TIMBRE TOPOLOGIES – PERCEPTUAL AND CONCEPTUAL SPACES
International Conference: 3 / 4 February 2023.
Zurich University of the Arts (ZHdK). Room 5.T05
Institute for Computer Music and Sound Technology (ICST)

Friday, 3 February 2023

	09.30 – 09.40	Welcome
	09.40 – 09.55	Introduction: Daniel MUZZULINI (ICST).
Session 1		Chair: Stefano PAPETTI (ICST)
	10.00 – 10.40	"Metaphors we listen with: Semantic (Conceptual?) Spaces of Timbre". Charalampos SAITIS (Queen Mary University, London)
Coffee Break		
	11.00 – 11.40	"Mathematics for Timbre and Color, Timbre for Data Analysis". Maria MANNONE (Università di Palermo)
	11.40 – 12.20	"A unitary model of auditory change perception". Kai SIEDENBURG (Universität Oldenburg)
Lunch Break		
Session 2		Chair: Hanna JÄRVELÄINEN (ICST)
	13.50 – 14.30	"To Infinity and Beyond – Timbre Dimensions and their Visualization". Christoph REUTER (Universität Wien)
	14.30 – 15.10	"The Acoustics of the Vowel – Indices". Dieter MAURER (ZHdK)
Coffee Break		
	15.30 – 16.30	Roundtable (Speakers, Moderator: Daniel MUZZULINI)

Saturday, 4 February 2023

Workshop I		
	09.00 – 10.30	Conceptual Spaces for Timbre? (Daniel Muzzulini, Charalampos Saitis)
Coffee Break		
Workshop II		
	11.00 – 12.30	The Acoustics of the Vowel (Dieter Maurer, IPF ZHdK)

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Metaphors we listen with: Semantic (Conceptual?) Spaces of Timbre.

Charalampos SAITIS (Queen Mary University, London)

Timbre is a perceptual property of sounds, encompassing a complex set of attributes collectively contributing to the inference of a sound's source but also acting as qualia. Typically, timbral qualities of sounds are verbally communicated through descriptions such as bright, rough, or full. There is converging evidence that timbral vocabularies can hold intersubjective reliability and are constrained by discrete conceptual-metaphorical schemas. These metaphors we listen with are not crucial for perceptualising timbre—one can compare and recognize timbres without having to tag them verbally—but are central to conceptualising timbre by allowing to make sense of its perceptual representation through indexing other, more commonly shared semantic representations. A major body of studies have sought to construct "semantic spaces" of timbre. These are geometrical configurations resulting from factor analysis of stimuli ratings along semantic scales. This approach has contributed greatly to our psychoacoustical understanding of timbre, but the broader cognitive questions concerning the ability of the human brain to draw metaphors across sensory and other experiential domains are far from trivial. In this talk, semantic spaces of timbre are examined in the context of Gärdenfors' theory of conceptual spaces, a framework for representing information on the conceptual level based on geometry, and vice versa.

Mathematics for Timbre and Color, Timbre for Data Analysis.

Maria MANNONE (Department of Engineering, Università di Palermo)

Artists are at ease with the complexity of timbre in orchestration and color in the visual arts. However, timbre and color are different phenomena in physics. Timbres result from the superposition of sinusoidal signals of longitudinal acoustic waves. Colors come from the superposition of transverse electromagnetic waves of visible light.

Colors and timbres have in common the idea of superposition, and their variations in some cases produce a similar perceptive effect in humans. We describe a recent experiment in this domain. Then, we describe perceptive similarities with definitions and tools of category theory. We define categorical groupoids, having as objects the colors (or timbres) and, as morphisms, color variations (or timbre variations). We model comparisons between colors and timbres via functors.

Finally, we present some case studies where timbres convey information in sonification, from sonified medical data to robotic movement feedback. Timbre-related sensitivity allows us to distinguish elements in a sonification, shape information such as the age of patients in a medical study, or help characterize the different robots of a swarm and their movements.

A unitary model of auditory change perception.

Kai SIEDENBURG (Department of Medical Physics and Acoustics, Universität Oldenburg)

Authors: Kai Siedenburg, Jackson Grave, Daniel Pressnitzer

Changes in the frequency content of sounds over time are arguably the most basic form of information about the behavior of sound-emitting objects. In perceptual studies, such changes have mostly been investigated separately, as aspects of either pitch or timbre. Here, we propose a unitary account of “up” and “down” subjective judgments of frequency change, based on a model combining auditory correlates of acoustic cues in a sound-specific and listener-specific manner. To do so, we introduce a generalized version of so-called Shepard tones, allowing symmetric manipulations of spectral information on a fine scale, usually associated to pitch (spectral fine structure, SFS), and on a coarse scale, usually associated timbre (spectral envelope, SE). In a series of behavioral experiments, listeners reported “up” or “down” shifts across pairs of generalized Shepard tones that differed in SFS, in SE, or in both. We observed the classic properties of Shepard tones for either SFS or SE shifts: subjective judgements followed the smallest log-frequency change direction, with cases of ambiguity and circularity. Interestingly, when both SFS and SE changes were applied concurrently (synergistically or antagonistically), we observed a trade-off between cues. Listeners were encouraged to report when they perceived “both” directions of change concurrently, but this rarely happened, suggesting a unitary percept. A computational model could accurately fit the behavioral data by combining different cues reflecting frequency changes after auditory filtering. The model revealed that cue weighting depended on the nature of the sound. When presented with harmonic sounds, listeners put more weight on SFS-related cues, whereas inharmonic sounds led to more weight on SE-related cues. Moreover, these stimulus-based factors were modulated by inter-individual differences, revealing variability across listeners in the detailed recipe for “up” and “down” judgments. We argue that frequency changes are tracked perceptually via the adaptive combination of a diverse set of cues, in a manner that is in fact similar to the derivation of other basic auditory dimensions such as spatial location.

"To Infinity and Beyond – Timbre Dimensions and their Visualization".

Christoph REUTER (Institut für Musikwissenschaft, Universität Wien)

Timbre can be described using various methods. One popular method is the use of timbre spaces, which plot the spectral characteristics of a sound in a mostly three- or four-dimensional space. However, these spaces have limitations and cannot be easily compared or generalized. Another method, Mel Frequency Cepstral Coefficients (MFCCs), has proven to be effective but the MFCCs are not particularly intuitive. Formants as pitch-independent maxima in the spectrum of an instrument's timbre with a defining effect on its overall character are less universal than MFCCs and also cannot be applied equally to all musical instruments. However, in the low and middle registers of most musical instruments they are easily recognizable and thus very intuitive, generalizable and easy to understand. Instruments with similar formant ranges tend to blend well together, while those with different formant ranges may not. Formants have been somewhat overlooked in English-

language literature, but they have the potential to be useful timbre descriptors. In this contribution, various types of timbre spaces and formant maps are presented, including interactive versions and formant maps that show timbre changes over the course of a musical piece.

Acoustics of the Vowel – Indices.

Dieter MAURER (ZHdK)

It seems as if the fundamentals of how we produce vowel sounds and how they are acoustically represented have been clarified: We phonate and articulate. Using our vocal chords, we produce a vocal sound or noise which is then shaped into a specific vowel sound by the resonances of the pharyngeal, oral and nasal cavities, that is, the vocal tract. Accordingly, the prevailing acoustic description of vowel sounds relates to vowel quality-specific patterns of relative energy maxima in the sound spectra, known as patterns of formants.

In the first part of this contribution, the formant theory is traced from the early understanding of the vowel sound as being an aspect of "Musikalische Klangfarben" and a phenomenon of resonances (von Helmholtz, 1863) to the theoretical foundation of the source-filter theory of speech production (Fant, 1960). Additional indications are given concerning the term formant, the method of formant pattern estimation, the controversy of formant patterns versus spectral shapes, and the structuralism as a basis for the formant theory.

In the second part, the formant theory is confronted with observations regarding intelligible speech (speech in everyday life and in the field of the performing arts) that are in contrast or in opposition to theoretical prediction. Above all, spectral characteristics of natural vowel sounds generally relate to their fundamental frequency level, in contrast to the supposed independency of source and filter or phonation and articulation.

In the third part, experiments and results are presented, revealing that it is not measured fundamental frequency but pitch to which perception and recognition of vowel quality relate.

This leads to some conclusions for the understanding of the vowel: Above all, (i) the vowel sound and its recognised vowel quality cannot be sufficiently explained on the basis of a physical or physiological model of sound production, (ii) the vowel–pitch relation and the aptitude of vowel sounds for a notation system give reason to argue for vowel quality as being a sound category of its own, not to be subsumed under sound timbre, (iii) the vowel sound is not directly comparable with a musical sound produced with a musical instrument, (iv) the vowel sound may indeed prove to be a phenomenon of a produced form that stands in contrast to other (acoustic) forms perceived.

For further information and preparation for the workshop, see:
www.phones-and-phonemes.org/230203

Speakers

Charalampos Saitis is Lecturer in Digital Music Processing with the School of Electronic Engineering and Computer Science at Queen Mary University of London (QMUL). At QMUL, he is member of the Centre for Digital Music (C4DM) and the Institute of Applied Data Science (IADS), and investigator and deputy director of the QMUL Centre for Doctoral Training in Data-informed Audience-centric Media Engineering (DAME). Outside QMUL, he is active in the UK Acoustics Network (UKAN) and non-partner member of the international Analysis, Creation and Teaching of Orchestration (ACTOR) Partnership. He was awarded a PhD in music technology from McGill University in 2014. In 2015-16, he joined Fondazione ISI as postdoc in the data science lab. Prior to joining QMUL, he was Humboldt Research Fellow at the Audio Communication Group of TU Berlin in 2016-19. He is a founding member of the International Conference on Timbre.

Maria Mannone (Palermo, 1985) earned her Master's in Theoretical Physics and three Masters in Composition, Conducting, and Piano in Italy. In Paris, at IRCAM – UPMC Paris 6 Sorbonne, she earned her Master 2 ATIAM in Acoustics, Signal Processing, and Informatics applied to Music. In the US, at the University of Minnesota, she achieved her Ph.D. in Composition.
She's the author and co-author of more than forty research papers and five books, including titles published by Springer and Palermo University Press, focusing on interactions between mathematics, music, and forms of nature. She invented the CubeHarmonic, a musical instrument based on Rubik's cube, developed with researchers from the Tohoku University and Toyo University in Japan.
Associate Editor of the Journal of Mathematics and the Arts, she is currently a postdoctoral researcher at the Department of Engineering of the University of Palermo, working on quantum computing for swarm robotics. She is also subject expert in computer science at Ca' Foscari University of Venice.

Kai Siedenburg is a research group leader at the University Oldenburg with a focus on the perception of sound and music. He studied mathematics and musicology in Berlin, Berkeley, and Vienna, and obtained a PhD from McGill University with a dissertation on musical timbre perception and cognition. Subsequently, Kai was Marie Skłodowska-Curie fellow at the University of Oldenburg, researching music perception of hearing-impaired listeners. Currently, Kai is Freigeist fellow (VolkswagenFoundation) and principal investigator of the Oldenburg Music Perception and Processing Lab. He is editor of the 2019 Springer Handbook of Auditory Research volume on "Timbre: Acoustics, Perception, and Cognition". Kai received the Lothar Cremer Award from the German Acoustical Society in Acoustics in 2020 and since 2022 is member of the Junge Akademie.

Christoph Reuter studied musicology at the University of Cologne, received his doctorate summa cum laude in 1996 and habilitated there in 2002. He has held guest professorships and lectureships at several universities (University of Vienna, Weimar) and was managing partner of an internet agency in Cologne from 2000 to 2013. Since 2008, Reuter has been a university professor for systematic musicology at the University of Vienna. His research interests include musical acoustics, music physiology and psychological aspects of music perception as well as music-related internet/software projects. His diverse studies in the field of systematic musicology include investigations on timbre perception, the variophone, music automatons, perception of unpleasant sounds and musical dice games. Reuter was a collaboration partner in the Sound Colour Space project at the Zurich University of the Arts and has contributed interactive content to timbre research.

Dieter Maurer, Prof. emerit. Former researcher and lecturer at the Zurich University of the Arts, the research affiliated with the Institute of the Performing Arts and Film and the Institute of Contemporary Art Research. His research addresses questions of basic syntactic form structures of human expression, above all of pictorial and vocal expression. His work is characterised by the creation of comprehensive corpora of sounds and pictures, a phenomenological investigation of these documentations and a deduction of general knowledge-based notions.