

# Repeat Body-Ownership Illusions in Commodity Virtual Reality

Pauline W. Cha\*

Davidson College

Tabitha C. Peck†

Davidson College

## ABSTRACT

Virtual self-avatars have been shown to produce the Proteus effect, however limited work investigates the subjective sense of embodiment using commodity virtual reality systems. In this work, we present results from a pilot experiment where participants are given a self-avatar in a simple virtual experience while wearing a cardboard head-mounted display. Participants then repeat the experience five days later. Overall, subjective embodiment scores are similar to those reported in experience using higher-fidelity systems. However, the subjective sense of embodiment significantly lowered from trial one to trial two.

**Index Terms:** Human-centered computing—Visualization—Visualization techniques—Treemaps; Human-centered computing—Visualization—Visualization design and evaluation methods

## 1 INTRODUCTION

Virtual body-ownership illusions [4], also known as virtual embodiment illusions have been shown to cause the Proteus effect [9]. That is, users take on the stereotypical behaviors of the self-avatar that they are embodying. Many behavioral and cognitive benefits of embodying self-avatars have been demonstrated. For example, taller avatars exude higher confidence [9] and light-skinned participants after embodying dark-skinned avatars demonstrated lower implicit racial bias [6].

Embodiment illusions are often demonstrated using Six-degrees-of-freedom (6dof) head-mounted displays (HMDs) with full-body tracking, such as demonstrated in Peck et al. [6]. However, only 4% of the world owns an HMD [8] thus limiting the number of people who can experience the Proteus effect. Cardboard VR has been shown to offer an acceptable amount of immersion compared to commercial VR head-sets [2], and approximately 85% of people in the world own smart phones [1]. This suggests that smartphone-based commodity virtual reality (VR) can make VR more accessible. However, due to the limitations in tracking and usability, commodity VR may not support the same quality experience as commercial VR headsets. Recent work supports that participants using commodity cardboard HMDs experience body-ownership illusions [7]. However, little research has investigated the effect of these illusions over multiple experiences.

## 2 METHODS

We present a within-participants repeated measures pilot experiment investigating the effects of repeated trials (two) on subjective embodiment using commodity VR. The experiment consisted of two identical trials that were five days apart. For each trial, all participants came to the lab at the same time. Participants donned a card-board VR headset playing a virtual reality application. Within the application, participants were instructed to select the self-avatar that best represented them from four self-avatars with varying skin

\*e-mail: pacha@davidson.edu

†e-mail: tpeck@davidson.edu



Figure 1: A view of the avatar selection screen.

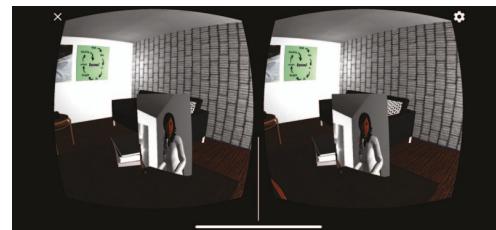


Figure 2: A view of the avatar looking in the mirror.

tones. See Figure 1 for a view of the selection scene, and Figure 2 for the virtual scene.

After selecting the self-avatar, participants found themselves seated in a virtual room and collocated with their self-select avatar. The avatar's head rotated, but no other agency was afforded to the user. A virtual mirror was also placed in the room. Participants were instructed to look around the room and at themselves in the mirror for two minutes.

After two minutes, participants removed the HMD and completed a computer based questionnaire administered through Qualtrics. Participants completed the Embodiment Questionnaire [5] as well as standard demographics questions. The Embodiment Questionnaire include submeasures of Appearance, Response, Ownership, and Multi-Sensory.

### 2.1 Participants

Eleven participants completed this repeated measures experiment. Participants self-identified their gender as Women ( $n = 4$ ), Men ( $n = 6$ ), and Non-Binary ( $n = 1$ ). Participants self-identified their race as Black ( $n = 2$ ), East-Asian ( $n = 3$ ), and White ( $n = 6$ ). Participants ages were 18-22 years. The experiment was approved by the (removed) institutional review board.

### 2.2 Equipment

Application was developed for both mac and android devices. Participants installed the applications on their personal cell-phones with guidance from the experimenter before the experiment began. Smartphones were placed into distributed cardboard VR devices.

## 3 RESULTS

Embodiment results were analyzed with a repeated measures ANOVA with the two levels of trial as a within-participants variable.

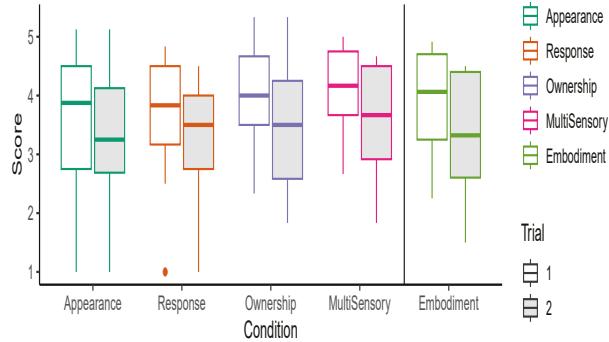


Figure 3: Box-plots of embodiment scores for trial one (white) and trial two (gray).

A significant difference between trials was found,  $F(1, 10) = 8.57$ ,  $p = .02$ ,  $\eta^2 = .05$ . Participants rated their subjective sense of embodiment as higher during the first trial ( $M = 3.84$ ,  $SE = .28$ ) compared to the second trial ( $M = 3.41$ ,  $SE = .31$ ). Similar significant results of participants reporting higher subjective ratings in trial one compared to trial two were seen in the Response, Ownership, and Multi-Sensory submeasures, but no significant results were found in the Appearance submeasure. See Table 1 and Figure 3 for results.

#### 4 DISCUSSION

After the first trial participants' mean subjective embodiment score was  $3.84 \pm .28$ . These values are higher than the means ( $3.48 \pm 1.04$  and  $3.43 \pm 1.30$ ) reported in two of the experiments used to validate the Embodiment Questionnaire [5]. These high scores support that subjective embodiment scores are sufficiently high when using commodity VR for a short (two minutes) amount of time. These results are further supported by prior work by Amin et al. [2] who found that immersion was also sufficient when using commodity VR compared to commercial HMDs.

Interestingly, the subjective embodiment scores significantly dropped between trial one and trial two, down to  $3.41 \pm .31$ . The initially higher embodiment scores could be due to an initial 'wow' factor of VR where participants are excited by their first two minute experience. However, during the second trial the 'wow' factor may have worn off, leading to lower scores. However, the Embodiment Questionnaire is often not taken after such a short duration but instead after a longer VR experiment and experience. As the questionnaire was likely not tested after such a short duration, it may be normal for participants to have higher subjective scores early in an experiment. Future experiments may need to test this theory.

Interestingly, a repeated measures study by Fribourg et al. [3] did have participants take the Embodiment Questionnaire at repeated times during the experiment. They did not find a significant change in subjective embodiment over time, however they did not look at

	Trial 1	Trial 2	F	$\eta^2$	p
Appearance	$3.63 \pm .38$	$3.33 \pm .36$	3.19	.02	.10
Response	$3.64 \pm .34$	$3.26 \pm .31$	8.59	.03	<b>.02</b>
Ownership	$4.02 \pm .28$	$3.45 \pm .35$	5.31	.07	<b>.04</b>
Multi-Sensory	$4.08 \pm .23$	$3.61 \pm .32$	6.54	.07	<b>.03</b>
Embodiment	$3.84 \pm .28$	$3.41 \pm .31$	8.57	.05	<b>.02</b>

Table 1: Tests statistics including  $F$ ,  $\eta^2$  and  $p$  – value of subjective embodiment scores for each trial. Descriptive statistics include the mean and standard error of each subjective embodiment measure.

days difference, but instead minutes. Their results provided some evidence that some questions related to Ownership may drop over time. Our results support that Ownership, as well as Response and Multi-Sensory did drop over time.

The environment used in this experiment was simple and participants did not have tasks or gamification within the experience. It is possible that the drop in subjective Embodiment over time may be due to the simplicity of the virtual experience. Participants did not have a task and were merely asked to look around a virtual room and in a mirror. Future work should investigate embodiment over time with more interactive environments.

Regardless, the final embodiment scores after trial two were still high and similar to the embodiment values reported with the Embodiment Questionnaire [5]. This suggests that, even though subjective embodiment significantly dropped, it may still be adequate when using commodity VR over repeated times.

#### 5 CONCLUSION

This work presents results from a pilot experiment where participants ( $n=11$ ) wore a race-matched self-avatar during two two-minute virtual experiences, five days apart. Participants reported adequately high subjective embodiment scores during both the first and second trials. However, subjective embodiment scores significantly dropped from the first to the second trial. This work supports that people can be embodied in a self-avatar using commodity VR and over repeated trials. However, the subjective sense of embodiment may lower over time. Future work should investigate this effect over more trials and with more interactive VR experiences.

#### ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant 1942146. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

#### REFERENCES

- [1] How many people own smartphones? <https://explodingtopics.com/blog/smartphone-stats>. Accessed: 2023-12-17.
- [2] A. Amin, D. Gromala, X. Tong, and C. Shaw. Immersion in cardboard vr compared to a traditional head-mounted display. In *Virtual, Augmented and Mixed Reality: 8th International Conference, VAMR 2016, Held as Part of HCI International 2016, Toronto, Canada, July 17-22, 2016. Proceedings* 8, pp. 269–276. Springer, 2016.
- [3] R. Fribourg, E. Blanpied, L. Hoyet, A. Lécuyer, and F. Argelaguet. Does virtual threat harm vr experience?: Impact of threat occurrence and repeatability on virtual embodiment and threat response. *Computers & Graphics*, 100:125–136, 2021.
- [4] K. Kilteni, R. Grotens, and M. Slater. The sense of embodiment in virtual reality. *Presence: Teleoperators and Virtual Environments*, 21(4):373–387, 2012.
- [5] T. C. Peck and M. Gonzalez-Franco. Avatar embodiment. a standardized questionnaire. *Frontiers in Virtual Reality*, 1:575943, 2021.
- [6] T. C. Peck, S. Seinfeld, S. M. Aglioti, and M. Slater. Putting yourself in the skin of a black avatar reduces implicit racial bias. *Consciousness and cognition*, 22(3):779–787, 2013.
- [7] S. Serino, M. Sansoni, D. Di Lernia, A. Parisi, C. Tuena, and G. Riva. 360-degree video-based body-ownership illusion for inducing embodiment: development and feasibility results. *Virtual Reality*, 27(3):2665–2672, 2023.
- [8] M. Weinberg. Virtual reality in ecommerce isn't there yet, but keep it in mind. <https://boldist.co/technology/virtual-reality-in-ecommerce/>. Accessed: 2023-12-17.
- [9] N. Yee and J. Bailenson. The proteus effect: The effect of transformed self-representation on behavior. *Human communication research*, 33(3):271–290, 2007.