

SEEING SOUND: A NEW TOOL FOR TEACHING MUSIC PERCEPTION PRINCIPLES

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1 Introduction

Interdisciplinary by nature, music perception research holds important lessons for multiple fields of study. Timbre, for example, lends insight into the perceptual and neural mechanisms underlying our experience of both musical and non-musical sounds. Understanding the acoustic consequences and timbral implications of subtle manipulations to bow pressure, embouchure changes, and the types of mallets used are of practical value to performing musicians.

Students from different disciplines approach common issues with different backgrounds and interests. For example, cognitive scientists are primarily interested in how timbre can inform our understanding of the mind, whereas musicians are more interested in how variations in timbre can be shaped to achieve artistic goals. Although these different perspectives are not necessarily incompatible, the ways in which information is most usefully represented and the types of sounds most helpful to analyze/explore differ between these different perspectives.

To help with pedagogical efforts related to music perception, we developed a software tool—MAESTRO—for novel exploration and analysis of musical timbre. Designed to be of use in diverse contexts, it offers the ability to visualize complex instrumental timbres in a variety of formats. Additionally it offers “deconstructions” of musical sounds, giving users the option to both see and hear (a) high quality audio recordings of different instruments, (b) synthesized power spectra generated from the same audio recordings, and (c) tones synthesized from this information tracking changes in each harmonic’s time varying amplitude.

2 Visualizing musical timbre

2.1 Power spectra representations

Most musical sounds are rich in harmonic structure, with overtones varying in strength amongst different instruments. For example, trumpets produce more overtones than clarinets, whose construction deemphasizes even-numbered harmonics [1]. These differences are typically visualized in textbooks using power spectra such as those shown in Fig 1. These representations highlight *one* aspect of acoustic structure that differs between instruments – average harmonic content. MAESTRO’s ability to easily compare sonified power spectra to natural sounds allows for clarification of the complex nature of musical timbre.

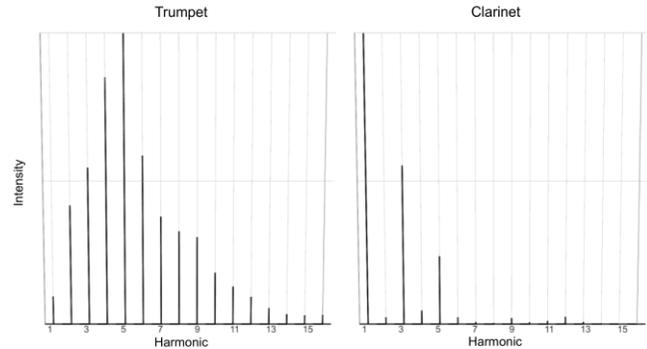


Figure 1: Power spectra of a trumpet and clarinet, showing differences in their average harmonic content.

2.2 Shortcomings of power spectra

Although power spectra capture certain aspects of the differences between instruments, they do not represent the rich temporal changes in strength of individual harmonics. These changes play an important role in timbre, and attention to these subtle manipulations form a crucial part of musical training (although musicians often talk in more general terms, such as a tone’s “warmth” or “harshness”, rather than discuss specific overtones). Note that although a waveform representation offers some insight into the temporal structure of sounds, it fails to capture the complex nature of the changes of each independent harmonic as shown in Fig 2.

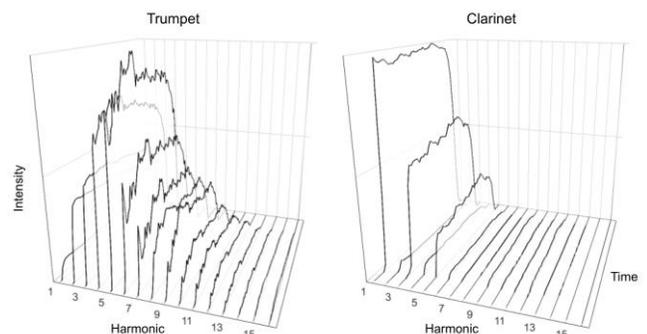


Figure 2: Natural musical sounds consist of many harmonics, with the relative strength of each harmonic changing rapidly over the course of the sound’s evolution.

3 MAESTRO software

3.1 Program overview

MAESTRO features multiple concurrent sound representations allowing users to simultaneously explore

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different aspects of a complex sound's acoustic structure. This includes traditional representations, as well as alternative visualizations useful for specific purposes (Fig 3). Additionally, it offers users the opportunity to “edit” power spectra to explore both the auditory and visual effects of varying typical waveforms (e.g. square waves, triangle waves, etc.). This tool is now freely available for non-commercial use at maplelab.net/pedagogy.

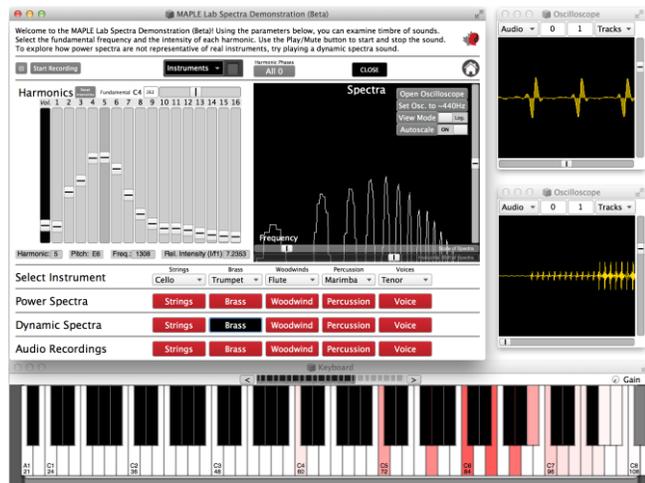


Figure 3: MAESTRO allows for simultaneous visualization of sounds in waveform, dynamic spectra, and a new “piano-style spectrum” intuitive for musical students.

3.2 Standard sounds

This software allows users to switch between standard acoustic demonstrations of sine, square, triangle, and sawtooth waves. The precise harmonic “recipe” for each tone is revealed in a series of sliders, allowing users to manipulate and explore the effects of changes in each overtone’s relative strength. The display also includes amplitude envelope, oscilloscope, and power spectra (using either a log or linear scale for frequency) representations.

In addition to these three standard visualizations, MAESTRO includes two specialized representations useful in further understanding musical timbre. The first maps a note’s overtone structure onto a conventional piano keyboard – a representation intuitive for musicians. The second involves continuously-updated sliders that dynamically indicate each harmonic’s strength while synthesizing musical sounds. This visually conveys the amount of change in harmonic amplitude found in musical instruments.

3.3 Musical instrument sounds

We have included instruments from different instrument categories (brass, woodwind, etc.) based on samples provided by the Iowa Electronic Music Studio library [2].

The software can play recordings of the instruments, as well as two synthesized tones based on the original recording. The first synthesized tone generates a sound with power spectra taken from the real instrument, sonifying

traditional descriptions of an instrument’s harmonic content. The second version synthesizes the natural temporal variation in amplitude strength, sonifying the dynamic amplitude changes important in an instrument’s harmonic content. This multi-faceted approach using different perspectives has been useful in teaching interdisciplinary classes consisting of students from a variety of backgrounds.

4 Conclusions

This tool provides a useful path to compelling auditory demonstrations in classroom settings. Developed primarily for teaching music and psychology students, it could be useful in courses focused on acoustics, sound synthesis, and other disciplines. Additionally, it holds the potential for pedagogical use in applied musical settings by providing new insight into nuanced differences in acoustic structure.

This software highlights the importance of dynamically changing amplitude information in our perception of musical sounds. Our interest stems in part from growing awareness of the under-studied role of amplitude envelope in auditory perception. Although real world sounds generally exhibit dynamic changes, perception research overwhelmingly focuses on amplitude invariant “flat” tones [3], which risks leading to conclusions failing to generalize to real world sounds [4]—such as those used in music.

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