Boulic - Virtual Reality
May 8th 2023

Embodied Virtual Reality; Limits and applications

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We can only experience the world from the perspective of our body

Virtual Reality Embodiment allows experiencing the world from the perspective of another body

Embodiment

- **Avatar**
  - Self-representation of a participant
  - ≠ virtual human / 3D character / NPC

- A concomitant factor to Presence

  The perceiving of one's world entails the co-perceiving of where one is in the world

  Gibson, 1979.

J. Lanier dataglove (1987)

Sense of Embodiment

- Definition *

The ensemble of sensations that arise in conjunction with being inside, having, and controlling a body.

  - Sense of self-location
  - Sense of agency
  - Sense of body ownership

Kilteni, K., Groten, R. and Slater, M. (2012) 'The Sense of Embodiment in Virtual Reality', *Presence* 21(4), 373–387.

* quite widely accepted in the VR community

Body ownership illusion

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

- Embodiment involves:
  - 1PP view of the body
  - Visuomotor or visuotactile synchrony

VR Embodiment via 1PP + Visuomotor Synchrony

eventLAB
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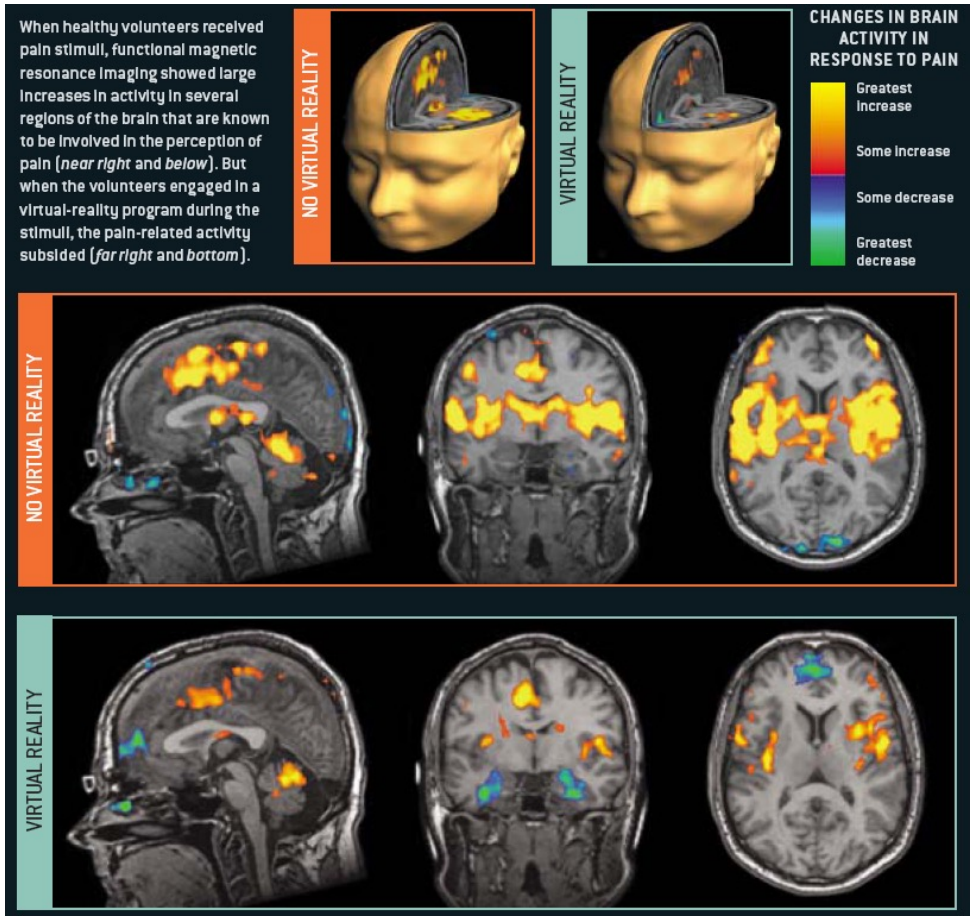
Mel Slater, University of Barcelona

Virtual Reality and Pain

Pain : beyond distraction, disembodiment.

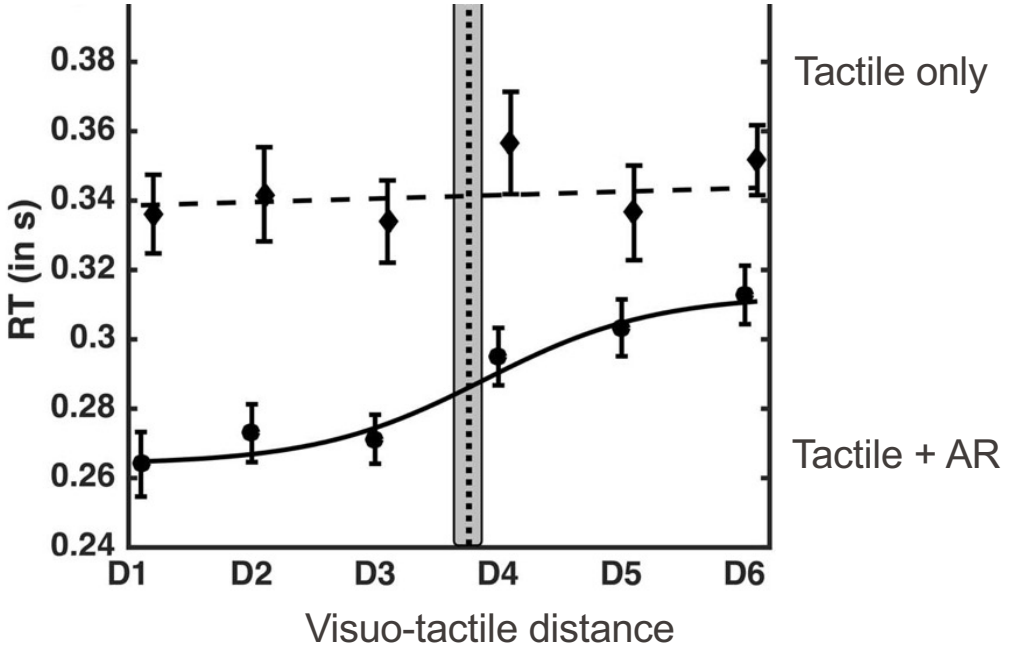
in VR the subject is no more present in her/his body, thus does not experience the pain of the real body

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



Hoffman, H. Scientific American, April 2004

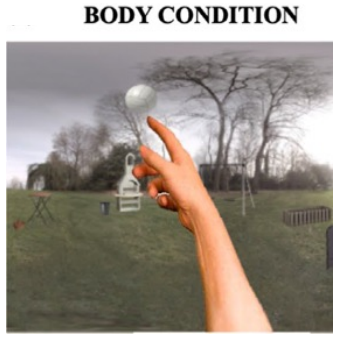
Recalibration of Peri-Personal Space in augmented reality

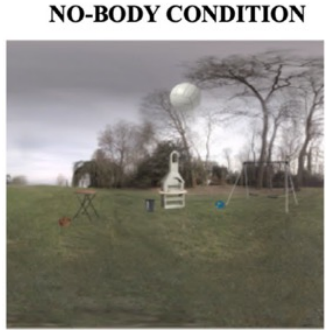


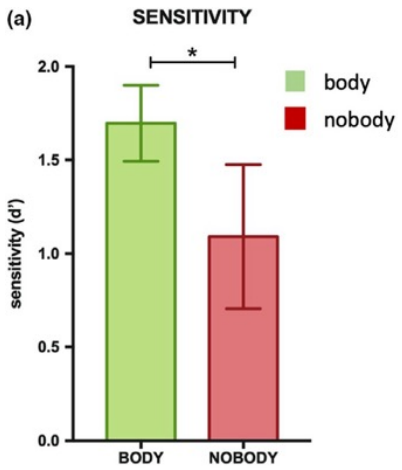
- Link psychophysics with ecological conditions
  - AR vs. Lab conditions
  - EEG
  - Neural Network model

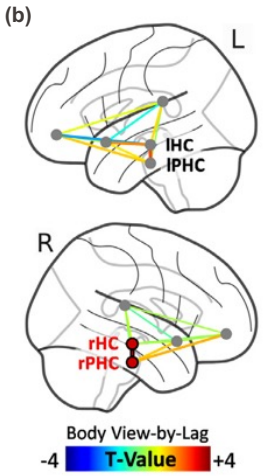
Noel, J.-P., Bertoni, T., Terrebonne, E., Pellencin, E., Herbelin, B., Cascio, C., Blanke, O., Magosso, E., Wallace, M. T., & Serino, A. (2020). Rapid Recalibration of Peri-Personal Space: Psychophysical, Electrophysiological, and Neural Network Modeling Evidence. ***Cerebral Cortex***, *30*(9), 5088–5106. https://doi.org/10.1093/cercor/bhaa103

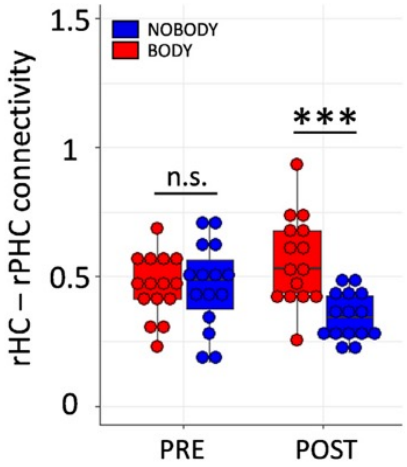
First-person view in immersive virtual reality modulates episodic memory











VR manipulation during memory encoding: presence or absence of self-body alters retreival performance (a) and shows neural differences pre- vs. post-encoding (b).

Bréchet, L., Hausmann, S. B., Mange, R., Herbelin, B., Blanke, O., & Serino, A. (2020). Subjective feeling of re-experiencing past events using immersive virtual reality prevents a loss of episodic memory. ***Brain and Behavior***, *10*(6), e01571.

Gauthier, B., Bréchet, L., Lance, F., Mange, R., Herbelin, B., Faivre, N., Bolton, T. A. W., Ville, D. V. D., & Blanke, O. (2020). First-person body view modulates the neural substrates of episodic memory and autonoetic consciousness: A functional connectivity study. ***NeuroImage***, *223*, 117370.

What are the conditions and limits of VRE?

Research work by Ronan Boulic (Immersive Interaction Group, EPFL) and Bruno Herbelin (LNCO, EPFL)

IIG
Immersive Interaction Group

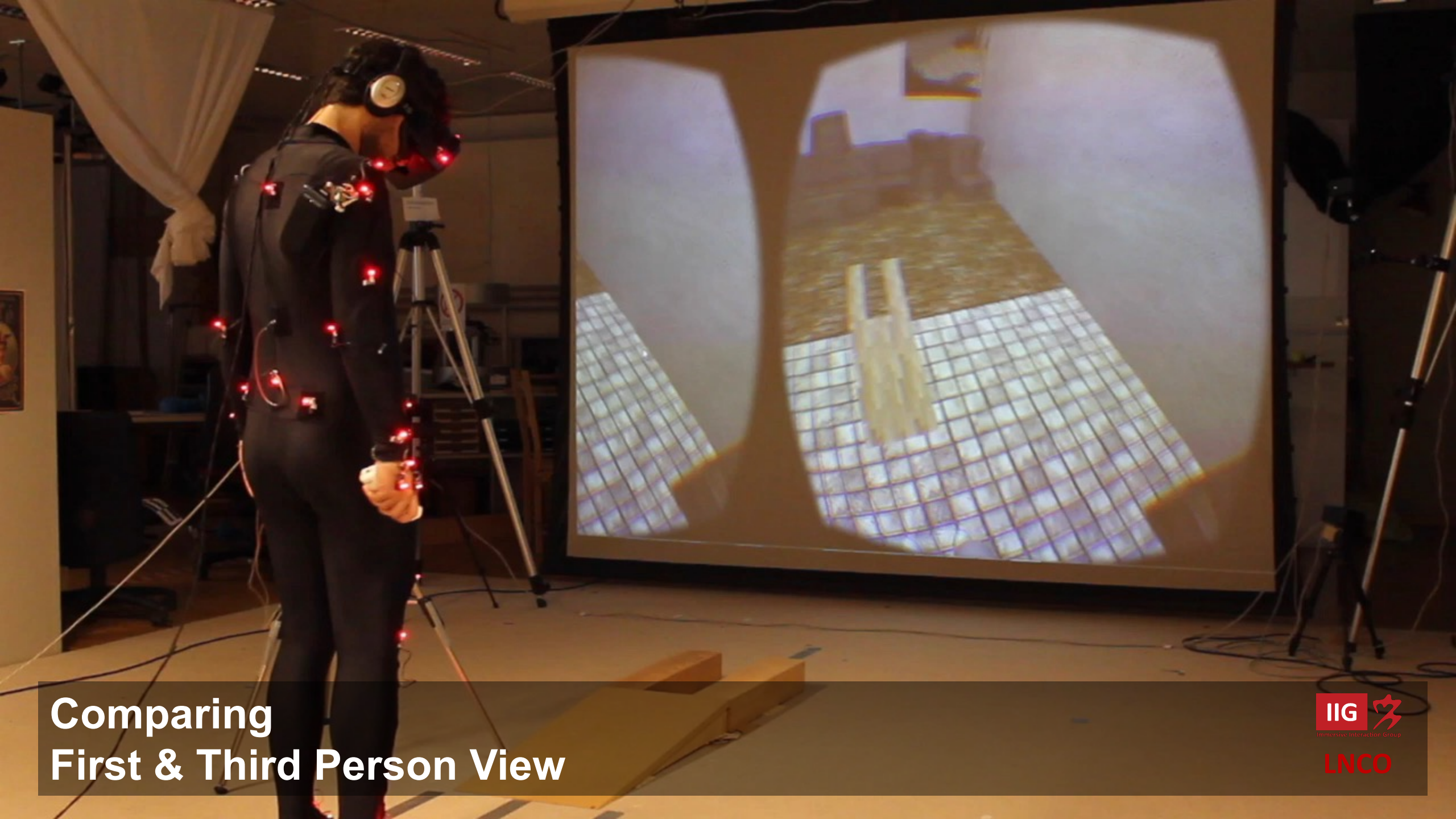
BLANKE LAB
CHAIR IN COGNITIVE NEUROPROSTHETICS

Physiological measure of Presence
Fear induction in the virtual pit room

Measure of fear with physiological sensors (GSR, ECG) shows high reaction to fear of height

Augmented Environment Lab 2007 Virtual Pit

Meehan et al. 2002



Comparing
First & Third Person View

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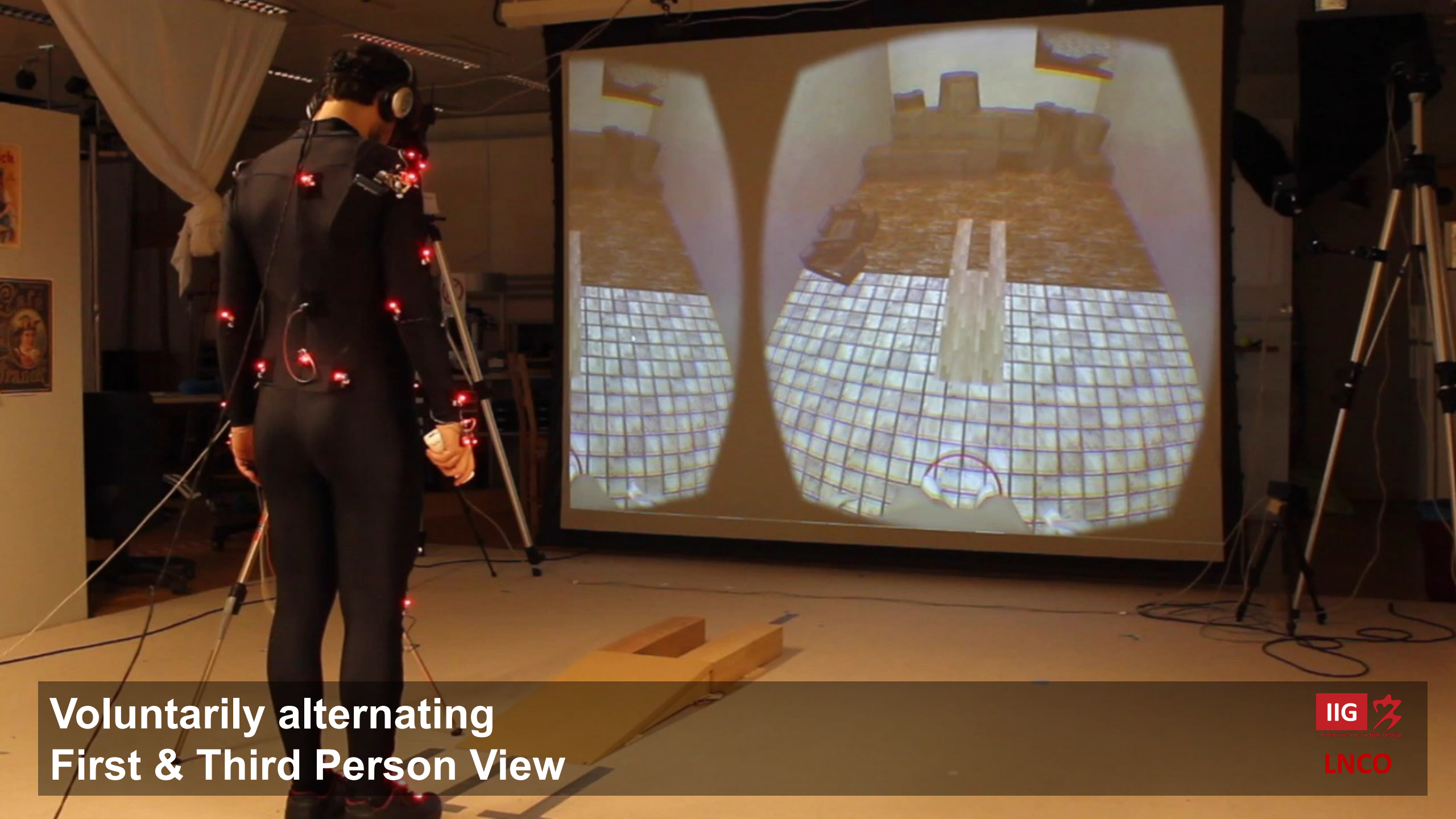

Voluntarily alternating First & Third Person View

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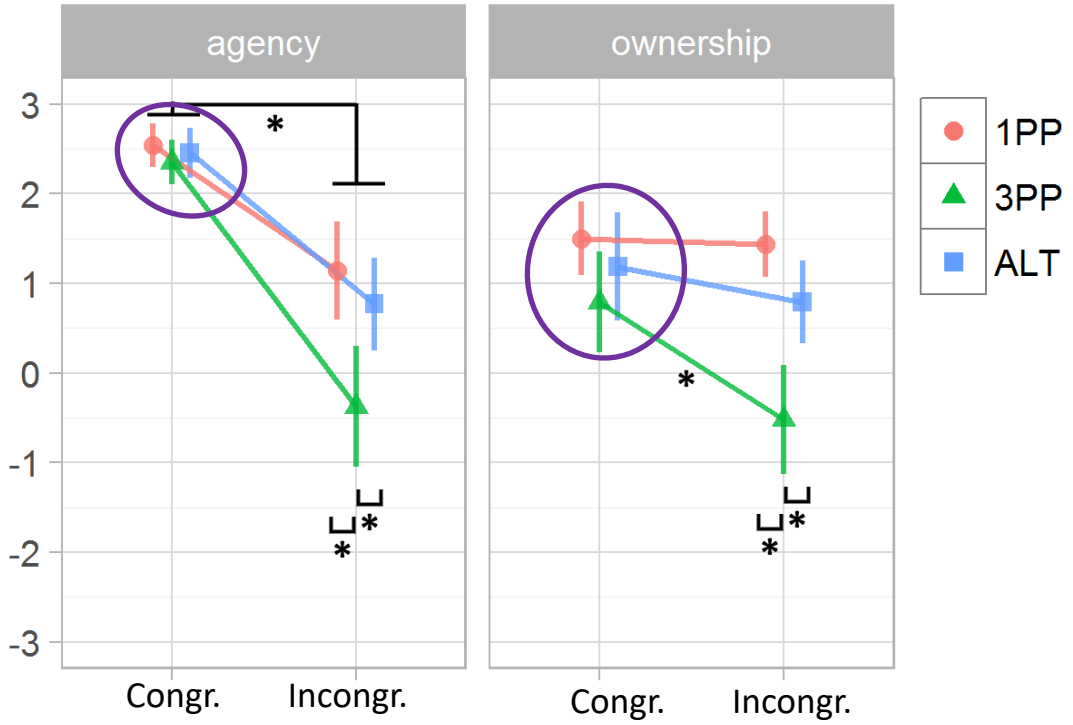
Voluntarily alternating First & Third Person View

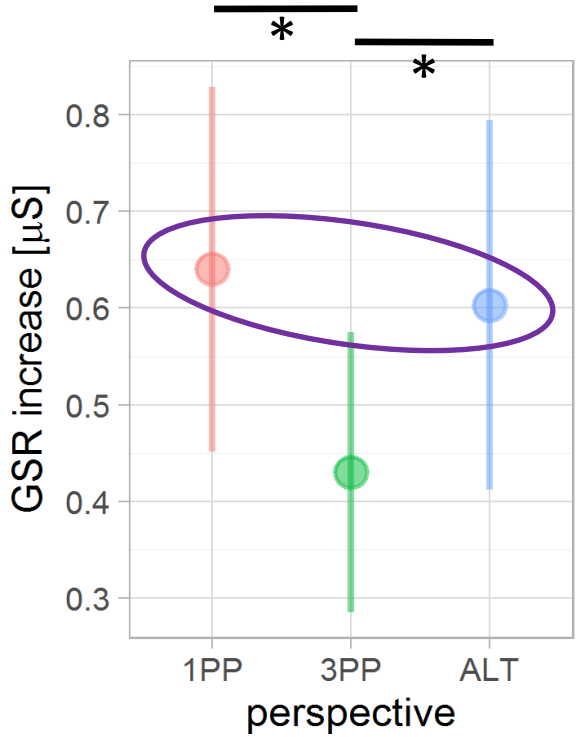
Galvan-Debarda et al. –PLOS ONE 2017

Questionnaire result



Strong embodiment in congruent visuo-motor-tactile condition for both 1st and 3rd P. view

Galvanic skin response to threat



Alternating views can combine the advantages of both

Self-Attribution of Distorted Reaching Movements

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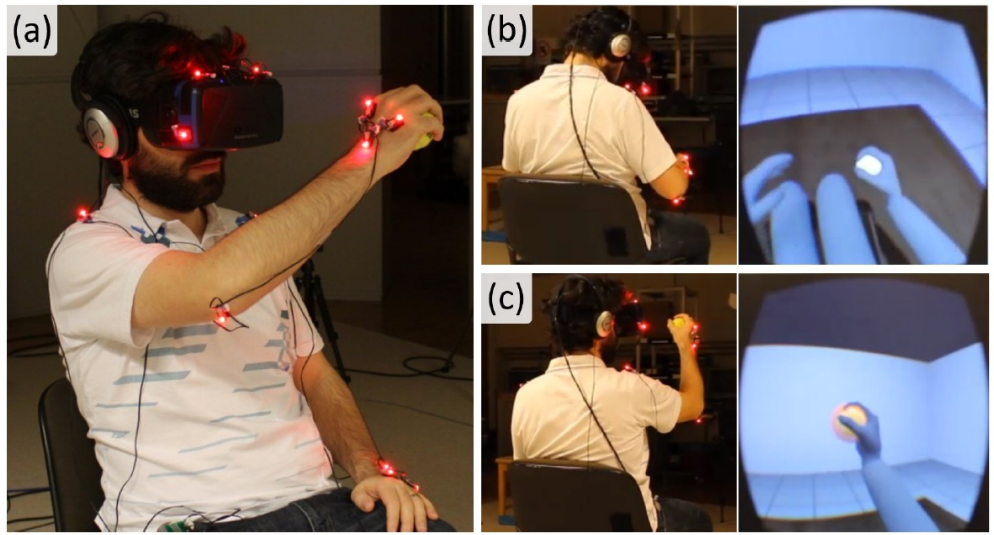
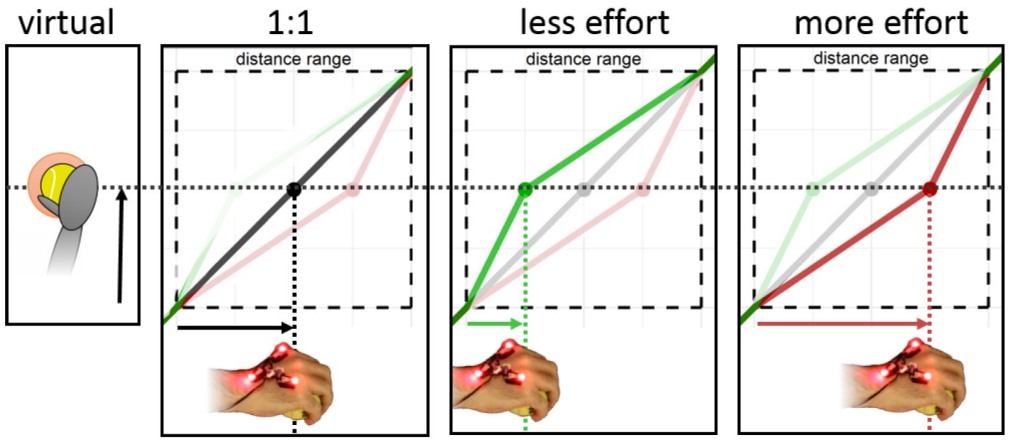
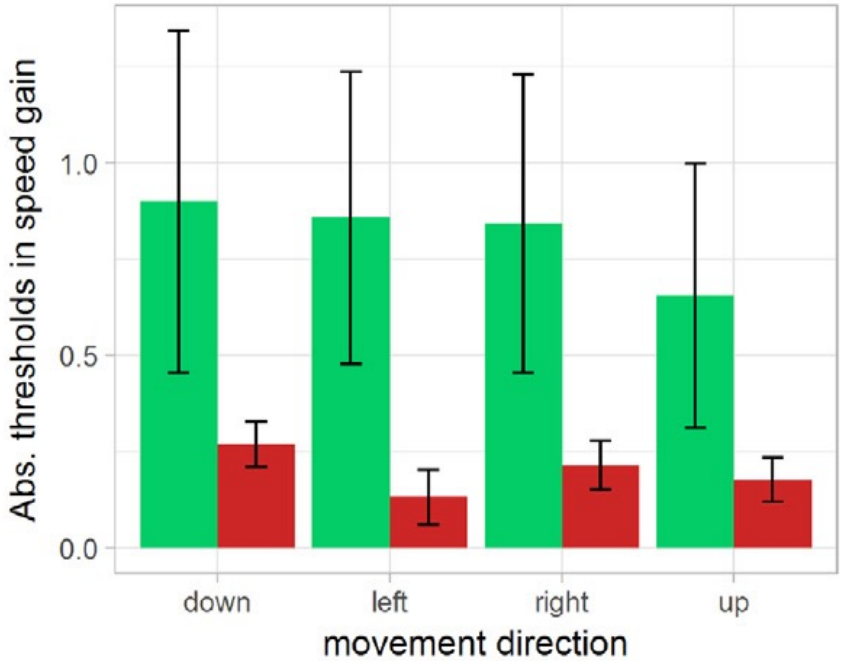
Self-Attribution of Distorted Reaching Movements

Galvan-Debarda et al. 2018 – Computer & Graphics 76(142-52)







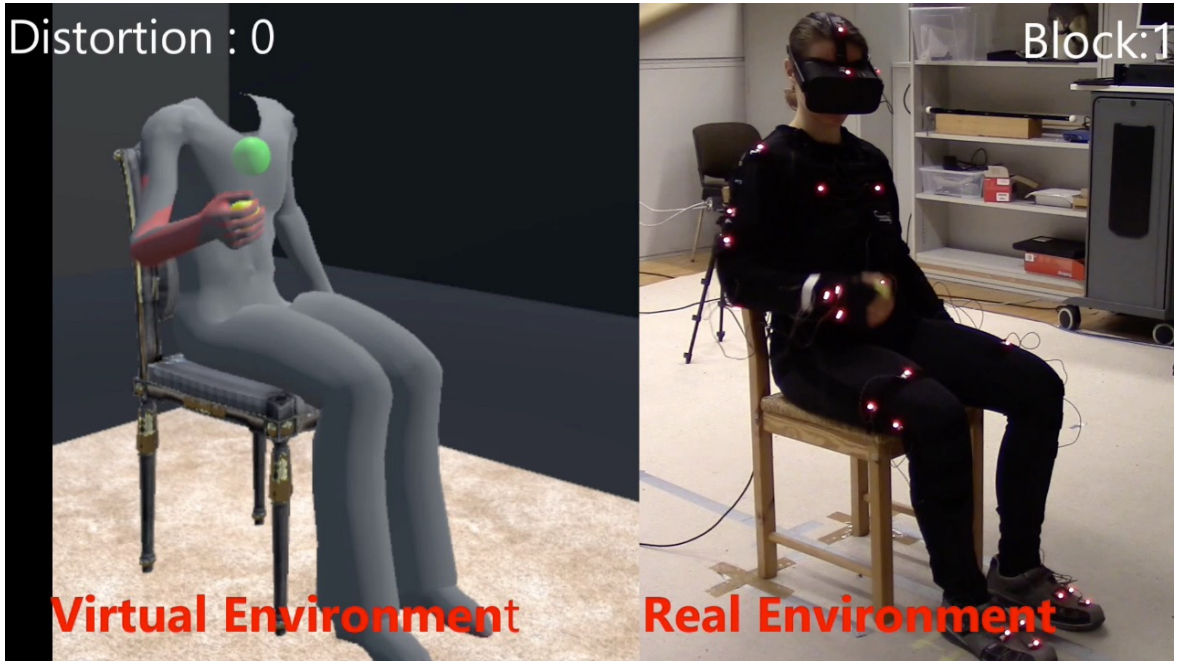
$$speed\ gain = \frac{speed_V}{speed_P} - 1$$

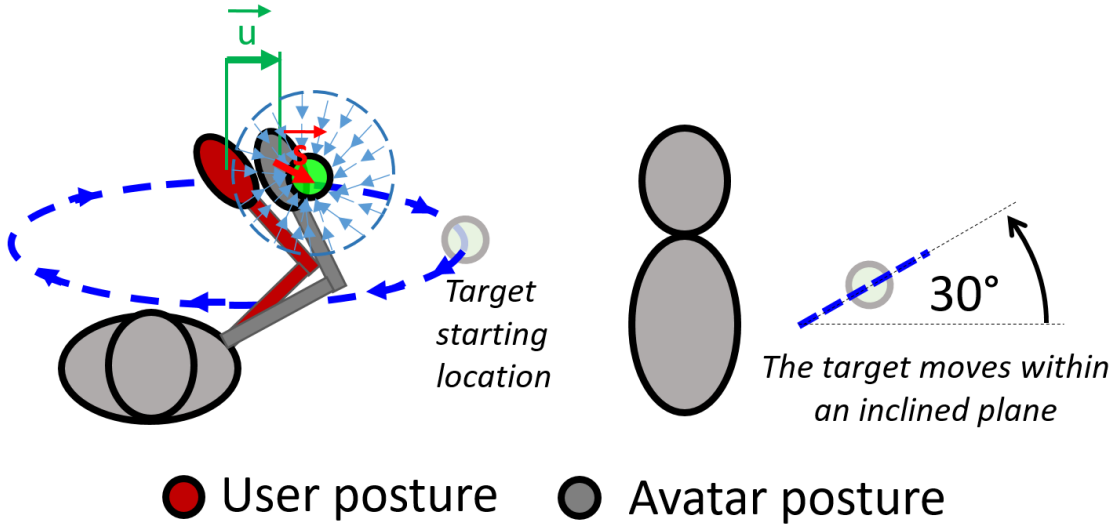
Helping reaching movement is good and not easily detected

Hindering movement is critical

Reconciling Being in-Control vs Being Helped

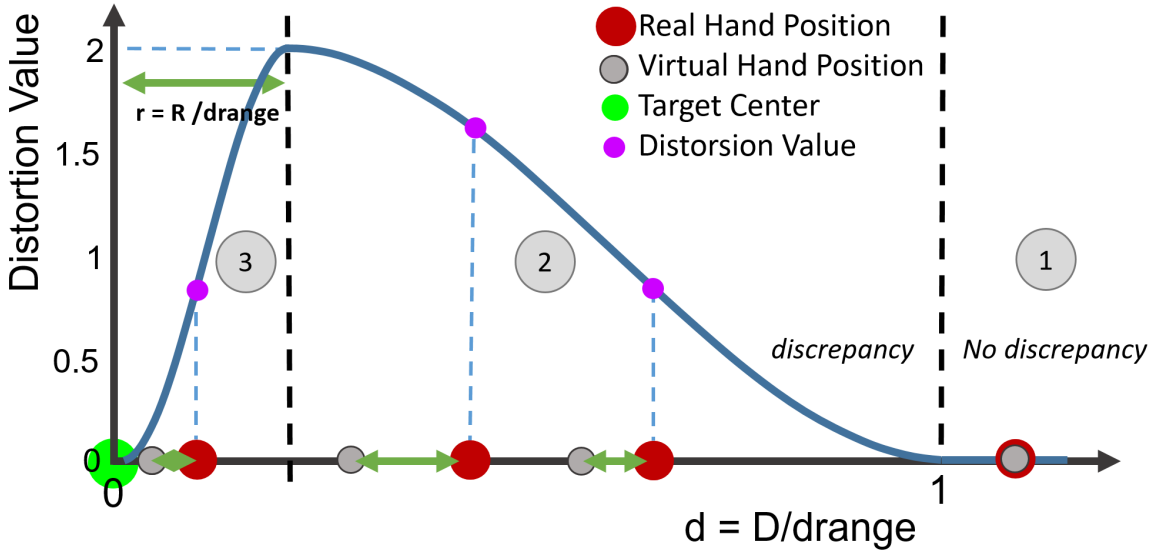
Porssut et al. – Accepted IEEEVR 2019

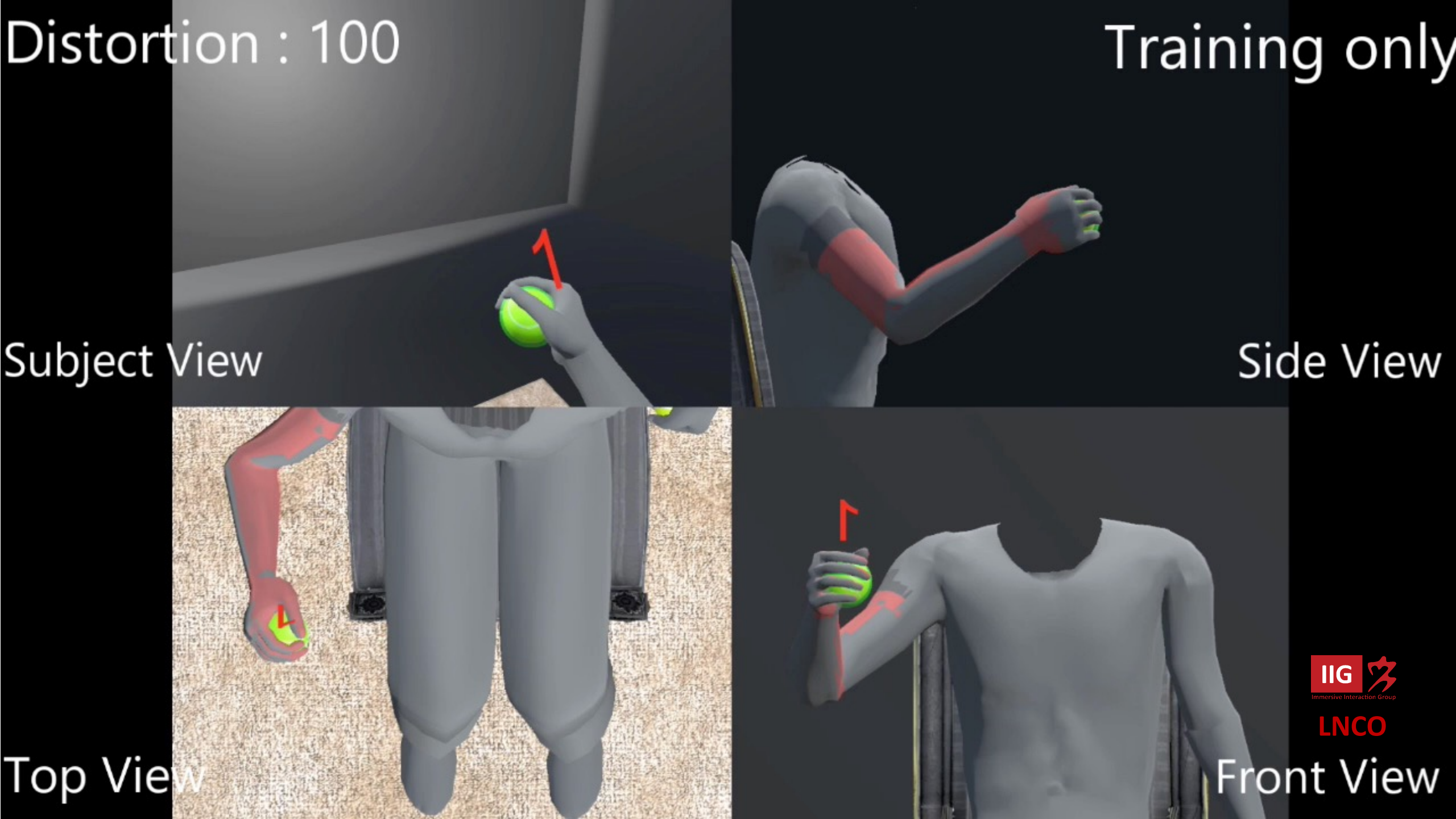




BLOC 1 - Self-attribution Threshold

BLOC 2 – Progressive Distortion




Distortion : 100
Training only
Subject View
Side View
Top View
Front View
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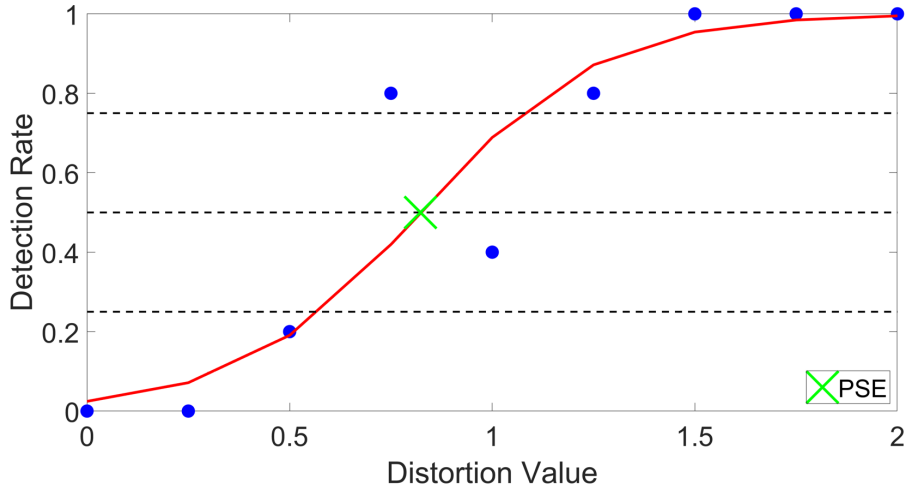
Reconciling Being in-Control vs Being Helped

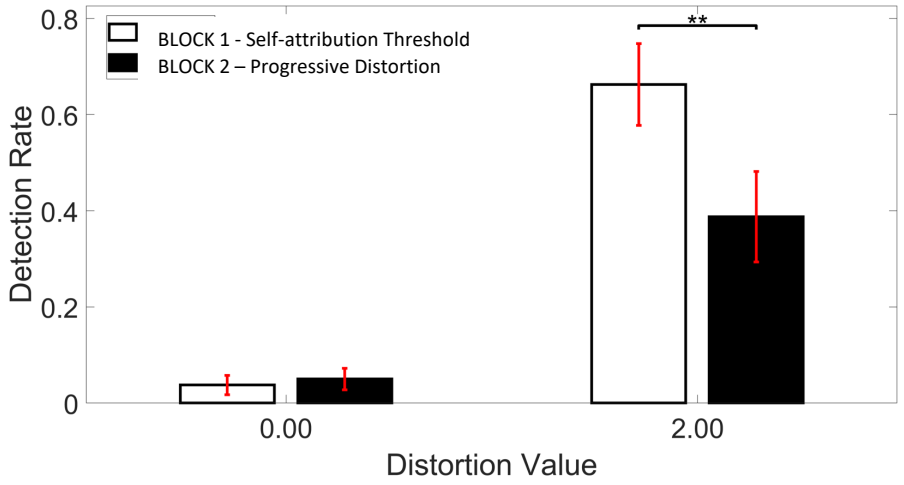
Results (N=24)

DETECTION RATE

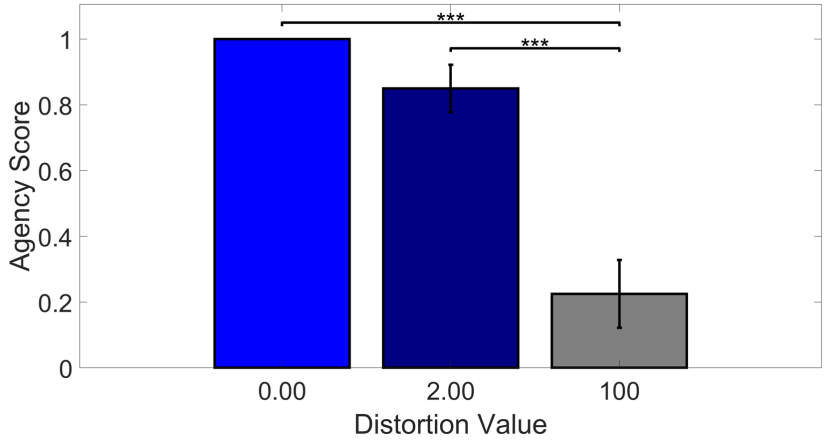
Example Subject

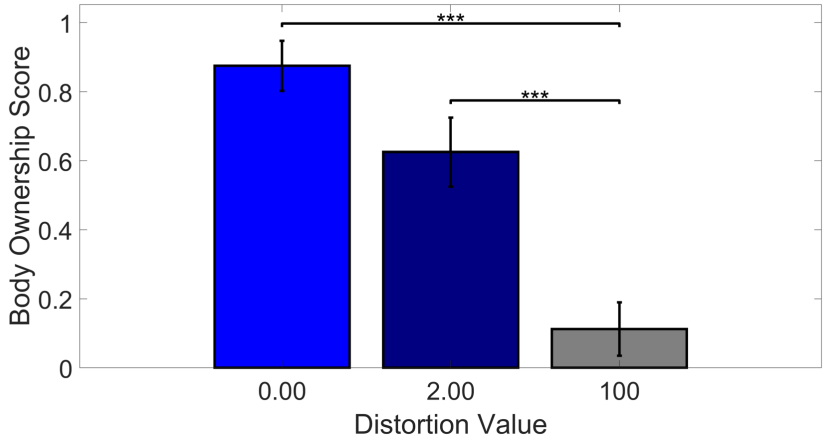


Group



AGENCY AND OWNERSHIP





Self-Contact Visuo-tactile Congruency is stronger than Agency

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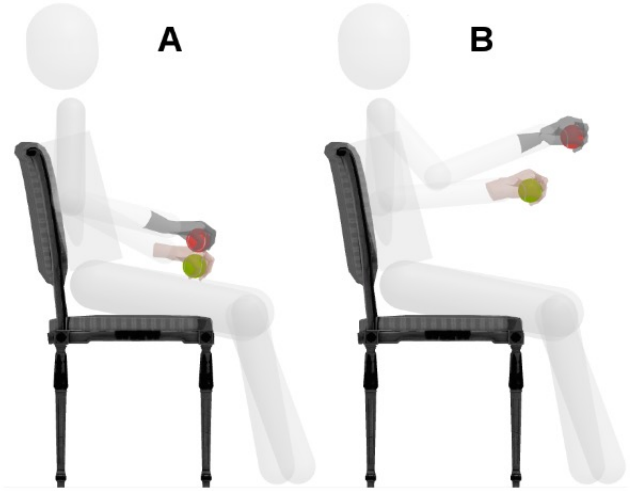
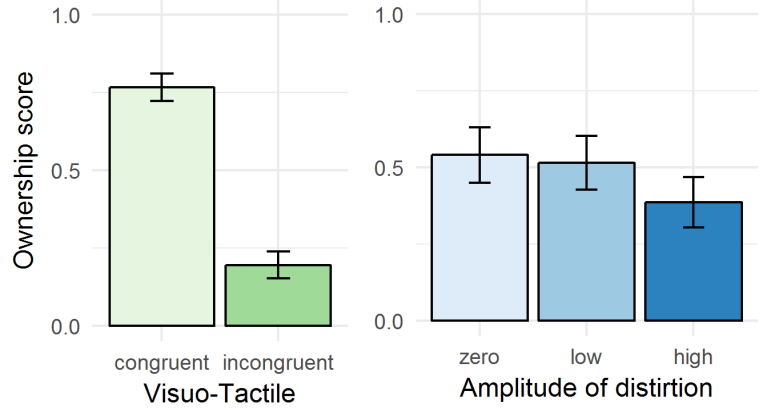
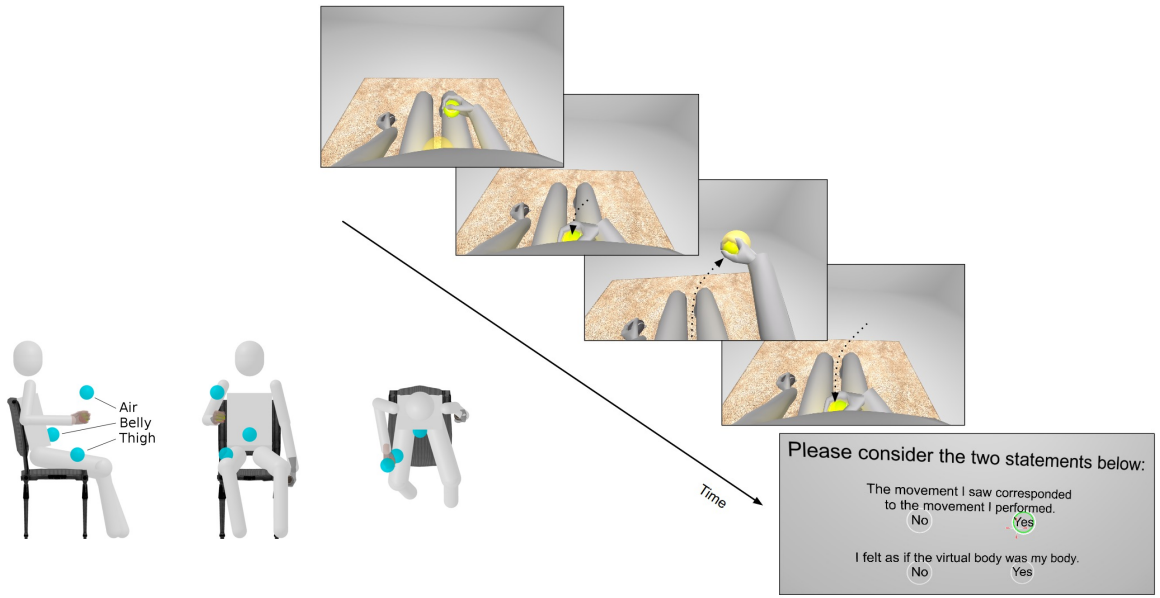
Self-Contact Visuotactile Congruency

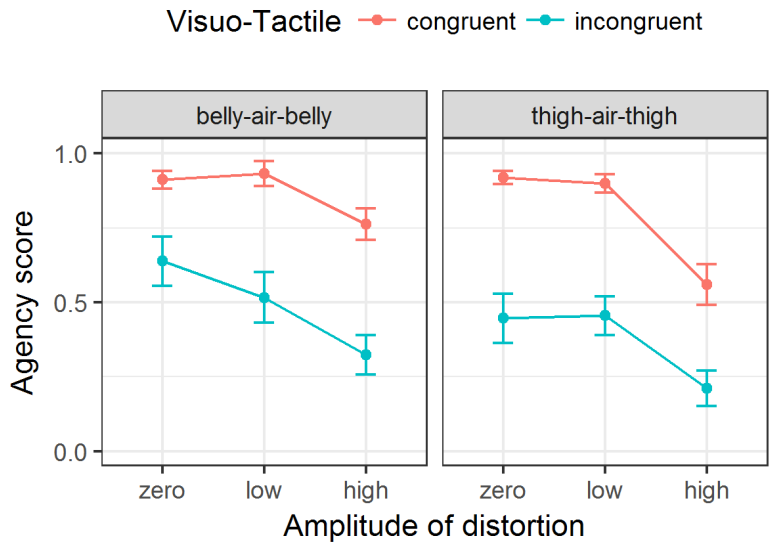
Bovet et al. – IEEEVR 2018



Self-Touch is critical,
And more important than agency







Changes in body representation lead to changes in perception, attitudes and behavior

Examples from **eventLab**
Prof. Mel Slater
Barcelona University

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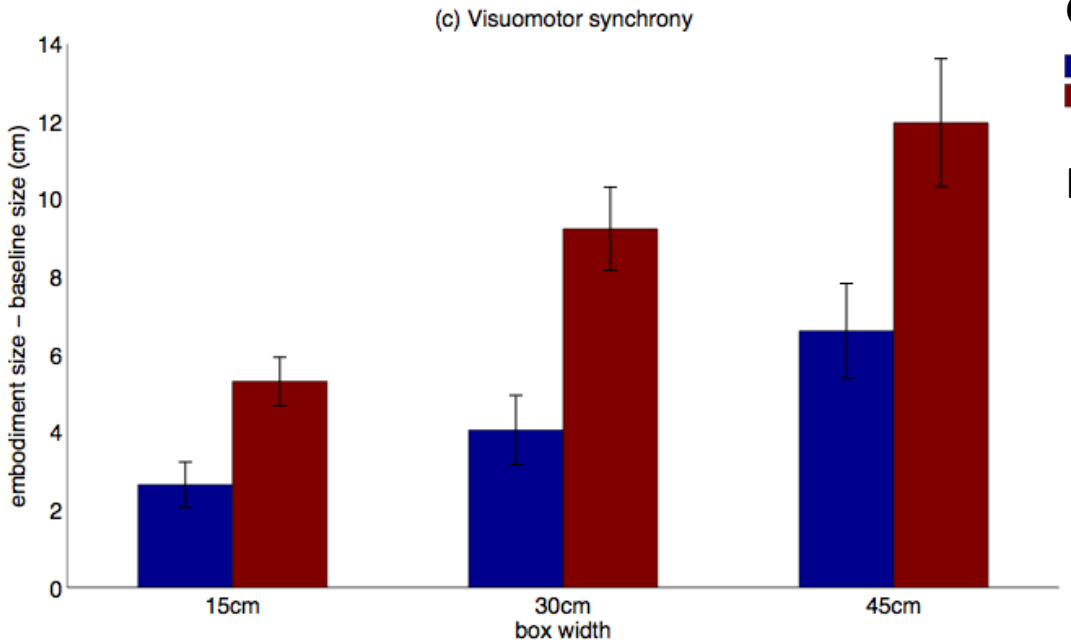
Becoming a Child

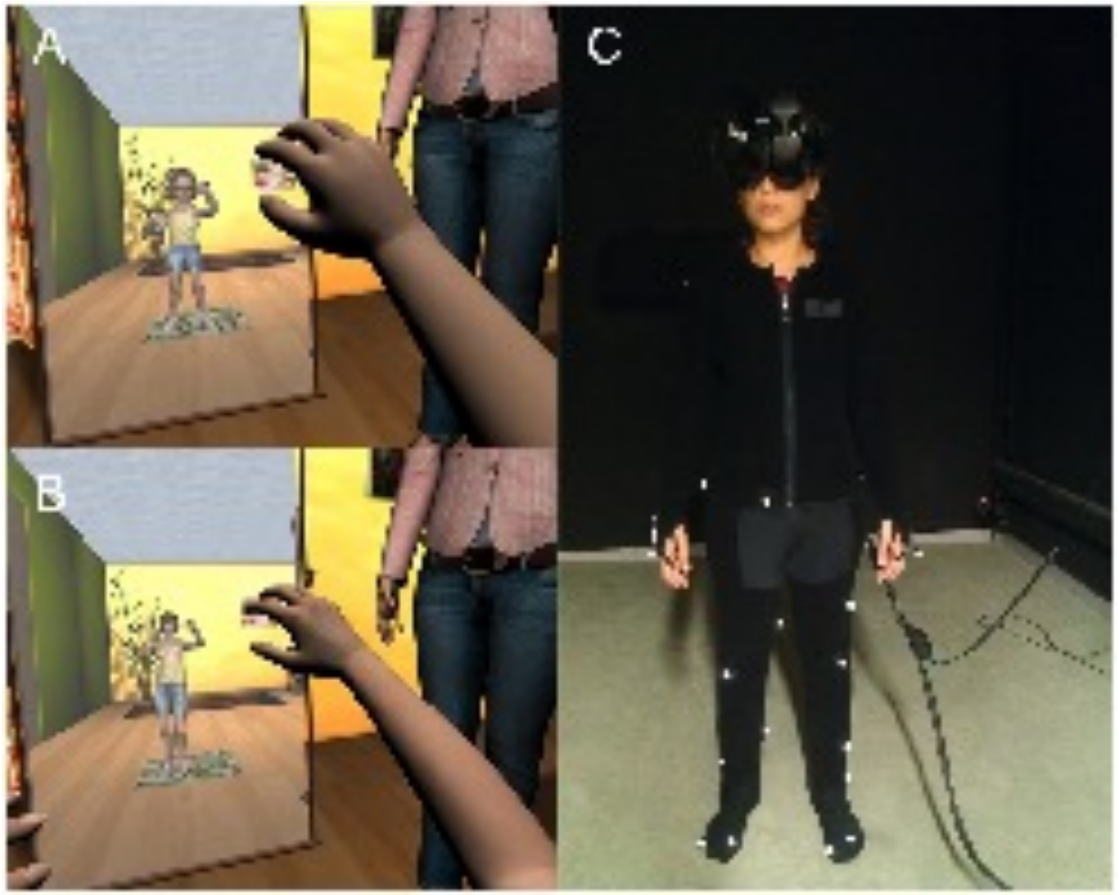
Just a few moments of multisensory stimulation leads to changes in size perception and self-attributions.



Groups:
Adult
Child

N=32

Both groups overestimated the sizes of objects. Those in the child group double overestimated.



Banakou, Groten, Slater (PNAS, July 2013)

Transforming the Self into a Child

Domna BANAKOU[1], Raphaela GROTEN[1], Mel SLATER[1,2,3]

[1] Facultat de Psicologia , Universitat de Barcelona, Barcelona, Spain
[2] Institucio Catalana Recerca i Estudis Avançats (ICREA), Universitat de Barcelona, Barcelona, Spain
[3] Department of Computer Science, University College London, London, United Kingdom

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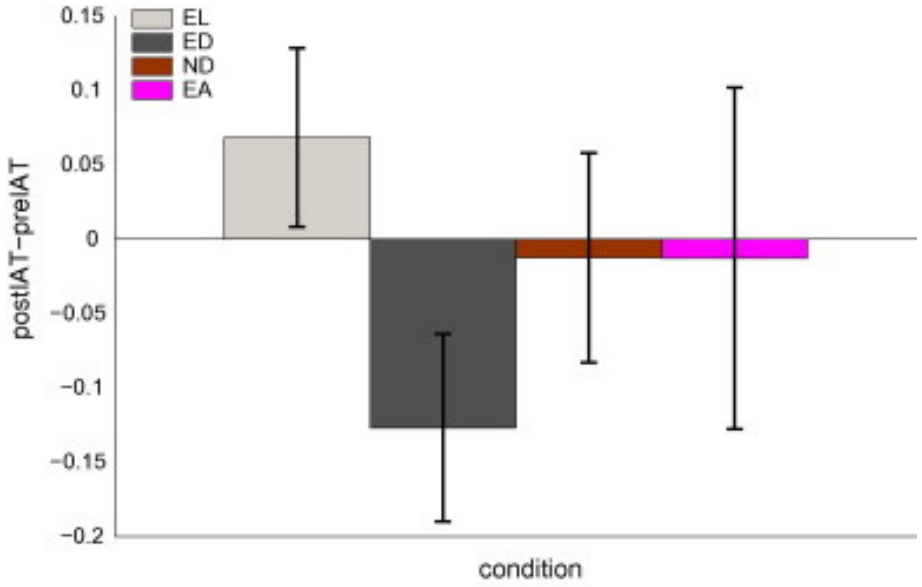
Reducing Implicit Racial Bias

Putting yourself in the skin of a black avatar reduces implicit racial bias

increased bias



decreased bias

Experimental conditions:
Embodied-Light-Skinned (EL)
Embodied-Dark-Skinned (ED)
Non-Embodied Dark-Skinned (ND)
Embodied-Alien-Skinned (EA)

Banakou, Groten, Slater (2013) PNAS
Peck, Seinfeld, Aglioti, Slater (2013) Consc. & Cogn

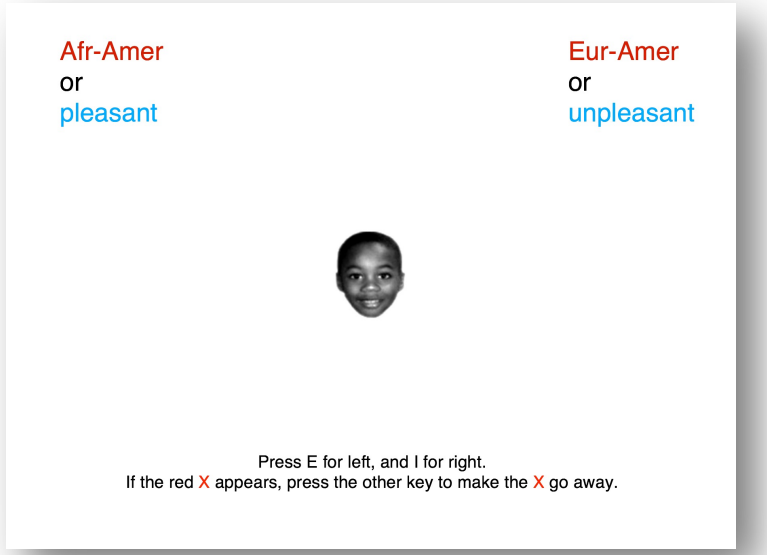
Note

Implicit Association Test (IAT)

If ‘Black’ are faces paired with negative words and ‘White’ faces with positive words faster than the other way around, this shows an ***implicit*** bias.

Note this does not mean that the person is prejudiced but reflects ***implicit*** bias (which may be socially determined)

[See https://implicit.harvard.edu/implicit/demo/](https://implicit.harvard.edu/implicit/demo/)

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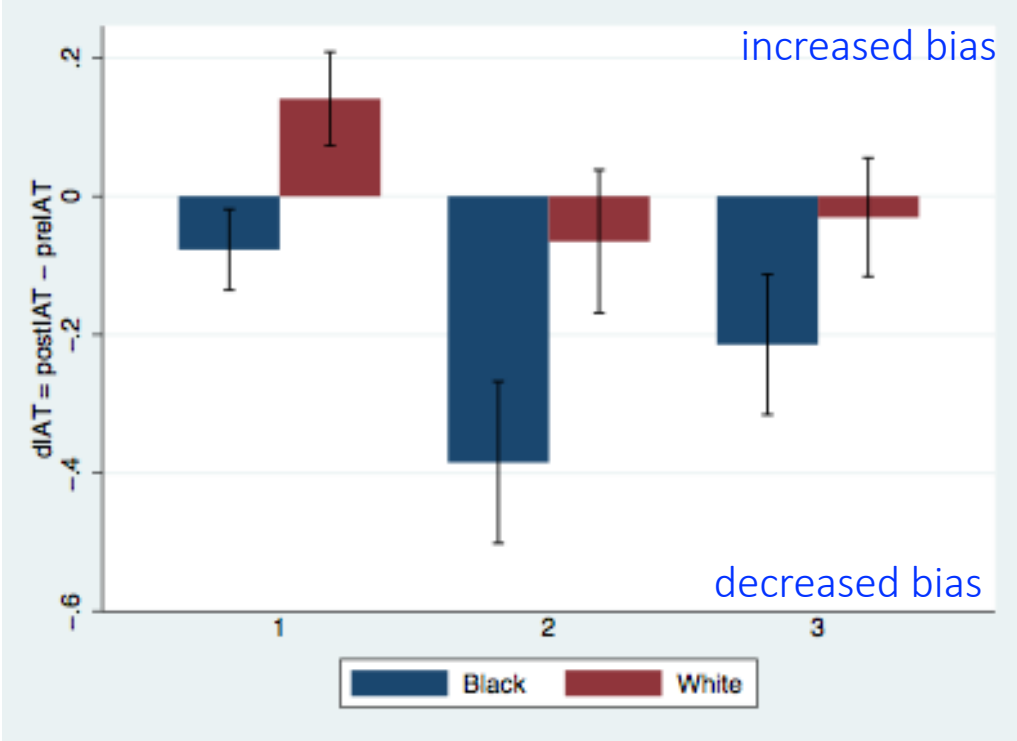
Repetition study - embodiment of White people in Black body reduces implicit bias?

- Between Groups Design: 3 groups
  - 1, 2, or 3 exposures, each separated by 3 days
- IAT measured 1 week before 1st exposure
- IAT measured 1 week after last exposure

- Diminution lasts at least 1 week after the end of the exposure
- One exposure is sufficient to observe this effect

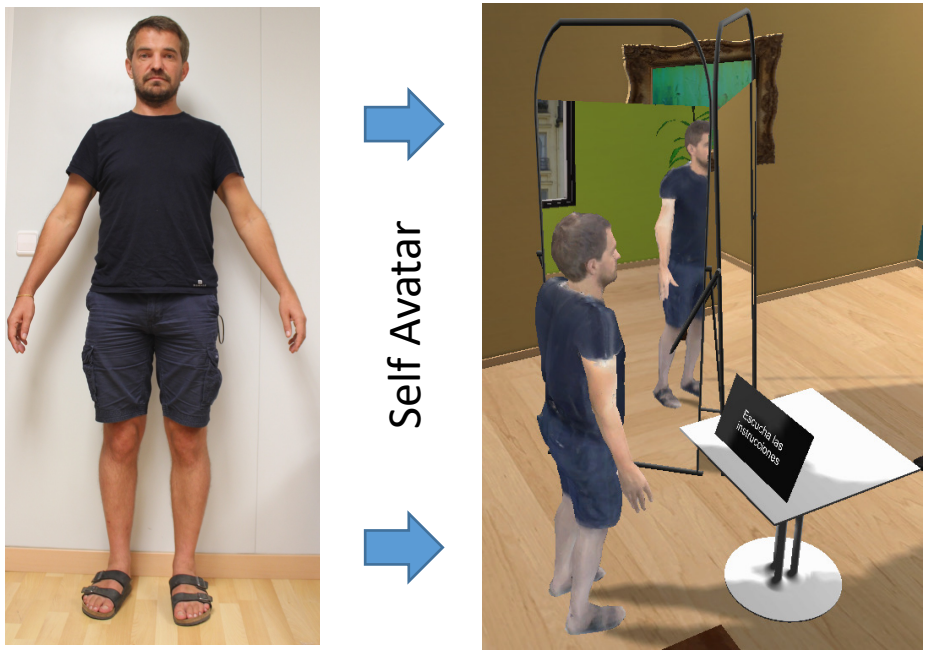
Change in IAT (N = 89)



Banakou, Parasuram D, Slater (2016) Front. Human Neuroscience

Self Counselling

Basic idea: talking with yourself as if with another person could be helpful for personal problem solving.



Osimo, S. A., Pizarro, R., Spanlang, B., & Slater, M. (2015). Scientific Reports.

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Conversations between Self and Self as **Sigmund Freud**

A Virtual Body Ownership Paradigm for Self Counselling

Potential social impact

Observation on violence of soccer supporters: identification with the victim (supporter of same club) leads subject to want to help

Application against domestic violence: rehabilitation of offenders by embodiment into a woman's body

Work led by Dr Mavi Sanchez-Vives with Justice Dept Catalonia

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Copresence

- The **“illusion of being there with the others, or virtual togetherness”**

- A corollary of the 3 illusions
  - PI : illusion to be in the same space as the others
  - Psi : take the interaction events as really occurring
  - Embodiment: avatar is needed for representing people in the scene

Slater, Banakou, Beacco, Gallego, Macia-Varela, Olivia (2022), A Separate Reality: An Update on Place Illusion and Plausibility in Virtual Reality, Front. Virtual Real, Volume 3 - 2022 | https://doi.org/10.3389/frvir.2022.914392

Copresence Questionnaires

- Tromp et al. (1998), Steed et al. (1999), Slater et al., (2000)

  There was a sense of being with other people rather than just experiencing computer images
  1 – Not at all Very much- 7

- Garau et al. (2001, 2003) – verbal interaction

  I had a real sense of personal contact with my conversation partner.
  I was very aware of my conversation partner

- Poeschl and Doering (2015) – social phobia exposure

  I had the feeling that I perceived other people in the virtual room.
  I felt alone in the virtual environment.

Steed, A., Slater, M., Sadagic, A., Bullock, A., and Tromp, J. (1999). Virtual Real. 1999, 112–115.
Garau, M., Slater, M., Vinayagamoorthy, V., Brogni, A., Steed, A., and Sasse, A. M. (2003). Proceedings of SIGCHI.
Poeschl, S., and Doering, N. (2015). Annu. Rev. Cybertherapy Telemedicine, 58–63

Synthesis

- Technologies for Virtual Reality Embodiment are available and effective
- Embodiment is robust to
  - Change of perspective
  - Movement distortion
  - Various appearance
  - Change of body
- Experiencing being in a different body impacts our perception and judgement of the world

Acknowledgements

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