



Boulic - Virtual Reality  
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# Immersive Virtual Reality, Telepresence and their cognitive foundations

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# Immersive and Embodied Virtual Reality

Part 1

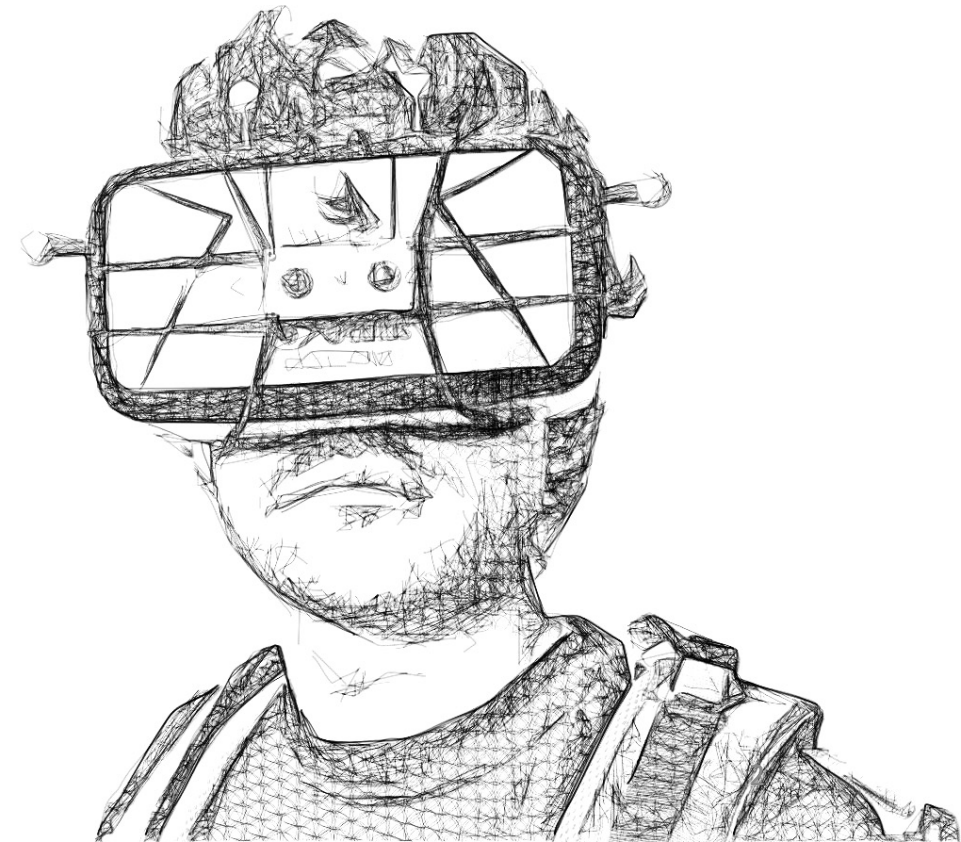
## **Immersive Virtual Reality**

Telepresence and their cognitive foundations

Part 2

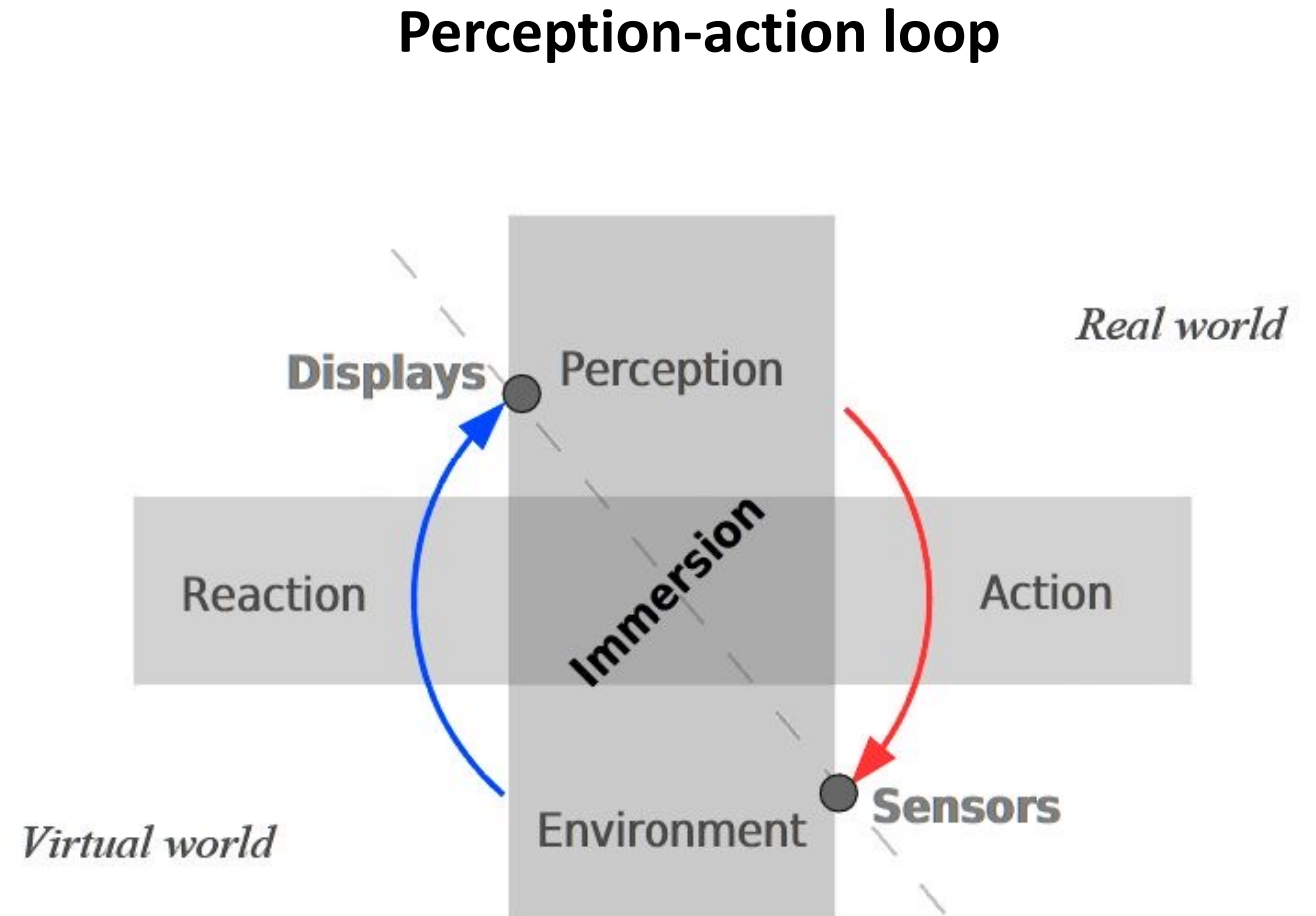
## **Embodied Virtual Reality**

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.

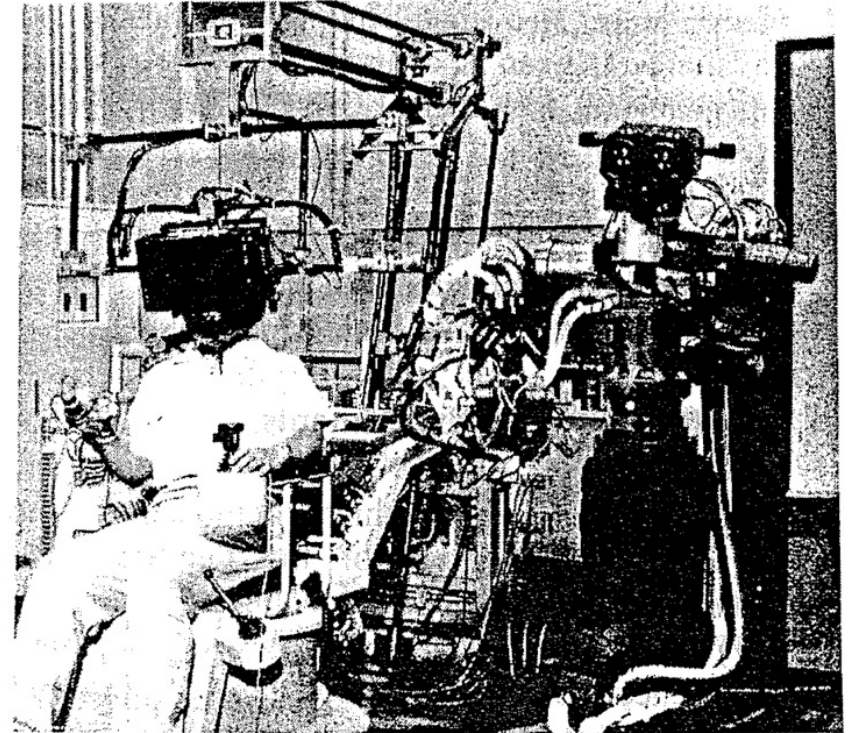


Fig.2 General view of the master system (left) and anthropomorphic slave robot (right).

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

**Presence (Place and Plausibility illusions) refers to how people respond to Immersion.**

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

Ask chat GPT...

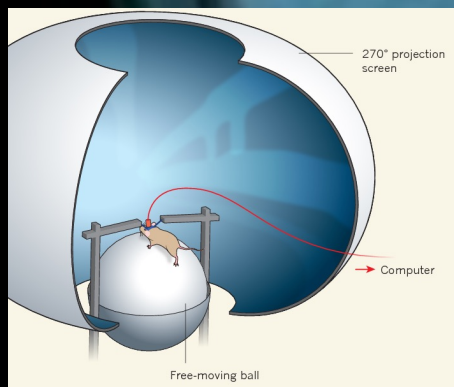


- Immersion in virtual reality refers to the degree to which a person is enveloped in, and surrounded by, a virtual environment.
- Presence refers to the sense of being physically present in a virtual environment, of feeling like the virtual world is real.
  - Place illusion is the illusion of being in a different place than one's physical body.
  - Plausibility illusion is the illusion that virtual objects and events are real or could be real.
  - Both PI and Psi contribute to creating a sense of presence

⇒ *Can be taken as an indication that these definitions are widely spread and accepted in the community*



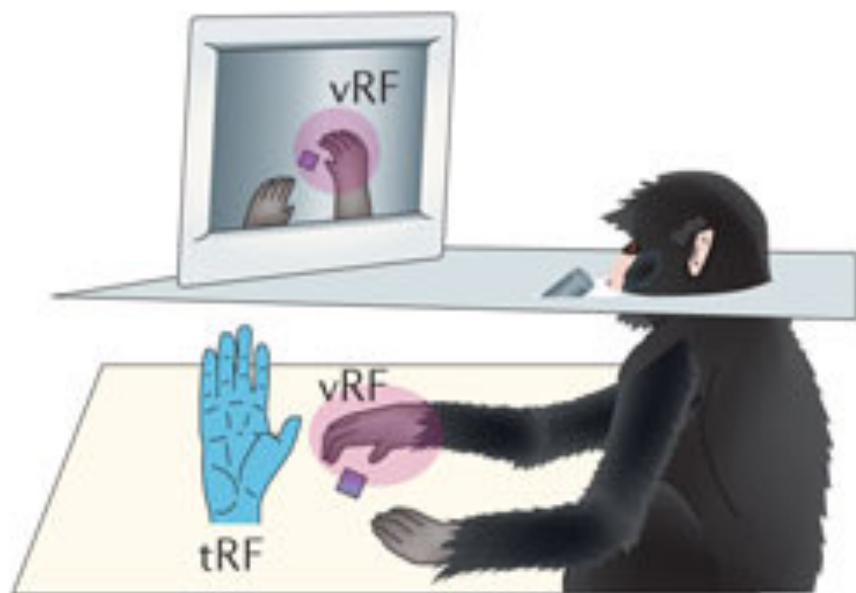
**IMMERSION**



**PRESENCE**



# 'Just' being there



“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*



NASA Research (1980)



Sense8 Corp. (~1980)



# Question of presence

SIGGRAPH (1992)



Comdex Spring (1992)

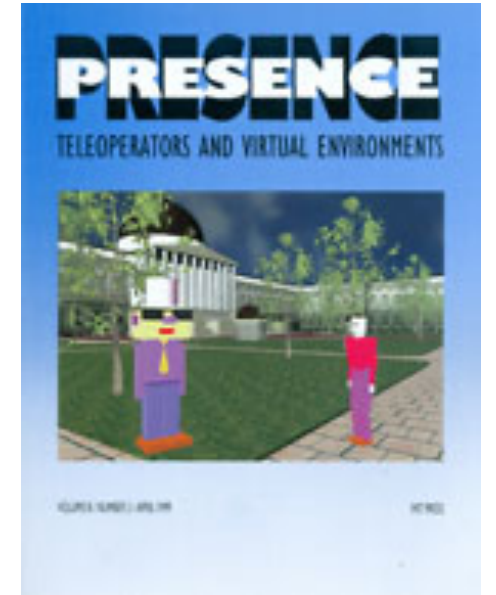


# (tele) Presence

## Sense of Presence

At the core of what defines virtual reality since its origins:

- Suspension of disbelief (Slater 93)
- Sense of spatially “being there” (Barfield 95)
- Experiential bodily experience (Waterworth 96)
- Illusion of non-mediation (Lombard & Ditton 97)
- Successful support of actions in IVE (Zahoric 98)
- Immersion, presence, performance model (Bystrom 99)



# Presence Questionnaires

- Slater et al. (1993, 1994) - 3 to 6 items, customized

To what extent were there times during the experience when the *office space* was the reality for you?

1 - at no time

almost all the time - 7

- Witmer & Singer (1998) - 32 items, the most cited

How completely were all your senses engaged?

How involved were you in the virtual environment experience?

- Others

- Baños (2000), Lessiter (2001), IPQ Schubert (2003) <http://www.igroup.org/pq/ipq>

# Questionnaires

- 86% of studies use subjective measures, 12% use both subjective and objective measure of Presence

Souza, V., Maciel, A., Nedel, L., and Kopper, R. (2022). Measuring Presence in Virtual Environments: A Survey. *ACM Comput. Surv.* 54, 1–37. doi:10.1145/3466817

- Scores are inconsistent if measured during or after immersion

Graf, S., and Schwind, V. (2020). “Inconsistencies of Presence Questionnaires in Virtual Reality,” in 26th ACM Symposium on Virtual Reality Software and Technology, 1–3.

# Think of yesterday. How colorful was your day?

**Were there times during the day that you would describe as having been colorful?**

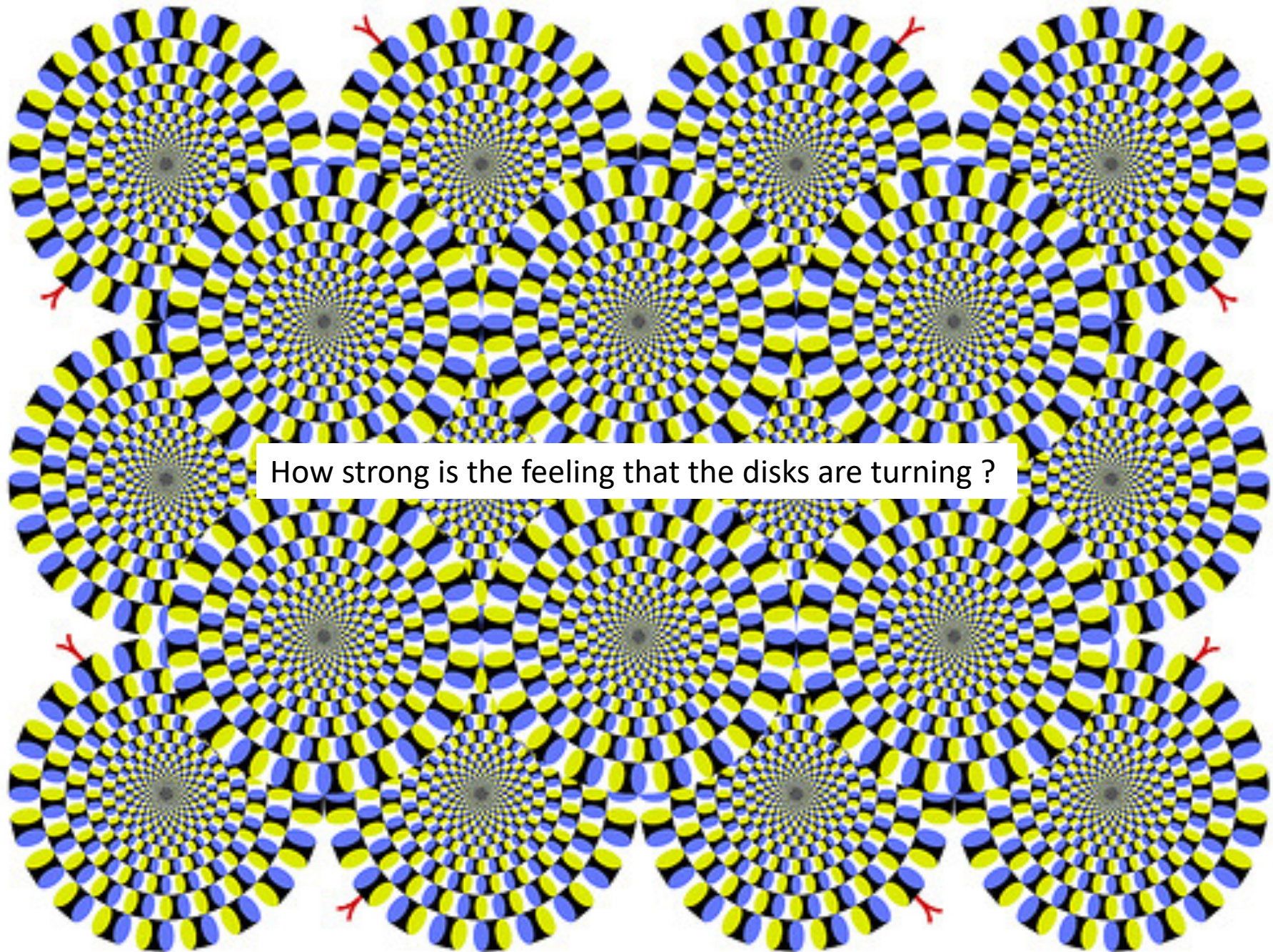
1 - not at all

a great deal - 7

- Limit of questionnaires
  - We cannot rule out the possibility that the concept exists to our experimental subjects only because questions are asked about it (Slater 2004)
  - No difference in PQ score in real vs. virtual environment (Slater & Usoh 2000)
- Frequent confusions with immersion, involvement, engagement, or sense of reality.

*NB: Results of regression analysis (N=74): a “colorful day” is a pleasant and not frustrating day, when one could get up later than usual.*





How strong is the feeling that the disks are turning ?



# 'Surrogates' for Presence

- If participants experience the illusions, then their reactions will be the same as in reality
  - e.g. threat
- Behavioral & Physiological measure
  - Correlations Presence & copresence scores
    - e.g. Ochs et al (2022)
  - Limited to situations with specific triggers that elicit physiological or brain responses

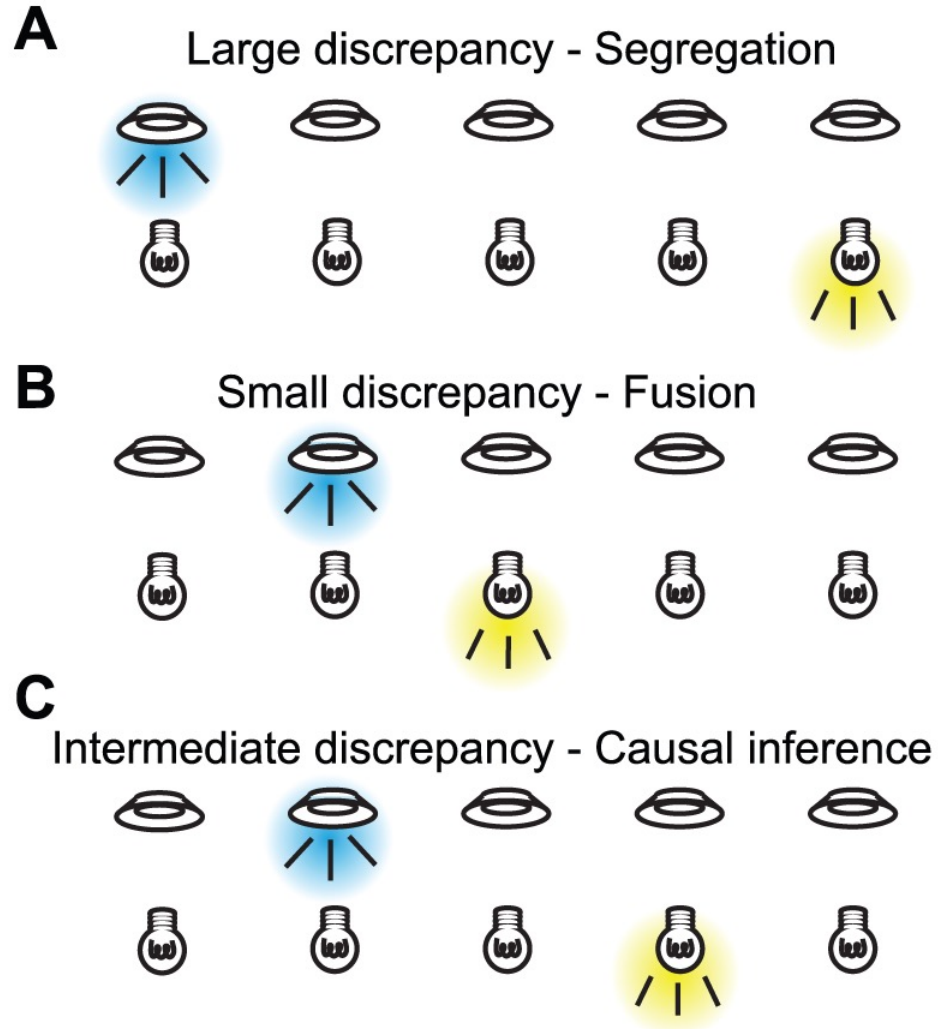
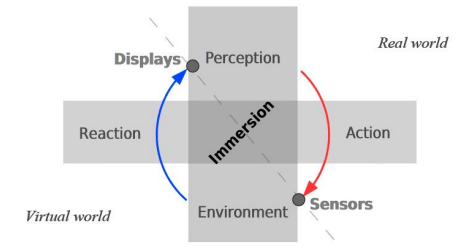


Meehan M, Insko B, Whitton M, Brooks FP Jr (2002) Physiological measures of presence in stressful virtual environments. *ACM Trans Graph (tog)* 21(3):645–652

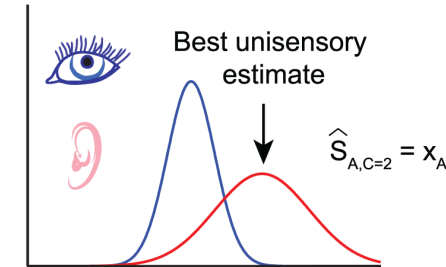
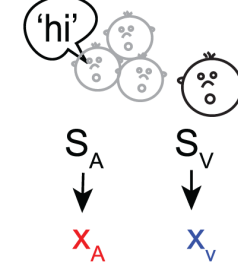
# The congruency hypothesis



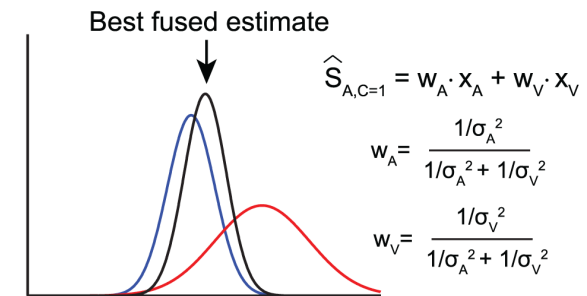
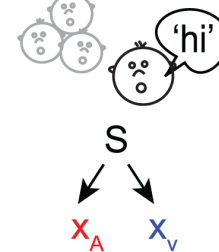
# Multisensory integration



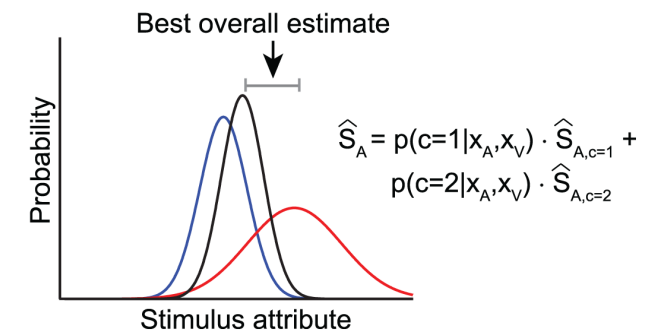
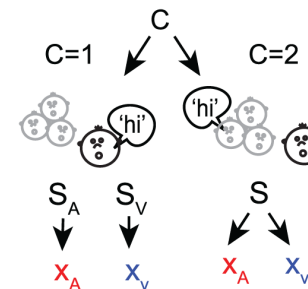
**A** Separate sources (C=2)



**B** Common source (C=1)



**C** Causal inference



# Multisensory integration: VR and illusions

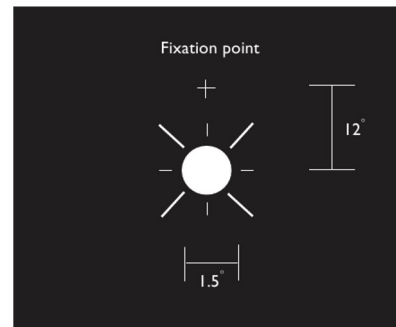
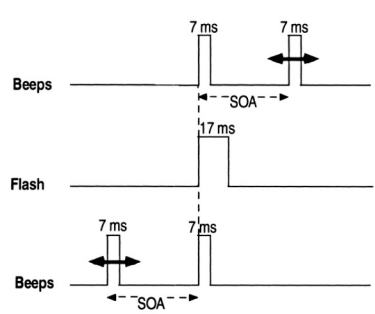
## Mc Gurk effect (The ventriloquist illusion)

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

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

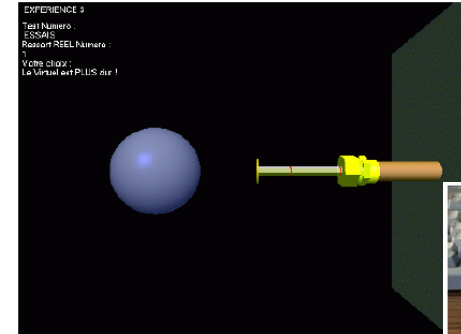


## Sound induced flash illusion



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

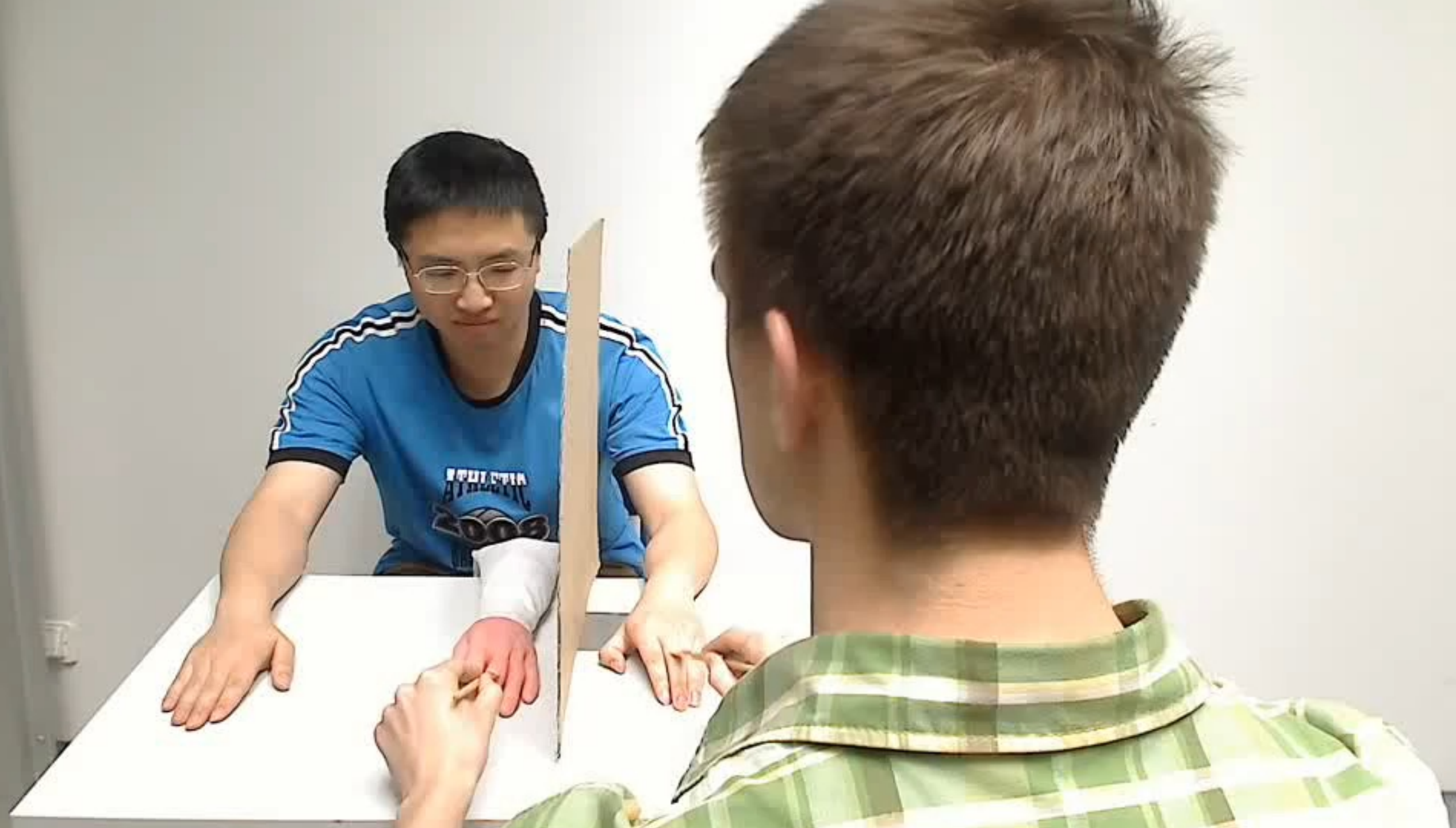




# The 'this is me' hypothesis



Disclosure (1994)



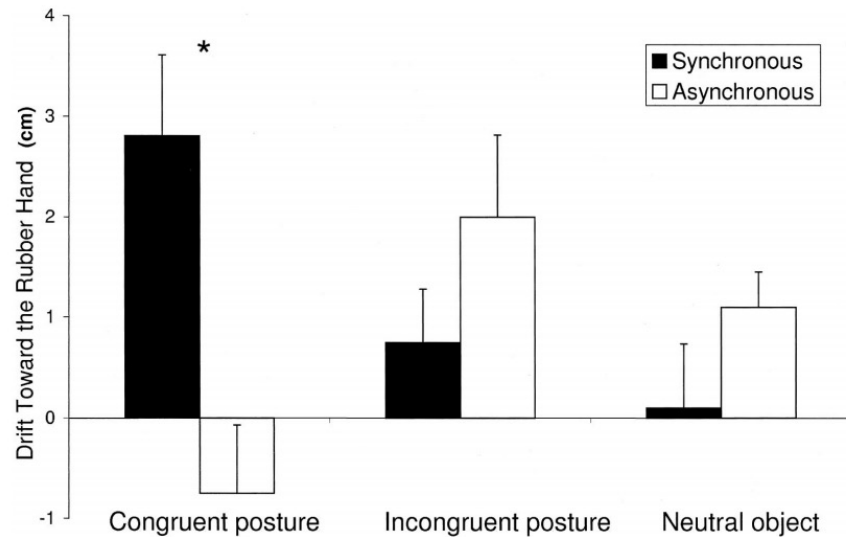


# Rubber Hand Illusion

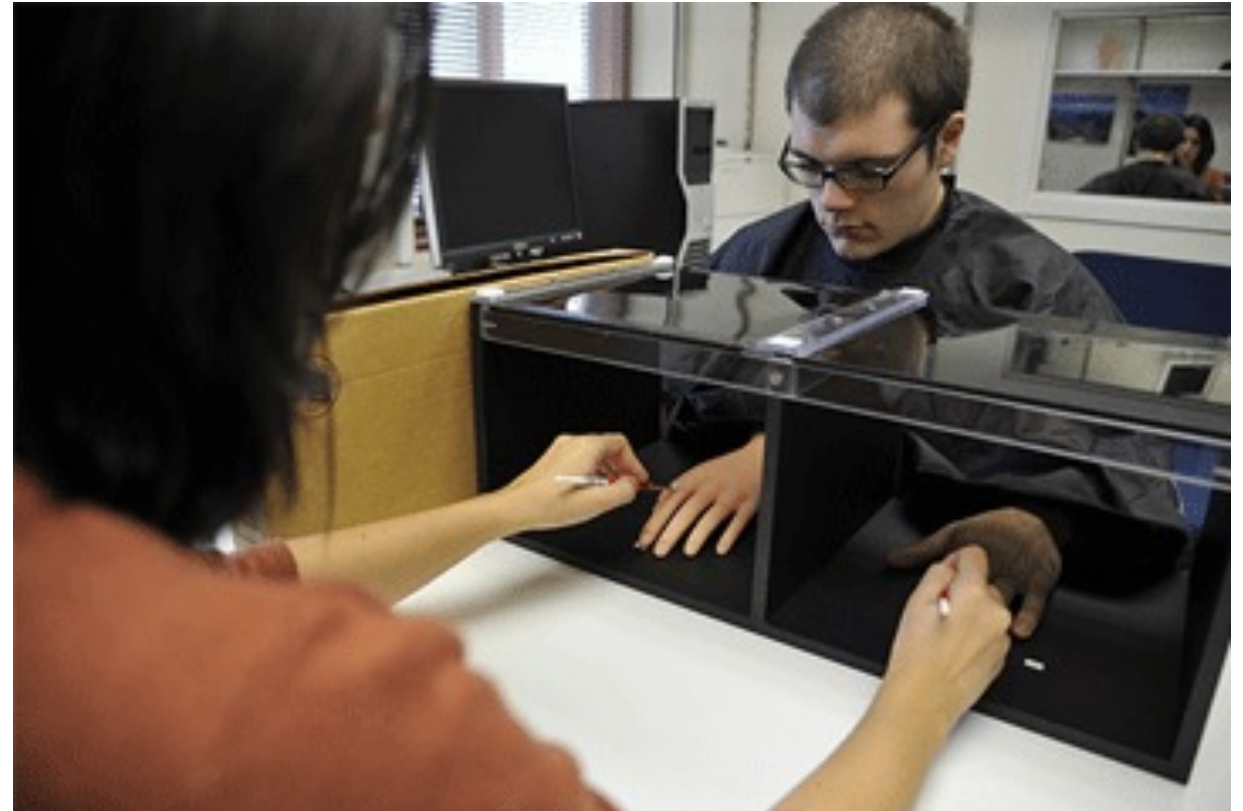
During bodily illusions like the “rubber hand illusion”, a fake body part is felt as the real one. This occurs after a few seconds of synchronous stroking of the hand; “if I feel touch on this hand, it must be mine!!”.



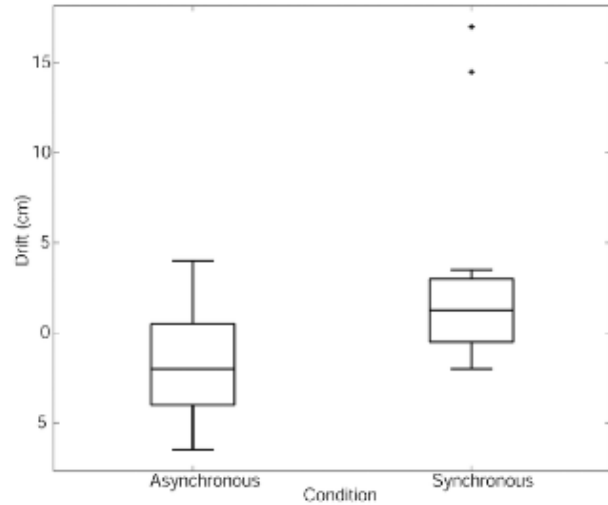
(Botvinick and Cohen, *Nature*, 1998)



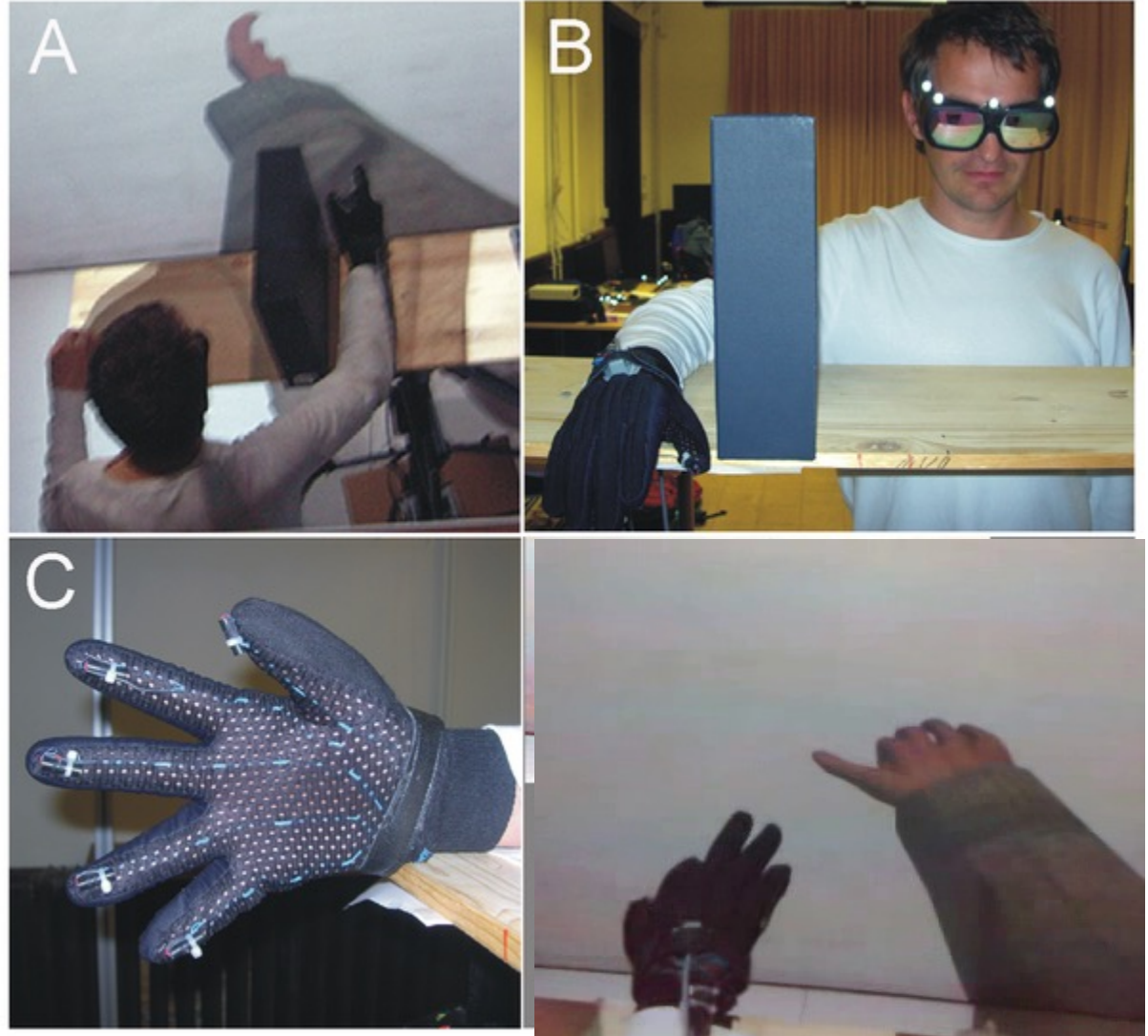
M Tsakiris, P Haggard - *Journal of Experimental Psychology*, 2005



# Virtual Hand Illusion



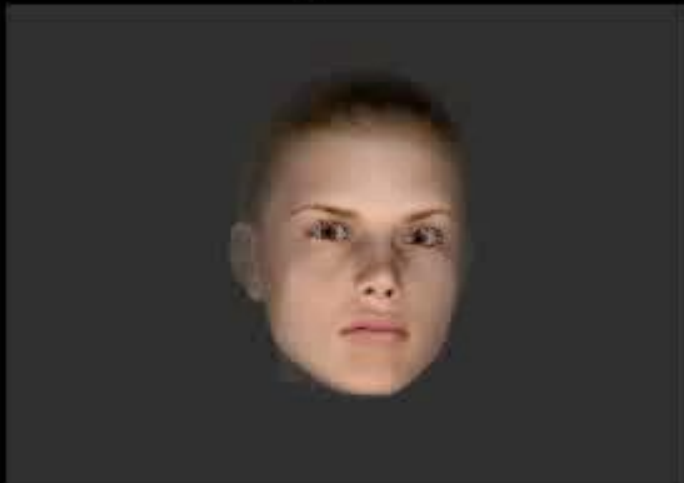
Sanchez-Vives, Spanlang,  
Frisoli, Bergamasco, Slater.  
PloS one, 2010

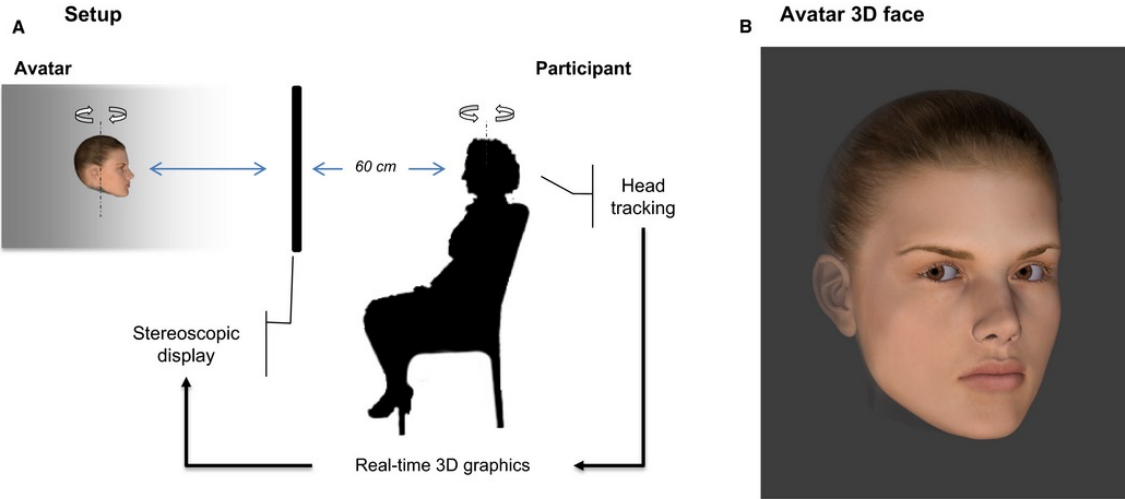


# The Enfacement illusion: Virtual mirror causes erroneous self-recognition

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.





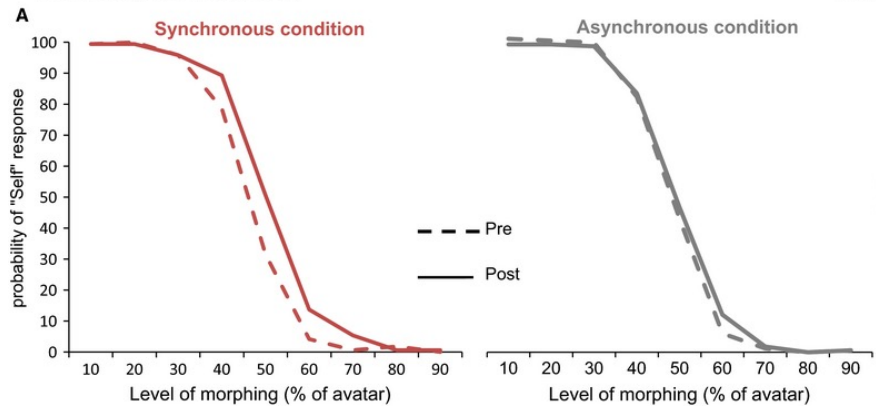
# The virtual mirror

## EPFL-LNCO

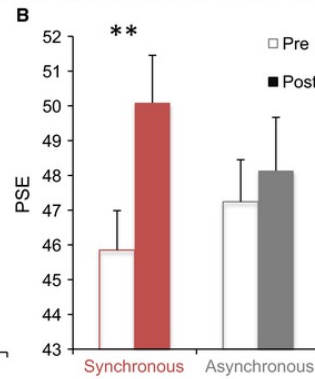
**C Levels of face morphing for self-face recognition task**



**Face recognition task: data**



**Face recognition task: PSE scores**



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.

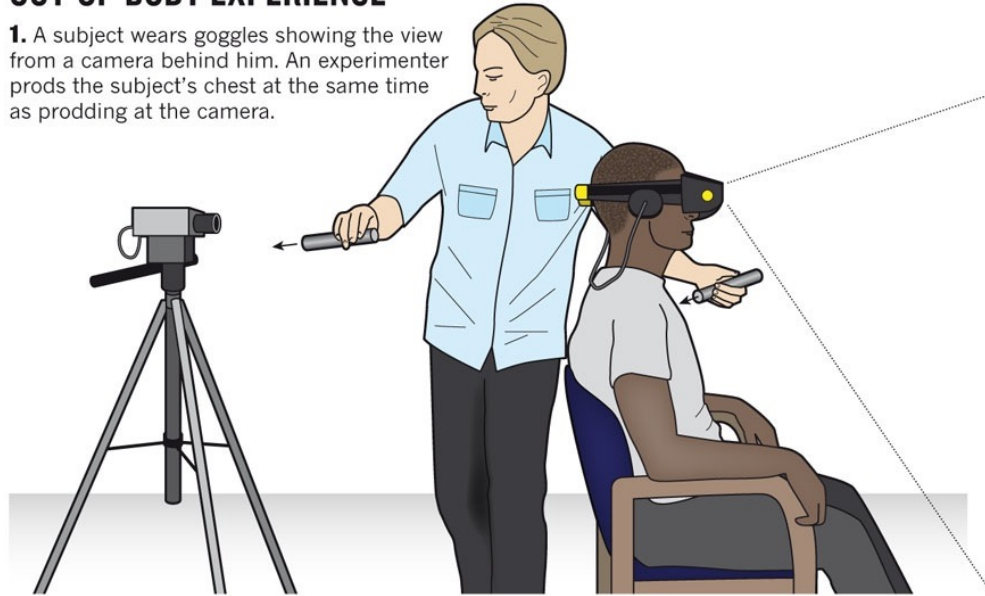
**Lenggenhager et al. Science, 2007.**



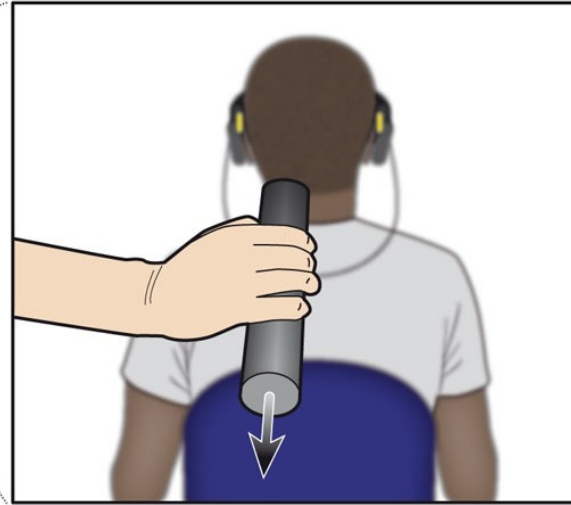


## OUT-OF-BODY EXPERIENCE

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.

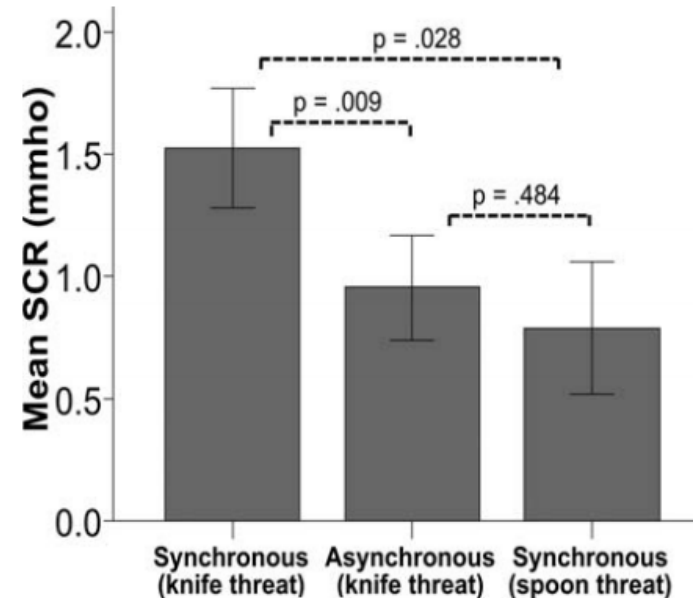


2. The subject sees the hand prodding towards the camera as he feels his chest being prodded. He also sees his body from behind. This creates a vivid sense that his real body is floating behind the one he sees.

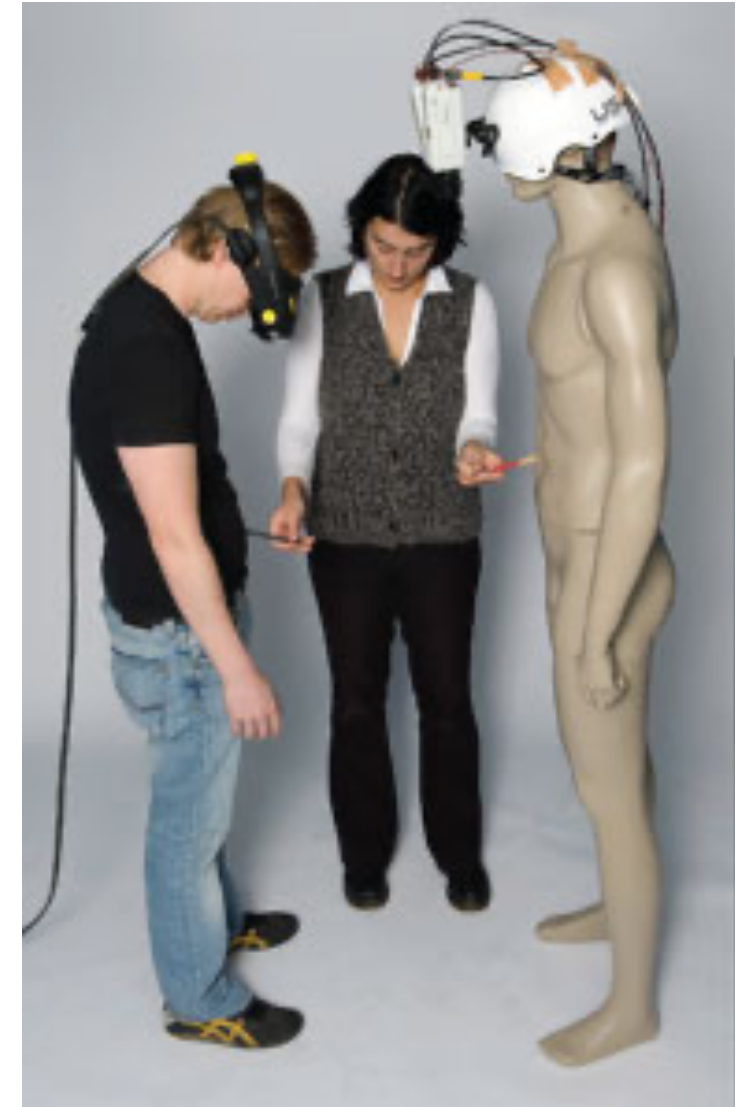


Ehrsson. Science 2007.

*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

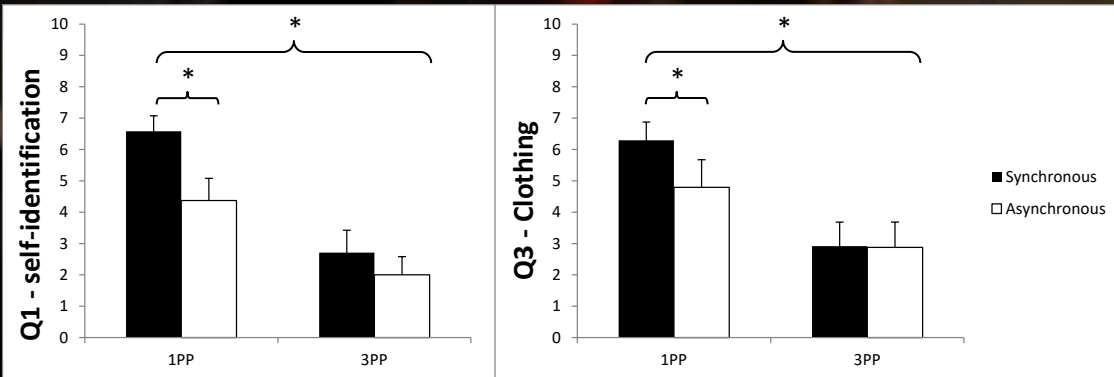


ventLab / Nov. 2010

# 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.*





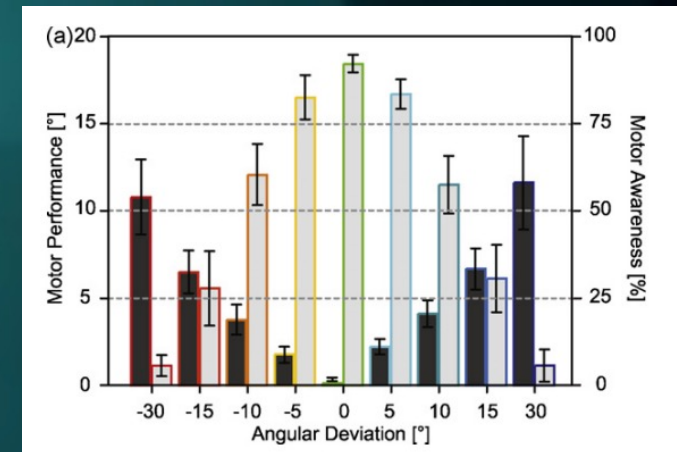
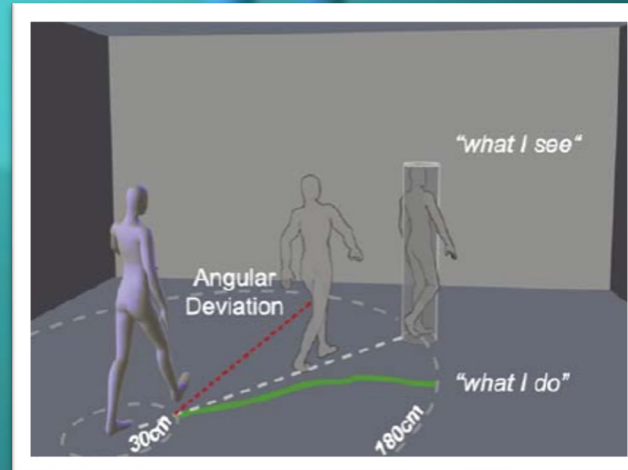


natgeotv.com

# 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



# Body ownership illusion

- The “**illusion that the virtual body is their own —even though they know for sure that it is not.**”

*Next part : Embodied Virtual Reality*

# Synthesis



- VR Immersion and (tele)Presence in VR
  - Cognitive mechanisms comparable to perceptual illusions
  - Cognitive sciences informs VR on the mental mechanisms behind VR Presence
- VR technology is about engineering illusions
  - Not a replication of reality
  - Benefit from *imperfections* of human perception



# Acknowledgements

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Thibault Porssut  
Mathias Delahaye



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Switzerland

# 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/mel Slater/ref-233/beingthere%202013.pdf>