EFFECTS OF TIMBRE AND PITCH REGISTER ON PERCEIVED EMOTION IN MELODIES

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1 Introduction

Timbre perceptually interacts with pitch. Examples include pitch shifts in tones without the fundamental [1, 2], and in Shepard tones as a function of the spectral envelope's center (e.g., [3]). Also, timbre and pitch are perceptually integral, as indicated by influences of each dimension on the other in speeded classification tasks [4].

Fewer studies have examined the related question of whether timbre contributes to the perception of emotion in music. It has been revealed that emotional interpretations of isolated tones change with the instrument producing them [5], though it might be argued that timbre's influence on emotion could be overcome by complex pitch relationships in melodies. Evidence on this issue is very limited, though changes in timbre can be enough to impact the emotional interpretation of melodic excerpts [6].

The current investigation sought to confirm timbre's contribution to the emotional interpretation of melodies while clarifying its role. In light of timbre-pitch interactions, influences on perceived emotion might be altered with changes in pitch register, which can impact timbre [7]. This experiment therefore manipulated octave/pitch register directly. The summarized experiment also extended previous work by establishing whether emotional interpretations could specifically be predicted by spectral characteristics of timbre.

2 Method

2.1 Participants

Twenty- five students with self-reported normal hearing from introductory psychology courses at JMU participated in partial fulfillment of course requirements. Data from nine were not analyzed due to configuration errors (5), missing or invalid responses (2), and premature responses (2). Age ranged from 18.8 to 21.7 years (M = 19.6; SE = 0.27). Musical experience ranged from 0 to 11 years (M = 4.75; SE = 1.07) as determined by responses to a questionnaire (see below).

2.2 Stimuli

Twelve, eight-bar, melodic excerpts were isolated from repositories of MIDI transcription files [8 - 10]. Lab staff selected excerpts from classical compositions that were unfamiliar, with six characterized as joyful, and six as sad.

Register varied by transposing melodies an octave (down for joyful, up for sad). Since transpositions exceeded the pitch range of instruments for two joyful and two sad melodies, their keys were adjusted until all notes were obtained.

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Stimuli were rendered (at 44.1 kHz (16-bit)), using sampled instruments from Ableton's *Live Suite* [11]. Excerpts were separately produced by Bb clarinet, trumpet, and violin. To assess perceived emotion without an instrument, sinewave versions were produced by our own plug-in (with 20 *ms* linear amplitude ramps for isolated onsets/offsets). Stimuli were equated for mean RMS amplitude and presented through a 4-pole, low-pass filter with an 11 *kHz* cut-off over Sennheiser HD 25-SP II headphones in a sound-attenuated chamber.

2.3 Procedures

After consent, participants completed a musical training and experience survey followed by the experimental task. The experiment was controlled by Empirisoft's *DirectRT* software [12]. Participants judged the strength of the intended emotion ("happy" or "sad") following each melody on a 7-point scale and made their responses using a button box.

All iterations of a melody occurred in one block of trials. Blocks began with a sinewave original melody, a standard for judging subsequent stimuli, followed by randomized timbre-register combinations. Block order varied across listeners.

Ratings for each emotion were hypothesized to decrease with transpositions, consistent with incongruent spectral shifts. Ratings were expected to (1) vary with instrument around the sinewave condition according to energy across the spectrum, and (2) to be reversed for joyful and sad melodies.

3 Results

Mean ratings of the strength of intended emotions were calculated as a function of register and timbre and are summarized in Figure 1. To assess how transposed melodies were influenced by instrument timbre relative to sinewaves, ANOVAs for joyful and sad melodies were conducted with timbre (clarinet, trumpet, violin, sinewave) as the factor. To assess influences of the critical variables, a 2x3 ANOVA for each intended emotion was conducted with register (original, transposed) and instrument (clarinet, trumpet, violin) as factors. Bonferroni pair-wise comparisons clarified effects, and Greenhouse-Geisser corrections are reported as applicable.

Perceived emotion changed with register and instrument for joyful melodies (panel A of Figure 1). Ratings decreased with transposition, producing a main effect of register, $F(1, 95) = 63.843$, $p < .001$, $\eta 2 = .402$. Ratings also were higher for violin and trumpet relative to clarinet, producing a main effect of instrument, $F(1.808, 171.790) = 18.473$, $p < .001$, $\eta 2 = .163$; p's < .001 for pair-wise comparisons. Furthermore, for the low register perceived joy was greater for trumpet and violin relative to the sinewave condition. This tendency contributed to an effect of timbre, $F(3, 285) = 12.432$, $p < .001$, $\eta 2 = .116$; all p's < .001 for pair-wise comparisons.

Register and instrument likewise affected ratings for sad melodies (panel B of Figure 1). Transpositions decreased perceived sadness for trumpet and violin, contributing to a main effect of register, $F(1, 95) = 6.102$, $p = .015$, $\eta 2 = .060$. Also, ratings were higher for violin and clarinet relative to trumpet, producing an instrument main effect, $F(1.671, 158.792) = 4.493$, $p = .018$, $\eta 2 = .045$; p's < .031 for pair-wise comparisons. Finally, transposition conveyed more sadness for instruments than sinewaves (p's < .033), contributing to a timbre effect, $F(2.746, 260.848) = 13.137$, $p < .001$, $\eta 2 = .121$.

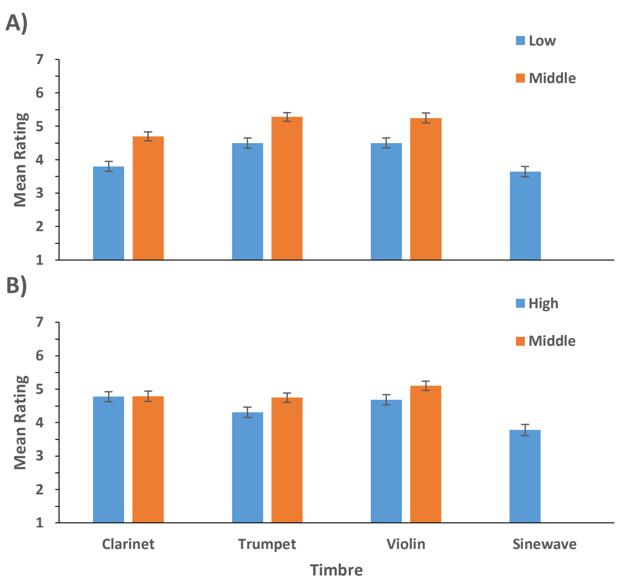

Figure 1: Mean ratings of the strength of intended emotions (along with standard errors) as a function of timbre and octave for initially joyful and sad melodic excerpts (panels A and B, respectively).

4 Discussion

The anticipated effects of timbre and octave generally were observed. Higher registers were more joyful/less sad, as were trumpet and violin trials relative to clarinet (see Figure 1)].

What timbre dimension(s) might be responsible for these primary findings? One measure used to distinguish spectra [13] that may reveal timbre-pitch interactions [2] is the spectral centroid, the frequency representing the center of spectral energy, which contributes to tonal brightness. We calculated the centroid for each excerpt's average spectrum.

Since pitch and timbre interact, changing register could influence emotion by changing timbre. Centroids increased across instruments for higher octaves, paralleling register effects, except for clarinet, where sad ratings did not change with register. Perhaps shifts in low centroids were insufficient to defeat pitch-based interpretations over a small pitch range.

Centroids provide a partial account of timbre effects. Centroids increased from clarinet to trumpet to violin, and were positively, though weakly related to ratings for joyful melodies, $r = .382$, $p = .011$. A corresponding correlation was absent for sad stimuli, $r = -.025$, $p = .443$. Listeners may have relied on another attribute, such as rise time, when rating sad violin melodies. After all, rise times were very long in these bowed samples (> 300 *ms*). We are pursuing this.

If adding parameters better predicts our findings, then future studies could benefit from manipulating timbre characteristics in combination. For now, results from this study confirm timbre's influence on perceived emotion, as found for individual tones and an alternative set of melodies [5, 6]. Furthermore, it appears that some of this contribution could be due to changes in perceived brightness, at least for joyful melodies. Thus, researchers should avoid assumptions that the emotional interpretation of melodic information can be evaluated independently of the timbre used to express it.

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