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ショートペーパー (応用) Paper

Influence of Touching Heartbeat on Emotional State and Interpersonal Closeness

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Abstract --- A haptic device has been developed that enables individuals to feel heartbeat through the sense of touch by converting heartbeat sounds into vibrotactile feedback. We conducted two experiments with this device: the first focused on feeling one's own heartbeat, and the second on feeling another person's heartbeat. Our findings indicate that feeling one's own heartbeat can reduce anxiety and make a person calm, while touching another person's heartbeat can enhance interpersonal closeness.

Keywords: heartbeat, affective haptics, emotional state, interpersonal closeness, social touch

1 Introduction

A person's heartbeat can speed up or slow down when they are excited or at peace, respectively. Conversely, the sound of the heartbeat is often used to elicit emotional engagement in movies [1]. In addition to listening to the sound of the heartbeat, touching the heartbeat also has been used to evoke the presence of oneself and others. In a workshop called "Heartbeat Picnic" [2], a device was used to convert heartbeat sounds into vibration, allowing participants to feel their own heartbeats and exchange them with others. It also has been shown that touching the heartbeat can alter physiological states [3].

The sense of touch is known to significantly impact human emotions, leading to creation of several devices that allow users to feel heartbeat-like vibration, particularly aimed at relieving anxiety. For example, Doppel [4] is a wrist-worn device that produces a heartbeat-like vibration to calm the users. Additionally, Haynes et al. [5] developed stress-easing a device in the form of cushions that simulate heartbeats or breathing.

Heartbeat information is also attracting interest for its application in interpersonal communication. Janssen et al. [6] demonstrated that hearing a heartbeat sound during interpersonal interaction increases intimacy. In addition, the role of touch has been explored in enhancing online communication. Several studies have shown that heartbeat vibration can convey emotions and enhance the sense of the presence of one's partner [7][8][9].

In this paper, we conducted two experiments using the device that converts heartbeat sounds into vibration. The first experiment focused on feeling one's own heartbeat and its effect on the user's emotional state, while the second experiment focused on feeling another person's heartbeat and its effect on interpersonal closeness.

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2 Experiment 1: Feeling one's own heartbeat

2.1 Method

Participants

Twenty females with normal hearing/sight/vision (mean age = 34.3, SD = 9.2) participated in the study after reading and consenting to the experimental description. This experiment was approved by the NTT Communication Science Laboratories Research Ethics Committee.

Apparatus

A haptic device was used to present heartbeat stimuli [2]. The haptic device was composed of a heart box with a vibro-transducer (VP408, Acouve Laboratory, Inc.), a stethoscope (HBS -NA, YAGAMI Inc.), and a custom-built processing circuit. The circuit transformed the sound signal into a vibration signal suitable for the heart box (the sound signals passed through the bandpass filter and were amplified 10 times below 400 Hz, 1 time at 700 Hz, and 1/100 times above 2kHz).

Procedure

Prior to beginning the experiment, participants were instructed to place a stethoscope connected to the haptic device on their chest and were asked whether participants could feel their heartbeat through the device. Participants were also asked about any feelings of

discomfort or noise, and the output volume and stethoscope position were adjusted until they no longer felt them. During the haptic feedback experience, participants sat in a recliner chair and experienced the haptic feedback of their own heartbeat for 10 minutes. Participants were asked to complete the Japanese versions of the STAI State Anxiety Score [10] and the PANAS [11] to assess their emotional state before and after the experience. This experience was repeated three times with a 15-minute break in between (i.e., 3 trials).

2.2 Results

STAI State Anxiety Scores

Fig.1 shows the averages of State Anxiety Scores (average of 20 items measured on a 4-point scale) before and after the haptic heartbeat feedback. The error bars indicate the standard errors. We conducted an analysis of state anxiety scores before and after the haptic feedback experience using a linear mixed model (LMM) with participants, trials, and scale items as random effects, and timing of response (before vs. after) as a fixed effect. The results showed that the effect of timing of response was significant ($\chi^2(1) = 7.492$, $p = 0.006$), indicating that state anxiety decreased after the experience.

PANAS Scores

Fig.2(A) and 2(B) show the averages and standard errors of the positive emotions score and the negative emotions score before and after the haptic feedback. Similar analyses using LMMs were conducted for the positive emotion items and negative emotion items

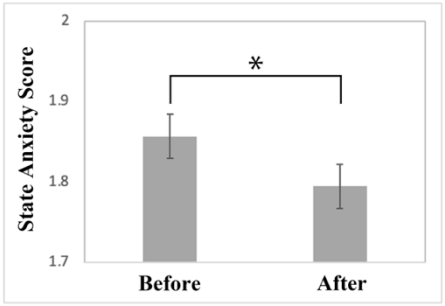

Fig.1 State Anxiety Scores before and after the haptic feedback experience. The error bars represent the standard error.

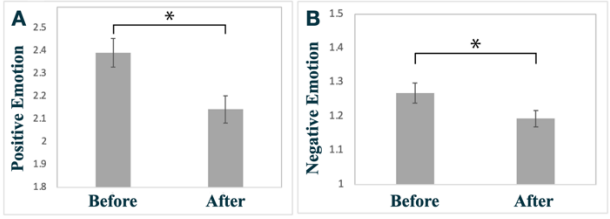

Fig.2 PANAS Scores (A) Positive emotions, and (B) negative emotions before and after the haptic feedback experience. The error bars represent the standard error.

before and after the haptic feedback experience.

The LMM showed that the positive emotion score was significantly lower after the experience ($\chi^2(1) = 24.387$, $p < 0.001$). Similarly, the negative emotion score was significantly lower after the haptic feedback ($\chi^2(1) = 5.259$, $p = 0.021$). Given that the emotions measured by the PANAS are high arousal emotions, both positive and negative (e.g., excited, enthusiastic, etc. as positive emotion items, upset, scared, etc. as negative emotion items) [11], it is likely that participants' arousal levels decreased, suggesting that participants become calm after the haptic feedback.

3 Experiment 2: Feeling another person's heartbeat

3.1 Method

Participants

Thirty-two participants (sixteen males, sixteen females) with normal tactile sensory ability participated in the present study after giving written informed consent. The mean age of the participant was 21.9 (SD = 1.0). None of the participants participated in "Feeling one's own heartbeat" experiment. This experiment was approved by the ethics committee of the Department of Design, Kyushu University.

Design

The present study comprised two experimental conditions: a haptic heartbeat feedback condition, where participants were presented with haptic heartbeat stimuli, and a control condition, where they were not. Participants underwent both conditions, with a 5-minute break in between. To counterbalance the order effect, participants were randomly assigned to one of two groups: (1) the H-C group, which underwent the heartbeat condition first, followed by the control condition, or (2) the C-H group, which underwent the control condition first, followed by the heartbeat condition. Both groups had 8 males and 8 females.

Apparatus

The same haptic device used in Experiment 1 was used to present haptic stimuli. A PC (MacBook Pro, 2021, Apple Inc.) was used for video call and tests.

Stimuli

Heartbeat vibration was presented through the heart box for 1 minute. To ensure that all participants received the same stimulus, the heartbeat vibration was the heartbeat sound of the experimenter, previously recorded with a stethoscope. The heartbeat was recorded using the same procedures and in the same environment as during

the experiment to minimize any difference between the actual heartbeat at the time of the experiment and the one used as the input. Fig.3 shows the waveform of the recorded heartbeat.

Procedure

The participant sat in a chair and joined a video call using the PC with the experimenter in an online communication setting. The experimenter was a 50 years-old female and had not ever met all participants before the experiment. First, a brief introduction, including the experimenter's alias, was given to the participant. Next, in the heartbeat condition, the participant received an explanation about the haptic device. Following this, the heartbeat stimuli were presented to the participant. Before feeling the stimuli, the participant was instructed how to hold the haptic device by an assistant beside them (Fig.4(A)). While participants felt the stimuli, the experimenter was silent and placed a stethoscope on their chest to give the participants the impression that they were feeling the experimenter's heartbeat in real-time (Fig.4(B)). Finally, the participant was explained about tests for measuring interpersonal closeness. After all the explanations, the video call ended promptly. In the control condition, the participant received an extra description irrelevant to the experiment, instead of the time for feeling heartbeat and the description of the device, to reduce the difference in time of the explanation between the conditions.

Following the explanation, participants were asked to select the figure describing the relationship with the experimenter most in the Japanese version of the Inclusion of Other in the Self (IOS) scale on the PC (Fig.5) [12]. The name of the right circle of each figure in Fig.5 was the fake name of the experimenter.

3.2 Results

Fig. 6 shows the averages and the standard errors of the IOS scores in both control and heartbeat conditions, after pooling the data from the group and gender conditions. We conducted a repeated measures ANOVA with one within factor, condition (heartbeat, control), and two between factors, group (H-C, C-H) and gender, to investigate the effects of heartbeat, condition order and gender on IOS scores, and their interaction effects. The results revealed the IOS score in the heartbeat condition was significantly higher than the score in the control condition ($F(1, 30) = 5.17$, $p = 0.03$, $\eta^2 = 0.04$). However, neither the group effect, gender effect nor the interaction effects was significant.

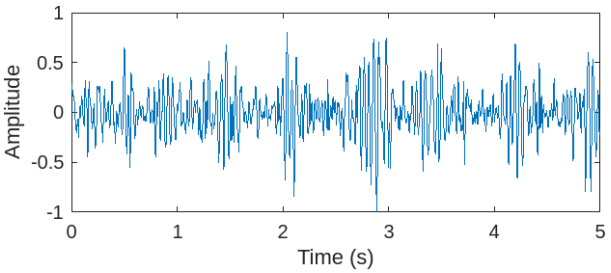

Fig.3 The waveform of the heartbeat sound

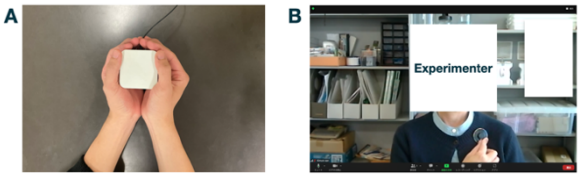

Fig.4 (A)The usage of the haptic device.
(B) The screen of the PC when the participant felt the heartbeat.

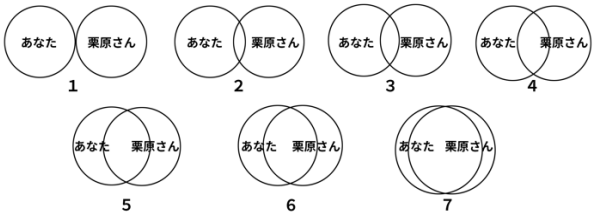

Fig.5 The Japanese version of IOS

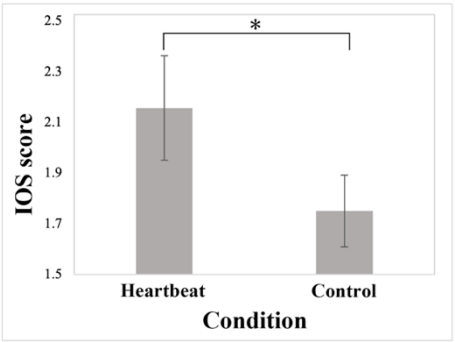

Fig.6 IOS scores in each condition.
The error bars represent the standard error of the mean.

4 Discussion

In Experiment 1: Feel one's own heartbeat, we found that touching one's own heart reduces anxiety and makes the person calm. In Experiment 2: Feel another person's heartbeat, we found that touching another person's heartbeat enhances interpersonal closeness. Touching one's own heart may activate self-soothing mechanisms, resulting in reduced anxiety and a sense of calm. Similarly, touching another person's heartbeat may establish a physical and emotional connection, promoting interpersonal closeness through the experience of feeling the heartbeat. Since only females participated in Experiment 1, future studies should investigate whether

similar results can be obtained regardless of gender. Overall, our findings suggest that the act of touching the heartbeat enhances mental calmness and facilitates interpersonal interaction.

Our finding from Experiment 2 is consistent with previous studies suggesting that both sound and haptic heartbeat feedback can create a sense of intimacy [6][7]. Specifically, Janssen et al. [6] found that heartbeat sound increased intimacy, as measured by the IOS scale. In their study, they found that the difference in the IOS score between the presence and absence of the heartbeat sound was approximately 0.6, which is larger than the difference observed in Experiment 2 of the present study (Fig. 6), where haptic heartbeat feedback was used. Apart from the distinction in feedback type, the difference in environmental settings between the studies may have influenced the contrasting results. In their study, interactions took place in a VR environment with an avatar, while in our study, interactions occurred via video calls on PCs with a human experimenter. Additionally, the recorded heartbeat used in our study may not have exhibited the distinctive features present in the generated heartbeat used in their study, potentially influencing the effects on IOS scores. In short, the choice of feedback modality, environmental setting, and the fidelity of the heartbeat waveform (Fig.3) should be carefully considered in order to optimize the effectiveness. For another future research direction, the value of using artificially generated heartbeat as stimuli is also worth consideration [7][8]. An advantage of artificially generated heartbeats is the ability to freely design the heart rate and amplitude depending on a purpose such as conveying specific emotions.

Although gender may influence interpersonal interactions, we did not observe any gender effect in Experiment 2. However, given that the experimenter was female, future research should explore the impact of the gender of the individual providing the heartbeat vibration.

In the present study, we investigated the impact of feeling another person's heartbeat through touch in a remote setting, an interaction known as mediated social touch [13]. One direction for mediated social touch is symbolic touch, which conveys abstract meaning or context through touch that does not necessarily occur in reality [14][15]. The experience of touching the externalized heartbeat of another person in our study was also a form of symbolic touch. Our finding that feeling heartbeat through touch enhances interpersonal closeness, suggests that symbolic mediated social touch could potentially enhance online communication.

References

[1] empathetic heartbeat: http://www.junji.org/eh/

[2] J. Watanabe, Y. Kawaguchi, K. Sakakura, H. Ando: “Heartbeat Picnic”: Workshop for Touching Heartbeats; Transactions of the Virtual Reality Society of Japan, vol. 16, no. 3, pp. 303-306, 2011, (in Japanese).

[3] Y. Zhou, A. Murata, and J. Watanabe: The Calming Effect of Heartbeat Vibration; in 2020 IEEE Haptics Symposium (HAPTICS), pp. 677–683, 2020.

[4] R. T. Azevedo, N. Bennett, A. Bilicki, J. Hooper, F. Markopoulou, and M. Tsakiris: The calming effect of a new wearable device during the anticipation of public speech; Sci Rep, vol. 7, no. 1, p. 2285, 2017.

[5] A. C. Haynes, A. Lywood, E. M. Crowe, J. L. Fielding, J. M. Rossiter, and C. Kent: A calming hug: Design and validation of a tactile aid to ease anxiety; PLoS ONE, vol. 17, no. 3, p. e0259838, 2022.

[6] J. H. Janssen, J. N. Bailenson, W. A. IJsselsteijn, and J. H. D. M. Westerink: Intimate Heartbeats: Opportunities for Affective Communication Technology; IEEE Transaction on Affective Computing, vol. 1, no. 2, pp. 72–80, 2010.

[7] J. Werner, R. Wettach, and E. Hornecker: United-pulse: feeling your partner’s pulse; Proceedings of the 10th international conference on Human computer interaction with mobile devices and services, pp. 535–538, 2008.

[8] D. Tsetserukou and A. Neviarouskaya: iFeel_IM!: Augmenting Emotions during Online Communication; IEEE Computer Graphics and Applications, vol. 30, no. 5, pp. 72–80, 2010.

[9] C. Dodge: The bed: a medium for intimate communication; CHI ’97 extended abstracts on Human factors in computing systems looking to the future - CHI ’97, p. 371, 1997.

[10] T. Hidano, M. Fukuhara, S. Iwawaki, S. Soga, Spilberger CD: STAI Manual New Edition; JITSUMUKYOIKU-SHUPPAN, Tokyo, 2000, (in Japanese).

[11] A. Sato, and A. Yasuda: Development of the Japanese version of Positive and Negative Affect Schedule (PANAS) scales; The Japanese Journal of Personality, vol. 9, no. 2, pp. 138‐139, 2001, (in Japanese).

[12] A. Aron, E. N. Aron, and D. Smollan: Inclusion of Other in the Self Scale and the structure of interpersonal closeness; Journal of Personality and Social Psychology, vol. 63, no. 4, pp. 596–612, 1992.

[13] A. Haans and W. IJsselsteijn: Mediated social touch: a review of current research and future directions; Virtual Reality, vol. 9, no. 2–3, pp. 149–159, 2006.

[14] Y.-W. Park, S.-H. Bae, and T.-J. Nam: How do couples use CheekTouch over phone calls?; in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 763–766, 2012.

[15] E. Hoggan, C. Stewart, L. Haverinen, G. Jacucci, and V. Lantz: Pressages: augmenting phone calls with non-verbal messages; in Proceedings of the 25th annual ACM symposium on User interface software and technology, pp. 555–562, 2012.

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