A Descriptive Analysis of Performance Models' Intonation in a Recorded Excerpt from Suzuki Violin School Volume I

By: John M. Geringer, Rebecca B Macleod, Julia C. Ellis

Geringer, J. M., MacLeod, R. B., Ellis, J. C. (2013). A descriptive analysis of performance model's intonation in a recorded excerpt from Suzuki Violin School Volume I. *String Research Journal, 4*, 71-88. Copyright © 2013 American String Teachers Association. 10.1177/194849921300400405

Abstract:

Given the importance of modeling in teaching young students to perform, particularly in the Suzuki approach, as well as the importance of playing intune, we studied intonation performances on four recordings of Suzuki Violin School Volume I. These are performances that many string teachers recommend as models for beginning string students. We also asked whether performances conform to a theoretical tuning system such as equal temperament (ET) or Pythagorean tuning. We analyzed the first eight measures and the repeat of Minuet I (Bach) in G-major. Individual note deviations of performers ranged from -17 cents to +26 cents relative to the accompaniment, although most deviations were smaller. Overall, three performers tended to be closer to Pythagorean (which is slightly sharper than ET for most major intervals) while one was closer to ET. However, inspection of individual intervals showed that two of the performers were often sharp relative to both tuning systems, particularly for minor seconds and thirds, and major thirds. No performer consistently conformed to either tuning system across the span of notes in the excerpt.

Keywords: string instruments | intonation | violin performance | string music education | Suzuki method

Article:

A large percentage of pedagogical and research literature addresses the importance of accurate intonation in ensemble and solo performance. Moreover, responses to intonation can engage listeners' attention over other elements of music (Geringer & Madsen, 1981, 1989, 1998;

Johnson & Geringer, 2007). In Geringer and Madsen (1998), for example, music major listeners responded primarily to intonation compared to all other rating categories in judging a number of performance aspects. Additional evidence of the value given to tuning and pitch accuracy is found throughout music behavior: for example, music contests and festivals at all levels include intonation ratings on adjudication forms. Music ensemble and studio teachers spend class and lesson time on tuning, discussing intonation, and sometimes instruct students to use alternate key or finger combinations to produce subtle pitch variations, and so on. Given the importance of intonation in music performance, and the importance of modeling in teaching string students how to perform particularly in the Suzuki approach to teaching, we investigated performances that many string teachers recommend as models for beginning violin students.

A number of researchers have noted a general tendency to perform with sharp rather than flat deviation in many contexts, particularly for older, more experienced musicians (Geringer, 1978; Geringer & Madsen, 1987; Geringer & Witt, 1985; Kantorski, 1986; Madsen, 1974; Morrison, 2000; Salzberg, 1980; Sogin, 1989; Yarbrough, Morrison, & Karrick, 1997). However, in some contexts a flatness tendency was found (Brittin, 1993; Duke, 1985); college wind players performed intervals less sharp than less experienced wind players.

Researchers in string performance and pedagogy also have shown an interest in intonation (e.g., Geringer & Witt, 1985; Kantorski, 1986; Salzberg, 1980; Sogin, 1989). In an early investigation of violin intonation, Greene (1936) studied six professional violinists' (including members of the St. Louis Symphony) unaccompanied performances of five intervals while playing standard literature. Greene sought to determine whether the intonation tendencies of the violinists most closely fit the equally tempered (ET) scale or the just (sometimes called the natural scale) scale, that is, whether they typically contracted or expanded certain intervals. Greene found that they performed in neither scale, however, players agreed in the direction of deviation from ET with only minor deviations in extent of deviation. Compared to both equal and just scales, the violinists contracted the minor seconds and thirds and expanded the major seconds and thirds. Perfect fourths approximated both scales. Greene concluded that this pattern of deviation most approximated Pythagorean (PYT) intonation, wherein major intervals are expanded and minor intervals are contracted relative to equally tempered intervals. He found no difference in ascending versus descending patterns (a summary of the various scale tuning systems can be found in Radocy & Boyle, 2003, pp. 225-230).

Nickerson (1949) studied solo and ensemble performances of Haydn's Emperor Quartet, in which each of the four quartet members performs the same melody within the same harmonic context. Performances of six different college string quartets were analyzed. Consistent with Greene's results, Nickerson found that performances of both solo and ensemble performances departed from equal tempered intonation, particularly on thirds and sixths (where differences between theoretical values of tuning systems are most pronounced). Although there were some differences between solo and ensemble performances of thirds, both performance contexts corresponded more closely to PYT intonation, however, performances did not conform completely to any theoretical temperament system. Nickerson concluded that "departures from

average or theoretical performance will be the rule and not the exception" (p. 595). He also found evidence for melodic based patterns of performed intonation rather than harmonic (vertical) based intonation patterns.

More recently, Loosen (1993) asked eight professional violinists to play ascending and descending three-octave C major scales without vibrato. Loosen found that just intonation fit the data most poorly, but that PYT and ET scales fit the data equally well when using the tonic as reference point. Analysis of individual intervals found that performances were approximately halfway between interval sizes defined in PYT and ET intonation. Departures were not different in ascending versus descending directions. Intonation deviated the greatest from theoretical models in performances of the highest octave (C6 - C7). Loosen added that it does not seem meaningful to try to fit data from real world violin performances to theoretical intonation systems, and noted that in daily performances, violinists never play exactly in one tuning or another.

Wind players' intonation performance also has been studied (e.g., Brittin, 1993; Duke, 1985; Morrison, 2000). Mason's (1960) analysis of solo and ensemble performances of two university woodwind quintets found a lack of conformity to any of the theoretical intonation systems. Solo performances differed little from ensemble performances and showed the greatest departure from just intonation. One of the quintets deviated least from ET and one showed the least variation from PYT. In 1998, Karrick studied the intonation tendencies of wind players performing harmonic intervals. Performances showed the least deviation from ET tuning. Kopiez (2003) examined intonation patterns of two professional trumpet players. Their performances were closer to ET than just intonation, which Kopiez attributed to long-term intonation practice with equal temperament. An earlier investigation showed that musical experience and training appear to impact listeners' preference for different intonation systems. Loosen (1995) found that violinists preferred sharper tuning of scales (closer to Pythagorean tuning) compared to pianists who preferred equal-tempered scales while non-musicians had no preference.

Modeling is a frequently used method in music teaching. Bandura (1977) underscored the importance of modeling in many aspects of human learning. Dickey (1992) reviewed research across various types of modeling in music classes and concluded that modeling was an effective means of communication in music classrooms and that modeling is often more effective than verbal descriptions. Furthermore, in order for teachers to be effective when modeling, they must have the necessary skills to model both correctly and incorrectly. Dickey also noted that the use of prepared recordings as a model appears to be an effective strategy for both elementary and college students and that musical models must be accurate models. In a series of investigations, Goolsby (1996, 1997, 1999) observed that experienced teachers spent more than twice as much time in non-verbal demonstration and modeling than did younger teachers. Moreover, Sang (1987) observed a strong relationship between teachers' modeling abilities, time spent modeling, and student performance levels. MacLeod (2010) observed instructional strategies of experienced band and orchestra teachers. Among other differences, she found that orchestra teachers modeled with their instrument, utilized echo techniques, and performed along with the

students with greater frequency than did band teachers. Across all observations, orchestra teachers demonstrated with an instrument more than three times as often as the band teachers.

Modeling is a technique used extensively in the Suzuki method (Kendall, 1996; Scott, 1992), based on the idea that individuals can learn to play musical instruments in the same way they learn to speak. The modeling of excellent performances occurs with respect to several of the main principles: "Begin early (listening from birth, playing from 2 1/2 or 3 years of age); postpone reading until the child is technically well established; use carefully graded, musically excellent literature with recordings to match (recorded for repeated listening); use repetition and reinforcement effectively through constant review of previously learned music" (Kendall, 1996, p. 43-44). Kendall also wrote, "What is appropriate for children to hear may be controversial, but the fact that they absorb whatever is pervasive in their early years of listening can hardly be denied" (p. 45-46).

Given the importance of intonation in music performance, and the importance of modeling in teaching string students how to perform particularly in the Suzuki approach to teaching, we thought it would be useful to analyze performances that many string teachers recommend as models for beginning violin students. We were interested specifically in the intonation of the performance models on currently available recordings of Suzuki Violin School Volume I and investigated intonation tendencies for each performer. Secondarily we questioned whether performances fit closest to equal tempered or Pythagorean tuning. Were pitch tendencies of the four performers similar in relation to the theoretical tuning systems? What were the differences in intonation between these model performers?

Method

Recordings

We obtained copies of the four compact disc recordings currently available for purchase of Suzuki Violin School Volume I. These included the recordings by violinists Shinichi Suzuki (1979), David Nadien (1986), David Cerone (1999), and the Revised Edition CD by William Preucil, Jr. (2003). All recordings include piano accompaniment. We selected one section of one excerpt for analysis: the first eight measures and the repeat of selection 13 in Suzuki Violin School Volume I, which is titled Minuet I, by J. S. Bach (this piece was adapted and arranged from Minuett III of the Suite in G minor for Klavier, BWV 822). The excerpt is in G-major, with several occurrences of the intervals that are among the most different between temperament systems (Radocy & Boyle, 2003): the major third, major sixth, and major seventh (see Figure 1). Durations of notes (most were quarter and half notes) during this excerpt were sufficiently long to provide reliable analysis of performed pitches.

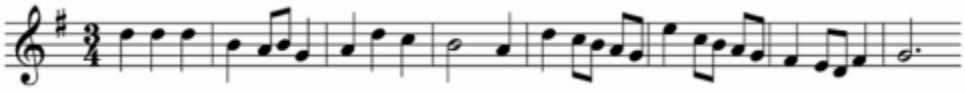


Figure 1. First eight measures of *Minuet 1* (Bach) from *Suzuki Violin School Volume 1*. These measures are repeated and were analysed both times.

Analysis Procedures

The selected excerpts from the four source CDs were transferred digitally to computer files for editing. The piano accompaniments were isolated from the violin tracks using Adobe Audition (v. 4.0) and Sony Spectral Layers (v. 1.0.2) software. This enabled analysis of the fundamental frequencies of the performed violin tones to be uninfluenced by the frequencies and related harmonics contributed by the piano accompaniment that were present in the original recording. Selected tones of the respective piano parts were analyzed also, to provide a reference point for each violinist's tuning. All frequency analyses were accomplished with Praat, v. 5.3.23 (Boersma & Weenink, 2012). We adjusted pitch settings in Praat so that the range of fundamental frequencies encompassed the performed notes of the soloist (D4 to E5). We set the frequency sampling rate to 100 Hz (one sample every .01 second).

Two of us independently analyzed the frequencies of 10 tones per performer and all of the notes of one performer. Reliability was high: the Intraclass Correlation Coefficient using an absolute agreement definition was .98. Thirtyfour tones per performer were analyzed across the 16 measures (the first 8 measures of the piece and the repeat). This included all quarter notes, half notes, and four of the eighth notes that we considered important because of their harmonic function. Repeated notes (for example, the three quarter notes in the first measure) were assigned a single value, the average of the repeated tones. We analyzed the 34 tones in their intervallic relationships to both the tonic and to the immediately preceding note. Table 1 shows the intervals that we analyzed, and the theoretical values (in cents) that would be expected if performers adhered strictly to the Pythagorean and equal tempered tuning systems.

Table 1. Intervals Analyzed in Excerpt: Relationships between Pythagorean and Equal Temperament

Interval	Cent Values of Pythagorean Relative to Equal Temperament
Major Intervals:	
Second	+4
Third	+8
Perfect Fourth	-2
Perfect Fifth	+2

Sixth	+6
Seventh	+10
Minor Intervals:	
Second	-10
Third	-6

Results

We first analyzed the consistency of the four violinists between the first and the repeat playing of the first eight measures. Table 2 shows the performers' overall cent deviation from their respective piano accompaniments. The table illustrates that the two most consistent performers, B and D had high correlations (r = .90 and .89 respectively) between the initial performance and the repeat. However, they also had the most variation in intonation within the eight measures. Standard deviations for these two ranged from 7.23 to 10.95 (cents). Lower correlations occurred with violinists A and C between the first and second playing of the eight measures (r = .62 and .74, respectively). Overall, three of the four performers performed sharp relative to their respective piano accompaniment, while performer C deviated, on average, just slightly below the piano (M = -1.47 cents) the first time through, and just above the piano on the repeat (M = 0.76 cents).

Table 2. Mean Turning in First Eight Measures and Repeat (in Cents Relative to Piano Accompaniment)

Performer	*Mean*	*SD*	*Pearson Correlation*
A			
First Eight Measures	5.00	5.83	
Repeat	4.82	4.64	.62
B			
First Eight Measures	5.53	10.95	
Repeat	2.65	9.45	.90
C			

First Eight Measures	-1.47	6.61	
Repeat	0.76	6.68	.74
D			
First Eight Measures	4.47	7.23	
Repeat	6.76	9.69	.89

Tables 3 and 4 show the overall deviations from Pythagorean (PYT) and equal tempered (ET) tuning. Performer C deviated most on average and in total from PYT, playing on the low (flat) side of most intervals according to that tuning system. The other three were closer to PYT: Performer D was the most sharp and averaged 1.5 cents sharp, A was just slightly sharp, and B was just slightly flat relative to PYT. In contrast, performers A, B, and D consistently were sharp relative to ET (which was calibrated slightly differently for each performer relative to the tuning of their individual piano). Performer C deviated very little on average from his accompaniment or from ET (M = -0.35 cents, SD = 6.64) with an overall total deviation of only 12 cents lower than the piano.

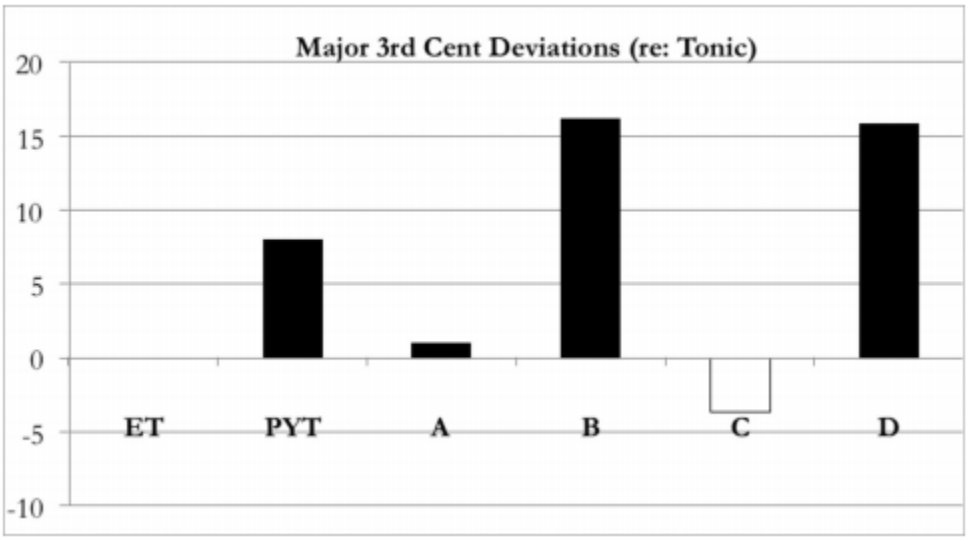
Table 3. Overall Deviation (in cents) from Pythagorean Tuning

Performer	*Mean*	*SD*	Low Deviation	High Deviation	Total Deviation
A	4.91	5.19	-6	+15	167.0
B	4.08	10.18	-11	+26	139.0
C	-0.35	6.64	-12	+16	-12.0
D	5.62	8.50	-13	+26	191.0

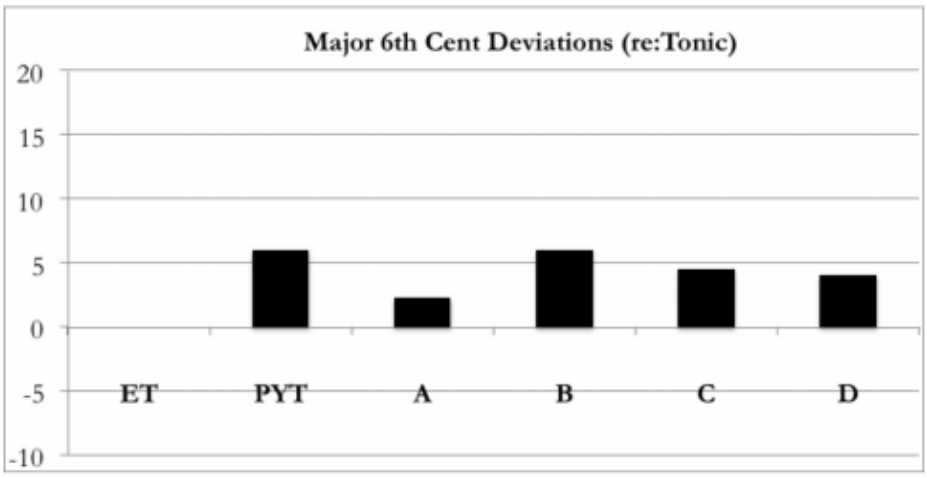
Intonation performances for individual intervals are shown in Figures 2 and 3 relative to equal temperament (ET) adjusted for the tuning of each piano (ET is shown as the zero point in all figures). The theoretical Pythagorean tuning (PYT) is shown as well. Figure 2 illustrates analyzed intervals compared to the tuning of the tonic note (G), and Figure 3 presents intervals compared to the previous note played. Figure 2A shows two performers were sharp on the major third compared to PYT (B & D). The other two soloists were close to ET, performer A was only slightly sharp and performer C was a few cents flat to ET. In Figure 2B, in performing the major sixth (E5) relative to the tonic, all were slightly sharp compared to ET with performer B closer to PYT, and the others were between the two tuning systems. In the major seconds (Figure 2C),

performer A played sharper than PYT while the other three performers were very close to ET. Deviations from the ET major seventh demonstrate a larger difference between soloists, although all were sharp compared to ET. Three performers were closer to PYT than to ET (B & D were sharper than PYT, and A was just below PYT). Performer C was a few cents sharp relative to ET for the seventh.

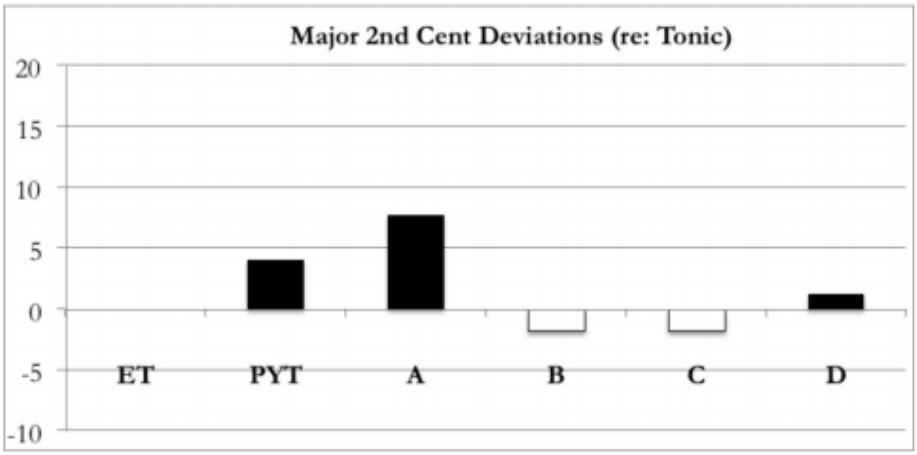
Analysis of intervals relative to the previous note shows similar patterns. For the major second, three performers were closer to PYT than to ET, and performer C was slightly flat compared to ET (Figure 3A). The same pattern exactly was present for the major sixth (Figure 3C). Performance tendencies for the major third show two players slightly sharp to PYT (B & D), and the other two were between ET and PYT (A & C in Figure 3B). In contrast, for the two minor intervals relative to the previous note (see Figure 3D & E), wherein PYT is flat relative to ET, a much different pattern is present. None of the performers played as flat as PYT for these two intervals. Performer C was the only one who performed flatter than ET, and that was only on the minor second. The others were sharp relative to ET (and even more to PYT) on the minor second, and all four were sharp on the minor third. Performers B & D were particularly sharp on both these minor intervals.



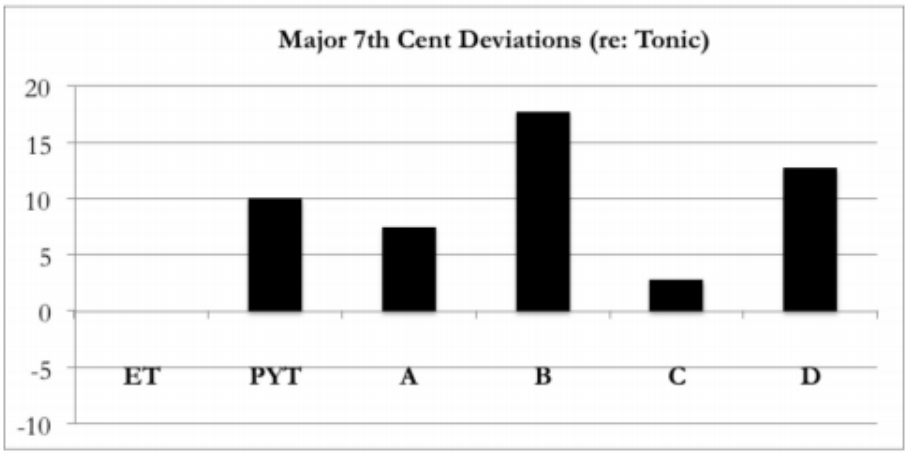
A



B

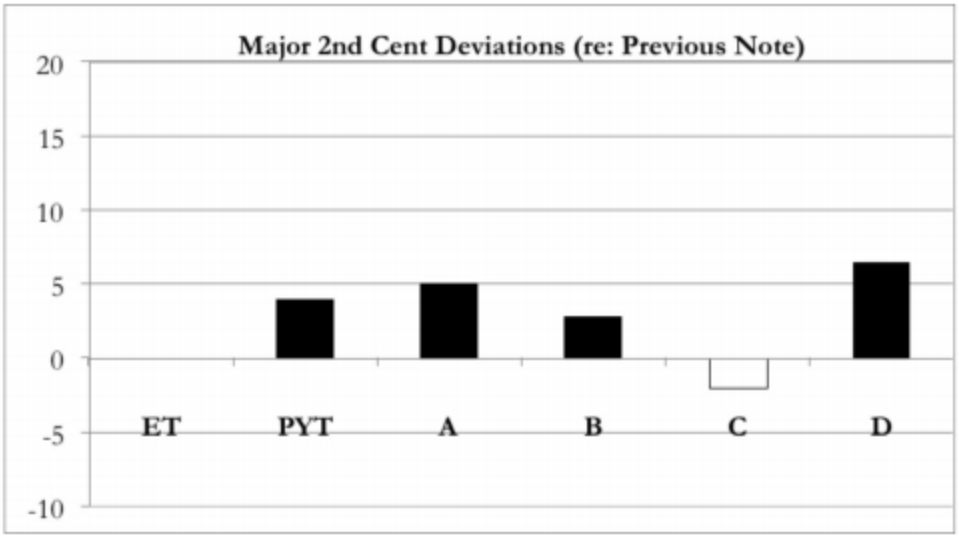


C

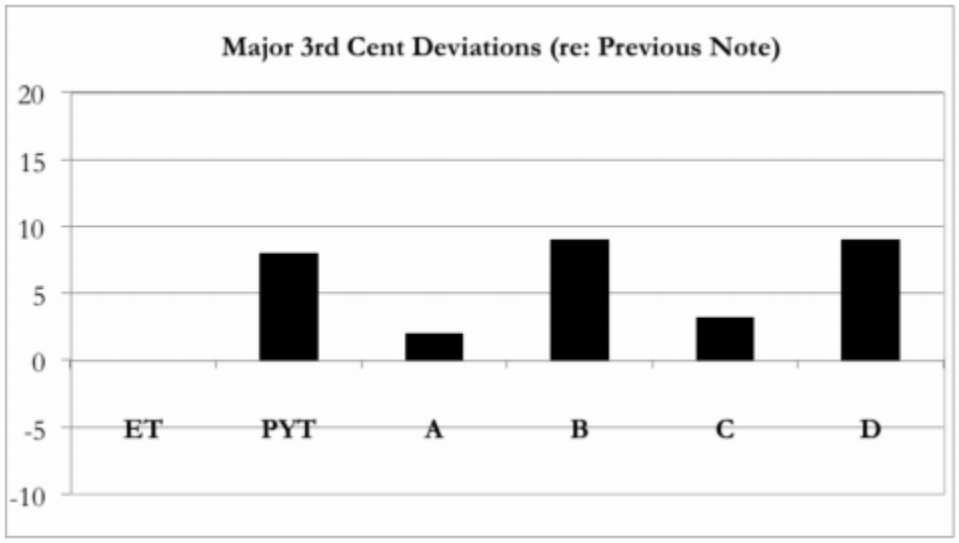


D

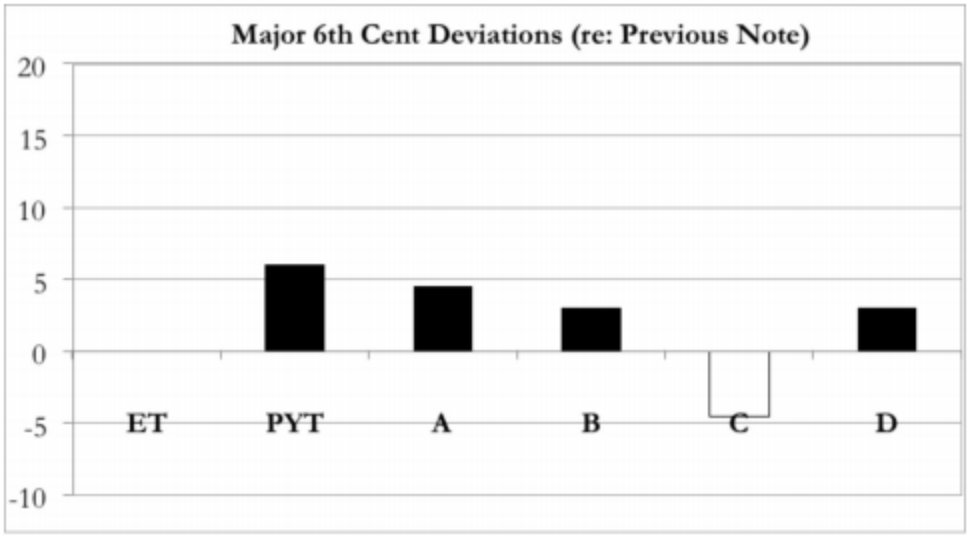
Figure 2 (A-D) Cent deviations (from ET) of performed intervals relative to tonic


Major 2nd Cent Deviations (re: Previous Note)
20
15
10
5
0
-5
-10
ET
PYT
A
B
C
D

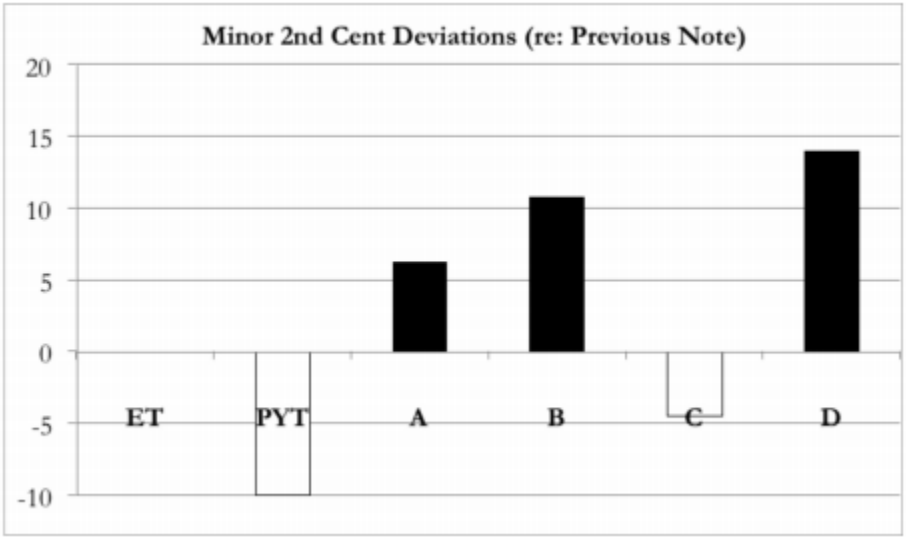
A


Major 3rd Cent Deviations (re: Previous Note)
20
15
10
5
0
-5
-10
ET
PYT
A
B
C
D

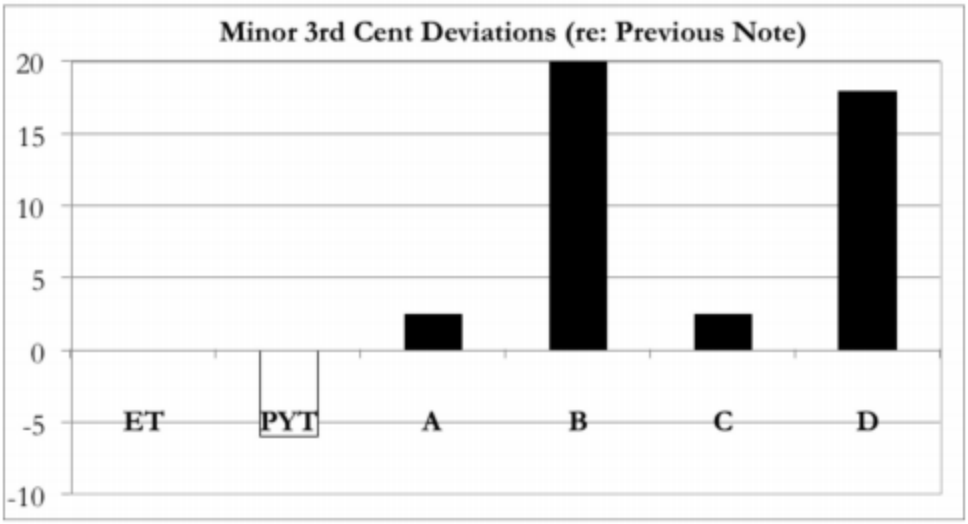
B


Major 6th Cent Deviations (re: Previous Note)
20
15
10
5
0
-5
-10
ET
PYT
A
B
C
D

C


Minor 2nd Cent Deviations (re: Previous Note)
20
15
10
5
0
-5
-10
ET
PYT
A
B
C
D

D



E

Figure 3 (A-E) Cent deviations (relative to ET) of performed intervals relative to previous note.

Discussion

Performers on these four recordings of the Bach *Minuet I* in *Suzuki Violin School Volume I* did show differences in intonation tendencies. No performer deviated more than 26 cents in either direction for any note. Deviations from the accompaniment tended to be in the sharp direction for three performers, in both frequency and magnitude. This outcome fits with previous research (cf., review of literature), and would be predicted if performers tended toward Pythagorean tuning when playing in a major key. Two of the performers (B & D) did tend to conform more to PYT than to ET on most major intervals, but not on the minor intervals relative to the previous note (both were quite sharp on the minor 2nd & 3rd). Performer A's average deviations were in between the two tuning systems throughout, with the exception of the two minor intervals, on which he was a few cents (2-6) sharp compared to ET, and 10 - 15 cents sharper than PYT. The fourth performer, C was closer to ET than PYT on all intervals with one exception, and that was by only two cents (major 6th relative to the tonic). Clearly the performers differed in their intonation tendencies.

Deviation scores for all notes were relative to the tuning of each performer's accompanying piano. We observed that the pianos were tuned according to usual tuning procedures in ET, that is, a few cents variation in tuning was present from note to note in all the accompaniments. After isolating the piano and soloist parts, we analyzed frequencies of piano tones where possible, and calculated each piano's average deviation away from A-440 Hz. This mean served as the basis for our analysis of individual performer's deviations from each piano (and from ET). It is possible that some soloists' deviations on individual notes were greater or smaller, depending upon the tuning of that specific note on the piano. As in all accompanied performances, the piano provides a only a template for tuning, that is, if a soloist tunes to the A

of the piano, that does not insure that all other notes would be in tune. Further, although the pianos were not tuned precisely to the theoretical frequencies of ET, it is also likely that performers do not conform exactly to any tuning system.

Unlike some of the earlier studies, in which violinists performed without accompaniment in order to determine the degree of conformity to theoretical tuning systems (Greene, 1936; Nickerson, 1949; Loosen, 1993), the present study included solos that were recorded with piano accompaniment. It can be argued, therefore, that this did not represent a valid test of players' congruence with Pythagorean tuning. However, our main purpose was to see what sort of model with regard to intonation was being provided in these recordings that do include a piano accompaniment. Most repertoire for this level of study does include piano accompaniment.

One difficulty in attempting to determine whether performers conform to one tuning system or another is the degree of note-to-note variation among individuals. Further, if one consistently plays sharp (in a major key), then generally that would fit more closely to PYT, as opposed to playing on the flat side which would fit more with just intonation. For example, two of the performers were consistently sharp throughout the eight measures and the repeat. That occurrence by default puts them closer to PYT than to ET. However, for the minor intervals that occurred, they were sharp also, deviations that do not conform to any tuning system. Both Nickerson (1949) and Loosen (1993) noted that departures from any one theoretical system of tuning, or from an individual's mean are to be expected in real world performance.

Teaching students to play "in-tune" is both important and difficult. Based on the results of this study, intonation variations exist on the Suzuki recordings that commonly serve as models for our young students. Teachers recommend that students listen to these recordings in order to learn and acquire many other musical skills beyond that of "good intonation." However, repeated listening to any model may impact how students conceive of pitch or affect their preference for different intonation models (Loosen, 1995). It was not the purpose of this study to determine which Suzuki recording provides a more "in-tune" model; it seems more important to ask what might be considered "in-tune"? How might a student learn to perform "in-tune" when the models we provide are inconsistent? Previous investigations in other contexts also have shown that string players do not strictly conform to any of the theoretical tuning systems (Green, 1936; Nickerson, 1949; Loosen, 1993).

Perhaps a more important question concerns what is meant by accurate intonation? What might be expected of an excellent intonation model? The basis for what is "accurate" appears to vary with different contexts. Differences might be expected according to the level of the performer, the difficulty of the music, whether the piece is accompanied or not, and so on. If playing with a piano, then comparing deviations to the piano seems reasonable. What should the standard be when playing in chamber or large ensembles, beyond the tuning note?

Because music is an aural art, then the ultimate choice regarding performance models should be based on listening. Future research could investigate how listeners respond to these performance models. How would listeners judge the intonation of the models? Are there other important differences present in the recordings such as tone, phrasing, dynamic contrast, and so

on? Young students who listen to these recordings repeatedly may model many aspects of the performance, and it seems important to identify all aspects of what the model provides.

References

Bandura, A. (1977). Social learning theory. Englewood Cliffs, N.J.: Prentice-Hall.

Boersma, P., & Weenink, D. (2012). Praat: Doing phonetics by computer (Version 5.3.23) [Computer program]. Retrieved September 10, 2012, from http://www.praat.org/

Brittin, R. V. (1993). Effects of upper and lower-register accompaniment on intonation. Journal of Band Research, 29, 43-50.

Dickey, M. R. (1992). A review of research on modeling in music teaching and learning. Bulletin of the Council for Research in Music Education, 113, 27-40.

Duke, R. A. (1985). Wind instrumentalists' intonational performance of selected musical intervals. Journal of Research in Music Education, 33, 101-111.

Geringer, J. M. (1978). Intonational performance and perception of ascending scalar patterns. Journal of Research in Music Education, 26, 32-40.

Geringer, J. M., & Madsen, C. K. (1987). Programmatic research in music: Perception and performance of intonation. In C. K. Madsen & C. K. Prickett (Eds.), Applications of research in music behavior (pp. 244-253). Tuscaloosa: University of Alabama Press.

Geringer, J. M., & Madsen, C. K. (1989). Pitch and tone quality discrimination and preference: Evidence for a hierarchical model of musical elements. Canadian Music Educator: Special Research Edition, 30, 29-38.

Geringer, J. M., & Madsen, C. K. (1998). Musicians' ratings of good versus bad vocal and string performances. Journal of Research in Music Education, 46, 522-534.

Geringer, J. M. & Madsen, C. K. (1981). Verbal and operant discrimination/preference for tone quality and intonation. Psychology of Music, 9, 26-30.

Geringer, J. M., & Witt, A. (1985). An investigation of tuning performance and perception of string instrumentalists. Bulletin of the Council for Research in Music Education, 85, 90-101.

Goolsby, T. W. (1996). Time use in instrumental rehearsals: A comparison of experienced, novice, and student teachers. Journal of Research in Music Education, 44, 286-303.

Goolsby, T. W. (1997). Verbal instruction in instrumental rehearsals: A comparison of three career levels and preservice teachers. Journal of Research in Music Education, 45, 21-40.

Goolsby, T. W. (1999). A comparison of novice and expert music teachers' preparing identical band compositions: An operational replication. Journal of Research in Music Education, 47, 174-187.

Greene, P. C. (1936). Violin performance with reference to tempered, natural, and Pythagorean intonation. In C. E. Seashore (Ed.), Studies in the psychology of music, 4 (pp. 232-251). Iowa City: University of Iowa.

Johnson, C. M., & Geringer, J. M. (2007). Predicting music majors' overall ratings of wind band performances: Elements of music. Bulletin of the Council for Research in Music Education, 173, 25-38.

Kantorski, V. J. (1986). String instrument intonation in upper and lower registers: The effects of accompaniment. Journal of Research in Music Education, 34, 200-210.

Karrick, B. (1998). An examination of the intonation tendencies of wind instrumentalists based on their performance of selected harmonic intervals. Journal of Research in Music Education, 46, 112-127.

Kendall, J. (1996). Suzuki's mother tongue method. Music Educators Journal, 83 (1), 43-46.

Kopiez, R. (2003). Intonation of harmonic intervals: Adaptability of expert musicians to equal temperament and just intonation. Music Perception, 20, 383-410.

Loosen, F. (1993). Intonation of solo violin performance with reference to equally tempered, Pythagorean, and just intonations. Journal of the Acoustical Society of America, 93, 525-539.

Loosen, F. (1995). The effect of musical experience on the conception of accurate tuning. Music Perception, 12, 291-306.

MacLeod, R. B. (2010). A comparison of instructional strategies used by experienced band and orchestra teachers when teaching a first-year class an unfamiliar excerpt. Bulletin of the Council for Research in Music Education, 185, 49-61.

Madsen, C. K. (1974). Sharpness and flatness in scalar vocal performance. Science de l'Art: Scientific Aesthetics, 9, 91-97.

Mason J. (1960). Comparison of solo and ensemble performance with reference to Pythagorean, just and equi-tempered intonation. Journal of Research in Music Education, 8, 31-38.

Morrison, S. J. (2000). Effect of melodic context, tuning behavior, and experience on the intonation accuracy of wind players. Journal of Research in Music Education, 48, 39-51.

Nickerson, J. F. (1949). Intonation of solo and ensemble performance of the same melody. Journal of the Acoustical Society of America, 21, 593-595.

Radocy, R. E., & Boyle, J. D. (2003). Psychological foundations of musical behavior. Springfield, IL: Charles C. Thomas.

Salzberg, R. S. (1980). The effects of visual stimulus and instruction on intonation accuracy of string instrumentalists. Psychology of Music, 8, 42-49.

Sang, R. C. (1987). A study of the relationship between instrumental music teachers' modeling skills and pupil performance behaviors. Bulletin of the Council for Research in Music Education, 91, 155-159.

Scott, L. (1992). Attention and perseverance behaviors of preschool children enrolled in Suzuki violin lessons and other activities. Journal of Research in Music Education, 40, 225-235.

Sogin, D. W. (1989). An analysis of string instrumentalists' performed intonational adjustments within an ascending and descending pitch set. Journal of Research in Music Education, 37, 104-111.

Yarbrough, C., Morrison, S. J., & Karrick, B. (1997). The effect of experience, private instruction, and knowledge of directional mistunings on the tuning performance and perception of high school wind players. Bulletin of the Council for Research in Music Education, 134, 31-42.