



Impossible outside Virtual Reality

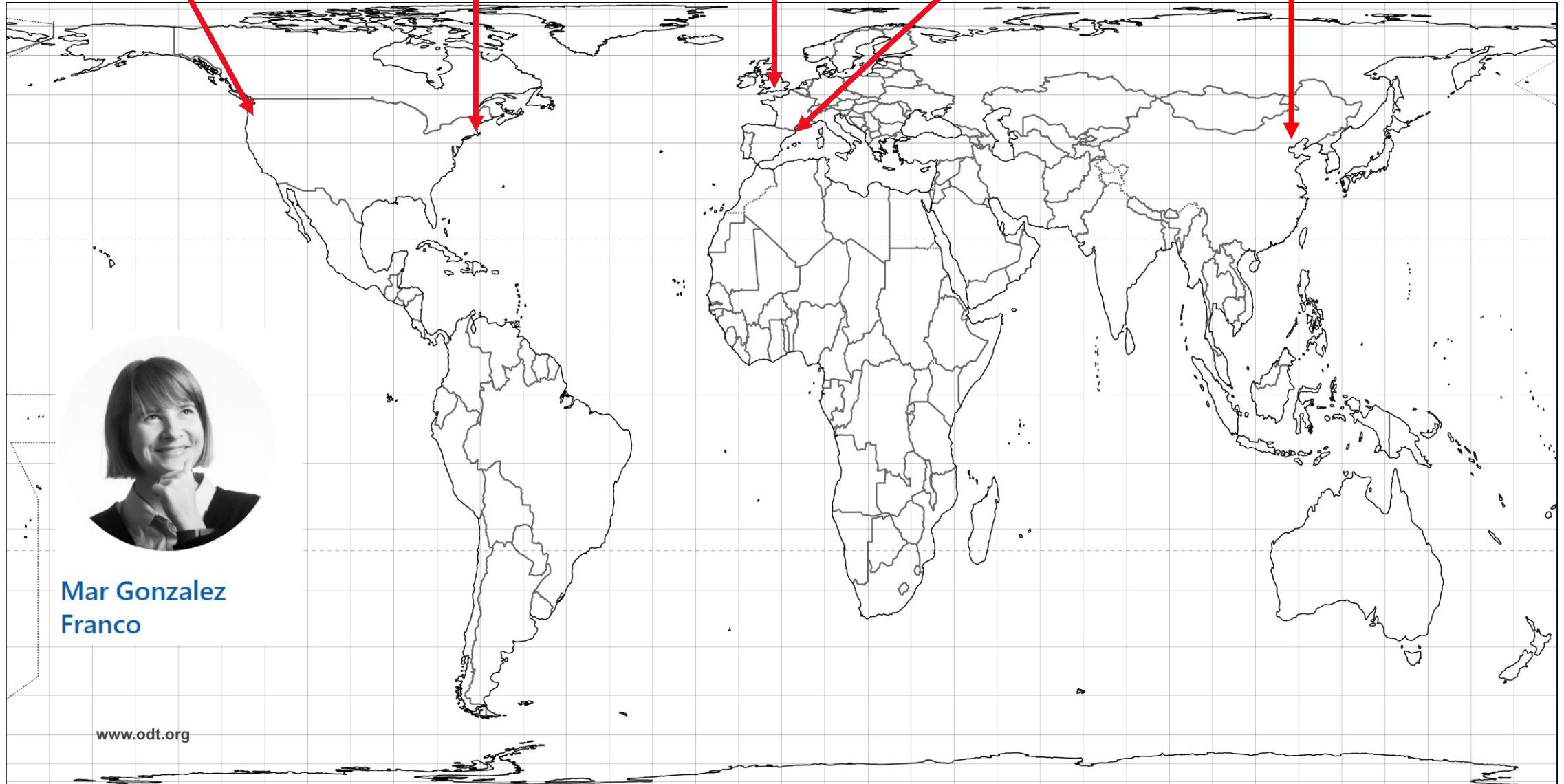
Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC)
Research Group

Microsoft Research
June 4th 2020



<https://www.microsoft.com/research/people/margon/>
Twitter: @twi_mar



Mar Gonzalez Franco

Impossible outside Virtual Reality

Dr. Mar Gonzalez-Franco

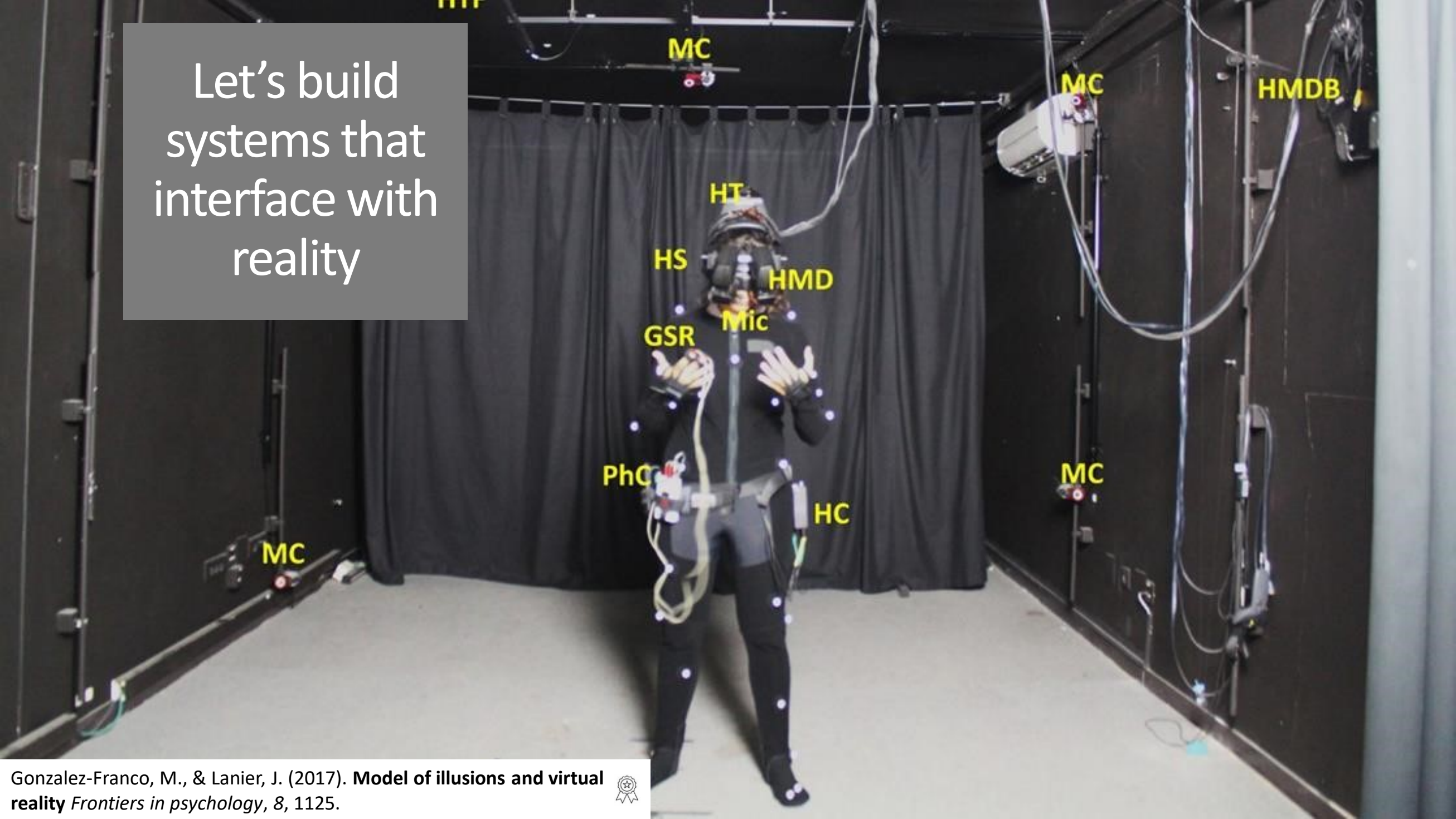
Extended Perception, Interaction & Cognition (EPIC)
Research Group

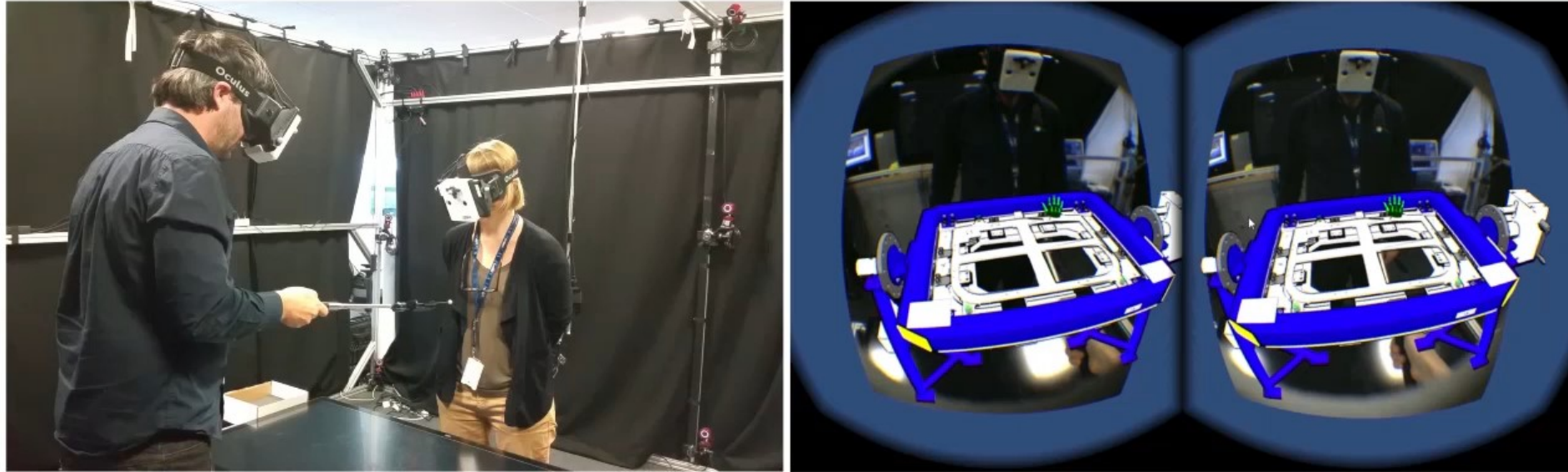
Microsoft Research
June 4th 2020



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

Let's build
systems that
interface with
reality





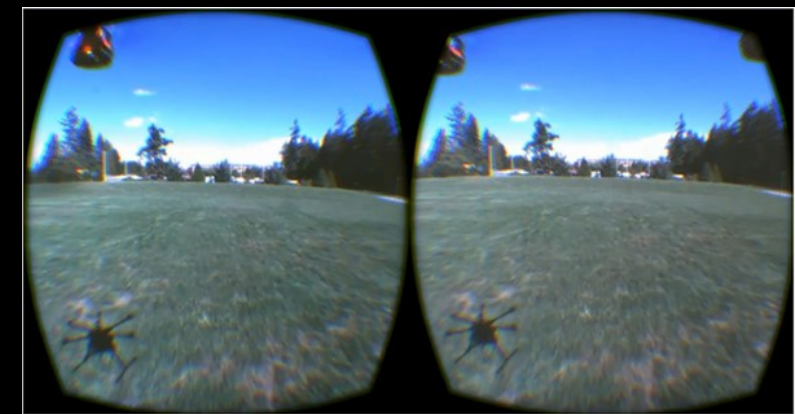
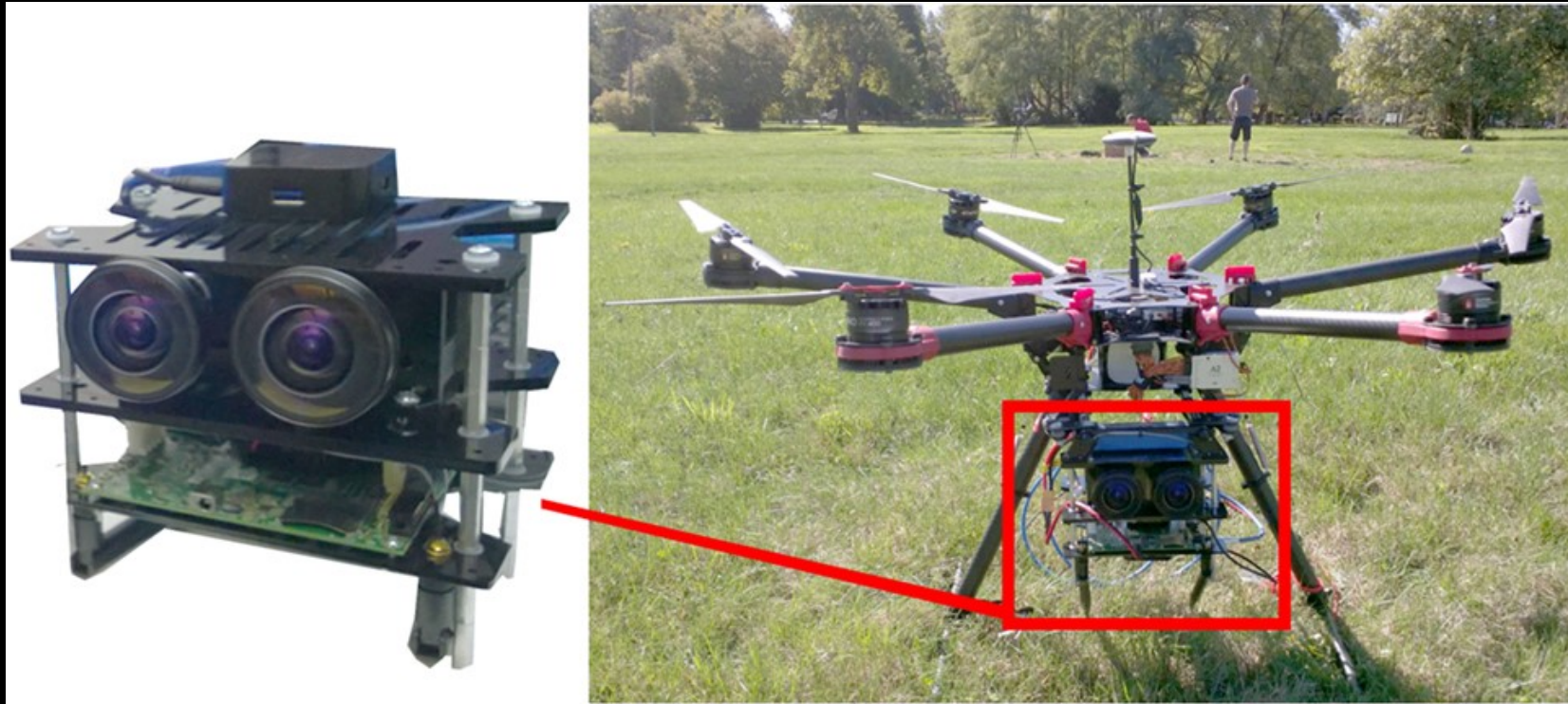
Immersive Mixed Reality for Manufacturing Training

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

AIRBUS
GROUP

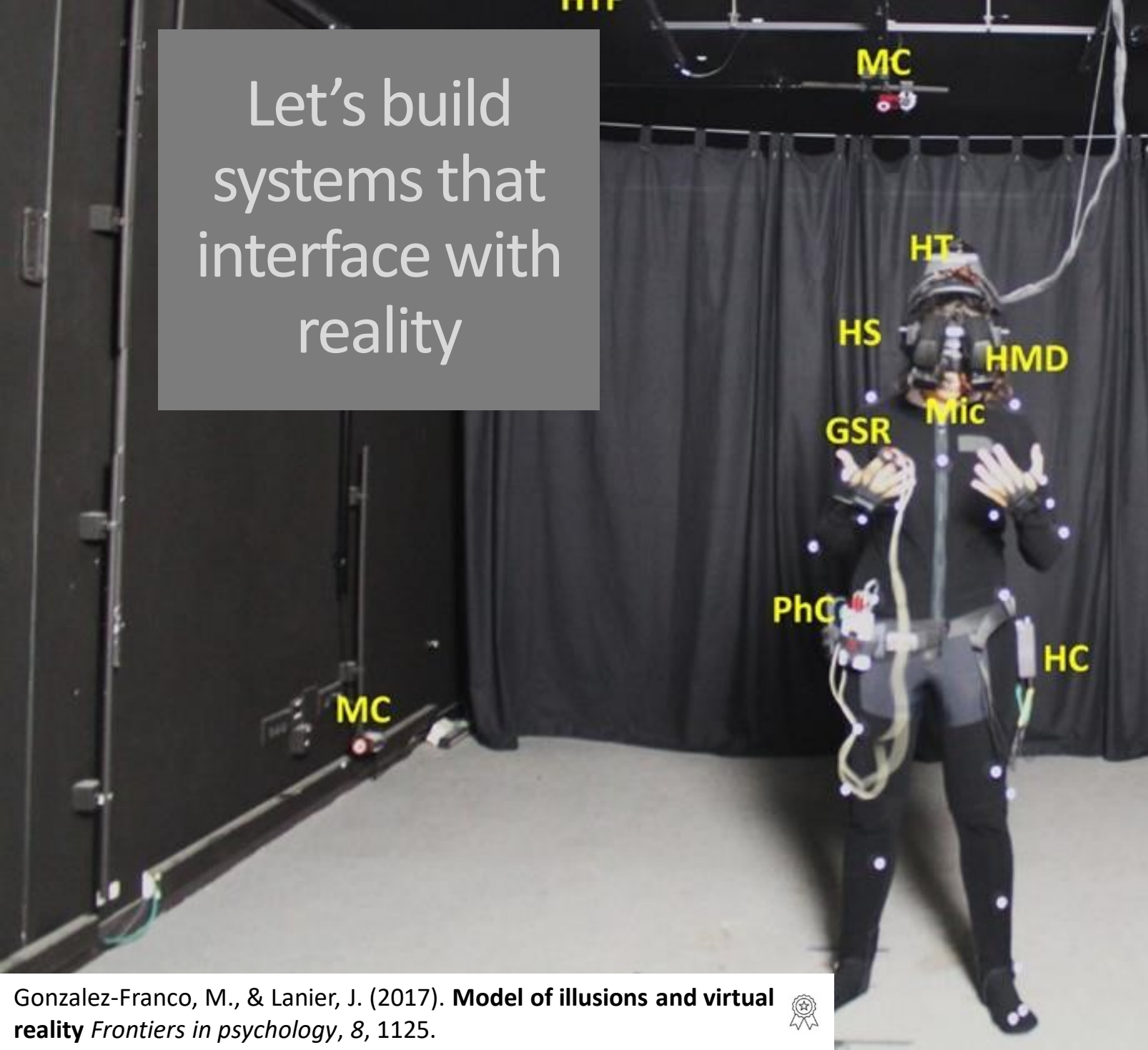
Gonzalez-Franco, Mar, et al. 2017 "Immersive mixed reality for manufacturing training." *Frontiers in Robotics and AI* 4: 3.

FPV Drone navigation in VR

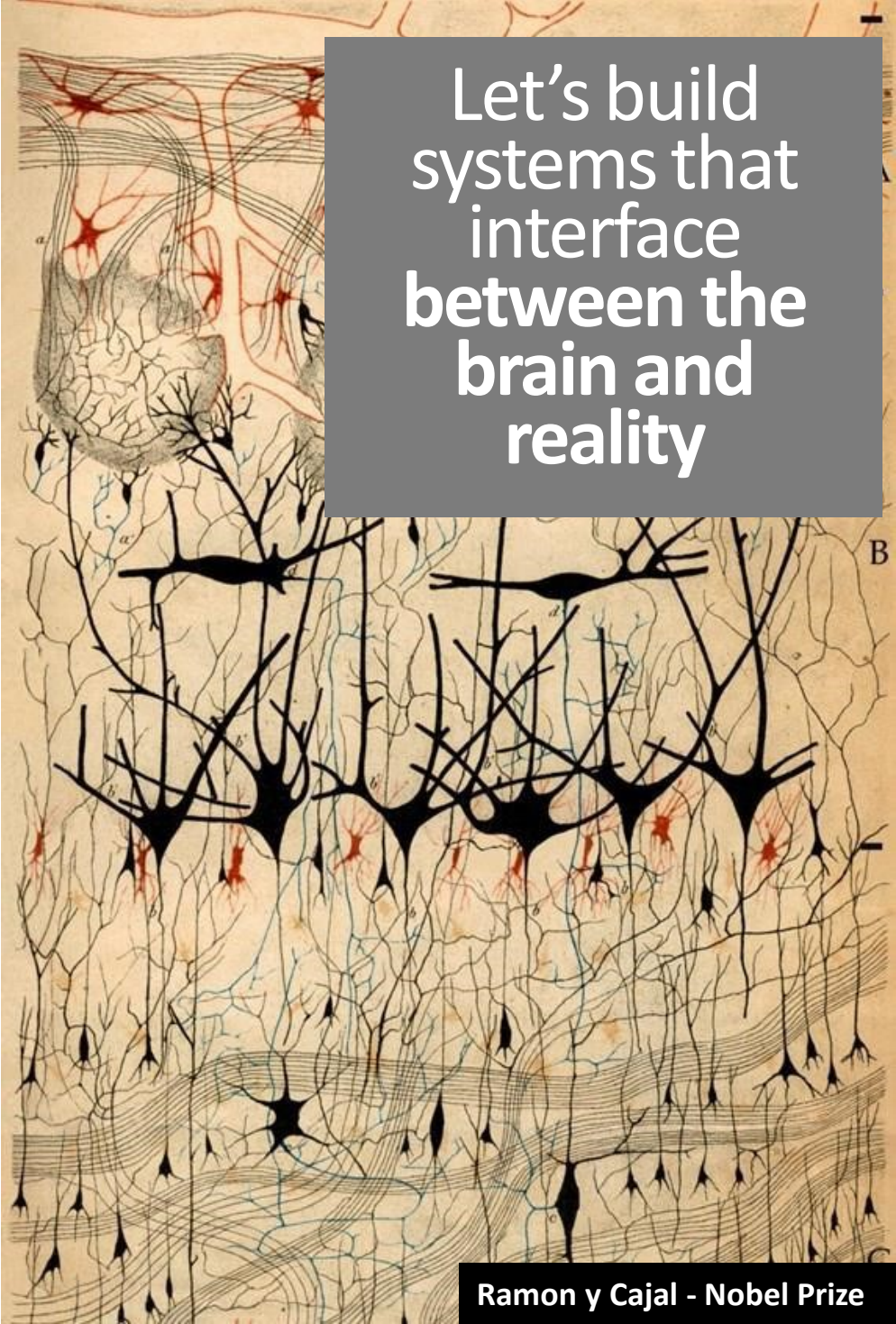


Modified DJI S900 hexacopter (right) with the stereo camera and the Tegra TK1 embedded board attached (left). 28–30 frames per second encoding speed at 1,600 × 1,080 resolution per camera/eye

Let's build systems that interface with reality



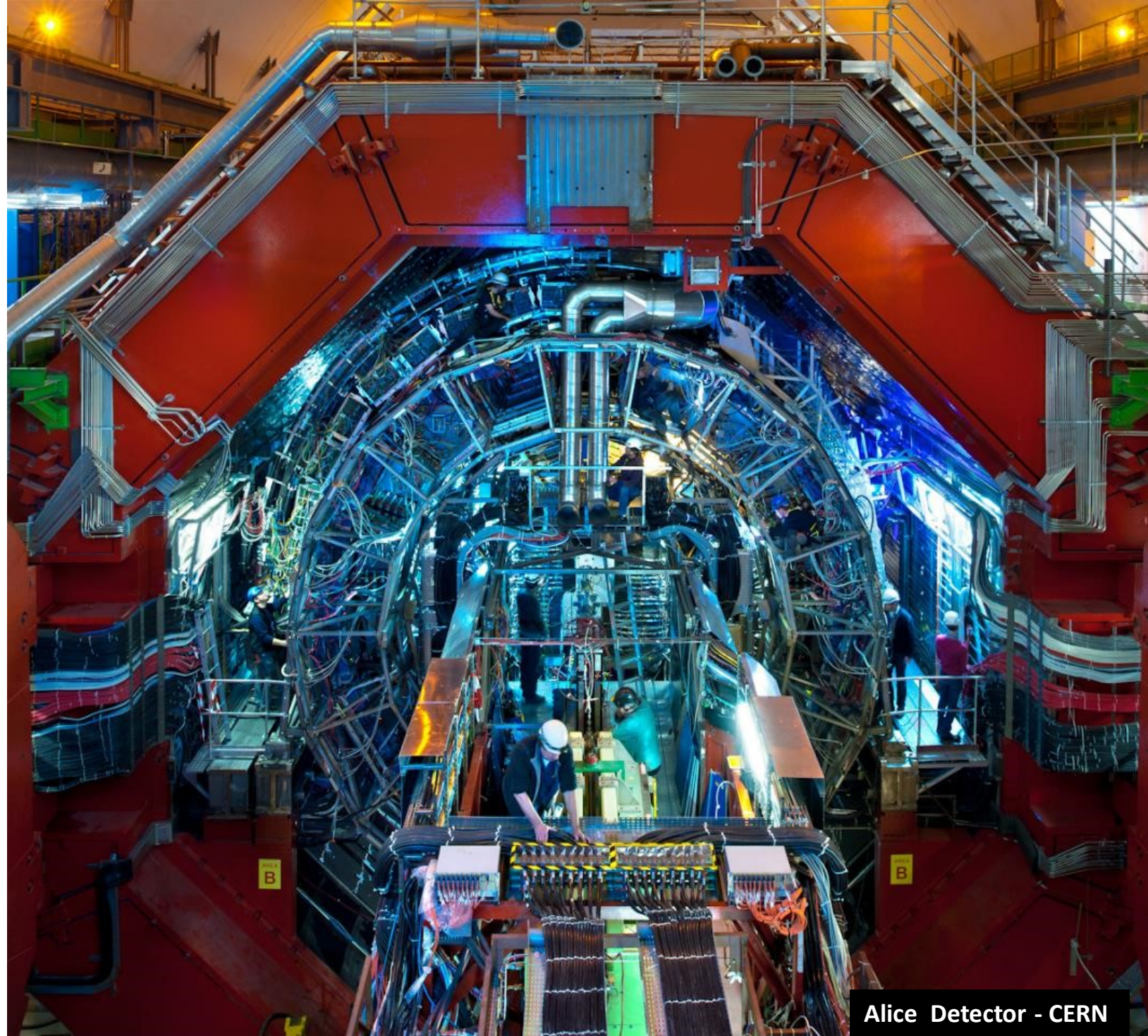
Let's build systems that interface between the brain and reality



Ramon y Cajal - Nobel Prize

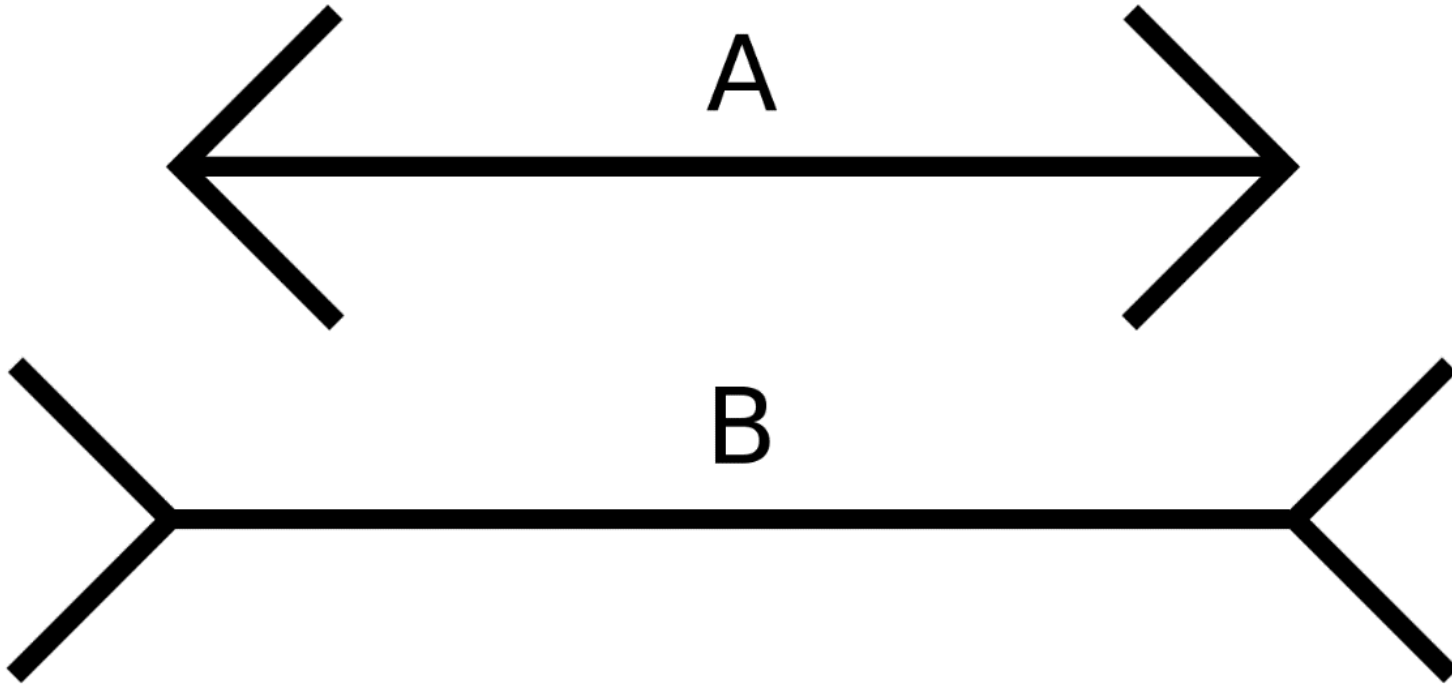
Complex system

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

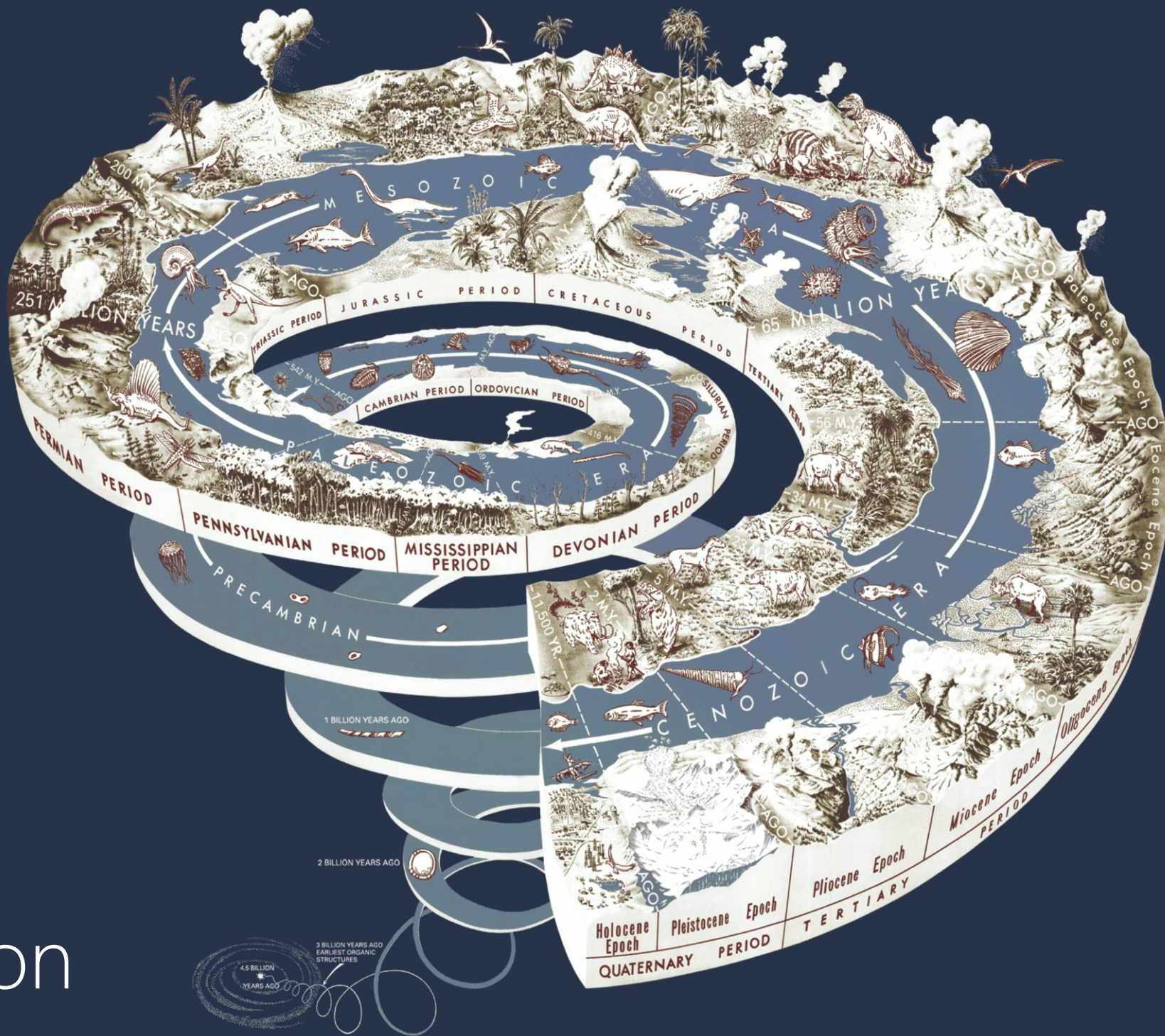


Alice Detector - CERN

Trick the brain



Perception





Sensory Dominance

Cortical homunculus by Sharon Price-James

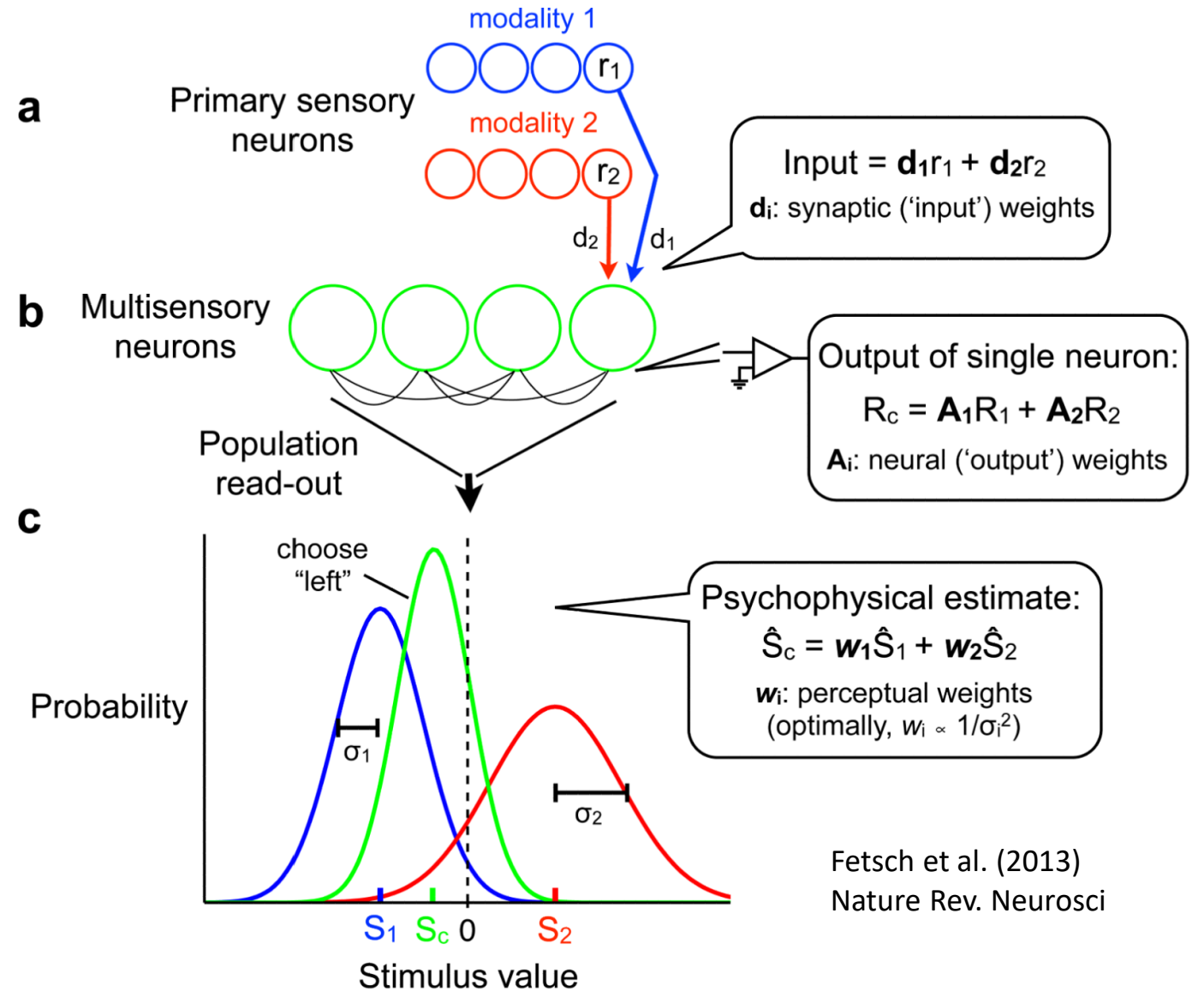
A mosaic-style image of a ballerina in a pink tutu, set against a background of blue and yellow dots. The ballerina is in a classic ballet pose, with one leg raised and arms extended. The background consists of a dense field of small, circular dots in various shades of blue and yellow, creating a textured, almost crystalline effect.

Sensory Expertise

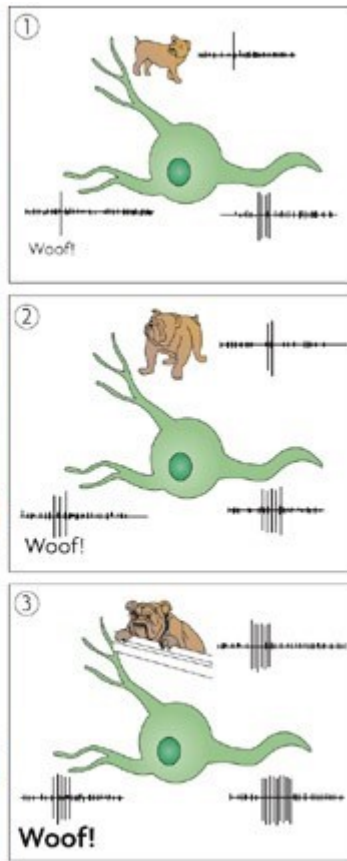
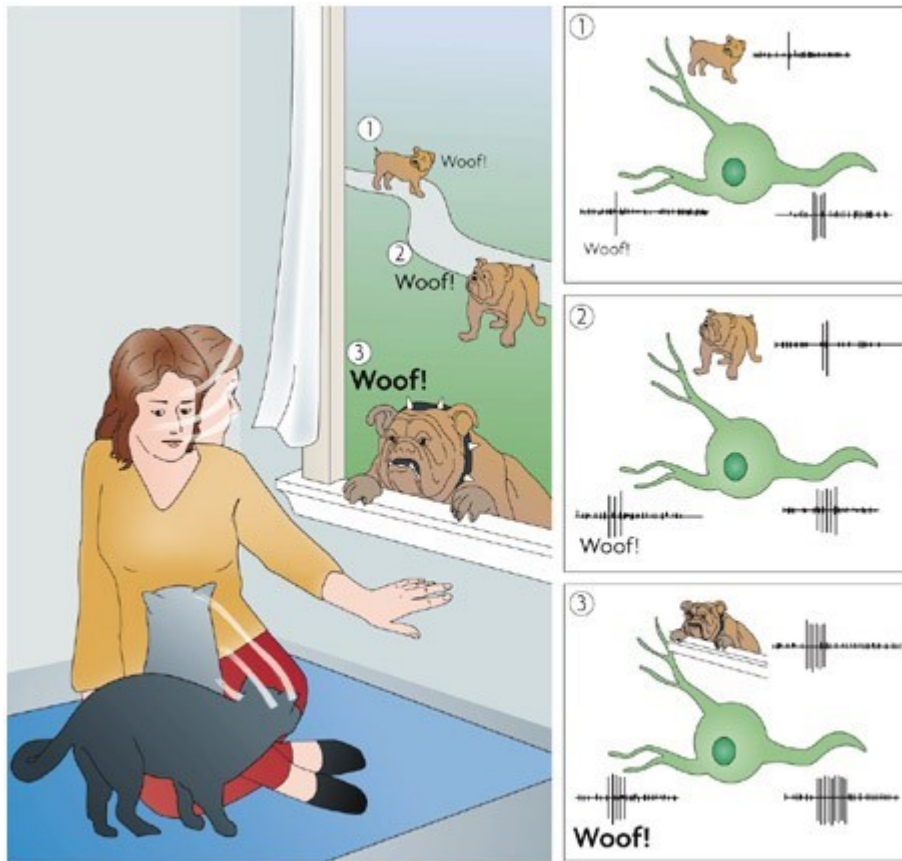


Multisensory Integration

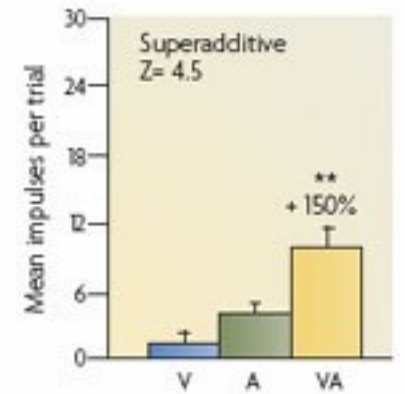
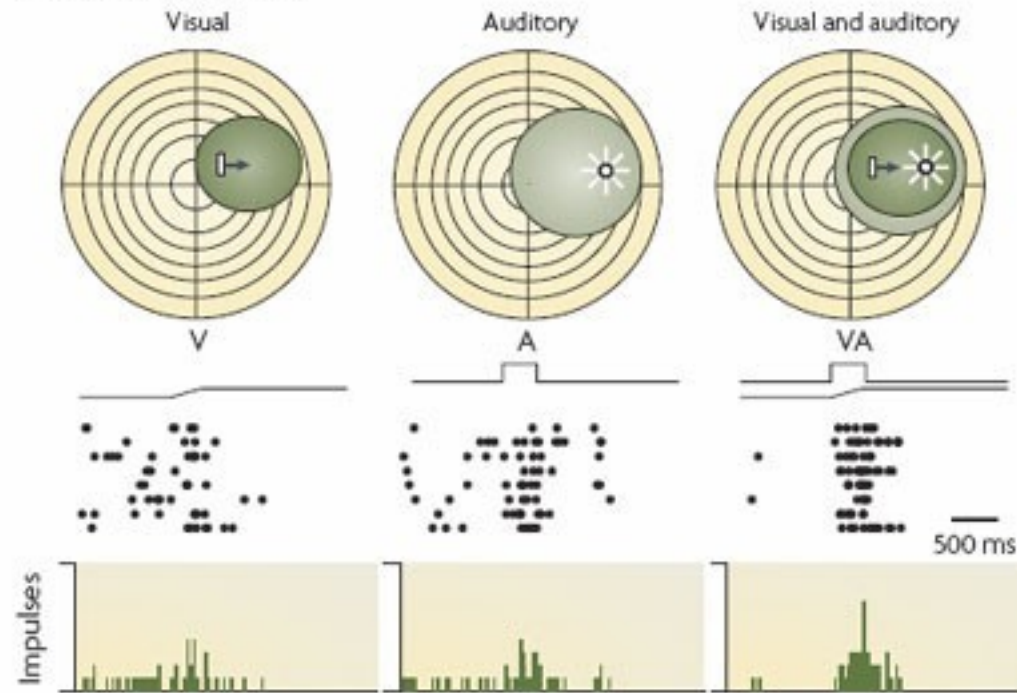
Multisensory Integration



Fetsch et al. (2013)
 Nature Rev. Neurosci



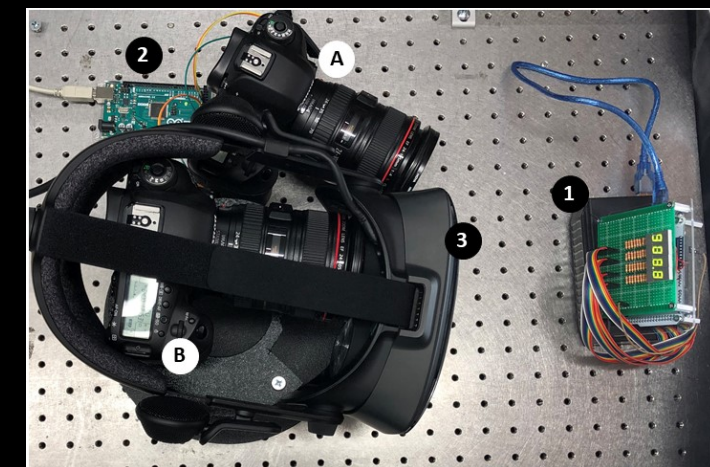
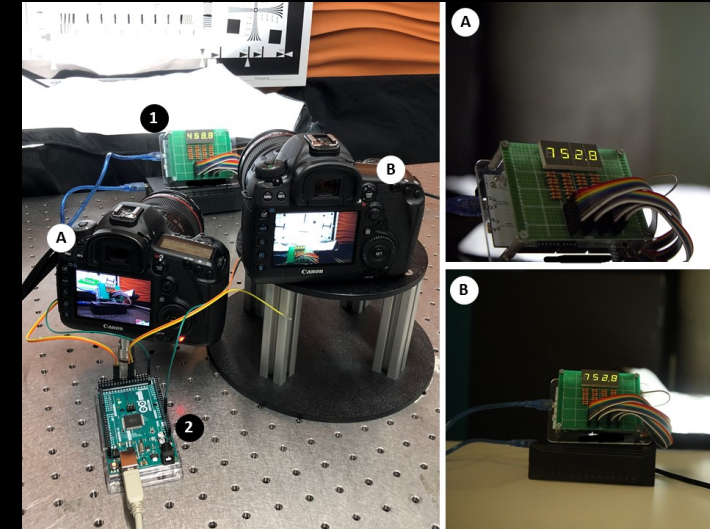
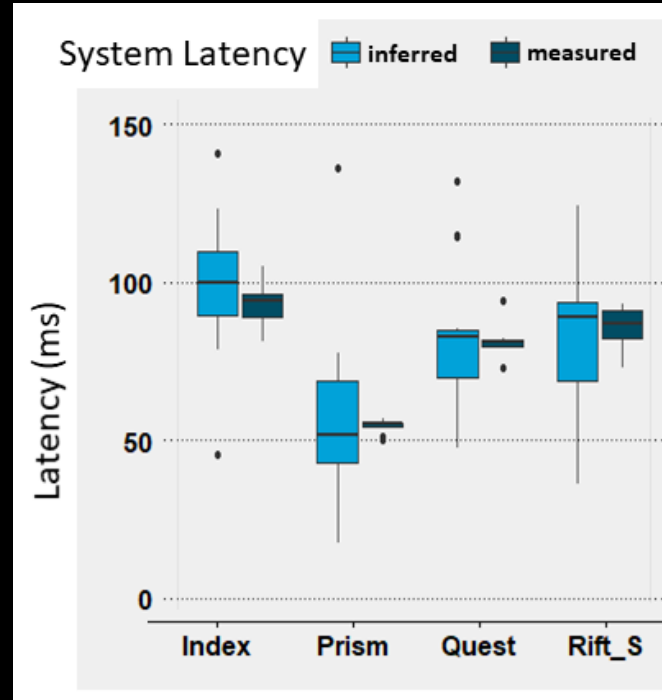
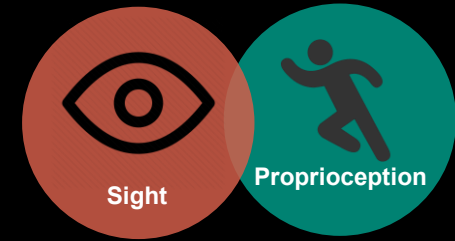
a Multisensory integration



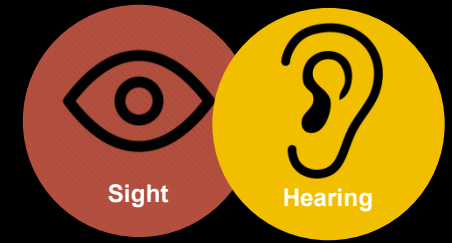
Nature Reviews | Neuroscience

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

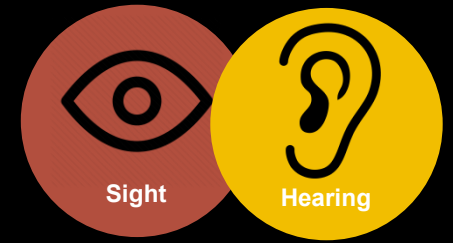


LIP CONDITIONS
Synch 14 % errors
Asynch 30% errors
NoLips 20% errors

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

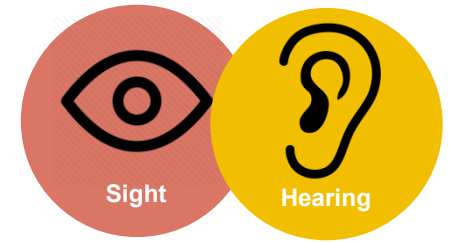


Generic HRTF might be enough in Virtual Reality.
Improving source localization through
cross-modal plasticity

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

Soundscape

<https://www.microsoft.com/en-us/research/product/soundscape/>



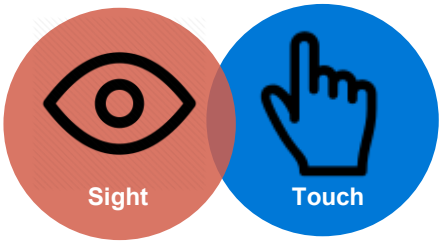
Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues

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

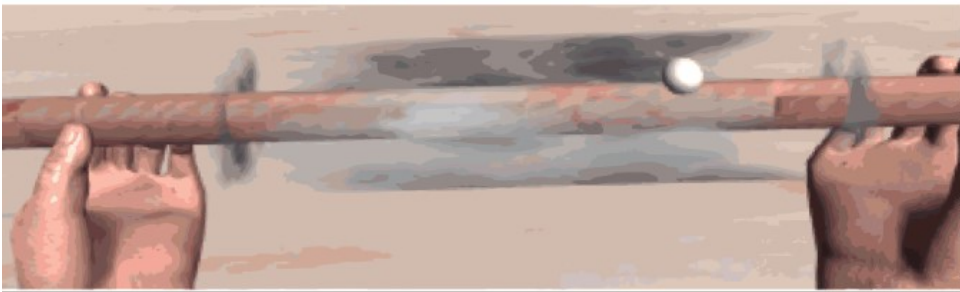
Microsoft Research, margon@microsoft.com

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

SCIENTIFIC
AMERICAN

Observations

.....

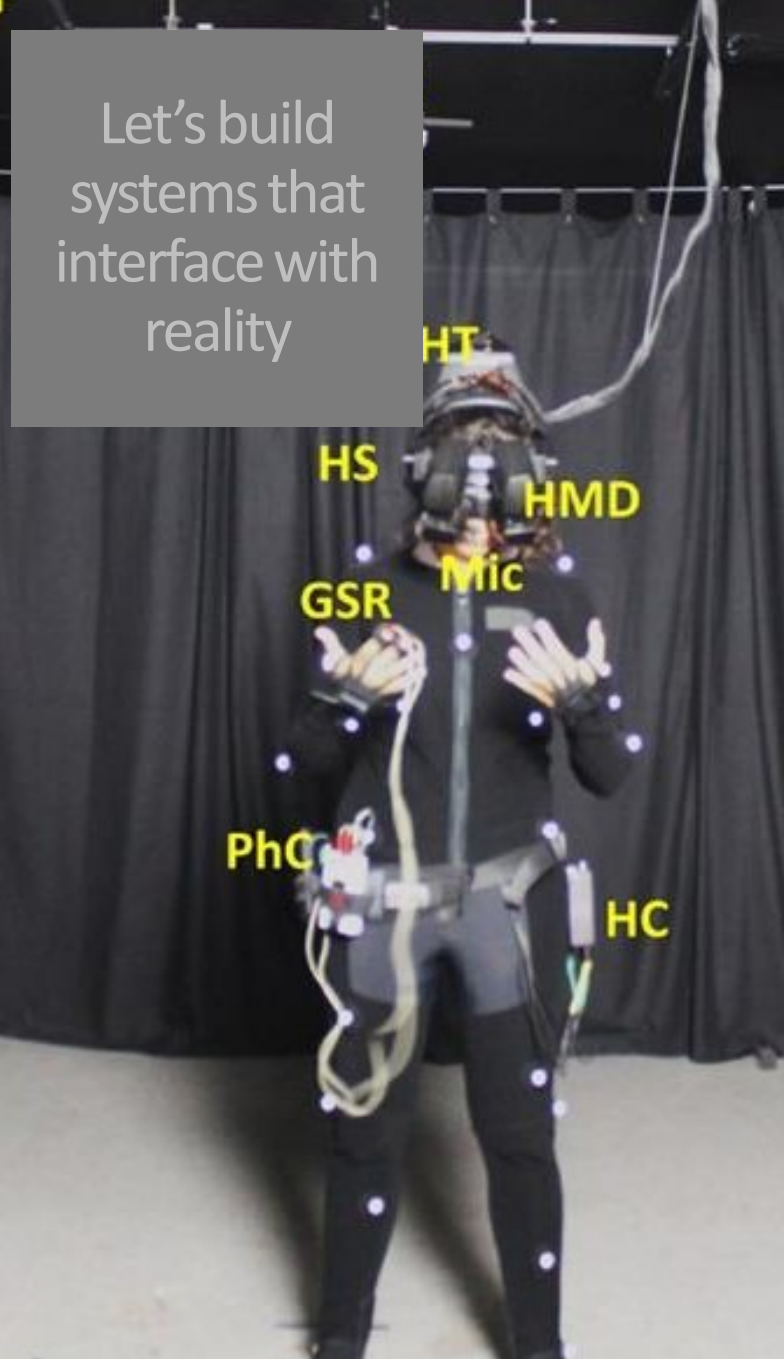
If (Virtual) Reality Feels Almost Right, It's Exactly Wrong

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

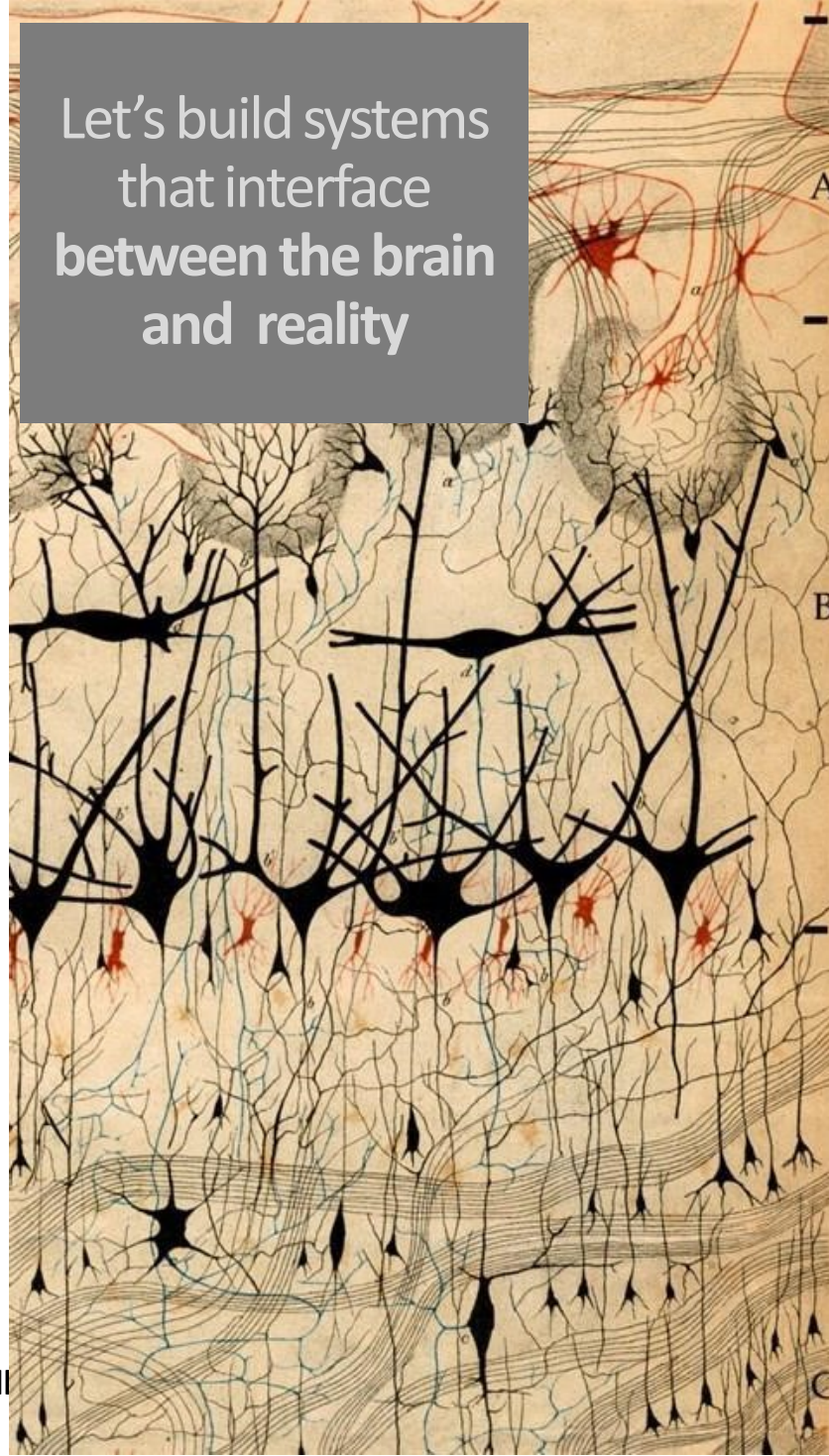
.....

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

Let's build systems that interface with reality



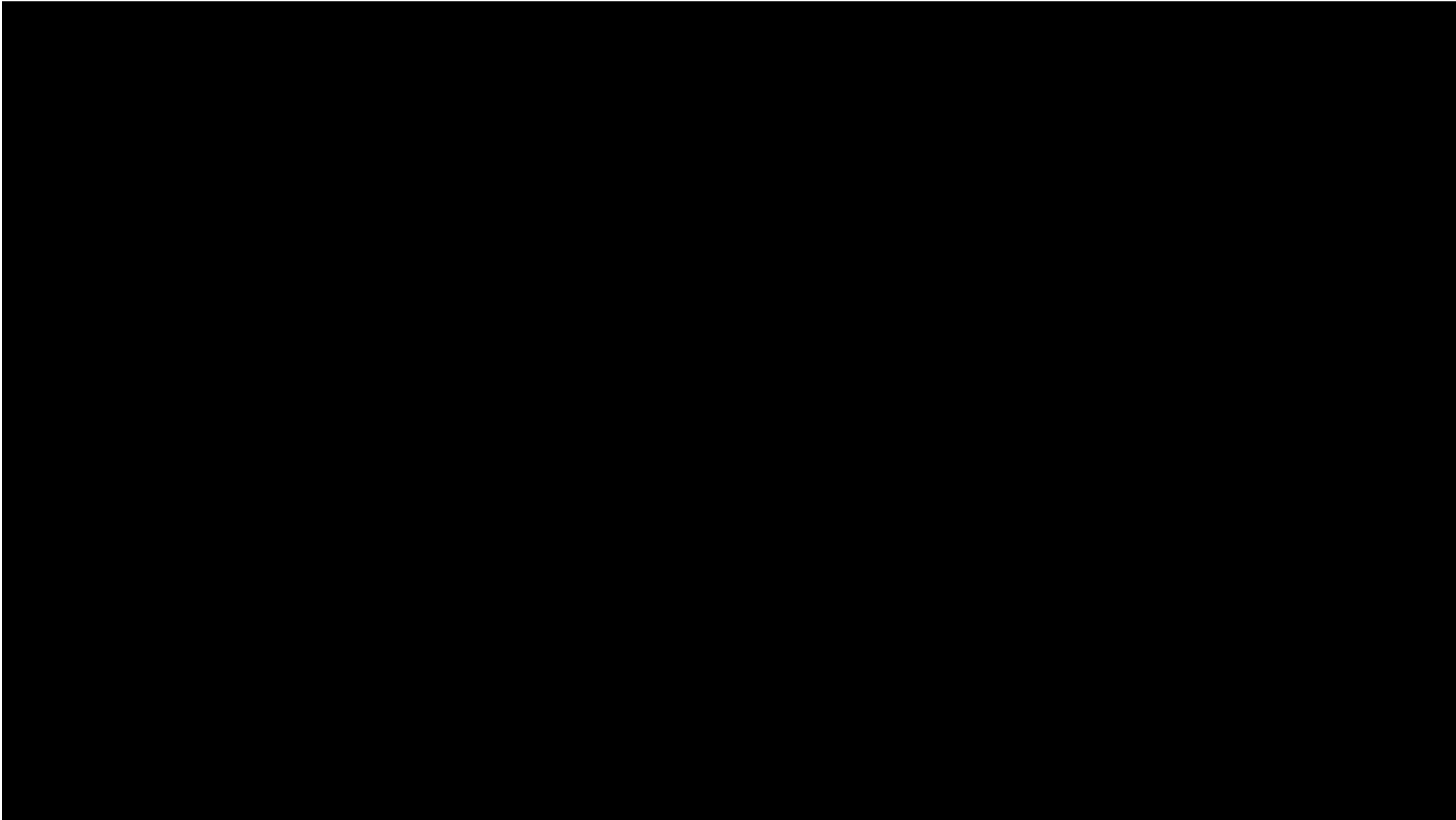
Let's build systems that interface between the brain and reality



Let's build systems that are impossible in reality



Gonzalez-Franco, M., & Lanier, J. (2017). Model of ill reality *Frontiers in psychology*, 8, 1125.



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

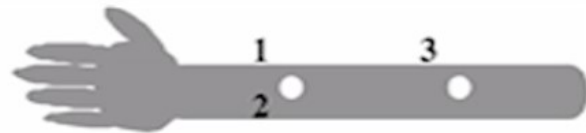
¹microsoft research, redmond, wa, usa, ²hasso plattner institute, university of potsdam, germany



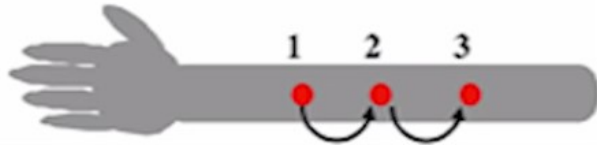
Microsoft | Research

Feeling touch outside of the body

Cutaneous stimulation
(40-200 ms equal intervals)




Percept

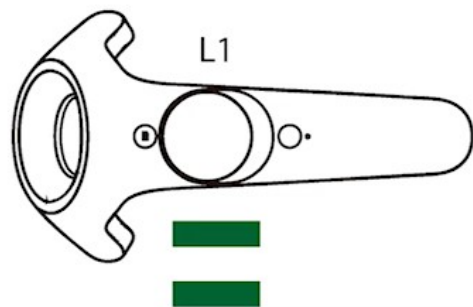


Geldard & Sherrick (1972). *Science*

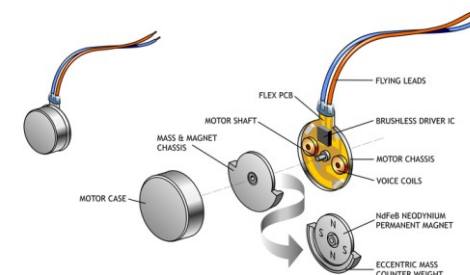
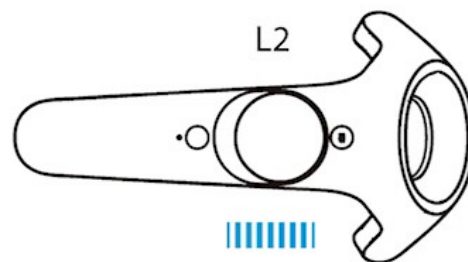
We reproduce the cutaneous rabbit illusion in VR



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. 

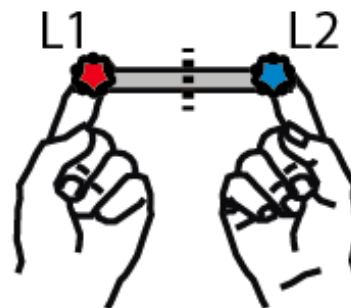


REAL TAPS

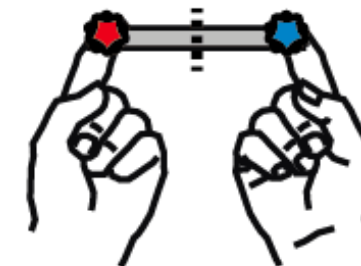


Motor Coin Vibrator

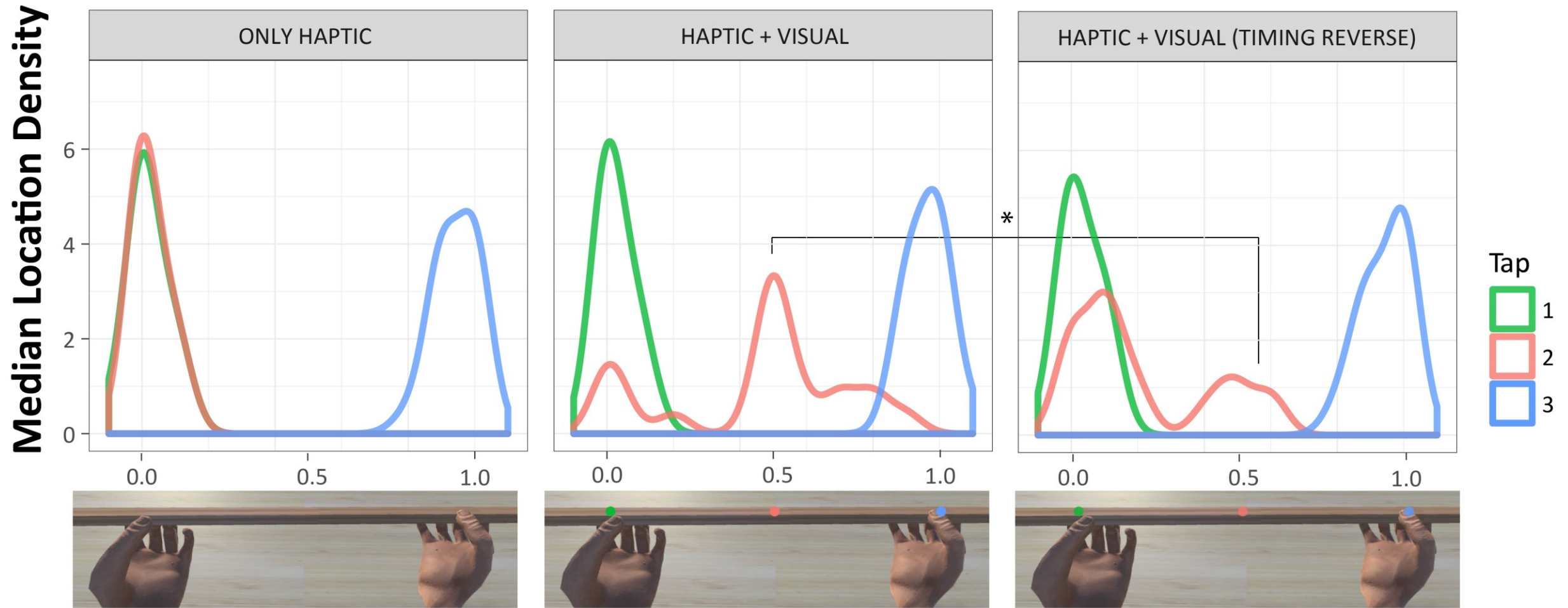
equal tactile strength



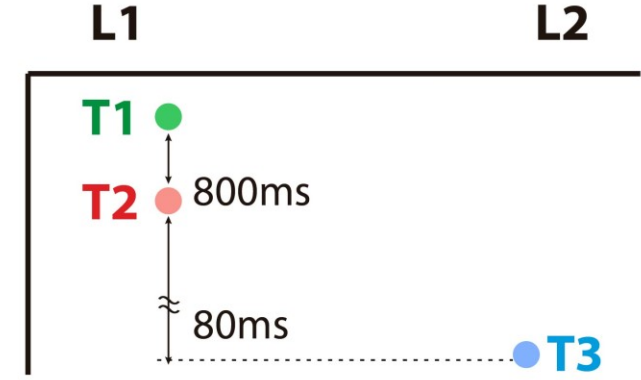
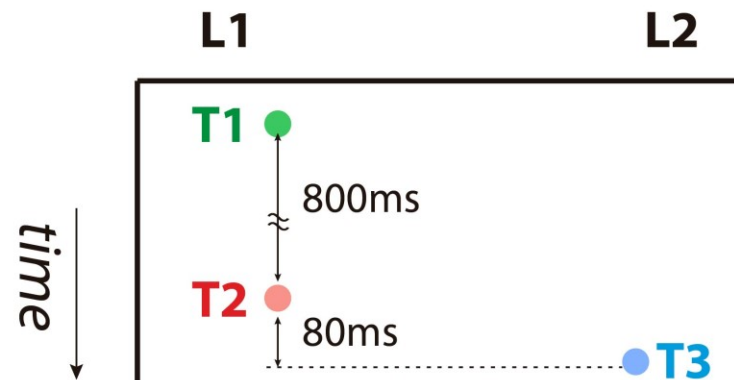
Red = Blue



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



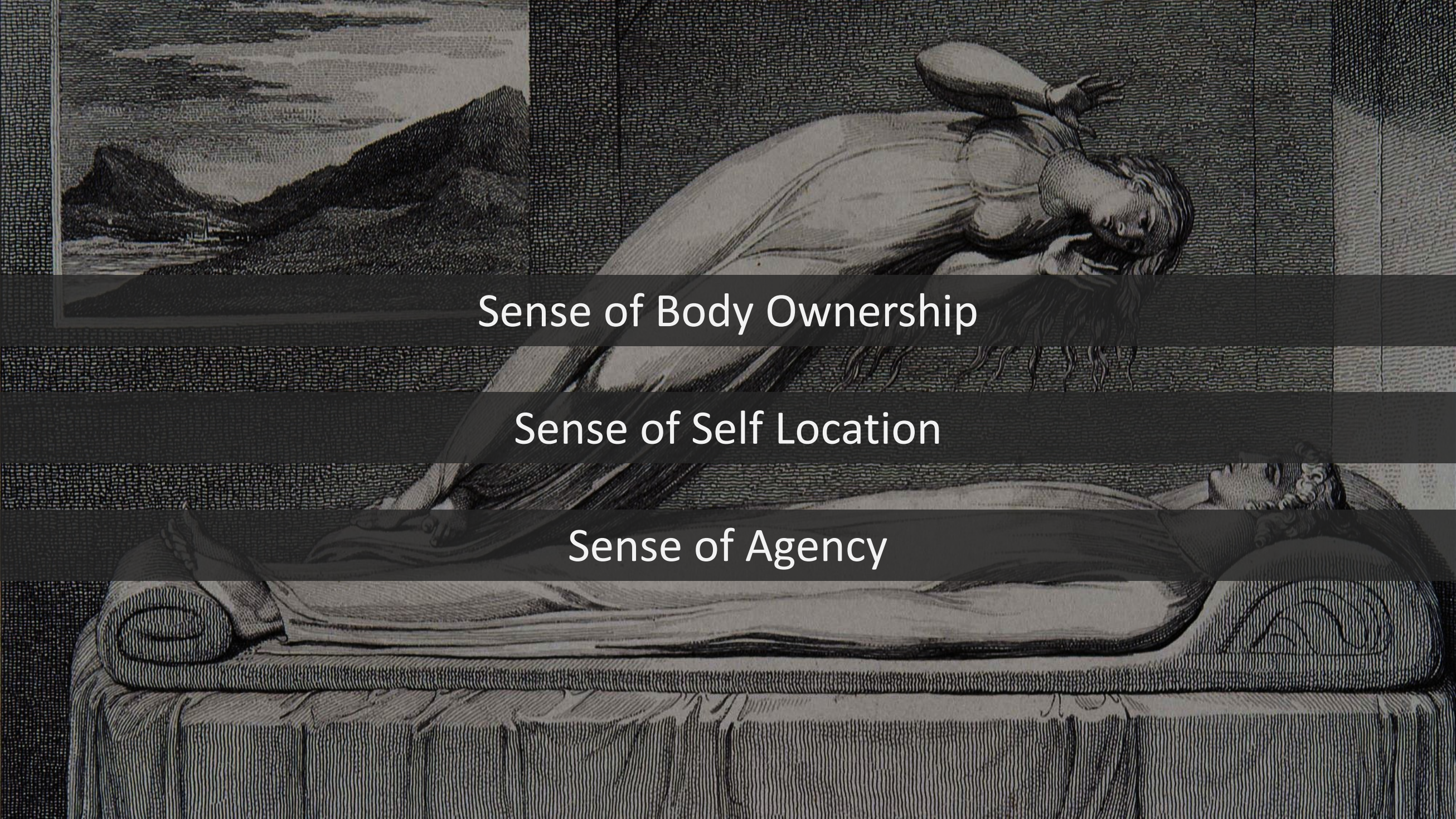
Background

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]



A black and white engraving of a woman in a long, flowing dress sitting on a bed. She is looking towards the right. In the background, there is a landscape with hills and a body of water. The image is overlaid with three horizontal text boxes.

Sense of Body Ownership

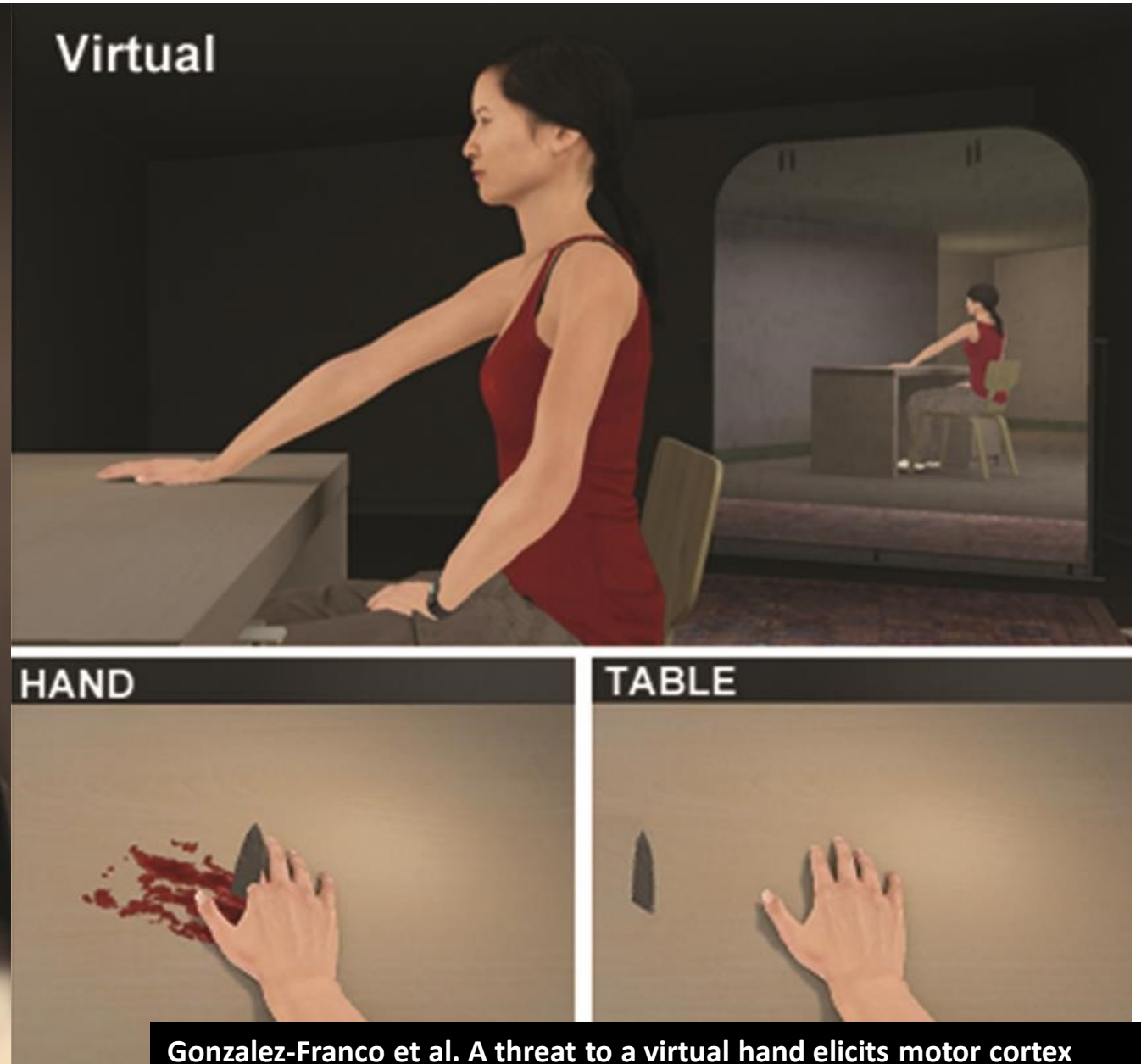
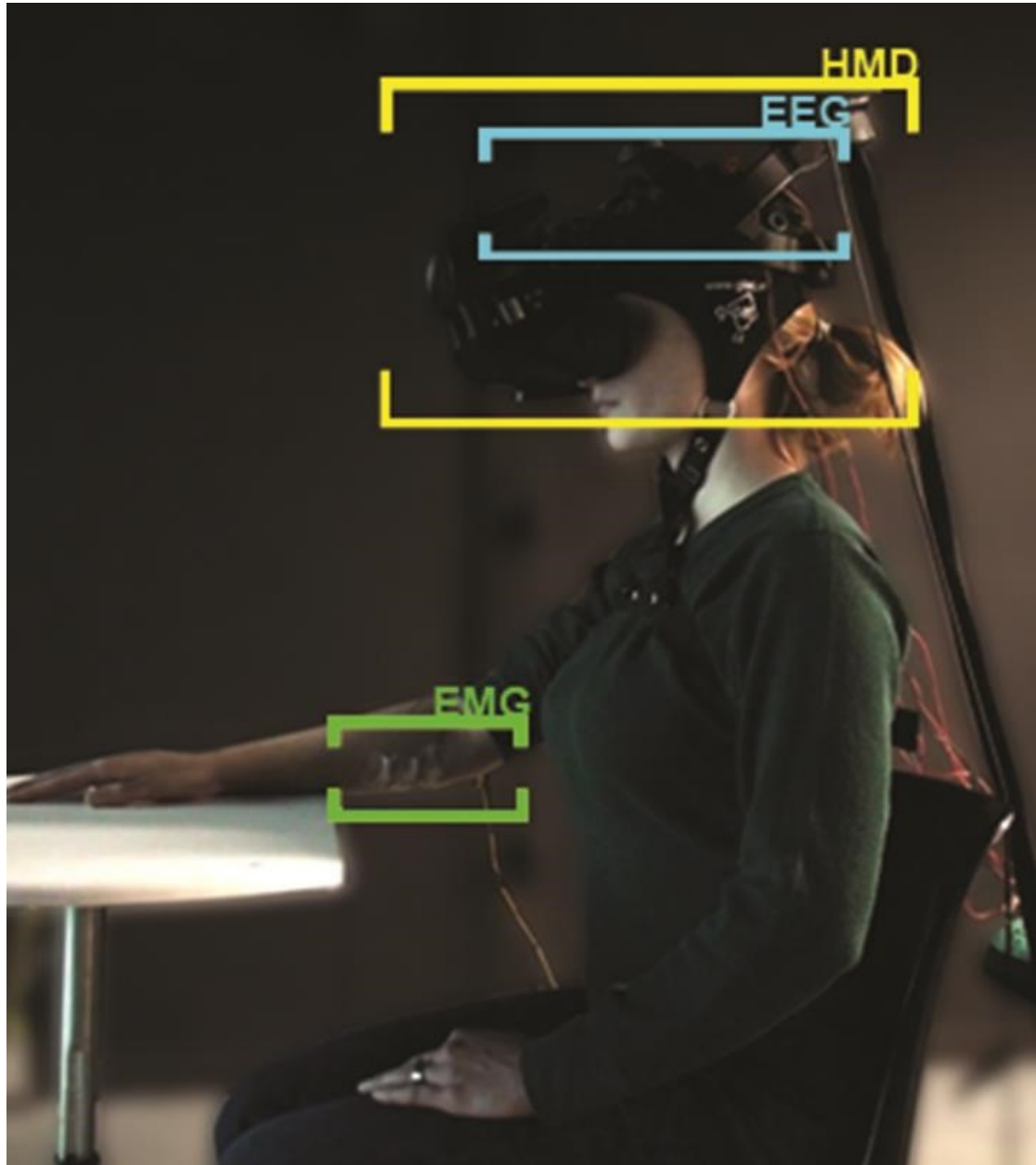
Sense of Self Location

Sense of Agency

Sense of Body Ownership



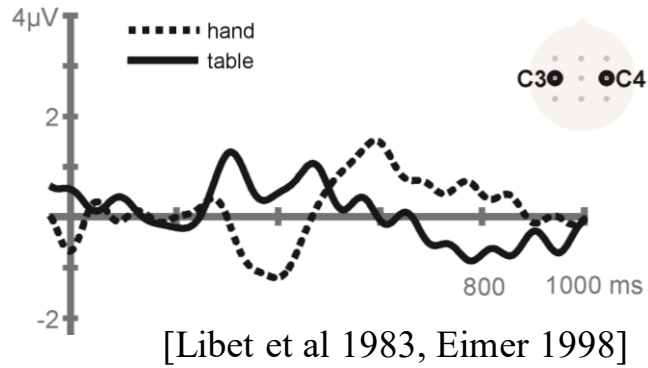
Sense of Body Ownership



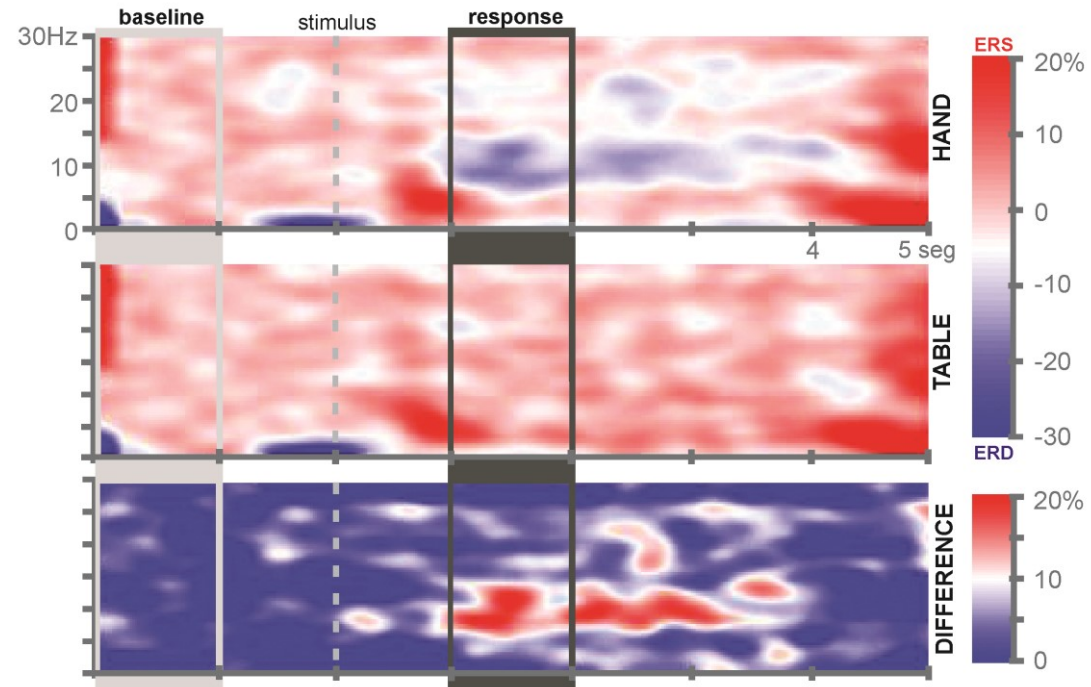
Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. *Experimental Brain Research* (2014)

A threat to the Virtual Body

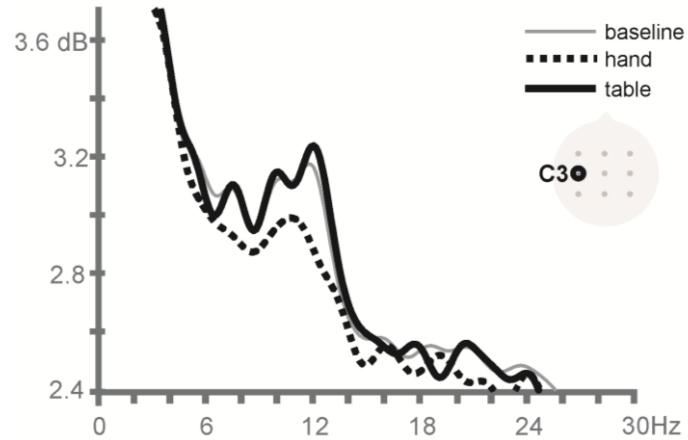
Readiness Potential C3-C4



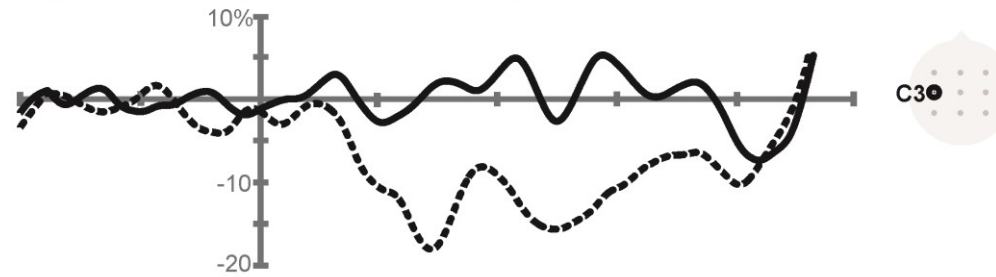
a) Time Frequency Evolution in C3



) Short Time Power Spectra

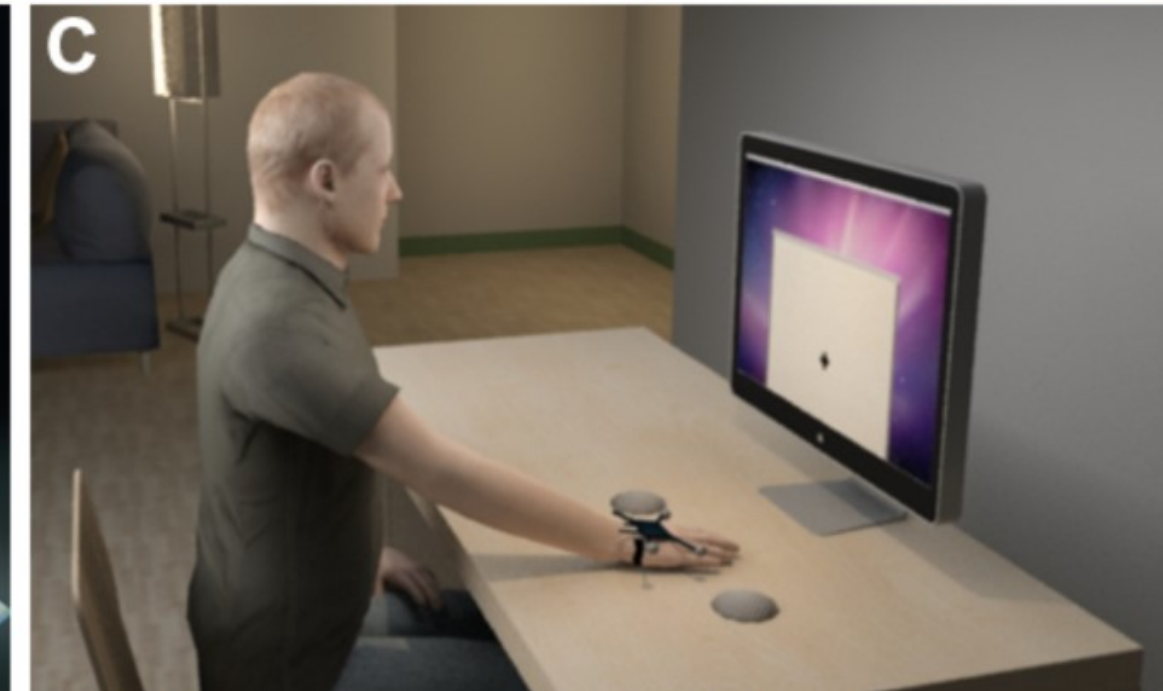
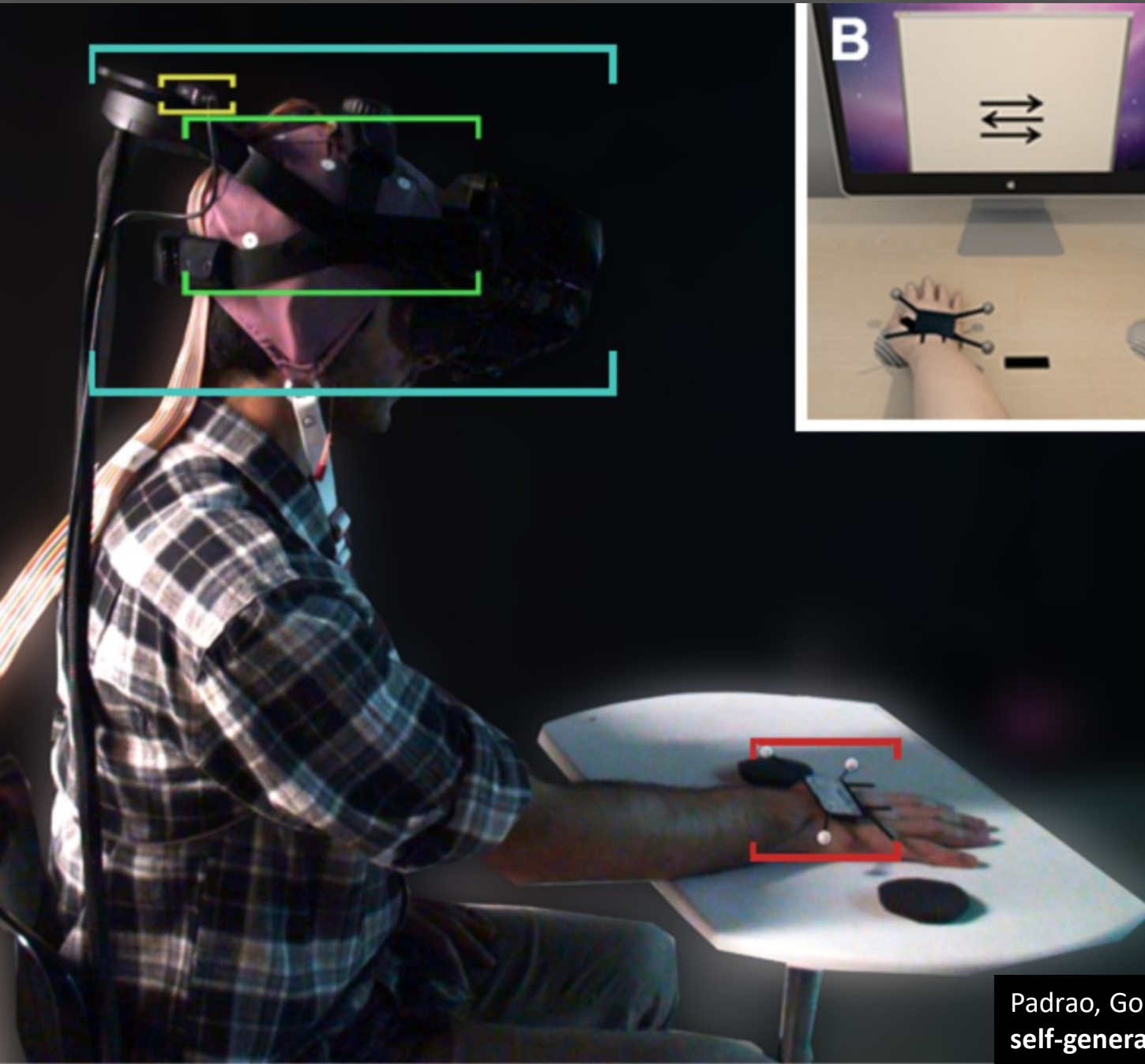


c) Mu-rhythm (10-12Hz) Event Related Desynchronization



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

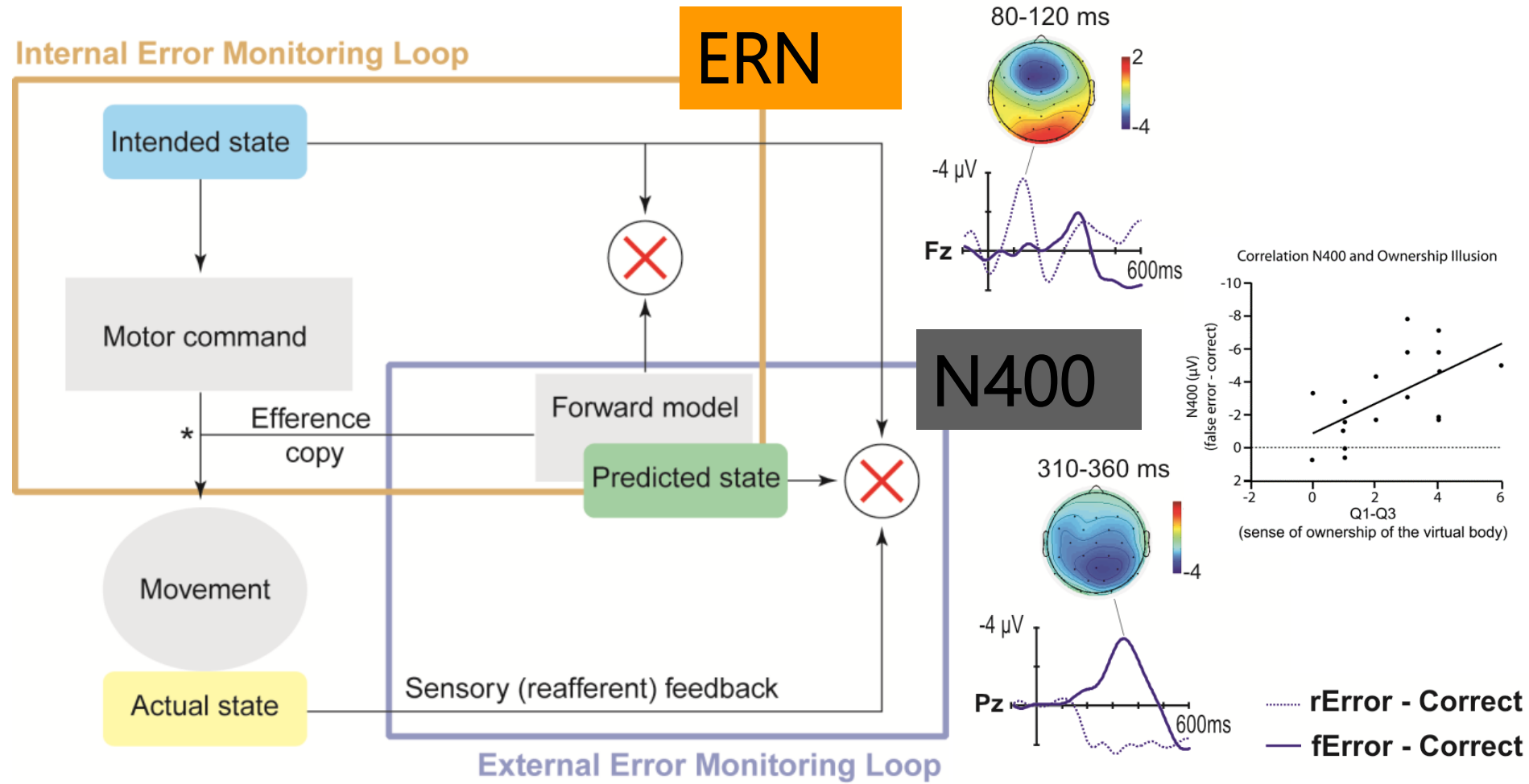
Sense of Agency



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

Home > 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.

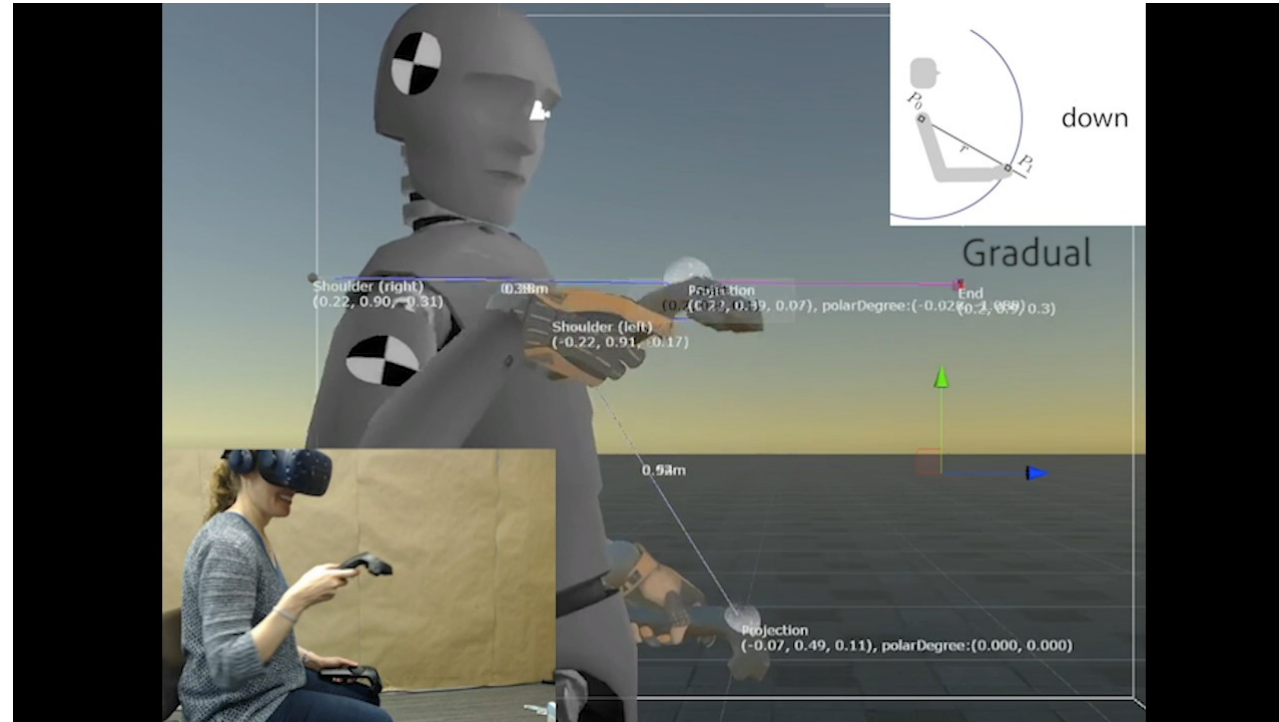
<https://notebooks.azure.com/margon/projects/EmbodimentQuestionnairePCA>

Analyzed 30 famous experiments and extracted 25 questions

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

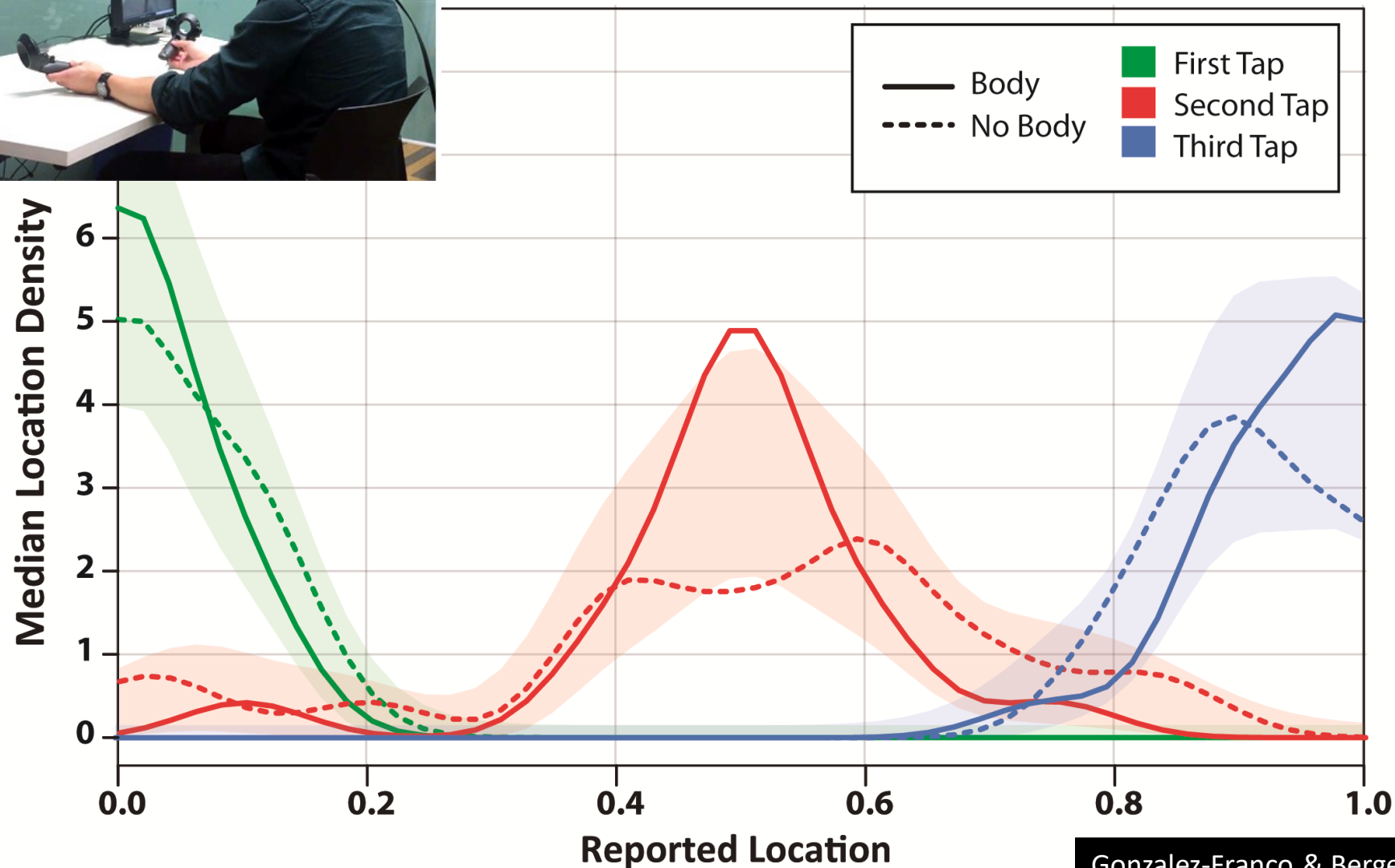


futuris

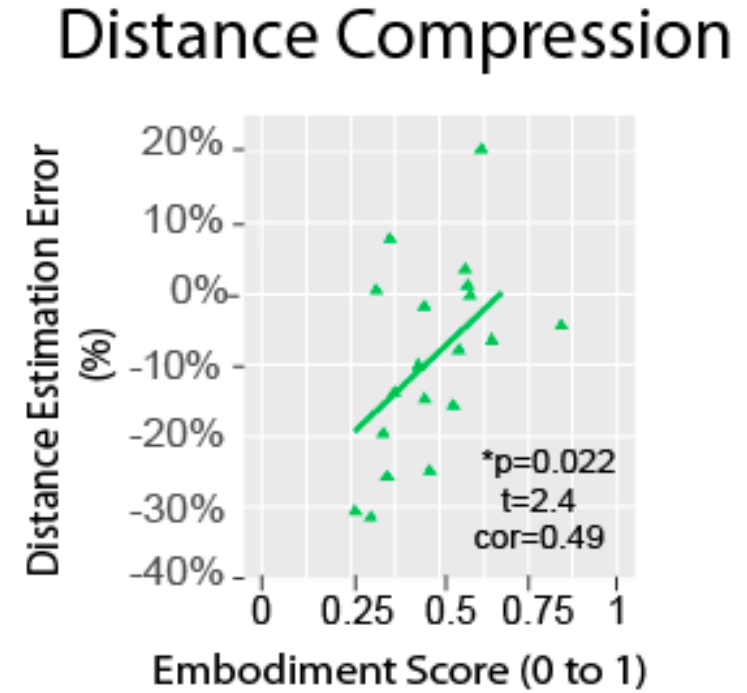
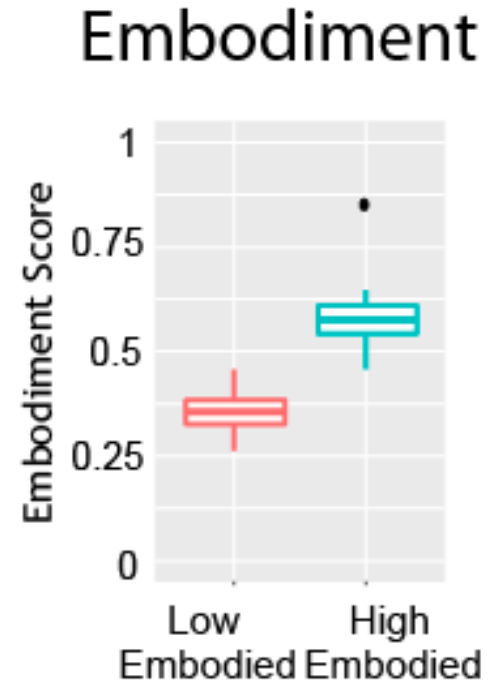
Embodiment increases haptic experiences



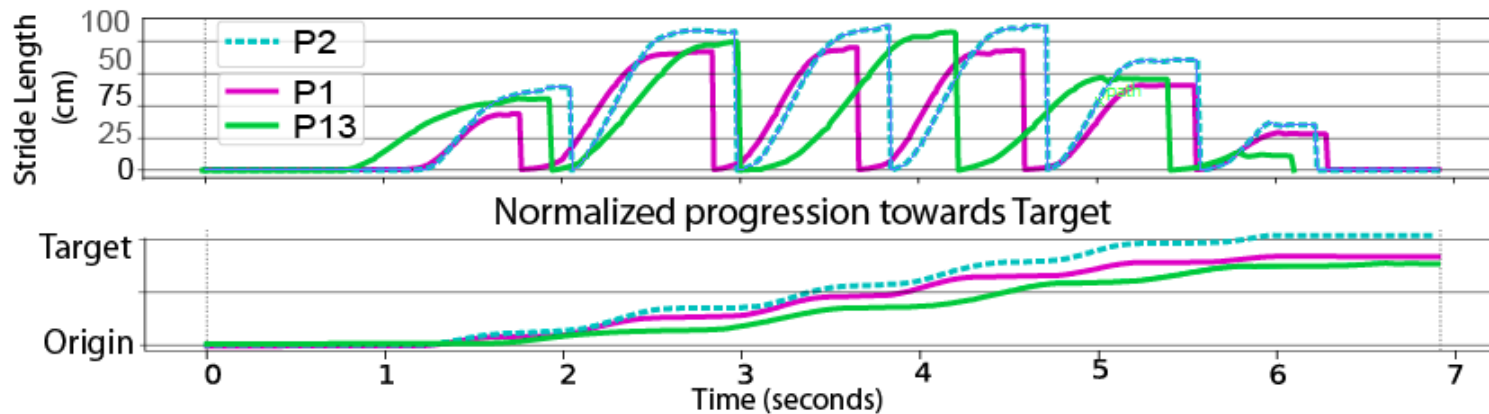
Perceived Tap Location



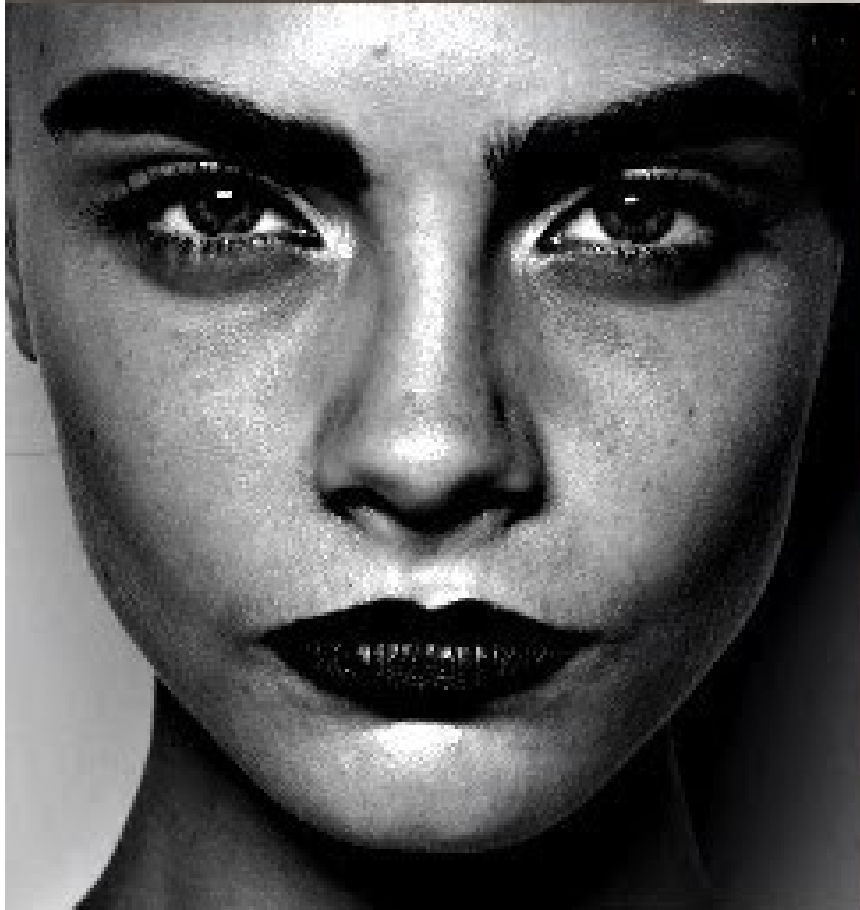
Many Individual Differences In Embodiment across participants



Individual Strides



Enfacement



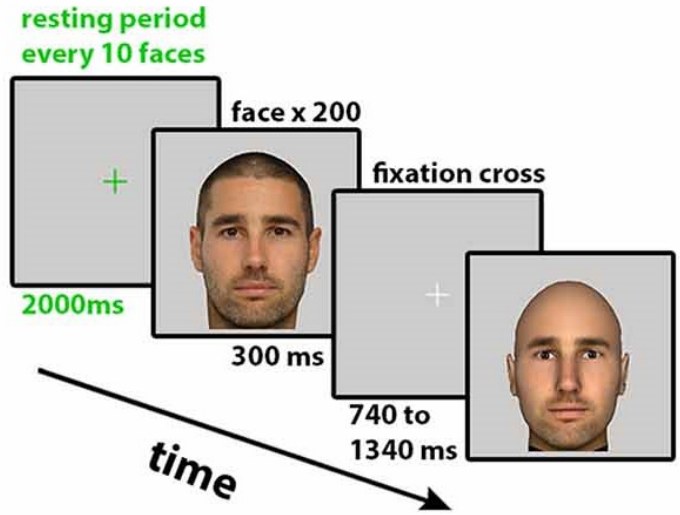
Self-recognition on Avatars

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

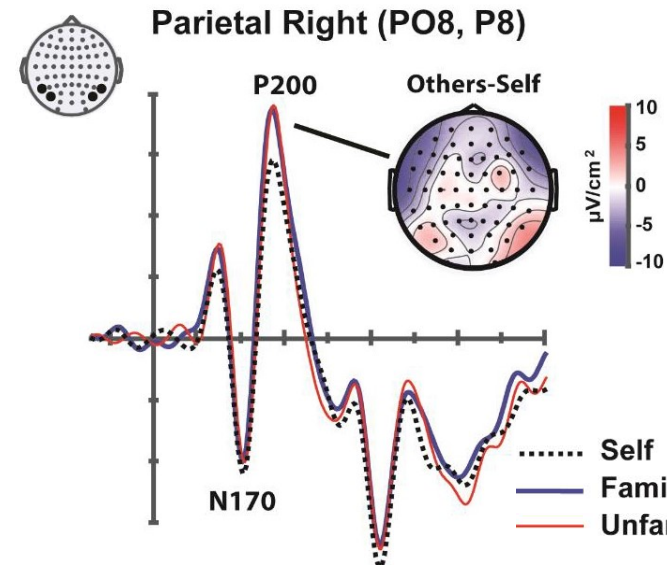
A Avatar creation



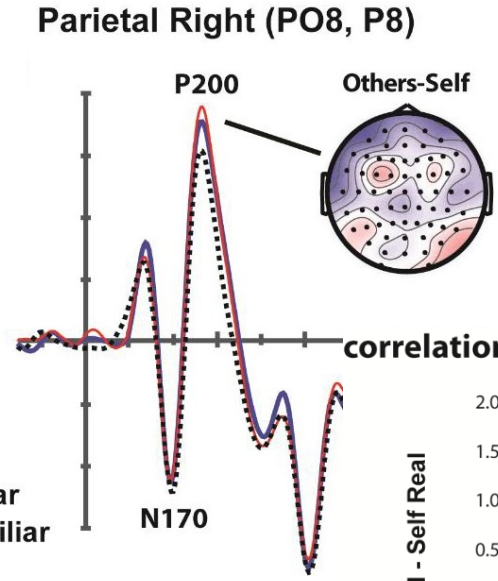
B Experimental Execution



Real Faces



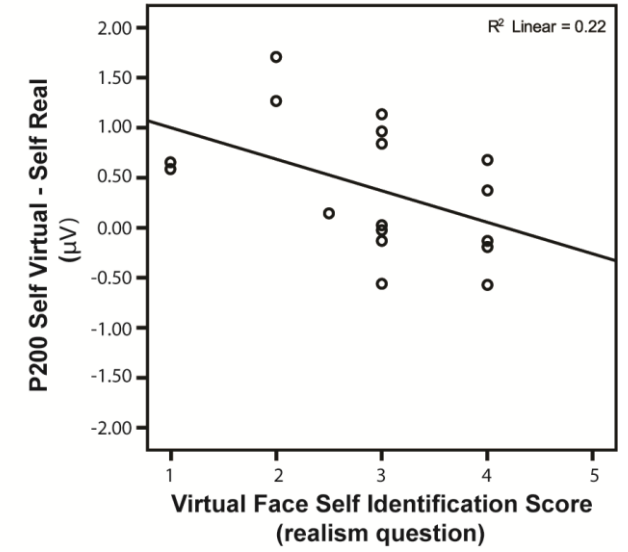
Virtual Faces



No N170 differences:
same class of object


P200/N250 250-300ms
self-recognition

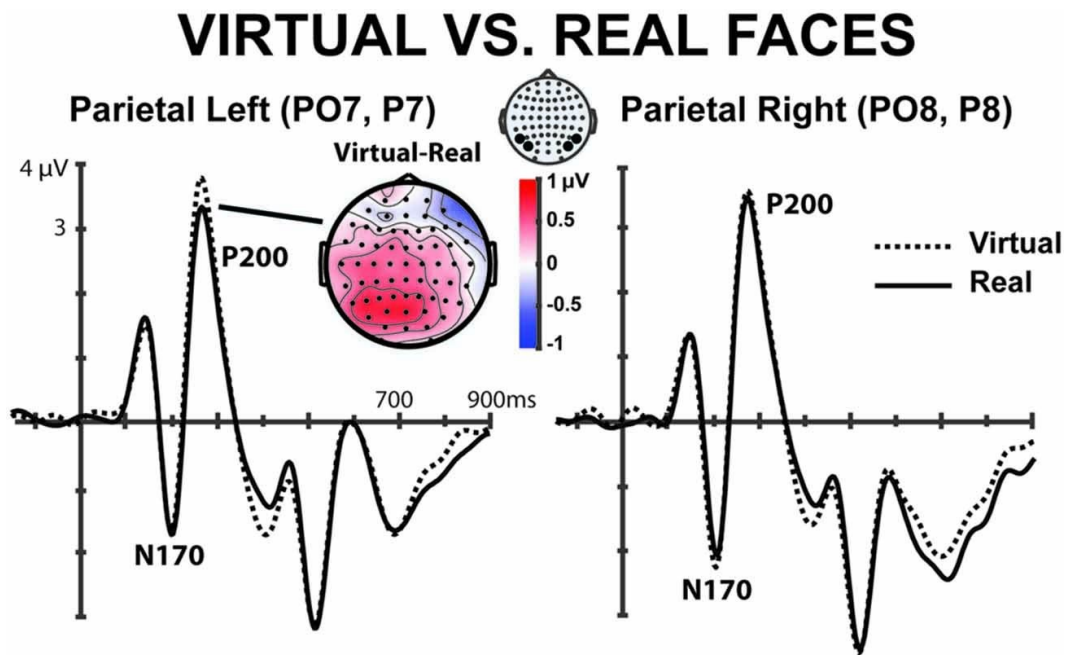
correlation subjective vs. unconscious identification



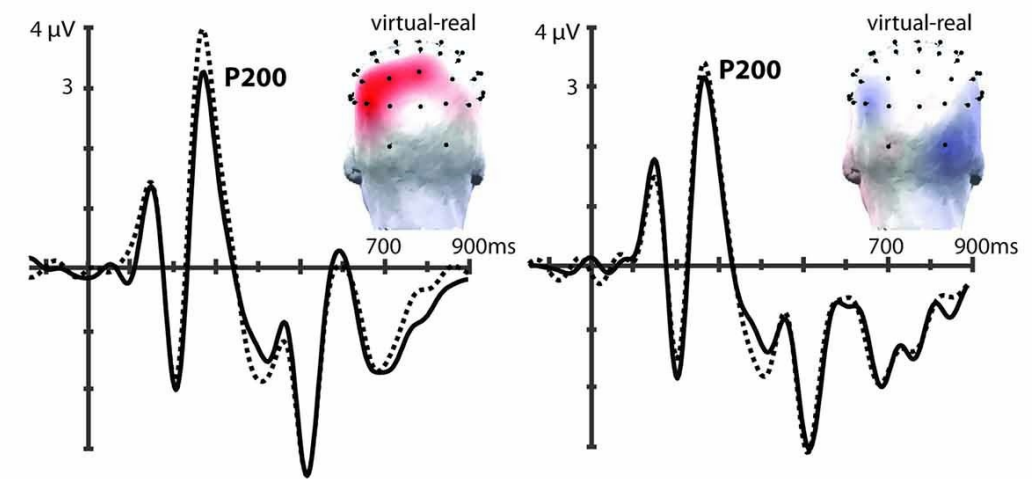
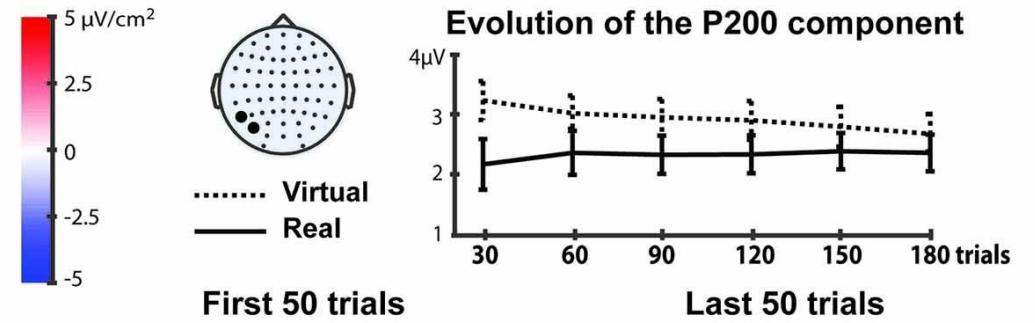
Self-recognition on Avatars



 Spatial



Fast Adaptive Effects in Virtuality (PO7,P7)



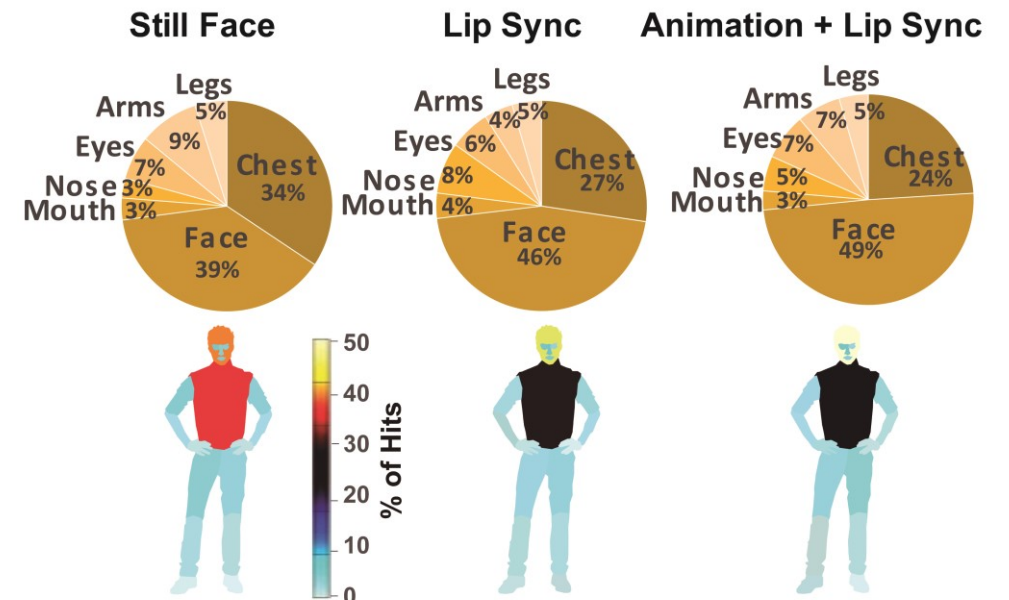
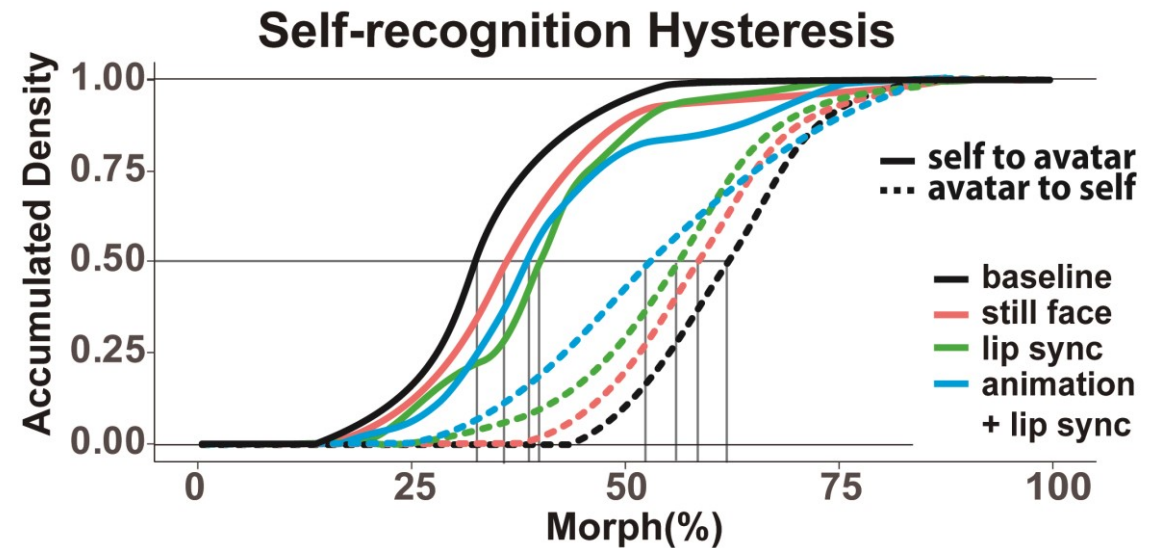
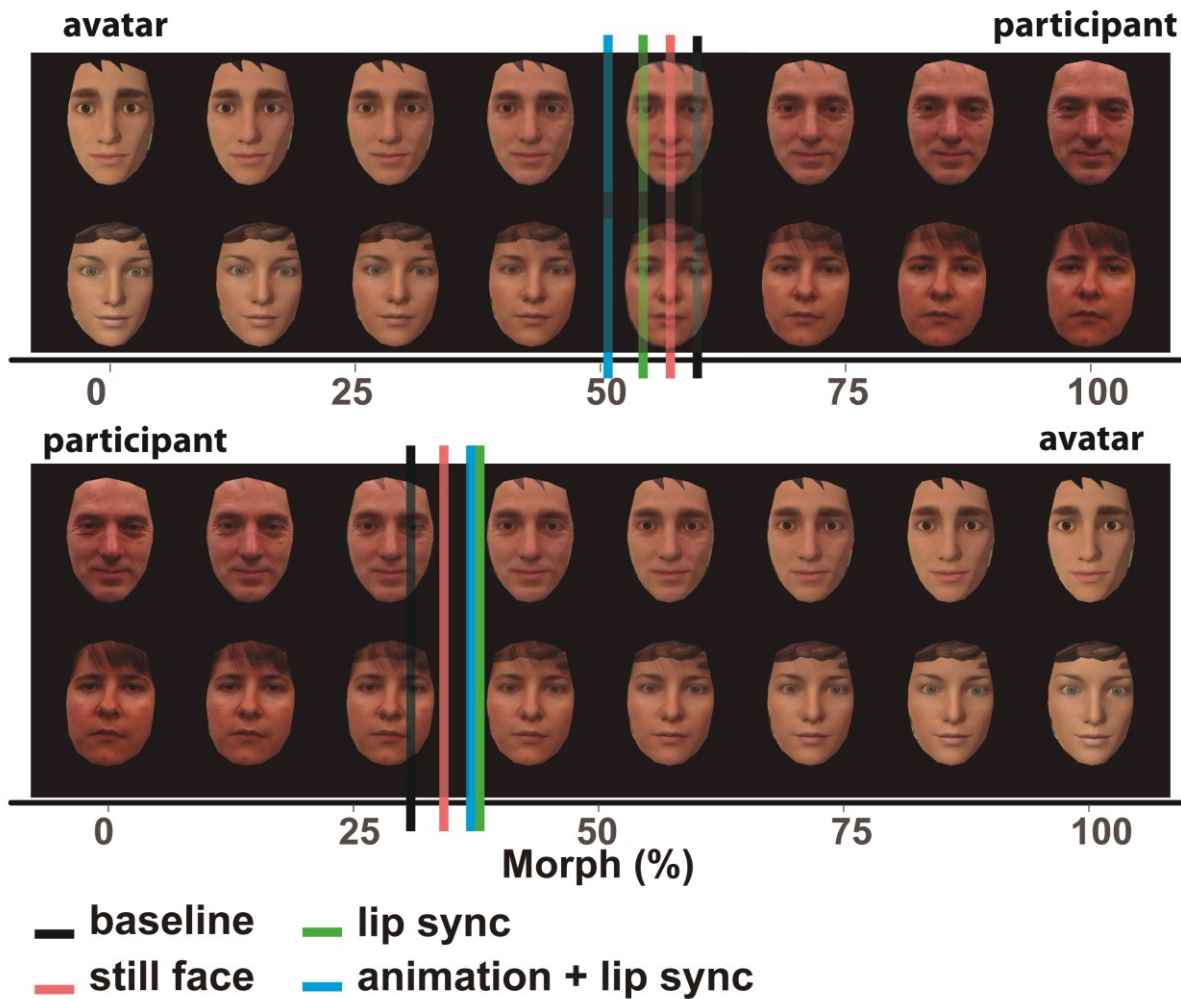
Enfacement on Avatars



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



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

Avatar BEHAVIOUR

REALISTIC
BEHAVIOR

Place Illusion

Presence
Illusion

Plausibility Illusion



Meehan et al. Siggraph 2002

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 [f Share](#) [t Tweet](#) [s Snap](#)



IMAGE: ALTSPEACEVR

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."

Thanks!

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Andy Wilson



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Impossible outside Virtual Reality

Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC)
Research Group

Microsoft Research
June 4th 2020



<https://www.microsoft.com/research/people/margon/>
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