. Participants with musical training of approximately 10.4 years (*SD* = 4.2) revealed higher gray matter volume in the left primary sensorimotor cortex and the right cerebellum, as well as higher white matter integrity in the right posterior limb of the

internal capsule than non-musician participants. The authors supposed that these differences were due to prolonged musical training (Han et al., 2009).

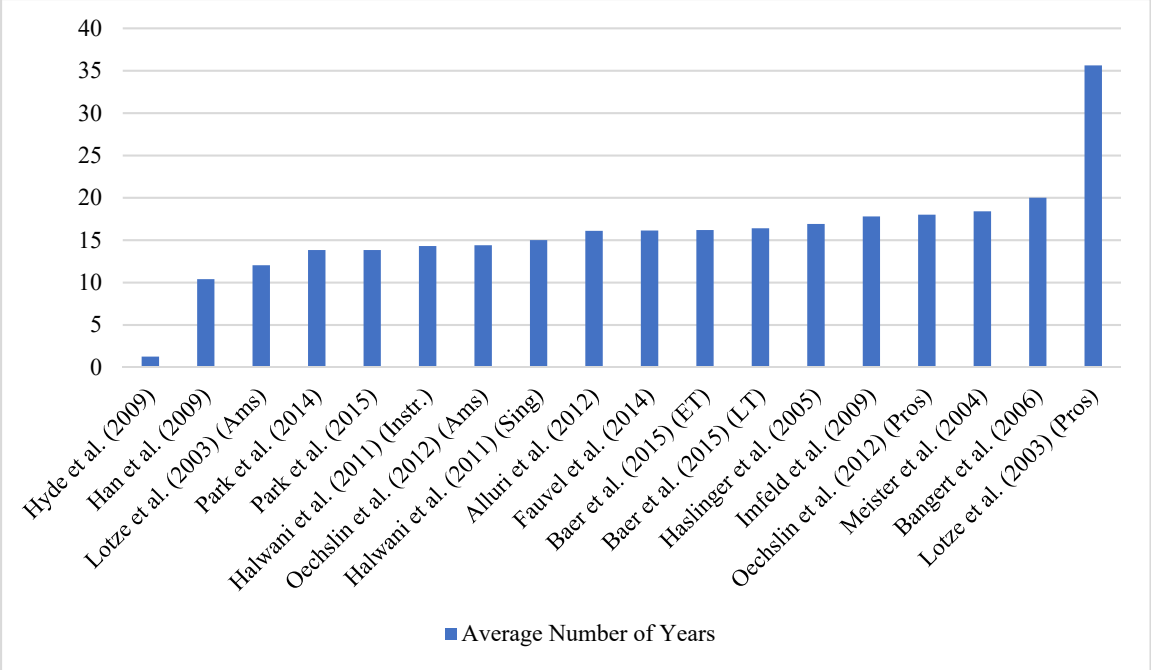

Figure 2. Average Number of Years of Training. This Figure Represents the Average Number of Years of Musical Training Reported by Participants in fMRI Studies.

In a separate study, participants with musical training also revealed activation in the sensorimotor cortex; however, there was a difference in how musician participants were grouped (Lotze, Scheler, Tan, Braun, & Birbaumer, 2003). Participants with musical training were separated into two subgroups: professionals (M = 35.63, SD = 6.37 years of training) and amateurs (M = 12.03, SD = 3.59 years of training). Although both groups of musicians showed greater activation in the sensorimotor cortex than non-musicians, activation in the professional musicians was more prominent. Perhaps

prolonged musical training led to enhanced efficiency in the task, as well as reduced effort.

In a different brain activation study, participants with musical training (M = 13.83, SD = 2.58 years) exhibited significant activation when compared to non-musicians (Park et al., 2014). Park et al. (2014) conducted research in which participants listened to musical stimuli that represented the emotions of happiness, sadness, and fear. Participants with musical training displayed significant activation in response to the fear and sadness examples ($z = -2.00$, $p < .05$; $z = -2.17$, $p < .05$). Specifically activated were the right prefrontal cortex for sadness and the right parietal cortex for fear, which suggested a link between musical training and "negative" emotions. In a later article, Park et al. (2015) utilized the same participant population and changed the stimuli from music to speech and that expressed the same emotions (happiness, sadness, fear). Musician participants demonstrated increased activation in the middle frontal gyrus, anterior medial prefrontal cortex, posterior cingulate cortex, and retrosplenial cortex. Park et al. thought that these findings were the results of increased sensitivity of emotional processing in musicians.

Another example of difference in white matter was found in several brain regions in a comparison of singers (M = 15, SD = 5), instrumentalists (M = 14.3, SD = 9.09), and non-musicians (Halwani, Loui, Ruber, & Schlaug, 2011). Musician participants exhibited a higher white matter tract volume and complexity in the superior temporal gyrus and the inferior frontal gyrus as a result of long-term training, which indicated better developed skills in sound perception and production. Similarly, musician participants were divided into professional and amateur groups for a study investigating responses to different

musical cadences (Oechslin, Van De Ville, Lazeyras, Hauert, & James, 2013). Professional musicians possessed a mean of 18 years (*SD* = 4.2) of training, and amateur musicians possessed 14.4 years (*SD* = 4) of training. Increased activity in the fronto-temporal network, implicated in working memory and attention, was associated with level of expertise.

Researchers revealed that this system of networks tended to develop during long-term piano training. A large-scale network was discovered in musically trained participants (*M* = 16.1, *SD* = 6 years) while completing a listening task that evaluated participants' responses to timbre and tone in a modern tango (Alluri et al., 2012). The cerebellum, sensory, and default mode networks were implicated in timbral changes, while cognitive-, motor-, and emotion-related areas were implicated during changes of pulse and tonality. The regions of the brain were working together and a large-scale network was exposed during fMRI scans. Gray matter in four different areas of the brain (right posterior cingulate gyrus, middle cingulate gyrus, left superior temporal gyrus, and right inferior orbitofrontal gyrus) was increased in musician participants with a mean of 16.13 years (*SD* = 4.29) of training compared to non-musicians (Fauvel et al., 2014). Researchers stated that expertise can structurally enhance the brain further than just the sensorimotor cortex. The nature of expertise and how expertise was acquired, however, has remained the subject of intense debate among both researchers and popular press writers.

In addition, an article that involved a finger tapping task required participants to tap with a metronome and then continue without the metronome. Participants with

musical training were separated into two subgroups: musicians with early training (ET), having begun before the age of seven, and musicians with late training (LT) having begun at or after the age of seven (Baer et al., 2015). The total participant population had a mean of 16.3 years (*SD* = 4.3) of musical training. Participants with ET had a mean of 16.2 years (*SD* = 4.1) of musical training, while participants with LT had a mean of 16.4 years (*SD* = 4.7) of musical training. Participants with early musical training had a reduced volume in bilateral cerebellar white matter compared to participants with late musical training and non-musician participants, resulting in better timing in the tapping exercise. These results led to a better understanding of the role of the cerebellum in the relationship between timing and music.

As various regions of the brain were being examined, it was possible to find the regions working in tandem, creating networks that functioned during specific tasks. For example, participants with musical training of approximately 16.9 years (*SD* = 2.7) exhibited stronger activation in the fronto-parieto-temporal and sensorimotor networks during a finger and thumb movement task with and without piano sound than non-musicians (Haslinger et al., 2005). An increase in unrestricted white matter pathways in the corticospinal tract (according to Banich, the pathway that links the brain to the spinal cord), was found in participants with a mean of 17.8 years (*SD* = 2.9) of musical training compared to non-musician participants (Imfeld, Oechslin, Meyer, Loenneker, & Jancke, 2009). In contrast to gray matter, Banich (2004) reported that the white matter of the brain consisted of "areas in which myelinated fibers run" (p. 59). An increase in myelin (fatty sheath that covers axons) has been associated with a faster speed of information

transfer through electrical signals (Banich, 2004). The authors submitted that plastic changes in white matter may have taken place as a result of musical training.

In a similar study by Meister et al. (2003), pianists with an average of 18.4 years of training displayed enhanced activation during finger performance and imagined performance in response to a Bartok piano piece, when compared to non-musicians in premotor areas, the precuneus, and Broadmann Area 40 (which has been implicated in reading). During the finger performance portion of the study, musically trained participants also showed greater activation in the primary motor cortex and the posterior parietal cortex, leading authors to conclude that musical training lead to a higher level of visuo-motor integration during motor tasks.

In contrast to the structural studies where researchers investigated differences in gray matter and white matter, researchers also evaluated brain activation in selected regions. For instance, in a music listening task that involved pressing keys on a muted keyboard, participants with approximately 20 years (*SD* = 8.7) of musical training exhibited increased brain activity compared to non-musician participants in the superior temporal gyrus and the primary sensorimotor cortex (Bangert et al., 2006). This was interesting to note because these areas were also involved in language production and indicated that the network used by professional musicians when listening to and performing music may be similar to a cross modal system.

In summary, the average years of musical training in participant groups was reported in sixteen studies. The average number of years ranged from 1.25 to 35.63 years, with an average of 15.92 years across the sixteen studies. Also of importance was that

when studies were placed in order from lowest number to highest number of average years of training, there was a large gap between the first two studies (1.25 and 10.4 years), as well as the last two studies (20 and 35.63 years).

Range of years. Instead of reporting an exact number of years of musical training, some researchers elected to convey a range of years of training that participants have received musical training (see Figure 3). For example, an investigation of resting state functional connectivity among motor and multisensory cortices revealed increased connectivity in participants with 6–20 years of musical training compared to non-musicians (Luo et al., 2012). Authors related that the plasticity of these cortices was due to musical training. In a similar fashion, researchers used a range of years to indicate participant experience as a middle or high school band or orchestra director (Hodges, Hairston, & Burdette, 2005). Conductors with 6–18 years of experience were compared to nonconductor controls to examine multisensory processing related to the demands of being a conductor. Hodges et al. (2005) wrote of greater activity in the visual cortex, specifically the bilateral occipito-temporal cortices of conductor participants than non-conductors, thus leading to the conclusion of a possible brain network for simultaneous processing of visual and auditory stimuli.

Also, researchers chose to examine two groups of musicians (pianists and violinists) and reported the range of years of musical training for each group (Luo et al., 2014). The functional connectivity of pianists with 6–20 years of training, violinists with 6–16 years of training, and non-musicians was investigated during a resting state condition that revealed higher connectivity in the salience system of participants with

musical training, due to the intensive training. The salience system (regions included: right insula, left insula, right temporoparietal junction, left temporoparietal junction, anterior cingulate cortex, right striatum, left amygdala, left middle frontal gyrus, left superior parietal lobule, and right superior frontal gyrus) was implicated in cognitive control and attention processes, both important skills in musical performance.

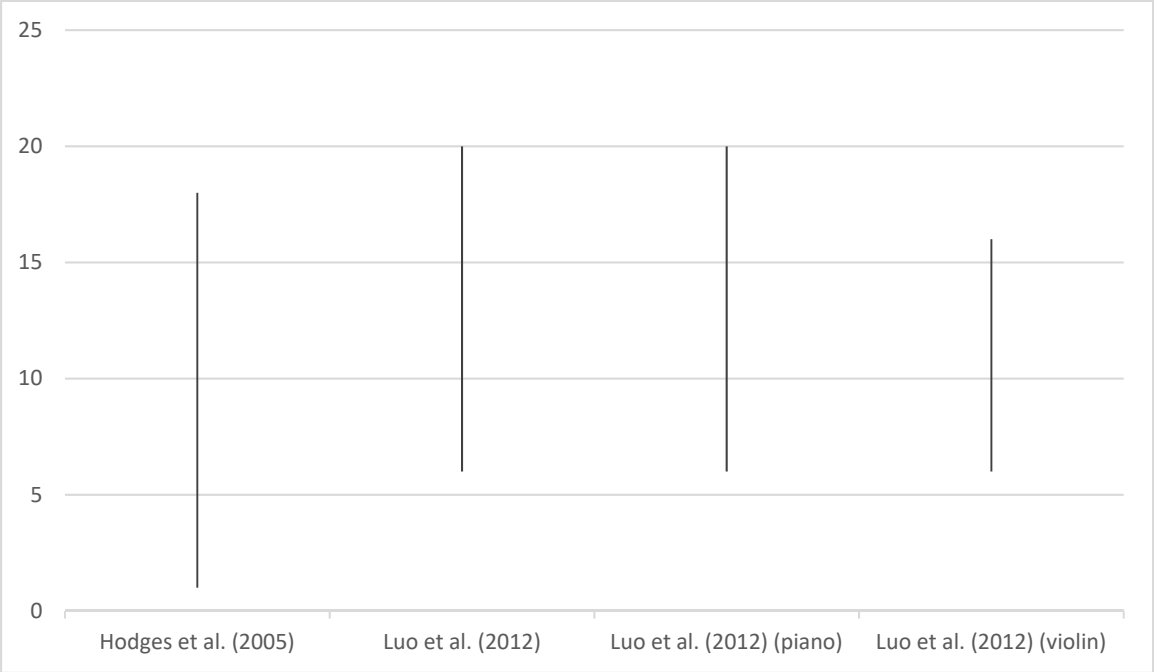

Figure 3. Range of Years of Training. This Figure Represents the Ranges of Years of Musical Training Reported in fMRI Studies. The Lowest Point of the Line Represents the Least Number of Years of Training from a Participant, and the Highest Point of the Line Represents the Highest Number of Years of Training from a Participant.

In summary, only two studies reported a range of years of musical training. Consistency was found in the lowest number of each range, with 6 years indicated in both of the studies, even in the sub-groups of Luo et al. (2014). Although two studies were reported in this review of related literature, it was noted that the total range of years of

training was stated by Luo et al. (2014), as well as the study's two sub-populations, piano and string players.

Combination of minimum and average. Another method for defining musicianship combined two of the previously stated methods: reporting the minimum number of years of musical training needed to participate in the study, as well as the average number of years of training. Of the studies reviewed, this method was found in four (see Figure 4). In a comparison of the corpus callosum anatomy and interhemispheric functional symmetry among participants with musical training and non-musicians, the musician participants were separated into two subgroups: keyboard players and string players (Burunat et al., 2015). All musician participants had a minimum of 5 years of training, with a mean of 15 (±4.7) years (keyboard, $M = 14.4$, $SD = 4$ years; string, $M = 15.9$, $SD = 3.8$ years). Participants with musical training demonstrated an increased posterior corpus callosum volume ($p = 0.05$, one-tailed, 7.3% difference between mean groups), as well as greater white matter structure (musician brain volume = 21.42 cm^3; non-musicians brain volume = 0 cm^3; brain volume referring to the amount of significant voxels different between musicians and non-musicians). However, keyboard players exhibited a greater amount than string players (keyboard brain volume = 10.37 cm^3; string brain volume = 0.90 cm^3; one-tailed *t*-test, $p < 0.01$), suggesting that the bi-modal training for keyboard instruments leads to a greater increase in information processing, specifically music perception.

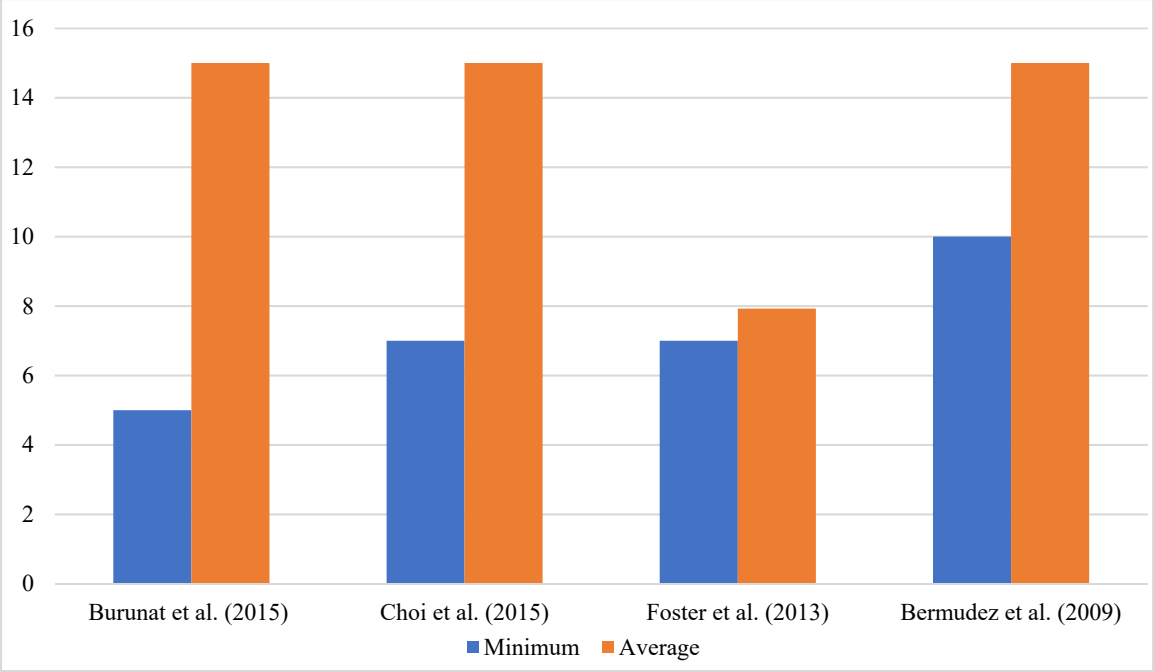

Figure 4. Minimum Number and Average Number of Years of Training. This Figure Represents the Studies That Reported Using a Required Minimum Number of Years of Musical Training in Combination with the Participant Reported Average Years of Musical Training.

In a structural and resting state functional connectivity study, the brain areas associated with lip and tongue movements were compared among participants with musical training on wind instruments (minimum = 7 years, $M = 7.93$, $SD = 1.21$ years) and non-musicians (Choi, Sung, Hong, Chung, & Ogawa, 2015). Structural results revealed an increase in cortical thickness in the postcentral gyrus of the right hemisphere (the area that controls the lips and tongue) in musicians. Resting state functional connectivity results demonstrated increased connectivity in the precentral gyrus and supplementary motor areas in participants with musical training. The authors supposed that intense musical training induced structural changes and the possibility of generating a new functional network.

Another example of this method was found in a study that recruited only participants with musical training—the participants having had at least 7 years of training (Foster, Halpern, & Zatorre, 2013). Participants, who had a mean of 15 years of musical training according to self-reports, completed a mental transposition and melody reversal task while being scanned. The authors found that the tasks were overlapping and activated the intraparietal sulcus. In a comparison of non-musicians and musicians with at least 10 years of musical training, researchers found greater gray matter volume in the superior temporal and dorsolateral frontal regions, as well as the postlateral Heschl's gyrus, in participants with musical training, which led to the conclusion that intense musical training created specialized abilities within the brain (Bermudez, Lerche, Evans, & Zatorre, 2009). Along with these findings, researchers reported participants' average years of training (M = 15, SD = 4.3), as well as average years of experience (M = 16.9, SD = 3.4).

In summary, of the four studies reviewed in the existing literature, the minimum number of years of training ranged from 5 to 10 years of musical training. In conjunction with the minimum number of years of training, the average number of years were also stated, and ranged from 7.93 to 15 years of musical training. It was also noted that Bermudez et al. (2009) indicated the average years of experience but did not express the difference in training and experience.

Combination of average and range. Researchers have also used the technique of combining an average number of years of musical training with a range of years of training. Of the studies reviewed, five used this method to record participants'

experiences with musical training. For example, the gray matter volume of the Broca's Area—which Banich (2004) described as an area in the left hemisphere that has been implicated in speech output—was increased in musicians with a mean of 20.4 years of musical training (SD = 9.4) and a range of 4–44 years of symphony orchestra experience in comparison with non-musician controls, which implied that musical performance promotes use-dependent retention (Sluming et al., 2002). Furthermore, in an investigation of resting state functional connectivity in musicians and non-musicians, participants with musical training had a mean of 10 (SD = 2.5) years and a range of 7–14 years (Palomar-García, Zatorre, Ventura-Campos, Bueichekú, & Àvila, 2016). In discussing the results of the resting state scan, researchers concluded that there was stronger functional connectivity between the right auditory cortex and the right ventral premotor cortex in musicians ($F_{1, 32} = 9.16$; $P < 0.005$). Additionally, the number of years of training correlated with the strength of the connectivity ($r_{(17)} = 0.50$; $P < 0.05$).

In like manner, Groussard et al. (2014) described the average number and the ranges of years of training for multiple groups of musicians and non-musicians. Comparisons were made among groups of musicians, as well as non-musicians, with musicians' training ranging from 0 to 26 years. Within the musician participant group, three subgroups were indicated: Novice, 1–11 years of training (M = 4.6, SD = 2.83); Intermediate, 9–14 years of training (M = 13.5, SD = 0.52); and Expert, 15+ years of training (M = 17.5, SD = 3.47). The purpose of this study was to determine which areas of the brain increased in gray matter volume faster than others in correlation with musical training. Although the right middle and superior frontal regions, as well as the left

hippocampus, exhibited changes early in training, areas such as the left superior temporal gyrus and the left posterior cingulate cortex increased in gray matter volume over a longer training period. The authors concluded that long-term musical training induced the structural changes.

Koelsch, Fritz, Schulze, Alsop, and Schlaug (2005) conducted a brain activation study that included adults and children with and without musical training. Adult participants with musical training had a mean of 9.4 years, with a range of 4–18 years. Although child participants were examined as one group, researchers stated that four of the children had musical training ranging from 1 to 8 years. Adult and child participants with musical training showed slightly stronger activation in the frontal cortex as a response to a music listening task that involved irregular chords (not major). Although non-musician participants' brains showed activation as well, their brain activity was weaker. Koelsch et al. suggested that because all the non-musician participants exhibited activation in the same area of the brain, perhaps everyday music experiences aided in helping humans figure out complex musical ideas, further making a case for the biological relevance of music.

The remaining studies that examined average years of musical training and recorded a range of years of musical training all had white matter integrity as their central focus. For instance, alterations of white matter networks were found in participants with musical training (M = 13.3, SD = 4.5, range = 6–20 years; Li et al., 2014). The authors thought that musical training produced more efficient transmission of information in local networks within white matter. Researchers also suggested that participants with musical

training, specifically bi-manual training needed for instruments such as piano and strings, had stronger white matter connections in the corpus callosum (Vollman et al., 2014). Participants with musical training in this study (M = 11.4, SD = 3.33, 6–16 years) were separated into two subgroups of pianists (M = 10, SD = 3, 6–14 years) and string players (M = 12.63, SD = 3.29, 6–16 years). The authors submitted that the resulting plasticity in the brain was because of specific instrument training.

The final study using both range of years and mean years of musical training examined the white matter integrity of musicians and non-musicians (Steele, Bailey, Zatorre, & Penhune, 2013). For the purposes of this study, participants with musical training were separated into those who began their training before the age of seven (Early Training) and those who started at or after the age of seven (Late Training). The Early Training group reported a mean of 11.5 (SD = 3.22) years of training with a range of 3–16 years for those who began before age seven, and a mean of 16.72 (SD = 3.89) years of experience with a range of 12–25 years for those who began before age seven. The Late Training group stated a mean of 9.42 (SD = 5.13) years of training with a range of 1–20 years for those who at or after age seven, and a mean of 16.58 (SD = 4.88) years of experience with a range of 9.5–24 years for those who began at or after age 7. Participants with early musical training exhibited greater white matter structure in the corpus callosum compared to participants with late or no musical training, indicating that there may be an ideal age for onset of musical training.

In summary, the combination of average years of training and range of training was reported in seven studies. Of the seven studies, the same information was indicated

for sub-group populations. However, the sub-group populations were different between studies. For example, Groussard et al. (2014) stated sub-populations of Novice, Intermediate, and Expert. Vollman et al. (2014) revealed sub-populations of string and keyboard players. Steele et al. (2013) indicated sub-populations of participants with early training and late training, as previously described.

Combination of minimum, average, and range of years. When examining studies that primarily reported years of training, only one study reported using a combination of the three methods: minimum number, average, and range of years of training. In a task-based study by Bianco et al. (2016), only participants with musical training (specifically piano) served as participants (minimum = 5 years, M = 17.2 years, SD = 4.8, range = 5–27 years). During the scanning session, participants completed two separate tasks. First, they listened to a chord progression and moved their hands in synch with the chords. Secondly, they viewed photos of hands playing chords on a piano, and the participants once again moved their hands, this time in synch with the photos. During both tasks, sub-regions in the right inferior frontal gyrus (an area association with movement inhibition) were connected with parietal and temporal areas (implicated in action and audio processing). Bianco et al. (2016) suggested that prolonged musical training can increase one's ability to predict motion, specifically motion related to musical structure, and that a network of brain areas was required for processing harmonies.

Summary of years of training. In the existing literature, years of musical training was represented in various ways. Singularly, required minimum years of musical

training, average years of musical training, and a range of years of training were utilized to group musician participants. Furthermore, a combination of minimum years and average years of training were used, as well as a combination of average years and range of years of training. Finally, a combination of all three methods—minimum years, average years, and range of years of training—were used to quantify musicians.

Age of Onset of Training

Another common method for defining a participant with musical training was to use the age of onset of training, and was reported in the following ways: (a) firm age (e.g., "participants began their musical training before the age of seven"), (b) average age ("participants had a mean age of 6.4 when musical training began"), and (c) a range of ages ("participants began their musical training between the ages of seven and nine"). The following studies used these methods of reporting age of onset either singularly or in combination as a defining factor for musician participants.

Firm age. Two studies that reported a firm age of onset of musical training have been previously mentioned. Huang et al. (2010) reported that all musically trained participants began training before the age of 7 years, as did Schlaug et al. (1995). In addition to these two studies, a structural investigation of gray matter and cortical surface area revealed differences between participants who began musical training at or before the age of seven (Early Training) and participants who began musical training after the age of seven (Late Training) (Bailey et al., 2014). These differences were discovered in the right ventral pre-motor cortex, indicating that auditory and motor interactions developed during musical training perhaps influenced the structural plasticity of the

brain. In summary, the age of seven was consistent among all three studies that indicated a firm age on onset of musical training.

Average age of onset. Of the 15 studies that reported the average age of onset of musical training, eleven have been previously mentioned in this review (see Figure 5). White matter structural differences were revealed among participants with musical training that began at a mean of 5.8 (*SD* = 1.4) years and non-musicians (Bengtsson et al., 2005). Oechslin, Descloux, et al. (2013) and Oechslin, Van De Ville, et al. (2013) separated participants with piano training into a professional group with the age of onset of training being 6.2 (*SD* = 1.9) years, and an amateur group with the age of onset being 7 (*SD* = 1.4) years. Hyde et al. (2009) recorded an average age of onset of training of 6.32 (*SD* = 0.82) years. Participants with musical training were grouped as singers and instrumentalists by Halwani et al. (2011), with a mean age of onset of training for singers of 6.6 (*SD* = 2.4) years, and a mean age of onset of training for instrumentalists of 7.4 (*SD* = 4.4) years.

Participants with musical training were separated into a professional group with the age of onset of training being 6.75 years, and an amateur group with the age of onset of training being 9.5 years (Lotze et al., 2003). Burunat et al. (2015) reported a mean of 8.2 (*SD* = 4) years as the age of onset, with a mean of 7 (*SD* = 6) years as the age of onset for keyboard players, and 8.3 (*SD* = 3.9) years as the age of onset for string players. Bermudez et al. (2009) indicated an average of onset of 7.6 (*SD* = 3.2) years. Fauvel et al. (2014) stated an average of onset of training of 7.75 (*SD* = *2*.02) years for participants with musical training. Alluri et al. (2012) indicated that all participants with musical

training played two instruments with the exception of one participant. Participants began training at an average of 9.1 (*SD* = 3.4) years for the first instrument, and an average of 10.5 (*SD* = 3.7) years for the second instrument. And similarly, Mesiter et al. (2003) reported an average age of onset of 8 years.

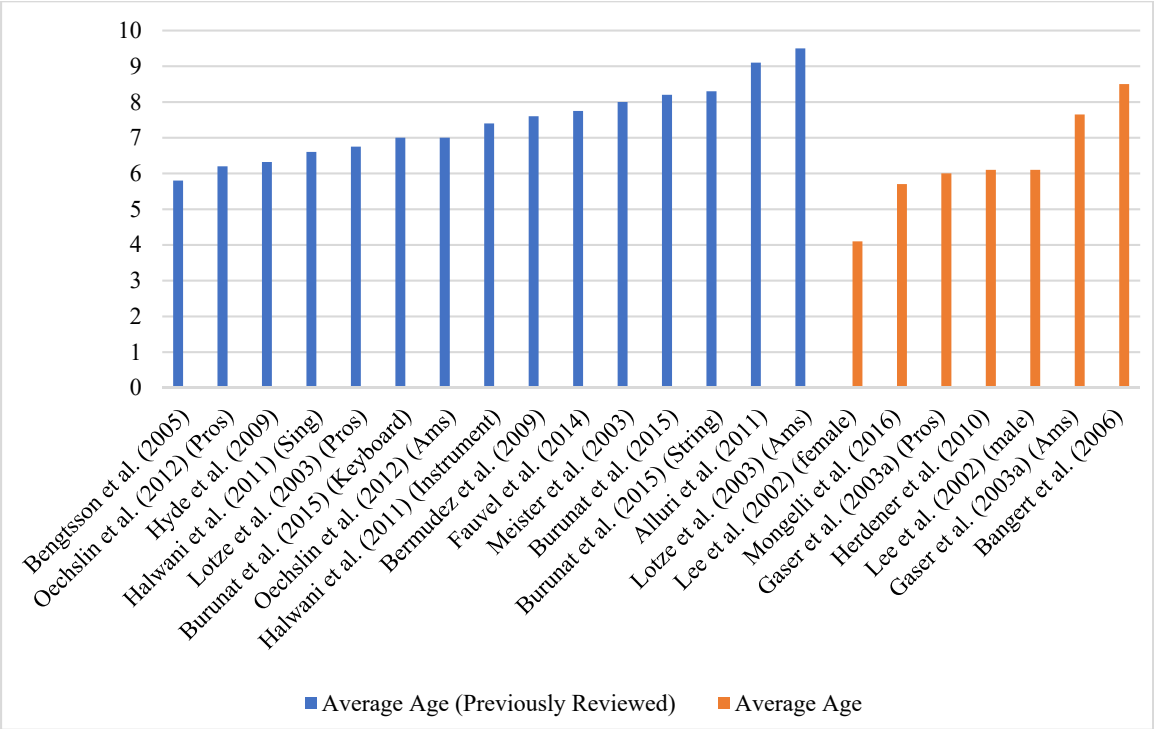

Figure 5. Average Age of Onset of Training. This Figure Represents the Reported Average Ages of Onset of Musical Training in fMRI Studies.

Lee, Chen, and Schlaug (2002) conducted an examination of gray matter in musicians and reported that males with musical training (*M* = 6.1, *SD* = 2 years) have a larger anterior portion of the corpus callosum than females (*M* = 4.1, *SD* = 1.4 years) or non-musicians. The authors came to the conclusion that this difference could be because of an early age of onset of training or because female brains tend to be more symmetric.

In a separate activation study, participants with musical training (*M* = 5.7, *SD* = 2.1 years) were compared to non-musicians in their responses to visual stimuli while undergoing an fMRI scan (Mongelli et al., 2017). The stimuli consisted of pictures of faces, tools, houses, pairs of words, and music scores. Although the activation occurred in the occipito-temporal cortex for all participants (an area that processes both words and music notation), it was detected in a slightly more posterior region for participants with musical training. The hypothesis given by the authors was that because the age of onset of musical training and reading acquisition were so close, the ability to read musical notation required more space.

Gray matter volume differences occurred in professional musicians (*M* = 6, *SD* = 1.81 years) as compared to amateur musicians (*M* = 7.65, *SD* = 4.17 years) and non-musicians (Gaser & Schlaug, 2003a). These differences were found in motor, auditory, and visuo-spatial regions of the brain, indicating possible links between specialized skills that involved training and brain structure. The plasticity of the hippocampus was exhibited in a comparison of participants with musical training (*M* = 6.1, *SD* = 2 years) and non-musicians (Herdener et al., 2010). Participants completed a listening task during the scanning session, in which the stimuli were a series of tones with pattern deviations. The right hemispheric secondary auditory cortex was activated in all participants, but the anterior left hippocampus revealed a significant activation difference in musicians. Herdener et al. (2010) advised that the hippocampus could be implicated in the encoding of time intervals. Lastly, Bangert et al. (2006) compared listening task results between pianists with an age of onset of training of 8.5 (*SD* = 4.8) years and non-musicians. Most

of the superior temporal gyrus was activated in both study groups. However, the pianist participant group had additional activation in frontal, temporal, and parietal cortical regions of the brain.

In summary, the average age of onset of training across all 16 studies was 6.87 years, with a range of 4.1–9.5 years. These numbers included the studies reviewed that contained sub-populations (Burunat et al., 2015; Gaser and Schlaug, 2003a; Halwani et al., 2011; Lee et al., 2002; Oechslin et al., 2012). Eleven studies were reviewed in previous sections which indicated a combination of reported average age of onset with one of the methods of calculating years of training.

Range of ages at onset. Of the studies reviewed related to a range of ages of onset, four articles reported a range of ages for onset of training, and all but one has been previously mentioned in this review (see Figure 6). Baumann et al. (2007) indicated an age of onset range of 5–13 years for participants with musical training. Sato et al. (2016) reported an age of onset range of 3–5 years for participants with musical training. Tanaka and Kirino (2016) indicated the same age of onset range as Sato et al. (2016), which could be attributed to the fact that both studies were completed in the same labs and could possibly be the same participant population. It was important to note that the age of onset range was only reported in these two studies for the group that consisted of all students majoring in music. The control groups consisted of students majoring in non-music disciplines, but researchers stated that a portion of the control group did possess musical training.

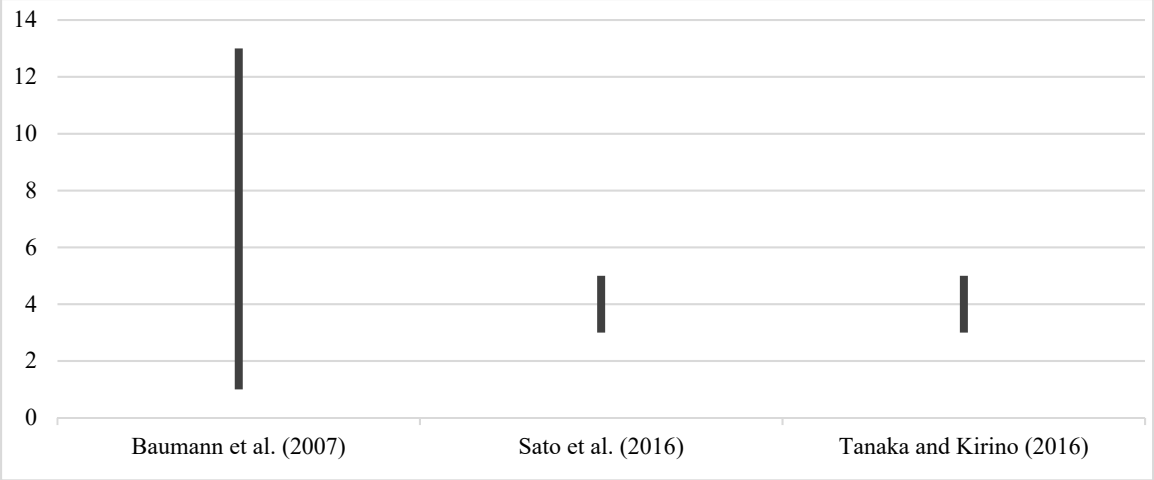

Figure 6. Age of Onset of Training Range. This Figure Represents the Ranges of the Age of Onset of Musical Training Reported in fMRI Studies.

Combination of firm age and average age of onset. Of the studies reviewed, six used the method of combining a firm age of onset of training with an average age of onset of training (see Figure 7). Of these six studies, three have been previously mentioned in this review. Baer et al. (2015) set a firm age of 7 years for the onset of musical training. Participants who received training at or before the age of 7 (M = 8.6, SD = 3.4) were placed in the Early Training group (M = 5.8, SD = 1.1 years), and participants who received training after the age of seven were placed in the Late Training group (M = 11.2, SD = 2.7). The surface area of the left planum temporale—according to Banich (2004), an area important in language comprehension—was examined by Elmer, Hänggi, Meyer, and Jäncke (2013). A correlation was found (r = .787, p = .007) between consonant-vowel syllable categorization and an increase in the surface area of the left planum temporale in participants with musical training that began before the age of 7 (M = 6.22, SD = 1.06 years). Therefore, a relationship was found to exist between musical

training, surface-area increase, and fast-changing phonetic cues. Zuk, Benjamin, Kenyon, and Gaab (2014) indicated that training should have begun before the age of 9, and musically trained participants had a mean age of onset of 5.73 (*SD* = 1.62) years. Imfeld et al. (2009) dictated that training should have begun before the age of 10 years, and participants with musical training had a mean of 6.8 (*SD* = 2.1) years of training.

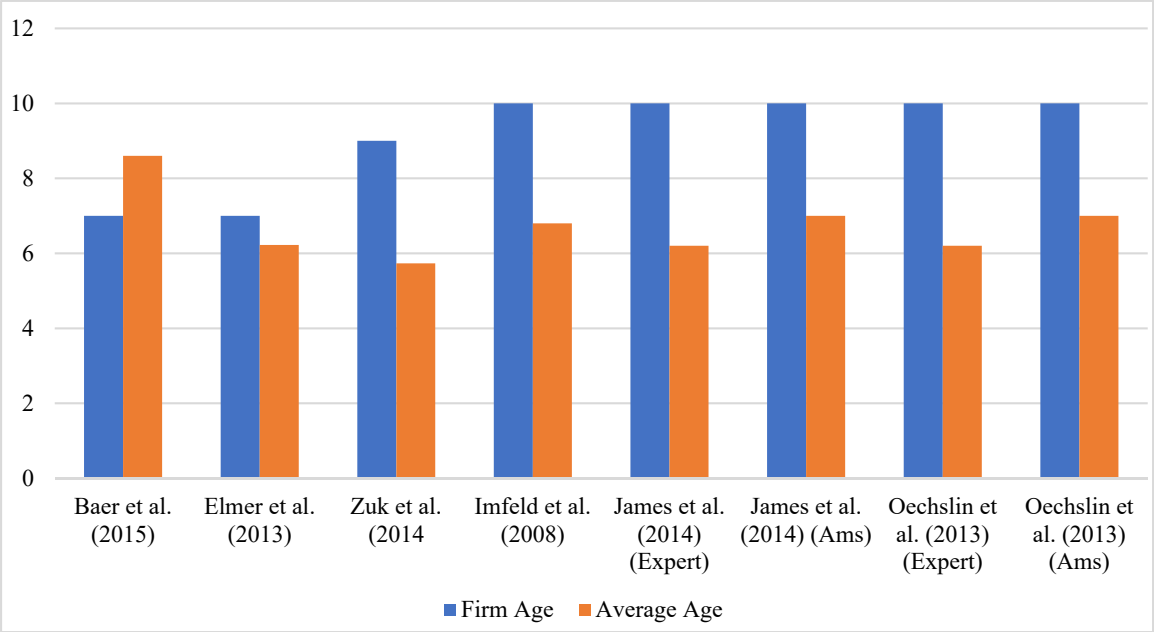

Figure 7. Firm Age and Average Age of Onset of Training. This Figure Represents the Studies That Reported Using a Required Firm Age of Onset of Musical Training in Combination with the Participant Reported Age of Onset of Musical Training.

Two of the remaining studies both required that training take place by the age of ten at the latest with two sub-groups of participants: Expert (*M* = 6.2, *SD* = 1.9 years) and Amateurs (*M* = 7, *SD* = 1.4 years; (James et al., 2014; Oechslin, Descloux, et al., 2013; Oechslin, Van De Ville, et al., 2013). James et al. (2014) revealed that gray matter density increased with the level of musical training in areas implicated in higher-order

cognitive processing. James et al. also indicated gray matter density decreasing with the level of musical training in areas of sensorimotor function. Authors suggested that this decrease was because of automated movements used by musicians. In addition, Oechslin, Descloux, et al. (2013) correlated intelligence scores with hippocampus volume. A greater hippocampal volume was found in musicians as compared to non-musicians. Oechslin, Descloux, et al. speculated that musical training required the use of cognitive resources provided by the hippocampus, such as learning and memory.

In summary, among the six studies reviewed in the existing literature, the age of 10 was the most common firm age of onset of musical training, with the other ages under 10-years old. The average age of onset of training, including the sub-populations (James et al., 2014; Oechslin, Descloux, et al., 2013), was 6.72. It was also assumed that James et al. (2014) and Oechslin, Descloux, et al. (2013) used the same participant populations because of identical firm ages of onset of training and average age of onset of training. 1

Combination of average age and age range of onset. Of the ten studies that used the combination of average age and age range of onset of musical training, six have been previously mentioned in this review. Although Groussard et al. (2014) indicated three musician groups, the mean age of onset, as well as the age range were reported: Novice (M = 20.27, SD = 5.33, range = 4–31 years), Intermediate (M = 7.45, SD = 0.82, range = 6–9 years), and Expert (M = 6.63, SD = 1.36, range = 5–9 years). Ohnishi et al. (2001) described participants with musical training as having a mean age of onset of training of 6.2 (SD = 2.79) years with a range of 3–16 years. Similarly, Palomar-García et al. (2016) reported a mean age of onset of training as 8.3 (SD = 1.6) years with a range of

6–10 years. Steele et al. (2013) stated a mean age of onset of training with a range of ages for both an Early Training group and a Late Training group: Early Training (M = 5.72, SD = 1.13, range = 3–7 years), and Late Training (M = 10.78, SD = 2.46, range = 8–18 years). Vollman et al. (2014) indicated a mean age of onset of training of 5.47 (SD = 1.25, range = 4–8 years), and included the same information for a subgroup of pianists (M = 5.57, SD = 1.62, range = 4–8 years) and a subgroup of string players (M = 5.38, SD = 0.92, range = 4–6 years). Han et al. (2009) stated an age of onset range of 5.5–15 years (M = 12.2, SD = 3.2) for participants with musical training.

In a study that included both average age and age range of onset of musical training (Foster & Zatorre, 2010), an increase in gray matter volume and cortical thickness was found in participants with musical training (M = 9, range = 3–16 years) compared to non-musicians. In association with a melodic transposition task, the increase in the volume and cortical thickness in the right Heschl's gyrus and bilateral intraparietal sulcus was indicative of the improved performance of the musician participant group. Pitch identification ability was correlated (r = 0.52-0.67, $P < 0.0001$) with resting state functional connectivity in musicians with an average age of onset of training of 10.67 (SD = 1.44, range = 8–20 years) and non-musicians (Hou, Chen, & Dong, 2015). Participants completed a computer-based pitch identification task prior to the scanning procedure, and an increase in functional connectivity was found in musicians in areas implicated in perceptual and auditory encoding.

In an activation study that involved stimuli consisting of violin excerpts and dramatic monologues, participants with musical training (M = 5.9, range = 3–8 years)

displayed higher activation than non-musicians in brain areas associated with speech while listening to the musical excerpts (Dick et al., 2011). Authors related this higher activation to long-term audio-motor activation acquired from musical training. Ellis et al. (2012) investigated areas associated with melodic and rhythmic pattern discrimination in children and adults with and without musical training. Children groups were labeled by a current age range, but a more specific range was given for the age of onset of training for each group: Ages 5–7 (M = 6.03, SD = 0.77, range = 4.84–6.91); Ages 9–11 (M = 5.74, SD = 1.35, range = 4.01–8.46); and Adults (M = 5.21, SD = 1.05, range = 4–8). Musical training effects were found in the posterior left superior temporal gyrus, which has implications in pattern matching.

In summary, of the ten studies reviewed, the average age of onset was 8.03 with a range of 3 to 31 years across all studies reported. Four of the studies included sub-populations. Groussard et al. (2014) separated sub-populations by ability level; Elli et al. (2012) separated sub-populations by life stages; Steele et al. (2013) separated sub-populations by age of onset of training (7-years old); Vollman et al. (2014) separated sub-populations by instrument training (piano and string).

Combination of firm age, average age, and age range of onset. In the studies reviewed, only one study used a method of combining a firm age with average age and an age range of onset. Sluming et al. (2002) reported a mean age of onset of musical training of 9.6 years (SD = 2.4) with a range of 4–13 years. A firm age of onset of training of before 7 years was indicated for three participants, while a firm age of onset of training of after 10 years was indicated for 17 participants.

Summary of age of onset of training. In summary, firm age of onset of training, average age of onset of training, and a range of ages of onset of training were all utilized separately in the existing literature to quantify musician participants. Combinations of these methods were used as well: firm age and average age of onset of musical training, and average age and ranges of age of onset of musical training. Finally, a combination of all three methods—firm age, average age, and range of ages of onset of musical training—was used as well to capture musical training for the purposes of grouping musician participants in neuroimaging studies.

Practice Hours

The third most common method for defining a participant with musical training was to use the self-reported number of practice hours and was stated as either the average number of practice hours or as a range of practice hours. Participants reported the average number of practice hours by using an estimate of hours per day, hours per week, or hours over a range of time. An example of range of practice hours would be "participants with musical training practice for 2–4 hours per day."

Average number of practice hours. Of the studies reviewed, ten studies reported an average number of practice hours for participant groups. For instance, Dick et al. (2011) indicated a mean of 4.2 practice hours per day for participants with musical training. Gaser and Schlaug (2003a, 2003b) reported practice hours per day for both professional and amateur musician groups: Professional (M = 2.23, SD = 0.91 hours per day); and Amateur (M = 1.15, SD = 1 hours per day). Lotze et al. (2003) also reported practice hours for professional and amateur groups: Professional (M = 30.87, SD = 3.95

hours per week); and Amateur (M = 1.45, SD = 1.6 hours per week). Herdener et al. (2010) also indicated practice hours per week for participants with musical training (M = 20.8, SD = 23.1). Adult and children participants were included in the participant pool in Zuk et al. (2014); practice hours per week were stated as M = 21.87 (SD = 11.49) by adults and M = 3.74 (SD = 2.63) by children. Practice hours per week were calculated for the entire musician participant population (M = 16.6, SD = 11 hours), and then calculated for two subgroups within the participants with musical training: keyboard (M = 15.6, SD = 13 hours); and string players (M = 17.3, SD = 12.6 hours; Burunat et al., 2015). Meister et al. (2003) reported an average of 22 practice hours per week. Bermudez et al. (2009) indicated an average of 13.9 (SD = 9.7) practice hours per week. See Figure 8.

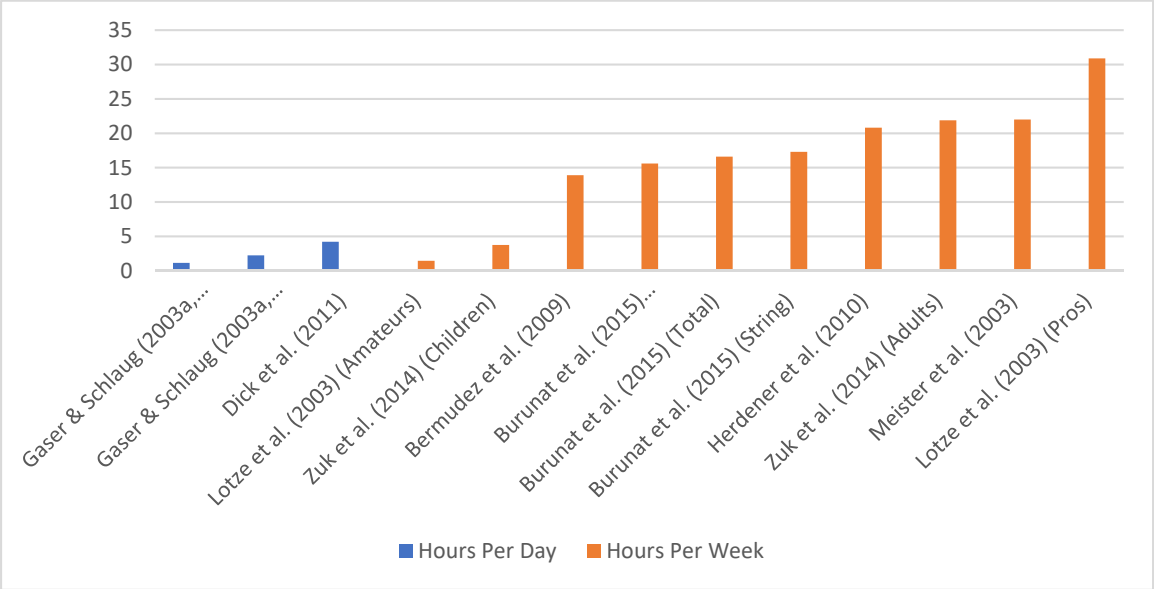

Figure 8. Average Number of Practice Hours. This Figure Represents the Reported Average Number of Practice Hours per Day (Blue) and Practice Hours per Week (Orange).

The following studies calculated practice hours by age ranges. Bengtsson et al. (2005) had participants with musical training estimate the total number of practice hours for different points through their lives. Childhood was defined as the age of onset of training to 11 years of age, and the mean practice hours was 1,618 (*SD* = 662) hours. Adolescence was defined as ages 12–16, and the mean practice hours was 3,195 (*SD* = 1515). Adulthood was defined as 17 years old until the time of the scan, and the mean practice hours were 22,971 (*SD* = 9,413). James et al. (2014), Oechslin, Descloux, et al. (2013), and Oechslin, Van De Ville, et al. (2013) reported practice hours per week for different age ranges throughout training for Expert and Amateur participants with musical training (see Tables 1–3).

Table 1

Practice Hours Per Week within Consecutive Age Brackets

	Amateur		**Expert**	
Age Ranges	***M***	***SD***	***M***	***SD***
6–8	3.0	1.90	3.10	1.7
8–10	3.5	0.50	4.20	0.5
10–12	4.0	2.30	6.50	4.3
12–14	4.7	2.60	9.00	5.3
14–16	5.3	3.12	14.80	7.7
16–18	4.7	2.20	19.90	9.3
18–25	4.8	2.90	30.70	8.5

Note. Source: James et al. (2014)

Table 2

Practice Hours Per Week within Consecutive Age Brackets

	Amateur		Expert	
Age Ranges	***M***	***SD***	***M***	***SD***
6–8	3.0	1.90	3.1	1.7
8–10	3.5	0.50	4.2	0.5
10–12	4.0	2.30	6.5	4.3
12–14	4.7	2.60	9.0	5.3
14–16	5.3	3.12	14.8	7.7
16–18	4.7	2.20	19.9	9.3
18–25	4.4	2.90	30.7	8.5

Note. Source: Oechslin, Descloux, et al. (2013)

Table 3

Practice Hours Per Week within Consecutive Age Brackets

	Amateur		Expert	
Age Ranges	***M***	***SD***	***M***	***SD***
10–12	4.0	2.30	6.5	4.3
12–14	4.7	2.60	9.0	5.3
14–16	5.3	3.12	14.8	7.7
16–18	4.7	2.20	19.9	9.3
18–25	4.4	2.90	30.7	8.5

Note. Source: Oechslin, Van De Ville, et al. (2013)

In summary, the average number of practice hours was reported in multiple ways: per day, per week, and over a designated period of time (i.e., childhood, adolescence, and adulthood). Practice hours per week were also indicated within consecutive age brackets

(James et al., 2014; Oechslin, Descloux et al., 2013; Oechslin, Van De Ville, et al., 2013). Average practice hours per day ranged from 1.15 to 4.2 hours. Average practice hours per week ranged from 1.45 to 30.87 hours.

Range of practice hours. Of the studies reviewed, two studies indicated a range of practice hours per day. Baumann et al. (2007) reported 3–5 practice hours per day for participants with musical training. Foster et al. (2013) stated 4–8 practice hours per day for participants with musical training.

Combination of average number and range of practice hours. Five studies reported a combination of the average number and range of practice hours for participants with musical training. Palomar-García et al. (2016) indicated that participants with musical training practiced for a mean of 12.8 (*SD* = 9.9) hours per week with a range of 4–25 hours. Similarly, Vollman et al. (2014) revealed that participants with musical training practiced for a mean of 6.6 (*SD* = 7.21) hours per week with a range of 0–25 hours. However, musician participants were separated into pianists and string players with the following practice hour information: pianists (*M* = 4, *SD* = 5.69, range = 0–15); and string players (*M* = 8.88, *SD* = 7.97, range = 2–25). Steele et al. (2013) also stated practice hours per week for participants with early musical training (*M* = 15, *SD* = 10.20, range = 3–35.5) and those with late musical training (*M* = 13.25, *SD* = 7.52, range = 4–34).

Two studies reported practice hours that had been calculated cumulatively over participants' lifetimes. Foster and Zatorre (2010) indicated a mean of 5,600 hours with a

range of 0–58,000 hours. Foster et al. (2013) revealed a mean of 17,000 hours with a range of 6,600–30,000 hours.

Summary of practice hours. Only two methods for reporting cumulative practice hours were used in the existing literature. The average number of practice hours was reported per day, per week, over lifetime periods (e.g., childhood, adolescence, adulthood), and at different age ranges. Researchers also used self-reports of a range of practice hours per day. Finally, a combination of average and range of practice hours was used by multiple studies, primarily as hours per week, with the exception of one study that collected cumulative practice hours over a participant's lifetime.

Performance Areas

Since training on a musical instrument has been considered a use-dependent training, it was important to consider the instrument choice in which the participant possessed training. The main difference in the 58 studies reviewed was that 14 did not report a performance area. Other differences included instrumental versus voice, and type of instrument (i.e., keyboard, strings, woodwind, brass, or percussion).

Keyboard. The presence of training on a keyboard instrument (piano, organ, etc.) was presented in two ways in the existing literature. The first way researchers employed the use of the grouping mechanism of keyboard players was by grouping them alone to preserve a more homogeneous participant group. An example of this was found in Haslinger et al. (2005), where participants with musical training had completed a conservatory degree in piano. The second way was by grouping keyboard players with other instrumentalists, and sometimes vocalists. For example, Alluri et al. (2012) reported

that participants with musical training had focused on the following instruments: keyboard, strings, wind, and percussion. In addition, the researchers indicated that musician participants had been trained in the following genres: classical, folk, jazz, and pop/rock.

Strings. Similar to the use of homogeneous keyboard groupings, string players were also grouped together or with other instruments/voice. For example, Dick et al. (2011) and Lotze et al. (2003) included participants with training only on string instruments. It was also common in the existing literature to group keyboard and string players together because of the similarity in their use-dependent training. Keyboardists and string players typically began training at an early age, compared to those who play wind instruments, and keyboardists and string players required the use of both hands, often in opposing motion. Included in the string instrument category were the following instruments: violin, viola, cello, double bass, harp, and guitar.

Winds and percussion. Studies that included participants who played wind instruments were either classified as strictly winds, or by specific instrument type. Woodwind instruments included in these studies were flute, transverse flute, pan flute, recorder, clarinet, oboe, and bassoon. Brass instruments included were trumpet, horn, and trombone. An example of the inclusion of only wind instruments was found in Choi et al. (2015), where the musician participant pool was comprised of woodwind and brass players who were members of junior or senior high school ensembles or university wind ensembles.

Voice. Of the 58 studies reviewed, only three studies included vocalists in their pool of musician participants. Foster and Zatorre (2010) reported participants with musical training, specifically classical music, on piano, strings, wind instruments, and voice. A similar participant population was found in Halwani et al. (2011); however, the genre in which the participants trained was not reported. Although Ohnishi et al. (2001) included vocalists, they were also grouped with participants who had received training on a keyboard instrument or percussion.

Other performance areas. Few studies reported performance areas outside of the previously mentioned instruments or voice. However, Hodges et al. (2005) defined participants with musical training as those who had experience as a conductor of a band or orchestra. There were also three studies that included the accordion as an instrument of musical training (Li et al., 2014; Luo et al., 2014; Park et al., 2014). Li et al. (2014) and Luo et al. (2014) also included training on the Chinese zither.

Summary

In conclusion, the purpose of this review was to demonstrate that there has been a lack of consistency among how musicians were categorized in brain imaging studies that investigated the effects of musical training on the brain. The three primary factors discussed (i.e., years of training, age of onset of training, and practice hours) have been most frequently found in the existing literature and have mainly focused on the quantity of musical training and not the quality. See Appendix A for summary charts of the literature review by all methods and by all performance areas. See Appendix B for a list

of brain physiology terms associated with the related literature. See Appendix C for labeled brain images.

CHAPTER III

METHOD

Restatement of Purpose

The purpose of the present study was to offer a method for measuring individual musical training and experiences through the use of a comprehensive survey in order to more closely group participant populations in neuroimaging studies. The assessment tool was created to ensure that the musical experiences and training of the participants in neuroimaging studies were analyzed for categorization in groups for the purposes of comparison. Additionally, participants in a neuroimaging study were screened using the survey to determine the differences that may exist between musicians and non-musicians and how to categorize these participants for optimal results when completing the brain imaging. Discrepancies in how participants were classified for the purposes of neuroimaging research were found frequently in extant neuroimaging literature that involved the study of music or musicians. By examining the different training backgrounds and musical experiences of a set participant pool, the researcher hoped to offer a more comprehensive tool for categorizing musicians for the purposes of neuroimaging studies. To fulfill the purpose of this study, the researcher:

1. Completed a comprehensive review of the research literature to establish the essential content of the assessment tool;
2. Developed an assessment tool to survey subjects about their musical training and experiences;

3. Pilot tested the assessment tool, and revised the tool according to the preliminary analyses of the validity, reliability, and usefulness of the assessment tool;

4. Established the content validity and reliability of the assessment tool with subjects participating in a neuroimaging study designed to analyze the influences of musical training and experiences on brain structures and functions, and

5. Determined if the assessment tool functioned effectively in the selection and grouping of musically trained and musically untrained subjects for neuroimaging studies.

Participants

Participants for the present study ($N = 42$) included individuals who were recruited on a volunteer basis for participation in a neuroimaging study. Participants were asked about the existence of musical training in their backgrounds before completing the assessment tool (see Appendix D), such as "Are you a musician?" and "Do you have any musical training?" Demographic information was gathered for each participant, including (a) age, (b) gender, (c) race, (d) ethnicity, (e) years of education, and (f) current occupation.

The age range of the participants was 18–48, with a mean age of 27.88 years (see Table 4). With regard to gender identification, 50% ($n = 21$) identified themselves as female, 48% ($n = 20$) identified themselves as male, and 2% ($n = 1$) identified themselves as transgender. Among the participants, 86% ($n = 36$) categorized themselves as White, 5% ($n = 2$) African-American, 5% ($n = 2$) Asian, 2% ($n = 1$) biracial (specifically, White and African-American), and 2% ($n = 1$) Native Hawaiian/Pacific Islander. Regarding ethnicity, 86% were non-Hispanic, while 14% identified themselves as Hispanic/Latino.

Table 4

Participants' Age

Age	*n*	%	Cumulative Percent
18–21	14	33%	33%
22–25	6	14%	47%
26–29	6	14%	61%
30–33	8	19%	80%
34–37	2	5%	85%
38–41	2	5%	90%
42–45	2	5%	95%
46–50	2	5%	100%
Total	42	100%	

Participants reported their current levels of education, with 12 years representing the completion of high school. The mean years of education were 16.63, with a range of 12–24.5 years (see Table 5). For the purposes of the total pool of participants, the reported occupations were separated into students and non-students, with subpopulations reported later in the study. Among the participants, 45% (n = 19) were students and 55% (n = 23) were non-students.

Table 5

Participants' Years of Education

Years of Education	*n*	%	Cumulative Percent
12–13	7	17%	17%
14–15	9	21%	38%
16–17	8	19%	57%
18–19	11	26%	83%
20–21	4	10%	93%
22–23	1	2%	95%
24–25	2	5%	100%
Total	42	100%	

Data Collection Instrument

The assessment tool, developed in this study, was designed and validated using a three-step construction process. In Step 1, a draft of the survey was created by Ms. Catheryn Shaw (hereafter known as 'the researcher') with the aid of Dr. Robin W. Wilkins, who both possessed advanced degrees in music and have experience teaching music in school environments (large ensembles) as well as privately (one-on-one). Dr. Robin W. Wilkins communicated with Dr. Jennifer S. Walter the assessment tool development notes found in Appendix E (R. W. Wilkins, personal communication, February 26, 2018).

After reviewing the related literature and examining other data collection instruments, the assessment tool was divided into 16 areas as related to musical training and experience (see Table 6). "Gaming and Typing" were included in the areas to

account for any motor areas that may be shared between this activity and playing a musical instrument (Vollman et al., 2012).

Table 6

Training and Experience Areas

1. Singing
2. Instrumental
3. Music Reading
4. Extracurricular Activities
5. Gaming and Typing
6. Band (Kindergarten thru 12th grade)
7. Orchestra (Kindergarten thru 12th grade)
8. Chorus (Kindergarten thru 12th grade)
9. Other School Music Classes (Kindergarten thru 12th grade)
10. Private Music Lessons
11. College/University Level Training
12. Teaching Experience
13. Community/Amateur/Professional Ensemble Experience
14. Piano Experience
15. Extra Musical Training
16. Religious Organization Experience

In Step 2 of the construction process, the researcher disseminated the assessment to five music educators and performers, with advanced degrees and expertise in music, for feedback in the following areas: (a) the importance of training and experience questions on the survey, (b) adequate coverage of the topics associated with musical

training and experience in the assessment, (c) the depth of questions, and (d) ease of use and readability of the assessment for participants. Changes were made to the survey to incorporate suggestions provided during this process, including the addition of examples of formal and informal settings, as they pertained to singing. For instance, when asked how many hours the participant sang in an informal setting, the examples "around the house" and "in the car" were added for clarity. Examples added as formal settings included church, community choir, and school. Another change made to the assessment involved descriptions of various music reading levels. The original assessment only incorporated the music-reading-level options of beginner, intermediate, and advanced. The following changes were made to the revised assessment, as related to music reading levels:

- Beginner—I can read notes in one clef (treble or bass), simple rhythms, basic time signatures, and basic musical terms.
- Intermediate—I can read multiple clefs, complex rhythms, multiple musical lines, complex time signatures (duple and triple), and more complex musical terms.
- Advanced—I can read all clefs, complex rhythms, a conductor's score, all time signatures (basic to mixed meter), and all musical terms.
- Other—I am more comfortable reading a lead sheet or guitar tabs.

Following Step 3 of the construction process, the assessment tool was administered to a pilot group of five additional people with varying levels of musicianship. Step 3 of the process was designed to determine the following: (a) ease of

use of the assessment, (b) any areas of musical ability and experience not previously mentioned, and (c) any other suggestions for improving the language, syntax, grammar, and/or structure of the assessment tool. The assessment was updated specifically to include any collegiate-level music courses that could have been taken by a non-music major after the pilot group made this suggestion.

When the assessment tool was applied to the purposes of neuroimaging research, as related to music training and experiences, an additional question was added prior to the tenth participant completing the assessment. Within the "Piano Experience" area, the following question was incorporated into the assessment for clarity: "What is the most difficult music composition that you have played on piano?" The previous nine participants were contacted by the researcher and asked to provide an answer for this question if they had reported any piano-playing experience.

Data Collection Procedures

Approval for the present study was granted by the Institutional Review Board (IRB) at The University of North Carolina at Greensboro (see Appendix F). Because the survey was part of a larger neuroimaging project, it was administered in addition to a battery of behavioral tests before the functional Magnetic Resonance Imaging (fMRI) scan took place. Demographic information, including gender, age, race, ethnicity, and education level, was collected prior to the administration of the assessment tool. The paperwork used was standard procedure through the Network Neuroimaging Lab for Complex Systems and was a portion of the standard study protocol. Under this protocol, the years that was equivalent to completion of high school was 12 years. Kindergarten

was not included intentionally because of generational differences of kindergarten attendance within the participant age range (that is, older participants may not have attended kindergarten). Also, college degree information was not obtained unless it was a degree in music.

The online survey platform, Qualtrics (Qualtrics, Provo, UT), was used to setup and administer the assessment tool. A private link was emailed to each participant upon receiving a signed consent form (see Appendix G) to participate in the study, and participants completed the survey on their own time under no direct supervision of the primary researcher. Follow-up emails were sent to the participants if they did not complete the survey within 24 hours after the scanning procedure. Data were collected from participants beginning in February 2016 and ending in May 2017.

Data Analysis Procedures

Following the administration of the finalized assessment tool via Qualtrics, the researcher analyzed responses using coding procedures developed by Glaser and Strauss (1967). The researcher used a grounded theory approach, in which the survey responses were reviewed and themes emerged during the coding process. Themes included descriptions of experiences and similar themes were grouped together to form concepts. Concepts included similar performance experiences and similar musical training backgrounds. The grouping of concepts resulted in three distinct participant groups: (a) Advanced Musical Training/Experience, (b) Moderate Musical Training/Experience, and (c) None to Minimal Musical Training/Experience. The participants were placed in one of the three categories based on their responses to the survey.

Finally, reliability for the survey was determined through inter-rater reliability. After the responses to each survey were coded by the researcher, a random number generator was used to extract 3 surveys (approximately 20%) from each previously determined group (Advanced Musical Training/Experience, Moderate Musical Training/Experience, and None to Minimal Musical Training/Experience). The researcher chose to extract 20% of the responses from each group instead of 20% of the total sample to eliminate the chance that all nine random surveys would be extracted from the same category. Two independent raters were enlisted to review the random surveys and to determine if they agreed with the coding assignments of the researcher.

Prior to reviewing the surveys, raters were trained on how to read the specific survey design and the coding categories were also clearly defined and were not informed that the random selections were generated from each previously established category. The raters received the following instructions for determining reliability:

Included in your packet are 9 completed surveys. The surveys have been placed in random order and assigned a number (upper left corner). This survey was created to capture a holistic picture of the extensive training and experience that musicians possess. Since you are both musicians, you know that there are varying levels of training and experience, and that is also what the survey is trying to determine. Each survey needs to be placed into one of the following groups:

Group 1: No/Minimal Musical Training or Experience

- Participants in this group may have no training or experience at all. However, they may also have minimal training or experience. Minimal is defined as no more than 4 years of training and limited experience. These participants did not participate in any extra ensembles, nor did they participate in extra-musical experiences such as workshops or camps.

Group 2: Moderate Musical Training or Experience

- Participants in this group possess musical training, with a minimum of at least 5 years. They could currently be in training or still making music with a group of

people, but they do not possess advanced degrees in music or have a healthy experience of teaching or advanced ensemble participation. Please keep in mind that ensemble participation is relative to their reported instrument(s). For example, it would be more difficult for a pianist or a guitarist to have a multitude of ensemble experiences. However, their years of training and other experiences, such as competitions and workshops/camps, should factor in.

Group 3: Advanced Musical Training or Experience

- Participants in this group possess many years of training. There is no minimum to their years of training or experience because some overlap may be found in this area between the Moderate and Advanced groups. Participants in this group usually have training/experience on multiple instruments, and this training can include advanced degrees, while the experience should include teaching experiences and various notable performance experiences. Please keep in mind that ensemble participation is relative to their reported instrument(s). For example, it would be more difficult for a pianist or a guitarist to have a multitude of ensemble experiences. However, their years of training and other experiences, such as competitions and workshops/camps, should factor in.

On the following page, you will find a list of the nine participants with a blank that follows. Please write your determination for which group that participant belongs.

Interrater reliability was determined to be 88.9% (see Table 7), and this was deemed acceptable for the purposes of this study.

Summary

For the purposes of this study, a thorough review of existing literature enabled the researcher to determine inconsistencies in the assessment tools used to select and group participants for the purposes of brain-imaging studies using fMRI. The goal of this research was to create an assessment tool that included as many salient factors related to musical training and experience as identified via a review of research on brain structures and functions, as related to musical training and experiences. Additionally, the present study was designed to thoroughly explore the musical backgrounds of participants, and to refine the definitions of what is considered to be musical training and experiences. The

results of analyzing the qualities of the assessment tool, and responses to the research objectives are presented in Chapter IV.

Table 7

Inter-Rater Reliability

Participant	Researcher	Reviewer 1	Reviewer 2	Conclusion
1	Group 2	Group 1	Group 1	Agree
2	Group 2	Group 2	Group 2	Agree
3	Group 1	Group 1	Group 2	Disagree
4	Group 3	Group 3	Group 3	Agree
5	Group 2	Group 2	Group 2	Agree
6	Group 1	Group 1	Group 1	Agree
7	Group 3	Group 3	Group 3	Agree
8	Group 3	Group 3	Group 3	Agree
9	Group 2	Group 2	Group 2	Agree

Note. 8 Agree / 9 Total Participants = 88.9%; Group 1 – None to Minimal Musical Training, Group 2 – Moderate Musical Training/Experience, Group 3 – Advanced Musical Training/Experience

CHAPTER IV

RESULTS

The purpose of the present study was to offer a method for measuring individual musical training and experiences through the use of a comprehensive assessment tool in order to more closely group participant populations in neuroimaging studies. To fulfill the purpose of this study, the researcher:

1. Completed a comprehensive review of the research literature to establish the essential content of the assessment tool;
2. Developed an assessment tool to survey subjects about their musical training and experiences;
3. Pilot tested the assessment tool, and revised the tool according to the preliminary analyses of the validity, reliability, and usefulness of the assessment tool;
4. Established the content validity and reliability of the assessment tool with subjects participating in a neuroimaging study designed to analyze the influences of musical training and experiences on brain structures and functions, and
5. Determined if the assessment tool functioned effectively in the selection and grouping of musically trained and musically untrained subjects for neuroimaging studies.

Music Training and Experience

When evaluating the number of years of musical training a participant possesses, it was important to know when training took place. Because of this, the assessment tool was divided into multiple levels of musical training that included: (a) grade school, (b) college/university training, (c) piano lessons, (d) private lessons, and (e) extra musical

training (e.g., workshops, camps). The researcher was then able to account for musical training by ensuring that questions in the survey measured musical events (e.g., school music, private lessons, house of worship music participation, etc.) that would have taken place throughout the course of the participants' lives.

The majority of the survey consisted of questions that covered the time period of K-12 school for two reasons: (a) because most people experienced music initially (and perhaps more formally) in K-12 schools; and (b) age of onset of musical training was an important component of both the related literature and the current study. There were four separate sections in the assessment tool that included items associated with K-12 school which included band, orchestra, chorus, and other music class participants. The band, orchestra, and chorus items on the assessment tool were very similar in nature in that participants were asked to report which instruments they played or voice part they sang. Participants were asked about the ensembles in which they took part, including honor(s) ensembles outside of their school. Questions related to awards received, notable ensemble performances (e.g., The Mid-West International Band and Orchestra Conference, state music educators' conferences, etc.), and the most difficult level of music their school ensemble performed were also included. Although not an extensive section, the researcher found it necessary to ask a question related to any other music classes undertaken during K-12 school. These classes included elementary general music, guitar, music appreciation, and Advanced Placement Music Theory, with the option of adding additional classes that were not previously mentioned.

For the college/university training section, participants had the option of indicating if they majored in music, minored in music, or simply participated in music training as a non-major. As music majors, participants were required to state the highest degree that was completed or in progress. If the degree was still in progress, participants reported how many years they had worked toward that specific degree. Participants were also asked to report on any secondary instruments they played, as well as any ensembles in which they participated not accounted for in previous responses. The questions were similar for the music minor and non-major participants, with the addition of private lesson participation.

For many, piano lessons were one way of receiving musical training outside of school. For this reason, a comprehensive section was incorporated into the survey on piano lesson participation. Participants were asked to state the number of years they had taken piano lessons and the number of years they had played the piano. For many participants, these were different responses. Other questions in this section included (a) awards received for playing the piano (e.g., scholarships, competition), (b) notable performances, (c) jobs obtained as a pianist (e.g., accompanist, solo artist), and (d) the name of the most difficult piece played.

The section on private lessons was brief, but important. This section contained a list of instruments on which students had taken private lessons, with the option of adding any instrument not listed. Participants were asked to select any instrument on which they had received private lessons and indicate the number of years of study.

On the assessment tool, the final training section was associated with any extra musical training. This section requested that participants list any music workshops or camps that they attended. The researcher investigated the requirements for being selected to attend or participate in the reported music workshops and camps separately.

The remaining areas of the survey focused on musical experiences with questions specifically related to teaching experience, community, amateur, or professional ensemble participation, and also religious organization experience. For example, the survey questions related to teaching experience were divided into private lessons and ensembles. Participants were first asked to indicate if they had any teaching experience; then they could select instruments on which they taught private lessons, including the number of years they taught and the level of difficulty of the lessons (i.e., beginner, intermediate, advanced). While difficulty level can be considered very subjective, it was helpful to the researcher to have the self-reported level(s) of difficulty. Participants could also describe any ensembles they taught and were asked to separate the ensembles by level. For example, instead of stating "Band – 4 years," they could indicate "Middle school band – 3 years; High school band – 1 year" for clarity.

The other two sections were brief but were included because of their importance in the overall music experience. Participants could report any involvement in community, amateur, or professional ensembles, and were also able to specify the ensembles and their number of years of participation. Because religious organizations such as churches and temples often proved to be a place where musical participation flourished, participants

selected from the following experience options, or included any not listed: (a) church choir, (b) hand bells, (c) praise band, (d) a cantor position, and/or (e) gospel ensemble.

The two other factors primarily found in the existing literature, age of onset of training and cumulative practice hours, also influenced several questions in the assessment tool. For each instrument for which a participant reported experience, it was also requested that the number of years of training be included so that the researcher could calculate the age of onset of training. Although an exact measure of practice hours was not requested, the participant was asked to estimate the number of practice hours per week for various levels of training (i.e., childhood/elementary, middle school, high school, college). Data were also collected from the participants regarding the number of times per week that a music class met.

Although the questions in the survey did not cover every possibility of musical training or experience, the data collected from the survey revealed a more comprehensive indication or musical training and experience. In short, the results of the participant surveys offered a more detailed account of his or her personal music training and experiences in order to more closely group participants for the purposes of a brain imaging study.

Differences Found Among Musician and Non-Musician Participants

For the purposes of addressing these research objectives, a grounded theory process was used to analyze data (Glaser & Strauss, 1967) and emerging themes and codes were determined by the researcher. The final step of the coding process resulted in the discovery of two distinct groups within the participant population: (a) non-musicians;

that is, participants with no or minimal musical training and/or experience, and (b) musicians; that is, participants with musical training and/or experience. Distinct differences emerged among participants that placed them into one of the two distinct groups listed above.

Non-Musician Participant Group

For the purposes of this study, participants with no or minimal musical training or experience possessed no more than 4 years of musical training and had limited music experiences, usually confined to only having participated in a music class in grade school. These participants may have had some grade school training; however, they had neither participated in any extra ensembles, nor had they participated in extra-musical experiences such as workshops or camps.

Thirty-three percent (n = 14) of the total participant population (N = 42) was placed in the non-musician group following a review of survey responses. Among the non-musicians, 43% (n = 6) identified themselves as female. The age range of the non-musicians was 18–47 with a mean age of 31.29 years (see Table 8).

Among the non-musician participants, 100% (n = 16) were White. Regarding ethnicity, 71% (n = 10) of musician participants were non-Hispanic, while 29% (n = 4) identified as Hispanic/Latino. The education level for each musician participant was collected, with the standard being 12 years for completion of high school. The average years of education across the Non-Musician group was 15.99 years, with a range of 12–20 years (see Table 9).

Table 8

Non-Musician Participants' Ages

Age	***n***	***%***
18–21	3	21%
22–25	1	7%
26–29	2	14%
30–33	4	29%
34–37	1	7%
38–41	0	0%
42–45	1	7%
46–50	2	14%
Total	14	100%

Table 9

Non-Musician Participants' Years of Education

Years of Education	***n***	***%***	**Cumulative Percent**
12–13	2	14%	14%
14–15	3	21%	35%
16–17	4	29%	64%
18–19	4	29%	93%
20–21	1	7%	100%
Total	14	100%	

The occupations of the non-musician group were varied. About 36% of participants indicated that they were students, and the remaining 64% had diverse occupations (see Table 10). Of the 14 participants who were placed in the Non-Musician

group, 11 participants reported that they did not play an instrument or sing, and three additional participants reported minimal musical training. Of the three additional participants who reported minimal musical training, the first indicated that she did sing, and she learned to do so in school; however, she did not report a specific singing class. She also specified minimal experience (< 4 years) playing the clarinet. The second of these participants who reported minimal musical training noted that he had taken guitar lessons for 2 years through a franchised guitar company, as well as 1 year of piano lessons through the same company. Finally, the third participant who reported minimal musical training stated that he played trombone for 3 years but did not progress beyond a beginner level.

Table 10

Non-Musician Participants' Occupations

Occupation	*n*	%	Cumulative Percent
Student	5	36%	36%
Business Owner	1	7%	43%
Janitor	1	7%	50%
Non-commissioned Officer	1	7%	57%
Receptionist	1	7%	64%
Rehabilitation Technician	1	7%	71%
Research Assistant	1	7%	78%
Retired US Air Force	1	7%	85%
Risk Analyst	1	7%	92%
Wirer	1	7%	100%
Total	14	100%	

Musician Participant Group

For the purposes of this study, participants were classified as musicians if they possessed musical training, with a minimum of 5 years of training. These participants indicated ensemble participation, private lesson experiences, and/or extra-musical experiences. Sixty-seven percent (n = 28) of all the participants (N = 42) were placed in the musician group. Fifty-five percent (n = 14) identified themselves as female, 43% (n = 12) identified themselves as male, and 4% (n = 1) identified themselves as transgender. The age range of the musician participants was 18–48, with a mean age of 26.18 years (see Table 11).

Table 11

Musician Participants' Ages

Age	***n***	***%***
18–21	11	39%
22–25	5	7%
26–29	4	14%
30–33	4	14%
34–37	1	4%
38–41	2	7%
42–45	0	0%
46–50	1	4%
Total	28	100%

Among the musician participants, 79% (n = 22) were White, 7% (n = 2) were African-American, 4% (n = 1) were biracial (specifically, White and African-American),

7% (*n* = 2) were Asian, and 4% (*n* = 1) were Native Hawaiian/Pacific Islander. Regarding ethnicity, 93% (*n* = 26) of musician participants were non-Hispanic, while 7% (*n* = 2) identified as Hispanic/Latino. The mean years of education across the Musician group was 16.95 years, with a range of 12 – 24.5 years (see Table 12).

Table 12

Musician Participants' Years of Education

Years of Education	*n*	%	Cumulative Percent
12–13	5	18%	18%
14–15	6	21%	39%
16–17	4	14%	53%
18–19	7	25%	78%
20–21	3	11%	89%
22–23	1	4%	93%
24–25	2	7%	100%
Total	28	100%	

Differences Found Among Musician Participant Populations

For the next step in the coding process, the survey responses of the musician participants were thoroughly reviewed to obtain the specifics of their musical training and experiences. Differences emerged among the participants that produced two subgroups: Moderate and Advanced. While these participants possessed musical training and varied musical experiences, the extensiveness of the training and experience varied from participant to participant. Disparity occurred in the following areas: (a) ensemble

participation, (b) institutional training (high school versus college/university), (c) extra-musical training and experience, and (d) teaching experience.

Musician Participants with Moderate Training/Experience

Among the musician participants, 50% (*n* = 14) were placed in the Moderate group, and 50% (*n* = 7) identified themselves as male and 43% (*n* = 8) identified themselves as female, and 7% (*n* =1) identified as transgender. The age range of the Moderate group participants was 18–32 years, with a mean age of 21.36 years (see Table 13).

Table 13

Moderate Group Participants' Ages

Age	***n***	***%***
18–21	10	71%
22–25	2	14%
26–29	1	7%
30–33	1	7%
Total	14	100%

Among the Moderate participants, 71% (*n* = 10) were White, 7% (*n* = 1) were African-American, 7% (*n* = 1) were biracial (specifically, White and African-American), 7% (*n* = 1) were Asian, and 7% (*n* = 1) were Native Hawaiian/Pacific Islander. Regarding ethnicity, 93% of Moderate participants were non-Hispanic, while 7% identified as Hispanic/Latino.

The education level for each musician participant was collected, with the standard being 12 years for completion of high school. The mean years of education for the Moderate group was 14.33 years, with a range of 12–21 years (see Table 14). The reported occupation of the Moderate group was primarily "student," with the addition of two other occupations (see Table 15).

Table 14

Moderate Group Participants' Years of Education

Years of Education	*n*	%	Cumulative Percent
12–13	5	36%	36%
14–15	5	36%	72%
16–17	2	14%	86%
18–19	1	7%	93%
20–21	1	7%	100%
Total	14	100%	

Table 15

Moderate Group Participants' Occupations

Occupation	*n*	%	Cumulative Percent
Student	11	79%	79%
Researcher	2	14%	93%
Architectural Technician	1	7%	100%
Total	14	100%	

When examining the group of musicians who had moderate musical training and experience, the primary instruments represented were violin (n = 3), viola (n = 1), cello (n = 1), string bass (n = 1), classical guitar (n = 1), and keyboard (piano; n = 5). Eight participants reported training and experience on multiple instruments including violin, viola, cello, flute, saxophone, trumpet, F horn, trombone, baritone, percussion, and organ. However, the remaining participants (n = 7) reported training only on their reported primary instrument (violin, n = 2; viola, n = 1; classical guitar, n = 1; keyboard, n = 3). Seven participants were pursuing an undergraduate degree in music performance or music education, while one participant indicated minoring in music performance. Participants (n = 6) also reported teaching experience, primarily at the beginning and intermediate levels. Acceptance and participation in various region and state ensembles was also reported (Arizona, Arkansas, Florida, and North Carolina). Other honors and awards included United States Army All-American Band, Mars Hill Choir Festival, Outstanding Performance—Association of Christian School International (ACSI) Piano Festival, Florida State University Orchestra Camp, and Tallahassee Youth Orchestra. The majority of training reported took place during grade school, starting at approximately sixth grade.

Musician Participants with Advanced Training/Experience

Among the musician participants, 50% (n = 14) were placed in the Advanced Group. In comparison to the Moderate group, 36% (n = 5) of the Advanced group identified themselves as male, and 64% (n = 9) identified themselves as female. The age range of the Advanced group of participants was 19–48 years, with a mean age of 31

years (see Table 16). Among the Advanced participants, 86% (*n* = 12) were White, 7% (*n* = 1) were African-American, and 7% (*n* = 1) were Asian. Regarding ethnicity, 93% of participants were non-Hispanic, and 7% were Hispanic/Latino.

Table 16

Advanced Group Participants' Ages

Age	***n***	***%***
18–21	1	7%
22–25	2	14%
26–29	3	21%
30–33	3	21%
34–37	1	7%
38–41	2	14%
42–45	0	0%
46–50	1	7%
Total	14	100%

The education level for each musician participant was collected, with the standard being 12 years for completion of high school. The mean years of education for the Advanced group was 19.18 years, with a range of 14–25 years (see Table 17). The occupations of the Advanced group were all associated with music, but the self-reported titles created variance among the group (see Table 18).

Table 17

Advanced Group Participants' Years of Education

Years of Education	*n*	%	Cumulative Percent
14–15	1	7%	7%
16–17	2	14%	21%
18–19	6	43%	64%
20–21	2	14%	78%
22–23	1	7%	85%
24–25	2	14%	100%
Total	14	100%	

Table 18

Advanced Group Participants' Occupations

Occupation	*n*	%	Cumulative Percent
College Professor	4	29%	29%
Music Teacher	4	29%	58%
Student	4	29%	87%
Musician	2	14%	100%
Total	14	100%	

When examining the group of musicians who had advanced musical training and experience, the number of years of training ranged from 10 to 34. The primary instruments represented in this group were violin ($n = 6$), viola ($n = 3$), cello ($n = 1$), keyboard (piano; $n = 3$), and percussion ($n = 1$). Many of the participants represented in this group also reported training on multiple instruments ($n = 12$), while only two

participants reported training on only one instrument (piano and violin). For example, one participant reported 31 years of training on keyboard, but also reported experience on the following instruments: flute (30 years), oboe (3 years), bassoon (6 years), clarinet (8 years), saxophone (28 years), trumpet (8 years), F horn (3 months), trombone (8 years), percussion (18 years), guitar (8 years), and ukulele (4 years). Many of the participants reported participation in grade school band, orchestra, and choral programs (n = 13); this includes keyboard primaries, although they played other instruments. For example, a participant who was pursuing a Doctor of Musical Arts (DMA) degree in Collaborative Piano at the time of survey completion also had 17 years of training on viola and participated in his school orchestra program, going as far as being selected for Region and District Orchestras in Texas.

All participants reported musical training at the college/university level. Many participants also indicated teaching experience at various levels including private lessons, grade school programs, and the collegiate level. Also included were awards and scholarships won, including, but not limited to multiple concerto competition winners, state piano scholarship, Atlanta Music Club Scholarship, Alternate in Young Artist Piano Competition (Music Teachers National Association—state level), and Outstanding Music Education Student. Participants also described participation in various workshops and festivals: Cannon Music Camp, Rock & Roll Hall of Fame Workshop, Brevard Music Center Festival, Suzuki School of the Arts Workshop, American Symphony Orchestra League Conducting Workshop, Summer Piano Institute—University of Illinois at

Urbana-Champaign, Young Artist Program at Kneisel Hall—Chamber Music Festival (Maine), and the Eastern Music Festival.

Content Validity Following Initial Analyses

Following the initial analyses of the assessment tool responses, the researcher found it necessary to run additional statistics regarding content validity. Three raters were enlisted to rate each assessment item based on its importance. Raters were instructed to use the following Likert scale to rate each item: 1=*Not important*; 2=*Slightly important*; 3=*Fairly important*; 4=I*mportant*; and 5=*Very important*. The ratings were compiled and an average rating was determined for each item (see Appendix H). Of the 82 total items, 73 items had an average rating of 4 or higher. The nine items that had an average rating of less than 4 all received at least a 3. The nine items that received an average rating below 4 were consistent in their subject matter. The items were as follows:

- Please list any honors you received in band (K-12)
- Please list any notable performances you had with your band (K-12) (Examples: Mid-West, state convention)
- Please list any honors you received in orchestra (K-12)
- Please list any notable performances you had with your orchestra (K-12) (Examples: Mid-West, state convention)
- Please list any honors you received in chorus (K-12)
- Please list any notable performances you had with your chorus (K-12) (Examples: ACDA, state convention)

- Please list any honors associated with music that you have received at the collegiate/university level.
- Please list any honors you have received associated with piano.
- Please list any notable performances you have had on piano.

Although these items were found to be "fairly important," it is the opinion of the researcher that these items speak directly to the quality of training and experience of the participant. Honors received in band, orchestra, chorus, or at the collegiate/university level could have a possible correlation with quality of musicianship. For example, if a participant was awarded a solo performer award at a sanctioned event, that speaks to their musicianship. Similarly, awards such as the John Phillips Sousa Award and the Louis Armstrong Jazz Award could indicate musical accomplishments at the high school level. Notable performances, both on the solo and ensemble levels, could also indicate the quality of training and experience. For example, if a high school band or orchestra is selected to perform at the Mid-West Band and Orchestra Clinic, it is an indication of high quality instruction. Although these items did not rate as highly as others on the assessment tool, perhaps with further explanation as to their placement in the tool, they would have received a higher rating.

Summary of Results

Participants

Participants for the present study included individuals who were recruited from a purposive sample to participate in a functional Magnetic Resonance Imaging (fMRI) study to investigate the effects of musical training on the brain. Participants were

recruited based on existing musical training and experiences, with participants needed for subpopulations of musicians and non-musicians. The age range of the participants was 18–48, with a mean age of 27.88 years.

Methodology

A comprehensive survey of musical training and experience was employed to determine individual characteristics of participants' backgrounds. The assessment tool was created by the researcher (an experienced music educator and performer) using a three-step instrument construction process. Following the initial draft, the survey was reviewed by five music educators and performers for critiques regarding (a) importance of training and experience areas, (b) adequate coverage of training and experience areas, (c) depth of questions, and (d) readability for the participant. The final step of the construction process was to pilot the survey with a small group of participants ($n = 5$) to determine any other possible areas for improvement.

Factors Included in Labeling Musician Participants

After reviewing the related literature in the field of neuroimaging and musical training, it was determined that the three most common factors found relating to musicianship (i.e., years of training, age of onset of training, and cumulative practice hours) were insufficient in capturing a holistic view of a musician's training and experience. However, stemming from these factors were numerous areas for consideration: (a) grade school training and experience (elementary, band, orchestra, chorus), (b) collegiate/university training and experience, (c) teaching experience, (d) piano training and experience, and (e) extra musical training and experiences. These

factors were then included in a comprehensive survey reviewing participants' musical training and experience.

Differences Found Among Musician and Non-Musician Participant Populations

Upon a thorough review of all participant surveys, it was concluded that differences among musicians and non-musicians occurred in several areas. For example, three out of the 14 non-musician participants responded with minimal musical training. The remaining participants responded that they neither played an instrument nor did they sing. The three participants who did indicate minimal musical training responded that they participated in school band for less than 4 years or were self-taught guitar skills. These responses contrasted with musician participant surveys, which revealed a minimum of 5 years of musical training and experience, ensemble experience, and teaching experience. All musician participant surveys indicated at least an intermediate level of music reading in addition to their musical training and experiences.

Differences Found Among Musician Participant Populations

After a further examination of the musician participant surveys, it was determined that two subgroups were evident among the participants: Moderate musicians and Advanced musicians. Common characteristics among the Moderate group included minimal postsecondary musical training; average ensemble experience, including secondary school ensembles and some auditioned honor ensembles; and minimal teaching experience, primarily in the area of private lessons. Compared to the Advanced group of musician participants, who possessed advanced degrees in music, extensive ensemble experience, and extra musical experiences such as clinics and auditioned

workshops, the Moderate group training and experience revealed a clustered effect of similar experiences that varied from the Advanced group.

CHAPTER V

CONCLUSIONS

Introduction

The creation of the assessment tool in the current study primarily was intended to group participants in neuroimaging research. Although the main three areas that have been the focus of the review of literature (years of training, age of onset of training, and cumulative practice hours) provide a glimpse into the training background of participants, those approaches do not take into consideration the quality of training or the potentially important differences, such as teaching or high-level music performances. The data analyses support the premise that the developed assessment tool provides accurate and necessary details related to quality of musical training and areas of experience. In this chapter, the research objectives are reviewed by providing a brief summary of each, a discussion of salient findings of the study, limitations of the study, and suggestions for possible implications and areas of future research.

Summary of Findings Associated with the Research Objectives

After reviewing existing literature that relates to the study of the effects of musical training on the brain through the use of functional magnetic resonance imaging (fMRI), it is evident that there have been no consistent approaches to grouping participant samples, causing inconsistent results among research studies. Researchers primarily have used years of musical training, the age of onset of musical training, or cumulative

practice hours to group participants. Although these are important characteristics of participants' musical training, the factors do not take into consideration the *quality* of musical training and experiences.

Throughout the development of the assessment, many facets of musical training and experience have been examined, as well as the multiple levels in which training occurs. To develop the assessment tool, therefore, it became necessary to include not only the various ways that musical training takes place in schools, but also participation and training through extra-musical experiences such as music competitions, competitive festivals, workshops, and music training and performance within the scope of civic and religious-focused organizations, such as community groups, churches, and synagogues. Although the three main areas in the review of related literature (i.e., age of onset of training, years of training, and practice hours) have been incorporated into the assessment tool, they are not the basis for the questions.

Differences Found Among Musician and Non-Musician Participants

For the purposes of determining musicianship for this study, participants were placed on a continuum from zero years of training and/or experiences to the highest number of years reported (n = 34). Natural breaks became evident not only in quantity of training and experiences, but also in quality of musical training and experiences. For example, with this particular group of participants, there was a natural division between non-musicians and musicians that occurred at 4 years. Although a majority of the participants in the non-musician group reported no musical training or experience (n = 11), three of the participants in this group reported minimal training. This would put the

minimum years of training for this total participant population at 5 years to qualify as a musician.

Differences Found Among Musician Participant Populations

The assessment tool was developed to be used in future research related to the influences of musical training and experiences on brain structures and functions, as measured via fMRI. When observing the placement of the musician participants on the spectrum of years of experience, the most notably detected break was between 10 and 13 years. Differences have been found in the quantity and quality of training and experiences among participants. These differences prompted the researcher to either place them in a group of musicians with moderate training/experiences or a group of musicians with advanced training/experiences. The rationale for creating two musician participant groups will be explained further in this chapter.

Discussion

Inconsistencies in Previous Studies

Upon reviewing the related literature in this field of study, the researcher found that the three most common ways to categorize musicians for the purposes of neuroimaging studies has been the age of onset of musical training, the years of musical training, and cumulative practice hours. Although these are important statistics related to neuroimaging participants' musical training, even combined they do not capture a holistic picture of musical training that considers quality of training and experiences. The term "quality" is subjective, but it must be considered when grouping musicians for the purposes of fMRI studies. The following examples demonstrate why the current common

assessments do not suffice when categorizing and characterizing participants with musical training.

The age of onset of training is an important factor when evaluating a participant's musical training. Sylva (1997) made reference to sensitive and critical periods of development in a child's formative years, echoing the theory of Jean Piaget and his theory of cognitive development. Piaget (1936) stated that there are four stages of development, and from the ages of 7 through 11, adolescents are in the concrete operational stage where we see the beginnings of logical thought. This stage is important in relation to the existing literature presented in Chapter 2 because the most frequently found age when reporting age of onset of musical training was 7. For example, Huang et al. (2010) and Schlaug et al. (1995) both reported that their participants began musical training before the age of 7. Bailey et al. (2014) used the age of 7 as a break point where participants who began before the age of 7 were considered "Early Training" and participants who began after the age of 7 were considered "Late Training."

Even though 7 years of age is considered a critical age for cognitive development, merely reporting the age of onset of training does not take into account the quantity, much less the quality of musical training that took place (Ellis et al., 2012; Elmer et al., 2013; Hou et al., 2015; Lee et al., 2002; Mongelli et al., 2017; Tanaka & Kirino, 2016). When researchers only use the age of onset of training to group participants with musical training, there are major gaps in the information that describes the participants. For example, a participant may have started musical training in the form of piano lessons at the age of 6, but only pursued lessons for 2 years. This training and experience is vastly

different from a participant, such as a male who participated in this dissertation study, who did not begin training until the age of 13 but has studied piano for 17 years and was pursuing a Doctorate of Musical Arts in Collaborative Piano at the time of the study.

Similarly, only reporting the number of years of musical training leaves out information regarding the quality of the musical training and experiences (Angulo-Perkins et al., 2014; Bangert et al., 2006; Bianco et al., 2016; Choi et al., 2015; Grahn & Rowe, 2009; Halpern et al., 2003; Haslinger et al., 2005; Hodges et al., 2005; Hyde et al., 2009; Koelsch et al., 2005; Limb et al., 2006; Li et al., 2014; Ono et al., 2015; Park et al., 2014; Schmithorst & Wilke, 2002). For example, Luo et al. (2014) utilized one participant group that had a range of 6–20 years of musical training. The issue here is grouping similar participants, and the possible differences between 6 years of training and 20 years of training. An example of training on each end of this spectrum can be found in our participant group, and the training and experiences are vastly different. Our participant with 6 years of training has reported extensive choral experience during high school, having been selected for All-State Chorus in his home state. He began piano lessons at the age of 12 and was still taking lessons at the time of the study (he was 18 years old at the time of the study). He was majoring in music at the time of data collection, and also had experience teaching beginner piano lessons.

In contrast, our participant with 20 years of experience had training on multiple instruments (i.e., violin, cello, string bass). Her high school orchestra experience was extensive, including chamber orchestra, All-County Orchestra, All-State Orchestra, Solo and Ensemble participation, Youth Orchestra, and the Georgia Governor's Honors

Program. She had also been a concerto competition winner for her high school orchestra, as well as an Advanced Placement Music Theory student. Following completion of high school, she has gone on to obtain a Bachelors of Music in Music Education, a Masters of Music in Music Education, and a Masters of Music in Viola Performance. She has experience playing with multiple symphony orchestras, including the Quad Cities Symphony and the Know-Galesburg Symphony. She possesses teaching experience that includes elementary orchestra, youth orchestra, and high school orchestra. Her extra-musical experiences include workshops at Furman University and Florida State University, as well as participation in the Britt Festival, which is a music and arts festival located in Oregon.

When participants are categorized by their musical training background and experiences rather than solely on the number of years of training they possess, it is clear that they should not be grouped together. While they are both musicians in their own right, they are not on the same level. Not only do their degrees set them apart, but their teaching experience and extra-musical experiences are not comparable. The participant with 6 years of training and/or experience has spent minimal time teaching private piano lessons at the beginner level, while the participant with 20 years of training and/or experience has spent time teaching private lessons and large-group ensembles for many years.

Another example of differences in quality of training related to average years of training is found in this dissertation study with the reported years of training by two of the participants. One participant has reported 4 years of training on clarinet, with no

significant extra-musical experiences and no ensemble participation, and another participant has reported 5 years of training on piano with very different musical experiences than the participant with 4 years of training. The participant with 5 years of musical training began playing piano and violin as a senior in high school and made progress very quickly. At the time of the study, this participant was in her senior year of a Bachelor of Arts in Music as a piano major. She has also performed junior and senior level collegiate recitals, as well as participated in multiple music festivals. Although these two participants are very close in years of training, the quality of the experiences and the amount of training is what separates them.

Even combining age of onset of training with average years of training does not seem to suffice. For example, two participants could have both began training at the age of 7 and trained for 8 years. How do those statistics inform the reader about the quality of their training and experiences? Although they started at the same time, it is possible that one achieved much more in 8 years than the other, including more significant ensemble participation and varied extra-musical experiences such as workshop and camp participation. One musician is not absolutely like the other.

In addition to the aforementioned factors is cumulative practice hours, either reported over a participant's lifetime (Baumann et al., 2007; Bengtsson et al., 2005; Foster et al., 2013) or over the course of a day (Dick et al., 2011; Gaser & Schlaug, 2003a, 2003b) or week (Bermudez et al., 2009; Burunat et al., 2015; Herdener et al., 2010; Lotze et al., 2003; Meister et al., 2003; Zuk et al., 2014). Unless a participant has been diligent in recording practice hours, the accuracy of the self-reporting of cumulative

lifetime practice hours is somewhat questionable (Madsen, 2004). For most musicians, there are peaks and valleys in practice time, dependent upon major performances and evaluations, therefore making practice hours inconsistent from year to year. Reporting weekly practice hours may be slightly more accurate, but there are still several unanswered questions. How was the practice time used? What was the quality of the practicing? Was the practice time uninterrupted? Even for professional musicians, practice hours can be inconsistent from day to day in quantity and quality, making it difficult to use this one factor in determining musicianship.

In summary, the quality of musical experiences matters. Once researchers are able to move beyond the numbers of age of onset of training, years of training, and cumulative practice hours, music training quality and music experiences are what separate the participants. The researcher would argue that the obtainment of a music degree is also different from participant to participant. To use an analogy from the medical field, the person to graduate last in their class with a degree in medicine is still referred to as "doctor." Similarly, there are levels of 'first and last' differences among graduates of music programs. Because of these differences, participants with similar ages of onset of training or like average years of training cannot be grouped together under one broad category. Time must be taken by the researcher(s) to examine the individual training and experience differences of each of their participants to ensure consistency among fMRI participant groupings for brain and music research.

Participants: Instrumentalists and Vocalists

The skills needed to play an instrument, whether keyboard, string, wind, or percussion, are different than the skills needed to sing. These two performance areas are similar in the fact that mentally, performers have to make in-the-moment decisions regarding reading pitch, rhythm, and dynamics. Wind players and vocalists both utilize air and require certain breathing techniques. Although keyboard players do not have this issue, string players, wind players, percussionists, and vocalists must also take into account intonation on their instrument, making slight changes as they perform in order to produce the best sound possible. However, vocalists do not require the same level of demanding motor skills and overall physical activity as instrumentalists, particularly those instruments that demand fine-grained dynamic coordination of opposing performance techniques between a musician's fingers, hands, and/or arms.

The motor training that is required to play an instrument is thought to induce neuroplasticity, or changes in the brain (Bezzola, Mérillat, & Jäncke, 2011). This motor training includes familiarity with the mechanisms that make the instruments work. For example, a pianist must know the correct technique for pressing a piano key to get the desired sound. String players must understand the correct hand/finger placement for the left hand that presses the strings, while balancing this with the right-hand bow hold, creating the correct grip and pressure to ensure a correct tone. Wind players should know the correct combination of fingers to press to produce the desired pitch, as well as the correct embouchure. Similarly, percussionists should be aware of the correct grip for each mallet and/or stick they must use, as well as the correct stroke to create the right sound.

For those playing instruments without ‘keys’ (i.e., violin, viola, cello, and bass), an additional demand is placed on them to adjust their fingers, arms, and hands to achieve the necessary musical pitch (accuracy of the note) and style of music performance and demand requirements.

Use-dependent training causes these changes in the brain, in addition to the mental complexity of reading and playing music. While vocalists are considered musicians in the sense that they use their instrument to create music, the motor training requirements are different from that of playing an instrument. Although the argument can certainly be made that wind players, specifically woodwind players, should have been included in this study because of the certain similarities in bi-modal training, the researchers chose to stay within the confines of what appeared most predominantly in the existing literature, due to the fine-grained, sensory-motor coordination demands across whole brain connections and brain hemispheres of both string and piano instrumentalists.

Applications of the Assessment Tool

The goal of this research is for the assessment tool to be made readily available for public use, not only for neuroimaging studies, but for psychological studies that focus on behavioral differences between musicians and non-musicians as well. For an example of a behavioral study, Bailey and Penhune (2012) have examined the differences between non-musicians, musicians with early training (having begun musical training before the age of 7), and musicians with late training (having begun musical training after the age of 7) in a rhythm synchronization task that required them to listen and tap along with rhythms presented via audio recording.

Through the use of this survey to create consistency among participant groups, there could potentially be more consistency in research findings. The existing literature is an excellent indicator that there is great interest in the effects of musical training on the brain, but without a dedicated research team member with substantial musical training, the right questions are not being asked of participants. This survey could bridge the knowledge gap between researchers in the scientific field and musicians by focusing in on quality and musical training and experiences in order to produce more closely related participant groups.

Western Focus

The assessment tool items are based on a very Western idea of what counts as musical training and experience. The idea of Western musical training centers around the focus of being trained in a highly structural and institutional manner. Learners are taught by very skilled professionals who possess many years of training and usually an advanced degree in music. The relationship between student and teacher is clearly defined and there are certain expectations. In this type of training, students receive regular instruction, either through a private teacher or as part of a group setting, mainly in a class or an ensemble. There are schools and institutions designated for this type of instruction, and it can be very rigorous.

This concept is not one of a global nature. For many cultures, music is part of everyday life and is not necessarily taught through lessons or in school. For example, traditional Irish music is taught in either the home or in sessions held in public places (Williams, 2010). Another example can be found in the Indian tabla drumming tradition,

which is primarily oral, but requires great skill and training (Siedenburg, Mativetsky, & McAdams, 2016). There are many countries that do not have music in schools, but only in houses of worship or the home. This does not take away from the structure that exists within these ways of learning music, but it is different than the Western school of thought.

Because the research has typically been conducted in a Western setting where institutional musical training has been provided, it was important to craft the survey questions in a manner that reflected the training and experiences found in the West. The survey could be adapted to fit other types of musical training throughout the world, and that will be an important contribution to the field. For now, however, it was best to stay within Western parameters to begin to create consistency in the field.

Limitations of the Study

The researcher acknowledges that there are possible limitations to the assessment tool and to the current study. The first limitation is related to the size of the sample. If a larger sample of participants were used, it is possible that the natural breaks between levels of training and experience may have occurred at different points. The 6-year gap that was found between the Moderate and the Advanced musician group (with the exception of the participant with 13 years of training) might have been closer, causing the researcher to have to make careful decisions as to which group participants belonged. Another limitation related to the participant sample is the location in which the study took place: a medium-sized city in the Southeastern United States. It is possible that if the study was conducted in an area without access to a university there would have been a

smaller number of students and the age range would have been more evenly distributed. The third limitation is related to the review of literature. In the existing literature, it is possible that further details regarding musical training and experience were collected but not disclosed in the research studies.

Implications and Areas of Future Research

Implications from the results of this survey could be found in areas such as musician identity research and supporting the existence of music education in schools. Although the researcher has chosen not to pursue any research questions related to musician identity, it should be noted that during the recruitment process several participants stated that they had no musical training and were not musicians, but their survey responses revealed different results. Although a majority of the participants in the non-musician group reported no musical training or experience (n = 11), three of the participants in this group noted minimal training. The first of these participants indicated 2 years of beginning guitar lessons through a franchised guitar company, as well as 1 year of piano lessons through the same company. The second participant described 3 years of band participation on trombone during middle school, but also indicated that the most difficult level of music performed was at the beginner level. The third participant reported 4 years of clarinet experience, but neither indicated any ensemble participation, nor any extra-musical experiences, such as festivals or workshops. However, it is the opinion of the researcher that the quantity and the quality of these participants' training and experiences did not closely align with other musician participants. It is interesting that these three participants neither considered their limited training important enough to

initially report during the recruitment process, nor did their training prompt them to identify as a musician.

Implications can also be found in advocacy for music education through brain-based learning. For many years, music educators have turned to scientific findings to try and validate their existence in schools. Phenomena such as the "Mozart Effect" have lost their place in advocacy information because of the inability to replicate original findings (Jones & Zigler, 2002; Rauscher, Shaw, & Ky, 1995; Steele, Bass, & Crook, 1999). Findings in existing literature are not consistent because of inaccurate participant groups and are written in such scientific language that it would be difficult for music educators to use findings to their advantage. Because this larger neuroimaging project focuses on the effects of musical training at different levels of training and experience, the findings could be potentially useful to music educators in their advocacy efforts.

Suggestions for future research include first, testing and re-testing neuroimaging studies that utilize the survey to construct participant groups. The results of a neuroimaging study that incorporated the survey to group participants must be compared against existing results found in the literature. Additionally, future research could include comparing results of participants grouped by methods found in the existing literature (age of onset of training, years of training, and cumulative practice hours) and the same participants grouped by the survey method. This would be a step in ensuring that results are more consistent and more accurate.

A second suggestion for future research involves the inclusion of other instruments in participant populations. Once other instruments, such as woodwind and

brass are included, comparisons could be drawn between the results of participants trained on woodwind instruments to participants trained on keyboard instruments. There are multiple ways to bin the data (i.e., keyboard versus brass, string versus woodwind, wind versus percussion), and comparisons could also be made between instrumentalists and vocalists.

Conclusion

Even though there are numerous ways to group neuroimaging participants already, the present study was needed because of inconsistencies and the lack of a uniform way to select and group participants in neuroimaging research (Bianco et al., 2016; Ellis et al, 2012; Gaser and Schlaug, 2003b). One's musical training can neither be captured by merely reporting the age of onset of training or the years of training, nor can the use of self-reported cumulative practice hours be entirely reliable. This assessment tool will serve as a way of codifying participant groups and providing a consistent measurement tool for designing research procedures. The results of studies related to the effects of musical training on the brain can be a very powerful tool, especially in advocating for music education, but consistency in research methods is needed in order to provide the most accurate results possible.

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APPENDIX A

LITERATURE REVIEW SUMMARY CHARTS

All Studies—All Methods

Author	1	2	3	4	5	6	7	8
Alluri et al. (2012)		●			●			
Angulo-Perkins et al. (2014)	●							
Baer et al. (2015)		●		●	●			
Bailey et al. (2014)				●				
Bangert et al. (2006)		●						
Baumann et al. (2007)	●					●		●
Bengtsson et al. (2005)					●		●	
Bermudez et al. (2009)	●	●			●		●	
Bermudez and Zatorre (2005)					●		●	
Bianco et al. (2016)	●	●	●					
Burunat et al. (2015)	●	●			●		●	
Choi et al. (2015)	●	●						
Dick et al. (2011)					●	●	●	
Ellis et al. (2012)					●	●		
Elmer et al. (2013)				●	●			
Fauvel et al. (2014)		●			●			
Foster et al. (2013)	●	●					●	●
Foster and Zatorre (2010)					●	●	●	●
Gaser and Schlaug (2003a)					●		●	
Gaser and Schlaug (2003b)							●	
Grahn and Rowe 2009)	●							

Author	1	2	3	4	5	6	7	8
Groussard et al. (2014)		●	●		●	●		
Halpern et al. (2003)	●							
Halwani et al. (2011)		●			●			
Han et al. (2009)		●			●	●		
Haslinger et al. (2005)		●						
Herdener et al. (2010)					●		●	
Hodges et al. (2005)			●					
Hou et al. (2015)					●	●		
Huang et al. (2010)	●			●				
Hyde et al. (2009)		●						
Imfeld et al. (2009)		●		●	●			
James et al. (2014)				●	●		●	
Koelsch et al. (2005)		●	●					
Lee et al. (2002)					●			
Li et al. (2014)		●	●					
Limb et al. (2006)	●							
Lotze et al. (2003)		●			●		●	
Luo et al. (2012)			●					
Luo et al. (2013)			●					
Meister et al. (2003)		●			●		●	
Mongelli et al. (2017)					●			
Oechslin, Descloux, et al. (2012)		●			●		●	
Oechslin, Van De Valle, et al. (2013)		●			●		●	
Ohnishi et al. (2001)	●				●	●		
Ono et al. (2015)	●							
Palomar-García et al. (2016)		●	●		●	●	●	●

Author	1	2	3	4	5	6	7	8
Park et al. (2014)		●						
Park et al. (2015)		●						
Sato et al. (2016)	●					●		
Schmithorst and Wilke (2002)	●							
Schlaug et al. (1995)				●				
Sluming et al. (2002)		●	●	●	●	●	●	●
Steele et al. (2013)		●	●		●	●	●	●
Tanaka and Kirino (2016)						●		
Vollman et al. (2014)		●	●		●	●	●	●
Zuk et al. (2014)				●	●		●	

Note. 1 = Minimum Years of Training; 2 = Average Years of Training; 3 = Range of Years of Training; 4 = Firm Age of Onset; 5 = Average Age of Onset; 6 = Range of Ages of Onset; 7 = Average Number of Practice Hours; 8 = Range of Number of Practice Hours.

All Studies—All Performance Areas

Author	1	2	3	4	5	6	7	8	9
Alluri et al. (2012)	●	●	●		●				
Angulo-Perkins et al. (2014)									●
Baer et al. (2015)									●
Bailey et al. (2014)									●
Bangert et al. (2006)	●								
Baumann et al. (2007)	●								
Bengtsson et al. (2005)	●								
Bermudez and Zatorre (2005)									●
Bermudez et al. (2009)									●
Bianco et al. (2016)	●								
Burunat et al. (2015)	●	●							
Choi et al. (2015)			●	●					
Dick et al. (2011)		●							
Ellis et al. (2012)	●	●	●						
Elmer et al. (2013)	●	●	●						
Fauvel et al. (2014)	●	●	●						
Foster and Zatorre (2010)	●	●	●			●			
Foster et al. (2013)									●
Gaser and Schlaug (2003a)	●								
Gaser and Schlaug (2003b)	●								
Grahn and Rowe (2009)									●
Groussard et al. (2014)	●	●	●	●					
Halpern et al. (2003)									●
Halwani et al. (2011)	●	●	●	●		●			

Author	1	2	3	4	5	6	7	8	9
Han et al. (2009)	●								
Haslinger et al. (2005)	●								
Herdener et al. (2010)									●
Hodges et al. (2005)							●		
Hou et al. (2015)	●	●							
Huang et al. (2010)	●								
Hyde et al. (2009)		●							
Imfeld et al. (2009)	●	●	●	●					
James et al. (2014)	●								
Koelsch et al. (2005)									●
Lee et al. (2002)	●	●							
Li et al. (2014)	●							●	
Limb et al. (2006)									●
Lotze et al. (2003)		●							
Luo et al. (2012)	●								
Luo et al. (2013)	●	●						●	
Meister et al. (2003)	●								
Mongelli et al. (2017)	●	●	●	●					
Oechslin, Descloux, et al. (2013)	●								
Oechslin, Van De Valle, et al. (2013)	●								
Ohnishi et al. (2001)	●				●	●			
Ono et al. (2015)		●	●	●					
Palomar-García et al. (2016)	●		●	●					
Park et al. (2014)	●		●					●	
Park et al. (2015)									●
Sato et al. (2016)	●	●	●	●					

Author	1	2	3	4	5	6	7	8	9
Schlaug et al. (1995)	●	●							
Schmithorst and Wilke (2002)									●
Sluming et al. (2002)		●	●	●	●				
Steele et al. (2013)									●
Tanaka and Kirino (2016)	●	●	●	●					
Vollman et al. (2014)	●	●							
Zuk et al. (2014)	●	●	●	●					

Note. 1 = Keyboard; 2 = Strings; 3 = Woodwind; 4 = Brass; 5 = Percussion; 6 = Voice; 7 = Conducting; 8 = Other; 9 = Did Not Report.

APPENDIX B

BRAIN PHYSIOLOGY TERMS

Definition of Brain Physiology Terms

Following are the definitions of key brain physiology terms used in this dissertation.

- **Anterior**—toward the face end (Pinel & Edwards, 2008).
- **Auditory cortex**—processes sound information (Ehret, 1997).
- **Basal ganglia**—involved in regulation of motor function and cognitive functioning (Graybiel, 2000).
- **Bilateral lingual gyrus**—implicated in processing vision, specifically words (Mechelli, Humphreys, Mayall, Olson, & Price, 2000).
- **Broadmann Area 40**—part of the parietal cortex; involved in reading; located in the parietal lobe (Loubinoux et al., 2003).
- **Broca's Area**—involved in language production; located in the frontal lobe (Orrison, 2008).
- **Cerebellum**—primarily involved in motor function; also involved in language tasks and movement control (Glickstein, Strata, & Voogd, 2009; Orrison, 2008).
- **Corpus callosum**—supports the interhemispheric exchange of learned discriminations (Orrison, 2008).
- **Corticospinal tract**—collection of corticopontine fibers from areas involved in movement (Ferguson, Koide, & Rush, 2001).
- **Dorsal**—toward the surface of the back or top of the head (Pinel & Edwards, 2008).
- **Fissures**—the large grooves in the cerebral hemispheres (Pinel & Edwards, 2008).
- **Frontal lobes**—the two regions of the cerebral hemispheres, one in each hemisphere, that are in front of the central fissures (Pinel & Edwards, 2008).

- **Gray matter**—concentration of unmyelinated cell bodies (Banich, 2004).
- **Hippocampus**—important role in learning and memory, emotional behavior, and regulation of the autonomic nervous system (Knierim, 2015).
- **Inferior**—toward the bottom surface of the head (Pinel & Edwards, 2008).
- **Inferior frontal gyrus**—important for the production of spoken language; located in the frontal lobe (Orrison, 2008).
- **Inferior orbitofrontal gyrus**—implicated in reward and punishment (i.e., self-control, appropriate behavior, responsibility; Banich, 2004).
- **Inferior parietal lobule**—involved in the integration of visual, auditory, and somatosensory functions, especially as related to written language (Ackerman, 1992).
- **Lateral**—away from the middle of the brain; toward the left or right (Pinel & Edwards, 2008).
- **Medial**—toward the middle of the brain (midsagittal plane; Pinel & Edwards, 2008).
- **Middle cingulate gyrus**—part of the limbic system; involved in emotion processing; located above the corpus callosum (Banich, 2004).
- **Middle frontal gyrus**—supports higher cognitive functions related to personality, insight, and foresight (Orrison, 2008).
- **Myelin**—fatty substance that protects the axon from nearby nerve impulses (Ackerman, 1992).
- **Occipital lobes**—the two regions of the brain hemispheres that are at the back end each hemisphere (Pinel & Edwards, 2008).
- **Orbitofrontal cortex**—involved in cognitive processing and decision making; located in the frontal lobe (Banich, 2004).
- **Parietal lobes**—the two regions of the brain hemispheres, one in each hemisphere, that are behind the central fissures and above the lateral fissures (Pinel & Edwards, 2008).
- **Planum temporale**—involved in language function; located from the superior temporal gyrus to the parietal lobe (Altarelli et al., 2014).

- **Postcentral gyrus**—involved in the processing of tactile and sense of information; located in the parietal lobe (Orrison, 2008).

- **Posterior**—toward the rear end (Pinel & Edwards, 2008).

- **Postlateral Heschl's gyrus**—the location of most of the primary auditory cortex; located in the temporal lobe (Pinel & Edwards, 2008).

- **Precentral gyrus**—site of the primary motor area, responsible for conscious movement; located toward the posterior of the frontal lobe (Ackerman, 1992).

- **Precuneus**—involved in complex sensory appreciation; language comprehension; may be involved in orientation to time and space (Orrison, 2008).

- **Prefrontal cortex**—involved in the process of working memory and behavior regulation (Ackerman, 1992).

- **Retrosplenial cortex**—involved in evaluative functions (Banich, 2004).

- **Right parietal cortex**—involved in visual spatial information (Ackerman, 1992).

- **Superior**—toward the top or back surface of the head (Pinel & Edwards, 2008).

- **Superior frontal gyrus**—involved in higher cognitive functions related to personality, insight awareness, and judgment (du Boisgueheneuc et al., 2006; Orrison, 2008).

- **Superior temporal gyrus**—involved in receptive language functions (Orrison, 2008).

- **Temporal lobes**—the two regions of the brain hemispheres, one in each hemisphere, that are below the lateral fissures (Pinel & Edwards, 2008).

- **Ventral**—toward the bottom of the head (Pinel & Edwards, 2008).

- **Visual cortex**—the part of the brain that receives sensory impulses from the eyes preceding the visual association cortex; involved in informing us what we see or how we feel about it; located in the occipital lobe (Ackerman, 1992).

- **Voxel**—small three-dimensional blocks of brain tissue (Telesford, Simpson, Burdette, Hayasaka, & Laurienti, 2011).

- **White matter**—areas of the brain that contain myelinated fibers (Banich, 2004).

APPENDIX C

BRAIN IMAGES

Following are three figures of brain scans of the researcher illustrating the terms given in Appendix A.

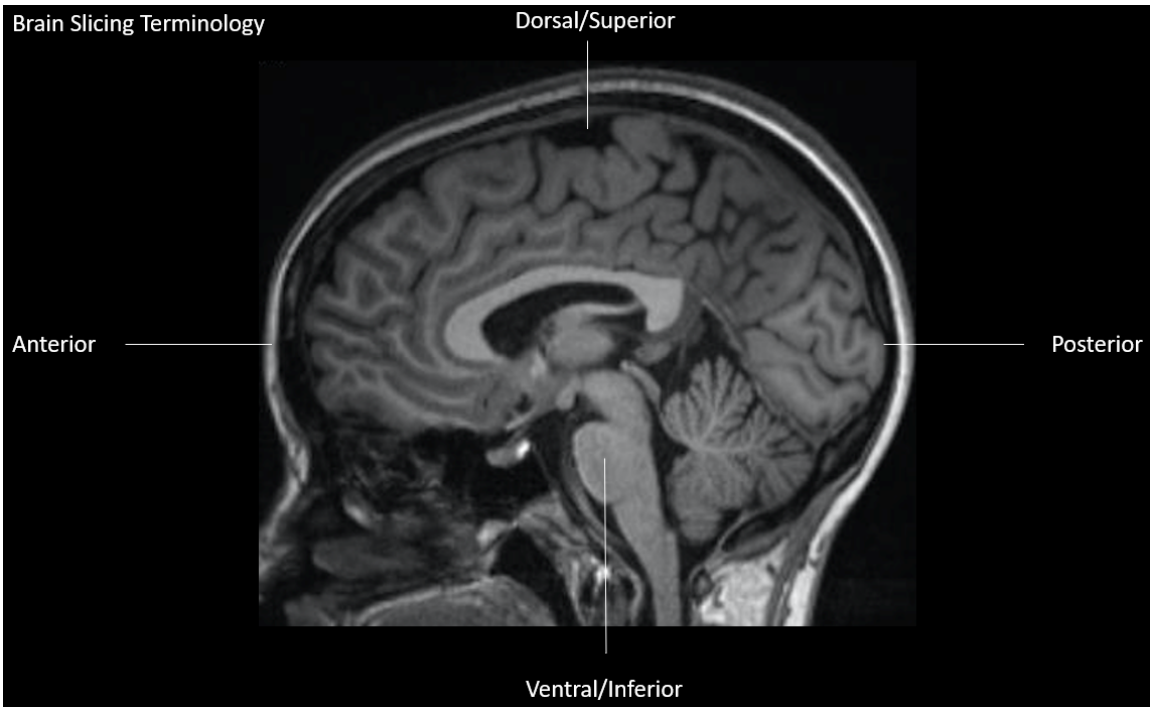

Figure 9. Sagittal View of the Brain Including Directional Terminology. Source: Gateway MRI Center, Joint School of Nanoscience and Nanoengineering, The University of North Carolina at Greensboro.

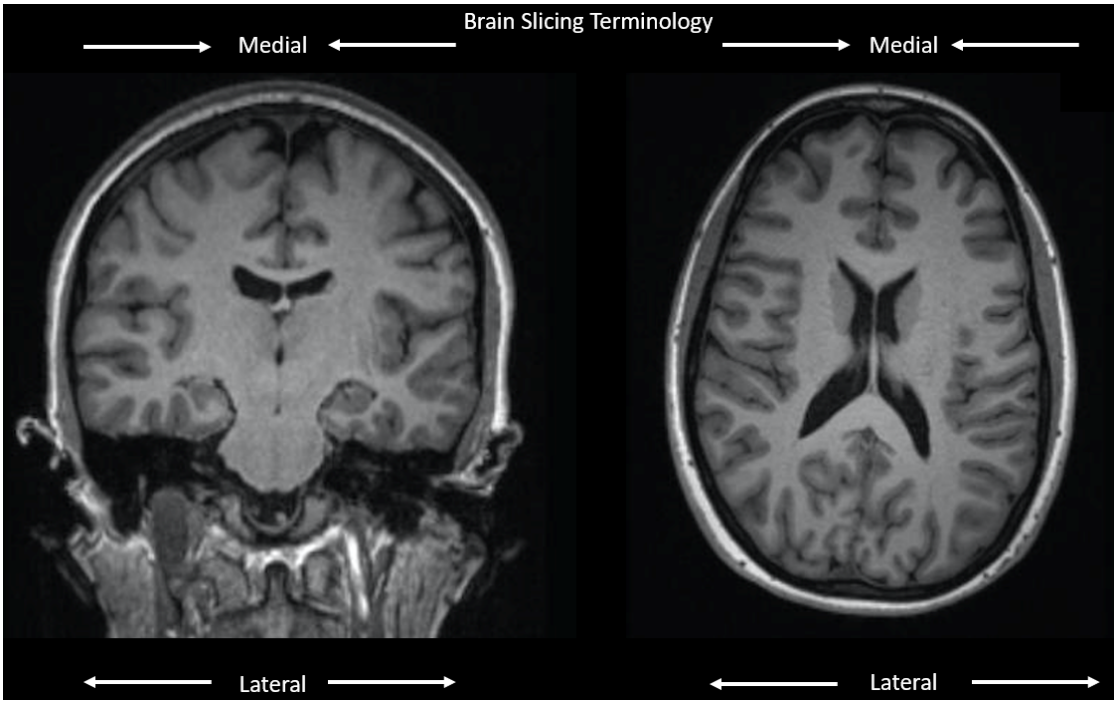

Figure 10. Coronal View of the Brain (Left) and Axial View of the Brain (Right). Both Images Include Directional Terminology. Source: Gateway MRI Center, Joint School of Nanoscience and Nanoengineering, The University of North Carolina at Greensboro.

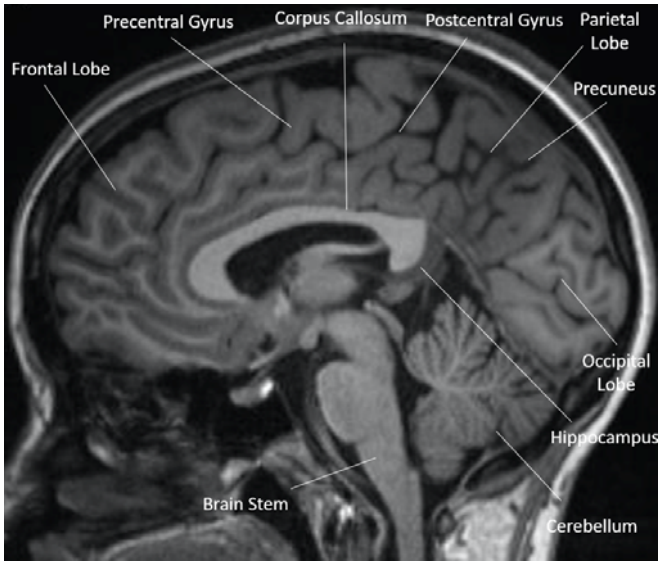

Figure 11. Sagittal View of the Brain Including the Location of Key Areas Within the Brain. Source: Gateway MRI Center, Joint School of Nanoscience and Nanoengineering, The University of North Carolina at Greensboro.

APPENDIX D

ASSESSMENT TOOL

Singing

Can you sing?
If YES, please indicate for how many years.

- ○ Yes
- ○ No

Where did you first learn to sing?

- ○ A family member
- ○ School
- ○ Religious organization
- ○ Other (Please indicate below)

How many hours per week do you sing in an informal setting? (Example: around the house, in the car)

- ○ 1 - 5 hours
- ○ 6 - 10 hours
- ○ More than 10 hours (Indicate the number of hours below)

How many hours per week do you sing in a formal setting? (Example: church, community choir, school)

- ○ 1 - 5 hours
- ○ 6 - 10 hours

- ○ More than 10 hours (Indicate the number of hours below)

Instrumental

Do you play any instruments?

- ○ Yes
- ○ No

Select which instrument(s) you play and indicate how many years you have played.

- ☐ Flute
- ☐ Oboe
- ☐ Bassoon
- ☐ Clarinet
- ☐ Saxophone
- ☐ Trumpet
- ☐ French Horn
- ☐ Trombone
- ☐ Percussion
- ☐ Violin
- ☐ Viola
- ☐ Cello
- ☐ Bass/Double Bass
- ☐ Keyboard (Piano, Organ, etc.)
- ☐ Guitar
- ☐ Banjo

- [ ] Baritone/Euphonium
- [ ] Mandolin
- [ ] Tuba
- [ ] Other (indicate in box)

How many hours per week do you play an instrument in an informal setting? (Example: jam sessions, around the house)

- ○ 1 - 5 hours
- ○ 6 - 10 hours
- ○ More than 10 hours (Indicate the number of hours below)

How many hours per week do you play an instrument in a formal setting? (Example: school, community band, church)

- ○ 1 - 5 hours
- ○ 6 - 10 hours
- ○ More than 10 hours (Indicate the number of hours below)

Music Reading

Do you read music?

- ○ Yes
- ○ No

Please indicate your level of music reading.

- ○ Beginner - I can read notes in one clef (treble or bass), simple rhythmics, basic time signatures, and basic musical terms.
- ○ Intermediate - I can read multiple clefs, more complex rhythms, multiple musical lines, complex time signatures (duple and triple), and more complex musical terms.
- ○ Advanced - I can read all clefs, complex rhythms, a conductor's score, all time signatures (basic to mixed meter), and all musical terms.
- ○ Other - I am more comfortable reading a lead sheet or guitar tabs.

Extracurricular Activites

Please select any extracurricular activities you participated in during grade school. Do NOT include music activities!

- ☐ Football
- ☐ Baseball/Softball
- ☐ Basketball
- ☐ Golf
- ☐ Wrestling
- ☐ Soccer
- ☐ Lacrosse
- ☐ Cheerleading
- ☐ Volleyball
- ☐ Reading
- ☐ Honor Society/Beta Club
- ☐ Art
- ☐ Drama
- ☐ FBLA - Future Business Leaders of America
- ☐ FHA or FCCLA - Future Homemakers of America or Family, Career, and Community Leaders of America
- ☐ 4-H or Ag Activities
- ☐ Science Club
- ☐ Other (please indicate in the box)

Gaming and Typing

How many hours per day do you spend typing on a computer keyboard?

- ○ 0-1 hours

- ○ 2-4 hours
- ○ 5-8 hours
- ○ 9+ hours

What is your preferred method of typing?

- ○ Using all 10 fingers
- ○ Using 2-3 fingers

Do you play video games?

- ○ Yes
- ○ No

If you answered Yes to the previous question, please select the gaming console(s) that you play on.

- ☐ Nintendo
- ☐ X-Box
- ☐ Playstation
- ☐ Wii
- ☐ Other:

If you do play video games, how many hours per day do you play?

- ○ 0-1 hours
- ○ 2-4 hours
- ○ 5-8 hours
- ○ 9+ hours

Band (Kindergarten through 12th grade)

Did you participate in band in grade school (K-12)?

- ○ Yes
- ○ No

Please select the instrument(s) you played.

- ☐ Flute
- ☐ Oboe
- ☐ Bassoon
- ☐ Clarinet
- ☐ Saxophone
- ☐ Trumpet
- ☐ French Horn
- ☐ Trombone
- ☐ Baritone/Euphonium
- ☐ Tuba
- ☐ Percussion
- ☐ Other (please indicate in the box)

Please list the ensembles you participated in and the number of years.

- ☐ Marching Band
- ☐ Concert Band
- ☐ Jazz Band
- ☐ Percussion Ensemble
- ☐ Other (please indicate in the box)

Indicate the stages during your training in which you practiced and estimate the

number of hours per week.

- [ ] Childhood/Elementary
- [ ] Middle School
- [ ] High School

Please indicate any honor ensembles you were a member of and how many times you participated (Examples: County, District, Region, All-State, Solo & Ensemble).

- [ ] County Honor Band
- [ ] District Honor Band
- [ ] Region Honor Band
- [ ] All-State Band
- [ ] Solo & Ensemble
- [ ] Other (Indicate the ensemble)

Indicate the number of times per week your band class met.

- [ ] Elementary Band
- [ ] Middle School Band
- [ ] High School Band

Please list any honors associated with band that you received (Examples: John Philip Sousa, Leadership Awards)

In which state did you participate in band?

What is the highest level of music your band played?

Please list any notable performances (Examples: Mid-West, Macy's, state convention)

Orchestra (Kindergarten through 12th grade)

Did you participate in orchestra in grade school (K-12)?

- ○ Yes
- ○ No

Please select the instrument(s) you played and indicate how many years you have played the instrument.

- ☐ Violin
- ☐ Viola
- ☐ Bass/Double Bass
- ☐ Other

☐ ☐

☐ Cello

Please list the ensembles you participated in and the number of years.

○ Symphony Orchestra ○ Other

○ Chamber Orchestra

Indicate the stages during your training in which you practiced and estimate the number of hours per week.

☐ Childhood / Elementary

☐ Middle School

☐ High School

Please indicate any honor ensembles you were a member of and how many times you participated (Examples: County, District, Region, All-State, Solo & Ensemble).

☐ County Orchestra

☐ District Orchestra

☐ Region Orchestra

- [ ] All-State Orchestra
- [ ] Solo & Ensemble
- [ ] Other (Indicate the ensemble)

Indicate the number of times per week your orchestra class met.

- [ ] Elementary Orchestra
- [ ] Middle School Orchestra
- [ ] High School Orchestra

Please list any honors associated with orchestra that you received

In which state did you participate in orchestra?

What is the highest level of music your orchestra played?

Please list any notable performances (Examples: Mid-West, state convention)

Chorus (Kindergarten through 12th grade)

Did you participate in chorus in grade school (K-12)?

- ○ Yes
- ○ No

How many years did you participate?

Please select the ensembles you participated in and indicate the number of years you participated.

- ☐ Auditioned Chorus
- ☐ Chamber Group
- ☐ Non-auditioned Chorus
- ☐ Other (please indicate in the box)

Indicate the stages during your training in which you practiced and estimate the number of hours per week.

- ☐ Childhood / Elementary
- ☐ Middle School
- ☐ High School

Please indicate any honor ensembles you were a member of and how many times

you participated (Examples: County, District, Region, All-State, Literary).

- [ ] County Chorus
- [ ] District Chorus
- [ ] Region Chorus
- [ ] All-State Chorus
- [ ] Literary
- [ ] Other (Indicate the ensemble)

Indicate the number of times per week your chorus class met.

- [ ] Elementary Chorus
- [ ] Middle School Chorus
- [ ] High School Chorus

Please list any honors associated with chorus that you received

In which state did you participate in chorus?

What is the highest level of music your chorus sang?

Please list any notable performances (Examples: ACDA, state conventions)

Please list any languages that you have studied through singing.

Other School Classes (Kindergarten through 12th grade)

Did you participate in any other school music classes? (Examples: Elementary music class, Guitar class, etc.)

- ○ Yes
- ○ No

Please indicate the class(es) that you participated in and the number of years you participated.

- ☐ Elementary General Music
- ☐ Guitar Class
- ☐ Music Appreciation
- ☐ AP Music Theory
- ☐ Other (Indicate the class)

Private Lessons (Kindergarten through 12th grade)

Did you take private lessons (instrumental or vocal)?

- ○ Yes
- ○ No

Please select the instrument/voice part you took lessons on. In the box, include the age at which you started and the number of years you took lessons (Example: 6yo, 9)

☐ Flute	☐ Viola
☐ Oboe	☐ Cello
☐ Bassoon	☐ Bass/Double Bass
☐ Clarinet	☐ Keyboard
☐ Saxophone	☐ Guitar
☐ Trumpet	☐ Banjo
☐ French Horn	☐ Mandolin
☐ Trombone	☐ Voice - Soprano
☐ Baritone/Euphonium	☐ Voice - Alto
Tuba	Voice - Tenor

- [ ]
- [ ]
- [ ] Percussion
- [ ] Voice - Bass
- [ ] Violin
- [ ] Other (please indicate in the box)

College / University

Did you participate in music at the collegiate/university level?

- ○ Yes
- ○ No

Did you major in music?

- ○ Yes
- ○ No

Please select completed or in progress degrees and specify the program (Examples: Bachelor of Music in Music Education, Master of Sacred Music, etc.)

- ○ Bachelors
- ○ Masters
- ○ Doctoral

Indicate your primary and secondary instruments OR voice part and the number of practice hours per week.

- [ ] Primary
- [ ] Secondary
- [ ] Secondary

If the degree is still in progress, please indicate the number of years you have majored in music.

Please select the ensembles in which you have performed and include the number of years in the corresponding box.

- [ ] Wind Ensemble / University Band
- [ ] University Chorale
- [ ] Jazz Ensemble
- [ ] Pep Band / Marching Band
- [ ] Symphony Orchestra
- [ ] Small Instrumental Ensemble
- [ ] Chamber Orchestra
- [ ] Other (please indicate in the box)
- [ ] Chamber Singers

Please list any honors associated with music that you have received at the collegiate /

university level.

Did you minor in music?

- Yes
- No

Indicate your primary and secondary instruments OR voice part and the number of practice hours per week.

- Primary
- Secondary
- Secondary

Please list the ensembles in which you have performed along with the number of years (include 1/2 years - estimate).

Did you participate in any ensembles or take lessons/classes as a non-major/minor?

- Yes
- No

Indicate your primary and secondary instruments OR voice part and the number of practice hours per week.

- [ ] Primary
- [ ] Secondary
- [ ] Secondary

List any ensembles in which you have performed including the number of semesters.

Did you take lessons at the collegiate / university level? If YES, please indicate the instrument / voice part.

- ○ Yes
- ○ No

Please list any music classes you took as a non-major/minor.

Teaching Experience

Have you ever taught music?

- ○ Yes
- ○ No

Please list the area in which you have taught PRIVATE LESSONS (instrument [specify]

or voice), the level (Beginner, Intermediate, Advanced), and number of years taught). Example: Percussion, Beginner, 4

- [ ] Flute
- [ ] Oboe
- [ ] Bassoon
- [ ] Clarinet
- [ ] Saxophone
- [ ] Trumpet
- [ ] French Horn
- [ ] Trombone
- [ ] Baritone/Euphonium
- [ ] Tuba
- [ ] Percussion
- [ ] Violin
- [ ] Viola
- [ ] Cello
- [ ] Bass/Double Bass
- [ ] Keyboard (Piano,Organ)
- [ ] Guitar
- [ ] Banjo
- [ ] Mandolin
- [ ] Voice - Soprano
- [ ] Voice - Alto
- [ ] Voice - Tenor
- [ ] Voice - Bass
- [ ] Other (please indicate in box)

List any ensembles that you have taught/conducted and the number of years you taught at that level. Please separate by level.

Example:
Middle School Band - 4 years
High School Chorus - 8 years

Community / Amateur / Professional Ensemble Experience

Have you participated in any community / amateur / professional ensembles?

- Yes
- No

List any of the aforementioned ensembles that you have performed with and the number of years.

Piano Experience

Have you ever studied piano?

- Yes
- No

How many years have you studied piano?

How many years have you played piano?

Please indicate the levels at which you have played and the number of practice hours per week.

- [ ] Childhood / Elementary
- [ ] Middle School
- [ ] High School
- [ ] College / University
- [ ] Post-College / University

List any honors you have received associated with piano.

Please list any notable performances you have had on piano.

Please list any jobs you have obtained as a pianist (Examples: church accompanist, orchestral soloist)

What is the most difficult piece you have ever played?

Extra Musical Training

List any music camps or workshops in which you have participated.

Church Experience

Have you participated in any church/religious music experiences?

- ○ Yes
- ○ No

Please select the ways in which you have participated and indicate the number of years.

- ☐ Church choir
- ☐ Handbells
- ☐ Praise Band
- ☐ Cantor
- ☐ Gospel Ensemble
- ☐ Other (Indicate)

APPENDIX E

PERSONAL COMMUNICATION

Draft 1 Working draft of Running thoughts/details to parse/tease out

Categories (4)

Formally Trained Professional Musicians,
Professional Musicians,
Amatuer Professional Musicans,
Players and Singers.

Formally Trained Professional Musicians

Degreed or in a formal degree program as-undergraduate-grad in music performance,music education, or music theory from an accredited institution.

At least 10 years regular, although not necessarily sequential, performing experience where the general public has attended. Public can have attended for free, and musician does not have to be paid, but must be a "performance/concert" type of experience, not the garage or for your own pleasure. These years can include Middle School.

player/singer

Someone who plays an instrument or sings for their own pleasure and the pleasure of their family and friends, but does not perform beyond that

Instrumental for FTPM

string, ,piano, wind brass,guitar, what about harmonica??

Percussion –separate category?? Not?? Trap set vs percussion section insts.

Voice

Voice area(s)

Tradiional/ Classically trained Soprano Alto Tenor Bass
Culturally trained Pop/Rock
Jazz

Professional Musicians.

Professional Musicians are musicians that have performed for at least 5 years in concert/recording venues where they have been paid for performing. They do not need to have had formal university-level musical training, but they must be financially compensated for their performance ability. This includes band member

who receive money, as well as studio musicians. Examples would be: Bobby McFerrin, Winners of Amerian Idol,

Amatuer Professional Musicians:

Amatuer Professional Musicians are musicians that have received early training,, and still perform, but likely have another career area. These musicians either performed in high school and/or participated in college in music ,but are not degreed in music. They also can have taught themselves and perform for audiences that may or may not pay for tickets. Amateur professional musicians are those who **play but are not compensated fina**ncially for their performances. Their work constitutes volunteering their musical ability for the betterment and enjoyment of others.

Musical Training questions;

At what age did you begin first experience with the instrument you currently play?

Did you begin first on another instrument? Age?

Do you play more than one instrument?

Did you start on one instrument and switch to another the first year? The second year? Third year?

Names of all instruments played, and years and half years played.

At what age did you begin each instrument you play?

Insturment/age
1
3
4

Number of Years, and half years, of private lessons on your primary instrument played

Number of years and half years of private lessons if you took on instrument(s) other than your primary.

Number of years you have performed in a school/university ensemble.

Names and number of ensembles you performed with;
in elementary school
in middle school
in high school
at the university level (list names of ensembles)
post university level

Years of total ensemble performance

Total years of private music teaching experience
Total years of public music teaching experience
Total years of ensemble music teaching experience
Years, if applicable, of university teaching experience

Draft 1 Working draft of Running thoughts/details to parse/tease out

Categories (4)

Formally Trained Professional Musicians, – here degree(s)
Professional Musicians, – no degree (set $)
~~Amatuer Professional Musicans~~, no degree set Amatur music no degree can play
Players and Singers.

Formally ~~-~~Trained Professional Musicians

Has arts in music an
Degreed or in a formal degree program as-undergraduate/grad in music performance,music education, or music theory from an accredited institution.

At least 10 years regular, although not necessarily sequential, performing experience where the general public has attended. Public can have attended for free, and musician does not have to be paid, but must be a "performance/concert" type of experience, not the garage or for your own pleasure. These years can include Middle School.

Yo Yo MA, Pianists(s)
Notable examples would be Joshua Bell, Midori, Edgar Meyer, Hillary Hahn, Eammuel Ax, Beaux Arts Trio members

Formaly Trained musician - these w/ colleg degrees in music that do not have years of performance

Professional Musicians.

Professional Musicians are musicians that have performed for at least 5 years in concert/recording venues where they have been paid for performing. They do not need to have had formal university-level musical training, but they must be financially compensated for their performance ability. This includes band member who receive money, as well as studio musicians. Notable examples would be: Bobby McFerrin, Natalie Cole

Amatuer Professional Musicians:

Amatuer Professional Musicians are musicians that have received early training,, and still perform, but likely have another career area. These musicians either performed in high school and/or participated in college in music ,but are not degreed in music. They also can have taught themselves and perform for audiences that may or may not pay for tickets. Amateur professional musicians are those who **play but are not compensated ~~financially~~** for their performances. Their work constitutes volunteering their musical ability for the betterment and enjoyment of others. Notable examples would be someone who plays or sings for a local orchestra or band, their church, or other events. Again, without being paid.

player/singer

Someone who plays an instrument or sings for their own pleasure and the pleasure of their family and friends, but does not perform beyond that

Comprehensive intake form

Musical Training questions:

(1) At what age did you begin ~~first experien~~nce with the instrument you currently play?

(2) What year were you in school at Rutgers?

Did you begin first on another instrument? Yes No

(3)

Age?

Do you play more than one instrument? Yes NO

Did you start on one instrument and switch to another the first year? Yes NO
The second year ? YES NO
Third year? Yes NO

Names of all instruments played, and years (including half years) played.

Instrument _____ Years _____
Instrument _____ Years
Instrument _____ Years
Instrument _____ Years

At what age did you begin each instrument(s) you play? _____

Instrument/age

1
2
3
4

If you are in a music education degree program (or have received a music education degree, and had to learn how to play all the instruments please circle yes, otherwise circle no. when the degree progr were required

Yes
No

Number of Years, including half years, of private lessons on your primary instrument played

Number of years, including half years, of private lessons you took on **other** instrument(s). (in addition to your primary).

Number of years you have performed in an educational setting: school/university/college ensemble(s). regularly

Your **elementary** ensemble lesson schedule dej Schal

Once a week
Twice a week
Everyday

Your **middle school** ensemble schedule
Every day
Blocked schedule
Rotating Block

Your **High school** ensemble schedule

Every Day
Blocked schedule
Rotating Block

Afterschool ensembles / private orchestras bands Youth Symp

Hopical ~~amount~~ required rehearsal Scheduled
trip
weekly
monthly

Amount 3 rehearsin Trips

Types and number of ensemble you performed with in an educational setting (band, orchestra, jazz band, string quartet, percussion ensemble, chorus, etc).

elementary school

middle school

high school

university level (list names of ensembles)

post university level

Years of total ensemble performance _____

Total years of professional instrumental or vocal music performance where you were financially compensated for your performance .

*The Local Federation of Musicians in the nationally recognized organization for musicians that regulates performers financial compensation and performance rules and regulations.

Total years of professional instrumental or vocal music performance, including conducting, where you were registered with a local federation of musicians union* and paid union rates.

Total years of conducting ensembles, both paid and unpaid, in performance venues in educational settings

Total years of conducting ensembles in local federation of musicians* paid settings

Total years of private music teaching experience -studio style (sum private lessons)

Total years of public music teaching experience school

Total years of ensemble music teaching experience instrumental ——

Years, if applicable, of university instrumental performance private studio teaching experience choral ——

Years, if applicable, of university ensemble ~~direction~~ conducting teaching/directing

Years, if applicable, of university pedagogy teaching experience i.e. String or HW Methods course

Instrumental/Vocal categories:

List all that apply

String with ~~bows~~ Instrument
Wind
Brass
Percussion
Drum Set
Harp/Guitar (~~string without bow~~)
Piano
Voice:
- Classical;soprano,alto tenor bass
- Pop/rock
- jazz
- ~~other~~
- Opera
- other (please list)

~~Were~~ Were
were your parents musicians?
If yes please explain
—
—
—

Do you have sibling that also have had musical training?

APPENDIX F

INSTITUTIONAL REVIEW BOARD NOTIFICATION

THE UNIVERSITY of NORTH CAROLINA
GREENSBORO

OFFICE OF RESEARCH INTEGRITY
2718 Beverly Cooper Moore and Irene Mitchell Moore
Humanities and Research Administration Bldg.
PO Box 26170
Greensboro, NC 27402-6170
336.256.0253
Web site: www.uncg.edu/orc
Federalwide Assurance (FWA) #216

To: Catheryn Shaw
Music Education
Music

From: UNCG IRB

Authorized signature on behalf of IRB

Approval Date: 2/12/2016
Expiration Date of Approval: 2/11/2017

RE: Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)
Submission Type: Initial
Expedited Category: 4.Noninvasive clinical data,7.Surveys/interviews/focus groups
Study #: 15-0453
Study Title: Music and Brain Networks

This submission has been approved by the IRB for the period indicated. It has been determined that the risk involved in this research is no more than minimal.

Study Description:

This study examines the effects of intensive musical training on structural and functional brain networks. Participants will complete a set of assessments about their musical training background, music listening preferences and cognitive approaches to solving problems. Following the completion of the surveys, participants will undergo an fMRI of their brain. Participants will be scanned in an MRI scanner for about 60 minutes. During the scanning session, participants will be asked to lay quietly in the scanner with their eyes closed at rest.

Investigator's Responsibilities

Federal regulations require that all research be reviewed at least annually. It is the Principal Investigator's responsibility to submit for renewal and obtain approval before the expiration date. You may not continue any research activity beyond the expiration date without IRB approval. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.

Signed letters, along with stamped copies of consent forms and other recruitment materials will be scanned to you in a separate email. **Stamped consent forms must be used unless the IRB has given you approval to waive this requirement.** Please notify the ORI office immediately if you have an issue with the stamped consents forms.

You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented (use the modification application available at http://integrity.uncg.edu/institutional-review-board/). Should any adverse event or unanticipated problem involving risks to subjects or others occur it must be reported immediately to the IRB using the "Unanticipated Problem-Adverse Event Form" at the same website.

Please be aware that valid human subjects training and signed statements of confidentiality for all members of research team need to be kept on file with the lead investigator. Please note that you will also need to remain in compliance with the university "Access To and Retention of Research Data" Policy which can be found at http://policy.uncg.edu/university-policies/research_data/.

CC:
Robert Kraft, Dean Office Joint Sch Nanoscie
Robin Wilkins, Dean Office Joint Sch Nanoscie

APPENDIX G

CONSENT FORM

UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

CONSENT TO ACT AS A HUMAN PARTICIPANT

Project Title: Music and Brain Networks

Principal Investigator: Robin W. Wilkins

Participant's Name: _____

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in the study is voluntary. You may choose not to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. There may not be any direct benefit to you for being in the research study. There also may be risks to being in research studies. If you choose not to be in the study or leave the study before it is done, it will not affect your relationship with the researcher or the University of North Carolina at Greensboro. Details about this study are discussed in this consent form. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. If you have any questions about this study at any time, you should ask the researchers named in this consent form. Their contact information is below.

What is the study about?
This is a research project. Your participation is voluntary. The purpose of this study is to examine the effects of music on the human brain.

Why are you asking me?
Your participation in this study is entirely voluntary. We are asking you to participate because you are between the ages of 18 and 50 and have self-reported that you have normal hearing. We are asking you to participate because you have expressed an interest in music or have musical training in your background. You will be asked to complete assessments to determine your handedness and color-sightedness.
MRI uses a very strong magnetic fields and powerful radio waves. While MRI an MRI exam is safe for most people, there are a number of instances when it is unsafe (even potentially fatal) for someone to be in or around a MRI scanner. In order to make sure the MRI procedure will be safe for you, you will be asked to fill out a screening form before starting the study. It is important that you tell the researchers in this study:

- if you have a heart pacemaker
- if you have metal in your head (not including dental work)
- if you have metal in your spine or heart
- if there is the possibility of metal in your eyes,
- if you have any implanted medical device in your body,
- if you have an implant in your body held in place with a magnet,
- if you have had surgery in the last 6 weeks,

UNCG IRB
Approved Consent Form
Valid from:
1/18/17 to **1/17/18**

Burn risks: In extremely rare cases, metal in the body (e.g., in tattoos) exposed to the powerful radio waves used in MRI may heat up. This heating occurs gradually but if it goes unreported during the MRI exam it could lead to burns. Such burns are easily prevented by reporting any heating sensations that you have to the technologists immediately. For your safety, you will be monitored the entire time you are in the scanner. The study team will be able to talk to you and hear you talk during the exam through an intercom. You will also be given a ball to squeeze with your hand if you want to stop the exam immediately and for any reason.

Fear of small places: MRI machines require you to enter a tube about 2 feet in diameter and place your head in small helmet. For people with a fear of small spaces this can cause anxiety. If you experience anxiety during your MRI exam please let the technologist know. If you decide that you cannot complete the scan, you will be removed immediately from the scanner, and released from the study.

Hearing loss: MRI scanners when taking a picture are very loud. You will be required to wear earplugs during the exam. When the earplugs are used properly, the noise from the MRI scanner is as load as a garbage disposal or food blender. If the earplugs are not inserted into the ear canal then temporary hearing loss is possible. If at anytime the noise from the MRI machine is too loud inform the technologist.

Muscle twitching and tingling: MRI machines turn magnetic fields on and off very quickly to make an image. In rare cases, this may cause your muscles to twitch and tingle. The muscle twitching and tingling are temporary and will stop as soon as the scanner stops. In some rare cases, some individuals find the muscle twitching and tingling to be uncomfortable and cannot continue with the MRI exam. If this happens to you let us know and you will be released from the study.

Other miscellaneous risks: There are other short-term effects that have been reported in very rare cases during the MRI exam. These effects range from dizziness, to taste sensations, to light flashes during the MRI exam. These effects are temporary and occur as you move in and out of the MRI machine. In most cases, these effects go away very quickly. If these sensations persist and you are unable to continue with the MRI exam, inform the researchers and you will be removed from the MRI exam and released from the study.

- The MRI images completed at our facility are part of a research study and are not for clinical diagnostic purposes. The MRI images in this study will not be reviewed by a physician. If you would like to review these images with your physician, we will give you a free copy of your images on a CD.
- In the case that we see a substantial deviation from normal anatomy we will notify you, provide you with a free copy of your data, and suggest that you contact your physician for follow up. The research team cannot diagnose conditions.

Pregnancy: It is unclear at this time whether strong magnets are a risk to unborn fetuses. Due to the unknown risk and potential harm to an unborn fetus from any MRI scan, pregnant women will be excluded. All women will be asked before entering the scanner if they are pregnant.

The MRI images completed as part of this study are not for clinical diagnostic purposes. The MRI images in this study will not be reviewed by a physician. If you would like to review these images with your physician, we will give you a copy of your images on a CD.
Would you be like a copy of your images? Yes □ No □

Signature: _____ Date: _____

If you have questions, want more information or have suggestions, please contact Dr. Robin Wilkins (robinwwilkins@gmail.com) .

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

Are there any benefits to society as a result of me taking part in this research?
We hope the information learned from this study will benefit society by providing information related to the effects of musical training on the brain.

Are there any benefits to *me* for taking part in this research study?
There are no direct benefits to participants in this study.

Will I get paid for being in the study? Will it cost me anything?
You will be compensated with a $25 Amazon gift card upon the completion of your MRI. It will not cost you anything to participate in the study.

How will you keep my information confidential?
All data will be de-identified and kept in a locked filing cabinet at the MRI suite at JSNN. A master list linking participant's names to their study ID will be kept separate from the data in a secure locker in the MRI suite at JSNN. All information obtained (fMRI data and questionnaire responses) from participants will be assigned code numbers; participant names will never be associated with their obtained information (e.g., participant number 4). Data will also be stored on the UNCG PACS system and will be password protected. The research team will use this number when analyzing, reporting, and (or) summarizing a participant's data; participants' names will never be identified/disclosed. All information obtained in this study is strictly confidential unless disclosure is required by law.

What if I want to leave the study?
You have the right to refuse to participate or to withdraw at any time, without penalty. If you do withdraw, it will not affect you in any way. If you choose to withdraw, you may request that any of your data which has been collected be destroyed unless it is in a de-identifiable state.

What about new information/changes in the study?
If significant new information relating to the study becomes available which may relate to your willingness to continue to participate, this information will be provided to you.

Consent to be contact for optional related studies:
The research study in which you are participating is part of a larger series of studies that we are doing on music and instrumental training. There are times when the information we collect from one study suggests new and different questions that can only be answered by seeing participants again. Because we cannot tell in advance when this might happen, we ask you now for your permission to contact you later for possible optional related research studies.

Voluntary Consent by Participant:
By signing this consent form you are agreeing that you read, or it has been read to you, and you fully understand the contents of this document and are openly willing consent to take part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you

are 18 years of age or older and are agreeing to participate, or have the individual specified above as a participant participate, in this study described to you by _____.

Signature: _____ Date: _____

APPENDIX H

ITEM RATING CHART

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Singing				
Can you sing? If yes, please indicate for how many years.	5	5	4	4.67
Where did you first learn to sing?	5	4	5	4.67
How many hours per week do you sing in an informal setting? (Example: around the house, in the car)	5	5	5	5
How many hours per week do you sing in a formal setting? (Example: church, community choir, school)	5	3	5	4.33
Instrumental				
Do you play any instruments?	5	5	3	4.33
Select which instrument(s) you play and indicate how many years you have played.	5	4	5	4.67
How many hours per week do you play an instrument in an informal setting? (Example: jam sessions, around the house)	5	4	5	4.67
How many hours per week do you play an instrument in a formal setting? (Example: school, community band, church)	5	4	5	4.67
Music Reading				
Do you read music?	5	4	3	4
Please indicate your level of music reading.	5	4	5	4.67

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Extracurricular Activities				
Please select any extracurricular activities you participated in during grade school. Do NOT include music activities!	4	5	4	4.33
Gaming and Typing				
How many hours per day do you spend typing on a computer keyboard?	4	5	4	4.33
What is your preferred method of typing?	4	4	4	4
Do you play video games?	4	4	4	4
If you answered Yes to the previous question, please select the gaming console(s) that you play on.	4	4	4	4
If you do play video games, how many hours per day do you play?	4	4	4	4
Band (K-12)				
Did you participate in band in grade school (K-12)?	5	5	5	5
Please select the instrument(s) you played.	4	3	5	4
Please list the ensembles you participated in and the number of years.	5	4	5	4.67
Indicate the stages during your training in which you practiced and estimate the number of hours per week.	5	5	5	5
Please indicate any honor ensembles you were a member of and how many times you participated (Examples: County, District, Region, All-State, Solo & Ensemble).	5	4	4	4.33
Indicate the number of times per week your band class met.	5	5	4	4.67

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Please list any honors associated with band that you received (Examples: John Philip Sousa, Leadership Awards)	4	3	3	3.33
In which state did you participate in band?	4	5	4	4.33
What is the highest level of music your band played?	4	5	4	4.33
Please list any notable performances (Examples: Mid-West, Macy's, state convention)	4	3	4	3.67
Orchestra (K-12)				
Did you participate in orchestra in grade school (K-12)?	5	5	5	5
Please select the instrument(s) you played and indicate how many years you have played the instrument.	5	3	5	4.33
Please select the instrument(s) you played and indicate how many years you have played the instrument.	4	5	4	4.67
Indicate the stages during your training in which you practiced and estimate the number of hours per week.	5	5	5	5
Please indicate any honor ensembles you were a member of and how many times you participated (Examples: County, District, Region, All-State, Solo & Ensemble).	5	4	4	4.33
Indicate the number of times per week your orchestra class met.	5	5	4	4.67
Please list any honors associated with orchestra that you received	4	3	3	3.33

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
In which state did you participate in orchestra?	4	5	4	4.33
What is the highest level of music your orchestra played?	4	5	4	4.33
Please list any notable performances (Examples: Mid-West, state convention)	4	3	4	3.67
Chorus (K-12)				
Did you participate in chorus in grade school (K-12)?	5	5	5	5
How many years did you participate?	5	4	5	4.67
Please select the ensembles you participated in and indicate the number of years you participated.	5	4	5	4.67
Indicate the stages during your training in which you practiced and estimate the number of hours per week.	5	5	5	5
Please indicate any honor ensembles you were a member of and how many times you participated (Examples: County, District, Region, All-State, Literary).	5	4	4	4.33
Indicate the number of times per week your chorus class met.	5	5	4	4.67
Please list any honors associated with chorus that you received	4	3	3	3.33
In which state did you participate in chorus?	4	5	4	4.33
What is the highest level of music your chorus sang?	4	5	4	4.33
Please list any notable performances (Examples: ACDA, state conventions)	4	3	4	3.67

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Please list any languages that you have studied through singing.	4	5	3	4
Other School Classes (K-12)				
Did you participate in any other school music classes? (Examples: Elementary music class, Guitar class, etc.)	5	5	5	5
Please indicate the class(es) that you participated in and the number of years you participated.	5	5	5	5
Private Lessons (K-12)				
Did you take private lessons (instrumental or vocal)?	5	5	5	5
Please select the instrument/voice part you took lessons on. In the box, include the age at which you started and the number of years you took lessons (Example: 6yo, 9)	5	4	5	4.67
College/University				
Did you participate in music at the collegiate/university level?	5	5	5	5
Did you major in music?	5	4	5	4.67
Please select completed or in progress degrees and specify the program (Examples: Bachelor of Music in Music Education, Master of Sacred Music, etc.)	5	4	3	4
Indicate your primary and secondary instruments OR voice part and the number of practice hours per week.	5	5	5	5
If the degree is still in progress, please indicate the number of years you have majored in music.	5	4	4	4.33

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Please select the ensembles in which you have performed and include the number of years in the corresponding box.	5	5	5	5
Please list any honors associated with music that you have received at the collegiate / university level.	4	4	3	3.67
Did you minor in music?	5	4	5	4.67
Indicate your primary and secondary instruments OR voice part and the number of practice hours per week.	5	5	5	5
Please list the ensembles in which you have performed along with the number of years (include 1/2 years - estimate).	5	5	5	5
Did you participate in any ensembles or take lessons/classes as a non-major/minor?	5	5	5	5
Indicate your primary and secondary instruments OR voice part and the number of practice hours per week.	5	5	5	5
List any ensembles in which you have performed including the number of semesters.	5	5	5	5
Did you take lessons at the collegiate / university level? If YES, please indicate the instrument / voice part.	5	5	5	5
Please list any music classes you took as a non-major/minor.	5	4	5	4.67
Teaching Experience				
Have you ever taught music?	5	5	5	5

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Please list the area in which you have taught PRIVATE LESSONS (instrument [specify] or voice), the level (Beginner, Intermediate, Advanced), and number of years taught).	5	5	5	5
List any ensembles that you have taught/conducted and the number of years you taught at that level. Please separate by level.	5	5	5	5
Community/Amateur/Professional Ensemble Experience				
Have you participated in any community / amateur / professional ensembles?	5	5	5	5
List any of the aforementioned ensembles that you have performed with and the number of years.	5	4	5	4.67
Piano Experience				
Have you ever studied piano?	5	4	5	4.67
How many years have you studied piano?	5	4	5	4.67
How many years have you played piano?	5	4	5	4.67
Please indicate the levels at which you have played and the number of practice hours per week.	5	4	5	4.67
List any honors you have received associated with piano.	4	3	3	3.33
Please list any notable performances you have had on piano.	4	3	4	3.67
Please list any jobs you have obtained as a pianist (Examples: church accompanist, orchestral soloist)	4	4	5	4.33
What is the most difficult piece you have ever played?	5	4	4	4.33

Assessment Tool Item	Rater 1	Rater 2	Rater 3	Average Rating
Extra Musical Training				
List any music camps or workshops in which you have participated.	4	5	5	4.67
Church Experience				
Have you participated in any church/religious music experiences?	5	5	5	5
Please select the ways in which you have participated and indicate the number of years.	5	5	5	5