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Editor
FORUM: FIRST ISSUE GUEST EDITORIALS
Donald L. Hamann

It is rare in one’s career to have had the opportunity to present a premiere issue of a major research journal, much less premiere issues of two noteworthy research journals. In 2000, I was most fortunate to have had the honor to introduce the first issue of the Journal of String Research as its founder and editor. I again find myself in the auspicious position of introducing the premiere issue of a most significant publication, the only juried research journal in the world dedicated solely to string research, the String Research Journal.

This first issue of the String Research Journal, published through the American String Teachers Association, was made possible through the vision of several individuals, some of whom include: ASTA President, Kirk Moss, Past ASTA Presidents Jeffrey Solow, Mary Wagner and Bob Gillespie, ASTA Executive Director, Donna Sizemore Hale, the ASTA Research Committee, comprised of Michael Allen, Gail Barnes, Lisa Maynard, Jennifer Mishra, Bret Smith, and David Sogin, along with ASTA Collegiate Chair Jane Palmquist, and all of the ASTA National Board Members. It is the work of these dedicated and visionary individuals, along with others, that helped transform and transition the Journal of String Research, published at the University of Arizona, into the major juried research publication of the American String Teachers Association, the String Research Journal.

These are exciting times for individuals interested in conducting and reading string research. ASTA’s bold and insightful foray into the world of string research now provides another strong and vital component of support for its membership and for string researchers and teachers around the world. To further the visibility of the String Research Journal and other ASTA publications, ASTA has formed a new partnership with Alfred Music Publishing to distribute ASTA publications.

Therefore, it is with great pride and appreciation that I introduce this, the premiere issue of the String Research Journal, and in so doing, I turn over the editorship mantle. It has been a pleasure and an honor to serve as editor and to be involved in the transition of the Journal of String Research and in the creation of the String Research Journal. I know you will enjoy and benefit from the wealth of information found in this and future issues of the String Research Journal.
We would like to dedicate this inaugural *String Research Journal* to the late Dr. Michael Allen, Editor. As this journal went to press, Michael passed away following a difficult battle with cancer. Michael contributed a great deal of time and energy to launch the SRJ, and this volume speaks to the love and respect he had for disciplined inquiry and scholarship in his chosen field, string music education. I would also like to thank John Geringer for stepping in, at Michael’s request, to put the finishing touches on this issue.

**In Memoriam:**

**Michael L. Allen**

Michael Allen, professor of music education at Florida State University (FSU), editor of ASTA’s *String Research Journal (SRJ)* and co-author of “Essential Elements for Strings,” died this past August at age 55. Allen earned a bachelor’s degree from The Cleveland Institute of Music, a master’s degree from Case Western Reserve University, and a Ph.D. in music education from The University of North Texas.

He was an active member of ASTA since joining the association in 1996 and was a regular attendee of the national conference. He was the recipient of ASTA’s citation for leadership and merit in 2001. Most recently, he served as editor for the *SRJ*, ASTA’s scholarly journal in addition to serving as editor-in-chief for *The Florida Music Director*. He was also named College Music Educator of the Year by the Florida Music Educators Association in 2008. He conducted honor orchestras throughout the United States. According to his many colleagues and students, he was able to inspire people to become better teachers, musicians, and human beings. Generations of teachers and students will be forever impacted by his lifelong work.

He is survived by his wife, Terice; children, Christopher and Matthew; mother Mae; and sister, Jean Harvey. Donations may be made to the “Dr. Michael L. Allen Summer Orchestra Camp Scholarship Fund” at 2305 Kilkenny Drive West, Tallahassee, FL 32309.
Abstract
This article presents a summary of our presentation that was invited by the Research Committee of ASTA and given at the 2009 ASTA National Conference in Atlanta. In this article we describe and discuss previous and current research studies concerning string vibrato performance and listeners’ perception of vibrato. Topics addressing performance aspects of vibrato include rates and widths, pitch center, initial direction, and continuity during slurs. Investigations that have used various approaches to determine the perceived pitch center of string vibrato are also summarized. We present suggestions for further investigation of vibrato in both the study of listener perception and performance practice and discuss pedagogical applications of research findings.

Keywords
vibrato, string instruments, pitch performance, pitch perception, string pedagogy

Introduction
First, we would like to thank the Research Committee of ASTA and in particular Professor Donald Hamann for the honor of being invited to speak with you today. We take pleasure in being asked to share what we have learned about research in this area. Second, as we present the results of research that others have done, and that we have done, please keep in mind the following. There are usually several predictable reactions to summaries of research, including the question: Why would you want to study that? Conceivably the topic is viewed as dull, arcane, or outrageously wasteful in time and money (or all of the above!) and represents the outlook popularized by Senator Proxmire in the 1970s and 80s, who became known for his “Golden Fleece” Awards. After the actual results

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are reported, other responses may be forthcoming: 1) Well of course, that’s just common sense, I’ve always known that, or anyone who has been a teacher knows that; or 2) No, that can’t be right, that’s not what my experience has been, or how can you even say that? All of these reactions are normal, understandable, and we’ve all had them. The point is that we want to engage you in some thought about an important aspect of string playing and teaching, and if we are able to get you to think about some things that might not have occurred to you previously, or to think about them even a little differently, then we will have succeeded.

A research-based approach to any subject matter stresses the importance of extended and long-term investigation as opposed to one-shot studies. What we report here is not so much a comprehensive review of literature (although we believe we included many of the most relevant studies), but an attempt to illustrate a continuing research effort intended to be applicable to some extent in both experimental and applied settings.

Among the most important aspects of string performance include the development of a beautiful tone, playing in-tune, and playing expressively. One essential facet of all three of those attributes is the vibrato. Since individual components of vibrato are neither easily perceived by the ear nor easily seen, it is difficult to know exactly how the composite sound and motions are produced. A description of the process may be troublesome to many who attempt to teach vibrato techniques, perhaps even for those who perform with a beautiful vibrato. Consequently, much of our work in trying to understand vibrato has been developing ways to visually and aurally observe what is happening during vibrato performance. This has included analysis of slow-motion video and audio excerpts of vibrato performances, analysis of vibrato waveforms, and spectral analysis of artistic performances. All of these analyses were illustrated during our presentation, unfortunately only some of these can be shown in this paper.

Vibrato has a relatively long history in the research literature regarding performance practice. Early research at the University of Iowa in the 1930s coordinated by Carl Seashore produced a number of vibrato studies that were accomplished with a phono-photograph apparatus using a stroboscopic technique for recording frequency. Seashore (1938) defined vibrato as a periodic pulsation of pitch, loudness, or timbre, singly or in combination; in quantitative terms of these factors, any particular vibrato may be discussed adequately. As an illustration of this, Figure 1 shows a college student performing a violin E4 begun with a straight tone that is then “warmed” to a vibrato. Shown are both frequency and amplitude (what we perceive as pitch and loudness) as they change over time. With audio analysis tools such as Praat (Boersma & Weenink, 2009), we are able to determine vibrato rates and widths, pitch levels, relative intensities, and a number of other performance elements.
Research on Vibrato Rates
Analysis of phonograph recordings of virtuoso string performers (Reger, 1932; Hollinshead, 1932) found rates ranging from 5.6 to 7 Hz (see Table 1), with Kreisler among those with the fastest rate. This research concluded that although the extent of the violin vibrato is smaller than for singing, the rates are similar. Cheslock (1931) and Small (1937) analyzed phonograph recordings of performances by Kreisler, Menuhin, Szigeti and others. Vibrato was present in almost all tones, and the mean rate was around 6.3 Hz. Results from the Iowa studies have been largely confirmed in later studies, for example, Fletcher and Sanders (1967) found vibrato rates about 6 Hz, only slightly slower than some of the early reports. Thibeault (1997) studied solo bassists and found rates ranging from 5 to 7 Hz and reported a correlation of vibrato rate with tempo of excerpts, but not with pitch register. More recently, however, Geringer and Allen (2004) studied vibrato characteristics of 40 high school and college violinists and cellists. We analyzed whole notes performed in first position, and we found somewhat slower rates of vibrato, 5.5 Hz. This finding led us to speculate that various musical factors appear to influence vibrato rates, including tempo and duration, dynamics, pitch register, style, and so on. Subsequently, MacLeod (2008, 2010) and Allen, Geringer, & MacLeod (2009) studied the possible effects of dynamics and pitch register on vibrato rates of university and high school violin and viola players, as well as contemporary artist.
performers. MacLeod (2008) found that pitch height affected the vibrato rate of college and high school violin and viola players, but dynamics did not. As the instrumentalists in her 2008 study performed in a higher register, the rate of the vibrato increased slightly (.32 Hz). Differences in vibrato were also found between violinists and violists. Viola players’ vibrato rates tended to be slower than rates of the violin players.

Table 1

<table>
<thead>
<tr>
<th>Researcher(s)</th>
<th>Year</th>
<th>Instrument</th>
<th>Rate (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheslock</td>
<td>1931</td>
<td>Violin</td>
<td>6.4, 6.5</td>
<td>Adult, Prof. Soloists</td>
</tr>
<tr>
<td>Hollinshead</td>
<td>1932</td>
<td>Violin</td>
<td>7.0</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Reger</td>
<td>1932</td>
<td>Violin</td>
<td>6.9</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Small</td>
<td>1937</td>
<td>Violin</td>
<td>6.3</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Seashore</td>
<td>1938</td>
<td>Violin</td>
<td>6.0</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Fletcher &amp; Sanders</td>
<td>1967</td>
<td>Violin</td>
<td>6.0</td>
<td>College Concertmaster</td>
</tr>
<tr>
<td>Thibeault</td>
<td>1997</td>
<td>Bass</td>
<td>5-7</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Mellody &amp; Wakefield</td>
<td>2000</td>
<td>Violin</td>
<td>5.9</td>
<td>Professional/Faculty</td>
</tr>
<tr>
<td>Geringer &amp; Allen</td>
<td>2004</td>
<td>Violin/Cello</td>
<td>5.5</td>
<td>High School/College</td>
</tr>
<tr>
<td>MacLeod</td>
<td>2008</td>
<td>Violin</td>
<td>5.7</td>
<td>High School/College</td>
</tr>
<tr>
<td>MacLeod</td>
<td>2008</td>
<td>Viola</td>
<td>5.4</td>
<td>High School/College</td>
</tr>
<tr>
<td>Allen, Geringer &amp; MacLeod</td>
<td>2009</td>
<td>Violin</td>
<td>5.5, 6.3</td>
<td>Artist/Faculty</td>
</tr>
<tr>
<td>MacLeod</td>
<td>2010</td>
<td>Violin</td>
<td>6.6</td>
<td>Professional Soloists</td>
</tr>
</tbody>
</table>

Specific Artists

Cheslock 1931 Violin
  Elman Violin 6.4
  Heifetz Violin 6.7
  Kreisler Violin 6.2

MacLeod 2010 Violin
  Bell Violin 6.2
  Perlman Violin 6.5
  Mutter Violin 6.7
  Midori Violin 7.1

Allen et al. (2009) completed a case study on an artist level violinist whose credits include positions as concertmaster of the New York Philharmonic and other major orchestras. The rate of the artist’s vibrato increased in fifth position
compared to first position. The mean vibrato was 5.7 Hz in first position and 6.3 Hz in fifth position. Increases in vibrato rate in the higher register averaged about .5 Hz compared to that of the university and high school students’ mean increases of .32 Hz (MacLeod, 2008).

MacLeod (2010) investigated the influence of pitch register and dynamic level on vibrato rate of four contemporary solo artists: Joshua Bell, Anne-Sophie Mutter, Itzhak Perlman, and Midori. Overall mean vibrato rate of the performers was 6.63 Hz. A moderate correlation ($r = .44$) was found between the dynamic level of a tone and the rate of vibrato for the four artists combined. However, further analysis revealed that the degree of association varied considerably between individual performers. There was no correlation between pitch register and rate for these artist level performers.

**Research on Vibrato Width**

Researchers at the University of Iowa in the 1930s also investigated vibrato width. Table 2 summarizes much of this early research as well as more recent work. Reger (1932), for example, showed that widths varied with the experience level of the performers. The students he studied had average vibrato widths of about 38 cents, widths of teachers were about 42 cents, and those of professional soloists were 48 cents, about one-quarter tone. The violin examples in the McGill University Master Samples database (Mellody & Wakefield, 2000) and the high school and college students of Geringer and Allen (2004) had somewhat narrower widths, about 30 cents. We noted that violinists’ mean vibrato widths were about 8 cents wider than those of cellists, and we found slight differences in experience levels. Again, findings suggested that musical contexts contributed greatly to the performers’ widths. Subsequent research by Allen et al. (2009), and MacLeod (2008, 2010), has contributed to further understanding of these contextual factors.
Table 2

**Vibrato Widths**

<table>
<thead>
<tr>
<th>Researcher(s)</th>
<th>Year</th>
<th>Instrument</th>
<th>Rate (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollinshead</td>
<td>1932</td>
<td>Violin</td>
<td>52</td>
<td>Professional</td>
</tr>
<tr>
<td>Reger</td>
<td>1932</td>
<td>Violin</td>
<td>48</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Reger</td>
<td>1932</td>
<td>Violin</td>
<td>38</td>
<td>Students</td>
</tr>
<tr>
<td>Reger</td>
<td>1932</td>
<td>Violin</td>
<td>42</td>
<td>Teachers</td>
</tr>
<tr>
<td>Small</td>
<td>1937</td>
<td>Violin</td>
<td>44</td>
<td>Professional Soloists</td>
</tr>
<tr>
<td>Mellody &amp; Wakefield</td>
<td>2000</td>
<td>Violin</td>
<td>30</td>
<td>Professional/Faculty</td>
</tr>
<tr>
<td>Geringer &amp; Allen</td>
<td>2004</td>
<td>Violin/Cello</td>
<td>30</td>
<td>High School/College</td>
</tr>
<tr>
<td>MacLeod</td>
<td>2008</td>
<td>Violin</td>
<td>46.5</td>
<td>High School/College</td>
</tr>
<tr>
<td>MacLeod</td>
<td>2008</td>
<td>Viola</td>
<td>37.5</td>
<td>High School/College</td>
</tr>
<tr>
<td>Allen, Geringer, &amp; MacLeod</td>
<td>2009</td>
<td>Violin</td>
<td>40-108</td>
<td>Artist/Faculty</td>
</tr>
<tr>
<td>MacLeod</td>
<td>2010</td>
<td>Violinists</td>
<td>63</td>
<td>Professional Solos</td>
</tr>
</tbody>
</table>

**Specific Artists**

| MacLeod                | 2010 | Violin     | 61 (28-100) |
| Bell                   |      | Violin     | 63 (26-129) |
| Perlman                |      | Violin     | 68 (24-90)  |
| Mutter                 |      | Violin     | 60 (40-88)  |

MacLeod (2008) found that vibrato width of high school and university violin and viola players was influenced by both pitch register and dynamic level. Performers vibrated 26 cents wider during high tones than during low tones in her study. Consistent with these findings, Allen et al. (2009) found that the former concertmaster of the New York Philharmonic had widths of 40 cents in first position and up to 108 cents in fifth position. Furthermore, MacLeod (2010) investigated the influence of pitch height on width and found that Bell, Mutter, and Midori tended to increase vibrato extents in the upper register. However, Perlman’s vibrato was not consistently wider in the upper range. Notes with a frequency above A5 (880 Hz) generally were performed with wider vibrato ($M = 67.9$ cents) than notes in the lower register ($M = 54.7$ cents). The minimum cent deviation produced by these artists during vibrato was 24 cents (about 1/8 tone) and the maximum was 129 cents, more than a semitone. Although a trend for larger widths in higher registers was found, it should be noted that dynamics, expression, tempo, “warming”, and other contextual factors produced much variability in performances of each artist. Further research is necessary to understand and define specific effects of such factors on vibrato widths.
Dynamic levels also influenced vibrato widths of high school, university, and artist level upper strings players (MacLeod, 2008, 2010). University and high school violinists and violists increased vibrato width approximately 4 cents in the forte passages compared to the piano passages. Furthermore, violinists demonstrated a tendency to vibrate wider than violists, and university performers varied their vibrato width to a greater extent between the piano and forte passages than did high school performers. Moderate positive correlations were found also for dynamic level and vibrato width ($r = .49$) in artist level performers. The degree to which vibrato width changed with dynamic level varied from performer to performer (Perlman, $r = .63$; Bell $r = .58$; Mutter $r = .38$; Midori $r = .63$).

These findings are mostly consistent with previous research by Reger (1932) where more experienced performers and soloists performed with a faster and wider vibrato than did the students. Based on the results of current research (Allen et al., 2009; Geringer & Allen, 2004; Geringer, et al., 2005; MacLeod, 2008, 2010), it is apparent that artist level performers vibrate both faster and wider than student performers. However, a qualification should be added: Most of the analyses of artist-level players were based on material within a music performance context, that is, passages had faster tempi, larger range in pitch registers, and wider dynamic ranges than material written for the younger performers. These factors in addition to experience all appear to influence performed vibrato rates and widths.

**Research on Vibrato Pitch Center Performance**

A number of early studies provided evidence for Seashore’s view (1938) that vibrato oscillations extend both above and below conceived pitch. He and his colleagues concluded that the mean pitch of the vibrato cycle corresponds to the conceived pitch (with the exception of leading tones). Table 3 shows that most research has corroborated this idea. Shackford (1960), for example, studied violinists of the Boston Symphony by comparing intonation of performed open A4, stopped (non-vibrated) A4, and vibrated A4. Measurement of oscillations of the vibrated tones showed that the extent of vibrato was equal both above and below pitches performed without vibrato.

We have found only 3 sets of research studies that indicate contrary findings. Fletcher, Blackham, and Geertsen (1965) observed vibrato performances of one student on each string instrument. They found that the lower extent of vibrated tones of violin, viola, cello, and bass students approximated the target pitch frequency and that vibrato fluctuated above that pitch. Close inspection of the graphs included in the article show that the initial (sharp) tuning of the instruments might have influenced this outcome. Papich and Rainbow (1974, 1975) measured vibrato of four performers of each string instrument and observed that the lower part of the vibrato modulations tended to coincide
primarily with pitches associated with either Pythagorean or equal tempered tuning. They noted that pitch errors in ensemble performance appeared to be sharp; this tendency can be seen in the figure shown in the 1974 article. A second investigation by Fletcher (Fletcher & Sanders, 1967) was a continuation of the Fletcher et al. (1965) work and found results directly contrary to the initial study. Most of the violin tones performed by the concertmaster of a university orchestra oscillated from the intended pitch (based on an equal tempered A-440 standard) and below; however as in the first study, description of the tuning procedure used prior to recording was not clear, which may help account for the differing outcomes.

Table 3
Pitch Center

<table>
<thead>
<tr>
<th>Center</th>
<th>Researcher</th>
<th>Year</th>
<th>Reference Point</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Above:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fletcher, Blackham, &amp; Geersten</td>
<td>1965</td>
<td>equal temperament</td>
</tr>
<tr>
<td></td>
<td>Papich &amp; Rainbow</td>
<td>1974,</td>
<td>equal/Pythagorean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1975</td>
<td></td>
</tr>
<tr>
<td><strong>Below:</strong></td>
<td>Fletcher &amp; Sanders</td>
<td>1967</td>
<td>equal temperament</td>
</tr>
<tr>
<td><strong>Around:</strong></td>
<td>(Above and Below):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>1937</td>
<td>equal temperament</td>
</tr>
<tr>
<td></td>
<td>Seashore</td>
<td>1938</td>
<td>summary of series of studies</td>
</tr>
<tr>
<td></td>
<td>Shackford</td>
<td>1960</td>
<td>reference tone and individuals’ pitch center</td>
</tr>
<tr>
<td></td>
<td>Brown &amp; Vaughn</td>
<td>1996</td>
<td>listener perception</td>
</tr>
<tr>
<td></td>
<td>Mellody &amp; Wakefield</td>
<td>2000</td>
<td>equal temperament</td>
</tr>
<tr>
<td></td>
<td>Geringer &amp; Allen</td>
<td>2004</td>
<td>individuals’ pitch center</td>
</tr>
<tr>
<td></td>
<td>Geringer, Allen, &amp; MacLeod</td>
<td>2005</td>
<td>individuals’ pitch center</td>
</tr>
<tr>
<td></td>
<td>Allen, Geringer, &amp; MacLeod</td>
<td>2009</td>
<td>artist’s pitch center</td>
</tr>
<tr>
<td></td>
<td>Geringer, MacLeod &amp; Allen</td>
<td>2010</td>
<td>perception: listeners matched vibrato tones with non-vibrato tones</td>
</tr>
</tbody>
</table>

Most recently, our research with high school and university students (Geringer & Allen, 2004; Geringer, et al., 2005) and an artist-level case study (Allen, et al., 2009) has shown consistent support for the finding that vibrato is an oscillation both above and below the performer’s conceived pitch. In the 2004 study, we determined each individual’s intended center of pitch with 40 high
school and college violin and cello students by asking them to play stopped tones without vibrato followed by the same tone with vibrato. Means were found to be virtually identical; performers vibrated both above and below the conceived pitch (as determined by their non-vibrated tones) rather than chiefly above or below the conceived pitch. There was little asymmetry in either direction of the oscillations from the mean. In the 2005 study we asked another set of 40 high school and college cello and violin performers to “warm” a series of notes, that is, to initiate tone without vibrato for the first two beats of a whole note and then to begin vibrating on beat 3 for the duration of the note. If players vibrated mostly upward or mostly downward from the pitch center, the means of vibrated notes would have been correspondingly higher or lower than means of non-vibrated notes. Again we found that mean pitch levels of these performers were not significantly different when using vibrato versus no vibrato on the same note. An extended analysis (Allen, et al., 2009) of an artist-level performer showed that vibrato was equally above and below intended pitch in first position. In the fifth position, this observation was also chiefly accurate, however, there was a very slight tendency for the vibrato center to be slightly sharper (about 5 cents) than the non-vibrated center.

**Research on Initial Direction of Vibrato Motion**

Although there is much pedagogical material regarding the initial motion used in vibrato, there is a little research. Small (1937) and Papich and Rainbow (1974) reported that initial vibrato motion of more advanced players was toward the bridge (a sharpening motion). We have found no systematic investigation of this issue other than our own (Allen et al., 2009; Geringer et al., 2005). As noted in the section above, we used “warming” exercises in the attempt to determine whether performers’ initial vibrato movements were consistently backward (in the direction of the scroll) or a forward motion toward the bridge. In the case study (2009), we used a slow motion video analysis to help address this question; in the study with 40 high school and college students (2005), we analyzed frequency graphs of individuals’ vibrato. In the 2005 study we found no consistent patterns regarding the direction of change when initiating vibrato from non-vibrato. These student performers began vibrato cycles with a forward motion about as frequently as they began with a backward motion. We found no differences as a result of experience level, between cellists and violinists, fingers, or any combination of factors. We did find it difficult in a number of cases to judge exactly when the performer initiated vibrato and therefore to determine the initial direction. There was often a lack of pitch stability prior to obvious vibrato cycles. Slow motion video analysis of the artist-level performer demonstrated that generally, the frequency initially became very slightly unstable and the first relatively large frequency change occurred generally in a downward direction (in the direction of the scroll). Video showed that the performer’s left
hand was repositioned in preparation for the vibrato motion; the first finger knuckle was moved a greater distance away from the side of the violin neck. As with the younger performers, it was difficult to pinpoint the exact time of vibrato initiation (see Figure 2). Perhaps our “warming” task may have created an artificial situation and thus contributed to some hesitancy on the part of the performers in beginning their vibrato.

![Figure 2](image.png)

Figure 2. An artist-level violinist playing F#4 with no vibrato warming to vibrato. Note the instable frequency in preparation for the vibrato motion. Mean frequency of both portions is approximately 370.5 Hz. Rate of vibrato is 5.7 Hz; width is 38 cents.

**Continuity of Vibrato**

Little research literature exists regarding vibrato continuity, although as with initial movement, a number of pedagogues have recommended various exercises and routines to develop a continuous vibrato. In our second study of high school and college cello and violin players (Geringer et al., 2005), we investigated the continuity of vibrato during the transition between slurred notes. All performers stopped vibrating during at least some portion of the transition. The mean duration of the non-vibrato portion of university students was 0.42 second, and 0.50 second (one-half second) for the high school students. Most players stopped vibrating about .20 to .25 of a second prior to the change to the new note, in preparation for the finger change. Then, as the new note began, there was another brief period of non-vibration (about 0.20 second), before the regular pattern of vibrato was apparent. The artist-level performer (Allen et al., 2009) also stopped vibrating, though for a shorter period, during the transition between slurred notes. The mean duration of non-vibrato portions was .33 second. It was clear in graphic displays of this performer’s performances that almost all of the non-vibrating portions occurred during preparation for the change to the subsequent note; the new note was begun with full vibrato virtually immediately. When
listening carefully to the artist’s slurs, we often were unable to hear the non-vibrating portions (even though we knew they were there!), as opposed to when we listened to the younger players the non-vibrating segments were usually perceptible. Additional research with various experience levels would help clarify whether the lengthier non-vibrato portion of less experienced performers results chiefly from a delay of vibrato initiation on the new note.

**Listeners’ Perception of Pitch Center during Vibrato**

A number of empirical studies have investigated the pitch that listeners perceive in frequency-modulated sounds such as vibrato. Because of the necessity of stimulus control in experimental studies of perception, most all previous research has used electronic or synthesized sound sources in place of acoustical instruments. Most of these studies show that perceived pitch corresponds closely to the mean of the frequency-modulated sound (Iwamiya, Kosugi, & Kitamura, 1983; Seashore, 1938; Shonle & Horan, 1980). Shonle and Horan found that perceived pitch of wider (whole-tone) modulations corresponded more closely to the geometric mean of the extreme frequencies, a frequency only slightly lower than the arithmetic mean. Brown’s (1991) musician listeners located pitch of vibrato slightly higher in frequency than did non-musicians.

We found only one earlier study that used an unaltered acoustic string instrument for stimulus presentations. Brown and Vaughn (1996) recorded a professional violist performing with and without vibrato. The 11 listeners included six amateur musicians, four graduate violin students and one professional violinist. Auditors heard paired comparisons wherein a vibrato tone was followed by a non-vibrato tone that was either higher or lower in frequency than the vibrato tone. Although sample size was limited, results were consistent with most of the above empirical studies: judged pitch of vibrato tones corresponded to the arithmetic mean of the vibrato.

Recently we investigated the location of perceived pitch in string vibrato tones among 72 music majors (Geringer, MacLeod, & Allen, 2010). We used recordings of acoustic instruments (cello and violin) to provide both vibrato stimulus tones and the non-vibrato tones that listeners adjusted. Vibrato tone stimuli were presented in one speaker, and the non-vibrato tones in the other speaker. Listeners turned a CRDI (Continuous Response Digital Interface) dial to raise or lower the frequency of the non-vibrating violin or cello tone until they were able to match the pitch that they heard in the vibrato tone. We were interested also in whether there were differences in perceived pitch of vibrato tones between string performers and non-string music majors and between cello and violin stimuli. We found that both groups of music major listeners perceived the pitch of vibrato tones very near the center of the vibrato for cello and violin tones, not the high or low points of the vibrato extents. Mean vibrato pitch perception of those with string performance experience was no different than
music majors without string experience; however, there was a difference between these groups in the spread of scores. String players exhibited significantly less variation in tuning judgments than non-string players. Our results concerning the pitch heard in vibrato were consistent with earlier studies using electronic stimuli (Iwamiya, Kosugi, & Kitamura, 1983; Shonle & Horan, 1980; Seashore, 1938), as well as acoustic material (Brown & Vaughn, 1996). These results provide additional evidence that listeners apparently perceive the pitch intended by the performer, that is, the mean of the performed vibrato extents.

**Summary and Discussion**

Descriptive research is designed to do just that, to describe what occurred in a particular set of circumstances. It cannot, nor is it intended to tell teachers or students the correct way to do something; for example, nothing in the reported research on rates and widths suggests that there is a “best” rate or “ideal” rate or width for all contexts. Results of research do provide information however, that might be utilized in teaching by providing possible alternatives for various situations and musical contexts. As an example, if we determine that a virtuoso performer such as Perlman or Midori vibrates at rates between 6.5 and 7 Hz, does that mean that we should teach our students to do the same? The decision itself has nothing to do with research. The decision can only be informed by research, for example, are those rates characteristic of orchestral performers or only world-class solo artists? Some might suggest that if one were to vibrate with rates that fast at an orchestral audition, the job would be given to someone with a rate similar to the other section players, perhaps between 5 and 6 Hz.

Pedagogues have generally suggested rates should be in the range from 5 to 7 Hz (e.g., Applebaum, 1986; Fischbach, 1998; Rolland, 2000). Some advocate that the performer should control rates to create variety or expression (Applebaum, 1986; Galamian, 1962), while others suggest that rate should be constant and only width should vary (Joelson, 1964). Empirical studies from the 1930s to the present have observed that rates usually fall within this same range of 5-7 Hz. We have noted that 1) rates tend to be slightly higher with increased levels of expertise; and 2) vibrato rates tend to be higher with increased pitch levels. Further research should be undertaken to broaden our understanding concerning effects of dynamics, tempo, styles, and other contextual variables (such as solo vs. ensemble performance) on rates.

Pedagogical discussion of widths seems to be in general agreement that vibrato should approximate a quarter-tone (50 cents) in width (Fischbach, 1998; Lucktenberg, 1994; Rolland, 2000). Fischbach differentiated between width of soloists (approaching a half-step) and widths of ensemble performers (about a quarter-tone). Doscheck (1968) reported typical widths as between 25 and 35 cents with extremes from 10 to 60 cents. The research literature has shown that in general, training and level of expertise influences width: Professional
artists use a wider average vibrato (50 – 60 cents) than do ensemble and student performers (20 – 45 cents). Pitch register (wider vibratos are generally used in higher positions) and dynamic levels (wider vibratos are found with increased dynamic levels) also influence width. There appears to be some differences between instruments; violinists tend to vibrate slightly wider than violists and cellists. Perhaps this may result somewhat from the differences in spatial relationships on the fingerboards of instruments as opposed to decisions relating to expressive variation. As with rates, effects of other music context variables remain to be systematically studied.

A number of pedagogues, Galamian (1962), Fischer (1997), and Young (1999) for example, suggest that students should aspire to develop an uninterrupted vibrato. Not one of our high school or university cello or violin students demonstrated the ability to vibrate continuously from one finger to another. This was the case also with the artist-level performer we studied, although it should be noted that in most instances the non-vibrated portions were not aurally perceptible and were shorter than for the less advanced performers. More research is recommended with professional string performers to help establish the actual parameters and possibilities of a model vibrato. Physical constraints inherent in the vibrating components of the instrument and/or in moving between notes may preclude an absolutely continuous vibrato. It may be that advanced performers are able to only reduce the amount of non-vibrato present in changes between fingers, rather than eliminate it altogether.

Perhaps the most contentious information concerns the pitch center of vibrato and related topics that include the initial motion and how vibrato is perceived. Fischbach (1998) observed “Some string pedagogues are convinced that the vibrato ornament occurs from the perceived pitch downward, some believe vibrato happens above the original pitch, while others are adamant that the perceived pitch is in the middle of the sine wave” (p. 29). It seems logical that there would be a relationship between the recommended direction of initial movement and pitch center if vibrato occurs primarily above or below the conceived pitch. Descriptions of a backward motion (toward the pegs) are most prevalent in the pedagogical literature (e.g., Applebaum, 1986; Galamian, 1962; Hamann & Gillespie, 2004), although others advocate for initial motion toward the bridge (e.g., Fischer, 1997, Rolland, 2000). Only a few pedagogues report that the pitch center is in the middle of the vibrato with oscillations occurring both above and below conceived pitch (Mantel, 1972; Rolland, Mutchler, & Hellebrandt, 2000; Young, 1999). Fischbach (1998) concluded that the pitch center likely varies from performer to performer and is not consistent.

Although two early studies reported that initial vibrato motion of more advanced players appeared to be toward the bridge, in our study of high school and college cellists and violinists we found no consistent pattern either forward or backward regarding initial motion. We noted the difficulty in determining
exactly the point of initiation; pitch instability was common immediately prior
to onset of vibrato. With the advanced artist we studied, the first relatively large
frequency change appeared generally in a backward direction (in the direction
of the scroll), even though vibrato extents were clearly both above and below
conceived pitch. Additional study should consider using other means of assessing
initial motion in addition to the “warming task” we used.

The predominant research finding regarding the performed pitch center
of vibrato is that it coincides with the intended pitch, that is, vibrato oscillates
both above and below pitch. This outcome has been found consistently since
the 1930s with only a few, arguable exceptions. Our analyses of 80 high school
and college students and several advanced cellists and violinists showed that the
mean of vibrato tones coincided with the mean of the same notes played without
vibrato (either successively or in a “warming” context). In all of those analyses,
we did find some examples of vibrato oscillations that were mostly from the
conceived pitch and below, and a few that were mostly above. However, we
found no examples that were only in one direction or the other.

One of the most critical aspects of vibrato performance concerns pitch
perception, that is, whether or not the note is perceived as being “in tune”. Most
all perception studies, using either electronic or acoustic sound sources, have
shown that listeners perceive the pitch of modulated tones at the center (mean)
frequency of modulation. In our recent study, 72 music majors were asked to
turn a dial that controlled the pitch of a non-vibrated cello or violin tone until it
matched the perceived pitch of a corresponding vibrated tone. Average tuning
responses for all tones were within 2 cents of the center of the vibrated tone.
There was no indication that any listeners perceived either the highest or lowest
part of the vibrato cycle. Suggestions of pedagogues that vibrato should oscillate
around the pitch center (e.g., Fischbach & Frost, 1997; Mantel, 1972; Young,
1999) seem to be consistent with what listeners perceive. Mantel, for example,
summarized that “Thus, the tone that the listener hears is exactly in the middle
between the extreme pitches of the vibrato” (p. 108).

Obviously string players have learned how to vibrate for many generations
without having access to research results, and will continue to do so. However,
it may be that asking questions, analyzing performances, studying principles of
physical motion and acoustics of string instruments, and so on could contribute
a great deal to our collective efforts. Perhaps we as teachers could become more
effective and students might achieve increased and/or earlier success.

We would like to add one further cautionary note. Experimental research,
however well controlled, should be viewed as only one mode of inquiry
with which to pursue improving our teaching and becoming more effective
pedagogues. It is inadvisable that any one study or one mode of inquiry be
accepted as the final arbiter of truth. Continuing cycles of analysis and synthesis
should provide support or refutation for relevant aspects of individual studies.
With these and all other due cautions, we hope that information gained from this and any other systematic line of research studies will find application by music teachers to provide successful and rewarding musical experiences.

References


An Investigation of New String Programs Established in American Schools Between 1999 and 2009

The purposes of this study were to identify string programs created between 1999 and 2009, compile a profile of those programs, and identify resources and strategies that were used to create them that may serve as a model for establishing future new programs. One hundred-fifty string programs were identified from 33 different states. A survey form to gather data about the programs was created and administered to 132 of the programs. Eighty-two completed the survey for a response rate of 62%. The survey asked questions about the history of the program, its current status, and projected future status. Data revealed that most programs began after one or less than one year of discussion, most often first suggested by local music teachers or superintendent. Those factors considered critical to successful establishment of the program included parent support, administrative support, competent string teaching, and funding. Respondents were willing to found additional programs. They suggested that a how-to manual and outside grant funding would help establish future new programs.

Keywords
new string programs, string development, curricular development, community support

Introduction
The most recent studies on the status and profile of string programs in schools began in 1989 and continued into the early 2000s. Four national studies and two state studies have been conducted to investigate the extent of string instruction in the schools. In 1989, a national survey to investigate the status of arts education in the schools was conducted by the National Arts Education Research Center (Leonard, 1991). Results indicated that only about 35% of elementary schools,

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41.9% of large middle schools (more than 500 students enrolled), and 36.9% of large secondary schools (more than 1,000 students enrolled) offered string instruction. Leonard also reported that school principals indicate a 43% enrollment increase in orchestras in large middle schools between 1987 and 1989 and a 41% increase in orchestras in large secondary schools between 1984 and 1989.

In 1997 Smith surveyed school districts throughout the country and found that only 16% offered string instruction. Among those districts 71% included string instruction in elementary schools, 79% in middle schools, and 80% in high schools. Smith later continued the investigation by reviewing low-socioeconomic school districts (2000), and found that 28% of those districts in the country decreased string instruction between 1994 and 1999.

Delzell and Doerksen and completed the most recent national study on the status of string instruction in American schools (2000). The results of instrumental music coordinators surveyed in the study revealed that 18% of school districts offered string instruction, similar to the findings of Smith in 1997.

The status of string instruction in individual states also has been surveyed. In a statewide survey of schools districts in Virginia, Abeel (1994) found that 24% of school districts offered string instruction. Sixty-seven percent of respondents reported an increase in student enrollment due to stronger program support, greater student recruitment work, and population growth. Moss (2000a) investigated 44 rural school districts in South Georgia. Results indicated only 11% offered string instruction, while 92% included band instruction in the school music curriculum.

Three studies examined the profile of school string programs nationally by surveying string teachers. Descriptive data were compiled on those teaching strings in the schools, their students, level of local support, enrollment trends, program organization, and hiring and staffing practices. Leonard (1991) conducted the first study that included an investigation of the profile of string programs. Gillespie and Hamann conducted the next study in 1998 and then Hamann, Gillespie, and Bergonzi undertook a follow up study in 2002. Results from these studies revealed that the majority of string teachers were female, white, primarily played a string instrument, and have master’s degrees. String students were predominantly white and suburban. String teachers perceived adequate to strong support from their administrators, music-teaching colleagues, and parents of students enrolled in the programs.

All three studies reported a continuous increase in the number of students playing string instruments at all levels of instruction: elementary, middle, and high school. Data indicated that the number of students involved in string programs in the schools steadily increased from 1989 through 2002. The majority of teachers considered their teaching facilities adequate even though most were teaching in multiple buildings and at more than one level of instruction. Teachers indicated that most programs were suburban, and a written
Unique to the study by Hamann et. al (2002), was the extensive investigation of hiring and staffing practices in school string programs. Data revealed an extreme shortage of available string teachers for hire. Twenty-four percent of programs in the 1999-2000 school year and 43% of those in the 2000-2001 school year had string teacher vacancies. However, qualified candidates were not found to fill the vacancies. The researchers estimated there would be a shortage of 5,000 string teachers by 2004.

Research has found valuable descriptive information about school string programs not previously known. However, investigations on the status of school orchestra programs disclosed that the number of string programs in the schools is alarmingly small. Data indicate that less than one out of every five children in the schools has access to string instruction (Smith, 1997; Delzell & Doerksen, 2000). An investigation of factors and strategies used successfully to establish new programs could serve as models for the establishment of future new programs. No such study has been conducted. In a review of literature on creating new string programs, Moss concluded: “While anecdotal information on how to “grow” or develop a string program is available via the testimonials of string teachers who lead recognized programs, how those same programs actually started has not been systematically researched (Moss, 2002b, p. 37). Further, research relating to actually starting a new string program, that is, what to do before there is a school board appointed string teacher, is skimpy and empirical in nature” (Moss, 2002b, p. 57).

The purposes of this study are to 1) identify string programs created between 1999 and 2009, 2) compile a profile of those programs, and 3) identify resources and strategies that were used to create them that may serve as a model for establishing future new programs.

**Method**

*Identifying New String Programs*

The American String Teachers Association (ASTA) is the professional association of string teachers. In the fall of 2008 the 2,500 members of ASTA who identify themselves as string teachers in the schools were contacted. They were requested to send to the researchers information about any new string programs of which they were aware of that had been created between 1999 and 2009. A similar request was sent to the 49 ASTA state-unit presidents and to the 83 ASTA members who identified themselves as university faculty members primarily responsible for training future school string teachers. One hundred-fifty new string programs were identified. Each program was then contacted to verify that it was created between 1999 and 2009. All 150 met the criteria. A list of contact people for each program was compiled. The people were informed that during the winter of 2009 they would receive a new-program survey to complete.
Creating the Survey Instrument

In the spring of 2008 the first draft of the survey instrument, Pilot Test 1, was written and administered to 10 teachers from eight states. All of the teachers had created new string programs within the last 10 years. Five questions were added to the survey based upon the recommendations of the teachers, e.g., questions about the professional background of the program founder, the current level of local support for the program from local church and/or civic organizations, those factors considered most critical for the future longevity of the program, and what sources of funding currently underwrite the program. In the fall of 2008 the revised survey instrument was administered to four more teachers as Pilot Test 2. All four teachers had founded new string programs within the last five years. Two more changes were made to the survey instrument as a result of Pilot Test 2. A question was added regarding the level of support local organizations offered for the program when it was first established. Another question was added to assess the current level of support of local organizations.

The revised survey following Pilot Test 2 served as the instrument to gather descriptive data and strategies used successfully to establish the 150 new string programs. The survey consisted of 47 questions and was divided into four sections: 1) program identity, 2) history of the program, 3) profile of the current program, and 4) future new string programs.

Administering the Survey

The survey was administered online using Basic Zoomerang software (http://zoomerang.com/). Surveys were sent to those currently teaching in the 150 new string programs identified in the study. Respondents were asked to complete and return the survey within three weeks. A reminder email and another copy of the survey were sent during the third week. At the beginning of the fourth week another copy of the survey was sent and a two-week extension was given to those who had not completed the survey. At the end of this period another copy of the survey was sent with a two-week extension to those who still had not completed the survey.

Results

Eighteen surveys could not be completed. Two potential respondents chose not to receive the survey. The electronic addresses of nine other potential respondents had changed and the researchers did not know their new addresses. This prevented the survey from being sent to them. Six surveys could not be delivered because the recipients’ electronic mailboxes were full or an out-of-office message was received each time the survey was sent to them. One survey was only partially completed and therefore eliminated from the study. As a result, there were 132 potential respondents for the study. Eighty-two completed the survey for a response rate of 62%.
Descriptive Data

Program identity. Four questions comprised the Program Identity section of the survey. Respondents identified 150 new string programs in 33 states that represented 75 different school districts.

History of the program. The survey contained 17 questions on the history of the new programs. The largest percentage (20%) of programs was created during the 2005-2006 school year. Almost two-thirds (65%) of the programs took one or fewer years to begin, following initial discussions. School superintendents (23%) and local school music teachers (25%) were most often cited as those who first had the idea to create a new string program. Responses to the question about level of support to start the program appear in Table 1. Respondents used a Likert-type scale of 1 (No Support) to 5 (Strong Support) to indicate their opinion. Most respondents indicated that the strongest level of support came from the school superintendent, building principal, and parents of those students initially enrolled in the program.

Table 1
Level of Support for Starting A New String Program

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percent of Respondents who Choose Strong Support for the Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent of children enrolled in the program</td>
<td>61%</td>
</tr>
<tr>
<td>Building principal(s)</td>
<td>55%</td>
</tr>
<tr>
<td>Local parents</td>
<td>48%</td>
</tr>
<tr>
<td>School music-teaching colleagues</td>
<td>47%</td>
</tr>
<tr>
<td>School board</td>
<td>40%</td>
</tr>
<tr>
<td>Local music businesses</td>
<td>34%</td>
</tr>
<tr>
<td>Local arts organizations</td>
<td>34%</td>
</tr>
<tr>
<td>Local private teachers</td>
<td>33%</td>
</tr>
<tr>
<td>Local media</td>
<td>21%</td>
</tr>
<tr>
<td>State music profession associations</td>
<td>20%</td>
</tr>
<tr>
<td>Other</td>
<td>20%</td>
</tr>
<tr>
<td>Local university faculty</td>
<td>19%</td>
</tr>
<tr>
<td>School counselors</td>
<td>18%</td>
</tr>
<tr>
<td>Local youth symphony program</td>
<td>17%</td>
</tr>
<tr>
<td>Local professional performers</td>
<td>17%</td>
</tr>
<tr>
<td>Local church/civic organization support</td>
<td>11%</td>
</tr>
<tr>
<td>Local non-music businesses</td>
<td>5%</td>
</tr>
</tbody>
</table>

Note: Survey participants used a 5-point scale to indicate the number that best represented the level of support when the new program was started.
More than three-fourths (77%) of respondents indicated that the new program started with just one full-time teacher while 23% initially employed only a part-time teacher. Three-fourths of the new programs enrolled fewer than 100 students in the beginning.

Seventy-four percent of those completing the survey founded the new program. Twenty-six percent of the respondents were not founders but were currently teaching in one of the new programs. They indicated their responses were based upon talking with the founder or those local teachers who first taught in the program. Eighty-two percent of those who founded the programs were credentialed string specialists (certified teachers whose principal performing instrument is a string instrument).

More than half (61%) of new programs offered string instruction only during the school day when first established. The remainder began as before or after school programs. During the first year many programs were considered moderately strong or very strong, and two-thirds were funded by regular school tax support.

Respondents used a 5-point Likert-type scale, ranging from 1 (Not Important) to 5 (Extremely Important) to indicate their opinion on factors that were important for creating the new program. The majority of respondents indicated that the following factors were extremely important in creating the new program: student recruitment, parent support, and availability of someone to teach in the program. Two-thirds found the superintendent and school board support, along with student interest to participate in the program, extremely important to the eventual success of the new program. Complete results to questions about the rank order of factors important to establishing the program are reported in Table 2.
### Table 2

*Factors Important for Creating the New Program*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percent of Respondents who Indicated the Factor was Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available faculty to teach</td>
<td>73%</td>
</tr>
<tr>
<td>Effectiveness of student recruitment</td>
<td>73%</td>
</tr>
<tr>
<td>Parent support</td>
<td>71%</td>
</tr>
<tr>
<td>Superintendent support</td>
<td>66%</td>
</tr>
<tr>
<td>School board support</td>
<td>65%</td>
</tr>
<tr>
<td>Level of student interest</td>
<td>63%</td>
</tr>
<tr>
<td>Building principals(s) support</td>
<td>56%</td>
</tr>
<tr>
<td>Money for instruments and music</td>
<td>48%</td>
</tr>
<tr>
<td>Support of music teaching colleague(s)</td>
<td>46%</td>
</tr>
<tr>
<td>Other</td>
<td>31%</td>
</tr>
<tr>
<td>Instructional space</td>
<td>29%</td>
</tr>
<tr>
<td>Support of school counselors</td>
<td>19%</td>
</tr>
<tr>
<td>Local music business support</td>
<td>15%</td>
</tr>
<tr>
<td>Local PTA or PTO support</td>
<td>15%</td>
</tr>
<tr>
<td>Support of non-music teaching colleague(s)</td>
<td>14%</td>
</tr>
<tr>
<td>Local music organization support</td>
<td>13%</td>
</tr>
<tr>
<td>Local youth symphony</td>
<td>12%</td>
</tr>
<tr>
<td>Local church/civic organization support</td>
<td>8%</td>
</tr>
</tbody>
</table>

*Note:* Survey participants used a 5-point scale to indicate the number that best represented the level of importance of each factor based upon their experience with the new program.

One question asked respondents to list three factors they considered most important that led to the establishment of the program. The most frequently cited factors in rank order of importance were: 1) competent teacher(s), 2) parent support, 3) available funding, and 4) superintendent support.

A corresponding question asked respondents to list the three greatest challenges in creating the program. The following is the rank order of frequency of responses: 1) fund raising, 2) available space for string classes, and 3) finding a string teacher for the program.

*Profile of the current program.* The most frequently (75%) cited source of funding for current programs was regular school tax support. Data on current enrollment in the program revealed that 27% enroll fewer than 100 students, 28% between 101-and 200 students, 12% enroll more than 600 students. The majority of instruction occurs in five or fewer schools throughout a school
district. Twenty-eight percent offer string instruction in six to ten schools within a district. The majority of programs now employ up to four teachers and most of those teaching are credentialed string specialists.

Sixty percent of school districts with new string programs are suburban, 24% rural, and 15% urban. Most students in the districts are Caucasian with more female (55%) than male (45%) students. Slightly over one-half (54%) of the districts offer instruction entirely during the school day. Twenty-three percent offer instruction using a combination of instruction during and outside of the school day. The remaining districts offer instruction only before or after school. Almost all (97%) respondents rate their program at least moderately strong, with 33% judging it very strong.

Most of the new programs have not yet evolved to the high school. The most frequently cited year of instruction is sixth grade, followed by the seventh grade, and then eighth grade. Respondents indicate that their programs are strongly supported. Nearly three-fourths (72%) report strong support from parents of children currently enrolled in new program. Over half (58%) indicate strong support from the school superintendent and school music-teaching colleagues (52%).

Two questions asked respondents to predict the status of their programs five years from now. Almost three-fourths (72%) believe strongly that their program still will exist. A change in school funding was the most frequently (57%) cited reason by respondents who predicted their program might be discontinued within the next five years.

*Future new string programs.* The last section of the survey asked questions about creating new programs in the future. Participants were asked, based upon their experience, to indicate how likely they would consider creating another new program in the future. Almost three-fourths (72%) indicated they would be open to creating another program. Respondents were asked what resources would be most helpful to those wanting to start a new string program in the schools. Two-thirds of participants reported that most helpful would be, in rank order of frequency: 1) grant money for start up that could help fund teachers’ salaries for the first two years of the program, fund program assessment, and fund music and instrument purchases, and 2) a manual to follow to help create the new program. Respondents suggested topics to include if a manual was available. The most frequently (72%) cited topic to include was methods for developing support for the program among administrators, teaching colleagues, parents, and the local community. Other topics frequently cited included a checklist of tasks to complete to successfully establish the program, strategies for effectively recruiting students into the program, information on how to obtain available teaching space, and suggestions on class scheduling.
Regression Analyses
In addition to the descriptive data gathered in the study, six multiple regression analyses were performed to determine if there were any relationships between the following variables: criterion variable “Beginning Program Strength” and predictor variables “Level of Program Support” and “Program Creation Factor Importance”; criterion variable “Current Program Strength” and predictor variables “Program Creation Factor Importance” and “Current Program Support”; and, criterion variable “Project Program Longevity” and predictor variables “Program Creation Factor Importance” and “Current Program Support.”

In order to delete predictor variables that were highly correlated with each other ($r > .35$), as well as determine variables that were useful for model selection ($r > .20$), correlation matrices were computed for each of the six analyses and such variables were identified. If variables were highly correlated with each other, only the variable having the highest correlation with the criterion variable was entered into stepwise regression procedures (Neter, Wasserman, & Kutner, 1985).

Since high predictability for regression model predictor variables as well as identification of useful descriptor variables were desired for the design, the probability level for individual predictor variable contributions for t values in the regression model was set at $p < .10$. Thus, predictor variables that did not individually contribute significantly ($p < .10$) to the prediction value of the model were eliminated from regression analyses (Neter et al., 1985).

In the first regression analysis “Beginning Program Strength” was used as the criterion variable and items under “Level of Program Support” comprised the predictor variables. Two of the predictor variables from those in the “Level of Program Support” were found to contribute significantly to the model. The factors “Local Private Teachers” and “Local Non-music Businesses” contributed slightly over 21% of the variance to the model ($R^2 = .213$). Thus the factors “Local Private Teachers” and “Local Non-music Businesses” were found to predict over 21% of the “Level of Program Support” in beginning string programs. This suggests that beginning string program developers should seek the support of local private teachers and non-music businesses when getting their string programs started.

In the second regression analysis “Beginning Program Strength” was used as the criterion variable and items under “Program Creation Factor Importance” comprised the predictor variables. Two of the predictor variables from those in the “Program Creation Factor Importance” were found to contribute significantly to the model. The factors “Superintendent Support” and “Support of Non-music Teaching Colleagues” contributed approximately 11% of the variance to the model ($R^2 = .107$). Thus superintendent support and the support of non-music teaching colleagues do contribute to the beginning program strength of strings, however these two factors account for only about 11% of the total variance solution.
In the third regression analysis “Current Program Strength” was used as the criterion variable and items under “Program Creation Factor Importance” comprised the predictor variables. Two of the predictor variables from those in the “Program Creation Factor Importance” were found to contribute significantly to the model. The factors “Local Music Business Support” and “Local Youth Symphony” contributed slightly over 22% of the variance to the model ($R^2 = .222$). Over one-fifth of the current program strength of recently developed string programs can be accounted for by the support of local music businesses and local youth symphony support.

In the fourth regression analysis “Current Program Strength” was used as the criterion variable and items under “Current Program Support” comprised the predictor variables. Seven of the predictor variables from those in the “Program Creation Factor Importance” were found to contribute over 56% of the variance to the model. These factors were “School Counselors,” “Building Principals,” “Local Private Teachers,” “Parent of Children Enrolled in the Program,” “Local Media,” “Local Church/Civic Organization Support,” and “Local Youth Symphony Program.” Over one-half of the current program strength of recently developed string programs was accounted for by a host of factors including internal support from school leaders/counselors, professional music teachers and programs, parents, and other community support groups. This suggests that newly formed string program strength is derived from a complex combination of internal and external factors that all contribute appreciably to the program.

In the fifth regression analysis “Project Program Longevity” was used as the criterion variable and items under “Program Creation Factor Importance” comprised the predictor variables. Three of the items from those under the heading “Program Creation Factor Importance” were found to contribute significantly to the model. The factors “Available Faculty to Teach,” “Superintendent Support,” and “Local Music Organization Support” contributed slightly over 27% of the variance to the model ($R^2 = .271$). These three factors were identified as items contributing over 27% of the variance to string program longevity. It therefore is important that local music organizations support developing string programs, that there is support from the superintendent(s) of the district and that there are faculty available to provide string instruction if a string program is to develop some permanence in the district.

In the sixth regression analysis “Project Program Longevity” was used as the criterion variable and items under “Current Program Support” comprised the predictor variables. Three factors were found to contribute significantly to the string program longevity. The factors “School Superintendent,” “Local Music Businesses,” and “Local Youth Symphony Program” contributed over 48% of the variance to the model ($R^2 = .482$). Once again the support of the school superintendent was found to be a significant contributor to program longevity, along with support from local music businesses and the youth symphony program in the district.
Discussion

Research on the status of instrumental programs in the schools has shown that only 16-18% of school districts offer string instruction (Smith 1997; Delzell & Doerksen, 2000). Therefore, less than one out of every five students in the schools have access to string study. The purpose of this investigation was to 1) identify new string programs that have been established in the schools since 1999, 2) determine the profile of those programs, and 3) identify resources and strategies that were critical to founding them that may serve as models for the establishment of future new programs.

One hundred and fifty new string programs were identified. We were surprised to find such a large number considering the continuing economic funding challenges facing many school districts across the country. Furthermore, those identified were from 33 different states. There are probably more in other states. Data revealed that even in the midst of economic difficulties some school districts find a way to create new string programs. This is indeed encouraging news.

Also encouraging is that present data indicated that programs are established relatively quickly. Sixty-five percent of those established were done so successfully after one or less than one year following initial discussion about creating a new program. In addition, most programs began with only one teacher so that an entire string staff does not need to be hired to found the program. Data showed that often one teacher taught full-time in the program initially, but others employed a part-time teacher.

Data revealed that different scheduling models are used successfully to create new programs. Sixty-one percent of the programs identified in the study offered instruction entirely during the school day, while others meet only before or after the school day, or a combination of during the school day and outside of the regular school day. School districts can determine which scheduling model works best for their local community when establishing a new program.

Securing strong support from the superintendent, building principals, and parents of students initially enrolled in the program was found to be critical for starting a new program successfully according to the data. Therefore, it is important that discussions about beginning a new program include strategies for developing strong support from the local superintendent, building principals, and those parents of students initially enrolled. They in effect become first-line advocates for programs.

Along with superintendent support, regression analyses suggested that beginning string program developers seek the support of local private teachers, non-music businesses, and non-music teaching colleagues when getting string programs started. Suggesting that newly formed string program strength is derived from a complex combination of internal and external factors that all contribute significantly to the program, regression analysis revealed that local music businesses, local youth symphonies, school leaders/counselors,
professional music teachers and programs, parents, and other community support groups, all contributed to program strength. Further, it was found that local music organizations and businesses, youth symphonies, and superintendent support all contributed to program longevity. Additionally, analysis showed that string program permanence was strongly related to the availability of string faculty.

Data indicated that the availability of a teacher for the program and adequate teaching space were integral to success of a new program. String teacher availability has long been a problem for schools desiring to hire someone to teach strings and this shortage has now reached the crisis stage. (Hamann et al., 2002) As a result, one of the first tasks for creating a new string program is finding someone to hire to start teaching the students who will first enroll in the program. Data from the current study revealed that four out of every five teachers (82%) in the programs are credentialed string specialists. School districts will need to go beyond local resources to hire a string teacher. National professional organizations may have to be used to help find qualified applicants. The American String Teachers Association and the Music Educators National Conference provide job listing services that advertise school string teaching openings.

Available funding to support the program also was identified as critical to the success of a new program. Most of the new string programs identified in the current study are funded by local school tax support. This type of funding increases the possibility that financing the new program can be sustained. If tax-supported funding is not possible, those surveyed in the study suggested that grant money be secured to help provide for program start up costs, such as purchases of instruments, music stands, print music, and salaries for those teaching in the program. Possible sources of grant money available locally and nationally could be explored. The U.S. Office of Education and the National Association of Music Merchants (NAMM) are two national granting sources that may contribute to initial program funding. Perhaps national music associations such as the American String Teachers Association and the MENC: National Association for Music Education, along with their state affiliate organizations, could offer funding to help establish new programs. However, respondents indicated that grant money to establish the program should be considered short-term funding only. Eventually long-term funding needs to be provided through regular school tax support to maintain the program.

Respondents also indicated that a manual that guides the process of establishing a new program would be helpful. The manual could include checklists of tasks that need to be completed and suggest strategies for finding program funding and teaching space. Other possible topics, based upon the data of successful practices gathered in the present study, could involve methods for developing firm support from school district administrators, local music and non-music businesses, arts and civic associations, and music teachers. Also important would be strategies for successfully recruiting students into the program and
ways to encourage their parents to advocate for the program. Two manuals are currently available: *Getting It Right From the Start* from the American String Teachers Association (Goodwich & Wagner, 2001) and *Establishing A String and Orchestra Program* from the Music Educators National Conference (Dillon-Krass & Straub, 1991). These sources could be updated based upon the data found and topics suggested by the respondents in the present study.

Future research is needed. Five new school programs that had been established are now discontinued. Investigations on reasons why the programs were not sustained could help future founders of programs possibly avoid similar circumstances. Also, studies could be undertaken to determine strategies especially useful for establishing new programs in urban and rural settings since those identified in the current study were so few.

**References**


A Study of Self-Regulated Learning in College String Majors

Abstract
Recent research in music education has found that college or conservatory students demonstrate similar self-regulated learning behaviors to those of professional musicians. Yet, how a musician becomes an expert is still unknown. The purpose of my study was to investigate how college string majors demonstrate efficient self-regulated practice behaviors, how they use self-regulated learning behaviors in their practice sessions to become independent learners, and how the semi-structured practice diary can be an effective tool for enhancing self-regulated learning in instrumental practice. I conducted a collective case study on four college-level students: a freshman, sophomore, senior, and a recent college graduate. They were asked to keep a semi-structured diary based on an instrumental model of the self-regulated learning cycle. Through interviews, I also obtained information about their musical backgrounds and their attitudes toward practicing. Results substantiated previous research showing that college music students demonstrate a wide range of self-regulatory skills. Furthermore, results indicate that there are some plausible transition stages in becoming a skillful self-regulated learner.

Keywords
self-regulated learning, instrumental practice, college string majors, collective case study, practice diary

Introduction
Research in how musicians acquire and refine their performance skills has found that extensive training is a prerequisite to becoming an expert (Ericsson, Krampe & Tesch-Romer, 1993). This research found that international-level violinists have accumulated over 10,500 hours of “deliberate practice” by the age of 20. Other studies (Ericsson, Krampe, & Tesch-Romer, 1993; Sloboda, Davidson, Howe, & Moore, 1996; Hayes, 1981; Weisberg, 1999) confirmed that

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it takes more than 10 years of vast amounts of practicing to “master” a skill. However, just sheer repetitive practice is not sufficient to reach high levels of competence. The content and quality of practice are critical to understanding what helps produce the ability to excel in musical performance (Williamon & Valentine, 2000). Moreover, the quality of performance is directly related to the quantity of “deliberate practice”—a highly structured activity that provides optimal opportunities for learning and skill acquisition (Krampe & Ericsson, 1995; Ericsson & Charness, 1994). Ericsson and colleagues (Ericsson, et al., 1993; Ericsson & Charness, 1994; Ericsson & Lehmann, 1996) have discussed and studied the nature of expertise, providing some understanding of the structure and limits of human adaptation and optimal learning. Yet there is little understanding about how one becomes an expert or what students specifically learn as they practice.

Current educational research has focused on the processes that students adopt or acquire as they mature into independent learners. Self-regulated learning recently has become a focus in the study of cognitive development. Self-regulated learning is evident when students become “metacognitively, motivationally, and behaviorally active in their own learning process” (Zimmerman, 1986, p. 308). This is a paradigm from which one studies how learners acquire the skills necessary to take command of their own learning and hence make their learning experience more effective (Bandura, 1991). Learning requires a great deal of self-regulation, particularly when it comes to developing a motor skill, such as mastering a musical instrument. Some even speculate that learning to play an instrument may require more self-regulation than learning in some other domains (McPherson & Zimmerman, 2002).

Self-regulated learning is viewed as an open-ended process requiring cyclical activity that occurs in three major phases: forethought, performance/volitional control, and self-reflection (Zimmerman, 1998). Forethought is the influential thought processes and personal beliefs that precede efforts to learn. Performance/volitional control refers to the processes that affect one’s concentration and performance as one learns. The third self-regulatory phase, self-reflection, consists of the student’s reaction and response after learning has occurred. These self-reflections then influence forethought, which completes the self-regulatory cycle.

Self-regulated learning in instrumental practice has been observed in various situations, and different social contexts, with a wide range of age groups. Most of the research on practicing, especially work pertaining to self-regulated learning behaviors, has focused on children, adolescents, and professional musicians, but students in higher education have been mostly overlooked (Jorgensen, 2002). According to Jorgensen (2002), “students in higher music education ought to be experts both in their instrumental performance and their practicing behavior” (p.106).
Research investigating how college or conservatory students practice or learn through self-regulation has found that they exhibit similar behaviors to those of professional musicians. These students exhibited extensive self-regulatory skills that enabled them to optimize their learning and performances, set specific goals, engage in strategic planning, use self-instruction, and self-monitor at a detailed level (Nielsen, 2001). Other research has found that, generally, higher music education students apply cognitive, metacognitive, and resource management strategies during practice (Nielsen, 2004).

McCormick & McPherson (2003) found that, although practice plays a vital part in the development of a musician’s ability to perform well, self-efficacy was the best indicator of actual performance. Other findings indicated that music students with high self-efficacy were more likely to be cognitively and metacognitively engaged during their practice sessions compared with students with low self-efficacy (Nielsen, 2004). In terms of performance, self-efficacy moderated the relation between performance-avoidance goals and self-regulatory strategies for students in a competitive, performance-oriented context (Braten, Samuelstuen, & Stromso, 2004).

Although all these findings help in understanding the nature of how college music students practice, there is still some ambiguity about students’ tasks, goals, and strategies as they practice. Gruson (1988) noted the changes in practice patterns with increased experience; therefore, it would be necessary to consider different strategies and methods for a freshman versus a senior in college. With these considerations in mind, a teachable curriculum of strategic practice could be developed (Barry, 1992). Hence, the following research questions were investigated:

1. How do college music majors demonstrate efficient self-regulated practice behaviors? That is, how do they plan, strategize, set goals, self-reflect, problem-solve, monitor, and evaluate?
2. What are some cognitive characteristics of the transition learning stages among college music students?
3. How is the practice diary an effective tool for enhancing self-regulated learning in instrumental practice?

Methodology

Instrumentation

To ascertain how college music students self-regulate their practice behaviors and determine their cognitive characteristics in different transition stages, I conducted a collective case study for this research. According to Creswell (1998), a “case study is an exploration of a ‘bounded system’ or a case (or multiple cases) over time through detailed, in-depth data collection involving multiple sources of information rich in context” (p. 61). A “bounded system” refers to an event, activity, or individual. There are multiple sources of
information for a case study (or multi-case study), which generally include interviews, observations, audio-video material, documents, and reports. Research has revealed that in order to become an expert in any field, one must develop techniques and strategies for effective practice. In the past, studies have investigated such behaviors through observations, interviews, questionnaires, and self-reporting of students’ problem-solving strategies and goals. Although all of these methods describe how practicing occurs, these methods are limited because of the range of observation is usually restricted to only a few instances. In order to examine how students learn on a daily basis, I adopted the idea of using a standardized diary (Schmitz & Wiese, 2006).

Schmitz & Wiese (2006) investigated the process of self-regulated learning in a sample of 40 civil engineering students, 21 of whom maintained standardized diaries over a period of five weeks. The major aim of their study was to advocate the use of standardized diaries in combination with a time-series analysis (a method to identify the nature of the phenomenon represented by the sequence of observations to forecast its variables) to investigate daily self-regulated learning and for the evaluations of a training program. They advocated the use of diaries because: 1) they allow for the observation of learning over time, 2) learning can be investigated with ecological validity as the learners use their diaries in their natural learning environment, and 3) as the diarists record learning over time and in their natural environment, it is possible to analyze the effects of situational factors on learning (e.g., daily stress).

The standardized diaries were constructed utilizing Zimmerman’s (2000) model of self-regulation, which was based on the social-cognitive perspective formulated by Bandura (1986). Three principles from this model were applied: 1) the diaries should depict the whole self-regulation cycle, 2) the diaries should support self-regulated learning, and 3) the diaries should capture training program effects.

The diaries promoted self-regulation because the students had to repeatedly answer questions in them. Maintaining a diary can be conceptualized as a kind of self-monitoring of one’s learning behavior. Webber, Scheuermann, McCall, & Coleman’s (1993) meta-analysis found that self-monitoring can significantly improve student’s learning behavior. This is because as students become aware of their behavior, the probability of behavioral change increases. More importantly, since the diary asked for all the components of the self-regulation cycle, this helped students focus their attention on the relationships between the different components, especially between implementing specific strategies and attaining goals.

The purpose of this study was also methodological: that is, to demonstrate the usefulness of diaries combined with a time-series analysis in applied research. By taking into account the contextual conditions and the process of everyday learning, the diary method was found to be well suited to examine
everyday learning in an ecologically valid way. Since the diary method was found to be an ecologically valid method to observe and enhance self-regulated learning in academic domains, this method may also help ascertain college music students’ self-regulated learning behaviors. It may also aid in surveying whether there are any transition stages during the college years.

I designed a semi-structured practice diary protocol that is based on Hallam’s (1997) instrumental practice model of the self-regulated learning cycle. Implementing this practice diary to examine how students learn on a daily basis would give us a better understanding of the characteristics of what is considered “deliberate practice.” This instrumentation may also possibly facilitate finding a pattern of transition stages of self-regulated learning behaviors during practice. Given that the diary method has not been used in examining self-regulated instrumental practice, I also conducted two interviews—a preliminary interview and an exit interview—to gain a more in-depth analysis of practicing behaviors of college music students. The questions for the interviews were based on Hallam’s (1995, 2001) study on practice methods of professional musicians and her study on the development of metacognition and performance planning strategies in musicians from the novice level to the professional level.

Participants and Analysis of Data
The participants of this study were recruited from a well-known summer music school for violinists, violists, and cellists in upstate New York. It was established in 1954 primarily to give students a place to practice without any distractions. The students are expected to practice at least five hours a day, with the option to practice on Sundays.

From a group of 14 students that participated in this study, four students—a freshman, sophomore, senior, and recent college graduate—were selected to be a part of the collective case study because they were the most descriptive and most consistent in the way they utilized the semi-structured diary (Kim, 2008). Two weeks’ worth of diary entries were analyzed by using different analytical techniques.

This collective case study was designed to represent a logical pattern of events and to test the construct validity, the internal validity, and the reliability of the data I gathered. To verify the construct of the case studies, I used multiple sources of evidence in chronological order: a preliminary interview, two weeks of journal entries, and an exit interview. In addition, each participant was asked to review the draft of the case study report to validate the data. To test the internal validity of this study, I implemented the following analytic techniques: triangulation, pattern matching, explanation building, a time-series analysis, and a logic model.

Triangulation is a process of gaining assurance that each important finding has at least three or more confirmations for the accuracy and interpretation of
the information (Stake, 2006). After data were collected, I compiled each week of journal entries separately and analyzed the patterns for each question of the diary. I then compared the pattern of practice behavior that was observed during the first week and second week practice sessions with the results of the interviews to confirm my interpretation of the results for accuracy.

A compilation of chronological events can be considered a special form of time-series analysis, particularly in a case study. The chronological sequence allows the investigator to trace events over time, that is, to investigate presumed causal events. Moreover, the chronology covers different types of variables and is not limited to a single independent or dependent variable (Yin, 2003). The semi-structured practice diary was designed to observe learning as a cumulative process. Therefore, the instrumentations of the preliminary interview, two weeks of journal entries, and the exit interview allowed me to investigate the causal events of self-regulated learning in instrumental practice. The chronological order of the instrumentations also allowed me to implement the logic model. This is used as an analytic technique to match empirically observed events to theoretically predicted events. Even though this analytical technique is analogous to pattern matching, it is differentiated by the sequential stages of events. The events form repeated cause-and-effect patterns, whereby a dependent variable—an event at an earlier stage—becomes an independent variable—a causal event for the next stage (Yin, 2003).

A pattern matching logic compares an empirically based pattern with a predicted one. If the patterns correspond, the results may reinforce the internal validity of the case study (Yin, 2003). Once the emergent themes were identified, I compared the findings of my study with previous research. Then, I implemented the explanation building technique, which is a special type of pattern matching. Each case study was analyzed by explaining a phenomenon that has already been stipulated with a presumed set of causal links. Since descriptive case studies are narrative and since narratives cannot be very accurate, the more effective case studies are the ones in which the explanations have reflected some significant theoretical propositions (Yin, 2003). I used this analytic technique in the cross-case analysis of the case studies.

Results

Freshman

The freshman is from the Pacific Northwest. She is 18 years old and has studied the violin for about 10 years. She is a violin performance major in a music conservatory in the Northeast. In the freshman’s opinion, her practicing skills are about average compared with those of her peers, and she enjoys practicing, especially when it comes to problem solving and working on the mechanics of playing the violin. However, sometimes she realizes that she doesn’t practice well after her sessions. She stated:
If I am extremely tired and I can’t focus, then I don’t enjoy practicing, but other than that, actually, I quite like the problem solving kind of aspect. And also after working on a piece until I can play it is very rewarding having put in the time. I quite like etudes. Lots of people don’t ‘cause it’s tedious, but I really like thinking about the mechanics of what I am doing with my bow. … Sometimes I practice well and sometimes after an hour I will think back and think about what I just did and decide it was not good at all. It’s kind of … I’m aware afterwards if I haven’t practiced well.

Based on the diary entries, the freshman is a conscientious self-regulated learner, who is intrinsically motivated to practice even when faced with certain daily obstacles, such as losing focus and getting frustrated with her technique. Her positive self-efficacy beliefs were evident in how she set proximal goals for herself and chose task-oriented practice strategies. That said, her self-efficacy was also dependent on whether she could concentrate well or managed her time well. According to Hallam’s (1995) study of professional musicians’ learning styles, the freshman would be considered a serialist learner because she focused on specific elements of the task and examined immediate logical connections in her approach to practicing. Although she was generally intrinsically motivated to practice and learn music because of her love for music and the violin, at times she was extrinsically motivated to have a good lesson. Gellrich et al. (1986) found three levels of motivation in musicians, and the freshman experienced all of them in the following order: a general achievement motivation, a specifically music-focused achievement motivation, and a sensual-aesthetic motivation.

Although the freshman did not create a mental or aural image of what she was about to play, she used other cognitive and metacognitive strategies to help her practice more effectively. She instructed herself to solve technical problems, think out loud, specify what she needed to work on, and monitor her playing. The main obstacles that she struggled with during the two-week period of writing in the diary were keeping focused, being frustrated with her technique, planning poorly, and balancing technical work with musical work. However, over the course of the study, she was able to manage these problems. The semi-practice diary was a helpful tool; it assisted her in becoming more metacognitive about learning and achieving her goals. The diary provided structure to plan out her practice sessions in detail, helping her to concentrate better. Moreover, the diary provided a framework of the self-regulated learning cycle that enabled her to gain more control over her learning. She commented:

The practice diary forced me to plan out my practicing more thoroughly, and think about how I was going to practice ahead of time. Normally, I would just think about practice when it was time to practice. I think that that helped me to organize my time better. Also, the reflection section was useful because it really forced me to evaluate myself objectively. Oftentimes when I think that my practicing
has gone badly, I just try to forget about it, or tell myself better next time, but the practice diary required me to identify what could have been better, and come up with a plan for how to accomplish it better next time.

**Sophomore**
The sophomore is from the Northeast and is a violin performance major at a music conservatory in the Northeast. She is 18 years old and has been playing the violin since she was four years old. In the past, the sophomore used to hate practicing because she didn’t know how to practice. She would just play through pieces without thinking and get frustrated because she didn’t hear any progress. But now, she thinks that she is moving in the right direction. She commented:

I used to hate it. I used to really hate practicing because I think that I was just hacking away and not thinking … not consciously practicing. I was just kind of just sawing through it, and it wasn’t getting any better, and that is the most frustrating thing. You can practice, but you know it sounds horrible, and you don’t want to keep practicing because it sounds horrible. But now, I feel like I’m getting better at being able to gear my practice in a more productive direction and to zero in on problems. So, I think the more advanced I become, the more fulfilling my practice becomes because I can see progress, even if it’s slow, I can at least see that I’m taking steps in the right direction. So I guess it makes it more enjoyable.

Based on the diary entries, the sophomore demonstrated skillful self-regulated learning behaviors: she planned her practice sessions, set proximal goals, selected practice strategies, applied problem-solving skills, instructed herself, and sought opportunities to be evaluated. However, her self-efficacy was influenced by certain internal and external conditions. She felt confident about her abilities to accomplish her goals if she concentrated well or was in a good mood to practice. Her self-efficacy also depended on the amount of time she had to practice methodically and the level of difficulty of the piece she was working on.

According to Hallam’s (1995) study of professional musicians’ learning styles, the sophomore would be considered a serialist learner because she mainly focused on specific elements of the task; for instance, she made a list of all the material she wanted to cover during each practice session, along with practice strategies that addressed technical or performance problems. Even though she was intrinsically motivated because of her love for music, she seemed to be more extrinsically motivated by the challenge of mastering something that was difficult for her, as well as other external pressures—such as an upcoming audition, lesson, or performance in a master class. Gellrich et al. (1986) found three levels of motivation in musicians, and the sophomore experienced two different levels of motivation in the following order: a general achievement motivation and a specifically music-focused achievement motivation.
The sophomore used self-guided verbalizations during her practice sessions to solve problems and play more musically. She also created visual and aural images of the sound she wanted to produce in her head before she played it on her violin. This strategy made her more specific about how she should practice, and it helped her play more musically. She also analyzed the music and tried to practice in an intelligent methodical way. However, the main obstacles that she encountered on a daily basis were technical problems and a lack of control of her affective and cognitive states. The other problems that she struggled with were focus, time management, and control of her mood.

Over the two-week period of keeping the practice diary, the sophomore learned to practice more efficiently. For example, she did the following to become more efficient: practiced methodically, mentally practiced the piece before she practiced, that is, discerned which parts required more attention, and created visual and aural images in her head before she played. Moreover, the semi-structured diary was a catalyst for her to learn how to practice more efficiently because it made her more conscientious about the way she should practice. Thus, she was able to achieve her goals over the summer. She commented:

I think it [the practice diary] was [helpful in making me more aware of the way I practice]. I think a lot of the things that I have been thinking about during my practice, but a lot of the things that I wrote about that I talk about in my practice journal [I] was already doing. But, writing them down helped me to articulate them better and it brought it forward to my mind a little bit, and so I was consciously doing that. And so it helped me be more efficient.

**Senior**

This 21-year-old senior is a violist from the East South Central region, and is currently a performance major at his home state college. He started his music education on the violin when he was eight years old and switched to viola the following year. He said that when he started the viola, he liked music, but did not like to “work at music.” He did not become serious about practicing until he was a junior in high school.

In general, the senior enjoys practicing when he has a clear goal that he can obtain or when he works efficiently. He enjoys practicing when he feels like he is accomplishing something. The senior practices well when he has enough time to practice because that means he can work through things at his leisure.

Based on the diary entries, the senior is a self-regulated learner, who is metacognitive about practicing. He demonstrated skillful self-regulated learning behaviors, such as analyzing the music, creating an aural image of the music before he played, instructing himself, and applying problem-solving skills to help him get to a problem’s root. However, his confidence in his ability to accomplish his goals depended on what he was working on and how familiar he was with the piece.
According to Hallam (1995), the senior would be considered a versatile learner because, even though he generally worked on specific elements of the task during his practice session, he also saw the “big picture” of the music by analyzing the score. He was extrinsically motivated to practice by peer pressure, as well as by pressure to have a good lesson, a good concert, or a good performance. The senior experienced two of the three levels of motivation in musicians (Gellrich, et al., 1986) in the following order of frequency: a general achievement motivation and a specifically music-focused achievement.

The problems that he encountered mainly had to do with his left-hand technique, namely, overcoming poor intonation and not playing musically while he was focusing on his technique. Over the course of the summer, he gained a better awareness of his technical deficiencies, as well as what he needed to do to solve his own problems. Moreover, he learned how he could practice more efficiently.

The senior found that the diary was an effective tool because it helped him to be more organized during his practice sessions. The diary forced him to think more about how he should practice, since he had to keep a record of how he was practicing, and it provided him the structure he needed to prioritize his time. After the period of this study, the senior gained a better understanding of how to teach himself. Thus, he became a more self-efficacious self-regulated learner. He said:

I gained a much greater knowledge of the holes in my techniques and how to build them. You know instead of being kind of high and dry without the ability to play a lot of the music. I kind of learned how to fix some of these problems and how to make some progress on my own. So, when I get home, I feel like I can spend a month or two before even having a lesson just working on the stuff I’ve been given so far.

The Recent College Graduate
The recent college graduate is a violinist from the Northeast. She recently received her Bachelor of Music in performance from a music conservatory in the Northeast. She is 22 years old and has been playing the violin for 18 years. She would like to become a musician because she “really loves playing music.”

The recent college graduate enjoys practicing when she is not stressed to meet any deadline. She said that when she has the time to practice, she can pay more attention to the way she plays because she does not have to cram to learn something. She added that she practices well when she is not under stress because she is more aware of what goes on when she practices.

Based on the diary entries, the recent graduate is a metacognitive self-regulated learner. She demonstrated skillful self-regulated learning behaviors, such as monitoring herself, teaching herself, practicing mentally by studying the score, applying problem-solving skills, setting proximal goals, analyzing the music, and creating specific aural and visual images of the music in her head.
before she played. Overall, she was satisfied with the way she practiced. Yet, she struggled because she often overanalyzed her playing when she performed in front of an audience. In order to change this tendency, she was adopting a new way of playing by not micromanaging her playing especially when she is performing.

According to Hallam (1995), the recent graduate would be considered a versatile learner because, even though she worked on specific elements of the task, she strived to have the “big picture” of the music in mind. She was intrinsically motivated to practice because she loved playing music. However, at times, her motivation decreased because of external pressures, such as an upcoming lesson or a performance. The recent college graduate experienced all three levels of motivation (Gellrich et al., 1986) in the following order of frequency: a specifically music-focused achievement, a general achievement, and a sensual-aesthetic motivation.

The main problems that the graduate encountered were not directly related to practicing her instrument; rather, her frustration stemmed from the micromanagement of her playing and from her inability to control her body and mind when she experienced external pressures. According to Carver & Scheier (1981), she was trying to shift her self-monitoring to a more general level—that is, from the action itself to the outcome of that action.

The diary helped the recent graduate practice more efficiently because, rather than keeping a mental checklist, she was obliged to articulate how she practiced. Otherwise, the diary was not helpful in adopting the new way of playing. Nevertheless, she felt that she had improved over the summer because she was becoming more comfortable with the new way of playing and she was playing technically difficult pieces that she never thought she would be able to play. Moreover, since she was becoming better at solving her own problems, she became more self-efficacious about becoming an independent learner. She said:

I’m not sure about the way that it exists now. I don’t know. I’ve been reading *The Inner Book of Tennis* and it’s all about, like at first, just being observing and not being so direction specific. And I felt like sometimes this would prompt me to think of a certain way, which is probably the purpose of it. But instead of just going with it, I was like, I’m going to dissect everything I did, and articulate it. And I’m not sure how good or bad that was, I’m just not sure about it. Probably next year, keeping track of tangible form would be good, since I won’t have that weekly hour to find out what’s going on. But, I would probably cut the number of questions.

**Discussion**

All four students demonstrated a range of efficient self-regulated practice behaviors. They planned out their practice sessions by making a list of technical studies and repertoire for each practice session. They also noted specific
problems they would encounter. Then, they chose appropriate task-oriented practice strategies and set proximal goals for themselves. However, each student’s approach to practicing differed.

During the practice sessions, all four students reported using self-guided verbalizations to help them monitor their playing and implement practice strategies. They also instructed themselves to change strategies when a particular practice strategy was not working well. Some of the students applied problem-solving skills to get to the root of the problem. Thus, it is evident that these students monitored and evaluated themselves at a detailed level. In addition, each student analyzed the music according to his or her experience in music theory. Furthermore, the more advanced students constructed an aural or visual image of the piece they were working on to help them practice more effectively or play more musically.

The younger students had trouble staying focused and managing time during their practice sessions. This struggle seemed to effect their self-efficacy beliefs; self-efficacy beliefs oscillated even during the same practice session. The older students did not struggle as much with asserting volitional control. However, they had trouble with performance issues, such as resolving technical problems, not playing musically, and micromanaging one’s playing. Nevertheless, these students’ motivation was generally high because of their love for music. Yet, motivation varied from either intrinsic or extrinsic factors on a daily basis.

In accordance with previous research, the participants in this study demonstrated self-regulated learning behaviors comparable to that of professional musicians. Moreover, I noticed a plausible progression of transition stages among the college music students who participated. The cognitive characteristics of the transition learning stages include: the approach to learning new music; the way a student sets specific goals; the way a student uses self-guided verbalizations; the varied range of practice strategies; the way a student constructs an internal image of the music; and the way a student analyzes the music. Moreover, the younger students in my study were more susceptible to internal and external distractions.

While the results of this study concur with previous research that there are considerable differences in the ways musicians approach practicing, this study also found some similar characteristics in the ways college music students self-regulated their learning during practice. Furthermore, the semi-structured practice diary seemed to be an effective tool to investigate self-regulated learning in instrumental practice. In addition, it also encouraged and improved self-regulated learning, particularly for students who had been less experienced with this form of learning.
Conclusion

Educational Implications

Gruson (1988) observed that there are changes in practice patterns as students grow older and gain more experience, and my findings are in line with her observations. Given the changes in practice patterns, we should consider which learning strategies and methods might be most appropriate for each year of schooling—for instance, from freshman year through senior year of college. I would agree with Barry (1992) that a teachable curriculum of strategic practice could be developed. According to present results, the younger students struggled to resolve technical issues, stay focused during their practice sessions, manage their time, and manage volitional control. The older students struggled with performance issues: They experienced technical issues, did not play musically, and sometimes micromanaged their playing during a performance.

The freshman and the sophomore appreciated their teachers because they discussed and demonstrated technical practice strategies during lessons on a regular basis. In my study, it was evident that the younger students did not have as wide a range of practice strategies as the older students. They were also not as experienced at analyzing the music or constructing a visual or aural image of the music. However, when these younger students analyzed the music and constructed a visual or aural image, they seemed to practice more effectively. Therefore, teachers should discuss and demonstrate a wide range of practice strategies and analytical skills during the lesson.

The younger students struggled to stay focused and manage their time during their practice sessions. The older students self-regulated their cognitive and affective behaviors by implementing certain strategies, such as keeping the mind more engaged on the task at hand or practicing a different piece to help them stay focused. Consequently, they practiced more efficiently. The students found that making a list of what they were going to practice and allotting a certain amount of time to each item on the list helped them manage their time better. Setting goals for each practice session also helped them focus better during their practice sessions. Thus, implementing a variety of practice strategies may help control one’s cognitive and affective states.

All four students enjoyed practicing more when they played musically, and they all played more musically when they were intentional about doing so. They also played more musically when they analyzed the music and constructed a visual and aural image of the piece they were playing. Thus, teachers might consider discussing and modeling musical behaviors during the lesson.

Finally, the semi-structured practice diary can be used as a tool to enhance self-regulated learning in instrumental practice. It can also be a tool for teachers to better understand their students’ practice behaviors. With the practice diary, teachers can assist students to develop more efficient practice habits by examining students’ practice habits and diagnose persistent problems. The
practice diary can also serve as a catalyst for the exploration of better practice strategies and habits between the student and teacher, as well as among the students in the same music studio.

**Recommendations for Further Research**

In order to substantiate the findings of my study and to better understand how a student becomes a skillful self-regulated learner, I would recommend a larger sample size of a wider range in age of participants in future research. In addition, in order to understand diverse stages of self-regulated learning, I would also recommend further research on students who have just entered a significantly different transition stage, such as freshmen in college and recent college graduates.

In addition to the interviews with the students, I would recommend including an interview of the teachers to find out more about rapport between students and teachers, as well as their assessment of student abilities. In addition to the interviews and the semi-structured practice diary, other forms of documentation, such as video or audio recordings of the student’s practice sessions and performances, should also be examined in future research. Since the goal of skillful self-regulated learning is to become an effective performer, further investigation is needed to better understand how self-regulated learning affects musical performance.

**Author’s Note**


**References**


Examining Possible Influences of String Students’ Self-Efficacy and Musical Background Characteristics on Practice Behaviors

Abstract
High school string students from one South-Central Texas district were studied. Purposes were: (1) to describe the musical backgrounds and self-efficacy beliefs of string students (N=101), (2) to measure the relationship between string playing self-efficacy and achievement (n=65), and (3) to describe the practice behaviors and strategies of high versus low self-efficacy string students (n=16). Descriptive questions included whether or not students took private lessons, started in public school, and how much students practiced. Sixty-five of the 101 chose to audition for their All-Region orchestra. A significant relationship between self-efficacy scores and performance rankings was found. The 8 higher self-efficacy students tended to use more cognitive practice strategies than the 8 lower self-efficacy students. If musical self-efficacy is related to musical achievement and more cognitive practice, music educators should have a better understanding of musical self-efficacy, how it can influence practice, and how aspects of students’ musical backgrounds may influence it.

Keywords
string students, self-efficacy, practice, practice strategies, musical characteristics

Introduction
Music educators understand that the isolated act of deliberate music practice is necessary for students to succeed in their musical endeavors. Deliberate practice has been defined by researchers as “a regimen of effortful activities” (Ericsson, Krampe, & Tesch-Römer, 1993, p. 363), often begun at a young age in efforts to achieve optimum success in any given area. Some music education research has stressed the importance of motivation and incentive (Hallam, 1997; Harnischmacher, 1997). This research has included general concepts, such as

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the influences of intrinsic and extrinsic motivation (Schmidt, 2005; Schmidt, Zdzinski, & Ballard, 2006), as well as three main theoretical frameworks related to cognitive motivation: attribution theory, goal theory, and expectancy-value theory; all of which have implications in the study of self-beliefs and self-efficacy (Bandura, 1997).

According to Bandura (1997), self-beliefs and self-efficacy are key elements in directing people’s choices and decisions, such as how much effort they might exert when challenges emerge, or what they want to do toward self-improvement and development. It is these self-monitoring actions that incorporate self-regulation and cognitive motivation: in goal theory or setting goals, people plan and anticipate outcomes; in attribution theory, people qualify successes or failures, redirecting behavior as a result; and with expectancy-value theory, expectations are based on judgments and values, affecting decisions and behaviors.

Bandura (1986) claims that self-beliefs need to be considered when interpreting impetus for any human behavior or action, and that self-efficacy in particular, can be important to human functioning in motivation and personal achievement. It may be that students who have sufficient skills in a certain field of study, such as music, might have a better chance of succeeding and persisting, even despite unforeseen challenges, if they have a positive sense of self-efficacy. Bandura (1997) believes that self-efficacy reflects judgment of what people think they can do or accomplish in a given circumstance, and is therefore, task, skill, or field oriented. It can be influential to human functioning and directly affects personal achievements.

Self-efficacy research in education has shown that success and achievement are usually associated with high levels of individual and subject-related self-efficacy (Bong & Clark, 1999; Bouffard-Bouchard, 2001; Schulz, 2005; Yassir, 2006). Self-efficacy has also been found to be a good motivator to help sustain students’ perseverance in academia (Margolis & McCabe, 2004; Multon, Brown & Lent, 1991). In music, Davison (2006) took a unique approach and found that band students’ musical self-efficacy increased when given the opportunity to be creative and engage in musical improvisation.

While Davison looked at the self-efficacy of band students, Barnes (1998) considered self-efficacy and its influence in music education by investigating pre-service string teachers, their self-efficacy beliefs of their own teaching, and self-assessments of their teaching. The positive correlation between self-efficacy and self-assessment increased each term over a period of three terms. At the end of the study, the experienced string teachers’ effectiveness ratings of the pre-service teachers were higher than the pre-service teachers’ own self-ratings. Barnes concluded that pre-service teachers might be over-confident at first, but become more critical and aware of their own effectiveness as their experience increases, more appropriately matching their self-efficacy of teaching with their self-assessments.
When considering musical self-efficacy, deliberate music practice, and musical achievement, among other variables, McCormick and McPherson (2003) found that self-efficacy was not only positively related to performance achievement for music students, but the best predictor of success. The researchers investigated correlations between a musical examination, deliberate music practice, and aspects of motivation in music learning, and found self-efficacy to be the most highly correlated among all variables. McPherson and McCormick (2006) replicated their research with a larger group and found that self-efficacy was again the strongest predictor of success in a graded music exam. Both studies used a variety of instrumentalists, including string players.

While McPherson and McCormick (2003, 2006) considered how self-efficacy, among other variables, correlated to a graded music exam for pre-college students, Nielsen (2004) investigated the practice habits of first-year collegiate music majors in a study that investigated self-efficacy, music practice, and area of specialization. Findings indicated that students tended to use a wide range of different strategies when practicing, regardless of their principal instrument or area. Nielson also found that students who had a higher sense of musical self-efficacy tended to use more cognitively engaged strategies when practicing.

Because Bandura (1997) explains self-efficacy under the umbrella of cognitive motivation, in order to consider self-efficacy and its relationship to music practice it might be informative to also consider music practice research within the different areas of cognitive motivation, including self-regulation (Austin & Berg, 2006; McPherson & Renwick, 2001; McPherson & Zimmerman, 2002). Austin and Berg (2006) considered music practice of beginning band and orchestra students using the theoretical framework of self-regulation and goal theory. Self-efficacy is a key element and determining factor in self-regulation, therefore affecting the level of people’s motivation. In goal theory this affects how people might develop goals, or how they might face challenges while attempting to reach those goals; challenges that require effort, perseverance, and cognitive forethought (Pajares, 2002).

Austin and Berg (2006) found that students who had low self-regulation and low levels of motivation tended to write less if anything for their practice narrative. They also showed less interest in their practice experience. Students who had high self-regulation and indicated a higher level of motivation wrote down at least two goal strategies they used in their practice and showed genuine interest in practicing.

Smith (2005) also considered goal theory and practice strategies with aspects of implicit motivation, but among collegiate music students, and found that task goals were related to cognitive practice strategy factors, while ego goals may have hindered deeper cognitive strategy use and self-regulation in individual practice. Therefore, a balanced self-regulation of one’s goals and behavior can be
beneficial in the music learning process. Researchers have also considered other aspects of cognitive motivation associated with music learning and practice, including attribution theory (Asmus; 1986; Austin & Vispoel, 1998; Nielsen, 2001; Smith, 2002) and expectancy-value theory (Stewart, 2005).

To investigate the numerous aspects of deliberate music practice in general, researchers have used retrospective questioning and interviewing (Davidson, Howe, Moore, & Sloboda, 1996; Hallam, 1997; Madsen, 2004; Sloboda & Howe, 1991), questionnaires (Hamann & Frost, 2000; McCormick & McPherson, 2003), diary or written accounts (Geringer & Kostka, 1984; Wagner, 1975), and video observation (Pitts, Davidson, & McPherson, 2000; Rohwer & Polk, 2006). With large samples, questioning about past or even contemporary practice habits seems to be the most convenient method, but researchers have warned that investigating practice behaviors in this way may not be completely accurate (O’Neill, 1997). For example, Rohwer and Polk (2006) found a significant positive relationship between the number of deliberate practice strategies students could describe and improvement between two videotaped performances. However, students did not always use the strategies that they referred to in their interviews. Therefore, video-recording to gather data (Nielsen, 1999; Pitts, Davidson, & McPherson, 2000; Rohwer & Polk 2006) has been advised. Byo (2008), for example, used videotaped observation as well, and organized the observation based on a self-reported practice by participants, but also found inconsistencies in results between the two.

Williamon and Valentine (2000) determined that quality of practice had just as important an influence on a successful performance as did the amount of time spent practicing. Researchers found that practice excerpts increased in length and difficulty as age and level of ability or expertise in practice increased. Hallam (1997) found similar results when investigating deliberate music practice research using observation and interviews. Hallam analyzed the practice habits of 55 students. Forty-nine were considered novices from a beginning level to grade seven, and six were considered advanced. Data revealed that practice strategy use was more significantly related to levels of expertise than to age and its related development or performance outcomes.

Hallam (1997) categorized students’ practice strategies and correction attempts according to their levels of expertise: Strategy level 1: Task requirements incomplete. This was the lowest level defined. Strategy level 2: Material played through, no corrections. Strategy level 3: Material played through, single notes corrected. In this middle level category, students played through the repertoire and may have recognized some errors, but only stopped to correct single notes. Strategy level 4: Material played through, short sections repeated. At level four, more attempts at corrections were noticeable. Students “repeatedly played through the piece, but on making an error stopped and replayed a short section of the music before continuing” (p. 100). Strategy level 5: Material played through,
large sections practiced en route. Students played through the repertoire, but stopped to repeat larger, more complicated sections in need of improvement. Strategy level 6: Material initially played through, difficult passages identified and practiced in isolation. In this final strategy level, students played through the repertoire to gain an overall understanding of the piece, then went back to sections identified as problem areas for more focused practice.

Research into music practice behaviors and strategies as well as possible connections between music and Cognitive Motivational Theories, including self-regulation, may have influenced the beginnings of investigative interest in self-efficacy and music. Some researchers have studied this possible connection between music related activities and self-efficacy (Barnes, 1998; Davison, 2006; McCormick & McPherson, 2003; McPherson & McCormick, 2006; Nielsen, 2004), but there still seems to be less self-efficacy research in the field of music when compared to general academics. Also, other than Barnes (1998), self-efficacy research has related to general instrumental music, not specific to strings. It might be valuable to not only add to this body of knowledge in music, but also apply it to string playing, and consider the possible influence that musical self-efficacy and certain musical experiences may have on practice behaviors. Because self-efficacy has been found to relate to success and achievement, investigating the self-efficacy beliefs of string students and their practice habits may help string educators better understand the motivation and strategies behind their students’ practice routines and successes.

Therefore, the current study focused on the practice habits of high school string players’ and considered the possible connections between their practice, their achievements, and their level of musical self-efficacy. The intended purposes of this study were: (1) to describe the musical background characteristics and self-efficacy beliefs of a group of high school string students through questionnaire, (2) to measure the relationship between self-efficacy scores and performance achievement of a group of high school string students, and (3) to describe the practice behaviors of high and low self-efficacy string students through observation.

Method
Participants
Participants were 101 high school string students, ages 14 to 18, from a district in South-Central Texas: 52 violins, 20 violas, 19 violoncellos, and 10 basses. The district was considered one of the five largest in the state, and included 12 high schools. Nine of the 12 high schools had string programs and participated in the study. String students from all nine programs were approached, but only 101 permission forms were returned, and all 101 completed the questionnaire (SSQ): 43 females and 58 males.

To address the first purpose, musical background information was considered
and self-efficacy scores were summed. For the second purpose, summed self-efficacy scores of those who took the audition (n=65) were correlated with All-Region rankings. There were 30 violinists, 16 violists, 10 violoncellists, and 9 double bassists. For the final purpose, 8 high self-efficacy and 8 low self-efficacy students were chosen to be observed (Rohwer & Polk, 2005; Byo, 2008) as they practiced and prepared for an All-Region audition.

Research Procedures
There were 25 questions on the questionnaire (see Figure 1). The first 7 questions asked about musical and personal background characteristics. The 18 musical self-efficacy items on the questionnaire were developed using Bandura’s (2006) guidelines for constructing self-efficacy scales, and based on a similar questionnaire investigating the self-efficacy beliefs of band students (Davison, 2006). For this portion of the questionnaire, students were asked to rate their confidence level from 0 (“certain I cannot do at all”) to 10 (“certain that I can do”), with a moderate statement listed at 5 (“moderately certain I can do”). These items were summed to estimate each participant’s musical self-efficacy score (possible range of 0 to 180).

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**String Student Questionnaire**

**SECT. I:** Please answer the first 6 questions with an exact number or write YES or NO:

- How many years have you been playing your instrument? ________
- Did you start in a public school program? ______
- Do you take private lessons on your instrument? ______
- Do you plan to continue playing your instrument after high school in some way? ______
- Do you own your own instrument? ______
- How many hours per week (outside of orchestra) do you practice? ______

Please circle one:  
F – Female  
M – Male

**SECT. II:** Questions 1 through 18

This portion of the questionnaire is designed to gauge how confident you are at doing musical tasks on your string instrument. There is no right or wrong response to these questions. For each item there is a space to the right for you to write your response.

Rate how confident you are that you can do each task as of now. Rate your degree of confidence by writing a number from 0 to 10 using the scale given on the next page.
USE this SCALE to ANSWER QUESTIONS 1 – 18

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain I <strong>cannot</strong> do at all</td>
<td><strong>Moderately</strong> certain I can do</td>
<td>Certain that I <strong>can</strong> do</td>
<td></td>
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</tbody>
</table>

Please rate your confidence regarding the following statements:

I can overcome most problems I encounter when learning difficult music my teacher has given me.

I can keep a steady beat when I am playing alone.

I can play my string instrument in tune when performing with a small group.

I can successfully do most things that are required in orchestra.

Even when a musical task is very hard, I can work on the problem until I succeed.

It is easy for me to tell when other students are playing out of tune.

I can keep a steady beat when I am playing with others.

When learning new solo music, I can easily follow the marked bowings.

Overall, I can play my string instrument with a good tone.

I can vibrato well when playing a solo piece.

If I make a mistake I can continue playing without too much distraction.

Even when playing very softly or loudly, I can still play my string instrument with a good sound.

I can sight-read challenging orchestra music without stopping.

When I am reading music, I can play most rhythms correctly.

When playing in orchestra, I can follow the marked bowings correctly.

I can vibrato on my string instrument in most orchestra music.

Even when other students in my section are making mistakes I can still follow the marked bowings correctly.

I can slur difficult rhythms into one bow.

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Figure 1. String Student Questionnaire

Summed self-efficacy scores of the string students (n=65) who auditioned were correlated to their All-Region rankings. A *Pearson product-moment correlation* was calculated. Possible rankings ranged from 1, or “first chair,” being the highest ranking a student could receive, to 45, the lowest ranking a student could receive. Self-efficacy scores ranged from 79 to 180 with 180 being the highest possible self-efficacy score.

Sixteen string students, 8 with high self-efficacy scores and 8 with low self-efficacy scores, were then approached and given separate permission forms for the final purpose of the study. The 16 students were videotaped in two practice sessions. Sessions were 10 minutes each to give the researcher/observer a guideline and to keep the observations of 16 students within a reasonable timeframe.

First, students were asked to practice a three-octave scale beginning on their lowest open string. Second, students were asked to practice their assigned
All-Region etude excerpt. Third, students were asked to choose two All-Region repertoire excerpts (five minutes each). Local teachers (private and public school orchestra directors) suggested that a scale be included, as all students were also asked to practice related scales. A researcher-designed observation form was used for each string student’s practice session. General concepts included: where a student began each practice session, correction attempts, tempi, repetition, the size of isolated and repeated sections, technique, rhythm, use of a metronome, dynamics, and slurs. Also on the form were some items regarding the identification of difficult passages and a place for open comments.

**Reliability.** A pilot study was conducted to test reliability of the self-efficacy portion of the questionnaire (SSQ) with 38 pilot subjects. When considering all 18 self-efficacy questions, the alpha coefficient for internal consistency was .96. Taking out one and two questions did not increase the reliability; therefore, all 18 self-efficacy questions were kept in the final SSQ. The final reliability coefficient was $r = .96$. The musical characteristic and gender questions were given to the pilot subjects as well. These 7 questions and responses were considered and discussed with three experts prior to the pilot.

Regarding the observation procedures of the videotaped practice sessions, an experienced string teacher viewed three pilot practice session videotapes along with the researcher. Comparisons were made between the expert’s and the researcher’s data to ensure that the researcher was making accurate and non-judgmental observations, true to the student participant. An observation form was developed based on string teacher recommendations and extended pilot student-observed practice sessions. The form was shown to two expert researchers and two string teachers for reliability.

**Results**
String students ($N=101$) answered 6 musical characteristics questions and a gender question. Data are summarized in Table 1.
Table 1
Musical Background Characteristics

<table>
<thead>
<tr>
<th>Item Addressed</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Years playing instrument</td>
<td>1 to 11 years ($M=5.60$ yrs, $SD=1.80$)</td>
</tr>
<tr>
<td>2. Started in public school</td>
<td>90.10%</td>
</tr>
<tr>
<td>3. Private lessons</td>
<td>47.52%</td>
</tr>
<tr>
<td>4. Continuation after HS</td>
<td>84.16%</td>
</tr>
<tr>
<td>5. Own instrument</td>
<td>73.27%</td>
</tr>
<tr>
<td>6. Mean number of hours practiced</td>
<td>0 to 30 hours ($M=4.53$ hours, $SD=4.95$)</td>
</tr>
<tr>
<td>7. Gender</td>
<td>43 females and 58 males</td>
</tr>
</tbody>
</table>

Self-efficacy scores
The mean self-efficacy score for all students who took the questionnaire ($N=101$) was $139.43$ ($SD=21.35$). Scores ranged from 79 to 180. Students exhibited a moderate level of certainty in believing that they could achieve the tasks listed in the SSQ. When considering self-efficacy of different sub-groups within all subjects, male students had an average self-efficacy score of $139.10$ ($SD=22.43$) and female students had an average self-efficacy score of $139.70$ ($SD=20.22$). The two students in the study with the highest (180) and lowest scores (79) were both male students. The average self-efficacy score for all string students who auditioned for All-Region ($n=65$) was $140.43$ ($SD=20.50$). Scores of the 8 students chosen for the lower self-efficacy sub-group ranged from 99 to 120, and the 8 students with higher self-efficacy scores ranged from 148 to 173.

All students who participated in the study and took private lessons had an average self-efficacy score of $154$ ($SD=22.48$, ranging from 90 to 180); those who participated and did not take private lessons had a lower self-efficacy score average of $131$ ($SD=20.08$, ranging from 79 to 177). Students in the higher self-efficacy sub-group (Mean self-efficacy score of $158$) all took private lessons, but two from the lower sub-group (Mean self-efficacy score of $110$) did not.

Relationship between self-efficacy scores and All-Region rankings
An inverse relationship between self-efficacy scores and All-Region rankings ($r_s = -.37$) was statistically significant ($p=.001$) and explained $14\%$ of the variance between the two tests ($r^2 = .14$). That is, there was a tendency for students with higher self-efficacy scores to be placed in lower chair positions (“1” or first chair being the best possible ranking), indicating higher performance achievement.

Observations
Practice behaviors of high and low self-efficacy sub-group string students
were videotaped for observation prior to the All-Region audition. A researcher-designed observation form was used. The following section summarizes the students’ behaviors: how students practiced scales, etude and repertoire excerpts, and general observations.

**Scale practice.** Six out of the eight students in the higher self-efficacy sub-group started their scale practice in quarter notes. Five students from the higher self-efficacy sub-group slurred notes together at various amounts, such as two, three, four, six, eight, and twelve notes per bow. Each of the higher sub-group students also did something specialized in their scale practice: focusing on vibrato, shifts, isolated finger patterns, or difficult string crossings.

Four of the lower self-efficacy sub-group students also started with quarter notes, but the other four students from the lower sub-group started with half notes. Some of the students from the lower self-efficacy sub-group practiced their scales with slurring variations as well, but they did not slur as many notes together, go in any particular order or practice as many slurred variations. Only one lower self-efficacy sub-group student practiced with a unique technique of repeated spiccato notes, while students from both groups incorporated dotted eighth sixteenth rhythms.

**Etude and repertoire practice.** Students in the higher self-efficacy sub-group all practiced larger sections or areas that needed attention. They practiced half of an excerpt and then repeated that section, sometimes more than once, focused on three or more measures to practice them before going on to the rest of the excerpt, or isolated other large sections. Two students from the higher self-efficacy sub-group did an initial run through of their etude excerpts, one student playing the entire etude before going back to practice any particular sections.

All students in the higher self-efficacy sub-group attempted to begin their etude excerpt practice at performance tempo. Students K and M, the students with the highest and third highest self-efficacy scores, played through the etude excerpt at performance tempo. Both students also focused on musical phrasing and dynamics. Six of the lower self-efficacy students started at the beginning, stopped immediately to isolate a problem, and used different methods to practice, such as varying the tempo, rhythm, or bowing, or repeated a note, motive, or measure; all as they played through the excerpt.

Three students from the higher self-efficacy sub-group played double stops slowly for intonation. Another higher self-efficacy student compared some notes to others to tune sections, including open strings instead of using octaves. Three other students from the higher self-efficacy sub-group used repetition and slower tempi to practice intonation. These three students had the highest self-efficacy scores and one of them focused on tone to help with intonation by adjusting the angle of her bow as well as the distance from her bridge. The other 5 students in the higher sub-group worked on pitch and intonation in other ways. One student used a scale to help find pitch, while another student used a tuning note from a
tuner to adjust intonation. Three students from the lower self-efficacy sub-group used slower tempi to practice intonation, while one used double stops.

To practice rhythm and difficult slurred passages, all of the students generally slowed things down or used repetition. One student from the higher self-efficacy sub-group took out the slurs and played double notes. Another higher self-efficacy student took away the left hand and played the rhythms and slurs with open strings.

*General practice techniques observed.* The most common techniques used to practice rhythm or intonation, were repetition and tempi variations. One student from the higher self-efficacy sub-group used a metronome during all of his practice. Also in the higher sub-group, one student used her watch as her metronome during the repertoire practice, and another mentioned that she did use a metronome at home.

Some higher self-efficacy students demonstrated techniques that indicated an awareness of how to correctly create dynamics on their instruments: using more bow, adjusting the bow’s distance from the bridge, adjusting the weight of the bow, and using more hair to increase volume. Three students from the higher sub-group incorporated dynamics in their practice, while two exaggerated them, using the mentioned techniques above. Overall practice techniques observed are summarized in Table 2.

**Table 2**
*Practice Strategies of Self-Efficacy Sub-groups Observed and Summarized*

<table>
<thead>
<tr>
<th>Practice Task</th>
<th>Higher Self-Efficacy</th>
<th>Lower Self-Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale Practice</td>
<td>quarter notes first, ordered number of notes per bow</td>
<td>half notes first, some slurred, non-ordered</td>
</tr>
<tr>
<td>Etude and Excerpts</td>
<td>at tempo, larger sections isolated and practiced, two students did an initial run-through</td>
<td>slow, starts and stops as students read through, small sections isolated</td>
</tr>
<tr>
<td>General</td>
<td>more metronome use or mention and use of dynamics</td>
<td>no metronome use and little use of dynamics</td>
</tr>
</tbody>
</table>

**Conclusions and Recommendations**
The purposes of this study were: (1) to describe the musical background characteristics and self-efficacy beliefs of a group of high school string students, (2) to measure the relationship between self-efficacy belief scores and performance achievement, and (3) to describe the practice behaviors and thoughts of high and low self-efficacy string students. This research was done through a combination of questionnaire and video-observation.
Musical background characteristics
When investigating the descriptive data regarding high school string students’ musical background characteristics, there was a wide range in the number of years students claimed to have played their instruments. Other research (Hallam, 1997) has found that developing expertise may be important in performance achievement, and that practice strategy depends on level of expertise. When comparing average number of years playing between the high and low self-efficacy sub-groups, they were quite similar. Therefore, perhaps self-efficacy does not necessarily depend on developed expertise over number of years, despite its possible connection to achievement. String teachers might want to consider working on developing positive self-efficacy from the beginning of a student’s music learning and at each level of development, rather than waiting until a student shows any signs of negativity or struggle. It could be that self-efficacy in general may be connected to other personal or societal influences, such as family and peers. Csikszentmihalyi et al. (1993) found that students who were considered exceptionally talented spent more time with parents and families than most young people, and were encouraged to develop positive work ethics in their learning environments.

A majority of the students who participated in the current study started in a public school program, and a majority of these students indicated on the questionnaire that they wanted to continue playing their instruments after high school. In a nationwide survey, Gillespie and Hamann (1997) found that 84% of the string students surveyed started in public school programs between the fourth and sixth grades with most continuing through high school. However, Gillespie and Hamann found that only 5% went on to major in music in college. String students who claim that they may want to continue, might do so by being supportive, sharing their interest within their communities and helping to retain, build, or increase the success of programs.

In past research, taking private lessons was found to be a motivational factor for string students (Hamann & Frost, 2000). In the current data, slightly less than half of the 101 participants studied their instruments privately, and students who took lessons had a higher self-efficacy average than students who did not. Encouraging students to take lessons or helping them do so may retain and motivate them.

Most of the students in this study owned their own string instruments (73.27%). However, two of the highest achieving students, who placed first chair in their respective sections, did not. These two students had high self-efficacy scores and placed in the All-State orchestras. If school districts, orchestra programs, or private donors could provide deserving students with quality instruments, students who already have a strong sense of self-efficacy might be able to achieve their goals despite limitations.

Research has stressed the importance of the amount of time spent practicing
(Ericsson, Krampe, & Tesch-Römer, 1993). Similar results were found in the current study; students who placed in the All-Region orchestra tended to practice more prior to the audition than students who did not make the orchestra \( (n=65) \), and students who auditioned tended to practice more than those who did not \( (N=101) \). Researchers have also considered the quality of practice and the importance of practice strategies (Geringer & Kostka, 1984; Hallam, 1997; Rohwer & Polk, 2006; Williamon & Valentine, 2000). The current study found more cognitive and structured strategy use as well as higher achievement by students who had higher self-efficacy \( (n=16) \). For example, the main difference between higher and lower self-efficacy string students in scale practice tended to be organization. Higher self-efficacy students varied scale practice by adding, in order, number of notes per bow, such as 2 to 12, versus lower self-efficacy students playing two per slur or bow, then six, and finishing, or not even completing the scale.

Males and females had similar self-efficacy score averages as well as practice time in the current study. This has not been typical in gender research. Research in self-efficacy, music, and gender at the collegiate level (Nielsen, 2004) found that it may depend on the program in which students are involved. Also, in the past, people have had certain expectations, such as the elementary music teacher to be a female, or the high school band director to be a male (Moisala, 1999). Therefore, further research could be conducted regarding gender in music and self-efficacy, and music educators need to continue to be sensitive to this issue.

**Self-efficacy and achievement**

Past research has found significant relationships between self-efficacy and achievement, whether in general academic research (Bouffard-Bouchard, 2001; Schulz, 2005) or in music research (McPherson & McCormick, 2006). The current study supports these findings in that the relationship between high school string students’ self-efficacy scores and rankings in a high school All-Region orchestra competition were significantly correlated. If students who are successful also have a higher musical self-efficacy, it might be important for string teachers to understand how the successful students plan and execute deliberate practice behaviors, as well as find ways for the students who are typically less successful to build a more positive perception of musical self-efficacy.

In researching how music students’ self-efficacy might be strengthened, Davison (2006) found that improvisation helped to increase band students’ musical self-efficacy. Improvisation is often linked to jazz band, particularly in the public schools. It has only been in recent years that improvisational methods for strings, sometimes related to jazz as well, have become popular and more commonly published (Grunow, et al., 2008; Sabien & Phillips, 2000;
Wexler, 2000). Other methods that are being used focus on creativity, such as incorporating theatre concepts (Music for People, 2008). Experimenting with improvisational ideas in the string classroom could help teachers build self-efficacy.

**Practice habits**

Supporting Nielsen’s (2004) research, findings from the current study have indicated that students who had a higher sense of musical self-efficacy tended to use more advanced practice techniques. For example, the higher self-efficacy group tended to choose larger sections or even run through the entire excerpt first. The lower sub-group chose smaller spots to stop and start while playing through the excerpt.

The practice techniques used by self-efficacy sub-groups \((n=16)\) in this study were similar to Hallam’s (1997) six “task oriented strategies” (p. 100). Students from the lower self-efficacy sub-group tended to use Hallam’s practice levels two and three. Hallam’s level two was defined as playing material with no corrections, and level three as playing the material through, stopping to correct single notes. Students from the higher self-efficacy sub-group used Hallam’s practice levels four through six. These levels were defined as playing through material repeating short sections, level four; practicing large sections en route, level five; or level six, playing through the material first, then identifying trouble spots and practicing these passages in isolation. Two students with the highest self-efficacies from the sub-groups used level six. These two students also placed higher in their All-Region sections than the other sub-group students.

This study not only considered achievement in relationship to self-efficacy, but also described how students with higher and lower self-efficacies approached practice. Using Hallam’s (1997) practice strategies as a model for simpler to more advanced tasks, the practice strategies that string students used in the self-efficacy sub-groups tended to increase in task level as levels of self-efficacy increased. Music educators might want to consider this relationship between self-efficacy and practice strategy, as well as self-efficacy and success. Differences found between practice techniques of higher versus lower self-efficacy string students might be useful in devising effective practice strategies for all students. Considering musical characteristic backgrounds and encouraging the practice habits that higher self-efficacy students tend to use, might give other less assertive or sure students a higher probability of success.

**Future Research**

Hurley (1992) concluded that string students’ interests as well as motivational needs were important aspects of retention in string programs. Hurley found that many students joined beginning string classes for social reasons, and “continuing motivation might be fostered through cooperative learning situations that
stress effort in a community of students with similar interests” (p. 233). Future researchers could examine the social aspects of playing a string instrument. How does getting to play with other string students, either in large or small ensembles, affect their musical self-efficacy or their interest in continuing to play?

Research looking at the relationship between students’ academic self-efficacy and their musical self-efficacy might help us understand how to help our students learn. Determining if there is a relationship between these self-efficacy areas could also help in the understanding of how students perceive themselves and how they might be motivated. A detailed investigation of whether their study habits are similar or different from their practice habits could help direct appropriate and productive instruction as well.

Also, similar investigations could be done with larger sample sizes, different ages, or a different focus, such as the middle student with average success and self-efficacy, the “non-varsity group” student. To help all string students succeed, it may be beneficial to consider their self-efficacy, their achievements, any motivational reasoning, their musical backgrounds or experiences, as well as their deliberate practice habits. Further research is needed in these areas, possibly focusing on a statistical interaction effect. Combining the influence of self-efficacy with practice habits could be enlightening in investigating what motivates students to not only practice, but to practice with intent and deliberateness that may lead to more successful achievement.

Author’s Note
This article is based on the author’s doctoral dissertation, “String student self-efficacy and deliberate music practice: Examining string students’ musical background characteristics, self-efficacy beliefs, and practice behaviors,” completed at the University of North Texas, in 2008.

References


A Pilot Study of Relationships Between Pitch Register and Dynamic Level and Vibrato Rate and Width in Professional Violinists

Abstract
The purpose of this research was to investigate whether dynamic level and pitch register influence vibrato width and rate of four professional violin soloists. Data were obtained from recordings of Bell, Midori, Mutter, and Perlman. Analysis of data indicated that both dynamic level and pitch register influenced the vibrato width of the performers, whereas vibrato rate was influenced by dynamic level but not pitch register. Artists’ vibrato was wider in the upper register than in the lower register. Mean width of the soloists’ vibrato was 63 cents (slightly more than one-quarter tone) and mean vibrato rate was 6.63 Hz. Discussion includes implications for string pedagogy and suggestions for additional research.

Keywords
vibrato, string instruments, violin performance, dynamics, pitch register, string pedagogy

Introduction
Vibrato has been identified as essential in string performance. However, many young students struggle to acquire this skill. Furthermore, pedagogues disagree on some of the fundamental components of vibrato. Aspects such as appropriate width, rate, and purported pitch center are frequently debated. In order to better inform pedagogical practice, in this study I investigated some of the fundamental characteristics of artist-level violinists’ vibrato. The individual components of an artist level vibrato may serve as a pedagogical model for teachers to increase clarity and effectiveness in instruction. Artist performers’ vibrato may also serve as an inspiration for students as they learn to develop their own. Pedagogues and performers agree that beautiful vibrato is balanced, even, and
free of tension (Applebaum, 1986; Fischbach, 1998; Galamian, 1962; Gillespie, 1996; Lucktenberg, 1994; Potter 1980; Rolland, Mutchler, & Hellebrandt, 2000; Young 1999). However, the initial motion involved in producing a vibrated tone provokes disagreement among pedagogues. Many performers and pedagogues imply a backward motion in which the pitch oscillates below the conceived pitch (Applebaum, 1986; Galamian, 1962; Hamann & Gillespie 2004; Lucktenberg, 1994), some imply a forward motion (Fischer, 1997; Rolland et al., 2000), and still others profess that vibrato oscillates both above and below the pitch center (Fischbach, 1998; Rolland, et al., 2000; Young, 1999).

Research has attempted to measure purported pitch centers and has produced mostly consistent results. Early investigations of violin vibrato by Seashore and associates (1936) revealed that the mean pitch of a vibrated tone corresponded to the written pitch on the score for the majority of tones analyzed with the exception of tendency tones. More recent investigations of high school and college violin and cello players reinforced Seashore’s findings. Both high school and college participants performed vibrato that oscillated above and below the pitch center (Geringer & Allen, 2004; Geringer, Allen, & MacLeod, 2005). In contrast, Papich and Rainbow (1974, 1975) reported that performers demonstrated an initial sharpening once vibrato commenced and that the oscillations were primarily above the pitch center. Despite the belief that oscillations above the intended pitch will be perceived as sharp (Galamian, 1962; Lucktenberg, 1994), research has found that listeners perceive the mean pitch or center of a vibrated tone, not the highest frequency of the vibration (Brown & Vaughn, 1996; Geringer, Allen, & MacLeod, 2010).

The appropriate rate for an expressive vibrato suggested by performers and pedagogues varies from 5 to 7.5 Hz: 5 to 7 Hz (Potter, 1980); 5 Hz (Applebaum, 1986); 6 to 7.5 Hz (Fischbach, 1998); and 6.5 Hz (Rolland et al., 2000). Empirical research has investigated vibrato rates of professional violinists, violists, cellists, teachers and students, high school and college violin and cello students and results have varied. Mean ranges encompass 5.5 Hz to 7 Hz (Geringer & Allen, 2004; Hollinshead, 1932; Papich & Rainbow, 1974; Reger, 1932; Seashore, 1936). Seashore (1936) analyzed vibrato and discovered that the rate was approximately 6 Hz and constant. Hollinshead (1932) measured 11 professional violinists performing 11 different pieces and found that the mean vibrato rate was 7 Hz. Reger (1932) measured the vibrato rate of professional violinist Fritz Kreisler, three violin teachers, and four violin students and determined that the vibrato rate varied: Kreisler (6.9 Hz), violin teachers (5.95 Hz), and violin students (6.35 Hz). Papich and Rainbow (1974) determined that vibrato rate was different between the string instruments; violinists vibrated at 6.5 Hz, cellists at 5 Hz, and bassists at 4 Hz. More recently, Geringer and Allen (2004) measured the vibrato of high school and college violin and cello players and found that the vibrato rate was approximately 5.5 Hz. It is possible that
professional artists vibrate at a faster rate than professional teachers and students, though caution must be taken due to the small sample size in Reger’s study. No conclusions were drawn concerning the difference in rate between teachers and students in the study.

Some pedagogues have stated that the speed or rate of vibrato is partially dependent on the dynamic level of the passage (Galamian, 1962; Gillespie, 1996). Reger (1932) investigated the effect of dynamic level on vibrato rate and found that *fortissimo* excerpts were performed with a vibrato rate .13 Hz faster than *pianissimo* passages. Galamian (1962) believed that vibrato corresponded primarily to the dynamics of the bow and required greater width and intensity during *forte* and a more subdued, narrow and slow vibrato during *piano* passages.

A larger number of pedagogues and performers have suggested that the width of vibrato varies in accordance with dynamic level (Galamian, 1962; Gillespie, 1996; Potter, 1980; Rolland, et al., 2000; Young, 1999). Wide vibrato has been associated with loud passages and narrow vibrato with soft passages (Galamian, 1962; Potter, 1980; Rolland et al., 2000; Young 1999). Seashore (1936) analyzed the violinist Arnold Small and found that the width of his vibrato increased during the louder portion of tones and decreased near the end of tones. Reger (1932) found that increases in dynamic level were accompanied by a marked increase in vibrato width of approximately 26 cents.

Pitch register has been noted as a key factor in establishing the appropriate width and speed of vibrato. The kinesthetic space between intervals decreases in the upper register of string instruments, therefore it has been suggested by pedagogues that the width of vibrato decreases in higher registers to prevent oscillations that exceed one half step (Applebaum, 1986; Lucktenberg, 1994). Some studies have found that lower string instruments vibrate at slower rates than violins, which may imply an effect of pitch register on vibrato rate (Papich & Rainbow, 1974; Reger, 1932). Reger compared mean vibrato rates of two professional violinists, one professional violist, and one professional cellist, and discovered that mean vibrato rates of violinists (6.9 Hz) were faster than mean vibrato rates for cellists (6.3 Hz) and violists (6.1 Hz). More recently, Geringer and Allen (2004) found that the width, not the rate, of vibrato was different between high school and college violin and cello players. Violinists’ average vibrato width was approximately 34 cents, compared to 26 cents for the cellists; no significant difference in vibrato rate was found. Cheslock (1931) compared four tones (F₃, C₄, G₅, D₅) in fifth position with the second finger on each string and found no difference in vibrato rate or width.

Style and performance context may further impact vibrato rate and width. Fischbach (1998) suggests that solo performers often vibrate a total width of a half step while ensemble players vibrate about a quarter tone. Hollinshead (1932) measured the average vibrato width of artist performers and determined that the mean width of violinist’s vibratos was .26 tone (52 cents). Pedagogues
and limited research have suggested that an individual’s vibrato may be affected by a multitude of contextual factors, including solo versus ensemble playing, the tempo and style of a piece, pitch register, dynamic level, and note length. The purpose of this research was to explore the possible relationship between dynamic level and pitch register and the width and rate of professional violin soloists’ vibratos.

**Method**

Four well-known violin soloists (Midori, Bell, Perlman, Mutter) were selected for this study in order to analyze the vibrato of established professional soloists. Recent artists were used to control for possible effects of recording quality on pitch analysis. The first movement of the *Violin Concerto in G Minor, Op. 26* by Max Bruch was chosen. This selection was chosen for two reasons: measures six and ten are cadenzas performed without orchestral accompaniment and it covers a three-octave range on the violin, G₃ to G₆.

A recording of each artist performing the first movement of the Bruch violin concerto was copied from the original recording on compact disc to computer hard drive, and then analyzed using Praat software (Praat v.4.1.4, 2004). Sustained tones that contained a minimum of three complete vibrato cycles were isolated for each artist (Mutter, 14; Midori, 14; Bell, 17; Perlman, 16) and the following characteristics were measured and recorded: mean pitch (frequency in Hz), minimum and maximum pitch in a given vibrato (Hz), mean intensity (in relative dB), and rate (Hz). The minimum and maximum frequencies of each isolated note were then converted to cents to determine the width of the vibrato. The vibrato rate for each tone was calculated by dividing the number of complete vibrato cycles during the middle portion of a tone by the duration of those cycles. To compare possible differences in vibrato as a result of dynamic changes, tones with a *diminuendo/crescendo* were isolated and analyzed during the loudest and softest portions of the same note.

**Results**

Each soloist’s performance was analyzed with regard to the following dependent variables: pitch register (expressed in Hz), dynamic level (relative dB level), vibrato rate (Hz), and width (cents). Correlations between pitch register and vibrato rate, pitch register and vibrato width, dynamic level and vibrato rate, and dynamic level and vibrato width were computed for each artist individually and overall (see Tables 1 and 2). Moderate positive correlations were found for dynamic level and rate ($r = .44$), dynamic level and width ($r = .49$), and pitch register and width ($r = .42$), but not for pitch register and rate ($r = -.08$).
Table 1

Correlations Between Dynamic Level and Vibrato Rates and Widths of the Four Artists

<table>
<thead>
<tr>
<th>Artist</th>
<th>Rate $r$</th>
<th>Width $r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perlman</td>
<td>.44</td>
<td>.63</td>
</tr>
<tr>
<td>Bell</td>
<td>.64</td>
<td>.58</td>
</tr>
<tr>
<td>Mutter</td>
<td>.52</td>
<td>.38</td>
</tr>
<tr>
<td>Midori</td>
<td>.93</td>
<td>.63</td>
</tr>
<tr>
<td>Overall</td>
<td>.44</td>
<td>.49</td>
</tr>
</tbody>
</table>

A moderate correlation ($r = .44$) was found overall between the dynamic level of a tone and the rate of vibrato for the four artists combined. Further analysis revealed that the correlation between dynamic level and vibrato rate varied considerably between individual performers (Perlman, $r = .44$; Bell, $r = .65$; Mutter, $r = .53$; Midori, $r = .93$). The strongest correlation was found in Midori’s performance, where the relationship between dynamic level and vibrato rate produced an $r$ of .93 (see Table 1).

Moderate positive correlations were found for dynamic level and vibrato width ($r = .49$) and pitch register and width ($r = .42$) overall. The degree to which vibrato width deviated corresponding to dynamic level and pitch register, also varied from performer to performer (see Tables 1 and 2). Correlations between dynamic level and vibrato width varied from $r = .38$ (Mutter) to $r = .63$ (both Perlman and Midori). Three of the artists showed moderate positive correlations between pitch register and vibrato width (Bell, $r = .55$; Mutter, $r = .40$; Midori, $r = .57$). The width of Perlman’s vibrato did not correspond with changes in pitch register ($r = .09$) (see Table 2).

Table 2

Correlations Between Pitch Register and Vibrato Rates and Widths of the Four Artists

<table>
<thead>
<tr>
<th>Artist</th>
<th>Rate $r$</th>
<th>Width $r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perlman</td>
<td>.14</td>
<td>.09</td>
</tr>
<tr>
<td>Bell</td>
<td>-.28</td>
<td>.55</td>
</tr>
<tr>
<td>Mutter</td>
<td>-.09</td>
<td>.40</td>
</tr>
<tr>
<td>Midori</td>
<td>-.16</td>
<td>.57</td>
</tr>
<tr>
<td>Overall</td>
<td>-.08</td>
<td>.42</td>
</tr>
</tbody>
</table>
The overall mean of the four performers’ vibrato width was 62.87 cents (Mutter, \( M = 67.9 \) c; Midori, \( M = 59.56 \) c; Bell, \( M = 61.06 \) c; Perlman, \( M = 62.97 \) c), over a quartertone (50 c). Notes with a frequency above A5 (880 Hz) generally produced wider vibrato (\( M = 67.9 \) c) than notes in the lower register (\( M = 54.7 \) c). The minimum cent deviation produced during vibrato was 24 cents (1/8 tone) and the maximum was 129.2 cents, more than a semitone. Both minimum and maximum widths were produced during tones with fundamental frequencies above 1000 Hz.

**Table 3**

*Performers’ Means for Vibrato Rates and Widths*

<table>
<thead>
<tr>
<th>Artist</th>
<th>Mean Rate (Hz)</th>
<th>Mean Width (Cents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perlman</td>
<td>6.46</td>
<td>62.97</td>
</tr>
<tr>
<td>Bell</td>
<td>6.24</td>
<td>61.06</td>
</tr>
<tr>
<td>Mutter</td>
<td>6.73</td>
<td>67.90</td>
</tr>
<tr>
<td>Midori</td>
<td>7.10</td>
<td>59.56</td>
</tr>
<tr>
<td>Overall</td>
<td>6.63 (sd=.37)</td>
<td>62.87 (sd=3.63)</td>
</tr>
</tbody>
</table>

The mean vibrato rate of the four performers was 6.63 Hz. The average vibrato rates also varied between performers (Mutter, \( M = 6.7 \) Hz; Midori, \( M = 7.1 \) Hz; Bell, \( M = 6.2 \) Hz; Perlman, \( M = 6.46 \) Hz) (see Table 3). A relationship was not found between rate of vibrato and pitch register of tones (\( r = -0.08 \)). The lack of correlation between vibrato rate and pitch register was the most consistent category between the four performers in this study (see Table 3).

**Discussion**

Data in this study indicated that vibrato width is related to the dynamic level and pitch register of a given tone, whereas vibrato rate correlates positively with dynamic level, but not the pitch register, of a given tone. While some consistencies were noted between performers, such as the lack of relationship between the rate of vibrato and the pitch register of the note, other aspects of vibrato varied from performer to performer. For example, dynamic level and rate produced a moderate correlation of \( r = .44 \), however individual performers produced correlations ranging from .93 (Midori) to .44 (Perlman). The degree to which vibrato width related to dynamic level between the four artists may be attributed to a number of additional variables such as: artistic choice, habit strength, chosen tempo, or chance. Further research on this topic, with an increased participant pool, would shed light on the differences between artists.

A consistent observation in this study was the lack of relationship between pitch register and vibrato rate. Results of previous research regarding the vibrato
rate of upper and lower string instruments are inconsistent. Allen and Geringer (2004) found no significant difference between the vibrato rate of violinists and cellists, while other studies found that low string instruments vibrated at slower rates than the violin (Papich & Rainbow, 1974; Reger, 1932).

The excerpt used in this study had a range of over three octaves and it would appear from the results that vibrato rate was not affected by pitch register. It is possible that low string instruments sometimes vibrate at a slower rate for reasons other than pitch register. One possible explanation is the difference in size between the string instruments. Production of an identical vibrato width between a violinist and a cellist would require the cellist to move farther on the fingerboard and therefore faster, to maintain the same rate. Reger (1932) concluded that the difference in vibrato rates was not due to size, but artistic choice. More research is needed to clarify whether there is a difference, and if so, the reasons for the difference.

A positive correlation was found between pitch register and vibrato width. Contrary to some pedagogical suggestions that higher frequencies require a narrower vibrato (Applebaum, 1986; Lucktenberg, 1994), analysis of performances in this study found that notes above 900 Hz (Bb5) generally were associated with wider vibrato ($M = 67.9$ cents) than notes in lower registers ($M = 54.7$ cents). Although this difference is relatively small, it demonstrates that width does not decrease in the upper range; rather it increases or remains the same despite the reduction in physical distance required to perform comparable vibrato. This information seems important when describing the correct vibrato motion to students. Requiring the student to minimize the width of the vibrato in the upper positions to maintain a musical width of one-quarter tone may increase the possibility of tension in the left hand. Based on the information collected from these four artists, it appears acceptable for width to increase in the upper positions of the instrument.

The degree of correspondence between pitch register and width did vary among individual artists. Midori, Bell, and Mutter all demonstrated wider vibrato in the upper register than in the lower register. These performers’ average increase was 13 cents in the higher register. Perlman was the exception, as his vibrato did not vary with pitch register. The difference in his vibrato width between the lower and higher registers was only 2.3 cents.

The mean vibrato width of the four artists was slightly greater than a quartertone and sometimes approached a half step. The average vibrato rate was 6.63 Hz. Midori demonstrated the fastest mean vibrato rate, averaging 7.1 Hz, and Bell demonstrated the slowest mean vibrato rate, 6.24 Hz. These rates correspond to some of the rates proposed by pedagogues and early researchers (Fischbach, 1998; Hollinshead, 1932; Potter, 1980; Reger, 1932; Rolland et. al., 2000; Seashore, 1936).

Analyses in this study show that vibrato width and rate are not constant and
vary from person to person, based on musical choice, dynamic level, and pitch register, and probably other factors. One practical suggestion that teachers might make is to have students vary the width and rate of their vibrato for expressive purposes. In particular, during forte passages, a wider vibrato appears to be utilized while a narrower vibrato may be used during piano passages. It seems prudent to recognize that vibrato rates and widths are affected by many contextual factors and avoid making global statements that do not apply to every musical situation, such as limiting the width in the upper range of the instrument or suggesting that all vibrato width should be around one-quarter tone. The individual artists in this study varied the width of vibrato sometimes to over one half step.

Caution should be taken when considering the results of this study. A small sample size was analyzed with only four artists performing the opening of only one piece. Increasing the number of performers and pieces or including stylistic and contextual variables may produce entirely different results. An increased sampling of the same performers could alter the results of this study. More information is needed to clarify the composition of a beautiful vibrato.

String students should have the opportunity to learn to vibrate with a beautiful sound. Further research examining other contextual factors will help shed light on this musical and technical challenge. An investigation of professional musicians and preferences of various vibrato rates and widths in many contexts is important to advancing a clear pedagogical method for teaching vibrato. Further investigations that include the physical aspects involved in creating the correct vibrato motion are also necessary to advance vibrato teaching techniques. Carefully designed research that provides additional information is needed to accurately describe and guide further teaching practice.

References


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When a manuscript is received the author of the manuscript or the lead author of a multi-authored manuscript is notified of its receipt by the editorial office. Three members of the editorial board will review manuscripts in a blind review process. Reviewers will evaluate each manuscript based on the following criteria: (1) importance of the problem under investigation, (2) discussion of the problem and its importance, (3) review of relevant literature and/or theory, (4) application of procedures appropriate to the purpose of the study, (5) presentation and analysis of data, (6) validity of conclusions given the data reported and/or the literature cited, (7) writing mechanics, communicability, and conformity to style guide, and (8) quality of research endeavor. Each reviewer will either (1) suggest
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