# Sonification Strategies for Affective Display

Master Thesis Proposal; Music Technology
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## Introduction

Sonification is an interdisciplinary field broadly interested in the use of sound to convey information (Hermann, Hunt, & Neuhoff, 2011; Kramer et al., 1999). A classic example of sonification, the Geiger counter, conveys the amount of radiation in the nearby environment using audible clicks. Radiation is one type of data, but today we find many more. Through sound, unseen patterns in stock market behaviour unfold, movements in the earth's crust become audible, and the blind play sports. Capitalizing on the strengths of the auditory channel, sonification offers a valuable tool for data perception with persistent applications and increasingly codified techniques.

A fundamental attribute of sound is its ability to evoke emotion, a feature perhaps best exemplified by the importance of music in film. For sonification however, there has yet to be a dedicated investigation into the special case of conveying affective information. New music research points to a select group of emotionally salient acoustic cues (Gabrielsson & Lindström, 2010), but these have yet to be applied outside of affective music generation (Groux, 2011). For my thesis, I will implement sonification strategies based upon these acoustic features and evaluate the resulting model for its utility in real-world contexts. My research will contribute to empirically informed sonification strategies for conveying affect and better technologies for affective display.

## Previous Work

My proposed project draws upon three areas of research: sonification, affective computing, and empirical research into the origins and elicitors of musical emotion. Sonification, as described in the previous paragraph, is my field of expertise (Winters, 2011a, 2011b) and my recent work in the Input Devices and Music Interaction Lab (IDMIL) has focused on the sonification of expressive gesture in music performance (Winters, Savard, Verfaille, & Wanderley, submitted) and dimensional models of emotion (Winters & Hattwick, 2012). Although sonification of affect has not yet received thorough investigation in the literature, the proposed research benefits from the recent publication of *The Sonification Handbook* (Hermann et al., 2011), the first major textbook of the field since its beginnings in 1992 (Kramer, 1994). The book features chapters dedicated to evaluation (Bonebright & Flowers, 2011), parameter mapping (Grond & Berger, 2011), and process monitoring (Vickers, 2011)—all of which are immediately relevant.

Sonification will be applied in affective computing, a field of research that has arisen in recent years to address the challenge of bestowing computers with "emotional intelligence" (Picard, 1997). This research benefits from and contributes to research in affective science (Davidson, Scherer, & Goldsmith, 2003) and dialog on emotion more generally (Lewis & Haviland-Jones, 2000). Recent textbooks (Scherer, Bänziger, & Roesch, 2010) and journals (*IEEE Transactions on Affective Computing*, n.d.) are now dedicated to precise topics in this field. Sonification links these developments in affective computing to current research in musical emotion. Specifically, recent research has compiled over three quarters of a century's worth of studies on the structural and acoustic elicitors of musical emotion into a relatively small group of emotionally salient features (Gabrielsson & Lindström, 2010). Current research now frames cultural and personal specificity in terms of shared categorical mechanisms for emotional response (Juslin & Västfjäll, 2008), biological determined predispositions (Peretz, 2010), and the relationship to speech (Juslin & Laukka, 2003).

# Proposed Research/Methodology

The project is organized to address two research questions: 1) How well do sonification strategies based upon the acoustic elicitors of musical emotion convey arousal and valence? 2) Can the additional information provided through sonification be used in real-world contexts where visual or verbal attention is already occupied?

The project will involve three stages—literature review and design, implementation, and evaluation. In the first stage, sonification strategies will be designed based upon current research in affective computing and musical emotion. For affective computing, it is important to determine the real-world contexts where sonification can best be applied, and what benefits it may offer compared to other affective display modalities (e.g. vocal, facial). This knowledge can be used to hypothesize upon the potential role of sonification and develop tests to evaluate its ability to meet these goals. The sonification will use tempo, loudness, timbre, mode, and sensory dissonance to convey an underlying two-dimensional arousal/valence space. These cues all have strong emotional salience (Gabrielsson & Lindström, 2010; Peretz, 2010) and minimize demands on attention and cognitive processing compared to more musical cues (e.g. melody, form). Mappings will be rigorously determined by the results from these studies (e.g. high arousal $\rightarrow$ high tempo, loudness).

The sonification strategies will be implemented in SuperCollider,[1] an environment and programming language for realtime audio-synthesis. The basis of the sonification will be a synthesis object (DynKlank) that creates a rich timbre with independent and dynamic controls of resonant modes, their decay times and relative amplitudes. To convey tempo, the object will be excited repeatedly in alternating stereo channels at variable speed. Timbre will be controlled by modifying the resonant modes and the characteristics of the excitation. Sensory dissonance and mode will be conveyed by transposing instances of the object by desired intervals, and loudness will be conveyed by controlling the overall gain of the system. A GUI will be created to experiment with mappings, control motion through the space, and play through pre-recorded data at variable speed.

The evaluation stage will involve two experiments. In the first, participants will hear short ($\approx$ 1s) samples of sounds generated from particular points in the arousal/valence space. Using acoustic differences, participants will judge the sounds in terms of arousal and valence, indicating how well the two variables were conveyed. The model will then be tested in a case-study identified in the literature review as likely to benefit from sonification, such as when visual and/or verbal attention is occupied with another task. Using questionnaires and interviews, a small set of participants will then assess if the sonification was annoying, distracting, and to what extent useful in conveying the additional emotional information.

# Contributions

The research immediately addresses the two research questions presented in the previous section. For sonification, this research will produce an empirically informed and evaluated model for conveying emotional information. Such a model has not yet been designed or evaluated specifically upon its utility for affective display. For musical emotion, a systematic and theoretically informed model can be used to verify or challenge existing theories, and perhaps be used as stimuli in future experiments (Juslin & Västfjäll, 2008, p. 574). For affective computing, sound provides a well-prepared medium for affective display, fundamentally different from facial or vocal paradigms. By integrating contemporary knowledge about musical emotion, sound's powerful affective capacity can best be embraced, contributing to better and more diverse technologies for affective display.

[1] http://supercollider.sourceforge.net/

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