Initial Movement and Continuity in Vibrato among High School and University String Players

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Abstract:

The purpose of the present study was to investigate aspects of vibrato performance among high school and university string players. The main questions were to determine whether students consistently initiate vibrato in an upward or downward direction and whether players vibrate continuously when performing slurs. Forty high school, and university violin and cello students played exercises that included tones performed with and without vibrato. We measured direction and magnitude, of change when initiating vibrato, pitch levels of vibrated and nonvibrated tones, and duration of nonvibrato when performing slurs. Results showed that these high school and university players did not reveal consistent, initial vibrato movements in either direction or magnitude. Performers vibrated both above and below conceived pitch, rather than only upward or only downward. All performers stopped vibrating during the transition between slurred notes. Mean duration of nonvibrato portions of university students (0.42 second) was slightly less than that of high school students (0.50 second). Implications of these results for string pedagogy are discussed.

Article:

Vibrato is frequently described as a vital feature in string performance that enhances musicality. Pedagogues agree that a beautiful vibrato is balanced, even, consistent, and free of tension. However, despite widespread agreement about the importance of vibrato, several fundamental aspects of vibrato performance are inconsistent within the pedagogical literature. As is discussed in the literature below, contradictions are apparent regarding the purported pitch center of vibrato and the direction of initial motion. In the present study, we attempted to address whether students initiate vibrato in an upward or downward direction, whether players vibrate continuously when performing slurs, and related aspects of pitch performance.

Empirical research about string vibrato was first published at the University of Iowa in the late 1920s and 1930s and was coordinated by Carl Seashore. Results of these studies (summarized recently by Geringer & Allen, 2004) revealed that vibrato rates of virtuoso performers ranged from 5.6 to 7 Hz and that mean vibrato width was ' approximately a quarter tone. Seashore (1938) concluded that the mean pitch of the vibrato cycle corresponds to the true pitch (with the exception of tendency tones); that is, vibrato oscillations extend both above and below conceived pitch. Subsequent investigation largely confirmed the results of the Iowa studies, including recent research by Geringer and Alien (2004), who noted, however, that in two studies, researchers found vibrato oscillations to be primarily upward in direction from conceived pitch (Flelcher, Blackham, & Geertsen, 1965; Papich & Rainbow, 1974).

Some of the pedagogical literature about vibrato does reveal agreement. To promote balance and freedom, for example, most teachers and performers agree that vibrato is best introduced in a middle position with the second or third finger (Applebaum, 1986; Fischbach, 1998; Galamian, 1948; Gillespie, 1996; Hamann & Gillespie, 2004; Potter, 1980; Rolland, Mutchler, £ Hellebrandt, 2000). It is recommended that vibrato instruction commence once the student has mastered the correct left-hand position, demonstrates adequate hand-strength and flexibility, and plays reasonably in tune. The width and rate of vibrato oscillations vary in accordance with dynamics (Rolland et al., 2000): Loud passages require a wide slow vibrato, while soft passages use a narrower,

faster vibrato (Galamian, 1948; Lucktenberg, 1994; Potter, 1980; Rolland et al., 2000; Young, 1999). Violin vibrato is classified into three categories: wrist/hand, arm, and finger. All three are important to provide a variety of colors, but some disagreement exists as to which method provides the best vehicle for introducing vibrato to a beginner. Applebaum (1986) recommends that students learn all three vibrato types, beginning with the style that is most natural to the individual; others insist that arm or wrist vibrato is the most conducive to a free and balanced motion (Lucktenberg, 1994; Rolland et al., 2000; Suzuki, cited in Perkins, 1995). In contrast, cellists generally do not categorize vibrato in terms of method of production as do violinists, but refer to variations in speed and width of vibrato to create various expressive qualities in the music (Stowell, 1999).

String experts agree also that continuous vibrato is an important attribute. Galamian (1948) promoted vibrato practice with slurs to encourage constant vibrato through bow changes. Young (1999) creatively attached streamers or shaker devices to the arms of cellists so that disruptions in vibrato would create a visual or rhythmically audible disturbance. Fischer (1997) nolated an exercise that used continuous vibrato as fingers were silently placed and removed on another string. Lucktenberg (1994) recommended that the next finger stay near the string to increase the probability of continuous vibrato.

Perhaps the most inconsistent information concerns the initial direction of the vibrato motion. Descriptions of a backward motion (in the direction of the pegs) are more prevalent in pedagogical literature and are often notated in the form of exercises that begin on a pitch and oscillate to a pitch a half step below (Applebaum, 1986; Galamian, 1948; Hamann & Gillespie, 2004; Lucktenberg, 1994). However, some pedagogues believe that the initial motion should propel forward toward the bridge. Rolland et al. (2000) described the vibrato motion as "cyclical with no apparent beginning or end" and provided exercises that initiate with a flattened fingertip that immediately "propels forward" then returns to the starting position. Fischer (1997) described vibrato as a "forward-forward-forward" motion that moves toward the bridge and back to the original position, and Suzuki developed a sequence that promotes a forward motion (Perkins, 1995).

Furthermore, pitch center and initial direction of the vibrato motion as described in pedagogical literature do not always correspond. Some pedagogues recommend a forward direction (which would produce a higher frequency) but then indicate that the pitch should vibrate below and return to the original pitch (Fischer, 1997; Suzuki, as cited in Perkins, 1995). Opposing viewpoints suggest that the pitch begins in tune, and, with a backward motion, oscillates lower (Applebaum, 1986; Fischbach, 1998; Hamann & Gillespie, 2004). Some suggest that this is because the human ear would perceive vibrato that travels above the pitch as sharp (Galamian, 1948; Lucktenberg, 1994). Only a few of the pedagogues report that the pitch center is found in the middle of the vibrato and that oscillations occur both above and below the original pitch (Rolland et al., 2000; Young, 1999). Fischbach (1998) concluded that the pitch center of the vibrato likely varies from performer to performer and is not consistent.

The purpose of the present study was to address some of the fundamental aspects of vibrato discussed above. Recommendations of pedagogues are inconsistent as to the direction of initial vibrato motion. The discrepancy is extended when combined with descriptions of the purported pitch center of the vibrato. Although pedagogues have stressed the value of continuous vibrato during slurs, there is little if any research on this aspect of performance. Therefore, the main problems addressed were to determine the extent to which high school and university students in the United States initiate vibrato in an upward or downward direction and the extent to which string performers continue to vibrate during slurs. The following research questions were asked: Is the pitch level of high school and university violin and cello players the same when vibrating and when not vibrating? Are there differences in string players' initial vibrato movement in either direction or magnitude? Are there differences in pitch level when performing slurs with vibrato in ascending versus descending directions? Do high school and university string players vibrate continuously when performing slurs, or does the vibrato pattern stop for a brief period before and after the transition?

Comparisons were made in these aspects of vibrato performance between performer levels, instruments, and the four fingers used to vibrate. To address these questions, 20 high school and 20 university violin and cello

students played exercises that included tones performed with and without vibrato. The following aspects of vibrato tones were of interest: pitch levels of vibrated versus nonvibrated tones and of ascending slurs versus descending slurs, the direction and magnitude of change when initiating vibrato, and the duration of nonvibrato when performing slurs.

METHOD

The 40 participants in this study included: 10 high school student violinists, 10 high school student cellists, 10 university music-major violinists, and 10 music-major cellists. High school students were volunteer participants recruited from summer music camp at a large school of music in the southeastern United States. Students were members of the advanced orchestra at the camp and were in Grades 9-11. All had studied with private teachers for a minimum of 3 years and were considered to be at or above appropriate performance level for their age. University students were volunteers recruited from classes in the same school of music. These students were undergraduate or graduate students in music performance and averaged 11.6 years of private study. Participants were informed that recordings were made to analyze performance practice of string players.

We created two exercises to be performed by participants specifically for the questions posed in the present study. We labeled bow direction and notes to be played with and without vibrato. Fingerings were marked clearly to help control for the finger to be used. One set was written for violinists, and a separate set was created for cellists. The first of the two passages consisted of eight measures that alternated between whole notes and whole-note rests in 4/4 meter. The four whole notes were arranged in an ascending pattern; each was clearly notated to begin with nonvibrato for two beats and to start vibrating on the third beat. The violinists began on first line E in the treble clef (E_4), followed by a whole-note rest, then $F\#_4$, rest, G_4, rest, and A_4. Cellists began an octave lower on E_3 (third space in bass clef), also playing nonvibrato for two beats and initiating vibrato on the third beat, followed by the same pattern on F_3, $F\#_3$, and G_3, with a whole-note rest between notes. The patterns for the two instruments thus made use of all four fingers and allowed analysis of the initial movements made by performers in the transition from nonvibrato to vibrato, as well as comparison of intonation between identical notes played with and without vibrato. The second passage consisted of half-note slurs, using the same notes for each instrument as in the first passage. Students performed slurs in ascending and descending patterns beginning with fingers 1 to 2, then a measure of half-note slurs using fingers 2 to 1, then a whole-note rest, then half-note slurs using fingers 1 to 3 and 3 to 1, rest, fingers 1 to 4 (4 to 1), rest, 2 to 3 (3 to 2), rest, 2 to 4 (4 to 2), rest, and fingers 3 to 4 (4 to 3). This arrangement allowed analysis of vibrato duration and intonation patterns in both ascending and descending slurs.

Performances occurred in a studio designed for making audiorecordings of small ensembles and solo performers. Recording equipment included a Shure 57A microphone and a Sony 59ES digital audio tape recorder. Participants were brought to the recording room individually. They were given a few minutes to warm up, accommodate to the room acoustics, and look over the material to be recorded. A metronome was used to give a suggested tempo for the excerpts to be played (60 beats per minute), but was turned off during the actual performance session. A tuning meter was provided, calibrated to A4 = 440 Hz as a reference point for tuning. All performers tuned their own instruments.

The digital tape recordings were transferred directly to computer files via coaxial cable and a 24-bit, 96 KHz sound card (M-Audio Audiophile 2496). Sound files were analyzed using the software program Praat (2004). Praat allows accurate analysis of frequency and duration (for details, see Boersma, 1993), as well as other parameters. For the present study, frequencies were sampled at a rate of 100 times per second.

RESULTS

We analyzed the following dependent variables in each participant's performance: pitch level (frequency) of nonvibrato and vibrato portions of tones in the first exercise (expressed in cents); direction (sharper or flatter) and magnitude of change in pitch level (expressed in Hz) when initiating vibrato; pitch levels during the lower, upper, and final (lower) note of slurs (cents) in the second exercise; and the duration (in hundredths of seconds)

of nonvibrato portions of slurs during the transition from the lower to upper notes and from the upper to lower notes. Analysis of variance was used for all statistical analyses, and we used a significance level of .01. Reliability based on half of the total observations was very high for frequency analysis of vibrato and nonvibrato portions of tones (Pearson r = .99) and of slurred notes (r = .98). Agreement indices between independent observers were lower regarding the duration of nonvibrato portions during note-changes in slurs (86% agreement, ± 0.1 second), direction of change (80% agreement), and magnitude of change (89% agreement, ± 0.5 Hz). These three measures required observer judgment as to the precise ending and beginning point of vibrato cycles.

Pitch levels of vibrato and nonvibrato portions. We compared pitch levels (in cents) of tones during the vibrato and nonvibrato portions of tones in the first exercise. A four-way analysis of variance with two between-subjects factors (performer level and instrument) and two within-subjects factors (finger and vibrato condition) revealed no significant differences between levels, instruments, fingers, or vibrato condition. There were no significant interactions between any of the variables. Mean pitch levels during vibrato were not different than during nonvibrato portions of tones. Although not significantly different, violinists tended to be more consistent in pitch across the four fingers than were the cello performers.

Initial direction and magnitude of vibrato movement. String performers showed no consistent patterns regarding the direction of change when initiating vibrato from nonvibralo. The frequency with which performers began vibrato cycles in an upward direction (84) was nearly identical to the frequency beginning in a downward direction (76). There were no tendencies apparent in comparisons of performer levels, instruments, fingers, or interactions of variables. There was only one cello player who began the vibrato portion consistently in the upward (higher pitch) direction; no cello player began consistently in the downward direction. Two violinists (one high school and one university student) consistently began all vibrato cycles in the downward direction, and one began vibrato in an upward direction with all four fingers. See Figure 1 for a graphed example of the transition from nonvibrato to vibrato.

Analysis of the magnitude of change in the transition to vibrato from a nonvibrato tone also revealed no significant differences between performer levels, instruments, fingers, or their interaction ($F < 1$). Means for the two levels and two instruments were close to zero (less than 0.1 Hz), indicating that upward direction changes were similar in magnitude to downward changes, and standard deviations were also similar (approximately 1.0 Hz).

Pitch levels of slurred notes. We compared pitch levels of the six slur patterns. All slurs began either on fingers 1, 2, or 3 and required performers to slur up to fingers 2, 3, or 4 and then back down to the initial note. A four-way analysis of variance with two between-subjects factors (performer level and instrument) and two within-subjects factors (the 6 slur patterns and the 3 notes) was used. There were no significant differences in pitch levels between instruments ($F < 1$), between levels, $F(1,36) = 2.19$, $p > .10$, or between the six slur patterns, $F(5,180) = 2.67$, $p > .05$. A significant difference was found between the three notes of the pattern, $F(2,72) = 8.47$, $p < .001$, partial &eta² = .19. The initial note of each slur pattern was performed 3 cents lower in pitch than the final note (which was a return to the same note as the first) and about 2 cents lower in pitch than the second note in the pattern. The difference between the first and third notes was significant ($p < .001$ using the Bonferroni adjustment for multiple comparisons), but not between the other pairs of means. However, there was a significant interaction between the slur patterns and the three notes, $F(10,360) = 7.99$, $p < .001$, partial $\eta^2 = .18$. It can be seen in Figure 2 that in slurs going from fingers 2 to 3 and 3 to 4, the third note (the descending slur returning to the initial note) was performed approximately 10 cents sharper than either the first or second note. In the slurs from fingers 1 to 4 and 2 to 4, the second note (the ascending slur up to the fourth finger) was played about 6 cents sharper than the first note and about 4 cents sharper than the third note. Pitch levels of the slurs using fingers 1 and 2 and 1 and 3 were approximately the same for all notes.

Duration of nonvibrato in slurs. Visual displays of the vibrato patterns show clearly that all performers stopped vibrating during at least , some portion of the transition from note to note in the slur patterns. Durations of

nonvibrato ranged from less than .2 s to over 1.0 s. Figure 3 shows a typical performance pattern. In this example, a violinist performed a slur from first finger E_4 to third finger G_4 and back to E_4. It can be seen that just prior to the slur up to the G, the vibrato oscillation flattens out and a consistent vibrato pattern does not begin on the G until the second cycle. Similarly, in moving down from the G to the E, the performer stops vibrating. The duration of nonvibrato segments shown is approximately one-half second (s).

The mean duration of nonvibrato portions was not significantly different between the instruments (cello M = .48 s, violin M = .45 s), and the standard deviations were similar (approximately .11 s). There was a significant difference between performance levels, $F(1,36) = 8.55$, $p < .01$, partial η^2- = .19. University performers (M = .42 s) had shorter durations of nonvibrato than high school students (M = .50 s). There was no difference between ascending and descending slurs; both were performed with mean nonvibrato durations of approximately .47 s. However, there were significant differences between the six slur patterns, $F(5,180) = 16.55$, $p < .001$, partial $\eta^2 = .32$, and a significant two-way interaction between the instruments and the slur patterns, $F(5,180) = 3.62$, $p < .01$, partial $\eta^2 = .09$. The slurs using adjacent fingers (1-2, 2-3, 3-4) had nonvibrato portions shorter in duration (about .43 s) than slurs using nonadjacent fingers (1-3, 1-4, 2-4), which were approximately .51 s in duration. The interaction between instrument and the slur patterns revealed that nonvibrato portions of tones were similar between the two instruments for all patterns with the exception of the 3-4 pattern. Overall, violinists had slightly shorter (about .05 s) nonvibrato durations than cellists. For the 3-4 slur pattern, however, cellists' nonvibrato durations (M = .40 s) were shorter than the violinists' (M = .46).

DISCUSSION

Results of the present study may be summarized as follows:

1. Mean pitch levels of high school and university violin and cello players were not significantly different when using vibrato versus no vibrato on the same note. This indicates that performers vibrate both above and below conceived pitch, rather than only upward or only downward from the pitch center.

2. These performers did not reveal consistent initial vibrato movements. There were no differences in the direction or magnitude of initial vibrato motion.

3. Performances were not consistently sharper or flatter in the ascending and descending slur patterns. The final note of the threenote slur pattern (which was a return to the initial note) was performed sharper (about 3 cents) than the initial note, although differences were found in comparisons between finger patterns. Vibrato on finger 4 tended to be performed sharper relative to the other fingers.

4. All these performers stopped vibrating during the transition between slurred notes, and averaged slightly less than one-half second of nonvibrato. Nonvibrato durations of university performers were shorter than those of high school students, which is consistent with their increased development as performers. Slurs between adjacent fingers had shorter nonvibrato portions than slurs between nonadjacent fingers.

These high school and university violin and cello players did not initiate vibrato movements consistently. Both Small (1937) and Papich and Rainbow (1974) studied more advanced performers and reported that the initial vibrato motion is toward the bridge (a sharpening motion). If accurate, the results of their research would support the pedagogical writings of Rolland et al. (2000), Fischer (1997), and Perkins (1995), who suggested that students be taught to vibrate using a sharpening motion for the initial movement. In contrast, Hamann and Gillespie (2004), Lucktenberg (1994), Applebaum (1986), and Galamian (1948) all asserted that vibrato should be taught using a flattening motion for the initial movement. However, no empirical studies were located that corroborate this pedagogical viewpoint. We found no consistent pattern in either direction, although we sometimes found it difficult to judge the exact point in time that the performer initiated vibrato and therefore to determine the direction of initial movement. In some cases, intonation modulated slightly (1 or 2 cents) during the nonvibrato portion of a tone, and pinpointing the moment of initial vibrato was challenging. Such cases reduced the reliability between independent observers. We set a somewhat arbitrary criterion for determining

when the vibrato began by agreeing upon a constant amount of frequency change: 0.5 Hz in the case of cello tones, and 1.0 Hz for violin tones. These modulations (in their respective octaves) approximate 5 cents, and generally corresponded to our ability to aurally detect the onset of vibrato modulations. Performers did not rapidly change frequency in magnitudes greater than 5 cents unless they were initiating vibrato.

In a recent study of high school and college string players, Geringer and Alien (2004) added support for Seashore's (1938) conclusion that string players vibrate both above and below the conceived pitch, rather than chiefly above or chiefly below the conceived pitch. Results in the present study also showed that mean pitch levels of the performers were not significantly different when using vibrato versus no vibrato on the same note and thus provide further corroboration. If vibrato is indeed equally distributed above and below the conceived pitch, then it is quite possible that the initial surge in the vibrato motion might be equally distributed as well, even in the same performer, as was the case in the present study. Future studies should investigate the initial surge of vibrato among professional-level string performers to provide the basis for an appropriate pedagogy. The present study seems important in establishing the feasibility of such an analysis. Perhaps slow-motion video analysis could also aid in detection of initial vibrato movement.

Another central feature of string vibrato described in the pedagogical literature is the desirability of the performer to vibrate continuously from one finger to the next. Galamian (1948), Fischer (1997), and Young (1999) suggested that students should aspire to develop an uninterrupted vibrato. We found that not one of the 40 participants was able to sustain a continuous vibrato from one finger to the next finger (although a few were able to resume vibrato in less than 0.2 second). In all slurs, both levels of violinists and cellists stopped vibrating on the initial finger and began the second note prior to reinstating the vibrato movement (averaging about one-half second of nonvibrato per shir). Although the students were accomplished performers for their age level, they were still developing as performers and probably do not represent an artistic ideal in their ability to vibrate continuously. Researchers who do future studies should investigate the continuity of vibrato among professional-level string performers in establishing the parameters and possibilities of an ideal vibrato. It may be that physical constraints inherent in moving between notes (including attack and decay transients) prevent an absolutely continuous vibrato.

Additionally, we found several intonation tendencies that should be noted. In the exercises designed to examine the continuity of vibrato in slurs, students were asked to play a pattern that began either on fingers 1, 2, or 3 and slurred up to fingers 2, 3, or 4, then repeated the top note and slurred back to the original finger. As previously noted, the third note (the return to the original note) was significantly sharper than the first note. This tendency would seem to confirm the following casual observation of many string teachers: Performance with a lower finger that moves to a higher finger often results in a sharper pitch on the return to the lower finger. It seems that the placement of the lower fingers is drawn toward the higher fingers, thus creating a tendency to play sharp when returning to the original finger. Such tendencies might well be exaggerated in younger performers.

Researchers in future studies should investigate the influence of music contextual elements such as dynamics and tempo on the width and speed of string vibrato, as well as on the continuity of string vibrato when shifting. Furthermore, all aspects of the present study should be explored with more advanced performers, including professionallevel string players, so that string pedagogues have an empirical basis for recommendations about the critical element of vibrato.

GRAPH: Figure 1. Example of violinist performing ($F\#_4$) nonvibrato initially and changing to vibrato. Frequency average is 363.6 Hz during nonvibration portion and 366.8 during vibrato portion. The initial movement is in the upward direction.

GRAPH: Figure 2. Interaction of slur patterns and the three notes of each pattern.

GRAPH: Figure 3. Example of violinist slurring from first finger E_4 to third finger G_4. Duration of nonvibrato segments is approximately one-half second.

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