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Emotional Responses to Bach's Sarabande from Cello Suite #6: A Comparison of Continuous Measurement Instruments

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Abstract

How are the emotions perceived in music different from those actually experienced by the listener, and how can these perceptions and experiences be best measured in a continuous fashion? In this experiment participants listened to four samples of music and were asked in different sessions to report their experienced emotion and the emotion they perceived in the music using each of two different continuous recording instruments. One LabVIEW-based software instrument employed a two-dimensional space consisting of a circumplex with emotion labels, while the second employed two sliders with labels only at each end. Location along the two principal dimensions of pleasantness and activation was recorded each second as the participant moved a pointer toward the chosen labels. Hierarchical linear modeling showed that prior musical training increased the difference between experienced and perceived pleasantness. Responses recorded with the emotion space showed a significantly greater decrease in pleasantness than those recorded with the sliders when a distant key change occurred in J.S. Bach's "Sarabande, Suite #6 D Major." The key change may have been an ambiguous stimulus for emotion that the labels of the emotion space helped define, suggesting that the instrument with a labeled circumplex is more sensitive to music-elicited emotion.
Keywords: Music, Emotion.

1. Introduction

Emotions awakened by the music of Stravinsky's ballet, *The Rite of Spring* caused fistfights and rioting to ensue in a Paris concert hall in 1913. This piece was an example of primitivism, a musical style intended to contrast the fragile melodies of the music written prior to it with unexpected rhythms and dissonance. The *Rite of Spring* debacle illustrates the intertwined relationship music shares with emotion. There is little dispute that music and emotion are connected; however there is an ongoing debate within music psychology between the emotivist viewpoint which claims that emotion in music is experienced by the listener, and the cognitivist viewpoint which holds that emotion is only perceived. Because emotion in music has proven difficult to empirically measure, relatively few studies have been done on the subject. This study is an attempt at refining the instruments used to capture listener's emotional responses to music as well as identify the causes that led to participants indicated responses.

There is a great deal of evidence suggesting that emotion can be perceived in music, dating back as far as the late 1800's. Numerous studies have been done having participants listen to some kind of musical stimuli and then report the emotions they perceived in the music using free description, ratings, or a choice of adjectives. These studies have shown that composers can effectively communicate emotional expression in music and have also indicated what harmonic, melodic, and rhythmic devices in the music are used to convey specific emotions [1,2]. Evidence of emotional experiences to musical stimuli is not vast due to the difficulty of empirically measuring responses; however the current body of evidence certainly suggests that they exist. The common approach in these

experiments is to link the subjective reports of listeners with behavior or physiological changes. This approach realizes two of theorists' components of experienced emotion and shows that participants are not simply doing what is socially desirable in the laboratory by reporting emotions that do not actually exist. A study by Sloboda obtained reports of physical responses in listeners such as lump in throat, goose bumps racing heart, and shivers [3]. In a third of these reports the induced physical response was caused by a single theme, chord, or moment in the music. In another study done by Krumhansl, significant changes in the autonomic nervous system were found to complement the subjective emotion reports of listeners [4]. Significant changes in the ANS were found for each of the pieces that expressed different emotions such as happiness, sadness, or fear.

It has been established that emotions have a strong connection to music, but how does music give rise to these emotions? A theory presented by Juslin and Sloboda regarding the sources of emotion in music divides musical emotion into two categories, intrinsic emotion and extrinsic emotion [5]. Intrinsic emotion is caused by the creation, fulfillment, or disruption of musical expectation within a listener. These musical expectations are created and disrupted through musical devices such as cadences, appoggiaturas, or as in the case of *The Rite of Spring*, melodic dissonance and unexpected rhythm changes. This intrinsic "proto-emotion" becomes a genuine emotion when it accompanies an extrinsic source of emotion. Extrinsic emotion consists of two parts, iconic and associative. Iconic emotion refers to the emotion that arises when music resembles something non-musical, such as fast notes being equated with a feeling of high energy. Iconic emotions are accessed equally by musicians and non-musicians and account for the similarities in reported emotion when people listen to a piece of music. Associative emotions arise when music serves as a stimulus for the recollection of a past event, and the emotion elicited is then related to that specific event. Due to the unique set of experiences each individual has collected over their life, these associative emotions account for the differences in emotion between listeners hearing the same piece of music. In listening to a piece of music the different sources of intrinsic and extrinsic emotion may occur individually, all at once, or even not at all. Emotion coming from different sources may be in opposition, leading to an ambiguous emotion, or in agreement, leading to further clarity.

Emotional responses to music have been measured and recorded using both asynchronous and more recently continuous measurement methods. Asynchronous responses sample listeners' responses at fairly infrequent intervals over the course of the music. This has been done in a variety of ways in past music emotion studies dating back to Hevner in the 1930's. In Hevner's experiment participants listened to the music and, at the end of sections in the music, selected adjectives from a checklist that described their emotion judgment [1]. This checklist method yields a low sampling rate and does not allow for the correlation of emotion judgments to specific musical events. Furthermore the task of selecting a word from a checklist takes attention away from them music and interferes with the task of listening and perceiving emotion. Using lists of adjectives to describe emotion is also conducive to the categorical approach to emotion. This categorical method has been criticized because researchers have defined different sets of basic emotions creating the problem of choosing what adjectives to use in the list [6].

Another format for recording emotion in response to music is the rating scale. Rating scales often measure one or two dimensions of emotion labeled only with vague descriptive words at their boundaries. This format operates on the assumptions of the dimensional approach to emotion, which says that emotions lie on a few dimensions such as valence, activity, and potency. Rating scales mitigate the problem of task interference while listening to music and negate the problem of selecting adjectives; however this approach has been criticized for blurring distinctions between different emotions.

The continuous response method responds to many confounds of previous approaches. Continuous response measurement methods have been developed using the two-dimensional model of emotion, asking participants to indicate their responses along the dimensions of an emotion space on a computer interface [6,7]. In the continuous measurement method, responses are recorded without interruption by a computer during the listening process. This allows for a high sampling rate while taking only minimal attention to indicate a response. Continuous response measurement allows for the study of moment-to-moment fluctuations in listeners' responses, which can then be linked to the musical events that caused them. This method can also be used to study differences in group or individual responses. A problem with the currently developed two-dimensional emotion space, however, lies in the use of or selection of labels. By creating a two-dimensional emotion space and using labels along the axes or scales, one can combine the dimensional and categorical approaches to emotion. While this conglomeration of theories into one instrument initially sounds like the perfect tool for capturing emotion responses there is evidence that the use of labels can result in more extreme responses of emotional experience in listeners using a two-dimensional emotion space [8]. While the methodology for recording emotional responses to music has developed dramatically there are still effects measurement methods have on psychological processes that are not understood. This study was conducted to investigate these effects through differences in participant responses of perceived and experienced emotion as recorded by two different continuous response instruments.

Recent work in our laboratory suggests that the labels on the emotion space produce somewhat more extreme responses than does the same space with only the axes labeled [8]. In the present study we tested whether participants report similar emotions if supplied with two sliders (analogous to the two dimensions of the space) rather than a space. Since the distinction between experiencing and perceiving emotion remains problematic in the literature, the present experiment also investigated the effects of two instructional conditions designed explicitly to separate experiencing emotion from simply perceiving it in the music.

2. Methodology

2.1 participants

Twenty-eight students from Bethel College participated in the study. The data from one participant was unusable and was dropped. Four of the twenty-seven students were music majors. Participants reported an average of 3.4 years of musical participation with a range of 0 to 14 years. Participants had an average of 3.2 years of private lessons with a range of 0 to 13 years.

2.2 apparatus

There were two different LabVIEW (National Instruments, Austin, TX) virtual instruments used to capture emotional responses. The first was a two-dimensional emotion space consisting of a circumplex surrounded by labels based on the two-dimensional structure conceived by Barrett and Russell [9]. The vertical dimension of the circumplex measured activation with the top half bordered by activated emotion labels and the bottom half having labels indicating feelings of deactivation. The horizontal dimension measured pleasantness with pleasant emotion labels on the right half of the circle and unpleasant emotions on the left. Each of the dimensions was labeled with emotion words such as “happy”, “upset”, “tense”, or “serene” placed in appropriate locations around the circumplex. Labels opposite each other on the circumplex represented opposite emotions. A small red “X” could be placed in different locations around the circumplex using a computer mouse. The closer the “X” was to a particular label the more purely that label identified the participant’s emotion. The center point of the circumplex where the axes cross was a neutral point. Positioning the “X” at this location indicated that the participant was indifferent to the music. The location of the “X” was recorded by the computer once per second as a set of coordinates on the two dimensions of the circumplex.

The second instrument, also in LabVIEW, was a set of two bars on which sliders could be moved on scales from zero to ten. One bar again measured the dimension of pleasantness and the other bar measured activation. Each of the bars was only labeled with the poles of the dimension it measured. The bar measuring pleasantness was on a scale of zero to ten, with zero at the left labeled as “Unpleasant” and ten on the right labeled as “Pleasant.” The bar measuring activation, also on a scale of zero to ten, was labeled “Deactivation” on the left at zero and “Activation” on the right at ten. Sliders could be moved along each of the bars using a computer mouse. The point 5.00 on the bars was the neutral point. If each slider was placed at this value it indicated that the participant was indifferent to the music. The location along the scale of each of the sliders was recorded once per second as a set of coordinates on each of the dimensions.

2.3 experimental stimuli

The four instrumental musical excerpts chosen for this experiment are as follows: (1) “The Dreams and Prayers of Isaac the Blind”, Osvaldo Golijov; (2) “Sarabande” from Cello Suite #6 in D Major, Johann Sebastian Bach; (3) “Tanguedia III”, Astro Piazzolla; (4) “Gran jota”, Francisco Tarrega. Each excerpt was 1-2 minutes in length and played in a random order.

2.4 procedure

Each participant completed two twenty-minute sessions. In one session participants were asked to indicate their own emotional response to the music using the both the emotion space and the sliders. The order as to which instrument participants would use first was determined at random. For the emotion space each participant was read a set of instructions asking them to move the “X” to the location on the circumplex that best described their current

emotion. Students were encouraged to move the "X" every time their emotion changed, and the computer recorded their moment-to-moment changes. At the end of each excerpt the program paused until the participant clicked a 'Continue" button on the instrument which moved the "X" back to the neutral point and started the next excerpt. Participants completed two practice excerpts where their responses were not recorded in order to familiarize themselves with the instrument. Following the practice excerpts, the experimenter asked a series of questions to ensure that the participant understood the task. Upon successfully answering the questions, the participant then performed the task of listening to the four excerpts used in the experiment and rating their emotional response. In this same session participants then performed the same task of indicating their own emotional response to the music but this time using the sliders. Each participant was again read a set of instructions asking them to move one or both of the sliders every time their emotional response changed. The same format was followed as with the circumplex, using two practice excerpts, asking questions to ensure comprehension, and then proceeding with the four tracks used in the experiment.

In the second session participants heard the same four tracks and were asked to indicate not their emotional response, but what emotion they perceived to be in the music itself. Participants were read the same instructions as previously described only clarifying that they were to rate the music itself as opposed to their own emotions. The same procedure was followed as in the first session with participants again performing this task on both the emotion space and sliders.

The order of the two sessions was randomly determined as was the order of which instrument they used first. At the conclusion of the experiment participants were asked to fill out a questionnaire regarding age, gender, year in college, and musical training, experiences, and music preferences.

2.5 data analysis

The data were analyzed by means of hierarchical linear modeling using HLM, version 6.0 software [10]. This approach allows prediction of the emotion data using repeated-measures variables on the one hand – such as instructions, measurement method (emotions space or sliders), key change, and interactions among these variables – and participant variables on the other, such as amount of prior musical experience or training. The resulting models have two hierarchical levels, with level 1 referring to repeated measures and level 2 referring to participant variables. For example, the best model we found for the pleasantness data is shown below:

LEVEL 1 MODEL

$$\text{PLEAS0} = \pi_0 + \pi_1(MORE) + \pi_2(SPORSL2) + \pi_3(KEYCHNG2) + \pi_4(SPKEYINT) + e$$

LEVEL 2 MODEL

$$\pi_0 = \beta_{00} + r_0$$
$$\pi_1 = \beta_{10} + \beta_{11}(YRSPRIV) + r_1$$
$$\pi_2 = \beta_{20} + r_2$$
$$\pi_3 = \beta_{30} + r_3$$
$$\pi_4 = \beta_{40} + r_4$$

In this model MORE is a code for the instruction to rate music or emotion; SPORSL2 codes the measurement method (emotion space or sliders); KEYCHNG2 codes before and after the key change; and SPKEYINT is the interaction between the previous two variables. YRSPRIV is a participant-level variable – reported number of years of private music lessons (instrumental or vocal). Further detail is provided in the results.

3. Results

Overall no significant differences were found in activation responses between the four conditions. Pleasantness responses on the other hand revealed some intriguing differences. Time series graphs were created for participants' average responses for each track in all of the four conditions. The graph of J.S. Bach's "Sarabande" revealed a significant difference between the sliders and the emotion space when participants were indicating experienced pleasantness. At eighty-five seconds into the piece there is a distant key change in the music and at this time the mean pleasantness rating drops only when participants used the emotion space as seen in Figure 1. Participants indicated no change in pleasantness when using the sliders at the time of this same key change eighty-five seconds into the piece.

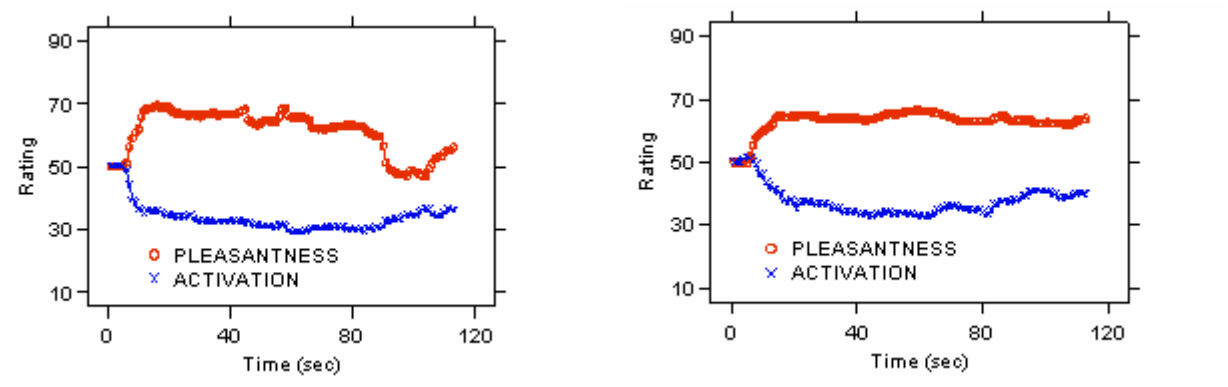

Figure 1: Mean emotion ratings for Bach's "Sarabande" for all participants using emotion space method (left) and slider method (right) (n=27)

Data from individual participant emotion responses to Bach's "Sarabande" using the emotion space were studied, and it was determined that seven of the twenty seven participants indicated a large drop in experienced pleasantness at the time of this key change eighty-five seconds in the piece causing the drop in the group average. The responses of these seven participants who indicated a large decrease in experienced pleasantness using the emotion space at the time of the key change were then averaged and graphed, as were the emotion space responses of the other twenty participants who indicated little or no change in experienced pleasantness in response to this key change. Figure 2 shows a dramatic decrease in pleasantness rating for those seven participants who show the key-change effect while using the emotion space to report experienced emotion. However, when using the sliders the group showing the key-change effect shows only a slight decrease in pleasantness. The twenty participants who did not show the key change effect reported only a slight decrease in experienced pleasantness on the emotion space and no change when using the sliders.

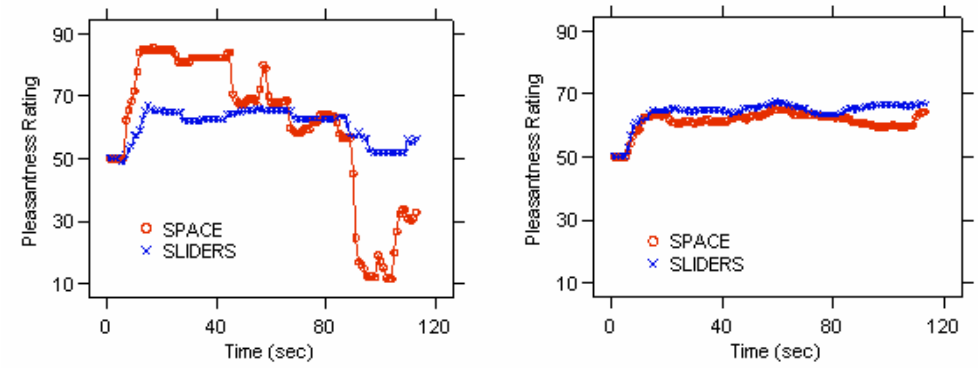

Figure 2: Mean pleasantness ratings for participants showing key-change effect (left) (emotion space method vs. sliders method, n=20) and mean pleasantness ratings for participants showing no key-change effect (right) (emotion space method vs. sliders method, n=7)

The effects of the key change and the different measurement instruments were reflected in the HLM models that emerged from our data analysis. While the only clearly significant effect in models of activation was its overall level (significantly below neutral, as Fig. 1 above suggests), there were several significant effects on the pleasantness dimension. The p-values and brief interpretations for the model shown above (see section 2.5) are:

0.001 – overall level of pleasantness significantly above neutral
0.546 – MORE, non-significant overall difference between music and emotion rating
0.019 – interaction of MORE with YRSPRIV, significantly more pleasant rating for emotions than for music as years of private lessons increase
0.140 – SPORSL2, non-significant overall difference between emotion space and slider instruments
0.010 – KEYCHNG2, significant decline in pleasantness rating after the key change (see Figure 1)
0.008 – SPKEYINT, significant interaction between space vs. sliders and key change, reflecting a greater effect of the key change with the emotion-space instrument, as suggested by Figure 2.

4. Discussion

The findings from this study indicate that there are individual differences in how people experience emotion elicited by music. Graphical analysis showed a drop in experienced pleasantness in Bach's "Sarabande" for seven individuals only when using the emotion circumplex and not the sliders. The remaining twenty participants indicated little or no change on either instrument. At the time in the music when seven of the participants indicated this decrease in pleasantness there is a distant key change in Bach's "Sarabande" from the key of A major to E minor. The peak dissonance of the piece occurs at this time in the music with a D#, a note a half step away from the piece's original key of D Major. The elicited response of decreased pleasantness echoes the findings of past studies that show an association between major mode and happy emotions and minor mode and sad emotions [2]. This key change from major to minor, taking the listener from happy to sad, may have been an ambiguous stimulus that created an emotion in the listeners that the labels of the emotion space helped to define. The key change may have created a situation within listeners that created a conflict of Juslin and Sloboda's sources of emotion leading to an emotion that may have been hard to define. Evidence in the non-musical world that sources and states of emotion can be confusing are shown in Dutton and Aron's study where the males interviewed by an attractive female on a precarious suspension bridge were more likely to call the interviewer back than those interviewed over the low sturdy bridge [11]. Male participants misinterpreted their activated emotions as being caused by the attractive interviewer as opposed to the high bridge. Just as the bridge caused an emotion that the participants did not know whether to interpret as fear or as love, the distant key change in Bach's Sarabande may have elicited a similarly confusing emotion in listeners. Because the dramatic decrease in pleasantness only occurred when participants used the labeled emotion space to report their experienced emotion, the current study also suggests that labels play a role for some individuals in defining the ambiguous emotion created by the key change. The study done by Bower, Karlin, and Dueck where participants were shown droodles and were later asked to draw what they had seen, showed that labels help the recall of an ambiguous stimulus [12]. Personal identification of emotion is a sort of recalling a label we have learned that matches and communicates an experienced internal state or emotion to our peers. The labels of the emotion space may have provided the thematic clue that facilitated the identification of the ambiguous emotion created by Bach's key change, just as attaching labels to droodles made them easier to identify and recall. The results of this study support the findings of Dain, that labels reduce the ambiguity of the emotion space and can affect the emotional self-report process. However, the current study shows that the effect of labels is not universal but that it varies among individuals as seven participants indicated the decrease in pleasantness and twenty did not.

The findings of this study also shed light on the emotivist-cognitivist debate as to whether or not emotion can be experienced in music or only perceived. The HLM analysis shows that the more private lessons participants had, the higher their pleasantness ratings were when reporting experienced as opposed to perceived emotion. The number of years of private lessons increased the level of experienced pleasantness relative to perceived pleasantness. This difference between experienced and perceived pleasantness in participants who have had private lessons shows that the two conditions are indeed separate and emotion can be experienced when listening to music. Furthermore, this finding shows an effect of musical experience on emotion ratings that has rarely been observed in past studies. Previous comparative studies using continuous measurement have found no differences in either perceived or

experienced emotion between musicians and non-musicians [6]. This study shows that musical experience in the form of private lessons can affect a person's emotional experience while listening to music, making the experience of listening to the same piece of music different between people with musical training and people with little or no musical tutelage.

In summary, this study revealed differences in both individuals' experiences of emotion in music and the continuous response instruments used to capture them. For some individuals the labels of the emotion space may have helped to define the ambiguous emotion created by the key change, making the labeled emotion space a more sensitive instrument than the sliders for capturing music-elicited emotion. Individual differences between trained musicians and less trained musicians were also observed, creating a possibility for future comparative research in an area where few differences had previously been shown. Finally this study also exposed a difference between perceived emotion and experienced emotion while listening to music, suggesting that music can not only be perceived in music but also experienced.

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