Toward Augmenting Emotion: Study On Real Time ECG Feedback

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Recently, recognizing emotion through physiological information has flourished. Next research interest is how such information feedback influences user's emotion, because controlling emotions is a key to keep our performance. Aiming at augmenting emotion in real-time and daily-usable system, we studied the influence of physiological information feedback on user's emotion using standardized emotional movie clips. We built real-time Electrocardiogram (ECG) visualization system and studied the influence of the feedback. We believe that this study offers significant implications when designing real-time physiological information feedback system. Finally, a possible study direction toward augmenting emotion with wireless ECG sensor is discussed.

1. Introduction

1.1 Toward Augmenting Emotion

Recently, recognizing emotion through physiological information has been flourished [1][2]. Next research interest is how such information feedback influences on user's emotion.

For example, we easily get into trouble when experiencing strong emotion like anger or sadness. This kind of emotion leads to misunderstanding of other person's emotion or their situation. In other words, we might not be able to act rationally with strong emotion.

Augmenting emotion with physiological information such as GSR, ECG is one possible solution. However, study on the effectiveness of such information feedback is not so many.

Toward designing augmented emotion system, we first worked on the effectiveness of physiological information feedback.

1.2 Our Goal

Our final goal is to design a system that augments emotion in real-time and daily-usable manner. In this report, we studied the influence of physiological information feedback on user's emotion using standardized emotional movie clips.

2. Related Work

2.1 Related Work

Van der Veen et. al. studied feedback processing and remedial action in schizophrenia using fMRI [11]. While their study suggests that emotion feedback plays a important role in remedial action, fMRI is difficult to use in daily-usabale manner. So we focused on ECG.

The study of Mishra et. al. concluded that users accept affective feedback from the computer but do not necessarily respond to it the same way as they do if they receive the same feedback from humans [7]. While their study is suggestive in the relationship between humans and computers, our motivation is building self-feedback loop to control user's emotions.

Arapakis et. al. published a thought-provoking study on affective feedback while information seeking process [3]. Though this research is suggestive on information seeking in front of computer, our goal is to design augmenting emotion system in real-time and daily-usable manner.

2.2 Physiological Information

In this section, we introduce physiological information that is considered to be useful in emotion estimation.

・*fMRI*

Functional magnetic resonance imaging (fMRI) is a powerful tool that can visualize brain activity in high resolution. Moreover, it can analyze deep brain activity that is difficult to analyze by EEG [12]. However, it requires huge facility so it is difficult to be used in a daily manner.

・*EEG*

Electroencephalography is a well-used tool to analyze brain activity [9]. However, it is sensitive to environmental noise and it is difficult to analyze deep brain activity to assess emotion because of the problem of volume conduction.

・*GSR*

Galvanic Skin Response (GSR) is easier to implement and well-used in the field of affective computing [10]. It is said to be correlated with arousal, however, assessing emotion using GSR is itself quite a challenge.

・*ECG*

Electrocardiogram (ECG) is also well-used tool to diagnose heart problem or autonomic response [6]. Heart Rate Variability (HRV) is well-used index of emotion estimation. ECG signal is relatively strong so it could be used in a daily situation. Clinical implementation is huge, however, it can be reduced to 3-leads and can be implemented in small-sized device.

2.3 Heart Rate Variability (HRV)

Number of indexes calculated from ECG signal has been proposed, like HRV, pNN50, rMSSD, etc [2]. In this

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report, we used HRV as an index of emotion.

3. Experiment

3.1 Subjects

Eight subjects (six males and two females, 19-35 years old; M: 25.3 years, S.D.: 4.8) were recruited for participation in an experimental session lasting approximately 1.0 h.

3.2 Movie Clips

Standardized movie clips from Emotional Movie Database (EMDB) were used to elicit the discrete emotions of amusement, anger, sadness, contentment, and a relatively neutral state [5]. The clips were approximately 40 seconds each, and were presented on a 20.1-inch flat-panel display approximately 1m from the subject.

3.3 Questionnaires

Experienced affect was assessed using an 18-item affect self-report scale. The scale is consistent with a hybrid model of affective space and contains items traditional to both discrete (amused, fearful, angry, sad, disgusted, and content) and dimensional (good, calm, unpleasant, passive, excited, negative, relaxed, active, positive, agitated, bad and pleasant) models. Responses to all items were based upon a 7-point Likert scale assessing the degree to which the word accurately described affective experience.

3.4 ECG recording and Feedback system

Electrocardiogram (ECG) was recorded with the e-Health Sensor Platform [1] (Figure 1). The ECG was obtained through Arduino on-board ADC (9600Hz) and visualized with Heart Rate. (Figure 2)

3.5 Procedure

Subjects were told they would be watching a number of short movie clips with different emotional content and that they were told to pay attention to stay calm while watching. Experiment was conducted in a quiet room and subjects were told to wear earmuff for reducing noise. The affect self-report scale was completed after presentation of each movie clip to assess affective responses during the film. Following completion of the scale, a 30-seconds rest was given to subjects. The next stimulus presentation then commenced. This procedure was repeated for the five stimulus conditions. The experimental procedure was divided into two sessions; without-ECG session and with-ECG session. In a with-ECG condition, subjects can look at their ECG signal and heart rate while watching the movie clips. Subjects are divided into two groups; group 1 does without-ECG session followed by with-ECG session, group 2 does with-ECG session followed by without-ECG session. Averaging two groups conditions, the effect of learning was canceled.

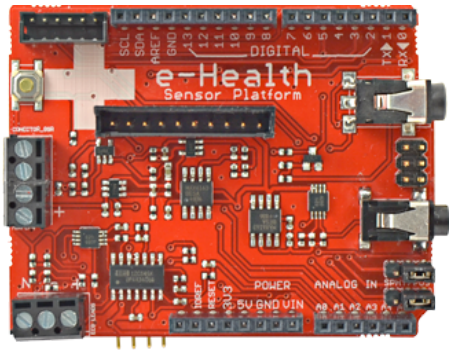

Figure 1 e-Health Sensor Platform.

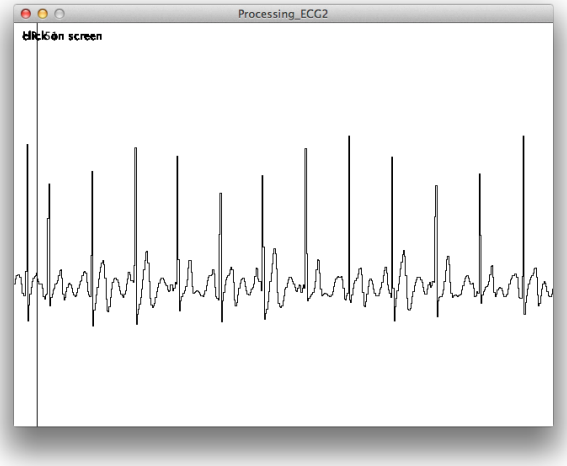

Figure 2 Visualized feedback of real time ECG and Heart Rate.

3.6 Results

・*Elicitated Emotions*

While we observed that elicitated emotions are consistent with the ones EMDB anticipates [5], the results between conditions (with-ECG and without-ECG) does not show differences. Figure 3 shows the result of questionnaire of Amusement condition as a representative image. As experimental session lasts only within 1 hour, subjects' impression on the movie clips does not differ significantly between conditions. Other questionnaires in different emotions also show similar result between conditions.

In order to conclude that there is no difference between conditions, two-sided paired-t test of affect self-report scale between with-ECG condition and without-ECG condition are conducted. Confidence intervals are set to 95%. Table 1 shows the result of the test. For any emotions, $p > 0.05$ is true. That means there is no significant difference between with-ECG and without-ECG conditions.

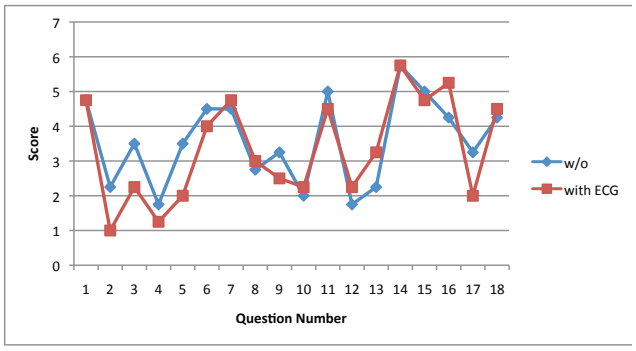

Figure 3 Result of Questionnaire of the Amusement condition.

Elicitated Emotion	p value
Amusement	0.529
Anger	0.427
Sadness	0.83
Contentment	0.091
Neutoral	0.132

Table 1. The result of paired-t test.

・*HRV differences with feedback*

Figure 4 shows the result of HRV differences between conditions of all subjects. HRV itself means variance of the heart rate, we plotted all the subjects' result in a scatter plot. The differences of averaged HRV is plotted as a black line.

The result shows that HRV significantly decreases with-ECG condition among all emotional stimuli. This suggests the possibility that ECG visual feedback moderates user's HRV.

4. Discussion

In this report, we investigated the possibility of augmenting emotion through real time ECG feedback. The result shown in Figure 3. and Table 1. means that emotions elicitated by movie clips are strong enough that the questionnaires shows no significant differences. On the other hand, HRV shows significant difference between without-ECG and with-ECG conditions. Together with the result of questionnaire, it suggests tiny emotional differences that subject does not notify are made while watching their physiological information feedback in real time. This implies the possibility of augmenting emotion through real time feedback.

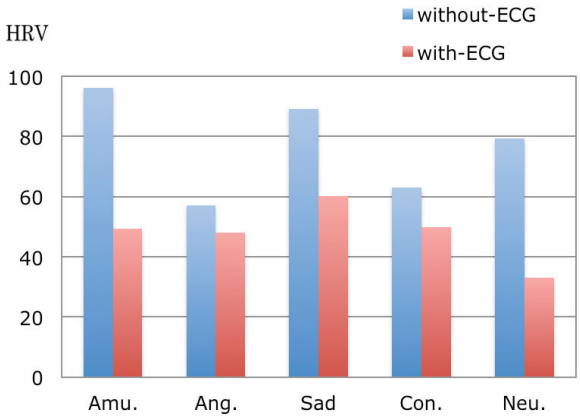

Figure 4. Result of HRV differences. Vertical axis denotes HRV. Key: Amu, Amusement; Ang, Angry; Con, Contentment; Neu, Neutral.

5. Future Work

5.1 Appropriate feedback

In this report, we used simple ECG graph and Heart Rate display as a feedback. Different feedback system could be considered using other index (pNN50, rMSSD, etc.), or other modality (audio feedback, haptic feedback, etc.) We will study on the effectiveness of different feedback systems.

5.2 Wireless ECG sensor

We are designing and implementing small and wireless ECG sensor board that can be used in a daily-life. (Figure 5) The size is 2.5cm x 8 cm x 1.5cm. Our goal is to design augmenting emotion system in real time, daily-usable manner. We will work on this project toward that goal.

5.3 Effect on social interaction

In this study, we investigated well-studied one-person emotion analysis using Emotional Movie Database. However, social interaction among two or more persons is crucial for emotion elicitation. We believe this kind of multi-person and real-time emotion analysis should be investigated in this field. We will study this topic using wireless ECG sensor described above.

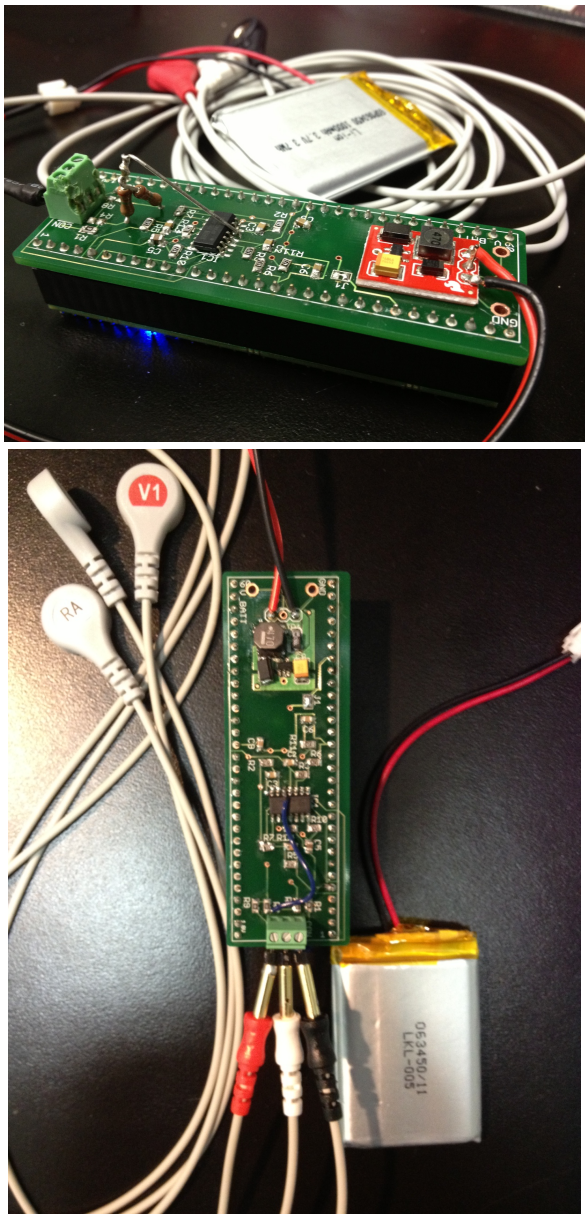

Figure 5. Wireless ECG sensor.

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