Does the Audience Hear My Heart?
Comparing the Physiological Responses of Listeners with Those of the Composer

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Abstract: Based on the assumption that composers compose with specific "intentions" in mind, we have conducted experiments to compare the "impressions" perceived by individual listeners with those "intentions" of the composer. We recorded physiological signals (skin conductance and finger tip temperature) of both the composer and listeners as they listened to the same music. Listener data was then cumulated and averaged for each song and compared to the data of the composer. Overall tendencies in physiological data, as well as a separate survey taken regarding emotions conveyed in the music, showed similarities between composer "intentions" and listener "impressions", indicating positive possibilities for using physiological data as an objective index of composers in future studies.

1 INTRODUCTION

Musical pieces abound everywhere we turn in society today. They exist as entertainment at concert halls and in movies, as public announcements at shopping malls, as an indicator on home appliances and even as apps in our mobile phones. The modern world is certainly no longer a quiet world.

Every musical piece or jingle we hear was designed by someone, with the intention of conveying something to those who hear it. It may be an emotion that it seeks to evoke to highlight a scene in a movie, or perhaps a warning to cause concern about an error in a computer system. A composer's intention could be either a concrete message or an abstract emotion.

Empirical study of emotion conveyed through music has been pursued for more than a hundred years (MacDorman, 2007). However, hardly any research has been done to evaluate the emotional intentions of the composer behind music. Although musical intention is a topic discussed in musical aesthetics, most of those studies deal with the intentions of composers who lived many years ago, making it nigh on impossible to obtain objective information regarding what those composers were intending when composing their music.

Physiological data has been widely used as an indicator for listener impressions to music, though it is still uncertain what exactly listeners are responding to. It may be caused by emphatic resonance with the song, directly induced by the music, caused by memories reflected upon during the music, etc. We have incorporated physiological analyses of composer data into our research to test the grounds for using it as an indicator of composer intention in future research.

The aim of this research is to record objective data of the composer and listeners, and to see what correlation can be drawn between the two. We recorded physiological data of the two parties listening to the same music and have conducted preliminary comparisons of the between-subject data. Contrasting this with data gained from surveys, we have listed some noticeable attributes of both composer intention and listener impression, and have concluded this paper with some points of discussion for further research in this area.

2 RELATED WORK

2.1 Music and Physiological Data

Much research has been done regarding the physiological responses listeners feel towards the music they listen to. Nakamura found a correlation

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between the impressions of the listeners and their skin conductance response (SCR, also known as GSR: galvanic skin response) while they were listening to music (Nakamura, 1984). Rickard also found significant differences in SCR change, as well as the number of chills listeners would experience, when listening to different types of music (Rickard, 2004). Matsui et al. found statistical difference in levels of arousal and variance in the number of breaths of the listeners when using multiple varied arrangements of the same original song (Matsui, 2003). Van der Zwaag et al. investigated the emotional impact pop and rock songs had on listeners while conducting a typical office task (Van der Zwaag, 2011). They found SCR to increase with the percussiveness of the music. They also noticed physiological responses reveal patterns that may not have been revealed in the self-reports of participants.

As far as we know, no research has dealt directly with the physiological data of composers. We believe this is due to the difficulty of obtaining objective data regarding a composer, since composer data for classical songs are hard to obtain and copyright regulations prohibit research from using music and data from more recent composers. In this research, we have used music written by one of the authors, which has allowed us some freedom into investigating composer intention and considering whether physiological data is usable as an indicator of that intention.

2.2 Composer Intentions in Music

Previous research dealing with the emotions conveyed through music can be split into two basic categories: research on the impressions of listeners and research on the emotions listeners think the music is intended to convey (Nakamura, 1983). Not much research has been done on the intentions of the composer, nor on the relation those have with the impressions of the listener. The few studies that have been conducted in these areas are as follows.

Baraldi had performers play a single note on a MIDI (Musical Instrument Digital Interface) piano and compared their intended emotions with the impressions of the listeners (Baraldi, 2006). Weale, using Electroacoustic Music, evaluated the listening experiences of listeners as they were gradually given more and more information regarding the song, the composer and the intentions of the composer (Weale, 2006).

3 PHYSIOLOGICAL DATA AND EXPERIMENTAL EQUIPMENT

In this research, we measured three types of physiological data from both composer and listeners. They are skin conductance response (SCR), skin conductance level (SCL) and finger tip temperature (FTT). All three of these represent peripheral functions of the sympathetic nervous system and are known to have an intimate relation with emotional states. In particular, previous research has found skin conductance to be a good indicator of strong impressions as a response to music (Rickard, 2004) and also as an indicator of anxiety (Mauri, 2010).

SCR signals indicate rapid change in skin conductance and are used to measure transitory excitement. To measure SCR, we used an original measuring device developed in our previous work (Munekata, 2006) which incorporates circuitry by Fowles (Fowles, 1981). Acquired analogical data is converted to a digital signal (8bit, sampling rate 20Hz) and sent to a computer via optical cables.

SCL signals indicate gradual change in skin conductance and are used to measure transitions from equilibrium to states of stimulation. SCL was measured using a device we are currently co-developing with Asahi Kasei Corporation. SCL data is acquired as a digital signal (16bit, sampling rate 20Hz) and transferred to a computer using Bluetooth transmission. We have provided an example of a typical signal trace in Figure 1.

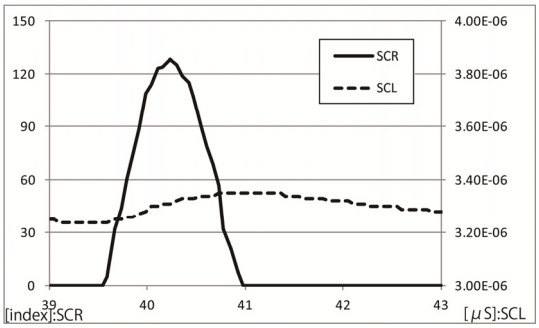

Figure 1: Typical signal trace of SCR and SCL.

FTT has been used to monitor if a person is relaxed or not (Shivakumar, 2012). For our experiments, we used an original device which includes a thermocouple and original circuitry to measure FTT. The device measures temperatures between 21 and 38 degree Celsius in increments of 0.0667 degrees. Data is transmitted to a computer digitally (8bit, sampling rate 20Hz) using Bluetooth transmission.

4 EXPERIMENTS

4.1 Description of Songs

We chose four songs from those which Evans (author) had written/arranged and performed at least 12 months prior to these experiments. Each song was submitted as an mp3 audio file, converted from standard MIDI files of the original sheet music used in the performances. Each song was rearranged as an instrumental piece with no lyrics included.

In a preliminary experiment, participants reported an initial nervousness at the beginning of the experiment, mostly due to being attached to multiple physiological response-measuring devices. We therefore decided to play two songs in each experiment, always starting with a stabiliser song. Data from the second songs (A and B) only will be analysed.

Song A was written in C minor, in 8/12 time, and as a piano solo piece. Partway through, song A would modulate to E flat major, but would modulate back to C minor for the conclusion of the song. Song B was also written in 8/12 time, but in B flat major, and as a capella piece. Song A was made using the MIDI sound "Steinway Piano", while song B used "Choir Ahs".

4.2 Listener Experiment

Fourteen faculty and students (two females, twelve males) from the information engineering department of Hokkaido University, Japan, participated in a two day experiment. All participants were naïve to the purpose of the experiment, including the fact that one of the experimenters was also the composer of the songs they were to listen to.

Participants were lead to the experiment room where they received an explanation of the experiment procedure. The room was dimly lit and kept at a constant comfortable temperature throughout the experiment. Participants were then attached to the physiological measurement devices explained in section three. Audio-Technica noise cancelling headphones were placed on the participants' heads, and after a brief volume check, a list of sounds and songs were played. After all sounds were played, the experimenter removed the headphones and all measurement devices. Participants were then asked to complete a survey regarding the impressions they had of the final song played.

The list of songs was as follows. First, participants listened to ambient forest sounds for a minute. Second, they listened to a stabilizer song. Third, participants listened again to the same ambient forest sounds, and fourth, participants listened to either song A or B. All participants listened to all four songs produced by the composer over the two days of experiments. Participants heard songs A and B in a counter-balanced order across sessions.

In the survey, participants were given a set of nine emotions to be evaluated in a five-point Likert-type scale ranging from 'not at all' to 'extremely' regarding the impressions they had of the last song they had heard in the experiment (song A or B).

Many emotion sets have been studied and used in the research fields of both psychology and musicology. In this research, we have used the emotion set compiled by Bruner (Bruner, 1990) from more than 30 experiments, and in particular, seven related works by other researchers regarding music and marketing. Bruner also compiled a list of musical characteristics researchers have found associated to each of those emotions, as can be seen in Table 1.

4.3 Composer Experiment

Prior to our experiment with listeners, the composer also answered a similar survey to listeners regarding the intentions he had when composing songs A and B. We also measured the physiological responses of the composer as he listened to the two songs in a two day experiment identical to that of the listeners. The composer did not listen to the songs or sound files for at least a month before the experiment. In the

Table 1: Musical Characteristics for Producing Various Emotional Expressions (Bruner, 1990).

	Serious	Sad	Sentimental	Serene	Humorous	Happy	Exciting	Majestic	Frightening
Mode	Major	Minor	Minor	Major	Major	Major	Major	Major	Minor
Tempo	Slow	Slow	Slow	Slow	Fast	Fast	Fast	Medium	Slow
Pitch	Low	Low	Medium	Medium	High	High	Medium	Medium	Low
Rhythm	Firm	Firm	Flowing	Flowing	Flowing	Flowing	Uneven	Firm	Uneven
Harmony	Consonant	Dissonant	Consonant	Consonant	Consonant	Consonant	Dissonant	Dissonant	Dissonant
Volume	Medium	Soft	Soft	Soft	Medium	Medium	Loud	Loud	Varied

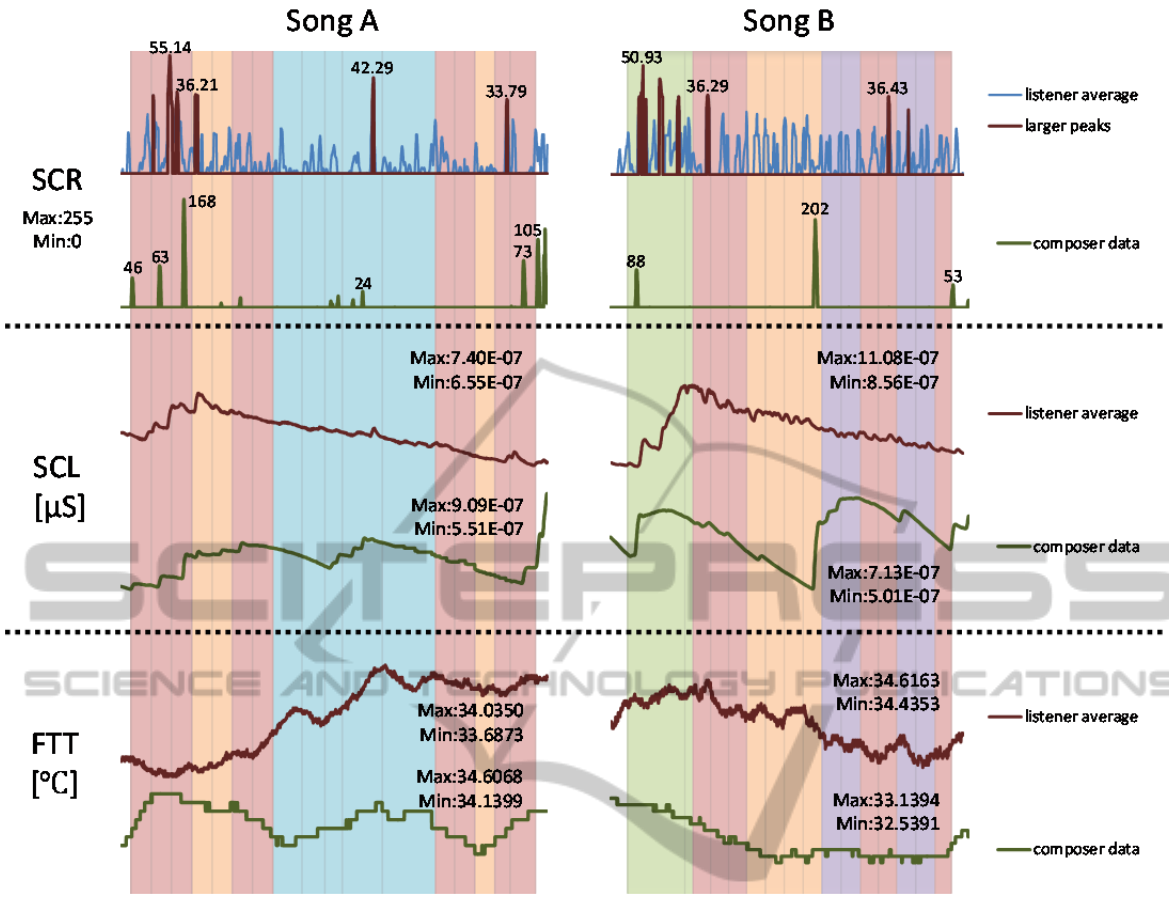

Figure 2: Physiological data acquired from experiments of listeners (n=14) and composer.

experiment, the composer was to focus on the music itself and not the performance for which he had originally composed the music.

5 RESULTS

5.1 Physiological Data

Each individual is known to have different baselines for each of their physiological status. Their responses can also differ widely in both magnitude and frequency. In this research, we chose to compare the general responses of listeners with those of the composer by cumulating and averaging the physiological data acquired from participants for each song (figure 2).

Coloured shadings behind each graph of figure 2 correspond to the structure of the song being played. Red, orange and purple represent the main melody, an arranged version of the main melody and a second main melody respectively. The blue area of song A indicates the modulated portion of the song where the melody is in a major key. The green area of song B indicates the introduction for the song. Gray vertical lines represent boundaries of musical phrases identified by the composer. Below we have listed some noticeable characteristics from these graphs regarding both listener and composer data.

We first notice a uniform trend between the two songs regarding skin conductance data. SCR figures are high for both songs roughly ten to twenty seconds after the song has begun, and right before the song ends. SCL figures begin to decrease right around the first major change in melody, which, in the case of song B, is also the end of the introduction.

The composer shows a uniform response to both songs in the change of SCL. The composer's skin conductance changed greatly at the beginning, ending and centre of each song. The rise in skin conductance observed in the middle of song B, though, cannot be seen in the listeners' response.

When looking at FTT, we notice the listeners' temperature rises for song A, but decreases for song

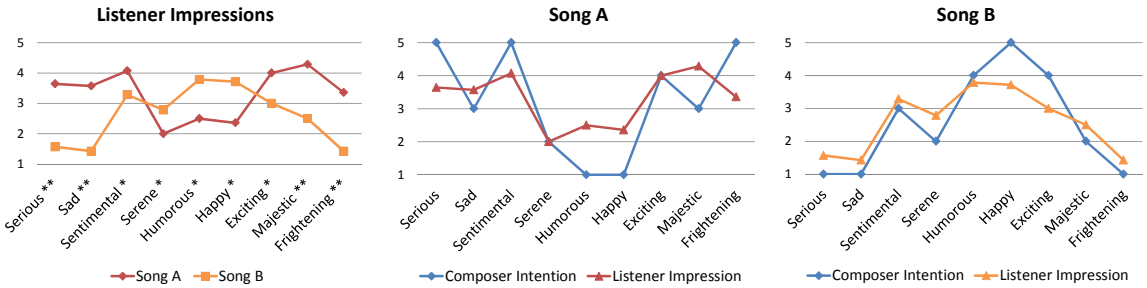

Figure 3: Survey results regarding composer intention and average of listener impressions (* p<0.5, ** p<0.1).

B. The rise during the modulated part of song A is particularly noticeable. The composer's FTT does not rise as much throughout the whole duration of song A, but does change in a similar way to listeners' from the modulated part of the song, through to the end of the song. The composer's FTT decreases for song B in a similar way to the listeners' temperature.

5.2 Survey Data

A One-way ANOVA of the emotional values evaluated in the survey revealed a significant difference between songs A and B for all nine emotions. This difference was most significant for emotions 'Serious' ($F(1,13) = 29.00$, $p < 0.01$), 'Sad' ($F(1,13) = 71.34$, $p < 0.01$), 'Majestic' ($F(1,13) = 31.61$, $p < 0.01$) and 'Frightening' ($F(1,13) = 20.56$, $p < 0.01$). This indicates participants received a significantly different overall impression of the two songs in regards to emotions conveyed by the songs.

Also, a similarity in the emotional evaluation of listeners and composer can be noticed, as seen in figure 3. Both composer and listeners have evaluated song A in an overall convex manner and song B in a concave manner. This would indicate the composer's overall intentions behind songs A and B were, for the most part, successfully conveyed to the listeners.

6 DISCUSSIONS

Despite the fact that the span of this experiment covered music by only one composer, and was analysed by only a small group of listeners, the parallelisms between composer intention and listener impressions (as seen in the data of figures 2 and 3) do give us multiple aspects of this research we would like to further investigate.

The first thing we notice is how the FTT of listeners and composer decreases throughout song B. This, combined with the fact that there is a consistent change in listener SCR throughout the song, implies that there is a constant stimulus in song B causing some sort of tension throughout the whole song. Analyses of the rhythms in song B show that the melody is heavily syncopated, with 35 out of 63 bars of music containing some sort of syncopation; mostly missed-beat syncopations, but in some cases suspensions across beats. Syncopation is widely used as a means of generating musical tension, but these results may indicate they cause physiological tension in listeners also.

Another noticeable characteristic is how skin conductance figures rise during the initial phrases of both songs. Both composer and listeners show SCR responses at the beginning of each song. This could imply there is a uniform excitement (or anticipation) among listeners regarding songs they are about to listen to. This excitement/anticipation may be either a conscious or subconscious response to the music depending on the person.

It is also interesting to note how participant SCL has peaked right at the first major change in melody for both songs. The descent of SCL for the remainder of the song would indicate listeners were generally more relaxed once they got accustomed to the song, and it was individual musical events, not the song as a whole, which would later cause physiological responses in the listeners.

The changes noticeable in physiological data during the modulated part of song A has left much room for speculation. Overall, FTT has risen in this section of the music for both listeners and composer. The difference in temperature change of listeners is particularly noticeable when compared to the slightly concave graph structure in the first and last parts of the song. It is uncertain at this point whether this change in temperature pattern is due to the change in the musical mode (major and minor), or due to the change in melody structure and thus deserves further investigation.

7 CONCLUSIONS

In this research, we have taken physiological data of both composer and listeners listening to the same music. We also had listeners evaluate their impressions of the music using an emotion set derived by Bruner, and compared that to the evaluation of intended emotions by the composer. Both physiological data and survey data show some correlation between that of the composer and listener averages, suggesting composer intentions are, to a degree, successfully conveyed through music.

A distinctive point of our research is that we have taken the concept of composer "intention", a concept similar to that which one will find in musical aesthetics, and have tested the grounds for investigating it in light of physiology and musicology. That is why in this paper we have focused mainly on the structure, or form, of attained data and have not done many detailed analyses. We have laid out some outstanding observations from the data, but have limited attributing musical and psychophysiological opinions to these observations.

We will now take our findings from these experiments and structure more specific plans for future research. Recruiting multiple composers will be necessary in forming general models of composer intention and also finding concrete relations between those intentions and listener impressions. Musical variables, such as melody and rhythm structure, will need to be controlled in order to find distinct musical attributes, if any, that affect the relation of composer intentions and listener impressions. Finally, evaluation of individual's physiological data would be worthy of future investigation also, as it may shed light on the diverse listening preferences and habits of listeners, giving composers insight into the audience of their music.

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