

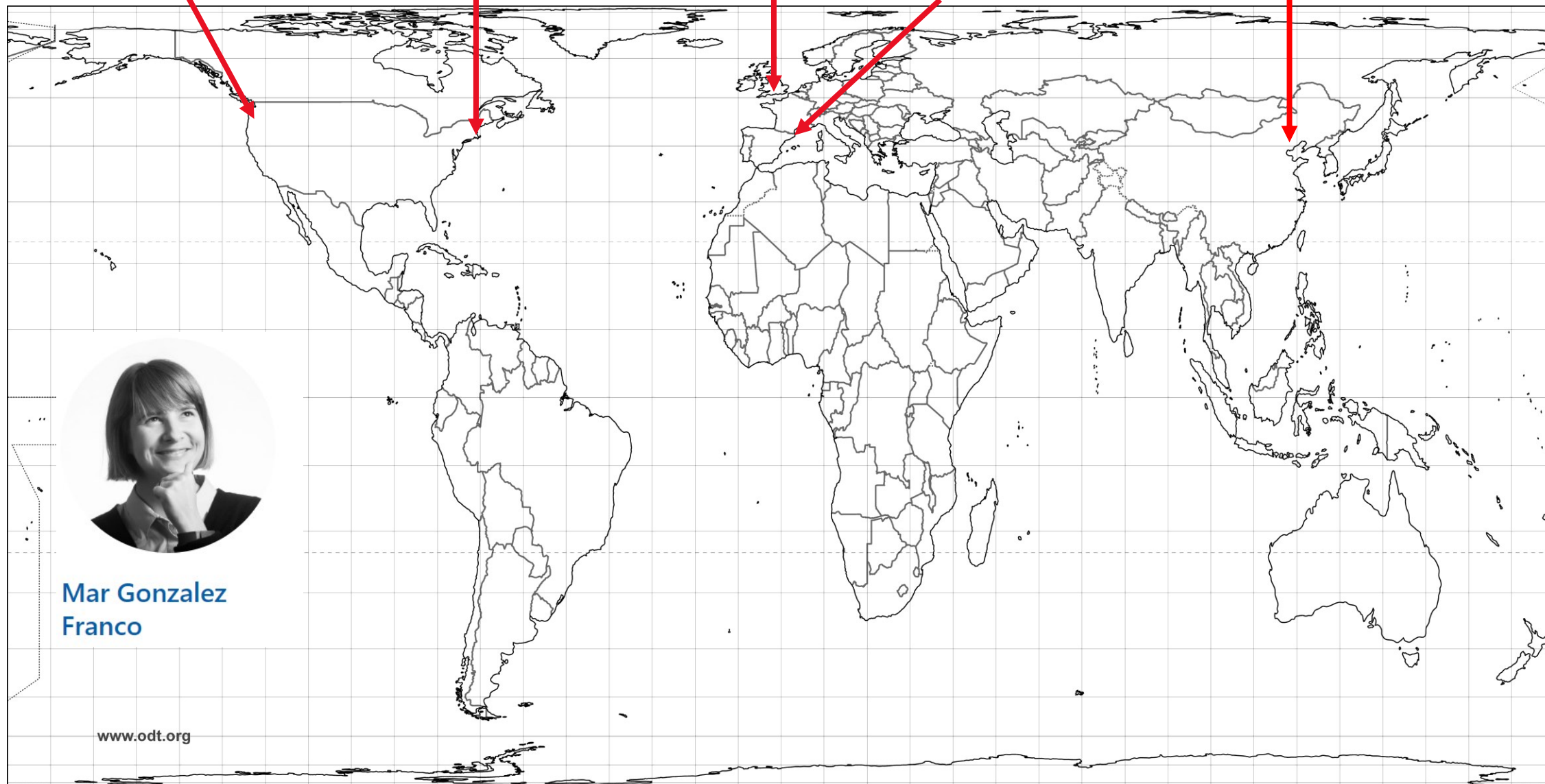
Impossible outside Virtual Reality

Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC)
Research Group

Microsoft Research
June 4th 2020





Mar Gonzalez
Franco

Impossible outside Virtual Reality

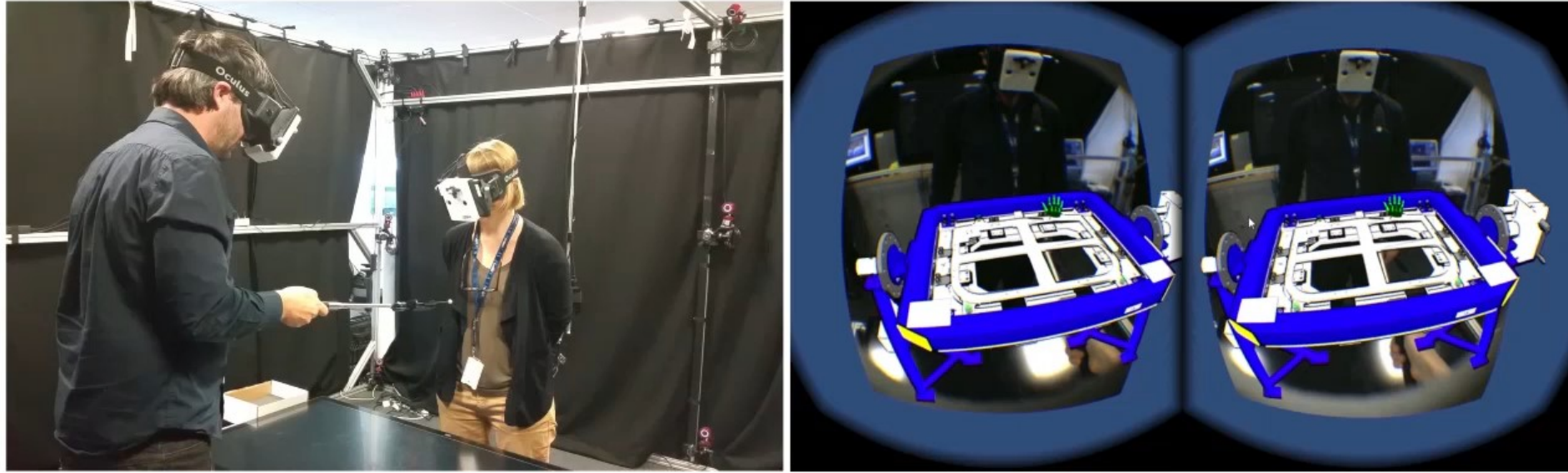
Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC)
Research Group

Microsoft Research
June 4th 2020



Abtahi, et al. (2019) I'm a giant: Walking in large virtual environments at high speed gains ACM CHI



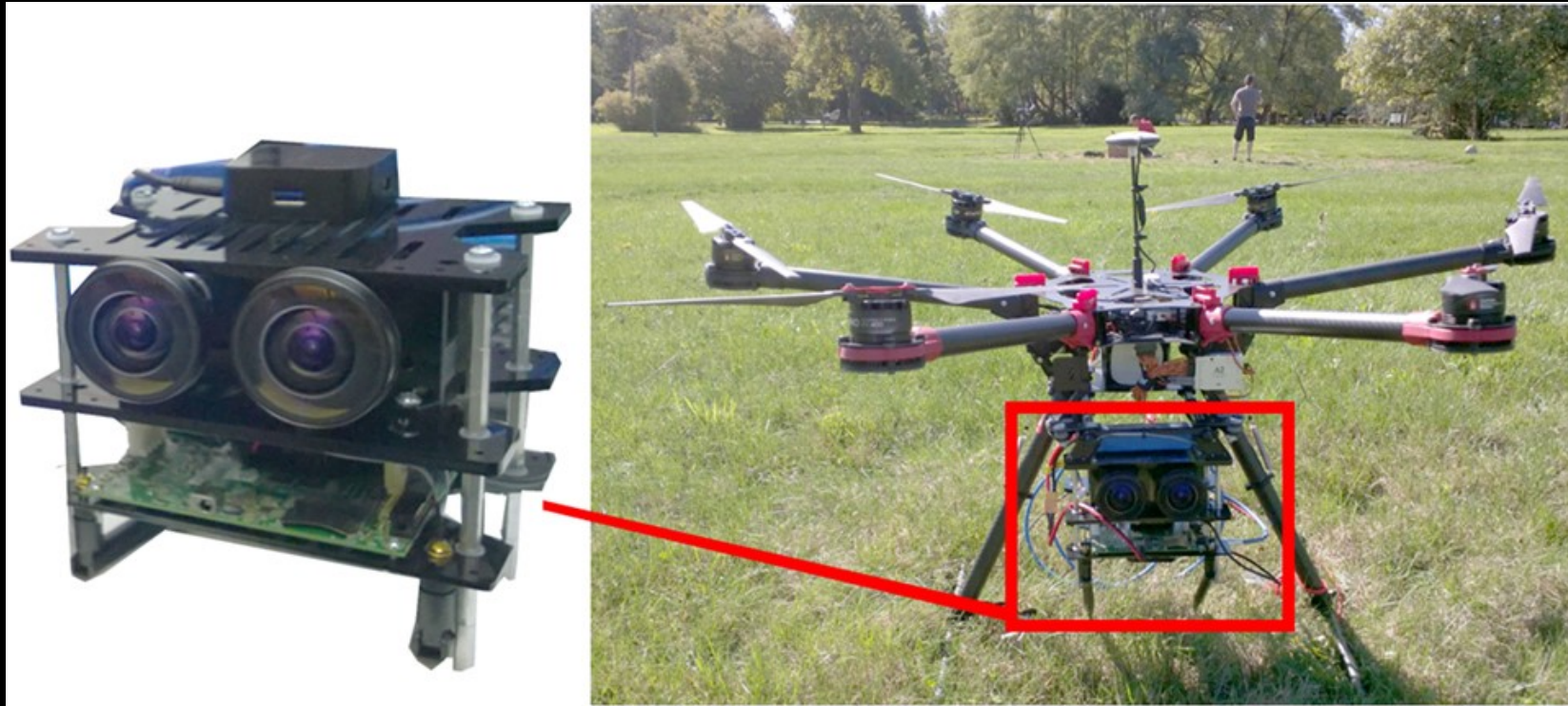
Immersive Mixed Reality for Manufacturing Training

M Gonzalez-Franco, R Pizarro, J Cermeron, K Li, J Thorn,
W Hutabarat, A Tiwari, P Bermell-Garcia

AIRBUS
GROUP

Gonzalez-Franco, Mar, et al. 2017 "Immersive mixed reality for manufacturing training." *Frontiers in Robotics and AI* 4: 3.

FPV Drone navigation in VR



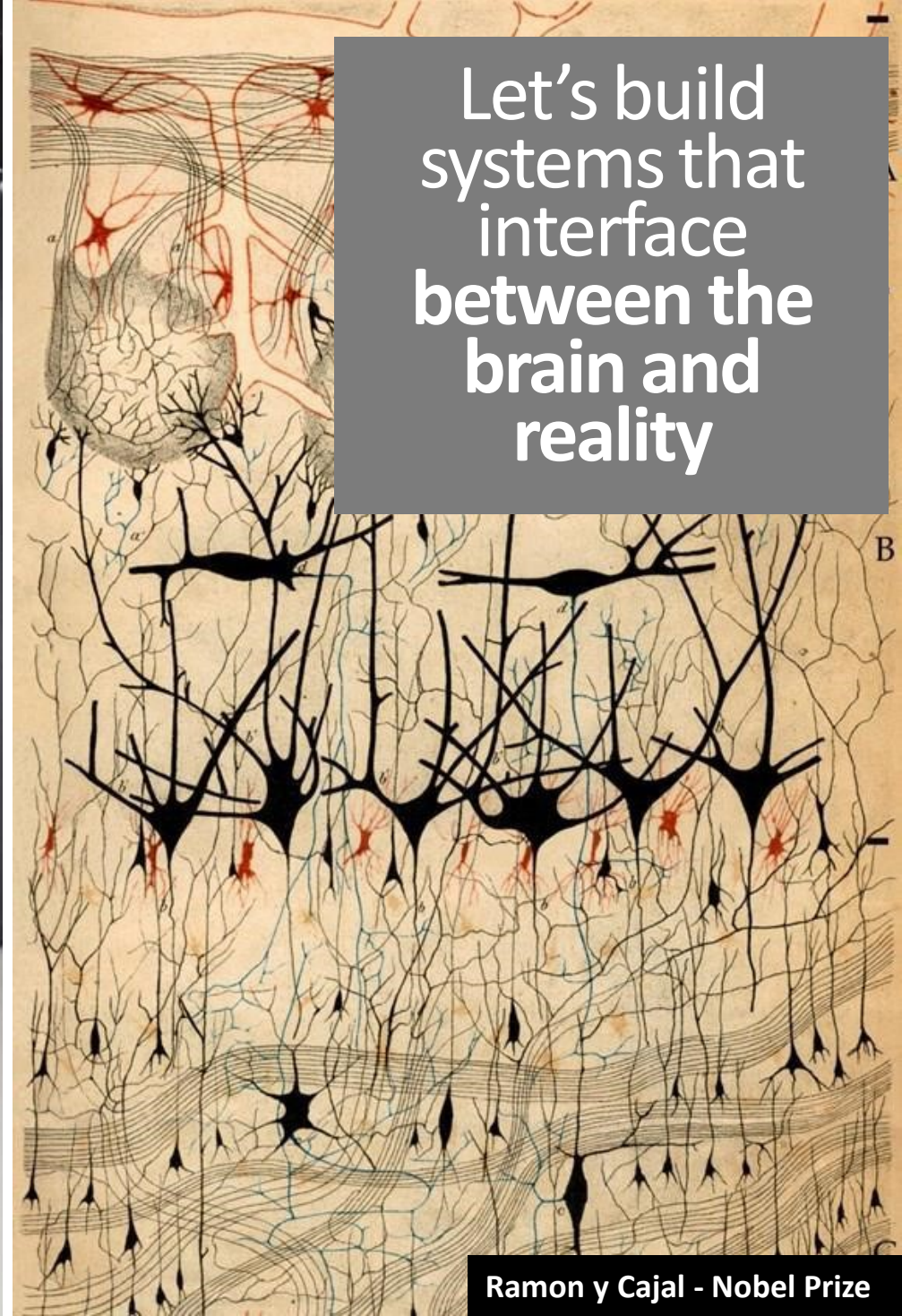
Modified DJI S900 hexacopter (right) with the stereo camera and the Tegra TK1 embedded board attached (left). 28–30 frames per second encoding speed at 1,600 × 1,080 resolution per camera/eye



Let's build
systems that
interface with
reality

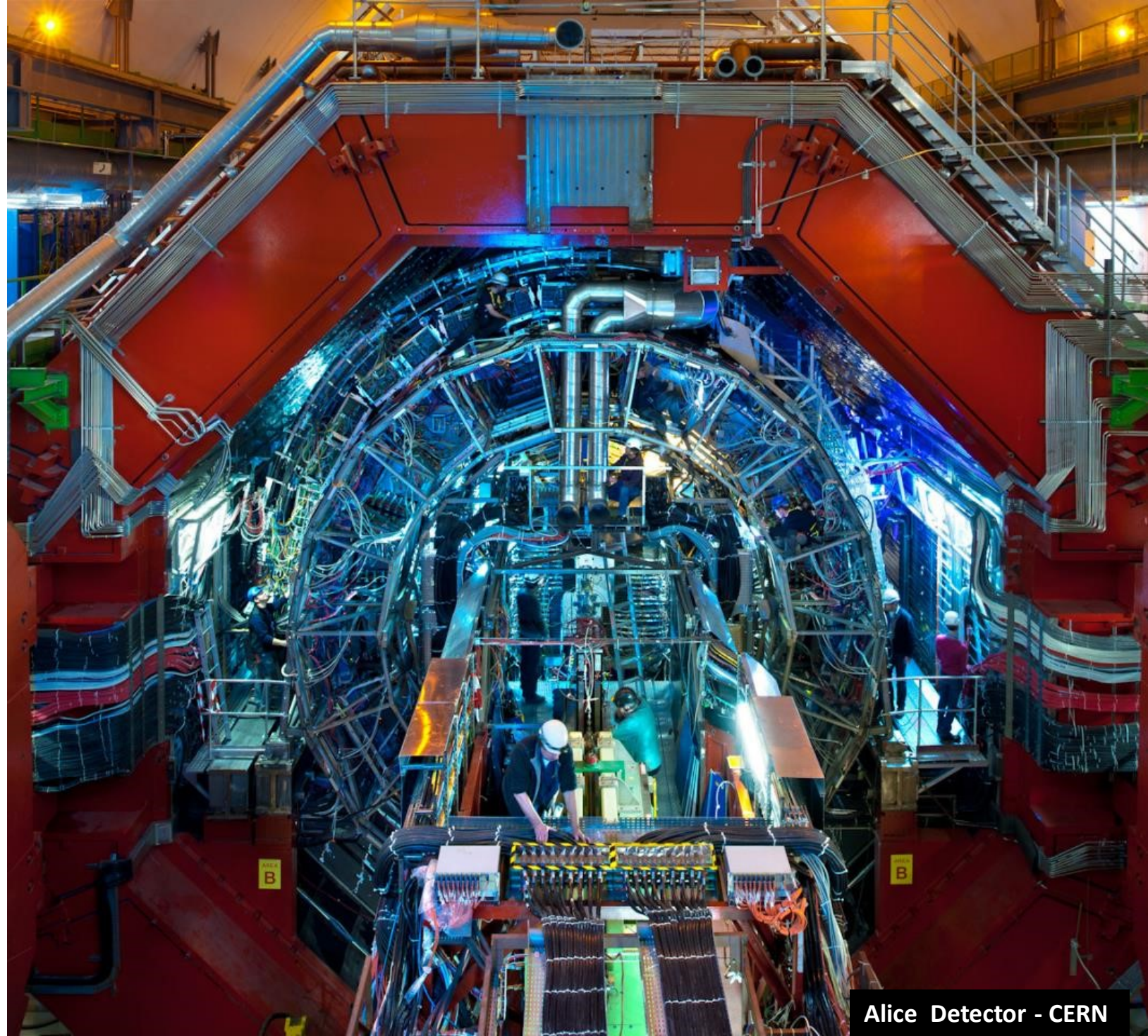


Let's build
systems that
interface
between the
brain and
reality



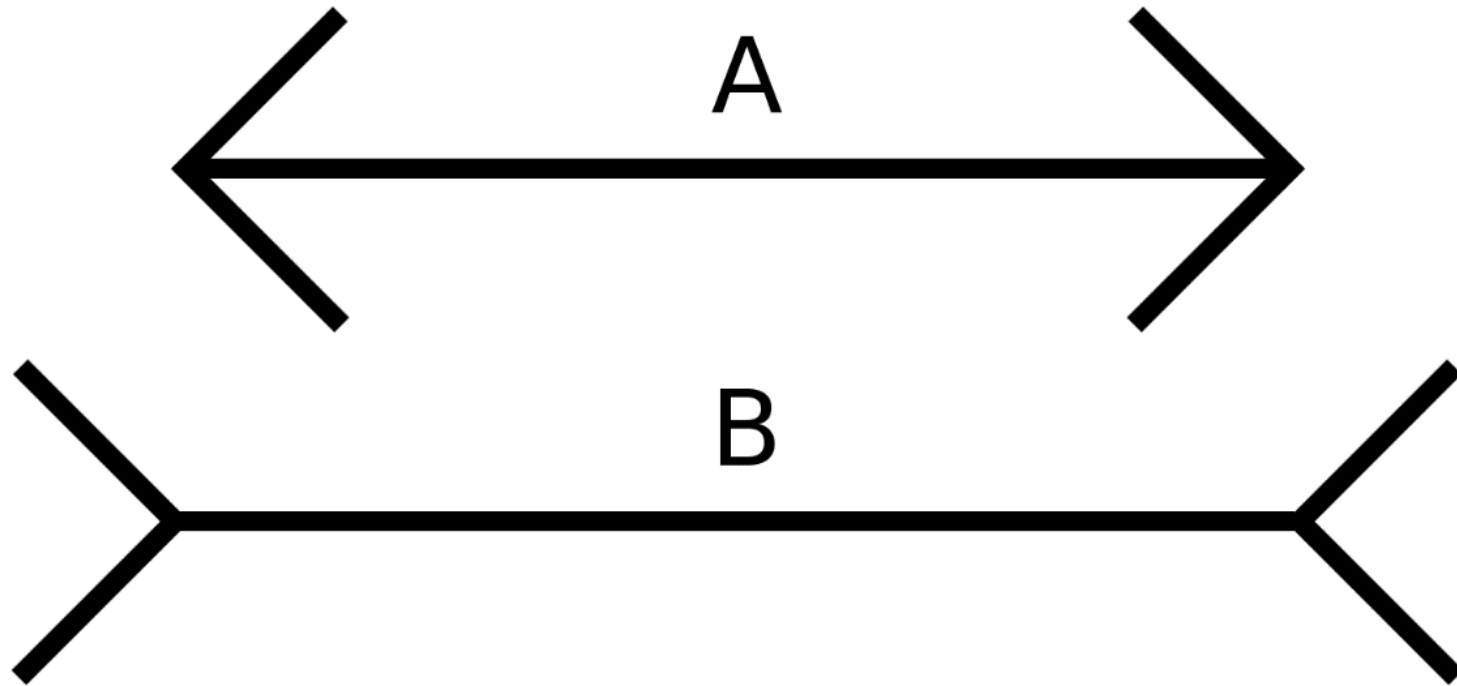
Complex system

- Dynamic
- Priors + Pathways
- Errors + Corrections
- Concurrent stimuli of different type

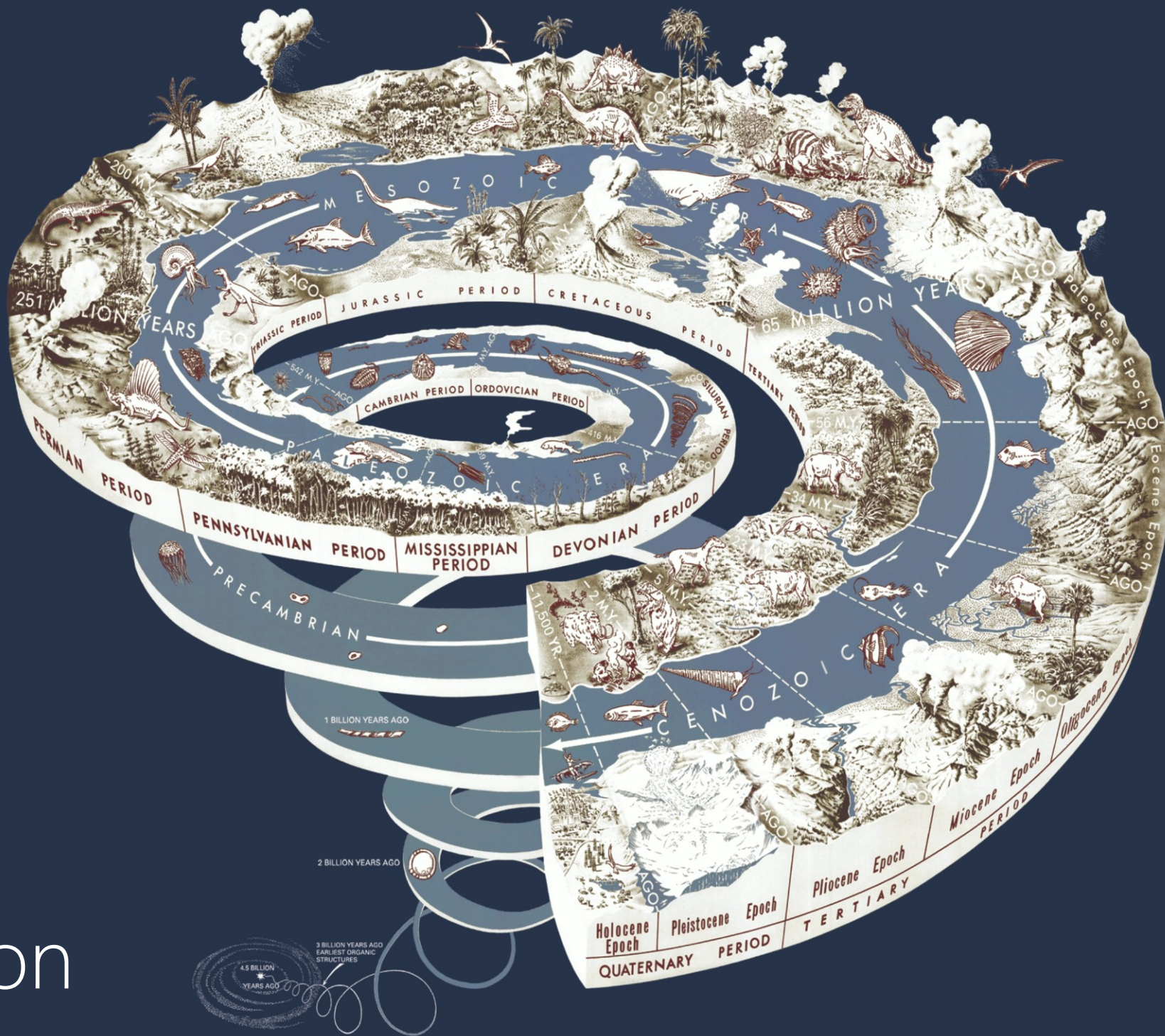


Alice Detector - CERN

Trick the brain



Perception





Sensory Dominance

Cortical homunculus by Sharon Price-James

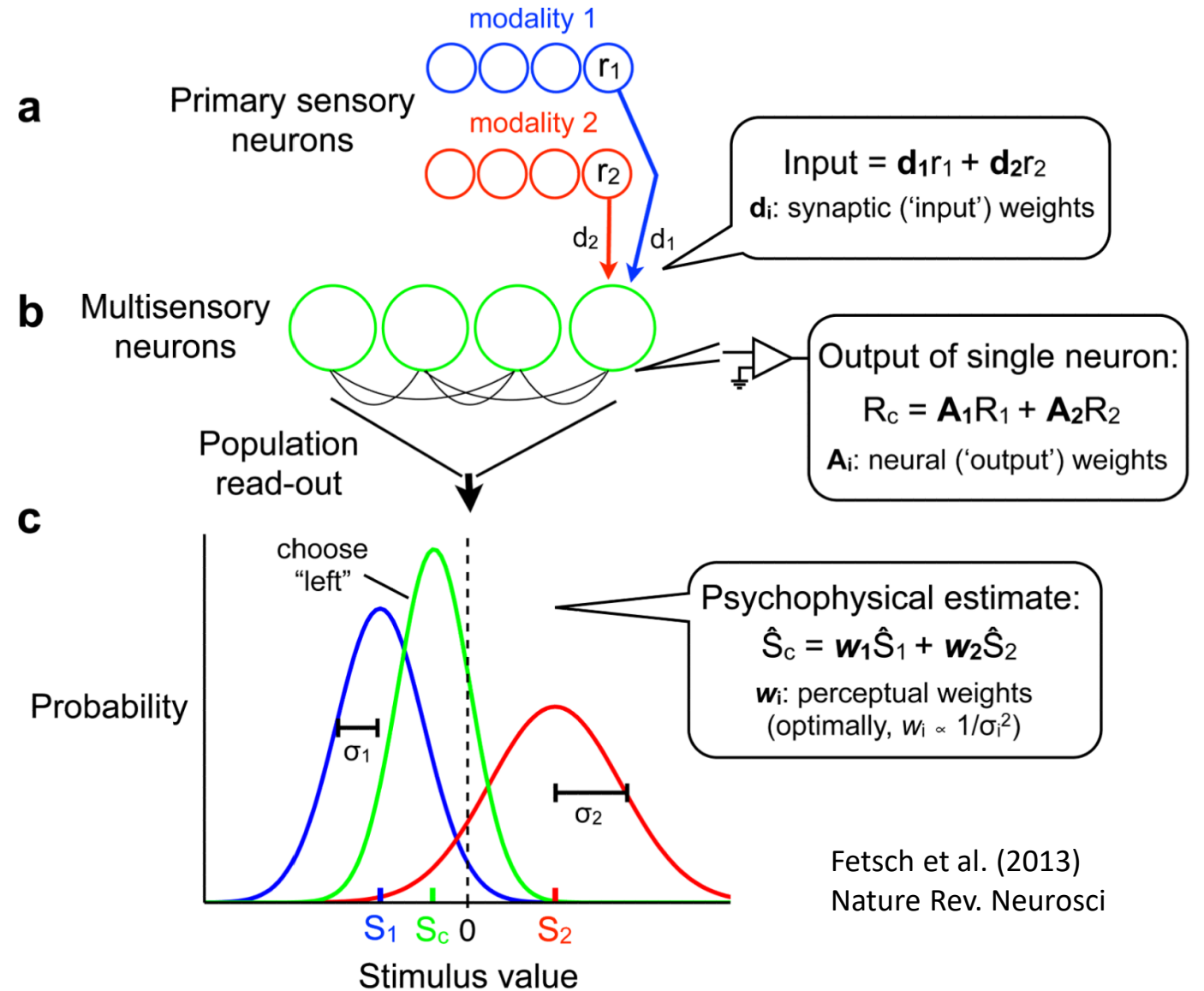


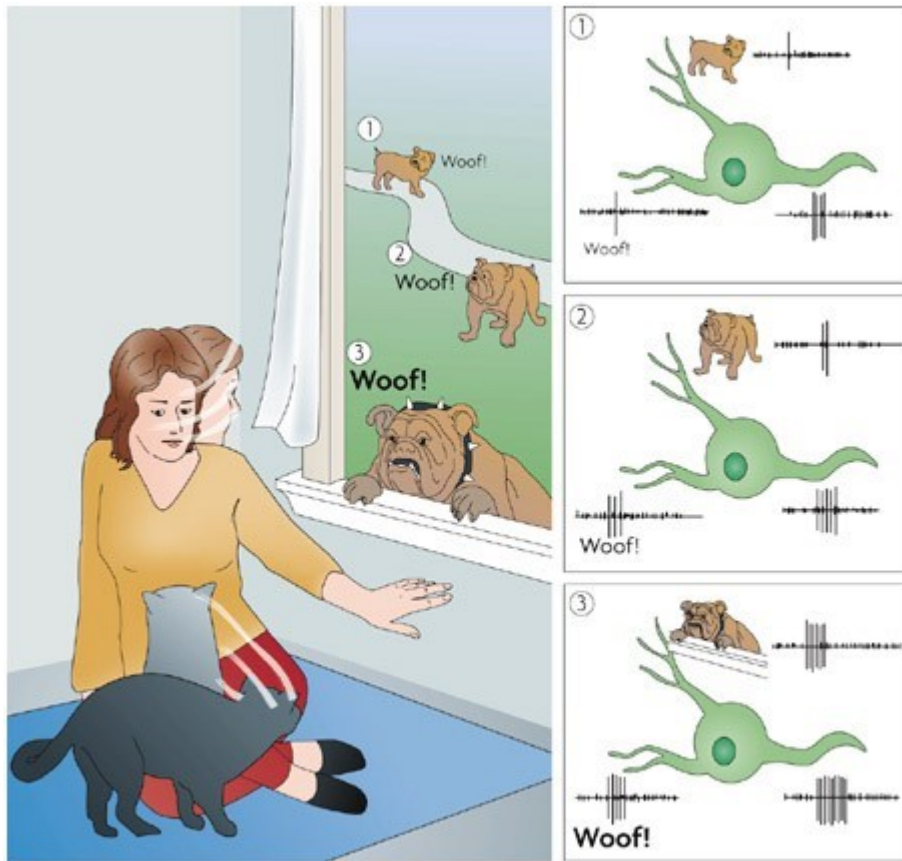
Sensory Expertise



Multisensory Integration

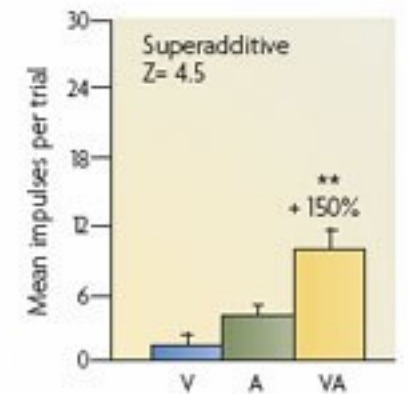
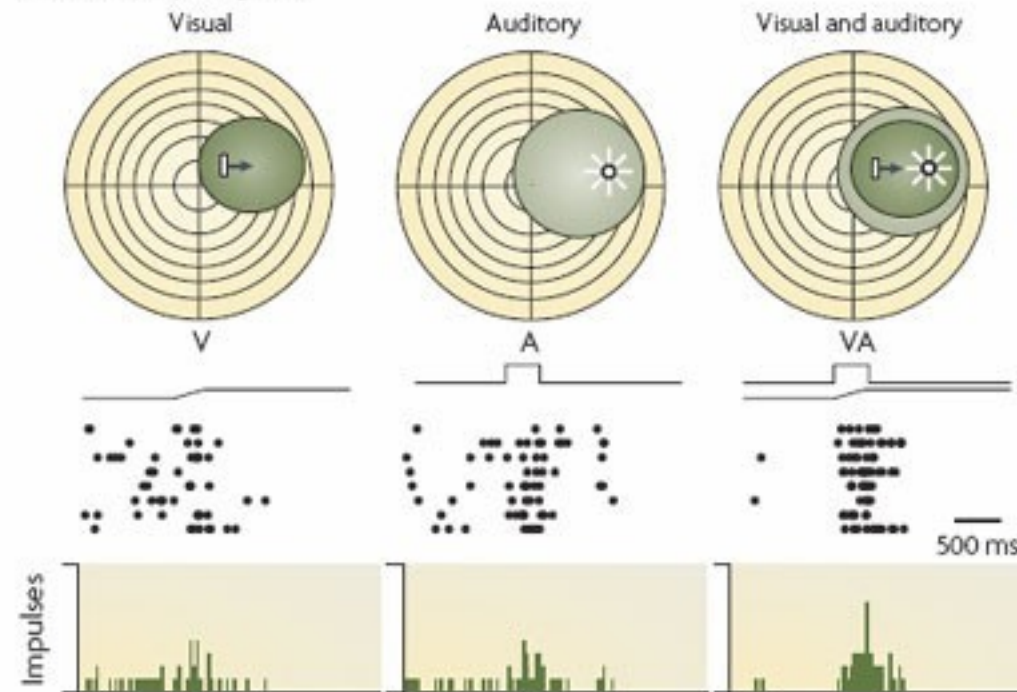
Multisensory Integration





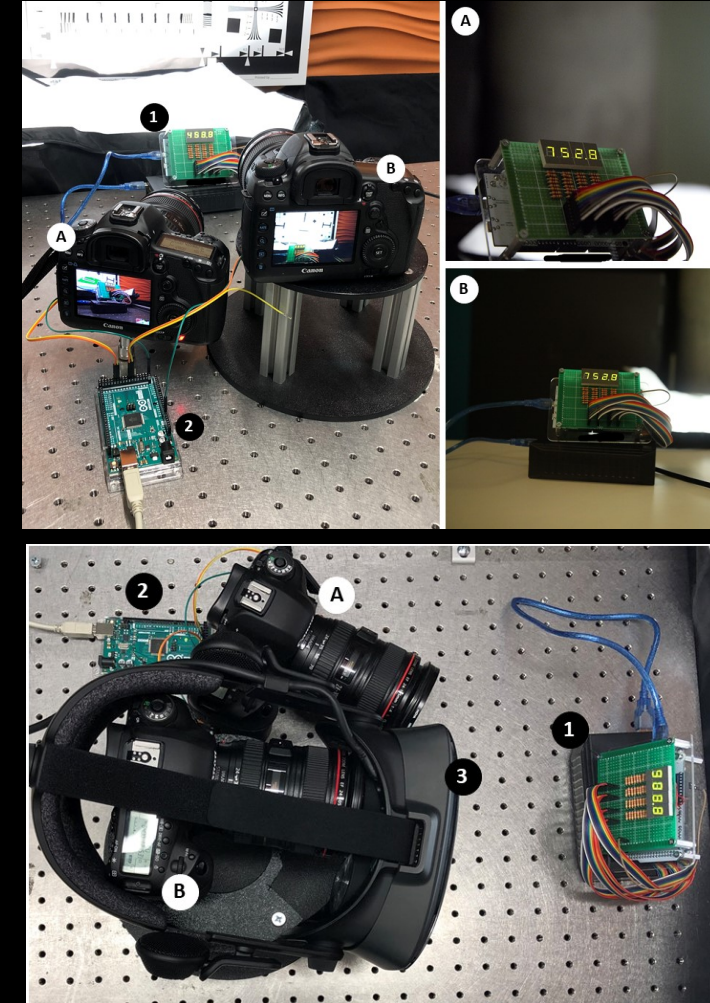
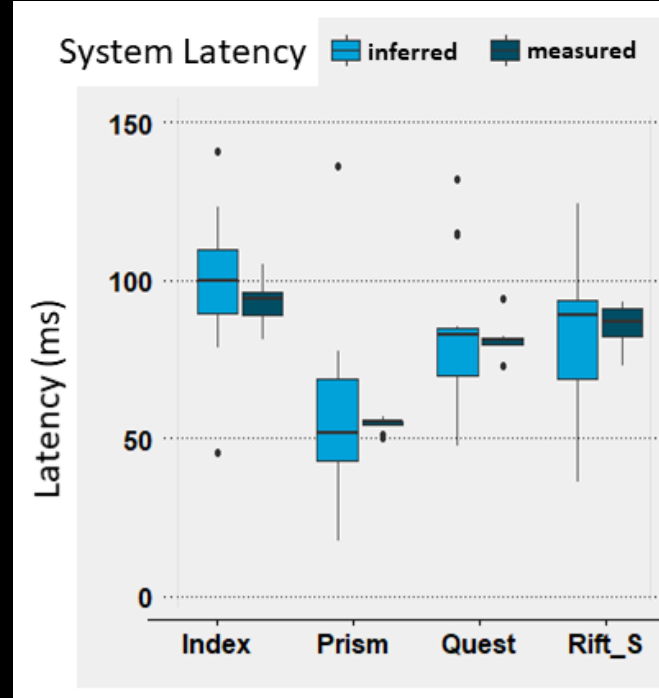
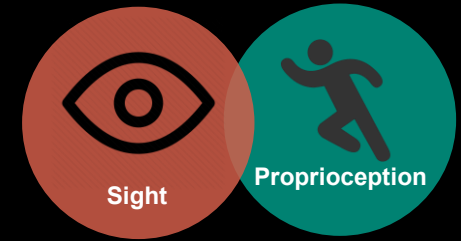
Nature Reviews | Neuroscience

a Multisensory integration

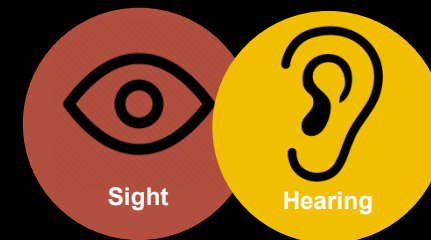


Stein, Barry E., and Terrence R. Stanford. "Multisensory integration: current issues from the perspective of the single neuron." *Nature Reviews Neuroscience* 9.4 (2008): 255-266.

Cognitive Latency to measure VR system latency



Visual dominance + 3D audio



Coordinate response measure (CRM) corpus



LIP CONDITIONS

Synch 14 % errors

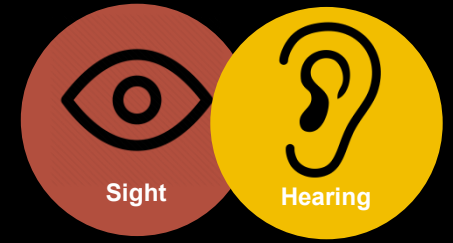
Asynch 30% errors

NoLips 20% errors

Gonzalez-Franco, et al. 2017 "Concurrent talking in immersive virtual reality: on the dominance of visual speech cues." *Scientific reports* 7.1: 3817.

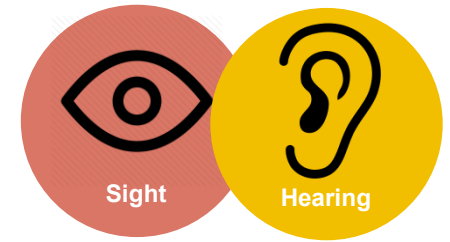
Gonzalez-Franco, M. (2017) Corpus Data for: "Hearing lips: on the dominance of vision in immersive cocktail party phenomena" *Harvard Dataverse*, doi:[10.7910/DVN/KHXBBB](https://doi.org/10.7910/DVN/KHXBBB) .

Visual dominance Recalibration of 3D Audio



Generic HRTF might be enough in Virtual Reality.
Improving source localization through
cross-modal plasticity

C C. Berger, M Gonzalez-Franco*, A Tajadura-Jiménez
D Florencio, Z Zhang

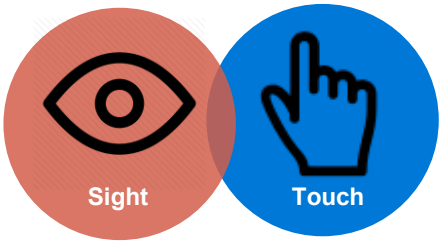


Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues

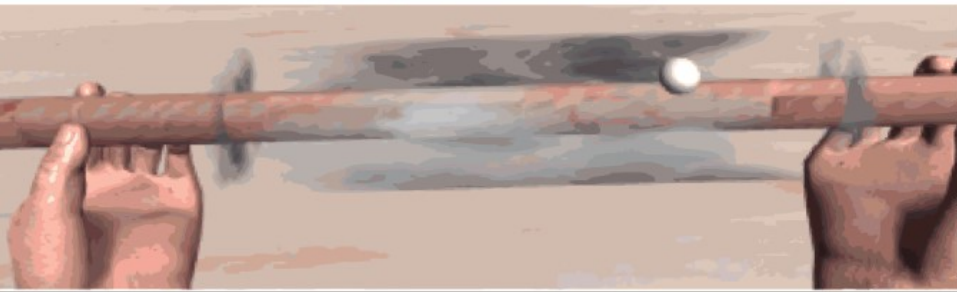
Gregory D. Clemenson, Antonella Maselli, Alex Fiannaca, Amos Miller, Mar Gonzalez-Franco*

Microsoft Research, margon@microsoft.com

Clemenson, Maselli, Fiannaca, Miller, Gonzalez-Franco, (in review). **Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues.** *PlosOne*



Using Voice Coil Actuators (VCA)



 Tactile Cue

 Perceived haptic location

we can stimulate different strengths

The Uncanny Valley of Haptics

C C Berger, M Gonzalez-Franco*, E Ofek, K Hinckley
Microsoft Research



Our exploration with controllers in VR
brings to the conclusion that we can reach an uncanny valley of haptics

SCIENCE ROBOTICS | FOCUS

HUMAN-ROBOT INTERACTION

The uncanny valley of haptics

Christopher C. Berger,^{*†} Mar Gonzalez-Franco,^{†‡} Eyal Ofek, Ken Hinckley

During teleoperation and virtual reality experiences, enhanced haptic feedback incongruent with other sensory cues can reduce subjective realism, producing an uncanny valley of haptics.

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American Association
for the Advancement
of Science. No claim
to original U.S.
Government Works

Observations

SCIENTIFIC
AMERICAN

If (Virtual) Reality Feels Almost Right, It's Exactly Wrong

How adding touch to VR can lead to an “uncanny valley” of sensations—and what we can do about it

By Mar Gonzalez-Franco, Christopher C Berger and Ken Hinckley on April 19, 2018

Let's build
systems that
interface with
reality

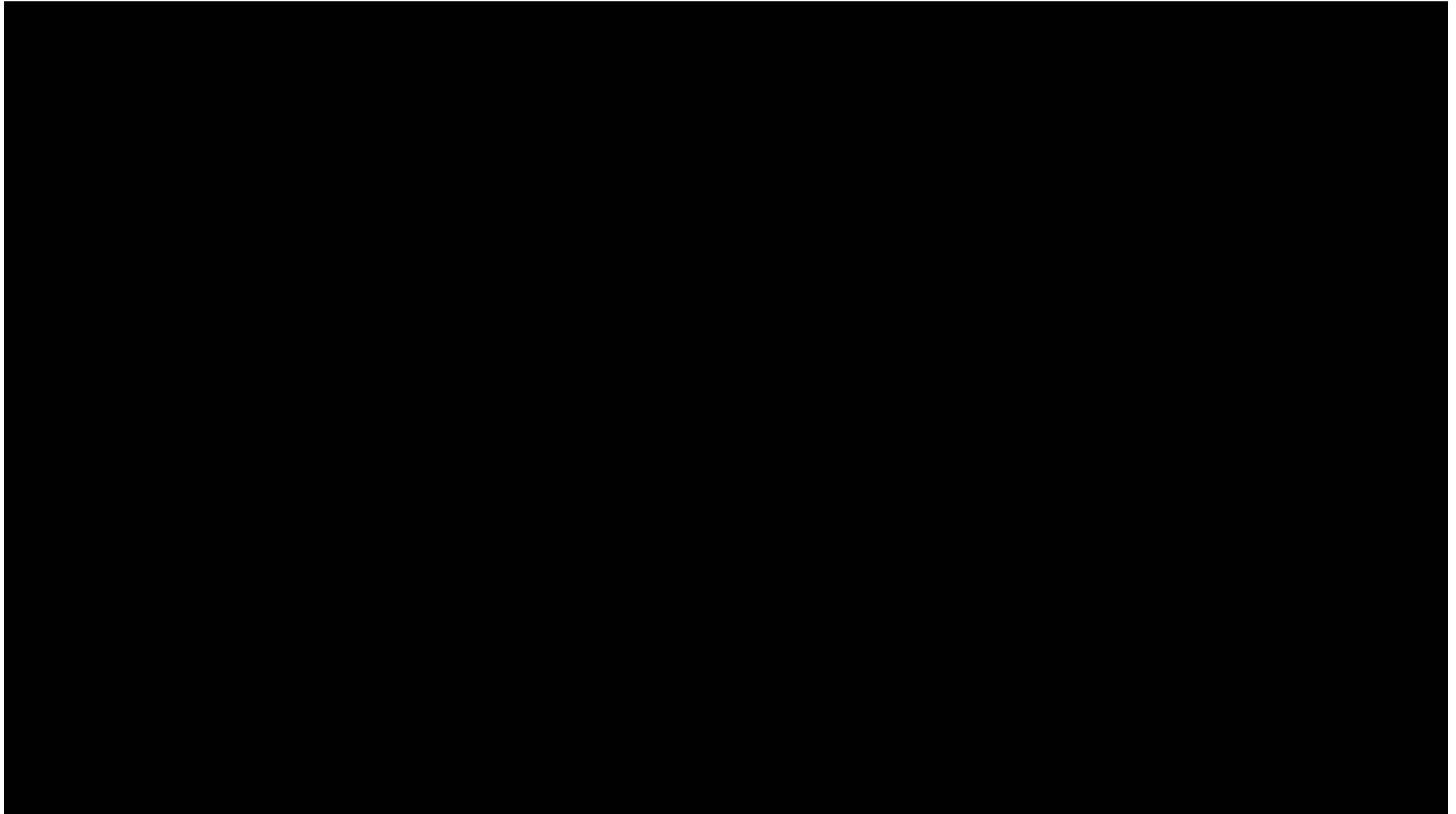


Let's build systems
that interface
between the brain
and reality



Let's build
systems that
are impossible
in reality





McDuff, Hurter & **Gonzalez-Franco** (2017)

“Pulse and Vital Sign measurement in mixed reality using a HoloLens” ACM VRST

Mise-Unseen

using eye tracking to hide virtual reality scene changes in plain sight

sebastian marwecki^{1,2}, andrew d. wilson¹, eyal ofek¹, mar gonzalez franco¹, christian holz¹

¹microsoft research, redmond, wa, usa, ²hasso plattner institute, university of potsdam, germany



Microsoft | Research

Feeling touch outside of the body



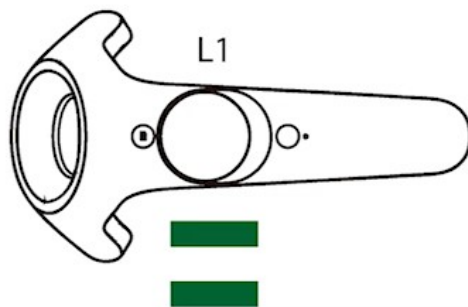
Geldard & Sherrick (1972). *Science*

We reproduce the cutaneous rabbit illusion in VR

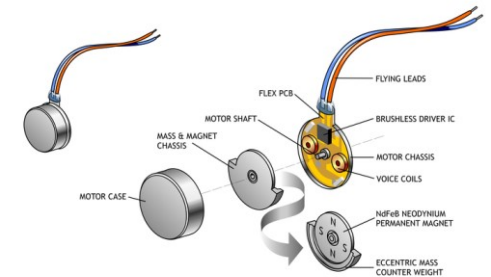
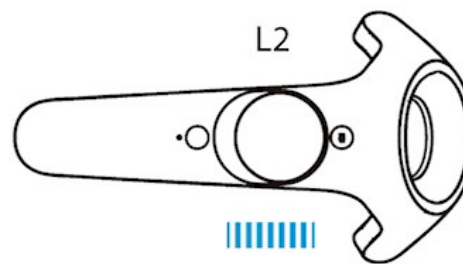


Berger, C. C., & Gonzalez-Franco, M. (2018). **Expanding the sense of touch outside the body.** In *Proceedings of the 15th ACM Symposium on Applied Perception* (p. 10). ACM.



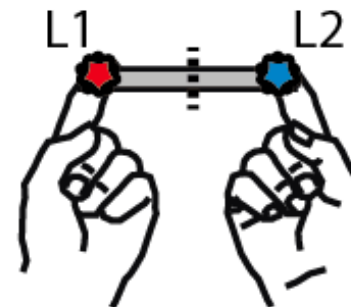


REAL TAPS

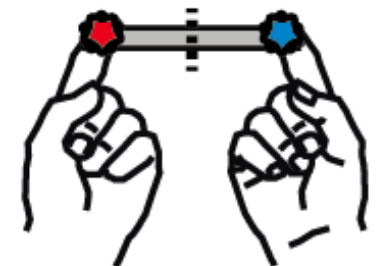


Motor Coin Vibrator

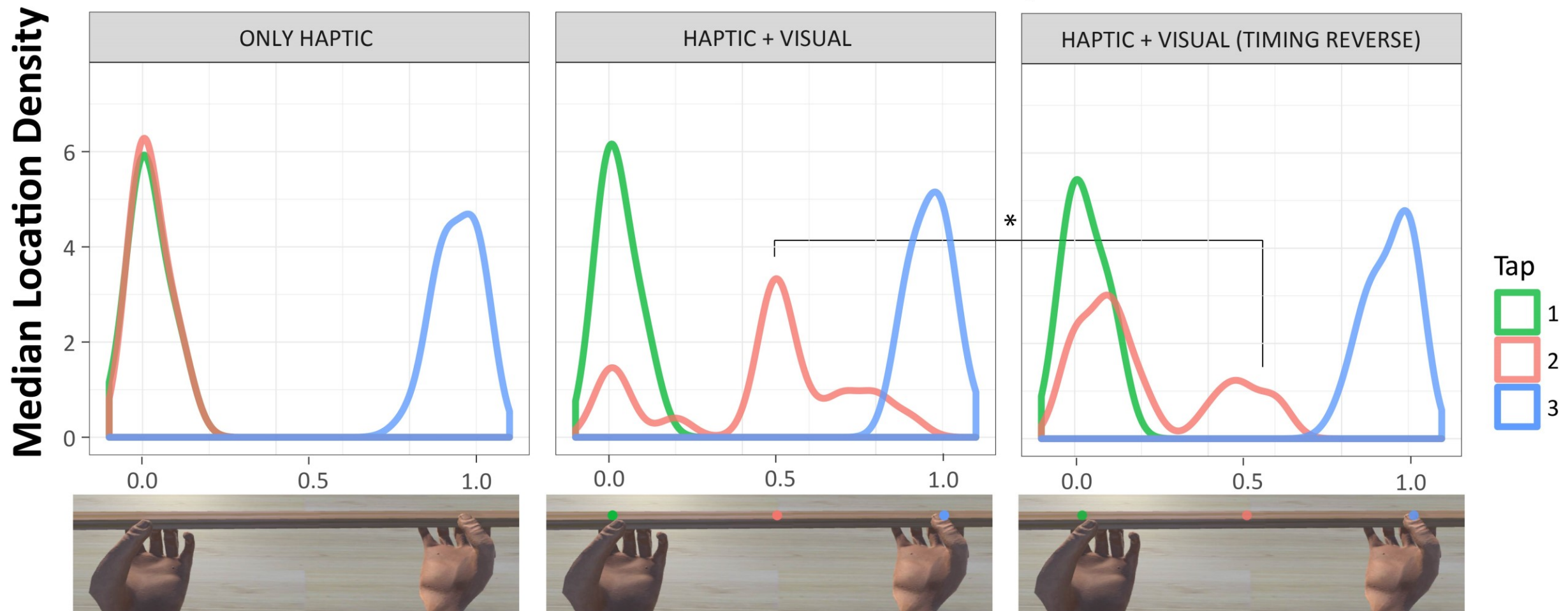
equal tactile
strenght



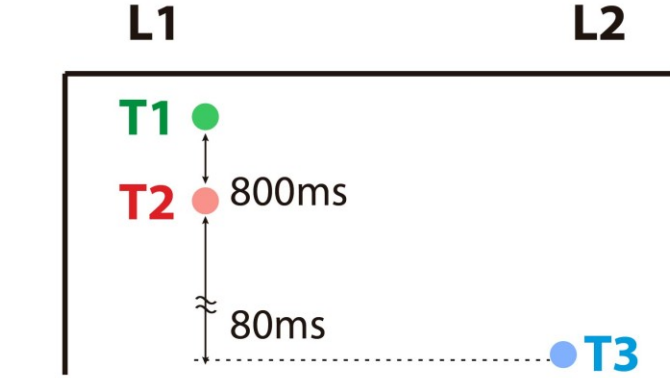
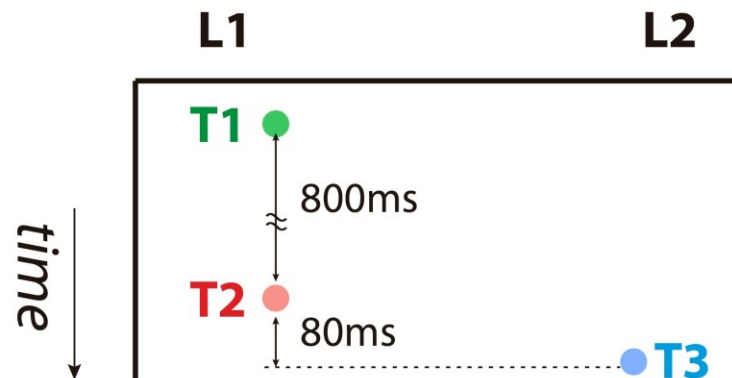
Red = Blue



Perceived Location of the Tap



* Significant difference
 $p < 0.01$



Delusions of the perceptual system

- Our brain will believe the stimuli to be real when exposed to congruent inputs
- Under correct stimulation we can affect our own body experience





Bodily illusions on avatars



Spanlang et al. (2014) *How to Build an Embodiment Lab: Achieving Body Representation Illusions in Virtual Reality* Frontiers in Robotics and AI

EVENTLab – Universitat de Barcelona

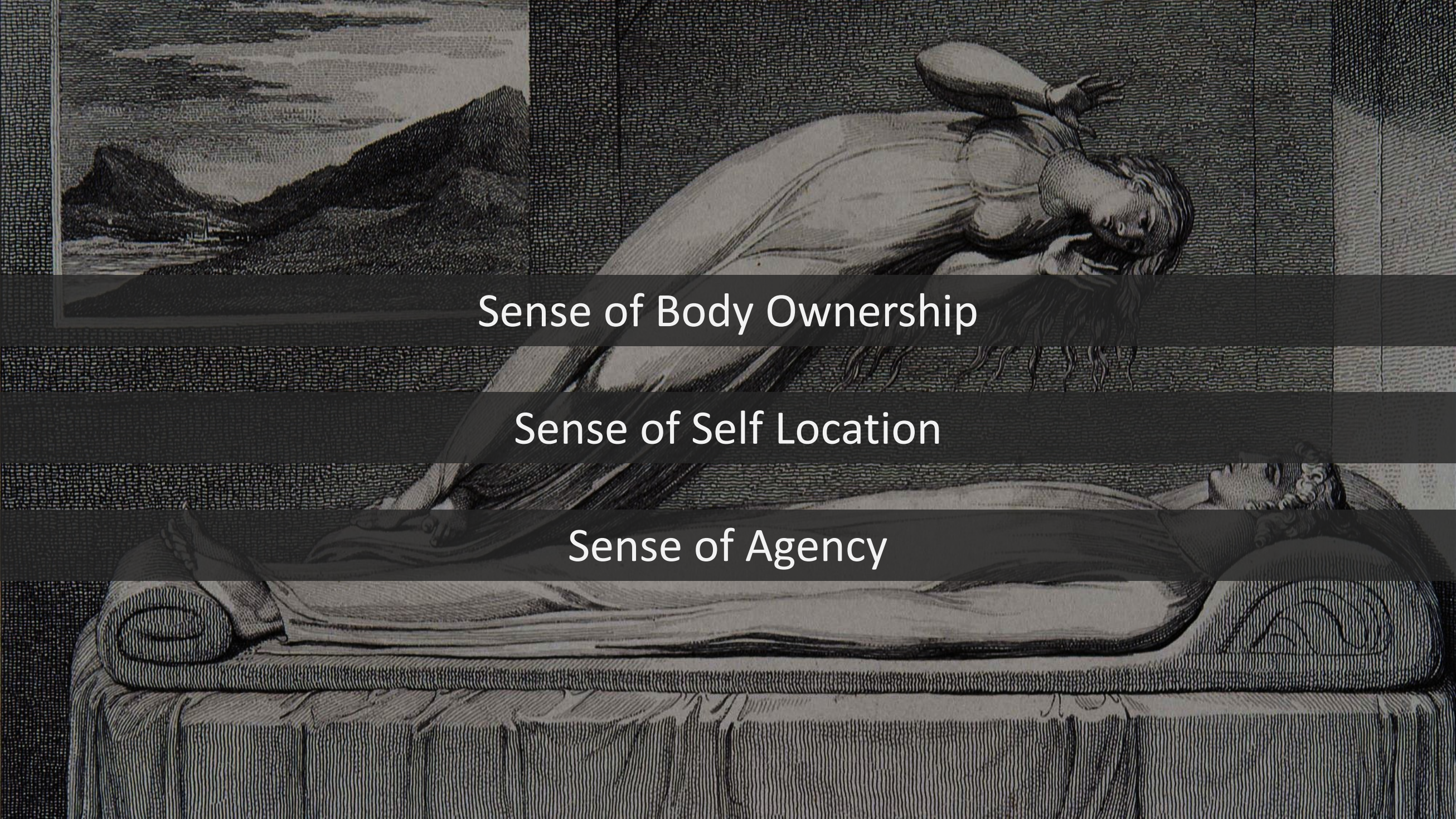
Background

Embodiment illusion

- Normally when we have direct control (agency) of the avatar we experience embodiment: “A 1 to 1 substitution of our body”.
- Research has shown that embodiment can alter motor behavior in different ways
- Is there a common mechanism that underlies some of these motor compensations?

[Slater et al 2010 Siggraph]



The background is a composite image. On the right, a woman in a long, flowing dress is shown from the waist up, looking down at her hands. On the left, there is a small rectangular inset showing a landscape with a body of water, a small boat, and a large, dark, rocky island or headland under a cloudy sky.

Sense of Body Ownership

Sense of Self Location

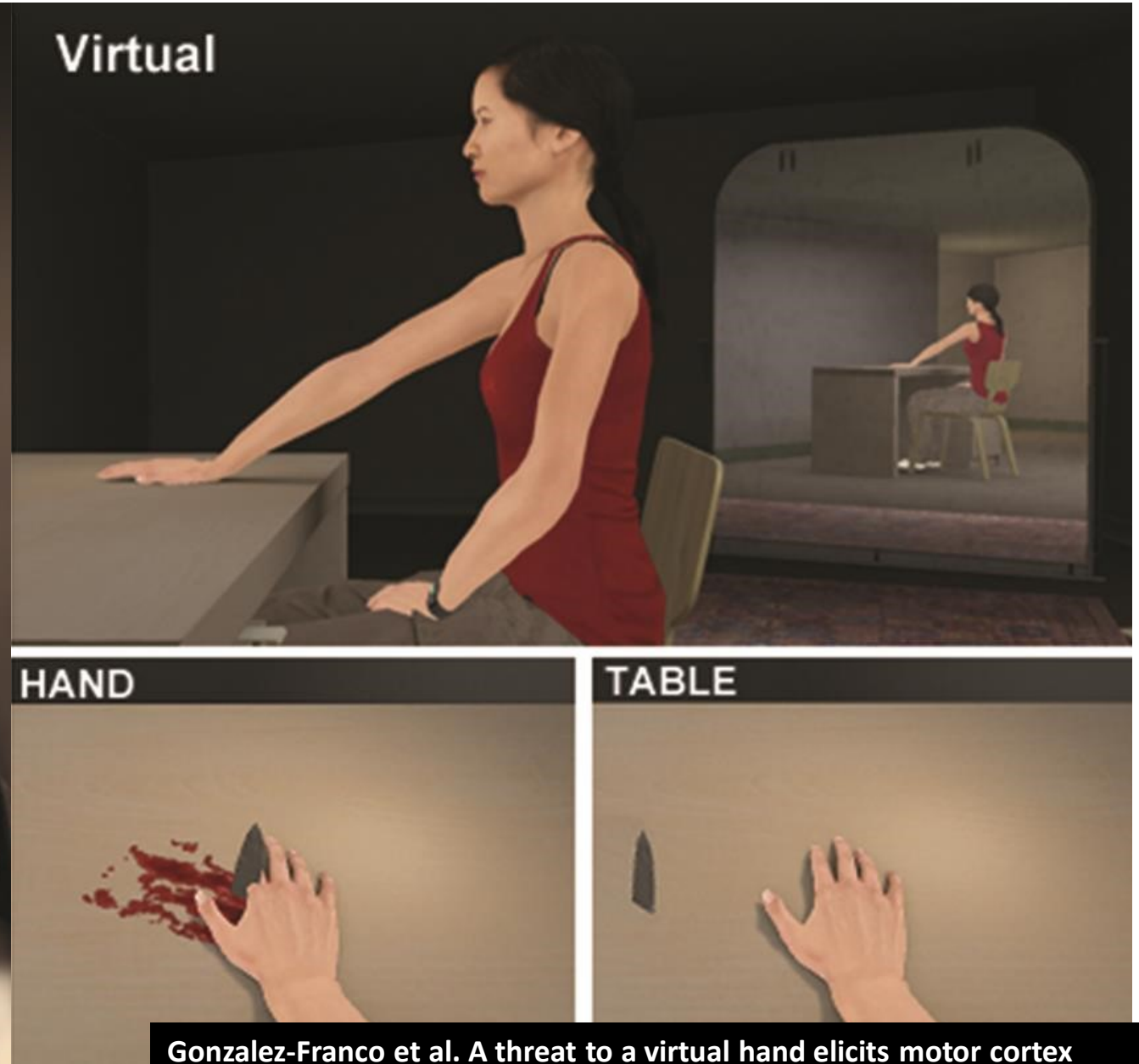
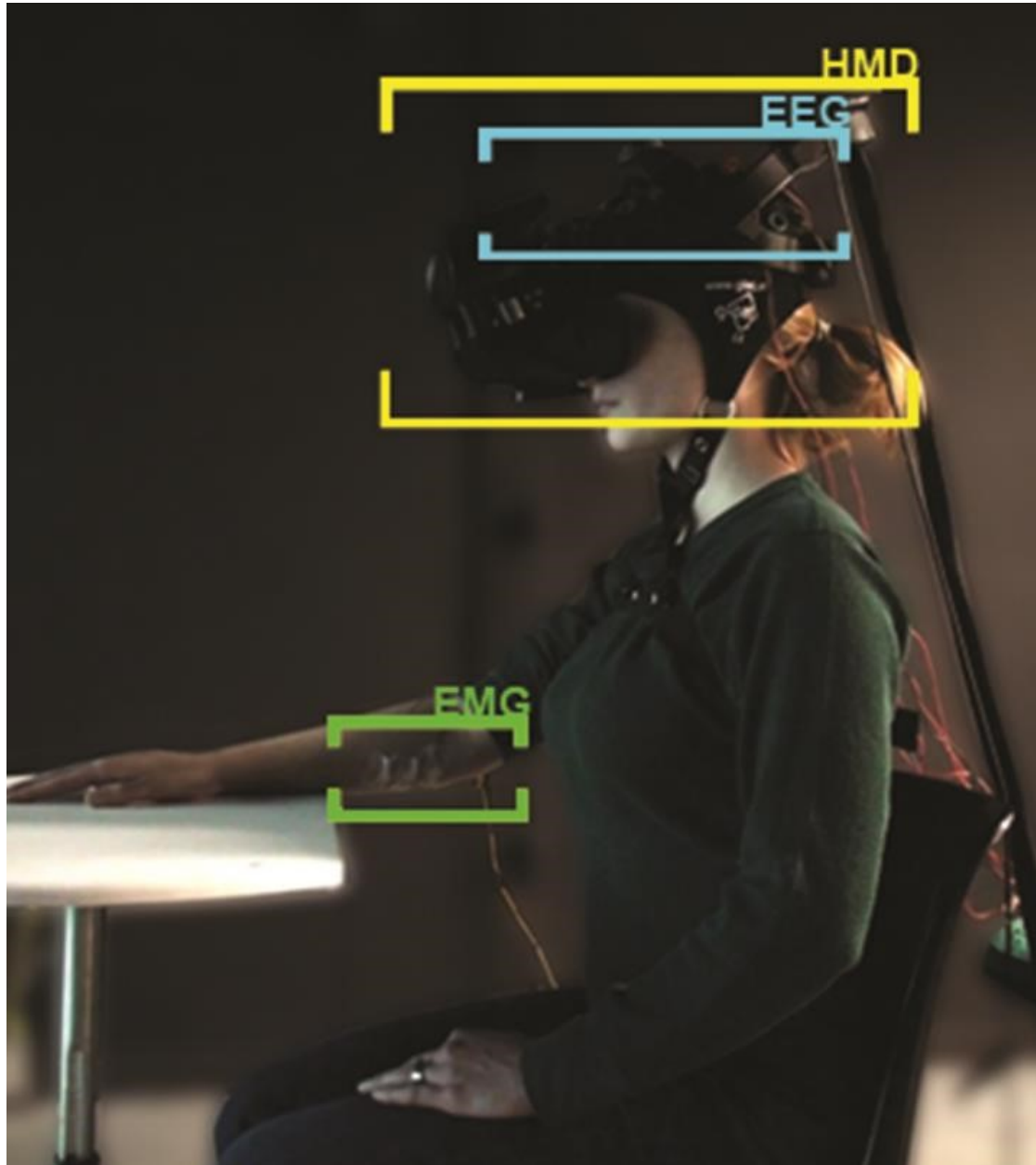
Sense of Agency

Sense of Body Ownership



Gonzalez-Franco et al. (2010) **The Contribution of Real-Time Mirror Reflections of Motor Actions on Virtual Body Ownership in an Immersive Virtual Environment** IEEE VR

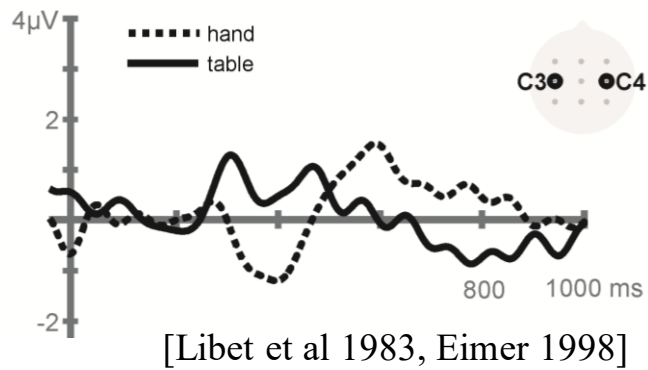
Sense of Body Ownership



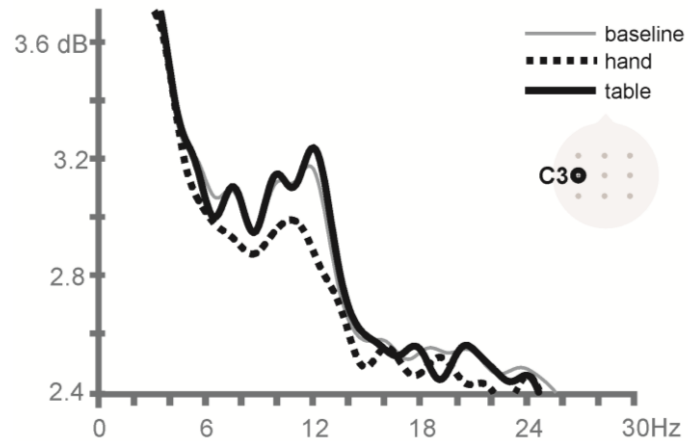
Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. *Experimental Brain Research* (2014)

A threat to the Virtual Body

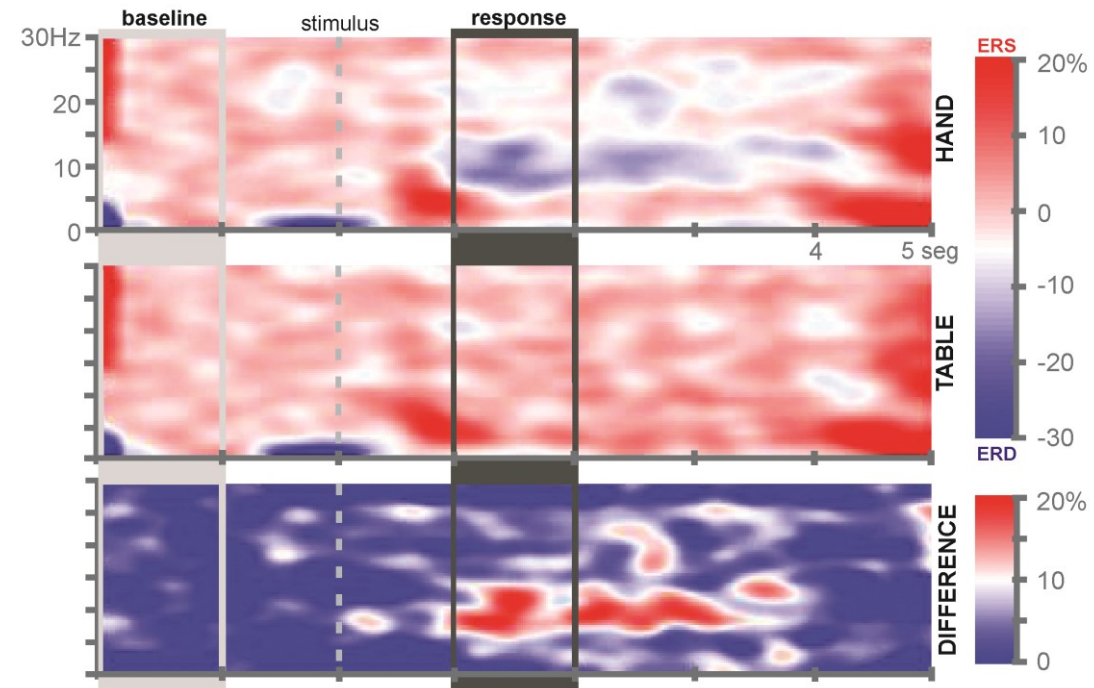
Readiness Potential C3-C4



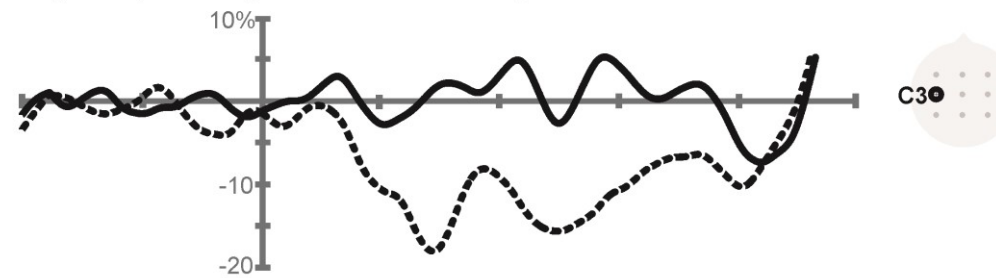
j) Short Time Power Spectra



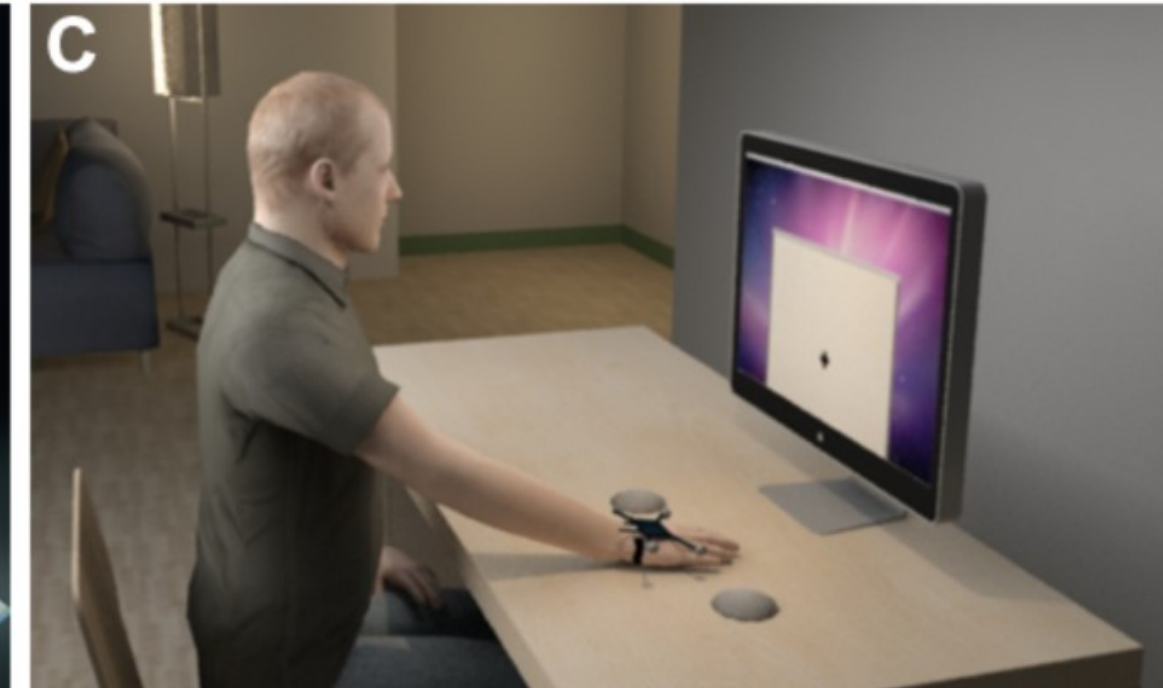
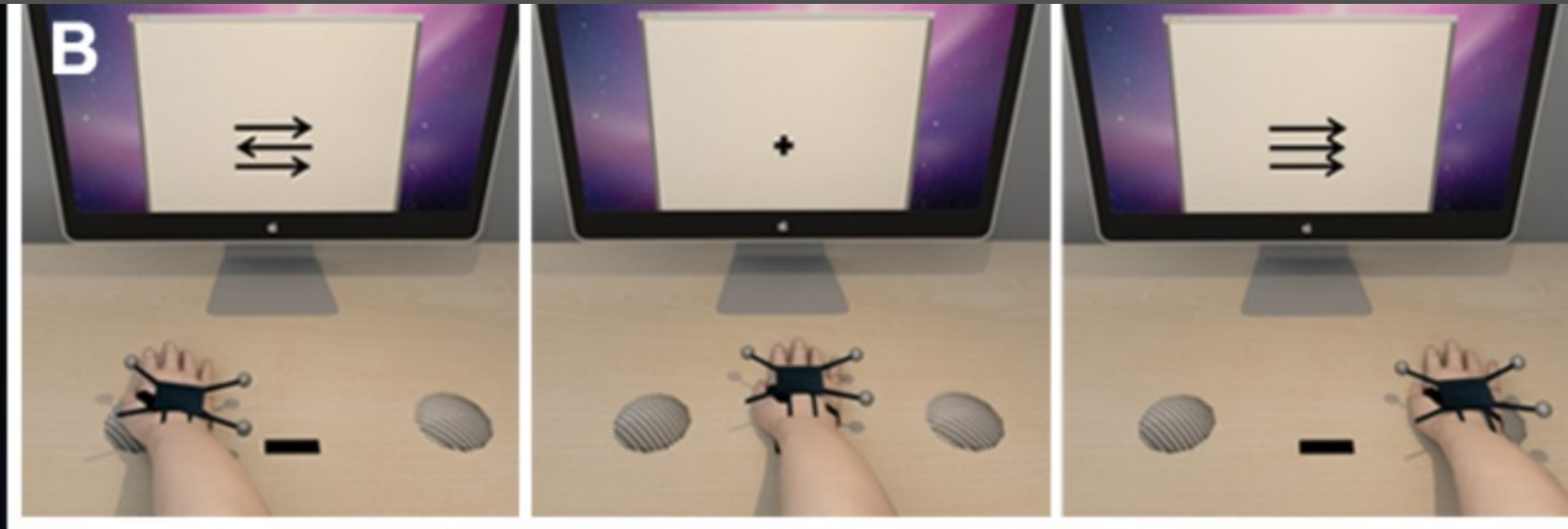
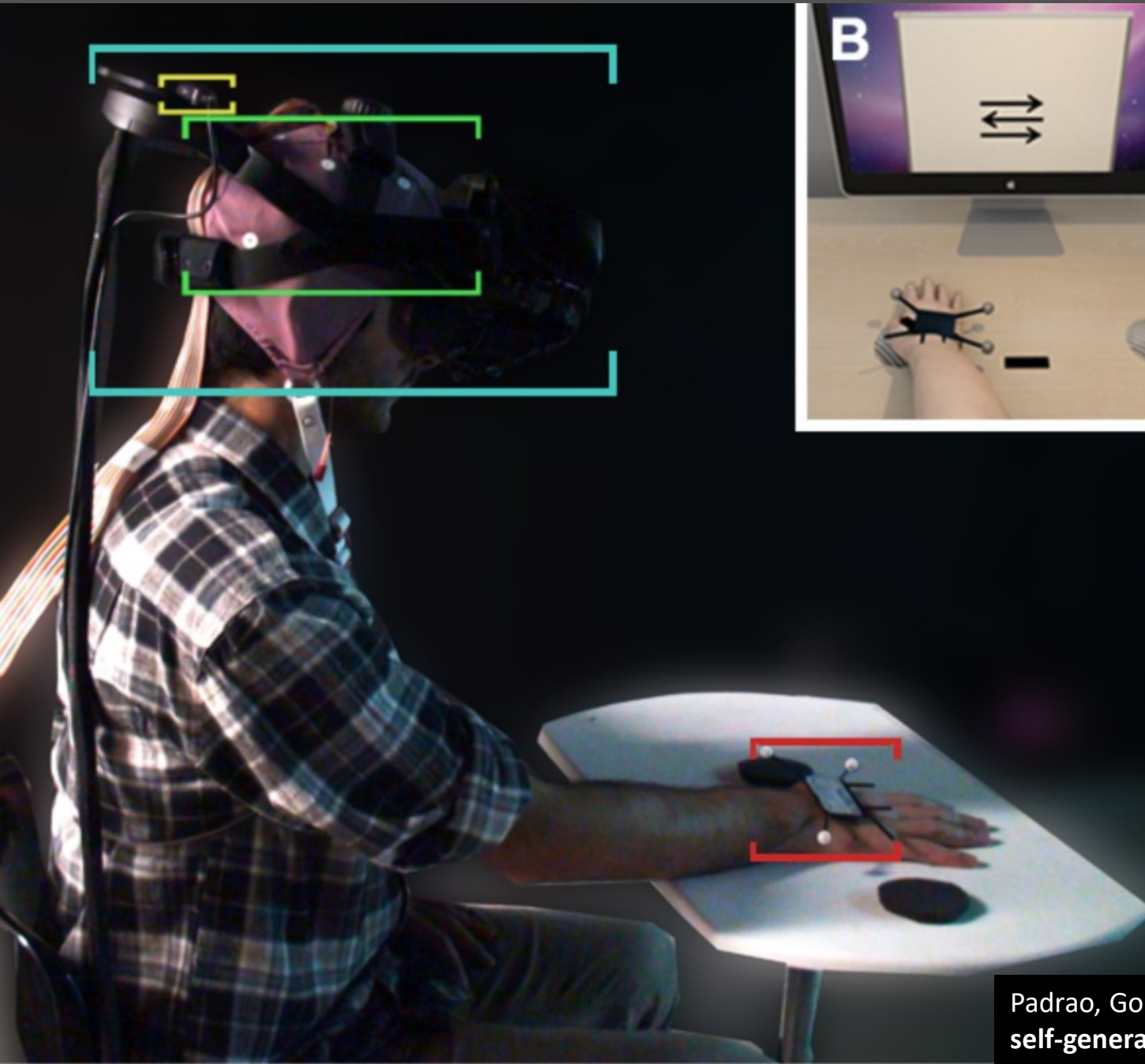
a) Time Frequency Evolution in C3



c) Mu-rhythm (10-12Hz) Event Related Desynchronization



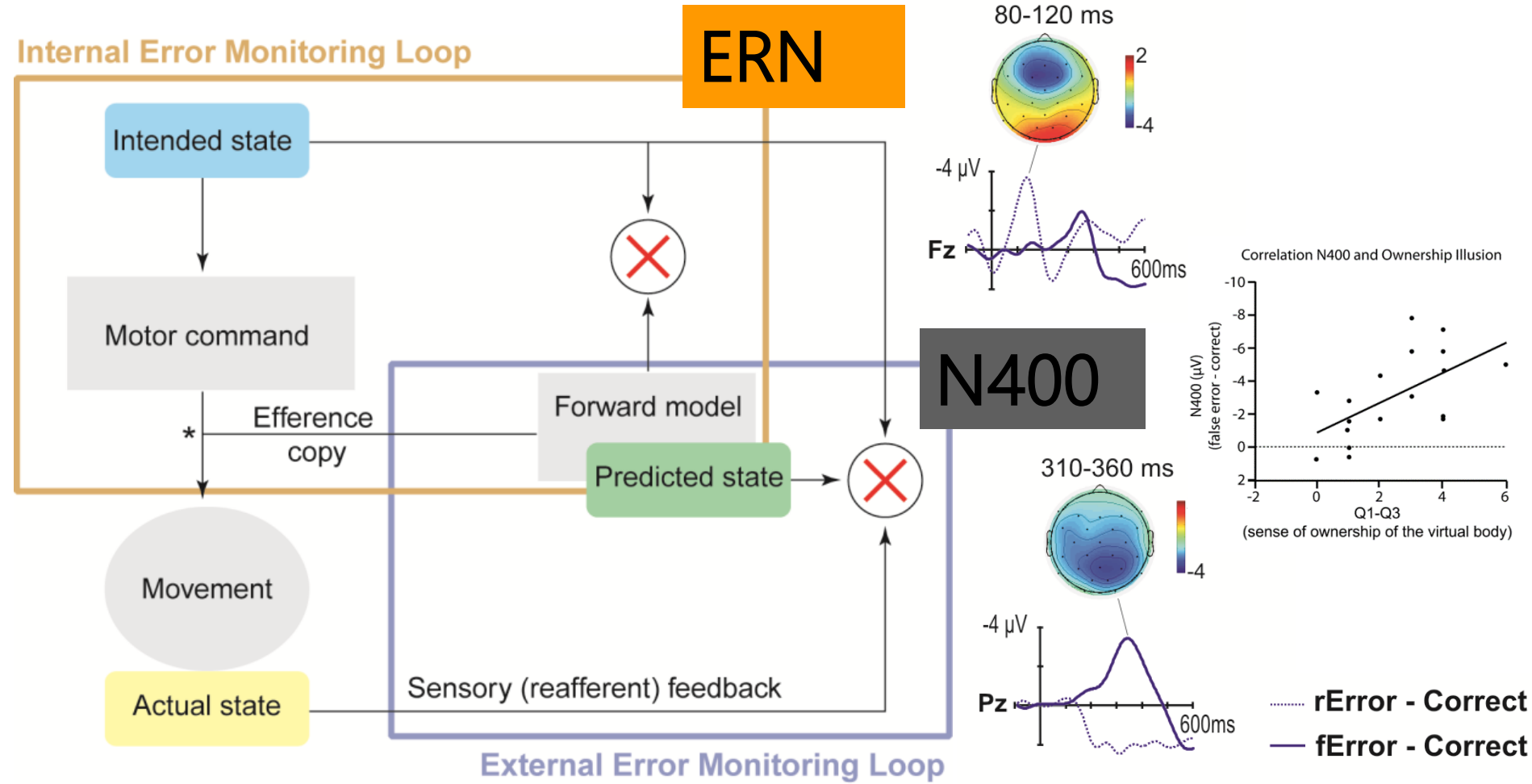
Sense of Agency



Padrao, Gonzalez-Franco et al. 2016. **Violating body semantics: neural signatures of self-generated and external-errors.** NeuroImage (2016)

Disrupting the sense of agency of the VB

Error Monitoring Models. Motor Control



[Gallagher 2000, Frith et al. 2000]

Beyond electrophysiology: questionnaires

Gonzalez-Franco M and Peck TC (2018) Avatar Embodiment. Towards a Standardized Questionnaire *Front. Robot. AI*

Microsoft Azure Notebooks Preview My Projects Help

🏠 > margon > Projects > Embodiment_Questionnaire_PCA

Embodiment_Questionnaire_PCA

Questionnaire Factor Analysis

📄 Clone 22

⬇️ Download Project

QuestionnaireAnnalysis.ipynb

Embodiment Questionnaire Analysis

This notebook provides an starting point to use Principal Component Analysis (PCA) to study the responses of the Embodiment questionnaire proposed by Gonzalez-Franco & Peck.

If the questionnaire results are in an online url use RCurl library to load them

```
In [2]: library(reshape)
library(ggplot2)
library(psych)

#library(RCurl)
#URL <- "https://notebooks.azure.com/margon/Libraries/EmbodimentQuestionnairePCA/html/responses.csv"
#x <- getURL(URL)
```

We have identified 6 main types of questions that are present depending on the experimental setup:

1. **Body ownership.** Present whenever there is a substitute body or body part. It is possible to have body ownership over a body that participants feel is not in the same location as their own body.
2. **Agency and motor control** of the body. Present whenever there is motion tracking and the participant can move parts or all of the virtual body.
3. **Tactile sensations.** Present whenever there is tactile or haptic stimulation to enhance the embodiment illusion.
4. **Location of the body.** Present whenever there is a substitute body or body part that is either collocated or not collocated with the participant. Participants must feel that their body is in the same location as the virtual body in order to experience an embodiment illusion. Participants may sense an out-of-body effect, or that the location of their body has drifted toward the location of the avatar. These questions are often only asked when the avatar is not collocated with the participant.
5. **External appearance.** Present when the self-avatar is a look-alike avatar or as control questions when there are shape, gender, race, clothing, or other visual modifications to the avatar different from the self.
6. **Response to external stimuli.** In many occasions during the experiment there is an event that modifies or threatens the body or body parts of the self-avatar.

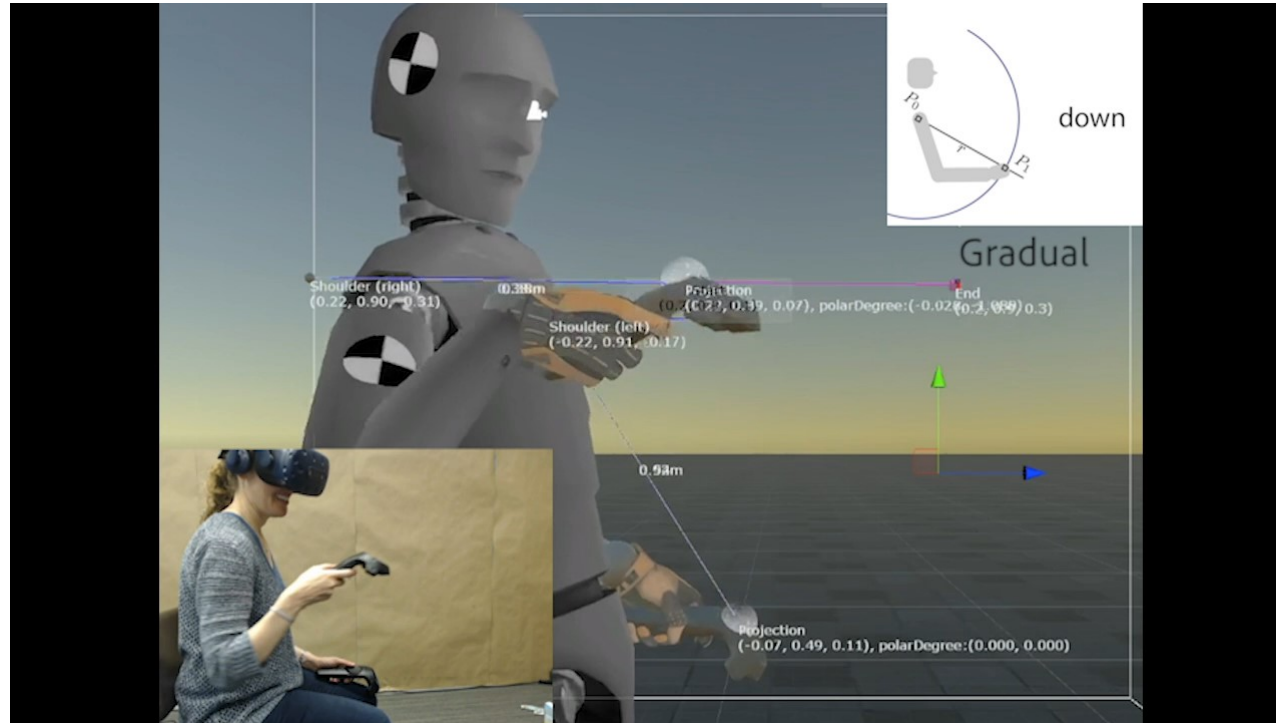
Analyzed 30 famous experiments and extracted 25 questions

<https://notebooks.azure.com/margon/projects/EmbodimentQuestionnairePCA>

Self-avatar follower effect

We have an implicit need to fill the spatial gap between the physical and the self-avatar bodies, whenever the system allows for these types of compensation. That is the **self-avatar follower effect**.

If we drift the avatar, the user will try to compensate



Embody avatars of different shape, size, gender etc

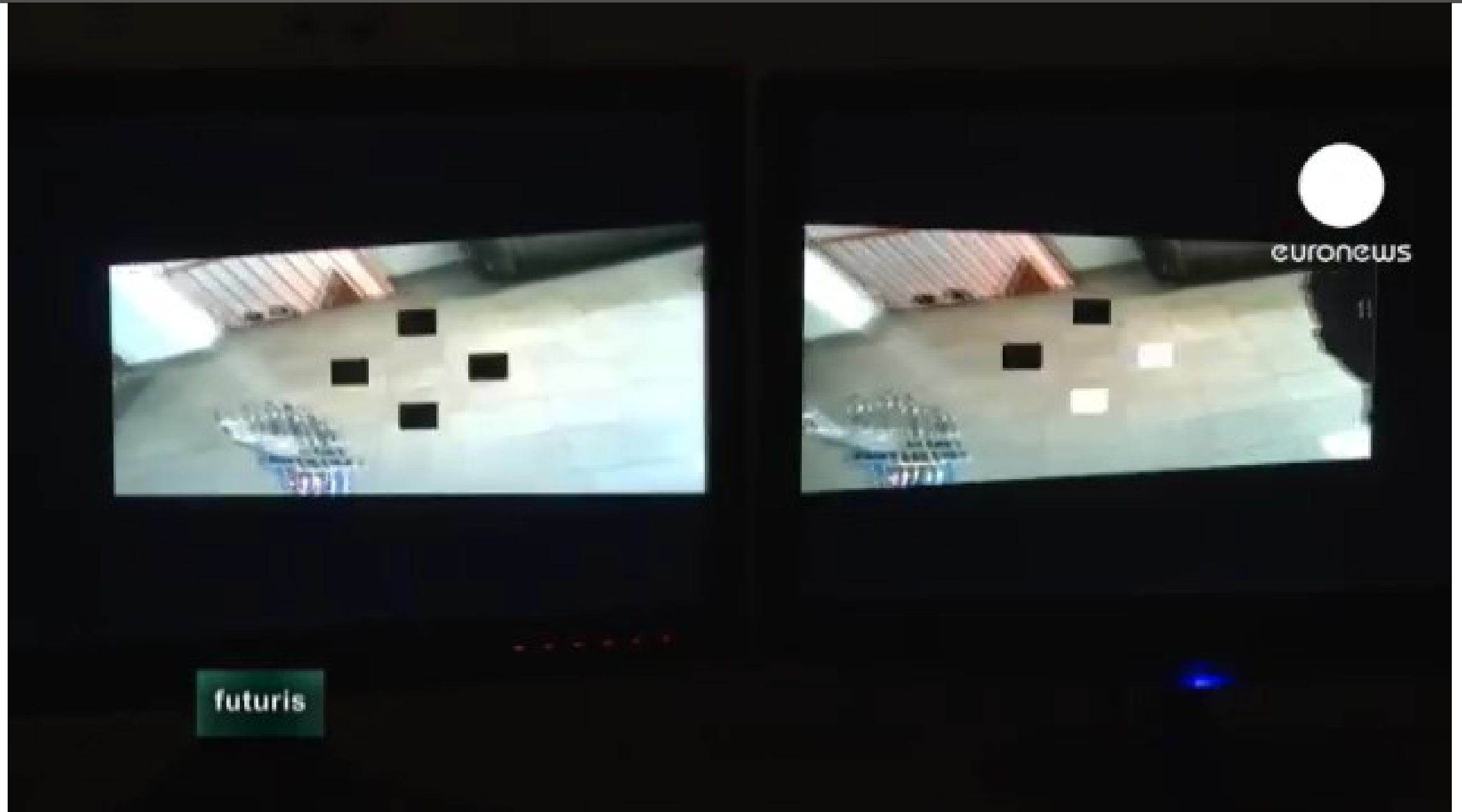
I'm a Giant: Walking in Large Virtual Environments at High Speed Gains

Parastoo Abtahi^{1,2}, Mar Gonzalez-Franco¹, Eyal Ofek¹, Anthony Steed^{1,3}

¹Microsoft Research, ²Stanford University, ³University College London



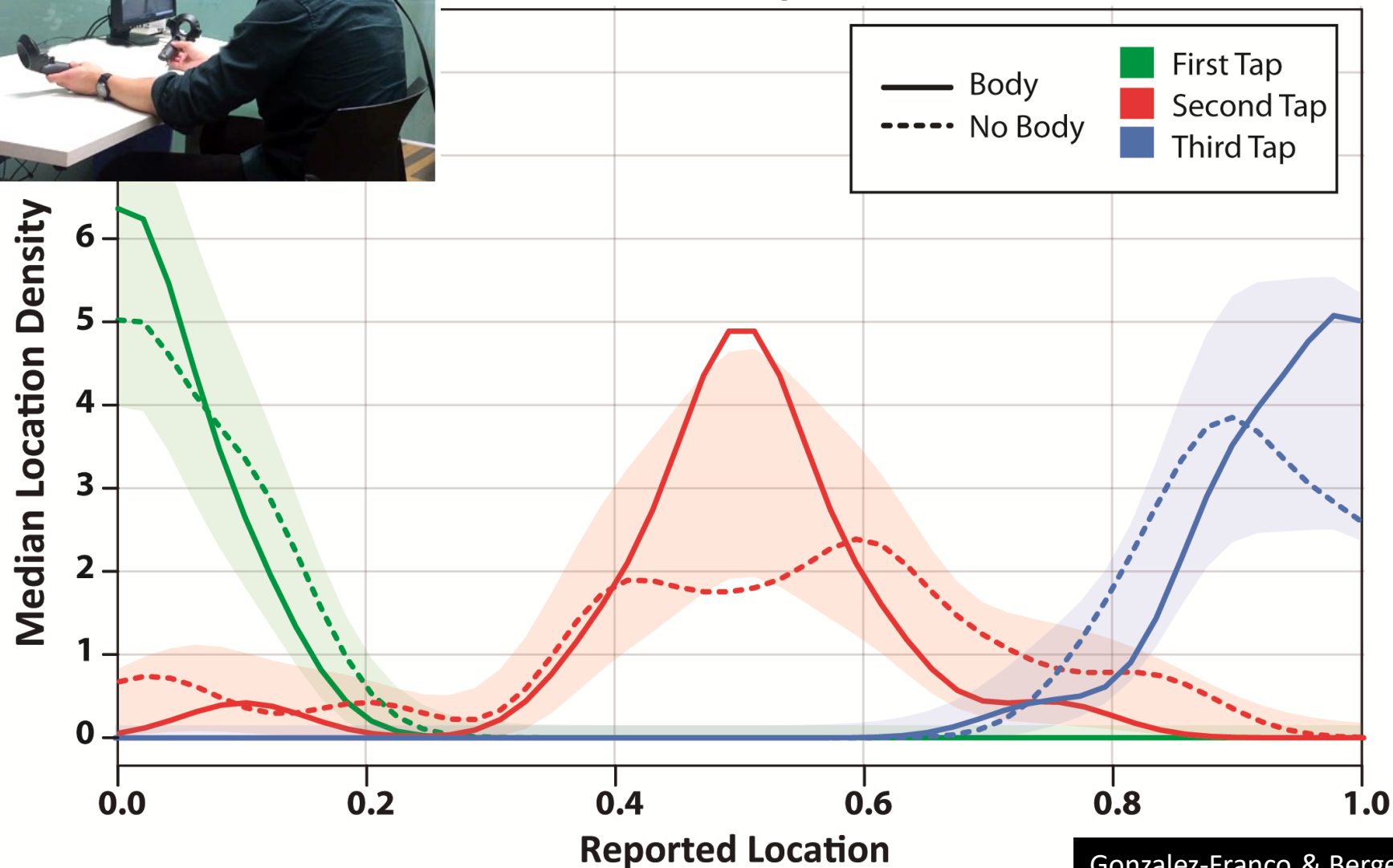
Embodiment in Robots



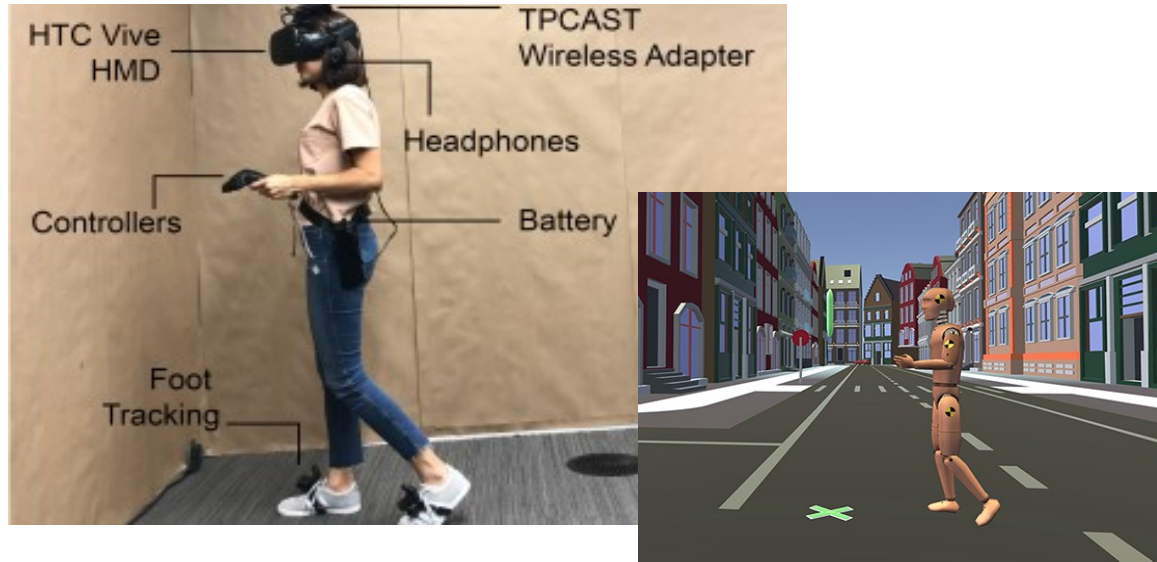
Embodiment increases haptic experiences



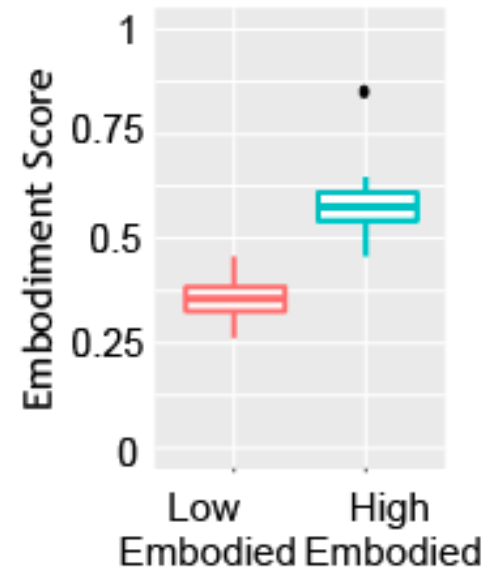
Perceived Tap Location



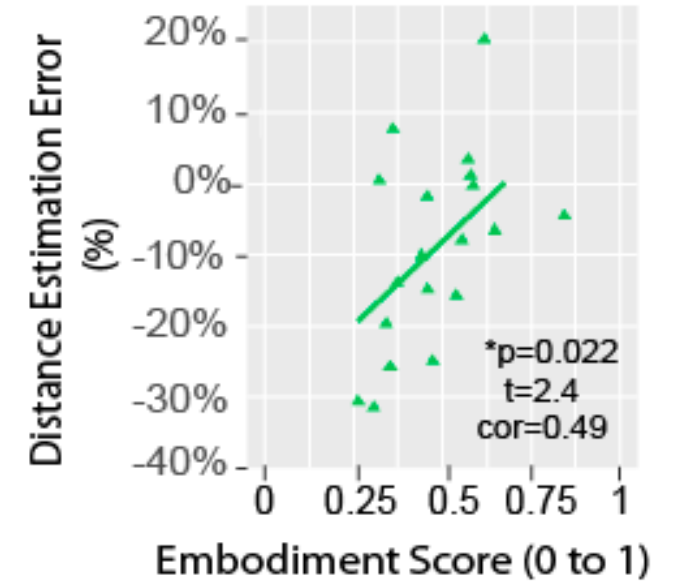
Many Individual Differences In Embodiment across participants



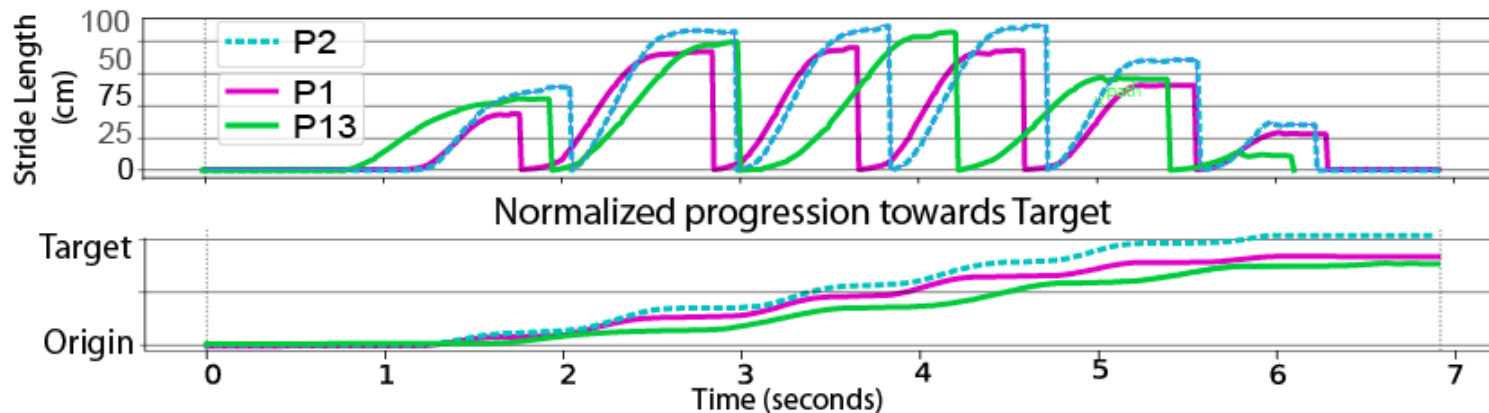
Embodiment



Distance Compression



Individual Strides



Enfacement



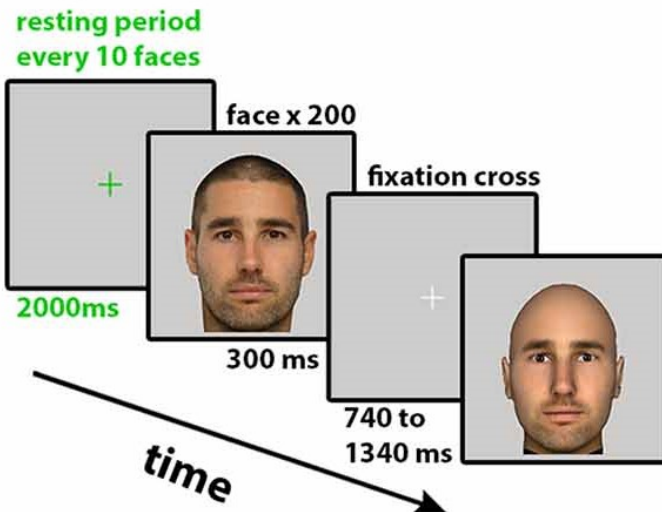
Self-recognition on Avatars

Gonzalez-Franco et al. 2016. The neurological traces of look-alike avatars
Frontiers in Human Neuroscience

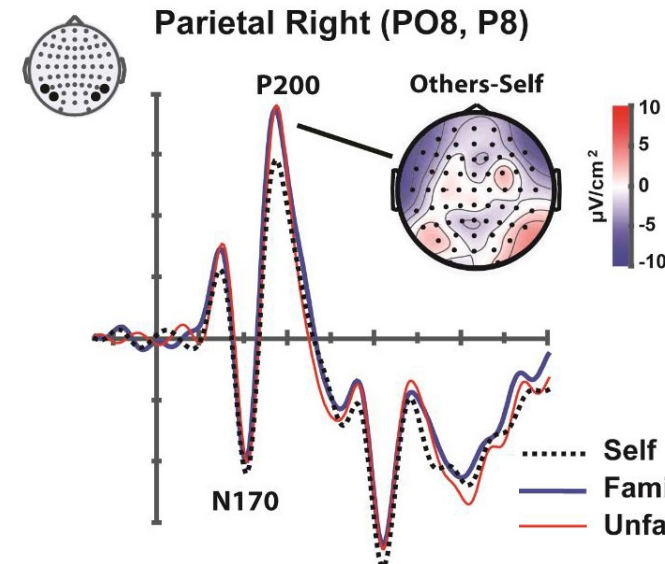
A Avatar creation



B Experimental Execution



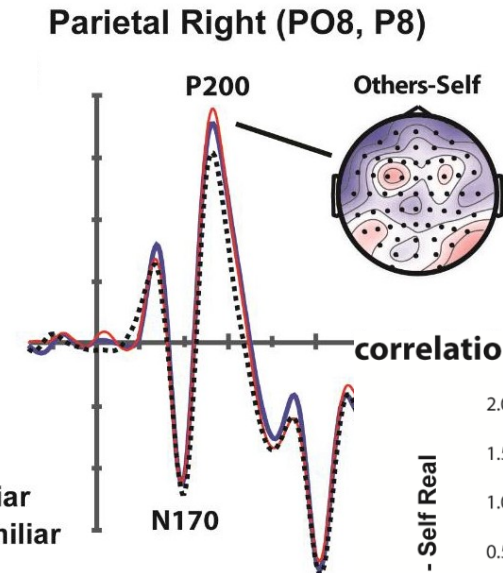
Real Faces



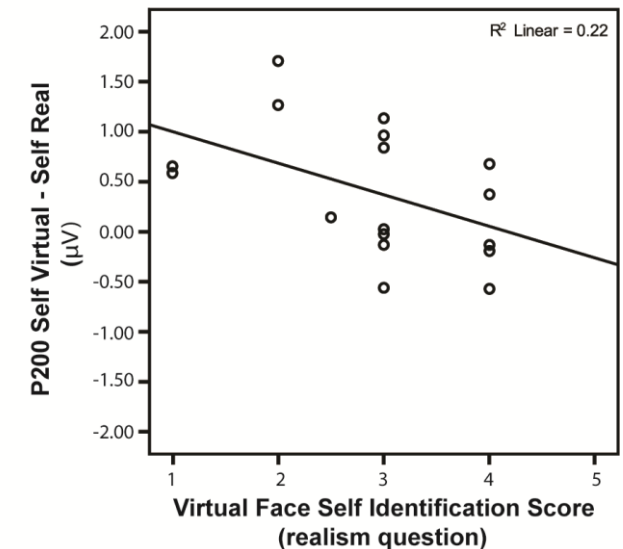
No N170 differences:
same class of object

P200/N250 250-300ms
self-recognition

Virtual Faces



correlation subjective vs. unconscious identification

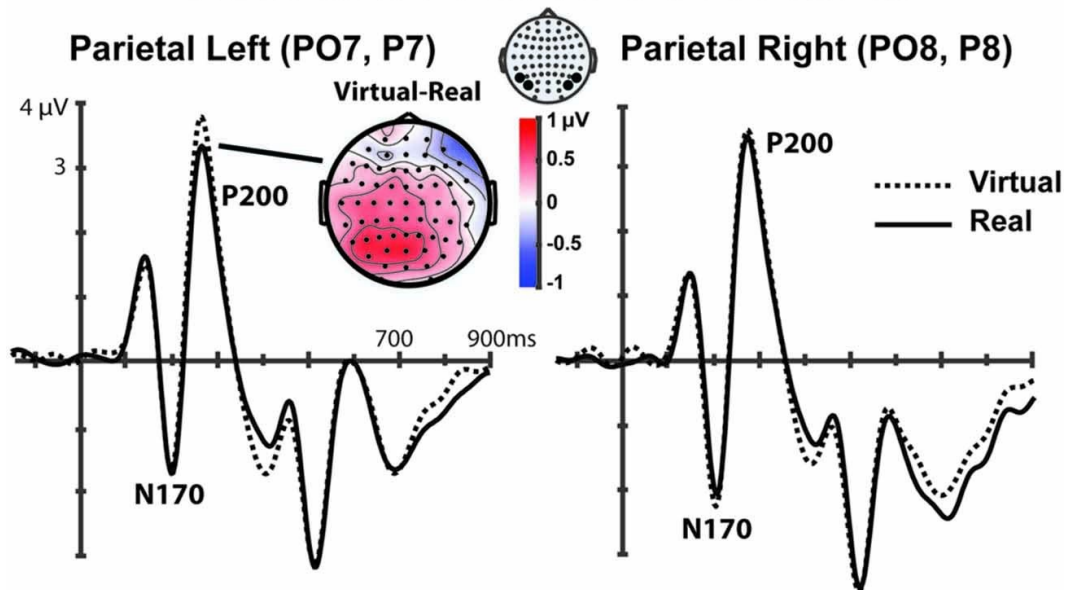


Self-recognition on Avatars

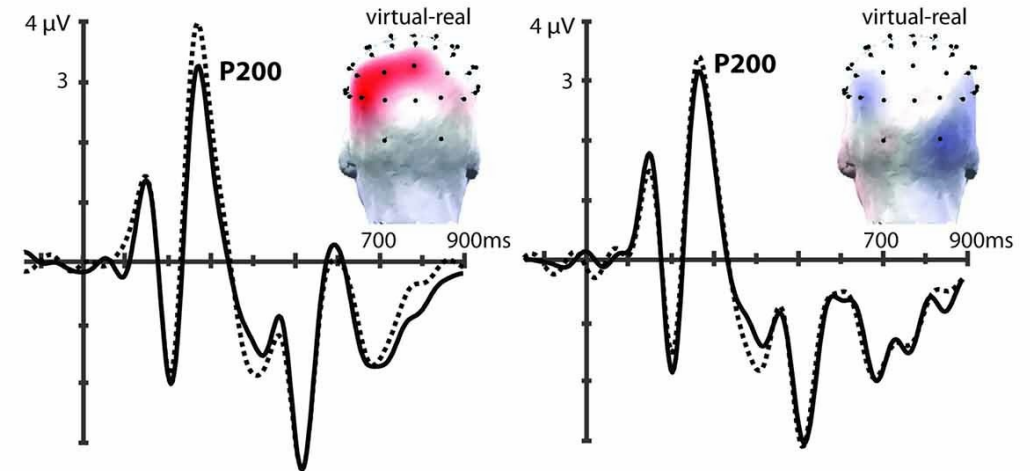
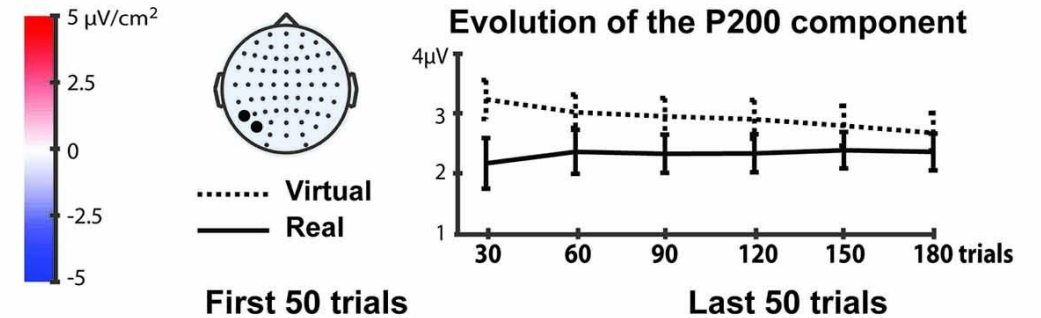


 Spatial

VIRTUAL VS. REAL FACES



Fast Adaptive Effects in Virtuality (PO7,P7)



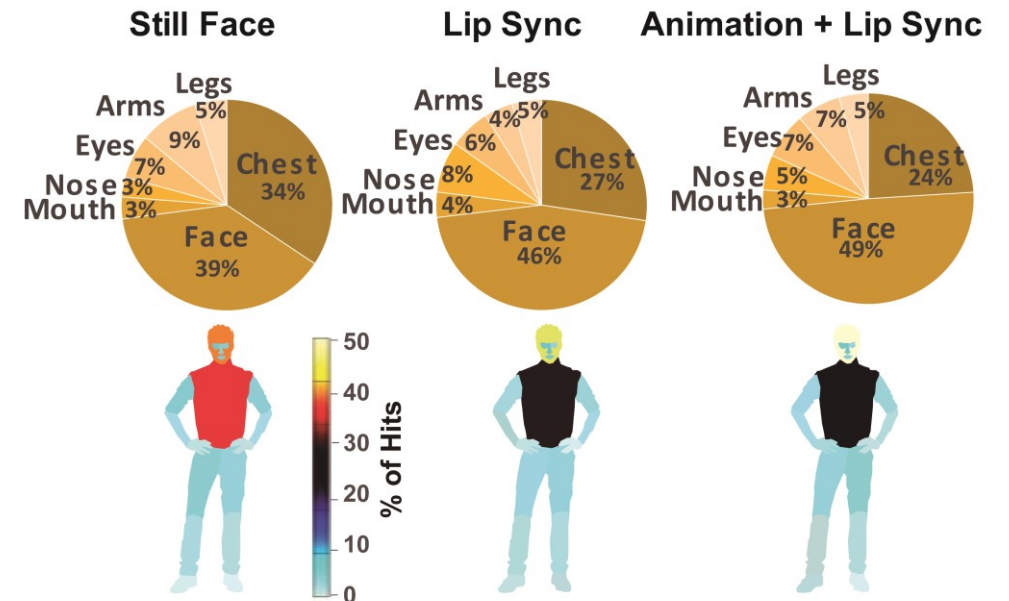
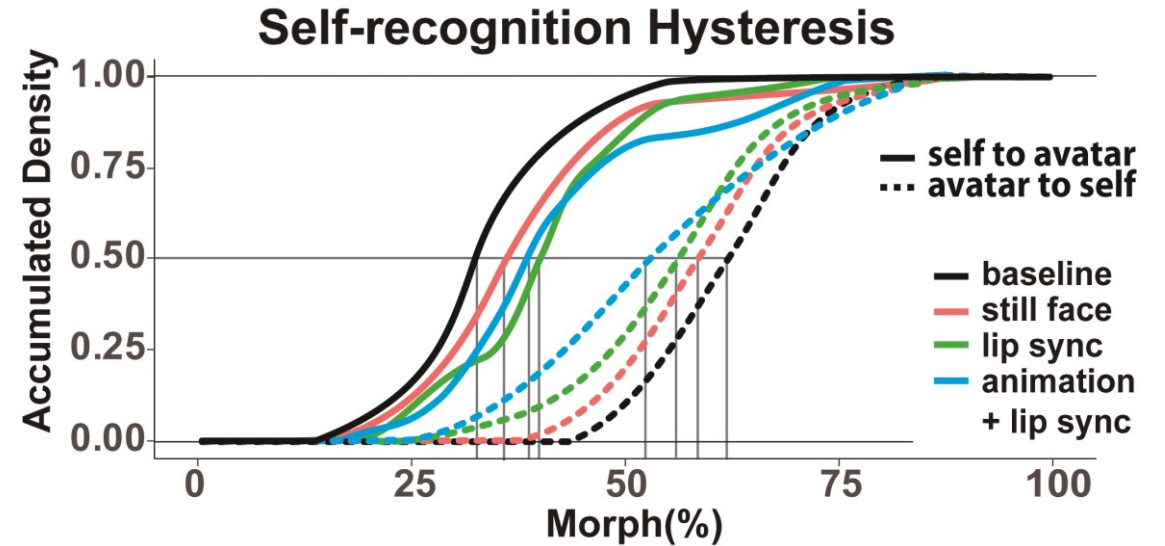
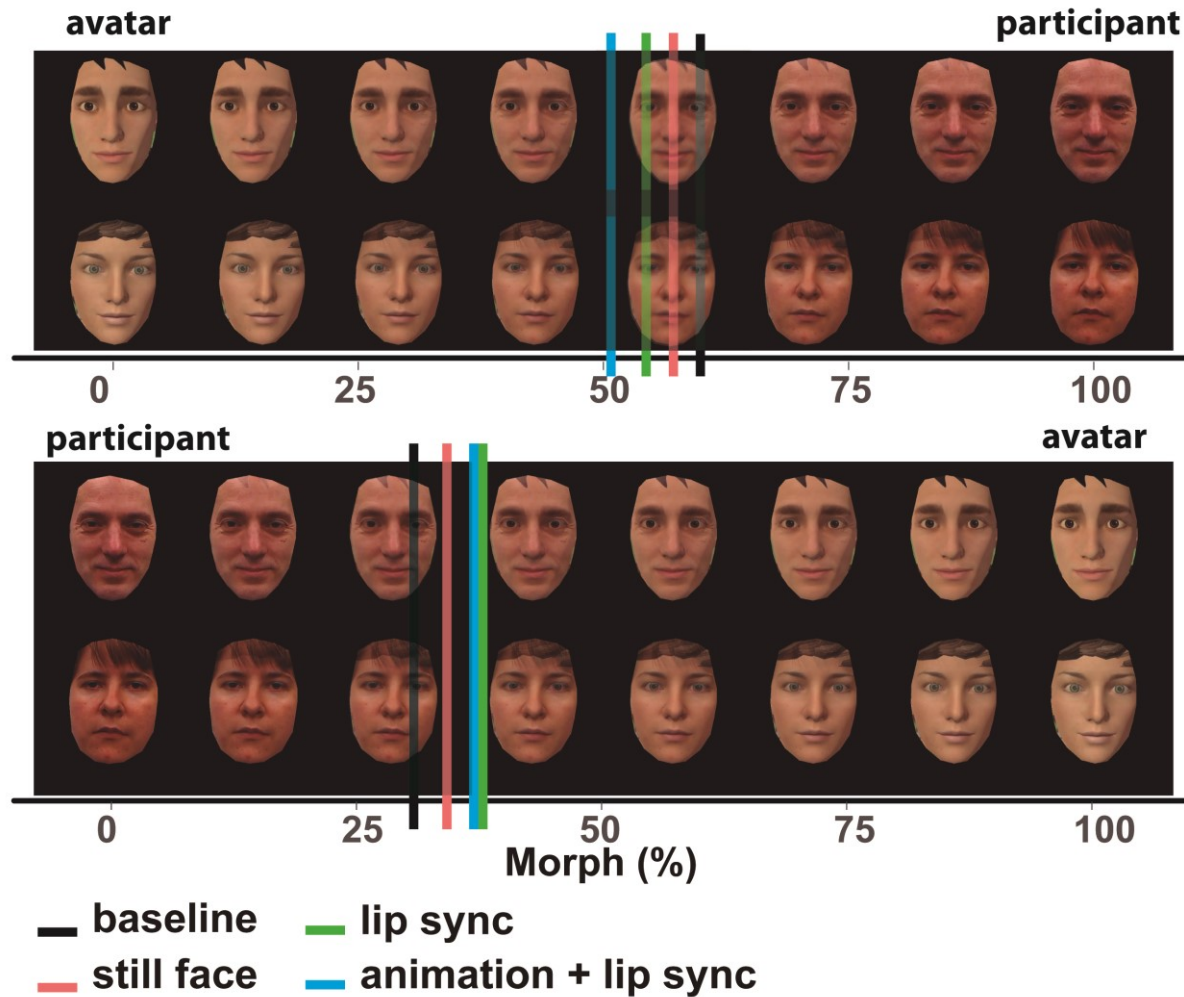
Enfacement on Avatars



Gonzalez-Franco et al. 2020 **Using Facial Animation to Increase the Enfacement Illusion and Avatar Self-Identification.** IEEE VR.
IEEE Transactions on Visualization and Computer Graphics



Enfacement on Avatars



Avatar BEHAVIOUR

**REALISTIC
BEHAVIOR**

Place Illusion

**Presence
Illusion**

Plausibility Illusion



Would You Give a Virtual Electric Shock to an Avatar?

In a repeat of a classic experiment, we find that people who are only unenthusiastically obeying unethical orders still experience trauma

By Mar Gonzalez-Franco, Mel Slater on April 12, 2019

One common trait of repressive governments or laws is the emergence of an organized resistance, often involving high-ranking officials and civil figures who aren't keen on obeying their leaders.

clear evidence of a kind of disobedience among our participants. They did not enter an “agentic” state, blindly and carefully carrying out the orders of the experimenter, as executioners of harmful behavior. Instead they fit more the profile of an “engaged follower,” someone who apparently engages but nevertheless tries to get around the specifics of the orders. Essentially, they were disobeying or quietly resisting while appearing to follow orders.



Participant concerns for the Learner in a Virtual Reality Replication of a Milgram Obedience Study

Gonzalez-Franco, M., Slater, M., Birney, M.,
Swapp, D., Haslam, S.A. & Reicher, S.D.

Virtual Reality Makes Avatars More Important Than Ever

Immersing yourself in an alternative universe is VR's selling point. But how do the avatars that populate these worlds impact our experiences and our behaviour?

By Emily Reynolds

Dec 11 2016, 1:00pm  Share  Tweet  Snap



IMAGE: ALTSPACEVR

Microsoft Rocketbox

library of rigged avatars free for academic
and research use



<https://github.com/microsoft/Microsoft-Rocketbox>

Gonzalez-Franco, Ofek, Pan, Antley, Steed, Spanlang, Maselli, Banakou, Pelechano, Orts Escolano, Orvahlo, Trutoiu, Wojcik, Sanchez-Vives, Bailenson, Slater, and Lanier. Frontiers in VR (in review) "Importance of rigging for procedural avatars. Microsoft Rocketbox a public library."

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Impossible outside Virtual Reality

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