SMART Lab Research: An Overview

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Résumé

Notre recherche explore la science de la musique, la recherche auditive, et la technologie. Nous sommes intéressés par la perception musicale, les discours émotionnel, et par les paysages auditifs. Nous étudions l'utilisation de la musique pour réhabiliter divers troubles de communication et afin de développer de nouvelles technologies afin d'améliorer la perception musicale. **Mots clefs :** Musique, perception, auditif, recherche, perte auditive

Abstract

Our research spans the science of music, auditory research, and technology (SMART). We are interested in the perception of music, emotional speech, and soundscapes. We are also investigating the use of music to rehabilitate various communication disorders and the development of novel technologies to support the perception of music.
Keywords : Music, perception, auditory, research, hearing loss

Research in our lab is situated at the intersection of music, mind, and action. What follows is an overview of a few of the studies currently underway in the lab.

To support research in emotion communication, we released the Ryerson Database of Emotional Speech and Song (RAVDESS). The RAVDESS was spearheaded by Dr. Steven Livingstone, a former Post-Doctoral Fellow. The database consists of 7,356 recordings of 24 professional actors vocalizing matched statements in face-only, voice-only, and face-and-voice formats. Using the Stanislavski system for emotional induction, actors were recorded singing a standard text with five different emotional expressions (calm, happy, sad, angry, fearful) and speaking the text with seven different emotions (adding surprise and disgust), each with two levels of emotional intensity. The database (http://smartlaboratory.org/ravdess/) provides a balanced and validated set of stimuli to use in research on different aspects of emotional communication.

Figure 1: A still taken from a "Happy" RAVDESS video

Dr. Naresh Vempala, a research associate in the lab, has been researching the acoustic cues underlying emotion in speech and music and their physiological effects on the listener. Acoustic variables considered include pitch, spectral, and temporal measures. Using the results of a behavioural experiment, we developed a computational model for emotion perception in music [1]. We followed up this work by collecting physiological responses, such as galvanic skin response (GSR), breathing rate, heart rate, and electromyography (EMG) of the zygomaticus ("smiling") and corrugator ("frowning") muscles of the face. Using data collected from both of these studies we were able to model induced emotion in a normal hearing individual [1-3]. The current modelling work is geared towards hearing loss and hearing aids. Ultimately, this line of research will allow us to conduct rapid prototyping of new hearing aid algorithms with less reliance on testing of human participants.

Hearing impaired and hearing aided individuals have difficulty distinguishing emotions in speech. Gabe Nespoli, a PhD candidate in the lab, recently completed a project on physiological responses to emotional speech in normal hearing, hearing impaired and hearing aided listeners. Participants were presented with stimuli from the RAVDESS and asked to judge the emotion conveyed while we recorded electrophysiological responses. Results showed lower responsiveness to emotional stimuli in hearing impaired and hearing aided participants. These findings raise important questions about the signal processing strategies employed in modern digital hearing aids.

Hearing is the dominant sensory modality for perceiving music, but not the only one. Dr. Paolo Ammirante, a Postdoctoral Fellow in the lab, has been leading research on the ability to perceive music presented to the skin. Mechanoreceptors in the skin are structurally similar to those in the ear and exhibit frequency tuning enabling coarse pitch perception. Although the skin is only equipped with a few broadly tuned frequency channels and without a "place code", this appears to be enough to enable discrimination between complex vibrotactile waveforms that possess the same level and fundamental frequency (i.e., timbre perception; [4,5]). The skin is also capable of giving rise to the perception of rhythm; however, this capacity proves challenging in the face of complex rhythms [6].

The lab has a strong interest in neural entrainment. Using electroencephalography (EEG), neural entrainment to

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the beat has been found to vary as a function of stimulus parameters, as well as listener history. In a recent study participants were asked to listen to 30-second excerpts of popular songs that had been previously rated as low-, mid-, or high-groove [7], where groove refers to the urge to want to “move to the beat”. Participants’ brain activity was monitored with EEG while they rated the groove of each excerpt. Fourier analyses of the EEG activity linked to motor sources revealed that the extent of entrainment to the beat was correlated with participants' ratings of perceived groove. These findings suggest that neural entrainment to the beat is related to the subjective feeling of groove.

Figure 2: Groovy music induces motor entrainment

Groovy or not, music can play a long lasting role in shaping neuronal networks. For example aging musicians show less neuronal degeneration in auditory signal processing than non-musicians [8]. Currently, no evidence exists regarding whether music training can support the regeneration of neural networks supporting music and language. A project in the lab led by Master’s student Ella Dubinsky is investigating the efficacy of a ten-week singing program for older adults with hearing loss. Early findings are very promising; participants show significant improvements in speech-in-noise perception, pitch discrimination, and the neural response to voiced sound, as well as cognitive measures of attention. These results lend support to the use of choir participation and musical training as an intervention for older adults, to help mitigate age-related declines in audition and cognition.

Figure 3: Participants involved in choir study

We are also interested in the dark side of music making. In particular, Alberto Behar, a Senior Research Fellow has been investigating the relationship between noise exposure and hearing loss in professional orchestra musicians [9]. Although our first study did not find evidence for clinically significant losses in these musicians, we found that some instrument groups experienced more loss than others and that the type of loss corresponded to the extent of noise exposure. For example, brass players had mid-frequency thresholds that were 15dB higher than those of their peers. By combining noise exposure and hearing loss assessment, this study provides information that extends current understanding of the occupational risks faced by professional orchestral musicians. This information may be particularly useful in the design and use of hearing protectors, such as earplugs. We are currently reassessing the same orchestra five years later; these longitudinal findings will help us to better understand the occupational risks faced by orchestral musicians.

While the effects of noise exposure on hearing health are reasonably well understood, less is known about its short-term effects on attention and cognition. In a busy city like Toronto, the often cacophonous auditory environment can make considerable demands on selective attention. In a recent experiment, we presented 30 two-minute soundscapes to participants and asked them to make visual judgments. Results indicated that soundscapes tend to have an immediate influence on visual attention, suggesting that sounds in our local environments can consume limited attentional resources. Our motivation for this research is to inform urban planners, architects and acousticians, in the ongoing dialogue about sound quality in our cities [10].

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