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Secondary Band Participation and Executive Function

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by

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DEDICATION

To Casey Marie and Aaliyah Michele Graham: my heart, my soul, and every breathe I take.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Data on standardized tests is often used to advocate for the inclusion of music programs in secondary education curriculum. There have been studies that claim to identify a relationship between music participation and higher earned test scores; however, correlation does not necessarily equate to causation. The argument between whether music instruction improves student testing ability or if higher achieving students are attracted to music courses is still prevalent within the music education domain. Executive function represents the processes within the brain that encompass a number of cognitive ability processes used in the transfer of knowledge. These processes are essential to progression and success in education (Caine & Caine, 2006; Chan, et. al., 2008). Research demonstrates that music instruction has the capacity to enhance various executive function processes in young students with previous music instruction and individualized violin training (Bugos, 2010; Ho et al., 2003; Chan et al., 1998). The purpose of this study was to evaluate the effects of secondary music instruction, specifically in the band setting, on executive function processes of processing speeding and working memory. 40 high school students, 20 students who had received previous band instruction and 20 who had not received previous band instruction ages 13 to 18, completed various cognitive and musical assessments to gauge musical ability and cognitive function (measuring attention, working memory, and processing speed). Students from both groups were paired using the Wechsler Abbreviated Intelligence Scale. Analysis of the results demonstrated that students who received prior band instruction demonstrated enhanced processing speed and working memory indices, as well as increased attention abilities.

CHAPTER ONE:

INTRODUCTION

Many processes used in everyday human activity require the application of higher order processes within the brain. These higher-order processes are most commonly known as executive function within the brain. As technology begins to play a more active role in today's society, life success depends increasingly upon the role of various executive function. These executive function (EF) play a substantial role in education with a standard-based curriculum. The skills of goal-setting, planning, organizing, and memorizing are among the skills shared cross-subject that aid in student functionality and achievement. Gardner and Moran define executive function as, "the mental process of planning and organizing flexible, strategic, appropriate actions" (Meltzer, 2007, p. 19). Within this definition lie several other aspects under the umbrella of executive function such as goal-setting, memorizing, attention, and self-regulatory processes such as self-monitoring (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). The aforementioned concepts each involve more complex systems of the brain than simple recall. Just as with physical skills, executive function can be isolated and developed. The various processes involved in executive function serve to enhance the way in which people complete activities, including the skills necessary in education.

Background of the Problem

The art of music is an innately human activity, experienced by all regardless of culture or geographic location. From a philosophical view, Small presents that music, in and of itself, does not exist, rather, it is an activity in which humans participate (1998). Small refers to this activity as *musicking* and it involves musical participation in any capacity in a performance, whether by performing, by listening, by rehearsing or practicing, by providing material for performance (what is called composing), or by dancing (Small, 1998, p. 9). Although the degree varies, the interaction and active participation in a musical activity stimulates various cognitive processes within the brain (Bugos & Mostafa, 2010; Bugos & Mazuc, 2013). Various studies suggest that there is a connection between participation in music programs and success in education, particularly with standardized test scores (Andrews, 1997; Cobb, 1997; Bugos & Mostafa, 2010; Bugos & Mazuc, 2013; Costa-Giomi, 1999; Johnson & Hemmott, 2006; Kemmerer, 2003; Miranda, 2001; Neuharth, 2000; Olson, 2008; Olson, 2009; Perry, 1993; Schneider, 2000; Trent, 1996; Underwood, 2000; Whitehead, 2001). These findings have served to promote educators world-wide to encourage music advocacy. However, statistics have shown that the number of students currently enrolling in traditional music courses decreases exponentially every year (Florida Department of Education, 2013). Research suggests that reasons contributing to this decline in participation include the erosion of public support for music programs, the emphasis on lath, reading, and science over the arts in curriculum development and the No Child Left Behind Act, and a major decrease in the education budget (Music for All Foundation, 2004).

Contrary to the diminishing reputation and participation quantity, research studies involving the developmental incentives of music participation have increased. Through the use of novel technologies, researchers have the opportunity to investigate specific processes within the brain that interact with the participation in music. Many of these processes include higher order cognitive processes, more commonly referred to as executive function. The role of executive function in the realm of education has become increasingly more researched since the beginning of the 21st century. The general consensus of definition among psychologists, neurologists, and other theorists is that executive function is an umbrella term for the complex cognitive processes that facilitate ongoing, goal-directed behaviors (Meltzer, 2007). The cognitive processes that comprise executive function are stated to be located in the frontal lobe of the brain, an area which also associated with coordination and synthesis of emotions, thinking, memory and physical movement (Caine & Caine, 2006). The cognitive processes underlying executive function include goal setting, planning, organizing of behaviors over time, flexibility (not to be confused with plasticity), attention, working memory, and self-monitoring.

Statement of the Problem

Music programs throughout the United States are continuously seeking to be viewed as a significant aspect of the education curriculum. Fine arts support within the public school system has never matched the support of their private school counterparts (Vaughn & Winner, 2000). One explanation for this belief is that private school administrators promote the arts in education, to improve standardized tests scores and/or for enhancing aesthetic value. Lack of administrative support in public schools has led to the notion that instrumental programs are privileged activities, rather than essential for academic success, valuing music, and developing musicianship.

Heilig, Cole, and Aguilar (2010) suggested that arts programs are thought of predominantly as a curriculum for the wealthy. Reasons for this statement originate from the amount of fees required to run a successful program (due to minimal support provided by the school systems), the amount of money required in renting or owning an individual instrument, and the amount of money required for transportation and instrument repair and maintenance.

There is a separation of participation, a prejudice, in the ability of students to participate in music due to socioeconomic status.

Although a number of studies have provided examples of the benefits of participation in music programs and increased standardized testing scores, these findings are not widely accepted. With such studies as Johnson and Memmott (2006), the argument is made of whether the extrinsic values such as organization skills or creativity inspired students to study more or if it is the participation in a music program that has improved cognitive abilities. Findings from this particular study suggest that improved test scores may have been a consequential result of music program participation. However, improved test scores was not the reason for students' desire to participate. Participation was determined through a personal aspiration to improve their lives, either through emotional investment or mental challenge. Regardless of the reasoning, students enrolled in a quality music program, the definition of quality being a program that successfully meets the national standards established by the Music Educators National Conference, tend to score higher than their non-music counterparts (Johnson & Memmott, 2006).

Current trends in education show the necessity for music teachers to be competent in teaching additional core curricular subjects such as reading and math. Some administrators now even require that their arts teachers be professionally certified to teach a core subject. Cox and Stephens (2006) recommend that this training be offered by school administrators in order to facilitate assimilation of the arts teachers into the common curriculum. This would provide the music teachers an opportunity to continue to work at the school without having the arts eliminated. With this mandate in place, there are music teachers covering periods of disciplinary actions (i.e., In-School Suspension) and teaching reading, writing, mathematics, and other subjects. In an effort to advocate the necessity to maintain arts programs in the public school system, Cox and Stephens (2006) believed the various school boards needed more research as to how music affects the attitude, dedication, and organizational skills of students in the academic classroom. Following this research, connections between math and music were identified, possibly outlining reasons why students who participated in music programs often produced higher scores on math assessments than their non-musician peers. As a result, it is believed that students who participate in music programs demonstrate distinct skills and abilities that separate them organizationally and academically from other students in math classes who do not participate in music programs.

Purpose of the Study and Research Questions

The purpose of this study is to determine the effects of musical training on executive function, with specific attention to information planning, processing speed, and working memory in high school students. These executive function are necessary for continued growth and development of cognitive skills in academic success. The specific research questions were:

1. What are the effects of musical training on executive function processes, specifically selective attention, processing speed, and working memory?

2. How do executive function processes of selective attention, processing speed, and working memory differ between students who had received prior band instruction and those who had not received formal band instruction?

3. What is the strength of relationship between years of ensemble exposure and cognitive performance?

4. What is the strength of relationship of AMMA/MST/MNT scores between students who have received secondary band instruction and those who have not received secondary band instruction?

5. What is the strength of relationship between music aptitude and IQ?

Rationale of the Study

Executive function are regulatory behaviors or goal-directed behaviors that drive individuals to succeed in education (Moran & Gardner, 2007). Research suggests that students who participate in fine arts programs, particularly instrumental (band and orchestra) programs, tend to score higher on standardized testing than their non-musician counterparts (Andrews, 1997; Black, 2005; Broh, 2002; Bugos & Edwards, 2012; Bugos & Mostafa, 2010; Bugos & Mazuc, 2013; Cheek & Smith, 1999; Cobb, 1997; Costa-Giomi, 1999; Dewar, 2008; Hodges & O'Connell, 2005; Johnson & Hemmott, 2006; Kemmerer, 2003; Kinney, 2008; Miranda, 2001; Neuharth, 2000; Olson, 2008; Olson, 2009; Perry, 1993; Schneider, 2000; Stewart, 2007; Trent, 1996; Underwood, 2000; Vaughn & Winner, 2000; Whitehead, 2001; Zwark, 2006). Although many studies provide data to support the role of music training on cognitive transfer, the results still are not unanimously accepted. The rationale for this study stems from a desire to present specific information as it pertains not simply to the numbers and statistical percentages as they are seen with test scores, but as they are identified with specific generalized cognitive processes that contribute to these findings. Specific interests are geared towards the executive function of selective attention, processing speed, and working memory.

Assumptions

This research study was performed under the assumption that all participating students answered the preliminary questionnaire honestly and without reservation, in order to correctly match by age and gender to experimental and control groups. Furthermore, it was assumed that students were not receiving additional assistance in any of the observed subject areas outside of the testing setting.

Delimitations

With the numerous possible definitions of terms integral to the purpose of this study, it was necessary to narrow the scope of the specific variables present in the current research. This study consisted of two categories of subjects, high school (grades 9-12) students who have previously received band instruction and those who have not. As this study specifically focused on the effects of band instruction, criteria for selection in the group of students who had received prior band instruction consisted of individuals currently enrolled in their high school band class. These individuals must have received a minimum of two consecutive years of music instruction at the high school level. Students who participated in individual private music lesson were omitted from the current study as they received additional instruction that may create an additional variable. Students identified as not having received prior formal band instruction were students who had not received any formal music training, including general music classes, through the middle school and high school years. This study focused on measures of executive function at a specific moment in time and will not concentrate on other moderating and mediating, or extraneous variables present in student development. Individual student academic success will only be taken into account during the preliminary matching of students.

Definition of Terms

Executive function consist of goal setting, planning, organizing behaviors over time, flexibility, attention, working memory, and self-regulatory processes such as self-monitoring (Meltzer, 2007; Miyake et al, 2000). Any number combination of these processes can aid in not only knowledge assimilation and comprehension, but also information synthesis and analysis. The current study will focus on the role of information planning, processing speed, and working memory. For the purpose of this study, executive function refers specifically to the processes of attention, processing speed, and working memory. The term *non-musician* is used in numerous research studies to identify an individual who has not received previous formal musical training, including general music classes. This term is synonymous for students who have not received formal band instruction. This standing definition will be the designation for this study as well. Due to the target age group of this study being high school secondary students, the term *musician* will be defined as any student currently enrolled in their instrumental band program with at least two prior years of wind band experience. This specification eliminates high school members who are participating in the wind instrumental program for the first year, or students who only participated in one year of middle school band.

Summary

The main focus of this study centered around the effects of musical training on executive function. This effect was measured through group administered musical and cognitive assessments. This study contrasts with past research identifying the effects of musical training and participation in secondary music programs. Two groups of students, students who had received formal band instruction and those who had not, completed a number of musical and cognitive assessments in order to determine the effects of music instruction, specifically band, on the executive processes of attention, processing speed, and working memory. The research design was non-experimental (causal-comparative or ex post facto) as there was no manipulation of variables by the researcher (Gall, Borg, & Gall, 1996). The following chapter outlines research focused on the role of executive function in education and music.

CHAPTER TWO

REVIEW OF LITERATURE

Chapter 2 is divided into three sections: executive function, cognitive transfer, and executive function and musical training. This section will lay the foundation for the specific areas of EF focused upon in this research. The second section will address cognitive transfer. Section three provides an overview of the interaction of executive function and music by introducing various models used in contemporary education strategies.

Defining Executive Function

The term *executive function* was introduced by behavioral psychologists attempting to identify deficit brain processes essential to the meaning of attention-deficit/hyperactivity disorder in the late 1980's (Barkley, 1997). Implications as to the functionality of the processes of executive function spurred research for the next decade which contributed to the medical model of executive function, consisting of neuropsychological and neuropsychiatric perspectives on executive function. Through these models, connections have been made, through the identification of specific processes, creating a bridge into the education psychology and general education fields. This connection occurred through the use of common processes such as processing speed, selective attention, and working memory, which had been studied for many years prior to their categorization as executive function.

Executive function are differentiated by appropriate self-regulatory skills, task switching, and inhibition (Delis, et. al, 2007; Denckla, 2001; Goldberg, 2001; Welsh, Pennington, &

Grossier, 1991). Due to the underlying principle of adaptation inherent in executive function, it serves to reason that it can be considered an important aspect of the human experience. Barkley (2001) attributes mankind's ability to adapt to changing situations and environments while also creating innovative methods of problem-solving to executive function - a higher-order function unique to our species. It is that ability to adapt that has aided in the continued growth and development of the human species.

Executive function account for the manner by which people process and implement information. This is the key difference between executive function and general cognitive ability. One differentiating factor involves the acquisition of information and not the execution of the acquired knowledge. An area of executive function is problem-solving; the manner by which an individual devises a solution is reflexive of the efficiency of their cognitive flexibility (Caine & Caine, 2006, Denckla, 1999). Initiating problem-solving skills requires the application of acquired knowledge to develop and execute potential solutions (Denckla, 1994, Goldberg, 2001; Struss, 1992). Contrary to the intuitive thought that basic cognitive skill sets are required to commence higher order thinking, there is not necessarily a one-to-one correlation between basic and higher order cognition. Recent studies suggest that it is possible for an individual's executive functioning ability to function independently of general intellectual ability (Delis et al., 2007). General cognitive ability and executive function, therefore, are not synonymous which is shown in the ability of some individuals to have higher relative executive functioning while others demonstrate low levels of executive functioning as compared with their general intellectual ability. The development of one type of process does not necessitate the growth and development of the other.

Executive function processes are progressive and begin in infancy while continuing through early adulthood (Barkley, 2001; Denckla, 1994; Goldberg, 2001; Welsh, Pennington, & Grossier, 1991; Ylvisaker & Feeney, 2002). Various studies suggest that the development of executive function is similar to that of the frontal lobe, also linking the various processes with the frontal lobe as their locus (Brocki & Bohlin, 2004; Casey, Giedd, & Thomas, 2000; Denckla, 1994; Rabbit, 1997; Tranel, Anderson, & Benton, 1994; Welsh, Pennington & Grossier, 1991). As individuals mature and age, the frontal lobe develops which stimulates the development of complex cognitive abilities (Denckla, 1994; Denckla, 1999; Rabbitt, 1997). This development is integral to the acquisition of cognitive skills. Research suggests that successful performance on executive functioning tasks is often dependent on successfully developed ability on basic cognitive tasks (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Goldberg, 2001; Kramer, et al., 2007).

As an encompassing term, executive function include various cognitive processes within the brain. In its earliest inception, developmental research literature has served as the basis for identifying the individual components included within this concept. Research literature has an extensive base in the roles and definitions of cognitive processes such as planning and attention as separate, individual cognitive processes (Brocki & Brohlin, 2004; Lyon & Kransnegor, 1996; Rindermann & Neubauer, 2004; Zelazo & Frye, 1998), but not as their inclusion within the executive function domain. Within the base of research, there is a great amount of variability in the various processes which make up executive function. This may be attributed to the propensity for the same ability to be identified by different names within the literature (i.e., "switching" and "set-shifting") (Kalkut, 2010). Kalcut (2010) also identifies that this attribution may be due to the difficulty in identifying each individual component of executive function (7).

Although the processes of attention and memory have dominated the majority of research in executive function (Denckla, 1996; Meltzer, 2007), these are not the sole representations of the processes involved. This dominance has caused a rift in the amount of literature focused on these processes versus the other aspects of cognitive performance.

As previously stated, there are a number of various processes included under the veil of executive function (Denckla, 1994). Elliott (2003) concludes that the executive function include working memory, reasoning, and task flexibility. Monsell (2003) disputes that problem-solving is also an integral part of executive function. Chan et al. (2008) include planning and execution as component processes. In various studies by Bugos (2009 & 2011), strong cases are made for the inclusion of processing speed. These processes, although unique in function, are related which has led to their inclusion. Due to their inter-relatedness, there has been much debate as to whether the term *executive function* represent a unitary or multifaceted paradigm (Denckla, 1994; 1996; Gioia et al, 2002; Meltzer, 2007). From the unitary viewpoint, executive function facilitates the completion of goal-directed behaviors (Gioia et al, 2002; Goldberg, 2001). In completing goal-directed tasks, the various components work cooperatively to complete the desired task. Due to their close working relationship, researchers experience difficulty identifying the individual components.

To the contrary, the various processes that comprise executive function may also be observed as multifaceted and operating separately, as opposed to in tandem. Denckla (1994 & 1996) and Gioia et al. (2002) argue that while the various components of executive function may relate to each other, they exist as separate, identifiable abilities. In identifying specific processes, neurologists have developed methods of mapping out the various locations of brain patterns and processes that complete specific functions. The neurology literature supports the notion that executive function are composed of identifiable processes that work in tandem (Denckla, 1999; Nauta, 1971; Salloway, 1994; Tranel, Anderson, & Benton, 1994). This work is supported by literature examining executive dysfunction with frontal lobe development, the area in which many executive function have been localized through imaging studies (Baddaley, Della Sala, Papagno, & Spinnler, 1997; Denckla, 1996; Goldberg, 2001; Nauta, 1971; Salloway, 1994; Tranel, Anderson, & Benton, 1994).

Models of Executive Function

There are a number of different models of executive function that outline the manner in which these cognitive processes interact within the brain. One notable model focus on the executive function of working memory (WM). Baddeley's multicomponent model of working memory suggests that WM is composed of a central executive system that regulates three other subsystems: the phonological loop, which preserves verbal information; the visiospatial sketchpad, which retains visual and spatial information; and the episodic buffer which integrates short-term and long-term memory, holding and manipulating a limited amount of information from multiple domains in temporal and spatially sequenced time periods (Baddeley, 1986, 2002).

Another conceptual model is primarily derived from work examining behavioral inhibition. The Self-Regulatory Model depicts executive function as a system composed of four main abilities: working memory, goal-directed behaviors, self-directed speech, and information synthesis (Barkley, 1997). According to this model, working memory allows individuals to resist interfering information. Next, goal-directed behaviors are achieved through the management of emotional responses. Following this is the internalization of self-directed speech which is used to control and sustain rule-governed behavior. This internalization generates plans for problem-solving. Finally, information is analyzed then synthesized into new behavioral responses to meet the goals of the individual. Altering behavioral responses to meet new goals or modify an objective is considered a higher level skill that requires a combination of executive function including self-regulation, as well as the accessing of prior knowledge and experiences.

A widely accepted conceptual model of executive function was created by Lezak (1995, 2004) and proposes that four broad domains work together to accomplish global executive function needs. In this sense, the term *global* refers to the executive function operations needed throughout the brain (Lezak, 1995, 2004). The four domains include volition, planning, purposive action, and effective performance. Although this model may appeal to researchers as it assists in identifying and assessing various executive function components, it lacks a distinct theoretical basis and has had relatively few attempts at validation (Anderson, 2008).

The Miller and Cohen Model of executive function argues that cognitive control is implemented by increasing the gain of sensory or motor neurons that are engaged by task- or goal-relevant elements of the external environment (2001). They also claim that this process is the primary function of the prefrontal cortex. This model draws upon a theory of visual attention that identifies perception of visual scenes in terms of competition among various elements such as colors and objects. The ability to selectively narrow the focus of attention to search for a specific object acts as a selective attention mechanism. This selective attention mechanism is a facet of cognitive control (Miller & Cohen, 2001). According to this model, the prefrontal cortex can exert control over sensory input or response output neurons, as well as functions involved with memory and emotion. This cognitive control is mediated by joint prefrontal cortex connectivity with the sensory and motor cortices and the limbic system (Miller & Cohen, 2001). Miller and Cohen apply the term 'cognitive control' to any instance in which a signal is used to elicit task-appropriate responses. This control is responsible for regulating processes such as selective attention, error monitoring, decision-making, memory inhibition, and response inhibition (Miller & Cohen, 2001).

The final model outlined was created by Miyake and Friedman and proposes that executive function contain three specific facets: updating, inhibiting, and shifting (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). Understanding the individual differences within executive function is paramount to this framework. This model suggests that executive function reflect both unity and diversity within each component. Updating is defined as the continuous monitoring and quick addition or deletion of content within working memory. Inhibition refers to the capacity to override responses that are associated with a given situation. Shifting is the cognitive flexibility to switch between different tasks or mental states. These characteristics of updating, inhibition, and shifting within the executive function are related, however, each remains an independent unit. The Miyake and Friedman Model also purports that there are four general conclusions about executive function found within the literature. The first conclusion refers to the unity and diversity of the processes mentioned earlier (Vaughan & Giovanello, 2010; Wiebe, Espy, & Charak, 2008). The second conclusion is the executive function skills are inherited. This is seen through studies involving twins (Miyake, Friedman, Young, DeFries, Corley, & Hewitt, 2008). The third conclusion gleaned from the literature was that measures of executive function can differentiate between normal and regulatory behaviors, such as ADHD (Friedman, Haberstick, Willcutt, Miyake, Young, Corley, and Hewitt, 2007; Friedman, Miyake, Robinson, & Hewitt, 2011; Young, Friedman, Miyake, Willcutt, Corley, Haberstick, & Hewitt, 2009). The final conclusion was that longitudinal studies demonstrated that executive function skills are relatively stable throughout development (Mischel, Ayduk, Berman, Casey, Gotlib, & Jonides, 2011; Moffit, Arseneault, Belsky, Dickson, Hancox, & Harrington, 2011).

Each of these models offers a perspective on the significance of executive function in development. Understanding how executive function operates and interacts within the brain allows for the ability to observe the influence of external stimuli on their output function.

Identifying Components of Executive Function

Over the past decade, executive function have become an increasingly investigated area. However, in this investigation, there still lies much controversy over the various components included. As identifiable processes within the brain, sustained mental activities, such as abstract reasoning, planning, sequential processing, and problem solving (Barkley, 2001; Chan et al, 2008; Denckla, 1996; Goldberg, 2001), represent additional aspects of executive function. These meta-cognitive components represent the actions which occur during the period of time between delay and response, or during mental activity (Denckla, 1996), and are most often identified on cognitive tasks (e.g., problem solving). Although traditional models of executive function tend to identify EF as encompassing a set of inter-related, but separate processes rather than a singular process, it remains unclear what specific processes define executive function. Since the various processes involved with executive function are often inter-related, it may be difficult to distinguish the executive function from one another (Denckla, 1996). The present research will focus upon attention, working memory and processing speed.

Denckla (1996) also introduces various behavioral components (e.g., inhibition, delayed-responding, set maintenance) as the "control processes" of executive function because of their relationship to motor processes and behavioral output. Similarly, Barkley (1997) argues that the behavioral aspects of executive functioning represent a separate aspect within the domain. He purports that behavioral inhibition, in particular, is central to other executive function in that it allows for sustained mental attention to occur. It has been identified as both an important precursor to other executive function and one of the earliest executive function to emerge (Barkley, 2001; Brocki & Bohlin, 2004; Kalcut, 2010). The ability for delayed gratification surfaces in early infancy. During this time, infants also become more efficient at regulating their emotions and controlling their behavior. Although this processes has been shown to act as a precursor to other executive function, major cognitive developmental advances occur between the ages of 7 - 12 (Brocki & Bohlin, 2004). Another aspect of behavioral inhibition that brings it to the forefront of executive function is that it can be an observable characteristic of executive function, particularly to educators and caregivers working with children during this time, as they are experiencing various developmental stages (Denckla, 1996 & 1999). For example, the behavior of a young child has to be regulated through constant reminder by a supervising adult as the appropriate course of action, while an adolescent is more capable of self-regulation. An individual's ability to control an initial response in the presence of an immediately stimulus and engage in self-regulation is an indication of successful development of behavioral inhibition (Barkley, 1997 & 2001).

Attention

Attention, one of the foremost attributes of executive function, is closely related to behavioral inhibition; this stems from the concept that when one behavior is being engaged or inhibited, the antithesis is taking place to another (Denckla, 1994 & 1996). Posner (2004) proposed a model of how inhibitory mechanisms involved in the attention networks interact. Within Posner's model, this concept is identified and suggests that attention develops from a relative controlled response. As per this model, infants are initially reactive to various stimuli within their surrounding environment. This external stimuli operates to regulate their internal distress through alerting and dictating responses, which ultimately transforms into the ability to shift orientation and attention towards the external stimuli (Rueda et al., 2004 & 2005). This level of attention differentiation acts as a precursor to more complex attention control. This characteristic of attention processes leads it to be grouped into the executive function processes.

Control of the ability to shift from one external stimuli to another involves self-regulation, or conscious effort of personal action. As command of this ability improves, children advance toward goal-oriented attention (Rueda et al., 2005). In this volitional attention, children chose to attend to stimuli due to its novelty and attraction, not because of the distress it may cause. This form of attention continues to develop through adolescence (Anderson et al., 2001; Casey et al., 1997; Lyons, 1996; Rueda et al., 2004). Individuals who demonstrate a stronger command over the ability to switch attention are considered to posses more flexible thinking skills (Zelazo & Frye, 1998). This flexibility may also result in novel and divergent thinking patterns. The maturation of this ability also demonstrates the capability of attending to more complex tasks. With this maturity also comes the ability to shift attention across tasks and engage in more cognitively stimulating activities (Zelazo & Frye, 1998).

Executive function are differentiated from basic brain function by the duality in the processes which encompass the domain. The processes within executive function serve as a dual process of cognition and behavioral control (Kalcut, 2010). Executive function itself is the result of an integration of multiple mental functions. Once these various functions are developed they interact and operate with fluidity to accomplish the goal of self-guided behavior in an individual (Barkley, 2001). The motor skills involved in the functioning of EF processes must be acquired prior to the development of the appropriate complimentary cognitive process. The executive function component of these motor skills involves the voluntary behavioral inhibition and attention selection in order to engage in self-regulated activities. Once individuals claim a strong control over the self-regulation of the executive processes, they are able to engage in various cognitive tasks associated with executive function more efficiently (Barkley, 1997; Denckla, 1996 & 1999; Goldberg, 2001).

Working Memory

Working memory is the ability to represent various forms of information within the mind acquired through experience (Barkley, 2001; Schulze & Koelsch, 2012). Working memory differs from simple recall in that it involves the ability to manipulate mental activity and integrate the past with current perceptions while maintaining vision toward the possible future (Barkley, 2001; Denckla, 1996 & 1999). The designation itself as working memory and not simply memory implies a more dynamic function as opposed to a stagnate storage system. Received information is stored as potential material for a subsequent task. An example of this would be simple recall tasks such as hearing a list of numbers, mentally sequencing them, and repeating them back in sequence. In music, this may be demonstrated by listening to a melody and repeating it back either via an instrument or vocally.

The operations that take place through the function of working memory help to facilitate the ability to engage in complex thought processes. An aspect of this brain function is the internal dialogue that is developed which allows tasks to be worked through without the aid of external assistance or direction. As working memory processes increase and improve, solutions can be created completely internally, consisting of weighing solutions and various outcomes and ultimately selecting a course of action. This effective function of working memory is composed of an "awareness of the activity of the mind" (Denckla, 1996). This use of working memory as an internal trial and error process is more efficient than an external application of the same process.

Baddeley and Hitch (1974) suggest a model of working memory that contains three components: the phonological loop, the visuospatial sketchpad, and the central executive. The phonological loop, also known as the articulatory look, is said to be responsible for maintaining speech-based information. The visuospatial sketchpad is assumed to establish and manipulate visuospatial imagery. Each of these components facilitate the functionality of the working memory, however, the central executive aspect serves as the primary connection with other executive function processes. This primary system is supplemented by the two subsidiary slave systems (Baddeley & Hitch, 1974). The central executive is illustrated as the ability to divide attention between two simultaneous tasks (Baddeley, Chincotta, & Adlam, 2001; Wecker et al., 2005). Research suggests that the central executive aspect of working memory can be affected with frontal lobe lesions (Baddeley et al, 1997), speculating the connection and association with other processes involved with executive function. Other studies divide working memory into verbal and spatial components (Smith & Jonides, 1998). In equating the two models, the phonological loop serves as the verbal component to working memory, while the non-verbal component is represented by the visuospatial sketchpad. This separation within working memory is supported by various studies which indicate that different brain regions are involved in the processing of the various tasks (Smith & Jonides, 1998).

Processing Speed

The ability to attend to specific stimuli, manner by which behaviors are directed and inhibited, and the ability to internally represent information are all operations involved with executive function and constitute an essential role in higher level cognitive thinking. The speed of information processing also constitutes an important basis for cognitive abilities (Rindermann & Neubauer, 2004). Processing speed is defined as the rate by which an individual processes information, or the incoming stimuli received from the surrounding environment. Four fundamental principles have been identified as integral to the information processing speed model. These pillars include thinking, the analysis of stimuli, situational modification, and obstacle evaluation (Wallace, Ross, & Davies, 2003).

In contemporary society which values speed and efficiency as a necessity in order to thrive and compete, the rate at which individuals process information can serve to be an extremely valuable tool. In its earliest inception, information processing speed was measured in terms of reaction time (Galton, 1883). Galton (1883) also observed diverse sensory and motor variables in relation to independent indicators of accomplishment or intelligence.

For quite some time, very little research is recorded in addressing these factors and their association with brain function. This function reappeared in research studies addressing oscillation rate (Jensen, 1982) and neural efficiency (Vernon, 1993). These processes have aided in the construction of the mental speed theory of intelligence. According to the mental speed theory of intelligence, the speed of information processing constitutes an important basis for cognitive abilities (Rindermann & Neubauer, 2004). Intelligence plays a significant role in the identification of processing speed. According to various studies, individuals who possess a higher IQ use their brain more efficiently. The higher cognitive abilities, such as intelligence and creativity, are said to influence real world cognitive performances (Rindermann & Neubauer, 2004). Mental performance speed has been viewed as a limiting factor in the development of cognitive abilities (Deary, 1995). In the early stages of perception, the development of general intelligence is determined by the speed of apprehension in which differences in processing speed may amass to greater discrepancies in intelligence, vocabulary, and performance (Deary, 1995; Jensen, 1982). Higher cognitive operations are a result of a high speed of processing in basic brain functions, resulting in higher brain efficiency.

Each of these cognitive processes contribute to the overall productivity involved with executive function. As noted, these various processes overlap in order and work together in order to increase efficiency and cognitive performance ability. The next section will identify various connections with executive function and educational performance, leading to connections between musical instruction and executive function.

Executive Function and Educational Performance

Executive function plays a substantial role in education. The skills of goal-setting, planning, organizing, and memorizing are among the skills shared cross-subject that aid in student functionality and achievement. In its earliest reference to education and in much of contemporary research, *executive function* is most commonly associated with attention-deficit/hyperactivity disorder and learning disabilities (Barkley, 1997; Denckla, 1996; Gardner, 2006; Lyon & Krasnegor, 1996; Meltzer, 2007; Stanberry, 2008). Since 1980, the cognitive emphasis on *attention* has dominated much of the executive function association with ADHD/LD (Denckla, 2007). Over time, and through collaborative, cross-domain research efforts, this term has encompassed more familiar terms including planning, organization, study skills, and self-monitoring/checking skills. The identification of these terms in the area of executive function have allowed for connections to be made between the educational, educational psychology, and medical research fields. These specific terms appear throughout education research literature dating back over 40 years (Adams, 1987; Anderson, et al., 2001; Baddeley, Chincotta, & Adlam, 2001; Barkley, 1997; Bugos & Mostafa, 2011; Caine & Caine, 2006; Denckla, 2007; Glaser, 1984; Goldberg, 2001; Lyon & Krasnegor, 1996; Nauta, 1971; Rabbitt, 1997; Stanberry, 2008; Vernon, 1993; Zelazo & Frye, 1998).

As mentioned before, both executive function and executive dysfunction account for cognitive processing within the brain. Inhibitory control, in an educational context, concerns the effects of ADHD which directly influence both EF and EDF (Barkley, 1997; Denckla, 2005). Inadequate inhibitory control has been traced back to reading disabilities (Block, 1993; Lovett et al., 1994; Loranger, 1997; Rosenshine & Meister, 1997; Vidal-Abarca & Gilabert, 1995). These studies have also illustrated a connection between ADHD, various learning disabilities, and reading disability. According to much of the research within the education domain (i.e., Graves, Juel, & Graves, 1998; Eisenberg, Lowe, & Spitzer, 2004; Selfe, 1999), reading, in most terms included under the category of literacy, is essential to the learning process. Literacy is an essential and necessary element in learning and cognitive transfer (Barnard, 2005; Cormier & Hagman, 1987; Leberman, McDonald, & Doyle, 2006) and as such, understanding the various aspects of executive function which can affect the development of this skill is important.

Howard Gardner relates the role of executive function to three parameters of human psychology: the *hill*, *skill*, and *will* (2006). The *hill* represents a clearly established goal. The *skill* follows the *hill* and is the abilities and techniques required to attain the established goal. The final step in this goal-oriented process is the *will*, which is the decision to engage in and persevere until the goal is completed. With respect to education, executive function represents the skills and processes involved with completing Gardner's process. The ability to successfully complete these processes stems from the person’s capacity to access and use self-relevant information, or intrapersonal intelligence (Meltzer, 2007). The manner in which individuals demonstrate executive functioning are widely different. These differences are in part developmental. The various processes involved in executive function each serve to enhance the way in which people complete activities, including the skills necessary in the educational environment.

Caine and Caine (2006) approach the influence of executive function in the educational domain by identifying the components of associated with learning, as opposed to introducing an association with the various processes in the realm of executive function. Caine and Caine (2006) and Kauchak and Eggen (1998) postulate that *learning* is the result of a constructivist doctrine - a process in which learners use their own experiences to create understandings that make sense to them, rather than having understanding delivered to them in an already organized form. They also identify the main components of learning to include memorization, gaining understanding, having an insight, behavioral change, skill development, and maturation (Caine & Caine, 2006). According to their studies (Caine & Caine, 1994, 2001), skill acquisition stems from a person's ability to make sense of one's self, irrespective of how much others know and how much instructional assistance they receive. An indispensable social and individual association to this acquisition is also seen as integral to the learning process, implying that learning is highly dependent upon the individual development and cognitive function. Executive function, as defined by Caine and Caine (2001, 2006), located largely in the frontal and prefrontal cortex of the brain, are associated with the coordination and synthesis of emotions, thinking, memory, and body or physical movement. Due to the responsibility given executive function as outlined in this definition, EF plays a crucial role in the development and maturation of integral control processes.

Executive function operate in a similar manner to a supervisor, or manager of a team. To use an education specific analogy, EF can be viewed as the principal of an institution. The principal does not teach the students or necessarily perform the same tasks as the teachers who are providing the instruction to the students, however, he or she is responsible for how the instruction of the faculty body works in tandem for the success of the students. The principal is responsible for determining the teacher-leaders and administration responsible for making curricular decisions, the amount of time given to a class period, and influences integration of specific materials within the classrooms. In this vain, the principal is acting as a moderator. In this same way, executive function combine elements of affect, self-regulation, working memory and inhibition, along with other processes included within the EF domain. EF are integral to higher order brain function and refer to abilities involved in purposeful and effective performance (Boone, 1999; Denckla, 1999).

Cognitive Transfer

Education is at the most basic level is based on the transfer of knowledge. In relation to executive function and education psychology, cognitive transfer is the specific process by which information is integrated and understood by a person (Glaser, 1984; Robertson, 2001). The term *cognitive transfer* may be viewed as a smaller umbrella within executive function as it relates to multiple specific functions, such as problem-solving and reasoning skills. The process involving cognitive abilities as they relate to education is also related to as *transfer* (of learning). *Transfer* most specifically entails how knowledge acquired in one context can be related to other contexts (Cormier & Hagman, 1987; Singley & Anderson, 1989; Leberman, McDonald, & Doyle, 2006). As a process of learning, *transfer* can take place in various ways. A number of categories of transfer have been identified throughout education research literature (Butterfield & Nelson, 1991; Mayer & Wittrock, 1996; Robertson, 2001; Singley & Anderson, 1989).

Transfer of learning is a fundamental assumption of education. Through the various processes, information is retained in order to be recalled during appropriate circumstances (Perkins & Salomon, 1996; Ripple & Drinkwater, 1982). In many arenas, transfer is observed on a dichotomous structure. For example, transfer is considered positive if performance and acquisition is facilitated and negative if it is impeded. When observing transfer in the context of one's work place, transfer is defined as the process of applying skills, knowledge, and attitudes acquired during a training regimen, whose successful application leads to a lasting improvement on job performance. Cormier and Hagman (1987) suggest that transfer of learning is one of the most general phenomena of learning. They also postulate that almost all learned behavior is interrelated in complex ways. Two encompassing perspectives on transfer include a process-model perspective and a situation-model perspective. Within these two perspectives there are a number of transfer labels and theories. For instance, transfer may include *near* vs. *far*, *specific* vs. *general*, *positive* vs. *negative*, *high-road* vs. *low-road*, *reproductive* vs. *productive*, *strategic* vs. *theoretic*, *meaningful* vs. *rote*, and *analytic* vs. *nonanalytic*, to name a few (Haskell, 2001; Leberman, McDonald, & Doyle, 2006; Mayer & Wittrock, 1996; Robertson, 2001; Salomon & Perkins, 1989; Singley & Anderson, 1989). These examples of contrary pairs within transfer theory illustrate the varying perspectives within educational research.

The process-model perspective on transfer focuses on the information being transferred and how that transfer occurs (Singley & Anderson, 1989) based upon meta-cognition and rule based thinking. An example of the process-model of transfer is *reproductive* vs. *productive* transfer. *Reproductive* transfer refers to the processes involved in the application of knowledge to a novel task. Its counterpart refers to the assimilation and enhancement of the retained information (Robertson, 2001). Another example of this form of transfer is *high-road* vs. *low-*

road transfer. In *high-road* vs. *low-road* transfer, the distinction is between instances of transfer in which active retrieval, mapping, and inference processes take place, as opposed to those occurrences which happen spontaneously or automatically (Mayer & Wittrock, 1996; Salomon & Perkins, 1989). *Low-road* transfer relates to frequently employed mental representations and automated knowledge, and occurs typically in what are known as *near* transfer contexts (Mayer & Wittrock, 1996; Salomon & Perkins, 1989). In contrast, *high-road* transfer requires cognitive and meta-cognitive effort.

Another illustration of a dichotomous distinction involving transfer of learning is that of *knowledge* transfer vs. *problem-solving* transfer. This exists due to the nature of these specific processes. *Knowledge* transfer occurs when knowledge acquired through a specific task facilitates or obstructs the learning process or performance in another task (Mayer & Wittrock, 1996). The specific knowledge utilized may be applicable to both tasks, causing an interaction of the information previously acquired. *Problem-solving* transfer, however, involves the application of acquired problem-solving skills stemming from one task onto another (Mayer & Wittrock, 1996). The specific problems may share little in terms of specific knowledge or procedures, but require similar approaches to determining a solution.

The situation perspective focuses on more tangible aspects of information transfer. Two of the more prominent types of situational transfer are *specific* vs. *general* (*near* vs. *far*) transfer. *Specific* vs. *general* transfer involves the relationship between the source of the transfer and the transfer target. This type of transfer involves the use of information from prior experience on a newly introduced concept. The relationship between these two transfer types as knowledge are limited in scope or applicable across diverse tasks and disciplines (Singley & Anderson, 1989). This is similar to the operational definitions of *near* vs. *far* transfer.

Near and Far Transfer

There is increasing evidence for the power of education on near and far transfer capabilities. Learning refers to near transfer of information, concepts, or skills. Without the transfer of information in education, learning does not occur. Learning contexts of information often differs from the context of application (Meltzer, 2007). Successful transfer of learning requires the completion of three main objectives: training content must be relevant to the task; the learner must learn the training content; and the learner must be motivated (Clark, 1999). It is imperative to remember these paradigms when constructing curriculum which requires near transfer or far transfer in order to facilitate transfer completion.

Near transfer of learning has been defined as an instance in which the stimulus for the initial learning event is similar to the stimulus for the transfer event (Cree & Macaulay, 2000; Laker, 1990; Royer, 1979). The skills and knowledge used in near transfer are applied in the same manner each time the set of skills and knowledge are encountered. Near training typically functions during procedural tasks. For example, the skills and knowledge used in the operation of a personal vehicle are also applicable if learning to operate a commercial vehicle. The advantages of near transfer are that the skills and knowledge sets are easier to train and transfer of learning is usually a success. The disadvantage is that near transfer is not adaptive in nature (Clark, 1999). If contexts change, the learner is unlikely to be able to adapt their skills and knowledge to the change. In reference to curricular design and instruction, educators should teach sequential processes that do not typically occur in an altered pattern in order to facilitate near transfer retention processes.

The main difference between near and far transfer is the environment in which the acquired knowledge is being applied. Far transfer involves skills and knowledge sets learned in a specific context with the potential to change. It can be specifically defined as the extent to which acquired knowledge is applied to a situation different from the context in which it was acquired.

This type of transfer relates closely with general cognitive transfer (as opposed to specific transfer). Far transfer allows for the process of generalization (the extent to which knowledge, skills, and attitudes acquired through learning are applied to different tasks of settings outside of the learning context) to occur (Adams, 1987). With regards to instructional design, generalization is of particular importance when looking to engage in far transfer. Far transfer provides learners with the ability to make judgments and adapt to different situations. However, far transfer skills are more difficult to instruct (Adams, 1987; Clark, 1999).

In reference to the varying degrees of difficulty in instruction of near and far transfer skills and knowledge, the literature suggests that each type of transfer requires a different type of learning. Requirements for near transfer depend mostly on the similarity between the task and the training (Kim & Lee, 2001). The skills required for far transfer depend on whether the instruction includes specific information about the assumptions underlying the skills and behaviors being learning (Laker, 1990). Henceforth, greater far transfer occurs in learners who best understand the underlying concepts, principles, and assumption of the instructed information (Goldstein, 1986). Another cited method of increasing far transfer efficiency stems from the amount of practice in various contexts involving new approaches and techniques in practice exercises (Baldwin & Ford, 1988; Cree & Macaulay, 2000; Goldstein, 1986). Positive reinforcement and self-efficacy also plays a role in the efficiency of far transfer. The more encouragement received both during and after instruction the greater the far transfer (Goldstein, 1986; Noe, 1986).

Factors Influencing Transfer

As previously discussed, transfer is a fundamental understanding in education. In this sense, the term *education* is representative of the institutional concept, involving primary and secondary schools, as well as colleges and universities, workplace concepts, various job training and facilitation programs. Within the professional, non-education realm, *transfer of training* involves the extent to which the knowledge, skills, and abilities acquire in training can be applied, generalized, and maintained over time and is seen as a benefit from investments in training and development (Baldwin & Ford, 1988; Salas & Cannon-Bowers, 2001). Information transfer, or learning, is an aspect of human existence that everyone is engaged in from birth until death. Due to its lifelong, universal applicability, there are a number of factors that have potential effects on the efficiency and longevity of the process. Research suggests that any number of these factors can influence transfer in both positive and negative ways (Ausubel, Novak, & Hanesian, 1978; Burke & Hutchins, 2007; Clarke, 2002; Eva, Neville, & Norman, 1998; Lim, 2000). Throughout the literature, there are five recurring elements that have been observed as playing a role in efficiency of transfer of knowledge. These elements include age, race/ethnicity, pre-existing knowledge, self-efficacy, and self-regulation.

Age

Age is viewed as a factor effecting many aspects of life. As an individual gets older, various abilities change in their function, whether the development and strengthening of a skill or the weakening and diminishing of an ability. The primary purpose of education is to develop specific skills as individuals get older to make them effective in society. A number of educational institutions base their learning curriculum on a spiral model of education, a model that builds from prior knowledge and relates specifically to the grade level or age of the students. According to Jellison (2006), a functional curriculum is also age-appropriate (p. 266). Research suggests that there must be a correlation between materials taught and the age of the individuals in order to yield the greatest and longest-lasting results (Burke & Hutchins, 2007; Kohler & Field, 2003; Jellison, 2006; Lim, 2000).

In elderly individuals, research has been conducted on the effects of the decrease in dopamine within the brain as they age. Dopamine is a neurotransmitter released within the brain that is responsible for stimulating a number of functions including those within the executive function domain. According to Volkow, Gur, Wang, et al. (1998), the decline in dopamine levels with age plays a significant role in the function, or dysfunction, of cognitive abilities, including transfer. This particular study documented an association between dopamine and measures and performance on behavioral measures of frontal lobe functioning, specifically the executive function processes of attention, mental flexibility, and response inhibition.

Cognitive aging is a term used to reference the process of brain maturation over time. One of the central findings in cognitive aging research is that the efficiency of transfer operations declines with age in adults (Paas & Rikers, 2001). This has been attributed to reduced working memory capacity, slowed processing speed, difficulties inhibiting selected-against or irrelevant information, and deficits in integrative or coordinative aspects of working memory (Paas & Rikers, 2001). This reduced capacity suggests that an age-related loss impairs the ability to engage in higher-order cognitive operations. Research intimates that age-related declines in cognitive performance are most likely to occur in complex cognitive tasks requiring individualized effort (Gilinski & Judd, 1994; Salthouse, Mitchell, Skovronek, & Babcock, 1989; Wingfield, Stine, Lahar, & Aberdeen, 1988). Since these tasks are highly dependent on the availability of sufficient cognitive resources for their successful completion, age-related declines in cognitive capacity cause uneven imbalances. When tasks become more complex or require large amounts of mental processing, older adults appear to be slower than younger adults.

Variances in speed are argued to be at the center of observable age performance differences (Fisk & Warr, 1996; Salthouse, 1994b). Light, Zelinski, and Moore (1982) established that older adults were not able to integrate information across multiple principles, even when these principles could be accurately recognized.

Race/Ethnicity

The role of race and ethnicity in education is another element of interest in research. Much of educational research is focused upon identifying factors that contribute to learning disparities between ethnicities. The terms of *race* and *ethnicity* are used interchangeably throughout the body of research. In American research literature, the main separation in racial categories lies between *mainstream white youths* and African-, Mexican-, and Puerto Rican-Americans (Anastasi & Cordova, 1953; Banks, 1988; Chan & Schmitt, 1997; Chan, Schmitt, DeShon, Clause, & Delbridge, 1997; Ellis & Ryan, 2006; Loehlin, Lindsey, & Spuhlet, 1975; Lynn, 1996; Nalodka, 1995; Tashakkori & Thompson, 1989; Turner & Turner, 1982; Wightman, 1997), but generally focuses on the relationship between White and African Americans. The Asian and Pacific Indian counterparts are often not addressed.

There are a number of elements within various ethnicities that contribute to learning and cognitive differences. The element that is observed most often is the aspect of standardized testing and implemented educational assessment tools. Research has illustrated that African Americans tend to score approximately 1 standard deviation lower than White Americans (Bobko, Roth, & Potosky, 1999; Brill, 1974; Ellis & Ryan, 2006; Jensen, 1980; Lynn, 1996; Neisser et al., 1996; Scarr, 1981; Schmitt, Clause, & Pulakos, 1996; Temp, 1971; Wightman, 1997). Some research suggests the majority of the learning gap between African American and White American cognitive-ability test performance is a result of heredity (Ellis & Ryan, 2006;

Jensen, 1984; Loehlin, Lindsey, & Spuhler, 1975), while alternate studies assert this disparity is the product of environmental causes (Driesbach & Keogh, 1982; Helms, 1992). Other research addresses the role of the tests themselves and the testing situation. While assessing the testing instruments, researchers have investigated possible cultural bias of question items (Williams, 1971; Wollack, 1994), the effect of stereotypes on ethnic minority performance (Banks, 1988; Steele, 1990; Steele & Aronson, 1995), and motivational differences between African Americans and White Americans (Chan & Schmitt, 1997; Chan, Schmitt, DeShon, Clause, & Delbridge, 1997). Within the body of research, the latter two aspects have accounted for a small explanation of the difference in test scores. Due to the limited findings, researchers have proposed other variables as factors impacting cognitive-ability test performance. These additional variables include the use of test-taking strategies, test preparation, and test-taking self-efficacy (Eels, David, Havighurst, Herrick, & Tyler, 195 1; Ellis & Ryan, 2006; Goslin, Epstein, & Hallock, 1965; Guion, 1998; Helms, 1992; Kalechstein, Kalechstein, & Doctor, 1981; Ortar, 1960; Schmitt & Chan, 1998). Of these three strategies, Ellis and Ryan (2006) found that the greatest equalizing variable among ethnicities in using test-taking strategies was the implementation of programs that identified ineffective strategies, as well as those determined effective.

Pre-existing Knowledge/Prior Experiences

The most important single factor influencing learning is previously acquired knowledge (Ausubel, Novak, & Hanesian, 1978). Research suggests that prior knowledge and experience have been shown to play a role in the learning process. More commonly referred to as experiential learning, experience-based learning postulates that the experience of the learner is the central to all facets of knowledge acquisition (Andersen, Boud, & Cohen, 2000). The role of experience in the learning process has been identified throughout the catalogue of time. Aristotle argues that men of experience succeed better than those who have theory but lack experience (Andersen, Boud, & Cohen, 2000). John Locke is also quoted contesting the importance of experience as responsible for teaching what reason cannot (Woozely, 1964). A more contemporary view identifies experience as both the foundation and stimulus for learning (Boud, Cohan, & Walker, 1993).

Experiential learning states that learning occurs through significant personal learning experiences. In order for learning to occur through experience, the event must be considered meaningful. These experiences may compose past or current life events, or experiences from activities implemented by teachers or facilitators. This definition would suggest that learning is a lifelong process. With this concept in mind, research suggests that learning functions as a continuous process grounded in experience (Kolb, 1984; Miller, 1993; Reason, 1988; Reason & Rowan, 1981).

Self-Efficacy

Self-efficacy, as it relates to academics and learning, has been described as personal judgments of one's capabilities to organize and execute courses of action to attain designated types of educational performances (Bandura, 1995). Bandura (1991) found that the stronger the perceived self-efficacy of an individual, the higher the goal challenges the individual sets for themselves which leads to a firmer commitment to accomplishing the established objectives. According to the research, learner commitment results in increased overall achievement. A study of complex learning and decision making demonstrated the significant influence of self-efficacy on cognitive processes (Wood & Bandura, 1989).

Self-efficacy has been linked to behavior within the academic setting (Bandura, 1986; Schunk 1989). This is significant because behavior is seen as a function of numerous variables including skills, self-esteem, outcome expectations, and the perceived value of outcomes (Schunk, 1989). It is important to note that while self-efficacy plays a role in successful transfer, high self-efficacy will not necessarily produce adept results without the presence of fundamental skills. In this manner, the perception of the outcome expectations play a significant role as individuals are not typically motivated to act in a way which results in negative outcomes.

Research involving self-efficacy and transfer has also been tied to specific ethnicity societal roles. Various studies stated an expectancy to observe a lower self-efficacy within the African American population as opposed to the White American population with regards to test ability, but instead discovered that African Americans possess a more positive general self-assessment and have self-esteem levels which are equal to or greater than their White counterparts (Crocker & Major, 1989; Ellis & Ryan, 2006; Hughes & Demo, 1989; Tashakkori & Thompson, 1989; Turner & Turner, 1982). These studies have also suggested that this variance may be due to the quality of the home life of the participants or the relationship between self-efficacy and self-esteem, creating a greater sense of self-worth in those individuals. Regardless, individuals who exhibited more prominent self-efficacy, tended to score higher on the administered assessments.

Self-Regulation

Self-regulation is the means by which an individual manages themselves in order to attain their goals (Barkley, 1997). More specifically, self-regulation involves any self-directed action that results in a change in behavior in order to attain a goal or avoid future consequence. The elements within self-regulation are closely related to those included in the concept of executive function including goal setting, self-monitoring, self-instruction, and self-reinforcement (Bandura, 1986; Harris & Graham, 1999; Schraw, Crippen, & Hartley, 2006, Schunk, 1996;

Schunk & Rice, 1987; Schunk & Zimmer, 2003). As with learning and cognitive transfer, self-regulation continues throughout the lifespan of an individual. This process can be one of the more influential aspects of learning, similar to self-efficacy, in that it can establish high goals and expectations an individual desires to accomplish. Because the expectations are originated by the individual who is responsible for accomplishing them, there is a great opportunity for success.

Self-regulation itself is composed of three key sub-processes: self-monitoring, self-instruction, and self-reinforcement (Schunk and Zimmerman, 2003). Self-monitoring involves purposeful attention to a specific behavior, taking into account the frequency and intensity (Mace & Kratochwill, 1988). This is an integral aspect of self-regulation as individuals are unable to regulate behavior is they are unaware of their actions. Regularity and proximity are also essential to the self-monitoring process by providing consistency with reinforcement (Bandura, 1986). Self-instruction stimulates self-regulatory responses that lead to reinforcement. Through this process, individuals develop a sense of responsibility for their learning. Schunk and Rice (1987) established a process in order to assist individuals in increasing ability in the self-instruction process. With the implementation of this process, students were found to experience greater levels of transfer than students who were not self-regulated and did not engage in the self-instruction activities (Schunk & Rice, 1987). Self-reinforcement, the final component of the self-regulation sub-processes, is the process by which individuals engage in reinforcement activities dependent upon their performance and increases the likelihood of a positive future response. Research has demonstrated the effectiveness of the self-reinforcement aspect on cognitive transfer or learning (Bandura, 1986). Each of these elements, although able to act independently, function as an aspect of self-regulation, which has been shown to have a positive influence on transfer, as previously discussed. Self-regulation has also shown a connection with motivation (Zimmerman & Schunk, 2001, 2008).

Executive Function and Music Learning

Research involving the connection between musical training and cognitive development is a growing area of interest. Many studies suggest that music training is associated with increases in cognitive performance (Bugos & Mostafa, 2011; Moreno, Bialystok, Barac, Schellenberg, Cepeda, & Chau, 2009; Olson, 2009; Schellenberg, 2004, 2005). There is a counter argument that suggest that smarter individual enroll in music programs or that music has the capacity to generally enhance overall cognition rather than specific cognitive processes (Schellenberg, 2005). The research support for cognitive transfer as a result of musical training should not be ignored, but rather investigated more thoroughly with experimental research.

The processes involved in executive function, also play a role in music learning. Goldberg (2001) uses an analogy of an orchestra director to elaborate on the operation of executive function. In the same manner by which an orchestra director directs the movement and flow of the musical performance without performing on the instruments themselves (controlling the soloist and ensemble volume, adjusting the ebb and flow, etc.), so executive function is responsible for the interaction between the various cognitive processes in the brain. Often the question has been asked whether or not participation in structured, academic music courses increases students' intelligence. Various studies support the role of music instruction in increased cognitive functions (Bugos & Mostafa, 2011; Moreno, Bialystok, Barac, Schellenberg, Cepeda, & Chau, 2009; Olson, 2009; Schellenberg, 2004, 2005). The executive function identified in research literature include processing speed (Bugos & Mostafa, 2011; Schellenberg, 2005), working memory (Berz, 1995; Schulze & Koelsch, 2012), and attention (Flowers, 2001; Shih, Huang, & Chiang, 2012).

In recent past, Schellenberg (2004, 2005) has studied the role of executive function (transfer and processing speed, respectively) on human activity and intelligence scores. His results demonstrate a noticeable difference in intelligence scores with participation in music courses. In regards to the specific character of music participation that increases the efficiency of executive function, Schellenberg (2005) postulates that music lessons can lead to short-term and long-term cognitive benefits. He also identifies four key components to his hypothesis on the uniqueness and effectiveness of music instruction on cognitive skill increase: music instruction is a school-like activity that many children enjoy, multiple skills are trained in music lessons, music is a domain that improves abstract reasoning, and acquiring musical knowledge is similar to acquiring a second language (Schellenberg, 2005, p. 320). His third point addressing the improvement of abstract reasoning is significant. This observation ties in with the role of far transfer, the process involving the ability to have flexibility in the manner by which the knowledge and skill of specific concepts are used in out-of-domain arenas. As previous literature has pointed out, far transfer involves more intricate cognitive processes that are not as easily trained and mastered by the majority of learners (Adams, 1987; Goldstein, 1986; Kim & Lee, 2001). This finding would imply that a benefit of music learning and a contributing factor to a possible increase in intelligence stems from the ability to identify, access, and develop more intricate cognitive processes through music participation. Denkla (1999) suggests that executive function are central to higher order brain operations and contain strong overlap with attention and memory.

Unlike Schellenberg's studies, Degé, Kubicek, and Schawrzer (2011) investigated the role of multiple processes involved in executive function on intelligence. This study sough to identify an association between music lessons and intelligence as mediated by executive function. The specific observed functions included working memory, planning, set shifting, selective attention, fluency, and inhibition. Results of this study discovered significant associations between music lessons and all measures of executive function. Executive function acted as a mediator between intelligence and music lessons, which was partially accredited to the positive influence music lessons have on executive function. This positive influence, in turn, improves performance on intelligence tests. The most robust results were found in the areas of selective attention and inhibition. These findings contribute to the argument raised by Schellenberg involving the ability of formal music training on higher order cognitive processes (Schellenberg, 2004, 2005).

Another aspect of executive function that has been researched in regards to music is that of information processing speed. Whereas transfer observes the travel of information, information processing speed is defined as the ability to receive and react on attained information (Kail & Salthouse, 1994). Wherein Denckla (1999) suggested that all executive function was central to higher order cognitive processes, Rindermann and Neubauer (2004) suggest that processing speed is, in fact, the integral aspect for higher-order cognitive abilities. With regards to its role in music training, information processing speed is evident in the everyday recall of past material required to perform. Musicians use their prior knowledge to continue to build upon new information. Music students are encouraged to use near and far transfer to adapt new information. Bugos and Mostafa (2011) suggest that music training enhances overall processing speed. This attribute may be responsible for more flexible problem-solving and strategic skills.

A Model of Executive Function as it Relates to Music

The Expertise Model focuses on the role of practice time on expert performance and relates to music instruction (Ericsson, Krampe, & Tesch-Romer, 1993). Ericsson, Krampe, and Tesch-Romer (1993) illustrate expert performance as a result of effort to improve performance over an extended amount of time while negotiating motivational and external constraints. One of the main aspects in practice accounting for discrepancies in ability is deliberate practice. They argue that expert performance does not stem from an innate talent that is only held by expert performers. The differences between expert performers and normal adults are a result of an extended period (ten years is prescribed in this study) of deliberate effort to improve performance ability within a specific domain. This model asserts that through prolonged repetition, improvement occurs. This model agrees with the conclusions of various studies (Bugos & Mostafa, 2011; Bugos & Mazuc, 2013; Caine & Caine, 2006; Gruhn, Galley, & Kluth, 2003) which cite the improvement of various aspects of learning, specifically cognitive processes, through longer exposure.

Another aspect of the expertise model is the adaptive view on non-expert performers. This model asserts that untrained adults can overcome limitations on cognitive skills (speed and processing capacity) by acquiring new cognitive skills that avoid the limitations (Ericson, Krampe, & Tesch-Romer, 1993). This is not to say that everyone is capable of the same high level of performance. This model does not present a utopian perspective that everyone has the potential to become masters of a craft, however, everyone has the potential to become an expert performer. The practices of expert performers also aid in attaining their high level of performance prowess. There are other variables that play a role in attaining this level of performance, i.e., engaging in private instruction from an early age. Although this model cites the significance of the time variable, research remains unresolved as to the significance of practice time as the crucial factor in developing musical expertise (Gruhn, Galley, & Kluth, 2003).

Music training has been seen to enhance executive function, specifically in relation to the function of processing speed (Bugos & Mostafa, 2011; Bugos & Mazuc, 2013). Research involving violin instruction found significantly enhanced processing speed index scores for *musicians* versus *non-musicians* (Bugos & Mazuc, 2013). These particular results enforce the results of an earlier that gleaned similar results in college *musicians* and *non-musicians* (Bugos & Mostafa, 2011). Research with expert musicians found strong correlations between the level of musical performance and formal practice with enhanced processing speed and motor skill acquisition (Ericsson, Krampe, & Heizmann, 1993; Sloboda, Davidson, Howe, & Moore, 1996; Howe, Davidson, & Sloboda, 1998). These results suggest a positive relationship between music instruction and processing speed at the expert and novice levels.

Summary

Executive Function processes consist of various cognitive processes that contribute in some way to an individual's development. These functions relate to the efficiency of the transfer of learning. There are a number of factors that may affect the operation of the various executive function. Research demonstrates a relationship between these cognitive processes and music participation; however, the body of literature lacks focus on secondary music and instrumental band participation as it relates to this relationship.

CHAPTER THREE

METHODOLOGY

The purpose of this research was to compare the performance of adolescent students who have previously received formal band instruction and those who have not on measures of executive function, specifically the processes of attention, processing speed, and working memory. The research design is causal-comparative or non-experimental (Gall, Borg, & Gall, 1996) as the principal investigator did not manipulate any specific variables. There are a number of measures that were adapted for group administration. The participants met in an auditorium at a pre-disclosed date and completed the initial research questionnaire. Next, they completed the musical measures in groups. The participants returned the following weekend to complete the cognitive measures. The data were then analyzed for correlations in the strength of relationship between cognitive and musical scores with key variables. The participants were matched by age, gender, educational level, socio-economic status, and an estimate of intelligence.

Participants

Recruitment for this study included one hundred twenty high school students enrolled at Claude Leon King High School in Tampa, FL. The participants included male and female students between the ages of 13-18 and in grades 9-12. The researcher categorized the students into two separate groups, students who have received at least two years of formal band instruction with music reading ability and those students who have not received at least two years of continuous formal music instruction within the past two years, not practicing an instrument, and not engaged in music reading. As this study centered around the effects of formal music instruction, participation in private individual lessons or any other form of music instruction without enrollment in the band program served as an excluding variable. Half of the student participants (60) were individuals enrolled in at least one band course at King High School. The remaining members originated from the non-music student body. Students were recruited through their homeroom classes. The principal investigator visited each homeroom in the school and explained the study to elicit participation. Informed written consent was obtained from legal guardians and child assent in accordance with the procedures of the Institutional Review Board (IRB).

All participants underwent a battery of cognitive measures focused upon three areas of executive function. Attention and working memory were observed through the administration of the *Digit Span*, *Arithmetic*, and *Letter-Number Sequencing* subtests. The raw scores of these measures formulate an overall working memory index. Processing speed was assessed through the *Coding* and *Symbol Search* subtests. These assessments from the WAIS-IV measure were chosen due to their reliability and content validity. The participants also completed a the Advanced Measures of Musical Audiation, the Music Reading Assessment, the Musical Nuance Test, and the Test of Musical Sensitivity. These musical assessments were chosen because they represent the standard of musical assessments used in current research to gauge the musical ability and aptitude of students.

King High School is an International Baccalaureate Program with an Advanced Placement program option for tradition program students. The goal in participant selection was to have an equal representation of individuals from each of these programs. Age, gender, and ethnicity were not accounted for in the initial recruitment of participants, however, demographic information recorded served as data for future variable correlational analyses. Prior to study participation, students and parents received information regarding the description of the study, as well as, the nature of the research. Students invited to participate met music education and educational institution criteria, as previously explained. Inclusion criteria included students ages 13-18 years enrolled at King High School in ninth through the twelfth grade. Exclusion criteria included the following, as they identified aspects outside of the assessment criteria: students younger than 13 and older than 18, private music instruction participation, *musicians* who have received less than two years of music instruction, and *non-musicians* who have received formal music instruction in an ensemble setting while in their middle school programs. Additional exclusion criterion included the following, as they could affect performance on neuropsychological assessments: individuals diagnosed with cognitive impairments, a previous history of electroconvulsive therapy or neurological illness, individuals currently taking sleep medications, anti-depressants, ADHD medications, and/or psychoreactive medications such as antichlorenegics (any medications that can adversely affect cognitive performance). Assessments required five hours to complete and students did not receive any incentive for participation. The initial research questionnaire collected demographic data for the sample (Appendix A).

Baseline Intelligence Measures

The two subset form of the *Wechsler Abbreviated Intelligence Scale* (WASI; Wechsler, 1999) generates an estimate of intellectual functioning (Full Scale IQ) and consists of Vocabulary and Matrix Reasoning. According to the WASI manual, the WASI two-subtest FSIQ score has an internal consistency reliability coefficient for children of .93 (vocabulary) and .91(matrix reasoning). This is consistent with reliability coefficients for a FSIQ obtained from the full *Wechsler Adult Intelligence Scale*-Third Edition (WAIS-III) (Wechsler, 2008). The WASI manual reports that the WASI FSIQ and the WAIS-III FSIQ are highly correlated (r =

.92). The WASI was nationally standardized with a representative sample of 2, 245 individuals aged 6-89 years. The WASI has been demonstrated to have good reliability and validity. Administration of the WASI was modified for group administration and took approximately 30 minutes.

Music Measures

Gordon's *Advanced Measures of Music Audiation* (AMMA; Gordon, 1989) is an evaluation of aptitude, potential, and not achievement. This assessment provides tonal and rhythmic composite scores based on aural stimuli that consists of 30 paired melodic phrases. The audiation measure requires individuals to indentify if the phrases are the same, tonally different, or rhythmically different. Tonal and rhythmic scores are generated from the results and combined to produce the composite scores. The test-retest reliability of the tonal test is 0.81 using the raw scores for high school students. The rhythm test is structured similarly to the tonal assessment with the exception that the rhythm may change, but the tones and tempo remains the same. The rhythm test has a test-retest reliability of 0.82. The composite score generated by the AMMA is a composite total. The test-retest reliability for the raw composite score is 0.84 for high school students. AMMA performance is correlated ($r = .78$) to the *Music Aptitude Profile* (MAP; Gordon, 1989).

The *Musical Nuance Task* (MNT; Bugos, Heller, & Batcheller, 2014) is a 30-item measure that includes 15 items of three short musical motifs performed on the same instrument (cello, clarinet, or piano) and 15 items of three short musical motifs performed on each of these same three instruments. Two of the three performed phrases were considered the “same” in nuance and one was considered “different” in nuance. In a comparison of performance on the MNT between student musicians and non-musicians, performance by musicians significantly exceeded that of non-musicians, t (64) =-5.0, $p<.01$ (Bugos, Heller, & Batcheller, 2014). This analysis supports the use of the measure as a reliable and valid tool for measuring musical nuance perception.

An *Abbreviated Music Reading Assessment* (MRA; Bugos & Groner, 2008) identified the ability of the participants to read music. This measure was used to confirm that the musician group had knowledge of musical notation and was able to read noted in either treble or bass clefs or both. This measure was used to screen for status of formal band instruction or musical knowledge.

Another music assessment employed was a subtest of the *Music Aptitude Profile, Musical Sensitivity* which contains three subtests to measure phrasing, balance, and style characteristics. These preference subtests required the participants to decide which of two renditions of the same musical phrase made the better musical sense. In the *Phrasing* subtest, each excerpt was played twice and the participant was asked to decide which rendition was performed with the better musical expression. In the *Balance* subtest, a phrase is played twice; however, the ending was altered in the second recording. The participant decided which ending best followed the beginning in terms of both tonal and rhythm aspects. In the final subtest, the *Style* assessment, the same phrase is performed twice at two different tempos. The second phrase is either faster or slower than the first, with all other musical aspects remaining exactly the same. The participant was asked to decide which tempo was best suited to the phrase. If the student had no preference or cannot make a decision on the selection, they were instructed to choose the in-doubt response. The reliability of this assessment ranges from .88 to .90 for high school students (Grade 9 - .90, Grade 10 - .90, Grade 11 - .89, Grade 12 - .88) and the validity ranges from .54 to .85.

Cognitive Measures

The *Processing Speed Index* subtests (*Coding* and *Symbol Search*) and *Working Memory Index* subtest (*Arithmetic*, *Letter Number Sequencing*, and *Digit Span*) of the Wechsler Adult Intelligence Scale (WAIS-IV; Wechsler, 2008) were developed to assess cognitive ability in adults and older adolescents. This assessment functions as an examination of the relationship between intellectual functioning and memory. This version was chosen instead of the previous editions due to the enhanced measures of processing speed and working memory (reduced fine motor demands). The test-retest reliabilities range from 0.70 (7 subscales) to 0.90 (2 subscales). For the purposes of this study, the Working Memory and Processing Speed subtest were administered in their entirety. This assessment required approximately 60 to 90 minutes to complete.

This study observed the specific functions associated with processing speed and working memory. The WAIS-IV subtests associated with these functions were *Coding* and *Symbol Search* (processing speed) and *Digit Span*, *Arithmetic*, and *Letter-Number Sequencing* (working memory). As this study focused on these two specific processes of executive function, the provided PSI and WMI subsections of the WAIS-IV were appropriate. The measures for processing speed indices (the combined *Coding* and *Symbol Search* subtests) posted reliability coefficients between 0.88 and 0.90. The *Coding* subtest reliability is r = 0.85 and *Symbol Search* subtest reliability is r = 0.81. The working memory index reliability coefficients lie between 0.93 and 0.94. The reliability coefficients of the *Digit Span* (r = 0.89-0.92), *Arithmetic* (r = 0.88-0.89), and *Letter-Number Sequencing* (r = 0.90) reinforce the consistency of the WAIS-IV measures of working memory. The WASI-IV measures were correlated to other standards of Wechsler measures and produced good content validity and criterion-related validity.

Procedure

The principal investigator contacted students informing them about the research study and informational parent meeting. At the informational meeting, parents and students received information regarding background, the nature of, and procedures for the research study and parental informed consent and student assent forms (Appendix A). Upon receipt of the consent forms, parents and students received the assessment dates in which data collection took place. Families had two weeks to review the materials and return the consent and assent forms.

The principal investigator developed a battery of measures to examine within domain skills in music and skills related to cognitive transfer. These measures were administered over two sessions and required 180 minutes.

Group Administration Procedures

Due to testing constraints of space and time, some standardized measures were modified for group administration. These modified measures included the WASI Matrix Reasoning and all elements of the WAIS-IV including measures of processing speed and working memory. Group modification for the Matrix Reasoning measure included a projected presentation of visual stimuli obtained from the traditional Matrix Reasoning subtest. Participants were required to write the number of the item that would appear next in the presented sequence. Group modification for all remaining items consisted of paper-pencil administration and aural script of all presented items. In its individual administration, the WAIS-IV measures call for a discontinue protocol following a specified number of consecutive scores of 0. Due to the group administration, all participants completed the assessment in its entirety.

During the first session, the student participants completed a demographic questionnaire. Following questionnaire completion, the participants completed the WASI assessment in order to attain pairings for the data analysis. Upon completion of the WASI, participants completed the four musical measure assessments in order to gain a measure of musical knowledge. Participants returned for the second session to complete the cognitive components of the assessment, which consisted of the components of the WAIS-IV assessment. This principal investigator implemented the two session method in order to allow participants the opportunity to maximize their performance by eliminating fatigue. Upon completion of the second session, the principal investigator thanked the students for their participation and finalized data collection. Group administration of the cognitive measures presents a limitation as they are traditionally administered individually.

The hypotheses of this study was that there will be no relationship between students who have received music instruction and those who have not on the cognitive measure assessments. As this study involved a series of musical and cognitive assessments, possible limitations included the amount of sleep the night prior, student diet prior to assessment administration, the quantity of individual musical practice within the musicians group, and the technical demands of the various instruments played by the musician students. Delimitations of the study included the exclusion of students who receive private individual musical instruction. Private music lessons may influence the amount of focus and ability of the students and could result in disparity with the results.

Analyses

Upon completion of data collection, the principal investigator matched data sets between students who had received band instruction and those who had not by age, gender, and estimate of intelligence. In order to facilitate accurate analyses, the researcher matched individuals within the two groups using the Wechsler Abbreviated Intelligence Scale (WASI) in order to eliminate discrepancies caused by intellectual ability and aptitude. Matches for each student resulted from the students' FSIQ (Full Scale Intelligence Quotient) scores calculated from the short-form, two subtests, Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). This was done in order to control for as many extraneous variables as possible. Musical achievement was analyzed by the raw scores of the musical measures. A two-group design paired samples *t*-test of the WAIS-IV results for Working Memory Index (WMI) and Processing Speed Index (PSI) was conducted with post hoc variable comparisons. The matching was analyzed using a two-group paired samples *t*-test to determine significant differences between the groups in relation to the identifying variables of age and estimate of intelligence. Following the paired samples *t*-test, a series of correlations between variables was conducted to determine the strength of relationship among all key variables and cognitive and musical performance.

The raw scores from the *Coding* and *Symbol Search* subtests were combined to produce an index of *Processing Speed*. The indices of *Working Memory* were generated from the raw scores on the *Digit Span Forward* and *Backward* and *Arithmetic* assessments. The *Letter-Number Sequencing* measure was used to observe the role of attention. The musical assessments each produced a raw score. These indices and scores were correlated with the key variables.

CHAPTER FOUR

RESULTS

Demographic Information and Descriptive Analyses

A total of 82 high school students participated in this study. There was a greater number of female participants (N=50) than male participants (N=32). The students represented two groups, those who previously received band instruction and those who had not. The research sample consisted of 82 participants; however, per our protocol, 40 data sets were able to be matched based upon age, gender, and estimate of intelligence. The average age of participants was 16.12 years (15.75 - received band instruction, 16.5 - no band instruction). The group included 16 male students and 24 female students. The estimate of intelligence was measured with the Wechsler Abbreviated Scale of Intelligence (WASI). The two-subtest model contains a section for *Vocabulary* and another for *Matrix Reasoning*. Although students were matched for age within two years, all scores on the WASI were scaled by age to eliminate potential age-related differences. In both groups, the average scaled score for the *Matrix Reasoning* section was higher than that of the *Vocabulary* subtest (50.65/48.65 and 45.15/46.4, respectively). The mean IQ score for the group that received band instruction (musicians) was 96.45, while the mean for the group that had not received band instruction (non-musicians) was 95.9. Table 1 illustrates the demographic information. Figure 1 illustrates the ethnicity break down of the entire test sample. Results of a paired samples *t*-test for demographic variables of age and estimate of intelligence reveal no significant ($p>.01$) differences. The paired samples *t*-test was used because the participants were linked through the matching process. A significance level of

.01 was determined through the Bonferroni adjustment/correction to control for error of multiple comparisons.

In order to match students according to a baseline, the Wechsler Abbreviated Scale of Intelligence (WASI) 2-subtest form was used to elicit an estimate of the intelligence quotient for all student participants. This test provided a total scaled score derived from raw scores of the Vocabulary and Matrix Reasoning tests. The mean estimate of IQ provided a baseline measure to match similar students. A paired samples *t*-test demonstrated that there was no significant difference in the matches based on the estimate of intelligence ($t(38)=.2$). The IQ estimates ranged from 79 to 120 with a standard deviation of 8.57. The mean IQ score was 96.18.

Table 1. *Demographic Table*.

	Band Instruction (N=20)	No Band Instruction (N=20)
Age	15.75 (.97)	16.5 (1)
Gender (M/F)	8/12	8/12
Ethnicity (%)		
White	45%	45%
African American	30%	50%
Asian	10%	5%
Other	15%	0%
Heritage (%)		
Hispanic	20%	5%
Non-Hispanic	80%	95%
Primary Home Language (%)		
English	95%	90%
Other	5%	10%
Handedness (%)		
Right	85%	90%
Left	15%	10%

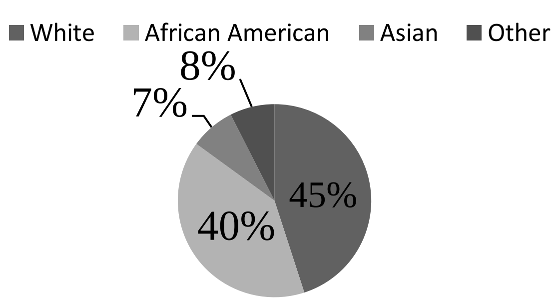

Figure 1. Ethnicity division of student participants.

Music Measures

Both groups participated in a battery of musical measures to assess musical ability and prior knowledge. The results are illustrated in Table 2. The *Music Reading Assessment* evaluated strict knowledge of musical elements and yielded the greatest difference in raw scores between the two groups. This musical measures was used as a screening tool to determine the music reading ability of the participants. Table 3 illustrates the effect sizes and *t*-values of all significant attributes from the study. For every element of the musical measures, the data intimates a significant difference between groups, with the exception of the tonal measure from Gordon's *Advanced Measures of Music Audiation*. These assessments were used as a preliminary measurement of musical knowledge and understanding and were not used to separate the groups.

Table 2. *Music Measures Data*.

	With Band Instruction (N=20)	Without Band Instruction (N=20)
AMMA Tonal	24.85 (4.40)	23.00 (4.48)
AMMA Rhythm	27.30 (3.66)	24.95 (3.17)
Music Reading Assessment*	45.00 (6.55)	1.60 (4.72)
Music Nuance Task (MNT)*	23.25 (2.65)	14.15 (5.19)
Music Sensitivity Test (MST)*	20.15 (3.31)	12.00 (3.87)

*Significant ($p<.01$) group difference in performance.

Table 3. *Effect Sizes of Dependent Measures*.

	p-value	*t* score	*df*	Cohen's *d*	Effect size *r*
Music Nuance Task (MNT)	.000	7.04	38	2.28	.75
Music Sensitivity Test (MST)	.000	8.17	38	2.65	.79
Processing Speed Index (PSI)	.000	4.45	38	1.44	.59
Working Memory Index (WMI)	.002	3.50	38	1.13	.49
Letter-Number Sequencing	.002	3.67	38	1.19	.51

Figure 2 illustrates the difference between the groups on their musical assessment measures. There are a number of outliers on many of the assessments. The *t*-values for the MNT ($t(38)=7.04$, $p<.01$) and MST ($t(38)=8.17$, $p<.01$) suggest a significant difference between groups. A bivariate correlation of each musical test was also completed to gauge the strength of relationship between assessments. The AMMA scores were positively correlated with the MNT ($r=.45$, $p<.01$). The MRA yielded a positive correlation with the MNT ($r=.75$, $p<.01$) and MST ($r=.74$, $p<.01$), but not the AMMA, although the correlation did demonstrate a trend. The MNT and MST were positively correlated ($r=.61$, $p<.01$). As the aforementioned results suggest, the MNT demonstrated a positive correlation with each of the other musical assessments. There was a negative correlation between the group variable and each of the musical measures. There was a strong negative relationship between the MNT ($r=-.75$, $p<.01$), MRA ($r=-.97$, $p<.01$), and MST ($r=-.76$, $p<.01$). Both the MNT and MST music assessments had extremely large effect sizes ($d=2.26$ and $d=2.32$, respectively).

Cognitive Measures

Selected tests were used from the Wechsler Adult Intelligence Scale (WASI-IV) to determine a processing speed and working memory index of all participants in this study. Results of a paired samples *t*-test show significantly enhanced working memory ($t(38)=3.50$, $p<.01$) and processing speed ($t(38)=4.45$, $p<.01$) for students who received band instruction compared to those students who had not received the band instruction. Each index was derived from multiple assessments. Table 4 provides the breakdown of the cognitive assessments and their components.

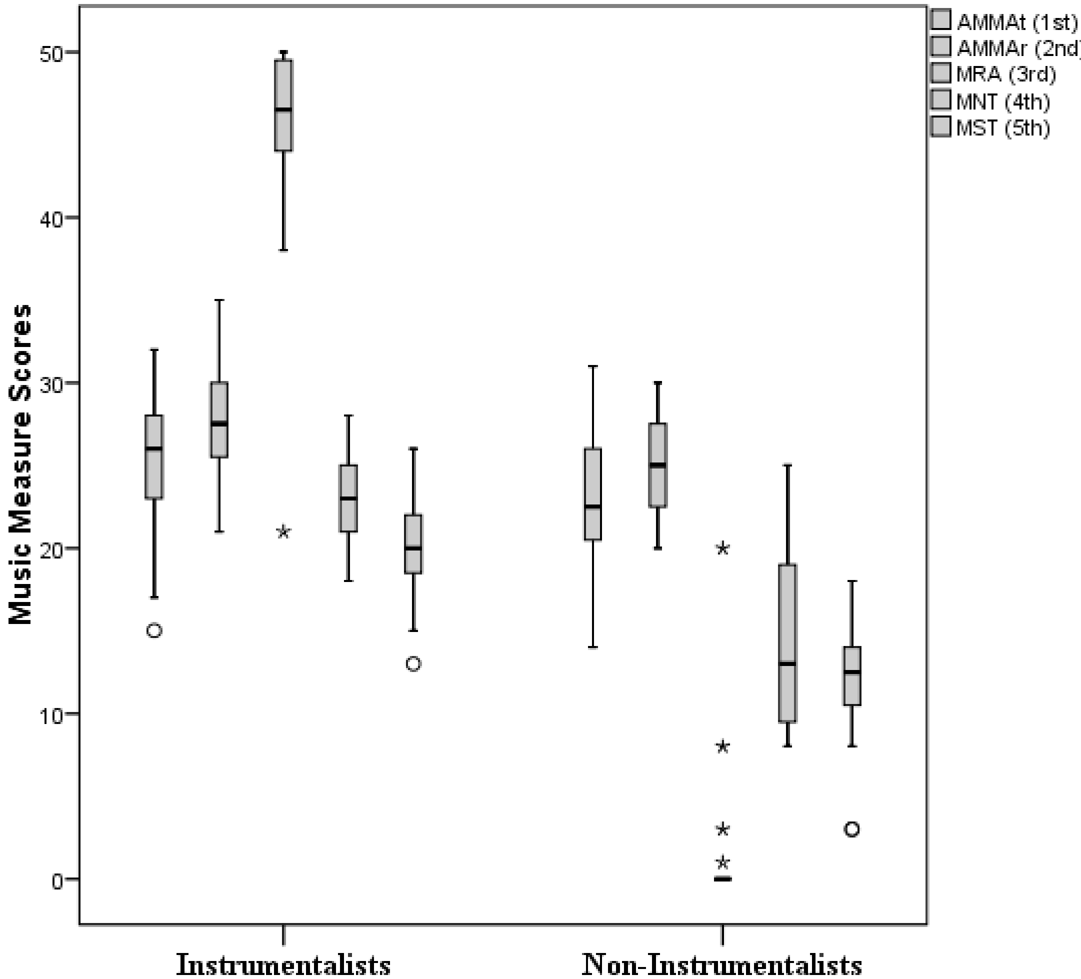

Figure 2. Musical Measures Group Comparison.

Table 4. *Means and Standard Deviation Cognitive Assessment/Measurement Data*.

	Band Instruction (N=20)	No Band Instruction (N=20)
IQ	96.5 (8.57)	95.9 (8.91)
Processing Speed Index (PSI)*	109.3 (15.59)	98.1 (10.30)
Coding	77.2 (18.01)	64.5 (11.2)
Symbol Search	40.4 (6.85)	38.7 (11.52)
Working Memory Index (WMI)*	100.5 (13.30)	88.1 (10.29)
*Digit Span (Forward)**	11.5 (1.82)	8.7 (2.08)
*Digit Span (Backward)**	12.3 (3.13)	8.9 (2.55)
Arithmetic	16 (3.89)	14.4 (2.95)
*Letter-Number Sequencing**	21.9 (3.15)	16.5 (6.71)

IQ are derived from 2-subtest WASI scores.
*Significant (p<.01) group difference in performance.

Cognitive Indices (PSI and WMI)

The *Processing Speed Indices* (PSI) for each participant were derived from the scaled scores each student received on the *Coding* and *Symbol Search* subtests. According to the paired samples *t*-test, students who receive band instruction demonstrate significantly increased PSI than their counterparts who do not receive band instruction ($t(38)=4.45$, $p<.01$). Figure 3 illustrates a boxplot that represents the PSI comparison between groups. The results of a paired samples *t*-test demonstrated significantly increased speed on the coding tasks by students with band instruction as compared to those without band instruction ($t(38)=4.45$, $p<.01$). The symbol search subtest, however, did not yield significant results. Figure 4 illustrates the differences between group scores on both cognitive assessments.

Working Memory Indices (WMI) for each participant were derived from the scaled scores each student received on the *Digit Span* (both Forward and Backward) and *Arithmetic* subtests. Figure 5 illustrates the score differentials between the two test groups. The results of a paired samples *t*-test suggest that individuals with band instruction demonstrated higher working memory indices than those without band instruction, $t(38)=3.50$, $p<.01$). The *Digit Span* subtest contained two separate assessments in which the items are presented forward and then backward. The *t*-score of the *Digit Span* subtest total score suggests students who have received band instruction exhibit elevated working memory indices ($t(38)=4.74$, $p<.01$). The *Digit Span* Forward assessment yielded a greater *t*-value than the Backward assessment, however, both were significant ($t(38)=4.52$, $p<.01$ and $t(38)=3.71$, $p<.01$, respectively). The *Arithmetic* measure *t*-value was not significant ($t(38)=1.47$, $p>.01$) between the groups and is displayed alongside the *Digit Span* data in Figure 6. Both the working memory and processing speed indices elicited a large effect size at $d=1.07$ and $d=0.87$, respectively. Out of the two subtests that derived the indices for each participant, only one measure from each index yielded a significant effect size, the *Coding* measure (d=.87) and *Digit Span* measure (Forward - d=1.47; Backward - d=1.2). All effect sizes were calculated using an *Effect Size Calculator* (Becker, 2000) which uses the t-test value for a between subjects t-test and the degrees of freedom. The traditional formulas for this calculation are used (Cohen's d: $d=2t/\sqrt{(df)}$) (Cohen, 1992).

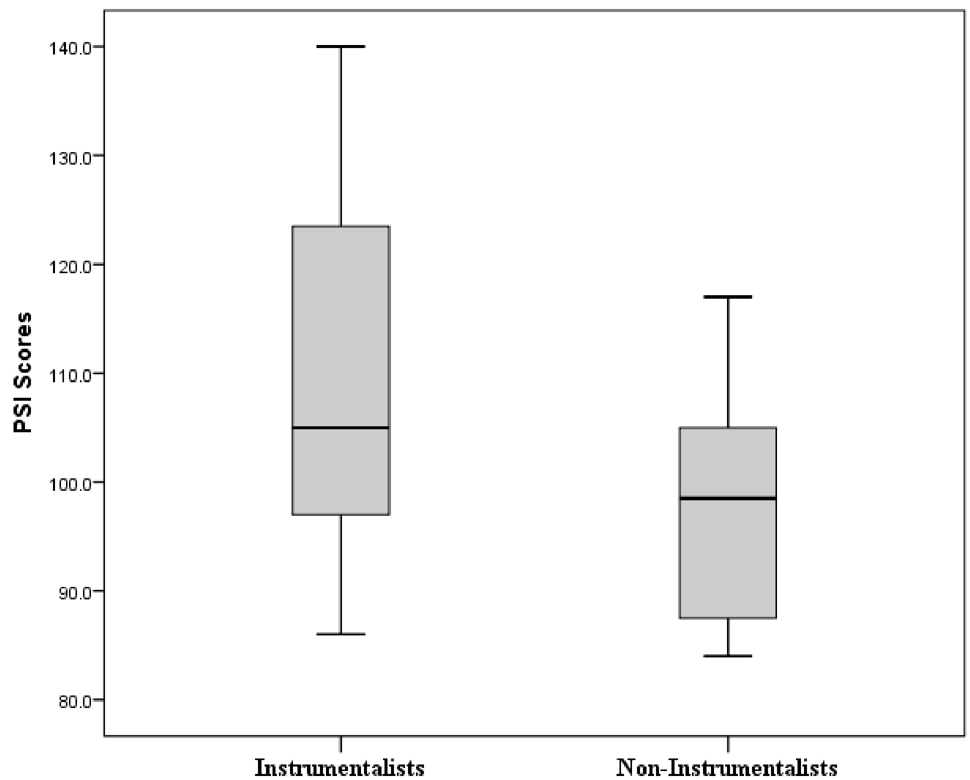

Figure 3. Processing Speed Indices (PSI).

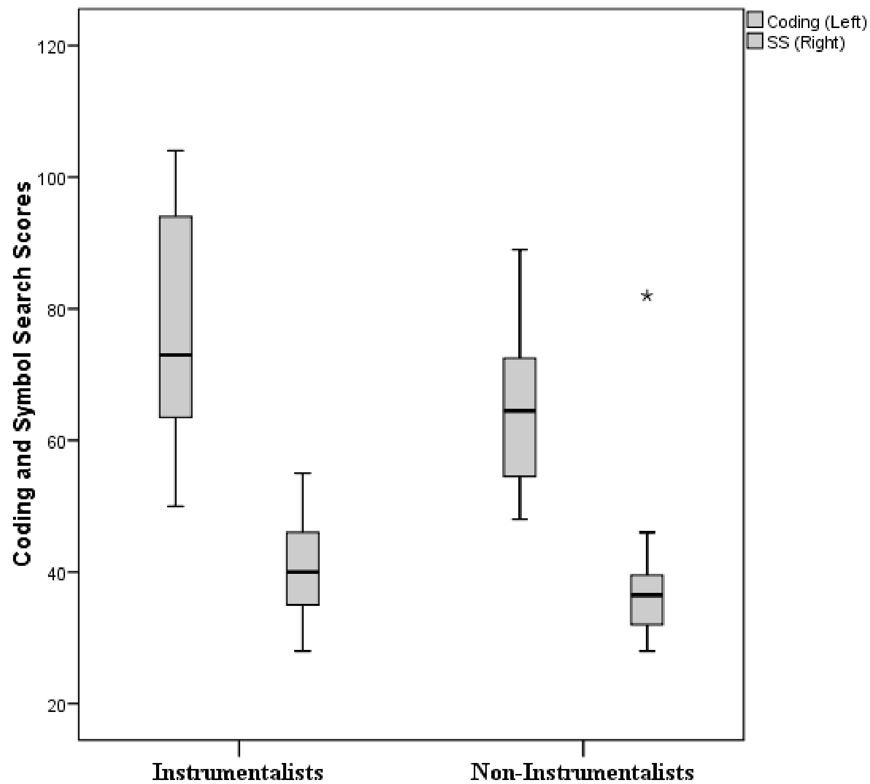

Figure 4. Coding and Symbol Search Measures

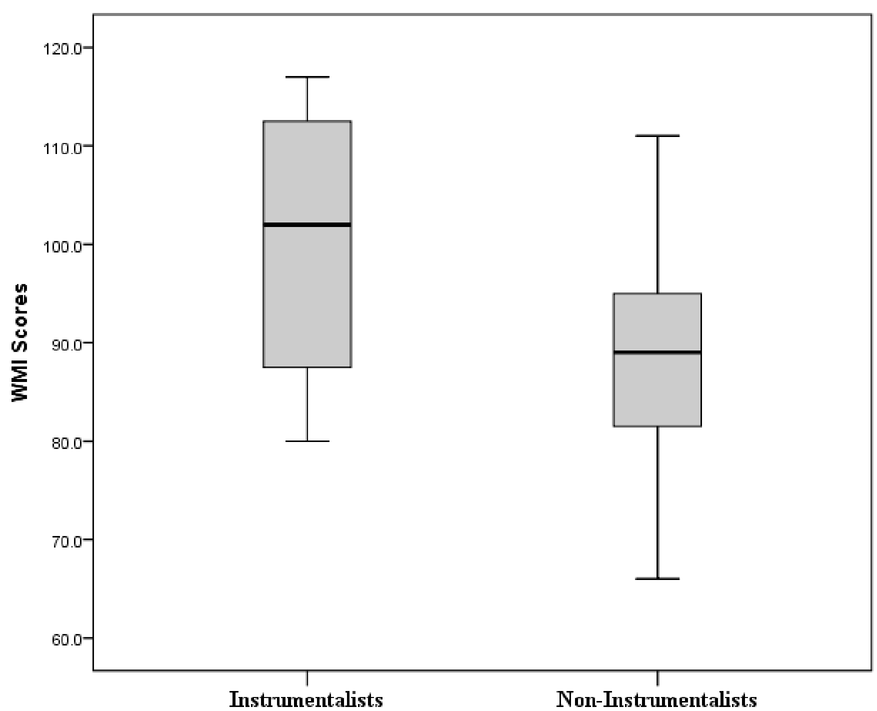

Figure 5. *Working Memory Indices* (WMI).

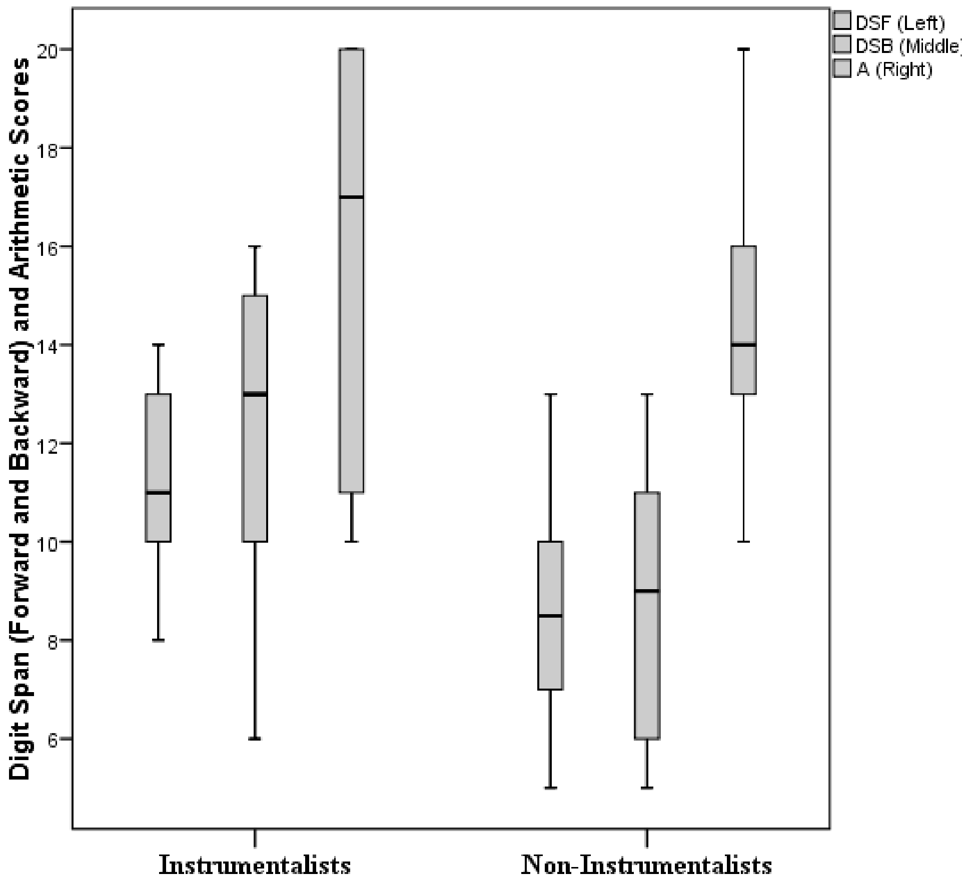

Figure 6. *Digit Span* (Forward and Backward) and *Arithmetic* Measures.

Selective Attention

The *Letter-Number Sequencing* (LNS) measure relies heavily on selective attention. Scores on the *Digit Span* assessment also depend on the attention of the individual. Results from a paired samples *t*-test suggest that the students with band instruction demonstrate significantly increased attention ability than those without band instruction ($t(38)=3.67$, $p<.01$). The mean score of the control group was 16.5 (6.71), while the instructional group mean was 21.85 (3.15). Although the WASI-IV does not generate a specific index for this cognitive function, there are correlations identified that demonstrate the role of attention in the LNS measure. Figure 7 represents a box plot of the LNS scores compared by group.

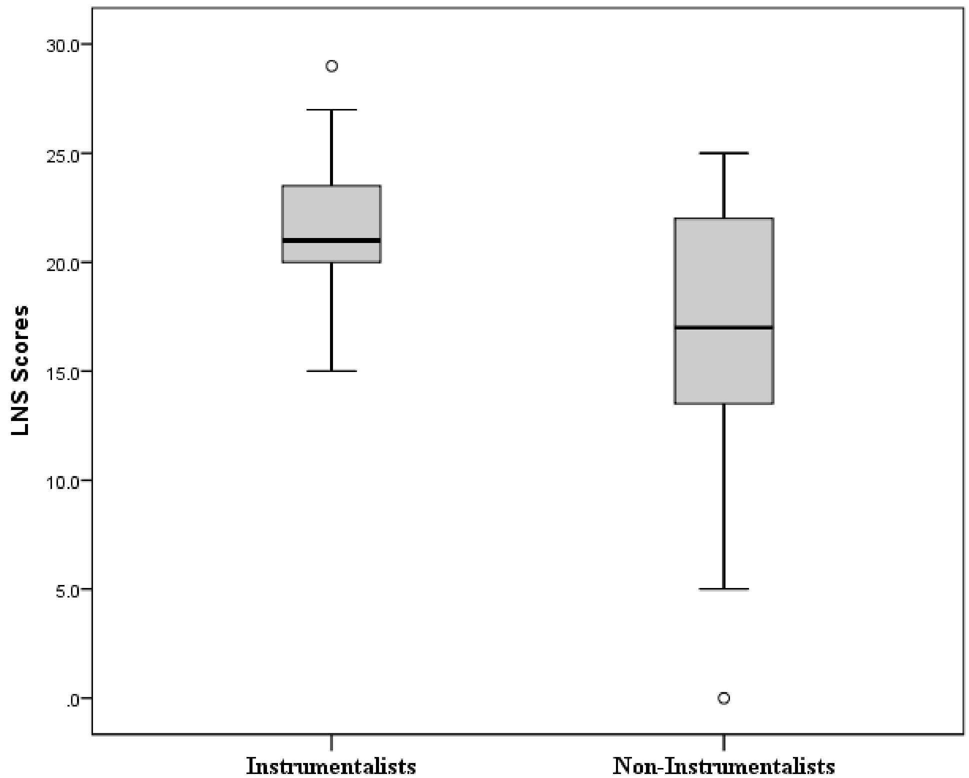

Figure 7. *Letter-Number Sequencing* Measure.

Correlations

A number of Pearson correlations were run in association with various research questions which originated from the data. These correlations were generated in order to evaluate the strength of relationship between the various measures used in this study. One of the guiding research questions of this study is to evaluate the strength of relationship between the numerous cognitive assessments. Two of the four music measures used, the AMMA and the MST, were created by Gordon. After running a correlation of the musical assessments, the results suggest a positive correlation between the rhythmic scores of the AMMA and both the MRA (r=.33, p<.05) and the MNT (r=.56, p<.01). It is interesting that neither section of the AMMA positively correlated with the MST (r=.23). The AMMA rhythm score is also positively correlated with both PSI (r=.41, p<.01) and WMI (r=.41, p<.01). It is interesting to note that within the group that received band instruction, the estimate of IQ was positively correlated with both PSI (r=.64, p<.01) and WMI (r=.45, p<.01). Table 5 illustrates the correlations between all music and cognitive measures.

Table 5. *Music and Cognitive Measure Correlations*.

	IQ	AMMAt	AMMAr	MRA	MNT	MST	C	SS	PSI	DSF	DSB	A	LNS	WMI
IQ		.04	.17	.12	.26	-.01	.48*	.16	.55*	.09	.16	.44*	.53*	.35
AMMAt	.04		.69*	.21	.29	.14	.12	.51*	.3	.28	.23	.21	.12	.28
AMMAr	.17	.69*		.33	.56*	.23	.24	.53*	.41*	.26	.38	.36	.13	.41*
MRA	.12	.21	.33		.75*	.74*	.43*	.1	.43*	.6*	.50*	.30	.52*	.37
MNT	.26	.29	.56*	.75*		.61*	.36	.32	.42*	.4	.43*	.32	.39	.51*
MST	-.01	.14	.23	.74*	.61*		.18	-.05	.2	.48*	.32	.16	.44*	.34
C	.48*	.12	.24	.43*	.36*	.18		.3	.91*	.36	.4	.46*	.46*	.52*
SS	.16	.51*	.53*	.1	.32	-.05	.3		.44*	.02	.18	.27	-.002	.23
PSI	.55*	.3	.41*	.43*	.42*	.2	.91*	.44*		.38	.46*	.53*	.53*	.58*
DSF	.09	.28	.26	.6*	.4	.48*	.36	.02	.38*		.61*	.22	.44*	.59*
DSB	.16	.23	.38	.5*	.43*	.32	.4	.18	.46*	.61*		.52*	.52*	.82*
A	.44*	.21	.36	.30	.32	.16	.46*	.27	.53*	.22	.52*		.58*	.88*
LNS	.53*	.12	.13	.52*	.39	.44*	.46*	-.002	.53*	.44*	.52*	.58*		.65*
WMI	.35	.28	.41*	.51*	.44*	.34	.52*	.23	.58*	.59*	.82*	.88*	.65*	

*Significant at the .01 level.

AMMAt = Advanced Measures of Music Audiation Tonal Score
AMMAr = Advanced Measures of Music Audiation Rhythm Score
MRA = Music Reading Assessment
MNT = Music Nuance Task
MST = Music Sensitivity Test
C = Coding
SS = Symbol Search
PSI = Processing Speed Index
DSF = Digit Span Forward
DSB = Digit Span Backward
A = Arithmetic
LNS = Letter-Number Sequencing
WMI = Working Memory Index

CHAPTER FIVE

DISCUSSION

This research was guided by three specific research questions:

1. What are the effects of musical training on executive function processes, specifically selective attention, processing speed, and working memory?
2. How do executive function processes of selective attention, processing speed, and working memory differ between musicians and non-musicians?
3. What is the strength of relationship between years of ensemble exposure and cognitive performance?
4. What is the strength of relationship of AMMA/MST/MNT scores between students who have received secondary band instruction and those who have not received secondary band instruction?
5. What is the strength of relationship between music aptitude and IQ?

The findings of this research highlight the differences of selective attention, processing speed, and working memory abilities between secondary (high school) students who receive band and students who have not received band instruction. Analyses of were completed to assess the relationship between various executive function processes and music instruction. The data were analyzed using paired samples *t*-tests and univariate correlational analyses. Results suggest that students who receive band instruction posses an increased level of processing speed, selective attention, and working memory abilities.

The results of this study align with numerous studies involving the relationship between processing speed and music instruction (Bugos & Mostafa, 2011; Moreno, Bialystok, Barac, Schellenberg, Cepeda, & Chau, 2009; Schellenberg, 2004, 2005). According to the results, the engagement in music instruction elicits increased processing speed ability. This relationship may account for the disparity between the overall estimates of IQ between individuals who have received music instruction and those who have not. Rindermann and Neubauer (2004) suggest that processing speed is a fundamental component of higher-order cognitive ability and that it can influence intelligence. Academic performance in language arts, science, mathematics, and humanities is also attributed to processing speed (Rindermann & Neaubauer, 2004). Therefore, students involved in music instruction may have higher academic achievement. This is not to say that students who are not involved in music cannot achieve highly in academics; however, their intellectual equal may achieve higher if he is engaged in music instruction. Further research is necessary to experimentally evaluate this claim.

Working memory indices were also higher in students who received music training. Many of the activities involved in a music class require recall of various melodies or musical lines at a rehearsal or performance in the future. In most secondary music institutions marching band is a required ensemble for band students. An aspect of marching band is memorizing music while marching to a specific set of coordinates on the marching field. In this manner, every time a student recalls the remembered musical selection, they are exercising working memory processes. Musical recall takes place many times within a marching session. The use of working memory processes for recall of melodies and other musical elements within the rehearsal and performance settings align with Baddeley's model of working memory. These recall activities may be responsible for the increased score of the group of students who received band instruction.

As mentioned earlier, Baddeley's Model of Working Memory consists of three components that are regulated by a central executive system. The first component, the phonological loop, acts to preserve the verbal information. In the example of the marching band music, this is the area of WM that the melodic lines and aural recordings of the music are stored for future recall. The visuospatial sketchpad is where any physical or visual-specific aspects of marching band would be stored. An example of this would be horn visuals, specific marching band sets or locations on the field, or other visual cues. The final area of Baddeley's WM model is responsible for integrating the short-term and long-term memory. The marching band season consists of a number of rehearsals that require students to remember many small things and recall them immediately (an example of their short-term memory in effect). The information they learn at each rehearsal is recalled a number of times throughout the course of the year; either at the following rehearsal or another future event (i.e., a performance). Continued exercise of WM through tasks such as those incorporated in the marching band increases memory capacity and allows for greater flexibility (Baddeley & Hitch, 1974; Denckla, 1996).

Flexibility and shifting is another skill that is often used in music instruction activities. Often individuals are required to transition from one task to another, especially in the music classroom, within the confines of a single lesson or rehearsal. This element is paramount to the Miyake and Friedman model of EF (2000). In this EF model, self-regulation of behavior is driven by past experiences. The process of updating and shifting, which are two of the four major elements of the Miyake and Friedman Model, are continuously applied within the musical rehearsal setting. Updating, the continuous monitoring and quick addition or deletion of content within working memory, applies when any changes are made to a piece of music or area of performance prior to the show. Many conductors change various items in music for aesthetic, aural, or practical performance purposes. Shifting is the cognitive flexibility to switch between different tasks or mental states. In many band classrooms, music educators transition through numerous tasks during a lesson including counting, singing, and playing tasks. The disparity between instrumentalists' and non-instrumentalists' cognitive performance scores may be due to instrumentalists continuous engagement in activities involving shifting and updating. Although this model cites that the functions are independent, it also alludes to the potential of cognitive increase through compound use of multiple strategies simultaneously.

The results of this study also align with the Expertise Model involving the interaction of executive function and music education. One of the primary differences between the two groups in this study was the exposure to band instruction. Continuing with the marching band illustration, this model identifies expert performance as a result of effort to improve performance over an extended amount of time while negotiating motivational and external constraints. The amount of hours spend rehearsing and refining the marching product is akin to the prescribed period of extended effort to improve performance ability within the music domain. The primary assertion of this model parallels the claims of this study that prolonged repetition elicits improved executive function. This model agrees with the conclusions of various studies (Bugos & Mostafa, 2011; Bugos & Mazuc, 2013; Caine & Caine, 2006; Gruhn, Galley, & Kluth, 2003) which also cite the improvement of various aspects of learning, specifically cognitive processes, through longer exposure. This finding would also suggest that prolonged exposure to or participation in music instruction would increase cognitive function, however, there was no significance found in the relationship between years of musical study and cognitive function in this study. Although there was no significance in this relationship, the data illustrated a trend that approached significance.

More research is necessary to assess the influence of music instruction on attention performance with regard to selective attention. The cognitive assessments used were geared specifically for developing a PSI and WMI. However, the results indicate that music instruction may positively influence selective attention as well. Music engagement requires constant attention to numerous tasks at one time. Not only are the instrumentalists attending to the notes on the sheet music, they are also observing the various articulations, dynamics, and stylistic attributes of the pieces performed. The instrumentalists are also making the physical adjustments necessary to produce the musical nuances they are reading. Particularly while in an ensemble setting, musicians are transitioning between various stimuli in order to perform. Not only are musicians reading the musical notation, they are attending to their intonation in context of their section, their instrument category (woodwind/brass), and the ensemble as a whole. Along with intonation, musicians are constantly aware of articulations, dynamics, and other musical elements of the performance. The development of attention skills is a characteristic of a better developed, more flexible attention ability (Zelazo & Frye, 1998). This ability accounts for higher levels of success in various activities. Marching band is an example of an ensemble that employs and exercises an individual's attention abilities as musicians march and perform their rehearsed program.

The foundations of Barkley's self-regulatory model of EF align with those of music instruction. The basis of this model relies heavily on goal-oriented behaviors regulated through working memory processes. The WM processes store prior knowledge and experiences that are used to meet new goals or modify an objective, much in the same way that an ensemble rehearses in preparation for a performance. Musicians are required to remember various aspects of a previous rehearsal, as well as previously discovered or learned performance techniques, contributing to playing precision. This knowledge guides the musicians' practice strategies and rehearsal techniques in order to reach their performance goals. In this manner, WM also acts to guide preparation for each rehearsal. As mentioned before, this exercise of WM increases flexibility and functionality of cognitive processes.

When observing the relationship between cognitive performance and years of ensemble exposure, no significant correlation (r=.06) was found. However, the data suggest a trend. With a larger sample size, a significant result may be found. Executive function research suggests that cognitive function improves over time and through exercise of specific skills (Denckla, 1999; Gioia et al., 2002; Meltzer, 2007; Nauta, 1971; Salloway, 1994; Tranel, Anderson, & Benton, 1994). The activities involved in secondary band participation have shown to correlate with increased PSI and WMI. Therefore, it would beg to reason that there should be a more significant positive correlation between music instruction and cognitive performance. The techniques and activities used in music education align with the various EF models mentioned to elicit an increase in cognitive function. Further research would need to be conducted in this area in order to investigate the trends seen in this study.

When looking into the music measures used for this study, the chosen assessment were used for their prevalence in the music education literature. The validity and reliability of the measures has been reported by Gordon at a high level (0.82). Gordon also reports a high correlation between the AMMA and the *Music Aptitude Profile* (MAP) (r=.78). However, the results of a correlation analysis of this data from this study do not indicate a positive correlation between the AMMA and the *Music Sensitivity Test* of the MAP (r=.2). In addition, the only other music assessment that demonstrated a correlation to the AMMA was Heller's *Music Nuance Task* assessment (r=.45, p<.01). The MNT was significantly correlated with each of the other musical assessments including the MRA (r=.75, p<.01) and the MST (r=.61, p<.01). This finding is interesting as the ability to determine subtle differences in music can be a trained skill. In the same manner that this skill can be improved, so can the cognitive skills of EF. When looking at the group variable in the correlation of the music assessments, there is a significant negative correlation with all of the music measures except for the AMMA (MNT: r=-.75; MRA: r=-.97; MST: r=-76). This may be due to the content of the assessment and the processes that the assessments measure. The AMMA is slated to analyze the potential of an individual to succeed within music instruction. The other assessments measure the student's ability within the music education construct. It could be implied that individuals without music instruction would not perform well on the music ability assessments, but by design, could still score well on the measures of music aptitude. There was not a significant relationship between the estimates of IQ and music aptitude. The lack of relationship between estimates of IQ and music aptitude may be due to the potential for any person, regardless of age or IQ, to possess an affinity for music. Although the results of this research suggest that the activities involved with music instruction may increase various cognitive functions, an individual does not have to possess a high IQ in order to participate in music. Regardless of IQ level, any individual may possess an aptitude for music.

Limitations

There were a number of limitations that arose during this study. In an effort to eliminate as many extraneous variables as possible, students were matched to specific factors before the data were analyzed. Although instrument selection was recorded, it was not taken into account with the matching or student selection process.

Due to the sample size and time restrictions of the participants, the implementation of the cognitive assessments were administered in a large group. This served as a limitation as the cognitive assessments are typically administered individually. Since the measures were group-administered, querying options elements of the *Vocabulary* subtest were not available. Students were not given the opportunity to expound on their answers verbally and the researcher did not have the opportunity to elicit explanation or elaboration on participant answers, an aspect of WASI.

Implications

Much of the literature involving EF observes either young children or the elderly. The years in secondary education represent both pivotal and stressful times for students due to maturation and the onset of puberty. Understanding how the processes in the brain develop and what stimuli can improve or increase the various EF process is important for a variety of reasons including developing curricula that can best caters to this age. Data from this research provide an opportunity to examine the effects of instrumental training on executive function that may be most sensitive to music training.

These findings suggest an association between music instruction, particularly band instruction, and enhanced cognitive processes. This research is causal-comparative or non-experimental research; thus, it is not possible to determine causality. There is still the question of whether students who enroll in music programs demonstrate enhanced intelligence due to training or if it is simply the population who chooses to take music courses. The purpose of music education is not solely to increase academic or overall cognitive achievement, although this may be a result of participation.

A unique element of this study is the significant difference between the two groups' attention scores. In another study that conducted similar research involving senior citizens and their level of selective attention using the LNS subtest of the WAIS-III, it was found that there was no difference between the two groups' attention scores (Bugos & Mostafa, 2011). It is significant to note that attention varies across the lifespan of an individual. Older adults and adolescents have incredibly different attention spans. However, the finding within the current study presents the question of what contributes to the degradation of attention ability of individuals over time; if music instruction positively effects selective attention, at what point do functional changes to cognitive performance resulting from musical training cease?

The high school band curriculum is highly performance-based. In Florida, marching and concert bands participate in semester Music Performance Assessments in which their performances are evaluated by a panel of adjudicators. Aside from the typical concert Music Performance Assessments (MPAs) in the Spring, high school programs are required to participate in Fall MPAs. Most schools also perform a Winter and Spring concert. These common practices exercise the basic process in music reading that contribute to enhancing executive function. Bands that have additional concerts and performance opportunities outside of the general curriculum increase the potential for these cognitive processes to be developed. Although events such as parades and community events may seem cumbersome and inconvenient, they may serve as a medium for cognitive development. Participation in solo and ensemble festivals is also a chance to enhance cognitive ability. Music performance, as opposed to the discussion of music as an abstract construct, engages cognitive processes within the brain that contribute to overall cognitive enhancement.

Future Research

Literature based on the relationship between music instruction and executive function processes can benefit from more research involving secondary education. This study represents one of few involving secondary music education (middle and high school) and EF. Investigation involving alternative mediums of music performance (i.e., orchestral or vocal music instruction) would present another vantage point on the role of music instruction on the development of EF. Also, looking into the role of specific genres of music instruction, i.e., jazz instrumental music instruction, or instrument preference may yield varying degrees of results. Comparing the disciplines of music instruction with one another may assist in further developing this body of literature and defining the specific elements that contribute to the relationship between music instruction and executive function. In order to determine a great association of cognitive processes and music instruction, an experimental design study would need to be conducted to observe possible cause and effect.

The present study demonstrates the association between music instruction and enhanced cognitive performance. Activities specific to music instruction including, but not limited to, memorizing melodies, reading and interpreting musical signs and written notation, identifying and analyzing aural musical stimuli, exercise various processes within the brain that influence cognitive performance. Future research should address the following questions: Is this association a cause and effect relationship? To what extent does music instruction in other mediums influence cognitive performance enhancement? Which activities involved with music instruction enhance cognitive performance at higher levels?

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