1aMU7. Properties of violin glides in the performance of cadential and noncadential sequences in solo works by Bach

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This study examines the articulatory changes ('glides') between the leading tone and tonic of cadential vs. noncadential semitone sequences in solo violin performance. It was predicted that though these glides would have similar slopes, they would differ in duration and in semitone intonation, and that these latter properties could characterise the expression of cadential finality and the structural insignificance of noncadential sequences. Cadential (46) and noncadential (58) targets from 17 recordings by 13 professional violinists were analysed using narrow-band spectrograms. Glide durations comprised 6.9% of the overall duration of semitone sequence irrespective of structure function. However, cadential glides comprised 28% of the duration of the leading tone compared with 11% for noncadential glides. As predicted, the leading tone tended to be sharp in both contexts, but the mean cadential interval was nonsignificantly larger by 18 cents, mainly because the tonic tended to be tuned more accurately in cadential sequences. Finally, the glide direction was linear and followed the natural vibrato trajectory in both contexts as expected. These data confirm that articulatory modifications play a prominent role in the performance of intended musical structure and suggest that such distinctions will influence structural expectancies.
INTRODUCTION

It has been repeatedly suggested that we listen to music with its underlying structure in mind (Kofka 1935, Meyer 1956, Krumhansl 1997, Cook 2001). Within this real-time processing of acoustic content, intentionally performed musical articulations aid the listener in abstracting the identity and function of the sounds perceived. String pedagogues throughout the centuries have noted sharpened tuning of leading notes at cadential points (Podnos 1981) and performance practice has advocated use of portamento for expressive phrasing (Flesch 1924, Lee 2006). To circumvent the rich musical connotations of portamento, I propose we call this targeted articulatory gesture by its English translation, ‘glide.’ While such comments reveal what performers think they do and what teachers endorse, there has been relatively little empirical investigation into what performers actually produce. Of particular interest is the modification of pitch that seems to have expressive, and indeed structural, implications in music performance.

To this end, this study examines the acoustic aspects of the pitch glide between adjacent semitones in cadential and noncadential sequences, as well as the intonation of both tones, in a collection of recordings of Bach’s solo violin works by 13 violinists spanning 1934 to 2010.

The aim is to shed light on the prospective functional role of the glide in distinguishing cadential and noncadential sequences. It was predicted that though these glides would have similar slopes, they would differ in duration and in semitone intonation, and that these latter properties could characterise the expression of cadential finality and signal the non-terminal nature of noncadential sequences. Specifically, longer glide durations and more ‘true’ intonation were predicted for cadential sequences.

METHODS

A collection of recordings of J.S. Bach's solo violin sonatas and partitas by 16 violinists was analysed for performers’ use of glides. These recordings spanned from that of Yehudi Menuhin in 1929 to Isabelle Faust in 2010, covering a large range of performer styles but were all of the same music. To control for variance in instrument and historical versus modern performance practise, only recordings made on non-Baroque violins and tuned to equal temperament were selected. These resulted in 17 recordings from 13 violinists spanning from 1934 to 2010.

Perfect cadence semitone resolutions (46) and noncadential passages with the same two pitches (58) were examined. These were defined to be scale-degrees seven to eight (‘ti’ to ‘do’) resolutions that are single notes, temporally adjacent, and in the same register. Praat (version 5.1.12) was used to analyse the narrow-band spectrograms and waveforms. Sequences were segmented into ‘ti,’ ‘glide,’ and ‘do’ based on agreement between visual and audio information. Sixty-eight segments were reanalysed blind by the author 5 months later with 88% agreement in segment classification.

As Praat is primarily used for speech analysis, pitch settings had to be tweaked in order to accommodate the numerous harmonic partials, octave jumps, and pitch range of violin music. F0s were sampled at the midpoint of the segment where the pitch was expected to have settled to a relatively stable frequency. Should there be vibrato, a ±3 cent standard allowance of deviation from equal temperament tuning was accepted.

RESULTS

Glide durations comprised an average 6.9% of the total duration of the semitone sequence irrespective of structural context. However, the hypothesis that there would be a durational difference between cadential (8.0%) and noncadential (5.7%) glides was confirmed, (p = 0.003). However, a survey of string players revealed that although they do not consciously attach the glide to one specific note as they perform, they do admit to modifying their cadential notes in order to achieve a convincing cadence. Glides are unlikely to be distributed equally between the ‘ti’ and ‘do,’ but rather as an extension of the leading tone. This observation was evidenced in glide duration differences when taken as part of the leading tone (p = 0.0000); glides comprised 28% of the duration of cadential leading tones but took up only 11% of the duration of the noncadential ones (see Table 1).
The overall mean intonation of each pitch of the semitone resolution was not significantly different from their equal temperament tunings (see Figure 1 and Table 2). As predicted, the leading tone was sharpened in both contexts, with the mean cadential interval non-significantly larger by 18 cents, mainly because the tonic tended to be tuned more accurately in cadential sequences. However, a paired Wilcoxon signed-rank statistical comparison between cadential and noncadential cent change revealed no significant difference (p = 0.1672). This result is unsurprising to the perceiving ear, which when listening in context, does not notice the narrower semitone. This observation is also in line with previous findings that pitch perception allows up to a ±15-20-cent variation in intonation accuracy within appropriate musical contexts (Vurma and Ross 2007).

**FIGURE 1.** Deviation in intonation from equal-temperament tuning (red lines), C#4=277Hz, D4=294Hz, C#5=554Hz, D5=587Hz. Differences are not statistically significant.

**TABLE 2.** Sampled F0 frequency (Hz) at segment midpoints compared to that of equal temperament target. All differences were not statistically significant as calculated from a paired Wilcoxon signed-rank test.

<table>
<thead>
<tr>
<th>Tuning/Intonation</th>
<th>F0 (Hz)</th>
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<tbody>
<tr>
<td></td>
<td>C#4</td>
</tr>
<tr>
<td>Equal Temperament</td>
<td>277</td>
</tr>
<tr>
<td>Overall mean</td>
<td>278</td>
</tr>
<tr>
<td>C mean</td>
<td>277</td>
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<td>NC mean</td>
<td>278</td>
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not undershoot or overshoot the fundamental frequencies of ‘ti’ and ‘do.’ This prediction was confirmed in that glide pitch in both contexts was on the linear path of the pitch change in the two-note sequence and followed the natural vibrato trajectory (see Table 2).

CONCLUSIONS

These data confirm that articulatory modifications play a prominent role in the performance of intended musical structure. The differences in glide durations in cadential versus noncadential contexts demonstrate a systematic variation in the function of glides in musical expression. The intonation of the semitone resolution also differed depending on structural context, suggesting that performers are more careful in producing more ‘true’ intonation in cadential sequences than in noncadential ones. This is unsurprising given the musical structural importance of a cadential resolution as compared to the passing nature of a noncadential one. Future research on the perceptual salience of such glides would further elucidate their role and significance in shaping structural expectancies in the real time processing of a live musical soundstream.

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REFERENCES