Timbre Trait Analysis: The Semantics of Instrumentation

Lindsey Reymore
Schulich School of Music, McGill University, Montréal, Quebec, Canada
reymore.1@osu.edu

Introduction

The cognitive linguistics of timbre—that is, the study of the interaction among language, thought, and perception of timbre—has recently emerged as a promising sub-field in timbre studies, and research supports a strong link between timbre perception and semantics (Saitis & Weinzierl, 2019). The current proceedings article provides an overview of some of the work reported in my dissertation (Reymore, 2020), which addresses how study of the cognitive linguistics of timbre can inform music theoretical discourse and analysis. I review the studies of timbre semantics that were used to generate a cognitive linguistic model of musical instrument timbre *qualia* and describe how this model can be used in timbre and orchestration analysis through a method I call Timbre Trait Analysis.

Method

Building a cognitive linguistic model of musical instrument timbre qualia

The model-building process began through interviews with 23 musicians who were asked to imagine and describe the sounds of 20 musical instruments. The use of imagined stimuli was motivated by the goal of characterizing "prototypical" sounds of each instrument rather than any specific recorded instantiation. A pile sort analysis (deMunck, 2009) of the interviews yielded 77 categories of timbre descriptors.

These 77 categories were used in a subsequent online rating task (Rating Task #1) in which 460 musician participants were asked to rate imagined instrument sounds using 7-point Likert scales. The resulting data were subjected to Principle Components Analysis (PCA); creating the final model from the PCA involved further input from musicians (for more detail, see Reymore & Huron, 2020). The final 20-dimensional model is reported in Table 1 in the Results section.

Generating Timbre Trait Profiles

Next, the 20-dimensional model was used in a second online rating task (Rating Task #2) of imagined timbres with the goal of providing characterizations, or "Timbre Trait Profiles" of 34 common Western large ensemble musical instruments. In this study, 243 musicians rated 11 of the 34 instruments on the 20 dimensions. The Timbre Trait Profiles comprise the average means and standard deviations of the ratings for each instrument. These data can be visualized through radar plots, as illustrated in Figures 1–3.

Illustrating the semantics of instrumentation

The Timbre Trait Profiles were then used as the framework for a computational program which generates semantic orchestration plots given a musical piece as input. This "Timbre Trait Analysis" provides information on how the semantic dimensions of timbre evolve throughout a piece of notated music. At the moment, only the information from the prototypical profiles is used; however, the eventual goal is to incorporate refinements to each of the profiles with respect to dynamics, register, and other factors (initial work is described below). For each beat of the piece, the program calculates an average value for the model's 20 semantic dimensions. The total value of a given dimension is divided by how many instruments are playing at that moment so that semantic values are not skewed by the number of sound source types.

Mapping the effects of register and dynamics

The Timbre Trait Profiles provide characterizations of the prototypical sounds of musical instruments. As such, they have already proved useful in musical analysis (see "Illustrating the semantics of instrumentation" and Results sections); however, more nuance may be achieved in future analyses by

incorporating information on timbral variation within instruments relative to factors such as dynamics, articulation, range, register, or duration. These variations are huge in scope and will require further research to map comprehensively. As an initial step, Rating Task #3 mapped timbre *qualia* across pitch range and dynamics on the oboe and the French horn. Participants (47 Ohio State music majors) used the 20-dimensional model to rate 36 two-second recordings of single tones played by either the oboe or the horn in four registers, where each register was represented by three pitches, and each pitch was recorded at three dynamic levels (*pp*, *mm*, and *ff*).

Results

Table 1: 20-dimensional cognitive linguistic model of instrument timbre qualia*, Rating Task #1. The left column lists all terms belonging to a given dimension, while the right column contains shorthand labels.*

Dimension descriptors	Shorthand label
rumbling, booming, low, deep, thick, fat, heavy	*rumbling/low*
soft, smooth, singing, voice-like, sweet, gentle, calm	*soft/singing*
direct, projecting, loud, aggressive, commanding, assertive, powerful	*direct/loud*
nasal, reedy, buzzy, pinched, constrained	*nasal/reedy*
shrill, harsh, noisy	*shrill/noisy*
percussive	*percussive*
pure, clear, precise, clean	*pure/clear*
brassy, metallic	*brassy/metallic*
raspy, guttural, grainy, gravelly	*raspy/grainy*
ringing, long decay	*ringing/long decay*
sparkling, shimmering, brilliant, bright	*sparkling/brilliant*
airy, breathy	*airy/breathy*
resonant, vibrant	*resonant/vibrant*
hollow	*hollow*
woody	*woody*
muted, veiled	*muted/veiled*
sustained, even	*sustained/even*
open	*open*
focused, compact	*focused/compact*
watery, fluid	*watery/fluid*

Timbre Trait Profiles were generated for 34 large ensemble instruments. Figs 1–2 below provide example illustrations of the Profiles. Average ratings are indicated on each of the dimensions around the circle via the circles' radii, which are connected to create timbral "thumbprints" for each instrument.

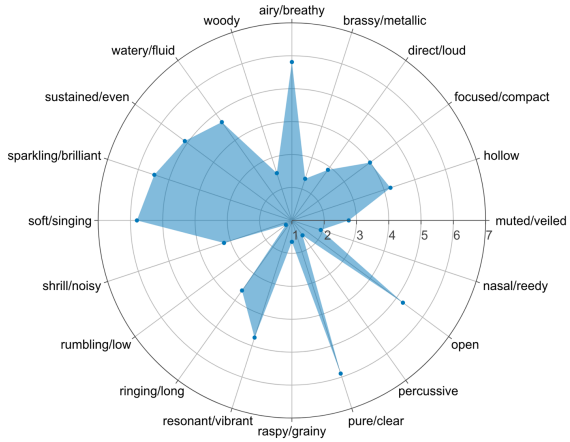

*Fig 1: The **FLUTE** was rated highly on dimensions including pure/clear, airy/breathy, and soft/singing.*

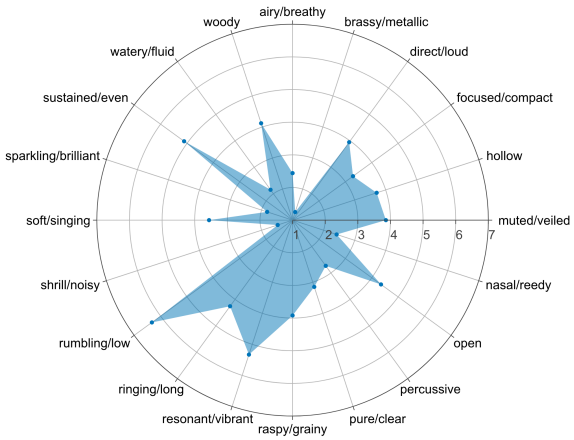

*Fig 2: The **DOUBLE BASS** was rated highly on dimensions including rumbling/low, resonant/vibrant, and sustained/even.*

In Rating Task #3, in which participants rated recorded tones varied in pitch and dynamic, dimensions implicating the manipulated factors (e.g. *rumbling/low*, *shrill/noisy*, *direct/loud*) tended to demonstrate similar, roughly linear trends in both oboe and French horn. Some dimensions varied greatly across dynamics and/or register for one instrument but not for the other. For example, the total range (max-min, on a 7-point scale) of average values on oboe stimuli for *airy/breathy* was 3.35, while the range for the horn was only 1.46. On the other hand, horn varied much more on *raspy/grainy* (range = 4.07) than the oboe (1.37). Some dimensions, notably *soft/singing*, yielded arch-shaped graphs, where the middle ranges of the instruments were on average rated more highly than the extreme registers. Complete results from this study can be found in Reymore (2020).

Model consistency & reliability

Rating Tasks #1–3 provided the opportunity to test the consistency and reliability of the 20-dimensional model for representing timbre semantics. To judge whether the 20-dimensional model is a reliable reduction of the initial 77 categories, data from Rating Task #1 was used to predict data from Rating Task #2. The aggregate correlation between predicted and actual data was $r = .96$, indicating a high degree of reliability. Next, Timbre Trait Profiles generated from Rating Task #2 for the oboe and French horn were compared to the data collected for recorded sounds on these instruments in Rating Task #3. Correlations for both instruments were positive, with a very strong correlation between datasets for the oboe ($r = .92$) and a moderate correlation between those of the horn ($r = .42$). I conjecture that the different correlation strengths may relate to differences in timbral flexibility between the oboe and horn with respect to the variables manipulated in task #3 (dynamics and register). That is, because the horn can produce a wider range of timbres with respect to dynamic and pitch variability, the collection of recorded tones in Rating Task #3 for the oboe was much closer to the prototypical sound of the oboe imagined by participants in Rating Task #2 than were the recorded horn tones to the prototypical horn sound.

Timbre Trait Profiles in action

The music analytical method described above in the section "Illustrating the semantics of instrumentation" was applied to the first movement of Mahler's Symphony No. 1. This process resulted in a series of graphs mapping each of the 20 semantic dimensions over time in the piece. A sample graph for the *sparkling/brilliant* dimension is produced in Fig 3 below.

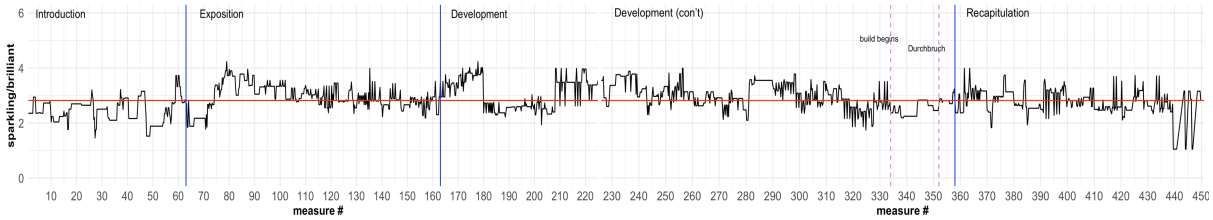

Fig 3: Semantic graph of the sparkling/brilliant *dimension of the instrumentation in the first movement of Mahler's first symphony. Formal boundaries are given in solid blue, while the horizontal red line represents the average value for sparkling/brilliant over the course of the piece.*

For example, we can observe that the instrumentation in the introduction is relatively low on the *sparkling/brilliant* dimension as compared to other formal sections and to the average value for this dimension across the pieces. Computationally, the data suggest sets of *qualia* that are especially relevant for the instrumentation of particular formal sections of the piece, shown in Table 2 below. In this movement, the semantics of instrumentation considered by formal section seems to tell a story that is consistent with the narrative of the musical work.

Table 2: Prominent qualia *of instrumentation by formal section, Mahler, Symphony No.1, first movement.*

Introduction	**Exposition**	**Development**	**Recapitulation**
rumbling/low	*soft/singing*	*sparkling/brilliant*	*shrill/noisy*
raspy/grainy	*watery/fluid*	*brassy/metallic*	*direct/loud*
muted/veiled	*pure/clear*		*nasal/reedy*
hollow	*sparkling/brilliant*		*airy/breathy*
direct/loud	*focused/compact*		*brassy/metallic*

Discussion

The semantic graphs provided in this analytical approach are not intended as ends in themselves, but rather as navigable summaries of a piece that can be used for both close and distant readings. They are intended as tools to help with musical analysis. The metaphor INSTRUMENTS ARE VOICES has been identified as critical for timbre semantics (Wallmark, 2014), and it is an important metaphor for the approach described here to applying Timbre Trait Profiles in musical analysis. The profiles tell us about the characters that are speaking (musically) at any given moment. In much music, considering a musical idea divorced from the voice that speaks it may be like analyzing the line of a play without taking into account information about the character who speaks it. Timbre Trait Profiles may help us understand how the "conversation" goes in any given piece; we can consider the ways in which composers tend to combine different types of instrumental characters.

It should be noted that statements about the timbre *qualia* in the movement are not made about musical perception. The point is not, for example, to claim that this or that moment as a whole is perceived as especially *sparkling/brilliant*. Rather, it is to note that the composer used instruments with conventionally *sparkling/brilliant* traits in a given passage—that is, the collection of voices comes from a combination of individual instruments that tend on average to be rated relatively highly on *sparkling/brilliant*. Furthermore, because this analytical approach is rooted in cognitive representations of timbre, it is not intended to comment on timbral blends or other perceptual effects, nor does it account for factors such as pitch or intensity. In the future, I plan to incorporate data regarding timbral variability in range and dynamic, such as that gathered in Rating Task #3, providing a more refined analysis. Following additional research, the approach to musical analysis with the Timbre Trait Profiles can be modified to reflect updated understanding of the semantics of instrumental blend, registral/dynamic variability, and more.

The vocabulary and profiles of the timbre *qualia* model confer the advantage of enabling the comparative discussion of diverse instruments using the same set of 20 measures. The Timbre Trait Profiles allow us to use consistent language to point to specific ways in which instrumental characters are considered to be the same or different: working from the consistent vocabulary of the timbre *qualia* model has advantages for clarity of communication that may prove beneficial in music theoretical analysis.

References

De Munck, V. (2009). *Research Design and Methods for Studying Cultures*. Plymouth, UK: AltaMira Press.

Reymore, L. & Huron, D. (2020). Using Auditory Imagery Tasks to Map the Cognitive Linguistics Dimensions of Musical Instrument Timbre Qualia. *Psychomusicology*.

Reymore, L. (2020). Empirical approaches to timbre semantics as a foundation for musical analysis. (Doctoral dissertation), The Ohio State University, Ohio.

Saitis, C. & Weinzierl, S. (2019). The Semantics of Timbre. In Siedenburg, K., Saitis, C., McAdams, S., Popper, A.N., Fay, R.R. (eds.), *Timbre: Acoustics, Perception and Cognition* (pp.119–149). Springer Handbook of Auditory Research, vol 69. Springer, Cham.

Wallmark, Z. (2014). *Appraising timbre: embodiment and affect at the threshold of music and noise*. (Doctoral dissertation), University of California, Los Angeles.