

Immersive Virtual Reality, Telepresence and their cognitive foundations

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Immersive and Embodied Virtual Reality

Part 1

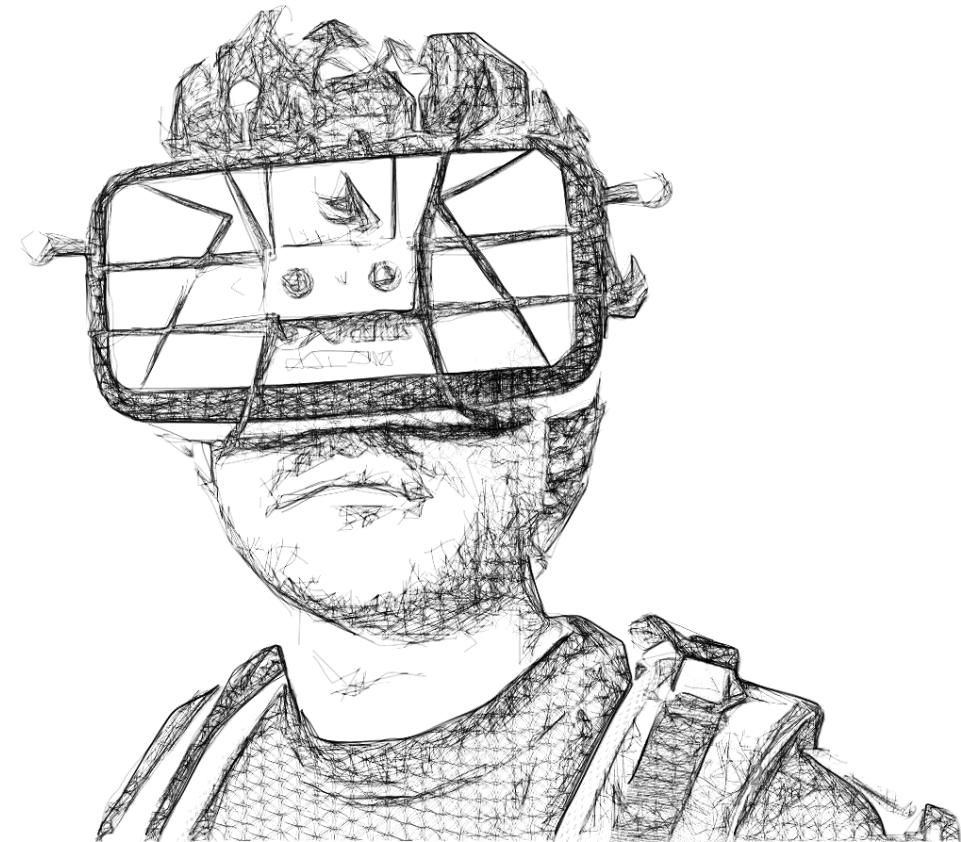
Immersive Virtual Reality

Telepresence and their cognitive foundations

Part 2

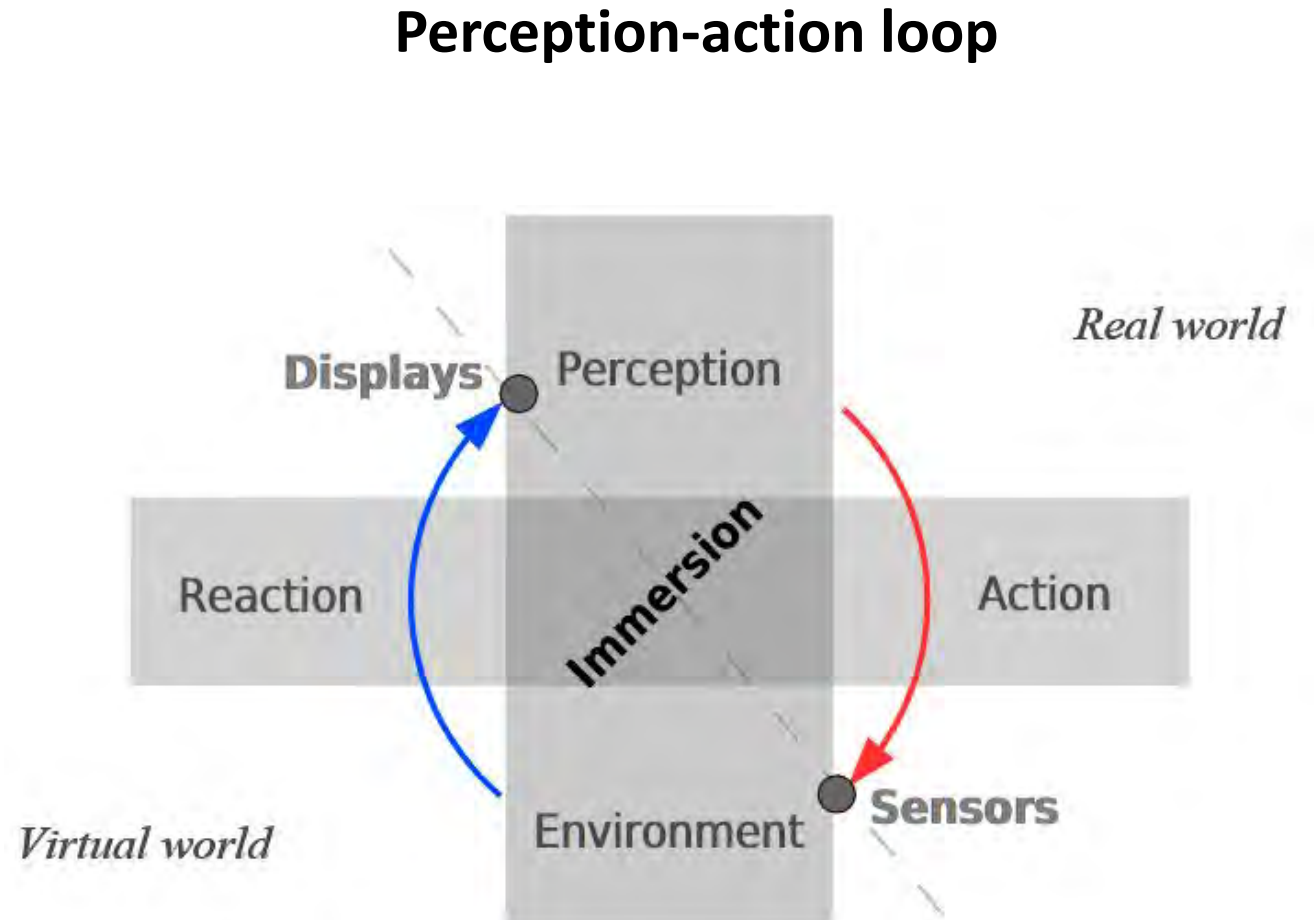
Embodied Virtual Reality

Limits and applications



Immersion

- Immersive systems properties
 - HMD field of view
 - Rendering resolution
 - etc.
- **Immersive virtual environment (IVE)**
(Slater & Usoh 1994)
- Support natural sensorimotor contingencies for perception & action
(Slater 2018)



Immersion

- Definition *

Immersion is a *quantifiable* aspects of a VR technology representing its ability to deliver a surrounding and convincing environment.

Synthesized from Slater (1995, 1999, 2003, 2018)

* Most widely accepted in the VR community

(Tele) Presence

- ‘Out of the body’

“What you don’t realize until you do it is that tele-presence is a form of **out-of-the-body** experience.”

Rheingold, H. (1991). *Virtual Reality: Exploring the Brave New Technologies*. Simon & Schuster Publishing Group.

- ‘Being there’

“**Second person** VR is an almost outrageous leap of faith, to transfer yourself into a world on the screen.”

Heeter, C. (1992) ‘Being There: The Subjective Experience of Presence’, *Presence* 1(2), pp. 262–271.

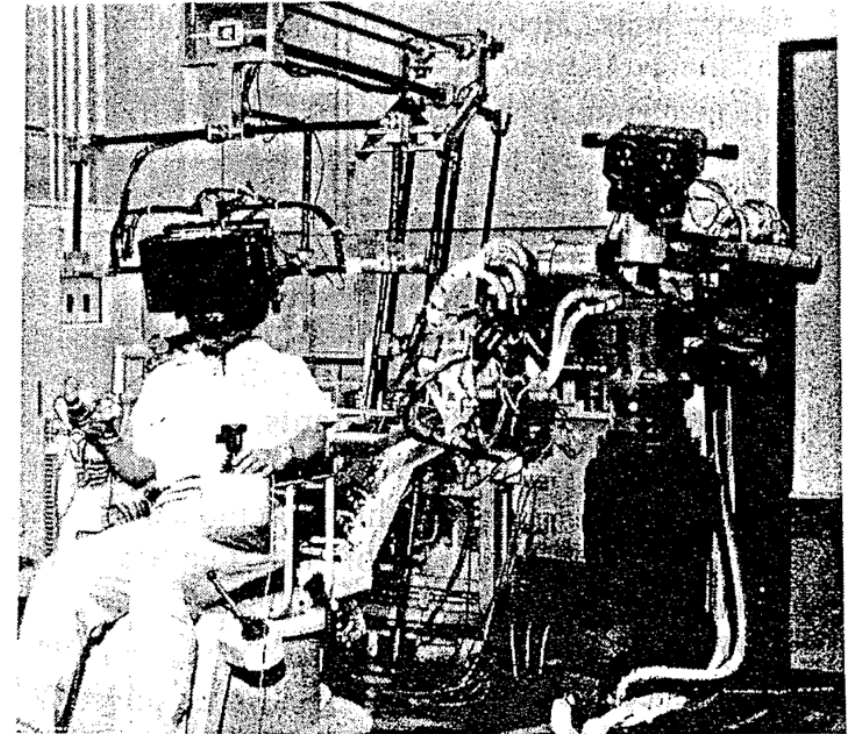


Fig.2 General view of the master system (left) and anthropomorphic slave robot (right).

Tachi S, Arai H. & Maeda T. (1990) Tele-existence Master Slave System for Remote Manipulation, IEEE Conference on Decision and Control (1) 85-90, USA.

Presence

- Definition *

Presence (place illusion) is the strong illusion of being in a place in spite of the sure knowledge that you are not there.

Slater, M. (2009) 'Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1535), pp. 3549–3557.

* Most widely accepted in the VR community

NASA Research (1980)



Sense8 Corp. (~1980)



Question of presence

SIGGRAPH (1992)



Comdex Spring (1992)



Clinical impact of Virtual Reality

Cognitive Behavioral Therapy



Rizzo & Wiederhold

- 2005 Virtual Iraq
- 2008 Virtual Afghanistan

Pain distraction



Hoffman et al., 1996, 2000, 2004, 2006

Virtual Reality Exposure Therapy of Social Phobia



PhD Thesis at VRLab (2005)





Symbolic exposure scenario



Ekman's gazes



Only subjects sensitive to the stimulus do experience the scenario as a social situation.

Liebowitz social anxiety scale

- G1: Non social phobic (N=5)
- G2: Social phobia tendency (N=5)

Groups show very different anxiety responses from exposure (subjective rating of stress and pulse)

- G1 : stable low stress, stable pulse
- G2 : high & increasing stress, increasing pulse

Herbelin et al., VSM 2002.

(tele) Presence

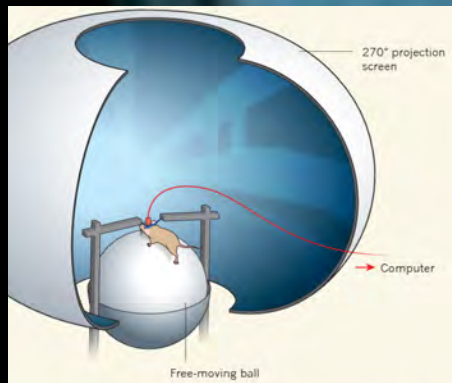
Sense of Presence

Where have you been ?



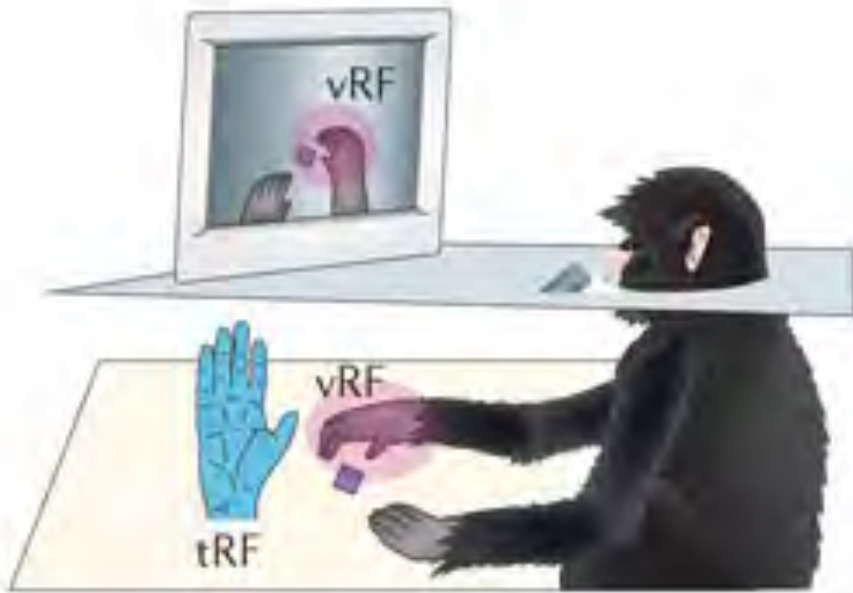
- Suspension of disbelief (Slater 93)
- Sense of “being there” (Barfield 95)
- Illusion of non-mediation (Lombard & Ditton 97)
- Proto, core and extended Presence levels (Riva & Waterworth, 2003)
- Place and Plausibility illusions (Slater 2009)

IMMERSION



PRESENCE

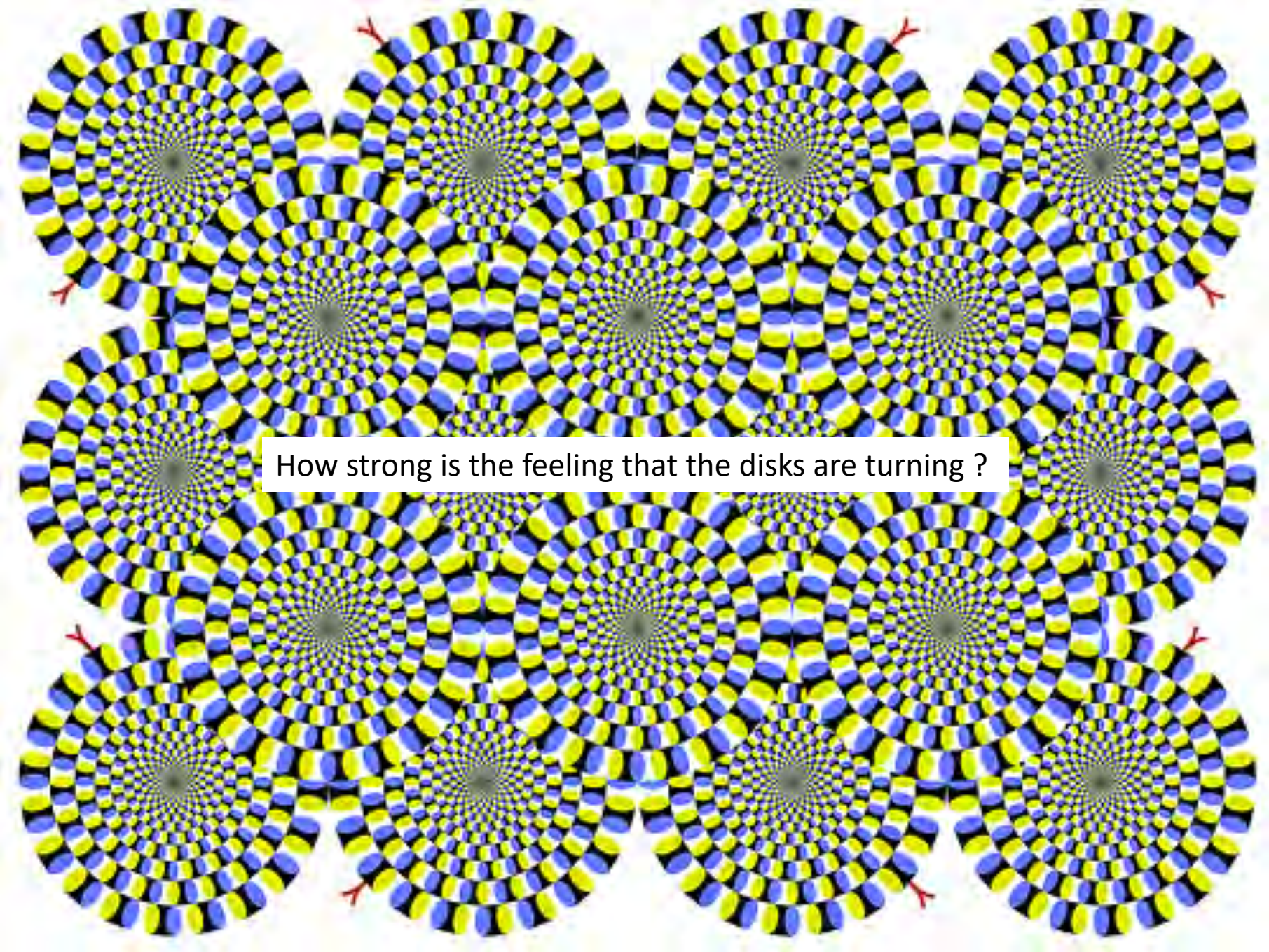
Virtual Reality !



“Evolutionary precursors for introspective manipulation of an abstract sign, or eventually a symbolic representation of the own body, might be already reserved as neural machinery in the monkey brain[...]

Iriki et al. (2001). *Self-images in the video monitor coded by monkey intraparietal neurons*





How strong is the feeling that the disks are turning ?

The congruency hypothesis



VR and illusions: multisensory integration

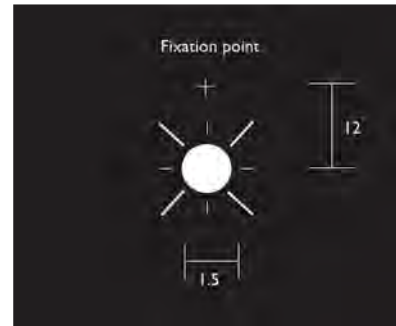
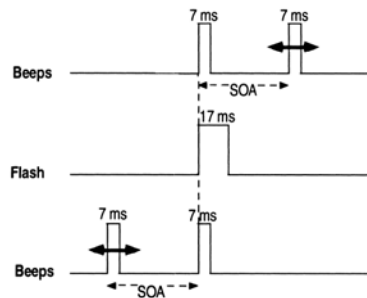
Mc Gurk effect

McGurk H. and MacDonald J. (1976).
Hearing lips and seeing voices,
Nature 264, 746-748 (1976).

<http://www.youtube.com/arnte>

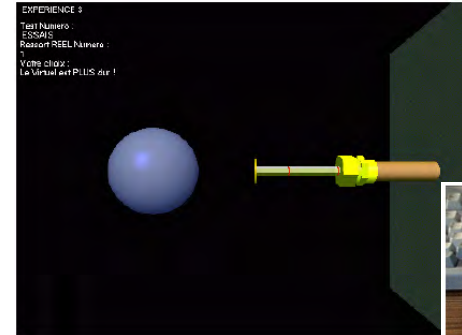


Sound induced flash illusion



Ladan Shamsa, Wei Ji Ma and Ulrik Beierholm. Sound-induced Flash illusion as an optimal percept, AUDITORY AND VESTIBULAR SYSTEMS, NEUROREPORT, Vol 16 No 17 28 November 2005, pp1923-1927.

Pseudo-haptic feedback



Lecuyer A., Coquillart S., Kheddar A., Richard P. and Coiffet P. (2000). Pseudo-Haptic Feedback : Can Isometric Input Devices Simulate Force Feedback?, VR '00: Proceedings of the IEEE Virtual Reality 2000 Conference, Washington, DC, USA.

Redirected Touch

Visual dominance over touch



The 'this is me' hypothesis



Disclosure (1994)

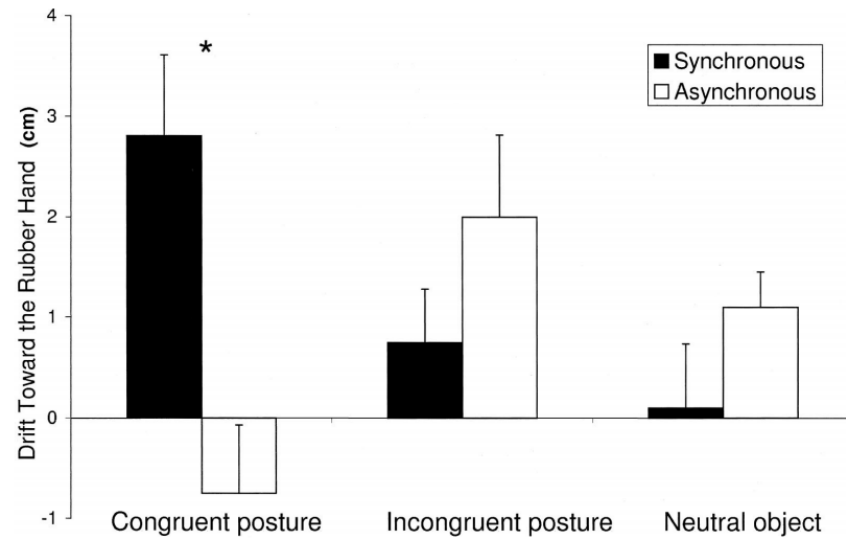


Rubber Hand Illusion

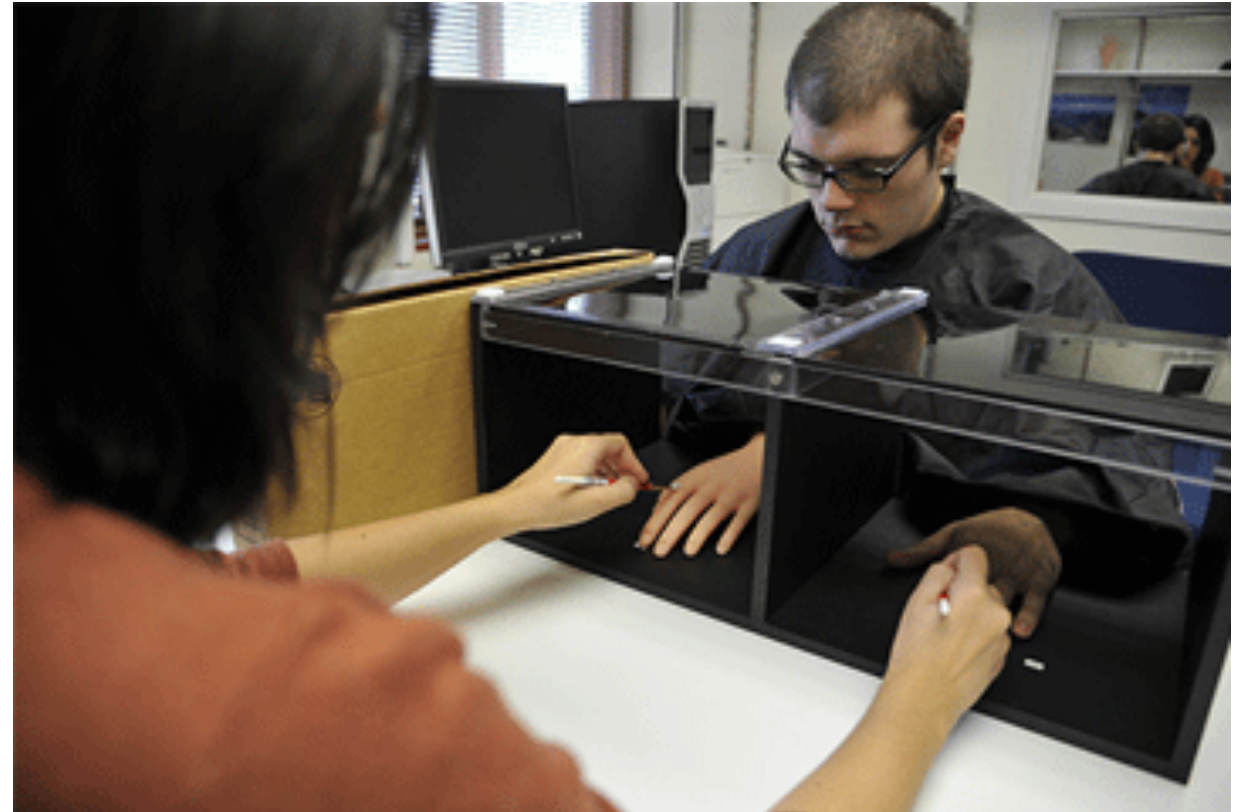
During bodily illusions like the “rubber hand illusion”, a fake body part is felt as the real one. This occurs after a few seconds of synchronous stroking of the hand; “if I feel touch on this hand, it must be mine!!”.



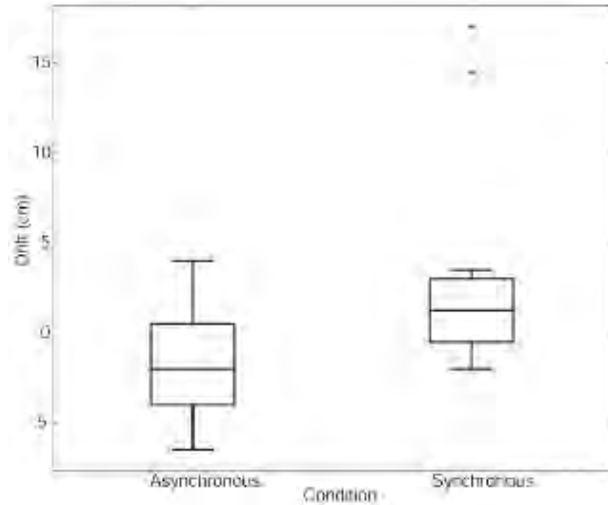
(Botvinick and Cohen, *Nature*, 1998)



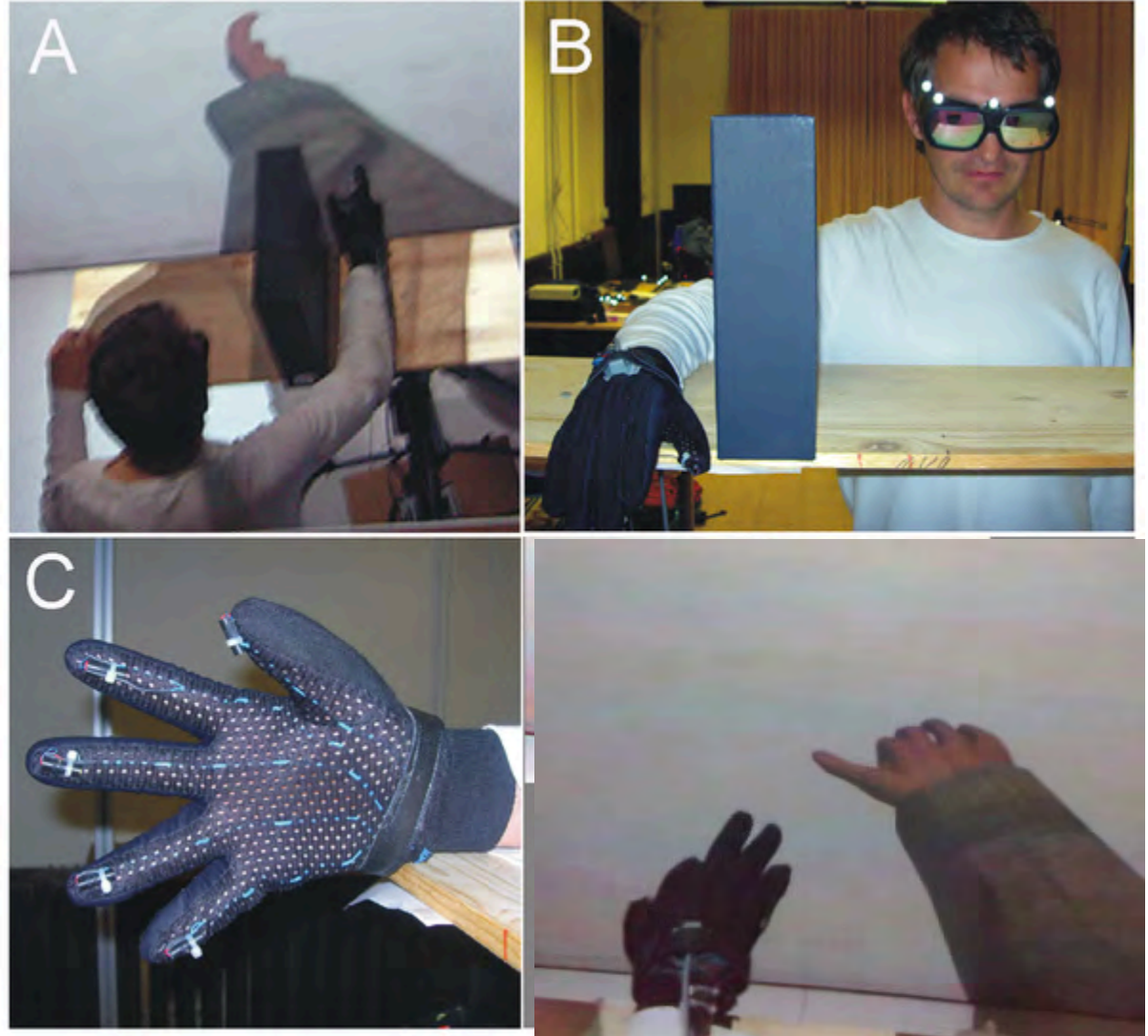
M Tsakiris, P Haggard - Journal of Experimental Psychology, 2005



Virtual Hand Illusion



Sanchez-Vives, Spanlang,
Frisoli, Bergamasco, Slater.
PloS one, 2010

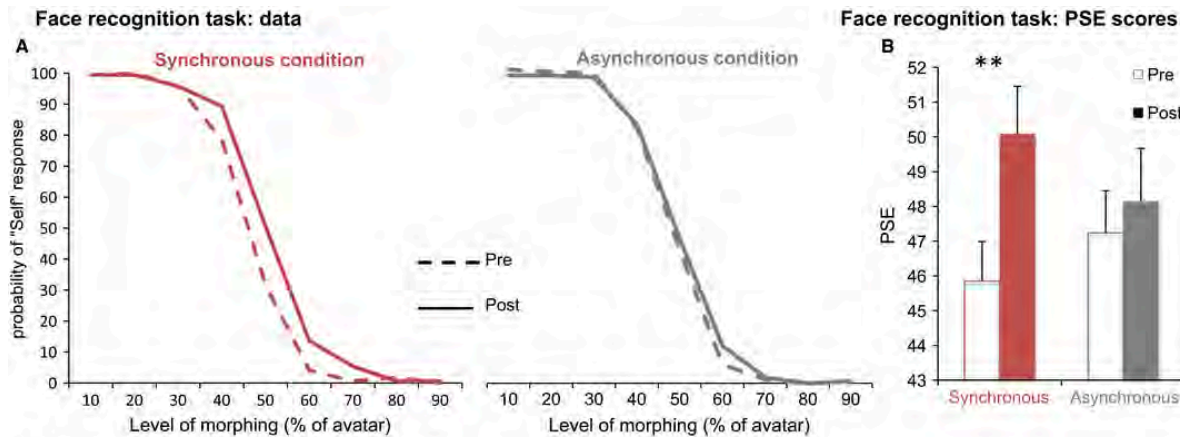
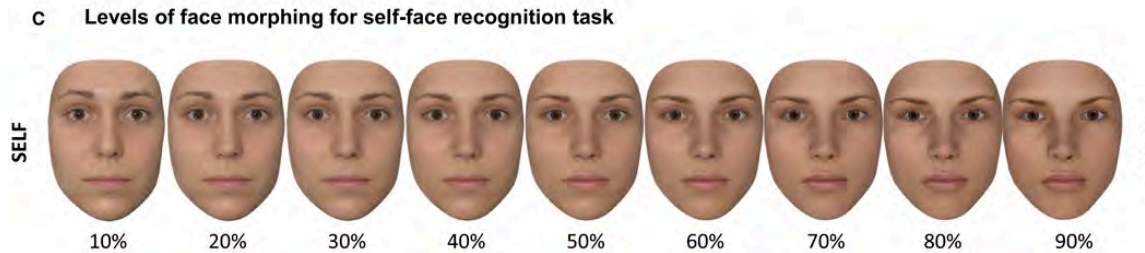
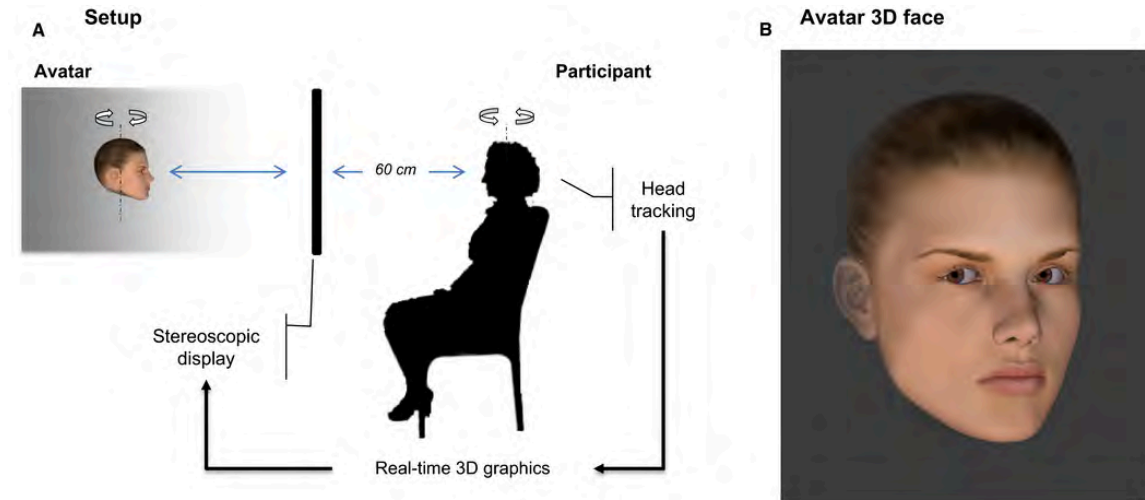


The Enfacement illusion: Virtual mirror causes erroneous self-recognition

Recognizing a face as one's own is considered a hallmark of self-awareness. But the self-face representation is not fixed, but constructed over time, depending on experience.

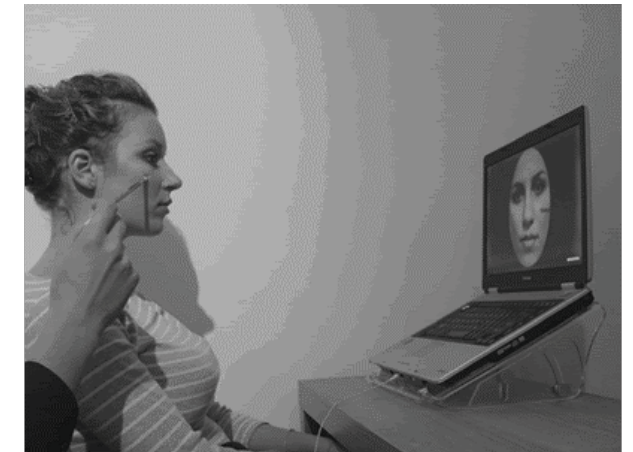
Serino, Sforza et al. J.Neuro, 2015.





The virtual mirror

EPFL-LNCO



Sforza AL, Bufalari I, Haggard P, Aglioti SM. (2009). My face in yours: visuo-tactile facial stimulation influences sense of identity. *Social Neuroscience*, 7: 1-15.

The 'I am here' hypothesis



TRON (1982)



Out of Body Experience

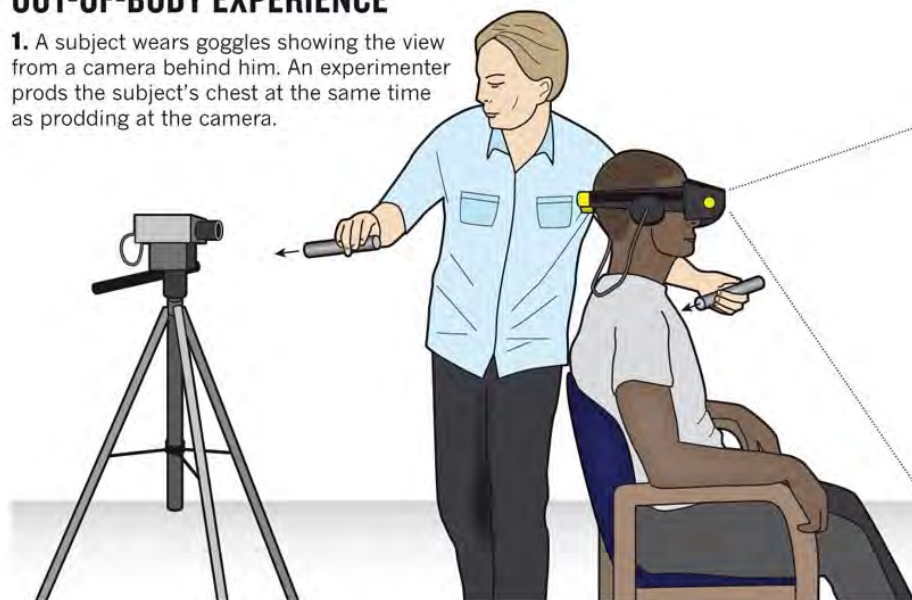
Conflicting visual-somatosensory input in virtual reality disrupts the spatial unity between the self and the body: participants feel as if a virtual body seen in front of them is their own and mis-localize themselves to a position outside their bodily borders.

Lenggenhager et al. Science, 2007.



OUT-OF-BODY EXPERIENCE

1. A subject wears goggles showing the view from a camera behind him. An experimenter prods the subject's chest at the same time as prodding at the camera.

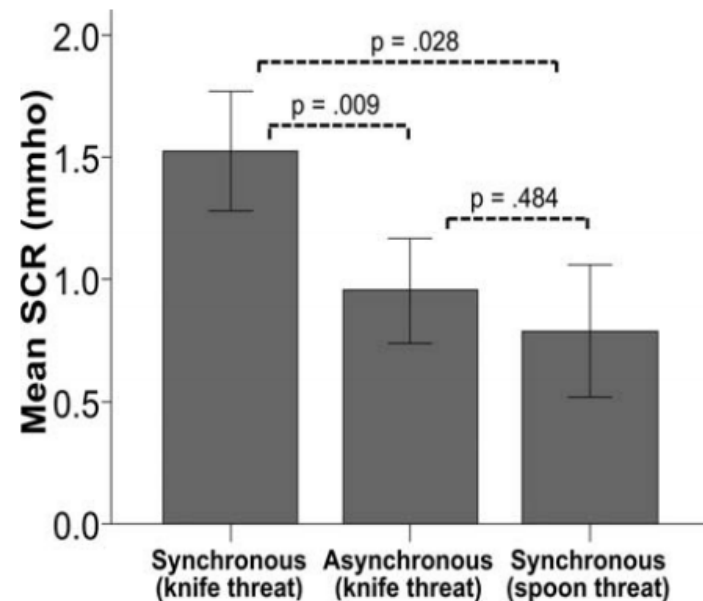


2. The subject sees the hand prodding towards the camera as he feels his chest being prodded. He also sees his body from behind. This creates a vivid sense that his real body is floating behind the one he sees.



Ehrsson. Science 2007.

The illusion is caused by the first-person visual perspective in combination with the correlated visual and tactile information from the body.



Petkova & Ehrsson.
PLOS One, 2008.



First-person experience of body transfert in VR

EXPERIMENTAL PROTOCOL for EEG RECORDING

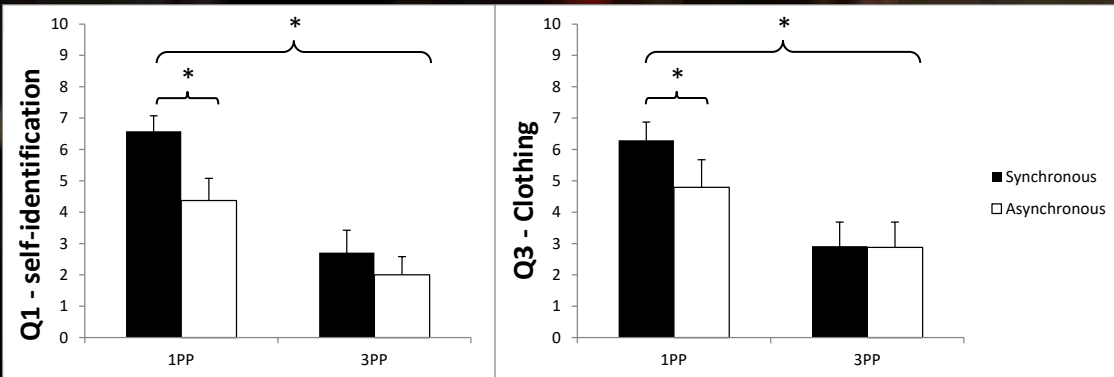


eventLab / Nov. 2010

External multisensory congruency determines my bodily presence

First person view defines where my self is in the world, and the complementary multisensory experience builds up the illusion of embodiment.

Slater, Spanlang, Sanchez-Vives & Blanke
First person experience of body transfer in virtual reality, PloS one, 2010.



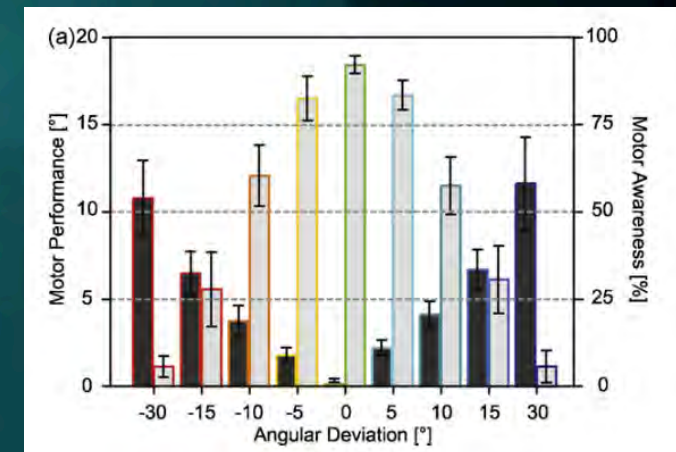
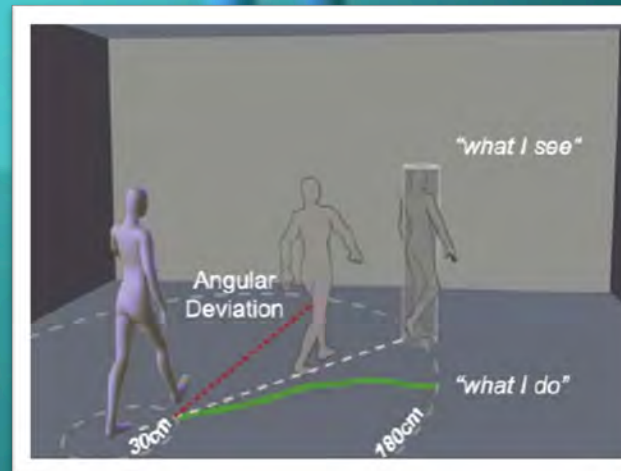


natgeotv.com

Limits of Agency


Providing full-body motion control over an avatar to subjects immersed in Virtual Reality gives them a strong sense of embodiment and of being the agent of their action. But the brain tolerates large visuo-motor discrepancies and automatically compensates.

Kannape & Blanke, J. Neurophysiologia, 2010.
Kannape & Blanke, Current Biology. 2017



Synthesis



- VR Immersion and (tele)Presence in VR
 - Complex cognitive mechanisms
 - Comparable to perceptual illusions
 - VR is used as experimental tool in cognitive neuroscience
- 
- Cognitive sciences informs VR on mental mechanisms behind telepresence



Immersion (physics of the system)	Illusion	Interpretation
Sensorimotor contingencies	Place Illusion	I am here
(i) Reponsive (ii) Personal (iii) Congruent	Plausibility	This is really happening
Bodily multisensory integration	Embodiment	This is my body

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If you are curious..

Neural Mechanisms of Bodily Self-Consciousness and the Experience of Presence in Virtual Reality. B. Herbelin; R. Salomon; A. Serino; O. Blanke (2016). De Gruyter, Human Computer Confluence, 80-96.

<https://infoscience.epfl.ch/record/220684>

Being There Together: Experiments on Presence in Virtual Environments (1990s) Mel Slater, Anthony Steed, Martin Usoh (2013). Technical Report, Department of Computer Science, University College London, UK.

<http://publicationslist.org/data/melslater/ref-233/beingthere%202013.pdf>