AN INVESTIGATION INTO BEGINNING STRING PLAYERS' INSTRUMENTAL INTONATION ACCURACY IN RELATIONSHIP TO STABILIZED TONAL MUSIC APTITUDE AND VOCAL INTONATION ACCURACY

by

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ABSTRACT

With the intent of improving string pedagogy, the purpose of this study was to examine the relationship between stabilized tonal music aptitude and instrumental intonation and the relationship between vocal intonation accuracy and instrumental intonation accuracy of beginning string players. The following research questions were investigated: (a) Is there a relationship between beginning string players' stabilized tonal music aptitude and their ability to play their instruments with accurate intonation?, and (b) Is there a relationship between beginning string players' ability to sing with accurate intonation and their ability to play their instruments with accurate intonation?.

Participants for this study were 28 beginning sixth grade string students from three intact classrooms. Participants were from two schools, School A and School B; the researcher acted as a teacher-researcher for this study.

The study was conducted over a five-week period. The teacher-researcher administered the Intermediate Measures of Music Audiation (IMMA) tonal subtest (Gordon, 1979a) to measure the stabilized tonal music aptitude of the participants. The teacher-researcher taught an eight- measure researcher-composed etude, first vocally and then instrumentally to the participants for a total of four instructional periods. During the sixth visit, participants sang and played the etude into an audio recorder. Using a 5-point continuous rating scale, two independent judges rated participants' ability to both sing and play the etude with accurate intonation. Pearson product-

moment correlations were conducted to determine whether there was a relationship between stabilized tonal music aptitude and instrumental intonation accuracy, or between instrumental intonation accuracy and vocal intonation accuracy.

Results from this study yielded a moderately low relationship between instrumental intonation accuracy and stabilized tonal music aptitude ($r = .32$) and a low relationship between instrumental intonation accuracy and vocal intonation accuracy ($r = .23$). A number of factors may have contributed to these results. The small sample size ($N = 28$) and moderate interjudge reliability for the rating scale may have contributed to the lack of statistical findings. Other contributing factors may have been environmental factors such as student participation in choral groups and instrumental chamber ensembles.

Chapter 1

REVIEW OF LITERATURE

The ability to accurately interpret one's own intonation is a fundamental skill required throughout the development of a students' musicianship. In addition to proper playing posture and bow hold, string students' struggle with intonation is a continual challenge for string teachers. Being able to discriminate between musical pitches is a critical step in the journey toward correct intonation, both vocally and instrumentally. The development of a students' aural musicianship is vital in the transformation from student to successful musician. For instrumentalists and vocalists alike, developing the correct sense of pitch is an outgrowth of tonal audiation (Schleuter, 1997). Through audiation, a person will gain an understanding of the music he hears, plays, and composes. Gordon describes audiation as "hearing and comprehending in one's mind the sound of music that is not or may never have been physically present. It is neither imitation nor memorization" (Gordon, 2004, p. 361).

Musical Comprehension

Simply hearing sound does not mean that one will musically comprehend the pitches. Aural perception takes place at the moment the sound is heard, whereas audiation can only take place after the sound has been perceived. It is through audiation that one comprehends the musical sounds being heard. Audiation is a reflective and thoughtful process in which the brain gives meaning to the musical sounds it hears. Whereas in imitation one recalls music that was just previously

performed or heard, audiation is a complex skill that allows one to predict or anticipate what should come next in the music.

Parallels can be drawn between musical development and language development. Audiation is to music as thinking is to language. One cannot be taught to audiate, but a student can learn *how* to audiate, meaning he can learn "…how to use their audiation potential to maximize their music achievement" (Gordon, 2004, p. 2). In developing language, one listens to the words being spoken to them and makes connections by recalling previous encounters with those words. At the same time, that person is anticipating what might be said next. The same can be said for listening to music. When a student listens to musical sound through audiation, he or she is making the same types of musical connections with previous encounters.

Development of Auditory Perception and Pitch Discrimination

The musicianship of a student is often driven by his/her internal representation of sound, or, by musical imagery (Bergan, 1967). A positive correlation exists between pitch identification and imagery[1] as well as between pitch identification and musical memory (Bergan, 1967). The relationship between pitch identification and imagery suggests the importance of an *image tone*, in which other tones being heard can be compared to the recognizable image tone. This image tone may "serve as a standard against which to compare other tones being judged" (Bergan, 1967, p. 108). A student will recognize something, whether it is pitch or

[1] Musical imagery is defined as auditory imagery. "An image is defined as a perceptual experience for which there is no apparent physical stimulus" (Bergan, 1967, p. 102).

tonality, by recognizing what it is not (Gordon, 2003b). One's ability to make judgments about pitches he hears, based on an internal representation of those pitches, may lead to more successful intonation when playing an instrument.

Students' auditory perception (Petzold, 1963) and pitch-matching abilities (Geringer, 1983) will increase with age. The ability to discriminate among pitches is an obvious step in successfully learning an instrument; however, a lack of proper ear training instruction may adversely affect students' ability to discriminate between those pitches. Acquiring musical discrimination skills can be developed with consistent and regular training (Delzell, 1989), through receiving aural/oral pitch-matching instruction (Smith, 1995). Students learn to recognize what is familiar during discrimination learning and will develop the listening vocabulary needed for discrimination through receiving an aural/oral foundation (Gordon, 2003b).

The development of pitch discrimination and auditory perception is crucial for any beginning musician, especially a string player. Without buttons to press or frets to guide them, the ability to discriminate between pitches and perceive pitch internally is of the utmost importance to string players. String players tend to perform with sharp intonation, as opposed to flat intonation, at the conclusion of the pitch set, whether ascending or descending (Sogin, 1989). Being able to hear and remedy intonational problems is vital for becoming a successful musician.

Development of Aural Musicianship

Numerous researchers have studied the development of aural musicianship and instrumental performance. Surrounding students with an aural-based improvisation-focused curriculum, consisting of singing, playing by ear, and verbal

association, will result in higher levels of student performance (Azzara, 1993). Students who improvise will learn to have an internalized sense of musical vocabulary and will be able to spontaneously express musical ideas. One must think musically to truly understand music (Gordon, 2003b). Improvising music, whether through singing, rhythmic chanting, or performing on instruments for example, is analogous to engaging in spoken conversation. Once a person learns to speak and converse, they are provided with the readiness to read language. The same principle applies to music. Participating in a musical conversation, or improvising, provides students the readiness for reading and performing notated music with meaning (Burton, 2011). The path to creating meaning through improvisation begins at the aural/oral level. Providing students with the complete learning cycle of aural, kinesthetic, and visual modes of instruction will also develop improved aural musicianship and instrumental performance (Kendall, 1988). Concerning high school band students, researchers who have studied the effect of vocalization on pitch accuracy have found that with combining the vocalizations of melodic, tonal intervals, and playing the intervals on one's instrument, students were more likely to develop improved pitch accuracy than those who received only instrumental instruction (Schlacks, 1981a).

Singing and the Development of Aural Skills and Intonation

The effect of singing on the development of aural skills and intonation is a topic studied by researchers and educational theorists alike. Research results regarding the effect of vocalization on instrumental pitch accuracy have been contradictory. Researchers have found that the use of simple vocalizations, such as humming isolated pitches, does not have an effect on the improvement of intonation accuracy in band

students (Bennett, 1994). Similarly, in a study with college wind players, researchers found no significant differences between the intonation of performers who vocalized prior to performance and those students who did not include vocalizations prior to performance (Smith, 1984).

Contrary to the above findings, results have indicated that students who participate in regular vocalizations in instrumental music classes have a greater sense of relative pitch (Elliott, 1974), resulting in increased accuracy of intonation. Students will perform with more accurate intonation if they receive an aural-based curriculum, consisting of singing rote songs, chanting rhythms, and singing tonal patterns (Dell, 2003c). Researchers have also concluded that instrumental classes that include structured singing activities result in higher levels of students' instrumental performance skills (LaPointe, 1981). Also, a direct relationship between the accuracy of singing intonation and the accuracy of string instrument intonation has been found (Frank, 2006c). Along with these findings, researchers have found a relationship between vocal accuracy and instrumental performance (Dunlap, 1989a).

According to a number of researchers and pedagogues, the integration of vocalization into the instrumental classroom provides students with the foundation needed to become successful musicians (Dell, 2003c; Mursell, 1931; Robinson, 1996). Mursell (1931) stated that it is through the voice that the ability to meaningfully hear music is developed. According to Gordon (2004), it is through vocalization and singing that the contextual development of tonality takes place; however, singing alone will not develop a sense of tonality, one must learn to audiate the tonal context, or tonality. The more singing that occurs in the music classroom the more likely tonal audiation will occur.

Researchers and pedagogues believe that if students can audiate in tune, they will ultimately play in tune (Gordon, 2003b; Grunow, 2005; Martin, 2005; Norman, 2005; Schleuter, 1997). Instrumentalists who incorporate singing as part of their training will play more in tune because they will be able to develop an "ear" for what is out of tune (Schleuter, 1997). Before playing melodies or patterns on an instrument, one should sing, and then audiate them. If students are audiating properly, they will be able to correct their own pitches (Schleuter, 1997). According to Gordon (2000), an "…instrument is simply an extension of the body of the person who used it" (p. 155).

Researchers suggest that singing in the instrumental classroom will assist students in better internalizing the pitches they will produce on their instruments and will in turn develop better intonation. Students who include simple vocalizations in tandem with playing on their instruments will perform with improved pitch accuracy (Dell, 2003c; Elliott, 1974; Frank, 2006c; LaPointe, 1981; Schlacks, 1981a).

Aural Readiness for Correct Intonation on Stringed Instruments

The most daunting challenge for beginning string players to play in tune is the limitless possibility for producing pitches on a stringed instrument. The ability for school students to produce correct intonation on a stringed instrument has been studied by few researchers. A common strategy in leading a student to correct intonation is the aide of tapes or stickers on the fingerboard, providing a kinesthetic and visual reference for students playing a stringed instrument. String players tend to play better

in tune with the help of a visual aide (Bergonzi, 1997). However, other researchers and pedagogues state that the finger placement marker is simply used as a crutch and will mask students' aural readiness skills (Gordon, 2003b; Martin, 2005).

A beginning musician's ability to discriminate between pitches and harmonic context is an important skill developed over time (Geringer, 1983), just as the developed internal representation of pitch is vital to the growing musician (Bergan, 1967). Gordon (2003b) believed that in order to help facilitate students' aural readiness, students must learn to audiate and hear the internal representation of the pitch (Bergan, 1967). The ability to audiate a pitch within a tonal context before the finger is placed on the fingerboard is critical for developing a musical and well-rounded string player (Martin, 2005).

Due to the lack of keys to press down or the lack of frets to use as a reference, some pedagogues may say string players are at a disadvantage when it comes to initially learning the correct pitches of their instruments. Because of this visual and kinesthetic disadvantage, it is crucial that the aural musicianship of a string student be developed. The more teachers know about a students' *potential* to develop this aural understanding, the better educators can facilitate this imperative development.

Music Aptitude

A person's music aptitude is defined as his potential to learn music. Everyone is born with some level of music aptitude (Gordon, 1979c, 1986, 2003a, 2003b, n.d.); however, heredity is not a significant factor in determining a child's music aptitude (Hong, 1999; Kehrberg, 1989). Hong (1999) researched the

relationship between music aptitude and heredity and music aptitude and environment, and did not find significant correlations between music and the combination of heredity and environment; yet, the unique mixture of genes and neurons may influence a child's music aptitude (Gordon, 2003b). Not to be confused with music achievement, music aptitude develops in tandem with appropriate instruction until the child reaches approximately age nine. A child's music aptitude fluctuates during the first nine years of life, which is why it is called developmental music aptitude. Upon reaching age nine, music aptitude stabilizes and instruction no longer has an effect on a person's aptitude. After age nine, music aptitude is referred to as stabilized music aptitude. Throughout life, a person's potential to achieve in music remains that of what it was at age nine.

Developmental music aptitude does not have an effect on vocal accuracy (Persellin, 2006) or singing achievement (Hornbach & Taggart, 2005), although stabilized music aptitude has been shown to affect the aural skills of students (Harrison, Asmus, & Serpe, 1994). While there is evidence to suggest that there is not a relationship between developmental tonal music aptitude and music achievement (Hornbach & Taggart, 2005; Mota, 1997; Persellin, 2006; Rutkowski, 1996), other researchers have found a positive relationship between stabilized music aptitude and instrumental music achievement (Brokaw, 1982). More specifically, regarding aural skills, tonal achievement, rhythmic achievement, and performance achievement, some researchers have found that music aptitude, academic ability, and musical experience do affect students' achievement in aural skills, with stabilized music aptitude being the leading factor (Harrison, Asmus, & Serpe, 1994). Tonal, rhythmic, and performance

achievement have also been found to be affected by students' stabilized music aptitude (Schleuter, 1978).

Music Aptitude Tests

Music aptitude can only be measured through a reliable and valid test. Gordon created a number of reliable and valid music aptitude tests for all ages. With the results from a sound music aptitude test, educators can differentiate their instruction to fit their students' needs (Gordon, 1979c, 1986, 2003b). A student can benefit musically from a teacher who knows his music aptitude score. A music aptitude score will reveal students' musical strengths and weaknesses; this knowledge can lead teachers to differentiate their instruction upon the specific needs of the student. Students who have high music aptitude may go unnoticed by a teacher or parent if not for finding out the results of a valid music aptitude test.

Music Achievement

A student's music aptitude, or his potential to learn music, should not be confused with music achievement. As previously defined, a student's music aptitude is his potential to learn music, whereas his music achievement is what he does with that potential. How a student utilizes his musical potential or the way in which a student has been instructed musically, has an effect on his music achievement.

A student with a high level of music achievement will have a high music aptitude; yet, if a student has a low level of music achievement, this does not mean he

or she will have a low music aptitude (Gordon, n.d.). Students with low or average music aptitude who receive proper instruction can gain high levels of music achievement. For example, a student with low music aptitude who attempts to learn a challenging piece of music may be able to do so with high-quality guided instruction and personal dedication to learning his or her instrument. Music achievement is a product of the developing musical skills needed to become a successful musician. This achievement is often measured by rating scales or teacher designed assessments. The areas of music achievement, whether physical, technical, or musical, can be quite subjective. However, comparing these achievements to a students' music aptitude makes the measuring of music achievement more objective.

Music Aptitude and Achievement

The relationship between music aptitude and music achievement is a subject that has received particular attention in the research literature. A significant relationship was not found between *developmental* music aptitude and singing (Mota, 1997), vocal accuracy (Persellin, 2006), or students' singing achievement (Hornbach & Taggart, 2005) in recent research. Some researchers have found that there is no relationship between developmental music aptitude and music achievement (Atterbury & Silcox, 1993; Harding, 2010; Hornbach & Taggart 2005; Mota, 1997; Persellin, 2006; Rutkowski, 1996). Regarding *stabilized* music aptitude in relationship to instrumental music, researchers have found that tonal, rhythmic, and performance skills were strongly affected by a students' stabilized music aptitude (Schleuter, 1978). A strong relationship between music achievement and stabilized music aptitude has been found in research regarding middle school wind players (Zdzinski, 1991). Music

aptitude scores have also been found to predict the musical success of a student (Young, 1971).

Summary

Music aptitude is defined as a person's potential to learn music (Gordon, 1979c, 1986, 2003a, 2003b, n.d.). A person has developmental music aptitude from birth through approximately age nine. One's developmental aptitude is in flux, affected by musical environment and education. Once age nine is reached, a person's music aptitude is considered to be stabilized and instruction will no longer have an effect on one's music aptitude. A person's music achievement or potential to learn is what he or she does with that aptitude. A thorough survey of the literature revealed that no significant relationship has been found by researchers between developmental music aptitude and vocal music achievement (Mota, 1997; Persellin, 2006; Hornbach & Taggart, 2005). However, researchers have found a significant relationship between stabilized music aptitude and instrumental music achievement (Brokaw, 1972; Schleuter, 1978; Zdzinski, 1991).

In regard to music aptitude's effect on singing and intonation, stabilized music aptitude has been found to affect both the aural skills of students (Harrison, Asmus, & Serpe, 1994) and the tonal skills of students (Schleuter, 1978). However, research regarding the effects of vocalization on the improvement of students' instrumental intonation has been contradictory. While some researchers have found vocalizations such as humming or singing to not affect intonation accuracy in instrumental students (Bennett, 1994; Smith, 1984), others have found that vocalizations in the music classroom do result in improved intonation skills among

instrumental students (Dell, 2003c; Dunlap, 1989a; Elliott, 1974; Frank, 2006c; LaPointe, 1981). Research regarding singing, string intonation and music aptitude is limited. This topic requires further investigation, which signifies the importance of the current study.

Rationale for the Study

A string player's ability to interpret his intonation is a vital skill needed to become a successful musician. Methods and instructional techniques for improving string intonation accuracy have been topics of discussion between educators and theorists alike; however, little research has been conducted on the topic. Research pertaining to a possible link between singing and instrumental intonation accuracy is limited and contradictory.

It is through singing that one develops a sense of audiation (Gordon, 2003b; Schleuter, 1997). The more one audiates, the more accurate one's instrumental intonation should become. By audiating, a student will then internalize the sounds he produces. The emphasis between an aural-oral connection will strengthen the audiation of the tonal context in which a student is playing. For example, the overall context of major tonality will be strengthened when students make an aural-oral connection between hearing and singing. Understanding and internalizing the context will result in more accurate content in terms of intonation.

Instrumental string intonation and the relationship between singing and string players' intonation accuracy as well as the relationship between stabilized tonal music aptitude and string players' intonation accuracy have received little attention in the research literature. The current study aims to explore the relationship between

stabilized tonal music aptitude and string instrumental intonation accuracy as well as the relationship between string instrumental intonation accuracy and vocal intonation accuracy.

Purpose of the Study and Research Questions

Due to the lack of research on the development of string players' intonation, and the need for more pedagogical practices used to refine this development, more information is needed regarding the relationship between stabilized tonal music aptitude and string instrumental intonation accuracy and the relationship between string instrumental intonation accuracy and vocal intonation accuracy. Therefore, with the intent of improving string pedagogy, the purpose of this study was to examine the relationship between stabilized tonal music aptitude and instrumental intonation accuracy and the relationship between vocal intonation accuracy and instrumental intonation accuracy. The following questions were investigated:

1. Is there a relationship between beginning string players' stabilized tonal music aptitude and their ability to play their instruments with accurate intonation?
2. Is there a relationship between beginning string players' ability to sing with accurate intonation and their ability to play their instruments with accurate intonation?

Directional Hypotheses

The directional hypotheses of the researcher in regard to the relationship between stabilized tonal music aptitude and string intonation and the relationship between instrumental intonation accuracy and vocal music accuracy are:

Hypothesis 1: A significant relationship between beginning string players' stabilized tonal music aptitude and instrumental intonation accuracy will be found.

Hypothesis 2: A significant relationship between beginning string players' ability to sing with accurate intonation and play with accurate instrumental intonation will be found.

Summary

Developing an internal representation of sound has been noted as essential for fostering auditory perception. By creating an aural/ oral foundation for students, educators may better facilitate the development of a listening vocabulary, which may lead to more success in students' ability to discriminate between pitches. The avenue in which to achieve this foundation requires further investigation.

One way in which to develop this foundation is through improvisation. Researchers have found that through improvisation, whether tonally or rhythmically, students will be able to express musically cohesive and spontaneous musical ideas (Azzara, 1993; Burton, 2011). Overall, the research regarding vocalization and instrumental intonation has been contradictory. Some researchers found that through simple vocalizations, instrumental intonation was improved, while other researchers have not come to this conclusion.

Integrating vocalizations into the instrumental music classroom may provide a foundation for becoming a successful musician (Dell, 2003c; Mursell, 1931; Robinson, 1996). Singing will also facilitate a students' ability to audiate, or, the ability to internally hear pitches without the sound being present (Gordon, 2004). String players rely heavily on their internal sense of pitch due to the somewhat abstract nature of their instrument. Because of this, developing an aural readiness for

string players is especially valuable. To better assist students, it is important for educators to know a students' potential to develop an aural understanding. Through valid music aptitude tests, an educator can do just that.

A students' potential to learn music, or their music aptitude, will stabilize at age nine. What a student does with that potential to learn is his or her music achievement. Although one may have low music aptitude, with quality instruction, the student may acquire high music achievement. Researchers have recently studied the relationship between developmental music aptitude and vocal achievement and have not found a significant relationship (Hornbach & Taggart, 2005; Mota, 1997; Persellin, 2006), whereas there has been a significant relationship found between stabilized music aptitude and instrumental music achievement by recent researchers (Brokaw, 1972; Schleuter, 1978; Zdzinski, 1999).

While research has been conducted regarding music aptitudes' relationship to instrumentalists' music achievement (Brokaw, 1972; Schleuter, 1978; Zdzinski, 1999), more specifically, woodwind players and brass players, little research has been done in regards to music aptitudes' relationship to string instrumentalists' music achievement. A closer look is needed at the existing literature on the topic of stabilized tonal music aptitude and instrumental intonation as well as the relationship between vocal intonation accuracy and instrumental intonation accuracy. Looking more specifically into the avenues in which to achieve proper intonation on a string instrument, the current study is intended to further pedagogy concerning the relationship between stabilized tonal music aptitude and its relationship to string players' intonation, as well as the relationship between singing with accurate intonation and playing with accurate intonation.

Chapter 2

RELATED LITERATURE

The focus of the current study is to examine the relationship between stabilized tonal music aptitude and beginning string players' intonation and the relationship between the ability to sing with accurate intonation and beginning string players' ability to play their instruments with accurate intonation. The current literature regarding music aptitude, singing intonation, and instrumental intonation may be categorized as follows: (a) vocalization and the development of instrumental intonation, (b) singing and instrumental performance skills, (c) singing and the development of string intonation, and (d) music aptitude and instrumental intonation. These categories are viewed in light of the purpose and research questions of the current study.

Vocalization and the Development of Instrumental Intonation

The relationship between vocalization and instrumental intonation relates directly to the current study. While the following study was conducted with band students, valuable comparisons can be made to the current study. Bennett (1994) studied the effects of simple vocalizations on brass and woodwind players' intonation. Participants ($N = 84$) were junior ($n = 49$) and senior ($n = 35$) high students from a metropolitan area in Arizona. Schools participating in the study were chosen because they did not regularly use vocalizations as part of their curriculum. The following research questions were addressed (Bennett, 1994, p. 5):

1. Can an instructional period using simple vocalization help improve the intonation of wind players?

2. When simple vocalization is used as a method of improving intonation, is grade level a factor in determining the accuracy of intonation of wind players?

3. Among high, middle, and low auditors, which group of subjects benefit the most from the use of simple vocalization as a means of improving the intonation accuracy of wind players?

4. Of the brass students and woodwind students used in the study, does one instrumental group exhibit greater improvement in intonation accuracy when using simple vocalization?

Two pretests were administered, followed by four weeks of instruction. At the conclusion of the four weeks, a posttest was administered. To determine participants' music aptitude, Advanced Measures of Music Audiation (AMMA) (Gordon, 1989) was used as a pretest. A researcher designed pitch-matching test was administered as a pretest and a posttest. For the pretest, students heard nine pitches from an audio recording that corresponded with pitches notated for the students to see. After a pitch was played for fifteen seconds, students were asked to repeat the pitch for ten seconds on their instruments. This data was recorded and converted to Hertz for analysis. During the posttest, students heard the pitch for ten seconds, as opposed to fifteen seconds heard during the pretest. After five seconds, students were asked to hum the pitch while the pitch was still being played.

The instructional period for the study occurred once a week, for twenty to thirty minutes, during a four week period. It is unclear whether or not the researcher acted as the instructor or the students' regular band teacher acted as instructor during this time. The description of the instructional period, as described by the researcher, is

also very vague and reads as follows: Each instructional session consisted of the following procedures:

1. Explanation of the purpose of the study in brief. No experimenter expectations were revealed.
2. Explanation and demonstration of simple vocalization.
3. Ten-minute warm-ups.
4. Sounding of the pitches on the Korg Auto Chromatic tuner AT-12.
5. "Humming" of the pitch by subjects. (If a subject could [not] "hum" or refused to "hum", the data for that particular subject(s) was recorded as missing data.) (Bennett, 1994, p. 31)

Data were analyzed using the paired sample *t*-test, Pearson product-moment correlation, ANOVA, Scheffé's multiple comparison tests, ANCOVA, and the multivariate analysis of variance repeated measures.

Bennett concluded no significant differences between pre- and posttests, indicating that the use of simple vocalizations did not improve students' intonation accuracy. Regarding students' music aptitude, no significant difference found between intonation accuracy and the low, middle, or high aptitude groups. No significant difference was found between junior high students' intonation accuracy, senior high students' intonation accuracy, or between woodwind and brass student's intonation accuracy.

Discussion

The lack of significant findings in Bennett's study may be a result of a few factors. First, regarding the pitches being vocalized, the pitches were not put into any

melodic or harmonic context for the students. The pitches were also extremely out of vocal range. Some notes went has high as an E6 (three ledger lines above the treble clef staff) and as low as a B-flat 1 (two ledger lines below the bass clef staff), which is not in a comfortable range for an untrained singer to sing. The fact that Bennett explained the purpose of his study to his participants each time they took part in vocalizing, may have been a threat to the external validity of the study. Also, regarding the gathering of data, Bennett recorded the students' humming while the pitch was still being played for the participants on the audiotape. This method may not have allowed Bennett to gather an accurate reading of the vocal pitch being produced by the students because the students may have been simply imitating the pitches being heard. The number of participating schools was not specified by the researcher, nor was the reliability coefficient of the researcher designed pitch-matching test. This missing information may affect the validity of the study.

Similarities can be drawn from Bennett's study to the current study. Although Bennett's study investigated the effects of vocalization on instrumental intonation and the current study investigated the *relationship between* vocalization and instrumental intonation, both studies aimed to enhance the pedagogical practices of improving students' intonation through the use of singing. Another similarity is the investigation of music aptitudes' relationship to accurate intonation among students. A difference between Bennett's study and the current study is that participants in Bennett's study hummed *isolated* pitches, while the current study used the singing of an etude in a tonal context.

Comparable to Bennett's (1994) conclusions, Smith (1984) did not find vocalization to affect instrumental intonation accuracy. The purpose of Smith's study

was to investigate the effects of vocalization on the intonation of college wind instrumentalists. Specific research questions were not provided by the researcher; however, three null hypotheses were tested (Smith, 1984, pp. 63-64):

1. Vocalization will not significantly affect the performed intonation of college wind players.

2. Male and female subjects will not differ significantly in intonational deviation of the performed exercises.

3. There will be no significant difference in the intonational deviation of woodwind versus brass instrument performers.

Participants from the study ($N = 94$) consisted of students currently in The Florida State University Wind Ensemble and Symphonic Band. Students were asked to perform four arpeggiated exercises in the key of concert B major on their respective instruments. Participants could enter the practice room in any order to record the four arpeggiated exercises. Depending on that order, the odd numbered students played exercise A on their instrument, vocalized exercise B for thirty seconds followed by playing exercise B on their instrument, played exercise C on their instrument, and vocalized exercise D for thirty seconds followed by playing exercise D on their instrument. The order of which exercises were played only or sung and played were reversed for the even numbered students, allowing each exercise to be played only and each exercise to be sung first followed by playing. A starting pitch was provided for each exercise.

Data were analyzed using the ANOVA with repeated measures. Regarding the first hypothesis, Smith found no statistical significance at the $p < .01$ level of confidence. However, Smith reported that if a $p < .05$ confidence level had been selected, a statistical significance *would* have been found. The second hypothesis was

accepted at the $p < .01$ level of significance. The mean deviation for male subjects was 36.90 cents while the mean deviation for female subjects was 32.80, indicating a difference of 4.10 cents. The proportion of variance was .0003. The third hypothesis regarding no significant difference in intonation deviance between woodwind and brass players was rejected. Brass players displayed greater deviation from the pitch by 10.22 cents. The proportion of variance was .084 for the instrument variable. Regarding vocalizations effect on instrumental intonation, Smith concluded that vocalizations did not affect intonation of college wind instrumentalists.

Contrary to Smith (1984) and Bennett's (1994) findings, Schlacks (1981a) found the vocalization of intervals through an interval-training program to have a positive effect on the pitch accuracy of high school band students. The following research questions were addressed by Schlacks (1981a, pp. 34-35):

1. Is the vocalization of intervals a factor leading to improved accuracy skills of high school band students?
2. Is the instrumental playing of intervals a factor leading to improved pitch accuracy skills of high school band students?
3. Is the combination of vocalization of intervals and the instrumental playing of intervals not only a factor leading to improved pitch accuracy skills of high school band students, but also a better method than the vocalization of intervals only or the instrumental playing of intervals only?
4. Is the vocalization of intervals and/or the instrumental playing of intervals an improvement factor on the sight reading of high school band students?
5. What are the effects of piano experience on the outcomes of the interval training program?
6. What are the effects of private lesson experience on the outcomes of the interval training program?

7. What are the effects of music theory experience on the outcomes of the interval training program?

8. What are the effects of choral music experience on the outcomes of the interval training program?

Schlack's study consisted of three experimental groups and a control group. Participants (N = 136) for the study were from four schools that were randomly assigned to either an experimental group or the control group. The three experimental groups were from Schools A, B, and C, while the control group was from school D. In School A, participants (n = 31) both sang intervals and played the intervals on their instruments, School B participants (n = 28) only sang the intervals, School C participants (n = 32) only played the intervals on their instruments, they did not sing, and School D participants (n = 45) continued with their normal rehearsal procedure.

Three pretests were administered as well as a researcher-designed questionnaire (Schlacks, 1981c). The three pretests included the pitch recognition portion of Colwell's Music Achievement Test (1970), a researcher-designed Interval Performance Test (Schlacks, 1981b), and the Watkins-Farnum Performance Scale (1962). During the Music Achievement Test (Colwell, 1970), students saw a series of two notated pitches. The first note was played for the students. The students then heard three more pitches and were asked to match one of the three pitches to the second note written on the page. A reliability coefficient was not given for this measure.

For the researcher-designed Interval Performance Test (Schlacks, 1981b), participants were asked to play ten intervals chosen at random by the researcher. Participants were recorded and data were analyzed by the number of cents deviated

from the second note. Students could score a total of 100 points. A split-half reliability coefficient of .94 was given for the measure.

To examine students' sight-reading ability, the Watkins-Farnum Performance Scale (1962) (r = .95) was administered. Students were asked to sight-read twenty exercises, increasing in difficulty. Points were taken off from the students score if an error in pitch, time, rhythm, tempo, expression, or articulation occurred. If students played two consecutive exercises without scoring any points, they were asked to stop. There were two forms for this test. The first form was used as the pretest and the second form was used as the posttest. Differences in the forms were not specified by the researcher. Along with the second form of the Watkins-Farnum Performance Scale (1962), posttest included the pitch recognition portion of the Music Achievement Test (Colwell, 1970), and the researcher-designed Interval Performance Test (Schlacks, 1981b).

Students in the three experimental groups participated in the interval training program for five to six minutes a day for one month. Because of the school calendar, the total number of days students participated in the program was twenty. During the first five days, only one interval was incorporated. For the remainder of the study (days six through twenty), two intervals were incorporated. Teachers in all three experimental schools were allowed to correct students' intonation problems during the five to six minute training period.

Data were analyzed using ANOVA, the Scheffé test for differences of means, and *t*-tests. Schlacks reported eight conclusions: (a) students who received vocalizing only treatment had improved instrumental interval pitch accuracy, although

not significantly; (b) students who received instrumental only treatment, improved in instrumental interval pitch accuracy, but not a significant amount; (c) students in the experimental group that utilized both the singing and playing of intervals benefitted the most, with significant improvements in their instrumental interval pitch accuracy; (d) very little improvement in sight-reading was reported for all groups; (e) significant differences were not found between students who had piano experience and those who did not; (f) significant differences were not found between students who received private instrumental lessons and those students who did not; (g) significant differences were not found between students' who had music theory experience and those students who did not; and (h) significant differences were not found between students who received choral training and those students who did not.

Discussion

The "normal rehearsal procedure" used in the aforementioned study was not specified by Schlacks. Knowing this information may have increased the overall validity of the study and would have made it easier to replicate the study. Schlacks' conclusions suggest that pitch accuracy will be improved with interval training that incorporates both singing and the playing of instruments. This finding is important to the current study because although an interval training system was not used, the transfer from vocalizations to instruments was incorporated. Along with Schlacks' study, the vocalizations in Smith's study were also put into a tonal context, similar to the current study. Bennett, however, used isolated pitches to investigate the effect of vocalizations on instrumental intonation. Both Bennett's study and Schlacks' study utilized the use of an instructional period before testing, similar to the current study.

Participants from Schlacks' (1981a), Bennett's (1994), and Smith's (1984) studies were all instrumental band students. Little research has been conducted on the relationship between vocalization and *string* players' performance achievement, signifying the importance of the current study.

Although Elliott's (1972) study was conducted with beginning band students, some parallels can be made to the current study. The purpose of Elliott's study was to determine the effects of vocalization on beginning band students' sense of pitch. The following research questions were addressed:

1. What effect on the development of the sense of pitch will regular practice of singing in band class have on beginning band students?
2. Will the singing that takes place during class have an equal effect on the sense of pitch for all students?
3. Will the development of students' sense of pitch be affected by outside private piano study?
4. Will there be a difference in the development of the sense of pitch between brass and woodwind players?
5. Will participating in an outside vocal ensemble effect the development of students' sense of pitch?
6. What effect will regular participation in band classes have on the pitch discrimination and tonal memory abilities of the students? (Elliott, 1972, p. 14)

Elliott described a sense of pitch in four ways: one's ability to (a) discern slight differences in the pitches of tones sounded consecutively; (b) recall correctly, after a brief interval, short melodic passages; (c) mentally convert sounds perceived aurally into musical notation; and (d) mentally convert musical notation into musical

sounds (Elliott, 1972, p. 16). Only the first two definitions were considered for Elliott's study because music notation was not a factor.

Participants in the study ($N = 196$) consisted of beginning band students from six different elementary schools. Three classes were used for the control groups ($n = 97$) and three classes were used for the experimental groups ($n = 99$). A pretest was administered to all six groups to measure their development of pitch before the study began. The pitch discrimination and tonal memory subtests of the Seashore Measures of Musical Talents (Seashore, Lewis, & Saetveit, 1939) were administered to the participants. A reliability coefficient was not given by the researcher for this measure.

Posttests used for the study were the pitch discrimination and tonal memory subtests of the Seashore Measures of Musical Talents Test (Seashore, Lewis, & Saetveit, 1939), a researcher-designed test entitled Subtest C (Elliott, 1972a), to measure students' ability to match aural musical examples to notation, the Kwalwasser-Ruch Test of Musical Accomplishments (Kwalwasser & Ruch, 1927), and a researcher-designed questionnaire (Elliott, 1972b).

Subtest C pilot tests were given to a different group of students than the participants in the study, and the measure was revised a total of four times to come to a final version with a reliability coefficient of $r = .76$. The Kwalwasser-Ruch Test of Musical Accomplishments ($r = .77$) measured students' ability to detect musical mistakes in notation. The tune of "America" was written out for the students to look at, with five measures incorrectly notated. While following along with the notation,

students were asked to listen to the tune and mark which measures were notated incorrectly from what they heard.

Instructors for the three experimental groups were asked to teach in their usual manner but, in addition, add vocalization of pitches and exercises using only the syllable "la." There were two parts to the procedure. Instruction for the first part consisted of playing the exercises from the *First Division Band Method* (n.d.), vocalizing the pitches, and then playing the exercises again. If a new note was introduced, students were instructed to vocalize the new note before playing on their instruments. Exercises from the book that had difficult rhythms were avoided to maintain focus on vocalizing the pitches. Only the exercises that were written for all of the instruments were used for vocalization. Because of these criteria, roughly one to three exercises per page were vocalized.

During the second part of the study, the exercises were not played first, but instead were vocalized first and then played on instruments. The students were asked to sing the exercises, only being given a starting pitch, before playing them. The amount of time designated for part one and part two was not specified in Elliott's study, nor was the explanation of when it was time to switch to part two of instruction.

Data were analyzed using ANOVA. In comparing pretest means regarding pitch discrimination skills and tonal memory, the experimental group means (50.43) and control group means (49.50) were similar. Experimental groups scored significantly higher than control groups on subtests A, C (the ability to match aural examples to notation), and D. The experimental group scored higher on subtest B than the control group, but no significant difference between brass players' and woodwind

players' posttest scores was found. When taking into account private piano study, students receiving private piano study scored significantly higher than non-pianists. When the pianists' scores were removed, the experimental groups still scored higher on the posttests than the control groups. Students in the experimental group who participated in a vocal ensemble scored significantly higher than students in the control group who had participated in a vocal ensemble.

Upon data analysis, Elliott interpreted the results to form the following conclusions: (a) pitch discrimination and tonal memory abilities improved with the participation of regularly held band classes, with a greater increase shown in the experimental group, (b) students' sense of pitch was significantly affected with the inclusion of vocalizations in regular band classes, (c) there was no significant difference between the scores of brass and woodwind players, (d) students' sense of pitch was not affected by their participation in outside piano study, (e) outside participation in a vocal ensemble had little effect on students' sense of pitch, and (f) students who showed the least developed sense of pitch in the pretests results displayed the most improvement in their posttest scores.

Discussion

Although the participants for Elliott's study consisted of band students, and string students were utilized for the current study, the conclusions Elliott drew from this study assisted in the development of the directional hypotheses for the current study, in that singing in an instrumental classroom would increase a student's sense of pitch, resulting in better intonation on an instrument.

Summary

Studies regarding the effects of vocalization on instrumental band students have led to contradicting conclusions. Some researchers have found that simple vocalizations do not have an effect on instrumental intonation accuracy (Bennett, 1994, Smith, 1984). Other researchers (Elliott, 1972; Schlacks, 1981a) have concluded that vocalizations positively affect students' sense of pitch and pitch accuracy. This contradiction validates the importance of the current study to add to the body of literature regarding the relationship between vocalization and instrumental intonation.

Singing and Instrumental Performance Skills

Dunlap (1989a) studied the effect of singing and solmization training on the musical achievement of beginning fifth-grade instrumental students. The purpose of the study was to determine if singing and solmization exercises had an effect on the development of vocal accuracy, melodic ear-to-hand coordination, melodic aural-visual discrimination, instrumental performance, and instrumental sight-reading skills. Ninety-two beginning fifth-grade band students ($N = 92$) participated in the 14-week study. Students from intact music classes were randomly assigned to either the control or experimental group (two classes of each). Identical instruction was given to both groups for the first four lessons, which focused on the basics of instrumental playing. Both groups received instruction based on the activities from *The Comprehensive Music Instructor: Listen, Move, Sing, and Play for Band*, Book 1, by Froseth (1984a) along with the Rhythmic Training cassette tape (Froseth, 1984b) and Solfege Training and Intonation Studies (Froseth, 1984c) cassette tape. Students in the experimental

group chanted using rhythm syllables, sang melodic patterns, and sang songs with lyrics to be played on instruments. The control group did not sing or use solmization activities. In addition, the Rhythmic Training tape was duplicated with a drum machine for the control group, but without the use of rhythm syllables.

To measure the students' musical backgrounds, Dunlap administered two researcher-designed surveys, and Froseth's *How I Feel About Music* survey (1973). The Post-Experiment Student Survey (Dunlap, 1989e) was used to determine the level of involvement in music class for each student. The General Music Teacher Survey (Dunlap, 1989b) was administered to determine the consistency of musical activities within each classroom. Reliability coefficients were not given for the two post-surveys. Music aptitude was measured using Gordon's Music Aptitude Profile (MAP) (1965b). The MAP has split-half reliabilities ranging from $r = .70$ to $r = .85$, with a total composite reliability of $r = .91$ for fifth grade.

Five posttests were used to measure the students' musical achievement. Melodic ear-to-hand coordination was measured using Froseth and Dunlap's Melodic Ear-to-Hand Coordination Test (1982) with a reliability coefficient of $r = .95$ and an inter-judge reliability of $r = .97$. Froseth's Test of Melodic Reading Recognition (1989) was used to measure melodic aural-visual discrimination ($r = .73$). Instrumental performance was measured using the researcher designed Instrumental Performance Test (Dunlap, 1989c) ($r = .95$), and instrumental sight-reading was measured using a researcher designed test called the Instrumental Sight-Reading Test (Dunlap, 1989d) with a reliability coefficient of $r = .96$. Vocal accuracy was measured both before and after the study using the Melodic Echo Test designed by Stauffer (1985) ($r = .92$).

Dunlap concluded that vocal accuracy was significantly related to melodic ear-to-hand coordination, melodic aural-visual discrimination, instrumental performance skills, and musical aptitude. Dunlap concluded that students' participation in singing and solmization activities was not reflected in the test score results of vocal accuracy, melodic ear-to-hand coordination, melodic aural-visual discrimination, instrumental performance, or instrumental sight-reading. Moreover, the relationship between test scores in all of the areas *did* become stronger after being exposed to instruction in the experimental group.

Dunlap's conclusions suggest that singing and solmization activities may influence the development of melodic ear-to-hand coordination, melodic aural-visual discrimination, instrumental performance skills, and music aptitude and that there is a relationship between vocal accuracy and the aforementioned elements. The purpose of Dunlap's study relates to the current study, which focuses on the relationship between vocal intonation and string intonation, as well as the relationship between music aptitude and string intonation.

Singing and the Development of String Intonation

Some researchers question whether singing has an effect on instrumental intonation accuracy. Frank (2006c) examined the relationship between singing intonation and string instrument intonation. Thirty-one beginning violinists and violists participated in the study. Because of the similar ranges of the violin and viola, Frank limited the study to students who played those two instruments. Participants ($N = 31$) were fifth ($n = 20$) and sixth ($n = 11$) grade students who met three times a week for 40 minutes to receive string instruction. It was noted in Frank's study that

singing activities were used during instruction; however, the amount of time dedicated to singing in the instrumental classroom is unknown.

A pilot study was conducted to allow students to become familiar with the testing procedure. During the pilot study, participants were asked to fill out a researcher-designed musical experience survey (Frank, 2006b). Participants were then asked to sing the familiar tune, "Row, Row, Row, Your Boat" into an audio recorder. The first 14 participants were given an introduction of a tonic-subdominant-dominant-tonic chord progression in the key of D Major. After an informal analysis, the researcher discovered the key of D Major was too high for the participants' undeveloped voices. The remainder of the participants were given a starting pitch and asked to sing in B-flat Major. Participants were allowed to sing on a neutral syllable, or hum the pitches. The pilot study also served as a means for Frank to test the researcher-designed rating scale used in the study (Frank, 2006a). Three vocal judges evaluated the singing portion of the test and three string judges evaluated the playing portion of the test. Pearson product-moment correlations were computed for interjudge reliability of vocal judges' scores (r = .79) and the string judges' scores (r = .55). The rating scale was modified for the current study because of the low reliability found from the string judges. A different set of three string judges was used for the primary study (r = .69).

During the primary study, participants sang the song "Yankee Doodle" in E-flat major, with the words, and played the song in G major on their respective instruments. The researcher taught the song to the participants' two class periods prior to testing, the method used for teaching the song is unknown. The procedure for testing was identical to the second half of the pilot study, students were given a

starting pitch and asked to sing the song and then play the song on their instrument. Data were recorded and analyzed using Pearson product-moment correlation. After analyzing the results, Frank concluded that a significant relationship (r = .41) was found between string intonation and singing intonation.

Discussion

Frank's study poses many inconsistencies that diminish the validity of the study. Changing the melodic key half way through the pilot study demonstrates one inconsistency. Frank had the participants fill out a survey about their prior musical experience, but the data was not used in drawing conclusions for the study. The students received singing instruction prior to the study, but no details were provided by the researcher about the method of this instruction. Another critique of the study is that Frank allowed participants to either hum or sing. These types of vocalizations are different from each other and may produce different results. In addition, the song used for rating participants' intonation accuracy was sung and played in different keys.

Although Frank's study may lack consistency, Frank, like the current study, investigated the relationship between string students' instrumental intonation accuracy and vocal intonation accuracy. Both studies will contribute to the limited body of literature regarding string instruments specifically and vocal intonation.

Dell (2003c) studied the effects of singing and tonal pattern instruction on beginning string students' intonation skills. The impact of pitch matching, pitch discrimination, and students' prior experiences on intonation was also considered in the study. The following research questions were addressed (Dell, 2003c, p. 11):

1. Is there a difference in the intonation performance posttest scores of string groups instructed using the Aural-Based, Aural-Based with Tonal Pattern Enhancement, and Notation-Based methods?

2. Do the intonation performance scores of beginning string students differ as a function of treatment, pitch discrimination, and prior experiences while controlling for music aptitude?

Participants (N = 158) for this study were beginning fifth- and sixth-grade string students of nine intact classes from seven schools. Students were either in their first or second year of string instruction, depending on their grade level. Over half of the students (n = 90) received five days of instrumental instruction per week, while the remaining students (n = 68) received three days of instrumental instruction a week. Although the students were *beginning* string students, 25.3% of the participants had prior experience on their current instrument. Instruction for the study began in August of the school year and continued for 25 weeks. The study concluded at the end of the school year in May.

A multi-group, quasi-experimental posttest-only design was used for Dell's main study. Participants were divided into three experimental treatment groups: Aural-Based (n = 59), Aural-Based with Tonal Pattern Enhancement (n = 53), and Notation-Based (n = 46). Teachers who worked with the Aural-Based Experimental Group and the Aural-Based with Tonal Pattern Enhancement Experimental Group each received a three-credit college course on the use of these methodologies. Because of this, intact classes were randomly assigned to be a part of these two experimental groups, either the Aural-Based or Aural-Based with Tonal Pattern Enhancement Experimental Group. The remaining teacher in the study that did not receive this

training taught the Notation-Based Experimental Group. Intact classes were also randomly assigned to this group.

Students were taught both right and left hand techniques that allowed them to play simple folk songs in D and G major. Students in the Aural-Based Experimental Group were taught new concepts aurally through singing rote songs (consisting of melodic lines and bass lines) and chanting rhythmic chants. The Aural-Based with Tonal Pattern Enhancement Experimental Group received the same instruction as the Aural-Based Experimental Group, but with the addition of singing and performing sequential sets of tonic and dominant tonal patterns. Students who received instruction from the Notation-Based Experimental Group were taught concepts through notation, discussion, and then performance.

Teachers from the first two audiation-based groups received daily detailed researcher-designed lesson plans to use. The Notation-Based Group followed lesson plans found in the Teacher Resource Kit from the *Essential Elements for Strings: A Comprehensive String Method* book (Allen, Gillespie, & Tellejohn-Hayes, 1994).

The Aural-Based Group (n = 59) was comprised of four string classes in two school districts. New songs and concepts were taught through singing both the melodic and bass lines. Solfege names were used to label pitches as opposed to using actual note names, using solfege syllables was done to encourage the understanding of intervallic relationships. Participants used the *Jump Right In: The Instrumental Series for String* CD (Grunow, Gordon, Azzara, & Martin, 1995) to practice; however, all tonal pattern tracks were removed from the participants' CD's. During the fifth month of instruction, reading skills were taught using the *Essential Elements for Strings: A*

Comprehensive String Method for Strings (Allen, et al., 1994) book. Participants sang each exercise using solfege syllables, followed by chanting the note names. Each exercise was played first with pizzicato and then bowed. Ten minutes of each lesson was dedicated to reading activities. To smooth the transition from solfege to letter names, participants were taught lessons five through eight from the *Jump Right In: The Instrumental Series* (Grunow, 1993) book.

The Aural-Based with Pattern Enhancement Group (n = 53) also consisted of four string classes from two school districts. Activities were identical to the Aural-Based Group, with the addition of ten-minute lessons using 16 two- and three-note tonic and dominant patterns in major and minor modes. Participants sang the patterns first and then played the patterns on their instruments. Participants used the *Jump Right In: The Instrumental Series for Strings* CD (Grunow, et al., 1995) to practice, including all of the pattern tracks. Notation was taught, during the fifth month of instruction, through the familiar order of patterns. Once the students could read these familiar patterns through notation, the *Essential Elements for Strings: A Comprehensive String Method for Strings* (Allen, et al., 1994) book was used, as in the Aural-Based Group. The same procedure was used as in the Aural-Based Group (of singing, chanting, pizzicato, and bowing) as well as the teaching of technical skills using lessons five through eight from the *Jump Right In: The Instrumental Series* (Grunow, 1993) book.

The Notation-Based Group (n = 46) consisted of three string classes in two school districts. New material was taught through notation using the *Essential Elements for Strings: A Comprehensive String Method for Strings* (Allen, et al., 1994) book. Finger charts, diagrams, and note names were used to teach left hand technique.

Right hand technique was taught using different bowing styles as outlined in the method book. Very little singing was used in this group. This group was used as the control group.

Criterion measures used in this study were (a) the IMMA tonal subtest (Gordon, 1965a) to measure participants tonal music aptitude, (b) the Pitch Discrimination Measure (PDM), adapted from Fyk (1981), to measure pitch discrimination skills, (c) Pitch Matching Measure (PMM) (Dell, 2003b) to measure students' pitch matching abilities, and (d) the Intonation Performance Measure (IPM) (Dell, 2003a) to measure students' intonation. The IMMA was administered four months into the study, the PDM was administered during the eighth month of the study, the PMM was administered during the eighth and ninth month of treatment, and the IPM during the ninth and tenth month of the study.

The IMMA (Gordon, 1965a) consists of tonal and rhythmic subtests. Only the tonal subtest was used for this study. Participants heard a series of three pitches followed by a pause, and three more pitches. The reliability ranged from $r = .72$ (split halves) to .85 (test-retest) for fourth grade, as notated in the IMMA test manual.

To measure the pitch discrimination skills of the participants, Dell (2003c) adapted Fyk's (1981) Pitch Discrimination Measure by using American folk songs instead of the original Polish folk songs. The PDM consisted of 40 folk songs divided equally by melodic cadences. Participants were asked to identify if the two phrases played ended on the same melodic cadence. The PDM had a split-half reliability of $r = .86$.

Administered during the eighth month of treatment, the PMM was used to measure the participants pitch matching abilities. While being recorded, participants were asked to listen to a recording of a note and match the pitch on their instruments. The note was held for six seconds with a two second pause in between notes. All six notes in first position on the G, D, and A strings were performed. The researcher told the participant the appropriate fingering of each note. Recordings were then converted to a CD. The Cool Edits Pro software program (Version 2) was used to analyze the sound recordings. Using Cool Edits Pro software, two raters performed a frequency analysis. The beginning and the end frequencies of each note were analyzed by the software and a mean frequency was calculated. Once calculated, the absolute deviation from equal temperament was found and the sum of these deviations was used to calculate an overall pitch performance score. There was an inter-rater reliability of $r = .98$ for this measure.

Two eight-measure researcher-designed etudes were used for the IPM. Participants were recorded playing the etude and, like the PMM, two raters used the Cool Edits Pro software to analyze the sound recordings. An inter-rater reliability of $r = .96$ was found for this measure.

Data were then analyzed using descriptive analysis and ANCOVA. Dell (2003c) concluded that training which incorporated singing and tonal pattern enhancement had a positive effect on the development of beginning string students' intonation skills. When compared to the Notation-based control group, students in the Aural Based and Aural Based with Tonal Pattern Enhancement performed more in tune. This conclusion suggests that an aural based instructional program, which incorporates singing, will result in more accurate intonation of beginning string

students. The second research question addressed the effect of the combination of pitch discrimination, experience, and treatment on intonation performance skills, while factoring out the effects of music aptitude. Dell used the IMMA as a covariate and found that both treatment and music aptitude had an effect on intonation.

Discussion

Dell studied the effects of singing and tonal pattern instruction on the intonation of beginning string players. A critique of this study is that Dell added the element of notation, after the fifth month of instruction, to the treatment for the experimental groups. Although this addition may have been due to the needs of the schools' curriculum, it may have been wise to conclude the study at that point in order to obtain the most accurate data. Another element called into question is Dell's use of Fyk's PDM (1981). This measure required participants to identify if two melodic cadences were the same or different. This seems to be more of a *harmonic* development measure than a pitch discrimination measure.

Dell's study draws parallels to the current study because the effect of singing on beginning string players' intonation was examined. The conclusion made by Dell regarding the positive effect of singing on string students' intonation, supports the directional hypothesis of the current study that state a positive relationship will be found between vocal intonation accuracy and instrumental intonation accuracy.

Music Aptitude and Instrumental Intonation

Music aptitude is defined as a person's potential to learn music. While research has been conducted regarding *developmental* music aptitude and singing

(Harrison, Asmus, & Serpe, 1994; Hornbach & Taggart, 2005; Mota, 1997; Persellin, 2006; Rutkowski, 1996), few researchers have studied the relationship between *stabilized* music aptitude and instrumental music achievement. Schleuter (1978) found tonal, rhythm, and performance achievement are strongly affected by music aptitude. Schleuter studied the effect of music aptitude, gender, and combinations of lateral dominance on instrumental achievement. More specifically, Schleuter investigated student's music aptitude, their difference in gender, and how their level of handedness[2], eyedness, or footedness would affect their music achievement and executive skills. Specific research questions were not provided by the researcher.

Instrumental music students who played flute, clarinet, trumpet, French horn, trombone, percussion, violin, and cello ($N = 104$) from grades four ($n = 40$), five ($n = 41$), and six ($n = 23$) from two elementary schools participated in the study. Instrumental classes and large ensemble classes met weekly.

Data were collected from each student regarding music aptitude, music achievement, sex, handedness, eyedness, and footedness. Music aptitude was tested using the Music Aptitude Profile (MAP) (Gordon, 1965b). A researcher-designed rating scale was used to rate students' music achievement skills. Students received a score of one to five for four separate categories: (a) tonal skills (sense of tonality, tone quality, and intonation), (b) rhythmic skills (consistency of keeping beat, accuracy of meter, and melodic rhythm patters), (c) instrument physical manipulation skills (finger, hand, arm dexterity, and muscle coordination when handling the instrument),

[2] The preferred hand, foot, or eye used for a set of familiar tasks (Schleuter, 1978).

and (d) general instrumental performance skills. An inter-rater reliability coefficient was not provided by the researcher nor was a sample of the rating scale.

Investigator observations during interviews with the students were used to measure characteristics of the students' handedness, eyedness, and footedness. Students were individually asked to perform certain tasks such as writing their name, holding a toothbrush, throwing a ball, looking through a paper tube, kicking a ball, and hopping on one foot.

A five-way multivariate analysis of variance (MANOVA) was used to analyze the data. A *t*-test was computed to obtain the achievement variable means for students' music aptitude. Schleuter found no evidence to suggest that combinations of music aptitude, gender difference, handedness, eyedness, or footedness had an effect on music achievement. However, Schleuter reported that tonal, rhythmic, and performance achievement were strongly affected by music aptitude, though direct statistical data was not provided by the researcher.

Discussion

With such vague details regarding the researcher-designed rating scale and the informal nature of the investigator observations, the validity of this study is called into question. How the informal observations of students' handedness, eyedness, and footedness were coded, was not provided by the researcher. The reason for using a *t*-test is also called into question. A *t*-test should be conducted with no more than 30 subjects; however, there were 104 participants in Schleuter's study. Although Schleuter concluded tonal, rhythmic, and performance achievements were affected by students' music aptitude, the criterion measures for tonal, rhythmic, and performance

achievements were not provided. However, this conclusion in Schleuter's study was considered while developing the directional hypotheses for the current study.

Brokaw (1982) studied the relationship between musical achievement and music aptitude. The purpose of the study was to investigate the relationship between parental supervision of practice time and student achievement of technical-physical performance and musical performance. Technical-physical achievement included proper embouchure, acceptable hand position, correct instrument position, and correct posture. Musical performance achievement included elements such as correct articulation, accurate melody, precise rhythm, and proper phrasing. Along with music aptitude, Brokaw studied the relationship between student achievement (although undefined by the researcher) and (a) total minutes of student home practice, (b) students' expressed interest in music prior to instrumental study, (c) students' age in months, (d) student grade level, and (e) percentage of time English was spoken in the home.

The study, conducted in Yokohama, Japan consisted of two heterogeneous beginning band classes. Students in grades six (n = 8), seven (n = 5), and eight (n = 12) participated in the study. Evaluation occurred after ten weeks of instruction (n = 25) and after seven months of instruction (n = 14), however, only statistical data gathered after ten weeks of instruction were analyzed. Pre- and posttests were administered and distributed to participants. Pretests used for the study were Gordon's MAP (1965b) and Froseth's *How I Feel About Music* survey (1973).

The *Individualized Instructor- Preliminary Book* (Froseth, 1977) was used as the instructional band book for this study because it incorporated parental

instructions for at-home supervision. A parental meeting was held at the beginning of the study, in which the instructional program was explained, a consent form was signed, and a survey was distributed to collect data regarding the percentage of time English was spoken in the home and children's ages.

After ten weeks of instruction, students were evaluated on both physical-technical achievement and musical achievement. Five researcher-designed etudes were used, two etudes focused on physical-technical achievement (I-A, II-A) and three etudes focused on musical achievement (I-B, II-B, III). After seven months of instructions, achievement was evaluated using six new researcher-designed etudes. Two etudes focused on physical-technical achievement (I-A, II-A), two etudes focused on musical achievement (I-B, II-B), and the remaining two etudes were used for sight-reading purposes (III-A, III-B). One week prior to testing, students were given etudes I-A and I-B and received help from their instructor in learning the etude. Students were also given etudes II-A and II-B, but were instructed to learn those etudes at home, without the help of an instructor.

Although Brokaw stated that the B etudes were only evaluated for musical achievement, a 'technical-physical' category was included in the rating scale. Two independent judges watched videotapes of the students' performances and evaluated participants using a 5-point numerical rating scale (physical criteria $r = .75$, musical criteria $r = .92$, combined criteria $r = .89$). The judges' musical backgrounds were also not clarified.

Data were analyzed using Pearson product-moment correlations to determine the relationship between student achievement and (a) total minutes of

parental supervision of home practice, (b) total minutes of student home practice, (c) MAP scores, (d) interest inventory scores, and (e) student age in months. In order to eliminate the effect of skewness due to two parents failing to complete weekly reports, a Spearman rank-order correlation was calculated to determine the relationship between parental supervision of home practice and the total number of minutes spent at home practicing. ANCOVA was used to compare home practice with and without supervision and student achievement as well as student achievement with the percentage of time English was spoken in the home and students' age.

Brokaw (1972) found a moderate positive relationship between music aptitude and musical achievement, ($r = .46$, $p < .05$). No relationship was found between music aptitude and technical-physical achievement, however. No significant relationship was found between the percentage of English spoken in the home and music achievement, nor was a significant relationship found between student achievement and grade level. Implications of Brokaw's study are that when considering enrolling a student into a music program, one should consider the following factors: (a) physical characteristics, (b) MAP scores, and (c) academic achievement. Brokaw also concluded parental supervision to be strongly related to high musical achievement.

Similar to Brokaw, Zdzinski (1991) studied the relationship between parental involvement, music aptitude, and music achievement. The specific research questions investigated by Zdzinski were the following (Zdzinski, 1991, p. 116):

1. What is the relationship between cognitive musical achievement and parental involvement?

2. What is the relationship between performance achievement and parental involvement?

3. How does cognitive musical achievement differ as a function of parental involvement, music aptitude, grade level, and gender?

4. How does performance achievement differ as a function of parental involvement, music aptitude, grade level, and gender?

Randomly selected woodwind and brass students ($N = 113$) were selected from grades six ($n = 23$), seven ($n = 43$), and eight ($n = 47$). Tests were administered to students by their instructors during two ninety-minute sessions. It was not specified by the researcher what music students played in order to be measured. The scoring criteria for the performances was also unclear, though performances were reported to be judged by the researcher.

Criterion measures consisted of the following: (a) a researcher designed questionnaire, the Parental Involvement Measure (PIM), (b) Gordon's (1965b) Music Aptitude Profile (MAP), (c) Colwell's (1969) Music Achievement Test (MAT), and (d) Watkins-Farnum Performance Scale (WFPS) (1954). The PIM was a 5-point Likert-scale research-designed questionnaire used to examine students' perceptions of parental involvement. The questionnaire consisted of fifteen items in which students were asked to rank parental involvement from one to five, and fifteen questions in which students were asked to answer "both", "neither", or "father only, mother only". There were a total of nine additional items to be answered 'yes' or 'no'. The PIM was used to gather descriptive data on gender, grade, age, school, playing experience, practice time, and outside musical instruction. The questionnaire was used in a pilot study to verify the content validity of the measure (test-retest reliability $r = .94$).

To measure students' music aptitude, the tonal imagery and rhythmic imagery subtests of the MAP (Gordon, 1965b) (split-half reliability $r = .93$) were used. Six subtests from Colwell's (1970) MAT (split-half reliability $r = .93$) were used to measure cognitive musical achievement. The subtests measured (a) major-minor mode discrimination, (b) feeling for tonal center, (c) pitch recognition, (d) instrument recognition, (e) rhythmic test of music reading, and (f) pitch test of music reading. Performance achievement was measured by the Watkins-Farnum Performance Scale (1954) (intraclass correlation $r = .95$) in which reliability coefficients ranged from $r = .86$ for bassoon and flute, to $r = .77$ for trumpet and French horn.

Data were analyzed using Pearson product-moment correlations to determine the relationships between performance achievement and all variables except parental involvement. MANOVA was conducted to analyze the interactions between parental involvement, music aptitude, student grade, and gender. Results indicated (a) a significant relationship between performance achievement and parental involvement, (b) a relationship of little practical significance between both musical achievement and music aptitude and parental involvement, (c) a significant three-way interaction for performance achievement between parental involvement, music aptitude, and gender, and (d) a strong relationship between music aptitude and both musical and performance achievements. Zdzinski concluded that parental supervision was strongly connected to music achievement and that music aptitude was strongly related to music achievement. This conclusion supports the directional hypothesis of the current study that states that a significant relationship will be found between students' music aptitude scores and their instrumental achievement of accurate intonation.

Discussion

The studies analyzed regarding the relationship of stabilized music aptitude to instrumental intonation demonstrate a positive relationship between the two factors (Brokaw, 1972; Schleuter, 1978; Zdzinski, 1991). As noted, all of the above studies were conducted primarily with band students. The current study will add to the body of literature regarding the relationship between stabilized tonal music aptitude and instrumental intonation, but more specifically, *string* instrumentalists' intonation.

Summary

The research studies examined in this literature review relate to the current study regarding the investigation of relationships between music aptitude and instrumental intonation and the relationships between instrumental intonation accuracy and vocal intonation accuracy. The literature on the relationship between vocalizations in the music classroom and instrumental intonation also relates to the current study.

Research regarding these relationships has been contradictory, stressing the importance of the current study. While some researchers have found vocalizations to not affect instrumental intonation accuracy (Bennett, 1994; Smith, 1984), others have found interval-training programs to have a positive effect on instrumental intonation (Schlacks, 1981a) and regular vocalizations in band class to significantly affect students' sense of pitch (Elliott, 1972). A relationship has also been found between vocal accuracy and the following elements: (a) ear-to-hand coordination, (b) melodic aural-visual discrimination, (c) instrumental performance skills, and (d) music aptitude (Dunlap, 1989a).

Little attention has been given to the relationship between vocalizations and string students' intonation, specifically. Recently, Dell (2003c) concluded that training which included singing and tonal pattern enhancement had a positive effect on the development of beginning string students' intonation skills. Frank (2006c) found a significant relationship between string intonation and singing intonation, supporting this conclusion.

Along with studying the relationship between instrumental intonation accuracy and singing intonation accuracy, the current study examines the relationship between instrumental intonation accuracy and stabilized tonal music aptitude. Few studies have been conducted regarding the relationship between *stabilized* music aptitude to instrumental performance skills. Schleuter (1978) found tonal, rhythm, and performance achievement to be strongly affected by stabilized music aptitude. Zdzinski (1991) and Brokaw (1972) also concluded that a strong relationship exists between music achievement and stabilized music aptitude. The current study will investigate the relationship between stabilized tonal music aptitude and instrumental intonation, adding to the body of literature.

Chapter 3

METHODOLOGY

With the intent of improving string pedagogy and adding to the literature regarding string intonation, the purpose of this study was to research the relationship between stabilized tonal music aptitude and string players' intonation and the relationship between the ability to sing with accurate intonation and a string players' ability to play their instrument with accurate intonation. In this chapter, the directional hypotheses, method of the study, theoretical framework, criterion measures, data collection, data analysis, and the role of the researcher will be discussed.

Directional Hypotheses

Upon consulting the research literature, the directional hypotheses of the researcher in regard to the relationship between stabilized tonal music aptitude and string intonation and between instrumental intonation accuracy and vocal music accuracy were:

Hypothesis 1: A significant relationship between beginning string players' stabilized tonal music aptitude and instrumental intonation accuracy will be found.

Hypothesis 2: A significant relationship between beginning string players' ability to sing with accurate intonation and play with accurate instrumental intonation will be found.

Terms and Definitions

Specific terms and definitions used in the current study are as follows:

Audiation- "Hearing and comprehending in one's mind the sound of music that is not or may never have been physically present. It is neither imitation nor memorization" (Gordon, 2003b, p. 361).

Intonation- A person's ability to sing or play accurate pitches, in solo or within an ensemble, in relationship to the other pitches performed within a specific tonal context; the overall sense of pitch accuracy.

Keyality- "The pitch name of the tonic" (Gordon, 2003b, p. 369).

Macrobeats- "The fundamental beats in a rhythm pattern" (Gordon, 2003b, p. 369).

Microbeats- "The equal divisions of a macrobeat" (Gordon, 2003b, p. 370).

Music Achievement- "A measure of what one has learned" (Gordon, 1979c, 1986, p. 3).

Music Aptitude- "A measure of one's potential to learn music" (Gordon, 1979c, 1986, p. 3) and ability to audiate.

Pitch Accuracy- Individual pitches performed with minimal cent deviation in equal temperament.

Tonality- "That which is determined by the resting tone. If DO is the resting tone, the tonality is major…" (Gordon, 2003b, p. 378).

Setting of the Study

The current study was conducted in two middle schools in the cities of Newark, Delaware (School A) and Wilmington, Delaware (School B). School A consisted of approximately 991 students in grades six through eight, in a typical middle school setting ("State of Delaware," 2011b). School B, which had a visual and

performing arts focus, consisted of 841 students in grades six through twelve ("State of Delaware," 2011a).

Participants

Students

Participants ($N = 41$) in this study were all beginning strings students from two middle schools (School A and School B) located in the suburbs of a city in the Mid-Atlantic region of the United States.

School A. There were a total of four middle schools in School A's district, which served over 8,000 students. School A was part of a Choice Program, which allowed parents to apply for their children to go to a school outside of their district. School A's student body consisted of 0.2% American Indian, 33.8% African American, 3.7% Asian American, 18.7% Hispanic, 43.3% Caucasian, and 0.4% Multi-Racial students during the 2010-2011 school year. The population of School A was 53.5% male and 46.5% female ("State of Delaware," 2011b).

At the beginning of the study, School A had twenty-three participants ($n = 23$). Participants from School A ($n = 13$) were reduced to thirteen, due to students dropping the class or failing to return the consent form. Participants received string instruction approximately two hours a week, which included vocalizations as part of the curriculum. Two intact classes from School A participated in the current study.

School B. Eighteen students (n = 18) participated from School B, from one intact classroom, which had a visual and performing arts focus. Participants received string instruction three times a week for two hours. Like School A, this school district had a Choice Program through which families could choose specific schools within the district for their students to attend. School B served 847 students during the 2010-2011 school year ("State of Delaware," 2011a). The student body consisted of .2% American Indian, 17.9% African American, 5.4% Asian American, 5.4% Hispanic, and 71.0% Caucasian students ("State of Delaware," 2011a). The population of school B was 26.2% male and 73.8% female during the 2010-2011 school year ("State of Delaware," 2011a).

Students from low income households from School B comprised of 10.7% of the school population during the 2010-2011 school year ("State of Delaware," 2011a), while 54.2% of students from School A came from low income households ("State of Delaware," 2011b). As part of the requirements of the federal No Child Left Behind legislation, schools are rated between one and five, with five being the highest, indicating the level of student achievement in academic subjects for each school year. School B received a five out of five school rating, while School A only received a two out of five school rating.

Informed Consent Procedures

The use of human subjects in the current study was approved by the University of Delaware Human Subjects Review Board (see Appendix A). All of the participants received a consent form (see Appendix B) in which the participants were given the option to opt out of the study. Participation was required since the research

being conducted was during and without disruption of, their daily instruction; however thirteen participants from School A either chose to not have their data used for the study, failed to return the consent form, or dropped the class. All participants from School B (n = 18) returned the consent form and took part in the study.

Teacher-Researcher

The teacher-researcher was a second year graduate student at the University of Delaware and served as the current strings teacher for the participants of School B as part of an assistantship program. Along with teaching strings at School B, the assistantship program had allowed the researcher to act as the coordinator of the University of Delaware's Community Music School's early childhood music program. In addition to teaching early childhood music classes, the researcher had also taught cello privately for over ten years. The teacher-researcher also held Early Childhood Level I certification form the Gordon Institute of Music Learning and a Bachelors degree in Music Education with an instrumental emphasis in cello, from the University of Delaware.

Theoretical Framework: Music Learning Theory

Audiation

Edwin Gordon's music learning theory (MLT) (Gordon, 2003a, 2003b) provides a detailed description of the types and stages of audiation, or the way people learn music. Through audiation, a person gains an understanding of the music they hear, play, and compose. MLT offers music educators an explanation of how students learn when they learn music. According to Gordon, giving meaning to musical sounds

through audiation is the foundation for musicianship. There are eight types and six stages of audiation, which will be discussed in further detail. It is necessary to understand the types and stages of audiation in order to fully understand the process a student goes through to learn music.

The eight types of audiation are not sequential, but can be categorized as the following: (a) Type 1, listening to familiar or unfamiliar music; (b) Type 2, reading familiar or unfamiliar music; (c) Type 3, writing familiar or unfamiliar music from dictation; (d) Type 4, recalling and performing familiar music from memory; (e) Type 5, recalling and writing familiar music from memory; (f) Type 6, creating or improvising unfamiliar music while performing or in silence; (g) Type 7, creating and improvising unfamiliar music while reading; and (h) Type 8, creating and improvising unfamiliar music while writing (Gordon, 2003b, p. 14).

The six stages of audiation are hierarchical and are categorized as the following: (a) Stage 1, momentary retention; (b) Stage 2, imitating and audiating tonal patterns and rhythm patterns while recognizing and identifying a tonal center and macrobeats; (c) Stage 3, establishing objective or subjective tonality and meter; (d) Stage 4, retaining organized tonal and rhythm patterns in audiation; (e) Stage 5, recalling organized tonal and rhythm patterns and audiating them in unfamiliar music; and (f) Stage 6, anticipating and predicting tonal and rhythm patterns (Gordon, 2003b, p. 18).

Gordon states that all humans can learn to sing, just as they have learned to speak (Gordon, 2003a, 2003b). Several researchers have found that the best way to develop tonal audiation is through singing (Gordon, 1970, 1979c, 1986, 2003a, 2003b,

2004; Schleuter, 1997; Smith, 2005). Moreover, Gordon (2004) suggests it is through singing that one develops a sense of tonal audiation, just as talking will initiate thought through language. Teaching and learning with an emphasis on the aural (hearing)/oral (singing) connection, a students' tonal intonation will develop through audiation.

Music Aptitude

A person's music aptitude is defined as his potential to learn music. Everyone is born with some level of music aptitude (Gordon, 1979c, 1986, 2003a, 2003b, n.d.), which develops in tandem with appropriate instruction until the child reaches approximately age nine. Upon reaching age nine, music aptitude stabilizes and instruction no longer has an effect.

Music aptitude can only be measured through a reliable and valid test to diagnose musical strengths and weaknesses. With the results from a sound aptitude test, educators can differentiate their instruction to better fit their students' individual needs (Gordon, 1979c, 1986, 2003b). "A music aptitude test is concerned with the personal inferential process by which each student synthesizes what is being heard as music, rather than with an analytical description and notational definitions of a finished musical product" (Gordon, 2003b, p. 48).

Music Achievement

A student's music aptitude, or his potential to learn music, should not be confused with music achievement. As previously defined, a student's music aptitude is his potential to learn music, whereas his music achievement is what he does with that

potential. How a student utilizes his musical potential has an effect on his music achievement.

A student with a high level of music achievement will have high music aptitude, however, if a student has a low level of music achievement, this does not mean he or she will have a low music aptitude (Gordon, n.d.). Children with low or average music aptitude that receive proper musical instruction can gain high levels of music achievement.

Procedural Overview

Overview of the Study

The purpose of the current study was to investigate the relationship between beginning string players' stabilized tonal music aptitude and their instrumental intonation accuracy as well as to investigate the relationship between beginning string players' ability to sing with accurate intonation and their ability to play their instruments with accurate intonation.

The researcher acted as a teacher-researcher in two schools, for three beginning string classes. The study was conducted over a five-week period. The researcher entered the music classroom of School A for a total of seven times, once to develop a rapport with the participants and hand out the consent forms, and six more times to conduct the research. The procedure for the current study was integrated into the regular string classes of School B.

During the first instructional period, the teacher-researcher administered the IMMA tonal subtest (Gordon, 1979a) to test for music aptitude, which addressed

the first research question. An eight measure researcher-designed etude was taught by the teacher-researcher during four instructional periods lasting between ten and twenty minutes. Participants were taught how to both sing and play the etude on their instruments using a rote song procedure adapted from the *Jump Right In: The Instrumental Series for Strings Teacher's Guide* (Grunow, Gordon, Azzara, & Martin, 2002). During the sixth instructional period, participants were audio recorded singing and playing the etude on their instruments.

A 5-point continuous rating scale, developed by Saunders (1994), was used by two independent judges to measure participants' ability to sing and play the etude with accurate intonation. This procedure addressed the second research question. Pearson product-moment correlations were conducted to determine whether there was a relationship between beginning string players' stabilized tonal music aptitude and their instrumental intonation accuracy, and whether there was a relationship between beginning string players' vocal intonation accuracy and instrumental intonation accuracy.

Duration of the Study

The study took approximately five weeks to complete for each school. Originally scheduled for three weeks, inclement weather and standardized state testing caused the research to extend two weeks longer than planned. The IMMA (Gordon, 1979a) tonal subtest was administered during the first class of the research period. Four additional class periods were dedicated to teaching the participants how to sing and play the etude. Ten to twenty minutes were used during each class to teach the participants how to sing and play the etude. Because of the necessity of teaching

different fingerings across all four instruments (violin, viola, cello, and bass), classes with all instrument types took longer to teach (approximately twenty minutes) than classes with only violins and violas. The sixth instructional period was then used to test participants' singing and playing of the etude.

Intermediate Measures of Music Audiation

Stabilized tonal music aptitude was measured by the tonal subtest of the IMMA (Gordon, 1979a). The IMMA is a 45-minute audio-recorded test to measure participants' music aptitude in grades one through six. The test is divided into two subtests, tonal and rhythm. Each subtest has approximately 12 minutes of questions with an additional eight minutes of examples and spoken instruction. The tonal subtest of the IMMA was administered during the first class session.

Etude Instruction

During the month of January, 2011, the researcher taught participants how to sing and play an eight measure researcher-composed etude (see Appendix C). Three music educators evaluated and confirmed the accuracy and appropriateness of the etude being used for this study.

The researcher taught both the singing and playing of the etude, for ten to twenty minutes during four consecutive class periods. This procedure was modeled after Hornbach and Taggart's study (2005), where four instructional class periods were used to teach the subjects a simple song. During the instructional period, the etude was taught using rote song procedure. The rote song procedure was adapted from the *Jump Right In: The Instrumental Series for Strings Teacher's Guide*

(Grunow, Gordon, Azzara, & Martin, 2002). In brief, the rote song produce was taught using the following process:

1. The teacher-researcher established tonality on neutral syllables.
2. The teacher-researcher sang the etude for the participants using neutral syllables.
3. The teacher-researcher sang the resting tone (on a neutral syllable) and asked the participants to sing back the resting tone (on a neutral syllable).
4. Participants audiated the resting tone while listening to the teacher-researcher sing the etude in its entirety.
5. The teacher-researcher asked the participants to move their heels to the macrobeats while the teacher-researcher sang the etude again.
6. Participants were asked to move their hands, on their thighs, to the microbeats while listening to the teacher-researcher sing the etude.
7. Participants moved to both the macrobeat and microbeat while listening to the teacher-researcher sing the etude.
8. Participants were asked to audiate the entire etude, raising their hands when finished.
9. Participants sang the etude using neutral syllables, being sure to take a breath in tempo before they began.
10. The teacher-researcher went over any parts of the etude that were not sung correctly by the group. For example, if the participants were not singing the end of the etude correctly, the teacher-researcher sang that part to the participants and asked the participants to repeat it.
11. The teacher-researcher added tonic and dominant chords on the piano while the participants sang the etude on neutral syllables.

Once participants were able to sing the etude, the researcher taught the participants how to play the etude on their instruments. The following procedure was used:

1. The teacher-researcher reviewed the etude, singing the song on neutral syllables while participants audiated the song.
2. The participants sang the etude back to the teacher-researcher on a neutral syllable.
3. The teacher-researcher taught the etude, phrase by phrase, with solfege syllables while participants moved to the macrobeat and microbeat.
4. Participants repeated the phrases to the teacher-researcher, singing on solfege syllables.
5. Once the participants sang the etude correctly on solfege syllables, the teacher-researcher taught the antecedent of phrase one by modeling the fingerings and singing the phrase on solfege syllables.
6. Participants imitated the phrases by singing on solfege syllables and fingering the phrases as they sang.
7. The teacher-researcher then played the phrase on the piano while the participants sang (on solfege syllables) and fingered along.
8. The participants played the phrase on their instruments.
9. Steps five through eight were repeated for the consequent of phrase one.
10. Steps five through nine were repeated for the remaining two phrases of the etude.

A day-by-day detailed description of the procedure can be found in Appendix D.

After the instructional period, participants were audio recorded (a) singing the etude, and (b) playing the etude on their instruments. Two independent judges rated the performances using Saunders' (1994) rating scale for both the vocal and instrumental portion.

Testing Procedure

The testing procedure was practiced with the entire group during the fifth day of instruction as well as during the sixth day, before individual testing began. During the testing period, participants entered a quiet room with the teacher-researcher to record their singing and playing of the etude. The teacher-researcher used a Roland brand professional high-resolution digital voice recorder to record participants. Once participants entered the room, the teacher-researcher gave the participants a starting pitch using a Boss brand Dr. Beat DB-30 metronome that sounds pitches based on A = 440 Hertz. The participants then sang the etude using solfege syllables, however, some participants (n = 6) were not comfortable singing with syllables, so the teacher-researcher allowed those participants to sing on a neutral syllable. Once finished, the participants were given the starting pitch again and were instructed to play the etude to the best of their ability.

Participants were given the following instructions, individually, during the testing period:

> After I state your number, I am going to give you the starting pitch and ask you to sing the etude we learned in class. When you are done singing the etude, I am going to give you the starting pitch once again and ask you to play the etude on your instrument. Do the best that you can! Are there any questions?

Once there were no questions, the researcher, while singing on the starting pitch, gave the participants the following instructions:

> Here is your starting pitch, DO. Can you sing the etude for me? [Once participants sang the etude, the starting pitch was given again.] Here is your starting pitch again, DO. Can you play the etude for me?

The completion of participants playing the etude on their instruments concluded the testing portion.

Criterion Measures

Intermediate Measures of Music Audiation

To measure stabilized tonal music aptitude, the IMMA (Gordon, 1979a) was used. Participants were to identify if the two examples heard were the same or different by circling a box with two smiling faces (for same) or a box with a smiling face and a frowning face (for different). The audio-recorded tonal examples were void of rhythm and were performed using a synthesizer. Specific instructions were given for how to administer the IMMA in the IMMA manual (Gordon, 1979c, 1986). The IMMA tonal subtest was administered to the participants by the teacher-researcher in accordance to the directions found in the test manual. The IMMA has a strong reliability for measuring a student's tonal audiation. The tonal subtest reliability for grade six is .80 (E. E. Gordon, personal communication, September 14, 2010).

For this study, the researcher only used the tonal subtest. The first page of the tonal answer sheet can be found in Appendix E. Scoring masks were provided and used to score the tonal subtest. The correct number of answers from each side of the test was added together to give each participant a raw score. Once the raw score was

determined, it was converted to a percentile norm found in the test manual. A sample of raw scores and percentile norm conversions for grade six are provided in Table 3.1.

Table 3.1 IMMA tonal subtest percentile norms for sixth grade (Gordon, 1979c)

Percentile Rank	Raw Score
99	40
90	39
80	38
65	37
50	36
35	35
20	34

Tonal and Instrumental Intonation Rating Scale

During the sixth class, participants were assessed using Saunders' (1994) instrumental performance rating scale. Although originally designed for instrumental use, the current study also used the rating scale to assess participants' vocal accuracy. The 5-point continuous rating scale was tested in a pilot study conducted by the researcher during the month of November, 2010 and was found to have a high reliabilities for both vocal and instrumental intonation accuracy (r = .89 for vocal and r = .84 for instrumental).

Interjudge Reliability

Two independent judges (Judge A and Judge B) rated participants' singing and playing during a pilot study of the rating scales. Judge A received a degree in music education with a vocal concentration and is currently teaching general elementary school music at a high-performing charter school. Judge A is also in the process of completing a master's degree in music education. Judge B has been a general elementary school music teacher for eight years, and like Judge A, graduated with a degree in music education with a vocal concentration and is completing a master's degree in music education. Judge C received a bachelor in music education with an instrumental concentration, as well as jazz studies. Judge C taught eighth grade strings during undergraduate student teaching and is currently in the process of completing a master's degree in music education. All judges were trained by the researcher on the use of the rating scale.

Using a Pearson-product moment correlation for each dimension, a reliability of 0.89 was determined for the vocal portion of the assessment and a reliability of 0.84 was determined for the instrumental playing portion of the assessment. Thus, Saunders' rating scale was deemed acceptable for use for the current study.

Data Collection

Intermediate Measures of Music Audiation

In January, the IMMA tonal subtest was administered during the first class session, in School A, to determine participants' stabilized tonal music aptitudes. The

test was administered during the beginning of the school year for School B because it was a part of the regular curriculum. Raw scores were calculated and percentile norms, as provided in the testing manual, were determined for each participant. This data were used to address the first research question regarding the relationship between stabilized tonal music aptitude and string players' intonation.

Rating Scale

Saunders' (1994) rating scale was used to measure participants' ability to play and sing the researcher-designed etude with accurate intonation. Data were collected on the sixth and final class period of the study. Two independent judges scored participants' audio recordings using Saunders' rating scale. Data from participants' instrumental performances were used to address both research questions, where as data from participants' singing performances were used to address the second research question regarding participants' ability to sing with accurate intonation and play their instruments with accurate information.

Data Analysis

Data were collected and organized and descriptive statistics were calculated for each measure. Pearson product-moment correlations were conducted to determine whether there was a relationship between stabilized tonal music aptitude and instrumental intonation, or between instrumental intonation accuracy and vocal intonation accuracy.

Data were analyzed and results were used to form conclusions. Suggestions for future research were made and implications for music education were derived at the end of the study.

Role of the Researcher/ Researcher Bias

In order to provide consistent instruction, the researcher fulfilled the role of the teacher in the current study. The researcher spent a prolonged period of time on the topic of music aptitude and achievement. The researcher administered Gordon's IMMA tonal subtest (Gordon, 1979a) and taught the etude for four consecutive class periods. The researcher also audio recorded the participants' singing and playing of their instruments. To control for researcher bias, independent judges rated the participants' singing and playing performances.

Chapter 4

DATA ANALYSIS AND RESULTS

The purpose of this study was to research the relationship between stabilized tonal music aptitude and string players' intonation, and the relationship between the ability to sing with accurate intonation and a string players' ability to play his instrument with accurate intonation.

Twenty-eight participants from two cities located in the mid-Atlantic region of the United States participated in this study from three intact classes. Two classes from School A met two or three times a week for two hours, and one class from School B met three times a week for two hours. The study took five weeks to complete. Data analysis and results of the current study will be presented in the following chapter.

Data Collection

The teacher-researcher administered the IMMA tonal subtest (Gordon, 1979a) during the first week of instruction for School A and during the second month of the school year for School B to measure participants' stabilized tonal music aptitude. Participants were then taught how to sing and play an eight- measure researcher-designed etude (see Appendix C) by the teacher-researcher during four consecutive instructional periods. After the instructional periods, participants were audio recorded (a) singing the etude, and (b) playing the etude on their instruments. Using a 5-point continuous rating scale (see Appendix F), two independent judges

rated each vocal performance of the etude for accurate intonation. They then rated each instrumental performance of the etude for accurate intonation. The following section presents the analyses and results of the data that were collected.

Data Analysis and Results

Data were analyzed to examine the specific research questions using the following statistical procedures: (a) interjudge reliabilities for the 5-point continuous rating scale, (b) means and standard deviations of participants' instrumental intonation scores, (c) means and standard deviations of participants' vocal intonation scores, (d) stabilized tonal music aptitude (IMMA) raw scores and percentile ranks, (e) descriptive statistics for means and standard deviations for participants' stabilized tonal music aptitude scores, and (f) Pearson product-moment correlations to determine the relationship between stabilized tonal music aptitude and instrumental intonation and between instrumental intonation and vocal intonation.

Interjudge Reliability

Saunders' (1994) rating scale was used for the current study to measure participants' instrumental and vocal intonation accuracy. Since no reliability coefficient was provided, the researcher conducted a pilot study to determine the reliability of the measure. Two independent judges scored participants' vocal intonation accuracy and instrumental intonation accuracy using the rating scale. A Pearson product-moment correlation was used to determine the interjudge reliability for the scale in regard to both vocal and instrumental intonation. Results indicated a high reliabilities for both instrumental (r = .84) and vocal scoring (r = .89).

Table 4.1 Pilot study interjudge reliability

Intonation	*r*
Instrumental	0.844
Vocal	0.895

$p < .01$

For the current study, interjudge reliability was calculated using a Pearson product- moment correlation (see Table 4.2). Although not as high as the reliability for the pilot study, a moderately high reliability ($r = .72$) for instrumental intonation and a moderate reliability ($r = .68$) for vocal intonation was found.

Table 4.2 Current study interjudge reliability

Intonation	*r*
Instrumental	0.722
Vocal	0.689

$p < .01$

Instrumental and Vocal Intonation Accuracy Descriptive Statistics

Instrumental Etude Intonation Accuracy

The sum of scores, means, and standard deviation was calculated for participants' ($N = 28$) instrumental etude intonation (see Table 4.3). Judges were allowed a range of 1-5 points for the instrumental etude.

Table 4.3 Sum, mean, and standard deviation for sixth grade instrumental intonation

	Instrumental
Sum	210
Mean	3.75
SD	1.79

$N = 28$

Vocal Etude Intonation Accuracy

The sum of scores, mean, and standard deviation was calculated for participants ($N = 28$) vocal intonation scores (see Table 4.4). Just as with the instrumental rating scale, judges were allowed a range of 1-5 points.

Table 4.4 Sum, mean, and standard deviation for sixth grade vocal intonation scores

	Vocal
Sum	235
Mean	4.20
SD	1.64

N = 28

Stabilized Tonal Music Aptitude

Sixth grade percentile norms for the tonal subtest of the IMMA (Gordon, 1979c) as provided in the testing manual can be found in Table 4.5.

Table 4.5 IMMA tonal subtest percentile norms for grade six (Gordon, 1979c)

Raw Score	Percentile Rank
40	99
39	90
38	80
37	65
36	50
35	35
34	20

The sum, means, and standard deviations were computed for IMMA scores (see Table 4.6). The total number of points allowed for this measure was forty. The participants' scores ranged from 35 to 40 points.

Table 4.6 Sum, mean, and standard deviation for IMMA sixth grade tonal scores

	Tonal Music Aptitude
Sum	1,059
Mean	37.82
SD	1.47

N = 28

Table 4.7 presents the descriptive statistics for the instrumental and vocal etude intonation and tonal music aptitude data.

Table 4.7 Sum, mean, and standard deviation for sixth grade scores

	Instrumental	Vocal	Tonal Music Aptitude
Sum	210	235	1,059
Mean	3.75	4.20	37.82
SD	1.79	1.64	1.47

N = 28

Instrumental Etude Intonation and Stabilized Tonal Music Aptitude

To answer the first research question, "Is there a relationship between beginning string players' stabilized tonal music aptitude and their ability to play their instruments with accurate intonation?" a Pearson product-moment correlation was conducted to determine the relationship between instrumental intonation accuracy and stabilized tonal music aptitude. A moderately low correlation of $r = .32$ was computed demonstrating a slight relationship between the two dimensions (see Figure 4.1).

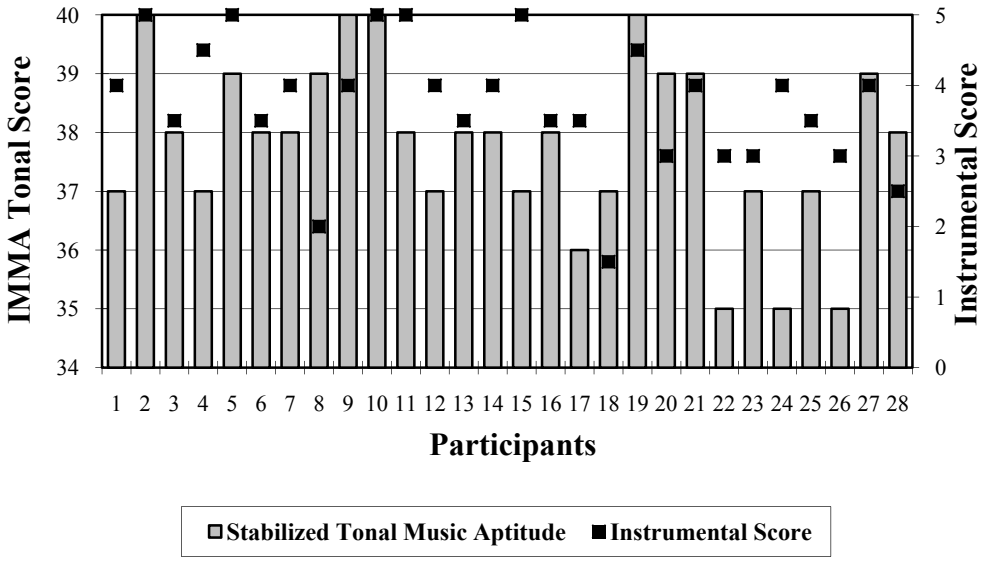


Figure 4.1 Relationship between stabilized tonal music aptitude and instrumental intonation accuracy

To answer the second research question, "Is there a relationship between beginning string players' ability to sing with accurate intonation and their ability to

play their instruments with accurate intonation?" a Pearson product-moment correlation was conducted to determine the relationship between instrumental intonation accuracy and vocal intonation accuracy. A low correlation of $r = .23$ was computed (see Figure 4.2) for the measure, showing a slight relationship between the two dimensions.

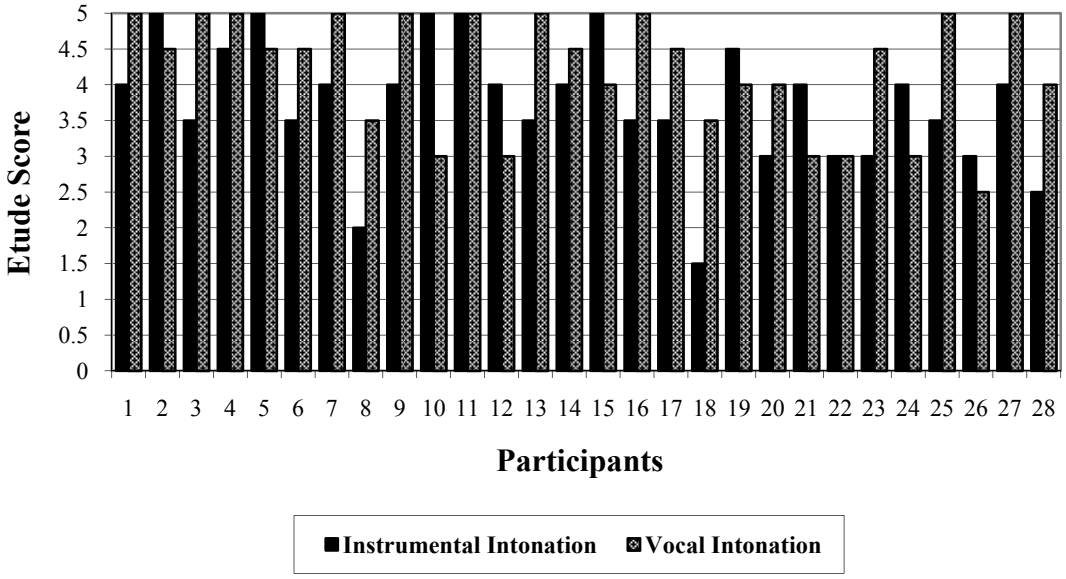


Figure 4.2 Relationship between instrumental intonation accuracy and vocal intonation accuracy

Intercorrelations for all dimensions are presented in Table 4.8. The low intercorrelations demonstrate that overlap between dimensions was low.

Table 4.8 Sixth grade intercorrelations for instrumental intonation, vocal intonation, and IMMA scores

	Instrumental Intonation	Vocal Intonation	IMMA
Instrumental Intonation	1		
Vocal Intonation	0.232653	1	
IMMA	0.316452	0.291822	1

$N = 28$

Directional Hypothesis. The two directional hypotheses for the current study were rejected. Results from the current study indicate a moderately low relationship between stabilized tonal music aptitude and instrumental intonation accuracy and a low relationship between instrumental intonation accuracy and vocal intonation accuracy.

Summary

Results of the current study indicated a moderately high interjudge reliability ($r = .72$) for Saunders' rating scale when used to rate instrumental intonation. When utilized for vocal intonation accuracy, a moderate reliability ($r = .68$) was also found. The sums, means, and standard deviations for instrumental intonation scores, vocal intonation scores, and IMMA were calculated.

Pearson product-moment correlations were conducted to determine the relationship between standardized tonal music aptitude and instrumental intonation accuracy and the relationship between instrumental intonation accuracy and vocal intonation accuracy. A moderately low correlation of $r = .32$ was calculated between stabilized tonal music aptitude and instrumental intonation and a low correlation of $r = .23$ was calculated between instrumental intonation accuracy and vocal intonation accuracy. These results lead the researcher to reject both directional hypotheses.

Further Investigation

To gain additional insight into the data regarding a relationship between participants' tonal aptitude and instrumental intonation, and vocal intonation and instrumental intonation, the researcher conducted further investigation. Participants ($N = 28$) were first divided into three groups according to their instrumental scores. Participants ($n = 15$) who received an average score of 5, 4.5, or 4 were categorized as High Instrumental. Participants ($n = 10$) who received an average score of 3.5, 3, or 2.5 were categorized as Average Instrumental and participants ($n = 3$) who received an average score of 2, 1.5, or 1 were categorized as Low Instrumental. Participants with high ($n = 20$), average ($n = 8$), and low ($n = 0$) vocal intonation scores were then categorized in the same manner as the instrumental scores. Participants' music aptitude scores were categorized as high, average, or low depending on the participants' percentile ranks. Participants ($n = 17$) in the 80th percentile or above were categorized in the High Stabilized Tonal Music Aptitude group, participants ($n = 11$) who scored between the 21st and 79th percentile were in the Average Stabilized Tonal

Music Aptitude group, and participants (n = 0) who scored at the 20th percentile or lower were in the Low Stabilized Tonal Music Aptitude group (Gordon, 1979c).

Instrumental Intonation. Upon examination of the High Instrumental participants (n = 15), 80% of participants (n = 12) were found to have received high vocal intonation scores and 20% received average vocal intonation scores (n = 3). When analyzing the High Instrumental participants' stabilized tonal music aptitude, 67% of participants (n = 10) were found to have high stabilized tonal music aptitude and 33% of participants (n = 5), average stabilized tonal music aptitude. No High Instrumental participants were found to have low stabilized tonal music aptitude.

Of the participants in the Average Instrumental category (n = 10), 60% of participants (n = 6) received high vocal intonation scores and 40% (n = 4) received average vocal intonation scores. Fifty percent of participants (n = 5) had high stabilized tonal music aptitude and 50% (n = 5) had average stabilized tonal music aptitude.

In the Low Instrumental category, 67% of participants (n = 3) received high vocal intonation scores and 33% of participants (n = 1) received low vocal intonation scores. Sixty-seven percent of participants (n = 2) had high stabilized tonal music aptitude and 33% (n = 1) had average stabilized tonal music aptitude. See figure 4.3 for a display of these results.

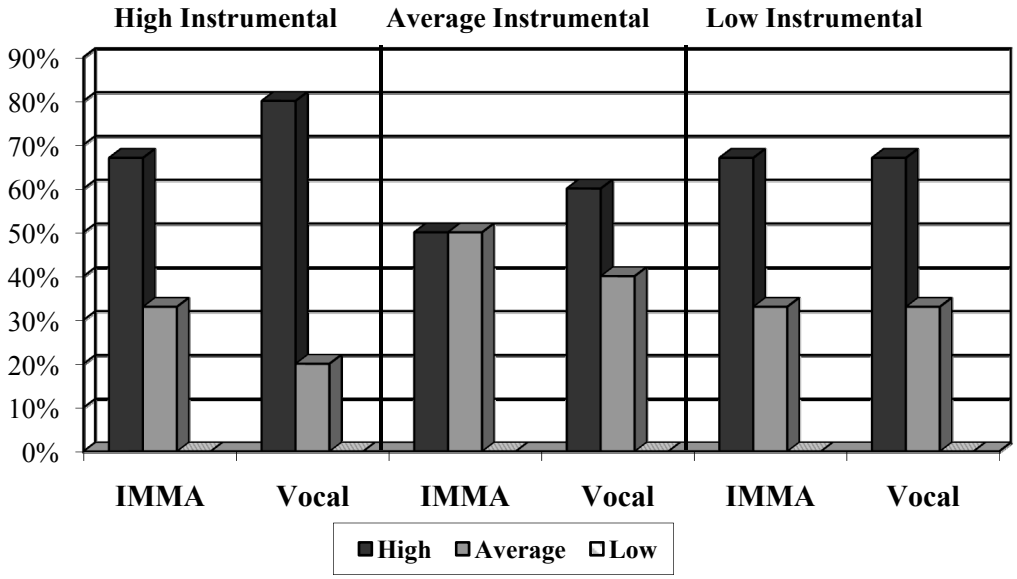


Figure 4.3 Stabilized tonal music aptitude and vocal intonation scores by instrumental intonation segment

Vocal Intonation. Further investigation of participants' with High Vocal Intonation scores (n = 20) revealed 55% of participants (n = 11) to have received high instrumental scores, 40% received average instrumental scores (n = 8), and 5% received low instrumental scores (n = 1). When comparing stabilized tonal music aptitude, 70% of participants (n = 14) had high stabilized tonal music aptitude and 30% of participants (n = 6) had average stabilized tonal music aptitude. No High Vocal Intonation participants were found to have low stabilized tonal music aptitude.

Of the participants in the Average Vocal Intonation category (n = 8), 50% of participants (n = 4) received high instrumental scores, 25% (n = 2) received average

instrumental scores, and 25% received low instrumental scores (*n* =2). Thirty-eight percent of participants (*n* = 3) had high stabilized tonal music aptitude and 63% (*n* = 5) had average stabilized tonal music aptitude (see Figure 4.4). No Average Vocal Intonation participants were found to have low stabilized tonal music aptitude.

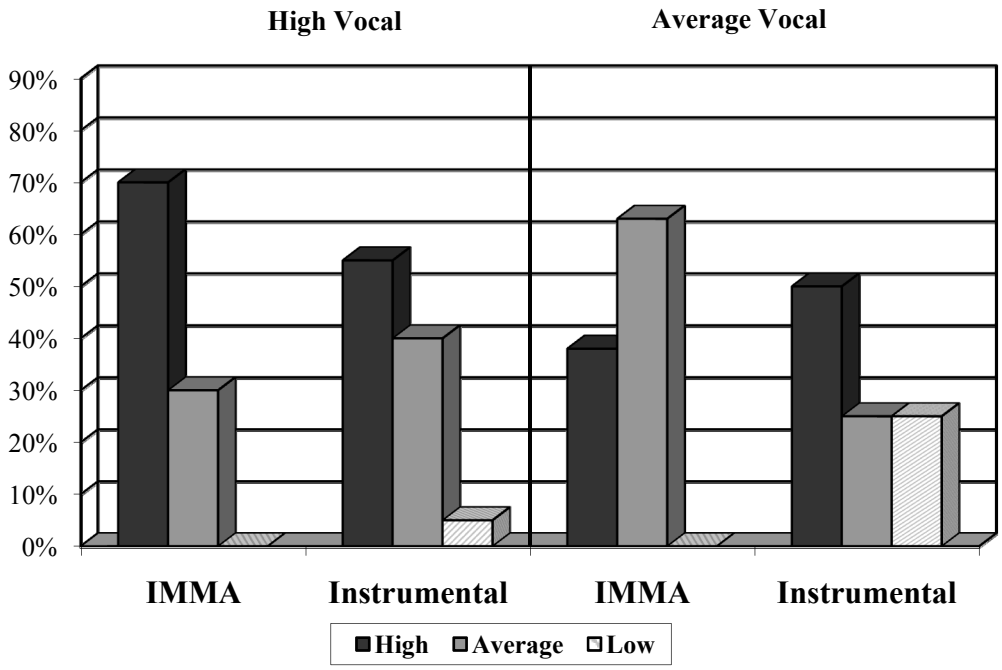


Figure 4.4 Stabilized tonal music aptitude and instrumental intonation scores by vocal intonation segment

Stabilized Tonal Music Aptitude. Further investigation of participants with High Stabilized Tonal Music Aptitude (*n* = 17) revealed 65% of participants (*n* = 11) to also have received high instrumental scores, 29% received average

instrumental scores (n = 5), and 6% received low instrumental scores (n = 1). When comparing stabilized tonal music aptitude and participants' vocal intonation scores, 82% of participants (n = 14) had high vocal intonation scores and 18% of participants (n = 3) had average vocal intonation scores. No participants with High Stabilized Tonal Music Aptitude were found to have low vocal intonation scores.

Of the participants who had Average Stabilized Tonal Music Aptitude scores (n = 11), 45.5% of participants (n = 5) received high instrumental scores, 45.5% (n = 5) received average instrumental scores, and 9% received low instrumental scores (n =1). Fifty-five percent of participants (n = 6) had high vocal intonation scores and 45% (n = 5) had average vocal intonation scores (see Figure 4.5). No Average Stabilized Tonal Music Aptitude participants were found to have low vocal intonation scores.

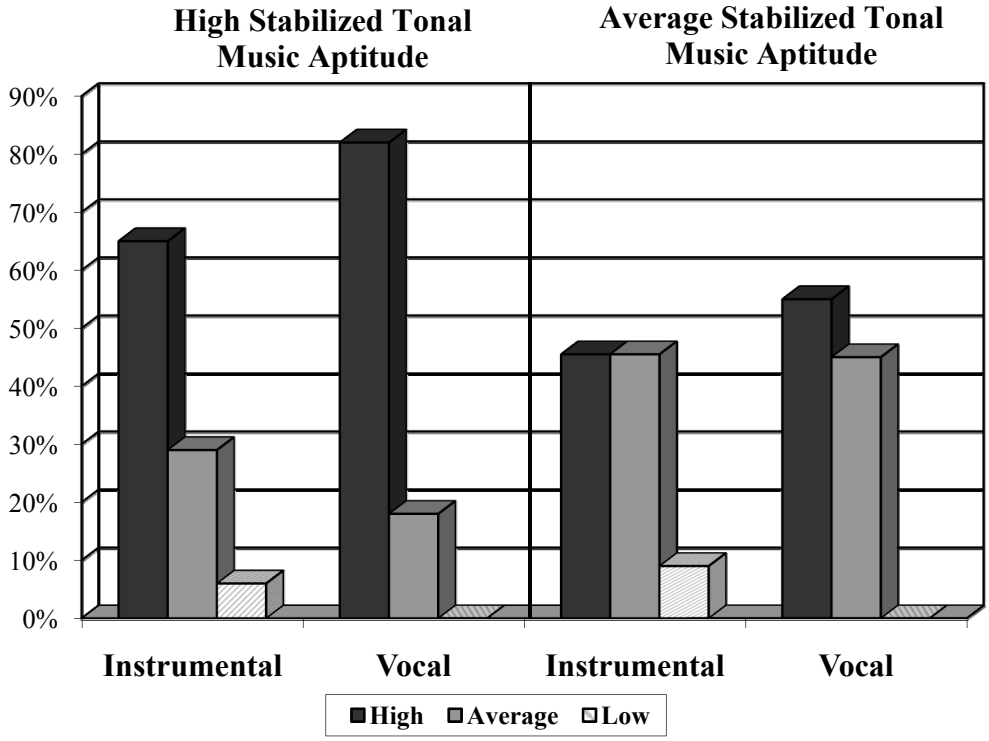


Figure 4.5 Instrumental and vocal intonation scores by stabilized tonal music aptitude segment

Interpretation of Results

The results of this study indicate a moderately low relationship between stabilized tonal music aptitude and instrumental intonation accuracy (r = .32). A low relationship was found between instrumental intonation accuracy and vocal intonation accuracy (r = .23). These results yielded a moderate relationship between stabilized tonal music aptitude and instrumental intonation accuracy and a low relationship between instrumental intonation accuracy and vocal instrumental accuracy. Several

aspects such as the number of participants ($N = 28$) or the moderate interjudge reliability may have contributed to these results.

Upon further investigation, computed percentages revealed that 80% of participants with high instrumental intonation scores also received high vocal intonation scores, however, 67% of participants with *low* instrumental scores received *high* vocal intonation scores. Of the participants who received high stabilized tonal music aptitude scores, 67% of participants received high instrumental scores and 82% of participants received high vocal intonation scores. When examining the data in this light, these results indicate that a majority of participants who played their instruments with accurate intonation could also sing with accurate intonation. These results support the research of Dell (2003c) and Frank (2006b) who found a significant relationship between instrumental intonation and vocal intonation. However, over half of the participants who received low instrumental intonation scores could sing with accurate intonation. A majority of participants with high stabilized tonal music aptitude received both high instrumental intonation scores and high vocal intonation scores, supporting the literature that there is a significant relationship between stabilized music aptitude and instrumental music achievement (Brokaw, 1982; Schleuter, 1978; Zdzinski, 1991).

Chapter 5

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary

Music educators and researchers alike have explored many possible avenues for students to reach their full musical potential. Regarding string instruments, many elements need to be in place: Aside from proper playing technique, the development of a student's musicianship is vital. For string players, developing a keen sense of pitch (an outgrowth of tonal audiation) seems to be important. Through audiation, one should comprehend and understand the musical sounds being presented to him or her as well as comprehend in one's mind the musical sounds that may never have been physically present. Researchers have concluded that auditory perception and pitch-matching abilities increase with age (Geringer, 1983; Petzold, 1963), but how music educators facilitate that growth is key to developing these abilities.

Drawing parallels between musical development and language development, music educators and researchers can better understand how students learn to comprehend musical sound. Improvising musically, whether through singing, rhythmic chant, or performing on an instrument, is the musical parallel to engaging in spoken conversation (Burton, 2011). Through singing, a person's contextual development of tonality will occur (Gordon, 2004), enabling the development of audiation. Tonal audiation develops with singing, and it is through audiation that musical understanding occurs. Incorporating singing exercises into instrumental

training better helps students develop an "ear" for what is essentially out of tune (Schleuter, 1997). In this light, numerous researchers and pedagogues stress the importance of using vocalizations in the instrumental classroom (Dell, 2003c; Gordon, 2004; Martin, 2005; Mursell, 1931; Robinson, 1996; Schleuter, 1997).

For string players, the understanding and comprehension of musical sound is especially important. Without frets to indicate where to place their fingers or buttons to push, students must rely on their aural perception. Although a common strategy in string pedagogy is to place tapes on the fingerboard to help students improve their intonation (Bergonzi, 1997), this strategy can be seen as a crutch, masking the students' aural ability to play a string instrument in tune (Gordon, 2003b; Martin, 2005). Discriminating between pitches and harmonic context is a skill that develops over time (Geringer, 1983). The ability to audiate pitches within a tonal context before the finger is placed on the fingerboard is imperative to developing a well-rounded, musical string player (Martin, 2005).

For music educators, knowing a student's potential to learn music is a key element in creating and implementing an appropriate curriculum to best facilitate the student's musical needs. A person's music aptitude is defined as his potential to learn music. The subject of music aptitude and its relationship to music achievement has been a topic studied by many researchers. A survey of the literature revealed that no significant relationship has been found by researchers regarding developmental music aptitude and vocal music achievement (Hornbach & Taggart, 2005; Mota, 1997; Persellin, 2006; Rutkowski, 1996). However, regarding stabilized music aptitude and instrumental music achievement, researchers have found a significant relationship (Brokaw, 1972; Schleuter, 1978; Zdzinski, 1991). Literature regarding instrumental

music achievement and music aptitude is limited, particularly in relationship to string instruments, illustrating the need for the current study.

Regarding the relationship between singing intonation accuracy and instrumental intonation accuracy, researchers have found contradicting results. Researchers have studied this relationship with band students and have found that simple vocalizations such as humming do not have an effect on instrumental intonation accuracy (Bennett, 1994, Smith, 1984). However, others (Elliott, 1972; Schlacks, 1981a) have concluded that vocalizations positively affect students' sense of pitch and pitch accuracy. Little research has been conducted regarding string players and the relationship between vocal intonation accuracy and instrumental intonation accuracy. Both studies examined in the literature review (Dell, 2003c; Frank, 2006c) demonstrated a relationship between string intonation accuracy and vocal intonation accuracy. The contradiction discussed above and the lack of string research on this topic validates the importance of the current study to add to the body of literature regarding the relationship between singing and instrumental intonation.

The purpose of the current study was to examine the relationship between stabilized tonal music aptitude and beginning string players' intonation and the relationship between the ability to sing with accurate intonation and a beginning string player's ability to play his instrument with accurate intonation. Specific research questions were:

1. Is there a relationship between beginning string players' stabilized tonal music aptitude and their ability to play their instruments with accurate intonation?

2. Is there a relationship between beginning string players' ability to sing with accurate intonation and their ability to play their instruments with accurate intonation?

After reviewing the literature regarding the topics of music aptitude, vocal intonation accuracy, and instrumental intonation accuracy, two directional hypotheses were made:

Hypothesis 1 A significant relationship between beginning string players' stabilized tonal music aptitude and instrumental intonation accuracy will be found.

Hypothesis 2 A significant relationship between beginning string players' ability to sing with accurate intonation and play with accurate intonation will be found.

Twenty-eight sixth-grade participants from three intact music classes from two schools located in Wilmington, Delaware and Newark, Delaware participated in this five-week study. Participants received etude instruction two or three times per week. The researcher acted as a teacher-researcher for this study. The teacher-researcher administered the IMMA tonal subtest (Gordon, 1979a) and taught an eight measure researcher-designed etude both vocally and instrumentally to the participants for a total of four instructional periods lasting between ten and twenty minutes. During the sixth visit, participants sang and played the etude into an audio recorder. Using a 5-point continuous rating scale (Saunders, 1994), two independent judges rated participants' intonation on their vocal and instrumental performance of the etude. Pearson product-moment correlations were performed to determine whether there was a relationship between stabilized tonal music aptitude and instrumental intonation, or between instrumental intonation accuracy and vocal intonation accuracy. A moderately low relationship was found between stabilized tonal music aptitude and

instrumental intonation, and a low relationship was found between instrumental intonation accuracy and vocal intonation accuracy.

Conclusions

Based on the results of the current study, two conclusions were formed. Results from the current study illustrate a moderate relationship between instrumental intonation accuracy and stabilized tonal music aptitude and a low relationship between instrumental intonation accuracy and vocal instrumental accuracy. There may not be a relationship between string players' instrumental intonation accuracy and their ability to sing with accurate intonation; likewise, stabilized tonal music aptitude and instrumental intonation accuracy do not appear to be related.

A relationship may not have been found between instrumental intonation accuracy and vocal intonation accuracy due to the low number of participants ($N = 28$) in the study, as well as the moderate interjudge reliabilities for vocal and instrumental intonation. Another possibility exists: While participants were learning the etude, a harmonic accompaniment was played. Thus, what may have provided a harmonic basis for participants' referential intonation during the learning process was not present when the participants were asked to perform individually during testing.

Although a low relationship was found, a majority of participants that received high instrumental intonation scores also received high vocal intonation scores. This result supports the previous literature that indicated a significant relationship exists between string students' instrumental intonation and their ability to sing with accurate intonation (Dell, 2003c; Frank, 2006b). Moreover, over half of the participants who received *low* instrumental scores received *high* vocal scores. With

these results in mind, it is possible that instrumental technique may have held participants back from playing with accurate intonation.

A majority of students who received high stabilized tonal music aptitude also received high instrumental and high vocal scores, which supports previous research regarding the existence of a relationship between stabilized music aptitude and music achievement (Brokaw, 1982; Schleuter, 1978; Zdzinski, 1991).

Informal conversations between the teacher-researcher and individual participants indicated that a number of participants were involved in outside musical ensembles including vocal choirs and chamber orchestras. Although classified as beginning string players by their grade level, several participants had been playing their instruments for more than five years. Other students displayed a lack of vocal training and/or a lack of string instrument technique, which may have prohibited the participants from displaying their full musical understanding of the etude. Six participants ($n = 6$) could not sing the etude using solfege syllables, but instead sang the etude on the neutral syllable "ba". These aspects may have had an effect on participants' vocal performances and scores, affecting the significance of the results for the current study.

Suggestions for Future Research

The lack of research regarding the relationship between string players' instrumental intonation and vocal intonation and between instrumental intonation and stabilized tonal music aptitude is evident in the review of related literature. The following recommendations illustrate the need for further investigation.

The current study may be used as a model. When investigating the relationships between string intonation accuracy, vocal intonation accuracy, and stabilized tonal music aptitude, significant results may be found with a larger number of participants. Due to the lack of sixth grade string teachers in the Delaware and Pennsylvania area, the number of participants was limited to only two schools. The researcher also chose a narrow lens through which to look, consisting of only sixth-grade students. A cross-sectional study, involving participants in more than one grade, may reveal developmental trends regarding intonation accuracy in both vocal and instrumental areas. Expanding the research to accommodate more than one grade is recommended.

A similar study conducted with judges who have experience teaching stringed instruments may have resulted in higher interjudge reliability. Ideally, judges should be music educators, both vocal and instrumental, and trained on the use of the rating scale.

The possible relationship between string intonation accuracy, vocal intonation accuracy, and stabilized tonal music aptitude may be developmental. A replication of this study could be conducted with a longer period of instructional time. The instructional period for the current study was only four visits, of ten to twenty minutes each. A longitudinal study, similar to Dell's (2003c) study that examined singing and tonal pattern enhancement on beginning string students' intonation skills over a period of an entire school year, may give more reliable results. An experimental replication of this study might be conducted with two groups, one group with singing as a part of the regular curriculum (treatment), and the other group without singing as a part of the regular curriculum (control), similar to Dell's (2003c) study. A true-

experimental design with randomized participants incorporating a pretest-treatment-posttest design may also give further insight into the relationship between singing and instrumental intonation accuracy.

Distributing a questionnaire to participants to determine prior musical experiences, such as participation in chorus or private instrumental lessons, or how long participants have been playing their instruments will aid in creating a sample with the least contamination of prior experience. An informal analysis of participants in the current study showed participants, although all in the same grade, to have drastically different musical backgrounds.

The current study focused on four string instrument types, violin, viola, cello, and bass. A cross-sectional study exploring how students of each instrument are affected by incorporating singing activities into the curriculum is recommended for future study.

Further research regarding the relationship between vocal intonation accuracy and instrumental intonation accuracy along with the relationship between a student's music aptitude and instrumental intonation accuracy is needed. More specifically, further research is needed concerning the improvement of string players' intonation.

Implications for Music Education

Although the current research did not find a strong relationship between instrumental intonation accuracy and vocal intonation accuracy, a slight relationship was found. Past research indicates a significant relationship between instrumental

intonation and singing (Dell, 2003c; Frank, 2006b), and therefore it is recommended to music educators to incorporate singing into the instrumental classroom. Integrating singing into the instrumental music classroom provides a foundation for becoming a successful musician and will facilitate a student's ability to audiate, or, the ability to internally hear and comprehend pitches without the sound being present (Gordon, 2004). Creating an aural/oral foundation for students' learning will further the development of audiation, which researchers believe improves students' intonation. Researchers have also examined the effect of singing on instrumental intonation and have found singing to positively affect students' sense of pitch and pitch accuracy (Elliott, 1972; Schlacks, 1981a). These results, as well as the modest results from the current study, support the importance of incorporating singing into the instrumental classroom.

To better assist students, it is important for educators to know a student's potential for developing an aural understanding of the pitches they are creating. Through reliable valid music aptitude tests, an educator can do just that. Every student is born with the potential to learn music; it is what the student does with that potential to learn that is his music achievement (Gordon, 2003b). The current study supports previous research that has concluded there to be a strong relationship between stabilized music aptitude and music achievement (Brokaw, 1982; Schleuter, 1978; Zdzinski, 1991). While the current study found a moderately low relationship between stabilized tonal music aptitude and instrumental intonation accuracy, a majority of the participants with high stabilized tonal music aptitude also received high instrumental intonation and high vocal intonation scores. It is important for music educators to

know this potential in their students to better match their instruction with students' musical needs.

Integrating singing into the instrumental music classroom should be considered by all music educators. Singing activities will develop a students' ability to audiate, which will provide the student with the tonal foundation needed for becoming a successful musician. By utilizing valid music aptitude tests, music educators can gain a better understanding of their students' musical potential. By incorporating these aspects into string instruction, music educators will be able to provide their students with the most effective music education possible.

Appendix A

UNIVERSITY OF DELAWARE HUMAN SUBJECTS REVIEW BOARD APPROVAL

RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	September 17, 2010
TO:	Kathryn Makos
FROM:	University of Delaware IRB
STUDY TITLE:	[186824-1] The Effect of Singing and Stabilized Tonal Music Aptitude on Beginning String Players
IRB REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	September 17, 2010
EXPIRATION DATE:	September 16, 2011
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Appendix B

CONSENT FORM

School A

Dear Parents and Guardians,

My name is Kathryn Makos and I am a graduate music education student at the University of Delaware. I am near the completion of my graduate work and am starting my work on my Master's Thesis. I am interested in string education and the parallels between a students' music aptitude (their potential to learn music) and their music achievement (what they do with that potential). I am also interested in singing's relationship to string intonation.

To study this relationship, I will be entering your students' string music class, under the instruction of the music teacher, and teaching them a short etude. I will ask your student to play the etude and sing it back to me. I would like to audio tape these assessments. There will not be any videotaping taking place and the students will remain anonymous. The audio tapes will be kept confidential and will be erased after I and two other researchers/ evaluators have listened to them.

Please complete the consent form below and return it to your music teacher. If you have any questions, feel free to contact me by e-mail at kmmakos@udel.edu. If you would like more information regarding the rights of participants in research, please contact the University of Delaware Research Office: (302) 831-2137, or udresearch@udel.edu.

Thank you,

Kathryn Makos
UD CMS Early Childhood Music Coordinator
School for the Arts, String Teacher

I hereby grant permission for _____ to

(Child's Name)

have his/her etude audio taped by Miss Kathryn Makos. I understand that my child's identity and audio tape will be kept confidential and that the audio tapes will be erased after the completion of Miss Makos' evaluation.

Signed,

_____ _____

(Parent or Guardian) (Date)

School B

Dear Parents and Guardians,

Along with being your child's string teacher, I am a graduate music education student at the University of Delaware. I am near the completion of my graduate studies and am starting to work on my master's thesis. I am interested in string education and the relationship between a students' music aptitude and their music achievement. I am also interested in the relationship between singing and string intonation.

To study this relationship I will be teaching a short etude. I will then ask your student to sing the etude and then play it for my on his/her instrument. I would like to audio tape these assessments for further analysis. All students' identities will remain confidential. The audio tapes will be kept confidential and will be erased at the end of the study.

Please complete the consent form below and have your student return it to me, Miss Makos. If you have any questions, feel free to contact me by e-mail at kmmakos@udel.edu.

Thank you,

Kathryn Makos
UD CMS Early Childhood Music Coordinator
School for the Arts, String Teacher

I hereby grant permission for _____ to

(Child's Name)

have his/her etude audio taped by Miss Kathryn Makos. I understand that my child's identity and audio tape will be kept confidential and that the audio tapes will be erased after the completion of Miss Makos' evaluation.

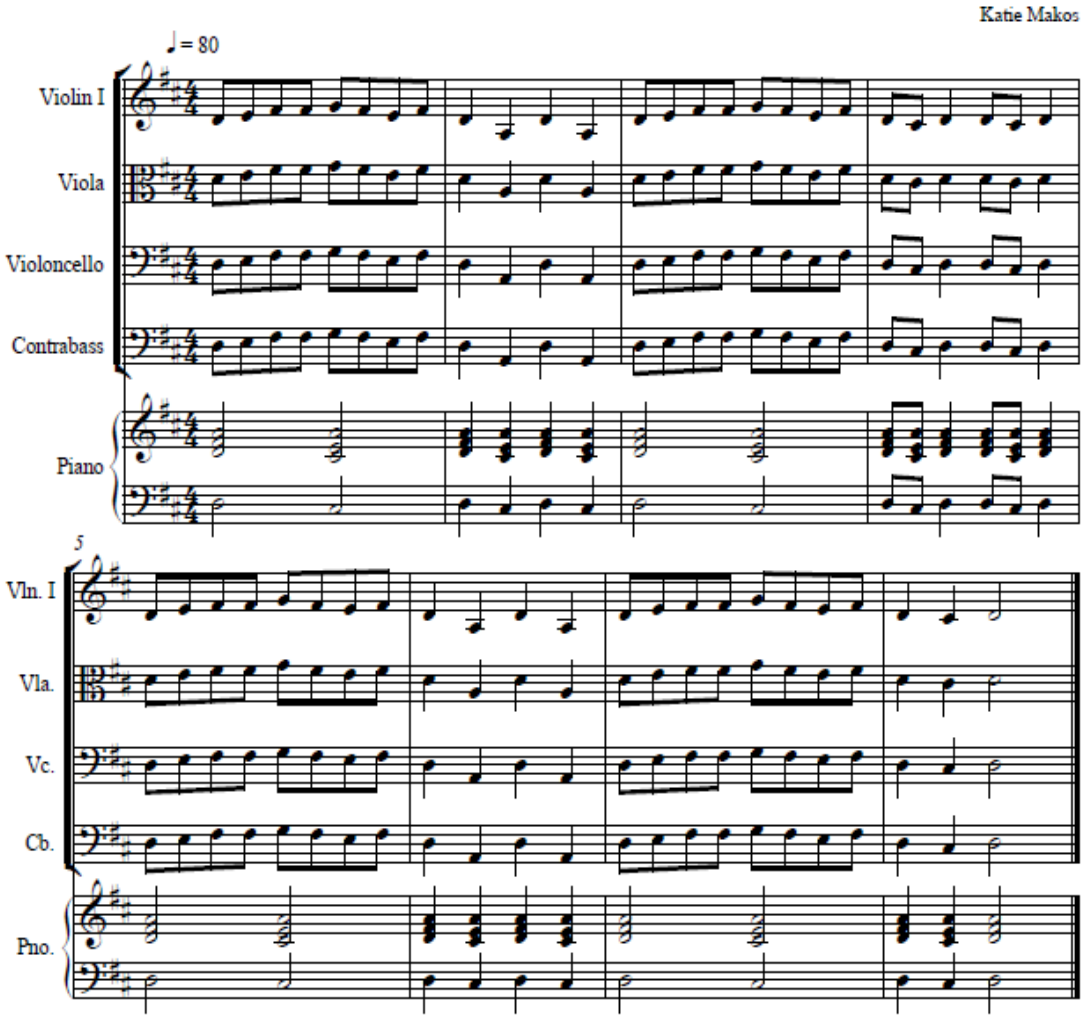
Signed,

_____ _____

(Parent or Guardian) (Date)

Appendix C

MAKOS (2011) ETUDE



Appendix D

DAY BY DAY PROCEDURE

Day	Description
1	• Administer IMMA
2	• Establish tonality on neutral syllable • Sing etude on neutral syllable • Sing resting tone (on neutral syllable) ask participants (P) to sing it back • P audiate resting tone while teacher-researcher (TR) sings whole etude • Move heels to macrobeat (MB) while TR sings etude • Move hands to microbeat (mb) while TR sings etude • Move to both MB and mb while TR sings etude • P audiates entire song, raise hand when done • P sings etude with TR • P sings etude while T play tonic and dominant chords on piano
3	• Establish tonality on neutral syllable • Sing etude (to review) on neutral syllables while P moves to MB and mb • Sing resting tone (on neutral syllable), ask P to sing back • P audiates entire song, raise hand when done • P sings on neutral syllable without TR • Go over any parts that are sung incorrectly • P sings etude while TR plays tonic and dominant chords on piano

4	• Sing on neutral syllables to review (while P are moving to MB and mb)
	• Sing phrase by phrase on solfege syllables (while P move and repeat phrases)
	• Teach phrase by phrase by modeling fingers and singing on solfege syllables
	  • P imitate- sing and finger phrase by phrase
	• TR plays phrases while P sings and fingers along
	• TR sings etude phrase by phrase while modeling fingerings
	  • P imitate- sing and play phrase by phrase

5	• Repeat Day 4 • TR sings song in its entirety on neutral syllables, P plays entire etude • Repeat until P feels comfortable with etude • Review testing procedure
6	• Testing

Note. P = participants; TR = teacher-researcher; MB = macrobeats; mb = microbeats.

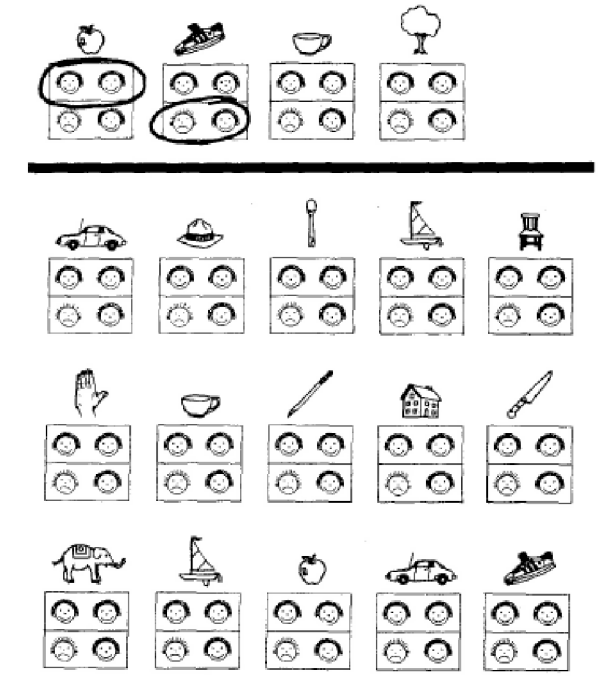
Appendix E

IMMA TONAL ANSWER SHEET

IMMA TONAL SUBTEST

Tonal subtest of *Intermediate Measures of Music Audiation* Test Form

T



Appendix F

SAUNDERS (1994) RATING SCALE

The student performance of a prepared selection included	
5	an accuracy of intonation throughout.
4	nearly accurate intonation with a minimal amount of imprecise intervals.
3	accurate intonation at the points of cadence (phrase endings); otherwise, there was a lack of precise intonation.
2	individual pitches included tonal center and the performance included an overall sense of tonality, however, with imprecise intervals and adjacent pitches.
1	individual pitches that lacked tonal center and an overall sense of tonality.

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