Microsoft

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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Universitat de Barcelona

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

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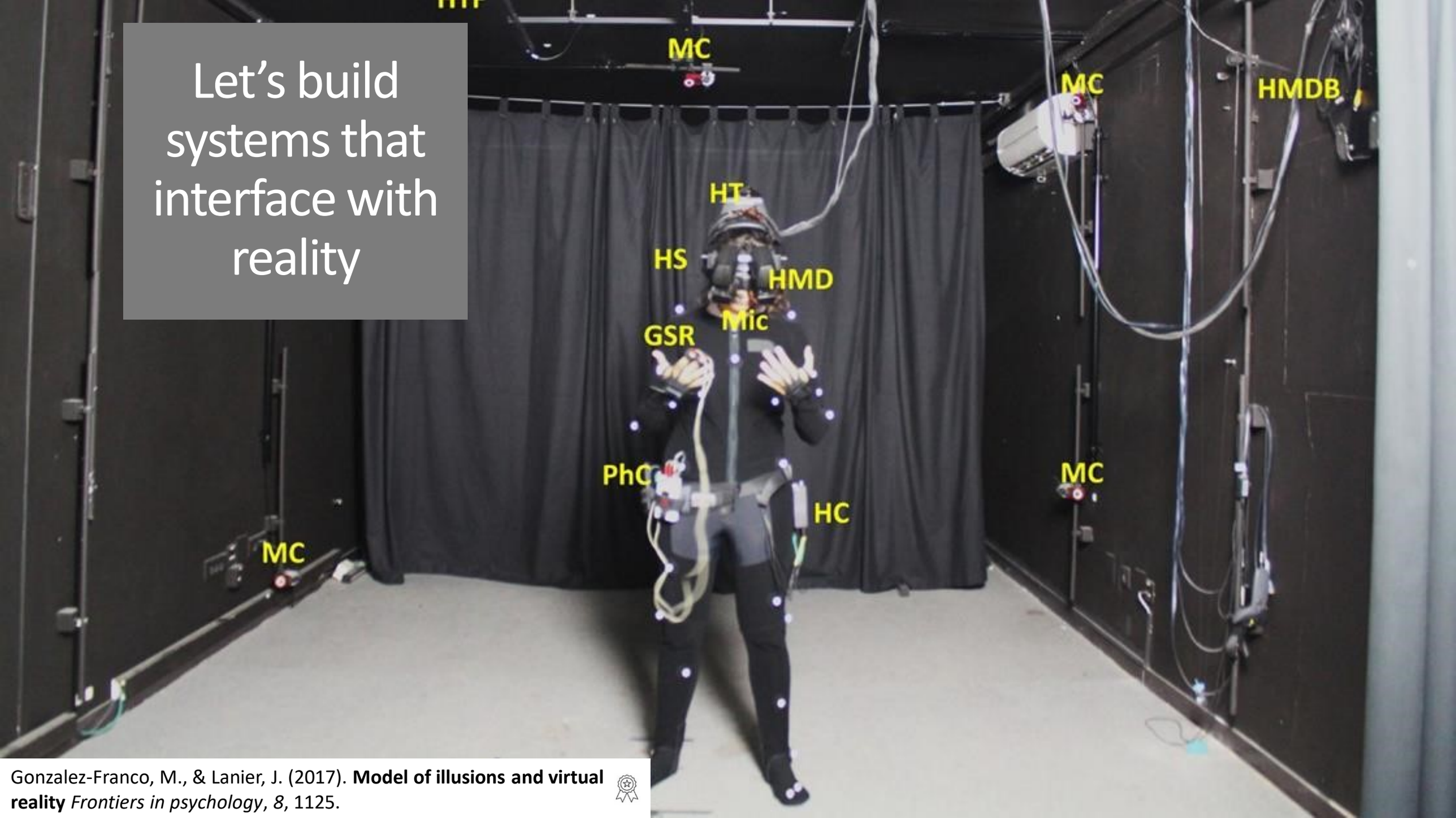
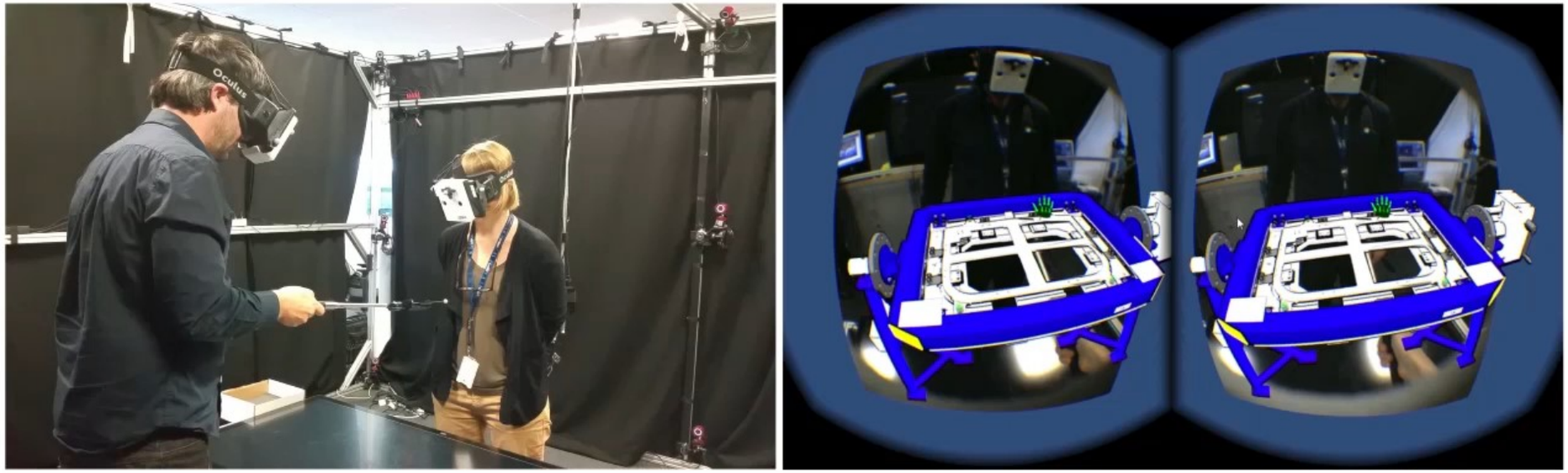


Let's build systems that interface with reality

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



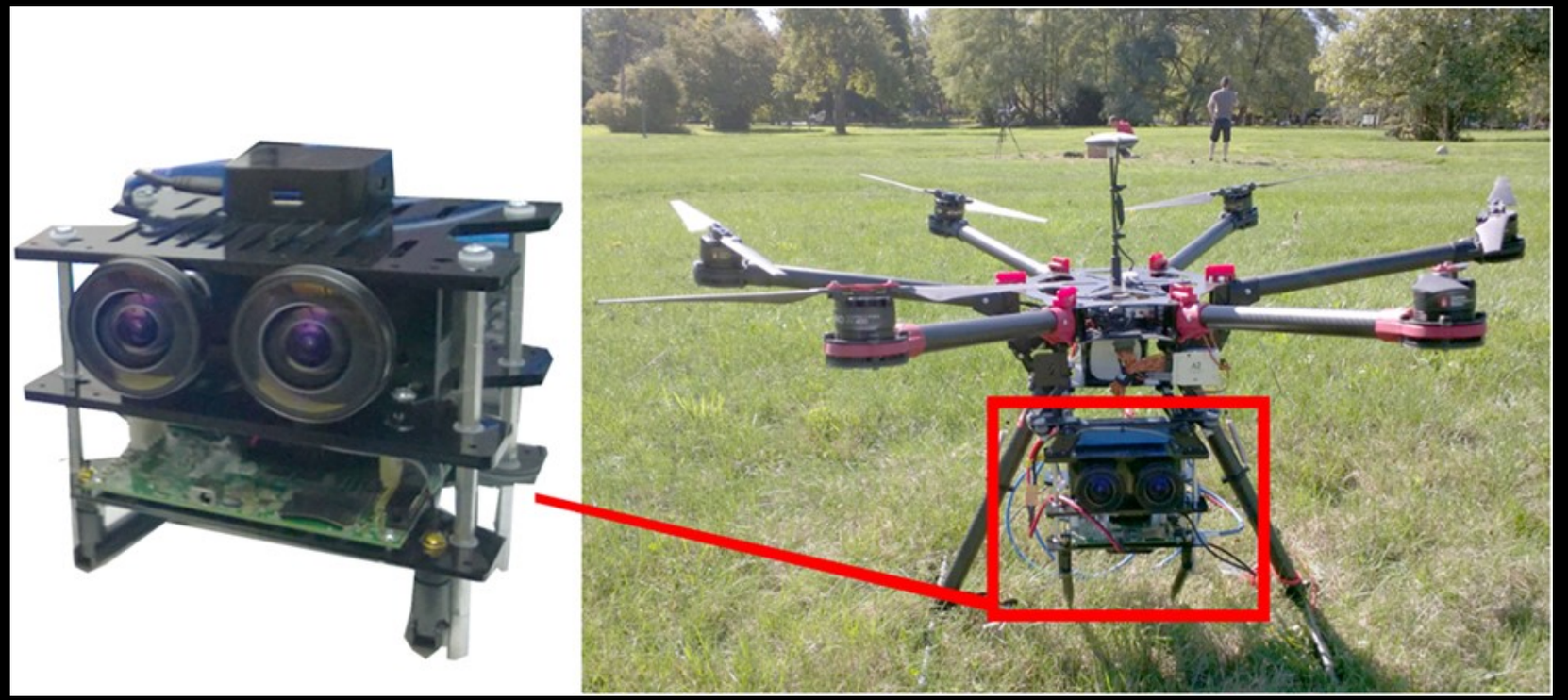
Immersive Mixed Reality for Manufacturing Training

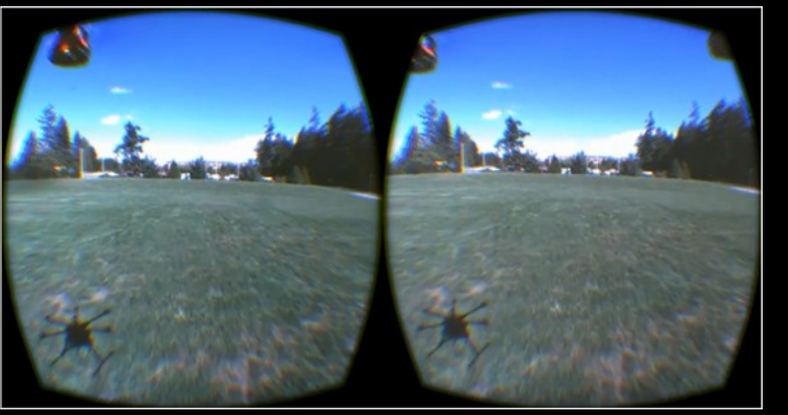
M Gonzalez-Franco, R Pizarro, J Cermeron, K Li, J Thorn,
W Hutabarat, A Tiwari, P Bermell-Garcia

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

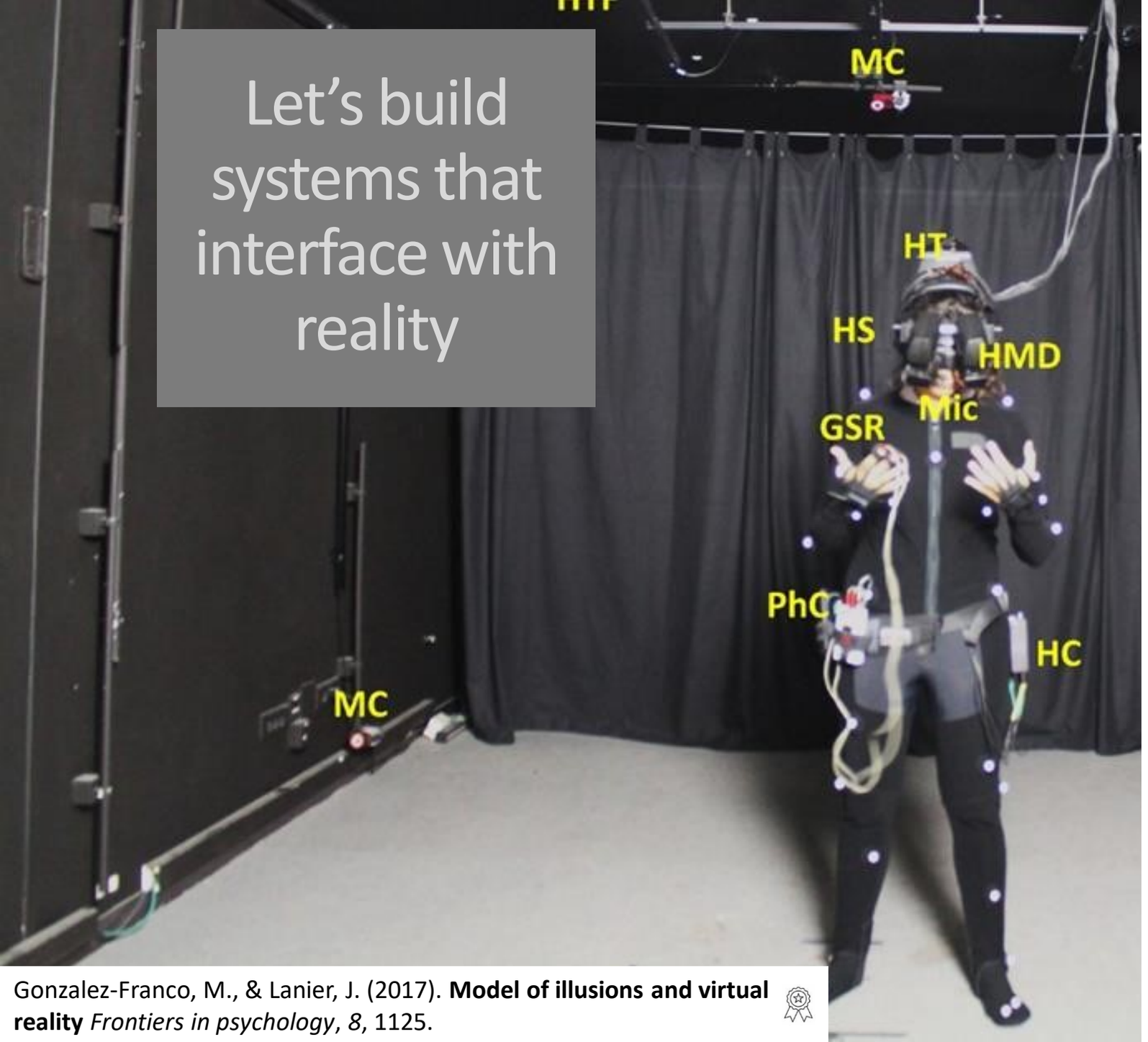




Modified DJI S900 hexacopter (right) with the stereo camera and the Tegra TK1 embedded board attached (left). 28–30 frames per second encoding speed at 1,600 × 1,080 resolution per camera/eye

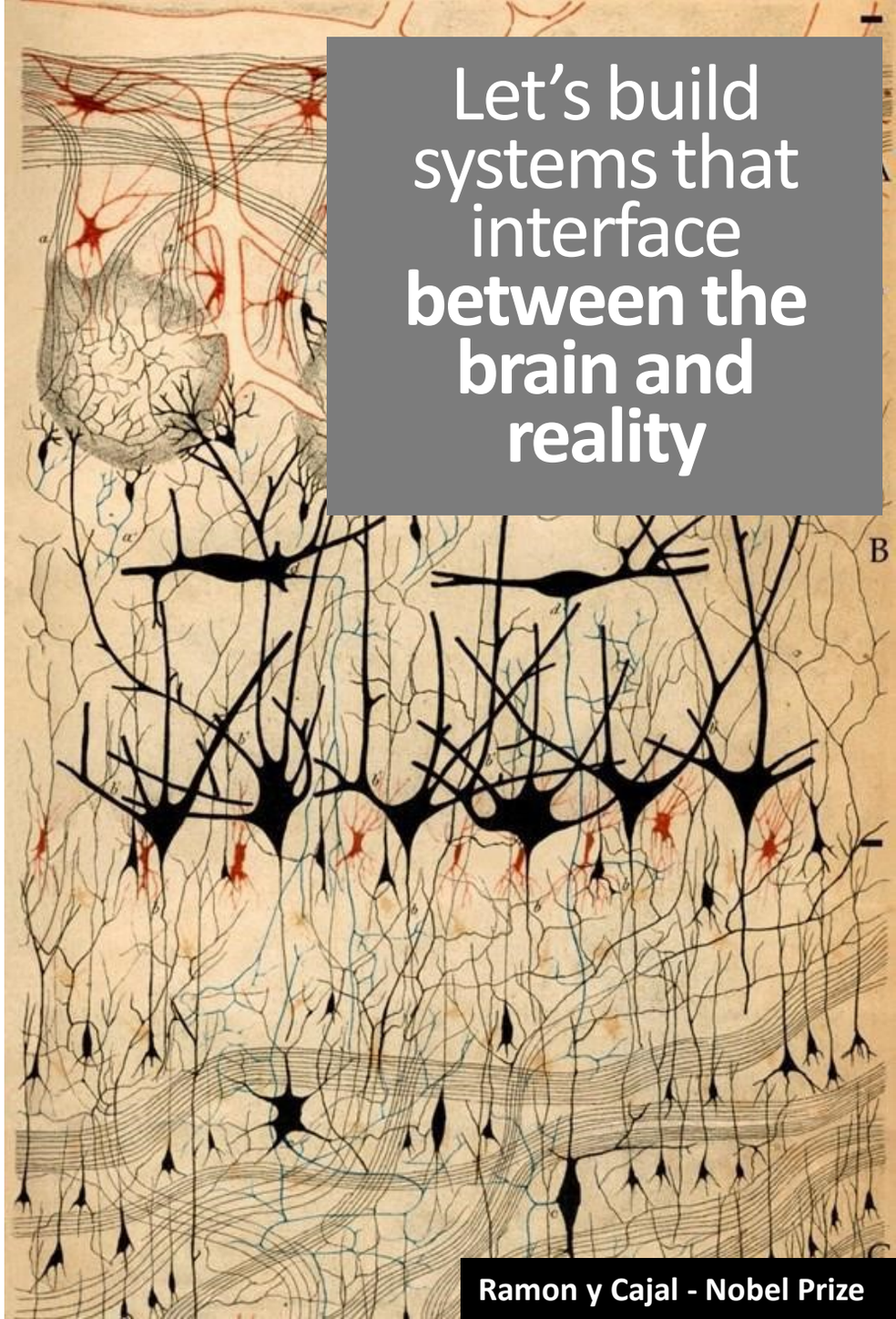
Smolyanskiy, N., & **Gonzalez-Franco, M.** (2017). Stereoscopic first person view system for drone navigation. *Frontiers in Robotics and AI*, *4*, 11.

Let’s build systems that interface with reality



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

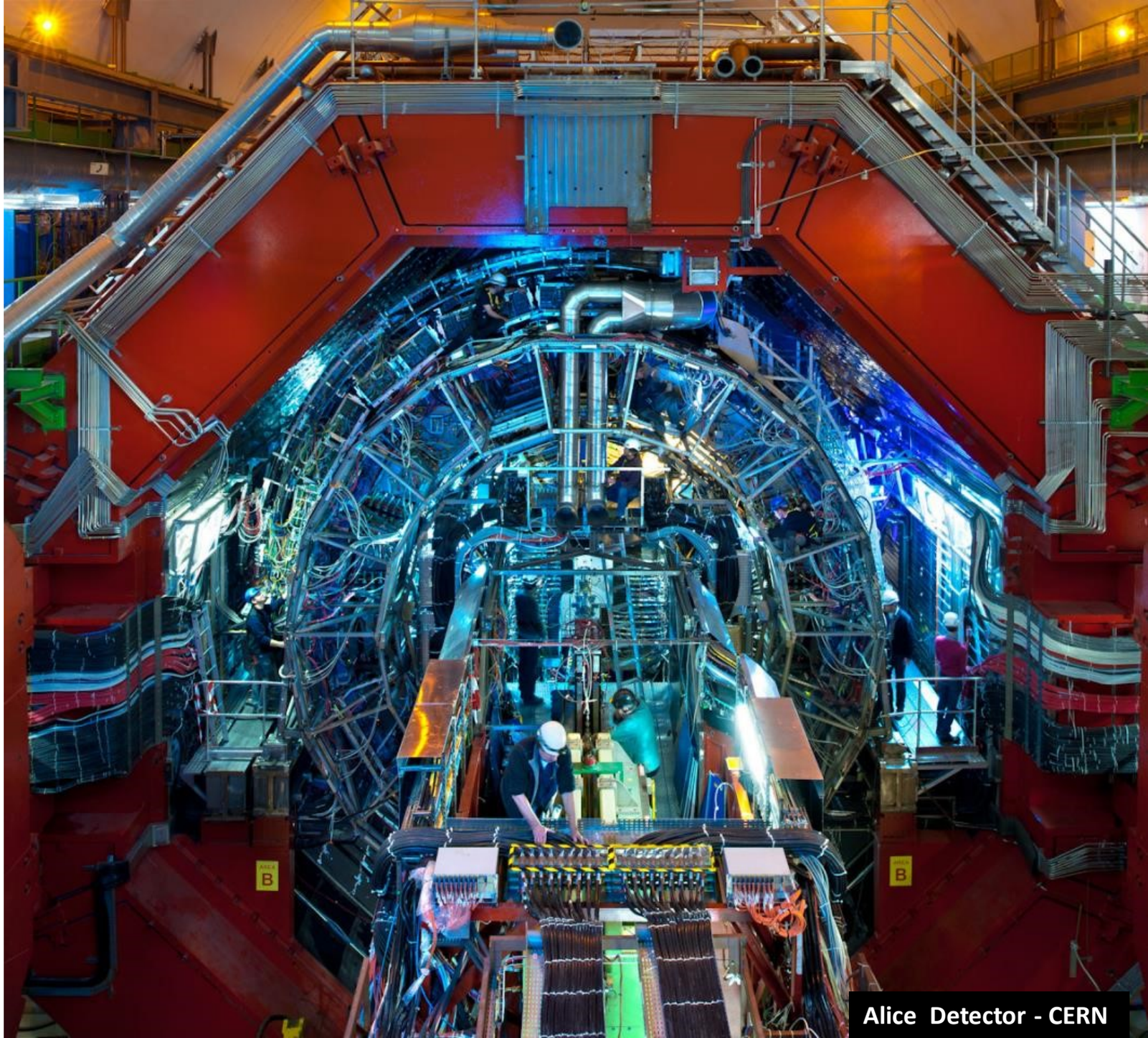
Let’s build systems that interface **between the brain and reality**



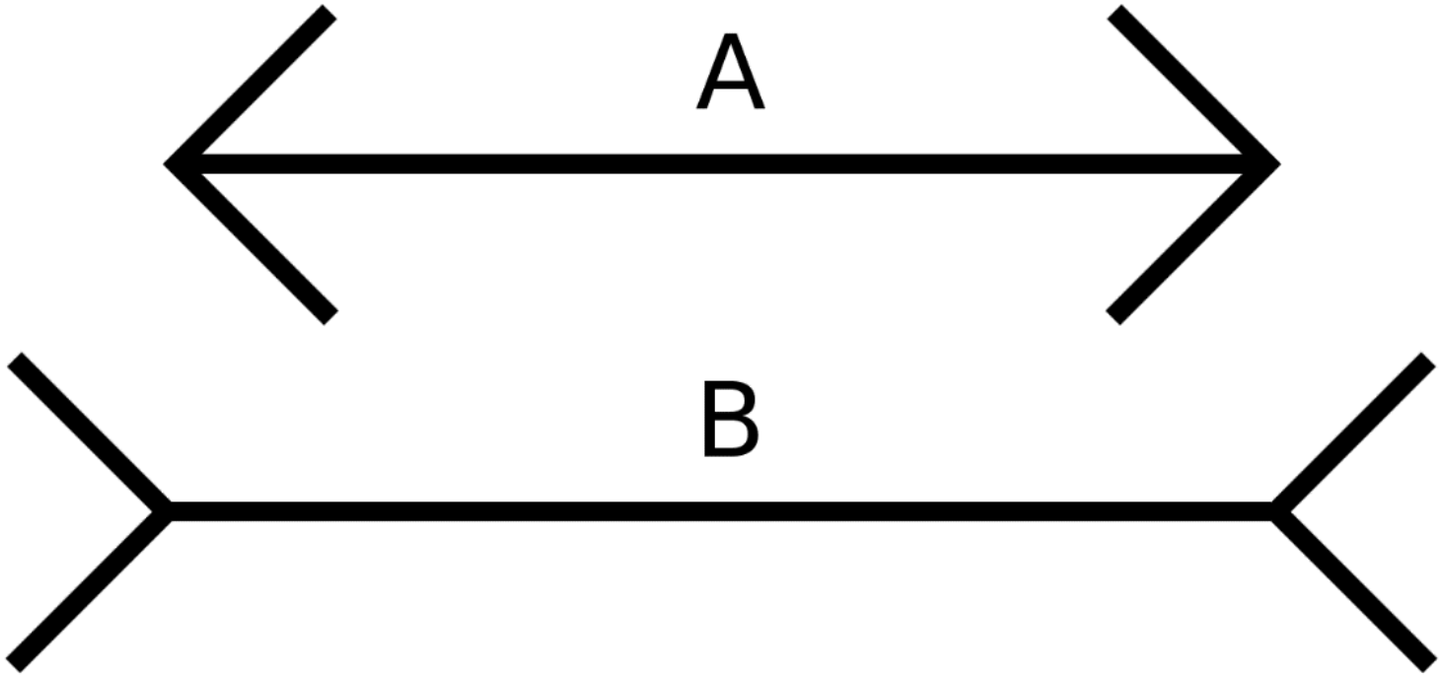
Ramon y Cajal - Nobel Prize

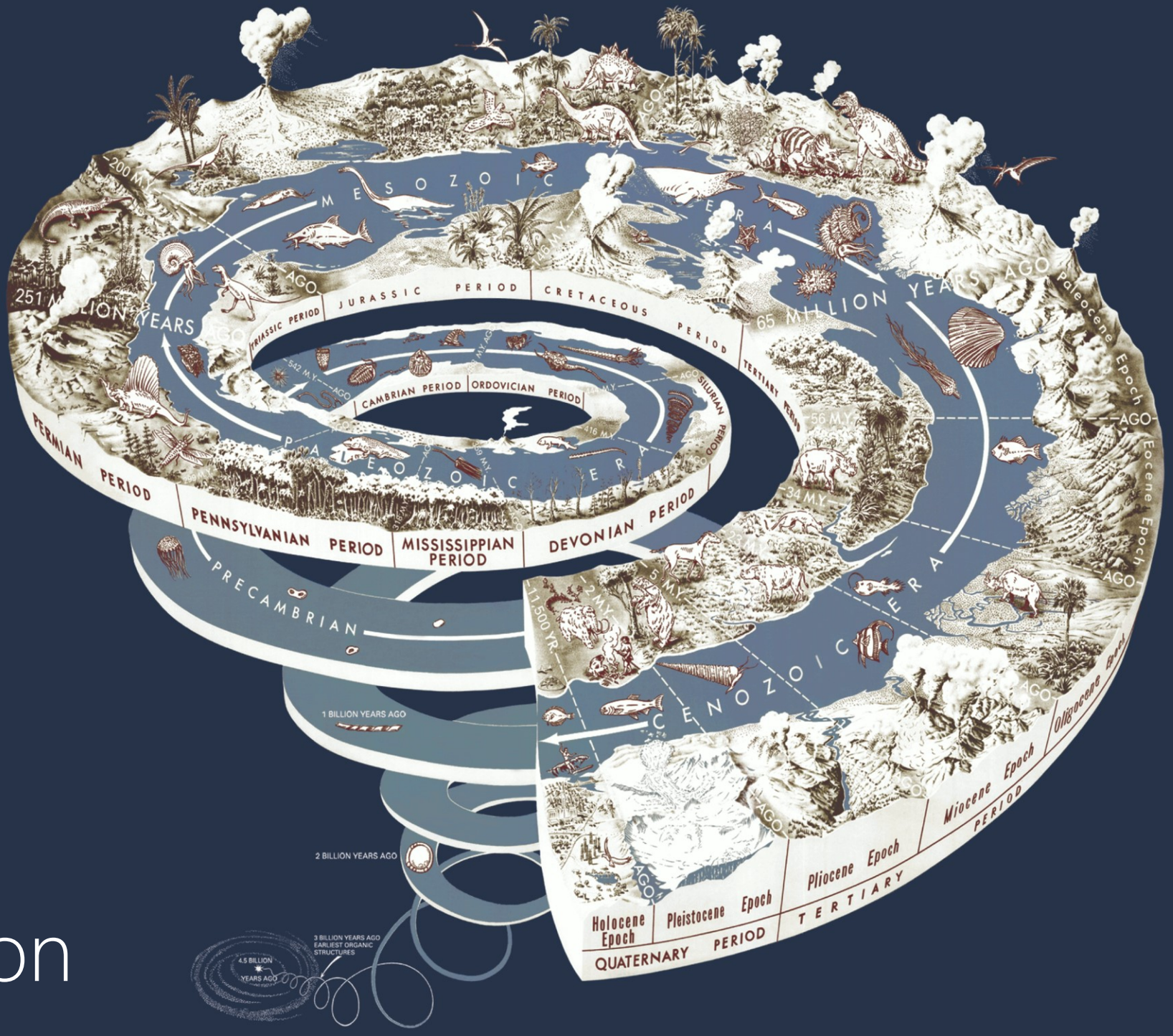
Complex system

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



Trick the brain




MESOZOIC ERA
PALEOZOIC ERA
CENOZOIC ERA
PRECAMBRIAN
200 M.Y. AGO
251 MILLION YEARS AGO
TRIASSIC PERIOD
JURASSIC PERIOD
CRETACEOUS PERIOD
65 MILLION YEARS AGO
542 M.Y. AGO
CAMBRIAN PERIOD
ORDOVICIAN PERIOD
SILURIAN PERIOD
416 M.Y. AGO
359 M.Y. AGO
299 M.Y. AGO
PERMIAN PERIOD
PENNSYLVANIAN PERIOD
MISSISSIPPIAN PERIOD
DEVONIAN PERIOD
TERTIARY PERIOD
Paleocene Epoch
Eocene Epoch
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
Pleistocene Epoch
Holocene Epoch
QUATERNARY PERIOD
TERTIARY PERIOD
56 M.Y. AGO
34 M.Y. AGO
23 M.Y. AGO
5 M.Y. AGO
2 M.Y. AGO
11,500 YR. AGO
1 BILLION YEARS AGO
2 BILLION YEARS AGO
3 BILLION YEARS AGO
EARLIEST ORGANIC STRUCTURES
4.5 BILLION YEARS AGO

Perception

Sensory Dominance

Cortical homunculus by Sharon Price-James

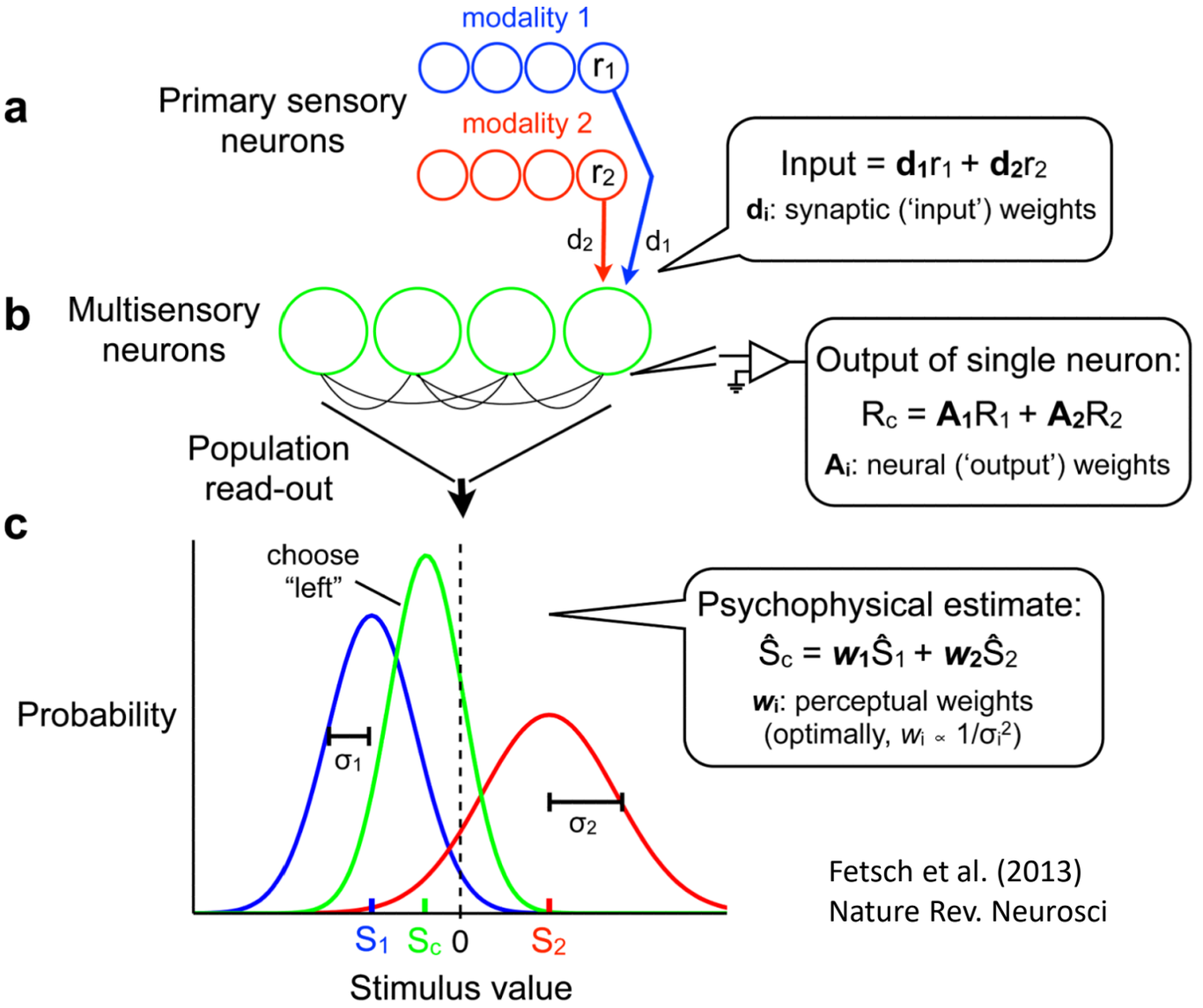

Sensory Expertise
David R Tribble

Ramon y Cajal - Nobel Prize

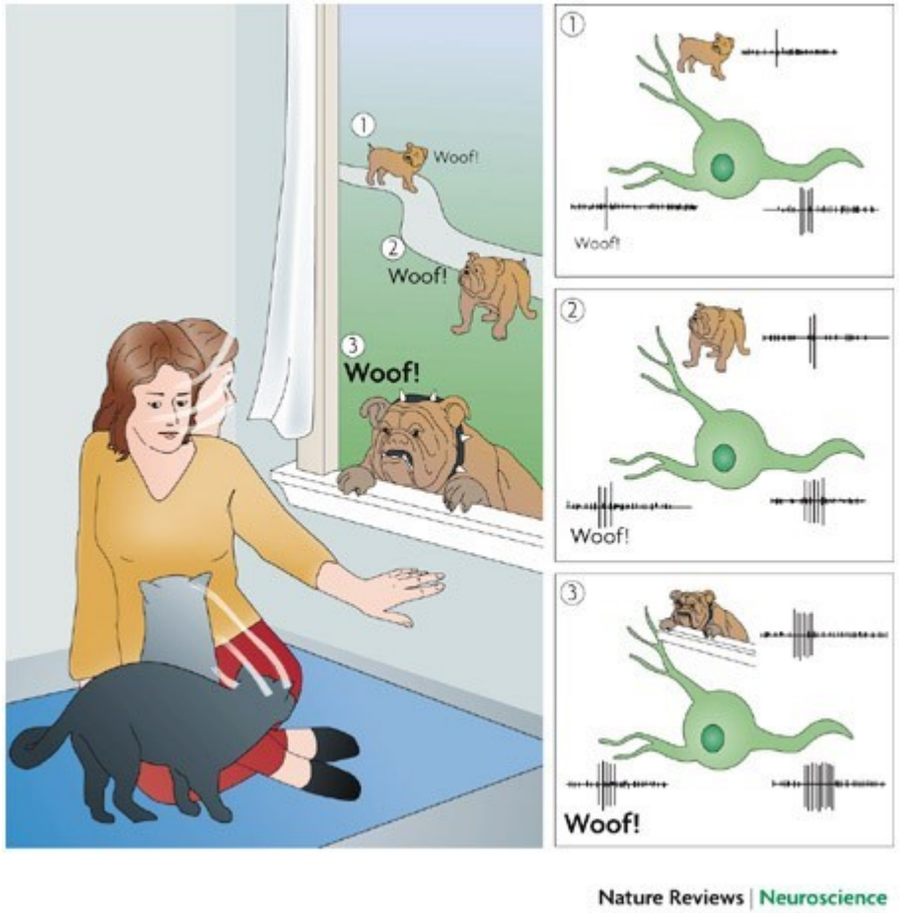
Multisensory Integration

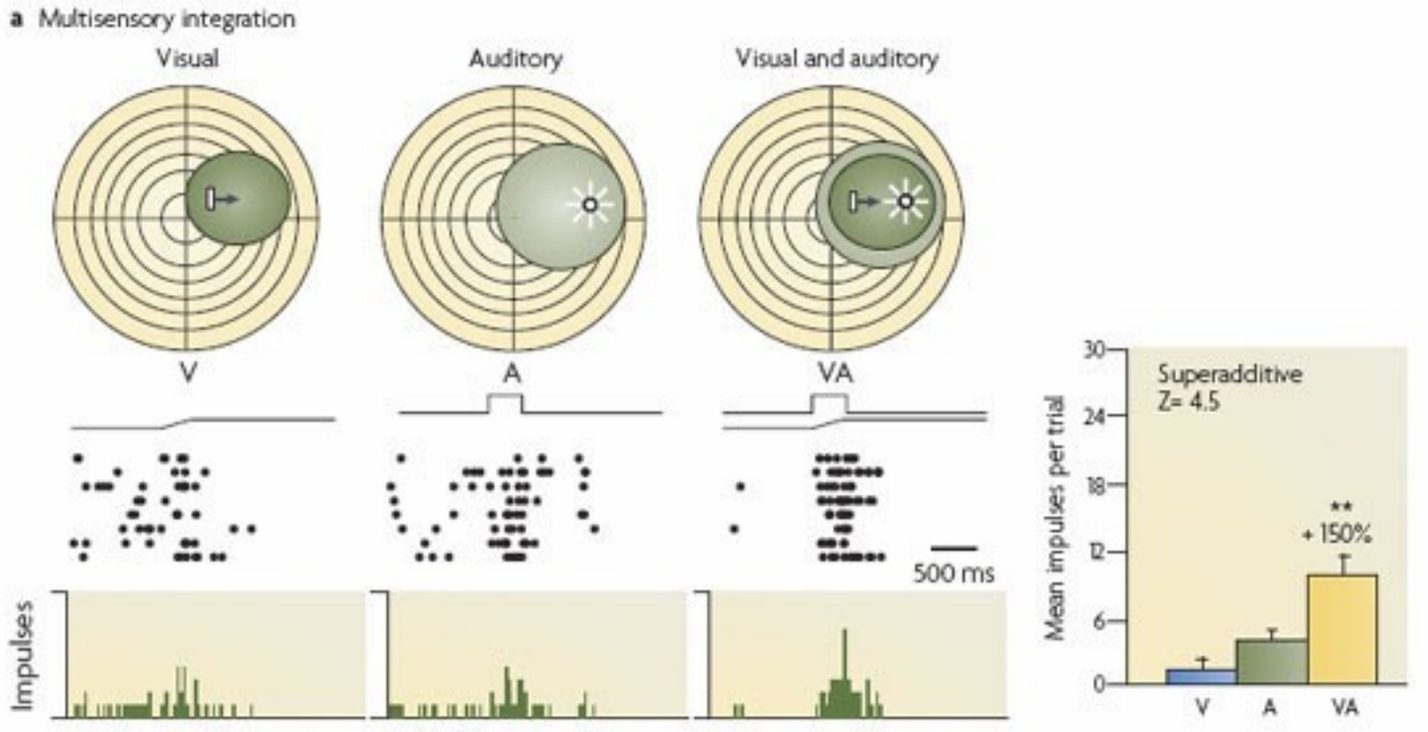
Ramon y Cajal - Nobel Prize

Multisensory Integration



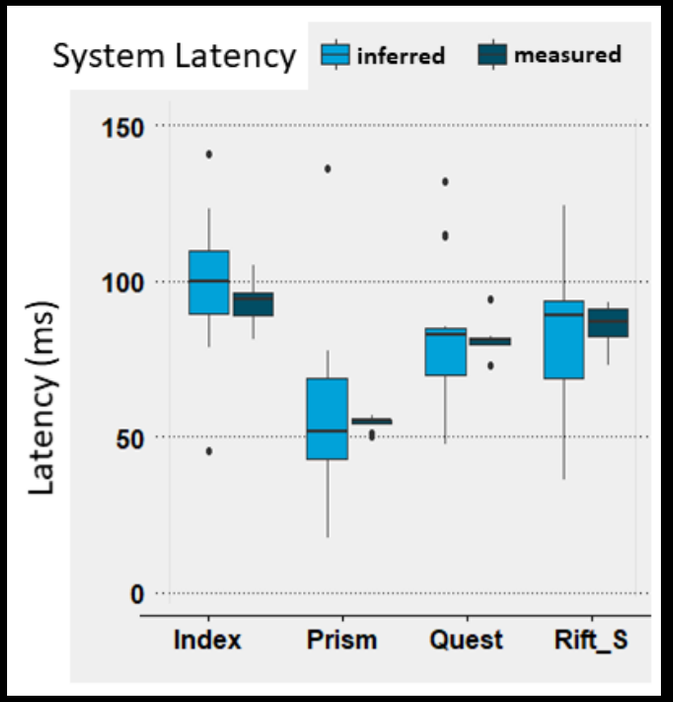
Fetsch et al. (2013)
Nature Rev. Neurosci

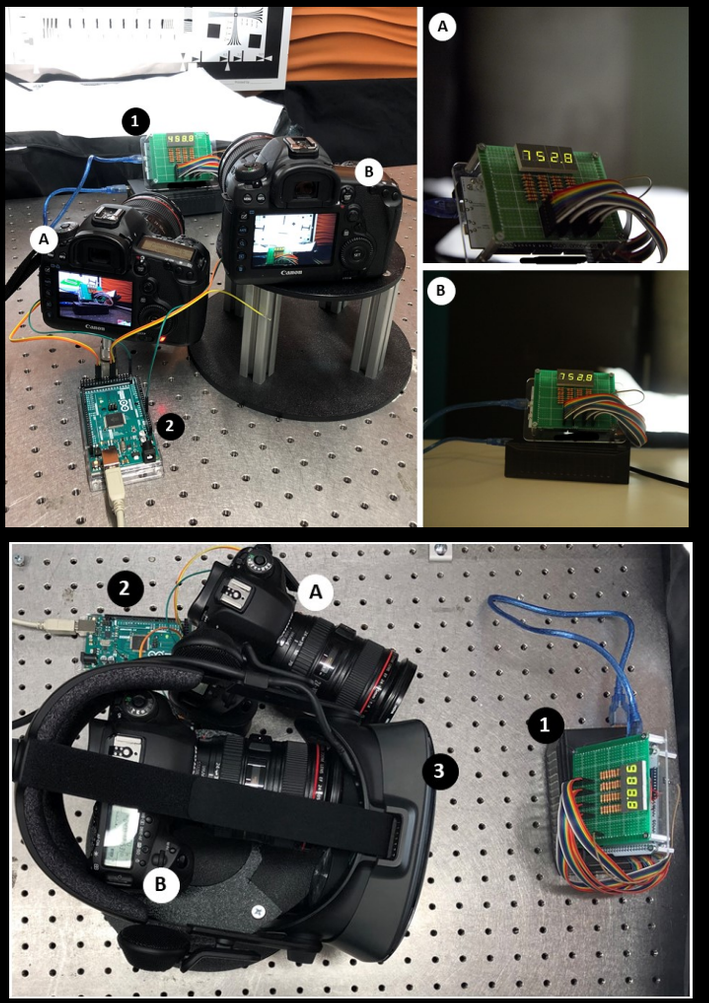




Stein, Barry E., and Terrence R. Stanford. "**Multisensory integration: current issues from the perspective of the single neuron.**" *Nature Reviews Neuroscience* 9.4 (2008): 255-266.

Cognitive Latency to measure VR system latency





https://github.com/microsoft/Microsecond-Arduino-Latency-Clock

Gruen, Ofek, Steed, Gal, Sinclair, **M Gonzalez-Franco***, 2020. **Measuring System Visual Latency through Cognitive Latency on Video See-Through AR devices**. *IEEE VR*

Visual dominance + 3D audio

Coordinate response measure (CRM) corpus

LIP CONDITIONS

Synch 14 % errors

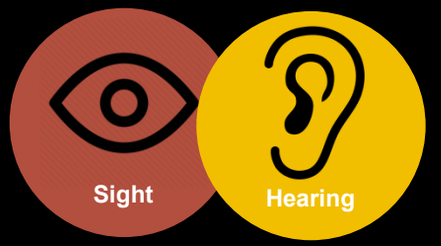
Asynch 30% errors

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 .

Visual dominance
Recalibration of 3D Audio



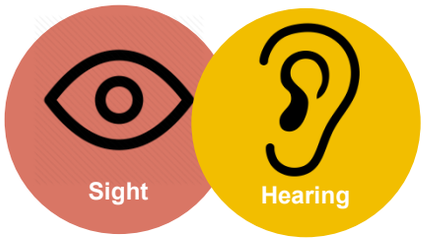
Generic HRTF might be enough in Virtual Reality.
Improving source localization through
cross-modal plasticity

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

Berger, C.C., Gonzalez-Franco, M., Tajadura-Jiménez, A., Florencio, D. and Zhang, Z., 2018. **Generic HRTFs may be good enough in virtual reality. Improving source localization through cross-modal plasticity**. *Frontiers in neuroscience*, *12*, p.21.

Soundscape

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



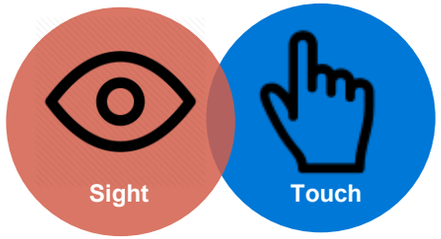
Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues

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

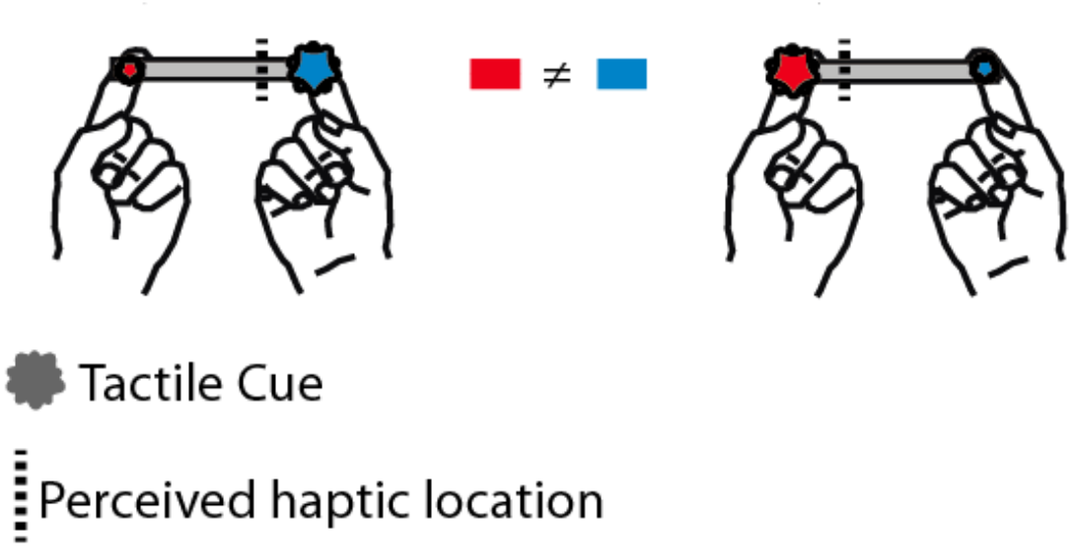
Microsoft Research, margon@microsoft.com

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

Microsoft



Using Voice Coil Actuators (VCA)



we can stimulate different strengths

The Uncanny Valley of Haptics

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

Microsoft

Science Robotics
AAAS

Berger, Gonzalez-Franco et al. (2018) The Uncanny Valley of Haptics

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.

SCIENTIFIC AMERICAN

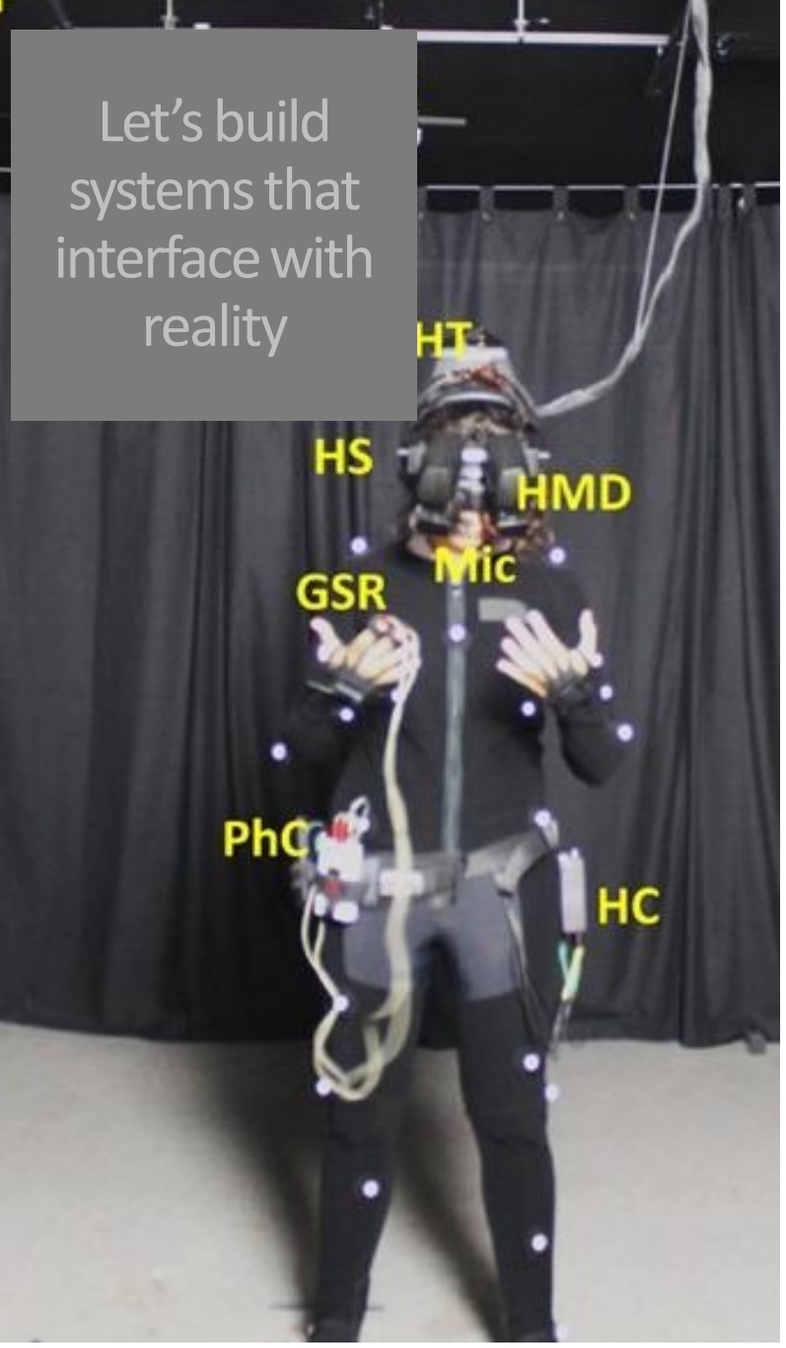
Observations

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

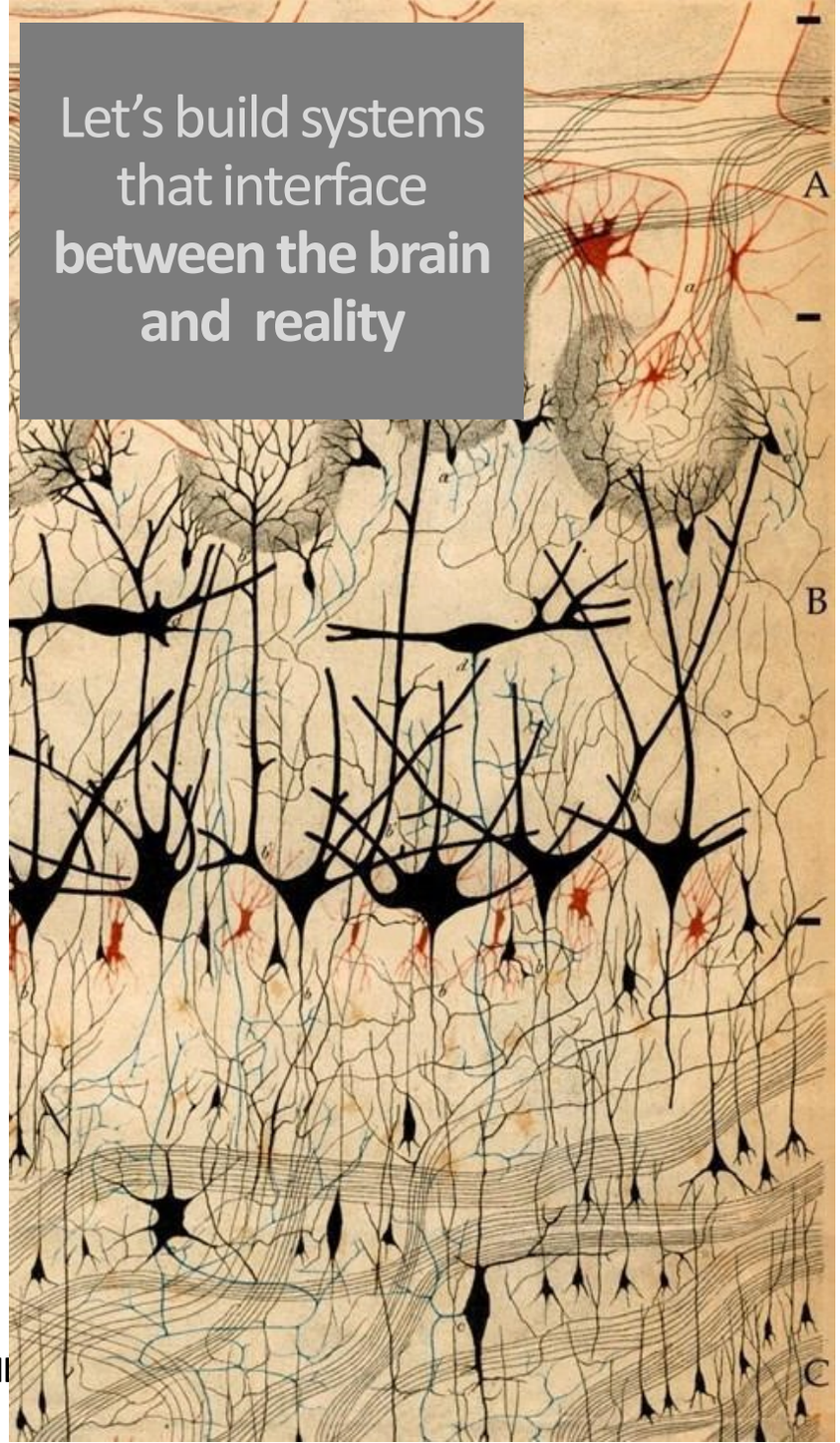
By Mar Gonzalez-Franco, Christopher C Berger and Ken Hinckley on April 19, 2018

Let's build systems that interface with reality

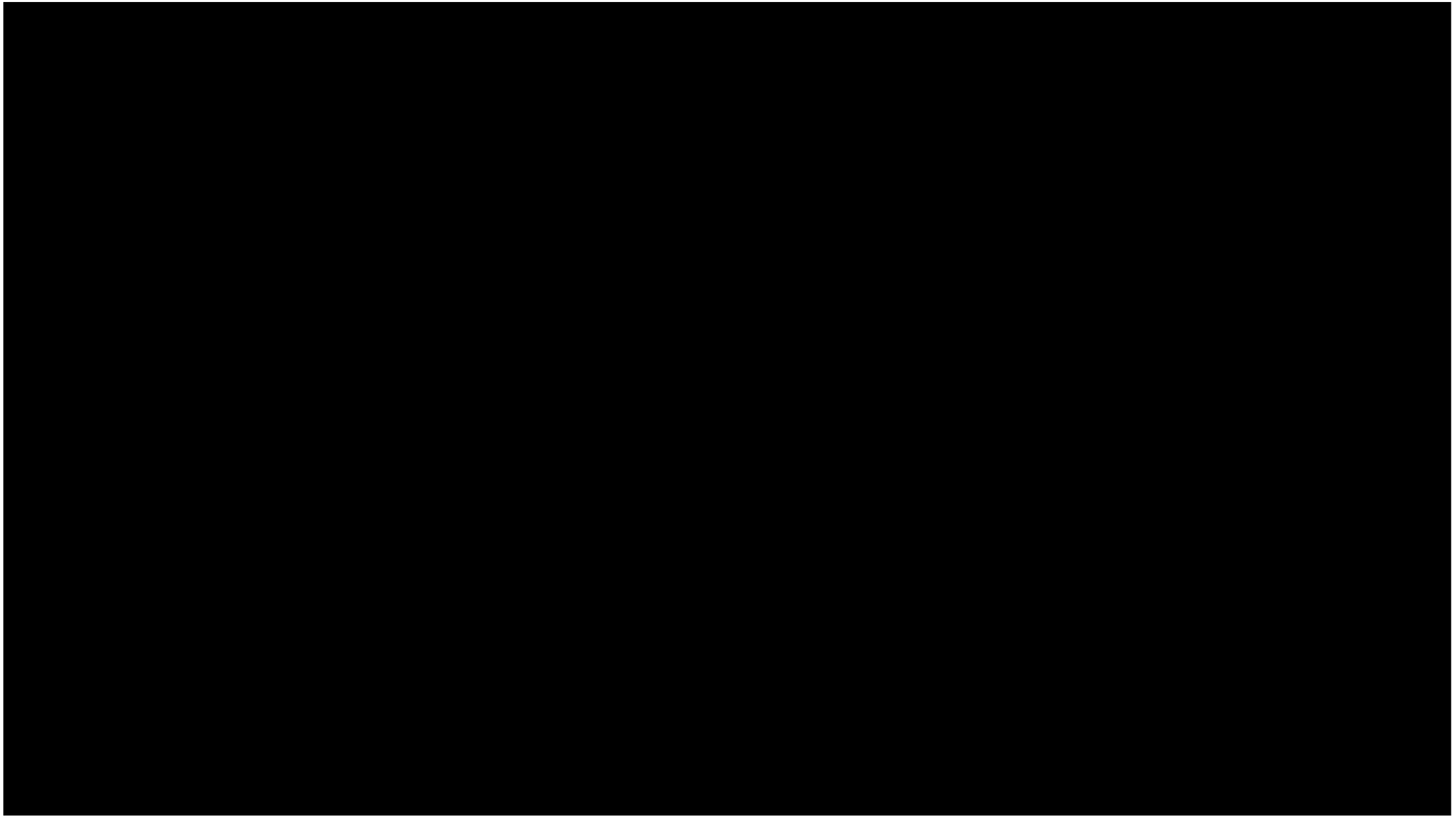


Gonzalez-Franco, M., & Lanier, J. (2017). **Model of ill**
reality *Frontiers in psychology*, *8*, 1125.

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



Let's build systems that are impossible in reality

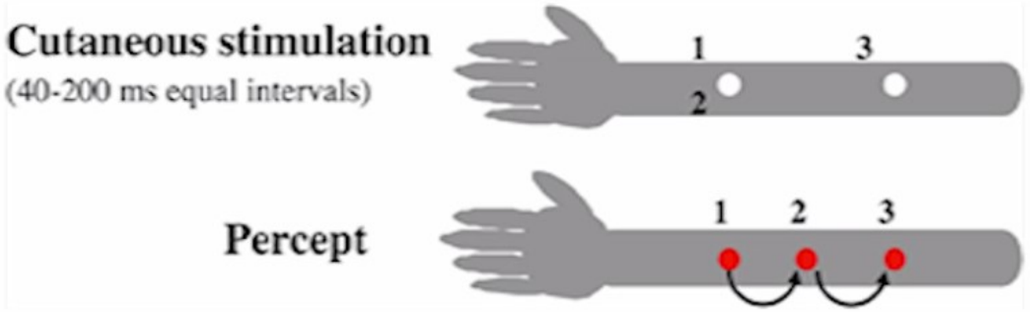


McDuff, Hurter & **Gonzalez-Franco** (2017)
“Pulse and Vital Sign measurement in mixed reality using a HoloLens” ACM VRST

Sense of Body Ownership

Marwecki, S, et al. "Mise-Unseen: Using Eye Tracking to Hide Virtual Reality Scene Changes in Plain Sight." *Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology*. 2019.

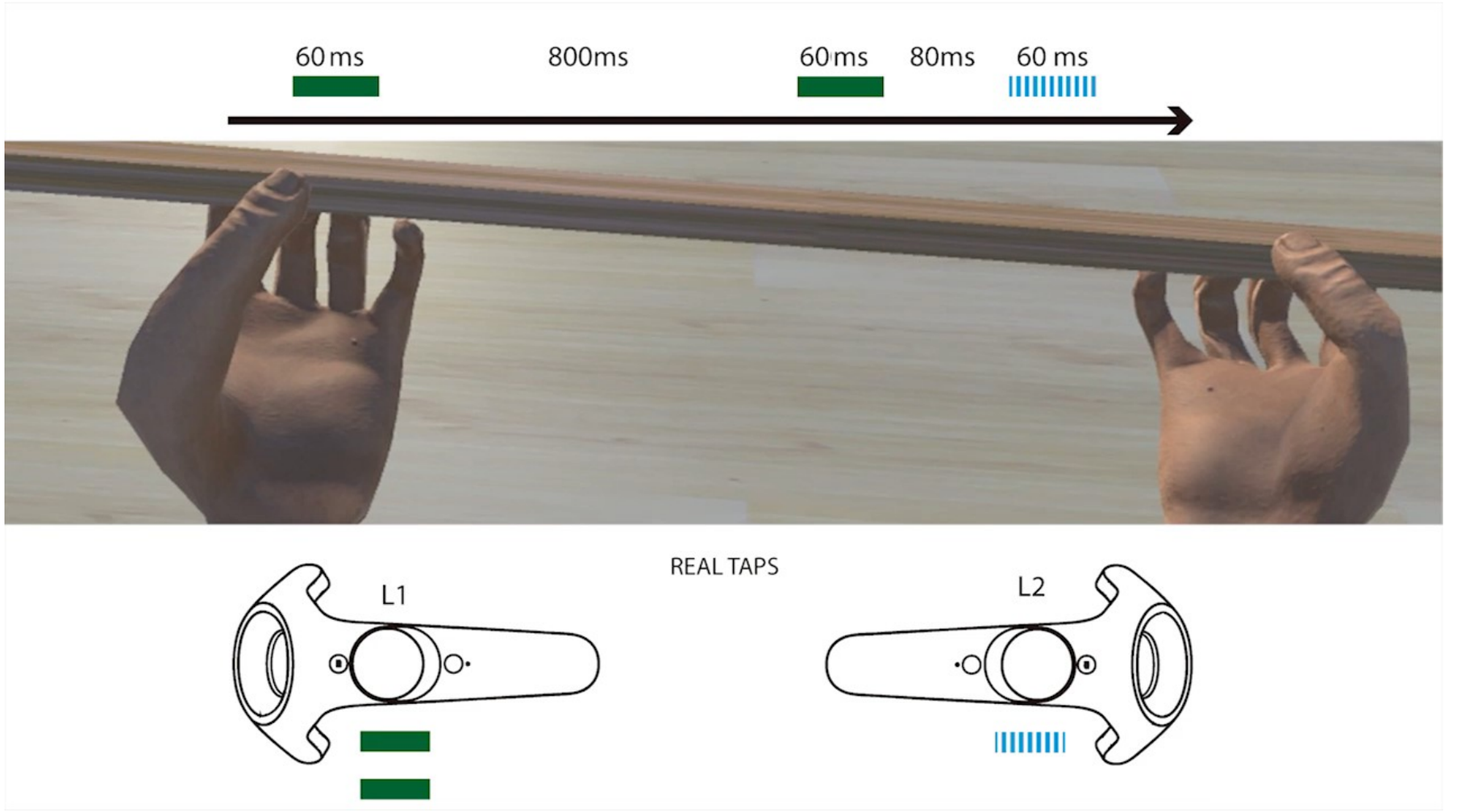
Feeling touch outside of the body

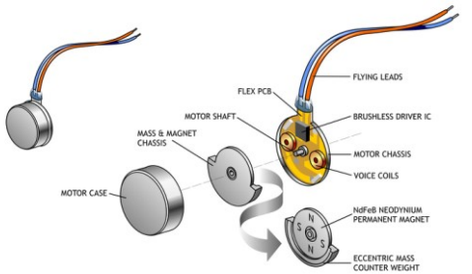


Geldard & Sherrick (1972). *Science*

We reproduce the cutaneous rabbit illusion in VR

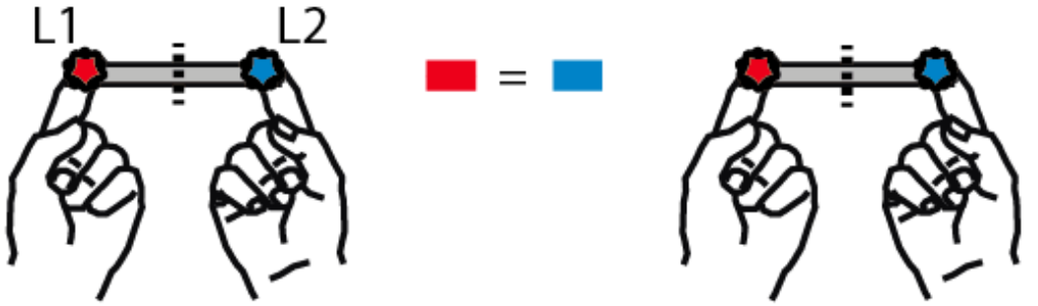
Berger, C. C., & Gonzalez-Franco, M. (2018). **Expanding the sense of touch outside the body**. In *Proceedings of the 15th ACM Symposium on Applied Perception* (p. 10). ACM.





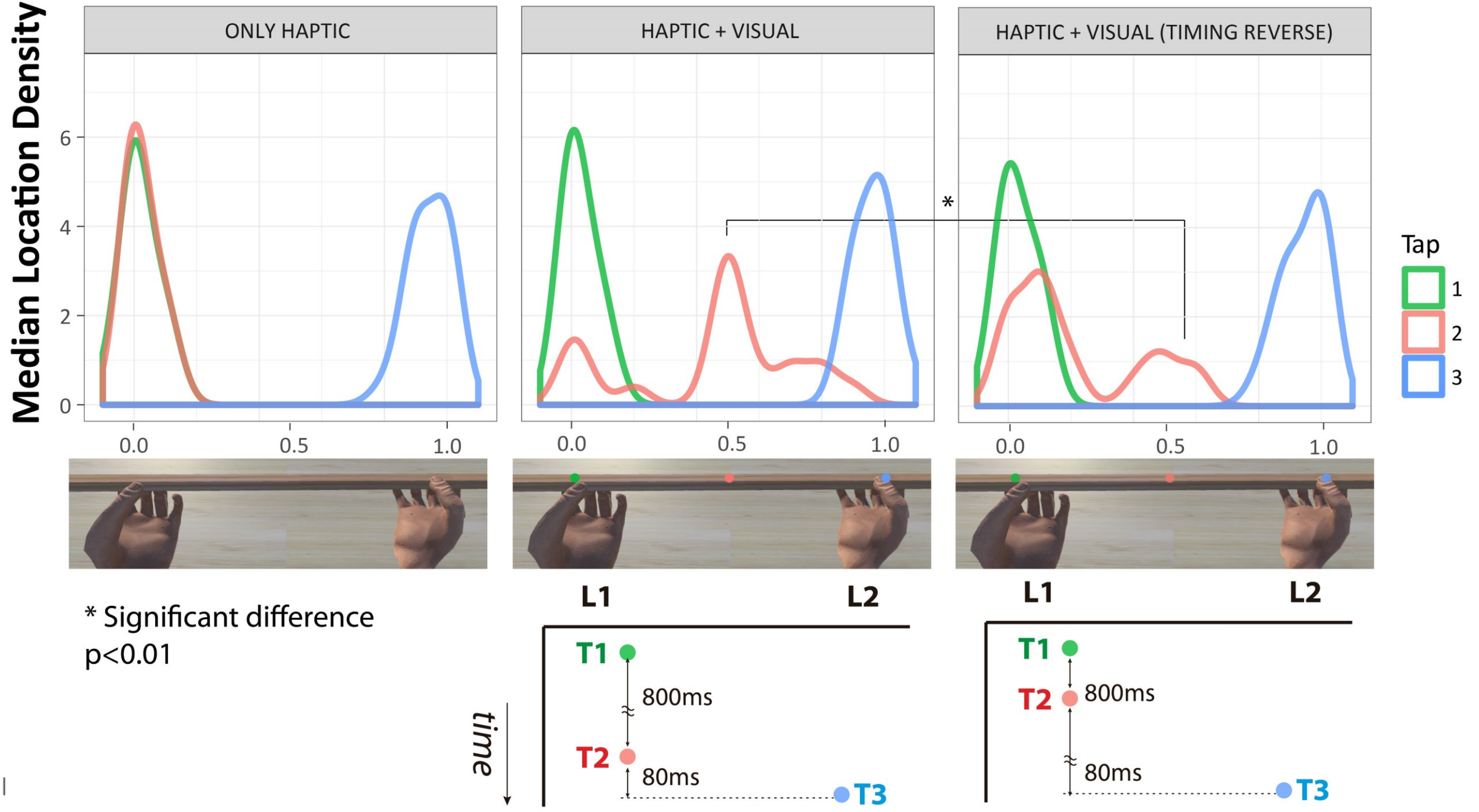
Motor Coin Vibrator

equal tactile strenght



Microsoft

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

George Hodan


Botvinick & Cohen - Nature 1998

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

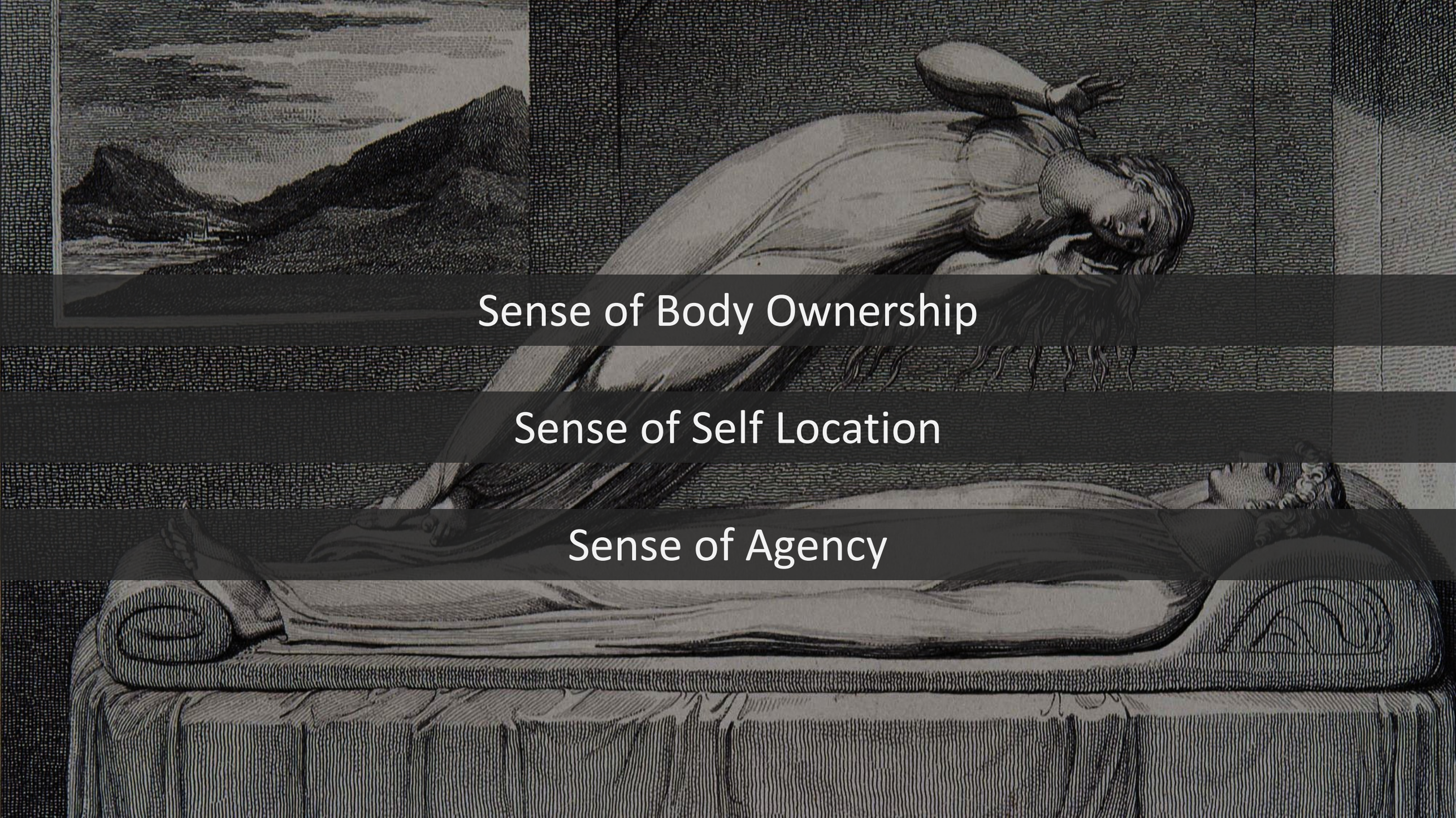
Background

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]

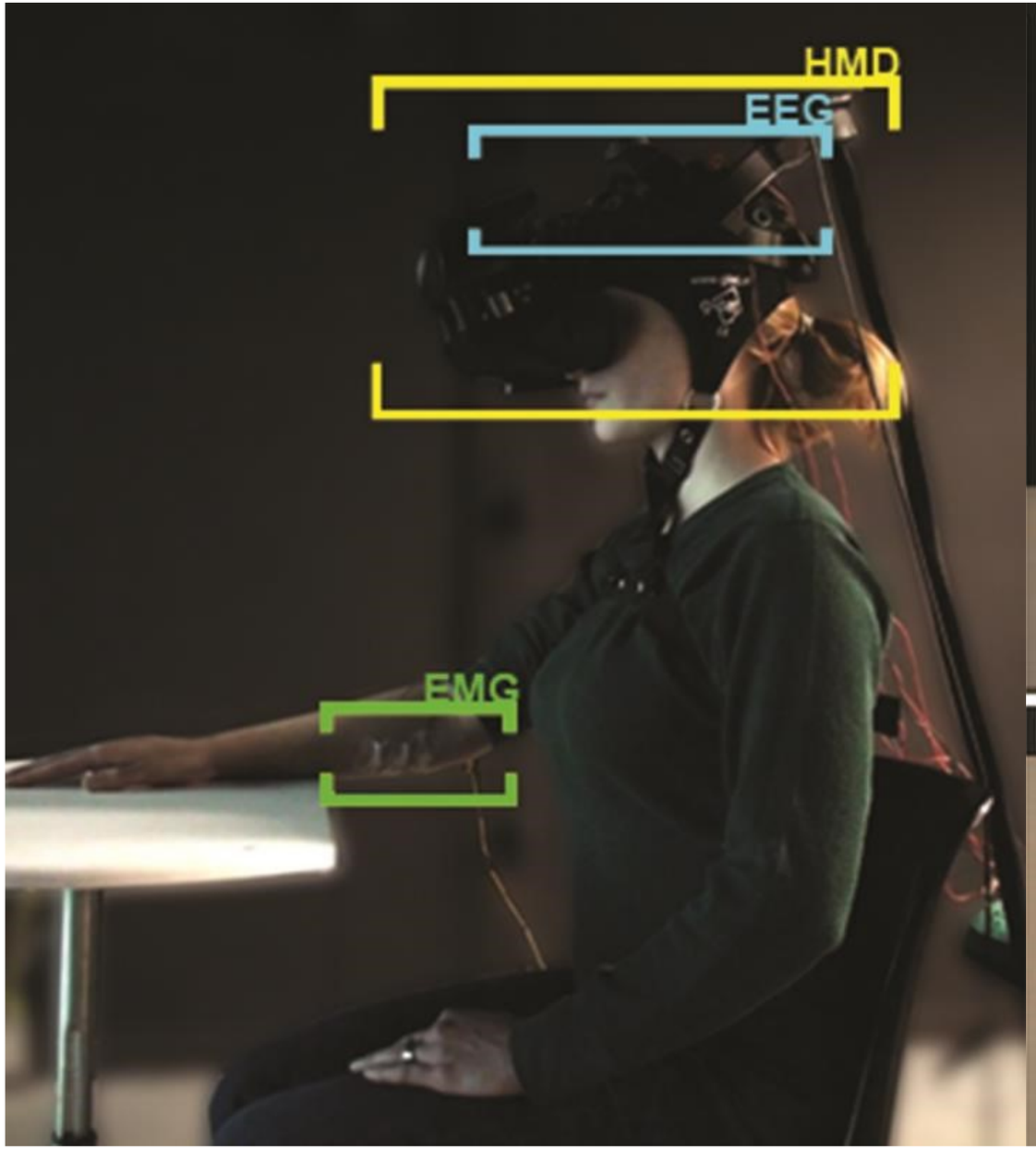
Spanlang et al. (2014) *How to Build an Embodiment Lab: Achieving Body Representation Illusions in Virtual Reality* Frontiers in Robotics and AI

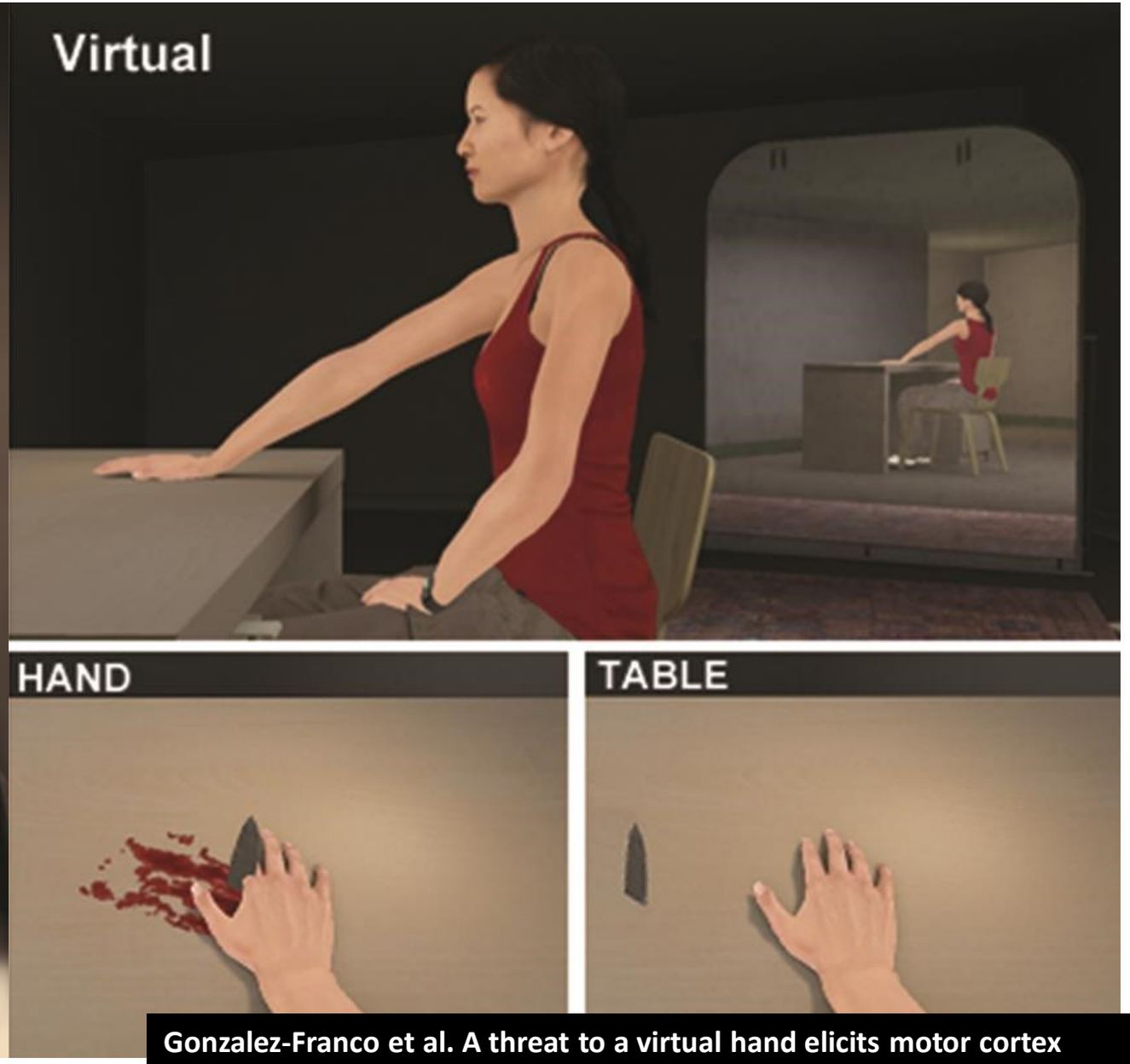

Sense of Body Ownership
Sense of Self Location
Sense of Agency

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

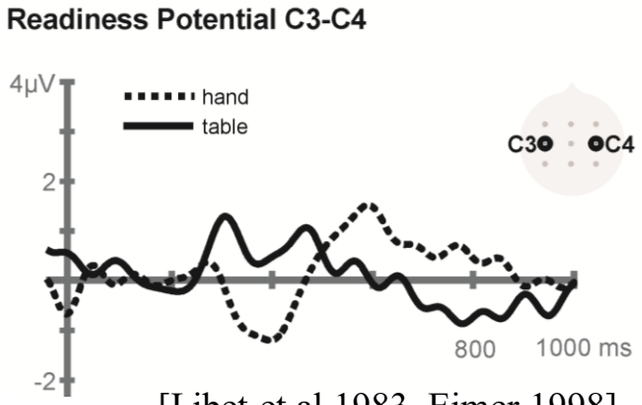
Sense of Body Ownership



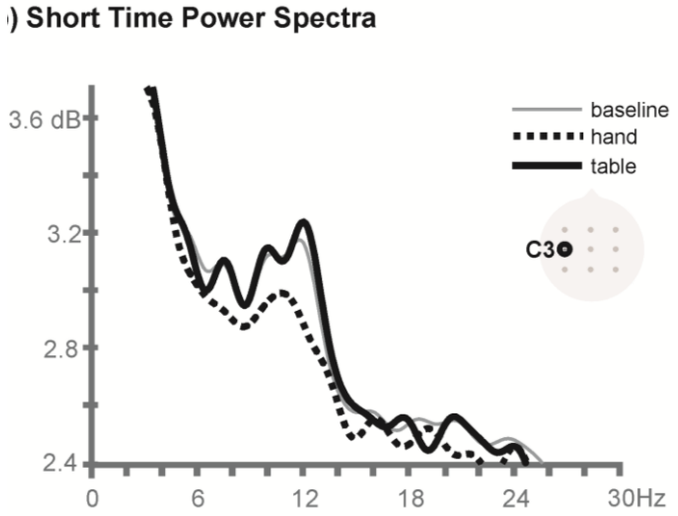


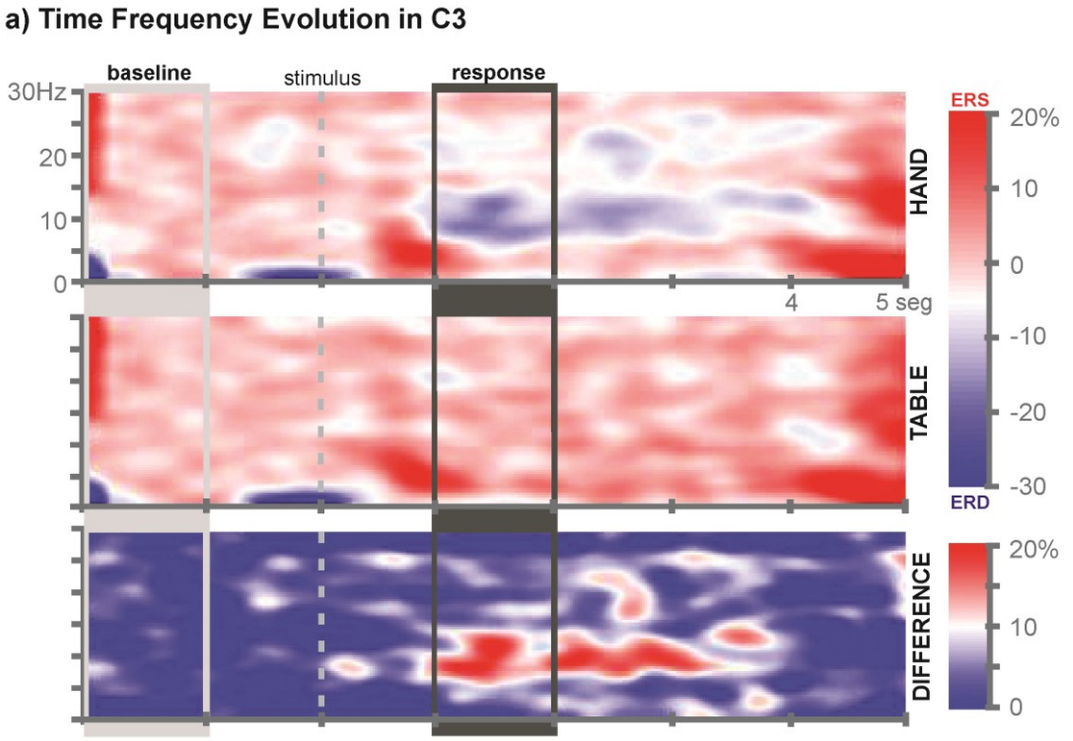
Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. Experimental Brain Research (2014)

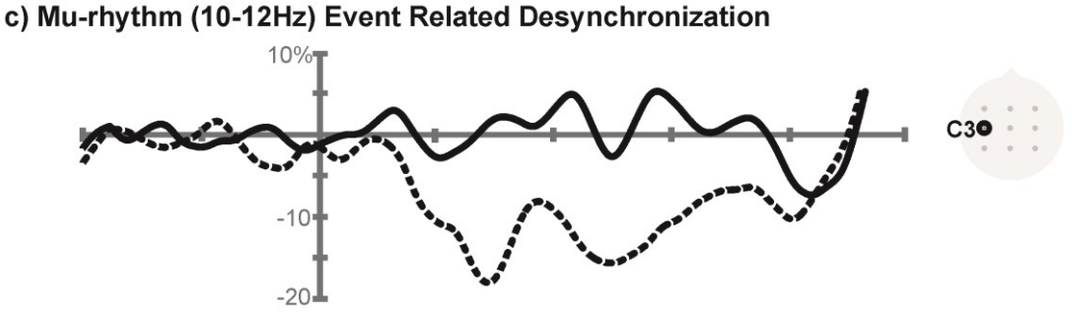
A threat to the Virtual Body



[Libet et al 1983, Eimer 1998]

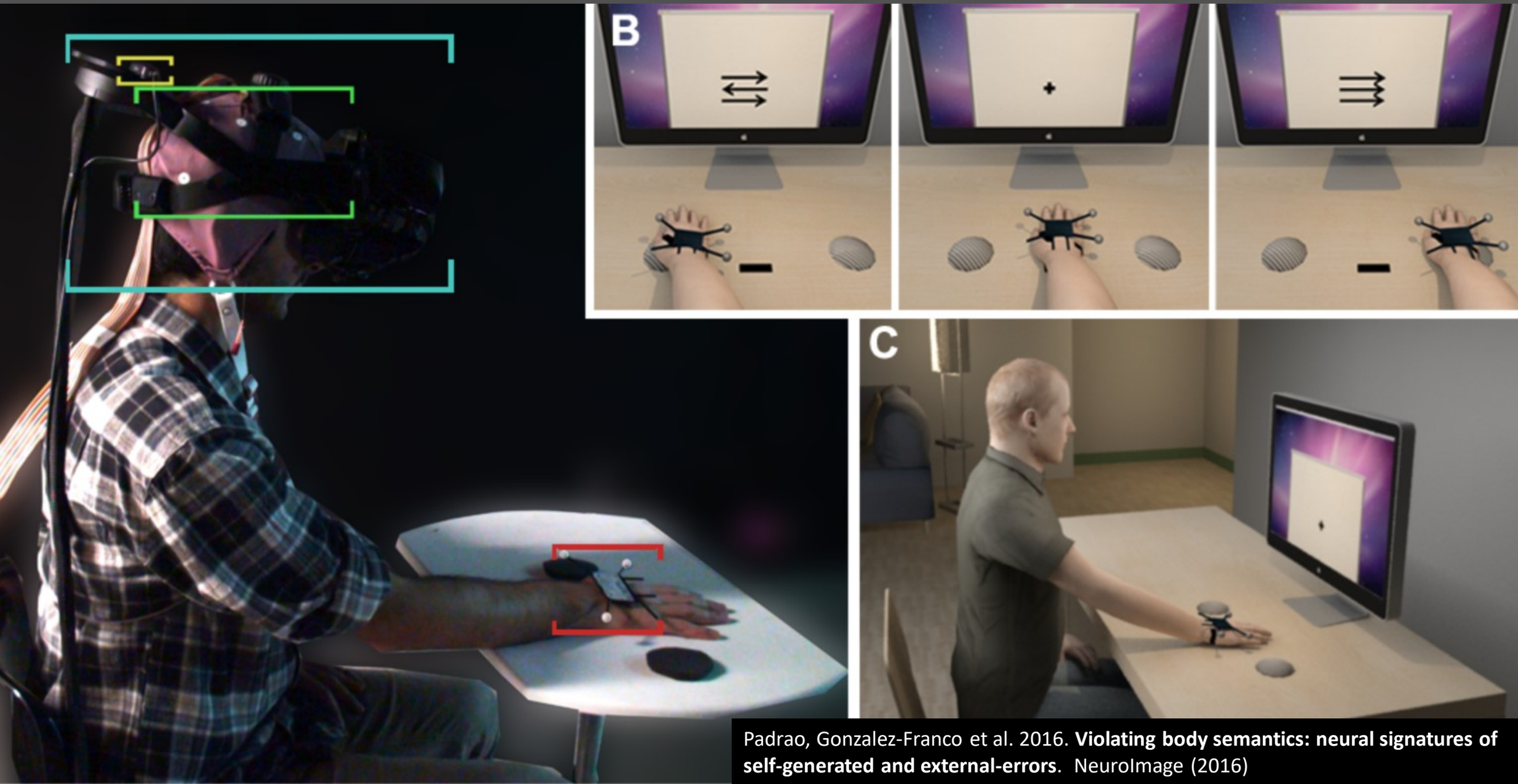






Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. Experimental Brain Research (2014)

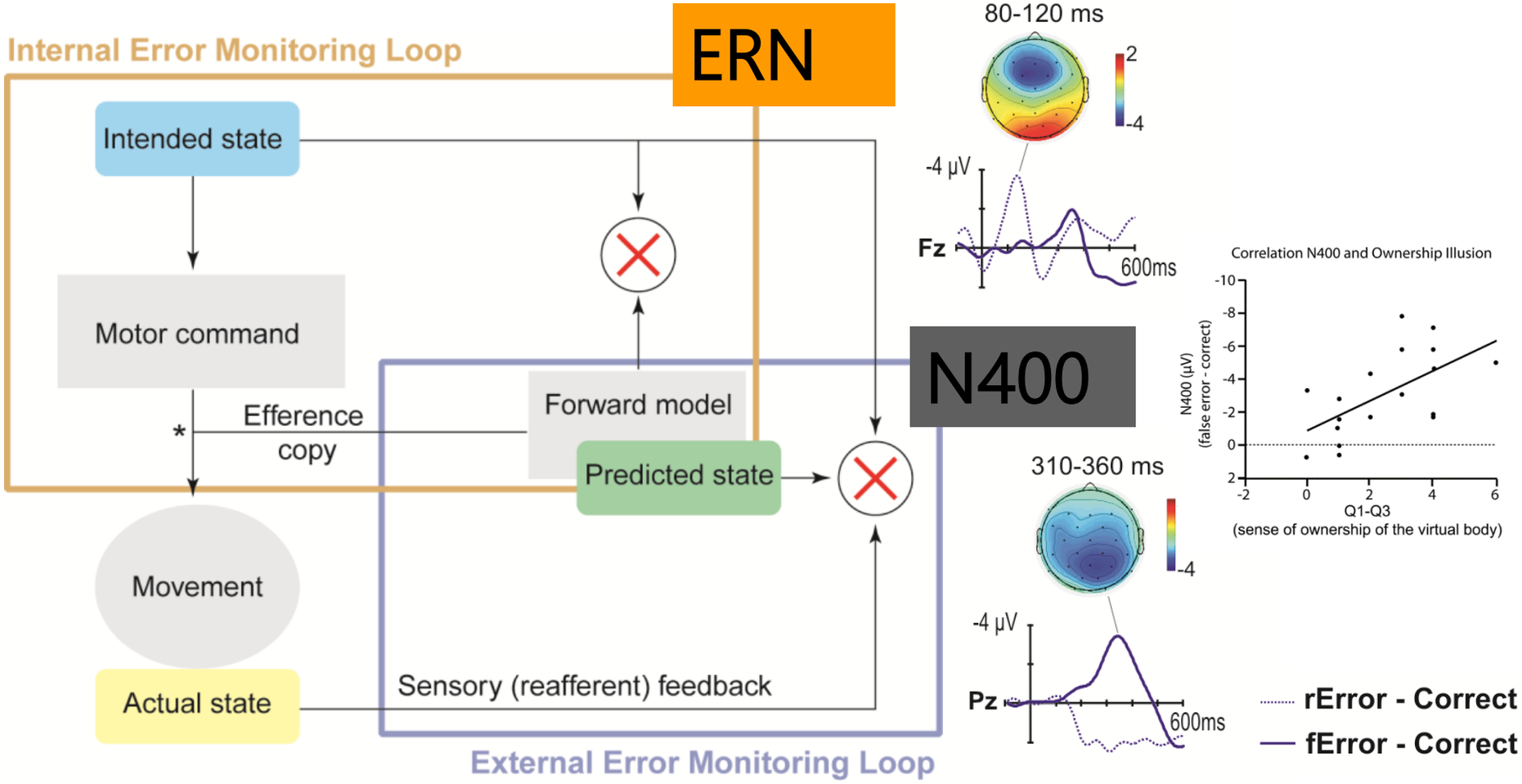
Sense of Agency



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

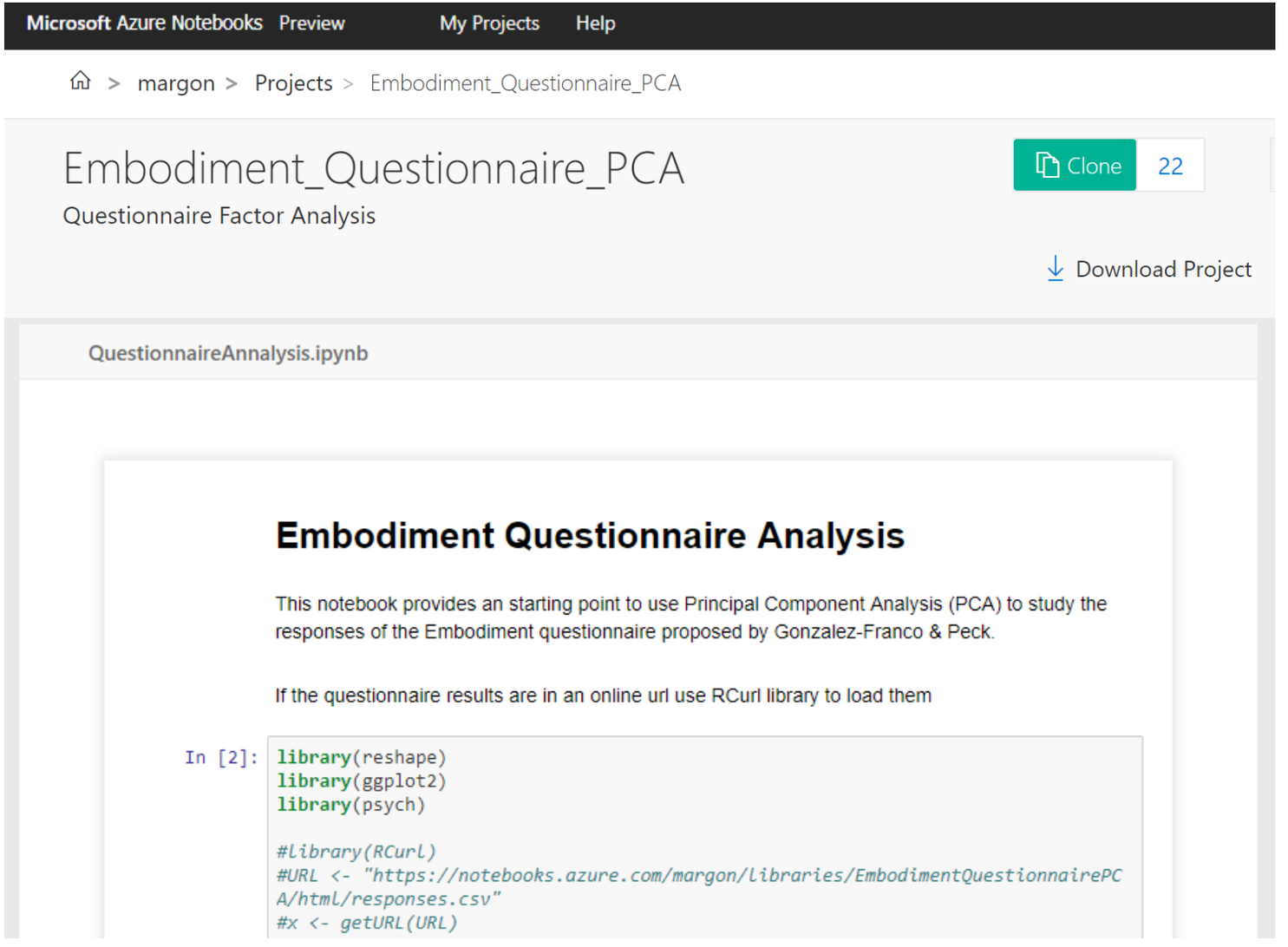


[Gallagher 2000, Frith et al. 2000]

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

Beyond electrophysiology: questionnaires

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



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.

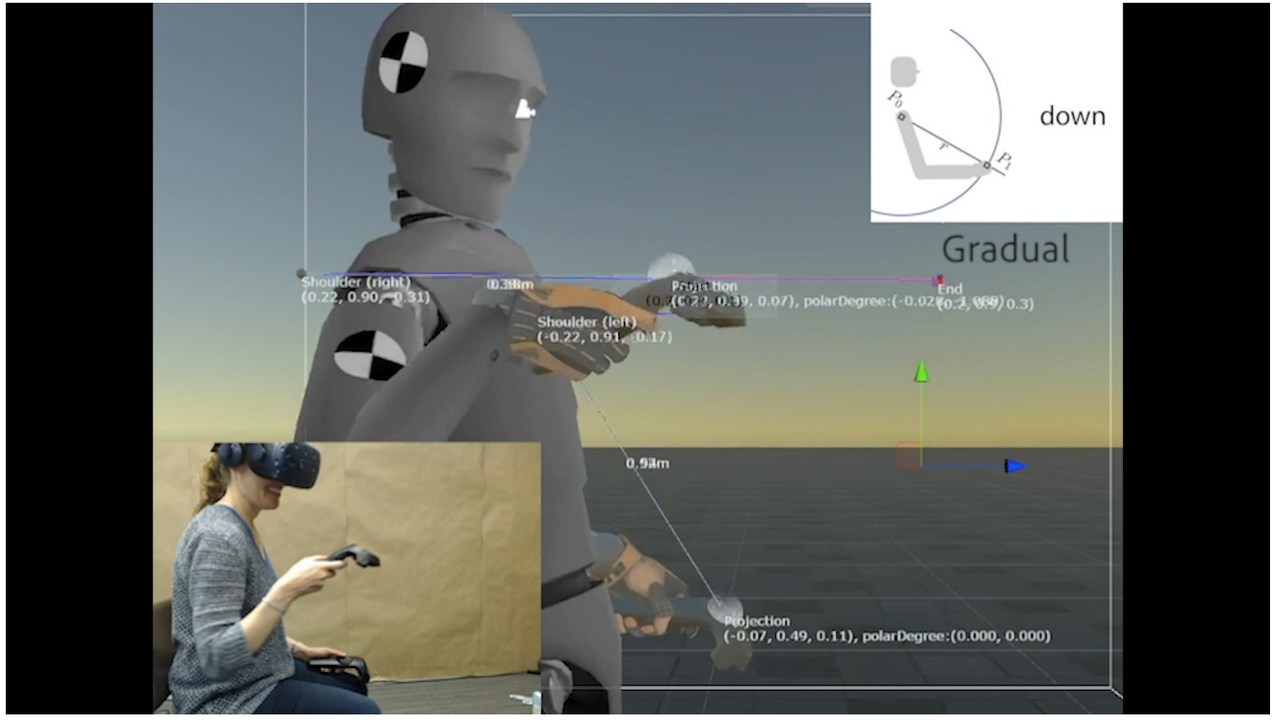
Analyzed 30 famous experiments and extracted 25 questions

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



Gonzalez-Franco et al (2020) **The Self-Avatar Follower Effect in Virtual Reality** *IEEE VR*

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-Franco[1], Eyal Ofek[1], Anthony Steed[1,3]

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

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

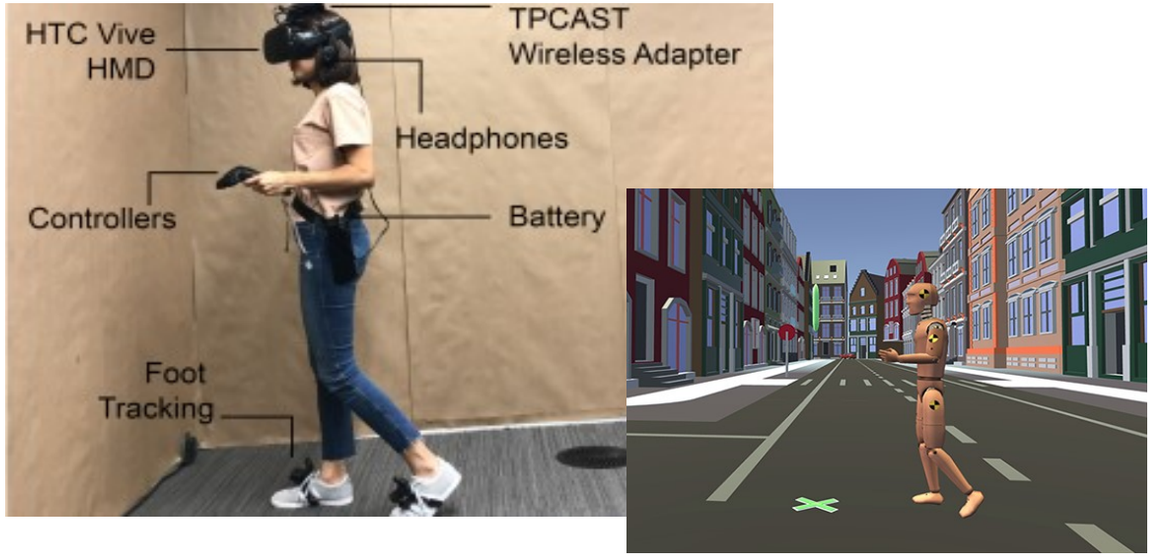
Embodiment in Robots

Kishore, Gonzalez-Franco et al. MIT Presence Teleoperators (2014)

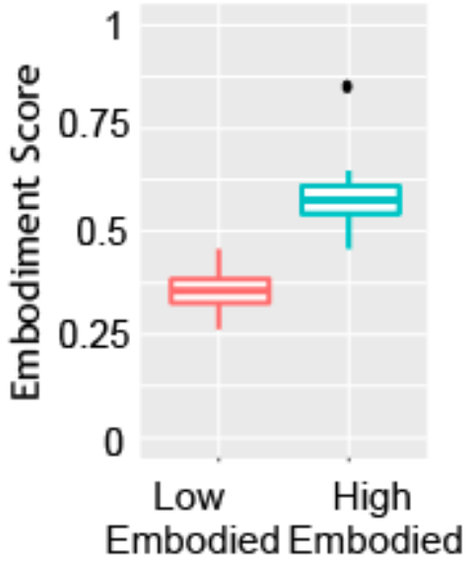
Embodiment increases haptic experiences

Gonzalez-Franco & Berger (2019) **Avatar Embodiment Enhances Haptic Confidence on the Out-of-Body Touch Illusion**. IEEE Transactions on Haptics

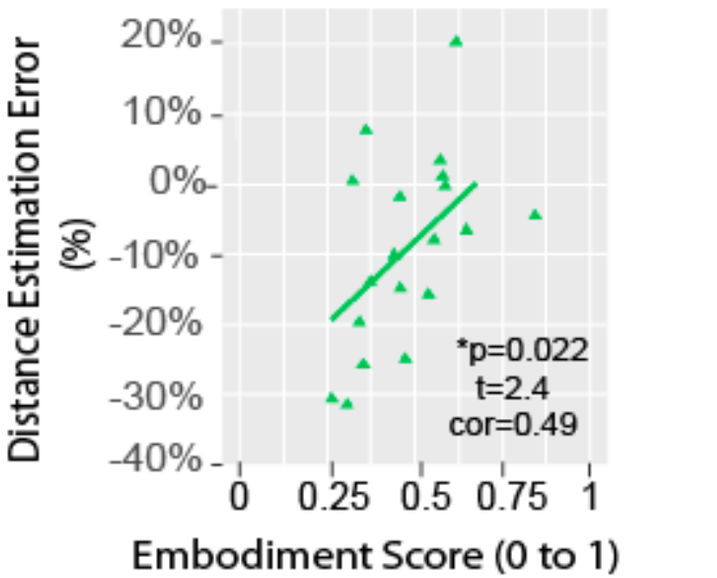
Many Individual Differences In Embodiment across participants



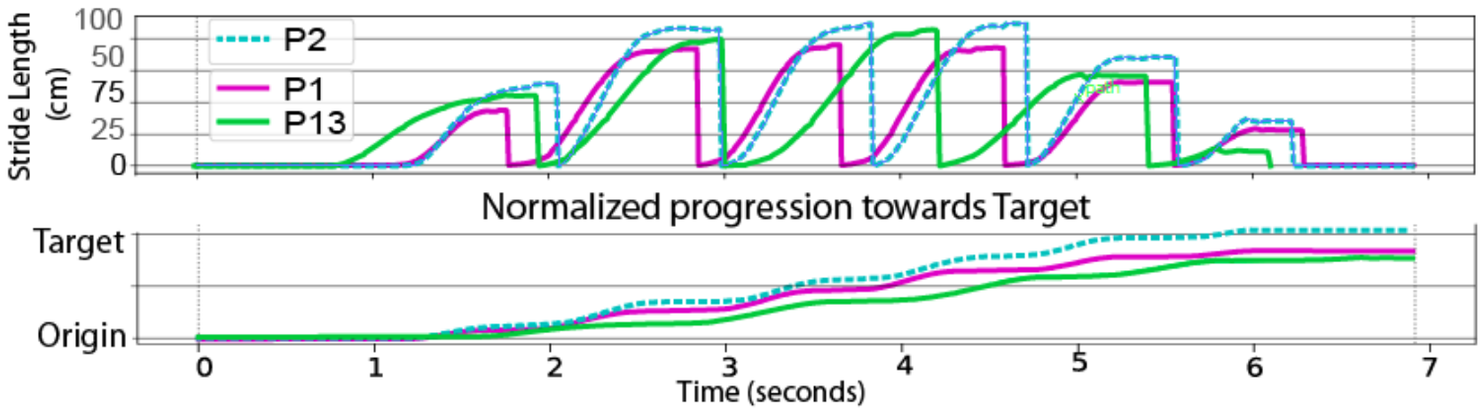
Embodiment



Distance Compression



Individual Strides



Gonzalez Franco,et al. (2019) Individual Differences in Embodied Distance Estimation in Virtual Reality IEEE VR

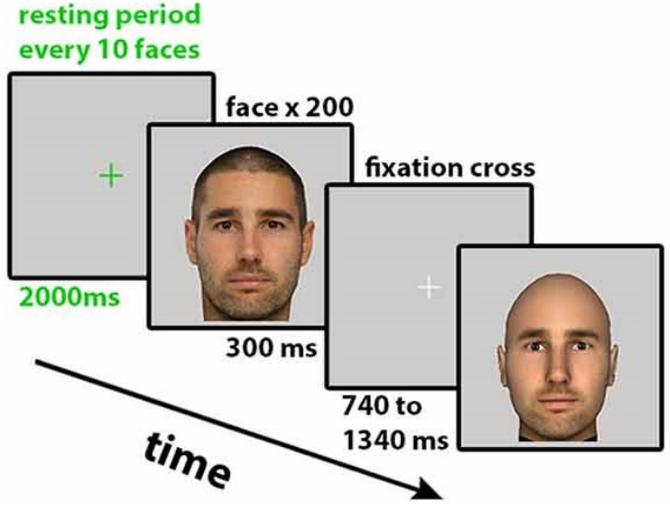
Enfacement

Self-recognition on Avatars

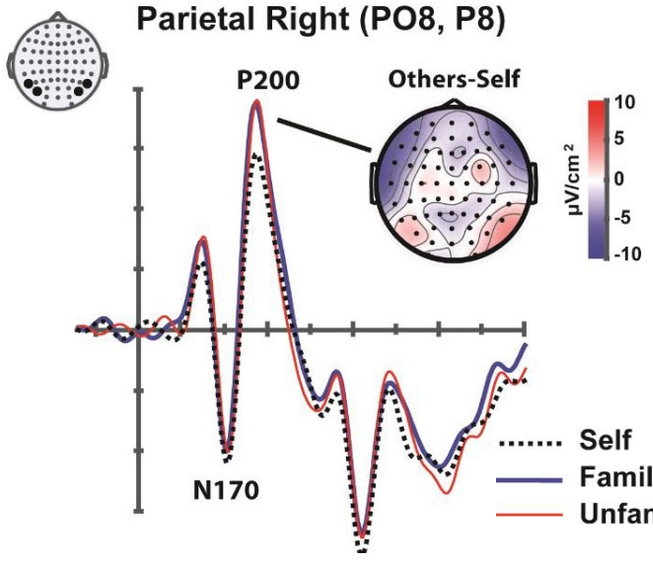
Gonzalez-Franco et al. 2016**. The neurological traces of look-alike avatars**
Frontiers in Human Neuroscience

A **Avatar creation**

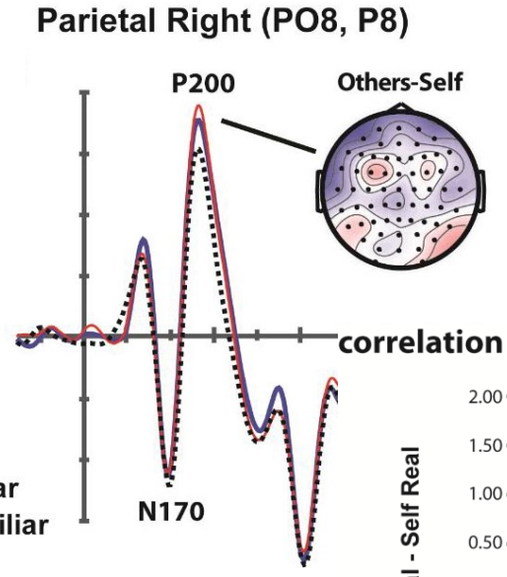
B **Experimental Execution**



Real Faces



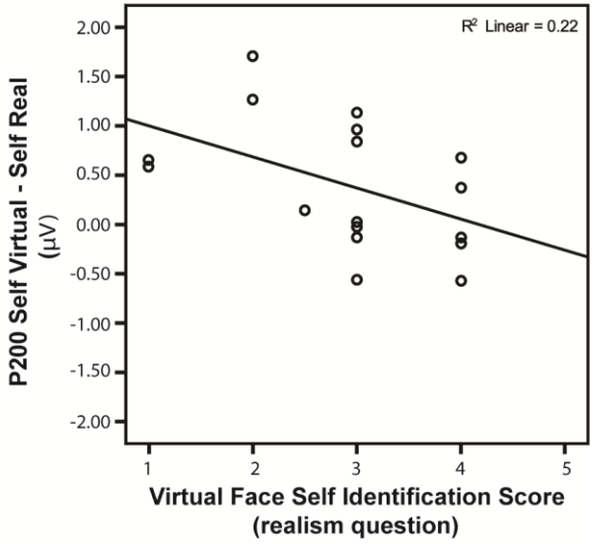
Virtual Faces



No N170 differences:
same class of object

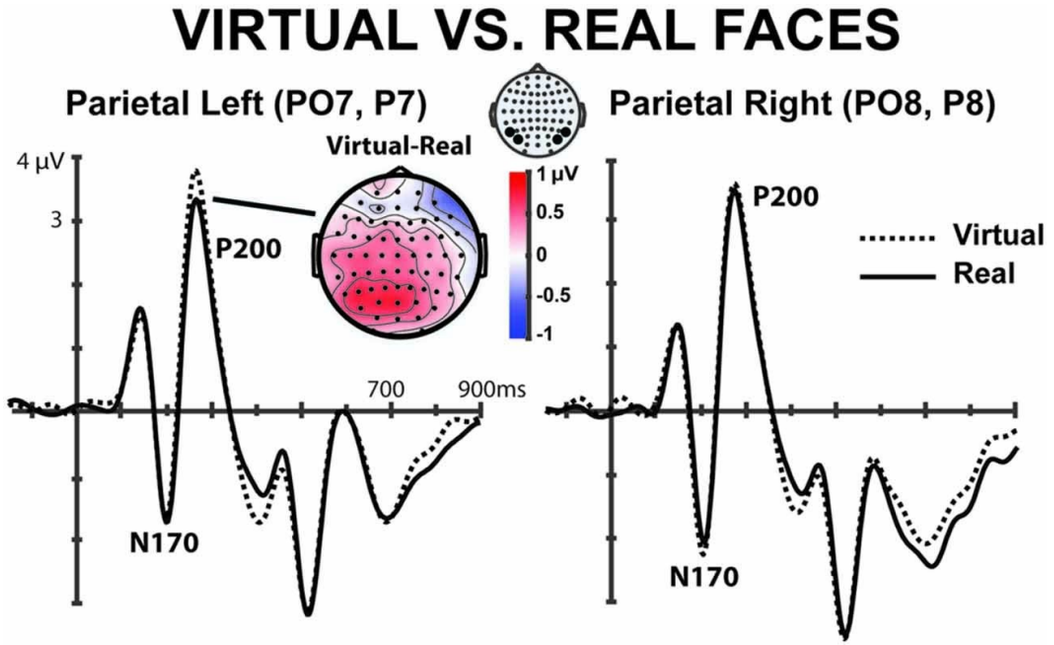
P200/N250 250-300ms
self-recognition

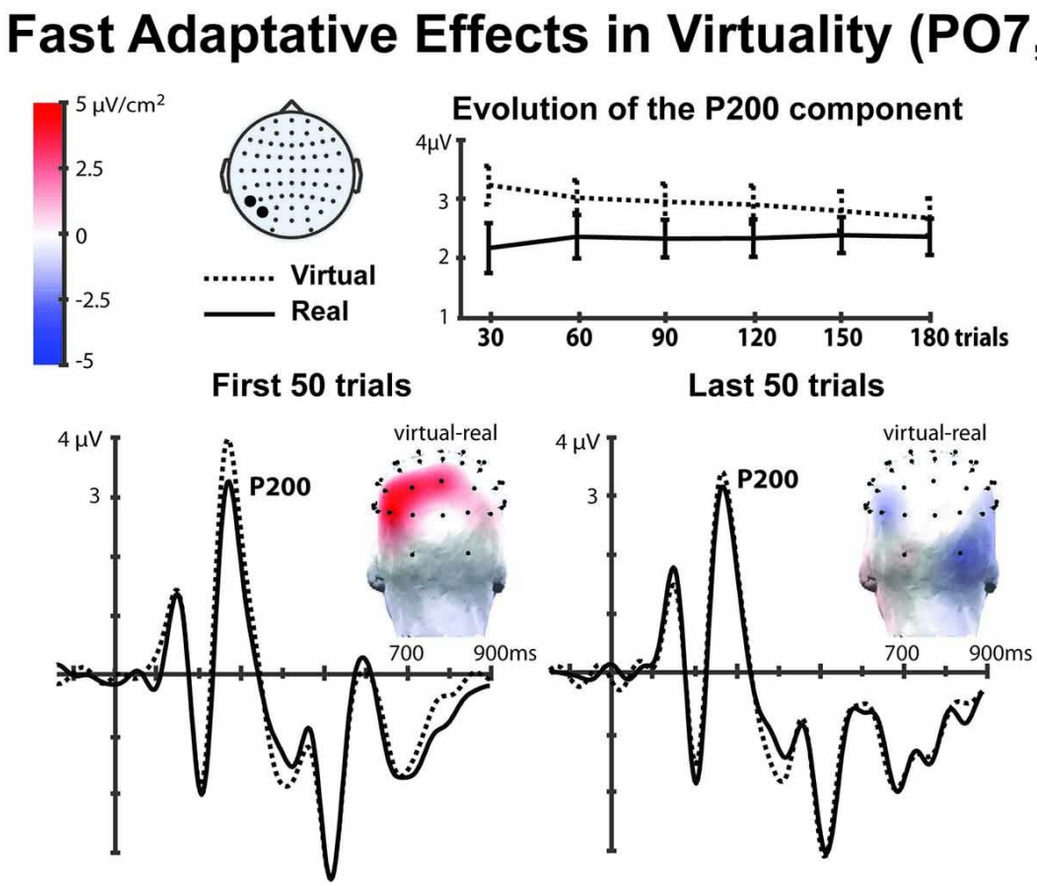
correlation subjective vs. unconscious identification



Self-recognition on Avatars

Spatial



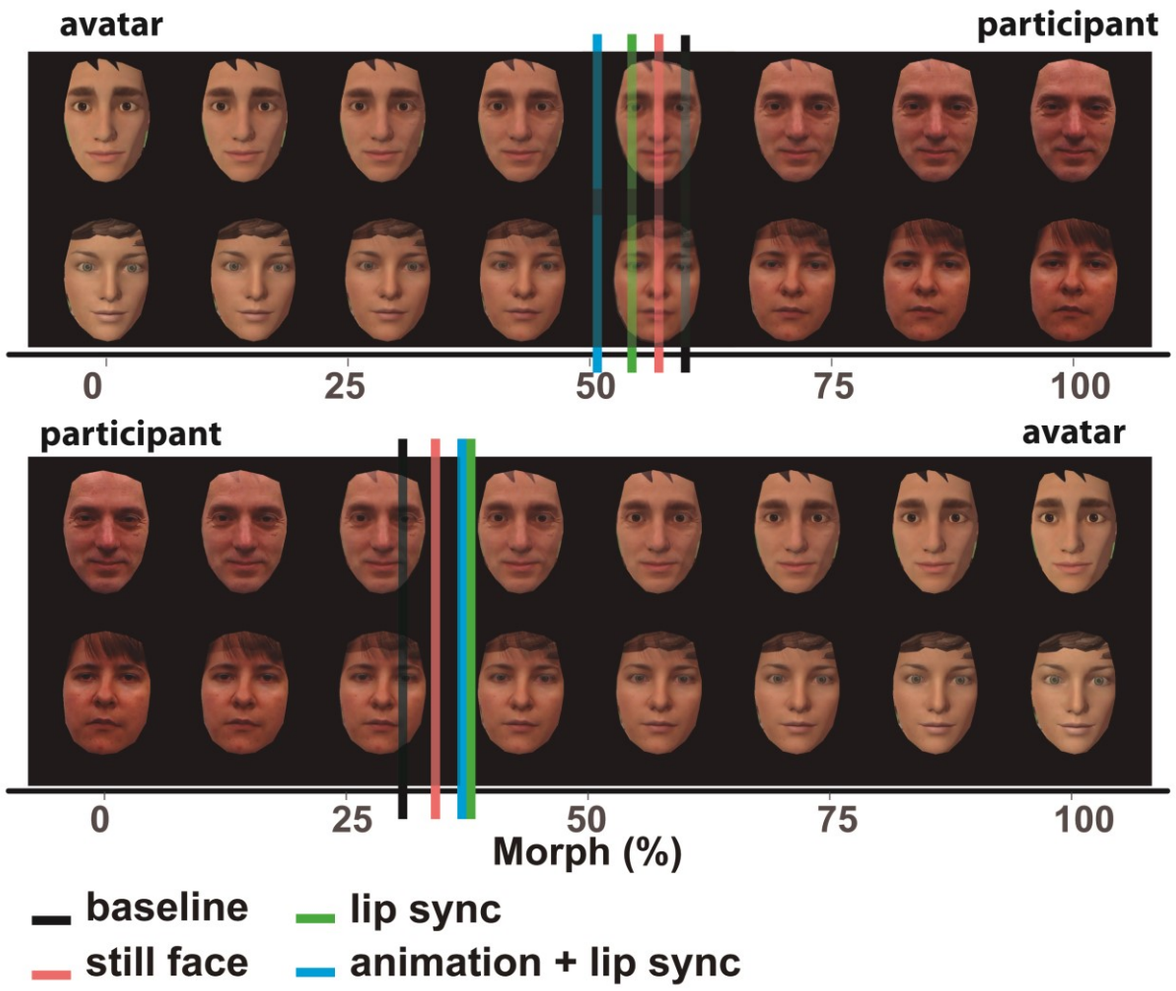


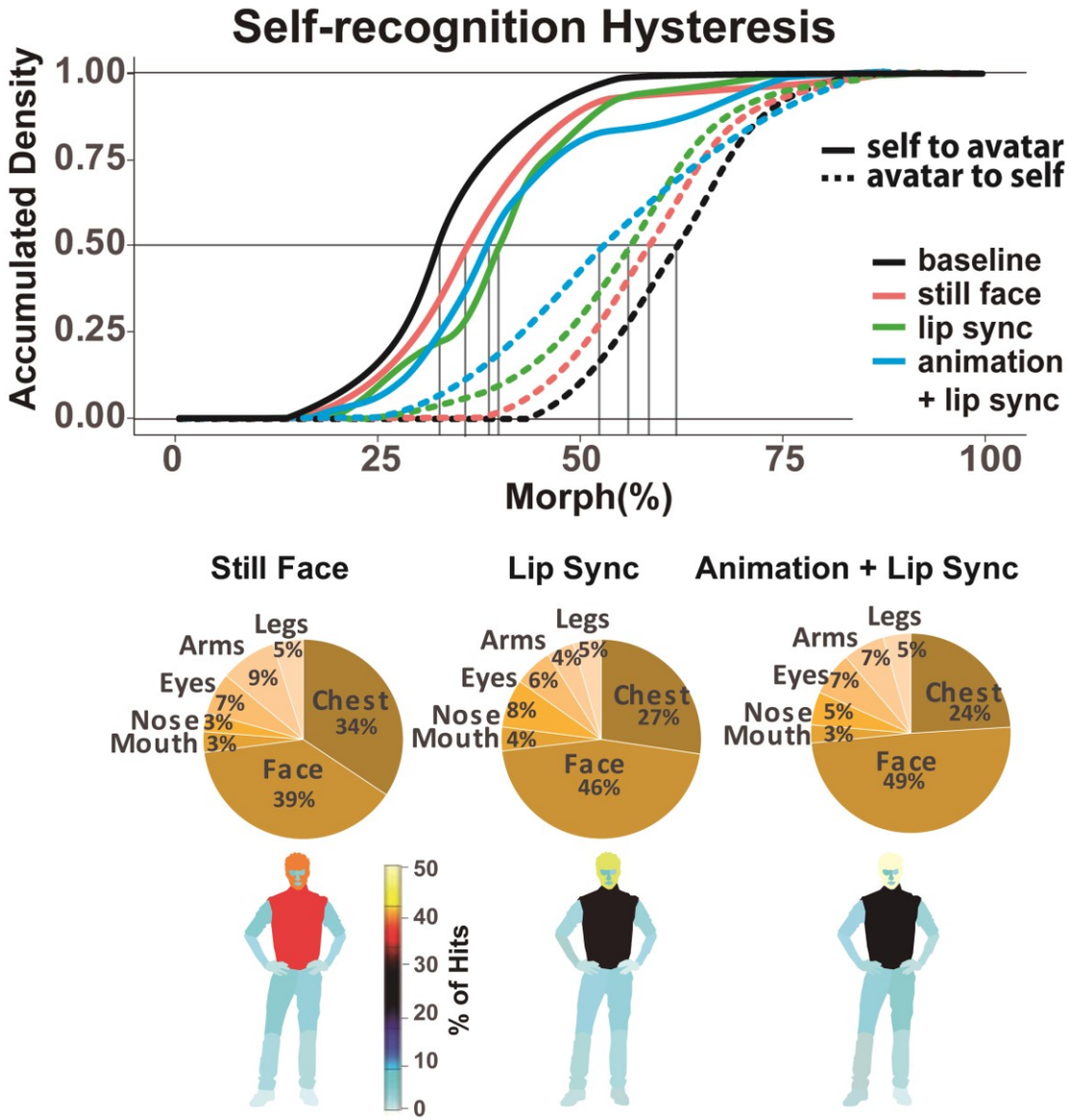
Gonzalez-Franco et al. 2016**. The neurological traces of look-alike avatars**
Frontiers in Human Neuroscience

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

Place Illusion

Presence Illusion

Plausibility Illusion

REALISTIC BEHAVIOR

Sanchez-Vives & Slater Nat Neurosci 2005

Meehan et al. Siggraph 2002

Nature Reviews | Neuroscience

SCIENTIFIC AMERICAN

Would You Give a Virtual Electric Shock to an Avatar?

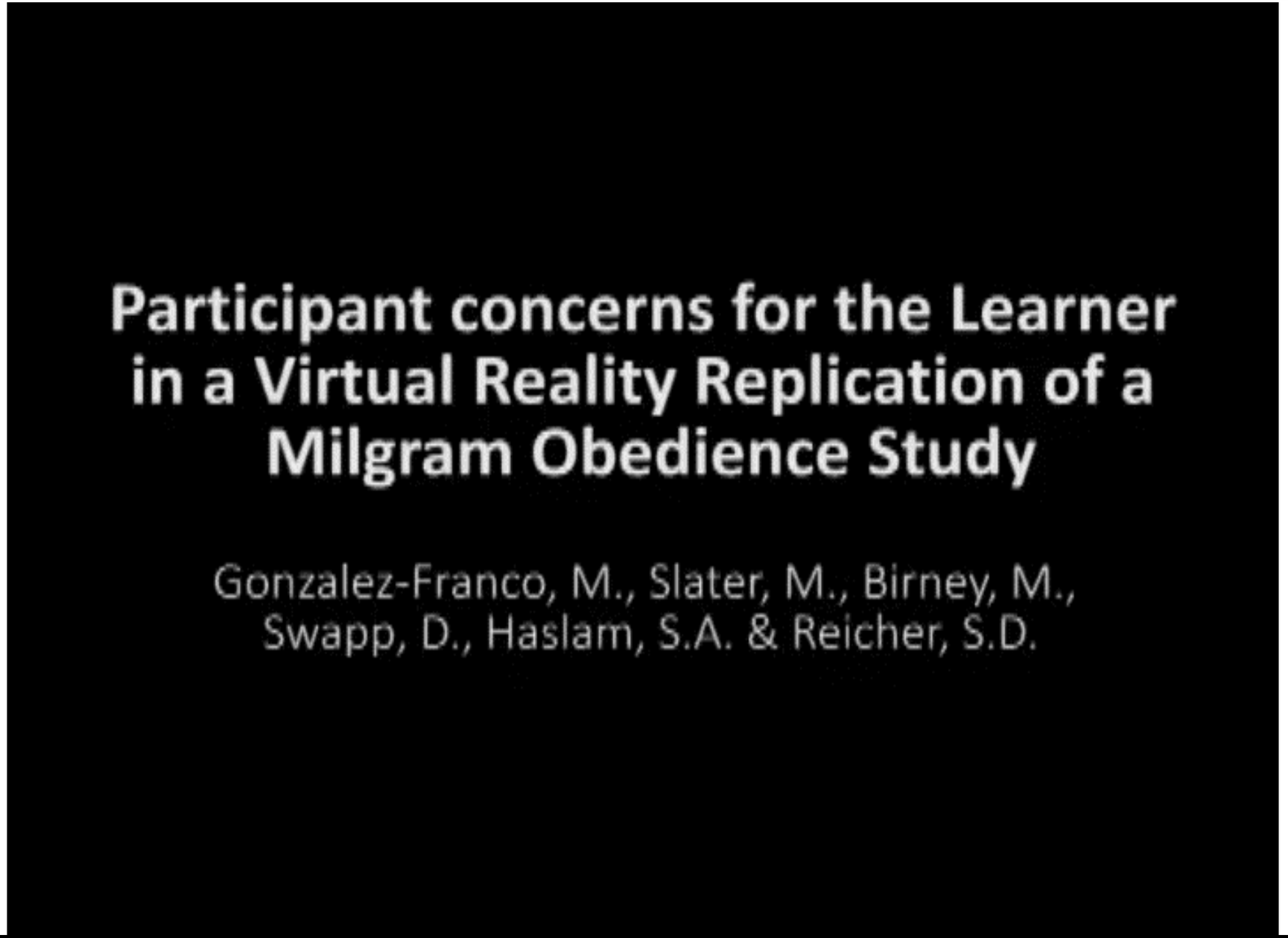
In a repeat of a classic experiment, we find that people who are only unenthusiastically obeying unethical orders still experience trauma

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.

Realistic reactions when interacting with avatars



Gonzalez-Franco et al. 2019 **Participant concerns for the Learner in a Virtual Reality replication of the Milgram obedience study**. Plos One

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TECH BY VICE

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

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."

Thanks!

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Microsoft

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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