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Editor
Forum: Collaboration for Our Greater Good

Abstract
In order for research to be relevant and applicable, it is important for us to remember our constituency. Our students and colleagues in the public schools may see research as something abstract and distant, but string education researchers are conducting studies in a variety of areas such as student teaching, vibrato, mentorship of first-year teachers and chamber music, to name only a few. Collaborating with our current students and public school colleagues may offer opportunities for greater understanding on both sides of this imaginary dividing line.

Keywords
string instruments, collaboration, best practices, k-12 music education, higher education, research

I am very grateful to Michael Allen for asking me to be the 2010 research speaker. I also want to thank my predecessors for beginning what promises to be an ongoing dialogue about research in teaching and playing stringed instruments. The first research speaker in 2008, Don Hamann, explored how we approach research and choose our topics. Last year’s research speakers, Michael Allen, John Geringer and Rebecca MacLeod provided a glimpse into their process by sharing their thorough exploration of the research on the performance and perception of vibrato. I have tremendous admiration for their careful approach and their dedication to “accurately describing what really happens when students and professionals vibrate on string instruments” (email to author, January 27, 2010).

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We probably don’t need to talk much about why we conduct research because we answered that question before we got started in this business. We are enthusiastic about a topic or there is a need and, in the best of worlds, both! If we were lucky, we had dissertation advisors who warned us against over-reaching and thinking we could solve life’s big issues with one study, so we endeavor to make our projects manageable. We do need to be excited about our topic. We also need steady productivity because we are interested in keeping our jobs, getting promoted and receiving raises. This requires some strategy. What topics and approaches are likely to be well received by the editorial boards of our top research journals? Some of us are employed by institutions that require us to document the level of eminence of the journals in which we publish and therefore, we must target our writing toward that audience or those editorial guidelines.

These are all real issues but for this particular discussion, I knew I wanted to talk about the Who. Who uses it? For whom do we do it? Patricia Shehan Campbell, in her speech as the MENC Senior Researcher in 2002, spoke of the multiple realities of research. She asserts that we are concerned with the “interests of our students and the teacher constituency from whom we derive our questions and to whom the results of research are returned.” I am relatively certain that we do get our questions from string students and teachers, but I am not sure the results always get conveyed back to them.

Teachers may contact us for research results on a particular topic. The one I am most frequently asked for are the results on grade start and generally that is in times of crisis when classroom teachers want to use research to defend their programs. We may offer information on research results that can be applied to specific situations. Recently, I was able to provide an Update article (Geringer, Allen, & MacLeod, 2009) that described the use of a pre-screening rubric for all-state violin auditions to our South Carolina Orchestra Division Executive Board. Other than these happenstance events, I wanted to know more.

**How Is Our Research Applied?**

To approach this question, I compiled a similar list to the one Don Hamann cited in 2008. I did a search in SAGE and JSTOR for articles of the last twenty years with either string or orchestra in the title. I added the articles from the *Journal of String Research*, *Bulletin of the Council for Research in Music Education (CRME)*, and ASTA poster titles from 2008 and 2009. For every published article, I did a title search on Google Scholar to determine the number of times the article had been cited. For the posters, I wrote to the authors for whom I had emails and asked if their work had been 1) submitted, 2) was in revision/press or 3) published. I also asked how their research had been applied. I know this may only represent a portion of our total research efforts because many of us conduct research in other areas but I wanted to limit this discussion to string research.
For the published articles, there was a range from 0 to 30 citations each, with an average of 3.96. Not surprisingly, articles from the *Journal of Research in Music Education* were the most frequently cited. This is not only due to the journal’s established eminence in our field, but also to its connection with online databases such as SAGE and JSTOR. I sent emails to poster authors or a representative of the research team and received many responses. Responses about how their research had been applied fell into four categories: a) basis for further research, b) informing practice c) in-press, or d) still-in-the-drawer.

**Basis for further research**

In this category, I had correspondence with two doctoral candidates. Eugenia Goldman (2008) presented her research on listening preferences in high school at a conference of art and music teachers and according to her, seemed to “generate some interest and awareness of the necessity to include interdisciplinary components into the performance curriculum in order to promote a deeper understanding of musical material among students.” (Email to author, January 25, 2010). Kristin Pellegrino’s (2008) research on perceptions of collaborations in the student teaching process was used as the basis for her dissertation research (email to author, January 25, 2010).

**Informing practice**

Research reported here either influenced the practice of researchers or of string teachers and string players. The three broad areas were: a) teacher education, b) classroom teaching, or c) studio teaching.

In Elaine Colpitt’s study (2008) on the “The Role of Self-Evaluation in String Teacher Education,” preservice teachers see positive and negative aspects of their teaching and, over time, document their improvement. “I see their confidence growing as they are able to effect change in their own teacher behaviors and, in doing so, they improve the students’ playing. The purpose is to help them to become reflective practitioners and to teach them how to continue to refine their teaching throughout a lifetime in the profession” (email to author, January 27, 2010).

Kristin Turner describes her work on mentorship of first-year string teachers (2008). The focus of her article in progress is mentoring practices new teachers either found helpful or wished they had experienced. Turner hopes current orchestra teachers “will be able to adopt these practices and strategies to foster and encourage new teachers. Non-music teachers who do not always understand the needs of a young music teacher may also be able to benefit from the information” (email to author, January 27, 2010).

For the “Challenges and Successes of First-Year String Teachers,” I presented first with case studies of two teachers in 2008 and added the remaining three for a poster in 2009. I collected journal entries from five recent graduates
and interviewed them at the end of their first semester of their first year of string teaching. I believe the most important part of this project was being able to mentor my recent graduates. For them, it was having an outlet to talk about their experiences. It has also helped me find a balance in methods class between divulging so much about real world challenges that it causes students to reconsider their major and ensuring they are prepared for some of the frustrations. The first-year teacher study was a follow up of a previous study (published in the ISME conference proceedings and not included in my search parameters) titled “Who Learned From Whom?” and involved two college-level seniors and myself as we reflected on teaching our respective beginning classes at our String Project. They were so capable that I didn’t realize until we were watching their teaching video together that they needed a bit more direction from me than I was providing. I believe that working on both of these studies helped me be a better teacher and in turn, should positively impact my future students.

For research applied to her string classroom, Nola Campbell presented on chamber music activities for young string students (2008). She wrote, “My favorite parent response came from a father who said, ‘I need to blame you for the fact that three other boys come over to my house each Saturday morning, and they go down to our basement and play music for hours. It’s terrific.’” She added, “Those boys would come to me every Monday morning asking for more chamber music” (email to author, January 25, 2010).

Jane Palmquist’s study on the attribution of repertoire in two recent beginning string methods (2008) should be very useful to classroom teachers endeavoring to provide cultural and historical context to the tunes in method books (email to author, February 7, 2010) and Michael Alexander’s study on instruction in String Projects compared to other methods of beginning instruction (2008) should be useful to directors and master teachers in String Projects (email to author, January 25, 2010).

Elizabeth Guerriero presented on finding the right fit for both shoulder and chin rests in 2009 and that lead to a panel at this year’s conference: “We’re Different, We’re the Same: Finding Usability in Shoulder Rests and Chin Rests.” She believes this research has bridged the gap between luthier, studio teacher, injured performer, and university professor (email to author, January 25, 2010).

In press, or published

Continuing with studio teaching, John Geringer, Michael Allen, and Rebecca MacLeod published their presentation on string vibrato research in the first issue of the String Research Journal (2010). They refer to the resistance they received both in their choice of topic and in their results. Even though they believe most applications of their research will occur in the future, the resulting dialogue has been interesting and useful, particularly if it caused teachers to reassess long-held beliefs.
For research applied to classroom teaching, Margaret Berg’s research, first presented as a poster entitled, “Strings Attached, The Reality Show” was published as a chapter in the volume *Musical Experience in Our Lives: Things We Learn and Meanings We Make* (Berg, in Kerchner & Abril, 2009). The chapter, a glimpse into the process of preparing for a middle school orchestra concert, helps “prospective teachers use the findings from this study when preparing a concert programming and long-term planning assignment for our instrumental methods class. My hope is that it will impact what they do when they are teaching full-time” (email to author, February 1, 2010).

Janet Jensen (2009) is co-authoring a chapter for the *Oxford Handbook of Music Education* describing her experiences in transitioning non-majors to lifelong participation in music (email to author, January 27, 2010). Her successes with creating positive musical experiences for non-music majors are inspiring to those developing campus orchestras.

**Still-in-the-drawer**

There were two or three poster authors who confessed to being part of this group and probably many more of us can identify with this syndrome of having an article or study not quite ready to send for blind review. There are many reasons for this. Our jobs are extremely service intensive and do not fall neatly into the discrete categories of faculty at most music schools: applied, ensemble or academic. We have work that can be associated with all of these categories. We are working with individuals on developing their performance and pedagogical knowledge and skills, similar to an applied teacher. If we are lucky, we may work with student orchestras in some capacity, either directing an ensemble on our campus or as a guest conductor. Finally, we are expected to be as productive as other academic faculty members who often have lighter teaching responsibilities and service. These have been discussed at length within the Collegiate Roundtable and were the reason we developed a profile of a string education faculty member. We need, however, to keep pushing forward with our efforts because in order for our research results to be applied, they need to be in print.

**Increasing Productivity**

The answer for easing some of the pressures of our workloads may be in collaboration. Witness the team of Allen, Geringer and MacLeod. Seven articles in six years would be challenging for a single researcher to achieve and is impressive for three persons! By teaming together, they were able to amass a body of work that has real meaning and a clear direction.

In my own experience, I would not have been able to complete several studies without collaboration: with colleagues, with graduate students and with orchestra teachers in public schools. Each of two surveys and two rating scales required a squadron of people. For a string performance rating scale, Steven
Zdzinski and I needed to recruit 50 teachers (Zdzinski & Barnes, 2002). For an orchestra performance rating scale, Bret Smith and I recruited 66 (Smith & Barnes, 2007). Bob McCashin and I conducted two surveys, one on All-State Orchestras (2002) and another on adjudicated orchestra festivals (2005), both studies requiring a contact in each of the 50 states.

Subsequent to completing the studies, we sent either the article or publication information to each of the participants, but I have little evidence on how or whether they have been utilized. The survey on All-State Orchestras might have been a small piece of the puzzle in revising the procedures for the All-State Orchestra auditions in South Carolina. Other researchers have utilized the rating scales. I am not certain, however, if the relationship was a reciprocal one and if our peers in the public schools received the same benefit as we did from our partnership.

**How to Get Out the Word?**

If our work is being cited and we are able to point to application of results and our association is involved, are we doing enough? How much should we be doing to serve the “students and teachers from whom we derive our questions?” On one hand, we have academic freedom on the side of being able to work with any topic that interests us or seems important. On the other hand, playing a stringed instrument tends to be an activity for those who are financially comfortable, who tend to have access to quality programs and studio teachers. Is there more we could be doing to alleviate this? How much responsibility do we bear for serving what Shehan Campbell calls our “constituency?”

**Who Will Narrow the Gap?**

We may not ever completely solve the conundrum of transmitting research results, but one piece of the puzzle may be finding ways to excite our current undergraduate and graduate students about research and inspire them to continue to be involved after completing their degrees. When I started teaching the introductory research class at the University of South Carolina, I thought motivating graduate students to be interested in research would be challenging. On the contrary, they were very enthusiastic about their particular topics and that was both inspiring and educational to me. Even though they knew that anything undertaken in one semester had little generalizability, they were very interested in what evidence they did find. In addition, there has also been a push on our campus to encourage undergraduate research. The Magellan Scholar program issues a twice-yearly call for proposals for $3,000 grants. The student and mentor have to demonstrate their collaboration on the proposed topic and work together toward a presentation at a campus event. My colleague, Bob Jesselson, developed a line of research and mentored two undergraduates in studying biofeedback to reduce tension in string playing. Two years ago, I worked with
an undergraduate who helped me develop the Online Community for Orchestra Teachers. We were able to create a best practices web site, something that had practical application, and also able to turn that experience into a book chapter: “An Online Community for String and Orchestra Teachers in Collaborative Action for Change: Selected Proceedings from the 2007 Symposium on Music Teacher Education,” edited by Margaret Schmidt (Barnes & Wiley in Schmidt, 2009). Developing enthusiasm for and keeping our graduates involved in research once they leave the campus may be a key in encouraging post-graduation collaboration.

Collaboration with Classroom and Studio Teachers
I believe collaboration with studio and classroom peers is essential. The reality is there are not enough of us and we each have a limited career span to approach all the areas in our field that merit investigation. We need to collaborate with our colleagues in studios and orchestra, however a few barriers still remain.

First, many teachers believe that research is used to justify what they already know. I am certain we have all heard this in one form or another. Those not directly involved with research may see a topic as dull or wasteful. They may believe the results are common sense (Geringer, et al., 2010). Second, people with large studios or orchestra teaching jobs have very busy schedules. There is a limited amount of time and cognitive resources to think about research. Both of these have an impact on being able to consume and apply research as well as becoming involved in research.

A contrast to this obstacle is that many teachers have moved beyond consumers of research and frequently conduct practical inquiry with the intent of “improving their own practice” (Richardson, 1994, p. 5). Action research such as this is very valuable in improving teaching practice but unfortunately is frequently perceived to have a lack of external validity (Zeichner & Nofke, 2002). Conversely, Zeichner & Nofke cite John Dewey in 1929 and his assertion that teachers’ contributions were an ‘unworked mine’ (Dewey, cited in Zeichner & Nofke, 2002).

Another part of the gap between research production and research consumption may be fueled by the demands of our own institutions for publishing in top-tier research journals. We probably have some pressure to successfully publish in the Journal of Research in Music Education, the Bulletin of the Council for Research in Music Education, or the String Research Journal as opposed to Music Educators Journal, Teaching Music, or even American String Teacher. However, there are several examples of research studies that were translated for more night-table-friendly journals that may have a greater chance of being applied to studios and classrooms.

Time pressure issues can be mitigated, both for collegiate faculty and classroom and studio teachers, by working together. The classroom teacher
may work with a collegiate colleague in finding a topic and in turn provides a laboratory. We may provide the literature review and data analysis. The interpretation of the results should be a mutual process. It is important that classroom and studio teachers be true partners and not just data collectors (Zeichner & Nofke, 2002).

One terrific example of teacher-research collaboration is a study currently taking place in Virginia. Christina Morton teaches at a high school that has over 66% economically disadvantaged students in Portsmouth, Virginia, along with five other violin teachers. In this grant-funded program, each student in third through sixth grades studies the violin. She wrote, “We are doing some research right now on self-efficacy in relation to students and learning violin in our mandatory program in Portsmouth. It is interesting. We have a researcher at Old Dominion University working on the data collecting and formulating our instruments” (email to author, February 2, 2010). Her collaborator at ODU, Tim Bostic, wrote that he is using Pintrich’s *Motivated Strategies for Learning Questionnaire* to assess intrinsic motivation, self-efficacy beliefs and self-regulation. This particular setting, with a relatively homogenous population and access to test scores, offers a rare opportunity to assess the impact of string study on student learning. Christina affirms their collaboration by the use of the word “we.” It is also wonderful that her partner is not specifically a music educator, but one who believes in the power of music to “make a difference in student achievement” (email to author, February 4, 2010).

**The Role of ASTA**

Our professional association also plays a role in sponsoring and disseminating research. In 2004, ASTA hosted a national summit of 17 leaders and determined the two most important areas of research were the shortage of K-12 string and orchestra teachers and access to string instruction by more students. Both before and after this event, several of our colleagues have conducted very important studies in these areas. The status of programs in the public schools (Gillespie & Hamann, 1998), factors in career choice among string majors (Gillespie & Hamann, 1999), access to underserved populations (Bergonzi, 1995; Smith, 1997, 2000; Moss, 2002) and teacher retention (Gardner, 2010). At this year’s ASTA conference, we heard of the status of string and orchestra programs in the United States (Smith & Alexander, 2010), new string programs (Gillespie & Hamann, 2010) and increasing access to strings (Benham & Doerksen, 2010). All of these are large impact studies and it is important that our peers in studios and classrooms be aware of the results in order to give context to their own practice.

**Conclusion**

There is no real conclusion as these are continuing issues in educational research.
We are all pedaling as fast as we can and we have made progress and produced some good results. Our work is being cited and applied to other research studies. We are using it to inform our own practice and toward our teacher education efforts. It is important, however, for all those who are invested in string teaching and playing to keep working together to produce relevant research that is applied to string teaching . . . for our greater good.

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**Web links:**
http://www.astaweb.com/Content/NavigationMenu/Home/ContactUs/Committees/CollegiateRoundtable/default.htm

http://web.mac.com/gailbarnes/orchestracommunity/Welcome.html (email gbnanes@mozart.sc.edu for user name and password). Related discussion group at: http://www.facebook.com/group.php?gid=120772024602045

http://www.pps.k12.va.us/schools/elementary_schools/park_view/default.aspx?id=933
Factors Influencing Secondary String Students’ String Teaching Career Choices

Abstract
The purpose of this research was to investigate factors influencing the decisions of high school string students planning to major in music teaching in college. High school string students (N = 246) from 14 schools in Utah, Nevada, and Idaho indicated their interest in pursuing a music teaching major and rated 15 factors believed to contribute to teaching interest. Data were evaluated using a multiple regression analysis. The dependent variable was Teaching Interest. The independent variables were the 15 interest factors. Three variables (conducting, teachers’ contracts of 9-10 months without summer teaching, and teachers’ pay) accounted for approximately 23 percent of the variance contributing to students’ interest in a teaching major. The process of conducting, a teacher’s contract, and surprisingly teacher pay contribute positively to students’ decisions to major in string teaching. Perhaps more emphasis should be placed on these 3 variables when recruiting students to the field of string teaching.

Keywords
string teaching career, music career, string teacher, string music education, music teacher, career choice

String teachers and string teaching advocates began addressing the critical shortage of string teachers in 1948 with the creation of the University of Texas String Project. Dr. E. William Doty, the String Project founder, stated that the number one objective of the String Project was “…to train teachers of strings and inspire them to effectively spread the instruction of strings wherever they may have an opportunity to do so” (Young, 1972, p. 1). The string teacher shortage has persisted since the launch of the University of Texas String Project,

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having garnered attention at the Tanglewood String Symposia of 1963 and 1964 and resulting in several American String Teachers Association (ASTA) initiatives (Gillespie, 1997).

During a strategic retreat in 1998, the National Executive Board of ASTA identified six items as priorities for the growth of strings in America. The first priority was to increase the number of string teachers in the United States. To this end, the National String Project Consortium was created to help fund String Projects whose mission was to create an environment that fostered and strengthened interest in string teaching (ASTA, n.d.). A grant from the US Department of Education (FIPSE) in July, 2000, funded the first group of 10 String Projects in this consortium. Since its inception, the National String Project Consortium has helped develop over 32 string teacher training programs or String Projects across the United States (National String Project Consortium, 2008).

Participants at the 2004 National Summit, *Advancing Strings in America: A Blueprint for ASTA*, identified a “shortage of school string teachers” as a key problem facing string teaching. One project that developed from this summit was *Careers in String Teaching*. Sponsored by ASTA and funded by the National Endowment for the Arts, *Careers in String Teaching* addressed the anticipated string teacher shortage using brochures, a DVD that advocated for string programs, and a White Paper (Jesselson, n.d.; Hamann, n.d.). An additional publication, *Imagine a Career with Strings Attached*, was designed to generate interest among string students to pursue a career in string teaching (Gillespie, n.d.).

The String Project, Tanglewood String Symposia, American String Teachers Association, and the National String Project Consortium have systematically promoted string teaching in the United States. In two national surveys, however, researchers found that a string teacher shortage existed and projected that the shortage would persist (Gillespie & Hamann, 1998; Hamann, n.d.; Hamann, Gillespie, & Bergonzi, 2002; and Hamann, 2002). In a continuing effort to further understand and address the critical string teacher shortage, the present study examines the factors affecting high school string students’ choices to pursue a string teaching career.

Music education researchers have investigated the influences on a student’s decision to become a music teacher. Bergee, Coffman, Demorest, Humphreys, and Thornton (2001) responded to The National Association for Music Education (MENC) National Executive Board’s concern about a music teacher shortage by investigating the people, experiences, events, organizations, and other factors that had influenced music education majors’ career decision. Participants (*N* = 431) completed surveys that addressed these issues.

Bergee et al. (2001) found that 62% of respondents made their decision to become a music teacher while in high school and 14% while in elementary or middle school. The high school ensemble director and parents were the most influential people in participants’ decision making. Respondents identified school
music programs and honors ensembles as the most influential experiences. Orchestra directors and private instructors were particularly influential to instrumental music education majors. Respondents identified opportunities to teach, including small groups, as powerful events that impacted their decision. The researchers found a “deep love for and devotion to music” as an overriding theme for choosing a career in music teaching (p. 24).

Madsen and Kelly (2002) asked music education majors to describe in their own words their earliest memories of wanting to become a music teacher. The researchers found that the age students were when they decided and the influential people in their lives had the greatest impact on their decision to become a music teacher. School music teachers were cited most often as influential people. More than 70% of students reported having made their career decision prior to entering college, with most of those made during high school. Respondents recalled observing exemplary music teachers, receiving compliments from others, self-awareness of their abilities, recognition of the effect of music on one’s life, and simply not wanting to give up music as reasons for pursuing a music teaching career (p. 330). Madsen and Kelly argue that their findings place the responsibility on K-12 music teachers to positively influence students to pursue a music teaching career while providing them quality musical experiences.

Gillespie and Hamann (1999) surveyed string music education majors at 17 universities in order to identify strategies for attracting students to string teaching. The researchers found that string students chose music education for reasons that were different than their non-string peers in music education. The influence of their own teachers as role models, teaching opportunities, and private teachers were often of more influence than family and friends. The top two reasons cited for majoring in music education were that respondents liked teaching and enjoyed and loved music. Gillespie and Hamann encouraged music teachers to discuss the rewards and positive aspects of teaching with students in order to encourage their choice of a music teaching career.

Brumbaugh (2003) surveyed 11th and 12th grade public school string students in Texas to determine the reasons that string students do or do not choose music teaching as a career. From 1,683 surveys, 180 students — the String Orchestra Teaching (SOT) career group — identified themselves as planning to major in music education. The remaining 1,503 students were labeled the Fields Outside of String Orchestra Teaching (FOSOT) career group. Within the SOT career group, high school orchestra directors and family members had most often assisted students with their career choice. A higher percentage of subjects in the SOT career group also identified having family members who were teachers and/or musicians. The FOSOT career group cited low salaries, making another career choice, and a lack of patience as reasons for not pursuing a string orchestra teaching career. Brumbaugh concluded that family and the high school orchestra
director offered the greatest assistance and influence in guiding students toward a career in string teaching.

Byo and Cassidy (2005) evaluated the effectiveness of the National String Project Consortium goal of promoting string teaching by surveying more than 1,400 project directors, master teachers, student teachers, children and parents at 13 different String Project sites. They found that 80% of the student teachers in the String Projects planned to teach either immediately or subsequently following their studies. The student teachers valued opportunities they received in the String Project to lead small group and individual instruction, interact with their pupils and peers, and receive feedback and engage in discussion with master teachers.

Researchers have found that a majority of music education majors make their decision to pursue music teaching while still in high school and some as early as elementary and middle school (Bergee, 1992; Bergee et al., 2001; Madsen & Kelly, 2002). School music teachers were often cited as the most influential people in encouraging a career in music teaching, with immediate family also exerting influence (Bergee et al., 2001; Bright, 2006; Brumbaugh, 2003; Gillespie & Hamann, 1999; Madsen & Kelly, 2002). The love and commitment to music were also important reasons for pursuing a music teaching career; and opportunities to teach (whether they were individuals, small or large groups) positively influenced students’ decisions to become a music teacher (Bergee et al., 2001; Bright, 2006; Byo & Cassidy, 2005; Gillespie & Hamann, 1999; Madsen & Kelly, 2002).

Many music educators and researchers have attempted to address the issue of the music teacher shortage. String teachers, researchers, and advocates have made strides to promote string teaching as a career among string students with programs like the String Project. Few researchers have investigated K-12 string students’ career choices despite evidence that more than 70% of music education majors make their decision to major in music education prior to college (Bergee et al., 2001; Madsen & Kelly, 2002). Madsen and Kelly (2002) stated that “… additional investigations concerning the complex interrelationships between and among the many variables that influence the decision making process should be made” (p. 331). The purpose of the present research was to investigate the factors influencing the decisions of high school string students who plan to major in music at the college level.

Method
Participants for the study (N = 246) were volunteer high school bowed string students who had indicated they were planning to attend college after graduation and were considering majoring in music. These students were identified from a pool of 992 students who were drawn from 14 high school orchestras in Utah, Nevada, and Idaho, and who were surveyed using a researcher constructed
instrument titled the *String Education Survey* (SES). The sample consisted of 169 female and 77 male students, of which there were 59 freshman, 75 sophomores, 69 juniors, and 43 seniors. Of these students 120 played violin, 49 viola, 49 cello, and 28 double bass.  

The *String Education Survey* consisted of initial questions pertaining to demographic information. Students were then asked whether they were going to attend college and pursue a degree in music. If students responded positively to both inquiries they were then directed to rate their interest in pursuing a music teaching major in strings/orchestra using a scale of 10 (Definitely Would) to 1 (Definitely Would Not). This variable was referred to as TEACHMAJ.  

Students were then directed to rate the degree to which 15 factors contributed to their interest in string/orchestra teaching. A five-point scale was used to rate the 15 factors: 5 (Very Attractive), 4 (Somewhat Attractive), 3 (Neutral), 2 (Not Very Attractive), and 1 (Not At All Attractive). The 15 interest factors were: working with parents (PARENTS), working with administration (ADMIN), making music with groups (MAKEMUS), trips and activities (TRIPS), performing/performance (PERFORM), conducting (CONDUCT), recruiting (RECRUIT), fundraising (FUNDRAIS), teachers’ work load – hours worked per day/week/month (WORKLOAD), teachers’ contract – 9-10 months without summer teaching (CONTRACT), music teachers’ pay (PAY), job security (SECURITY), maintaining discipline in classes/orchestra (DISCIP), keeping records (RECORDS), and being in charge (INCHARGE).  

**Results**  

Data were evaluated using a multiple regression analysis. The dependent variable in the analysis was TEACHMAJ. The independent variables were the 15 interest factors: PARENTS, ADMIN, MAKEMUS, TRIPS, PERFORM, CONDUCT, RECRUIT, FUNDRAIS, WORKLOAD, CONTRACT, PAY, SECURITY, DISCIP, RECORDS, and INCHARGE.  

A correlation matrix was computed to determine which independent variables had an $r$ value of at least .25 with TEACHMAJ. Five variables met that criterion and were entered into the regression analysis. The five variables were ADMIN ($r = .25$), CONDUCT ($r = .37$), WORKLOAD ($r = .27$), CONTRACT ($r = .31$), and PAY ($r = .34$). Variables were eliminated from the regression when they did not contribute at a significant level ($p < .01$). Both ADMIN and WORKLOAD were eliminated from the analysis. The three remaining variables CONDUCT, CONTRACT, and PAY were found to contribute significantly to the overall solution. See Table 1. The total amount of variance in teaching interest accounted for by these three variables was approximately 23 percent (Adjusted $R^2 = .225$).
Table 1
Summary of Regression Weights of Significant ($p \leq .01$) Contributors

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>$SE\ B$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDUCT</td>
<td>.681</td>
<td>.137</td>
<td>.292</td>
</tr>
<tr>
<td>PAY</td>
<td>.616</td>
<td>.151</td>
<td>.244</td>
</tr>
<tr>
<td>CONTRACT</td>
<td>.349</td>
<td>.148</td>
<td>.146</td>
</tr>
</tbody>
</table>

Discussion

Conducting emerged as the strongest predictor of interest in string/orchestra teaching. The significant influence of conducting on the decision to pursue a music teaching career supports prior research (Bergee et al., 2001; Madsen & Kelly, 2002). Madsen and Kelly (2002) found that the decision to become a teacher was made as students received more leadership responsibilities in their school music groups, which may have included conducting. In Bergee et al. (2001), more than 70% of respondents indicated that opportunities to teach, including conducting, exerted “some” to “very significant” influence over the choice to become a music education major. More than 50% of the respondents in Bergee et al. identified “desire to conduct/perform/attain visibility” as an influential factor as well. Perhaps participants in this study had been given opportunities to conduct during their music classes and those experiences led them toward pursuing a string music teaching career.

Students also chose music teachers’ pay as an attractive part of string music teaching. Brumbaugh (2003) found contrasting evidence in noting that her respondents cited low salaries as a reason for not pursuing a music teaching career. Bergee et al. (2001) reported that anticipated salary was an influential factor in choosing a music teaching career, but only for less than 10% of respondents, and even noted negative comments that this item received on the survey form itself. Both Bergee et al. (2001) and Gillespie and Hamann (1999) recommended that teachers discuss positive aspects of music teaching, including compensation. Because music teachers are the most influential people in the decision making of students who choose a music teaching career, their promotion of teacher’s pay as a livable and comfortable salary would be meaningful.

The 9-10 month contract of teachers was another significant factor in choosing a string music teaching career that supports prior research. Bergee et al. (2001) also found that summer vacation was an influential factor for respondents. Students who imagine having two to three months free from work each year would certainly find this attractive. While many music teachers do spend the summer months in professional development activities and preparation for the following year, it is typically by choice. Music teachers can usually expect to have at least part of their summer months free of teaching and teacher activities if they wish.
The independence of the conducting variable and the being in charge variable is interesting. One might assume that students would equate conducting with being in charge of an ensemble or group of students. However in this research, the variables were independent of one another. Discovering how subjects differentiated conducting from being in charge might be useful. It is also interesting to note that the 9-10 month contract was significant, but teachers’ workload was eliminated from the analysis because it did not contribute significantly. Job security did not factor in at any level of the analysis. Students seemed to find the 9-10 month contract to be attractive, regardless of the hours worked during those 9-10 months, and were relatively unconcerned with job security.

Conducting, teachers’ pay, and the 9-10 month contract are factors that all music teachers and specifically string music teachers can address with students and parents to increase interest in music teaching. Music teachers can provide regular conducting opportunities to all students in their classes, and especially to those students who express an interest in music teaching. Discussion of teachers’ pay as a comfortable wage, and highlighting the benefits included like health care and retirement, may also be helpful. Teachers can also discuss their contract, which typically includes summers off. Though many teachers might use this time to pursue professional development, the time is indeed theirs. String teachers are encouraged to promote these positive aspects of music teaching to students and parents as a way to guide students toward a career in string teaching.

This sample included a larger representation of female than male subjects, and therefore future research with a more equitable gender distribution is recommended. Subjects were located within one region of the United States. Further research with students in other regions, and in urban, suburban, and rural areas is recommended. The significant factors of conducting, teacher pay, and the 9-10 month contract accounted for only approximately 23% of the total variance in teaching interest, leaving approximately 77% unaccounted for. While based in prior research, the 15 factors included in this survey were not exhaustive. Researchers are urged to continue studying and identifying the complex factors that affect students’ choices to pursue a string music teaching career.

References


Young, P. (1972). A report on the University of Texas String Project. (Unpublished manuscript). University of Texas at Austin, Austin, TX.
An Examination of Before and After Rehearsal Pitch Tendencies of String and Wind Musicians

Abstract
The purpose of this study was to examine the before and after rehearsal pitch tendencies of college string and wind musicians and compare possible: (1) differences in pitch before and after rehearsal, (2) differences in pitch between string and wind musicians and (3) differences between string and wind musicians’ reported tuning practices. Participants consisted of 59 college musicians (30 string musicians and 29 wind musicians). Prior to a large ensemble rehearsal, all musicians were individually recorded playing a concert A without tuning. Musicians participated in a rehearsal and again recorded their concert A immediately following the rehearsal. Mean pitches of string and wind groups were significantly different before the rehearsal compared to after rehearsal. Both groups of musicians’ mean pitch level increased from before to after rehearsal, particularly for the wind group. Responses collected through a tuning questionnaire found that string musicians reported tuning more often and with others, and wind musicians reported using a tuner more often.

Keywords
pitch, intonation, string instruments, wind instruments, tuning

Intonation is an obvious aspect of musical performance that can be observed by both musicians and non-musicians. Although instruments may use different procedures for tuning, such as comparison to a different reference pitch, initial tuning of an instrument is generally required for ensemble performance. The intonation of a musical instrument can be affected by temperature, humidity and musician skills. Within ensemble situations, it is the responsibility of the
musician to adjust the length (wind) or tension (string) of the instrument so that
pitch levels are relatively close to the other instruments.

The professional educational literature provides many examples of
suggestions for tuning a school band or orchestra (Alexander, 2008; Genevro,
1997). These suggestions include proper warm-up and the identification of
appropriate tuning pitches for specific instruments. Tuning exercises have been
devised to improve students’ tuning of string instruments (Alexander, 2008).
An analysis of violin performance tuning practices has labeled multiple forms
of intonation: harmonic, melodic, corrective and coloristic (Kanno, 2003).
Other literature provides suggestions for tuning woodwinds (Criswell, 2008) as
well as the whole band (Genevro, 1997; Smith, 2004). The use of a sustained
tuning pitch (electric or acoustic) is common practice when tuning an ensemble
(Alexander, 2008).

Research into musical performance has investigated the intonation of
musical intervals in both melodic and harmonic contexts. Early research found
no significant effect of either melodic or harmonic context (Duke, 1985) nor
direction of the intervals (Yarbrough & Ballard, 1990) on intonation performance
of wind players. String intonation performance, on the other hand, has been
found to be affected by melodic direction (Kantorski, 1986; Sogin, 1989).
Ascending intervals tend to be performed flat while descending intervals tend to
be performed sharp.

Tuning behaviors of musicians include their ability to tune another
sustained pitch (instrumental or electronic) and their intonation tendencies
during performance, either on static notes or with accompaniment. Previous
research has examined the relationship between a person’s ability to discriminate
intonation and their ability to perform with good intonation. In some contexts,
the perceived intonation of a tuning pitch can affect tuning performance.
Geringer & Witt (1985), for example, found that if a tuning pitch is perceived
as flat, strings tend to tune higher than the tuning pitch. In other contexts,
however, research indicates little to no relationship between the ability to
perceive intonation discrepancies and perform with accurate intonation (Ely,
1992; Geringer, 1978; Yarbrough, Morrison, & Karrick, 1997). One survey
found the self-perceptions of out-of-tune discrimination and in-class tuning
were significantly related to the self-perceived ability to tune independently
(Hamann, Frost, & Wieters, 2002). In a later study, middle school aged students
with stronger self-perceptions of tuning ability were better at tuning (Hamann,
Lauver, & Asher, 2006). Perception of tuning ability does appear to increase with
age (Hamann, et al., 2002).

Research has examined external factors that can affect intonation
performance, such as timbre (i.e., tone quality), feedback and mistuning
directional information. Timbre can be a factor in the perception of intonation
(Geringer & Worthy, 1999; Spradling, 1985; Worthy, 2000). Inexperienced
musicians perceive brighter timbres as sharper and darker timbres as flatter. Intonation discrepancies have also been found easier to detect when comparing two contrasting timbres (Ely, 1992). Although early research found unfamiliar timbre to be more difficult to tune to (Greer, 1970), later research found no effect of timbre on the ability to tune (Ely, 1992). More recently, no difference in tuning ability was found between string musicians tuning to an electronically produced tone (e.g., tuner) or an acoustic instrument (Hamann, et al., 2006).

In most learning environments, music teachers provide feedback to students to facilitate the learning process. Research has examined the practical effects of feedback on musicians’ ability to play with correct intonation. Although verbal feedback does not affect intonation on initial performances, it appears to improve subsequent performances (Salzberg, 1980). In a study of 137 band students, Morrison (2000) found that two treatment environments, verbal feedback of mistuning and tuning to a static pitch, had no effect on the ability to play with accurate intonation. Feedback using finger numbers rather than pitch names was found to improve intonation performance of young string students (Sogin, 1997).

Musicians, even within the same family of instruments, can have unique intonation tendencies. Research has examined the effect of knowledge of mistuning (i.e., knowing that a certain note tends to be flat or sharp) on musicians’ abilities to play with acceptable intonation. Whereas information of mistuning direction has been found to help younger students (Yarbrough, Karrick, & Morrison, 1995), this information was not found to improve intonation performance of older students (Geringer, 1978; Yarbrough, et al., 1997).

Some other factors studied in relation to intonation have been years of private study, the instrument, use of vibrato, and the performance situation. Tuning ability has been found to improve with the number of years of private study (Yarbrough, et al., 1997). In an examination of college and professional string musicians, Sogin (1989) determined that intonation did not differ between vibrato and non-vibrato performances. He also found no intonation tendency differences between the four string instruments (violin, viola, cello and bass). Intonation accuracy was not affected by solo or ensemble performance (Mason, 1960).

Musicians appear to have an easier time tuning to a reference pitch than tuning during actual performance (Morrison, 2000). In general, both string and wind musicians have been observed to perform sharp (Geringer, 1978; Geringer & Sogin, 1988; Kantorski, 1986; Sogin, 1989; Yarbrough & Ballard, 1990) compared to static tuning. Even when given a tuning note, string musicians (Geringer & Witt, 1985) and wind musicians (Yarbrough, et al., 1997) showed a tendency to tune their instruments sharp.

Although there are numerous studies about the tuning practices of string and wind musicians, there is less research on the effect of the rehearsal situation
on the instrument tuning practices of musicians. Early research in this area can be traced back to Lottermoser and Braunmühl (as cited in Winckel, 1967) who studied the tuning and intonation behaviors of the 1953 Vienna Philharmonic Orchestra, before, during and after a rehearsal. Findings indicated that different instruments tuned at different pitches during the tuning of the orchestra and that string instrument pitch held relatively stable from before rehearsal to after the rehearsal when compared to the wind instruments.

Although most instrumental ensemble rehearsals include a tuning pitch played at the beginning of the rehearsal to allow musicians to tune their instruments, the amount of change to the instrument from before rehearsal to after the rehearsal has not been extensively documented. The purpose of the present study was to examine instrument pitch tendencies of string and wind musicians before and after an ensemble rehearsal. In particular, to what extent do pitch levels change from before to after rehearsal? The following research questions were asked:

1. Are there differences in pitch levels between string and wind musicians before and after a rehearsal?
2. Are there differences in pitch level variances between string and wind musicians before and after a rehearsal?
3. Are there differences in reported tuning practices between string and wind musicians?

**Method**

College wind and string musicians (N = 59) from a medium-sized university in the Midwestern United States were selected on the basis of membership in the university’s orchestra or symphonic band. The sample consisted of 30 string musicians (14 violins, 8 violas, 4 cellos and 4 basses) and 29 wind musicians (4 flutes, 4 clarinets, 4 bassoons, 2 alto saxophones, 7 trumpets, 3 horns, 2 trombones, 1 euphonium and 2 tubas). Average age of the musicians was 20.57 years (SD = 2.24) with an average of 9.31 (SD = 3.65) years of music experience.

Prior to a large ensemble rehearsal, all musicians were individually recorded playing a concert A (55 Hz, 110 Hz, 220 Hz, 440 Hz or 880 Hz). Since it was important that each musician did not attempt to tune his or her instrument to a tuner or tone prior to the recording, musicians were notified the previous day not to tune before coming to rehearsal and to assemble their instrument as they normally would. This was an attempt to measure the pitch of their instrument before they tuned to the tuning pitch during rehearsal.

Three recording stations were set up in separate rooms to accommodate a large number of musicians in a short amount of time. Wind musicians were instructed to place their mouthpiece, head joint or tuning slide in its usual location. String musicians were instructed to tune each string of their instrument to another string on their instrument but not to a tuner or another string musician.
In other words, all musicians were to have their instrument tuning mechanism (e.g., tuning pegs, mouthpiece, tuning slide) where it would typically be when they walk into a rehearsal, before any group tuning procedure. Students were also asked to have their instruments indoors at least 30 minutes before the recording session and to warm-up for three minutes prior to recording.

Each musician recorded a concert A by sustaining it for or at least three seconds. After the pre-rehearsal recording, normal group tuning procedures were followed, and all students participated in an ensemble rehearsal of approximately 90 minutes. The regular ensemble conductors for both orchestra and band conducted the rehearsals and no attempts were made to control for factors within the rehearsal situation. Tuning pitches for both ensemble rehearsals were supplied by an electronic tuner calibrated at $A_4 = 440$ Hz. Temperature in the rehearsal hall was between 74°F and 78°F. Immediately following the rehearsals, students went back to the audio station to repeat the tuning procedure. Cards given to students during the first sampling were used to match their second recording with their first recording. All students were recorded using the software Pratt (Boersma & Weenink, 2008) and the built-in microphone on an Apple MacBook Pro.

Following the recording, participants were asked to complete a researcher-developed questionnaire that collected information about their experience and individual tuning habits. Questions asked the students to estimate the frequency of certain tuning behaviors during a typical practice session and before group tuning for a large ensemble rehearsal. Tuning behaviors included tuning (in general), tuning with a tuner, tuning to a pitch, tuning without any devices and tuning to another person.

Results

Recordings of performed tuning tones were analyzed for frequency using the software Praat (Boersma & Weenink, 2008). Praat has been used previously to analyze attributes of string vibrato (Geringer & Allen, 2004; Geringer, Allen, & MacLeod, 2005). Frequencies were then converted to cents deviation from equal temperament and these deviations became the source data for analysis. Tones produced by 3 students were removed from analysis as outliers (> 30 cents from the mean). Possible tuning differences before and after rehearsal and between instrument families (string or wind) were analyzed with a two-way analysis of variance with repeated measures. Results indicated a significant main effect in cent deviation between the before and after rehearsal tunings, $F(1, 54) = 8.87, p < .01, \eta^2_p = .14$. Mean cent deviations increased from before rehearsal ($M = .97$) to after rehearsal ($M = 3.94$) and standard deviation decreased (before $SD = 7.41$, after $SD = 5.78$). See Table 1. There was no significant difference in overall cent deviation between the string and wind musicians, $F(1, 54) = < 1, p > .50$, nor was there a significant interaction between instrument family and before-
after rehearsal tunings, \( F(1, 54) = 3.92, p > .05 \). Mean cent deviation of wind musicians was slightly flat before the rehearsal (\( M = -0.19, SD = 8.98 \)) and sharp after the rehearsal (\( M = 4.87, SD = 6.56 \)), whereas mean cent deviation of string musicians was slightly sharp before rehearsal (\( M = 2.06, SD = 5.52 \)) and slightly increased (\( M = 3.08, SD = 4.92 \)) after rehearsal (see Figure 1).

**Table 1**

*Means and Standard Deviations of Cents Deviations from Equal Temperament*

<table>
<thead>
<tr>
<th>Instrument Group</th>
<th>Pre-rehearsal</th>
<th>Post-rehearsal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>String</td>
<td>29</td>
<td>2.06</td>
</tr>
<tr>
<td>Winds</td>
<td>27</td>
<td>-0.19</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Bracket indicates significant difference at the .01 level.

**Figure 1.** Before and after rehearsal mean cent deviation for instrument groups.

To compare variance between the groups both before and after rehearsal, cent deviations were analyzed with Levene’s Test of Equality of Error Variances.
This test is commonly used to test the assumption of homogeneity of variance. Variances between the wind and string musician groups were significantly different before rehearsal, $F(1, 54) = 7.31, p < .01$, with winds showing greater dispersion of tuning than strings. However, variances of the two groups were not different after the rehearsal, $F(1, 54) = 1.64, p > .05$. Examination within instrument family groups found no significant differences in standard deviation before and after rehearsal tunings for either the strings, $F(1, 28) = 1.26, p > .05$, or winds, $F(1, 26) = 1.88, p > .05$.

Responses from the tuning questionnaire used a Likert-type scale for musicians to estimate tuning practice frequency where 1 indicated “Never” and 5 indicated “Always.” Results of Spearman rank-order correlation tests found three sets of answers to be significantly correlated: using a tuner during practicing and pre-rehearsal ($r = .58, p < .001$), tuning to a pitch during practicing and pre-rehearsal ($r = .52, p < .001$) and tuning by ear (no pitch) during practicing and pre-rehearsal ($r = .65, p < .001$). Because of these significant relationships, pairs were each averaged together into three overall variables: using a tuner, tuning to a pitch and tuning by ear.

These three variables and responses to the two remaining questions (“tuning your instrument” and “tuning to another person”) were analyzed using separate Mann-Whitney $U$ tests. Three of the comparisons revealed significant differences in response between string and wind musicians. String musicians reported more frequent practice sessions during which they tune their instruments, $U(32, 31) = 306.50, Z = -2.94, p < .01$. Wind musicians reported using a tuner more frequently, $U(32, 31) = 339.50, Z = -2.18, p < .05$ and tuning to someone else before a rehearsal more frequently, $U(32, 31) = 348.50, Z = -2.10, p < .05$ (Table 2).

Table 2
Means, Standard Deviations and Probability Values for Responses from Tuning Questionnaire

<table>
<thead>
<tr>
<th></th>
<th>String</th>
<th>Wind</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td>Tune during practice sessions</td>
<td>4.66</td>
<td>.65</td>
<td>3.94</td>
</tr>
<tr>
<td>Tune using a tuner</td>
<td>2.73</td>
<td>1.13</td>
<td>3.31</td>
</tr>
<tr>
<td>Tune by ear to a pitch</td>
<td>3.33</td>
<td>.97</td>
<td>3.23</td>
</tr>
<tr>
<td>Tune by ear (no pitch)</td>
<td>3.25</td>
<td>1.04</td>
<td>3.05</td>
</tr>
<tr>
<td>Tune to another person</td>
<td>3.19</td>
<td>1.06</td>
<td>3.74</td>
</tr>
</tbody>
</table>

* indicates significant difference at the .05 level

Discussion
The purpose of this study was to examine instrument pitch tendencies of string
and wind musicians before and after an ensemble rehearsal. Overall cent
deviation increased from before rehearsal to after rehearsal. Musicians tended
to be closer to the standard $A_4 = 440$ Hz before the rehearsal than they were
after the rehearsal. This variation occurred primarily in the wind musicians
whose mean pitch levels increased from before to after the rehearsal. Before the
rehearsal, mean cent deviation for the wind musicians was very slightly flat ($M =
-0.19$ cents). After the rehearsal, group mean cent deviation increased to about 5
cents ($M = 4.87$). This was different from the string musicians whose mean cent
deviation increased only slightly (about 1 cent). These findings are perhaps not
surprising since the internal warming from performers’ breath during rehearsal
would tend to produce pitch increases in wind instruments.

Practical applications include the finding of differences in variation between
the two instrument families before rehearsal, and the lack of differences after
the rehearsal. Variation in tuning among the wind musicians was higher than
the string musicians before the rehearsal. After the rehearsal, the variance of the
wind musicians decreased to be more similar to the string musicians. Further
examination within each instrument family did not find significant differences in
variance between before and after rehearsal conditions. One practical application
of this result would be that pre-rehearsal tuning seems particularly important
in a symphonic orchestra in which winds are present. Ensembles that are more
homogenous (i.e., string orchestra, wind band) may not be affected as much by
the pre-rehearsal tuning, but more affected by the tuning skills of the individual
musicians to adjust their pitch to other musicians.

Differences in tuning could be attributed to inherent differences between
instrument types. String instruments showed a lower magnitude of cent deviation
in both before and after rehearsal tunings. There is a high degree of similarity in
the string family with all string instruments producing sound in the same basic
way, usually tuning their A-string as the initial tuning note. The wind instrument
family contains less homogeneity due to the different types of sound production
mechanisms: edge tones (e.g., flute), single and double reeds, and lips.

From the tuning questionnaire, a difference was found between string and
wind musicians in their reported frequency of tuning (i.e., how often) during
practice sessions. Almost every string musician indicated that he or she always
or frequently tuned during a practice session. This was not the case with wind
musicians. When string musicians practice, it is essential to tune all four strings,
otherwise pitch relationships across strings can be problematic. On a wind
instrument, because the holes do not change location from day to day, the pitch
relationship between notes is mostly the same regardless of the overall pitch of
the instrument. Another interesting finding was that wind musicians indicated
that they used an electronic tuner more often than the string musicians. Future
research could examine the reasons and effects of using an electronic tuner
during practice sessions and rehearsal settings.
Wind musicians also reported that they tune to other musicians before a rehearsal more frequently than string musicians. This finding suggests that wind musicians may be more comfortable comparing their instrument pitch to fellow musicians, whereas string musicians wait for the tuning note before tuning. Overall, results of the questionnaire imply that string musicians tune their instrument more frequently than wind musicians tune their instrument. This could possibly explain the smaller amount of variance before and after rehearsal in the string musicians’ tuning. Future research could investigate effects of frequent tuning on variance and comfort levels of tuning.

In this study we found changes in wind instrument pitch from before to after rehearsal, but little change in string instrument pitch. In addition to decreasing variation in pitch within the ensemble, the common practice of tuning at the beginning of a rehearsal may be useful in ways other than intonation. It may serve as one of the few times an ensemble plays in unison, thus providing a sense of community within the group and assurance of group pitch. Initial tuning at the beginning of the rehearsal may also allow individual musicians to “test” out their instrument in front of others before playing. Warming up before rehearsal allows musicians to practice briefly before rehearsal begins, but matching the tuning note allows musicians to compare their pitch with other musicians.

References


How Does Rosin Affect Sound?

Abstract
The effects of rosin properties on the bowed-string sound are frequently discussed among string players and luthiers. The following comments and questions are common: Rosin is rosin. Should I use different rosins for summer and winter? Does anyone actually have a method for quantitatively measuring the physical behavior of different rosins? What are the effects of hair scales and hair flexibility? In this article the author, who has been studying these effects over a number of years both as a professional player and as an acoustician, presents some of the underlying physical aspects relevant for further discussion.

Keywords
rosin, bowed-strings, tone quality, bowed-string acoustics

Introduction: What affects the bowed-string sound?
In order to understand the interaction between rosin and the string, it is necessary to take a look at how the string is moving under the bow. In the classical Helmholtz\(^1\) analysis two segments of the string are moving in straight lines joined by a kink that rotates between the string’s two endpoints (see Fig. 1). Due to losses and the string’s bending stiffness the kink will never be perfectly sharp, but always somewhat rounded\(^2\) (see the fine dots drawn under the upper kinks). However, every time the rounded kink passes under the bow on its way toward the bridge, friction will to some degree sharpen it while the string makes a transient from the sticking phase (sticking to the bow hair) to the slipping phase (where the string slides back on the bow-hair ribbon). There might also be some sharpening when the bow captures the string again as the kink passes under the bow on its way back and the opposite transition takes place. It is the shape of this kink that determines the spectral outcome of the string and instrument: the sharper the corner, the greater the brilliance. It is here

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the properties of the rosin play a crucial role by determining how quickly this transition can take place.

**Figure 1. Helmholtz motion.**

In principle the string moves like that shown in the upper plot during a “normal” bowed tone. The rotating kink describes a parabolic trajectory on its way between the string end points. The propagating speed of the kink is always very high (290 meters/second on a violin A-string), therefore we never observe the straight lines with the naked eye, but are left with the impression of a string bent to a parabolic shape. The lower plot illustrates that at the instant the kink is hitting the bridge, the force on the bridge makes a sudden change of value whereupon a slower buildup takes place during the remaining part of the period (waveform a). If the kink is rounded, the instant change will be replaced by a more gradual one, and the force signal will contain much less energy in the upper part of the spectrum (waveform b). Waveform c shows the signal of a “scratchy” tone where more than one kink (slip interval) is present, noticeably weakening the fundamental frequency.

In simplified theory, the string will be sticking to the bow for most of the period, as long as the kink travels on the nut/finger side of the bow. It will slip back on the bow-hair ribbon with a much higher speed for the remaining time interval. However, since the ribbon occupies a certain width, and the straight
segments are changing angles all the time with respect to the bow, it should be clear from Fig. 1 that there will be a discrepancy between string speeds relative to the two hair ribbon edges: This implies that even during “stick” there will be small partial slips across the bow-hair ribbon, and even more so when the bow is tilted away from the bridge.3 These would be perceived as noise, either “spiky” or plain “hiss,” depending on the bow force.

**Rosin and bow-hair properties**

Before discussing further implications of the slips, let us have a look at the hair without and with rosin shown in Fig. 2. In the left panel, where the hair is not rosinied, the structure with scales is clearly visible. The height of these has been measured to less than 0.5 μm, which equals 1/2000 of a millimeter. Compared to the string’s diameter (even that of the violin’s E-string), this is negligible in terms of contributing to friction, a fact obvious to anyone who has tried to play with un-rosined hair. But, even more importantly, in order to quickly start the string oscillation, a rapidly changing friction coefficient is required. Any structurally related friction would merely contribute to pulling the string out to one side. The right panel shows the same hair after applying rosin. The rosin has partly melted and is now covering the scales completely. On top of this layer, solid particles of glassy rosin “crumbs” are scattered, causing small obstructions as the string slides on the melting surface.

Rocaboy,4 who measured scale heights and several other parameters concerning the hair, found that it is not its structure that makes horsehair well suited for holding rosin, but rather its chemical properties. He writes: “As a high polymer, keratin is capable of exhibiting surface activity, a property common to all high-molecular substances. The numerous secondary forces available in such large molecules are capable to attract and firmly hold together other substances such as rosin, thus making sound production possible.” Those searching for synthetic-hair materials should remember these words.

Further, any positive effect of cleaning hairs with alcohol or another dissolving and evaporating chemical would probably lie in its ability to assist in the removal of unwanted layers of fat, dust, or other substances attracted to the hair keratin (that is, of course, without replacing the contaminating substance). The main issue seems to be accommodation of an inner-layer foundation of rosin. This author has many times been forced to clean brand new hairs with benzene or acetone in order to get rosin properly on the hair. I suspect fat from the manual handling of the hair bundle to be the underlying reason.
“Dry” and “wet” friction

Earlier analyses regarded the resulting friction as “dry,” meaning that the friction coefficient would be a function of relative speed between the string and the bow hair: the greater the relative speed, the lower the resulting coefficient (down to a certain minimum value). At zero relative speed (i.e., stick) the coefficient would reach a maximum, and, dependent of the circumstances, the force could take any value between zero and this maximum. Subsequent and far more sophisticated analyses have shown that a much better match with truly dynamic measurements can be obtained if one considers the friction coefficient a function of, not relative speed, but the rapidly changing rosin temperature. Rosin gets soft right above room temperature (some even under), and any sliding between string and hair will cause the local contact-point temperature to rise. Dependent on temperature conductivity, a part of the rosin in the string’s vicinity will also soften (not necessarily melt), permitting the string to move with less frictional resistance. During most of the slipping interval the temperature will be rising, so when the string again takes the speed of the bow (goes into a cooling “stick”) the temperature is higher than when it departed, hence the lower frictional coefficient. The friction coefficient plotted against the relative speed thus describes a hysteretic loop (see examples in Figure 3). Together with the losses and the string’s bending stiffness the shape of this loop influences the rounding of the kink, or “Helmholtz corner.” If the temperature is slowly changing, the sharpening effect on the corner will be much less than if the temperature makes a sudden rise at release, causing the friction coefficient to fall correspondingly. In the latter case the kink would be more sharpened and the string would sound more brilliant or shrill.

The issue of choosing different rosins for summer and winter should be viewed in the perspective of ambient temperature. With modern air-conditioned
rooms and halls the need for seasonal changes has been significantly reduced. In earlier days harder rosin might have been preferable in the summer season, because of its higher softening/melting temperature. This is particularly relevant to attacks (see below).

**Friction and noise**
When the string slides on the bow hair, the slide will not be a smooth ride. When looking at the contact point in slow-motion video, one can see dusty particles of glassy rosin (similar to that seen in Fig. 2, right panel) being tossed around after having been obstructing the quickly moving string. The temperature and plasticity of the rosin will vary locally and cause rapid, small, random fluctuations in the string’s velocity. In sound these come out as noise or hiss, which is a characteristic part of the bowed-string tone. One interesting thing is that the spectrum of the noise, which is fairly independent of which note being played, invokes nearly all frequencies of the instrument and thus provides a wide-spectrum fingerprint. The instrument’s main air and wood resonances appear particularly strongly (i.e., on the violin: bands around C#₄ and A₄, respectively). A shrill instrument will sound even shriller because of this noise, which may constitute some 1% (–20 dB) of the instrument’s output energy. Another source of noise is the partial slips described above. These slips occur with some irregularity and are partly related to the so-called “secondary waves”: waves travelling between the bridge and the bow during stick. One might think that such small discrepancies in relative speed could be absorbed by bow-hair flexibility, thus avoiding these extra slips. The truth is that bow hair is remarkably stiff (around 0.2 N/mm for one hair of normal length). It is more likely that the entire hand-held bow is moving rather than local hairs prolonged in this process.

The farther away from the bridge the bow is positioned, the longer the noisy slipping interval will last within the nominal period. When playing *flautando* (flutelike) with the bow positioned *Sul tasto*, the combination of the bow’s speed, force, and position ensures maximum relative noise content in the radiated sound and in this way provides some similarity to the wind instrument.

**Attacks**
Perhaps the most important attribute of a rosin is its ability to facilitate clean attacks. Clean attack means the shortest possible time interval before a regular periodic stick-slip pattern between the string and bow hair is established. That is, an attack with the least possible onset noise: on one side you have attacks that are “choked,” “creaky,” or “raucous” on the other side attacks that sound “scratchy” or “slipping.” However, what produces a clean attack is not necessarily ideal for the timbre of a sustained tone.
In the following we shall look at three theoretical rosins, and, by use of numerical simulations, analyze how their differences play out. As shown in Figure 3, during slip (when the relative speed between bow hair and the string surface is different from zero) the temperature around the contact point determines the friction coefficient, with the supplied power being the product of friction force and relative speed. This implies that when the string starts sliding the temperature will rise, and soon thereafter the coefficient will drop. If holding a constant sliding speed, the temperature would drop to a certain quiescent level where the supplied power equals the power transmitted to the ambiance. In Fig. 3, the coefficients of two rosins, A (black) and B (gray), drop from nearly 0.8 to below 0.4 as the relative speed increases. Also the coefficient of rosin A is decreasing more quickly than the coefficient of B, and later returns in the same manner when speed is decreasing and the contact point is cooling off. During stick, the frictional coefficient can take any value up to a maximum (limiting) value, which is determined by further cooling. During normal Helmholtz motion, friction loops like these always exist. Due to the difference in loop shapes rosin A will sound more brilliant/sharp/shrill than B since it will provide a greater sharpening of the Helmholtz corner.

Figure 3. Friction loops of rosins A and B in a given steady-state situation with identical bowing parameters. As the friction-speed product causes the contact-point temperature to rise, the friction coefficients are falling, and vice versa.
A series of simulated attacks are presented to help determine which one of these two rosins, plus a third one, will behave best in terms of getting the string quickly started. Figure 4 displays three diagrams, which are to be interpreted in the following way: Each pixel in the diagram represents the outcome of a combination of bow force (“bow pressure”) and bow acceleration. There are some 12,000 combinations in each diagram. Perfect noiseless attacks are marked white, while darker shading indicates greater duration of attack-noise components. Above the white wedge, to the left, the attacks appear choked/creaky/raucous (Chk), while below it, to the right, they sound scratchy/slipping (Slp). The scale on the right-hand side in the figure gives the number of nominal periods elapsing before a regular “correct” slip/stick pattern occurs. In the high-tension and rather stiff violin G-string used for the simulations, 10 nominal periods last some 50 milliseconds, or 1/20th of a second. When comparing rosin A to B, we see that the light wedge of B’s panel is slightly wider than the light wedge of A. That is, rosin B plays slightly better than A, as it provides a larger range of bowing parameters that result in clean attacks. However, the best-playing rosin appears to be C, which provides clean attacks also for much lower bow-force values than the two others. What are the reasons for this? The only difference between A and B, as we saw in Fig. 3, was the temperature conductivity, or the rosin’s ability to quickly change temperature/friction coefficient. Both of these rosins would have maximum coefficients proportional to bow force at room temperature. However, rosin C is designed not to provide proportionality between bow force and the maximum coefficient. It behaves like some rosins designed for lower-pitched instruments (particularly for the double bass), where the friction coefficient gets higher as the bow force gets lower. These are “sticky” rosins with melting temperatures lower than for normal violin rosins. Such rosins provide clean attacks over the widest range of bow-force/acceleration. To some degree they would compensate for lack of bowing-parameter precision, and, which is of great importance to many double-bass players, they don’t require quite as much bow force in order to have the string speak. In all other respects, rosin C behaves like rosin B. It should be added that when rosin B performs somewhat better than rosin A in these tests, it is for the same reason as a stopped string gets more easily going than an open one: Rosin B gives more corner rounding, as does the finger pad on the fingerboard in a stopped string. Spiky reflected impulses tend to jeopardize the bow’s grip of string, particularly during transients.
Figure 4. Comparison of attack quality as a function of bowing parameters for three different rosins. Each pixel refers to the outcome of a bow-force/acceleration combination: the lighter the color, the cleaner the attack (see text).

Timbre
Research has shown that qualified violinists are quite good at hitting the attack qualities they want. In most cases this would be “clean attacks,” corresponding to the light areas of the figures. However, different musical contexts call for different attack qualities. If rougher attacks were appropriate, the onsets would consistently be found in the choked ranges (Chk), while some Baroque pieces would be performed with slipping attacks (Slp).

Analyses of steady-state tones are shown in Figure 5. In the left panel, bridge-force spectra resulting from rosins A and B are compared with respect to two very different bow-force values: 300 and 2000 mN. The bowing speed is 30 cm/s and the contact position is approximately 35 mm away from the bridge on the open string. There is a significant spectral difference between low and high bow forces for both rosins. We see that with low bow force, amplitudes fall about 35 dB at partial 6 compared to the fundamental, which implies a very soft tone color, suitable for mellow flautando playing. For rosin C (right panel), the corresponding partial appears about 15 dB louder, making true flautando almost impossible. Rosin C, which performed so well in the attack simulations, seems more limited when it comes to tonal variation. This is a typical feature of (very) soft rosins. The significant tone-color variation available with rosins A and B gets noticeably reduced with rosin C. The main cause lies in C’s inability to accommodate genuine soft-color playing at low bow force since friction coefficients approach infinite values as bow force goes to zero.

*Approx. 31 and 204 grams force, or 0.067 and 0.45 pounds force, respectively.
Figure 5. Comparison of spectral profiles resulting from the three different rosins. Upper and lower lines of each color indicate high and low bow force, respectively. Rosin A is slightly more brilliant than rosin B, but both rosins show great spectral variation between the two bow-force values (see left panel). At the right panel, rosin C is considerably more limited in this respect.

**Tone color and rosin additives**
Most rosins come with additives, whether it be waxes, oils, or metals. In principle there are two ways such ingredients may influence the tone quality: by changing the shape of the hysteretic loop, and by changing the noise content. With regard to the first, such changes could be caused by alteration of the plasticity/viscosity, which implies the general frictional resistance and/or temperature-related conductivity. The second could be related to change of homogeneity, which again might have an influence on noise level and noise spectrum. When the term “noise” is used in this connection, it is merely a technical term for stochastic (non-predictable) sound energy, not necessarily an unwanted sound component. The present author is unaware of any scientific study of the effect of such additives, some of which might be better sounding in advertisements than on the bow.

**Discussion**
The dynamic frictional behavior of rosin is very complicated to measure with accuracy. The flexible string is not only sliding on the bow hair, it is also rolling up and down the bow-hair ribbon during playing, and the frictional point of contact is constantly moving. This is the reason why numerical simulations of the bow/string contact are attractive: When the modeled string behaves in a way well matching the string as observed on the instrument, all relevant parameters are readily available for analysis. If manufacturers of rosin would provide information about one single property, melting temperature would be the most useful one, since it would most probably give information on how quickly frictional changes might take place, and thus the potential tone-color variation. In the same way string tension (now provided by several manufacturers) is a
The most useful piece of information on strings, since it affects loudness, playability, wolf adjustment, and other aspects.

Melting temperature would provide a fair first estimate of the “stickiness” of a rosin. Strings for the different instruments of the bowed-string family show certainly great varieties in thickness, weight, tension, etc., which implies great differences in their wave resistances (the strings’ resistance to being moved to any waveform): the higher the wave resistance, the higher the required frictional force. Between the instruments violin, viola, cello, and double bass, the characteristic wave impedance varies typically with relative factors of 1 : 1.6 : 4 : 10 (compared to the impedances of violin strings). If utilizing the same rosin for all instruments, this would imply a bowing “pressure” about ten times higher for the double bass than for the violin. To get around this problem, rosins are usually made more sticky (with lower melting temperature) for the cello and double bass, so that the bow force can be eased somewhat. However, if the melting temperature is lower than the normal room temperature, so that the rosin is slowly running out of its container when placed sideways on the table, you would know that you have a highly sticky rosin that will not permit true flautando playing. Paradoxically, it might also complicate the attack if you want to start the stroke from the string, as the potential friction rapidly increases with the hair’s resting time on the string before the first string release (while the rosin sets). To avoid unwanted “plings” at the tone onsets, many users hence try to limit this kind of preparation, and instead attack the string from the air.

It is my recommendation as a player to choose rosins that will not stick to the bow-hair bundle when the hair is pressed firmly straight down against the rosin cake, followed by a straight-up removal without any rubbing. With such rosins you are free to prepare the stroke as you like, and can choose from many more onset qualities at nearly any dynamic level. Another simple test to verify the softness/stickiness of rosin is to vary the bow force when playing the highest positions on the fingerboard. Soft rosins tend to cause much more pronounced pitch flattening at high bow force (due to prolonged sticking intervals) than do the harder ones. A third aspect is that the rosin should not be “powdery,” as excess powder might interfere with the hair-string contact, making attacks unpredictable.

The greatest variations are found among double-bass rosins. This has to be considered in the perspective of onset transients (tone buildup), the duration of which, by nature, is inversely proportional to frequency. The transient consists of two independent factors: the instrument-body transient and the string-buildup transient, of which only the latter can be manipulated to some degree. If a violinist and a bassist attack tones three octaves apart, applying the same bowing strategy, the bass will develop its tone eight times more slowly than the violin, which means that in most cases it will definitely sound late. For this reason many bassists choose a rosin in the C category, to increase the probability of the
cleanest and fastest buildup possible. However, it should be pointed out that this sacrifice of potential tone-color variation, which may or may not be noticeable in the orchestra, could have been avoided by combining a harder rosin (like B) with a more precise bowing technique. This strategy might be the better choice for solo playing if tone-color diversity is a prioritized feature. All in all there is a tradeoff between convenience and a palette of possibilities.

Author’s Note
Knut Guettler is a former principal double bassist of the Oslo Philharmonic, and professor of double bass at the Norwegian Academy of music in Oslo as well as the Royal Conservatory of Music in The Hague, Netherlands. He holds a Ph.D. in acoustics from the Royal Institute of Technology in Stockholm, Sweden, with particular focus on bowed-string attacks.

Endnotes


The Perceived Impact of String Programs on K-12 Music Programs

Abstract
We examined music teacher perceptions regarding the impact of string programs on overall music programs in K-12 schools. Research questions included: (1) What are the perceived positive and negative program and student outcomes? (2) What are the underlying issues of music teachers’ perceptions about the positive and negative impacts of string programs? (3) How do these underlying issues compare with one another (negative and positive)? and (4) What relationships, if any, exist between fixed factors and the perceptions of the impact of string programs? Questionnaires were sent to all MENC members in two Southwestern MENC states. Data from participants (n = 308) were analyzed using principal components analyses and correlation analyses. A majority of music teachers felt that string programs were beneficial and offered opportunities for student development as well as expanded opportunities within a music program. Concerns included program focus and support, logistical issues, budget concerns, and finding qualified instructors.

Keywords
string program, string teacher, string music education, music teacher, program impact

In 1961, the presidents of the MENC Federated State Units and the members of the National Board of Directors of MENC convened to discuss twenty topics. The resultant report was titled, What are Music Educators Thinking and Saying? (MENC, 1961). One of the issues discussed was music education’s relationship with other disciplines, specifically the role of music in the curriculum and the perception
of its contribution in the school setting. One-half century later, the thoughts and concerns expressed in 1961 are the same. Music educators want to know how the public, other educators, and colleagues in music view and value their programs. According to a Harris Poll taken in 2005, 93 percent of those polled stated that the arts were vital to providing a well-rounded education, and 54 percent indicated the importance of arts education to be a “10” on a scale of one to 10 (American Music Teacher, 2005). Over 83 percent of the individuals sampled agreed that arts education assisted in the improvement of children’s attitudes toward school and helped them communicate effectively with adults and peers. When looking at music research conducted in the early 1970s through 1990, researchers noted that support among administrators for various aspects of music instruction was positive. Administrators tended to support elementary general music programs (Stroud, 1980), the curricular goals of music programs (Liddell, 1977; Payne, 1990; Punke, 1972), and band and band competitions (Greenwood, 1991; Rogers, 1985). In a 2005 study, Abril and Gault compared preservice and inservice elementary educators’ perceptions of elementary general music curriculum goals. Respondents were asked to indicate their perceptions, using a Likert-type scale, of items in five general areas: entertainment/recreation, expressive/creative, interdisciplinary, musical, and sociocultural. Inservice and preservice educators responded positively in all areas, although preservice teachers had higher mean scores except the musical category. Abril and Gault (2006) then conducted a study of principals’ perceptions of elementary general music programs and reported that principals felt that music education programs were helping students achieve seven music learning outcomes and 13 broad educational goals. While principals believed students did learn to compose and create music through musical study, principals thought performing and listening skills were more effectively taught in music classes (Abril & Gault, 2006; Williams, 2007). Principals were also asked the degree to which 10 variables affected music programs. “No Child Left Behind,” budgetary concerns, standardized testing, and scheduling were found to have the most negative effect, while music teachers, parents, and students had the most positive effect on elementary music programs. In 2008, Abril and Gault (2008) also investigated principals’ perceptions of secondary music programs. They reported that principals believed music programs were successful in enabling students to meet musical and educational learning goals. When asked the degree to which 10 variables affected music programs, principals felt students, parents, music teachers, other teachers, school boards, and educational research findings positively impacted music programs, while budget/finances and scheduling negatively affected music programs. Researchers have explored various individuals’ perceptions of the value of music programs in general. More specifically, however, researchers have
primarily focused on general music and band programs. Relatively little is known of individuals’ perceptions of the benefits of string/orchestral programs. In the report from their 2004 National Summit, the American String Teachers Association (ASTA) listed one of their 11 objectives as the development of short- and long-range professional advocacy plans to market the values/benefits of string instrument playing. Authors of various ASTA publications have promoted the values/benefits of string instrument study (ASTA, 2006, 2008; Barnes, 2003; Hamann & Gillespie, 2004; League of American Orchestras, 2008). The benefits of string program development as articulated in these publications include curricular benefits such as expanded repertoire possibilities for all music students, greater exposure to world music, and more comprehensive music curricula. Additional benefits may include pragmatic or logistic benefits such as greater community support, improved opportunities for university/college scholarships, more career opportunities, and improved performance standards, increased cost-effectiveness of school districts, and greater recognition of students and their schools. Finally, the benefits of string/orchestra programs for individual students may include enhanced aural and motor skill growth, development of leadership skills and personal character, heightened quality of life, development of social skills, and growth of expressive skills.

Several authors have noted the importance of string programs in the public schools. Moss (2002), for instance, found that the majority of school superintendents in southern Georgia believed that school music curricula that omit orchestra are incomplete and that the majority believed that students should have access to string instruction. However, it is not clear how the public, in particular other music teachers, view these and other articulated benefits of string/orchestral programs. As string teachers advocate for the implementation or improvement of string programs in K-12 schools, it seems vital to understand how professional music educators believe their schools, programs, and students will be influenced.

The purpose of this study was to examine music teacher perceptions regarding the impact of string programs on overall music programs in K-12 schools. Research questions included: (1) What are the perceived positive and negative program and student outcomes? (2) What are the underlying issues of music teachers’ perceptions about the positive and negative impacts of string programs? (3) How do these underlying advantages and disadvantages compare with one another? and (4) What relationships, if any, exist between fixed factors and the perceptions of the impact of string programs? The first research question was addressed using descriptive statistics. Research questions two and three were addressed using two principal component factor analyses and the comparison of each. We used a Pearson Correlation analysis to examine data relevant to research question four.
Method
Participants responded to a researcher-created questionnaire that was developed through a focus group at one university and through peer review and small pilot ($N = 18$) at another university. The pilot participants included preservice music teachers and music education masters students and, therefore, did not represent the main study population. This process helped improve the clarity of the questionnaire as well as refine and add items not previously considered by the researchers. We included some items in the questionnaire from previous research (i.e., ASTA, 2006, 2008; Barnes, 2003; Hamann & Gillespie, 2004; League of American Orchestras, 2008).

We sent the final String Program Questionnaire Revised (SPQR) to music educators who were members of MENC in two Southwestern MENC states during the 2007-2008 school year ($N = 2193$). Each MENC member received a questionnaire by mail, including a cover letter, the questionnaire, and a self-addressed and stamped return envelope. A follow-up mailing was conducted four weeks later to increase the response rate. Three hundred and eight music educators completed and returned questionnaires ($n = 308, \text{ response rate } = 14\%, \text{ margin of error } +/- 5.18$). Such a poor response rate may be due to lack of interest of this topic, or due to a lack of extra time. Due to the low response rate, and prior to final data analysis, we conducted a series of t-tests and ANOVAs to ensure that no patterns of missing data existed. No significant differences were found suggesting that all groups were adequately sampled given the variables under study. All assumptions of statistical procedures were met. Future researchers could utilize findings from this study to inform additional studies that are able to collect more data and that focus on a larger regional or national representation.

Participants
Participants ($N = 308$) were music educators in one of two southwestern MENC states who were, on average, 43 years old, with 15 years of teaching experience. The majority of respondents (69%) was female, and held either a bachelor’s degree in music education (53%) or a master’s degree in music education (41%). Teachers indicated teaching in elementary (44%), middle/junior high (26%), or high school (30%). Only 10 percent of respondents reported primarily teaching orchestra, while 37 percent taught band, 21 percent taught choir, and 33 percent taught general music. The vast majority (98%) were certified to teach music in the state where they currently taught. These participants have similar demographics to music teachers based on national data.

Fifty-two percent of music educators reported working in a school that currently offered a string program during the regular school day, and only 31 percent were responsible for teaching string classes. The majority of teachers (84%) working in a school that did not have a string program indicated that they
wanted a string program in their school. However, only half (50%) disclosed a willingness to teach string classes. Teachers working in a school with a string teacher reported having a very positive relationship with that educator (88%).

The majority of participants (65%) played in an orchestra at some point. Very few participants (15%) indicated having more than two courses in string techniques (performance skills). Most participants took either one (45%) or two (25%) string techniques courses. Similarly, few participants indicated taking more than two string pedagogy classes (9%), while most had taken either one (55%) or two (14%) string pedagogy classes. The number of participants who had not had the opportunity to take a string techniques class was lower (15%) than the number of individuals not able to take a string pedagogy course (23%). The majority of participants (72%) had never taken private lessons on an orchestral string instrument.

Results

Research Question 1: What are the perceived positive and negative program and student outcomes?

Participants indicated their level of agreement (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) with a series of possible benefits for music programs and students. The greatest participant observed program benefits included the opportunity to offer a more comprehensive music curriculum, greater course offerings, and an expansion of the possible repertoire and overall participation in music. Few regarded pecuniary issues, such as budgets or fundraising, as well as participation in the participants’ own program (see Table 1), to be as important.
### Table 1

Mean Agreement Rating for Possible Program Benefits

<table>
<thead>
<tr>
<th>Possible Program Benefits</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>More comprehensive music curriculum</td>
<td>3.58</td>
<td>.62</td>
</tr>
<tr>
<td>More musical course offerings</td>
<td>3.48</td>
<td>.68</td>
</tr>
<tr>
<td>Expanded repertoire</td>
<td>3.48</td>
<td>.64</td>
</tr>
<tr>
<td>Greater overall participation</td>
<td>3.43</td>
<td>.71</td>
</tr>
<tr>
<td>Increased overall performance standard</td>
<td>3.40</td>
<td>.71</td>
</tr>
<tr>
<td>Jobs for string teachers</td>
<td>3.35</td>
<td>.71</td>
</tr>
<tr>
<td>Greater community visibility</td>
<td>3.32</td>
<td>.71</td>
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<tr>
<td>Collaborations with other ensembles</td>
<td>3.29</td>
<td>.70</td>
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<tr>
<td>Earlier skill development</td>
<td>3.26</td>
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</tr>
<tr>
<td>Greater community support</td>
<td>3.16</td>
<td>.79</td>
</tr>
<tr>
<td>Increased parental involvement</td>
<td>3.10</td>
<td>.74</td>
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<tr>
<td>Increased administrative support</td>
<td>2.98</td>
<td>.84</td>
</tr>
<tr>
<td>Increased enrollment in your program</td>
<td>2.95</td>
<td>.92</td>
</tr>
<tr>
<td>Increased budget</td>
<td>2.71</td>
<td>.95</td>
</tr>
<tr>
<td>Increased ability to fundraise</td>
<td>2.57</td>
<td>.84</td>
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</table>

The greatest student benefits participants observed included participation in musical experiences, enhanced self-esteem, and increased expressive development. Fewer rated the student benefits of travel opportunities, relaxation, and understanding other cultures as highly as other benefits (see Table 2).
Similarly, participants were asked to indicate their level of agreement (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) with a series of possible negative *program* outcomes or potential obstacles created by string programs on music programs and students. Although music teachers generally disagreed with the majority of possible negative program outcomes (no mean exceeds 2.76), the highest rated possible negative outcomes focused on logistical issues rather than instructional outcomes such as a lack of qualified string teachers available to teach the classes, instrument cost, lack of adequate facilities, and a lack of calendar space (see Table 3).

### Table 2

*Mean Agreement Ratings for Possible Student Benefits*

<table>
<thead>
<tr>
<th>Possible Student Benefits</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>More possible musical experiences</td>
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<tr>
<td>Increased participation in music</td>
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<td>.67</td>
</tr>
<tr>
<td>Foster commitment and self-discipline</td>
<td>3.50</td>
<td>.66</td>
</tr>
<tr>
<td>Develop student character</td>
<td>3.48</td>
<td>.65</td>
</tr>
<tr>
<td>Development of self-concept and self-esteem</td>
<td>3.44</td>
<td>.64</td>
</tr>
<tr>
<td>Develop student expression</td>
<td>3.44</td>
<td>.68</td>
</tr>
<tr>
<td>Further exposure to fine arts classes</td>
<td>3.41</td>
<td>.64</td>
</tr>
<tr>
<td>Development of social skills</td>
<td>3.38</td>
<td>.67</td>
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<tr>
<td>Increased motivation to participate</td>
<td>3.38</td>
<td>.70</td>
</tr>
<tr>
<td>Development of leadership skills</td>
<td>3.37</td>
<td>.68</td>
</tr>
<tr>
<td>Development of expressive performance skills</td>
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<td>.70</td>
</tr>
<tr>
<td>Dexterity development</td>
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<tr>
<td>Exposure to masterworks</td>
<td>3.33</td>
<td>.68</td>
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<tr>
<td>Opportunities for college scholarships</td>
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<td>.73</td>
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<tr>
<td>Collaborations with other musicians/ensembles</td>
<td>3.30</td>
<td>.71</td>
</tr>
<tr>
<td>Increased motivation to practice/succeed</td>
<td>3.25</td>
<td>.75</td>
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<tr>
<td>Develop understanding of different cultures</td>
<td>3.23</td>
<td>.70</td>
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<tr>
<td>Foster relaxation and stress release</td>
<td>3.22</td>
<td>.71</td>
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<tr>
<td>Travel opportunities</td>
<td>2.98</td>
<td>.79</td>
</tr>
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</table>
Table 3
Mean Agreement Ratings for Negative Program Outcomes

<table>
<thead>
<tr>
<th>Negative Program Outcomes</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of trained string teachers available</td>
<td>2.76</td>
<td>.99</td>
</tr>
<tr>
<td>Instrument costs (school instruments)</td>
<td>2.74</td>
<td>.94</td>
</tr>
<tr>
<td>Lack of performance facilities</td>
<td>2.50</td>
<td>.96</td>
</tr>
<tr>
<td>Calendar issues</td>
<td>2.47</td>
<td>.90</td>
</tr>
<tr>
<td>Teachers spread too thin</td>
<td>2.40</td>
<td>.91</td>
</tr>
<tr>
<td>Less funding for individual programs</td>
<td>2.35</td>
<td>.89</td>
</tr>
<tr>
<td>Decreased budget</td>
<td>2.30</td>
<td>.88</td>
</tr>
<tr>
<td>Performers spread too thin</td>
<td>2.21</td>
<td>.88</td>
</tr>
<tr>
<td>Decreased enrollment in your program</td>
<td>2.09</td>
<td>.88</td>
</tr>
<tr>
<td>Decreased ability to fundraise</td>
<td>2.04</td>
<td>.76</td>
</tr>
<tr>
<td>Lack of communication between fine arts faculty</td>
<td>1.96</td>
<td>.79</td>
</tr>
<tr>
<td>Too many elective choices</td>
<td>1.95</td>
<td>.81</td>
</tr>
<tr>
<td>Decreased administrative support</td>
<td>1.86</td>
<td>.74</td>
</tr>
<tr>
<td>Too many musical course offerings</td>
<td>1.80</td>
<td>.74</td>
</tr>
<tr>
<td>Less focused music curriculum</td>
<td>1.79</td>
<td>.70</td>
</tr>
<tr>
<td>Loss of community visibility</td>
<td>1.74</td>
<td>.65</td>
</tr>
<tr>
<td>Decreased overall participation</td>
<td>1.74</td>
<td>.72</td>
</tr>
<tr>
<td>Loss of community support</td>
<td>1.74</td>
<td>.67</td>
</tr>
<tr>
<td>Decreased overall performance standard</td>
<td>1.69</td>
<td>.64</td>
</tr>
</tbody>
</table>

Finally, participants indicated the extent to which they agreed or disagreed with a series of possible negative student outcomes. Again, participants generally disagreed with the possible negative student outcomes and focused on logistical issues rather than instructional outcomes. Only two outcomes had a mean of higher than two: lack of trained teachers to work with students, and student scheduling issues (see Table 4).
Table 4
Mean Agreement Ratings for Negative Student Outcomes

<table>
<thead>
<tr>
<th>Negative Student Outcomes</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling Issues</td>
<td>2.71</td>
<td>.89</td>
</tr>
<tr>
<td>Inadequate or Lack of properly trained instructors</td>
<td>2.56</td>
<td>.97</td>
</tr>
<tr>
<td>Indecision to play any instrument</td>
<td>1.87</td>
<td>.79</td>
</tr>
<tr>
<td>Decreased parental support</td>
<td>1.79</td>
<td>.65</td>
</tr>
<tr>
<td>Decreased student motivation to practice/succeed</td>
<td>1.72</td>
<td>.67</td>
</tr>
<tr>
<td>Too many collaborations with other musicians/ensembles</td>
<td>1.71</td>
<td>.65</td>
</tr>
<tr>
<td>Lack of development of expressive performance skills</td>
<td>1.69</td>
<td>.64</td>
</tr>
<tr>
<td>Decreased motivation to participate</td>
<td>1.67</td>
<td>.65</td>
</tr>
<tr>
<td>Decreased participation in music</td>
<td>1.66</td>
<td>.66</td>
</tr>
<tr>
<td>Detracts from an academic focus/career path</td>
<td>1.64</td>
<td>.70</td>
</tr>
</tbody>
</table>

Participants responded to a final item in which they reported if they felt string programs were beneficial or detrimental to music programs in general. An overwhelming 98% believed that string programs were beneficial to music programs. Only seven participants indicated that string programs were detrimental.

Research Question 2: What are the underlying issues of music teachers’ perceptions about the positive and negative impacts of string programs?

We conducted a principal components factor analysis to explore the fundamental issues that underlie teachers’ perceptions of the positive and negative outcomes of string programs, as well as to reduce data for further analysis. Due to the exploratory nature of this analysis, we employed a principal component factor analysis. Principal component factor analysis is an attempt to find factors that account for all common and unique variance in any given set of variables (Gorsuch, 1983). In order to find the least correlated factors, we used an orthogonal Varimax rotation method with Kaiser Normalization. This rotation required seven iterations to converge. Only components with an eigenvalue of 1 or greater were utilized in the analysis.

The factor analysis produced three components. The first rotated component accounted for 59.4% of the variance with an eigenvalue of 20.2. The eigenvalues of the following two components were 1.77 and 1.55 accounting for an additional 9.7% of the total variance. These eigenvalues suggest that although these components were weaker than the first component, music teacher perception of the benefits of string programs is not unidimensional. Sampling adequacy was established using the Kaiser-Meyer-Olkin measure (.97). The
assumption of sphericity was also met as evidenced in the Bartlett Test of Sphericity ($\chi^2 = 9730.17, p < .001$).

The rotated component matrix is clear and interpretable (see Table 5). Factor I represents student development benefits (SDB), Factor II represents expanded experiences (EE), and Factor III represents logistical and support issues (LSI). The reliability for each of these factors, as assessed using Cronbach’s alpha, were high (SBD = .97, EE = .94, LSI = .91).

Table 5

Rotated Component Matrix: Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Component:</th>
<th>SDB</th>
<th>EE</th>
<th>LSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of leadership skills</td>
<td></td>
<td>.797</td>
<td>.303</td>
<td></td>
</tr>
<tr>
<td>Fine motor skill development</td>
<td></td>
<td>.788</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of social skills</td>
<td></td>
<td>.767</td>
<td>.320</td>
<td></td>
</tr>
<tr>
<td>Development of self concept and self-esteem</td>
<td></td>
<td>.761</td>
<td>.410</td>
<td>.303</td>
</tr>
<tr>
<td>Development of student expression</td>
<td></td>
<td>.755</td>
<td>.421</td>
<td></td>
</tr>
<tr>
<td>Development of student character</td>
<td></td>
<td>.750</td>
<td>.398</td>
<td></td>
</tr>
<tr>
<td>Foster commitment and self-discipline</td>
<td></td>
<td>.738</td>
<td>.397</td>
<td></td>
</tr>
<tr>
<td>Development of expressive performance skills</td>
<td></td>
<td>.734</td>
<td>.398</td>
<td></td>
</tr>
<tr>
<td>Foster relaxation and stress release</td>
<td></td>
<td>.724</td>
<td>.382</td>
<td></td>
</tr>
<tr>
<td>Opportunities for college scholarships</td>
<td></td>
<td>.693</td>
<td>.333</td>
<td></td>
</tr>
<tr>
<td>Further exposure to fine arts classes</td>
<td></td>
<td>.636</td>
<td>.518</td>
<td></td>
</tr>
<tr>
<td>Travel opportunities</td>
<td></td>
<td>.631</td>
<td>.376</td>
<td></td>
</tr>
<tr>
<td>Increased motivation to practice/succeed</td>
<td></td>
<td>.590</td>
<td>.398</td>
<td>.466</td>
</tr>
<tr>
<td>Development of understanding of other cultures</td>
<td></td>
<td>.582</td>
<td>.343</td>
<td>.412</td>
</tr>
<tr>
<td>Increase motivation to practice</td>
<td></td>
<td>.576</td>
<td>.479</td>
<td>.424</td>
</tr>
<tr>
<td>Exposure to masterworks</td>
<td></td>
<td>.533</td>
<td>.456</td>
<td></td>
</tr>
<tr>
<td>More musical course offerings</td>
<td></td>
<td></td>
<td>.829</td>
<td></td>
</tr>
<tr>
<td>More comprehensive music curriculum</td>
<td></td>
<td></td>
<td>.800</td>
<td></td>
</tr>
<tr>
<td>Expanded repertoire</td>
<td></td>
<td>.321</td>
<td>.737</td>
<td></td>
</tr>
<tr>
<td>Collaborations with other ensembles</td>
<td></td>
<td></td>
<td>.704</td>
<td></td>
</tr>
<tr>
<td>More possible musical experiences</td>
<td></td>
<td>.428</td>
<td>.681</td>
<td></td>
</tr>
<tr>
<td>Increased overall performance standard</td>
<td></td>
<td>.395</td>
<td>.658</td>
<td>.312</td>
</tr>
<tr>
<td>Greater overall participation</td>
<td></td>
<td>.344</td>
<td>.621</td>
<td>.362</td>
</tr>
<tr>
<td>Collaborations with other musicians/ensembles</td>
<td></td>
<td>.472</td>
<td>.578</td>
<td>.332</td>
</tr>
<tr>
<td>Increased student participation in music</td>
<td></td>
<td>.525</td>
<td>.578</td>
<td>.337</td>
</tr>
</tbody>
</table>

(continued on next page)
We also conducted an additional factor analysis on participant responses to possible negative outcomes in order to explore similarities or differences in the underlying positive and negative perceptions of the impact of string programs. Again, we utilized principal component factor analysis with Varimax rotation and Kaiser Normalization. This rotation required ten iterations to converge. Only components with an eigenvalue of 1 or greater were considered in the analysis.

This factor analysis produced four components. The first rotated component accounted for 52.3% of the variance with an eigenvalue of 15.4. The eigenvalues of the following three components were 2.60, 1.22, and 1.00, accounting for an additional 16.6% of the total variance. These eigenvalues suggest music teacher perceptions of the possible negative outcomes of string programs are not unidimensional. Sampling adequacy was established using the Kaiser-Meyer-Olkin measure (.95). The assumption of sphericity was also met as evidenced in the Bartlett Test of Sphericity ($\chi^2 = 7218.98, p = <.001$).

The rotated component matrix is clear and interpretable (see Table 6). Factor I represents program focus and support (PFS), Factor II represents Logistical Issues (LI), Factor III represents Pecuniary Issues (PI), and Factor IV represents Qualified Instructors (QI). The reliability for each of these factors, as assessed using Cronbach’s alpha, were high (PFS = .94, LI = .90, PI = .88, QI = .90).
### Table 6
**Rotated Component Matrix: Possible Negative Outcomes**

<table>
<thead>
<tr>
<th>Negative Outcomes</th>
<th>Component: PFS</th>
<th>LI</th>
<th>PI</th>
<th>QI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of development of expressive performance skills</td>
<td>.889</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased student motivation to practice/succeed</td>
<td>.870</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased motivation to participate</td>
<td>.860</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased participation in music</td>
<td>.839</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased overall performance standard</td>
<td>.739</td>
<td>.309</td>
<td>.335</td>
<td></td>
</tr>
<tr>
<td>Loss of community support</td>
<td>.721</td>
<td>.501</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of community visibility</td>
<td>.716</td>
<td>.500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased parental support</td>
<td>.688</td>
<td></td>
<td>.322</td>
<td></td>
</tr>
<tr>
<td>Decreased overall participation</td>
<td>.677</td>
<td>.348</td>
<td>.365</td>
<td></td>
</tr>
<tr>
<td>Detracts from an academic focus/career path</td>
<td>.677</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too many collaborations with other musicians/ensembles</td>
<td>.676</td>
<td>.317</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indecision to play an instrument</td>
<td>.609</td>
<td>.379</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less focused music curriculum</td>
<td>.542</td>
<td>.455</td>
<td>.396</td>
<td></td>
</tr>
<tr>
<td>Decreased enrollment in your program</td>
<td>.490</td>
<td>.432</td>
<td>.375</td>
<td></td>
</tr>
<tr>
<td>Lack of communication between fine arts faculty</td>
<td>.452</td>
<td>.398</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calendar issues</td>
<td>.741</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument costs (school instruments)</td>
<td>.716</td>
<td>.372</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of performance facilities</td>
<td>.673</td>
<td></td>
<td>.391</td>
<td></td>
</tr>
<tr>
<td>Performers spread too thin</td>
<td>.417</td>
<td>.648</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers spread too thin</td>
<td>.614</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduling issues</td>
<td>.613</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too many musical course offerings</td>
<td>.524</td>
<td>.600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too many elective choices</td>
<td>.538</td>
<td>.593</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less funding for individual programs</td>
<td>.468</td>
<td>.687</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased budget</td>
<td>.467</td>
<td>.672</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased ability to fundraise</td>
<td>.429</td>
<td>.648</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased administrative support</td>
<td>.497</td>
<td>.623</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate or lack of properly trained instructors</td>
<td>.341</td>
<td></td>
<td>.778</td>
<td></td>
</tr>
<tr>
<td>Lack of trained string teachers available to provide instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Bold items signify items that loaded on each component. Factor loadings under .30 are suppressed. PFS = Program Focus & Support, LI = Logistical Issues, PI = Pecuniary Issues, QI = Qualified Instructor.
Research Question 3: How do these underlying issues compare with one another (negative and positive)?

Although the underlying perceived benefits and negative outcomes are somewhat similar (e.g. logistical issues and program focus and support), it seems that the possible negative outcomes are slightly more nuanced with more concern focusing on program pecuniary issues (e.g. budget and fundraising) as well as on finding highly qualified string teachers to teach courses.

Research Question 4: What relationships, if any, exist between fixed factors and the perceptions of the impact of string programs?

We conducted a Pearson Product Moment Correlation to see if any individual difference variables (teaching level, teaching genre, age, teaching experience, degree level, certification, orchestra playing experience, number of string techniques courses, number of string pedagogy courses, or private lessons on a string instrument) related to the underlying perceived benefits or negative outcomes of string programs. Three factors were significantly related to possible benefit factors ($\alpha = .05$). Participants who had performed in an orchestra ($r = .12$) and who had taken more string techniques courses ($r = .14$) were more likely to believe that programs would benefit in logistical and support issues (LSI). Although these relationships were significant, the magnitudes of these correlations are meager, indicating relatively little practical significance.

An additional four factors were significantly related to possible negative outcome factors ($\alpha = .05$). Female participants were more likely to believe logistical issues (LI) were possible negative outcomes of a string program ($r = .13$). Music teachers with orchestra playing experiences ($r = -.12$), as well as more experiences with string techniques courses ($r = -.12$), were less likely to feel that logistical issues (LI) were possible negative outcomes. Moreover, participants who had more experiences with string techniques courses were less likely to report a concern about finding qualified instructors to teach the courses. Only one variable was significantly related to possible negative outcome factors. Participants who took private lessons on an orchestral string instrument were also less likely to be concerned with finding qualified instructors to teach string classes ($r = -.19$). Again, the relatively weak relationships between the fixed factors and outcome factors do not argue for practical significance.

Discussion

When addressing the first research question “What are the perceived possible positive and negative program and student outcomes?” it was found that music teachers positively supported the vast majority of items pertaining to program and student outcomes. Of 15 program benefits items, 11 of the items received a mean rating above 3.0, indicating agreement. Items thought to have been benefits of string programs were: a more comprehensive music curriculum, more musical
course offerings, expanded repertoire, greater overall participation, increased overall performance standard, jobs for string teachers, greater community visibility, collaborations with other ensembles, earlier skill development, greater community support, and increased parental involvement.

When reviewing the music teachers’ mean ratings of the 19 items under the heading of student benefits, only one item was found with ratings lower than 3.0. The benefits to students participating in string programs were perceived as follows: more possible musical experiences, increased participation in music, greater commitment and self-discipline, development of student character, self-esteem, and student expression, further exposure to fine arts classes, development of social skills, enhanced motivation to participate, practice, and succeed, growth of leadership skills, expansion of expressive performance skills, dexterity development, exposure to masterworks, amplified opportunities for college scholarships and collaborations with other musicians/ensembles, improved understanding of different cultures, and relaxation and stress release.

Items acknowledged by music teachers as string program benefits in this study were similar to those cited as string program benefits by the American String Teachers Association (2006, 2008), Barnes (2003), Hamann and Gillespie (2004), and the League of American Orchestras (2008). Based on these findings it would appear that string programs do tend to support expanded repertoire possibilities for students in all ensembles, comprehensive music curriculums for schools, greater community support for music programs, enhanced aural and motor skill growth, development of leadership skills and personal character, improved opportunities for university/college scholarships, more career opportunities, heightened quality of life, greater exposure to world music, development of social skills, growth of expressive skills, improved of performance standards, increased cost-effectiveness of school districts, and greater recognition of students and their schools.

When assessing responses to possible negative outcomes of string programs, no items in either the negative program or student outcomes categories were rated higher that 2.76. The low rating was an indication that most music teachers did not feel a strong affirmation of negative benefits with string program outcomes. The highest negative outcomes ratings for programs were a lack of qualified string teachers available to teach the classes, instrument cost, lack of adequate facilities, and a lack of calendar space, all of which focus more on logistical issues than on instructional outcomes. Under negative student outcomes, only two items had a mean higher than 2.0. Those items were lack of trained teachers to work with students and student scheduling issues. Based on these findings, it appears that music teachers tend to agree that there are few negative student or curricular outcomes associated with string programs. This finding was additionally confirmed based on the results of a question that asked music teachers if they felt string programs were beneficial or detrimental to
music programs overall. Subjects could indicate that either string programs were beneficial or detrimental. Ninety-eight percent, or 301 of the music teachers, believed that string programs were beneficial to music programs, while only seven participants indicated that string programs were detrimental.

To investigate the second research question, “What are the underlying issues of music teachers’ perceptions about the positive and negative impacts of string programs?” two principal components analyses were computed. When assessing underlying issues contributing to positive benefits of string programs, almost 70% of the variance contributing to the solution was accounted for in the analysis. By far the largest contributor was student development benefits, accounting for almost 60% of the total variance. Items under this factor included student skill development in: leadership, motor skills, social skills, self-concept, self-esteem, and expression, and so forth. The two other factors that contributed approximately another 10% of the variance to the total solution were items that related to expanded experiences and logistical and support issues. These included items pertaining to expanded musical, repertoire, ensemble, and curricular offerings (Factor 2), and increased budget, community, parental, and administrative support, enrollment, and so forth (Factor 3).

When assessing underlying issues contributing to possible negative outcomes of string programs, again almost 70% of the variance contributing to the solution was accounted for in the analysis. The largest contributor in this analysis was program focus and support, accounting for over 52% of the total variance. Items under this factor included decreased student participation in other programs, motivation, and development of expressive performance skills, parental and community support, focus, and so forth. Three other factors, Logistical Issues, Pecuniary Issues, and Qualified Instructors contributed almost 17% of the variance to the solution and were items that related to scheduling, calendar, and performance facilities issues, as well as program costs, and lack of trained personal to provide string instruction.

The underlying perceived benefits and negative outcomes of string programs appear to be somewhat similar, however, it could be argued that the positive outcomes are slightly more instruction oriented, with a focus on student growth and development. Negative outcomes are focused on budgetary, funding and fundraising issues, as well as concerns of finding qualified string teachers.

Research questions three and four dealt with the relationships of fixed factors and the perceptions of the impact of string programs, and the comparison of underlying issues with one another. While correlations were found to be significant, they were low and deemed to have little practical significance. It can therefore be concluded that there are no meaningful relationships between fixed factors and the perceptions of the impact of string programs, nor the comparison of underlying issues with one another.
Summary

Although any generalizations should be avoided due to the low response rate and population of only two states, clearly, there appears to be strong support for string programs among music teachers. The benefits of string programs as promoted by various authors and organizations seem to be validated by the findings in this study. String programs, at least as perceived by music teachers, do offer expanded opportunities for student musical, social, and intrapersonal growth as well as enhanced interaction and programmatic development among all music/arts programs, potentially leading to increased community, parental, and administration support for music and arts programs.

Abril and Gault (2006, 2008) and Williams (2007) found that principals believed music programs were successful in enabling the realization of musical and educational learning goals and assisting in the development of student skill sets in such areas as composing, performance, and critical listening. Other researchers (Greenwood, 1991; Liddell, 1977; Payne, 1990; Punke, 1972; Rogers, 1985; Stroud, 1980) have found that administrators tend to support elementary general music programs, bands, and band competitions. While there seems to be general support for music programs among administrators, additional research is necessary to help clarify and determine the perceptions of principals regarding the value and benefits of string programs specifically. The perceptions of students and parents, as well as those of classroom teachers, could provide information leading to the development of effective strategies for the marketing and eventual creation of new string programs in school districts across the United States that do not now have programs. The value/benefit of string programs as assessed by music teachers is very strong and positive. It would seem important that should this perception prevail among all segments of the population, students, parents, administrators, and so forth, that a course of action be implemented to provide string instruction in all schools in America.

References


Effects of Stimulus Type, Distance, and Instrument on High School Students’ Open String Tuning

Abstract
High school string orchestra students (N = 139) were measured on their ability to tune their instruments’ open A-string in response to either a pure tone stimulus or a complex tone stimulus within a classroom setting. Proximity to the stimuli and possible differences between string instrument types were also tested. No significant difference was found between the two types of stimuli. Significant differences were found on the variable of distance, however, a significant interaction between distance and instrument type was also found. Graphic analysis showed that the poor tuning of cellists who were farthest away from the tuning source accounted for the differences found for the effect of distance. Implications for tuning string instruments and suggestions for classroom application, particularly for cello and double bass are discussed.

Keywords
string instruments, tuning, reference pitch, intonation, string music education

Although it is common practice for classroom string orchestra rehearsals to begin with the sounding of a reference pitch for the purposes of tuning the open strings, the reference pitch used may be broadcast by a variety of stimuli such as an electronic tuner, a tuning bar, a pitch pipe, a stringed instrument, or a piano (Lamb & Cook, 2002). These pitch reference stimuli may be divided into two categories: pure-tones and complex tones. Electronic tuners broadcast relatively pure tones which contain the fundamental frequency but few, if any, overtones. Complex tones are produced by acoustic instruments and consist of the fundamental pitch as well as the characteristic series of overtones for that instrument. Both pure tones and complex tones have been used as reference

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pitches for the task of tuning the open strings of school orchestras in classrooms across the United States (Garafalo, 1996).

A review of the extant research on tuning stringed instruments revealed that the effects of loudness, room acoustics, and instrumental timbre on pitch perception have been frequently researched in laboratory settings. However, there has been little research conducted in classroom settings that focus on string students’ abilities to tune the open strings of their instrument as a response to either a pure tone or complex tone stimulus. This would imply that string educators have made decisions regarding reference pitch stimuli for their classes based on information other than actual classroom research. A review of literature was conducted that addressed perception of tuning stimuli, performance of the tuning task on various instruments, and the effect of classroom acoustics on the tuning task.

Perception of Pure Tones and Complex Tones

Early quantitative research on the pitch discrimination of pure tones versus complex tones was conducted at the Bell Telephone Laboratories in the 1930s. It was discovered that pitch was perceived differently when heard at different loudness levels and that this effect was greater for pure tones than for complex tones (Fletcher, 1934; Shower & Biddulph, 1931). Stevens (1935) confirmed these results through independent replication of the earlier experiments. Further research found that the presence of overtones in the timbre of stringed instruments tempered the amount of pitch change so that the perception of violin and cello tones was not significantly affected by loudness level (Lewis & Cowan, 1936). Snow (1936) clarified the directional effect of loudness on pure tones: most observers perceived a lowering of pitch of the pure tone stimulus as loudness increased. Terhardt (1974) questioned whether the effect of loudness on pure tones was an artifact, caused perhaps by unsuitable methods and selection of participants. He found that, although the psychological and physiological implications of the pitch-intensity effect are rather vague, “... the phenomenon itself is obviously a fact” (Terhardt, 1974, p. 359). Zeitlin (1964) found that participants discriminated small pitch changes in complex tones more accurately than in pure tones; the middle range of frequencies (between 490Hz and 990Hz) was most efficient for discrimination. Henning and Grosberg (1968) further established that A-440 falls into the range in which participants were more successful at discriminating complex tones than pure tones. This information seems to indicate that the complex tone produced by a violin sounding the open A-string as a reference pitch would be perceived more accurately than the same pitch sounded by a pure tone stimulus.

A number of studies have examined the effect of maturity and musical training on students’ pitch perception abilities. Madsen, Edmonson, and Madsen (1969) studied auditory perception of participants ranging from second grade to
adult. They found that participants exhibited faster and more correct responses in relation to their age and years of musical training. Cooper (1994) found that the pitch discrimination ability of children improved with age but that differences on the direction task were less evident than for pitch difference detection. Parker (1983) found no significant differences between collegiate violinists, trombonists, and pianists on the ability to discriminate pitch. Similarly, Ely (1992) found no significant difference between collegiate woodwind music majors on their ability to perceive or discriminate pitch. However, participants performed best when matching their own instrumental timbres. He also concluded that findings were consistent with previous research studies showing that pitch judgments of complex tones are more accurate than those of pure tones.

**Individual Tuning Performance**

It was not until 1985 that researchers began to explore the relationship between pitch perception and the performance of the open string tuning task. Geringer and Witt (1985) asked high school and collegiate string instrumentalists to tune the A-string of their instrument to a recorded oboe performance of three stimuli: A4 = 440 Hz, twenty-five cents sharp relative to A-440, and fifteen cents flat relative to A-440. They were then asked whether they thought the stimulus was sharp, flat, or in tune. Both the task and the scoring process were administered on an individual basis in a music practice room. Participants performed below the sharp pitch and above both the flat and in tune stimuli. It was also noted that participants adjusted their tuning to the stimulus but often returned to their original pitch after the stimulus ceased. Geringer and Witt found only limited association between pitch judgments and tuning performance although those with more experience showed a higher correspondence.

Cassidy (1989) individually tested high school flute and clarinet students on their ability to tune a pitch on their instrument in response to one of three synthesized stimuli in three different octaves placements: sine wave (similar to flute), square wave (similar to clarinet), and sawtooth wave (similar to oboe). She observed that the majority of the students made little attempt to alter their pitch (similar to the conclusion of Geringer and Witt) and recommended that future studies use actual instruments as stimuli. Yarbrough, Karrick, and Morrison (1995) studied beginning and intermediate wind player’s knowledge of directional mistuning on their ability to tune their instrument. They concluded that sharp pre-tuning resulted in sharp responses, flat pre-tuning resulted in flat responses and that no prior knowledge of mistuning resulted in an equal number of sharp and flat responses. They also found that the more experienced students had a tendency to tune sharp. Similarly, in his study of tuning behaviors of first, second, third, and fourth-year band students, Morrison (2000) found that participants erred most often on the sharp side and that there was a strong tendency among more experienced players to tune sharp.
Hamann, Lauver, and Asher (2006) studied whether middle school string students’ perceived tuning ability was related to actual tuning ability and whether using either a bowed string instrument or an electronic tuner as a reference pitch would affect tuning accuracy. Each student was directed to a sound proof room where they were tested individually on their ability to tune their instrument using either a viola or an electronic tuner as a reference pitch. In contrast to the cited research showing differences in pitch perception between pure tones and complex tones, Hamann et al., found no significant difference between pitch stimuli on participants’ performance of the tuning task.

Classroom Tuning

Based on the conclusions of Hamann et al. (2006), who individually tested participants’ performance on the tuning task, it could be conjectured that the results would be similar if testing were conducted in a classroom setting. However, research on the effects of room acoustics on pure tones and complex tones suggests otherwise. While studying various stimuli for use in classroom musical aptitude and achievement testing, Sergeant (1973) found that pure tone signals had significantly greater variations of intensity, or loudness, than did complex tones in different areas of a classroom. Benade (1990) discussed the acoustical properties of rooms, the effect of furniture on room modes, and the response of rooms to pure tone stimulation. His findings on the variation of sound pressure levels in different locations of a room and the effect of furniture, and other features were similar to those of Sergeant. As applied to the current study, this meant that students’ seating placement within the classroom might affect their ability to accurately perceive pure tones and, consequently, their ability to tune their instrument. Using pure tones as stimuli in a classroom environment, Haack (1975) studied the effects of differing dynamic levels on pitch, loudness, rhythm, duration, timbre, and tonal memory in the perception and discrimination of collegiate undergraduates. He found that loudness levels did not affect perception of pitch. These results are inconsistent with those of Sergeant (1973), perhaps because Haack’s participants (four to eight at a time) were concentrated in a specific seating area, thus influenced equally by the distance from the stimuli. Hayslett (1990) studied the effect of classroom acoustics on tuning stimuli in a simulated band classroom utilizing nine collegiate band participants tuning to multiple stimuli. A significant difference was shown between the complex and electronic stimuli. Fogarty, Buttsworth, and Gearing (1996) studied the ability of collegiate musicians in a classroom setting to determine which of two stimuli was higher in pitch. They found no significant difference in intonation perception skills between players of different instrumental families but cautioned that performance on their specific instruments may produce different results.
Based on the previously cited research, it seems important also for teachers to consider pitch perception of pure tones versus complex tones and its relation to classroom acoustics when choosing tuning stimuli for the string orchestra classroom. The purpose of the current study was to investigate whether either type of stimulus was more effective in providing a tuning pitch in a high school string orchestra classroom and to clarify whether there are any effects of distance from the stimulus on the tuning process. Three lines of inquiry were applied to the open string tuning task in the high school orchestra classroom: 1) Is there a significant difference between groups performing the tuning task using a violin (complex tone) versus an electronic tuner (pure tone) as the reference pitch? 2) Does proximity to either stimulus have a significant effect on students’ performance of the open string tuning task? 3) Are there any significant differences in tuning ability between instrument types (violin, viola, cello, and bass)?

If either stimulus resulted in significantly more accurate tuning, it would have practical importance for high school string music educators. If there is an effect of distance from the stimulus on tuning accuracy, educators may wish to explore different placement of tuning stimuli or modify ensemble tuning procedures. Any significant differences by instrument type may have similar ramifications.

**Method**

The population of the current study consisted of high school orchestra students and the sample was derived from students in the orchestra programs at two matched, suburban, high schools in the southwestern United States. Both schools represented similar socio-economic status (upper middle class), had similar numbers of students on free or reduced-price lunch programs, and had comparable results on standardized tests. In addition, the two orchestra programs had comparable numbers of students selected for Region and All-State orchestras over the previous five years, had a similar number of solo and ensemble participants, and had a similar percentage of students in private instruction (approximately 70%). The number of students enrolled in both programs was comparable (n = 95 at School A and n = 105 at School B) for a total of 200 students. Consent forms were returned by 153 participants and their parents. Sample size was further reduced by fourteen participants through experimental mortality issues of self-removal from treatment or absence from school on the day of the posttest. The final sample size was 139 students.

Prior to the study, the annual audition procedure and materials were administered to all students of both orchestra programs to determine placement into one of three ability-level classes at each campus. These intact groups were utilized for treatment assignment purposes. Historically, both school programs used the complex tone stimulus most often; thus, the pure tone stimulus was
designated as the treatment. Possible differences between the two school orchestra programs were diffused by alternating treatments between similar ability groups and contrasting treatments in the two extreme ability groups on each campus. After an initial coin toss, which determined the stimulus for Group 1, the three ability groups at each campus were alternately assigned stimuli by ability level as illustrated in Table 1.

**Table 1**

<table>
<thead>
<tr>
<th>School</th>
<th>Group</th>
<th>Ability Group</th>
<th>Stimulus</th>
<th>Mean Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Highest</td>
<td>Pure Tone</td>
<td>90.9</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>Middle</td>
<td>Complex Tone</td>
<td>91.0</td>
</tr>
<tr>
<td>A</td>
<td>3</td>
<td>Lowest</td>
<td>Pure Tone</td>
<td>87.7</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>Highest</td>
<td>Complex Tone</td>
<td>90.9</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>Middle</td>
<td>Pure Tone</td>
<td>90.4</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>Lowest</td>
<td>Complex Tone</td>
<td>83.2</td>
</tr>
</tbody>
</table>

Prior to the first day of treatment, each group viewed a videotape on the importance of accurate tuning and how to manipulate the tuning mechanisms of stringed instruments. The school orchestra directors checked each instrument for properly working pegs and fine tuners in the two weeks preceding the treatment.

Each group was administered the treatment in the orchestra room at its own school to minimize novelty and disruption effects. The orchestra rooms at both schools were similar in size (45,000 cubic feet in School A, 43,000 cubic feet in School B). Both rooms had similar acoustical treatment (acoustical tile and carpeting), were rectangular in shape, and had 18’ ceilings. The two rooms appeared similar in reverberation time and ambient background noise. The participants were asked to sit within the standard placement of their section in the orchestra. Seating within these sections was mixed by individual playing ability (more advanced students shared a stand with less advanced students) during both the treatment and the posttest. This seating was visually confirmed by the school orchestra director prior to each day of treatment and prior to the posttest. To provide accurate data for possible effects of distance, the students were seated in concentric semi-circles at approximate distances of 6 feet, 10 feet, 14 feet, and 18 feet (see Figure 1) from the podium.
Figure 1. Orchestra Seating and Distance from Stimulus

The pure tone stimulus was provided by a McAdams Metronome/Tuner Model 10-A; the complex tone stimulus was provided by a violin open A-string. The assigned stimulus was sounded from the center of the conductor’s podium for 15 seconds while the participants listened. The students were then asked to tune the A-string of their instrument while the stimulus continued for 45 more seconds. The process was administered at the beginning of each instructional period.

During the treatment and post-test the loudness level of the stimulus (db = 75-80) was monitored for consistency using a Radio Shack Digital Sound Level Meter placed twelve inches from the stimulus. A second sound level meter was placed at the center of the back wall of the rehearsal room approximately four feet behind the last row of players in order to measure the overall dynamic level of the group (db = 70-75) and to monitor the group for a consistent dynamic level. Visual instructions by the monitor to play louder or softer were the only directions given to the students during the tuning process.

The treatment was applied over a two-week period. The length of treatment was considered appropriate because the participants were already familiar with the process of tuning their instrument. In essence, the treatment period served to sensitize the participants to the type of stimulus, the duration of the tuning period, the randomization of seating within sections, and the decibel levels prescribed.

The post-test was designed to determine each student’s ability to tune the A-string of their instrument to a given stimulus in relation to their proximity to that stimulus. Using a Peterson Audio/Visual Tuner Model 520, I prepared the
instruments in each group prior to testing by randomly tuning each A-string ¼ step sharp or flat (1/4 step = 50 cents). The same controls used in the treatment were replicated in the administration of the post-test (timings, decibel levels, placement of stimulus, distance from stimulus, placement of instrument sections, and randomization of seating within sections). At the end of each group’s tuning period, the students placed their instrument at their seat and left the room.

Before recording the A-strings of individual instruments, a 20-second sample of the stimulus was recorded for calibration of the equipment to be used for scoring. Each instrument’s A-string was then recorded while a decibel meter was monitored for consistent loudness level. As each instrument was recorded, the type of instrument (violin, viola, cello, or string bass), distance from the stimulus, grade level of student, and ability level group were entered into a separate ledger.

Five professional music educators instructed in the use of a Peterson Audio/Visual Tuner Model 520 evaluated post-test recordings. They were taught to observe and record any deviation (sharp or flat) from the A₄ = 440 Hz stimulus in cents (one hundredths of a semi-tone). The evaluators were instructed to evaluate only that portion of the sample that occurred during the middle of the bow stroke as a control for the pitch fluctuation that occurs as the bow changes direction at either the frog or the tip (Boutillion, 1991). The tuner was calibrated to match the stimulus pitch that had been recorded at the time of the post-test. The evaluators physically manipulated the strobe dial on the tuner in response to each participant’s recording. Each one-cent deviation from zero (in-tune) was scored as plus or minus one point (sharp or flat).

The research questions focused on the effect of the independent variables (stimulus, distance, and instrument type) on the dependent variable of tuning accuracy. Data produced by individuals in the two farthest distances (14 and 18 feet) were combined to increase cell size to an appropriate level. String bass students were excluded from calculations because they were few in number (n = 14) compared to the other instrument groups and were all seated at the farthest two distances. Removing the string bass students reduced the sample size from 139 to 125. Sufficient numbers of violins, violas, and cellos were seated throughout each of the distances from the stimulus to allow robust comparisons. Intonation accuracy was defined in terms of cents deviation (Geringer & Witt, 1985). Cent deviations from A₄ = 440 Hz (whether sharp or flat) were subtracted as an absolute value from a score of 100.

**Results**

An intra-class correlation coefficient (ICC) was used to measure the extent of absolute agreement or interchangeability of the judges. Single measure ICC was .91, indicating a relatively high level of inter-rater consistency on the 125 students taken one at a time. The average measure ICC was .98, indicating a high level of inter-evaluator consistency (equal to Cronbach’s alpha of .98).
Alpha levels were set at .05. A three-factor analysis of variance was conducted with stimulus, distance, and instrument type as between-subjects variables. No significant difference was found between the pure and complex stimuli, $F(1, 107) < 1, p > .50$, and there was not a significant difference between instrument groups, $F(2, 107) = 3.00, p > .05$. A significant difference was found between groups on the variable of distance, $F(2, 107) = 3.87, p < .03$. However, a significant interaction between distance and instrument type was found, $F(4, 107) = 7.67, p < .01$. An examination of the means of the distance and instrument variables revealed that cellos at the farthest distance tuned far less accurately than any other combination of instruments and distances (see Table 2). The magnitude of this interaction is illustrated in Figure 2. None of the other two or three way interactions were significant.

**Table 2**

*Mean Tuning Grade by Instrument and Distance*

<table>
<thead>
<tr>
<th>Distance</th>
<th>Violin</th>
<th>Viola</th>
<th>Cello</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 feet</td>
<td>93.5</td>
<td>94.6</td>
<td>94.0</td>
</tr>
<tr>
<td>10 feet</td>
<td>90.0</td>
<td>89.1</td>
<td>95.0</td>
</tr>
<tr>
<td>14 &amp; 18 feet</td>
<td>92.8</td>
<td>92.1</td>
<td>73.7</td>
</tr>
</tbody>
</table>
Mean tuning scores were calculated for each ability group at the two schools (see Table 1). Analysis of variance was used to discover any differences in scores by individual class and as combined into three ability groups. Although the lowest ability group at each school scored lower (had more cent deviation) than the middle and highest ability groups, no significant differences were found between the six individual classes, $F(5, 119) = 1.39, p = .23$, or between the three ability groups as a combination of both schools, $F(2, 122) = 2.46, p = .08$.

**Discussion**

High school string orchestra students were measured on their ability to tune their own instrument in response to a reference pitch when it was presented in a classroom setting as either a pure tone or a complex tone. A treatment / post-test design produced recorded performances which were evaluated for deviation (sharp or flat) from $A_4 = 440$ Hz stimulus in cents (one-hundredths of a semitone).
Examination of the individual cell means found in Table 2 (and Figure 2), it becomes apparent that the interaction of distance and instrument type \((p < .01)\) was responsible for the differences found in the main effect of distance. Cellists at the farthest distance comprised the single cell that markedly lowered the mean for distance. Considering that the players were seated randomly at each distance, it appears that either the stimulus was diffused enough at the farthest distance to make it difficult to tune the cello A-string (one octave lower than the stimulus and that of the violin and viola) or the presence of string basses (two octaves below the stimulus) in close proximity sufficiently confused the perception of the stimulus so that tuning accuracy of cellists at the farthest distance was impaired (See Figure 2).

Utilizing a typical orchestral seating arrangement resulted in almost all of the string bass participants being seated at the farthest two distance ranges (one string bass at 10 ft, six at 14 ft, and seven at 18 ft), which precluded them from meaningful calculations regarding distance or interactions. The interaction effect of distance and instrument type with the cello students suggests, however, that the normal orchestral placement of string basses (at the farthest distance from the tuning stimulus), combined with possible difficulties in tuning the string bass A-string \((A_2 = 110 \text{ Hz})\) to a stimulus sounding two octaves higher \((A_4 = 440 \text{ Hz})\), puts string bass students at a similar disadvantage for tuning purposes. This may account for string bass students scoring even lower than the cello students if it is included in calculations of mean tuning score by instrument type (cello = 86.3, string bass = 82.8).

Previous laboratory research on pitch perception indicated that complex tones are perceived more accurately than pure tones (Fletcher, 1934; Henning & Grosberg, 1968; Lewis & Cowan, 1936; Shower & Biddulph, 1931; Snow, 1936; Stevens, 1935; Terhardt, 1974; & Zeitlin, 1964). However, the results of the current study indicate that if there are differences in pitch perception in classroom settings, it apparently did not differentially affect tuning of these string players.

Earlier research in classrooms did find that acoustics found in those rooms made pure tones more difficult to perceive than complex tones (Benade, 1990; Hayslett, 1990; & Sergeant, 1973). To the extent that perception influences tuning of students, results of the current study do not support these earlier findings; rather, they are consistent with the orchestra classroom results of Haack (1975) and Hamann, et al. (2006). Participants did not tune significantly more accurately to either a stringed instrument or an electronic tuner as stimuli. The lack of difference between stimuli in the current study may possibly be attributed to the loudness levels used (not loud enough for pure tone pitch distortion to occur), length of treatment, or the ability of participants to manipulate the tuning devices on their instrument. It seems possible that students may have perceived small differences in pitch between the two types of stimuli, but that perception
was not directly correlated with their performance in the tuning task (Geringer & Witt, 1985). Further research is necessary to explore these possibilities.

Based on the parameters of this study, characteristics of the participants, and administration of the treatment and measurements, recommendations may be made to generalize these results to high school string orchestra students. Given the limitations mentioned above, it appears that both pure tones and complex tones are equally suited as tuning stimuli for high school string ensembles. The interaction of distance and instrument type on the cellists’ tuning accuracy (and the possibility of string basses confounding the cellists’ tuning) perhaps could be addressed by adopting some or all of the following practices in the string classroom: tune by sections or rows, have groups tune softly enough that all students can clearly hear the tuning tone, alter the placement of the stimulus to a location closer to those instruments tuning in different octaves, use a variable-octave tuner so that each instrument can be tuned to a stimulus in its own range, ask the principal player in each section to provide the reference pitch for their section, and teach cello and string bass students to perform primary and secondary harmonics so that they can produce the same tuning frequency as the A-440 stimulus.

The methodology used in the current study attempted to provide controls for various threats to validity in the midst of what is usually a less than perfect experimental atmosphere: the school classroom. Controls for decibel levels, distances from tuning tones, orchestral seating, room size, timings, and assignment of treatment to groups provide a replicable methodology for additional classroom research. Future researchers might place string basses at each distance to clarify the effect of proximity to the stimulus on string bass students as well as possible effects of string basses on tuning of other instruments. This methodology may be adopted in future research in order to: replicate the current study with a different population (middle school, urban school, etc.), compare additional stimuli such as piano or oboe, test the effect of participant interference with perception of the stimulus at increasing distances and by other instruments, assess the practice of teaching cello and string bass players the use of harmonics to tune to the reference pitch. This line of inquiry may also lead to investigation of group tuning procedures beyond the initial open-string tuning period.

References


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