THE ROLE OF STRING REGISTER IN AFFECTIVE PERFORMANCE CHOICES

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I. INTRODUCTION

For string players, one of the important musical decisions to be made when approaching a piece of music is the fingering, or how the string player will position their hand and fingers in order to play the notes in the score. There are two important aspects to consider when deciding on the fingering of a musical passage. One is playability. A certain location on the fingerboard or a specific hand position could facilitate fingering a musical passage better than another, especially for a passage with many string crossings or for chords. For the bulk of string pedagogical literature, left-hand technique is focused on ease and efficiency (Applebaum & Lindsay, 1986; Auer, 1921; Epperson, 2004; Fischer, 2013; Galamian, 1985; Kaplan, 2004; Mantel, 1975). The second aspect to fingering, mostly neglected by the above texts, is expression.

Most string pedagogues focus on the bow as the main expressive device when playing (Applebaum & Lindsay, 1986; Auer, 1921; Chudy, 2016; Epperson, 2004; Fischer, 2013; Galamian, 1985; Kaplan, 2004; Mantel, 1975). However, the left-hand also has expressive potential. The most widely acknowledged expressive techniques of the left-hand are *vibrato* and *portamento*. *Vibrato* involves rotating the left-hand consistently to create a slightly fluctuation in the pitch. *Portamento* involves an audible slide between two pitches. There have been many pedagogical texts and articles dedicated to how wide and fast vibrato should be (Applebaum & Lindsay, 1986; Fischer, 1997, 2013; Galamian, 1985; Geringer, 2010; Kaplan, 2004; MacLeod, 2008; Pope, 2012). There is little guidance, however, on how to alter vibrato expressively outside of the advice of using it in “good taste”. *Portamento* is usually briefly mentioned in these texts and once again in the context of “good taste” only.

Another left-hand decision is what string to play on. String players sometimes comment on tone color or quality in relation to specific strings. The A string, in particular, is often described as sounding *bright*. For example, in Moyer’s dissertation on orchestra excerpts for the cello, she routinely observes that if a player decides to finger a passage partially on the A string, they should take care to alter their bowing technique in light of the greater *brightness* of the A string (Moyer, 2009). Choosing what string to play includes deciding on what string register to play in. String instruments are unique in that there are multiple places in which one can play the same notes. For instance, on the cello, something played in a lower position (near the scroll) on the A string can also be played in a higher position (closer to the bridge) on the D string and in an even higher position on the G string. Therefore, if a cellist wanted to avoid the bright timbre of the A string for a passage that was meant to be played in a low position on the A string, they could transfer that passage up to a higher register on the D string (Figure 1).

The motivating observation for this study is that string players, specifically cellists, tend to move the fingering from a low position on a high string to a high position on a lower string when they want to make a passage sound more expressive. This study proposes an ecologically based theory that could explain this observed behavior. When communicating more intense emotions (such as panic, elation, and despair), humans tend to speak higher in their range than for less intense emotions (such as contempt, boredom, and shame) (Banse & Scherer, 1996). Humans are highly effective at predicting where in one’s voice someone is speaking (Honorof & Whalen, 2005). It may be possible to perceive this information from instruments as well. If one can hear cues of location in range from each string on a string instrument, this could support why

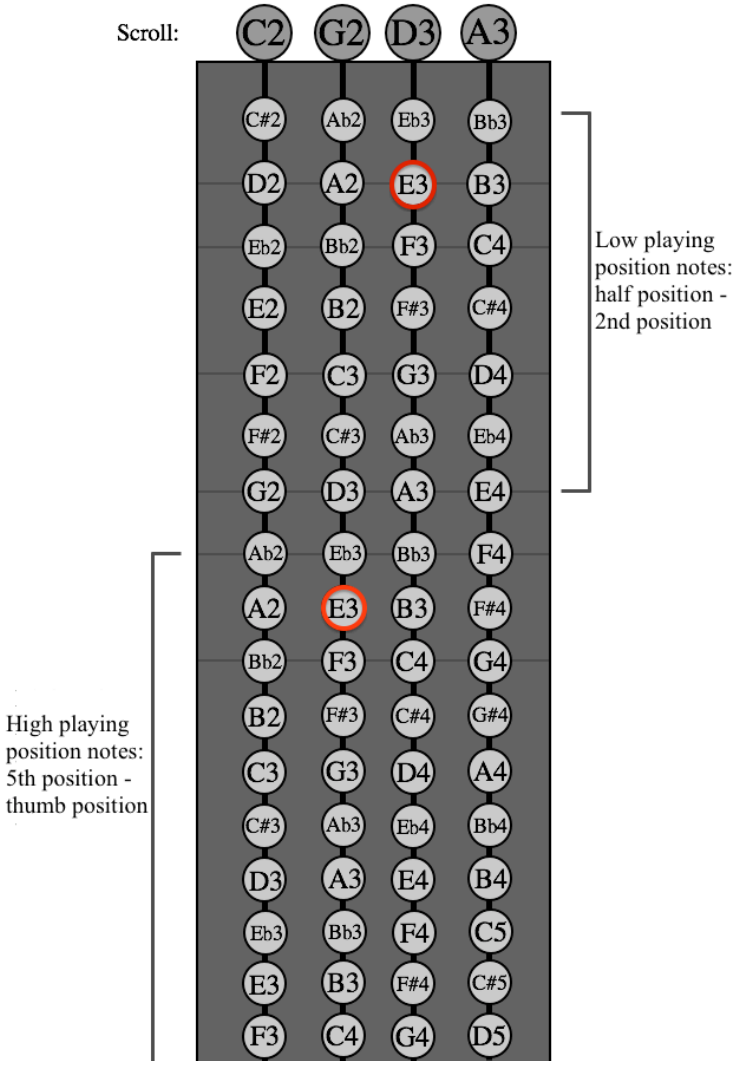

Figure 1. High and low playing positions on the cello with a demonstration of how the E3 can be played in two different places on the instrument, in a high position on the G string or in a low position on the D string.

using the upper register of a lower string might communicate a higher level of emotional intensity. In this study, part one tests whether or not it is possible to recognize pitch register from an instrument. Part two then studies whether there is an effect for emotional intensity based on high or low playing positions.

For Part one, the ability to hear pitch register on the cello was investigated by testing whether participants were able to categorize cello tones into high and low playing positions. Specifically, the following was hypothesized:

(H1) Participants will be able to sort pairs of recorded pitches into either high playing position notes or low playing position notes demonstrating an ability to aurally distinguish range on the strings of a cello.

For part two, to test whether there is an emotional effect of register, participants were asked to listen to a pair of cello melodies (one played in a high playing position and one played in a low playing position) and indicated which one was more expressive in a two-alternative forced-choice design. For part two, the following was hypothesized:

(H2) When exposed to a cello melody played once in the lower string register and once in the upper string register, participants will select the upper register version as the more expressive recording.

Anticipating our results, it is worthwhile to discuss possible reasons why the upper register of the instrument sounds more expressive. One potential reason is that vibrato changes as one moves up the fingerboard. Specifically, vibrato increases in width and rate. Allen, Geringer, & MacLeod (2009) found that the rate of vibrato of a professional violinist increased from a mean of 5.7 Hz in first position to a mean of 6.3 Hz in fifth position, and that their vibrato width increased from 40 cents in first position to 108 cents in fifth position (Allen, Geringer, & MacLeod, 2009). This finding extends beyond that single-case example. MacLeod (2008) found in another study with high school and university violin and viola players that the vibrato width was wider in the upper register with a mean of 58 cents as compared to 34 cents in the lower register, and that the rate was also faster in the upper register (MacLeod, 2008). Similarly, David A. Pope (2012) measured vibrato characteristics of high school and college level cellists and found that vibrato rates increased from a mean of 5.07 Hz in first position to a mean of 5.33 Hz in fourth and thumb positions, and that the width increased from 23 cents in first position, to 34 cents in fourth position, to 43 cents in thumb position (Pope, 2012).

The explanation for why vibrato widths and rates increase as one's hand moves up the fingerboard is partially related to physics while also being effected by cello technique and characteristics of the instrument. Generally, vibrato width increases as one moves up the string because the string length shrinks causing the physical distance between the notes to diminish as well (MacLeod, 2008). Because of this, pedagogues generally encourage students to use a smaller vibrato width as they move up the instrument. However, this instruction fails to completely account for the width change as one moves up the fingerboard. Meanwhile, executing a thinner vibrato width results in a reduction of the width of the oscillating motion of the hand. Consequently, the time it takes to complete a full oscillation is also reduced resulting in a faster vibrato rate. This phenomenon is further complicated by changes that hand position and vibrato technique go through as one moves to higher playing positions. For example, when moving into fourth position, the neck of the instrument ends and the left hand is partially obstructed, first by the upper bout of the instrument and then, moving further up, by having to rest on the fingerboard itself thereby shrinking the vibrato rate even further.

Acknowledging that vibrato rate and width both increase as one moves up the fingerboard, it is useful to examine what that increase might communicate affectively. Research on vocal vibrato, which is comparable in range and width to string vibrato (Seashore, 1931; Sundberg, 1995), gives insight into the affective information of vibrato widths. Sundberg *et. al.* had professional opera singers sing excerpts once as if they were in concert and once with as little musical expression as possible ("neutral"). For excerpts with a higher emotionality, they observed a significantly wider vibrato in the concert version compared with the neutral version. Contrastingly, for excerpts with a lower emotionality, the opposite was observed with the concert version having a less wide vibrato than the neutral version (Sundberg, 1995). Assuming that vibrato could carry the same emotional meaning for instruments other than voice, perhaps string players move to higher playing positions for a wider vibrato to give a passage a higher emotional intensity. In order to test our main hypothesis and account for this possible confound, the materials will include recordings with and without vibrato.

Another potentially expressive device, timbre, may be affected by fingering decisions as well. Open (un-fingered) strings have been found to have a *brighter* timbre than stopped (fingered) strings because the finger on the string dampens the higher harmonics (Schelleng, 1973). If a string player wants to avoid the *brightness* of the open strings, they may be tempted to move to a higher playing position to facilitate playing the closed versions of those notes. There may also be a timbral difference between notes played on a high string in a low playing position and those played on a low string in a high playing position. The design of this experiment presents the opportunity for a future third study that could add to the vibrato literature as well as to investigate timbral differences between high and low fingering positions.

II. METHOD

A. Participants:

There were forty-eight participants for this study. The participants were all undergraduate music majors at Ohio State University between the ages of 18 and 22.

B. Materials:

In string performance, another factor that influences timbre is whether a given pitch coincides with a harmonic of an open string. The resulting resonance due to sympathetic vibration can produce a marked change in timbre. Accordingly, both sympathetic pitches and non-sympathetic pitches were used as stimuli. Specifically, half of the stimuli involved sympathetic pitches and half were non-sympathetic pitches. The selected pitches also covered a large range on the cello and used each of the four strings. Each pitch had a low and high playing position note. Sixteen pitches total were recorded. Two of the other pairs of recorded notes served as examples of high and low pitches for the task. The remaining fourteen pairs of notes provided the main data for the experiment. A single, short melody that was composed by the experimenters for the task was also recorded, once in a lower playing position and once in a higher playing position. The melody was composed in the key of Eb Minor to eliminate open strings and sympathetic pitches.

It was written with the aim of being comfortably playable in both a low and high playing position. The melody was also composed at a slower tempo to allow for easy playability and give room for expressive potential.

To ensure that the predicted phenomenon did not apply only to specific instruments or cellists, three professional cellists were recorded. Each of the notes was recorded multiple times, both with and without vibrato. They were recorded as whole notes at 60 bpm with a metronome used periodically to ensure consistency. The melodies were each played several times after the cellists had time to practice them. They were also recorded both with and without vibrato. The cellists were told nothing of the hypotheses for the study. They were only asked to play the materials as musically as possible. The cellists were also given suggested bowings and fingerings that they were told they could change if they wanted to for easier playability. The recordings were made using a high-quality microphone and the program Audacity on a Mac computer.

C. Interface:

JavaScript and Jspsych were used to create the interface for this study (De Leeuw, 2015; Flanagan, 2006). When participants click on the first link for part one, a main window and a pop-up window appear. The pop-up window contains the audio examples of notes played in a high playing position (labeled Group A) and notes played in a low playing position (labeled Group B). The main window thanks them for participating and then proceeds to some demographic questions. Following the survey questions, participants are asked to familiarize themselves with the recordings in Group A & B. They are then presented with a pair of notes and asked to identify which of the two they believe belongs in *Group A* by pressing 1 or 2 on their computer keyboard (1 for Note 1 belongs in Group A, 2 for Note 2 belongs in Group A). Each participant is exposed to all 14 notes. For part two, a similar procedure occurs. Participants are presented with the pair of melodies and asked to select which performance they deem more expressive.

III. RESULTS

Recall that the first hypothesis predicted that participants would be able to hear a difference between the same notes played in a low playing position versus a high playing position. This ability was investigated by asking participants to listen to a pair of notes and choose which one was more similar to Group A (and therefore played in an upper playing position). Each participant was tested on 14 pairs of notes. Their answers were coded as "correct" (1) or "incorrect" (0). Therefore, if the results were consistent with the hypothesis, the resulting mean of scores should be higher than chance (0.5). The distribution of the means of each participant's answers was not normal and so a nonparametric test was used. A Wilcoxon signed-rank test demonstrates that the results are consistent with our hypothesis in that participants on average scored significantly higher than 0.5 ($M = 0.63$, $SD = 0.22$, $W(47) = 3.399$, $p < .001$) (Figure 2).

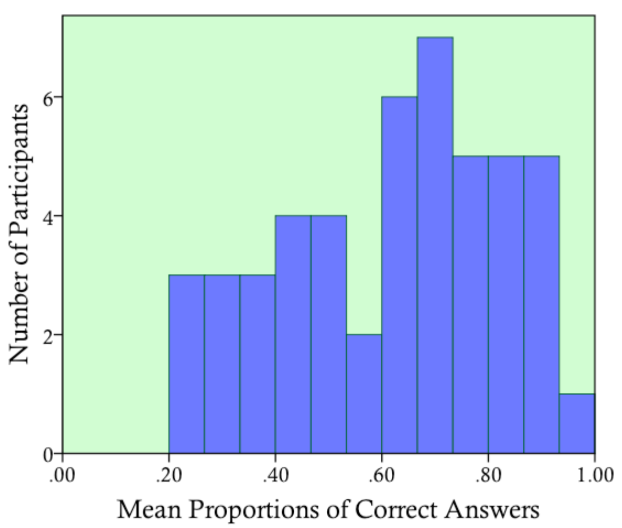

Figure 2. The distribution of the mean proportions of "correct" answers for determining which recorded single tone was played in an upper playing position.

Our second hypothesis predicted that melodies played in mostly upper playing positions would be perceived as more expressive than those played in lower playing positions. To test this, participants listened to a pair of melodies, one version played with higher playing positions and one with lower playing positions. In all cases, the same cellist played the contrasting versions. They were asked to select which of the two was more expressive. Our results were not consistent with our hypothesis in that 65% of the participants elected to choose the lower playing position version of the melody as the more expressive melody of the pair compared to 35% who picked the upper playing position. At first glance, the data suggests that our second hypothesis is simply incorrect. However, further *post-hoc* analyses demonstrate a more complex picture. When the individual cellists are accounted for in the analysis, they become a significant factor in the results (Pearson's Chi-Square test, $p = .006$). For the recordings by the first cellist, there was a slight preference for the high-register melody as most emotional. However, for the recordings by the second cellist, there was a strong preference for the low-register melody and more emotional, and only a slight preference in the same direction for the third cellist (Figure 3).

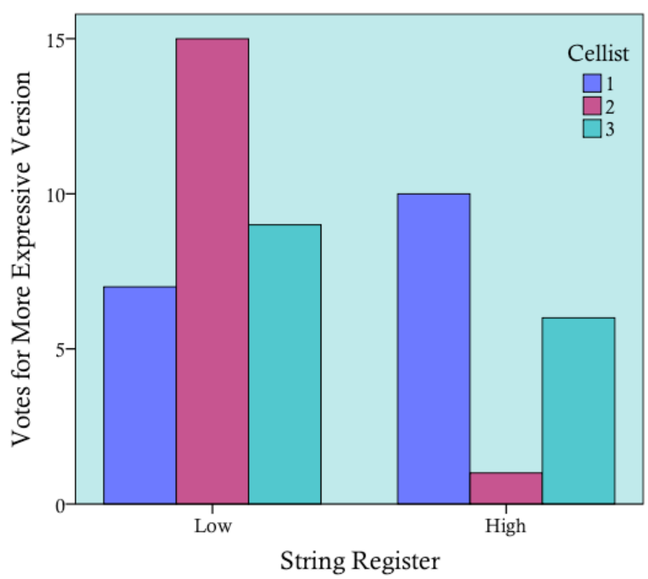

Figure 3. Results for part two of the study divided by cellist showing that the cellist was a significant factor for the results.

Finally, the effect of vibrato was analyzed in both parts of the study. For part one, the presence or absence of vibrato had no significant effect on the results (With vibrato: $M = 0.68$, $SD = 0.23$; Without vibrato: $M = 0.58$, $SD = 0.21$). For part two, however, the presence or absence of vibrato was a significant factor in the results (Pearson's Chi-Square test, $p = .005$) (Figure 4). For the recordings by the first cellist, the presence of vibrato led to more selections of the high-register melody as more expressive whereas the absence of vibrato led to an equal selection of both the high and low-register melodies. For the recordings by the second cellist, the presence or absence of vibrato had a marginal influence on the results. Finally, for the recordings by the third cellist, the presence of vibrato led to more selections of the high-register melody as more expressive whereas the absence of vibrato led to a complete switch in preference for the low-register melodies over the high-register ones, the most dramatic difference of all the cellists.

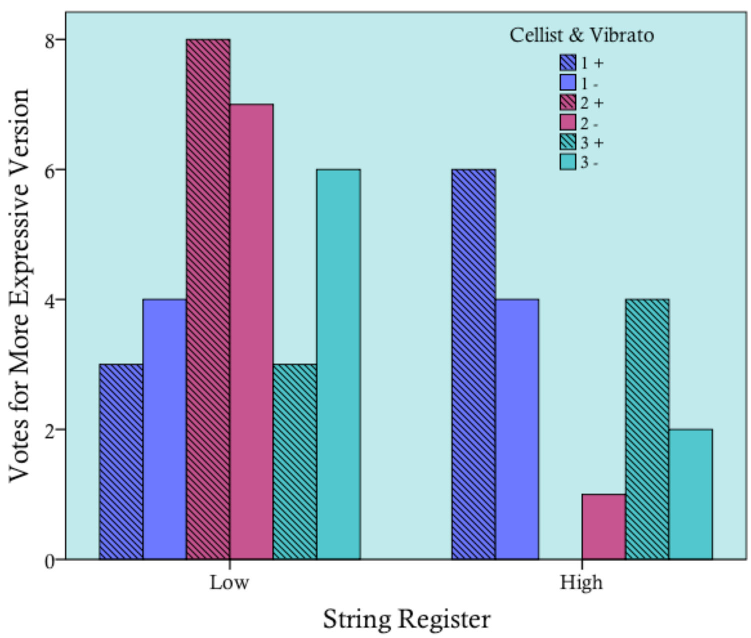

Figure 4. The results of part two distributed by cellist and by the presence (+) or absence (-) of vibrato in the recording.

IV. DISCUSSION

The results of the first part of the study were consistent with the prediction that listeners would be reasonably able to categorize cello pitches into high and low playing positions. In additional analyses of the data for part one, no effect was found for what instrument the participant played or for whether or not the tones played were sympathetic or non-sympathetic pitches. The results of the second part of the study were not consistent with the second main hypothesis. However, there is some suggestion in the results that the hypothesis may not be completely false depending on the presence of vibrato or a specific cellist or cello. The data collected is too small to draw any strong conclusions in relation to the presence or absence of vibrato. Future studies will run a similar version of these tasks with Amazon Turk for a larger number of participants. Additionally, acoustic analyses will be conducted on the recordings to analyze timbre and vibrato differences in each of the registers.

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