Influence of tactile presence and body ownership on virtual stroking pleasantness

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Abstract

The rise of social Virtual Reality brings reports of pseudosensations like touch experienced without physical stimuli. How factors like body ownership influence the pleasantness of such virtual affective experiences remains unclear. This work investigates the influence of concurrent physical tactile stimulation and the sense of body ownership on the perceived pleasantness of having one's avatar arm stroked in VR. Fourteen participants stroked their avatar's arm under two conditions (Visual-Only, Visual-Tactile) and rated pleasantness. Results suggest participants with strong body ownership perceived pleasantness even in the Visual-Only condition. In contrast, those with weak ownership relied heavily on actual touch. These findings indicate that body ownership critically modulates affective touch perception in VR. When ownership is strong, visual input can partially substitute tactile input.

Keywords: Virtual Reality, Affective Touch, Body Ownership

1 Introduction

The rapid popularization of social Virtual Reality (VR) platforms has led to widespread user reports of intriguing perceptual phenomena. Among these are experiences of phantom sensations, where users perceive tactile feelings from visual stimuli presented in VR, despite the absence of corresponding physical feedback [1]. This emerging phenomenon, sometimes discussed within the context of pseudo-haptic feedback, highlights the complex interplay between sensory information and perception within immersive virtual environments [2].

One relevant line of research that explores the link between visual information and pleasant touch was conducted by Morrison et al. [3]. In their study, they investigated the perception of pleasantness associated with affective touch. They demonstrated a significant correlation between two conditions: 1) the pleasantness ratings reported by participants who received a physical stroke on their own arm, and 2) the pleasantness ratings these participants inferred for another person they observed being stroked in a video. This suggests that visual information alone can trigger a representation of tactile pleasantness, especially when empathizing with another's experience.

However, Morrison's study focused on inferring another's pleasantness from a third-person, observational perspective. It remains unclear how these findings translate to the first-person embodied experience within VR, where users perceive their personalized avatar as their own body. In such an embodied state, visual stimuli directed at the avatar are often interpreted as self-directed. This raises the question of how the experience of having one's own avatar arm stroked in VR might be altered by the presence or absence of concurrent physical tactile feedback. Therefore, this study investigates what kind of influence the presence or absence of this tactile stimulation has from the perspective of pleasantness.

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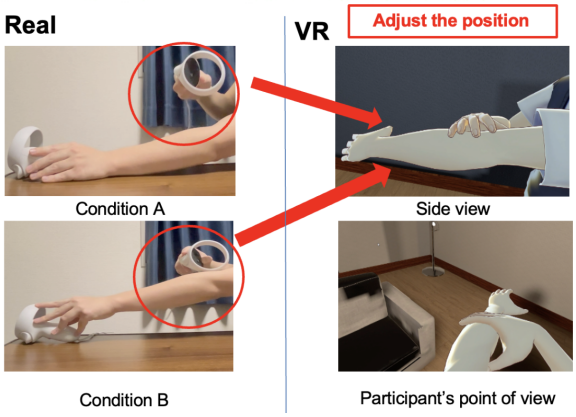

Figure 1: Image of the participants taking part in the experiment

2 METHODS

Fourteen individuals (age 21-46 years, mean age 25; two females) participated in the experiment after giving their informed consent. After the experiment, participants responded to a questionnaire regarding their sense of body ownership over the avatar, which was assessed with the question, "To what extent did you feel that the avatar used in the experiment was your own body?" on a 7-point Likert scale (1: not at all, 7: very much). Based on their responses, participants were categorized into a Low Body Ownership group (score $\leq$ 3, n=6) and a High Body Ownership group (score $\geq$ 5, n=8).

The experiment itself was conducted remotely within a custom world on the VRChat platform, where all participants used a standardized humanoid avatar provided by the experimenter to ensure consistency. Participants were instructed to sit at a desk and align their physical left arm with their avatar's left arm to enhance the sense of body ownership. The task was to stroke the dorsal side of the left avatar's forearm from elbow to wrist, as illustrated in Fig. 1. This was performed under two main conditions: Visual-Only (Condition A), in which participants stroked their avatar's arm with their avatar's hand without any corresponding physical contact on their real arm, and Visual-Tactile (Condition B), in which they stroked their avatar's arm while simultaneously stroking their physical left forearm with the flat surface of their right VR controller. For each of the two conditions, participants first determined the stroking velocity they found most pleasant. Following this, they were instructed to use that velocity as a baseline and freely adjust the speed to find two faster and two slower velocities, such that they subjectively felt the pleasantness was different between each trial. This procedure resulted in five distinct rated velocities per condition, centered around each participant's individual preference. The experiment was conducted using VRChat's standard avatar system, which does not implement self-collision detection. Consequently, the avatar's hand could visually pass through the forearm during the stroking motion.

Following each stroking trial, participants rated the pleasantness of the touch on a Visual Analog Scale (VAS) presented in VR, an-

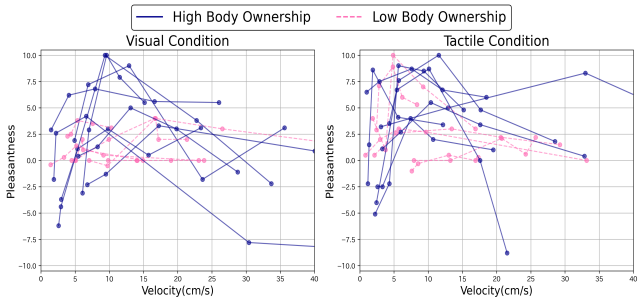

Figure 2: Perceived pleasantness ratings across all groups and conditions. Blue solid lines indicate the High Body Ownership group (n=8), and pink dash lines indicate the Low Body Ownership group (n=6). For clarity, the x-axis is truncated at 40 cm/s.

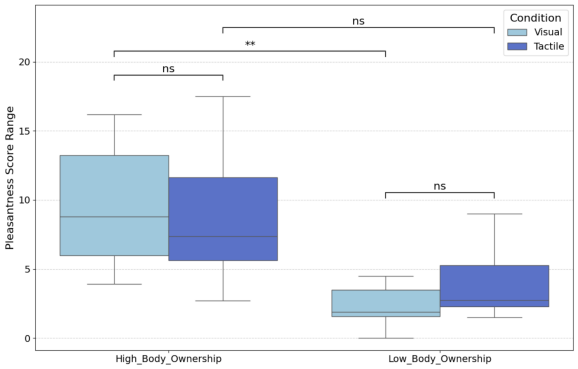

Figure 3: The plot compares the range of pleasantness scores (maximum - minimum) across Body Ownership groups and Tactile Conditions. Asterisks indicate a significant difference (**:p < 0.01, ns: not significant).

chored from 'unpleasant' (-10) to 'pleasant' (+10). For data analysis, we calculated the Pleasantness Score Range (maximum - minimum rating) and used non-parametric tests (Wilcoxon signed-rank for within-group, Mann-Whitney U for between-group comparisons) with a significance level of $\alpha = 0.05$.

3 RESULTS

First, we examined the individual pleasantness ratings plotted against stroking velocity for all participants across both conditions, as shown in Fig. 2. The plot reveals several key trends. Overall, ratings in the Visual-Tactile condition were generally higher than in the Visual-Only condition. More specifically, a notable difference is observed between the two ownership groups in the Visual-Only condition: the High Body Ownership group exhibited a wide variation in pleasantness, while the Low Body Ownership group reported ratings that were consistently low and clustered near zero.

To formally analyze this observed variability, we focused on the range of pleasantness scores (maximum - minimum rating) for each participant in each condition, as shown in Fig. 3. A key finding emerged from the statistical analysis. A Mann-Whitney U test revealed that in the Visual-Only condition, the High Body Ownership group exhibited a significantly larger Pleasantness Score Range compared to the Low Body Ownership group (p=0.0027). This result indicates that the perceived pleasantness from visual information alone is strongly modulated by the degree to which one perceives the avatar as their own body. In the Visual-Tactile condition, however, this difference between the groups was not statistically significant (p=0.0593). Furthermore, within-group comparisons using the Wilcoxon signed-rank test showed that the presence of tactile feedback did not significantly alter the Pleasantness Score Range for either the High Body Ownership group (p=0.3359) or the Low Body Ownership group (p=0.4375).

4 DISCUSSION & CONCLUSION

This work suggests that the sense of body ownership plays a crucial role in modulating the perceived pleasantness of virtual stroking. The results indicate that a strong sense of ownership may allow participants to experience a wider range of affective responses to visual stroking alone, as shown by the significantly larger score range in the High Body Ownership group. However, these findings must be interpreted with caution. The lack of a statistically significant difference between the Visual-Only and Visual-Tactile conditions for this group does not conclusively prove that visual input can fully substitute for tactile input; this could be a result of insufficient statistical power due to our small sample size, a potential Type II error.

Crucially, the Low Body Ownership group reported low pleasantness even in the Visual-Tactile condition. This suggests that for individuals with weak ownership, the visual information of a "non-self" avatar being touched might have attenuated the pleasantness that would otherwise be felt from the physical stimulus. Since the avatar's arm was always visible, this negative modulation from low body ownership may have persisted even when real touch was present, highlighting the powerful influence of the visual experience.

Interestingly, the average stroking velocity that participants found most pleasant in the Visual-Tactile condition was 11.58cm/s, which exceeds the typical optimal range of 1–10cm/s for C-tactile (CT) afferent activation [4]. This deviation is not necessarily anomalous. As recent research suggests that the perception of tactile pleasantness arises from a complex interplay of various physical characteristics and not just velocity [5], it is plausible that the preference for a higher velocity resulted from the specific nature of our stimulation, such as using a hard VR controller. This highlights a limitation of our setup: the visual artifact of the stroking hand clipping through the forearm, due to a lack of self-collision, might have disrupted the sense of realism. This effect could have been particularly pronounced for the Low Body Ownership group, further attenuating their perceived pleasantness.

In conclusion, our findings establish body ownership as a critical modulator of virtual affective touch. Future research should validate these findings with larger sample sizes and dedicated control conditions (e.g., tactile stimulation without VR). Using custom environments with realistic physics and exploring different stimulators (e.g., a soft brush) would also help disentangle the complex relationship between vision, touch, and body ownership.

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