International Conference on Artificial Reality and Telexistence
Eurographics Symposium on Virtual Environments (2024)
T. Tanabe and V. Yem (Editors)

Vibratory-interoceptive stimuli to enhance empathy

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Abstract

Vibration stimuli applied to the upper body, designed to stimulate interoception, can intensify emotional responses when watching videos or music. This study explores whether such stimuli can also enhance empathy. In the experiment, vibratory stimuli were delivered to individual participants while an experimenter exhibited emotional reactions. Nine participants observed a game scene, with vibratory stimulation triggered by the actor's emotional reactions in one condition and absent in another. Results showed that vibration increased empathy and excitement levels.

CCS Concepts

• ***Human-centered computing*** → ***Haptic devices;***

1. Introduction

Mechanical vibration stimuli to the upper body can intensify emotions evoked by emotional content such as videos, likely due to the stimulation of interoception, which is closely related to emotions [MO24]. This study explores this phenomenon to enhance empathy between individuals. Building on Schachter and Singer's work [SS62], where participants with hyperactivated sympathetic nervous systems showed increased empathy, we employ non-invasive, controllable vibratory stimuli to activate physiological responses. In our setup, both the actor and the participant view the same gameplay display, allowing participants to better understand and share the actor's emotional experience. The vibratory stimuli are then delivered to the participant's thoracoabdominal part. No systems have yet enhanced empathy through mechanical stimuli targeting interoception. This study could extend techniques for emotional manipulation in interactive media.

2. Method

2.1. Apparatus

An electrodermal measurement unit and amplifier were used to measure the change in skin conductance response (SCR). For this purpose, electrodes were attached to the distal phalanges of the index and fourth fingers of the participant's non-writing hand. The SCR signals reflect human's physiological arousal, and they typically respond to an emotional stimulus within 1–3 s. The vibratory stimuli to the upper body was provided by a voice coil motor. The motor was affixed to a vest, and firmly placed to the epigastric fossa. The skin conductance unit and voice coil motor were controlled by a data acquisition device and Matlab (R2023a, Mathworks, USA).

The experimenter played Minecraft (Microsoft Corp., USA). A game stage was specifically designed for the experiment. The player combated enemies and explored keys to move on to next stages. The locations of the enemies and keys were randomized so that the events happening in the game would not be fully predicted.

2.2. Procedure and participants

Fig. 1 shows a scheme of the experimental scene. First, participants wore the vest to present vibration stimuli and electrodes to measure SCR. The participant then watched a screen where the gameplay scenes were presented. It should be noted that the game was played by an experimenter.

During the gameplay, the experimenter reacted to in-game events in a way that allowed participants to infer the experimenter's emotions. Typical reactions included verbal expressions such as 'Oh no!' to convey tension or upset when attacked by an enemy. When finding a key to the next floor in a treasure chest, the experimenter said words of joy, such as "I did it!" The experimenter did not bring out words that would directly indicate his emotions, such as "I am very upset," or "This is exciting!"

Vibration stimuli were presented to participants when the experimenter stepped on the foot switch. This vibratory stimulation was conducted in conjunction with the aforementioned reactive words. The duration of the game was adjusted to range 120–150 s, during which the vibration stimuli were presented 25 times on average.

After the game ends, participants evaluated their overall emotional experience during watching the game play. Using a questionnaire, they rated seven different emotions (*dominance*, *upset*, *angry*, *frustrated*, *joyful*, *tense*, *excited*) on a scale of 1 to 9, where

DOI: 10.2312/egve.20241396

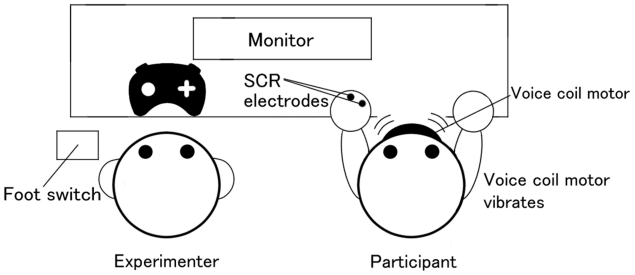

Figure 1: *Schematic diagram of the experimental setup. Experimenter played the game and initiated the vibratory stimuli to the participant.*

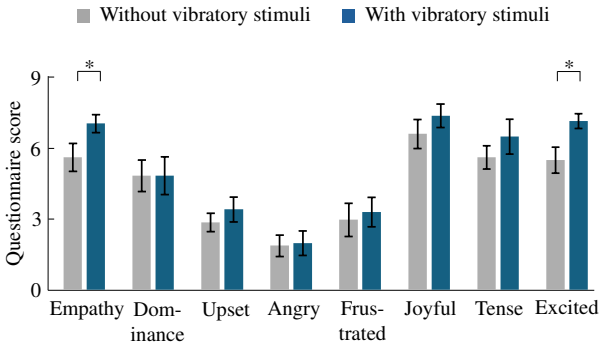

Figure 2: *Questionnaire scores. Means and standard errors among participants. * indicates the significance probabilities at $p < 0.05$ by signed rank tests with no p-value adjustment.*

1 indicated 'did not feel at all' and 9 indicated 'felt very strongly.' Additionally, they rated their sense of empathy for the player's feelings using the same 9-point scale.

The experiment was a within-participant design. Participants performed the aforementioned procedures twice, once with the vibratory stimulation, and once without. The order of these two conditions was counter-balanced across the participants.

Nine university students participated in the experiment. They were unaware of the experiment's purpose beforehand. They provided written informed consent before the experiments. These experimental protocols were approved by Institutional Review Board, Hino Campus, Tokyo Metropolitan University (R6-009).

2.3. Data analysis

The questionnaire ratings were compared between the vibration and no-vibration conditions using two-way analysis of variance and signed rank test (MATLAB, Mathworks, Inc., USA). Similarly, the SCR feature values were compared between conditions with and without vibratory stimulation. Regarding the SCR, the numbers of peaks in the wave profiles were compared. The SCR peaks were defined as peaks with a significant increase in the SCR signal lasting between 1 and 20 seconds and greater than 0.01 μS above the local minimum between the highest values of the most recent previous and following peaks. Additionally, the standard deviation of the SCR signals were compared.

3. Results

Figure 2 shows the means and standard errors of the participants' questionnaire ratings.

The results of the two-way analysis of variance indicate the effects of vibration ($F(1,128) = 6.31$, $p = 0.013$) and emotional attributes ($F(7,128) = 2.19 \times 10$, $p = 3.34 \times 10^{-19}$) are significant whereas their interaction was not observed ($F(7,128) = 0.54$, $p = 0.80$). We conducted post-hoc analyses for each type of attribute to test the effect of vibration by using the singed rank test. The significant effects of vibration were observed for the ratings of *excited* ($T = 0$, $p = 0.016$) and *empathy* ($T = 2.5$, $p = 0.039$).

The average number of SCR peaks per trial was 13.4 for the vibration condition and 10.5 for the no-vibration condition with a marginal difference ($T = 5$, $p = 0.039$). There was no significant difference in the standard deviations of SCR (vibration: 0.089, no vibration: 0.10, $T = 18.5$, $p = 0.68$).

4. Discussion

Figure 2 shows that vibration increased participants' empathy toward the experimenter, while SCR analysis indicates more peaks with vibration, suggesting heightened physiological activity. These findings are consistent with previous studies showing increased SCR with vibratory stimuli [MO24] and align with Schachter and Singer's findings [SS62] that empathy is enhanced by physiological arousal.

The two-way ANOVA results demonstrate that emotional attributes were rated higher in the vibratory condition. Specifically, Figure 2 shows increased excitement, an arousal-related emotions, supporting previous research [MO24]. Of the measured attributes, all except for *dominant* were related to arousal. Emotions like *angry*, *frustratied*, and *upset* were not affected by vibration, possibly because the game content did not effectively evoke these emotions.

Schachter and Singer's study [SS62] helps explain the results: participants with heightened physical activity were more influenced by others' emotions. In our experiment, vibratory stimuli likely increased physiological arousal, making participants feel more connected to the actor's emotions.

Acknowledgment

This study was in part supported by MEXT Kakenhi (24K22310).

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