Examining Illusory Touch Perception in Virtual Reality among Virtual Reality Users

Bingxin Huang *

Hangzhou Greentown Yuhua School, Hangzhou, China

* Corresponding Author Email: 196062107@mail.sit.edu.cn

Abstract. The phenomenon of illusory touch perception in virtual reality (VR) is a subject of increasing intrigue within online VR communities, where users report experiencing tactile sensations in the absence of direct physical contact, triggered solely by visual stimuli. This paper presents an exploratory study aimed at understanding the underlying mechanisms that contribute to the development of such illusory touch perceptions in immersive virtual environments. Through an online survey targeting VR users, this study collected qualitative data on the nature and frequency of these experiences. The survey was complemented by a review of existing literature on touch perception and multisensory integration, providing a foundational understanding of how sensory information is processed and perceived. The findings suggest that certain visual cues in VR can evoke tactile sensations, a phenomenon that may be enhanced by the immersive quality of the virtual environment and the user's previous sensory experiences and expectations. This paper discusses potential contributors to the phenomenon, such as the realism of the virtual environment, the user's level of immersion and presence, and the congruence of multisensory stimuli. Although this study sheds light on the conditions that may facilitate illusory touch perception in VR, the complexity of human sensory processing necessitates further research. Controlled experimental studies are required to establish a causal relationship between specific factors and the experience of illusory touch in VR, which could have significant implications for the fields of virtual reality and sensory augmentation technology.

Keywords: Illusory touch perception; Virtual reality; Phantom touch; Survey results.

1. Introduction

Virtual reality (VR) is vastly popular today due to its drastic advancements in recent decades, seeing roughly 20 to 30 million active users daily as of October 2023 [1]. VR hardware systems usually include a head-mounted display (HMD) that can look in all directions that users wear to observe the virtual plane they are accessing and some way for users to interact with the virtual plane- often in the form of controllers or hand-tracking mechanisms. Though many haptic add-ons that simulate the sense of touch and other sensations exist, some individuals experience virtually induced touch without haptic usage. To study these occurrences is to understand the correlation between the manifestation of illusory touch perception in VR and non-tactile stimulus.

2. Illusory Touch Perception in Virtual Reality

Illusory touch perception (or phantom touch in online VR communities) is often described as experiencing touch-like sensations based only on visual stimuli present in VR. However, no actual touch, haptics, or tactile stimuli are present during this experience. Individuals who encounter this illusory touch perception frequently claim to 'feel' touch on the corresponding location on their body as they are touched in VR despite the lack of physical contact [2][3]. Its occurrence has been frequent among online VR communities and is subject to many non-academic discussions. The research on VR illusory touch perception is few due to the recentness of VR technology that allows this phenomenon and the vagueness of its causes. Certain studies speculate that the experience of illusory touch is likely due to the dominance of vision over other senses and the sense of body ownership over virtual avatars- which can be manipulated to induce and enhance illusory touch perceptions in VR [2]. Other studies believe interpersonal touch in VR is the likely cause of developing illusory touch

perception [3]. However, it is more likely that a culminating effort of multisensory stimulus and various factors generate this perception of illusory touch in VR.

3. Previous Studies on the Role of Various Factors in Touch Perception

3.1. Auditory Stimulus

Spatially dependent and frequency-specific sounds have been shown to affect touch perception due to the likely interconnections between the auditory and somatosensory cortex, and these interconnections may be strengthened with use, similar to adult brain plasticities. Studies suggest that auditory stimuli initially evoke activities within the auditory cortex which then spread to the somatosensory cortex via cortico-cortical connections [4]. Hence, enhancing the individual's touch perception. Specific audio cues intensify the touch perception of related actions, such as a surface feeling less pleasant when touched as an unpleasant sound was played or the mislocalization of tactile and auditory stimuli due to irrelevant audio-tactile stimuli. Research has also confirmed the effect of audio-tactile interaction on individuals when walking on different surfaces and the material perception of virtual surfaces [5].

3.2. Visual Stimulus

The role of vision has been consistently shown to be dominant over touch in multiple circumstances [6] [7]. Within the rubber hand illusion, this holds as well. Two main components of the rubber hand illusion are key to its inducement. First, is the synchronization of visual and tactile stimuli? Second, is the persistent change in body representation of experiencing the rubber hand as an extension of one's body produced by the process [6]. In essence, this process pairs initial visual and tactile stimuli to induce a sense of body ownership over the rubber hand. This sense of body ownership and visual stimuli provided is what builds the rubber hand illusion.

3.3. Neurological Factors

In mirror-touch synaesthesia (or vision-touch synaesthesia), vision and the sense of body ownership are not considered as prevalent as neurological activations. Individuals with mirror-touch synaesthesia undergo subjective tactile sensation merely by observing touch on another person [8]. It has been hypothesized that this variant of synaesthesia is likely due to the activities within the bilateral primary somatosensory cortex, secondary somatosensory cortex, left premotor cortex, and additional activity in the anterior insula. Thus, it is concluded that mirror-touch synaesthesia is caused by a hyper-activation of regular visuotactile interactions within the neural network network [9] [10].

4. Participants

Participants were gathered from online VR-related communities to fill out a survey that included illusory touch perception-related questions. This resulted in a collection of 323 results with 320 relevant responses from individuals found on the online platforms of Reddit and Discord. Participants were self-volunteered and chosen from random VR-related communities and partook in VR-related activities. The sample includes 101 teens and 219 adults with an age range of 13 to over 40. Participants' genders were self-reported as 217 male, 66 female, 30 other, and 7 individuals who prefer not to say.

5. Procedure

Participants were questioned about their age range, gender, diagnosed mental disorders and neurodivergence, and experiences with illusory touch perception in VR and non-VR circumstances. These respondents answered a checklist-style survey containing the following questions:

Q1. What is your gender?

Q2. What age group do you belong to?
Q3. Do you suffer from any mental illnesses or any other neurodivergence for which you hold a formal diagnosis?
Q4. Do you experience any forms of synesthesia?
Q5. Do you experience illusory touch perception in VR?
Q6. How intensely do you experience illusory touch perception in VR?
Q7. How often do you experience illusory touch perception in VR?
Q8. Do you experience illusory touch perception in non-VR settings?
Q9. After what period of time using VR did you develop illusory touch perception in VR?
Q10. Where do you experience these illusory touches?
Q11. Where do you experience these illusory touches the strongest?
Q12. What kinds of sensations do you feel?
Q13. What triggers your illusory touch perception in VR?
Q14. What did you do (that you believe) caused you to gain illusory touch perception in VR?

6. Results and Discussion

In the relevant results gathered, 234 (73.13%) respondents reported experiences of illusory touch in VR with 68.75% of respondents reporting experiences of illusory touch in non-VR settings, and 27.81% of respondents reporting experiencing illusory touch in both VR and non-VR circumstances. This phenomenon of illusory touch perception is most common among females at 89.39% of all female respondents (fig. 1) and the age range of 19 to 25 with 73.11% experiencing illusory touch in VR (fig. 2). Of the respondents who reported encounters with illusory touch perception in VR, 34.19% claim to experience some form of synaesthesia- with 17.09% being specifically mirror-touch synaesthesia.

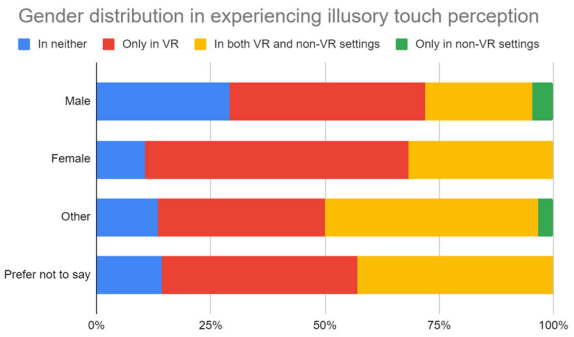

Fig 1. Gender distribution in experiencing illusory touch perception.

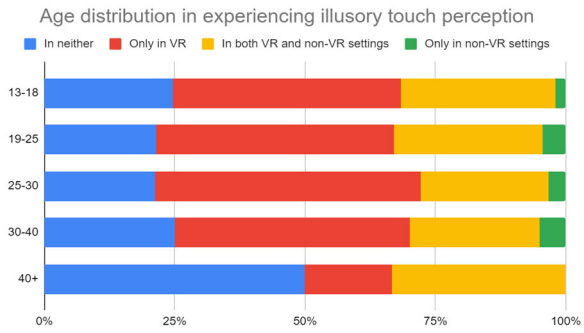

Fig 2. Age distribution in experiencing illusory touch perception.

Respondents also were quizzed on how intensely they experience illusory touch in VR, with 1 scoring lowest as little to no sensations of illusory touch and 10 scoring highest as extreme and intense sensations of illusory touch. The average intensity experienced is around a score of 4.68 with 20.51% of respondents who experience illusory touch in VR reporting an intensity score of 3 (fig. 3). 29.06% of respondents state that on a scale of 1 to 5- 1 being never experiencing illusory touch in VR and 5 being always experiencing illusory touch in VR- experience a score of 3, with the average score being 3.32 (fig. 4). Most respondents state their illusory touch perception develops within 1 year of VR usage. Surprisingly, 20.09% of respondents claim to experience illusory touch in VR immediately after exposure and usage of a VR hardware setup (Table 1).

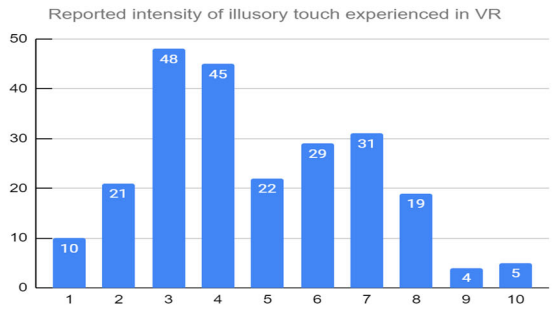

Fig 3. Reported intensity of illusory touch experienced in VR.

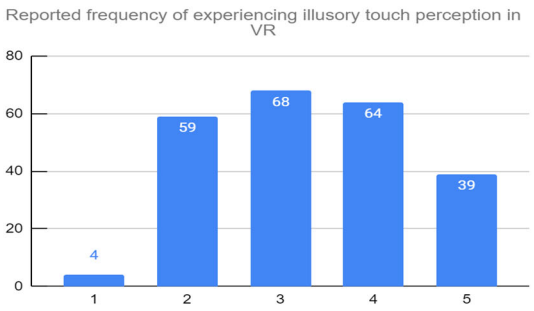

Fig 4. Reported frequency of experiencing illusory touch perception in VR.

Table 1. Time of usage spent by users before developing illusory touch perception in VR.

Time spent with VR usage	# of Respondents
Immediate usage	47
Within 1 week	30
Within 1 month	37
Within 3 months	47
Within 1 year	52
Within 3 years	17
Over 3 years	4

Among the respondents who experience illusory touch in VR, 64.53% are diagnosed with some form of mental disorder or neurodivergence, the most common being anxiety disorders (35.04%), ADHD (31.20%), and depression (30.34%). The most recurrent bodily location that undergoes illusory touch perception is the head and face at 49.15%, followed by the full body at 44.87%. 56.41% of respondents who experience illusory touch perception in VR describe the head and face as the location in which they detect these sensations the strongest. Most respondents report feeling touch as the primary illusory sensation they feel at 67.95%, with temperature changes as second to most experienced at 52.99% (Table 2). Respondents also disclosed triggers of their illusory touch- being touched by people was the most common trigger at 85.90% and the second most common being ambiance and environmental effects at 49.58% (Table 3). Most respondents believe that their illusory touch perception developed naturally with no specific cause. However, 50.85% believe their development of illusory touch perception in VR can be attributed to their extensive time spent in VR (Table 4). Participants also reported on their believed cause of developing VR illusory touch perception, with most believing their manifestation of these perceived illusory touches was from natural development (Table 4).

Table 2. Reported sensations and perception changes experienced among users.

Type of sensation/perception changes experienced	# of Respondents
Pain	37
Pleasure (non-sexual)	106
Pleasure (sexual)	67
Smell	31
Touch	157
Temperature (Warmth/Coolness)	124
Pressure	88
Tingling	146
Tickling	58
Taste	18
Weight changes	1

Table 3. Reported triggers of illusory touch.

Trigger	# of Respondents
Touched by people	201
Touched by objects	98
Touching people	99
Touching objects	76
Ambiance effects/Environment	109
Impaled by weapons	73

Table 4. Self-reported believed cause of the development of illusory touch perception in VR.

Believed cause	# of Respondents
Natural development	126
Hardware advancements/setup upgrades	35
Prolonged periods of VR usage	119
Hypnosis/meditation	20
Recreational drug use	13
Active imagination	4
Body ownership over avatar	1
Synchronized visual and tactile stimuli	1
Associative memory	4

7. Conclusion

Non-tactile stimuli- specifically audio and visual- have been proven to enhance touch perception. Spatially specific sounds strongly associated with somatosensory percepts intensify touch perception [3]. Visual stimuli and self-attribution analyzed within experiments of the rubber hand illusion have also verified their role in illusory touch perception [6]. Audio and visual stimuli are commonly found in the average VR experience. Spatially specific auditory stimuli are provided via speakers or headphones, while visual stimuli are presented through the head-mounted display (HMD). The sense of embodiment and self-attribution is very much present in VR experiences since individuals have complete control over their avatars. Hence, the phenomenon of illusory touch perception within VR experiences is not unfeasible.

Despite so, no specific cause can be attributed to the development of illusory touch perception in VR as individuals with any amount of VR usage exposed to any sort of stimulus can manifest illusory touch perception. There is no distinctive correlation between neural function, mental wellness, and the phenomenon of illusory touch perception in VR. Age is not a considerable factor in play within such a phenomenon. However, females do indeed appear to be more susceptible to its development. The most widespread trigger of illusory touch among VR users is generally interacting with people, with touch as the most felt sensation. Further study is needed to draw a definitive conclusion between particular factors and the manifestation of illusory touch perception in VR.

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