



A Longitudinal Pilot Study of Presence in Immersive VR

Yasin Farmani, Siqi Luo and Robert Teather

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A Longitudinal Pilot Study of Presence in Immersive VR

Yasin FARMANI ^a, Siqi LUO ^a and Robert J. TEATHER ^{b 1}

^a *School of Computer Science, Carleton University, Ottawa, Ontario, Canada*

^b *School of Information Technology, Carleton University, Ottawa, Ontario, Canada*

Abstract. We present a longitudinal pilot study of presence, comparing low- and high-fidelity virtual environments. We measured presence levels using a presence questionnaire, heart rate, and skin temperature over four sessions. We found no significant difference due to environment fidelity, nor any change in presence over four sessions. Subjective feedback suggests that using the same tasks in multiple sessions frustrates users, so may also affect participants' presence assessment.

Keywords. Presence, objective and subjective measurement, virtual reality

1. Introduction

Presence, the “feeling of being there”, is a subjective psychological response defined as a possible transfer of abilities or experience learned from virtual reality (VR) to the real world [1]. Immersion, on the other hand, is “the objective level of sensory fidelity a VR system provides” [1]. Many factors influence immersion, such as field of view (FOV), display resolution, lighting realism, refresh rate, and so on. More immersive environments are generally thought to better elicit a presence response [1].

Given the popularity of VR games, we are interested in how presence changes over time. After all, gamers may participate in long daily play sessions over weeks or months; it is as yet unclear how presence is affected by such long exposures. We conducted a four-session longitudinal study. We varied several immersion factors to detect potential interaction effects between immersion and time, on presence. Our hypothesis was that with repeated exposure at fixed levels of immersion, presence levels would decrease after 4 sessions as participants became “de-sensitized” to VR.

2. Related Work

Factors affecting presence include: **1)** Display characteristics (immersive qualities e.g., display size, FOV, resolution, etc.) **2)** Content characteristics (e.g., realism or task) and **3)** User characteristics (e.g., prior experience, willingness to suspend disbelief) [2]. We thus targeted users without VR experience, to elicit more consistent presence responses.

Meehan et al [3] measured presence via physiological responses such as heart rate, skin conductance, and skin temperature. They report that environment realism yielded

¹ Corresponding author, rob.teather@carleton.ca

differences in heart rate but not skin conductance or temperature. However, they measured skin temperature at the finger tips. We instead measure temperature of the participant's cheek. They also report a significant decrease in presence over several exposures to the VE, but note that presence did not drop to zero [3].

3. Experiment

Participants: We recruited 6 VR-novice participants (3 male, aged 18 to 39).

Apparatus: We used an *HTC Vive* head-mounted display, connected to a PC with a 3.2 GHz i5 CPU, 8GB RAM, and a GeForce GTX 970 graphics card. We measured skin temperature with a Fluke 568 IR and hear rate using an Arduino pulse sensor.

The virtual environment was partly based on Meehan et al [3] and was a house within which participants could walk from a living room to another room with a pit. Participants could stand on the edge of the pit and look down into the basement. This was intended to elicit physiological responses [3]. The living room included several game-like activities, such as shooting balloons with a bow, or rolling balls on the ground. We developed high- and low-fidelity versions of the VE. Differences are seen in **Table 1**.

Table 1. Low- and high-fidelity environment parameters

Environment	Resolution	Audio	Haptic	Details
Low Fidelity (LF)	600×400	Off	off	Simple
High Fidelity (HF)	1024 × 768	On	on	Furniture, colour

Haptic feedback like the vibration when pulling the bow and the sound when stepping on the wood floor were offered in the high-fidelity environment. The high-fidelity environment included more furniture, textures, and colours. See **Figure 1**.

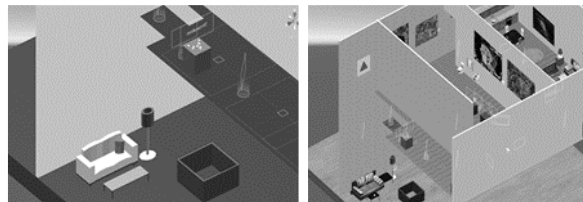


Figure 1. Low-fidelity (left) and high-fidelity (right) environments.

Procedure: Participants experienced both high-fidelity (HF) and low-fidelity (LF) conditions in each 20-minute session. We measured both their heart rate and skin temperature before and after each session. Participants completed tasks like shooting balloons with the bow and grabbing and dropping small objects. Participants completed the presence questionnaire at the end of every session and did a short interview.

Design: The experiment employed a within-subjects design with two independent variables, fidelity (LF, HF), and session (1, 2, 3, 4). Dependent variables included heart rate, skin temperature, and presence questionnaire (PQ) scores [4].

4. Results and Discussion

Data was analyzed with repeated measures ANOVA. There was a significant main effect

on PQ scores for session ($F_{3,5} = 4.9, p < .05$). Neither fidelity ($F_{2,5} = 1.4, p > .05$) nor the interaction effect ($F_{3,5} = 0.4, ns$) were significant. Presence scores are seen in **Figure 2**.

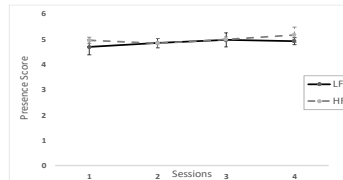


Figure 2. Presence by session and fidelity. Error bars show ± 1 SE.

Results for physiological responses are seen in **Figure 3**. ΔST generally decreased, while ΔHR generally increased with session. The repeated measure ANOVA indicated not significant effect for ΔHR for sessions ($F_{3,5} = 1.1, p > .05$), fidelity ($F_{2,5} = 0.3, p > .05$) and interaction effect ($F_{3,5} = 0.4, ns$). Surprisingly, the ANOVA results indicated the significant effect for ΔST for sessions ($F_{3,5} = 3.3, p = .02$). Neither fidelity ($F_{2,5} = 0.6, p > .05$) nor the interaction effect ($F_{3,5} = 0.1, ns$) were significant.

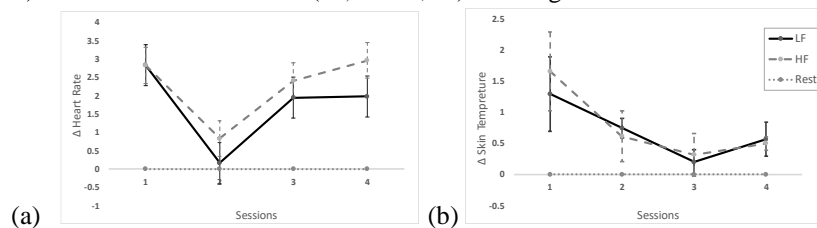


Figure 3. Change in (a) heart rate and (b) skin temperature, by session and fidelity. Error bars show ± 1 SE.

5. Discussion and Conclusions

Our physiological metrics indicated higher presence with the low-fidelity VE. Skin temperature changes decreased with session. Our PQ scores did not show a difference between the fidelity levels, but participants preferred the high fidelity VE due to the audio. Some participants indicated they could barely feel a difference between the LF and HF VEs. Overall, although we hypothesized that presence levels would decrease over sessions, it turns out the relationship is more complicated, and presence varied greatly from session to session. A longer study may yield more substantial differences.

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