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Human–virtual character interaction: Toward understanding the influence of haptic feedback

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Abstract

In this study, we compare haptic feedback and nonhaptic feedback conditions in which virtual characters bump into the participant who is immersed in a virtual environment. A questionnaire was developed to determine the influence of haptic feedback on a number of concepts (presence, embodiment, positive and negative affect, interaction realism with virtual character, and haptic feedback realism). Physiological data were also collected using galvanic skin response (GSR) to investigate the influence of haptic feedback on physiological arousal during human–virtual character interaction. Five conditions were developed (no haptic feedback, full intensity, half intensity, incorrect position, and delayed timing) to determine which aspects of haptic feedback are most important in influencing participant responses. Significant differences were found in embodiment, realism of virtual character interaction, and haptic feedback realism. In addition, significant differences were found in GSR amplitude after the first interaction with the virtual character. Implications for further research are discussed.

KEYWORDS

galvanic skin response, haptic feedback, haptic vest, virtual bump, virtual characters, virtual reality

1 | INTRODUCTION

In order to provide highly immersive experiences for virtual reality users, a number of interfaces and devices were developed over the past year. Among them were those designed to provide haptic feedback in order to recreate the sense of touch by applying forces, vibrations, or motions to the user.[1] Haptic feedback is present in many virtual reality experiences and games, but specific factors such as timing, intensity, and position accuracy remain underexplored. In addition, the literature is not yet conclusive regarding human perception of haptic feedback, especially in virtual reality scenarios in which humans closely interact with virtual characters.[2] Considering that virtual reality has great potential for inclusion in human behavior research,[3] a better understanding of the influences and potential realism of haptics on a variety of cognitive and social interaction concepts may aid in the creation of more believable human–virtual character interactions in virtual reality.

This study aims to understand human–virtual character interaction through haptic feedback by considering presence, embodiment, positive and negative affect, interaction realism, and haptic feedback realism. To this end, subjective data were collected by asking participants to self-report their sensations in relation to the abovementioned concepts, and objective data were collected by using a galvanic skin response (GSR) sensor.

This experiment was considered based on the assumption that feeling the bump with a haptic vest would elicit greater arousal than would simply watching the virtual character walk by, without the sensation of interaction with the virtual character due to haptic feedback. This study may cultivate a better understanding of human perception and physiological arousal as influenced by variations in haptic feedback by answering the following research questions.

- **RQ1:** Are there perceptual and physiological differences across the five experimental conditions?
- **RQ2:** How does more realistic haptic feedback compare to illogical or inaccurate haptic feedback?
- **RQ3:** Can we use GSR to predict self-report responses?

2 | RELATED WORK

Considering that virtual characters transfer information to humans on both a cognitive-analytic and emotional processing level,[4] it can be said that humans are able to understand an interaction with a virtual character and that the virtual characters may even evoke a sense of social presence,[5] especially when represented in an anthropomorphic way.[4] However, when examining human emotion and behavior during human–virtual character interaction scenarios, we relied mainly on visual and auditory information without considering other senses that might influence the interaction process. For this reason, we decided to examine how haptic feedback may affect the perception and arousal of participants when they closely interact with a virtual character.

Multiple studies have explored how humans perceive haptic feedback. In general, the literature includes a variety of studies regarding the design, development, and testing of haptic feedback devices that target improvement of haptic stimulus.[6] Some of these platforms[7] and haptic surfaces[8] are quite useful for virtual reality interaction.

Various studies were conducted demonstrating that haptic feedback improves the performance of participants within virtual environments[9,10] and that participants perceive the virtual environment as more realistic because they are able to touch and feel.[11] Lee et al.[9] found that providing additional stimuli (aural or haptic) associated with the virtual environment had the result of improving realism because more of the user's senses were engaged. Another study investigated the benefits of multimodal interaction (including haptic feedback), demonstrating that it can be used to enhance the learning performance levels of participants compared to unimodal environments.[12]

Most studies exploring haptic vest usage have either focused on the development process of the equipment or the development of applications relating to the use of haptic feedback for the navigation and guidance of users in unknown environments using vibrotactile stimulation or thermal actuators.[13] Haptic vests have been used in a number of different training scenarios, including tactical training,[14] medicine,[15] rehabilitation,[16] and serious games used in learning environments.[17]

It is believed that the appropriate haptic pattern of a vibration produced by a haptic vest may be an important factor in improving the level of realism provided for the user.[18] In addition, it has been found that the pattern of the haptic feedback can be quite useful for transmitting information.[19] However, it appears that researchers have focused less on how various parameters (duration, intensity, position, etc.) of haptic feedback may influence the emotion and behavior of participants when they are immersed in a virtual environment. Unlike a previous study that concerns haptic feedback patterns,[19] the objective of this study is to generate conditions of varying haptic feedback parameters in order to understand how participants' arousal and perception are altered within a virtual reality environment.

In the current study, we considered different concepts, including presence and embodiment, as well as self-report negative and positive affect. Previous studies have shown that haptic feedback in virtual reality can increase the sense of presence[20] and embodiment[21] and the influence positive and negative affect.[22] To the best of our knowledge, no recent study has explored (1) the use of a haptic vest, (2) variations of the haptic feedback stimuli, or (3) the alteration of these two concepts during human–virtual character interaction. The investigation of these three issues is our main contribution.

3 | EXPERIMENT OVERVIEW

This section describes the basic methodology and implementation of the study.

3.1 | Participants

For this experiment, 60 volunteers participated, including undergraduate and graduate students at a midwest U.S. university. Of the sample, 15 participants were female (age $M = 22.54$, $SD = 3.64$) and 45 were male (age $M = 21.78$,

FIGURE 1 The virtual reality scenario developed for this study

SD = 2.97). Because the experiment was conducted within the computer graphics technology department, 93% of subjects had experienced virtual reality prior to the study. Approval for this study was granted by the Institutional Review Board of Purdue University. All participants gave written consent before the beginning of the study. Note that this study had a between-group design, with 12 participants in each group.

3.2 | Hardware setup and the virtual environment

An experimental application was developed for the purpose of this study using the Unity3D game engine version 2018.2.12. The Oculus Rift head-mounted display (HMD) was used to immerse participants in the virtual environment, and the bHaptics gaming vest with its associated software development kit was used to deliver the necessary haptic feedback to participants. Lastly, a Shimmer GSR sensor was used to capture arousal state.

In the virtual environment, the participant stood at a busy crosswalk. Virtual characters were prescripted to walk by on sidewalks across the street, to walk toward the participant at the crosswalk, and to cross the street behind the participant. Figure 1 shows the virtual environment used for the purpose of this experiment. The scene was lit with afternoon sunlight, and audio was added to increase the feeling of being outdoors in a busy city. Sound relating to the virtual content was expected to enhance the participant's presence in the virtual reality scenario.[23] A few cars drove past as pedestrians walked by, crossing the street. The virtual environment was created in Autodesk 3ds Max and imported into the Unity3D game engine. The virtual characters in the scene were designed in Adobe Fuse, and animation was provided by Adobe Mixamo. In order to ensure that the participant had at least a minimum form of self-representation in virtual reality, we included a self-avatar body. We decided to assign gender to the self-avatar, based on which gender was selected by the participant on the demographic section of the questionnaire. We wanted to provide an embodied experience and make the participants feel that the body that represented them was their own. Thus, we decided to assign a self-avatar that most closely represented the participant's skin tone as well. To do this, we designed three male avatars and three female avatars with variations in skin color (light, medium, and dark).

3.3 | Experimental conditions

Five experimental conditions were developed for the purpose of the experiment. The same visual information was received by all groups, as all participants experienced the same virtual environment.

- **No haptic feedback (NH):** In this condition, the participant did not feel any haptic feedback during the entire experiment.
- **Full intensity haptic feedback (FIH):** The haptic feedback in this condition was set to 100% intensity, with no other adjustments.
- **Half intensity (50%) haptic feedback (HIH):** The haptic feedback in this condition was adjusted to 50% intensity.
- **Delayed haptic feedback (DH):** The haptic feedback in this condition was delayed by one second; therefore, the participant felt the bump one second after seeing the virtual character bump into them. This haptic feedback was set to full intensity.

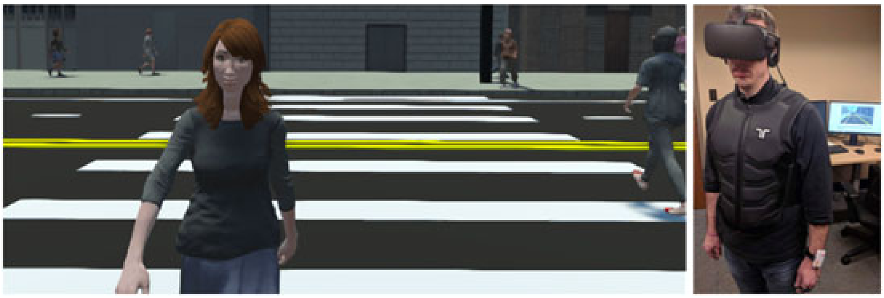

FIGURE 2 The virtual environment that was used for the purpose of this study (left) and the participant wearing a head-mounted display, a haptic vest, and a galvanic skin response sensor (right)

- **Incorrect-position haptic feedback (IPH):** The haptic feedback in this condition was felt on the opposite side of the body. For example, if the virtual character approached and bumped into the participant on the right side, the haptic feedback would be felt on the left side of the body, and vice versa. This haptic feedback was set to full intensity.

3.4 | Experimental procedure

Once participants arrived at the lab, they were asked to complete a demographics questionnaire concerning age, sex, and prior virtual reality experience. Next, they were fitted with the haptic vest. The Shimmer sensor, which sits on a wrist strap, was then placed on the wrist of the participant's nondominant hand, with the two electrodes placed on the index and middle finger of each participant. A participant wearing all the equipment and observing the virtual reality scenario is shown in Figure 2.

Before fitting the HMD to the participant, the experimenter relayed instructions for the participant to follow as closely as possible. Participants were told that they would first experience a baseline GSR period, which would last for two minutes. They were also told that, after two minutes, the virtual reality scene would start. Participants were informed that they would receive two sets of text instructions within the headset: the first telling them to feel free to explore to their left and right and look down at their body. After 30 seconds, a second set of text instruction would be provided, which instructed the participant to face forward and remain still. They were informed that this was when it was important to relax, remain still, try not to talk or move too much, and breathe normally. They were also informed that there would be no user interaction, so there would be nothing for them to do except relax and experience the scene.

Next, the experimenter started the GSR data capture and the timer. At the two-minute mark, the virtual reality scene was started. As explained by the experimenter, the participant saw instructions to explore. Participants looked on either side of themselves and down at their virtual body. When they saw the second set of instructions, participants relaxed in a stationary position, facing forward.

During the final two-minute time period (the stimulus window in which haptic feedback was present), the participant saw numerous virtual characters walking past him or her. At evenly spaced 15-20 second intervals, a virtual character walked too close and bumped into the participant, for a total of six bumps (instances of stimuli) per participant. The participant received one of five haptic feedback conditions (see the Section 3.3). All six bumps adhered to their condition, in that one participant would, for example, feel all the bumps with delayed haptic feedback, or feel no haptic feedback at all. Note that all participants wore the haptic vest, but no participant knew which haptic feedback condition he or she would receive in the virtual environment.

After the two-minute haptic feedback stimulus window ended, the experimenter stopped the GSR recording in iMotions and stopped the Unity3D application. The participant was instructed to remove the headset. Then, the experimenter helped remove the GSR wristband and the haptic vest. Finally, the participant completed the questionnaire, with the opportunity to add any comments or feedback at the end of the questionnaire. Each participant spent 4 min and 30 s in the virtual reality environment. The total time that each participant spent during the experiment was roughly 20 min.

3.5 | Measurements

In order to determine changes in participant perception and physiological arousal in our virtual environment, we used both subjective and objective measurements: questionnaire and GSR recordings, respectively. Both are discussed in more detail below.

3.5.1 | Subjective measurements

Our questionnaire included a total of 14 questions intended to explore the following concepts: presence, embodiment, positive and negative affect, realism of virtual character interaction, and realism of haptic feedback. Four presence questions were based on the Slater–Usoh–Steed questionnaire,[24] and four embodiment questions were based on body ownership illusion questions.[25] Four questions were based on the positive and negative affect schedule (PANAS[26]) in order to determine the subjective positive affect (two questions) and negative affect (two questions) experienced during the virtual scenario. The questions about the realism of character interaction and the realism of the haptic feedback were developed by the authors of this paper. The questionnaire was paper based and administered immediately following removal of the HMD. The questionnaire used in this study is provided as supplementary material.

3.5.2 | Objective measurements

We used GSR as a means to determine alterations in arousal across the five experimental conditions. While GSR cannot determine the valence of emotion, it can determine increases in physiological arousal,[27] here defined as a "necessary condition for the elicitation of an emotional state."[26] To determine GSR count, we measured the number of GSR peaks within the appropriate 1- to 5-s poststimulus time frame to determine event-related GSR, as this is the best way to determine direct measurements of arousal.[27] In our case, the stimulus was the virtual character bump. We also computed the average GSR amplitude of all peaks during virtual character interaction in order to determine intensity of physiological arousal. Additionally, we explored intensity of arousal upon the first virtual character interaction across all groups, as multiple participants expressed that the virtual scenario was predictable after experiencing the first virtual character interaction.

4 | RESULTS

To analyze our data, we used a one-way analysis of variance (ANOVA), using the five developed conditions as our independent variables, and the self-report results and the GSR measurements as dependent variables. The analyses of the subjective and objective data were performed individually. Before analyzing the data, the normality assumption was evaluated graphically using Q-Q plots of the residuals. We found that the collected data fulfilled the normality assumption. The post hoc comparisons were performed using Bonferroni-corrected estimates. The self-report data and GSR results for each examined concept of this experiment are presented in Figure 3 and Figure 4, respectively. Descriptive statistics are provided as supplementary material.

4.1 | Self-reported results

We compared the effect of haptic feedback on participants across the five experimental conditions (NH, FIH, HIH, DH, and IPH). No significant effects were found at the $p < .05$ level regarding presence [$F(4, 55) = .304$, $p = .874$], positive affect [$F(4, 55) = .806$, $p = .527$], or negative affect [$F(4, 55) = .695$, $p = .599$].

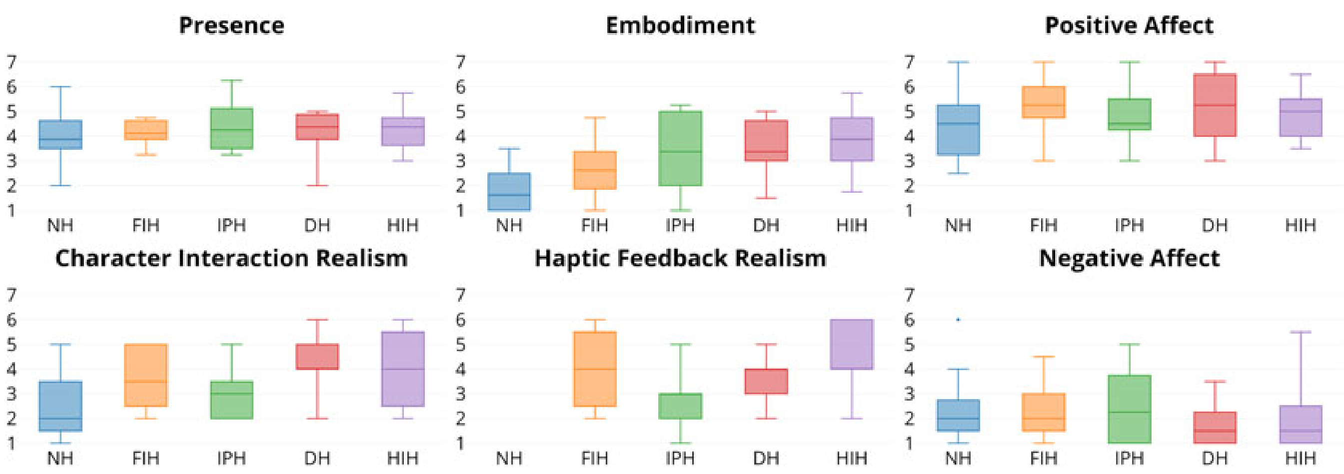

FIGURE 3 The questionnaire data for all the examined concepts. NH = no haptic feedback; FIH = full-intensity haptic feedback; IPH = incorrect-position haptic feedback; DH = delayed haptic feedback; HIH = half-intensity haptic feedback

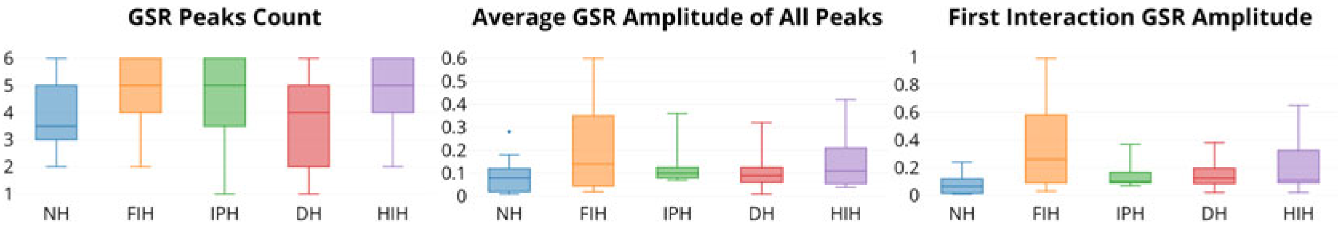

FIGURE 4 The results obtained from the galvanic skin response (GSR) analysis. NH = no haptic feedback; FIH = full-intensity haptic feedback; IPH = incorrect-position haptic feedback; DH = delayed haptic feedback; HIH = half-intensity haptic feedback

After analyzing the data concerning embodiment, we found a significant effect of haptic feedback across the five conditions [$F(4, 55) = 5.353, p = .001$]. Post hoc comparisons indicated that the mean score for the NH condition ($M = 1.81$, $SD = .87$) was significantly lower than that for the IPH condition ($M = 3.33$, $SD = 1.59$) at the $p < .05$ level, DH condition ($M = 3.63$, $SD = 1.09$) at the $p < .01$ level, and HIH condition ($M = 3.81$, $SD = 1.31$) at the $p < .01$ level. However, no significant differences were found between the FIH condition ($M = 2.65$, $SD = 1.16$) and any other haptic feedback conditions.

The results concerning the realism of the interaction with the virtual character also indicated a significant effect of haptic feedback across the five experimental conditions [$F(4, 55) = 3.779, p = .009$]. Post hoc comparisons show that the mean score for the NH condition ($M = 2.5$, $SD = 1.45$) was significantly lower than that for the DH condition ($M = 4.25$, $SD = 1.06$) at the $p < .05$ level. There were no other significant differences found between any of the conditions.

Finally, we were also able to identify significant differences in the realism of the haptic feedback across the four experimental conditions [$F(3, 44) = 4.708, p = .006$]. Note that the NH condition was omitted from this consideration. Post hoc comparisons indicated that the mean score for the HIH condition ($M = 4.50$, $SD = 1.31$) was significantly higher than that for the IPH condition ($M = 2.67$, $SD = 1.16$) at the $p < .05$ level. Moreover, post hoc comparisons indicated that the realism of the FIH condition ($M = 4.08$, $SD = 1.56$) was significantly higher than that of the IPH condition ($M = 2.67$, $SD = 1.16$) at the $p < .01$ level. There were no other significant differences found between any of the conditions.

4.2 | Results from the GSR data

We analyzed the number of event-related GSR peaks, the average GSR amplitude of these peaks, and the amplitude of the first GSR peak in response to the first virtual character interaction. From our data analysis, we were not able to identify significant differences at the $p < .05$ level across the five conditions for either the number of peaks [$F(4, 55) = 1.635$, $p = .179$] or the average amplitude of peaks [$F(4, 55) = 1.722, p = .158$]. However, a significant difference in GSR amplitude was found across the five experimental conditions [$F(4, 55) = 3.731, p = .009$] when analyzing the GSR after the first virtual character bump. Post hoc comparisons indicated that the mean score for the NH condition ($M = .0807$, $SD = .07891$) was significantly lower than that for the FIH condition ($M = .3510$, $SD = .31481$) at the $p < .01$ level.

4.3 | Subjective–objective correlations

Because both questionnaire responses and GSR data were collected, we decided to explore possible correlations between the data sets and, more specifically, between the six concepts examined in this paper. In total, we examined 18 combinations between the questionnaire and the GSR measurements (six components from the questionnaire and three GSR measurements) using a Pearson product–moment correlation coefficient. We found a moderate positive correlation [$r = .415, n = 48, p = .003$] between the realism of haptic feedback and the average GSR peak amplitude, and a moderate positive correlation [$r = .329, n = 48, p = .023$] between the realism of haptic feedback and the GSR peak amplitude after the first virtual character interaction.

5 | DISCUSSION

This study aimed to explore the effect of haptic feedback conditions on both subjective and objective measurements based on the analysis of collected GSR data. A simple scenario in which virtual characters bump into the self-avatar representing the participant in the virtual environment was developed. In response to our **RQ1**, from our data analysis, we were not able to identify differences for all examined concepts across the five developed conditions.

No significant differences were found between the five conditions when examining participants' presence. In the experiment, the participants were instructed to remain stationary in order to minimize muscular artifacts, so as to obtain clean, more accurate GSR data. Therefore, they were unable to control the self-avatar representing them or engage otherwise in the virtual environment. According to Slater et al.,[28] it may be necessary for the participant to act within an environment in order to elicit feelings of presence; therefore, perhaps our participants felt lower presence than expected across all groups because they had no actions to carry out within the environment. An important consideration, however, is that presence may generally be too difficult to capture with current questionnaires, perhaps because the concept of presence is loosely interpreted and highly dependent upon the moment, with its meaning most likely formed through actions and interactions, rather than the way the environment looks and feels.[28]

One of the participants, after the experiment, commented that “the elsewhere question (concerning presence) is confusing.” In addition to subjects “bracing themselves,” as one participant stated, it is also possible that no differences in presence were found due to the fact that the participants were told to stay still. Participants in other studies have likewise admitted confusion concerning “presence,” because participants do not necessarily share the same mindset and understanding of the concept of presence as do researchers.[29]

Participants' sense of embodiment was also examined. Our results indicate that participants who experienced the NH condition rated their sense of embodiment lower than the groups that experienced the half intensity, delayed, and incorrect-position haptic feedback. However, it should be noted that the group assigned the FIH condition experienced lower-than-expected levels of embodiment. Because embodiment was significantly greater for those who felt the half-intensity haptic feedback than for those who felt any other haptic feedback, it is possible that embodiment may depend partially on the logical interactions of the environment, and thus, embodiment would be less for an interaction that did not make sense, such as feeling a person bumps into you with a delay. Another finding that should be discussed is that those in the DH group experienced higher embodiment than those in the wrong position haptic feedback group, perhaps suggesting that logical timing is more influential in increasing embodiment than is logical position. To answer our **RQ2**, further research is necessary in order to replicate our results and to pursue why certain haptic feedback parameters appear to take priority over others, where embodiment is concerned.

We found that the DH group reported significantly higher realism of virtual character interaction than did the NH group. This result suggests that a haptic feedback condition, even if it is delayed and, therefore, may not align with perceived visual feedback, can enhance the realism of a virtual character interaction. However, the remainder of the results concerning the realism of virtual character interaction were highly unsatisfactory. We expected that at least one of the correct timing and correct position haptic feedback conditions (either the full intensity or half intensity) would alter the realism of the interaction during the virtual bump. We interpret our results as follows: when one human bumps into another, there is not only a touch sensation due to physical contact but also a physical sensation due to a shift in balance felt by the person who is bumped. In our experiment, physical sensations in addition to the brush of physical contact were not considered. Further studies that work to incorporate additional simulated physical sensations inherent to being bumped are needed to fully assess the realism of this kind of interaction.

The final question that participants were asked concerned the realism of the haptic feedback itself. With this question, we hoped to determine the perceived realism of each of the five developed conditions. Participants in the HIH group reported significantly higher levels of perceived haptic feedback realism than the participants in the IPH group. Additionally, participants in the FIH group also reported significantly higher levels of haptic feedback realism than participants did in the incorrect position group. Based on these results, it can be stated that haptic feedback at the correct position is important in making participants feel that the haptic feedback they received is realistic. Moreover, because no significant differences were found between the haptic conditions, realism of this haptic feedback might not be related to its intensity.

We were able to identify a significant difference in GSR peak amplitude between the NH group and the FIH group upon the first virtual character interaction. Additionally, we investigated the total number of peaks and the average amplitude of all peaks but were unable to identify significant differences in the existence or intensity of physiological arousal. The results concerning the collected GSR data were mixed because we expected to find significant differences for GSR count and total GSR amplitude as well. The obtained results indicate that haptic feedback might be able to alter the physiological arousal of participants, but that not all haptic conditions are able to do so, or that predictability of the scenario may critically influence arousal. In our case, because the only difference was between the FIH condition and the NH condition, participants might be more sensitive to logical and accurate haptic feedback than that which is illogical or inaccurate.

A participant from the FIH group commented, “after the first bump, you know what to expect.” Therefore, we argue that participants may have been less influenced by the following instances (bumps) of the haptic feedback due to their predictability after the first bump has happened. This might be the reason that the only difference we found in the GSR amplitude was found immediately following the first human–virtual character interaction. In the NH condition, participants commented “why didn't I feel anything?” and “is the vest supposed to do anything?” upon removing the vest after the virtual scene had ended. Numerous participants in this group were confused as to why they did not feel anything, and one wrote “I kept waiting for something to happen … but nothing occurred,” suggesting a feeling of anticipation and impatience. As others expressed similar sentiments, it is likely that numerous participants in the NH condition were equally impatient. Impatience is a state of increased arousal[30]; therefore, this feeling may have altered participants' arousal levels and prevented us from identifying the expected differences in the examined conditions. Future studies might consider including a condition in which no vest is worn. Our data analysis and the participants' comments suggest that experiencing haptic feedback could induce greater changes in arousal as compared to not receiving haptic feedback in virtual reality, perhaps if participants are unable to so easily predict when such feedback might occur.

Our findings suggest an ability to determine realism of haptic feedback with GSR data, as well as that haptic feedback can, in fact, trigger physiological responses that can be used to determine parameters of realistic haptic feedback during human–virtual character interaction. Additional studies may benefit from improved methods in order to assess emotional state. Perhaps this could be done with the inclusion of a questionnaire within the HMD, or including more than two questions that correspond to negative and positive affect, or with the use of the visual analogue scale, rather than a Likert scale. Also note that, while GSR data can measure changes in arousal,[27] it is highly affected by muscular artifacts such as limb movements and head turns,[31] which are normally essential for virtual reality interaction. Considering that a moderate correlation was found between haptic feedback realism and GSR peak amplitude, perhaps GSR peak amplitude could function as an indicator of haptic feedback realism, especially in studies which take our limitations into consideration. Given that this was an exploratory study regarding the effects of varying parameters of haptic feedback on human–virtual character interaction, we would like to reiterate that more extensive research is required in order to obtain more reliable, conclusive results. To respond to **RQ3**, we might say that, based on our findings, there is evidence that GSR could be used to determine optimal parameters of haptic feedback.

6 | CONCLUSIONS AND FUTURE WORK

For this study, a haptic vest was used to understand whether the haptic feedback delivered to virtual reality users during interactions with virtual characters alters their perception and physiological arousal within the virtual environment. As our research concerning the half intensity, delayed timing, and incorrect-position haptic feedback was exploratory, future research might focus on these conditions in more depth, as well as consider our findings concerning embodiment in order to better determine why delayed haptic feedback, for example, might elicit higher feelings of embodiment than incorrect-position haptic feedback. We also suggest exploring the possibility that each participant experiences several instances of every haptic feedback within the same environment. In addition to incorporating variety for the participant, it may be necessary to incorporate unpredictability, as mentioned previously.

We believe that an extensive investigation of the correlation between subjective and objective data is important in order to more effectively understand the way in which users perceive interaction with virtual characters. For this reason, we plan to further investigate the effects of haptic feedback during close interaction (bumps, virtual hugs, collision avoidance,[32] etc.) with virtual characters with variations in their appearance and motion.[33] In addition to adding variety and unpredictability to our haptic feedback conditions, it may be necessary to explore ways in which physiological data can accurately and realistically be obtained in virtual reality, a medium that is often interactive in the form of user movement. Lastly, the inclusion of participants with specific characteristics (e.g., students with phobias, anxiety, and depression) in our future studies may provide new insights into physiological arousal, human emotion, and perception where haptic feedback is concerned.

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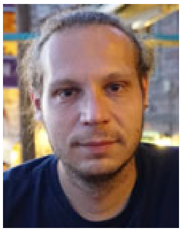

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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