

A New Test for Measuring Individual's Timbre Perception Ability

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Introduction

To date, tests that measure individual differences in the ability to perceive musical timbre are scarce in the published literature. The lack of such tool limits research on how timbre, a primary attribute of sound, is perceived and processed among individuals. We present a novel psychoacoustic assessment tool, the 'Timbre Perception Test' (TPT) (Lee & Müllensiefen, 2020), to fill the gap in the literature and to provide a robust measure that is specific to timbre and its distinct dimensions. This new test aims to examine an individual's perceptual abilities on three important dimensions of timbre (temporal envelope, spectral centroid, and spectral flux) initially proposed by McAdams et al. (1995). We employed a production adjustment task using a new interactive software interface and examined the validity and reliability of our newly developed test.

Method

The TPT was designed to measure participants' ability to reproduce a heard sound as closely as possible by utilising a movable slider that affects one sound dimension at a time (see Figure 1). The test was composed of three Blocks that correspond to the three dimensions of timbre (Temporal Envelope, Spectral Flux, and Spectral Centroid; presented in respective order) with each Block containing a learning trial, 5 match trials, and 10 memory trials.

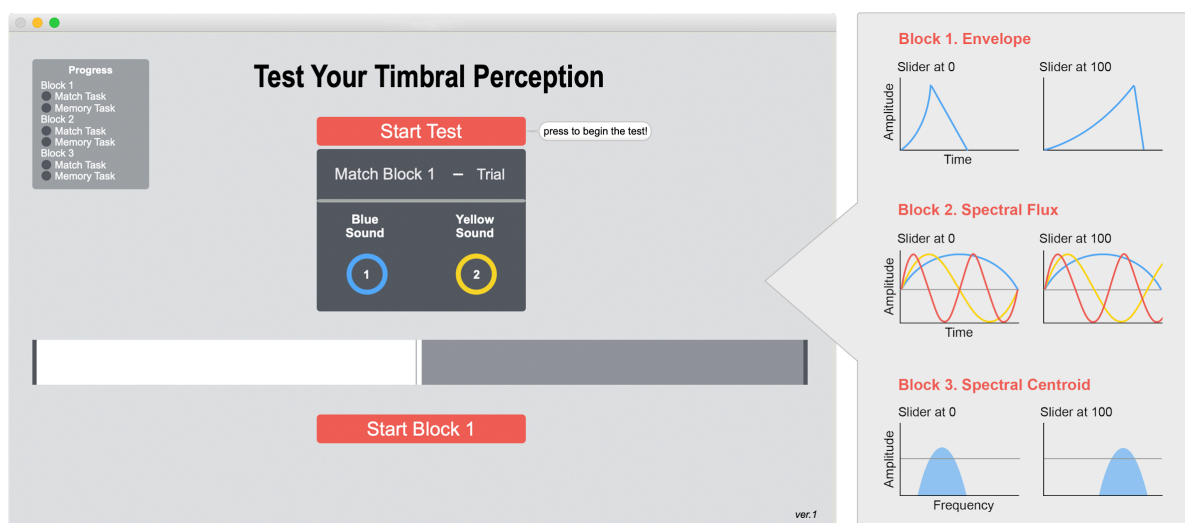


Figure 1. The layout of the TPT (left) and its testing dimensions (right). Graphic figures for the testing dimensions show how the reproduction tone is manipulated when the slider is positioned at '0' (far left) or positioned at '100' (far right). Envelope represent rise and fall time in amplitude, Spectral Flux represent the alignment of harmonics that results as more consonant when aligned in-phase, Spectral Centroid represent the filtered frequency area in the frequency spectrum.

The participant's task per trial was to first listen to the stimulus sound and then move the slider to adjust the reproduction sound to match the stimulus. Unlimited playback opportunities were given for the match trials, whereas only a single playback of stimulus was allowed for the memory trials.

In the Temporal Envelope subtask (Block 1), the slider bar altered the log attack time which also inversely influenced the decay time of the reproduction tone. In the Spectral Flux (Block 2) subtask, the ratios of harmonics to the fundamental frequency were altered to introduce dissonance caused by the beatings of frequency, characterised as *roughness*. Although such method of inducing roughness is strictly speaking - generating *inharmonic* - we propose that this technique can be applied as one of the approaches to systematically vary the amount of spectral flux when working with synthetic sounds (see Appendix A for a spectral analysis). In the Spectral Centroid subtask (Block 3), a bandpass filter was applied to the source sound to alter its spectral centroid, which has shown to be a good predictor of the perceptual *brightness* of a sound.

A sample of 95 participants performed the TPT and also completed existing tests and questionnaire related to timbre perception, namely the auditory threshold tasks included in the PSYCHOACOUSTICS toolbox (Soranzo & Grassi, 2014), the Timbre subtest from PROMS (Law & Zentner, 2012), and the Gold-MSI self-report inventory (Müllensiefen, Gingras, Musil & Stewart, 2014).

Results

Factor analysis was conducted to determine whether the match and memory variants of the three testing dimensions of timbre can be summarised to measure the same construct. This revealed that match variants of all three subtasks loaded on a single factor, whereas memory variants showed heterogeneous and weaker factor loadings. Interpreting these results, we additionally constructed a short-version of the TPT that excludes all memory subtasks as well as several items from the match variants with low discriminatory power.

The results indicated that the short-version of the TPT has acceptable internal reliability ($\alpha = .69$, $\omega_t = .70$) and good test-retest reliability ($r = .79$). Moreover, confirming its convergent validity, individuals' TPT scores were correlated with other related auditory tasks involving pitch discrimination ($\rho = .56$), duration discrimination ($\rho = .27$), and musical instrument discrimination abilities (i.e., Timbre subtest from PROMS, $\rho = .33$). Among all, the overall TPT performance showed the strongest relationship with self-reported levels of musical training ($\rho = .64$) and perceptual abilities ($\rho = .56$) that are hypothesised to be most closely related to timbre perception ability, and somewhat lower correlations with less related aspects of musical sophistication such as emotions ($\rho = .40$) and singing abilities ($\rho = .45$).

Performance accuracy increased when participants chose to listen to more repetitions of the target stimulus and the reproduction tones in the match condition. Considering the strong correlations with the self-reported perceptual ability, the observed correlations between stimulus repetitions and task performance could imply that the participants who were able to hear finer differences between the two tones repeated the tones a greater number of times to make more fine-grained adjustments to the slider position.

Assessed by the absolute slider distance between participant's slider position and target position, participants found the Temporal Envelope subtask to be easiest while Spectral Flux and Spectral Centroid subtasks to be of comparable difficulty. The accuracy to reproduce the timbre of tones was substantially reduced across all subtasks when performing the task from memory. More specifically, Temporal Envelope and Spectral Flux subtasks fell in accuracy by a similar amount while a smaller decrease was observed for the Spectral Centroid subtask (see Table 3 for acoustic values, Lee & Müllensiefen, 2020).

Discussion

Overall, the TPT has shown to be a promising tool for measuring individuals' timbre perception ability (see Lee & Müllensiefen, 2020 for an extensive discussion on correlations between TPT and related measures). Additionally, its use of a reproduction test paradigm and sliders to adjust timbral dimensions has the practical potential to combine short testing times (~8 minutes) with good measurement precision. We propose that the TPT can be broadly applied in the field of perceptual psychology to address outstanding questions on the individual differences on timbre perception. The current versions (full-version: including match and memory trials; short-version: including match trials only) of the TPT is openly available for

research purpose (download at www.osf.io/9c8qz) and its use does not require any coding skills, running as a standalone application on both Windows and Mac operating systems.

Acknowledgements

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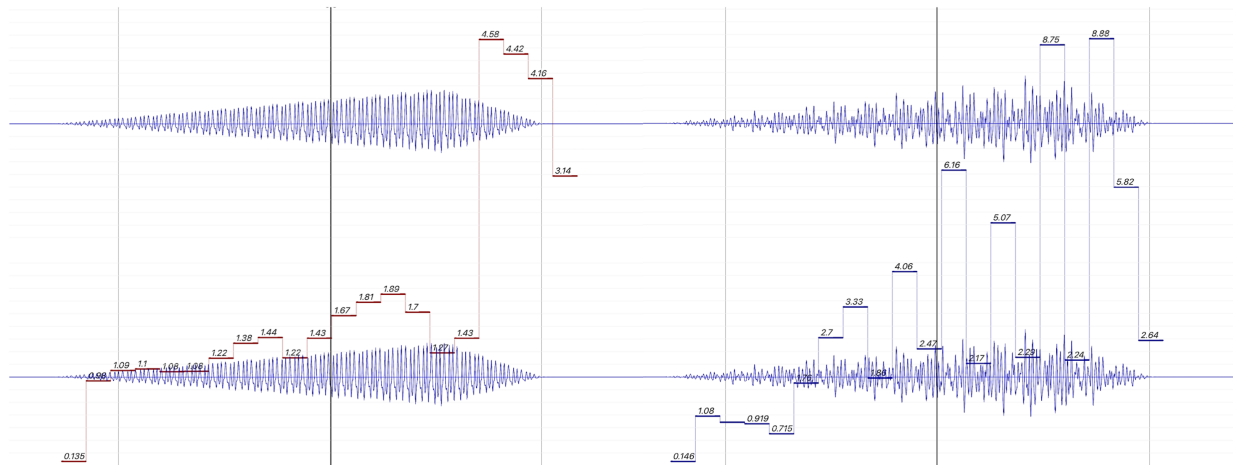
References

- Law, L. N. C., & Zentner, M. (2012). Assessing musical abilities objectively: Construction and validation of the profile of music perception skills. *PLoS ONE*, 7(12). <https://doi.org/10.1371/journal.pone.0052508>
- Lee, H., & Müllensiefen, D. (2020). The Timbre Perception Test (TPT): A new interactive musical assessment tool to measure timbre perception ability. *Attention, Perception, & Psychophysics*. <https://doi.org/10.3758/s13414-020-02058-3>
- McAdams, S., Winsberg, S., Donnadieu, S., Soete, G. D., & Krimphoff, J. (1995). Perceptual scaling of synthesized musical timbres: Common dimensions, specificities, and latent subject classes. *Psychological Research*, 58, 177–192.
- Müllensiefen, D., Gingras, B., Musil, J., & Stewart, L. (2014). The musicality of non-musicians: An index for assessing musical sophistication in the general population. *PLoS ONE*, 9(2), e89642. <https://doi.org/10.1371/journal.pone.0089642>
- Soranzo, A., & Grassi, M. (2014). PSYCHOACOUSTICS: A comprehensive MATLAB toolbox for auditory testing. *Frontiers in Psychology*, 5. <https://doi.org/10.3389/fpsyg.2014.00712>

Appendix A. Graphical representation showing variations in spectral flux induced by the alteration of harmonic phase alignments

Spectral Flux stimulus example from TPT

Visualised with Sonic Visualiser using BBC spectral flux Vamp-plugin with window size 256



slider value at 0: all harmonics aligned

slider value at 100: 4 harmonics varying in phase

Figure A1. Variations in the level of spectral flux of an example stimulus used for testing Spectral Flux dimension in the TPT. Slider position at '0' (left sound wave) aligns all eight harmonics to the integer multiples of f_0 . Slider position at '100' (right sound wave) shifts the integer multiple ratios of 4 harmonics by a small degree.