David Sears
MUMT 621
11/09/09

Final Project Proposal

In considering the effect of music on the emotional experiences of listeners, two methodological obstacles impede progress in emotion research: 1) the ability to provide a potentially objective measure for the study of emotions felt by listeners, and 2) an analytical technique that can account for how emotions change dynamically over time. In Spring 2009, Ogg attempted to provide solutions to these obstacles by 1) adopting psychophysiological measures that tap into bodily responses reflecting activity of the sympathetic nervous system, and 2) employing a continuous-rating paradigm, in which bodily responses were recorded continuously for the duration of a musical excerpt. Using the acoustic stimuli and psychophysiological data Ogg acquired, I will attempt to predict changes in psychophysiological responses by modeling changes in expressive performance features (dynamics, tempo variation) of the acoustic stimuli, as well as determine changes in the perceptual salience of these musical features over time using statistical techniques derived from time series analysis.

Background

In 2009, Ogg presented 20 musically-trained subjects with 19 Romantic piano stimuli in ABA form lasting between 50-90 seconds. In a preliminary study, subjects clustered the stimuli across two axes of the dimensional emotion space: valence (positive-negative) and arousal (excited-calm) (Russell, 1980). During the main experiment, Ogg recorded three psychophysiological measures: galvanic skin response (GSR), heart rate (HR), and facial electromyography (EMG), and then conducted statistical analyses of the mean psychophysiological measures across all subjects to determine if each of the quadrants of Russell's emotion space possessed specific psychophysiological profiles. Although the initial analyses did not capture the dynamic emotional experience of listeners over time, they did indicate the reliability of psychophysiological measures for valence (primarily in EMG) and arousal (primarily in GSR and HR).

GSR, a measure of psychologically-induced electrodermal (sweat gland) activity, indexes a number of processes: namely activation, attention, and the affective intensity of the stimulus (Cacioppo *et al*, 2000). Indeed, one author has noted a linear correlation between increasing arousal and increasing electrodermal activity (EDA), which suggests EDA is a more pure measure of emotional intensity than any other psychophysiological measure (Rickard 2004). Psychophysiologists currently hold that GSRs represent "orienting responses"—nearly automatic, defensive responses caused by a failure to predict change(s) in an external stimulus. It should therefore be conceivable to model changes in the musical stimuli in order to predict orienting responses in the GSR profiles.

Very few studies have actually considered analyzing GSR data over the period of an entire excerpt as a time series, instead preferring to use GSRs to record transient emotional events such as chills. However, a number of studies have considered continuous behavioural measurements of tension, resemblance or emotional force over entire pieces, in which subjects move a slider in response to their own experience (Schubert, 2001, 2004). Farbood (2006) proposed a quantitative parametric model of musical tension, in which she modeled tension profiles using musical features. She provided a multiple regression model that indicated the relative salience of each measure over the entirety of each excerpt. However, she did not consider how the contribution of each of these features to the tension curve changes over time.

Analysis

In order to account for changes in galvanic skin response, I will model changes in expressive performance features (dynamics and tempo variation). Clarke (1999) has suggested that these features are important for conveying structural and emotional information to the listener, and several researchers have attempted to model the rule systems that govern expressive performance parameters (Palmer, 1996). Gomez and Danuser (2007) have also suggested that tempo, accentuation, and rhythmic articulation are the features most strongly correlated with psychophysiological measures.

In order to maintain the ecological validity of the stimuli, recordings were taken from acoustic performances (rather than using mechanical midi performances). Although such a decision reflects a desire to study the effects of "real" music on listeners, it also poses the significant challenge of extracting performance features from the acoustic signal. In order to derive loudness information directly from the audio file, I will use jAudio, a feature extraction system developed by McEnnis and McKay. I will specifically extract RMS amplitude, and then transform the voltage data to A weighted dB, a feature that accounts for some of the perceptual constraints of the human auditory system.

To obtain tempo variation information, I will employ Simon Dixon's BeatRoot software (2001), which provides a means of manually extracting the beat at an experimenter-selected metrical level. Although his beat extraction algorithms are generally very reliable at automatically extracting tempo information (91% accuracy across multiple styles), I will manually extract the beat, using his software to facilitate data acquisition and analysis.

I will finally model these features using a multiple linear regression model derived from longitudinal data analysis, which attempts to predict a dependent variable (GSR) using multiple independent variables (musical features) over time.

References

Cacioppo, J. T., L. G. Tassinary, and G. Bernt. eds. 2000. *Handbook of psychophysiology*. Cambridge, UK: Cambridge University Press.

Caplin, W. 1998. *Classical Form: A Theory of Formal Functions for the Instrumental Music of Haydn, Mozart, and Beethoven*. New York: Oxford University Press.

Christian Landone, M. D. *Sonic Visualizer*. London, Queen Mary University of London.

Clarke, E. 1999. Rhythm and Timing in Music. In *The Psychology of Music*, ed. D. Deutsch, 473-500. San Diego: Elsevier Academic Press.

Dixon, S. 2003. On the Analysis of musical expression in audio signals. Draft for *SPIE/IS&T Conference on Storage and Retrieval for Media Databases*. Online http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.15.5379&rep=rep1&type=pdf.

Dixon, S. 2007. Evaluation of the Audio Beat Tracking System BeatRoot. Preprint for *Journal of New Music Research,* 36. Online http://www.elec.qmul.ac.uk/people/simond/pub/2007/jnmr07.pdf.

Dubnov, S., S. McAdams, and R. Reynolds. 2006. Structural and Affective Aspects of Music from Statistical Audio Signal Analysis. *Journal of the American Society for Information Science and Technology*, 57(11): 1526-1536.

Farbood, M. 2006. A Quantitative, Parametric Model of Musical Tension. PhD thesis, MIT Media Lab.

Gomez, P., and B. Danuser. 2007. Relationships between musical structure and psychophysiological measures of emotion. *Emotion*, 7(2): 377-87.

Guhn, M., A. Hamm, and M. Zenter. 2007. Physiological and Musico-Acoustic Correlates of the Chill Response. *Music Perception*, 24(5): 473-83.

Hedeker, D. 2006. *Longitudinal Data Analysis*. Hoboken, N.J.: Wiley-Interscience.

Krumhansl, C. L. 1997. An exploratory study of musical emotions and psychophysiology. *Canadian Journal of Experimental Psychology*, 51(4): 336-352.

McEnnis, D., C. McKay, I. Fujinaga, and P. Depalle. 2005. jAudio: A feature extraction library. *Proceedings of the International Conference on Music Information Retrieval*. 600–3.

McKay, C. 2010 (in press). Automatic music classification with jMIR. Ph.D. Dissertation. McGill University, Canada.

Ogg, M. 2009. Physiological Responses to Music: Measuring Emotions. Undergraduate thesis. McGill University.

Palmer, C. 1996. Anatomy of a Performance: Sources of musical expression. *Music Perception*, 13: 433-53.

Repp, B. H. 1994. On determining the basic tempo of an expressive music performance. *Psychology of Music*, 22: 157-67.

Rickard, N. 2004. Intense emotional responses to music: a test of the physiological arousal hypothesis. *Psychology of Music*, 32(4): 371-99.

Russell, J. A. 1980. A circumplex model of affect. *Journal of Personality and Social Psychology*, 39(6): 1161-78.

Schubert, E. 1999. Measurement and Time Series Analysis of Emotion in Music. Ph.D. Dissertation. University of New South Wales.

Schubert, E. 2001. Continuous Measurement of Self-Report Emotional Response to Music. *Music and Emotion*. Ed. P. Juslin & J. Sloboda. New York, Oxford University Press, 393-414.

Schubert, E. 2002. Correlation analysis of continuous emotional response to music: correcting for effects of serial correlation. *Musicae Scientiae* Special Issue 2001-2002: 213-36.

Schubert, E. 2004. Modeling Perceived Emotion with Continuous Musical Features. *Music perception*, 21(4): 561-85.

Widmer, G., S. Dixon, W. Goebl, E. Pampalk, and A. Tobudic. 2003. In Search of the Horowitz Factor. *AI Magazine*, 24(3): 111-29.

Zwicker, E. and H. Fastle. 1999. *Psychoacoustics: Facts and Models*, 2nd Edition. Berlin: Springer.