

Original Article

# Empathic Responses to Upper Body Vibratory Stimulation Paired with Emotional Vocal Cues

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**Abstract:** This study proposes a novel method to enhance empathy toward partner's emotions using mechanical vibration stimuli applied to the upper body. Such stimuli, designed to increase physiological arousal, have been shown to intensify emotional responses during multimedia experiences. Here, we investigated whether upper-body vibration can also influence empathy when the partner's emotional cues are present. In the experiment, participants observed an experimenter playing a computer game, while receiving vibration stimuli synchronized with the experimenter's vocal reactions—such as surprise and excitement—triggered by a footswitch. Fifteen participants experienced two conditions: one with vibration stimuli in synch with the experimenter's emotional reactions, and one without. Post-experiment questionnaire revealed that vibration stimuli significantly increased participants' reported empathy, excitement, and tension. These findings suggest that vibration, when paired with emotional vocal cues, can amplify empathy for others' emotions, offering a novel approach for designing interactive content that fosters richer emotional communication among users.

**Keywords:** Haptic device, Thoracoabdominal region, Misattribution of arousal, Gamification

## 1. Introduction

When viewing emotional content such as videos, mechanical vibration stimuli to the upper body intensifies the emotions evoked by the content (Branje et al., 2013; Danieau et al., 2012; Karafotias et al., 2017; Kitajima et al., 2024; Kosuge & Okamoto, 2024; Lemmens et al., 2009; Makioka & Okamoto, 2024; Tara et al., 2023; Turchet et al., 2021). For example, Karafotias et al. (2017) reported that vibration delivered by a jacket with vibrotactile actuators improved positive viewer experiences. Similarly, Tara et al. (2023) reported that adding vibration stimuli to the chest and abdomen amplified fear and excitement in response to horror and sports videos, respectively. These phenomena may be caused by the activation of interoceptive sensations closely related to emotions (Critchley & Garfinkel, 2017; Damasio, 2003; Valins, 1966). While similar effects have been observed for hand stimulation (Macdonald et al., 2022; 2024; Makioka & Okamoto, 2024; Mazzoni & Bryan-Kinns, 2016; Seim et al., 2021; Yoo et al., 2015), stimulation of the upper body appears to be more effective (Makioka & Okamoto, 2024). Other mechanical stimuli such as pressure stimuli to the chest potentially exhibit similar emotional effects (Sakurai et al., 2014). In this study, we leverage the emotional effects of mechanical vibration stimuli, particularly applied to the thoracoabdominal regions, to promote empathy toward others.

In online communication, the transmission of emotional information between participants is often limited, prompting research aimed at compensating for this deficiency (Curran et al., 2019; Oh et al., 2016; Rojas et al., 2022; Sonderegger et al., 2013; Taguchi et al., 2018). For instance, Rojas et al. (2022) analyzed participants' voice tones and facial expressions in real-time during remote communication, and visualized the predicted valence state, leading to behaviors associated with increased empathy. Similarly, Oh et al. (2016) reported that interacting with avatars featuring enhanced smiling expressions promoted more positive emotional communication between humans. These studies created environments conducive to empathy by directly conveying the type and intensity of others' emotions through audiovisual cues.

In contrast, our approach aims to enhance empathy through interoceptive stimulation, thereby minimizing reliance on cognitive interpretation and facilitating a more visceral, affect-driven process.

This study extends a research by Schachter and Singer (1962). In their experiment, participants were injected with epinephrine, which increases the activity of sympathetic nervous system. They were then exposed to an actor intentionally expressing either cheerful or angry emotions. As a result, participants experienced emotions similar to those played by the actor. This phenomenon can be interpreted as participants attributing the cause of their physiological arousal to the actor's behavior and labeling their own physiological changes with corresponding emotions. In other words, participants were more easily able to understand the emotions of others and share similar feelings, which can be seen as an amplification of empathy. Cuff et al. (2014) and Batson (2009) described one aspect of empathy, among the many definitions used by researchers, as a mental response that produces emotions similar to those of another person, whether those emotions are actually experienced by the other or merely imagined. Following Schachter and Singer's research, Erdmann and Janke (1978) conducted a replication study. They investigated three emotions: anger, happiness, and anxiety. While no effect of epinephrine was observed for anxiety, the results for anger and happiness were consistent with Schachter and Singer's theory. Nonetheless, Marshall and Zimbardo (1979) did not find marked effects in their replication study. In research on emotion, experimental paradigms that utilize non-pharmacological physiological arousal—known as misattribution of arousal—are more commonly used, they include the suspension bridge experiment (Dutton & Aron, 1974), exercise-and-insult paradigms (Zillmann et al., 1972, 1974a, 1974b), the heart-rate feedback experiment (Valins, 1966), studies examining the effects of caffeine on anxiety and negative emotions (Giles et al., 2018), and investigations on musical arousal and sexual attraction (Lee & Zaryab, 2023; Marin et al., 2017; Marin & Gingras, 2024).

Vibration stimuli have been also used as a method to evoke misattribution of arousal. Vibration stimuli are non-invasive and dynamically controllable, making them suitable for applications in interactive media. Therefore, in our study, we use vibration stimuli on the upper body that are well-documented to dynamically activate physiological activities (Branje et al., 2013; Kitajima et al., 2024; Kosuge & Okamoto, 2024; Lemmens et al., 2009; Makioka & Okamoto, 2024; Tara et al., 2023). In this experiment, participants watch a game screen played by an actor. This setup enables participants to better understand the situation the actor is in and share in the emotional experience.

Empathy is frequently categorized in academic literature into several types, comprising emotional empathy, cognitive empathy, and facial empathy (Baston, 2009; Cuff et al., 2014; Davis, 1983). Emotional empathy refers to the affective experience of sharing or mirroring another individual's emotional state, whereas cognitive empathy pertains to the capacity to understand another person's emotions through logical inference and perspective-taking. Facial empathy refers to the tendency for one person's facial expression to change in response to, and become similar to, another person's expression. The present study focuses primarily on emotional empathy. Accordingly, it should be noted that in discussing this form of empathy, we do not examine whether the actor genuinely experienced an emotion similar to that perceived by the participant. Rather, our concern lies in whether the participant reported feeling empathy toward the actor.

To date, systems designed to enhance empathy using mechanical stimuli that cause physiological arousal have not been reported, except for our previous study (Kitajima et al., 2024). This study provides a more detailed report of our prior research. Specifically, this study additionally applies the Temporal Dominance of Emotions (TDE) method (Jager et al., 2014; Silva et al., 2018) to assess dynamic emotional changes. During video game experiences, multiple emotions, such as enjoyment and excitement, are evoked at different times. Therefore, it is important to discuss the dynamic changes in these emotions and then assess the effects of vibration stimuli. The principles tested in this study contribute to the advancement of emotional manipulation techniques in interactive media.

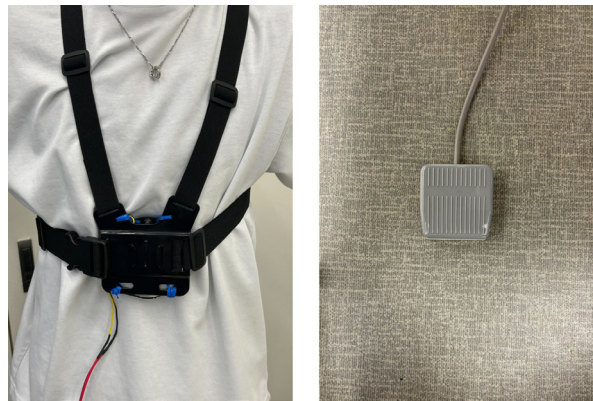
## 2. Method

### 2.1 Apparatus

To record changes in Skin Conductance Response (SCR), we used a measurement unit (AP-U030m II, Nihon Santek Co., Ltd., Japan) and an amplifier (MaP1720CA, Nihon Santek Co., Ltd., Japan). For this purpose, electrodes were attached to the distal phalanges of the participant's non-dominant hand's index and middle fingers. SCR signals measure changes in skin conductance, which reflect emotional arousal in humans (Kreibig, 2010; Sjouwerman & Lonsdorf, 2019). These signals typically respond to emotional stimuli, such as fearful images, within 1–3 s (Critchley et al., 2000; Dawson

et al., 2017), making them suitable for interactive content. In this study, SCR signals were used to record aroused emotional states such as excitement, tension, anger, and distress.

As shown in the left part of Figure 1, vibration stimuli to the upper body were delivered via a voice coil motor (Vp604, Acouve Laboratory, Inc., Japan). This motor was attached to a vest and firmly fixed to the upper abdomen (epigastric fossa). The experimenter initiated the vibration stimuli by pressing a footswitch (SFK-1, International Electrical Industry Co., Ltd., Japan) as shown on the right of Figure 1. The skin electrical response measurement unit and the voice coil motor were controlled by a data acquisition system (NI USB-6211, National Instruments Corp., USA) and MATLAB (R2023a, MathWorks, Inc., USA), with a sampling frequency of 1000 Hz. A 21-inch monitor displaying the game scene was positioned 60 cm in front of both the experimenter and participant, and the game audio was played through the built-in speakers of the monitor.

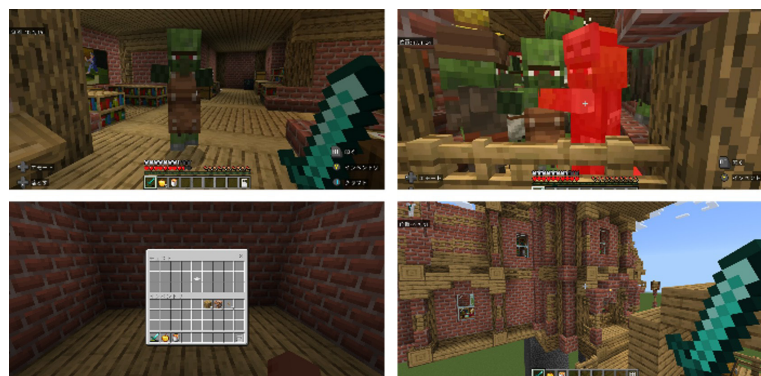


**Figure 1:** Voice coil motor attached to vest (left) and footswitch used to provide vibration stimuli (right). The motor was fixed to the upper abdomen.

## 2.2 Stimuli

### 2.2.1 Game experience

As shown in Figure 2, the experimenter played Minecraft (Microsoft Corp., USA) using a game stage specifically designed for the experiment. The player engaged in combat with computer-controlled enemies and searched for keys to unlock doors and advance to the next stage. To elicit various emotions, the number and strength of enemies were adjusted across different stages. For instance, weaker enemies were used to evoke a sense of superiority upon victory, while a larger number of enemies created urgency and induced anxiety. A particularly strong enemy was introduced in another stage to heighten excitement during combat, and the possibility of defeat was intended to generate frustration. The positions of enemies and keys were randomized to prevent full predictability, thereby varying the timing of emotional responses across trials. The game was designed to be completed within 120 to 150 s.



**Figure 2:** Game footage of Minecraft used in the experiment. The top two images show the player fighting enemies. The bottom-left image shows the player finding the key to the next stage from a treasure chest, and the bottom-right image provides an overview of the entire stage.

### 2.2.2 Vibratory stimuli to thoracoabdominal region

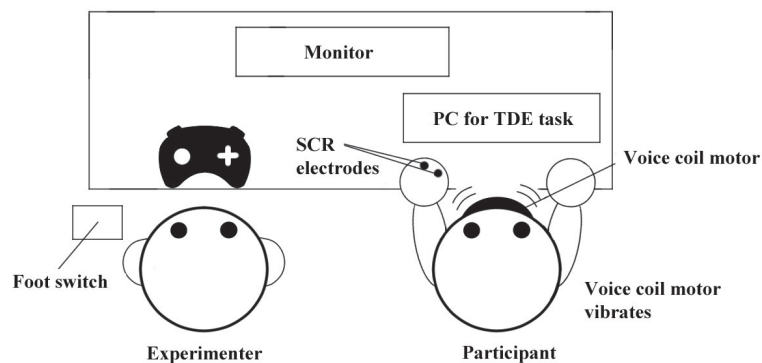
The vibration stimulus was applied to the thoracoabdominal region using a voice coil motor. Stimulation of this region has been shown to effectively induce both physiological and emotional arousal, compared with stimulation of the fingers (Makioka & Okamoto, 2024; Tara et al., 2023). The voltage command value applied to the voice coil motor was determined by Equation (1).

$$A \sin\left(\frac{\pi t}{2}\right) \sin(2\pi f t) \quad (1)$$

where  $t(t \geq 0)$  and  $f$  are time and frequency (80 Hz), respectively. This delivers the 80-Hz vibration of which amplitude gradually changed during 2 s.  $A$  denotes the amplitude of the voltage signal, which determined the vibration intensity, and was individually adjusted so that each participant could clearly perceive the stimuli through their torso.

### 2.3 Procedure

Figure 3 provides an overview of the experimental setup. Participants first wore a vest to deliver vibration stimuli and had electrodes attached for measuring SCR. They were then asked to remain still for at least two minutes until their SCR reached a steady state.



**Figure 3:** Schematic diagram of the experiment. The experimenter played the game and delivered vibration stimuli to the participant by pressing a footswitch. Adapted from Kitajima et al. (2024).

The game was played by the experimenter, who exhibited emotional reactions to in-game events. For example, when attacked by an enemy, the experimenter expressed anxiety or distress with phrases such as “Whoa!” or “This is bad!” When finding a key to the next room in a dungeon treasure chest, he expressed joy with exclamations like “Yes!” or “Alright!” However, the experimenter strictly avoided using direct statements such as “I’m confused” or “I’m so excited!” These emotional utterances signaled to the participants the nature and presence of the experimenter’s emotional engagement.

Vibration stimuli were delivered to the participant immediately after the experimenter pressed the footswitch, synchronizing the stimuli with the onset of the emotional vocal cues. In the condition without vibratory stimulation, the experimenter still uttered vocal cues and pressed the footswitch, but no stimulus was administered. The game lasted 120 to 150 s, during which vibration stimuli were presented an average of 25 times.

While watching the gameplay, participants evaluated their emotions in real time using the Temporal Dominance of Emotions (TDE) method (see Section 2.5.1). After each game session, participants rated their overall emotional experience using a questionnaire assessing seven different emotions, as described in Section 2.5.2. Before subsequent trials, participants rested for at least one minute to allow their SCR to stabilize.

The experiment employed a within-participants design. Each participant completed the procedure twice—once with vibration stimuli and once without. The order of these two conditions was counterbalanced across participants.

### 2.4 Participants

Fifteen university students participated in the experiment. The sample size was determined to achieve a statistical power greater than 0.80 for a two-tailed paired  $t$ -test with  $\alpha = 0.05$  and an expected effect size of  $d_z = 0.80$ . The actual achieved

power was 0.82. Power analysis was conducted using G\*Power (version 3.1.9.7; Faul et al., 2007). They were unaware of the experiment's purpose beforehand, including the effects of vibratory stimuli to activate physiological responses. They provided written informed consent before the experiments.

## 2.5 Subjective evaluation

### 2.5.1 Temporal Dominance of Emotions (TDE) method

In this study, we employed the Temporal Dominance of Emotions (TDE) method (Jager et al., 2014; Silva et al., 2018) to record the temporal fluctuations of multiple emotional states. Participants were presented with a computer panel displaying several buttons, each labeled with an adjective representing an emotion, as shown in Figure 4. At any given moment, participants pressed the button that best reflected their current emotional state, allowing for real-time recording of emotional transitions. Once a button was selected, it remained active until a different button was chosen, ensuring that only one emotion could be recorded at a time.



**Figure 4:** Computer panel presented in the TDE method

The buttons and corresponding adjectives used in this study were: neutral, dominant, upset, angry, frustrated, joyful, tense, and excited. These emotional attributes were selected based on Russell's circumplex model of emotions (Russell, 1980, 2003), and were expected to be elicited during the gameplay. The dominant emotion was described as the feeling of superiority over computer-controlled enemies. If participants did not perceive any salient emotion, they were instructed to select neutral.

### 2.5.2 Questionnaire

After each gameplay session, participants rated the extent to which they experienced seven different emotions while watching the gameplay, using a 1-to-9 scale (where 1 indicated "not felt at all" and 9 indicated "felt very strongly"). These ratings reflected their average emotional experience during the viewing period. The emotions assessed in the questionnaire were the same as those used in the TDE task, except for "neutral": dominant, upset, angry, frustrated, joyful, tense, and excited.

Additionally, participants were asked to rate their "empathy for the player's emotions" using the same 9-point scale. Empathy was explained as: "To what extent do you think you felt the same emotions as the experimenter did?"

## 2.6 Data analysis

For the seven items of the emotion questionnaires, paired *t*-tests with Holm correction were used to compare the vibration and no-vibration conditions. The empathy score, considered a separate outcome, was analyzed by a paired *t*-test without multiple-comparison correction.

The measured SCR signals were downsampled to 100 Hz. Local peaks in the waveform were then detected using the *findpeaks* function (MATLAB 2024a, MathWorks, Inc., USA). The peaks were defined by the following criteria:

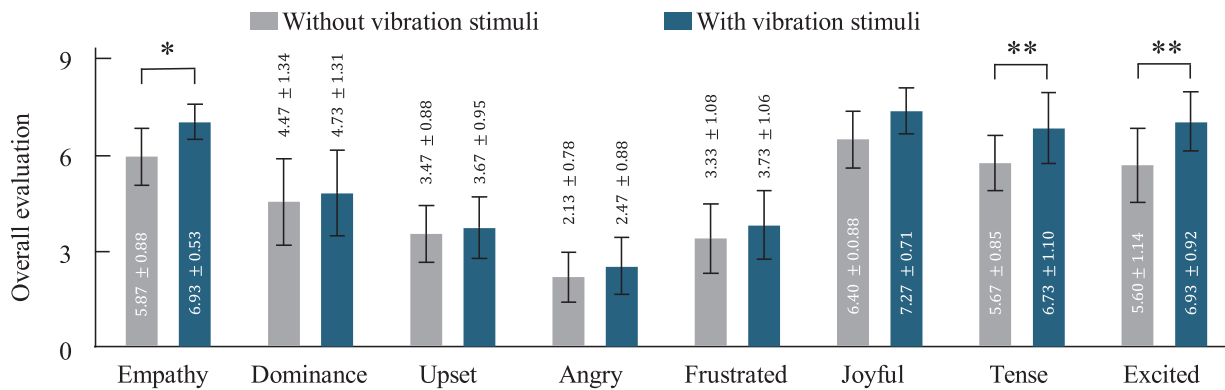
- Before the peak, the signal increased for more than 1 s and less than 20 s,
- The peak was at least 0.01  $\mu$ S higher than the local minimum between the closest adjacent peaks.

Additionally, the mean peak value and standard deviation of the SCR signal were calculated. These SCR features were compared between the vibration and no-vibration conditions using paired *t*-tests with Holm correction.

For analysis of the TDE data, the dominance duration of each emotional attribute was calculated. An attribute could be selected multiple times within a trial, and the dominance duration refers to the total time each attribute was selected during a trial (Pineau et al., 2009; ISO, 2016). The total duration was normalized by the task length to enable fair comparison between conditions. Paired  $t$ -tests with Holm correction were applied to compare dominance durations for each emotional attribute between the vibration and no-vibration conditions.

### 3. Results

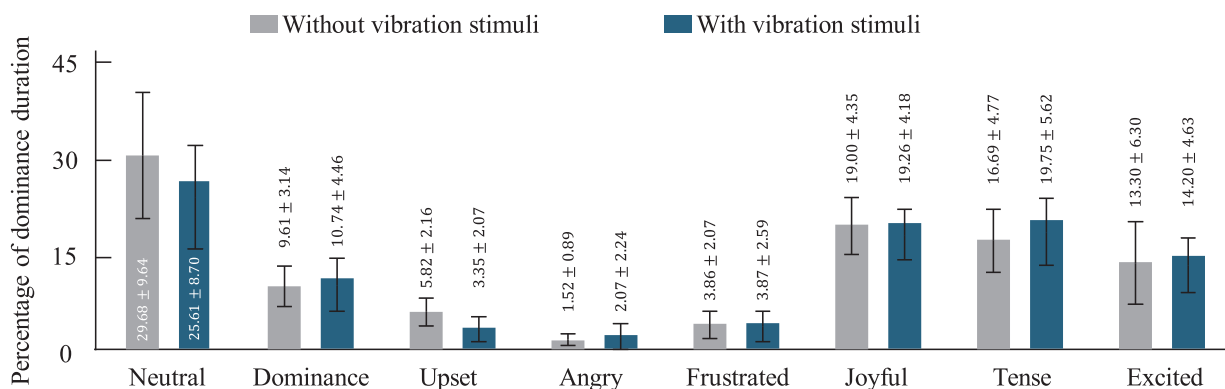
Figure 5 shows the mean values and 95% confidence intervals of participants' questionnaire ratings for each emotion. The scores for "excited" ( $t(14) = 4.53$ , corrected  $p = 0.0033$ ,  $d_z = 1.17$ ) and "tense" ( $t(14) = 3.96$ , corrected  $p = 0.0086$ ,  $d_z = 1.02$ ) were higher under the vibration condition than under the no-vibration condition.



**Figure 5:** Questionnaire scores. Means and 95% confidence intervals among participants. \* and \*\* indicate the significance probabilities at  $p < 0.05$  and  $0.01$ , respectively, by  $t$ -tests with  $p$ -value adjustment. For the empathy measure, the  $p$ -value adjustment was not applied.

For "empathy," the mean and 95 % confidence intervals were  $6.93 \pm 0.53$  and  $5.87 \pm 0.88$ , respectively, for the vibration and no-vibration conditions. Participants reported greater empathy in the vibration condition ( $t(14) = 2.98$ ,  $p = 0.010$ ,  $d_z = 0.77$ ).

Figure 6 presents the percentage of time spent on each emotional attribute, as calculated using the TDE method. No significant differences were observed between the vibration and no-vibration conditions for any emotional attribute.



**Figure 6:** Dominance duration of each attribute that is normalized as a percentage. Means and 95% confidence intervals among participants.

Table 1 summarizes the means and 95 % confidence intervals of SCR features. The average number of SCR peaks per trial was significantly higher in the vibration condition (10.24) compared to the no-vibration condition (7.08;  $t(14) = 4.03$ , corrected  $p = 0.0037$ ,  $d_z = 1.04$ ). No significant differences were found for SCR peak values (vibration:  $0.079 \mu\text{S}$ , no-vibration:  $0.091 \mu\text{S}$ ,  $t(14) = -0.56$ , corrected  $p = 1.00$ ,  $d_z = 0.17$ ) or standard deviation (vibration:  $0.10$ , no-vibration:  $0.12$ ,  $t(14) = -0.84$ , corrected  $p = 1.00$ ,  $d_z = 0.21$ ).

**Table 1:** Mean and 95% confidence interval of SCR features. Comparison between conditions with and without vibration.

Feature	Mean value with vibration	Mean value without vibration	Corrected <i>p</i> -value	<i>d<sub>z</sub></i>
Number of peaks	10.24 ± 2.92	7.08 ± 1.73	0.0037	1.04
Peak value (μS)	0.079 ± 0.034	0.091 ± 0.042	1.00	0.17
Standard deviation (μS)	0.10 ± 0.050	0.12 ± 0.056	1.00	0.21

#### 4. Discussion

Previous studies have reported changes in emotion resulting from mechanical vibratory stimulation applied to the trunk within emotional contexts (Branje et al., 2013; Kitajima et al., 2024; Kosuge & Okamoto, 2024; Lemmens et al., 2009; Makioka & Okamoto, 2024; Tara et al., 2023). These findings indicate that physiological arousal induced by vibration is misattributed to emotions evoked by other affective experiences, such as watching videos. In the present study, the addition of vibratory stimuli led to increased reports of excitement and tension. Furthermore, as shown in Table 1, the number of SCR peaks increased under the vibration condition, suggesting enhanced physiological activation. Taken together, these results suggest that applying vibratory stimuli to the upper body heightened physiological arousal, which participants then misattributed to the emotions experienced while viewing the video game in the presence of the actor's emotional utterances.

To provide a possible interpretation of why higher empathy ratings were observed in the vibration-plus-vocal-cue condition, we refer to the classic misattribution-of-arousal experiment by Schachter and Singer (1962). In their study, participants with heightened physiological arousal became more sensitive to the emotions they believed others were experiencing. Although the term “empathy” was not explicitly used in their paper, the fact that participants adopted the emotional expressions of the confederate can be interpreted as an instance of empathic response. It is reasonable to assume that a similar process occurred in our experiment. Unlike Schachter and Singer's study, in which a confederate expressed a single type of emotion, our experiment involved an actor displaying multiple emotions. Therefore, it remains unclear to which specific emotions participants felt empathy. Nevertheless, participants reported stronger excitement and tension under the vibration condition than in the no-vibration condition, suggesting that they may have empathized with the actor's excitement and tension. Future studies could address this limitation by refining the experimental design. For example, vibration stimuli could be triggered only when the actor expresses a particular emotion (such as excitement), thereby limiting the range of emotions with which participants can empathize.

As shown in Figure 5, vibration increased excitement and tension, both of which are classified as arousal-related emotions in Russell's circumplex model of emotion (Russell, 1980; Russell, 2003). This suggests that vibratory stimuli are particularly effective in enhancing arousal-related emotions, which is consistent with previous research (Branje et al., 2013; Danieau et al., 2012; Karafotias et al., 2017; Kitajima et al., 2024; Kosuge & Okamoto, 2024; Lemmens et al., 2009; Makioka & Okamoto, 2024; Tara et al., 2023; Turchet et al., 2021). These studies have generally reported that vibratory stimulation is likely to amplify arousal-related emotions, but not relaxing or low-arousal emotions.

Nevertheless, among the emotional items investigated in this experiment, all except “dominance” are classified as arousal-related. This raises the question of why emotions such as “angry,” “frustrated,” and “confused” were not affected by vibration. One possibility is that some of these emotions are more strongly characterized by valence rather than arousal. For instance, “joyful” is considered to possess both positive valence and high arousal, while “angry” and “frustrated” possess negative valence and high arousal. Vibratory stimuli may not effectively influence emotions that are primarily valence-driven. Another possibility is that the game content used in this study did not sufficiently elicit these emotions. For example, the video game rarely provoked anger in the observers, and participants reported low anger scores. Future research should apply the framework proposed in this study to different types of content that more clearly evoke emotions such as anger or joy, in order to identify which kinds of emotions are most susceptible to vibratory modulation of emotions.

Figure 6 shows that, using the TDE method, there were no significant differences in the duration each emotion was selected between the vibration and no-vibration conditions. One possible reason is that the timing of the vibration stimuli coincided with emotionally evocative scenes—such as battles with enemies—so participants may have experienced

similar emotions regardless of the presence of vibration. It is also important to note that the TDE method captures the dominance duration of emotions, that is, the length of time an emotion is sustained, rather than its intensity. In contrast, the questionnaire ratings reflected the perceived strength of emotions. These two approaches therefore measure different aspects of emotional response, and their results are not necessarily contradictory.

It should be noted that our study did not aim to dissociate the effects of vocal expressions and vibration. Rather, the purpose was to examine whether empathy could be amplified when vibratory stimulation was added to naturally occurring emotional cues. Without vocal expressions, participants would have had very limited access to the performer's emotions, essentially turning the task into one of emotion inference rather than empathy. Thus, our design focused on a naturalistic context in which emotions were primarily conveyed through vocal cues, and the results demonstrate that synchronized vibration can enhance empathic responses in this setting. Recognizing this methodological limitation, future studies will be needed to separately manipulate vocal and vibratory cues to clarify how each modality contributes to empathic responses.

It is also worth considering conditions in which vibration stimuli are delivered randomly or are not synchronized with the performer's vocal expressions. Although such conditions were beyond the scope of the present study, they may provide valuable insights in future work. If the effect of vibration on empathy is reduced or absent when the stimuli are decoupled from vocal expressions, this would support our claim that the temporal overlap of vibratory stimulation with emotionally evocative cues is critical. Such an investigation would further clarify whether the observed enhancement of empathy arises from the interaction between the vibration and other affective signals, that is, vocal cues in this study.

This study represents the first attempt to enhance empathy toward others using vibratory stimulation applied to the upper body. The experimental results suggest that empathy for certain emotions can be increased using this approach. However, several concerns need to be addressed before this method can be fully established.

First, as previously mentioned, it is necessary to identify the specific types of emotions for which empathy can be elicited. To achieve this, the experimental framework used in this study should be tested with other types of content. For example, employing scenarios in which the actor expresses intense anger—such as those used in prior studies (Taylor, 1967; Zillmann et al., 1972, 1974a, 1974b)—would enable investigation of empathic responses to anger, which could not be effectively examined in the present study.

Second, although this experiment focused on validating the concept, practical implementation will require automation of the timing for delivering vibratory stimuli. For instance, real-time emotion estimation technologies using facial images could be a promising solution. Vibratory stimuli could then be triggered immediately upon detecting changes in a person's emotional state via facial expression analysis.

Third, in this experiment, some degree of variability in the performer's behavior was unavoidable. The performer made every effort to act consistently across participants, including the timing to press the footswitch to trigger the vibration stimuli in coordination with vocal expressions. It is likely that complete uniformity across participants was not achieved, and the impact of this variability on the results remains unclear. Nevertheless, because approximately 25 trigger events occurred within each trial, it is reasonable to assume that incidental variations in timing were averaged out across participants.

As discussed in the introduction, empathy comprises several concepts such as cognitive and emotional components (Batson, 2009; Cuff et al., 2014; Davis, 1983). In reality, most previous studies define empathy as encompassing both aspects, which likely interact with each other (Cuff et al., 2014). Although the questionnaire items used in this study were designed to assess emotional empathy, it remains unclear which forms of empathy were actually involved in the experiment. To address this limitation, future research should employ multidimensional questionnaires that distinguish between cognitive and emotional components of empathy.

## 5. Conclusion

In this study, we extended the classic experiment by Schachter and Singer (1962) by applying mechanical vibration stimuli to the upper body, adapting the paradigm for use in interactive media. Participants observed a performer playing a game, and the emotions elicited during gameplay were the focus of investigation. The results showed that vibration, when synchronized with the performer's emotional vocal expressions, increased participants' reported levels of excitement and tension, as well as their empathy toward the performer. Physiological responses, such as increased skin

conductance, also confirmed heightened arousal under the vibration condition. Overall, this study presents a novel method for enhancing emotional communication in interactive content through upper body vibration.

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## Ethics Statement

The protocol of this study was approved by the institutional review board, Hino Campus, Tokyo Metropolitan University (Approval number: R6-009).

## Author Contributions

TK: designing and conducting the experiment, analyzing the data, and writing the manuscript draft and final editing. SO: conceptualization of the study, designing the experiment, analyzing the data, supervision of all the research activities regarding this work, and editing the manuscript. YK: conceptualization of the study, designing the experiment, and proof of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

## Conflict of Interest

The authors declare that they have no conflict of interest.

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