Difference in skin conductance dynamics to horror and family bond emotional movies

Tatsuki Makioka, Shogo Okamoto
Department of Computer Science
Tokyo Metropolitan University
Hino, Japan

Ibuki Tara
Department of Mechanical Systems Engineering
Nagoya University
Nagoya, Japan

***Abstract*—We investigated differences in skin conductance responses depending on the type of emotions evoked during the experience of audio-visual contents. We hypothesized that the dynamics of the skin conductance response would differ depending on the type of emotions aroused. We used two types of audio-visual contents: videos that evoke feelings of family bond and those of fear. The profiles of the measured skin conductance response were approximated using two exponential functions and a Gaussian filter to investigate the differences in dynamics in a parametric manner. Viewers' skin conductance responses changed in horror scenes and those evoking family-bond impressions. The skin conductance responses tended to change more quickly toward horror movies than those featuring family bonds. The results suggest that the type of emotions can be discriminated based on the changes in skin conductance.**

***Index Terms*—Emotion, Skin conductance, Fear, Family bond**

I. Introduction

A growing number of computer systems are attempting to estimate and leverage users' emotional states to decide about their behaviors and provide services. For example, music players read the emotions and moods of listeners and make playlists accordingly [1]. A conversational health-care system judges human emotions before advising them [2]. In these technologies, the estimation of human emotions is typically based on facial pictures, voices, and physiological signals, such as heart rates.

The skin conductance of human fingers changes upon emotional stimuli due to sweating, and it has been used in many psycho-physiological studies and engineering studies [3]–[5]. The skin conductance response is less privacy-sensitive than facial pictures or voice data. However, thus far, few studies have investigated the relationship between the type of emotions and dynamics of skin conductance responses whereas the dynamics of skin conductance responses were studied between different types of stimulus modalities [6]. The skin conductance could respond differently against different kinds of emotional stimuli considering that their neurophysicological processes differ [7].

In this study, we investigated the difference in the dynamics of skin conductance responses by using the two types of emotionally arousing short videos. One was horrific and the other featured family bonds. It is expected that the skin conductance response changes rapidly in response to aversive stimuli such as fear. In contrast, impressive family-bond scenes are speculated to require a cognitive process, which may cause relatively slow changes in physiological responses. We computed two parameters determining the dynamics of skin conductance responses after approximating the dynamic responses by using a combination of two exponentially decaying functions. These parameters were then compared between the two types of short videos.

II. Methods

This study was approved by the Institutional Review Board of Hino Campus, Tokyo Metropolitan University (#H21-046).

A. Emotionally Arousing Movies

Two horror movies were used for the experiment. In these movies, monsters suddenly appeared to horrify the viewers. Each video was approximately 2 min in length.

Further, we used two movies dealing with family love. In both videos, a child is reunited with his/her parent after a long time of separation. The length of each video was approximately 3 min.

These movies were played on a 21-inch display that was placed 60 cm away from the participant's head. The sounds were played through headphones.

B. Skin Conductance Response

The skin conductance response is a physiological index related to arousal. Sweating associated with tension or excitement changes the electrical properties of the skin, and it changes merely 1–2 s after the stimulus presentation [8].

A skin electrical activity measurement unit (AP-U030m II, Nihon Suntech, Japan) and amplifier (MaPI720CA, Nihon Suntech, Japan) were used to measure skin conductance. Each of the two electrodes was attached to the first and second fingers of participants. These devices were connected to a DAQ device (NI USB-6211, National Instrument Corp., TX) and controlled by the *Data Acquisition Toolbox* of Matlab (Matlab 2021a, Mathworks, MA).

C. Participants

Fourteen university students in their 20s that were unaware of the purpose of the study participated in the experiment. All participated in the experiment after providing written informed consent.

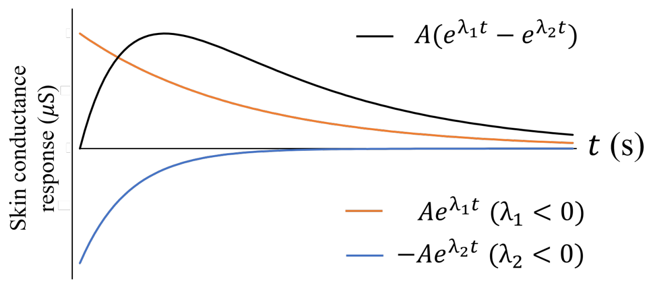

Fig. 1. Functional modeling of skin conductance responses. Temporal evolution of skin conductance (black curve) is approximated as the sum of two exponential functions (red and blue curves).

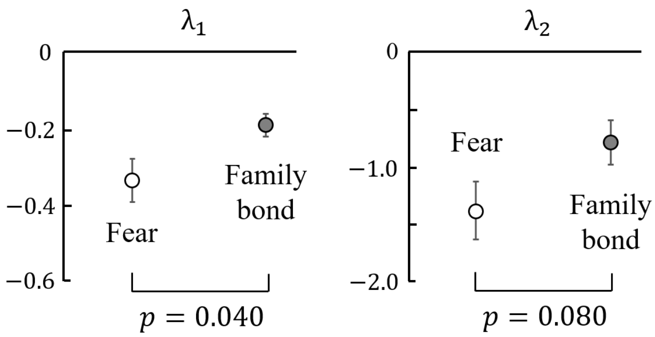

Fig. 2. Means and standard errors of λ_1 and λ_2 by fear and family-bond scenes. Left: λ_1. Right: λ_2.

D. Experimental task

Participants were asked to rest for 90 s to ensure that they were in a stable mental condition before experiencing each audio-visual content. They held a load cell while watching videos to report the subject magnitude of fear or family bond they felt by a grip force. These time-series grip forces were used to make sure that the changes in the skin conductance were caused by emotional experiences.

E. Analysis of Skin Conductance Responses

As shown in Fig. 1, the profile of the skin conductance response can be functionally approximated using two exponential functions and a Gaussian filter $N(t)$ [9] by

$$x(t) = A(\exp(\lambda_1 t) - \exp(\lambda_2 t)) \quad (1)$$

$$N(t) = \frac{1}{\sqrt{2\pi\sigma}} \exp(\frac{-(t-\tau)^2}{2\sigma^2}) \quad (2)$$

$$h(t) = x(t) \otimes N(t) \quad (3)$$

where $h(t)$ is the approximated curve and A, $\lambda_{1,2}$, and σ are the parameters to determine the dynamics. The $\lambda_{1,2}$ values are negative. The temporal changes of the skin conductance responses at the fear or impressive scenes were clipped and analyzed by using these formulae. The least-squares solutions were computed by using the *fmincon* function of Matlab. A few samples were excluded for the later analysis because of their low goodness of fit values.

We focused on λ_1 and λ_2 because they largely determine the waveform dynamics. We performed two-sample t-tests to compare the estimated λ_1 and λ_2 values between the horror and family-bond videos. For this comparison, we assumed that the variances were not equal for λ_1 and λ_2.

III. Results

Fig. 2 shows the mean and standard error for λ_1 and λ_2 for each type of video. λ_1 values barely exhibited a difference ($t(15) = 2.25$, $p = 0.040$), and those for the horror videos were smaller than those for the family-bond videos. In contrast, λ_2 values exhibited no difference among the two types of videos ($t(18) = 1.85$, $p = 0.080$).

The small λ_1 values for the horror movies indicate that the skin conductance responses caused by fear are more rapidly attenuated than those caused by a family-bond scene. Although the difference in λ_2 was not significant between the two types of movies, the rise in skin conductance tended to be quicker for horror scenes than for family-bond scenes. These suggest that the skin conductance response changes more slowly when feeling family bonds than when feeling fear.

IV. Conclusion

We investigated the differences in the dynamics of skin conductance responses when watching two types of videos that aroused fear or feelings of family bond. Thus far, such differences dependent on the type of emotions have yet to be reported. The two emotions were parametrically compared after approximating the skin conductance responses by using a linear combination of two exponential functions. For the fear emotion, it was suggested that the skin conductance response was more quickly attenuated than for the family-bond emotion. These results showed a tendency for skin conductance response to differ by emotion. This property allows comuter interfaces to estimate human emotions based on the parameters determining the dynamic skin conductance responses. A study on a variety of emotion types remains studied in the future whereas only fear and excitement were treated in this study.

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