Examining the influence of tone inharmonicity on felt tension and timbral semantics.

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Aims/goals

This piece of research aimed to investigate the relationships between tone inharmonicity, timbral semantics and perceived musical tension. A connection between the luminance-texture-mass (LTM) model of timbral semantics (Zacharakis et al., 2014; Zacharakis & Pastiadis, 2016) and the concept of musical tension -which is not often studied under the prism of timbre- was pursued.

Background information

Recent research has presented evidence that inharmonicity is a timbre attribute that contributes to inducing musical tension (Farbood & Price, 2017). The link between tension and inharmonicity in this study was examined using static tones with fixed amounts of inharmonicity. Zacharakis et al. (2014) also found a relationship between inharmonicity and timbral semantics. However, the results on which of the identified semantic dimensions (namely luminance, texture and mass) was more closely related to inharmonicity were inconclusive. In addition, evidence concerning how time-varying inharmonicity can relate to both tension and the LTM model of timbral semantics is lacking.

Methodology

Thirty-five musically trained listeners (12 male, mean age: 23, average years of musical practice: 13.5) were presented (through a pair of PreSonus HD7 headphones) with two synthesized tones (a sawtooth wave consisting of 30 harmonic partials and a square wave consisting of 15 partials) of two different pitches (220 & 440 Hz) and of time-varying inharmonicity. The inharmonicity was varied either through a random positive/negative displacement of each partial as a percentage of its harmonic frequency (with a maximum of 4%) or through a positive exponential displacement that affected higher partials more heavily according to the stiff piano string equation (Fletcher, 1964). Inharmonicity linearly increased towards the specified maximum inharmonincity level and then decreased back to zero within a total duration of 30 seconds. The stimuli can be found online at: http://ccm.web.auth.gr/timbreandtension.html. During repeated stimulus presentations, participants were asked to provide time-varying tension, luminance, texture and mass profiles for each tone (8 tones x 4 qualities = 32 profiles per participant) by horizontal hand movements on a Kensington Expert wireless trackball mouse and a custom designed LabVIEW GUI that sampled the trackball's horizontal axis coordinate every 5 milliseconds and offered participants a real-time visualisation of the profiles they were creating.

Analysis

Raw responses were subsampled by calculating the mean value over adjacent non-overlapping rectangular time windows (.5 secs = 10 samples). The resulting 60-sample time series were subjected to first-order differentiation and replacement of positive/negative values with 1 and -1, respectively. Each participant's data were then normalized within each quality by his/her maximum rating on this particular quality. The time series were next integrated and smoothed using a cubic spline interpolant. Finally, linear trends were removed from each individual participant's time series to ensure 'stationarity' (Dean & Bailes, 2010). (Dean & Bailes, 2010). The processed time series were averaged over every stimulus and each of the four qualities under study. Figure 1 presents the mean profiles along with their 95% confidence intervals.

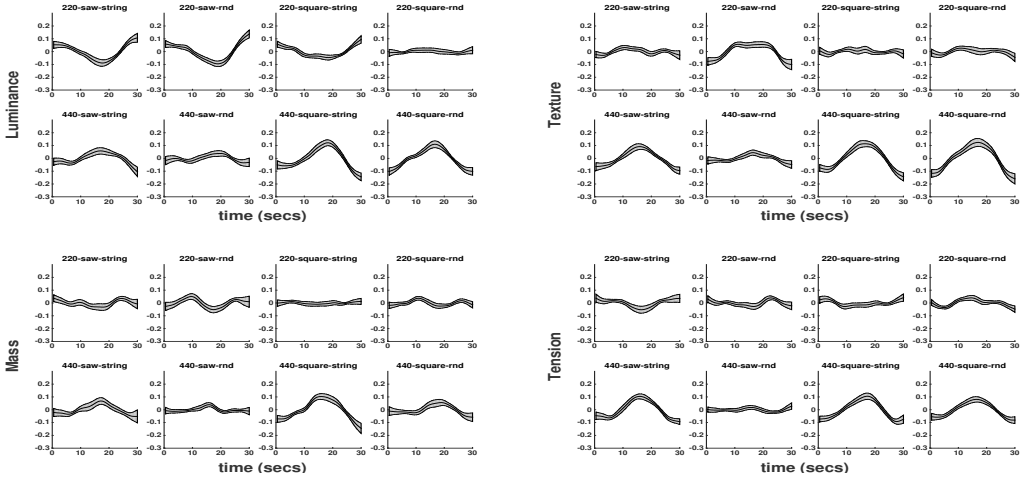

Figure 1. Mean temporal profiles of luminance, texture, mass and tension. Grey fills represent the 95% CI. Top rows: 220 Hz, bottom rows: 440Hz.

Conclusions

- The participants' agreement as represented by the Cronbach's Alpha was high for luminance, texture and tension (.93, .91, .90) but lower for mass (.79) in accordance with past evidence (Zacharakis et al., 2014; Zacharakis & Pastiadis, 2016).
- Statistically significant changes in tension can be induced through continuous manipulation of inharmonicity with a strong positive relation for higher F0s, thus expanding existing evidence for static sounds (Farbood & Price, 2017).
- Stepwise multiple regressions showed that stronger increases in tension (evident in stimuli 4,5,7 & 8) were more strongly predicted by texture (roughness). For the remaining four stimuli (1, 2, 3 and 6), tension changes were predicted through a synergy of texture with either luminance or mass, or through a synergy of all three.

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