Course Virtual Reality

Immersive Virtual Reality, Telepresence and their cognitive foundations

Dr Bruno Herbelin

Laboratory of Cognitive Neuroscience
Center for Neuroprosthetics
Brain & Mind Institute
EPFL

VR_I

Gilles Jobin in collaboration with Artanim (2017)

http://www.vr-i.space/

Mains technological steps of VR

1960

1961 – Servo-controlled camera-based telepresence with **Head Mounted Displays**: Headsight, Philco Corp. Comeau & Bryan

1965 – **Augmented reality with 3D stereoscopic** rendering: Sword of Damocles, Sutherland.

1970

1970 – 6 DOF electromagnetic tracker: Polhemus AC system

1971 – 3D **realistic rendering**: Gouraud's shading algorithm.

1977 – 3D virtual Human: Rendez vous a Montreal, Thalmann

1977 – **Data glove**: AT&T Bell Labs, Defanti & Standi.

1980

1984 – Virtual environment workstation at NASA, McGreevy.

1990

1992 – **CAVE** : surround-screen, surround-sound, projection-based virtual reality (VR) system, Cruz-Neira, Sandin, DeDanti.

2000

Virtuality continuum

Real Environment

Virtual Environment

Google Glass

Microsoft Hololens

Oculus

Clinical impact of Virtual Reality

Cognitive Behavioral Therapy

Rizzo & Wiederhold

- 2005 Virtual Iraq
- 2008 Virtual Afganistan

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., VSMM 2002.

NASA Research (1980)

Sense8 Corp. (~1980)

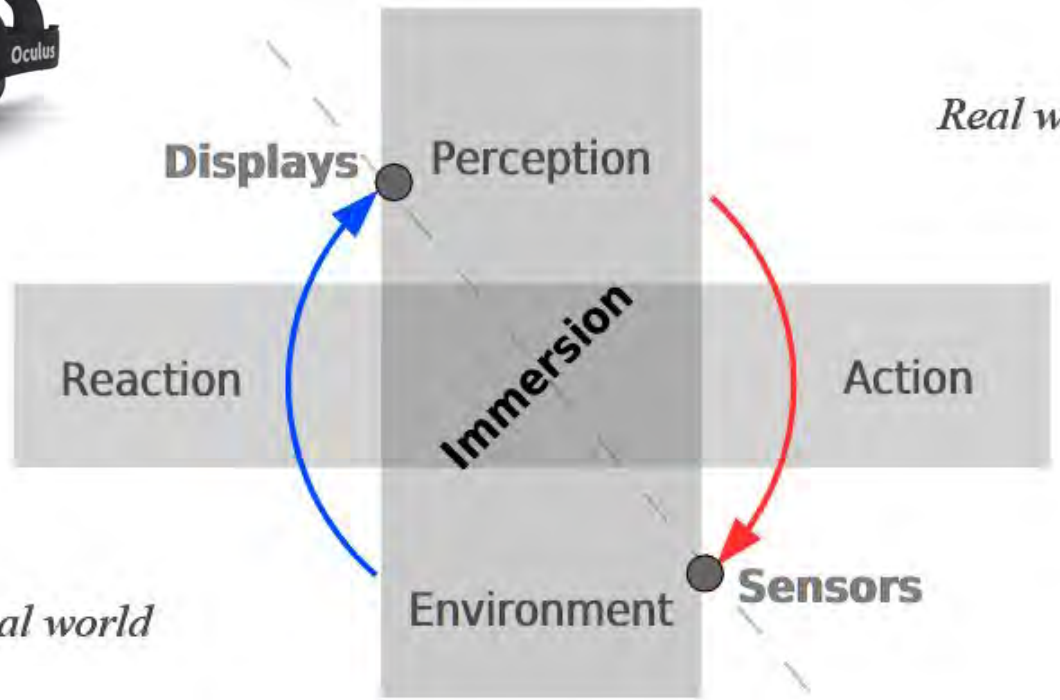
Question of presence

SIGGRAPH (1992)

Comdex Spring (1992)

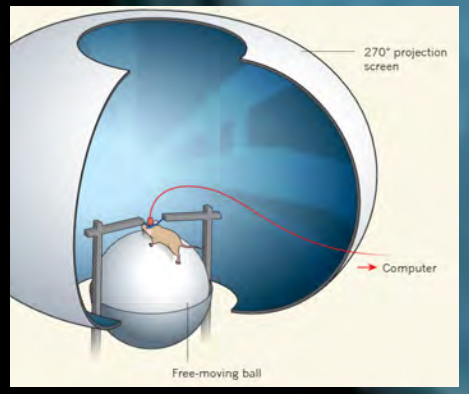
Immersion: Multisensory feedback loop

Head Mounted Display



Tracking devices

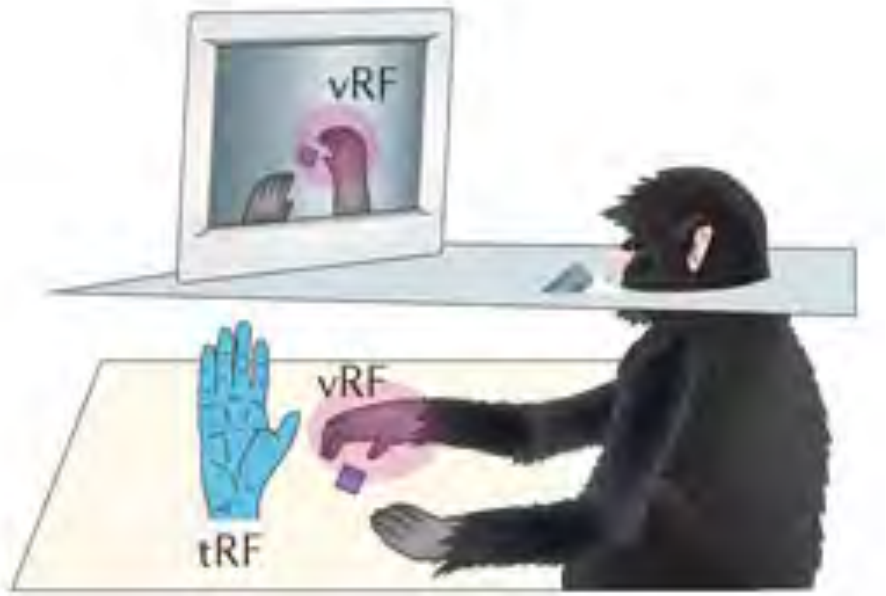
IMMERSION



PRESENCE

Erika Pastrana *Nature Methods* (2010)

Virtual Reality !



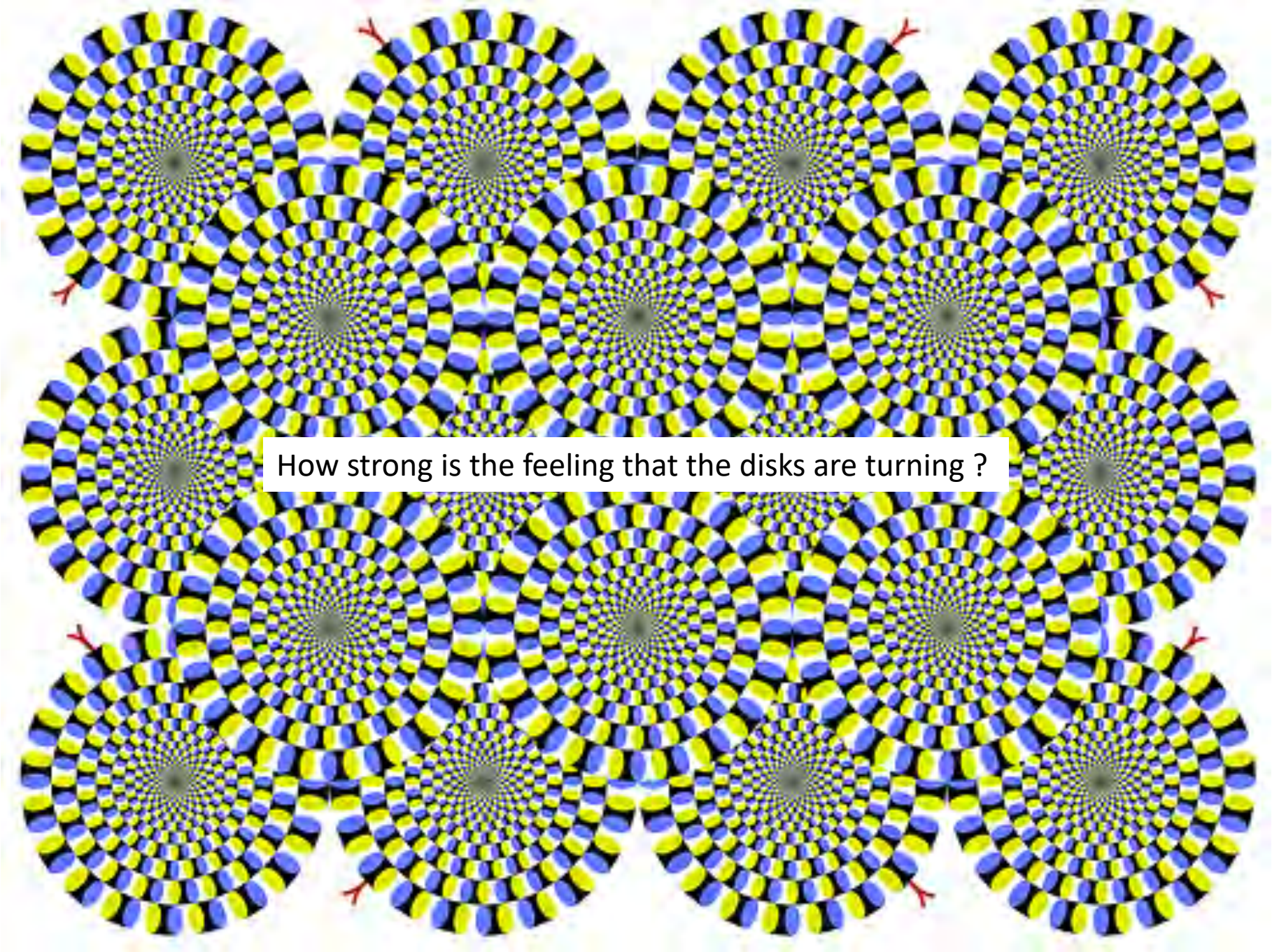
“Evolutionary precursors for introspective manipulation of an abstract sign, or eventually a symbolic representation of the own body, might be already reserved as neural machinery in the monkey brain[…]”
Iriki et al. (2001). *Self-images in the video monitor coded by monkey intraparietal neurons*

(tele) Presence
Sense of Presence

Where have you been ?

Suspension of disbelief

- 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)


How strong is the feeling that the disks are turning ?

The congruency hypothesis

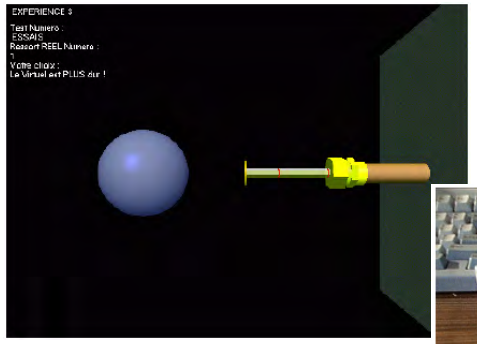
VR and illusions: multisensory integration

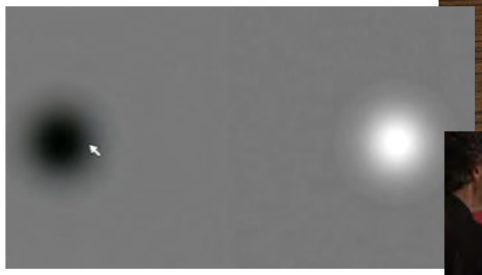
Mc Gurk effect

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

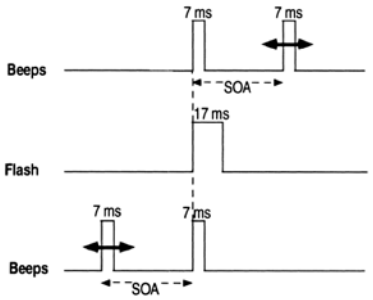
http://www.youtube.com/arnte

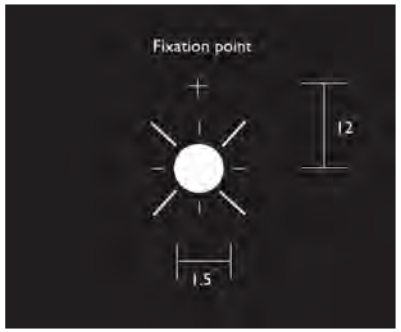
Pseudo-haptic feedback





Sound induced flash illusion





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

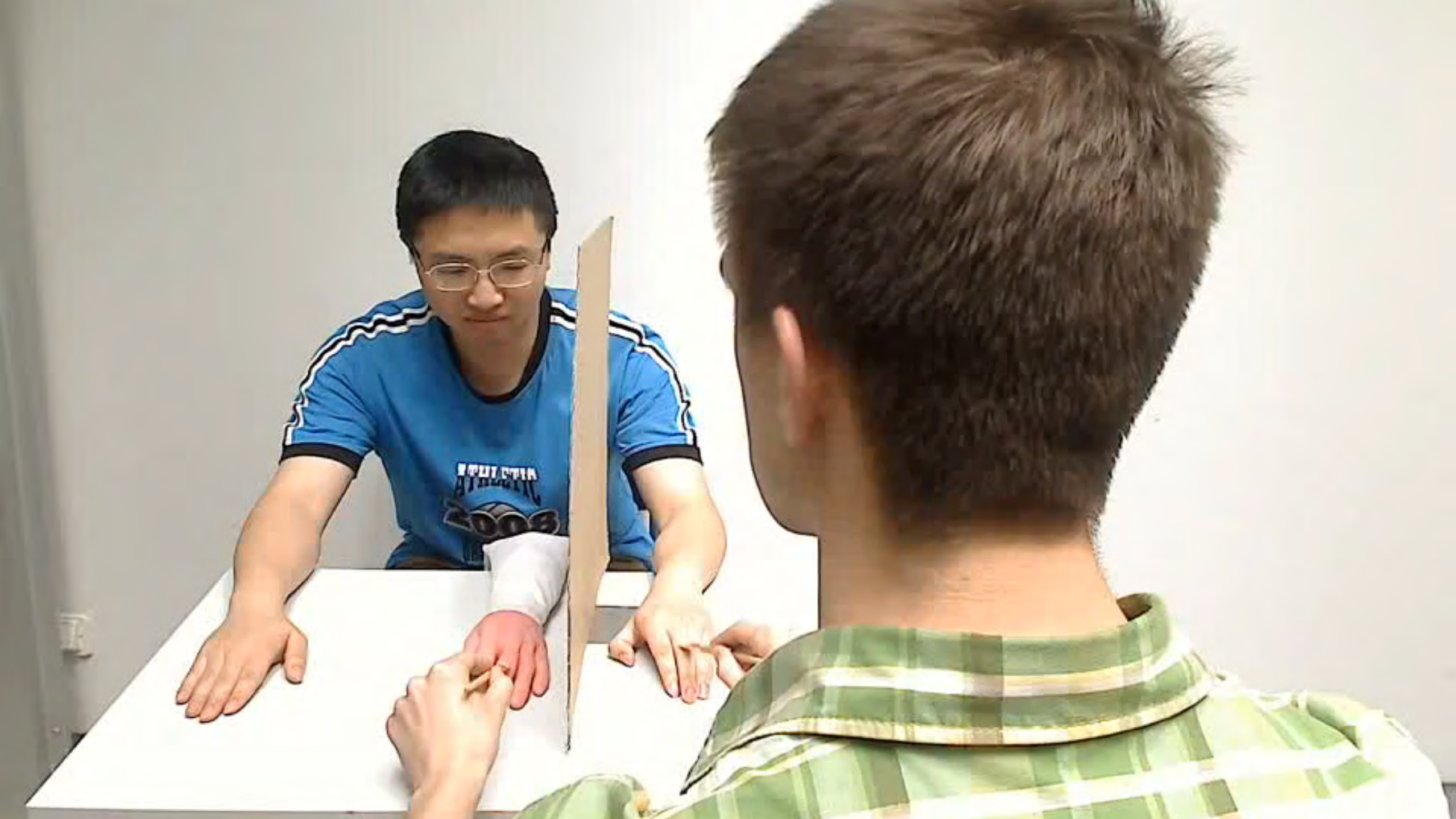
Lecuyer A., Coquillart S., Kheddar A., Richard P. and Coiffet P. (2000). Pseudo-Haptic Feedback : Can Isometric Input Devices Simulate Force Feedback?, VR '00: Proceedings of the IEEE Virtual Reality 2000 Conference, Washington, DC, USA.

Redirected Touch

Visual dominance over touch

The ‘this is me’ hypothesis

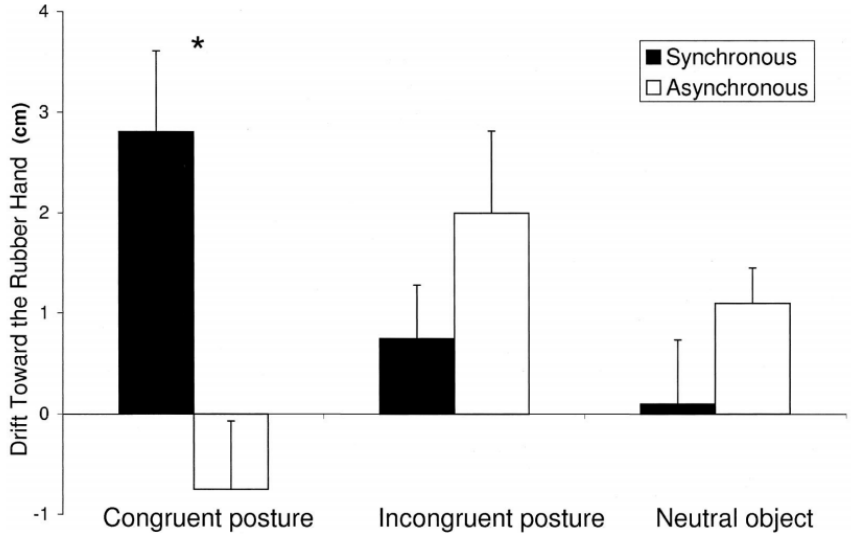
Disclosure (1994)



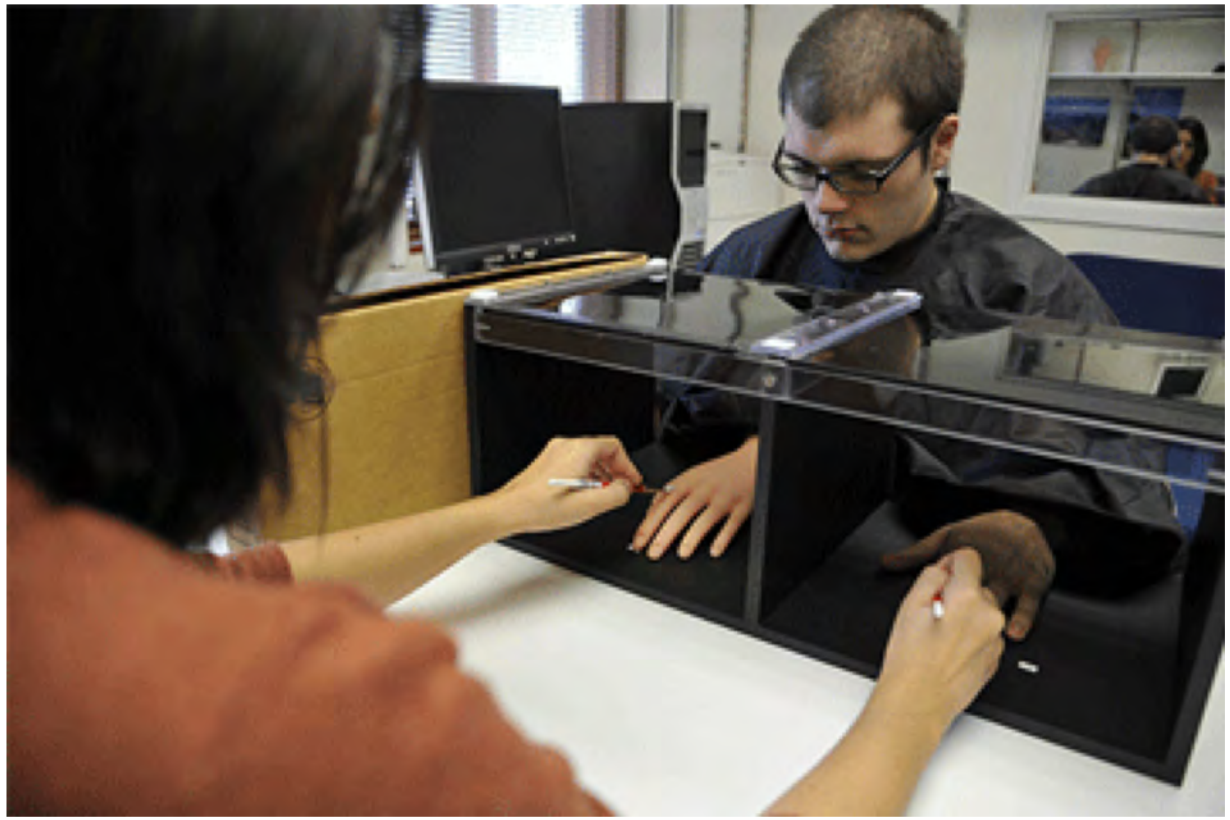
Rubber Hand Illusion

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!!”.

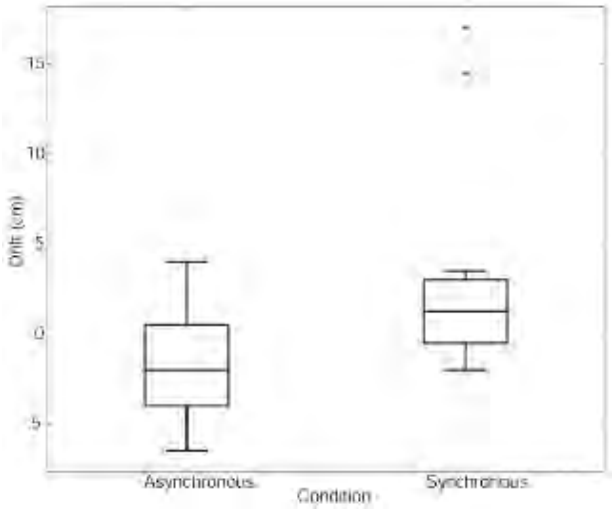
(Botvinick and Cohen, *Nature*, 1998)

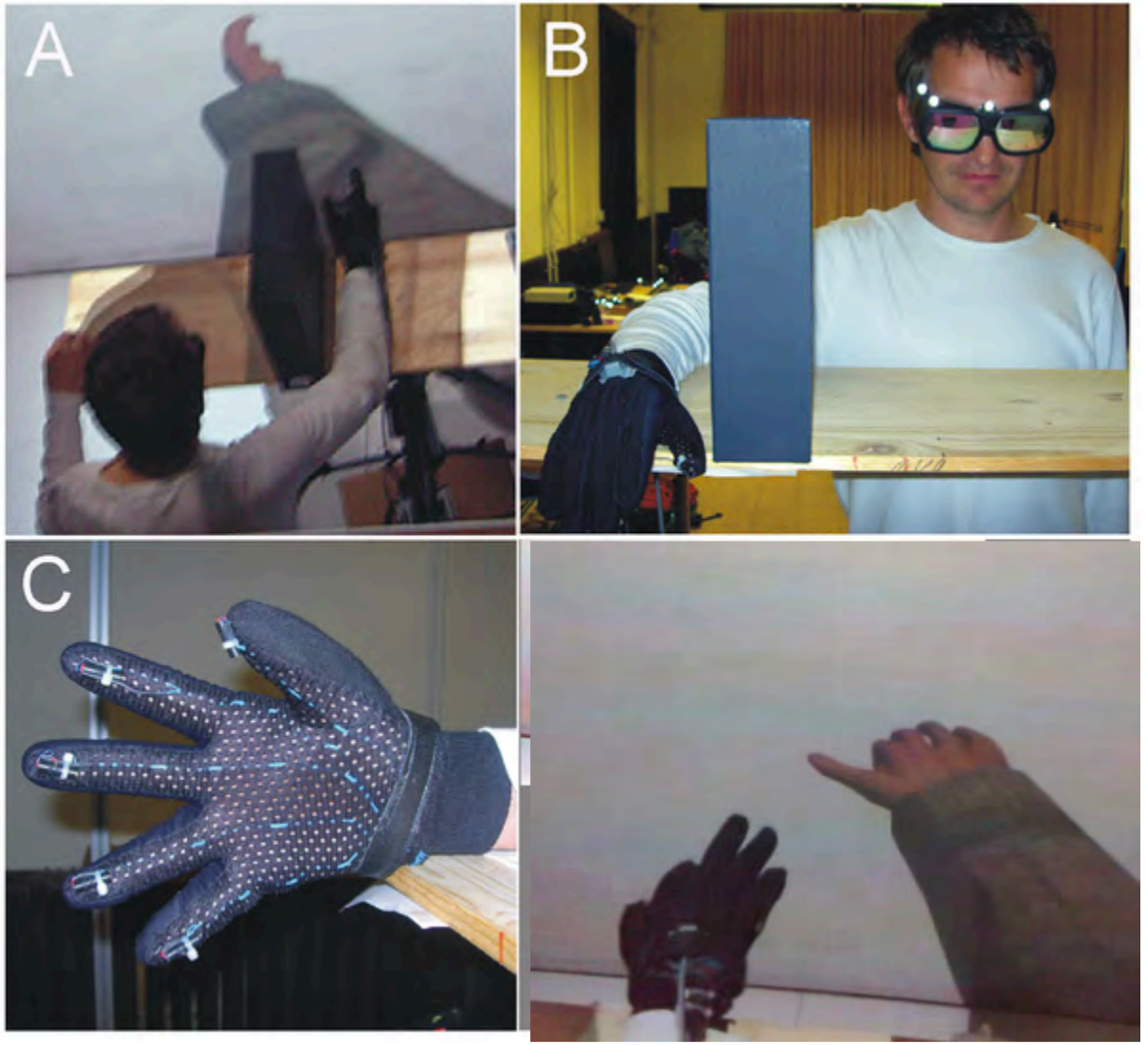


M Tsakiris, P Haggard - Journal of Experimental Psychology, 2005



Virtual Hand Illusion



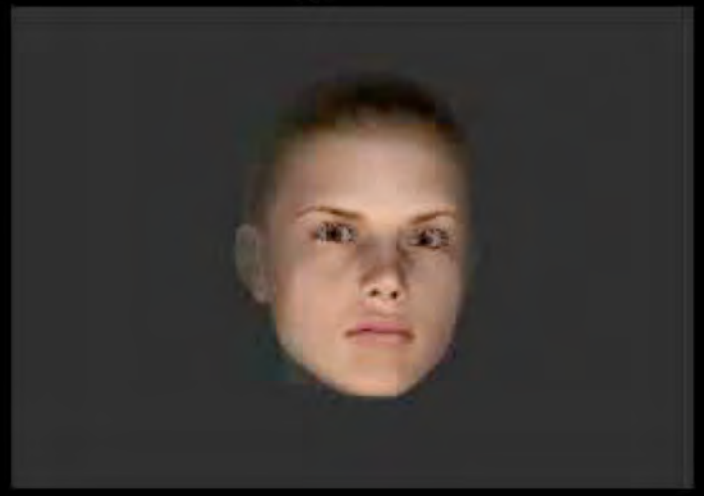


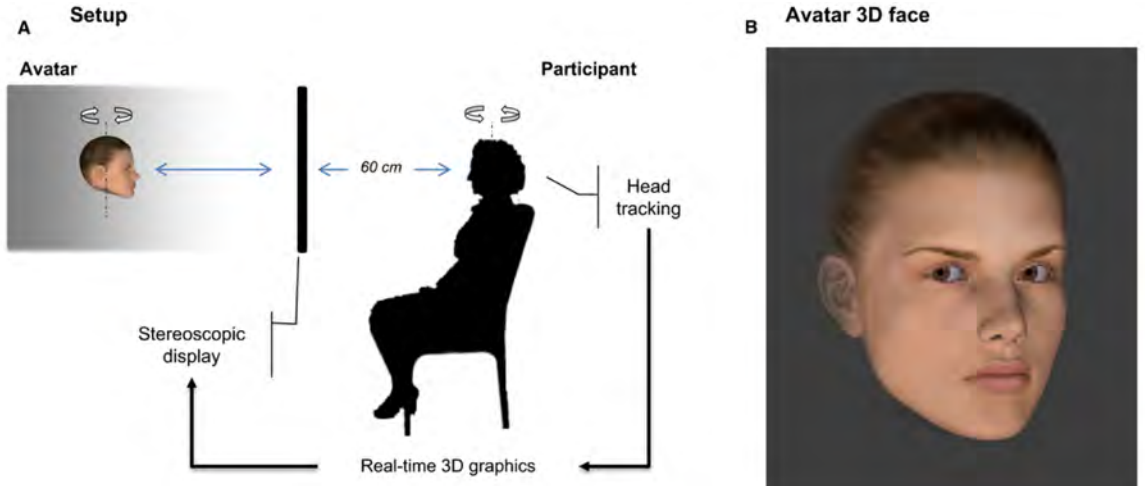
Sanchez-Vives, Spanlang, Frisoli, Bergamasco, Slater. PloS one, 2010

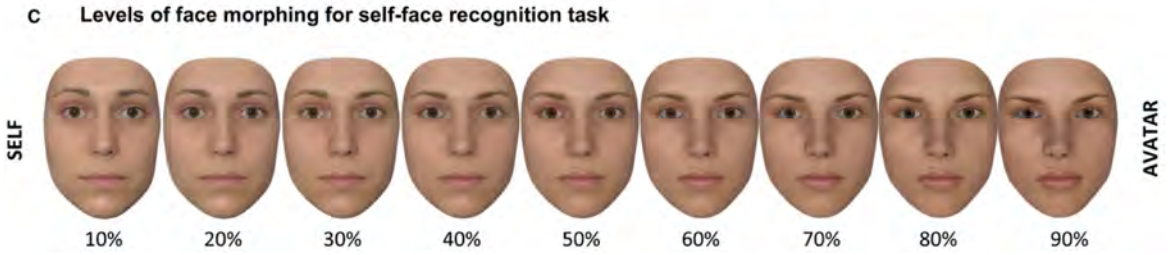
The Enfacement illusion: Virtual mirror causes erroneous self-recognition

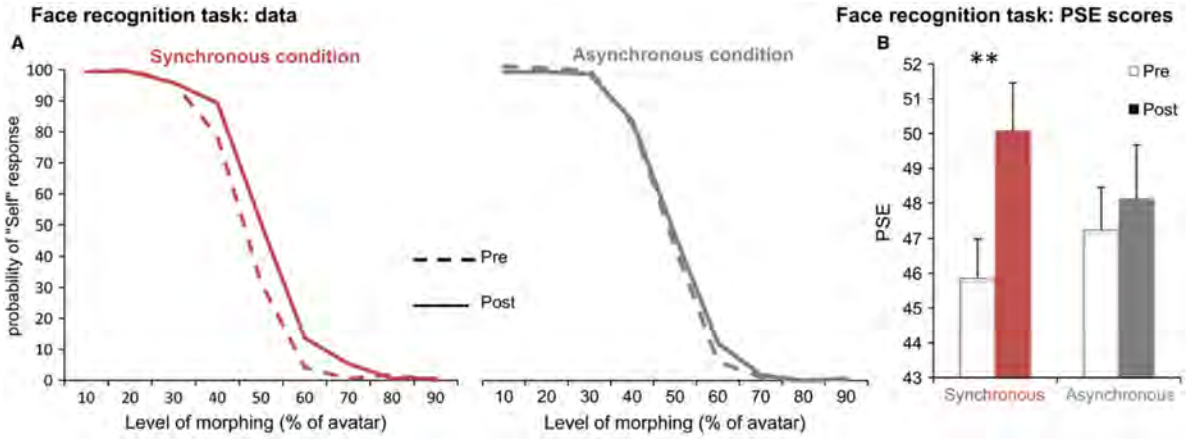
Recognizing a face as one's own is considered a hallmark of self-awareness. But the self-face representation is not fixed, but constructed over time, depending on experience.

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

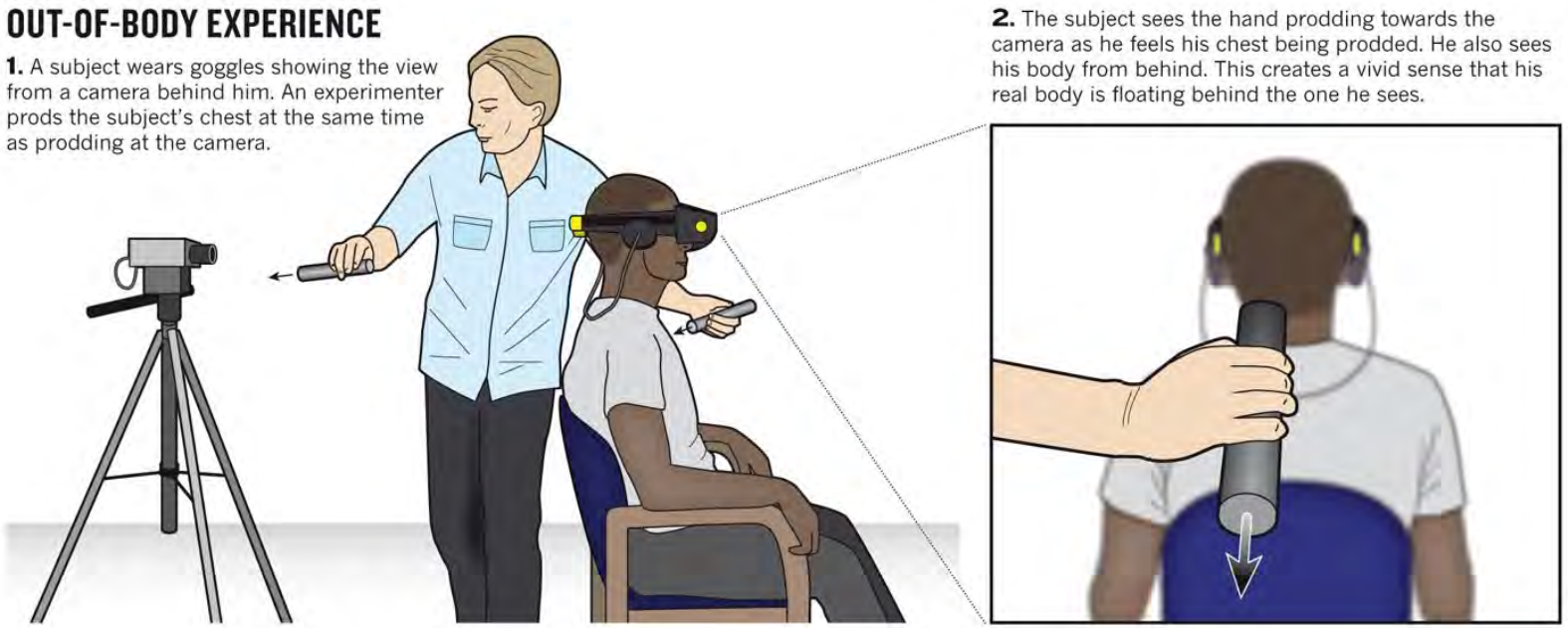
Conflicting visual-somatosensory input in virtual reality disrupts the spatial unity between the self and the body: participants feel as if a virtual body seen in front of them is their own and mis-localize themselves to a position outside their bodily borders.

Lenggenhager et al. Science, 2007.

Science

Blanke Lab - Video Ergo Sum 2007

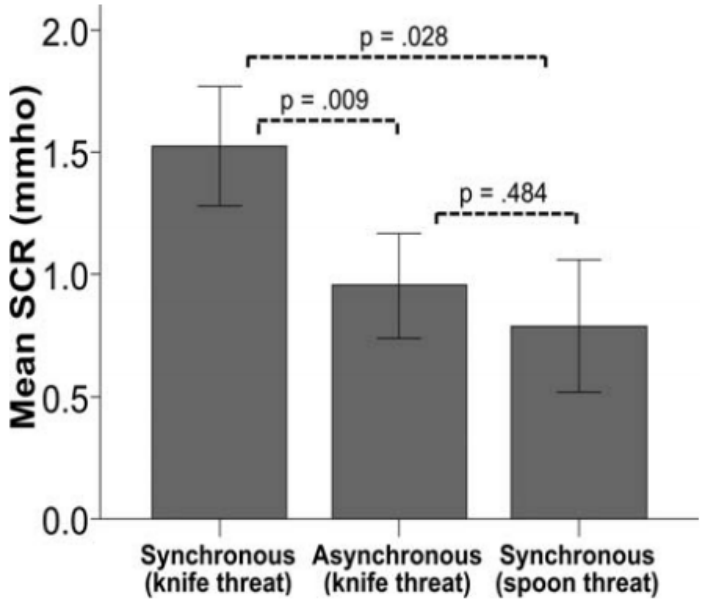
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE



Ehrsson. Science 2007.

Petkova & Ehrsson. PLoS One, 2008.

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



First-person experience of body transfert in VR

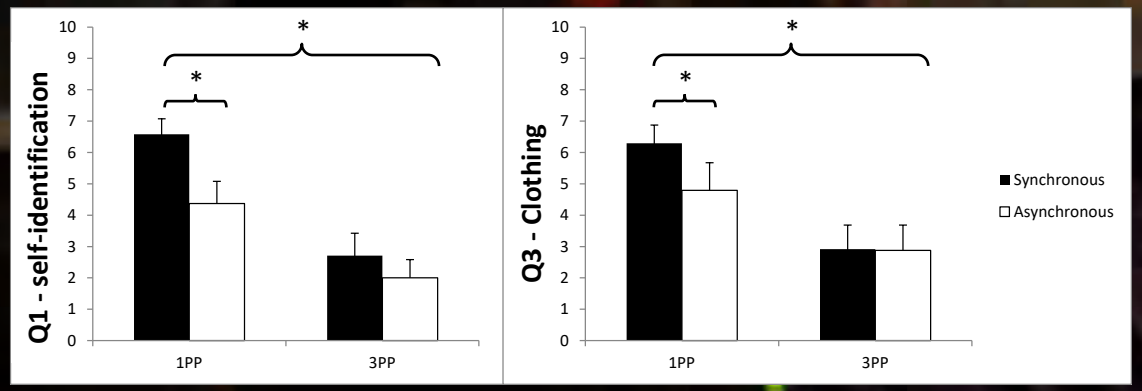
EXPERIMENTAL PROTOCOL for EEG RECORDING

ventLab / 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.**

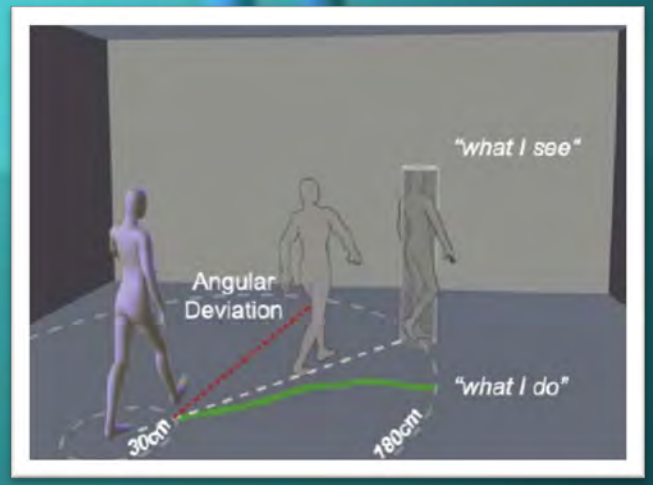


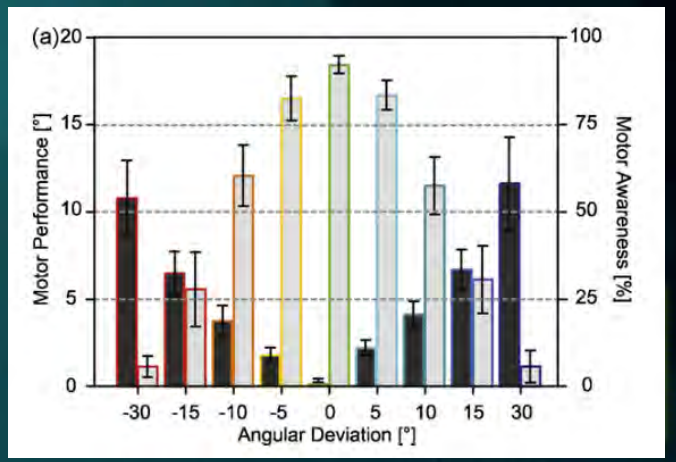

natgeotv.com

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

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). *Cognition*. 2016. Vol. 154. 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

Acknowledgements

Prof. Olaf Blanke
Laboratory of Cognitive Neuroscience
Olliver Kanappe
Maria Kaliujna

Dr Ronan Boulic
Immersive Interaction Group
Henrique Galvan Debarda
Thibault Porssut
Mathias Delahaye

Campus Biotech
Chemin des Mines 9
CH-1202 Genève
Switzerland