Avatar self-identification as a cognitive metric of self-presence

Andrea Stevenson Won and Jeremy N. Bailenson

Department of Communication, Stanford University
{aswon@stanford.edu, bailenso@stanford.edu}

Abstract

We propose a novel measure for presence in the form of a post-immersion self-identification task. A pilot study testing the new measure involved thirty-four female and male participants who completed a balloon popping task in virtual reality, using a low detail, gender matched avatar that did not resemble them. Participants' arm, leg and head movements were tracked and rendered. One week after the completion of the balloon popping task, participants completed an identification task, in which they were presented with 30, five-second animations of the neutral avatar they had used the week before. Each animation showed either a replay of their own recorded motions, or the motions of another randomly selected participant. Self-identification "false positives" correlated marginally significantly (p = .089) with the mean of participants' reported self-presence. Post-task self-identification of tracked and rendered motion may provide a novel way to reconsider self-presence in virtual environments.

Keywords: **identification, avatar, presence, self-presence, virtual reality, gesture**

1. Presence and self-presence in Virtual Environments

Presence, or "being there," is an important, but subjective, element of virtual experiences. As virtual environments become more interactive and more customized, assessing presence becomes more important. The experience of presence can be divided into several interdependent categories (Lee, 2004), including environmental, or spatial, presence (the feeling that the virtual environment is real); copresence, or social presence (the feeling that another entity is sharing the virtual experience); and self-presence (the feeling that one's body is present in the virtual environment). Of these three categories, self-presence has been least studied in virtual reality.

The experience of presence is subjective but driven by technological affordances as well as individual differences and states of mind (Sas and O'Hare, 2003). Thus, while it is possible to quantify technological advances, such advances do not directly measure presence. As Biocca (1997) states, "In immersive VR, more so than in any other medium before it, the representation of the user's body is a psychologically profound issue."

In assessing the experience of presence, including the "you are there" experience, researchers have often used self report (e.g., Lombard et al, 1997). Related work on embodiment has also measured proprioceptive distortion, (as in the rubber hand illusion, where participants' perception of the position of their physical arm was altered through visual and tactile stimulation, Botvinick & Cohen, 2006) and physiological measures (Slater, Spanlang, Sanchez-Vives, & Blanke, 2010). Self-presence is often considered to be related to the degree of interactivity between the virtual environment and a person's physical body. Slater and Usoh (1994) state, "The second aspect of immersion [is] that proprioceptive signals about the disposition and dynamic behaviour of the human body and its parts become overlaid with consistent sensory data about the representation of the human body, the 'Virtual Body.'" However, since presence is a subjective construct, the technical affordances of the system are not a sufficient measure.

Ratan (2012) further unpacked the concept of self-presence, building on definitions drawn from neuroscience and communications to create three interrelated categories of self-presence. These three categories are proto self-presence, core self-presence, and extended self-presence. Ratan describes proto self-presence as "using a virtual object as if it is an [unmediated] extension of the body," while core self-presence reflects the emotional responses derived from interactions between the mediated self and the mediated environment. Extended self-presence examines the personal identity aspect of the digital representation. In this study, our self-presence measures were based on the concept of proto self-presence.

2. Self Identification and Self Recognition

Point light displays, first investigated by Johansson in 1973, are a good example of how humans are able to draw inferences from very sparse visual input. In these displays, white dots or reflectors are placed on the major joints of a confederate, who is clothed in black and moving in front of a black background. Thus, the only information available to the viewer is the movement of the dots in relation to one another. Point light displays have been used to demonstrate humans' ability to differentiate gender (Mather & Murdoch, 1994) emotion (Atkinson, Dittrich, Gemmell, & Young, 2004) and states of mind (Michalak, Troje & Heidenreich, 2011). They have also been used to test participants' ability to distinguish between their own motions, those of friends, and those of strangers (Loula, Prasad, Harber, & Shiffrar, 2005).

In the following task, modeled after Loula and colleagues, we tested participants' ability to identify their own gestures from a very sparse visual display after they completed a brief task in virtual reality. Participants completed an active physical task in virtual reality and then completed a standard self-report measure of self-presence. The following week, they returned to the lab to view a series of five-second animations of the avatar they had embodied the previous week. Each clip was animated by either the participant's own motions, or the motions of another participant. For each clip, participants decided whether or not the motions were their own or another's. Responses were scored as hits, misses, false positives and correct rejections. We hypothesized that self presence, as measured through self-report, would correlate with participants' ability to correctly identify the avatar animated by their own recorded movements.

3. Methods

The 33 participants consisted of 23 female and 11 male undergraduate and graduate students, from an American west coast university. All received class credit for participation. Each participant was matched by gender to either a male or female avatar. Each avatar was modified from stock high resolution digital avatars provided as part of the WorldViz Vizard character animation package, and then textured with a uniform silver color. These avatars were scaled to each participant's height but were not otherwise customized (Figure 1).

3.1. Apparatus

Each participant wore a head-mounted display (HMD) with an attached accelerometer and infrared tracking device to measure the X, Y, Z position and pitch, yaw, and roll of the head. To accurately track and render body movements in the virtual world, four additional infrared trackers were attached to each participant's wrists and ankles (Figure 2) to measure the position of the hands and feet in X, Y, Z space. Head movements were recorded with an accuracy of 1° yaw, and 0.25° pitch & roll. The five trackers updated at up to 175 Hz, capturing movement with an accuracy of .25 centimeters over a 3 cubic meter volume. Wrist, elbow and knee joint movements were not tracked or rendered. Thus,

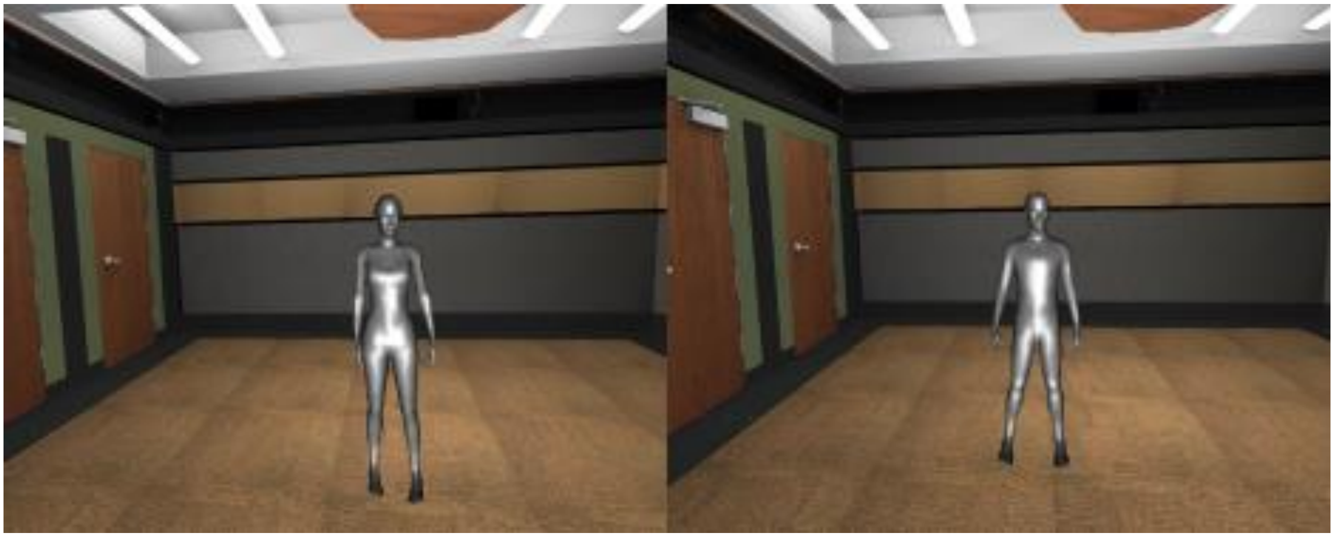

Figure 1. Female and male avatars, in virtual lab room.

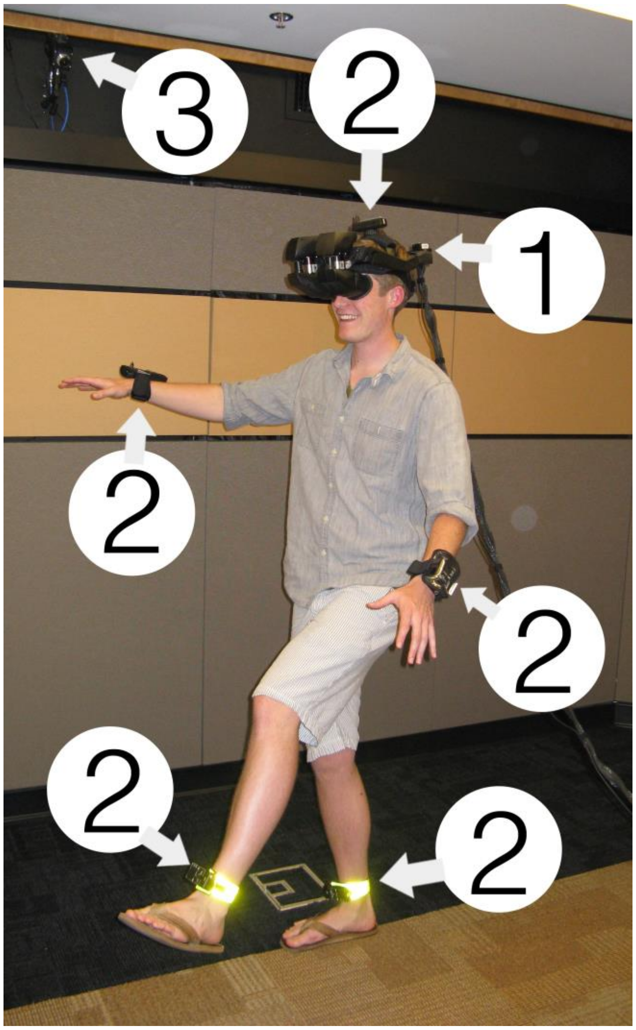

Figure 2. Participant in HMD showing attached accelerometer (1) and trackers (2) in front of camera (3).

regardless of the participants' real world motions, their avatars' wrists as rendered in virtual reality did not rotate or bend, and their avatars' elbows and knees did not bend, giving the avatar a stiff-limbed motion.

3.2. Procedure

3.2.1. Balloon-popping task. Participants were positioned in the center of the main lab room, which was 6.0 meters by 5.5 meters. Before the task began, participants were given a few minutes of instruction on moving their avatars' limbs, lifting and rotating them in front of a virtual mirror. Once this practice session was over, the virtual mirror was turned off, and participants were only able to see their avatar's arms and legs when they entered their field of view, as in real life (Figure 3).

The balloon-popping task lasted ten minutes. A sequence of balloons was programmed to appear in the center of the room in front of the participant, appearing randomly between the floor and the upper limits of the participant's reach. If a participant hit a balloon with their virtual hand or foot, it would pop and they would get a point. If a balloon was not popped within 5 seconds it would disappear. Participants popped between 151 and 481 balloons per session, with a mean of 344.55 and a standard deviation of 83.585.

After the balloon popping task was completed, participants were removed from the HMD and wrist and ankle tracking devices. They were then asked to complete a brief questionnaire in another room.

3.2.2. Self-identification task. One week after the balloon-popping task was completed, participants returned to the lab to complete a self-identification task. This task was modeled after the point light display self-identification task in Loula, Prasad, Harber, and Shiffrar (2005). The task consisted of a series of brief animations showing an avatar identical to the neutral male or female avatar which participants had used during the previous week's experiment. Each animation consisted of either a playback of the participant's recorded movements during the previous week's task, or a playback of an identical avatar controlled by another participant of the same gender. Half of the trials depicted the self while the other half depicted the unfamiliar other. These clips had been randomly selected from the section of the balloon-popping task recorded after the virtual "mirror" had been removed from the world, so no part of the animation consisted of movements that the participant would have been able to see previously from a third-person perspective. This was done so that self-identification would not be conflated with recognition of gestures that had already been seen in real life from a second-person perspective. The avatar was presented on a black background, and the balloons were not rendered, so no information was available except for the X, Y, Z positions of the head, arms and legs, and the pitch, yaw and roll of the head. The animations were presented on a desktop computer monitor in a series of 30 five second animations (Figure 4), separated by 2.5 second intervals showing a screen with a fixation X. Participants were instructed to view the recording for the full five seconds and then to press either the S or the O key to indicate whether they thought the recording was of themselves or of someone else controlling the avatar.

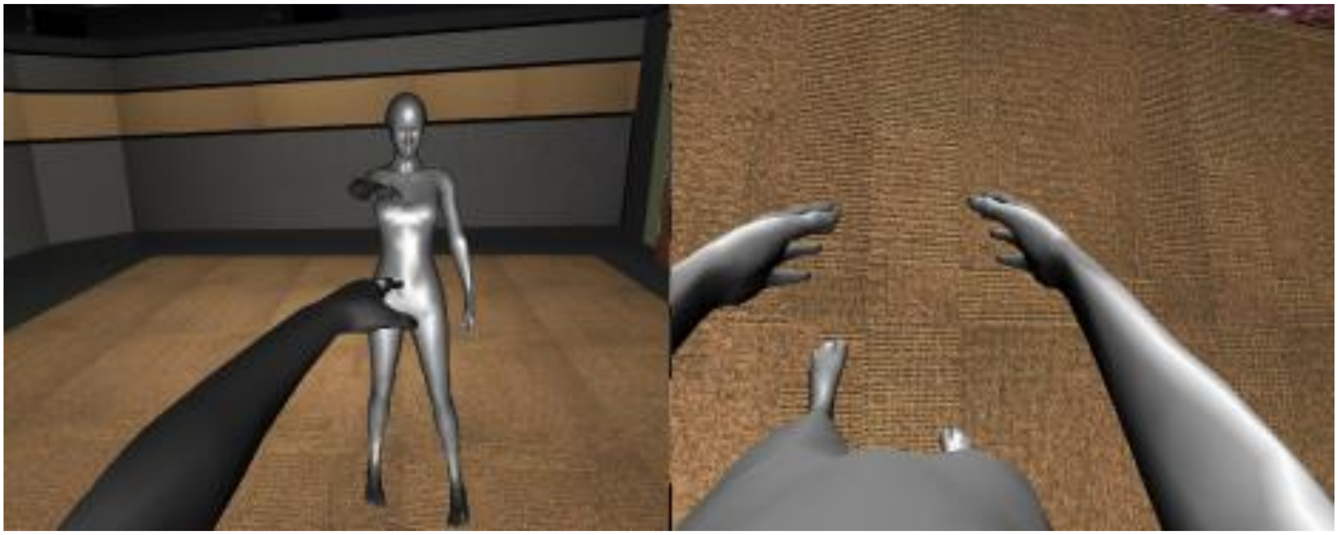

Figure 3. On the left, the avatar is shown seen in the "virtual mirror" with the left hand held up. The left hand is also visible as it is held up in front of the participant's field of view. On the right, the first person point-of-view is shown, with the avatar's hands and feet visible as the participant looks in front of herself.

Participants completed 2-3 practice trials using two non-participant avatars before beginning the task.

4. Results

While participants performed significantly better than average at identifying their own avatar (t=3.912, n 33, sig(2-tailed <.001)) their performance correlated negatively with their reported self-presence. We used four measures of self identification: 1) "hits," or instances where participants correctly identified their own motions; 2) "misses," where participants failed to identify their own motions; 3) "false positives," where participants incorrectly identified another participant's motions as their own, and 4) "correct rejections," where participants correctly identified the motions of others as done by others. In addition, we used the overall percentage of correct answers (shown as "% Correct" in the table below.)

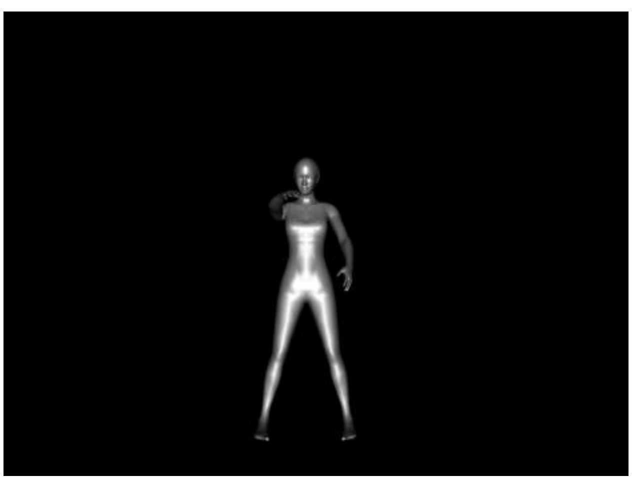

Figure 4. Screenshot showing a female generic avatar replaying recorded motions.

We correlated these measures with the individual questions on self-presence, which were rated on a scale of 1-5, with 1 being "not at all", 2 being "slightly", 3 being "moderately", 4 being "strongly" and five being "very strongly." In addition, we correlated the self-identification measures with the mean of all the self presence questions.

All self-presence questions, individually, showed positive correlations with false positives. In other words, people who reported a higher self-presence were more likely to accept the other avatar as their own. In addition, we found a significant positive correlation (p = 0.024) between false positives and the self-presence question, "To what extent did you feel that 'If something happened to the avatar, it was happening to me.'"

Reliability analysis for the self-presence scale was moderate, below 0.8. This, along with the difference in significance between self-presence questions, may imply that the presence self-report is, in itself, not a reliable measure.

Table 1. Correlation Between Self-Presence and Self-Identification

Self-presence measures	Self-report measures				
To what extent did you feel that...	**Hit**	**Miss**	**False Positive**	**Correct Rejection**	**% Correct**
1. If something happened to the avatar, it was happening to me.	-0.200	0.178	.386*	-0.393*	-.351*
2. The avatar's body was my own body.	0.093	-0.100	0.314†	-0.314†	-0.138
3. I was in the avatar's body.	-0.241	0.227	0.126	-0.097	-0.198
4. The avatar was an extension of me	-0.173	0.175	0.159	-0.169	-0.202
5. The avatar was me.	0.067	-0.069	0.132	-0.150	-0.051
6. Mean of self presence questions	-0.114	0.104	0.296†	-0.298†	-0.245

*significance with p value < .05
† significance with p value < .10

5. Discussion

Limited experiments and measures exist in effectively measuring self-presence. The mainstream way to measure self-presence has been through the self-report of subjective feelings by the user. The results of this pilot study demonstrate the potential and feasibility for a novel method for measuring self-presence beyond self-report. They also demonstrate possible gaps between self-report measures, which reflect participants' abilities to consciously articulate their sense of presence, and measures of the ability of participants to recognize their virtual selves. Though the correlations did not meet the significance value of .05, the fact that they approached significance with such a small sample size, and that success in self-identification correlated negatively with some aspects of self-presence, indicates that self-identification may be an important additional measure to consider when designing self-presence measures. The limitations of this study include the use of a convenience sample, a small sample size, and correlational data which limits our ability to look for causality and possible mediators. In order to validate these findings, future studies with a larger sample size should also include a greater battery of self-presence measures, including measures designed to examine concepts beyond the proto-self. We would also like to measure presence and self-identification over successive immersive experiences. In addition, further investigation on possible constructs that could link both self-presence and self-identification are warranted.

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Appendix A

If something happened to the avatar, it was happening to me.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

The avatar's body was my own body.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

I was in the avatar's body.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

The avatar was an extension of me.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

The avatar was me.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

I felt like I was really inside the virtual lab.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

To what extent did you feel that…

I felt surrounded by the virtual lab.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

8. I felt like I really visited the virtual lab.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

The virtual lab seemed like the real world.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

I felt like I could reach out and touch the balloons in the virtual lab.

______Not at all

______Slightly

______Moderately

______Strongly

______Very Strongly

Please state whether you are right handed, left handed or ambidextrous.

____

Please write the number of days per week that you participate in each of the following activities. If you do not participate in a given activity, leave the space blank.

___ICA sport

___athletic club

___intermural sports

___recreational sports

___other activity that requires hand-eye coordination such as billiards or darts (describe below)

____

Please list the number of hours per week that you participate in each of the following athletic activities. If you do not participate in a given activity, leave the space blank.

___Badminton

___Baseball

___Basketball

___Cross-country

___Fencing

___Field Hockey

___Football

___Golf

___Gymnastics

___Juggling

___Lacrosse

___Martial Arts

___Rowing

___Rugby

___Sailing

___Soccer

___Softball

___Squash

___Swimming

___Synchronized Swimming

___Tennis

___Track and Field

___Ultimate Frisbee

___Volleyball

___Water Polo

___Wrestling

Please list any other athletic activities you participate in that were not listed above.

____

____

____

____

____

When you raised your right arm over your head in real life, what part of your body would move in virtual reality?

constrain options

How high would it go?

constrain options

If you have any other comments on your virtual reality experience, please list them below. All of your comments are valuable to the lab.

____

What do you think was the purpose of this study?

____

Thank you!