An Inquiry into the Relationship Between Student Music Background and Academic Science Achievement –A Correlational Study

Dissertation Manual

Submitted to Northcentral University

Graduate Faculty of the School of Education
in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

by

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September 2017

Approval Page

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Abstract

The purpose of this quantitative correlational study was to analyze which combinations of academic, socio-economic status, and music background indicators best predicts academic science performance in high school students, and to preliminarily explore if cognitive transfer or resource sharing theories may be applicable from music to science. The problem addressed was whether transferable cognitive effects, which may be beneficial to academic science performance, may be lost due to reductions in instructional time and access to music and arts educational programs at U.S. public schools. This study utilized multiple linear regression in order to investigate which combination of music background, overall grade point average, and socio-economic status best predicts academic science achievement, as measured by the student's score on the California Standards Test in science. Forty-five student participants from the Northern Humboldt Union High School District in Northern California took an online survey about their own musical background. Each student's survey answers was paired with their score on the California Standards Test in science, their overall high school grade point average, and their socioeconomic status as measured by their eligibility for free and reduced lunch. A statistically significant result was found for the multiple linear regression equation (F (4,40) = 3.355, p = 0.018), with an R^2 = 0.251. However, the only significant predictor variable for academic science achievement was overall high school grade point average. There were no significant relationships found between music background, socioeconomic status and scores on California Standards Test in science. The results of this study must be interpreted with caution primarily due to low sample size and non-normal data in two of the predictor variables. The primary contribution of this study is that no evidence was found for either transfer effects or

resource sharing from music to academic science achievement. Therefore, it cannot be concluded from the results of this study that transferable cognitive effects were lost. It is recommended that future research continue to be done to investigate relationships between music and academic science achievement, ensuring an adequate sample size, and utilizing broader and more diverse measures of music background and academic science achievement.

Acknowledgments

I would like to express my sincerest gratitude to my dissertation committee chair, Dr. Sharon Kimmel, for her support and guidance throughout my dissertation process. I appreciate her optimism and enthusiasm for my study during those times when I needed a boost. I respect her knowledge and understanding of the dissertation process, her impressive knowledge of statistics, and her ability to get me to focus on key ideas that often eluded me. I would also like to express my appreciation to my subject matter expert, Dr. Shad Bailey, for her valuable feedback about my study, and her enthusiasm and understanding of music and education.

Also, I would especially like to thank my wife, Lori, for her love, support, and undying patience throughout my long Ph.D. journey. Her continued support was one of the main reasons I was able to complete the degree. Finally, I'd like to thank my sons, friends, and colleagues who gave me advice and encouragement throughout the years, and I look forward to spending more time with them now.

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Chapter 1: Introduction

Over the past decade, schools have been under pressure to ensure accountability and raise standardized test scores to satisfy the requirements of the No Child Left Behind Act of 2001, and the Department of Education Race to the Top (RttT) initiative (Onosko, 2011; Ravitch, 2010). In order to increase instructional time for tested subjects such as English language arts, mathematics, science, and social studies cuts and reductions have been made to other subjects such as music and fine arts (Baker, 2012; Center on Education Policy, 2007; Ravitch, 2010). Instructional time for art and music was reduced between 12-30% for 491 surveyed US school districts (Center on Education Policy, 2007). In one survey of public school principals in Ohio, 43% of Ohio's public school music programs were determined to have weakened since the passage of NCLB (Gerrity, 2009). In California, it was reported that student participation in music declined by 47% during the five-year period from 2000 – 2004 largely due to NCLB and statewide budget cuts (Music for All Foundation, 2004). However, in a more recent examination of nationwide music enrollment, Elpus (2014) reported that NCLB had no effect on overall music enrollment rates, but that it exacerbated preexisting underrepresentation of Hispanics students, students with individualized learning plans, and students with limited English proficiency in music courses.

Musical training has been linked with increased brain plasticity, improved efficiency of auditory neurons, improved working memory, and increases in hemispheric connectivity (Chin & Rickard, 2010; George & Coch, 2011; Habib & Besson, 2009). Structural and functional changes occur in the brain as a result of musical training and engagement (Bennet, 2008; Skoe & Kraus, 2012). Such changes can persist for years after training has stopped, and depend on the intensity, duration, and the age of onset of a person's musical training. Cognitive transfer and resource sharing are promising theories that might explain how skills learned by studying music make changes in the brain that can improve skills and abilities in other academic areas such as science (Hyde et al., 2009; Patel, 2012; Weinberger 1999). Music and verbal abilities, for instance, may share overlapping neural networks in auditory brain regions (Patel, 2012).

Many researchers report associations between music exposure or engagement with various measures of cognitive performance, especially auditory, spatial/temporal verbal, and IQ (Chin & Rickard, 2010; Schellenberg, 2004, 2006, 2008, 2011a, 2011b, 2011c). Associations between music training and cognitive abilities appear to be extremely general, extending across a wide variety of tasks (Schellenberg, 2011a). However, very few strictly experimental studies have been performed involving random assignment of participants. Therefore, the results of most studies do not allow one to make causal inferences. Potential confounders include IQ, socioeconomic status (SES) and self-selection of music training. Higher IQ children are more likely to take music lessons, and are more likely to perform better on a variety of tests of cognitive ability (Schellenberg, 2011b). Furthermore, it could be argued that the higher achieving students self-select music courses, or those who choose to engage with music also tend to earn higher scores on standardized tests (Costa-Giomi, 2004). Therefore, IQ, music engagement, and performance on cognitive or academic measures are all interrelated, making their relationships to each other difficult to interpret. High academic achievement could be a cause and/or a consequence of music participation (Schellenberg, 2011a).

Background

Researchers have found that possessing a music background is linked to student academic achievement in subjects such as mathematics and language arts (Bennet & Bennet, 2008; Gouzouasis, Guhn, & Kishor, 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Of particular interest to educators are the potential benefits that engaging in music could provide to students in various academic and affective domains. *Cognitive transfer* and *resource sharing* are two hypothesized mechanisms researchers have put forward to explain how engaging in music might affect performance in other academic domains (Hallum, 2010; Patel, 2012; Weinberger, 1999). Cognitive transfer is a mechanism whereby transfer of learning occurs from one cognitive or motor domain in the brain to another (Hallum, 2010). The resource sharing mechanism is where different types of domain-specific knowledge can share underlying neural resources (Patel, 2012). The most commonly found academic associations are those between music, language arts and mathematics (Bennet & Bennet, 2008; Gouzouasis et al., 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). However, few studies have been done investigating the effects of music background on specific academic subjects, such as science, social studies, visual arts, foreign language, industrial arts, or physical education (Gouzouasis et al., 2007). If associations between music and cognitive abilities are general and span a wide variety of disciplines, then similar associations are expected for other academic disciplines (Schellenberg, 2011a). Notably absent are studies involving music background and science.

Science is not only an academic discipline, but also a set of skills and cognitive processes involving problem solving, data analysis, experimental design, and formulation of hypotheses and theories (Ruiz, Bermejo, Ferrando, Prieto, & Sainz, 2014). Learning science uses many of the same cognitive and academic skills as does learning language and mathematics, such as spatial-temporal reasoning, symbolic decoding and interpretation, problem-solving and creative thinking (Hallum, 2010; Hetland, 2000). Engagement with music also requires a broad set of skills such as auditory processing, visual processing, symbolic decoding and interpretation, gross and fine motor control, short and long-term memory tasks, and creative improvisation (Hallum, 2010). If music requires many of the same cognitive processes as language arts, mathematics and science, and the associations between music training and cognitive abilities appear to be quite general, then it is reasonable to expect that such skills in common should transfer.

Only a few limited studies have investigated whether a music education or other measures of musical background influence student achievement in science (Fitzpatrick, 2006; Gouzouasis et al., 2007). Additional research is needed to further elucidate the relationships between music background and academic science achievement in high school in order to address the gap in the literature about possible cognitive transfers occurring from music to additional academic areas (Hyde et. al, 2009; Jaeggi, Buschkuehl, Shah, & Jonides, 2014; Skoe & Kraus, 2012).

Statement of the Problem

Transferable cognitive effects, which may be beneficial to academic science performance, may be lost due to reductions in instructional time and access to music and arts educational programs at U.S. public schools. These reductions occurred primarily as a result of the "No Child Left Behind Act" (NCLB) and the more recent Race to the Top (RTTT) programs (Center on Education Policy, 2007; Gerrity, 2009; Hyde et al., 2009; McMurrer, 2008; Ravitch, 2010; Weiss, 2014). Emphasis on accountability and high-stakes testing in a narrow subset of academic subjects has continued in U.S. public schools with the 2009 U.S. Department of Education "Race to the Top" initiative (Onosko, 2011). Cognitive transfer theory may explain how skills learned in one domain, such as music, could carry over to other domains such as mathematics, language arts or science because these domains share neural pathways in the brain (Hyde et al., 2009; Weinberger, 1999). Researchers have shown that music background is linked with higher academic achievement in subjects such as mathematics and language arts (Bennet & Bennet, 2008; Gouzouasis et al., 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Although researchers disagree about whether music enrollment numbers have decreased within the past decade (Elpus, 2014), reductions in music instructional time in certain sectors of public education may have the unintended effect of reducing opportunities for cognitive transfer. Relatively little is known about the relationship between music education and academic science achievement (A. Cabanac, Perlovsky, Bonnoit-Cabanac, & M. Cabanac, 2013).

Additional research is needed to further explore relationships between indicators of music background and academic science achievement (Fitzpatrick, 2006). Reduction in music instruction in public schools means fewer student choices in performing arts electives as well as fewer opportunities for skill transfer to occur from music to science (Hyde et al., 2009).

Purpose of the Study

The purpose of this quantitative correlational study was to analyze which combinations of academic, socio-economic status (SES), and music background indicators best predicts academic science performance in high school students, and to preliminarily explore if cognitive transfer or resource sharing theories may be applicable from music to science. The first predictor variable for this study as music background, a construct consisting of two separate measures of a student's prior music experiences: the number of hours per week spent practicing instruments or singing, and the total number of years the student has played all their instruments and singing. Quantitative data about student music background was acquired through an online web-based survey, after receiving consent from the school superintendent, the high school principal, participating students, and their parents/guardians. Two other predictor variables were overall grade point average (GPA) and socioeconomic status (SES). This totals to four separate predictor variables. The outcome variable for the study, academic science performance, as measured by the total number of correct answers obtained by students in their science California Standards Test (CST) in science, an exclusively multiple choice test. Information about the predictor variables was obtained from the survey data and school student records. Multiple linear regression analysis was used to analyze which combinations of academic indicators, SES, and music background indicators best predict academic science achievement. The participant group was grade 11 and 12 high school students at the Northern Humboldt Union High School District (*District*), a two-high school district in rural Northern California. This group was selected because of the relative stability of the district's school music programs, their location in California where music reductions have been relatively severe, and their relative homogeneity in native language and culture (Music for All Foundation, 2004). Power analysis for multiple linear regression indicated a minimum sample size of 98 students would be needed (Faul et al., 2009). However, only 45 students participated in the study. The low sample size reduced the power of the study, making the result merely indicative of trends in the data. Generalizability of the results of this study was only to U.S. public high school students. Results from the study were discussed with the current and former principals and superintendents of both high schools to inform their planning and implementing budgetary and curricular decisions at each school site. According to the current District superintendent, no budgetary reductions are planned for the 2017-18 school year (Macdonald, 2017).

Theoretical Framework

The cognitive transfer mechanism that occurs in the brain may explain how music affects performance in other cognitive domains such as science (Weinberger, 1999). Cognitive transfer refers to the movement of skills or knowledge learned in one domain, such as rhythmic interpretation or sight-reading in music, to other domains such as mathematics and language, because those domains have similarities or may overlap cognitive processes in the brain (Hallum, 2010). Cognitive transfer is a fundamental assumption in education, psychology, and cognitive science

(Weinberger, 1999). Skills or cognitive abilities gained in one area can improve skills or abilities in others (Woodworth & Thorndike, 1901). For example, the motor skills acquired learning to ride a skateboard can transfer to riding a snowboard. Alternately, skills learned playing the guitar can transfer over to playing the banjo. These are known as *near-transfer* effects (Hallum, 2010). The degree to which transfer of learning occurs depends on the similarity of the process and the degree to which the tasks share cognitive processes (Hallum, 2010).

While near transfer effects are easy to demonstrate, it is much more difficult to demonstrate *far-transfer*, where the resemblance between one domain and the transfer domain is much less obvious (Hyde et al., 2009). An example of far-transfer effects might be when skills gained through sight-reading musical notation help a student with reading decoding. Far-transfer effects due to musical training have been observed in spatial, verbal, mathematical and IQ tests (Wan & Schlaug, 2010). Strong associations were found between the length of music training and reading comprehension, strong evidence for the far-transfer mechanism (Corrigall & Trainor, 2011)

A related theory known as *resource sharing* has relevance for this study. Evidence from neuropsychology and neuroimaging studies indicates that different types of domain-specific knowledge can share underlying neural resources (Patel, 2012). Using scientific neuroimaging techniques such as event-related potential (ERP), functional magnetic resonance imaging (fMRI), and positron emission tomography (PET) researchers have detected overlapping neural networks mediating musical activities and language processing (George & Coch, 2011; Wan & Schlaug, 2010).

Transfer effects or resource sharing theories both appear to be relevant theoretical/conceptual frameworks for this study for two major reasons. First, many educators assume that the skills and knowledge gained by students in the classroom will be useful and applicable in a variety of contexts in the future. In other words, educators assume that acquired knowledge is transferrable to different situations. Second, all the research questions for this study focus on the transference of skills and experiences gained from acquiring and possessing a particular musical background to academic science achievement. This research study was not a randomized, controlled experiment in cognitive science; it will add to the body of knowledge regarding transfer of learning from music to science.

Research Questions

Previous researchers have revealed that musical education is linked with higher academic achievement in subjects such as mathematics and language arts (Bennet & Bennet, 2008; Gouzouasis et al., 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Relatively little is known about the relationship between music education and academic science achievement. In this quantitative study, the researcher attempted to analyze the relationships between music background, SES, and GPA with a single academic science performance outcome variable. The music background indicators were: *music intensity* and *music duration*, the academic predictor variable was: the student's overall high school GPA. This study will attempt to answer the following research question:

Q1. What combination of music background indicators, an academic indicator, and SES best predicts academic science achievement?

Hypotheses

$H1_0$. There is no statistically significant relationship between music background indicators, an academic indicator, and SES, and academic science achievement.

H1a. There is a statistically significant relationship between at least one of the music background indicators, an academic indicator, and SES, and academic science achievement.

Nature of the Study

This quantitative, correlational study was designed to explore the relationships between indicators of music background, grade point average, SES, and academic science achievement. Participants were consenting high school students who have taken a California Standards Test in science. Students were given a short, web-based survey about their musical background, with each survey taking approximately 10 minutes. The resulting numerical and scaled answers were matched with information obtained from the school district's student records about overall grade point average, SES, and results from the California Standards Test in science.

A field test of a preliminary questionnaire was conducted using two experts in the field of music education, as well as an expert experienced in survey construction (see Appendix B). The high school music education experts were knowledgeable in both instrumental and vocal music education. They reviewed the preliminary questionnaire to ensure that the questionnaire questions were clear, understandable, readable, properly sequenced, and free from grammar, syntax or other typographical errors. The subject matter expert reviewed the questions to clarify wording and assured that the questions were valid measures of student musical background. The preliminary questionnaire that was field-tested is included in Appendix A.

This study used a quantitative method with a multiple correlational design. Multiple linear regression is the specific statistical test that was used to test the null hypothesis. Multiple linear regression is an appropriate test when there is a single outcome variable and multiple predictor variables. A correlational study is appropriate when preliminary explorations of the relationships among variables are desired, and experimental approaches are not possible (Lammers & Badia, 2005). Correlational research is also appropriate as it can show whether the predictor and outcome variables are unrelated, which can inform future experimental studies (Lomax & Li, 2013). Multiple linear regression is the most appropriate research design method to explore the relationships and interrelationships between multiple predictor variables and a single, quantitative, outcome variable (J. Cohen, P. Cohen, West, & Aiken, 2013).

Significance of the Study

This researcher explored the nature and the extent of relationships between indicators of a student's music background and their subsequent performance on a standardized test of science achievement. Additionally, through the use of multiple linear regression, this study explored the interrelationships between the different indicators of a student's music background, as well as other predictor variables for academic science achievement. Results from the study may prove useful to administrators, board members, and teachers involved in planning and implementing budgetary or curricular decisions at each school site. This study will contribute to the literature about the generality of associations between music background and academic science achievement, and the extent to which cognitive transfer and resource sharing theoretical frameworks are applicable.

Definition of Key Terms

Academic science achievement. For purposes of this study, academic science achievement was defined as the raw score (total number of questions correctly answered) obtained by a student in the California Standards Test (CST) in science. The particular science test taken by the participants was primarily a life science test, containing 60 exclusively multiple choice questions. Although only the raw score on the CST was analyzed in this study, the state of California Department of Education converts raw scores into scaled scores using a mathematical formula in order to assess achievement proficiencies (California Department of Education Assessment Development and Administration Division, 2017b). There are five achievement classifications for the CSTs: far below basic, below basic, basic, proficient, and advanced. For all science CSTs, a student must earn a minimum score of 300 to achieve basic classification. A student must achieve a minimum score of 350 to achieve proficient classification (California Department of Education Assessment Development and Administration Division, 2017b). This measure of academic science achievement is to be associated with the predictor variables, *music background*, overall GPA, and socioeconomic status.

Cognitive transfer. Cognitive transfer is a mechanism whereby transfer of learning occurs from one cognitive or motor domain in the brain to another. Transfer of learning is a fundamental issue in the cognitive and brain sciences (Weinberger, 1999). Transfer of learning depends on how similar the tasks or processes are, and how much they share neural pathways. Additionally, the effects of cognitive transfer may be highly specific to particular cognitive abilities or may influence general cognitive processing (Weinberger, 1999; Hallum, 2010).

Far-transfer. Far-transfer is a form of cognitive transfer that occurs where the resemblance between training and transfer domains is much less obvious. Examples of far transfer effects in education might be the learning gained in a mathematics class transferring to a music theory class, or skills gained by playing piano transferring to a language arts class (Hyde et al., 2009).

California Standards Tests (CSTs) in Science. The California Standards Tests (CSTs) in Science are English language multiple-choice science examinations given to students in grades two through eleven. The tests are designed to show how well they are performing with respect to California's content standards in biology, chemistry, physics, earth science, and integrated science. The California content standards describe what students should know and be able to do at each grade level (California Department of Education Assessment Development and Administration Division, 2017b). CSTs were the key component in calculating a school and district's Academic Performance Index (API), which are used in determining Adequate Yearly Progress (AYP), a requirement of the federal Elementary and Secondary Education Act (ESEA), otherwise known as the "No Child Left Behind" (NCLB) Act. However, California schools have replaced the ESEA by implemented a new, multiple measures accountability system, that eliminates calculation of the API and AYP (California

Department of Education Assessment Development and Administration Division, 2017a).

Music background. For purposes of this study, music background was a construct consisting of two separate indicator constructs, *music intensity* and *music duration*. Music intensity was defined as the total number of hours per week the student is currently actively engaged with instrumental and vocal music. Therefore, music intensity is a composite construct calculated by summing the values for all questions querying the number of hours spent per week by the student actively playing an instrument and singing. The second construct, *music duration*, is defined the number of years actively engaged with instrumental and vocal music. Therefore, music duration is also a composite construct, calculated by summing the values for all questions querying the number of years the student actively playing and instrument, singing, and taking music lessons.

Near-transfer effects. Near-transfer effects are the most studied form of cognitive transfer. It can occur when there is a close resemblance between the original cognitive domain and the transfer domain. An example of a near-transfer effect relevant to this study might be the knowledge gained in a biology class about how to design a proper experiment transferring to designing an experiment in a chemistry class. Another example might be the skills learned playing guitar transferring to the banjo (Hyde et al., 2009).

Resource sharing. Resource sharing is a conceptual framework related to cognitive transfer proposed by researchers to explain how certain syntactic features of music and language share underlying neural resources in the brain (Patel, 2012).

Evidence from neuropsychology and neuroimaging studies indicates that mental representations of language and music are both similar and domain-specific (George & Coch, 2011; Wan & Schlaug, 2010). The brain shares neural resources between two separate domains, such as the syntactical representation in language or music, when their cognitive operations are similar (Patel, 2012).

Summary

Engaging in music has been associated with changes in brain anatomy (Skoe & Kraus, 2012), improvements in cognition (Schellenberg & Moreno, 2012), and improvements in student academic achievement in certain academic subjects as language arts and mathematics arts (Bennet & Bennet, 2008; Gouzouasis et al., 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Reported associations between music training and cognitive abilities appear to be quite general (Schellenber, 2011a). However, few studies have been done where researchers examine the effect of music background on a specific academic subjects such as science (Gouzouasis et al., 2007). As the cognitive demands of science draws on many of the same skills as does language arts and mathematics, such as spatial-temporal reasoning, symbolic decoding and interpretation, problem-solving and creative thinking, it seemed reasonable to explore the associations between music and science (Hallum, 2010; Hetland, 2000).

The purpose of this quantitative correlational study was to analyze which combinations of academic, socio-economic status (SES), and music background indicators best predicts academic science performance in high school students, and to preliminarily explore if cognitive transfer or resource sharing theories may be applicable from music to science. Using multiple linear regression methods, this study analyzed which combinations of music background indicators, GPA and SES best predicts academic science achievement as measured by the CST in science. Cognitive transfer and resource sharing theories may explain how skills obtained from music engagement may enhance skills and abilities in other academic areas such as science (Hyde et al., 2009; Patel, 2012; Weinberger 1999).

Chapter 2: Literature Review

Musical experiences come in variety of forms, such as listening, taking music lessons or classes, learning to play a musical instrument, learning to sight-read music notation, or playing in various ensembles and musical groups. Engagement with music has been associated with a variety of extra-musical benefits (Bennet & Bennet, 2008; Gibson, Folley & Park, 2009; Gouzouasis, Guhn, & Kishor, 2007, 2007; Hallam, 2010; Hetland, 2000; Johnson & Memmott, 2006; Kraus & Chandrasekaran, 2010, Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). These benefits may include language development, literacy, numeracy, general intelligence, creativity, motor skills, concentration, self-confidence, emotional sensitivity, social skills, team work, self-discipline, and relaxation (Hallam, 2010).

Studies about the effects of music exposure or music engagement on various measures of cognitive performance can be categorized into four broad groups. One set of studies is focused primarily on the changes in brain anatomy and physiology after exposure to or engagement with music as evidenced by fMRI, positron emission tomography (PET) scans, or other brain scanning technology. Another set of studies is focused on specific changes in cognition as measured by specific test of cognition. A third set of studies is focused on the effects of music engagement on academics as evidenced by test scores, classroom grades or other academic indicators. The final group of studies is focused on behavioral, social, personal, and other affective changes in the individual due to engagement with music.

In this literature review, several themes are examined. First, a brief history of music education is presented. Second, the *Mozart Effect* is discussed, as it is familiar to many, especially those in the field of cognitive science. The Mozart Effect has become associated with the idea that listening to music can make a person smarter (Helding, 2014a). Third, the effects music has on brain anatomy and cognition are discussed. Fourth, the nature of IQ and related cognitive measures are explored, along with an overview of studies of music's effects on IQ and other cognitive skills. Fifth, two prominent multiple intelligence theories are examined, and contrasted with traditional cognitive measures. Sixth, a discussion of cognitive transfer and resource sharing theories is made in order to link music engagement with academic performance. Seventh, links and associations between music exposure and/or engagement and non-musical domains such as academic performance or social skills are examined, along with some of the criticisms of drawing conclusions from those associations. Eighth, an examination the factors that are known to affect science performance is performed, and a mention of the relative lack of studies investigating the associations between music and science. Finally, an analysis is made of the consequences of reducing or eliminating of music courses in U.S. public schools primarily as a means to save money.

Documentation

A literature search was performed and periodically updated. The search for the relevant and pertinent studies in the literature began by entering appropriate search terms into Northcentral University's (NCU's) Library Roadrunner search engine, or into NCU's library databases including ProQuest, SAGE, and EBSCOHost. Full text searches of scholarly and peer reviewed sources were used. A variety of search terms and phrases were utilized, such as *music's effect on academic performance*, *music's effect on the brain, music and cognition*, *music's effect on science achievement*, *music and cognitive transfer effects*, and various combinations of such terms. Often, reference lists within specific literature were searched for other relevant studies. In addition to searches using NCU's library, other searches were performed using Google and Google Scholar, and JSTOR, part of Shanghai American School's library's fully accessible databases. Searches were almost exclusively performed of peer-reviewed journals within the last five years. Study abstracts were typically read first, followed by study introductions and summaries. Closer reading of procedures and results sections was done on particularly relevant and interesting papers.

History of Music Education

Music is ubiquitous in human culture. Anthropologists have never encountered a culture without music and music education has existed since ancient times (Sousa, 2009). Music was one of the subjects taught in the *paideia*, a system of education and training present in ancient Greece and other Hellenistic cultures, (Encyclopedia Britannica, 2012). Pythagoras and Plato promoted music education in ancient Greece as part of the *quadrivium*, a four-part educational system consisting of arithmetic, geometry, astronomy, and music (Martineau, Lundy, & Sutton, 2010).

In Europe, music became part of what was later called a *liberal education*. Music has been taught in schools in the US since the eighteenth century (Stanford, 2012). In America, music education was part of its liberal education history. In the nineteenth century, the influential Yale Report of 1828 emphasized the need for liberal education in American education (Kern, n.d.). The report stressed that the development of analytical and creative mental faculties was more important than providing specialized education for a particular profession. In contrast, critics of liberal education argued that a student should be taught specific skills or trades in order to be a positive contributor to the community (Kern, n.d.). Music was included in the curriculum of private academies in colonial America (Campbell & Kassner, 1995). In 1838, music was introduced into the elementary school curriculum in Boston (1995). The introduction of music instruction in teacher colleges in Boston began in the latter part of the nineteenth century (Stanford, 2012). American high schools experienced significant growth in marching band school and orchestra programs in the early twentieth century. This greatly expanded the numbers of students exposed to music education in the public schools.

By mid-century, school music programs were commonplace in the US (Mark, 2008). Federal education funding expanded during the Kennedy administration primarily to support science education (Mark, 2008). However, funding for the arts was also increased during the early 1960s (p. 138). Music curriculum expanded to include traditions beyond the Western European classical tradition such as world, contemporary, and popular music, such as jazz and rock. By the latter half of the twentieth century, more students had music education in US public schools than at any previous time (Mark, 2008). However, with the rise of the school accountability movement in the 1980s, demands for increased rigor in the core academic areas diverted resources away from music and arts education (Center on Education Policy, 2007; Ravitch, 2010). Some form of music education is still found in the vast majority of the nearly 100,000 public schools in the United States (The National Center for Education Statistics, 2012; Lowell & Zakaras, 2008). In most US public high schools, music is an elective course offered as part of a performing or fine arts curriculum.

Music education has been in the headlines quite a bit in the last couple decades. Two main reasons for this are that music programs in schools have been reduced and eliminated especially in US public schools largely due to budgetary reasons, and that music has been associated with improvements in cognitive skills and academic performance (Hallam, 2010). These two parallel developments created the dilemma of how educators can justify reductions of school music programs in the face of accumulating research evidence indicating academic benefits of music.

The Mozart Effect

Although studies had been done linking music and cognition prior to the 1990s, the idea that music helps improve thinking achieved international notoriety in 1993 when Rauscher, Shaw and Ky, researchers from the University of California at Irvine, reported that student IQ scores improved after listening to Mozart music (Rauscher, Shaw, & Ky, 1993). The researchers had 36 student subjects listen to ten minutes of a Mozart sonata prior to performing one of three possible tests of spatial reasoning skills, taken from the Stanford-Binet IQ test. The music group experienced an average of an 8 - 9 point IQ score increase when compared to those subjects who either listened to silence or to 10 minutes of taped relaxation instructions prior to taking the spatial reasoning test. However, the effects were short-lived. The enhancing effect did not last beyond 10 – 15 minutes. Shaw claimed that the effect was due to the complexity of Mozart's music, which facilitated neuronal patterns similar to those produced while doing math or chess (Witchel, 2010). Regardless, their reported findings led to widespread media attention and claims that merely listening to Mozart's music could make a person smarter (Heiding, 2014). "Mozart Effect" books were published, as well as CDs with derivative names like "Baby Mozart" (Heiding, 2014).

The “Mozart Effect” phenomenon did not originate with Rauscher, Shaw, & Ky, It was first described by French researcher Dr. Alfred A. Tomatis in the 1950s. Tomatis claimed that playing Mozart to his patients significantly aided in fixing speech and auditory disorders (Vitale, 2010). Controversy ensued when some researchers were unable to replicate the effect, whereas others could (Schellenberg 2011b). Subsequent research indicated that the “Mozart effect” was not limited to Mozart’s music, nor did it only affect spatial abilities, but extended to processing speed and creativity (Schellenberg, 2011b). The effect was replicated when subjects listened to an up-tempo Schubert piece, but was not replicated when subjects listened to a slow, sad sounding piece by Albionini (Schellenberg, 2003). Additionally, the effect was found to be primarily due to the changes in mood and arousal created in participants by the fast-tempo, upbeat Mozart sonata when compared to slow or sad music, or to silence. In fact, other stimuli besides music enhanced mood and arousal levels, such as listening to a short narrated story, and created a similar effect (Schellenberg, 2003). The Mozart effect appears to have been an epiphenomenon of arousal or mood (Schellenberg, 2003).

Music’s Effect on Brain Anatomy and Cognition

Although the Mozart Effect did not establish that listening to music by itself increases intelligence for either short or long durations, many researchers have been interested in the cognitive effects of listening to music, as well as engaging with music for more prolonged periods. A distinction must be drawn between music exposure and music engagement. Music exposure means either actively or passively listening to music - a primarily auditory activity that most everyone experiences in daily life. Music engagement involves not only listening, but also learning to play an instrument, practicing an instrument or singing, learning music theory or music history, reading music notation, or composing music.

A fundamental principle of cognitive science is that learning occurs when the learned material becomes encoded in memory through repeated practice (Heiding, 2014a). While exposure may be a necessary first step in the learning process of engagement, it is not sufficient in and of itself. Engagement also requires motivation, attention, and sustained effort. For the purposes of this dissertation, music engagement means the relatively long-term processes of taking music lessons, practicing an instrument or voice, taking music classes, learning to sight-read musical notation, composing, or performing music. Any non-musical benefits resulting from music would be much likely to occur when the student is engaged with music rather than simply being exposed to it.

Within the past couple of decades, many studies have linked music to structural and functional changes to the brain (Schellenberg & Moreno, 2009; Skoe & Kraus, 2012; Wan & Schlaug, 2010). Studies about the effects of music on the brain and cognition fall into two broad groups: those based in neuroscience and cognitive science, and those based in psychology and education. The former group tends to be experimental in nature, and based on analytical techniques, such as functional magnetic resonance imagery (fMRI) (Bennet, 2008; Skoe & Kraus, 2012). The goal of such experimental research is usually to ascertain structural or functional differences or changes that may occur in the brain during or after musical exposure or engagement. The latter group tends to be cross-sectional and correlational in nature (Bennet & Bennet, 2008; Gouzouasis, et al., 2007; Hetland, 2000; Johnson &

Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Typically, the primary goal of the latter group of psychological or educational studies is to explore associations between various kinds of music exposure, performance or other sort of musical engagement in specific measures of cognition or academic performance.

Studies from neuroscience indicate that both anatomical and physiological brain changes occur as a result of music engagement (Moreno & Bidelman, 2014; Skoe & Kraus, 2012). Researchers in several studies have shown that there are significant brain differences in individuals whom are musically trained compared to individuals whom are not (Cabanac, et. al, 2013). Researchers report that the physiology of brain is changed by exposure to music in a variety of forms, and that these changes persist after the exposure ceases (Skoe & Kraus, 2012). Extensive active engagement with music can stimulate neural reorganization, which changes how the brain processes information (Hallum, 2010). Long-term music engagement has been associated with an increase in the neural representation specific to musical scale tones in the brains of Western classical musicians (Pantev et al., as cited in Hallum, 2010). When such engagement occurs early in a child's life, the more likely the brain changes are more pronounced and more likely to become permanent (Münte, Altenmüller, & Jäncke, 2002). The left planum region of the left temporal lobe has been found to be larger in adult musicians than in non-musicians, and sections of the temporal lobes are asymmetric in those who have absolute pitch, (Schlaug, Jäncke, Huang, & Steinmetz, 1997). Several studies have shown that musicians have, on average, a larger brain corpus callosum - the thick band of nerve tissue connecting the two brain hemispheres active during inter-hemispheric communication (Levitin &

Rogers, 2005). Musicians who began their musical training at an early age have been shown to exhibit greater synchronization and communication between the left and right hemisphere of the brain (Bennett, 2008; Münte, et al., 2002).

Münte et al. (2002) called the musician's brain the ideal model of neuroplasticity. Plasticity is the degree to which the brain modifies itself or is modified by experiences within the external environment (Moreno & Bidelman, 2014). The degree to which music training influences brain plasticity depends on the age of training onset, number of years of continuous training, amount of practice, and musical aptitude (Kraus & Chandrasekaran, 2010). Making music is cognitively demanding, especially at the professional level. Concert pianist can play up to 1800 notes in one minute, all while continually self-monitoring their own performance (Münte, et al., 2002). Such accomplishments require high-speed integration of auditory, memory and motor neuronal systems. Such a multi-sensory process requires the nervous system to couple auditory, visual and tactile perceptions with motor skills (Wan & Schlaug, 2010). Learning to play an instrument requires many skills such as reading a complex symbolic notation system and translating it into precision motor activities necessary to play a particular instrument. Additionally, instrumentalists monitor and adjust their actions based on continual multisensory feedback. The myriad processes required to learn to play a musical instrument leads to long-term changes in brain morphology and function (Wan & Schlaug, 2010).

In addition to structural changes in the brain induced by musical engagement, functional differences have been observed in those having been exposed to music both short and long term. Enhanced frontal cortex activity was observed in trained musicians when compared to a non-musician control group during processes measuring divergent thinking, which is associated with creativity (Gibson, 2009). Limb and Braun (2008) used functional MRI to study brain changes that occurred during spontaneous jazz improvisation, a highly creative form of individual musical expression. They found that areas of the prefrontal cortex that inhibit certain behaviors are deactivated during jazz improvisation, whereas the emotional centers and sensorimotor regions of the brain showed heightened activation. Activation of brain regions responsible for focused attention and conscious self-monitoring inhibits spontaneity, thus impairing creative performance. These areas were deactivated during spontaneous jazz improvisation. It was suggested in the study that other kinds of creative activity stimulate similar neural patterns (Limb & Braun, 2008).

Musical training has been shown to make changes in brain regions involved with auditory and sensory cortical responses, (Herholz & Zatorre, 2012). Such changes enhance auditory processing abilities that result in improved musical and other related cognitive abilities such as listening skills and speech processing. Music training in children has resulted in accelerated development in auditory processing and enhanced abilities to discriminate tonal changes (Habibi, Cahn, A. Damasio, & H. Damasio, 2016).

Other examples of music-induced brain changes include: differences in pitch acuity and music perception (Bidelman, Hutka, & Moreno, 2013); improved auditory processing (Kraus & Chandrasekaran, 2010); increased strength of brainstem responses to certain sounds (Skoe & Kraus, 2012); enhanced frontal cortex activity (Gibson, Folley, & Park, 2009); improved working memory (George & Coch, 2011), and changes in cross-hemispheric connectivity in the left and right brain lobes (Moore, Schaefer, Bastin, Roberts, & Overy, 2014).

Musical training has also been linked to structural brain changes in regions known to be associated with non-musical tasks, such as working memory, language and spatial reasoning, cognitive inhibition and others (Kraus & Chandrasekaran, 2010; Limb & Braun, 2008). Individuals with superior pitch identification skills or those who had previous musical training performed better in tests of executive functions, including working memory, cognitive inhibition, and updating tests (Hou, et al., 2014). Other studies have indicated that mental abilities such as verbal memory and spatial abilities differ between musicians and non-musicians, (Brandler & Rammsayer, 2003, Hetland, 2000). Other evidence indicates that simply listening to music can enhance verbal memory (Chin & Rickard, 2010). Rauscher and Shaw, (1997, from Zokaje), report that students who had received keyboard instruction for six months performed 34% higher on tests measuring temporal-spatial ability than did students without instruction. Hetland (2000) did a meta-analysis of 15 independent studies examining whether on-going, active music instruction enhances spatial-temporal abilities, such as spatial memory, mental rotation and spatial visualization. Her conclusion was that music instruction does improve spatial-temporal performance in preschool and elementary students, at least while the instruction was occurring. The associations between music engagement and improved performance on spatial-temporal tasks could be due to the large numbers of brain regions stimulated by learning or practicing music, including the frontal lobe of the brain where spatial temporal processing primarily resides.

There is conflicting neuropsychology and neuroimaging evidence regarding the specificity of the language and music processing centers in the brain (Patel, 2012). The relevance of domain specificity is to better understand the similarities and difference in language and music processing as manifested in brain structures. Domain specificity is indicated in neuropsychological studies of patients with brain lesions who lost musical abilities but not language abilities, or those who have language but not musical deficits. For example, one patient who had suffered a stroke showed symptoms of amusia, where he lost his prior ability to discriminate musical key (Patel, 2012). Patel (2012) cites examples when individuals with a particular kind of brain lesions exhibit “pure word deafness,” where they can no longer understand spoken words but remain sensitive to music and other sounds.

Evidence from neuroimaging studies contrasts with that of neuropsychological studies. Neuroimaging has revealed significant overlap in certain aspects of musical and linguistic processing in the brain (Patel, 2012). In one study, brain scans of normal individuals were taken while they were asked to identify out-of-chord notes in a musical sequence. Additionally, brain scans were also taken of the same individuals when they were asked to identify syntactically incorrect sentences. Identical areas of brain were activated in individuals when they identified both the music and language incongruities. Another study indicated that both music and speech selectively concentrated in distinct regions of the non-primary auditory cortex, indicating separate cortical pathways for each (Norman-Haignere, Kanwisher, & McDermott, 2015). Begley (2007) argues that brain specialization is not dictated by anatomy or genetics as much as by experience (as cited in Bennet & Bennet, 2008, p. 279). Patel (2012) proposed a model called *resource sharing* theory that could explain how mental processes such as language processing and music processing could involve separate areas of the brain, yet involve overlapping neurological resources. More details about resource sharing will be discussed in a later section dealing with transfer effects.

Music, like language, has a grammar and syntax in the form or melodic sequence and chord progressions that proceed according to specific conventions. Comprehension of each can involve both overlapping brain regions responsible for auditory and visual processing. However, as studies from neuropsychology indicated, damage to certain brain regions can affect musical abilities but not language abilities (Patel, 2012). This indicates that there are regions of the brain exclusive to music.

In a recent literature review, Moreno & Bidelman (2014) conclude that the preponderance of research evidence indicates that musical training in particular provides robust, long lasting biological changes to auditory processing regions in the brain. Similar benefits were not observed for other kinds of training, such as training in visual arts. These structural changes appeared to transfer into functional and behavioral differences that benefitted performance. For example, improvements in verbal intelligence for the music group were accompanied by changes in functional brain plasticity during an executive function task. Improvements in verbal intelligence were found in 90% of preschool children subjects after only 20 days of training in a computerized music training program (Moreno, Bialystok, Barac, Schellenberg, Cepeda, Chau, 2011). Students who received similar computerized training in visual arts did not show statistically significant changes in verbal intelligence. Such results demonstrate transfer from music to a higher-level cognitive task involving verbal skills for young children. Researchers in a recent study found that enhanced language processing abilities evident in musicians was also seen in native speakers of tonal languages, such as Cantonese and Mandarin (Bidelman, et al., 2013).

Since Rauscher et al.'s (1993) so-called Mozart effect study, researchers had cause to revisit the idea of music's effect on intelligence, IQ and other cognitive performance measures. Even though Schellenberg (2011b) concluded that the temporary improvement in certain spatial tasks as a result of listening to Mozart music was likely an epiphenomenon due to increased arousal, music clearly had cognitive effects. As will be discussed further on, researchers began to try to determine which cognitive effects were specifically affected by music as opposed to speech or other auditory inputs. They also attempted to determine which kinds of musical activities had which specific kinds of cognitive effects. Schellenberg (2004, 2006, 2008, 2011a, 2011b), in particular, examined the details of music's effects on various indicators of intelligence.

Music's Effect on IQ and other Cognitive Measures

As discussed previously, the so-called Mozart effect suggested to many researchers that perhaps there were yet-to-be discovered relationships between music cognitive performance. The reported small increase in IQ in the experimental group due to music exposure was at the crux of the Mozart Effect (Rauscher, Shaw, & Ky, 1993). Many psychological and educational studies have been done since the Mozart effect studies Rauscher, et al. (1993) suggesting that many associations exist between music and a variety of measures of cognitive performance. The nature of these associations is complex and highly influenced by confounding variables. Music may have an effect on a general measure of cognitive performance, such as intelligence, and it is the effect of music on intelligence that underlies many individual cognitive abilities. Before discussing specifics of the studies regarding music and cognitive abilities, it is important to precisely define the three most familiar constructs for general intelligence: *intelligence quotient (IQ)*, *executive function*, and *general intelligence factor* (*g*, or Spearman's *g*). These three measures of intelligence will be discussed.

The intelligence quotient (IQ) can be narrowly defined as a score indicating a person's relative performance on a problem-solving test (Hunt, 2010). Simply put, the IQ is what a person scores on an IQ test. The IQ was originally defined as the ratio of the mental age to the chronological age multiplied by 100 (Hunt, 2010). One problem with this definition is that this method of calculating IQ only works for children, because intelligence does not increase linearly past childhood. More modern measures of the IQ rely on relative scores on standardized tests such as the Stanford-Binet or Wechsler tests. It is important to keep in mind that IQ is not equivalent to *intelligence*, as intelligence is a multidimensional construct (Arffa, 2007). Definitions for intelligence vary, as will be discussed later with Gardner's and Sternberg's multiple intelligences theories, but it can defined as the set of cognitive skills that allow each individual to think, learn and solve the problems of everyday life with different degrees of agility (Ruiz, et al., 2014). Heredity plays a significant role in a person's IQ, but the amount depends on a variety of factors including the shared home environment, and SES (Nisbett et al., 2012). An IQ score is not fixed, but instead can change depending on an individual's experience and environment. Additionally, IQ can be further separated into *crystallized IQ* and *fluid IQ*, which reflect different biological and behavioral aspects of intelligence. The former refers to problem-solving abilities that rely on stored, long-term memories, and the latter refers to the solving of novel problems independent of stored knowledge of the ability to learn

(Nisbett et al., 2012). However, IQ in its totality is often the construct of interest when researchers explore the relationships between music and cognition.

Another measure of human intelligence is the *executive function*. Similar to IQ, executive function refers to a set of interdependent cognitive process used for purposeful, goal-directed behavior (Arffa, 2007). Examples of such executive cognitive processes include voluntary initiation and inhibition behavior, planning, problem solving, insight, and assessment of consequences. The executive function and IQ have some similarities as will be discussed below in terms of their relation to music, but inconsistencies have been found in studies designed to distinguish them (Arffa, 2007). Scores on IQ tests do not correlate well with scores on tests of executive function. The IQ appears to be more strongly related to achievement than executive function. More evidence of their difference is that specific kinds of brain damage may affect one but not the other. Certain types of lesions to the frontal lobes of the brain do not impair IQ but do impair the executive function (Bechara, Damasio, Damasio, & Anderson, 1994). Some argue that the executive function is not even a viable construct fully separable from IQ (Schellenberg, 2011a).

General intelligence, (*g* or *Spearman's g*) is a third measure of human intelligence, and is similar to and often confused with IQ. General intelligence, *g,* is a scientific construct that relies on the underlying correlations among scores of various tests of human cognition. It is an established empirical fact in psychology that all human cognitive abilities have a positive correlation to each other (Colom, Abad, García, & Juan-Espinosa, 2002). The intelligence quotient, IQ, is not a scientific construct, but rather a normalized score ranging from about 50 - 200 obtained by an individual based on their raw score on a norm-referenced standardized test. General intelligence, *g* is a subset of IQ. The IQ is comprised of *g,* in addition to specific cognitive skills and abilities. Like *g*, the IQ is affected by the environment and education, and there are strong genetic components to both (Schellenberg & Moreno, 2009).

Schellenberg and colleagues have done numerous studies investigating the relationships between music engagement of various sorts and various measures of cognitive functioning including: IQ, executive function, *g*, non-verbal intelligence, spatial skills, visual perception skills, social skills, emotional intelligence and academic performance (Schellenberg, 2004, 2006, 2008, 2009, 2011a, 2011b). Many correlations between various types of music background and specific cognitive abilities have been found (Chin & Rickard, 2010, Moreno & Schellenberg, 2011, Schellenberg, 2004, 2006, 2008, 2011a, 2011b, 2011c, Schellenberg & Moreno, 2012; Swaminathan, Khalil, & Schellenberg, 2017).

Table 1.

Various Music and Cognition Simple Correlations Found by Schellenberg and Others.

Type of music engagement	Nature of Correlation	Affecting	Citation
music lesson duration	positive ($p < .0001$)	IQ	(Schellenberg, 2011a)
music aptitude	positive ($p < .001$)	non-verbal intelligence	(Swaminathan, Khalil, & Schellenberg, 2017)
music lessons	positive ($ps < .01$)	spatial skills, selective attention, visual perception	(Schellenberg, 2006)
music lessons duration	none ($ps > .15$; $p > .2$)	social skills, emotional intelligence	(Schellenberg, 2004; Schellenberg & Mankarious 2012)
music lessons	none ($d = .04$)	general intelligence factor "g"	(Schellenberg & Moreno, 2009)
music lesson duration	positive ($p < .01$)	academic ability	(Schellenberg, 2006)

Duration of music lessons has a positive correlation to both IQ and school grades in a dose-response relationship, where longer durations of musical training were predictive of better intellectual functioning (Schellenberg, 2006). For one sample of children, six years of music lessons was accompanied by an IQ score increase of over 7 points, equivalent to one-half of a standard deviation (p. 458). Although positive correlations have been found between music lessons and IQ, the direction of causation is difficult to determine. Interestingly, the association between music background and IQ was bidirectional. Possessing a music background predicted IQ, and IQ predicted the likelihood of taking music lessons (Schellenberg, 2006). Musical training was associated with non-verbal intelligence even after controlling for SES (Swaminathan, et al., 2017).

In a large experimental study performed with 144 families each having a 6-year old child, experimental groups were randomly assigned to one of four groups: those receiving piano lessons, those receiving vocal lessons, those receiving drama lessons or those receiving no arts lessons (Schellenberg, 2004). After one year, all of the children in the study were given an IQ test. On average, the two music groups scored more than seven points higher than either the drama group or the no-lesson group. Later studies indicate that association between music lessons and IQ remains statistically significant even after demographic variables such as family income, parents' education levels, parents' first language, and involvement in non-musical extracurricular activities were held constant (Schellenberg, 2006, 2011a).

As mentioned previously, those who have had previous musical training performed better in IQ tests, as well as tests of executive functions, including working memory, cognitive inhibition, and updating tests (Hou, et al., 2014; Schellenberg, 2011a). Although IQ and the executive function are related, no support was found that music training was mediated by executive function (Schellenberg, 2011a). In other words, it appears that executive function does not act as a mediator between music and intelligence. The length of time a child played music was correlated with adult IQ, even after controlling for demographic factors (Schellenberg, 2006, 2011a). However, one logical conclusion that could be drawn if music engagement duration predicts IQ is that musicians should have very high IQs as a group. However, this was not the case (Schellenberg, 2011a). Cognitive advantages due to music lessons occur for those students who engage in them in addition to their regular academic studies, not in place of them.

One explanation of the relationships between music and IQ might be that high functioning and high IQ individuals, especially children, tend to engage in musical activities and also perform well on a wide variety of cognitive measures. The bulk of available literature indicates that high achieving students tend to take music lessons (Schellenberg, 2011a). In other words, higher IQ children are more likely to take music lessons, and are more likely than lower IQ children to perform better on a variety of tests of cognitive ability. Schellenberg (2011a) found that students who take music lessons tend to have higher IQs than those who have not taken lessons. He also reports that taking music lessons predicts IQ when controlling for demographic factors. A general conclusion is that associations between music training and cognitive abilities are extremely general, extending across a wide variety of tasks (Schellenberg, 2011a).

The overall conclusion is that IQ, music engagement, and performance on cognitive measures are all interrelated and can influencing the other. Researchers in this field need to be aware of these clearly confounding variables. The general nature of the associations between music and cognitive performance and academic performance found by Schellenberg and others point to a need for additional studies where confounding factors are controlled or accounted for. At this point, very few studies strictly experimental have been performed involving random assignment of participants. Therefore, the results of most studies do not allow one to make causal inferences. Additional correlational studies would contribute to the body of evidence linking music and cognitive functioning. The internal validity of such correlational design can be improved by employing statistical techniques where various confounding variables are controlled.

Theories of Multiple Intelligence

Gardner’s seminal theory of multiple intelligences rejects traditional ideas of intelligence as a singular quality of mind measurable by a singular measure, such as an IQ score (Gardner, 1983). Gardner defined intelligence as ‘the capacity to solve problems or to fashion products that are valued in one or more cultural setting’ (Gardner & Hatch, 1989). To qualify as an intelligence, a particular capacity or skill had to satisfy or possess several of the following criteria: an identifiable core set of operations, a distinctive developmental and evolutionary history and plausibility, support from experimental psychological and psychometric task, isolatable by brain damage, the existence of prodigies, savants or other exceptional individuals with said intelligence, and was susceptible to encoding in a symbol system (Gardner, 1983; Smith, 2008). Determining if someone possessed a particular intelligence was as much an artistic judgment as a scientific assessment.

Gardner (1983) claimed that “musical intelligence” is one of seven *multiple intelligences*: spatial, linguistic, logical-mathematical, bodily-kinesthetic, interpersonal, intrapersonal, and musical. Linguistic and logical-mathematical were the two intelligences that were most valued by traditional schooling. According to Hetland (2000), making music taps into at least six of those, including spatial, linguistic, logical-mathematical, body-kinesthetic, interpersonal and intrapersonal. Gardner claims that even though the seven intelligences are anatomically separated, they rarely operate independently (Brualdi, 1996; Gardner, 1983). The nature of such interactions among intelligences is not made clear, but it is unique to every person (Armstrong, 2000). It may consist of cognitive transfer or some other kind other neurological sharing or overlap of mental resources.

Musical intelligence consists of aptitudes to discriminate aspects of pitch, melody, timbre, and musical contour within musical pieces. Gardner claimed that musical intelligence meets the test of intelligence in that it consists of a set of innate skills arising from within the brain, although somewhat delocalized (Gardner, 1983). Gardner claimed that musical intelligence runs nearly parallel to linguistic intelligence (Jackson, 2010). Wan & Schlaug (2010) conclude that certain areas in the brain’s right hemisphere are dedicated to auditory processes critical to melody and pitch comprehension, increased exposure to music as is found in professional musicians induces brain plasticity and specific domain-specific structural asymmetries.

Although Gardner’s multiple intelligences theory was praised by many educators as intuitively obvious, critics of Gardner work is that his theories are not well grounded in empirical research and that to date there are not adequate tests to identify or measure the different intelligences (Smith, 2008). However, specific tests of Gardner's multiple intelligence are available and have been used, such as the Multiple Intelligences Questionnaire and Gardner's Multiple Intelligence Inventory (Ekinci, 2015; Mohn, Corrienna, & Hayani, 2015). Other critics have stated that what Gardner considers "intelligences" are really capacities that are secondary or tertiary to Spearman's *g*.

Others besides Gardner have put forward multiple intelligence theories. Sternberg (2014) states that there are many different definitions of intelligence, but at the core of any definition should be an individual's interactions with their environment. He also stated that intelligence is too complex to be characterized exclusively by psychometric measures, but rather needs to be based on multiple, converging measures. Sternberg proposed a *triarchic* definition of intelligence, where intelligence consists of three critical aspects: analytical, creative, and practical (Sternberg & Grigorenko, 2004). Sternberg's triarchic model is broader and less specific than Gardner's multiple intelligences model. Only the latter specifies a uniquely musical intelligence. The Sternberg Triarchic Abilities Tests (STAT) was designed to assess these three aspects of intelligences (Ekinci, 2014, Sternberg & Grigorenko, 2004). Sternberg claims that practical intelligence has a much larger effect on life accomplishments and success than the other two intelligences. Sternberg claims that practical intelligence, which include interpersonal and intrapersonal skills, is a better predictor of academic and occupational success than either IQ tests or cognitive measures of general intelligence, *g* (Chooi, Long, & Thompson, 2014). Evidence of the relationships between the various measures of the three types of intelligence have been obtained in one study where a group of 326 gifted US high school students were given the STAT (Sternberg & Grigorenko, 2004). A subset of the participants who scored high in analytical, practical and creative intelligence, along with some who scored high in all three, were invited to participate in a college-level psychology course taught using Sternberg's practical intelligence model. Students were randomly assigned to a psychology discussion group where one of the triarchic (analytical, creative, or practical) instruction styles was emphasized. The results of the study were that all of the triarchic intelligences were highly predictive of overall course performance. Students who happened to be placed in the discussion section that best matched their particular learning style outperformed students who were placed in a mismatched discussion section. The conclusion drawn was that students do better in school when they are taught in a similar style to the way they think (Sternberg & Grigorenko, 2004). The most effective instruction style is that which is most similar to the particular kind of intelligence in which a student already excels. Schools tend to lean heavily on analytical intelligence, hindering the more creative or practical students.

One criticism of Sternberg's triachic intelligence theory is that it lacks empirical support (Gottfredson, 2003; Sousa, 2009). Other criticisms include Sternberg's failure to significantly distinguish triarchic intelligences from Spearman's *g,* and he ignores relevant psychometric evidence (Chooi et al., 2014; Gottfredson, 2003). Sternberg disagrees with the assertions that there is little evidence for the existence of triarchic (Sternberg & Grigorenko, 2004). Evidence from the STAT as well as from classroom studies have shown that three separate intelligences are separate from more traditional psychometric measures of intelligence such as the general intelligence, *g* or IQ, and that they are highly predictive of performance in a variety of tasks. Also, Sternberg (2014) criticizes the assumption that researchers truly understand the exact nature of *g* or how general *g* is. General intelligence, *g*, is derived from factor analyses of many psychometric tests of intelligence, independent of the surface structure (cosmetic appearance) of these tests (Spearman, 2014). Although researchers may disagree on the validity or even of different kinds of intelligences, musical aptitude does appear to exist.

Transfer, a Link from Music to Academics

A fundamental assumption in both education and psychology is that learning something new makes changes in the brain (Woodworth & Thorndike, 1901). Researchers utilizing neuropsychology and neuroimaging methods have shown that education and other training makes specific anatomical and functional changes to the brain (Münte, et. al, 2002). These can often manifest as changes in behavior or performance. What is not that clear is how the learning in one field such as the arts affects the brain in ways that might affect behavior or performance in another domain such as science or mathematics.

When skills or fields of study are similar, it is reasonable to expect that learning in one should transfer over to the other. For example, when a person has learned how to play tennis, it is reasonable to assume that some of those tennis skills should transfer over to a similar game such as racquetball. The converse also seems reasonable; possessing racquetball skills should influence one's tennis skills. Learning in a particular academic field of study is also expected to affect learning in closely related fields (Woodworth & Thorndike, 1901). For example, knowledge and skills learned in a geometry class should readily transfer to a trigonometry class. However, it is not expected for skills or knowledge to affect performance in an unrelated field of study. For example, one would not expect that learning algebra would help a student improve their creative writing. It is expected that the effects would be less the more remote the fields of study are to each other. The question then becomes how proximate must different learning domains be in order for knowledge in one to make a significant difference in the other. Also, how does one define the proximity of two fields of study?

Most educators expect that students can apply what they learn in the classroom to other situations. Much evidence exists that skills are not independent, but are closely interrelated and built upon each other (Taatgen, 2013). It is difficult to characterize this interrelationship. When specific knowledge or skills in one domain transfer to or overlap with other domains, this process is called a *transfer effect*. *Transference* is an old theory, dating back to the turn of the 20th century (Woodworth & Thorndike, 1901). Thorndike (1901) believed that task transfer occurred when knowledge elements between the tasks are identical. He was able to demonstrate limited transfer in experiments involving elements of mathematical knowledge (Thorndike, 1922). It is not well understood how skills or knowledge obtained through exposure to music transfer to other academic disciplines (Hyde et. al, 2009; Jaeggi, et. al, 2014, Skoe & Kraus, 2012). Two promising theories are *far-transfer theory* and *resource sharing theory* (Hyde et al., 2009; Corrigall & Trainor, 2011; Patel, 2012).

The effectiveness of learning transfer from one domain to another depends on the similarities between and the amount of sharing of their cognitive processes (Hallum, 2010). *Near transfer*, when learning domains are closely related, is typically stronger than *far transfer*, when they are dissimilar (Hyde et al., 2009). Salomon and Perkins (1989) distinguish between *low* and *high-road* transfer. Low-road transfer is essentially automatic and spontaneous, the kind that would occur with reading music and reading language. High road transfer requires deliberate reflection and conscious processing, the kind that might occur when applying similar skills to solve very different types of problems.

Another theory is that transfer effects are possible between dissimilar domains when the tasks required of each share the same underlying cognitive elements or structure, such as inputs into working memory or simple outputs to different areas of the brain (Taatgen, 2013). These cognitive elements form the basis of transfer. This theory that describes these underlying cognitive elements is known as *resource sharing* (Patel, 2012). Learning involves combining elementary cognitive steps into larger, more general processes. According to resource sharing theory, when learning from a single domain transfers to another it is because they share various numbers of similar cognitive processes. Evidence from neuropsychology and neuroimaging studies indicates that different types of domain-specific knowledge can share underlying neural resources (Patel, 2012). Using scientific neuroimaging techniques such as event-related potential (ERP), functional magnetic resonance imaging (fMRI), and positron emission tomography (PET) researchers have detected overlapping neural networks mediating musical activities and language processing (George & Coch, 2011; Wan & Schlaug, 2010).

Moreno and Bidelman (2014) propose a multi-dimensional cognitive transfer model, where musical training and cognitive transfer are represented as quantities along two axes, and general mental processing (i.e. executive function) is a quantity along a vertical third axis. See Figure 1. below.

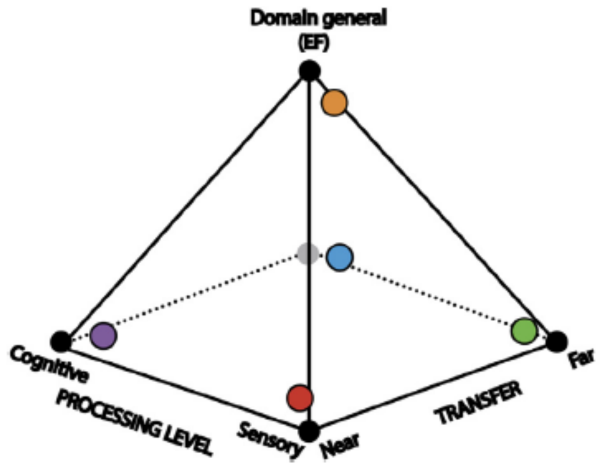

Figure 1. Multidimensional Cognitive Transfer Model (from Moreno & Bidelman, 2014)

The extent of cognitive transfer from music training to unrelated skills (e.g. academic performance tasks) is represented by the relative distances from points on the diagram (Moreno & Bidelman, 2014). The relative distances would indicate whether near or far cognitive transfer occurs. The length, type, and degree of musical training determine the extent of the cognitive processing level that is activated. Low-level musical processing would be simple auditory sensory stimulation, whereas high-level musical processing could involve mental processes such as gross and fine motor control, decoding and interpreting of music notation, improvisation, and other complex mental tasks. The specific amount of transfer from music to unrelated skills could be governed or mediated by higher-order cognitive abilities such as executive function, IQ, or working memory. These higher-order cognitive abilities are to some degree "tuned" by a person's musical training and engagement.

Learning music involves numerous cognitive processes. Music involves fundamental cognitive processes such as auditory processing, gross and fine motor control, visual processing, short, and long-term memory tasks. Additionally, playing music involves an understanding and interpretation of specific stylistic idioms. Music improvisation involves the even more complex skills of spontaneous creativity within a specific melodic and harmonic style. Listening to or engaging in music has a unique impact on perceptual and cognitive function (Schellenberg, 2003). Passive listening to music is very different from formalized music instruction. Listening to specific kinds of music such as a Mozart sonata can provide short-term performance gains on spatial-temporal tasks. However, this is attributable to changes in mood and arousal (Schellenberg, 2003).

Music and Academic Performance

Researchers have investigated the associations between music background and general academic achievement (Hodges, 2005). Most research is directed at broad measures of academic achievement rather than at specific academic disciplines (Gouzouasis et al., 2007). Nearly two decades ago, Weinberger (1998) addressed the lack of studies:

> Not enough is known about how music and arts education relate to other areas of education (e.g., reading, writing, mathematics, languages, social studies, history, science) and indeed to child development overall, and that has to be addressed in a focused, systematic, and rigorous manner: I suggest "educational trials." (pp. 10-11)

Since that time, a growing number of researchers have reported associations between music background and academic performance (Bennet & Bennet, 2008; Gibson, Folley & Park, 2009; Gouzouasis et al., 2007; Hallam, 2010; Hetland, 2000; Johnson & Memmott, 2006; Kraus & Chandrasekaran, 2010, Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Researchers have investigated the effects of a variety of types of music engagement or exposure on learning or benefits to other academic subjects. These include: listening to music, taking music lessons, completion of music courses, taking instrument or vocal lessons, performing music, or participating in specific musical training programs. Bennet, (2008) and Vanderbilt University (2008) found that students playing or practicing music achieve higher grades, higher exam scores and higher IQ scores. Standley (2008) reported that when music was paired with letter recognition, phonetic patterns, word, or sound patterns, reading instruction was greatly enhanced. Vocabulary words have even been taught to students using music. Köksal, Yağışan & Çekiç (2013) found that teaching English vocabulary to 5th graders using songs with easy rhythms and melodies led to higher scores on vocabulary retention when compared to traditional methods of vocabulary instruction. Johnson and Memmott (2006) found that students exposed to any kind of school music program regardless of its quality scored better on mathematics and English standardized tests than those with no exposure at all. This is significant because any kind of music exposure appears helps performance in certain standardized tests. Morrison (1994) conducted a study using data from a large sample of over 13,000 high school sophomores, and found that those who participated in music reported higher grades in English, math, history, and science than those who did not participate in music.

One definitive, nationwide, 10-year longitudinal study of 25,000 American secondary school students found that involvement in the arts was linked to higher academic performance, increased standardized test scores, lower drop-out rates and higher rates of community service (Catterall, 1998). The study also concluded that the benefits obtained from high arts involvement occur for most students regardless of socioeconomic status. The College Board, the organization responsible for creating the Scholastic Aptitude Test (SAT) and the Advanced Placement (AP) exams, claim that those students who spend more time studying the arts achieve higher SAT scores (College Board, 2007). A recent longitudinal study of 14,900 students indicated that high school music students were more likely to apply to and attend college than non-arts students (Elpus, 2016). The study found that art students had comparable rates of college acceptance into a variety of majors than non-arts students. Elpus (2016) concludes that taking arts and music classes in high school does not hinder and can even improve college acceptance rates.

In another study, researchers analyzed the relationships between participation and achievement in music and achievement in core academic courses for three separate groups of British Columbia (BC) high school students (Gouzouasis, et al., 2007). The researchers correlated the grades achieved in any of the BC grade 11 music courses: band, strings, choir, or music composition to standardized test scores in mathematics, English, and biology. Using simple linear regression analyses they found that music participation was consistently associated with generally higher academic achievement. The researchers also found that grade 11 music course grades were reliable predictors of grade 12 academic achievement.

The positive associations between music training and academic performance in school were found to be quite broad, as they applied to academic grades as well as a variety of standardized tests (Schellenberg, 2011a). No evidence of special links was found between music lessons and any particular school subject. The association between long-term music lessons and scholastic abilities were found even after controlling for IQ, family income and parents' education levels.

Although many studies have found associations between music and academic achievement, the exact nature of the relationships between music and academic achievement is unclear (Fitzpatrick, 2006). Most evidence of such associations comes primarily from correlational research (Elpus, 2013). Very few true experimental studies have been performed to examine the causal nature of these associations. Additionally, a large number of confounding and mediating variables makes any causal determination of specific music to academic effects extremely difficult. In fact, the association between music and academic achievement could be either direction. However, Hetland's (2010) concludes after an extensive review of the empirical evidence music's effects on a variety of cognitive and affective characteristics that although many associations are small or moderate and influenced by numerous confounders, the bulk of studies point to undeniable cognitive benefits as a result of active engagement with music, especially during childhood.

Criticism of Linking Music and Academic Achievement

In contrast to the studies showing a variety of associations between music and academics, some researchers have found weak or no correlations between music background and cognitive skills, overall academic achievement, or academic achievement in mathematics (Cox & Stephens, 2006; Elpus, 2013; & McCammon, 2008). Additionally, very few researchers have used randomized, controlled trials (Mehr, Schachner, Katz, & Spelke 2013). One randomized, longitudinal study was conducted (Costa-Giomi, 2004) over a 3-year, period investigating the effects of direct piano instruction in 4th grade students on various measures of academic achievement. In their randomized, controlled trial they found no statistically significant differences between the experimental and control groups in academic achievement for math and language as measured by standardized tests and school grades. Hedden (1982) even found a reverse correlation - namely that overall academic achievement was a strong predictor of performance in general music.

Potential symmetrical relationships between academic achievement and music suggest that common mental capabilities between academics and music may exist, and that skills are transferrable from one to the other (Gouzouasis et al., 2007). Schellenberg stated, “Indeed, the vast bulk of the available literature can be explained simply: high-functioning children are more likely than other children to take music lessons, and to perform well on virtually any test they take” (2011a, p. 285). If the relationship between music lessons and superior test performance is further substantiated, then high functioning students or students with high IQ students who engage in musical activities will also perform well on a variety of standardized tests and other cognitive measures. However, it is important to note that the association between music lessons and academic abilities remains even after controlling for IQ (Schellenberg, 2006, 2011a). Children who have had long-term engagement with music also tend to be good students, regardless of their IQ (Schellenberg, 2011a). One hypothesis is that the association between musically-trained students and high academic achievement or high test scores is that IQ influences the likelihood of taking music lessons as well as the score on standardized test or academic grades (p. 285). Affective factors may also contribute to the associations between music and academics. These can include: conscientiousness, work drive, openness, need for achievement, and other factors (Schellenberg, 2011a).

Elpus (2013) performed a large, nationwide analysis of the effects of enrollment in music courses on the college entrance Scholastic Aptitude Test (SAT), while controlling for several covariates, such as socio-economic status (SES), race/ethnicity, prior academic achievement, time use, and attitudes toward school. Using fixed-effects regression to control for the covariates, it was found that SAT results were not statistically different for the two groups. The results raise concerns over whether correlational studies finding positive associations between music and academic achievement are confounded due to inadequate controls for confounders. Although empirical, mostly correlational evidence is growing supporting modest positive associations between music participation and test scores, the degree of causality, the direction of causality, or whether the association was an epiphenomenon cannot be ascertained.

Researchers have shown that some of the pre-existing factors that influence students to enroll in music courses are themselves correlated with certain measures of academic achievement, such as scores on standardized tests (Elpus, 2013). Such factors include gender, socioeconomic status, race/ethnicity, and prior academic achievement. Studies that failed to control for these confounds have likely overestimated the degree of positive association between music background and academic achievement. Researchers have demonstrated that there are preexisting differences in the students who elect high school music courses and those who do not

(Elpus & Abril, 2011). Systemic difference such as gender, race, ethnicity, SES, prior academic achievement, and native language all play a role in the complex process of self-selection into high school music courses. Reported associations between music engagement and test scores are biased, or that degree and nature of the observed association are masked.

Cutietta (2001) argues that students who score high on the SAT or earn high grades are often the same students who study music. It takes self-discipline, concentration, and perseverance for quality performance, and high-achieving students often possess these characteristics. It may be purely coincidental that musical study and intelligence are positively correlated. Learning a musical instrument also requires delayed gratification, an aspect of self-control that has been separately linked to cognitive competence (Mischel, Shoda, & Rodriguez, 1989; Sternberg, 2003). This suggests that the mental discipline gained in learning to play a musical instrument strengthens academic performance.

The associations between music and various measures of performance and achievement are complex and difficult to untangle. Significant gaps and discrepancies in the literature are best addressed through additional research. One important area that needs further exploratory research is that of music's associations with other academic disciplines. Science seems to be an academic domain that has not been examined in relation to music. Despite the increasing numbers of studies linking music and academic performance, music programs particularly in US public schools have been reduced, eliminated, or otherwise threatened. Reducing music instruction in public schools reduces the opportunities for potential transfer effects from music to other academic disciplines such as science (Hyde et al., 2009).

Music Education Cutbacks

Numerous budget cuts have affected many school districts in the past two decades, forcing them to reduce or eliminate what they consider the non-essentials. Additionally, during the past three decades there has been a steady movement towards school accountability as measured by standardized examinations in the core academic areas (Ravitch, 2010). Cutbacks in music programs have occurred in the past two decades for several reasons: declining budgets, declining enrollment, and the reduction of non-tested curricula as a direct result of the Elementary and Secondary Education Act (ESEA), known as the "No Child Left Behind Act" (NCLB) of 2001 (Center on Education Policy, 2007; Ravitch, 2010). The educational consequences of reductions in music programs are not certain. However, critics of these policies bemoan the loss of this important elective, especially because of the growing number of studies linking music to positive educational outcomes (Center on Educational Policy, 2007; Ruppert, 2006; Sabol, 2010).

Since the 1983 release of the seminal report, *A Nation at Risk: The Imperative for Educational Reform*, school districts have pushed for increased curricular rigor and higher student test scores in the core academic areas, (National Commission on Excellence in Education, 1983). Later, the passage of the 2001 update to the Elementary and Secondary Education Act (ESEA), known as the "No Child Left Behind Act" (NCLB) of 2001, led to widespread implementation of standards-based educational reforms based on the premise that setting high standards and establishing measurable goals can improve individual outcomes in education, (USLegal, 2012). The Act requires that all states develop assessments in core academic areas. This led to an increased use of standardized testing throughout the US public school system.

Pressure to improve test scores forced school districts to divert more resources from non-tested curriculum to the core academic areas.

However, originally NCLB did not mandate assessments for all courses. Students would not be assessed in their elective courses, such as music, art, drama, or industrial, for instance. Consequently, schools throughout the US reallocated time and resources to the core academic subjects that were assessed, such as mathematics, language arts, science and social studies. As a result, it is claimed by some that elective courses and programs have been and continue to be scaled back in public schools throughout the United States, (Center on Education Policy, 2007; Gerrity, 2009; Harris Interactive, 2007). However, According to Elpus (2014), NCLB had no effect on overall music enrollment rates, but decreased the numbers of certain minority students in music courses. Perhaps school administrators, responding to new NCLB accountability measures, systematically denied access to music courses for these subgroups in favor of courses that were tested (Gerrity, 2009; Elpus, 2014).

In 2009, a federal, competitive grant program was introduced by the Obama administration called “Race to the Top” (RTTT), with the stated intent to reward and encourage states that innovate with bold education reform initiatives (Weiss, 2014). The program had several key components, one of which was the requirement that those states receiving grant funding implement teacher evaluation systems that substantially rely on measures of student achievement and growth, as measured primarily through standardized testing (Weiss, 2014). Decisions regarding teacher retention and tenure would thereby be based in part on how well a teacher’s students scored on specific tests. Race to the Top is similar to NCLB, as with both programs the emphasis is placed on quantitative measures of student and school accountability, as well as a focus on a narrow range of curriculum, especially language arts and mathematics. A fundamental difference between the programs is the whether they are primarily federal or state programs. The emphasis that with NCLB the onus was placed on the individual states to create their own curricula and measures of adequate yearly progress, whereas with RTTT the federal government spearheaded the adoption of the Common Core standards. Special grant funding priority was given to states that promised to emphasize science, mathematics, engineering, and technology (STEM) education (Weiss, 2014).

The effect that RTTT has had on music and arts education enrollment is unknown as it is still too early to see trends. (Weiss, 2014). One thing is certain – the emphasis in RTTT is on assessment of student and teacher progress in learning and teaching STEM and language arts. In order for states to qualify for the competitive RTTT grants, they had to agree to develop and implement teacher evaluation systems based on standardized measures of student achievement (Weiss, 2014). Virtually every state is delayed in its implementation of these measures, and standardized examinations designed to assess the Common Core standards have not been widely implemented (Weiss, 2014).

Budget cuts have affected many school districts in the past two decades, forcing them to reduce or eliminate what they consider the non-essentials. For example, student access to music education programs in US public schools were reduced approximately 20% in the early 2000s largely as a result of NCLB (Harris Interactive, 2007). In California, reductions in student spending of over 15% occurred in the four years from 2006 to 2010 (Shambaugh, Kitmitto, Parrish, Arellanes, & Nakashima, 2011). One survey of student participation in music education programs declined in California public schools by nearly 50% in the three years immediately following the passage of NCLB in 2001, the largest of academic subject area (Music for All Foundation, 2004). This drop in student participation in music occurred at a time when the total student population in California public schools increased 5.8 %.

In addition to reducing the number of elective courses available in high schools, cutbacks to music programs may have other unintended consequences. As described above, there is ample evidence linking music and academic achievement. Cutting music programs reduces the number of students that would be exposed to activities that could improve cognitive and academic performance. Perhaps eliminating or reducing elective courses in an attempt to raise achievement in the core academic subjects is not a wise educational choice.

Although cutbacks in music programs were severe in many parts of California, some districts fared better than others did. School boards and administrators within individual school districts have a great deal of discretion in how to support their music programs (Major, 2013). Student, teacher, and community pressure can affect the local budgetary decisions that are made at any given district. Elpus (2014) points out that most reports in the literature regarding the effects of NCLB on music education were mostly surveys of principals and music teachers about what they believed were the effects. However, when large, nationally representative high school datasets of music enrollment were analyzed, it was found that music enrollment, as defined by a student enrolling in at least one music course during high school, have remained relatively stable for nearly 30 years (Elpus, 2014).

Others contend that advocating music education as a means to bolster student performance in other academic subjects sends the wrong message (Cutietta, 2001; Vitale, 2011). Their argument is that the pleasure and joy gained through engagement with music should be an end in itself, and that the argument that school music programs should be retained as a means to other academic ends loses sight of learning and playing music for its own intrinsic value (Vitale, 2011). When music programs are threatened with reduction or elimination for the reasons discussed earlier, it has become increasingly necessary to argue for retaining school music programs based on the potential benefits that music provides to other academic subjects. This is becoming more common as additional evidence of the positive associations between music and other academic subjects emerges, primarily from correlational studies (Vitale, 2011).

Music cutbacks at the Northern Humboldt Union High School District. In the particular case of the Northern Humboldt School Union High School District (District), the public school district where this particular study occurred, cutbacks in music programs were not severe. Conversations with the District's sole music teacher, the current superintendent, and the former superintendent informed the researcher on the recent history of the District's music programs. Although some reductions in the District music program had occurred, most of these had to do with teacher retirements and declining enrollment (Hartley, 2017). The District's former superintendent stated that the number of District music teachers was reduced from two to one in the past decade, this was due in part to declining district-wide enrollment. The District's current superintendent stated that despite a 20% decline in enrollment District-wide in the past 15 years, down from approximately 1900 students to 1600, the District funding for music stayed relatively flat since 2008 (Macdonald, 2017). He also stated that NCLB played little or no role in District music funding decisions. The District's current and sole music teacher stated that despite the complete loss of the band program and African drumming class after two music teachers left the District, the orchestra and jazz band programs had expanded and continue to grow. The music teacher reports that approximately 100 students are scheduled for enrollment in those two programs for the 2017-18 school year (Moulton, 2017).

Factors Affecting Academic Science Performance

Scientific thinking is a general term that refers to the set skills and cognitive processes that allow individuals or groups to analyze and solve problems of a scientific nature or perform scientific activities (Ruiz, et al., 2014). Scientific activities include creative design of scientific experiments, synthesizing and analyzing data, using inductive or deductive reasoning to come to causal conclusions (p. 287). Additionally, doing science in an academic setting requires that the student be able to read non-fiction text, interpret numerical data or graphs, understand and solve mathematical problems, and communicate findings both verbally and in written form.

Doing science involves a broad and diverse set of tasks. Therefore, high performance in academic science would require the student to marshal and coordinate a variety of cognitive skills. Learning science uses many of the same cognitive and academic skills as does language and mathematics, such as spatial-temporal reasoning, symbolic decoding and interpretation, problem-solving and creative thinking (Hallum, 2010; Hetland, 2000). Certain skills or abilities obtained through playing or listening to music are similar to those needed when doing or learning science.

Socioeconomic status (SES), IQ, culture, gender, student and parental attitudes towards science, and school size all affect academic science achievement (Sun & Bradley, 2012). The correlation between IQ and educational achievement in science and mathematics is so strong that appear to be measures of the same construct (Lynn, Meisenberg, Mikk, & Williams, 2007). Additionally, associations between SES and general academic achievement are well established (Tucker-Drob, 2013). Researchers in Spain studying of the effect of spatial and verbal reasoning as well as scientific-creative thinking on academic performance in high school students reported that spatial reasoning test scores are highly correlated to academic performance in mathematics and science domains (Ruiz, et al., 2014). Verbal reasoning was moderately correlated and scientific-creative thinking had a small correlation to academic performance in science and math. Interestingly, scores on the scientific-creative thinking assessments had much higher correlations to academic performance in arts classes than to science classes, more so than even IQ scores.

Although SES is a strong predictor of academic achievement, motivational factors are strong mediators of the SES effects on academic science achievement (Steinmayr, Dinger, & Spinath, 2012). Motivational factors such as self-efficacy, self-concept, motivation, and the enjoyment of science all have significant predictive effects on achievement (Areepattamannil, Freeman, & Klinger, 2011). A student's attitude towards science achievement was the most important predictive factor for student achievement outcomes (Sun & Bradley, 2012). However, simply having a general interest in science is not predictive of science achievement. Students taking classes where science was taught using hands-on, manipulative activities showed greater science achievement than those students taking courses consisting primarily of student-led investigations (Areepattamannil, et al., 2011).

One study found no significant relationship between time spent on homework and grades achieved in science or math courses (Maltese, Tai, & Fan, 2012). However, a positive relationship was found in that same study between homework and performance on science and math standardized examinations. Family influences can affect academic achievement. In a study of talented science and mathematics students in Korea, it was found that family processes play a significant role in fostering achievement in those fields (Cho & Campbell, 2011). The influence of the father in the family was the most significant predictor of science and mathematics achievement from elementary through high school. Any study performed by researchers examining factors affecting science achievement ought to attempt to control for SES and IQ. However, such data may not always be available for certain students or schools.

As discussed, performance in academic science courses is affected by a large number of factors, all of which could be examined separately. However, to do so requires methods and statistical tests that either control for those factors or takes them into account. To study the effect of prior music engagement on science achievement, the effects of confounding factors can be analyzed using quantitative methods employing the multiple correlation statistical tests. These tests are ideally suited to determining the effects of various predictive factors on a single outcome variable such as academic science achievement. The details of the specific multiple correlation test to be used in this study will be discussed in Chapter 3.

Music and Academic Science Performance

There are many factors that could affect a student's performance in academic science. Science education occurs primarily in the school setting, and dedicated science classrooms are typically available in the middle school or high school setting. Limitations of existing studies include their limited focus on elementary or middle school students. Only a few studies have analyzed the relationship between musical background on high school science academic achievement (Fitzpatrick, 2006; Gouzouasis et al., 2007). Music participation was positively correlated with higher academic achievement in biology, mathematics and English for a large sample of high school seniors from British Columbia (Gouzouasis et al., 2007). Additionally, the seniors' grade 11 music course grades were reliable predictors of grade 12 academic achievement. It was found in one study that high school International Baccalaureate students specifically selecting music courses had higher academic grades in all of their classes than those who selected other fine arts courses (Cabanac, et. al, 2013). The IB student subjects were selected because of their relative homogeneity as a group in having equally high initial academic achievements prior to the study. The authors hypothesized that music helps overcome stress due to cognitive dissonance, and also helps in the process of accumulating knowledge.

Mohd, Noor, Corrienna, and Hayani (2015) found that students' preferred science teaching methods and science process skills were associated with kinesthetic and visual-spatial intelligence. However, no relationship existed between musical intelligence and academic science achievement. Participants in their survey-based study were 300 primary school students from five Malaysian primary schools. The students completed separate questionnaires related to science process skills, preferred method of science learning, and multiple intelligences. The results of the preferred science teaching and science process skills questionnaires were analyzed using inferential analysis. The authors concluded that their findings implied that multiple intelligences are related to science learning.

Practicing or learning science requires many of the same cognitive and academic skills as does language and mathematics, such as spatial-temporal reasoning, symbolic decoding and interpretation, problem-solving and creative thinking. Perhaps certain skills or abilities obtained through playing or listening to music are similar to those needed when doing or learning science.

There is a gap in research regarding the relationship between prior music background and academic science achievement (Cabanac, et. al, 2013). This study contributed towards filling that research gap. Although the literature is scant regarding the effects of music on academic science performance, some factors that affect it are known. Although correlational studies are limited in their ability to assess causation, they do provide insight into relationships among variables. Correlational studies are useful when researchers first begin to investigate relationships between specific variables. As so few studies have been done examining the effects of music on science achievement, a correlational study seems to be a reasonable type of investigation.

Summary

The numerous examples in of researchers reporting of positive associations between music and academic achievement appear to indicate that school music programs do not hinder, but likely enhance academic achievement. Although most reported effect sizes are small or moderate, it would seem that there could unwise to reduce music programs in schools in favor of increased time in other academic subjects. However, as discussed, national educational initiatives such as NCLB and RTTT prioritize achievement in a narrow range of core academic subjects. As more evidence emerges suggesting that cognitive transfer and resource sharing occurs between music and other academic subjects and skills, more reasons for keeping or expanding music programs and n the curricula in school. At one extreme, the argument could be made that music and art courses ought to be mandatory for all students, if for no other reason than to help improve standardized test scores in other academic areas. High schools attempting to increase test scores could consider adding music to their graduation requirements. Music courses could be made co-requisites for other academic courses. Others argue that music itself should be the focus of music education, and music should be studied for its own sake, and for enjoyment and fulfillment rather than as a means to an end. (Vitale, 2011).

Despite the lack of rigorous, causal experimental data, the belief that studying music “makes you smarter” has gained popularity. This might be an argument as to why educators ought to rethink elimination of music programs. With the increased emphasis on standardized testing and other threats to public school music programs, advocates have turned to arguments based on positive correlations between music participation and academic achievement to preserve school music and arts programs (Miksza, 2007). Participating in music provides its own intrinsic enjoyment and fulfillment. It is also up for debate whether scores on standardized achievement tests are valid or adequate measures of educational progress. Regardless, the routine practice of cutting music programs in order to devote more resources to assessed curricula may be in vain, especially if the preponderance of evidence links music education and improved academic achievement in a variety of disciplines.

Chapter 3: Research Method

Researchers have found that possessing a music background is linked to student academic achievement, especially with music, language arts and mathematics (Bennet & Bennet, 2008; Gouzouasis et al., 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). Cognitive transfer or resource sharing theories may explain how skills learned in one domain, such as music, could carry over to other domains such as mathematics, language arts or science because these domains share neural pathways in the brain (Hyde et al., 2009; Patel, 2012; Weinberger 1999). However, few studies have been done examining the effects of music background on specific academic subjects, such as science, social studies, visual arts, foreign language, industrial arts, or physical education (Gouzouasis et al., 2007). As associations between music and cognitive abilities appear to be quite general and reach across a wide variety of disciplines, then similar associations are expected for other academic disciplines (Schellenberg, 2011a).

The purpose of this quantitative correlational study was to analyze the relationship between music background and academic science performance in high school students to preliminarily explore if cognitive transfer or resource sharing theories may be applicable from music to science. The problem addressed was the potential loss of transferable cognitive effects that may prove to be beneficial to academic science performance due to reductions in instructional time and access to music and arts educational programs at U.S. public schools. These reductions occurred primarily as a result of NCLB (Center on Education Policy, 2007; Gerrity, 2009; Hyde et al., 2009; McMurrer, 2008; Ravitch, 2010). Additional research is needed to further explore relationships between indicators of music background and academic science achievement (Fitzpatrick, 2006).

This study addressed the following research question and hypothesis:

Q1. What combination of music background indicators, an academic indicator, and SES best predicts academic science achievement?

Hypotheses

$H1_0$. There is no statistically significant relationship between music background indicators, an academic indicator, and SES, and academic science achievement.

H1a. There is a statistically significant relationship between at least one of the music background indicators, an academic indicator, and SES, and academic science achievement.

This chapter describes the research method and design used to address the research question. Next, a discussion of the population, the participants and how they were recruited will be presented, along with the instruments and resources used to conduct the study. Next, the data collection, processing and analysis procedures used are discussed. Finally, the assumptions, limitations, delimitations, and ethical considerations are discussed.

Research Methodology and Design

The study applied the multiple correlational research design method. This method was used in order to address the relationships between various indicators of musical background, SES, overall high school grade point average (GPA) and academic science achievement. The specific correlational statistical test applied in this study was multiple linear regression. Quantitative research was selected for this study because both the predictor and outcome variables were measured numerically. A qualitative approach would not have accomplished this. The predictor variable, music background, consisted of two separate constructs: *music intensity* - defined as the total number of hours per week the student is currently actively engaged with instrumental and vocal music, and *music duration* - defined as the number of years actively engaged with instrumental and vocal music. The outcome variable was *academic science performance* - defined as the numerical raw scores obtained by students on the California Standards Test (CST) in science.

A correlational study was appropriate for this study because it was intended as a preliminary exploration of the relationships among variables, and an experimental approach was not possible or practical (Lammers & Badia, 2005). Additionally, an experimental method was not appropriate in this case as this study was meant to explore relationships between a student's cumulative uncontrolled previous musical background and subsequent academic science achievement that occurred prior to the onset of this study. Multiple linear regression is the most appropriate statistical test to explore the relationships and interrelationships between multiple predictor variables and a single, quantitative, outcome variable (Cohen et al., 2013). Analysis of variance (ANOVA), a related statistical technique to multiple linear regression, was not appropriate for this study, as it is best suited to experimental studies with separate treatment groups. Multiple linear regression analysis was uniquely suited to represent the various types and complexities that characterize the behavioral sciences (Cohen et al., 2013).

Measures of a student's music background were obtained through an online survey. Music background variables were either continuous or scaled numerical values. Descriptive analysis of the of music background indicators included histograms, means, medians, and standard deviations, skew, standard error of skew, kurtosis, and standard error of kurtosis. The outcome variable, academic science achievement, was defined as the raw score obtained by a student in one of the California Standards Test (CST) in science. California state law mandated in 2006 that the California Standards Tests (CSTs) be used in all California public schools as a measure of academic achievement (California Department of Education, 2014a). Therefore, it seems appropriate that a science CST serve as the quantitative instrument for measuring student science achievement at California public high schools. the CST science test taken by the participants was primarily a life science exam, containing 60 exclusively multiple-choice questions. Each student had already taken the CST before answering the survey. This measure of academic science achievement is to be correlated with each predictor variable in a multiple linear correlation. The California Department of Education converts the CST raw scores into scaled scores for each student using a mathematical algorithm. The scaled scores range from 150 – 600, with higher scores indicating greater academic science achievement. There are five achievement classifications for the CSTs: far below basic, below basic, basic, proficient, and advanced. For all science CSTs, a student must earn a minimum score of 300 to achieve basic classification. A student must achieve a minimum score of 350 to achieve proficient classification (California Department of Education Assessment Development and Administration Division, 2017). However, for purposes of this study, only the raw scores were analyzed, as these values were ratio variables, simpler, and free from the relatively complex mathematical algorithm used for creating the scaled scores.

The descriptive statistics were performed on the student scores from the science CST were: histogram, mean, median, standard deviation, skew, standard error of skew, kurtosis, and standard error of kurtosis. The multiple linear regression was performed using questionnaire data and data obtained from student records. The equation generated by the multiple linear regression provided several numerical coefficients, which indicate the strength the relationship of each predictor variable to the outcome variable in the multiple linear regression. The coefficients provided insight into the effects of each indicator of the predictor variable on the outcome variable. The intercept, also referred in equation to as $\beta_{0,}$ is the score of CST in science when all the predictor variables are equal to zero.

Population

The intended study population is U.S. public high school students. This population was selected because they were nearly completed with compulsory education, and thus had received most of their music and science education offered by the public school system. Additionally, this population had been impacted throughout their public school careers by the cuts in music education that have occurred largely due to the No Child Left Behind (NCLB) Act of 2001 and statewide budget cuts (Center on Education Policy, 2007; Music for All Foundation, 2004; Ravitch, 2010). This directly addresses the problem of a potential loss of transferable cognitive effects that may prove to be beneficial to academic science performance due to reductions in instructional time and access to music and arts educational programs at U.S. public schools. The estimated population size is 884,000 (California Department of

Education Assessment Development and Administration Division, 2015, 2016). This population consists of all the students statewide who completed a CST test in science during the 2015 - 2016 school years, the same examinations taken by the sample group.

Sample

The sample group was the high school students at Northern Humboldt Union High School District (District). Although this is a convenience sample, District high school students were selected for three reasons: completion of a uniform, standardized science assessment; familiarity of the school district to the researcher; students have nearly completed their compulsory education, and thus have received most of their music and science education offered by the public school system; and students were currently educated in a public California school where cutbacks in music programs after the passage of the No Child Left Behind Act of 2001 have occurred (Music for All Foundation, 2004).

This sample is appropriate to the study problem because although not severe, the District did experience a reduction in the number of music teachers and the variety of music course offerings. Certain student demographics, such as racial mix, first language, and cultural background were relatively homogeneous in the District, which served to minimize confounding and mediating variables. These included GPA, family income, student age, native language, country of birth, family prioritization of music education, and individual motivation. Data about these confounding variables were obtained with consent from the student survey and from school records.

Materials/Instruments

A field test of a preliminary questionnaire survey was conducted using two experts in field of music education, as well as an expert experienced in survey construction. The high school music education experts were knowledgeable in both instrumental and vocal music education. They reviewed the preliminary survey to ensure that the survey questions were clear, understandable, readable, properly sequenced, and free from grammar, syntax or other typographical errors. A summary of their findings is given in Appendix B. The subject matter expert reviewed the questions to clarify wording and determine if the questions were valid measures of a student's musical background. With the input of the music expert field testers and the subject matter expert the final survey was constructed. A web-based survey was constructed in order to measure the various indicators of the music background construct. The final survey was distributed using SurveyMonkey® due to security, and relative ease of distribution, collection, tabulation and exporting of questionnaire questions and results. The survey consisted mostly of short answer or closed-ended Likert-style questions. Only 11 % of the total number of recruited students (440) took the online survey. The actual questions used in the study survey are attached as Appendix A.

Operational Definition of Variables

Music Background

The predictor variable, *music background* is a construct consisting of two separate component constructs, *music intensity,* and *music duration*. Music intensity was defined as the total number of hours per week the student is currently actively engaged with instrumental and vocal music. Therefore, music intensity is a composite construct calculated by summing the values for all questions querying the number of hours spent per week by the student actively playing an instrument and singing. The music intensity construct did not include any questions querying the time spent by the student on passive music listening. The second component construct, *music duration*, was defined the number of years actively engaged with instrumental and vocal music. Therefore, music duration is also a composite construct, calculated by summing the values for all questions querying the number of years the student actively playing and instrument, singing, and taking music lessons. Descriptive analysis of these constructs variable included histograms, means, medians, standard deviations, skew, standard error of skew, kurtosis, and standard error of kurtosis.

Academic Science Achievement

The outcome variable, *academic science achievement*, is comprised of numerical, integer raw scores obtained by grade 10 students in the California Standards Tests (CST) in science. These examinations are standardized assessments designed to assess the California's science content standards, which describe what students should know and be able to do at each grade level (California Department of Education Assessment Development and Administration Division, 2014a). The students took the particular CST science examination analyzed in this study in the spring of their 10th grade year. The examination was a 60-question paper and pencil test, comprised entirely of multiple-choice questions. The number of items correctly answered by a student generates a raw score (i.e. the number of correctly answered questions out of 60). The California Department of Education converts these raw scores into scaled scores using a complex mathematical formula for purposes of assessing the student's mastery of the California science content standards appropriate for their grade level (California Department of Education Assessment Development and Administration Division, 2014a).

Table 2.

Approximate Score Ranges for each CST Classification, 2016

CST	Far Below Basic	Below Basic	Basic	Proficient	Advanced
Sciences	150 - 268	269 - 299	300 - 349	350 - 398	399 - 600

The California Standards Tests are analyzed yearly for validity and reliability (California Department of Education Assessment Development and Administration Division, 2017). The researcher obtained the CST raw scores for each participating student through examination of school records using the district's Multiple Measures database system.

Overall High School Grade Point Average (GPA)

This predictor variable is the average of all grade points received in high school level courses based on either a 4.0-point or 5.0-point scale. Therefore, the GPA data for each participating student will yield a continuous, ratio variable type. Grade points earned for each course is calculated by multiplying the number of credits the course is worth by grade points earned in that course. The grade point values at the Northern Humboldt Union High School District for all subjects, with the exception of Advanced Placement (AP) and International Baccalaureate (IB) courses are awarded as follows:

Table 3.

Grades and Grade Points for the Northern Humboldt Union High School District

Grade	Grade points for non-AP or non-IB courses	Grade points for AP or IB courses
A	4.0	5.0
A-	3.7	4.7
B+	3.3	4.3
B	3.0	4.0
B-	2.7	3.7
C+	2.3	3.3
C	2.0	3.0
C-	1.7	2.7
D+	1.3	1.3
D	1.0	1.0
D-	1.0	1.0
F	0	0

(NHUHSD Policies, Regulations, & Bylaws, n.d.)

Northern Humboldt Union High School District calculates each student's cumulative GPA and that information is stored as part of the official school records. One reason for statistically controlling for GPA in this study is that evidence exists that academic science achievement is influenced by general academic achievement as indicated by academic grades (Tucker-Drob, 2013). Additionally, obtaining student GPA information is important because Northern Humboldt Union High School District does not keep nor collect IQ data for each student, a known correlate with general academic achievement. The researcher obtained this information for each participating student from the District's Multiple Measures database system.

Free and Reduced Price Meal Eligibility –proxy for SES

The only socioeconomic (SES) data collected at the Northern Humboldt Union High School District is the eligibility for free and reduced price meals, a program of the California Department of Education (California Department of Education, 2014b). Eligibility for this program is based on income and family size, and has been used as a measure of SES in similar studies (Fitzpatrick, 2006). There are three levels of eligibility for this program: not eligible, eligible for reduced price meals, or eligible for free meals. Any participant who is eligible for either free or reduced lunch was counted as eligible. Therefore, SES data was categorical. The researcher obtained this information through examination of school records using the district's Multiple Measures database system.

Data Collection, Processing and Analysis

Survey data was collected from consenting Northern Humboldt Union High School students through the online SurveyMonkey® tool. Data was checked for completeness by tallying the numbers of unanswered questions in each survey. Data cleaning of the respondents' occurred so that SPSS was able to import the numerical data properly. Unanswered questions were treated in SPSS as a zero value in the data set. All quantitative measures of musical background were either ordinal, continuous, or ratio data types. The precision level was kept to the integer quantity value. For example, the total number of hours per week spent practicing an instrument was recorded to the nearest integer value in hours per week. Unique respondent identity codes were recorded in order to correlate responses with individual CST science data obtained from student records. The music background survey was first administered at McKinleyville High school on February 2, 2017. The second time it was administered was at Arcata High school on February 16, 2017. The survey was also administered a third and final time at Arcata High School on February 17, 2017 to one student who was absent the previous day.

The researcher met with the District data system coordinator on February 27, 2017 to download CST scores, SES eligibility, and GPA data. The District securely transferred the data Multiple Measures database in XLS data format to the researcher's password-protected and encrypted flash drive. A variety of statistical test were performed on the data. These results tests will be discussed in detail in Chapter 4.

Assumptions

The researcher assumed that the foundation of this study was sound, and that the assumed theoretical framework was an accurate reflection of the phenomena being studied. It is assumed that the effects of student music background on academic science achievement could be quantitatively measured, and that the survey determined intensity and duration of a student's music background. The researcher methodically and ethically performed the research, collected, and interpreted the data without bias. It was assumed in this study that all study participants read and understood written English. This was a reasonable assumption as the primary language of vast majority of students in the District is English (NHUHSD School Profiles, n.d.). It is assumed that students answered the questions in the survey honestly. This cannot be assured, but is a reasonable assumption as participation in the study was voluntary, and the online survey was short, non-coercive, and private. Participants were informed in advance that all data collected and stored in the study would be done in such a manner that it could not be associated with any particular individual. It is also assumed that the sample group reflects the population of U.S. public school students.

Limitations

The specific group of students who agreed to participate in this study was unknown, and depended on whose parents agreed to allow the researcher access to their child's student records. This was a factor not entirely under the control of the researcher. However, verbal and email agreements were made with Northern Humboldt Union High School District superintendent as well as the District data system coordinator that student data could be accessed with student and parent consent. The specific nature and rigor of each student's particular prior musical background experienced was not controlled. Additionally, the number, sequence, and quality of each student's prior science background was not controlled. Also, each student had to have taken a California Science Test (CST) in science. The CST was a validated, standardized examination given to all high school science students enrolled in California public high school districts up until 2016.

Delimitations

A delimitation of this study was the collection of data from a single California public school district (Northern Humboldt Union High School District). This was done to eliminate confounds that might result from large numbers of students taking music or science courses in different states, countries or at different school districts. Results might differ if data from another district or multiple districts were to be used. The researcher decided to limit the measure of academic science achievement to only the California Science Test of science. Although other standardized tests of science achievement are given at the district, such as Advanced Placement and the International Baccalaureate science examinations, the numbers of students taking these tests are quite small. The findings from this study may only be generalizable to US public high school students, as this population is from which the sample group was taken.

Ethical Assurances

Care was taken to assure that all ethical concerns were addressed in this study. Northcentral University IRB approval was secured, as well as written approval of the District approval, and the individual site principal. This educational study posed minimal risk to the subjects as it poses risks not greater than those ordinarily encountered in daily life (Hicks, 2008). The key ethical concerns in the study were privacy and confidentiality of school records accessed by the researcher. Parental consent and student assent was required by The Family Educational Rights and Privacy Act (FERPA) and the Protection of Pupil Rights Amendment (PPRA) in order to access student records kept in the District's multiple measures database (Hicks, 2008b). These records were necessary for cross-referencing questionnaire responses with science achievement test scores and GPA data.

Reasonable steps were taken to ensure protection of the students' privacy. Students interested in participating in the study were instructed to return their signed parent permission forms and student asset forms to a secure location at the school office, away from the classroom where they were recruited. In that way, no other students or teachers from the recruited classes were aware of which students planned to participate. The survey was administered in a secure computer lab at each high school away from all non-participating students. Student identifiers were collected as a component of the survey in order to locate the student's records. The researcher removed identifiers such as names and student identification (ID) numbers, from school records prior to data analysis, and substituted randomly-generated numbers for each student. Any cross-referencing information linking student questionnaire identifiers to student record codes were stored in a separate, secure location away from any coded data. All survey responses and electronic student records made available to the researcher were ultimately encrypted and stored on a password-protected and encrypted flash drive locked in secure location. All federal and California state rules governing access to school records were followed.

Summary

The problem addressed in this study was the potential loss of transferable cognitive effects that may prove to be beneficial to academic science performance due to reductions in instructional time and access to music and arts educational programs at U.S. public schools (Center on Education Policy, 2007; Gerrity, 2009; Hyde et al., 2009; McMurrer, 2008; Ravitch, 2010). The purpose of this study was to analyze the relationship between music background and academic science performance in high school students. A multiple linear regression study design chosen as the best method to investigate relationships among several quantitative indicators of musical background, SES, GPA, and a single standardized measure of academic science achievement.

High school students from the Northern Humboldt Union High School District were recruited in class for participation in the study. The study was conducted in a manner approved by the Northcentral University IRB. Issues of privacy and confidentiality were of utmost importance to the researcher. All obtained responses, test scores or other information were stored in a secure manner so that no identifiable student data are revealed. The results of the study will hopefully help inform board members and administrators involved in planning and implementing budgetary and curricular decisions at each school site.

Chapter 4: Findings

The purpose of this quantitative correlational study was to analyze which combinations of academic, socio-economic status (SES), and music background indicators best predicts academic science performance in high school students, and to preliminarily explore if cognitive transfer or resource sharing theories may be applicable from music to science. The data collection portion of the study consisted of administering a web-based questionnaire to 45 participants about their musical background, followed by matching of their questionnaire results to their student records to obtain their cumulative grade point average, SES, and their California Standards Test (CST) in science results. After exploratory principal components analysis and tests for normality of data were conducted, a multiple linear regression analysis was conducted in an attempt to answer the research question.

Recruitment and Description of the Sample. Permission to conduct the study was obtained both from the Northern Humboldt Union High School District and from the Northcentral University Institutional Review Board (IRB). Eleventh and twelfth grade students were recruited for the study at two high school campuses, McKinleyville High School and Arcata High School, both in the Northern Humboldt Union High School District. Recruitment occurred in music, social science, and English classrooms at both campuses. Recruitment consisted of a short oral presentation given by the researcher explaining the goals of the study and the research question being addressed. The presentation was made to approximately 440 students between the two campuses. This number is an estimate based on the sum total enrollment numbers for all the classes where the presentation was made. The exact number was not known, as attendance data was not provided to the researcher. Additionally, some of the students may have heard the presentation more than once, because they may have been enrolled in more than one recruited class. Such students were not identified, and would lower the actual number of students who heard the recruitment presentation might be lower than estimated.

Forty-eight parent consent/student assent forms were returned. The music background survey was administered using SurveyMonkey to a total of 45 students: 25 from McKinleyville High School (55.6%), and 20 from Arcata High School (44.4%). Twenty-six females (57.8%), and 19 males (42.2%), took the survey. Three of the students who returned consent/student assent forms were absent on the day the survey was administered. The percentage of completed surveys compared to the estimated number of recruited students was approximately 11%.

Trustworthiness of Data. Trustworthiness of the quantitative data was ensured by several means. A field test of a preliminary questionnaire survey was conducted using two experts in field of music education, as well as an expert experienced in survey construction prior to completing the final survey in order to ensure face validity. The researcher checked all completed SurveyMonkey surveys with each student to ensure it was their unique data. With the help of the District's data system's coordinator (DSC), the researcher matched each student who completed a survey to their records contained within the Northern Humboldt Union High School District's (the "District") Multiple Measures database to obtain their GPA, free and reduced lunch status (proxy for SES), and their CST score data. Data was transferred to the researcher using an encrypted and password-protected flash drive. Student identities were de-identified by substituting a randomly-generated number for each student. Identified data was stored on an encrypted and password-protected flash drive, and locked in a secure location. De-identified data was merged for each student onto Excel and SPSS for further analysis. Data was cleaned to remove extraneous or incoherent characters, ambiguities, and non-sense answers.

Results

Presented below are descriptions of the primary component analysis, descriptive statistics, multiple linear regression assumptions tested, and the results of the multiple linear regression analysis in an attempt to answer the research question.

Research Question and Hypotheses

What combination of music background indicators, academic indicators, and SES best predicts academic science achievement?

H1$_0$. There is no statistically significant relationship between music background indicators, an academic indicator, and SES, and academic science achievement.

H1a. There is a statistically significant relationship between at least one of the music background indicators, an academic indicator, and SES, and academic science achievement.

Cronbach's alpha, a statistical measure of reliability and internal consistency of the quantitative questionnaire items, was initially performed for 12 quantitative questionnaire items pertaining to musical background. The complete questionnaire is provided in Appendix A. The unstandardized Cronbach alpha value was .649.

Ideally, Cronbach's alpha values should be greater than .70 for sampling adequacy in the social sciences, (Agneslystats, 2012). This low Cronbach's alpha value indicated that it was probable that the 12 questionnaire items were measuring different components of the musical background construct.

As a result, it was decided by the researcher to conduct an exploratory principal component analysis (PCA) of the 12 quantitative ratio variable items in the student questionnaire. This was performed in order to ascertain construct validity and to reduce the number of variables, yet retaining as much of the original measurements' variance as possible (Conway & Huffcutt, 2003). After exploratory principal components, four components were extracted with eigenvalues exceeding 1.0. It was hypothesized by the researcher at the time that these components represented the following constructs: (a) time spent singing in school-based or private groups; (b) time spent on instrumental music; (c) time spent singing alone; and (d) multi-instrumentality. The Kaiser-Meyer-Olkin (KMO) test for sampling adequacy value was performed on the four components. The KMO result was .379, well below the level of acceptability of 0.500 (Beavers et al., 2013). The Bartlett's test of sphericity, χ^2 , was also performed, returning a value of 275.08, exceeding the χ^2 two-tailed test value of 90.349 for $p < 0.5$. Therefore, the null hypothesis of equal variances among the test items was rejected. Additionally, Cronbach's alpha tests were performed on the questions comprising four constructs, and it was determined that minimum requirements for sampling adequacy were not met for all four constructs. As a result, the researcher concluded that the primary component analysis with 4 four components extracted was not suitable to the purpose of the study.

Constructs used in the analysis. As stated in Chapter 1, *music background* is a construct consisting of separate measures of a student's prior music experiences, including the amount of time spent playing or singing and the number of musical instruments played. Two new constructs were created in order to assess musical background and to better align with the research question: "What combination of music background indicators, academic indicators, and SES best predicts academic science achievement?", as well as align with much of the literature discussed in Chapter 2.

The first construct, *music intensity*, was defined as the total number of hours per week the student is currently actively engaged with instrumental and vocal music. Therefore, music intensity is a composite construct calculated by summing the values for all questions querying the number of hours spent per week by the student actively playing an instrument and singing. The music intensity construct did not include any questions querying the time spent by the student on passive music listening. The second construct, *music duration*, was defined the number of years actively engaged with instrumental and vocal music. Therefore, music duration is also a composite construct, calculated by summing the values for all questions querying the number of years the student actively playing and instrument, singing, and taking music lessons. Four predictor variables: music intensity, music duration, cumulative grade point average (GPA), and free and reduced (FR) lunch status (a proxy for SES); and one outcome variable, CST # correct (the measure of academic science achievement), were used in the multiple linear regression analysis.

Assumptions tested for multiple linear regression. Certain assumptions are made when performing multiple linear regression, and these were checked prior to performing the analysis or interpreting the results:

- Sample size needs to be large enough to ensure adequate power and greater likelihood of normally distributed data.
- Outliers in the data are identified and removed.
- Linear relationships exist between predictors and outcome variables.
- Data is normally distributed.
- Multicollinearity between the predictor(s) and the outcome variable is absent.
- Autocorrelation in the data should be low.
- Data is homoscedastic (i.e. has normally distributed residuals)

Descriptive analysis, including measures of central tendency, along with tests for reliability and normality were performed. Descriptive statistics are presented in Table 4 for the continuous predictor variables: music intensity, music duration, GPA; and the responding variable, CST # correct. The dichotomous variable, FR lunch status, used as a proxy for SES, was coded as 1 = eligible, 0 = not eligible. Twelve of 45 participants (27%) were eligible for free or reduced lunch.

Table 4.

Descriptive Statistics - All Students

		GPA	Music Intensity	Music Duration	CST # correct
N	Valid	45	45	45	45
	Missing	0	0	0	0
Mean		3.33547	8.8444	11.3889	47.18
Median		3.55800	5.0000	10.5000	49.00
Std. Deviation		.657637	10.62310	5.54618	8.416
Skewness/SE ratio		-2.155	4.616	.994	-1.531
Kurtosis/SE ratio		-.922	2.380	-.826	-.941
Minimum		1.897	.00	2.00	28
Maximum		4.000	38.00	23.50	60
Cronbach's Alpha		N/A	.442	.146	N/A

Linearity of each predictor variable with the outcome variable was examined in the scatter plot matrix shown in Figure 2. A visual examination of the scatter plot matrix indicates no strong linear relationships among any of the variables. In addition, there appears to be no detectable curvature in the data, suggestive of higher-order (e.g. power or exponential) relationships among the variables.

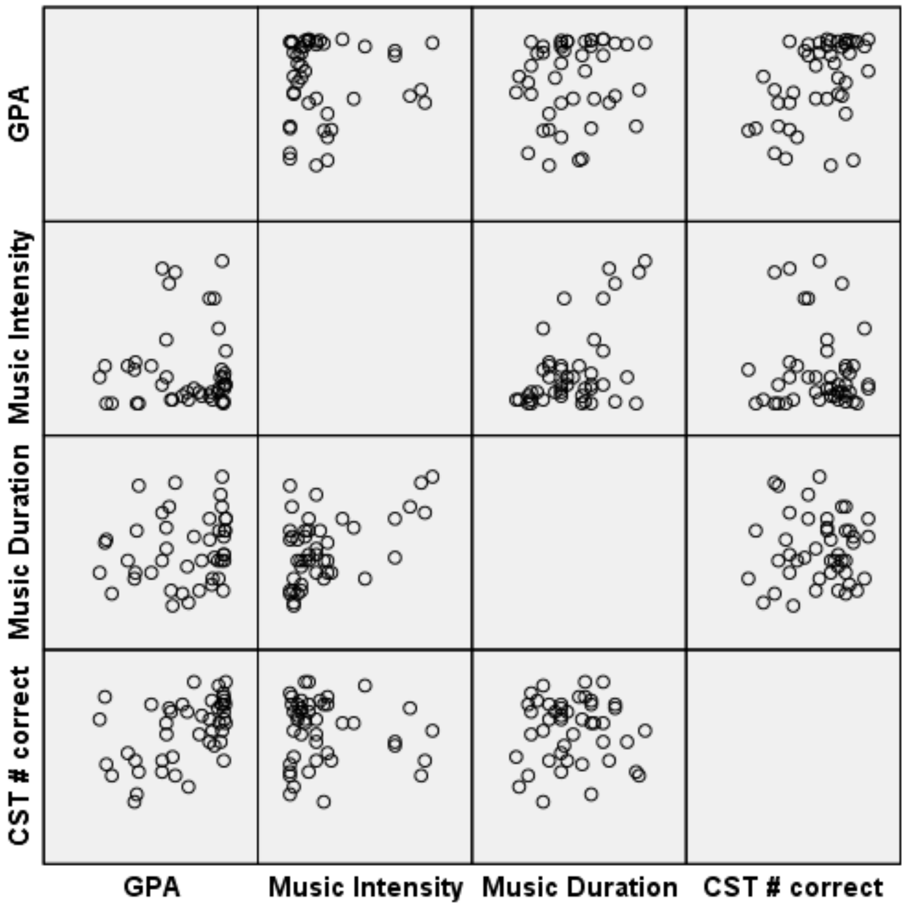

Figure 2. Scatterplot Matrix of Predictor and Outcome Variables

Testing the assumption of data normality was performed three ways. First, the skew and kurtosis of each variable was examined, along with a calculation of their respective *z*-scores. The calculated *z*-scores for skewness (*z*-score = skewness ÷ SE skewness) and kurtosis (*z*-score = kurtosis ÷ SE kurtosis) for the three independent scaled variables and the dependent variables are shown in Table 4. The skewness/SE skewness ratios exceed ±1.96 for the GPA variable (-2.16) and the music intensity variable (4.62), indicating non-normal data distribution (Cramer & Howitt, 2004). The calculated *z*-score for kurtosis/SE kurtosis exceeds ±1.96 for the music intensity variable (2.380). Therefore, because of the high *z*-scores for skewness and kurtosis the assumption of data normality cannot be made.

Second, the assumption of normality was conducted using the Shapiro-Wilk statistic. The results displayed in Table 5 indicated statistical significance ($p<.05$) for all variables except music duration. A statistically significant Shapiro-Wilk statistic indicates non-normal data distribution (Shapiro & Wilk, 1965). Therefore, the assumption of data normality cannot be made.

Table 5.

Tests of Normality- All Students

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
FR Lunch Status	.413	45	.000	.606	45	.000
GPA	.192	45	.000	.867	45	.000
Music Intensity	.234	45	.000	.757	45	.000
Music Duration	.100	45	.200*	.970	45	.285
CST # correct	.141	45	.025	.946	45	.036

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Finally, normal Q-Q plots were produced each continuous variable. These plots are shown in Appendix C. A visual inspection of these plots suggests that music duration and CST # correct appear normal, whereas GPA and music intensity do not. The music intensity Q-Q plot indicates marked deviation from normality. Based on these plots, the assumption of data normality cannot be made.

Tests for collinearity, autocorrelation, and heteroscedasticity were performed in conjunction with the multiple linear regression. Test results for collinearity between the predictor(s) and the outcome variable are shown in Table 8. All values were above .300 for the collinearity statistics tolerance, indicating the data met the assumption of non-collinearity. Autocorrelation was examined between the predictor(s) and the outcome variable using the Durbin-Watson *d*-test. The value produced was 2.48, indicating no meaningful autocorrelation between the predictor variables and the outcome variable. Evidence of heteroscedasticity was examined from the scatterplot shown in Figure 3. Figure 3 suggests that the data that is either homoscedastic or slightly heteroscedastic.

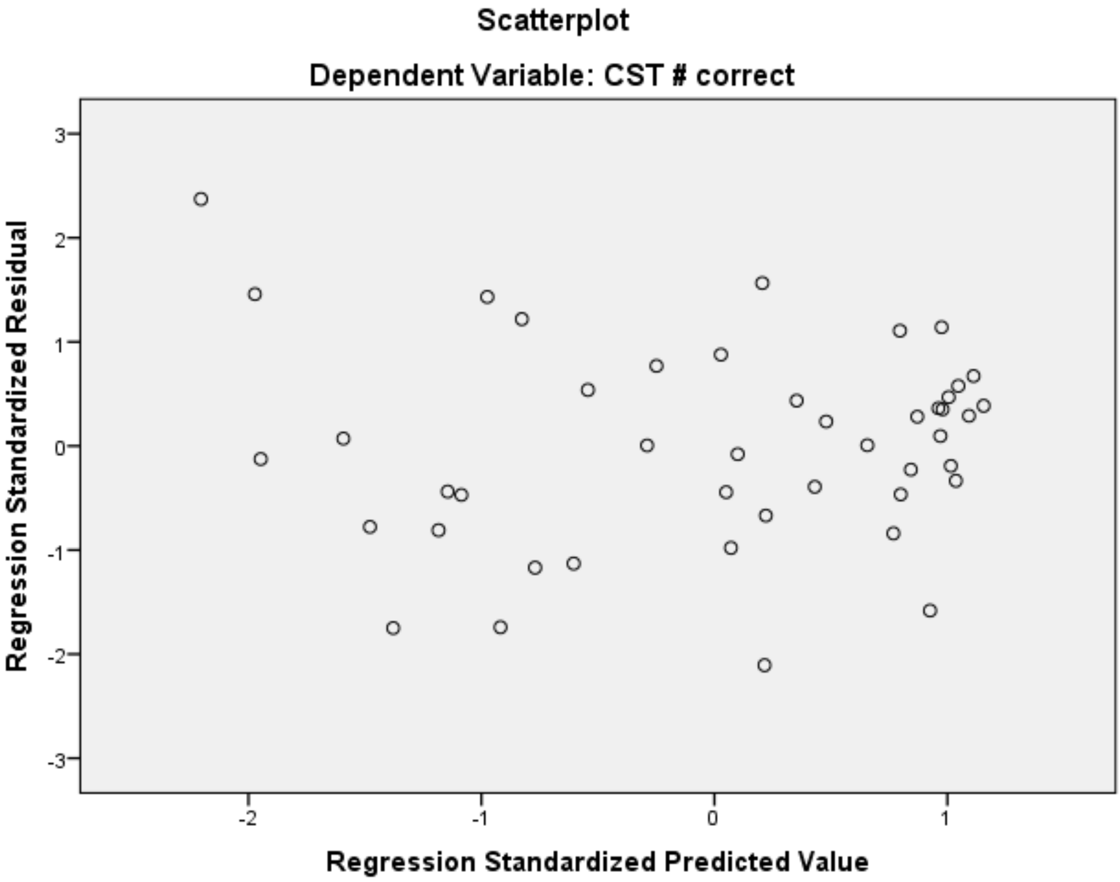

Figure 3. Scatterplot between Standardized Residuals and Predicted Values

Outlier removal and mathematical data transformation were performed in an attempt to normalize the data. First, extreme outliers were removed from the most non-normal variable, music intensity. However, doing so increased both the skewness and kurtosis values, and reduced the sample size. In addition, extreme outlier removal still resulted in a significant Shapiro-Wilk statistic. Mathematical transformation of variable data was performed using both SQRT and LOG(10) functions in an attempt to normalize the data. This was not successful. Neither the removal of outliers nor either of the transformations were successful in normalizing all variables.

The decision was made to move forward with multiple linear regression analysis because: (a) the skew values were low-to-moderate; (b) multiple linear regression is somewhat robust to the violations of normality; (c) assumption of normality typically leads to attenuation, or underestimating the correlation; (d) the findings will be considered in the context of this violation; and (e) findings will be considered specific to this sample only (Osborne, 2001; Osborne & Waters, 2002; Williams, Gómez, & Kurkiewicz, 2013). Therefore, it was determined by the researcher to proceed with the multiple linear regression analysis with the original, unmodified data set.

Multiple linear regression analysis. Multiple linear regression was performed in order to predict students' CST # correct based on music intensity, music duration, GPA, and FR lunch status. The multiple linear regression equation used for this study is given in equation (1):

$$\text{CST \# correct} = B_0 + B_1\,\text{Music Intensity} + B_2\,\text{Music Duration} + B_3\,\text{GPA} + B_4\,\text{FR Lunch Status} \qquad (1)$$

where B_0 = constant, and B_1 - B_4 can either be either unstandardized regression coefficients (*beta B weights*) or standardized regression coefficients (*beta β weights*) for each predictor variable as generated by the multiple linear regression. The results of the multiple linear regression analysis are displayed in Tables 6 - 8.

Table 6.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.501[a]	.251	.176	7.638	2.484

a. Predictors: (Constant), Music Duration, FR Lunch Status, GPA, Music Intensity
b. Dependent Variable: CST # correct

Table 7.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	782.994	4	195.748	3.355	.018[b]
	Residual	2333.584	40	58.340		
	Total	3116.578	44			

a. Dependent Variable: CST # correct
b. Predictors: (Constant), Music Duration, FR Lunch Status, GPA, Music Intensity

Table 8.

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collin-earity Statistics Tolerance
1	(Constant)	26.352	6.560		4.017	.000	
	FR Lunch Status	1.101	2.574	.063	.428	.671	.854
	GPA	6.483	1.819	.507	3.565	.001	.927
	Music Intensity	-.094	.132	-.118	-.710	.482	.677
	Music Duration	-.032	.244	-.021	-.130	.897	.722

A statistically significant regression equation was found (F (4,40) = 3.355, p = 0.018), with an R^2 = 0.251. The multiple linear regression equation with the unstandardized beta weights (B) for this study is given in equation (2):

$$\text{Participant's predicted CST \# correct} = 26.352 - .032\ (\text{MUSIC DURATION}) - .094\ (\text{MUSIC INTENSITY}) + 6.483\ (\text{GPA}) + 1.101\ (\text{FR LUNCH STATUS}) + \varepsilon \tag{2}$$

where music duration was measured as the number of years actively engaged with instrumental and vocal music, music intensity was measured as the total number of hours per week the student is currently actively engaged with instrumental and vocal music, GPA was the unweighted cumulative high school grade point average, and FR lunch status is coded as 1 = eligible, 0 = not eligible. Participant's number of correct answers on the CST decreased .032 for each year actively engaged with instrumental and vocal music, decreased .094 for each hour per week actively engaged with instrumental and vocal music, increased 6.483 for every 1 unit increase in GPA, and increased 1.101 if participants were eligible for free and reduced lunch.

The only significant predictor variable for academic science achievement was GPA (B_3 = 6.483, *p* = .001). There were no significant relationships between any of the other predictor variables: music intensity, music duration, and FR lunch status; with the outcome variable, CST # correct. In addition to the non-significance of all predictors except GPA, their unstandardized B values were low or even negative: B_1 = -.094 for music intensity; and B_2 = -.032 for music duration; and B_4 = 1.101 for FR lunch status.

One can compare the relative intensity of the predictor variables examining the standardized regression coefficients (β) shown in Table 7. The multiple linear regression equation with the standardized regression coefficients (β) for this study is given in equation (3):

$$\text{Participant's predicted CST \# correct} = 26.352 - .021\,(\text{MUSIC DURATION}) - .118\,(\text{MUSIC INTENSITY}) + .507\,(\text{GPA}) + .063\,(\text{FR LUNCH STATUS}) + \varepsilon \tag{3}$$

A post-hoc power analysis was performed using the G*Power tool version 3.1.4 to determine the power of the study. Using the actual number of participants (N = 45), and four predictor variables with an effect size of f^2 = .334, the computed power was .72. This was below an acceptable power of .80 (Faul, Erdfelder, Buchner, & Lang, 2009). This low power result was likely due to the inadequate sample size. Low power increases the probability of a Type II error.

Evaluation of Findings

For this study, the single research question asked about which combination of music background indicators, academic indicators, and SES best predicts academic science achievement. The particular hypothesis tested was whether there was statistically significant relationship between at least one of the various music background indicators, academic indicators, and SES, and academic science achievement. Of particular interest to the researcher was whether there were statistically significant relationships between the level of student music engagement and their academic achievement in science. In this study, a statistically significant relationship was found between the predictor variable GPA and the outcome variable academic science achievement. Therefore, the results are suggestive that the null hypothesis should be rejected, and there are no statistically significant relationships between any of the various music background indicators, academic indicators, and SES and the academic science achievement. However, the results of this study must be interpreted with caution due to low sample size, low power, low reliability in questionnaire items, and non-normality in two of the predictor variables. This means that confidence is not high regarding interpretation of the results of the multiple linear regression analysis. Results should be interpreted as merely suggestive of trends found in the data.

Researchers have found positive correlations between music background and student academic achievement, particularly in mathematics and language arts (Bennet & Bennet, 2008; Gouzouasis, et al., 2007; Hetland, 2000; Johnson & Memmott, 2006; Schellenberg & Moreno, 2009; Vanderbilt University, 2008). The positive associations between music training and academic performance in school were found to be quite broad, as they applied to academic grades as well as a variety of standardized tests (Schellenberg, 2011a). In this study, statistically significant relationships were not found for either of the music background predictor variables, which is not consistent with the literature results. Researchers have also demonstrated the predictive ability of standardized test scores and high school cumulative GPA on freshman college GPA (Letukas, 2015), or the predictive ability of intelligence on the standardized test scores such as the Scholastic Aptitude Test (SAT) (Angela & Martin, 2005; Hannon, 2016). Noticeably absent in the literature are studies examining the predictive ability of high school cumulative GPA on high school standardized test scores. The statistically significant result found in this study between GPA and academic science achievement suggests that the relationship between the variables could be bidirectional.

Summary

The results of this study suggest that there is a statistically significant relationship between at least one of the various music background indicators, academic indicators and SES and the academic science achievement. The academic indicator, cumulative high school GPA, showed a statistically significant relationship with academic science achievement. However, neither of the music background indicators, nor SES showed statistically significant relationship with academic science achievement. However, the results of this study must be interpreted with caution in consideration of insufficient power due to low sample size, low reliability in questionnaire items, and non-normality in two of the predictor variables. This means that confidence is not high regarding interpretation of the results of the multiple linear regression analysis. Overall, trends in the data suggest that this model is not a strong predictor of academic science achievement.

Chapter 5: Implications, Recommendations, and Conclusions

The specific problem addressed by this study is whether transferable cognitive effects, possibly beneficial to academic science performance, may be lost due to reductions in instructional time and access to music and arts educational programs at U.S. public schools. The purpose of this quantitative correlational study was to analyze which combinations of academic, socio-economic status (SES), and music background indicators best predicts academic science performance in high school students, and to preliminarily explore if cognitive transfer or resource sharing theories may be applicable from music to science. A correlational study was selected because this study was intended as a preliminary exploration of the relationships among predictor and outcome variables. Multiple linear regression was the specific statistical test used to test the null hypothesis that no relationships exist between any of the predictor variables and a single outcome variable.

The first predictor variable was music background, a two-component construct consisting music intensity and music duration. Music intensity was defined as the total number of hours per week the student was currently actively engaged with instrumental and vocal music. Music duration was defined the number of years actively engaged with instrumental and vocal music. Numeric, interval data about student music background was acquired through a web-based questionnaire after receiving consent from the school superintendent, the high school principal, participating students, and their parents/guardians. Two other predictor variables were cumulative grade point average (GPA) and socioeconomic status (SES) as measured by eligibility for free and reduced lunch. The outcome variable was academic science performance, as measured by the numerical, scaled scores obtained by students in the California Standards Test in science (CST).

Participants were recruited from two high schools in the Northern Humboldt Union High School District (*District*). Forty-five participants obtained parent consent completed an online music background questionnaire. Information about participants' GPA, SES, and was obtained from school student records with the permission of the District, the participants and their parent/guardians. The sole research question asked in this study was which combination of music background indicators, academic indicators, and SES best predicts academic science achievement. The particular hypothesis tested was whether there was statistically significant relationship between at least one of the various music background indicators, academic indicators, and SES, and academic science achievement as defined as the score on the CST in science taken by grade10 students in the Northern Humboldt Union High School District. Multiple linear regression analysis was used to analyze which combinations of academic indicators, SES, and music background indicators best predict academic science achievement.

A statistically significant result was found in multiple linear regression. In this study, the only predictor variable that showed a statistically significant relationship with the outcome variable academic science achievement was overall GPA. Of particular interest in this study were the predictive effects of music background indicators on academic science performance. Although the regression equation indicated that at least one of the predictors was significant, neither indicator of music background nor SES was statistically significant predictor of academic science achievement. The results of this study must be interpreted with caution. Due to low sample size, low power, low reliability in questionnaire items, and non-normality in cumulative grade point average and music intensity predictor variables, results should be interpreted as merely suggestive of trends found in the data.

Limitations and Delimitations. Participants were recruited from the Northern Humboldt Union High School District (*District*), a single California public high school district. This was done to minimize confounding variables that could result with student taking music and science courses in different school districts, different states, or different countries. To comply with ethical guidelines regarding human subjects research, participation in this research study was voluntary and confidential. Discretion was used in obtaining parental consent, student assent, and provisions for the participant students to take the survey in a secure computer lab located at each high school campus. Forty-five students assented, obtained parental consent, and completed the online survey. The District only had one music teacher, and that teacher taught all students enrolled in the District's music program at both high school campuses. As a result, variations in District students' music and science experiences were likely less than if students from other school districts participated. However, the specifics of each participant's musical background was not known by the researcher.

The researcher limited the measure of academic science achievement to one single exam, the CST science examination. This exam is the only measure of academic science achievement with District data available for all students during the 2014-2016 academic school years. Results from other standardized science examinations were available from the District, such as Advanced Placement and the International Baccalaureate science examinations, but the numbers of students who took these tests were quite small.

Implications

Based on the results of the multiple regression analysis the one statistically significant predictor of academic science achievement was cumulative overall grade point average. This seems consistent with expectations that students achieving high grades tend to do well on standardized tests of achievement (Brown, Halpin & Halpin, 2015; Hiss, & Franks 2014). Additionally, students who select music courses tend to have higher grades in most academic subjects (Cabanac, et. al, 2013). Also, SES is strongly correlated with academic achievement (Caldas & Bankston, 1997; Caldwell, G. & Ginther, 1996). Therefore, SES as measured by student eligibility for free and reduced lunch was an appropriate variable to examine and/or control. Of particular interest was to ascertain potential relationships among indicators of music background and academic science achievement. The results indicate no significant correlations were found among indicators of music background and academic science achievement.

It was unexpected that unstandardized regression coefficients were nearly zero, suggesting that virtually no relationship was found. This result was inconsistent with much of the literature (Catterall, 1998; College Board, 2007; Fitzpatrick, 2006; Johnson and Memmott, 2006; Morrison, 1994; Schellenberg, 2006. Schellenberg, 2011a). Fitzpatrick (2006) found that instrumental music students in Ohio consistently earned higher test scores in all academic subjects after controlling for SES. Schellenberg (2011a) stated that most of the available literature indicates that high-functioning children tend to take music lessons, and also tend to do well on most academic tests they take. It was expected that a moderate relationship would be found between music background and academic science achievement because such relationships had been found between music and mathematics. Three possible reasons for this result are the low sample size, non-normality of the data, and the nature of the CST science test of academic science achievement. Each of these reasons are discussed.

Obtaining a sufficient sample size was particularly challenging. Only junior and seniors students were recruited, because they all took the same CST science examination, and also had the opportunity to participate in two years of their high school music programs. Only about 11% of the recruited students completed the music background surveys, a rate lower than expected. The researcher's experience with teaching in California public high schools indicated that students tend not to participate in extra-curricular activities such as optional research studies unless mandated by the teacher or chosen by the students themselves. An appeal to the student's own intrinsic motivation was the only incentive offered in this study.

The researcher wanted to recruit a large number of students from the outset. Originally, the District wanted only their music students to be recruited and surveyed. However, in order to obtain a large enough sample size in order to increase the likelihood of greater variability of data for all of the predictor variables, including music background, the researcher convinced the District to allow recruitment from other classes as well. It was suggested by the District that recruitment could also take place in the social studies and English classes as these courses are grouped by grade level. Additionally, these classes were required for all juniors and seniors to take, and so were likely to contain students with a variety of SES, music backgrounds, and general academic abilities, including science.

A second possible reason for the results was that not all of the data was normally distributed. A full discussion of how non-normal data was handled in this study was given in Chapter 4. The predictor variables music intensity and cumulative grade point average had non-normal data distributions. Music intensity results exhibited high kurtosis and positive skew. A large proportion of participants spent very few or no hours per week engaged with music, with a few reporting with significantly greater number of engagement hours. It seems reasonable that a few students who are very interested in music would report a significantly greater amount of time playing or practicing music. It is likely that many of the students recruited in the social studies and English classes do not play instruments or sing regularly. This might explain why a large proportion of the participants reported very low numbers of hours per week playing an instrument or singing.

The GPA predictor variable was also non-normal for the participants, exhibiting negative skew. The participants in the study had relatively high average GPAs (3.34 = B+), which indicates a possible sample bias. The GPA predictor variable was the only one correlated with scores on the CST science examination. Yet, scores on the CST science examination were not heavily skewed. Also, CST science examination scores were higher than the District and California averages. Study participants' average scaled score was 389, which places them in the proficient CST classification (California Department of Education Assessment Development and Administration Division, 2017). District students taking the CST science examination in 2015 had an average score of 369.6 (California Department of Education Assessment Development and Administration Division, 2015). District students taking the CST grade 10 science examination in 2016 had an average score of 358.6 (California Department of Education Assessment Development and Administration Division, 2016). These scores place both cohorts in the proficient

CST classification. The average score for all of California students in 2016 was 353.5, placing them just within the proficient CST classification (California Department of Education Assessment Development and Administration Division, 2016).

One possible explanation for non-normal GPA distribution was that high achieving students would be more likely to agree to participate in the study, because it is expected that higher achieving students might be more intrinsically motivated by curiosity about the relationships between music and academic science. They would be more likely than average students to complete and return the required parent permission slips in order to participate in the study. Although the participants in my study had higher than average GPAs and CST scores, they did not necessarily have very high levels music intensity or music duration.

A third possible reason for the lack of relationship found between music background and academic science achievement could have been due to the nature of the CST science exam. This might be understood in context of the theoretical frameworks of cognitive transfer theory and resource sharing theory. Recall, cognitive transfer theory is when learning from one cognitive domain transfers to another cognitive domain (Hallum, 2010). The more similar the shared tasks or shared cognitive processes between domains the more likely the transfer (Hallum, 2010). Resource sharing theory is when learning from one skill or cognitive process transfers to another because they share cognitive processes or underlying neural resources (Patel, 2012).

The primary contribution of this study is that no evidence was found to suggest that transfer effects or resource sharing occurred between a participant's music background and their score on the CST science examination. Had any transfer effects occurred, positive correlations should have been found between either music intensity or music duration and scores on the CST science examination. This was not the case. Nor did this study suggest that resource sharing had occurred between music background and academic science achievement.

One possible reason that transfer effects were not observed in this study may have to do with the nature of the CST science examination. The CST science test is a life science exam, containing 60 exclusively multiple-choice questions. The actual CST science examination taken by the students was not available, but the publically released sample questions for the CST science examination were mostly of the type requiring students to recall facts from memory. For example, one sample question was, "During photosynthesis in plants, what is the source of the carbon in the sugar molecule ($C_6H_{12}O_6$)" (California Department of Education, 2008, p. 15). With so much emphasis on rote memory the CST science examination might be limited in the range of science skills and processes it can assess. Therefore, the likelihood of cognitive transfer and resource sharing from a student's music background to this examination is small. For example, there is little obvious relationship between practicing an instrument or sight-reading music and knowing the source of the carbon in the sugar molecule. The researcher believes that the CST science examination taken by the participants was not the type of assessment that students would benefit from any significant transfer of skills and cognitive processes found in music. The cognitive domains of each are simply too unrelated for transfer effects to be observed.

Mixed evidence has been found in the literature for transfer effects between music and academic achievement. Schellenberg (2006b) reported positive correlations between duration of music training and measures of academic achievement such as average grades in school and measures of reading aptitude. These positive correlations were observed even after controlling for IQ scores. Corrigall & Trainor (2011) reported that a positive correlation was found between total length of musical instrument training and reading comprehension skills, after controlling for IQ and SES. They suggest that their findings are consistent with *far-transfer*, the type of transfer effect where shared tasks or shared cognitive processes are not similar (Hallum, 2010). Yet, they found no correlations between length of music training and word decoding skills. Hyde et al. (2009) reported that despite their findings that keyboard training improves certain auditory and motor skills, no such improvements were found with visual or spatial tasks. They suggest the lack of far transfer could be due to low sample size, or that 15 months of keyboard training was either too short of a period or that the children didn't practice with enough intensity.

Recommendations

The ability to make recommendations for practice based on this study is quite limited. Due to non-normality of the data and low power as a result of low sample size, the strength of the correlation is uncertain; actual correlation coefficients are likely lower than those reported. Therefore, recommendations based on the results of this study are merely suggestive. The results suggest that of the four predictors only GPA has a significant relationship with academic science achievement. The findings from this study are only generalizable to this particular school district, or perhaps California public high school students from a medium-sized city.

It cannot be concluded from this study that the problem of reductions in music programs common throughout California and the US had any effect on achievement in academic domains such as science. Even though no relationship between music background and academic science achievement was found, the researcher can recommend not reducing music course offerings in the district in the future. At the very least, no further cuts should be made in music course offerings in public schools when many researchers are reporting in the literature positive academic outcomes for students involved with school and private music programs. One caveat is that this study along with most literature studies about the relationships between music and academics are correlational studies. One can never conclude causation from correlation. Therefore, one cannot conclude from a positive correlation (or no correlation) that exposure to music in one form or another necessary has a causal effect on positive academic outcomes.

Finally, the researcher recommends that whenever possible in the future, school districts should select or create standardized science assessments not exclusively multiple-choice, because academic science performance involves a broad range of knowledge, skills, and abilities such as: creative problem-solving, experimental design, spatial-temporal skills, auditory skills, tactile and fine motor skills, mathematical reasoning, verbal and writing skills. Multiple-choice tests often emphasize rote memory and recall, and are very limited in their ability to measure the full range of what constitutes academic science performance.

Although many studies exist in the literature examining music's effects on the brain, cognitive and academic performance, few researchers have examined relationships between music background and academic science achievement. It is suggested that future quantitative research should continue to investigate this field. Additionally, future researchers should strive to measure a broad range of musical background experiences. For example, researchers could attempt to measure improvisational skills, sight-reading proficiency, tonal recognition abilities, or musical composition experience. Some of these may reveal new and interesting relationships between music and academics. Researchers could also consider using data from other standardized assessments of academic science achievement, if available, not so reliant on memory and recall as was the CST science examination. The researcher encourages that researchers select science assessments with questions and activities that utilize many more of the kinds of knowledge, cognitive process and skills inherent in science.

The next logical step in this line of research would be to find methods to ensure that an adequate sample size is obtained. It is challenging to persuade non-adult high school students to participate in a non-mandatory activity in the school setting without offering some form of incentive. The only incentive offered in this study was an appeal to the student's altruism, curiosity, and willingness to contribute to this research. Additionally, the District discouraged the use of student email to remind students to participate. Therefore, it is likely some students intending to participate forgot to get the permission slip signed or even lost it. Future researchers need to explore ways to work with school districts and IRBs to better encourage students to participate in non-mandatory academic studies without significantly compromising their privacy or anonymity. Finally, with additional numbers of researchers and ample time, students from more than one school district could be recruited to participate, and would likely increase sample size. However, if researchers decide to include students from additional school districts, attempts should be made to control for or measure additional variances that might influence the outcome of such studies.

Conclusions

In this study a multiple linear regression was performed in order to answer the research question: What combination of music background indicators, academic indicator, and SES best predicts academic science achievement? A statistically significant result was found between the predictor variable overall GPA and the outcome variable academic science achievement, as defined as the score on the California Standards Test in science taken by grade 10 students in the Northern Humboldt Union High School District. Therefore, results suggest that the null hypothesis that there are no statistically significant relationships between any of the various music background indicators, academic indicators, and SES and the academic science achievement should be rejected. This result was due mostly to the positive correlation that existed between overall grade point average and the student score on the science California Standards Test in science. However, there were no significant relationships between any of the other predictor variables: music intensity, music duration, and FR lunch status with the outcome variable, academic science achievement. Also, low sample size, low power, and non-normal data distribution limited the interpretation of the results. Therefore, the results of this study must be interpreted with caution, and as merely suggestive of trends found in the data.

The problem addressed by this study was whether transferable cognitive effects may be lost due to reductions in instructional time and access to music and arts educational programs at U.S. public schools. The results of this study suggest that music background has little or no relationship to academic science achievement. The primary contribution of this study is that no evidence was found for either transfer effects or resource sharing from music to academic science achievement. Therefore, it cannot be concluded from the results of this study that transferable cognitive effects were lost, as evidenced the lack of correlation found between music background predictor variables and academic science achievement.

Although many researchers have reported positive relationships between music and performance in a variety of academic subjects using mostly correlational studies, this study does not support that conclusion. If the limitations with this study could be overcome, it would be interesting to see the results of future studies investigating relationships between music background and academic science achievement.

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Appendixes

Appendix A: Musical Background Survey Questionnaire

DIRECTIONS: Please give your answers to the following questions. You may skip any question.

1. Give your complete First Name

2. Give your complete Last Name

3. What grade are you in?

4. At which high school did you hear the presentation about the study?
   a) Arcata High School

   b) McKinleyville High School

5. What is the name of the class where you heard the presentation about the study? (e.g. US World History; jazz band)

6. Give your age in whole number of years.

7. Do you currently play a musical instrument at least one hour per week? (Yes/No). If "No", skip to Question 8.

   7a. If "Yes" to Question 7, give the total number of different instruments you currently play at least one hour per week.

   7b. If "Yes" to Question 7, give the total number of hours per week you currently play all your instruments.

8. Have you ever played a musical instrument in the past (but no longer play)? (Yes/No). If "No", skip to Question 9.

   8a. If "Yes" to Question 8, give the total number of different instruments you have ever played at least one hour per week.

   8b. If "Yes" to Question 8, give your best estimate of the total number of hours per week you use to play all your instruments.

Questions 9 – 11 are concerned with your experiences singing:

9. Do you currently sing in a school choir, school chorus, school musical play, or other school-sponsored vocal group? (Yes/No). If "No", skip to Question 10.

    9a. If "Yes" to Question 9, give the total number hours per week you currently sing in a school choir, school chorus, school musical play, or other school-sponsored vocal group.

    9b. If "Yes" to Question 9, give the total number of years you sung in a school choir, school chorus, school musical play, or other school-sponsored vocal group.

10. Do you currently sing in a *private* (non-school) choir, chorus, band or small vocal ensemble (5 or fewer vocalists)? (Yes/No). If "No", skip to Question 11.

    10a. If "Yes" to Question 10, give the total number of hours per week you currently sing in a *private* (non-school) choir, chorus, band or small vocal ensemble (5 or fewer vocalists).

    10b. If "Yes" to Question 10, give the total number of years you have sung in a *private* (non-school) choir, chorus, band or small vocal ensemble (5 or fewer vocalists)

11. Do you currently sing alone (for example, singing along with music you listen to at home, in the car, or at someone else's home? (Yes/No). If "No", skip to Question 12.

    11a. If "Yes" to Question 11, give the total number of hours per week you currently sing alone.

    11b. If "Yes" to Question 11, give the total number of years you have sung alone for at least 1 hour per week?

12. Choose the single most appropriate response regarding your prior music lessons or training:

    A. I have never had music lessons or training
    B. I have never had music lessons, but I have self-taught myself at least 1 instrument

C. I took music lessons for less than a year
D. I took music lessons for 1-2 years
E. I took music lessons for 2-3 years
F. I took music lessons for 3-4 years
G. I took music lessons for over 4 years

13. Which one of the following best describes your primary instrument sight-reading or vocal sight-singing abilities:

A. I cannot sight-read nor sight-sing
B. I can sight-read and/or sight-sing a little bit
C. I can sight-read and/or sight-sing OK
D. I can sight-read and/or sight-sing very well

14. Have you taken any courses specifically in music theory? (Yes/No/Don't know). If "No or Don't know", skip to Question 15.

14a. If "Yes" to Question 14, approximately how many total months of music theory courses have you taken?

15. Have you had any courses in musical ear training? (Yes/No/Don't know). If "No or Don't know", skip to Question 16.

15a. If "Yes" to Question 15, approximately how many total months of musical ear training courses have you taken?

16. Check any below that describe how you listen to music (check as many of these that apply to you):

A. I listen to radio
B. I listen to CDs,
C. I listen to MP3s,
D. I listen to online digital formats (such as internet radio, Pandora, Spotify, etc.)
E. I go to live music shows

17. Select the statement that *best* describes the amount of music that is played or listened to by others living in your household that you can hear:

A. None.
B. Less than 1 hour per day.
C. From 1 -2 hours per day
D. From 2 – 3 hours per day
E. Greater than 3 hours per day

Questions 18 – 19 are concerned with personal views about music:

18. Select the statement that best describes your family's view of music:

    A. My family does not think music is very important.
    B. My family thinks music is somewhat important.
    C. My family thinks music is very important.

19. Select the statement that best describes your friend's view of music:

    A. My friends think music is very important.
    B. My friends think music is somewhat important.
    C. My friends do not think music is very important.

Your results have been recorded. Thank you for your participation in this research!

Appendix B: Field Test Write Up Summary Form

Field Test Write Up Summary Form

Researcher's Name: Blake Brown

Title of the Study: The Relationship Between Student Musical Background and Academic Science Achievement –A Correlational Study

Dissertation Chair's Name: Dr. Sharon Kimmel

Date: August 21, 2015

Instructions: Please answer all the questions below.

1a. How many experts participated in the field test?

3. Two experts were high school music teachers, and one expert was a person well-versed in survey and questionnaire design and validation.

1b. Identify each participants expertise relevant to the proposed research study topic and/or methodology.

Ms. Karolina Pek: Ms. Pek is an international high school and middle school music teacher for over 20 years, primarily in East Asia. Ms. Pek is currently the senior member of the music faculty at Shanghai American School. She has taught a variety of instrumental and vocal music courses over the years, including concert band, jazz band, jazz vocal ensemble, concert band, guitar, and Advanced Placement music theory. She has taught music to students ranging in grades from elementary school through high school. Her students are come from a variety of countries and cultures. In addition to her music education experience, Ms. Pek is also a multi-instrumentalist, amateur musician, and flamenco dancer. Ms. Pek is eminently qualified as both an educator and musician to recognize the varieties of music background experiences that high school students typically have or could have. The questionnaire is concerned with determining relative levels of music background possessed by high school students.

Phillip Green: Mr. Green has over 35 years of experience as a music educator and orchestra performer. He was formerly the principal cello player of the Melbourne Symphony Orchesra and head of strings at the University of Melbourne. He holds a masters degree in orchestral and choral conducting from Queensland University. His students have come from a variety of cultures and nationalities. In addition to her music education experience, Mr. Green is also eminently qualified as both an educator and musician to recognize the varieties of music background experiences that high school students typically have or could have.

Dr. Sharon Kimmel:

2. If you validated an instrument(s) in the field test phase, please summarize the findings about the validity and reliability of the instrument(s) you piloted.

The following instructions were given to the two music subject matter experts:

—>Your task is to determine from the attached DRAFT survey/questionnaire if:

"The questions were clear, necessary and sufficient to determine the various aspects of a student's music background."

—>Please indicate any suggestions you have regarding wording or rewording, questions to be added, deleted, or modified. The key is to keep the survey short, clear, yet thorough.

Both of my music SMEs felt that my self-designed instrument was a valid test of a high school student's music background. The questions had the proper range and depth for a Likert-style quantitative instrument. The only suggestions they had to make a couple changes in wording, and add a question about the types of music students hear around the household played by other family members. This question was added.

3. For the actual dissertation study, are you revising any of the sampling/recruitment procedures and research procedures that you wrote in the Dissertation Proposal?
   ___ Yes __X__ No

4. What other changes (from the Dissertation Proposal proposed study plan) for the actual dissertation research study are you proposing to implement based on what you learned in the field test?

No others

Signature of Student Researcher: **Blakely M. Brown**
Date: **August 21, 2015**
Signature of the Dissertation Chair:
Date:

Appendix C: Normal Q-Q Plots of Predictor and Outcome Variables