# The Immersive VR Self: Performance, Embodiment and Presence in Immersive Virtual Reality Environments

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***Abstract***

Virtual avatars are a common way to present oneself in online social interactions. From cartoonish emoticons to hyper-realistic humanoids, these online representations help us portray a certain image to our respective audiences. Immersive VR systems like the Oculus Rift and HTC Vive track a user's physical body movement in real-time and utilize this data to drive the corresponding behavior of an avatar. What is then special about avatars in immersive environments and how does this difference play out in the relationship between a user's physical and virtual sense of presence? In this paper, we summarize academic research in this field, study the conditions that construct self-presentation in immersive VR, coin the term "immersive VR self" and detail its unique characteristics.

## Intro

It was about 10:30am when I got a message from Will saying: "What are you up to this lunch break? Let's go check out the new Oculus demo." An hour later I was inside a dark demo room donning a Rift headset and holding a pair of Touch controllers. A few seconds later I was in ToyBox, a social VR experience that facilitates 1:1 interactions in immersive VR. I saw an avatar in front of me waving hello and then I heard the voice coming from the avatar's mouth. The first few words were: "Hi Raz, how cool is this?!". It was Will. I looked down and saw a graphic representation of my hands that matched my physical hand movement. I moved my hands around and watched how accurately the avatar's hands moved. I waved hello back and gave Will a thumbs-up. "Yes, this is pretty neat." Will then reached out to a virtual ping-pong racket and handed it over to me. Soon

enough we were playing ping-pong in VR. And although Will was in a completely different location, I felt like we were there together in that ToyBox room.

Both Will's and my avatars were rudimentary but even with these low fidelity graphic bodies, our avatars facilitated a representation of self that was fundamentally different than other online avatars. The combination of high sense of body ownership with sense of presence (Slater 2009) resulted in this inquiry into the unique characteristics that construct the "Immersive VR Self" and the contribution that it has to the sense of "being there."

With the development of technology and the rising spread of VR headsets, we see a growing offering of immersive VR applications that facilitate social interactions. Applications ranging from multi-player games (such as Star Trek: Bridge Crew and Lone Echo) to live broadcast events (Bill Nye the Science Guy on AltSpace and live sports on NextVR) and general chat rooms such as Oculus Rooms and Facebook Spaces utilize VR avatars as a foundational part of the experience. In each of these applications a user is either assigned with a platform avatar (an avatar they created beforehand and that can be used across applications) or are presented with an app-level avatar editor option that allows them to customize their appearance.

Avatars in immersive VR environments are different. Prior to immersive VR systems such as non-immersive virtual worlds, the control of avatars generally used indirect input devices such a mouse and keyboard and thus did not reflect an immersed user's body actions. With immersive VR systems, the body movement it emits are immediately translated into a VR environment with the goal to mimic and create identical online patterns of physical actions.

The goal of this work is to provide a conceptual framing of this unique construct of an on online self. We detail the differences between immersive and non-immersive VR environments, survey existing related academic work that touches upon the presentation of self in online networks as well as experiments that examined the body illusion that is facilitated by immersive VR systems. Finally, we coin the term "Immersive VR Self", define its special characteristics and its relation to the larger concept of presence.

## Background

Social virtual reality environments are not a new concept. Since the early 80s and the pioneering but now primitive text-based MUD (Multi-user Dungeons) systems, researchers have studied and developed technologies to support remote social interaction in online virtual worlds (Ito 1997; Ren, Kraut, and Kiesler 2007; Slater and Sanchez-Vives 2016). The rise of the internet and 3D graphics technology contributed to the popularization of rich online virtual communities attracting millions of users such as Second Life and World of Warcraft. In Second Life people used their desktop computer to log into a networked platform hosting a vast user-created virtual world, complete with its own currency and tools for evolving that world. In this environment, users are able to create an avatar based on their likings and to start a digital life there while meeting people, buying and selling goods and exploring new places.

Until recently, this non-immersive mode of interfacing with virtual worlds has been the norm. Over the last few years, however, immersive VR systems that bring the user into the virtual environment with a wide-field-of-view stereoscopic and perspective-correct rendering have started to gather traction among the general public. Companies such as Facebook, Oculus, HTC, Sony, and Google are launching consumer products that aim to make immersive VR experiences more approachable and affordable.

Over the years, tech professionals, researchers and fans of the field heavily promoted the gospel of “Being There” that is facilitated by this technology (Slater, Usoh, and Steed 1994; Barfield et al. 1995; Rheingold 1991). For starts, immersive VR system require the user to wear a tracked headset that constructs the sense of presence. Just like a magic trick, when a person puts on the headset, both their visual and audio senses are being manipulated by this technology. This manipulation can create an experience that might teleport them to a different location such as a different country or provide stimuli to make them feel like they are in a different situation with other people or creatures (i.e. having a T-Rex running towards you while you are visiting a Natural History Museum in London).

***Immersive vs. Non-Immersive VR environments***

How are immersive VR systems, such as the Oculus Rift, different to non-immersive desktop-based VR? The fundamental difference is in the way this technology tracks a user's body movement and how its displays drive our perceptual senses. Immersive VR presents perspective-correct, wide field-of-view and stereoscopic imagery, which, together with spatialized audio, more closely mimics the natural and egocentric visual and aural sensory stimuli through which humans perceive the physical world. It does this by tracking the user's body movement, including hand movement, in real-time. Hence, natural sensorimotor actions can be performed to explore, move around and experience the virtual environment. Non-immersive VR systems do not directly track body motion, and so must rely on indirect interfaces, such as keyboard and mouse, to capture user input. Additionally, the displays do not surround the user and so they can only present a narrow viewport into the virtual environment.

From the visual aspect, to navigate in a non-immersive VE such as Second Life, the user sits in front of a standard computer screen and use a mouse or keyboard to look around. In addition to the narrow viewport, the common view in Second Life and other virtual worlds is not from the eyes of the user but rather from the avatar's proximity that includes a bigger area of the environment (although some virtual worlds allow a first-person view, these are generally not the default). As stated above, an immersive VR system provides rich three-dimensional imagery, head-tracked wide field-of-view, and controllers that mimic hand gestures.

In immersive VR audio feedback is spatialized based on the user's head position in relation to the virtual audio source. For example, going back to the T-Rex scenario, when the dinosaur is far away the sounds of its roar and breathing is much quieter than when it looms over me. Spatialized audio also exists in non-immersive VEs but the combination of spatialized audio, head tracking and immersive visual display is what makes the audio stimuli feel convincing and real.

Finally, head and hand gestures in immersive VR are driven directly from tracked body movement. Unlike non-immersive VR, the real-time tracked movement of users is

mapped directly onto their virtual avatar. In this way, as a user nods their head or waves, their avatar replicates the same movement with a direct mapping.

In summary, the combination of head tracking to drive the egocentric, stereoscopic and wide field-of-view into the VE, gesture-based input, and spatialized audio presents an experience that differentiates immersive VR from non-immersive. Immersive VR can result in the perceptual sensation of *presence*, which is best defined as a user's psychological response to patterns of sensory stimuli, resulting in the user having the impression of "being there", in a computer-generated space (Slater, Usoh, and Steed 1994).

### *Studying the Self in Immersive VR*

Existing research into the presentation of self in immersive VR has mostly looked at the technological and interaction based questions involving the design and behavior of avatars. However, it is hard to think about self-presentation in immersive VR without understating the broader landscape of scientific inquiry into the presentation of the self-online.

Today it is almost a cliché to cite Goffman's pivotal work into understanding the presentation of self in every daily life (Goffman 1959). Unsurprisingly, Goffman's concepts of frontstage and backstage during the performance of self in social interactions as serving the need to control impressions can also be applied to immersive VR where people engage in online interactions using their avatars (Schroeder 2002).

Academic investigation into the presentation of self and the role of avatars in online virtual works has been going on for decades now. From early works that looked at the construction and reconstruction of identity and the options to have multiple identities (Turkle 1994), to studies into gender bending and how and why people customize their avatar in multi-player online games (Ducheneaut et al. 2009; Yee et al. 2011).

Experiencing the self in a virtual environment can happen either by having technology that recreates our actual bodies from the physical world or by artificially constructing them (Biocca 1997; Mantovani 1995). In either way, no matter if a user has set their avatar to look like their physical self or an imagined, completely different, alter-self, the self-identification with their VR representation plays a major part in the feeling of an existence of a virtual self and embodiment (Lee 2004).

As defined previously, embodiment relates to a combination of sensations that appears in conjunction with being in, having, and controlling a virtual body (Kilteni, Groten, and Slater 2012). The academic investigation into this idea have been going on for several decades now and it is primarily trying to understand what are the conditions that construct sense of embodiment and what are the different ways these conditions come together.

More specifically, studying embodiment in social interactions in VR, researchers suggested the idea of Transformed Social Interaction (TSI) which defines three dimensions that can differ online representation of the self from a physical representation: self-representation, sensory abilities and situational context (Bailenson et al. 2008). For example, researchers had participants use different colored bodies (black and white) to test issues such as racial bias (Banakou, Hanumanthu, and Slater 2016). In this work, an experiment was designed to examine if the perceptual illusion of body ownership reduced implicit bias. The results of this research show that implicit bias decreased after going through the experiment and particularly more for white participants in the black body.

In another project, researchers conducted experiments that showed the existence of a "Proteus Effect" which describes how a person's behavior aligns with their avatar design (Yee and Bailenson 2007). This research found that when participants were assigned with attractive and tall avatars they behaved in a different way. More specifically, the research ran two experiments, the first study assigned attractive avatars to participants and as a result showed people engaged in more intimate conversations as well as closer distance than people who used less attractive avatars. In the second study, people who were given a taller avatar were more confident in negotiations than people with shorter avatars. A

follow up study looked at the priming effects of avatars and found that the look of the avatars primed their thoughts and ideas (Peña, Hancock, and Merola 2009).

Another seminal work in the field of body ownership in immersive VR reproduced the rubber hand illusion and showed that peoples' perception of their virtual body as their physical body is feasible (Slater et al. 2008, 2009). Using a series of experiments that included projecting a virtual arm, using a data glove and a brain computer interface (BCI), the results suggested that virtual limbs and bodies in virtual reality can have a strong sense of ownership.

The tail end of this research recap describes a project about virtual tails on avatars (Steptoe, Steed, and Slater 2013). In this experiment participants had an avatar that was enhanced by a tail that moved around. One group of participants had a tail that moved randomly and the other group could potentially learn how to control the tail using their hip movement. The researchers found that people that were in the group that could control the tail had a higher level of body ownership and responded to threats to their virtual tail more strongly than those whose tail moved randomly.

**Discussion**

As we can see, the above-mentioned research in immersive VR focused on how people perceive and view their own avatar as well as the derivative effects of the avatars on their own physical behavior. This past research exemplifies how many concepts from the physical world translate directly to immersive VR environments. Ideas around performance, sense of self, embodiment play out in a similar manner and results in perceptions and actions that construct the notion of presence.

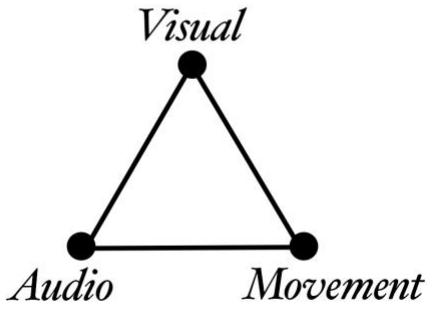
In this paper however we would like to look at more nuanced part of the idea of presence. This is the construct of the self in immersive VR systems and what are its unique characteristics. As Slater clearly articulates, presence is constructed by Place Illusion (PI) and Plausibility Illusion (PSI) (Slater 2009). Place Illusion creates the sensation of being in a real place while plausibility illusion creates the belief that the situation people are

experiencing is actually occurring. More specifically, Slater sees the body as "a focal point where PI and Psi are fused." Meaning, looking down and seeing the graphic representation of your hands or body makes you feel like you are there (PI). But the fact this virtual body also moves and responds in a certain logical way supports the plausibility illusion.

At this point, we would like to consider not only the actual presence and movement of the body as part of the factors that contribute to presence but also the sense of self that is created in that situation. Just like previous characteristic of online presentation of self, the immersive VR self carries the same traits but also incorporates three additional factors that distinguishes itself from previous online presentation of self:

- **Visual**: perspective-correct visual representation
- **Audio**: spatialized sounds
- **Movement**: physical body gestures

These three elements contribute to the enhanced sense of self that is enacted in immersive virtual environments. It can be described by the following diagram:




It is important to note that this diagram describes the perception of avatars in immersive VR from the spectator point of view. Meaning, these factors come into play when we see another avatar in front of us (or our own avatar in a mirror). When these three dimensions work as whole in an immersive VR environment they construct what we perceive as a representation of a person. In other words, this diagram depicts the observable signals

that construct the Immersive VR Self, each part is connected and affected by the others to create the presentation of oneself.

**Visual**: First, the visual depiction of the self. The fact that immersive VR provides a 3D and spatial view of the environment operates both on the perception of my body as well as other's people presence. In several immersive VR systems, when a user looks down they see a representation of their own body and hands. When looking at other avatars, their body occupies a volumetric space just like in the physical world. This visual representation of my personal body as well as others is the first part of the triangle. This part is affected by the two other parts, the body moves based on the physical gestures of people and in some cases the mouth animation based on the user's talk.

**Audio**: The audio is another crucial part of the presentation of self in immersive VR. The voice channel that feeds into the avatars is a live audio stream of the person's live talk. In this way, the person's voice is enacted by the avatar. This provides users the option to hear the voice of the person behind the avatar and their nonverbal utterances. This part is affected by the visual presentation as the audio is spatialized, if the visual and movement presentation is of an avatar that is far away or avatar that looks to the right or left, the audio will be heard correspondingly to be far or coming from one of the sides accordingly.

**Movement**: The final part of the diagram includes movement and gestures; movement data is being translated from the person's physical actions. For example, if a person is waving hello with their hand or pointing towards a direction with their finger, their avatar creates a similar action in the VR environment.

Sense of self is achieved when these three factors work in tandem. The Immersive VR Self therefore portrays these unique characteristics that combine visual, audio and movement signals from the physical world to construct an embodied representation in an online environment. A level of self-presentation can still be achieved with only one or two of these but the more signals the avatar can perform, the higher is the sense of presence and of self.

As we show in this paper, physical observable signals that are in turn translated into graphic signals in the VR environment create a unique representation of the self that is different from other online examples. Avatars in immersive VR environments are mimicking physical signals in a fidelity that did not exist before. Unlike previous venues of online social interaction, it is harder to fake or the behavior of the avatar in immersive VR. In many cases the movement of the head as well as other body gestures react naturally to various stimuli and these reactions are reflected instantly online.

If we go back to the definition of presence (Slater 2009), we argue that the Immersive VR Self is part of the illusion that supports the sense of being there. Together with the body, place and plausibility of the scenario, the person's performance and perception of the sense of self constructs the experience of the immersive VR environment. Until now, the majority of past academic research efforts gave little attention to theory of self-presentation and how it manifests itself in immersive VR. Our paper suggests that, when studying "Presence", in addition to looking at the technical perspectives of place, actions and body, we must take into consideration the performance and perception of the self.

**Conclusion**

In this work, we examine the presentation of self in immersive VR environments. First, we describe the difference between an immersive and non-immersive system and then survey academic research that studies different perspectives of embodiment and sense of presence in immersive VR. Finally, we propose the notion of the "Immersive VR Self" and identify the three factors that make it a unique construct of online self-presentation.

Future work in this field should extend the investigation of this presentation of self. For example, the role of the fluidity of the settings in which we experience the avatars is interesting topic to understand. In this way, being the same avatar in different contexts might replicate similar notion of context collapse we already saw appear in online social networks (Hogan 2010).

As we are in early stages of main stream VR systems, in the next few years we will see a growing adoption and use of these headsets and as a result, increasing venues in which

the Immersive VR self will perform. Studying and understanding the sociological forces that drive embodiment and sense of self in VR can help researchers further examine behavioral and group interaction dynamics as well as inform developers and practitioners design immersive VR environments that play to the strengths of this form of embodiment.

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