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Establishing a spectral theory for perceptual timbre blending based on spectral-envelope characteristics

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ABSTRACT

Background

Timbre blending between instruments is a common application in orchestration practice. Important perceptual cues for blend are known to be based on note onset synchrony or partial-tone harmonicity, which rely mainly on rhythmic or pitch relationships and hence compositional and performance factors. An orchestrator's choice of instruments, on the other hand, is more likely motivated by acoustical features of particular instruments. Previous studies have suggested the perceptual relevance of pitch-invariant spectral-envelope properties to characterize the timbre of orchestral wind instruments, with the relative frequency location of spectral maxima being relevant to perceptual timbre blending.

Aims

This study attempts to correlate instrument usage with acoustical and perceptual factors by investigating whether a perceptual relevance of pitch-invariant spectral-envelope traits can be shown. Based on the obtained behavioral findings, a spectral theory for perceptual blend is established which furthermore may allow acoustical predictions of perceptual blend.

Method

Based on holistic spectral-envelope descriptions for wind instruments acquired across their entire pitch range, a perceptual investigation concerning their relevance to blend is undertaken. Behavioral results are reported for an experiment that employs a stimulus presentation environment allowing real-time spectral shape modification of a synthesized sound that forms a dyad with a recorded wind instrument sound. Participants are asked to rate the relative degree of blend for a total of 5 sound dyads. In each dyad, the spectral shape of the synthesized sound is varied parametrically, based on a specific set of 5 synthesis parameter values for each instrument. The direct blend ratings serve as the dependent variable while several independent variables across different instruments, pitch levels, interval types and parameter value contexts are investigated. Performance for each of 6 wind instruments is assessed across 3-4 pitches to investigate whether certain parameter values are stable across pitch, for 4 instruments including non-unison conditions. Furthermore, a contextual change introduced across repetitions allows an assessment of whether ratings are affected by the presence or absence of parameter values at either extreme. A robust and consistent performance across pitches, intervals and contexts in the behavioral results would argue for a pitch-invariant perceptual relevance of spectral-envelope traits. A robustness for non-unison dyads would furthermore argue for instruments being suited for non-unison blend scenarios such as melodic coupling or chordal accompaniment.

Results

Behavioral results confirm pitch-invariant tendencies to apply to some important members of the wind instrument family (horn, bassoon, oboe and trumpet) and to be associated with the relative frequency location and/or magnitude of characteristic spectral maxima (formants). Higher degrees of blend were obtained whenever the synthesized formant magnitude was amplified or the frequency location was at or below the formant of the recorded instrument.

Conclusions

Results are expected to aid in the establishment of a spectral theory for perceptual blend that would serve as an instrument-specific complement to the other aforementioned composition- or performance-related cues. The finding that a pitch-invariant spectral envelope is relevant both acoustically and perceptually is expected to allow the compilation of charts over timbre-blend relationships across different instruments and musical dynamic markings based on acoustical predictors of perceptual blend.

Keywords

Blend, auditory fusion, orchestration, timbre perception, spectral envelope.