The Enhancement of Hearing using a Combination of Sound and Skin Sensation to the Pinna

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ABSTRACT
Recent development in sound technologies has enabled the realistic replay of real-life sounds. Thanks to these technologies, we can experience a virtual real sound environment. However, there are other types of sound technologies that enhance reality, such as acoustic filters, sound effects, and background music. They are quite effective if carefully prepared, but they also alter the sound itself. Consequently, sound is simultaneously used to reconstruct realistic environments and to enhance emotions, which are actually incompatible functions.

With this background, we focused on using tactile modality to enhance emotions and propose a method that enhances the sound experience by a combination of sound and skin sensation to the pinna (earlobe). In this paper, we evaluate the effectiveness of this method.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. – Haptic I/O.

General terms: Human Factors

Keywords: crossmodal displays, pinna, skin sensation, emotion, emotional amplification

INTRODUCTION
The development of modern sound technologies has enabled the realistic replay of real-life sounds. These technologies include highly sensitive microphones, wide dynamic range speakers, and 3D sound field reproduction techniques. Thanks to these technologies, we can experience a virtual real sound environment.

However, there are other types of sound technologies that enhance reality, such as acoustic filters, sound effects, and background music. They are quite effective if carefully prepared, but they also alter the sound itself. Their final goal is to enhance emotion, since the auditory sense is known to be directly linked to emotional activities [1].

In summary, sound is simultaneously used to achieve the incompatible functions of reconstructing realistic environments and enhancing emotions.

We sought to use another modality to enhance emotions. One such modality is skin stimulus. The Emoti-Chair, for instance, is a chair with embedded vibrators, whose vibration enhances the effect of sound [2]. Another is the tactile jacket, which is a jacket that has embedded vibrators designed to enrich movie viewing [3].These examples indicate that simple tactile stimulation using sound signals effectively enhances emotional experience when presented simultaneously with sound.

In this paper, we propose a method that enhances the sound experience by a combination of sound and skin sensation to the pinna (earlobe). The pinna was selected because we experience its sensitive reactions to many stimuli daily. Moreover, it was reported that patients who had had a mastectomy experienced a "phantom nipple" when their pinnae were touched [4]. From this knowledge, we speculated that the pinna is an appropriate region to effectively evoke emotion by tactile stimulus.

SYSTEM OVERVIEW
Figure 1 shows an overview of our system. An audio signal is divided into an output to an earphone and an output to a flat type vibration motor (Nichibeimusen, 4F412). To drive the vibration motor, the audio signal is rectified by a capacitor diode circuit (Figure 1).

Figure 1 System Overview

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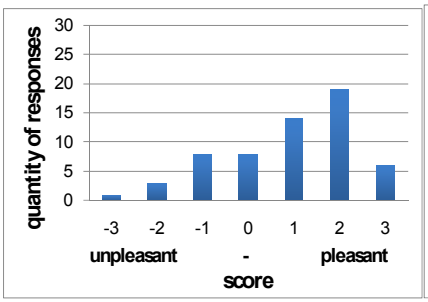

Figure 2: pleasant-unpleasant

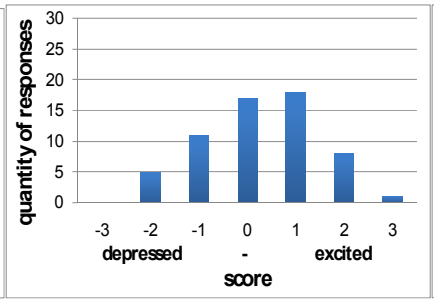

Figure 3: excited-depressed

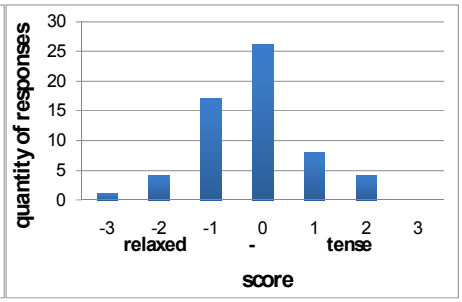

Figure 4: tense-relaxed

EXPERIMENT

We evaluated the effectiveness of this system with 10 participants (5 males and 5 females, 22-23 years old). During the experiment, the participants wore our system and a sleep shade to concentrate the stimuli.

We used voice stimuli that should evoke human emotion easily. We selected voice samples excerpted from the Hitsuji de Oyasumi CD/DVD series (Honeybee) of the same phrase being uttered by six different voice actors). One trial is composed of two patterns, one with tactile and auditory stimuli, and the other with only sound.

The timeline of the trial was as follows: (1) A voice sample with or without the proposed device was played for 15 s (2) An interval for 10 s followed (3) A voice sample with or without the proposed device was played for 15 s (4) The time allowed for the questionnaire was 40 s. The total duration of one trial was 80 s. Since there were six samples, the total time for the experiment was about eight minutes.

To balance the order effect, the participants were divided into two groups, one group used the proposed device at the beginning of each trial, and the other group used the proposed device at the end.

We used the following three adjective pairs to evaluate emotion using the Likert 7-point scale; "pleasant-unpleasant", "excited-depressed" and "tense-relaxed". These three adjective pairs were selected based on the "tridimensional theory of feeling" by Wundt [5].The participants were asked to evaluate the "change" in their emotions using the device. If the evoked emotion was not changed by the proposed device, the score was 0. If the participant felt more pleasant using the proposed device, the participant scored a positive value on a pleasant to unpleasant scale. After the experiment, participants were asked to write freely about the effect of the device.

RESULTS

Although we prepared two groups to balance the order effect, there was no significant difference between the two groups.

Figures 2-4 shows the distribution of all the answers. The horizontal axis is the Likert scale score and the vertical axis gives the number of responses. Because 10 participants tried six sets, the total number of responses was 60. Figure 2 shows that most participants perceived pleasant feelings using the proposed device. However, Figures 3 and 4 show that, the proposed device did not seem to have an influence on the "relaxed-tense" and "depressed-excited" aspects of emotion.

From the results of the open questionnaire, nine out of 10 participants answered that they wanted to use the proposed device again.

CONCLUSIONS

Experimental results indicated that the proposed device effectively influences the emotional parameter of the "pleasant-unpleasant" feeling.

Some participants responded that the sound of the vibration of the proposed device was noisy and the vibration was too strong. It is possible that these effects might have downgraded the assessment of the proposed device. We will improve the vibrator and adapt the vibration intensity so as not to hinder the sound experience. Moreover, we plan to integrate the vibrators and the earphones so that they can be quickly and easily put on and taken off.

For future work, we will apply our method to various sound devices such as headphones, mobile phones and game devices so that, anyone will be able to take pleasure in enjoyable sound experiences anywhere.

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