The Meat of the Matter: Social Touch and Body Ownership in Virtual Reality

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Abstract
In this position paper we argue that experience of body ownership (EBO) is essential to social touch interactions as well as to the experience of others’ virtual bodies in virtual reality. In addition, we argue that social touch, made possible by haptic technology, may be a way to induce EBO. We begin by discussing EBO from a cognitive science perspective and we provide examples of body ownership illusions in actual and virtual reality.

Author Keywords
Experience of Body Ownership; Virtual Reality; Haptics; Social Touch.

Introduction
In the short story They’re made out of meat by science fiction author Terry Bisson a duo of unidentified extraterrestrial beings is baffled by the fact that the hominid creatures wandering around on planet Earth are in fact entirely made out of meat:

“Yes, thinking meat! Conscious meat! Loving meat. Dreaming meat. The meat is the whole deal! Are you beginning to get the picture or do I have to start all over?”

Meat, or rather, our physical bodies are at the centre of theories on embodied cognition. Prominent theories in cognitive science such as Predictive Coding (PC) [3] propose that it is the brain inferencing about likely causes of sensory signals from our physical body that produce (conscious) percepts, including those about our own bodies [13]. Having a body - our meat - is central to our conscious existence.

Yet what exactly we experience as ‘our body’ is malleable. Experiences of body ownership (EBO) of objects foreign to the physical body can be created. A well-known example is the rubber hand illusion (RHI) [2]. In the RHI a participant’s real hand is positioned out of sight and, instead, the participant views a rubber hand. An experimenter will synchronously stroke the real and rubber hand with a brush and after a few seconds the participant will start to experience the rubber hand as his or her real hand.

Variations on the RHI exist, for example, there is a version where a blindfolded participant touches the rubber hand while his/her actual hand is touched synchronously by an experimenter [4], or versions that involve sense of ownership of an artificial face [15] or an artificial tongue [11]. Theories such as PC are able to explain how the mismatch between the brain’s expectations and the actual bodily signals can result in body ownership illusions such as the RHI. What is of particular interest here is that EBO of non-body objects extends to virtual objects in Virtual Reality [14].

Ownership of a virtual body
While the RHI requires a physical rubber hand as the target of the illusion current technologies enable new ways in which a person’s body can be represented. In essence, technology allows us to inhabit ‘non-meat’ bodies that are highly manipulable. VR has shown to be a promising technology that makes it possible for a person to inhabit a virtual body. State-of-the-art VR headsets (e.g. HTC Vive and Oculus Rift) work by tracking a person’s head motion through accelerometers to determine the position of a person’s head in space.

Haptic (i.e. physical sensations on the skin or exerted on the muscles and joints) and proprioceptive (i.e. the sense of the position of the body in time and space) feedback have been found to be key in inducing EBO in VR. A number of studies has investigated variations of the RHI in VR. Congruent visuo-tactile stimulation of an observed virtual arm, for example, produces the sensation that the virtual arm is actually one’s own arm [14]. Similar effects have been found for stimulation of a person’s back to induce EBO of a virtual body [9]. Studies featuring more extreme manipulations of virtual bodies have shown interesting results. For example, the experience of having a sixth finger [6], elongated arms [8], or even a third arm [17].

Social bodies in VR
Findings of studies into EBO in VR show that VR enables EBO of virtual bodies of various types. Such virtual bodies, when they are used to engage in social interactions in VR, have been found to impact social cognition [10]. EBO of a virtual body with a dark skin color can reduce racial biases towards individuals with a dark skin color [12]. In another example EBO of a child’s body in VR can cause someone to identify more strongly with child-like personality attributes [1].

Social interactions in VR may play a role in therapy settings, for example during treatment of post traumatic stress disorder, or in training scenario’s where a person engages with a virtual character as a coach. Companies such as Facebook are interested in social applications of VR more generally...
and seem to envision a future where social media interactions occur in VR through virtual embodiments. In all of these cases EBO is important in providing convincing interactions and is most readily induced using haptic technology. A benefit of haptic technology embedded in a VR application is that it can be triggered automatically upon contact with virtual objects in the virtual world. Thus, theoretically, it would be possible to induce EBO ‘on-the-fly’ in real-time.

Typically, technology mediated social interactions focus on audio-visual communication but the inclusion of haptic technology in social VR also enables social touch interactions. Social touches, such as hugs and handshakes, occur less frequently in social encounters than, say, facial expressions, but when individuals do engage in social touch the effects of touch are often profound. Social touch has been found to be able to elicit pro-social behavior (i.e. the Midas touch effect), to be a preferred channel for intimate communication, and to have stress reducing effects (for a review see [5]). Recent research suggests that some of the effects of social touch carry over to situations where touches are mediated by haptic technology (for reviews see [7, 16]).

We argue that, due to endeavors in the creation of social VR applications combined with developments of haptic technology, social touch will occur in social interactions in VR. This implies the following:

1) For these social interactions to be compelling one has to have a sense of ownership of one’s own virtual body as well as experience the virtual body of others as actual bodies. In VR, if one does not experience the virtual body to which a social touch is applied as actually being one’s own body, there is little reason to assume that effects of social touch would carry over to situations in which social touches are mediated by haptic technology.

2) Conversely, if one does not experience the body of the virtual social entity, which may either be a virtual embodiment of another person (i.e. an avatar) or an embodied virtual agent, as an actual ‘other social body’ it is again unlikely that effects of social touch transfer. This latter situation can be extended from VR to augmented reality where one’s own body can interact with virtual objects or indeed virtual social entities.

3) Interestingly, the typical RHI is usually induced in a ‘social’ setting where stroking touches are applied by an experimenter. Therefore, in addition, we would be interested to see whether technology mediated social, rather than non-social (e.g. contact with a virtual object) touches can induce stronger EBO of a virtual body. It is not unthinkable that the social connotations of being touched by another person influences one’s experience of one’s own body.

To make social touch interactions in VR compelling and to support EBO of one’s virtual body as well as support the experience of other’s virtual bodies, haptic feedback in conjunction with congruent visual feedback is indispensable. We believe that to make progress in the study of social touch technology [7] investigating EBO is essential. Conversely, investigating EBO by also considering social cognition [10], and social touch interactions in particular, can provide a more complete view of embodiment. Only through these combined efforts can we get to the meat of the matter of our (future) virtual bodies.

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