Brain Computer Interfaces for Full Body Movement and Embodiment

Intelligent Robotics Seminar

21.11.2016

Kai Brusch

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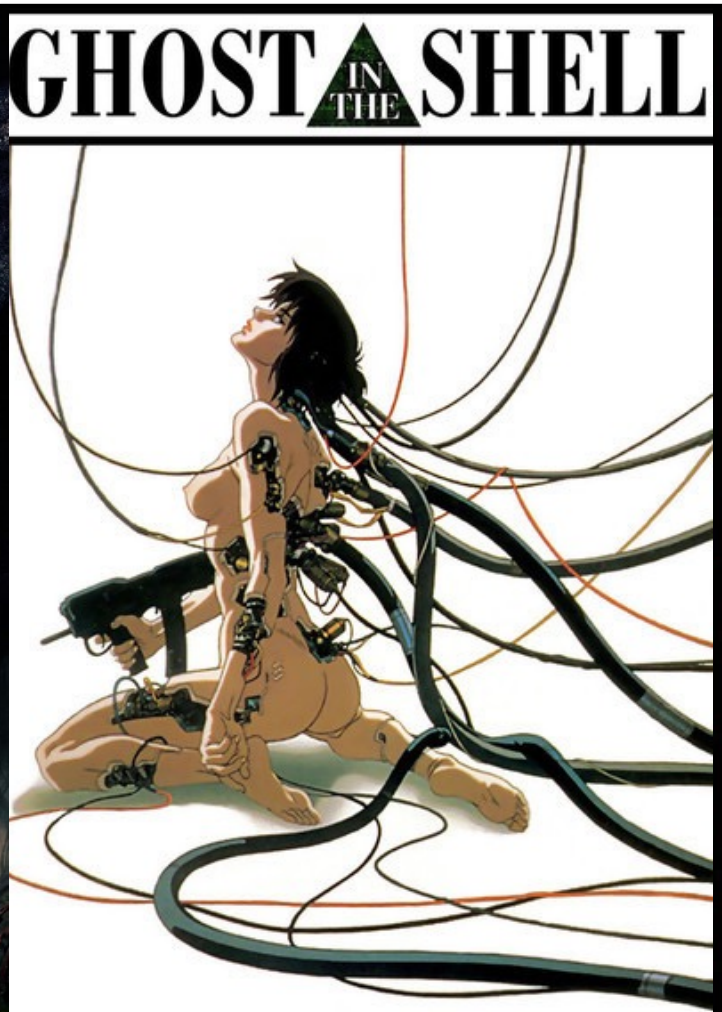
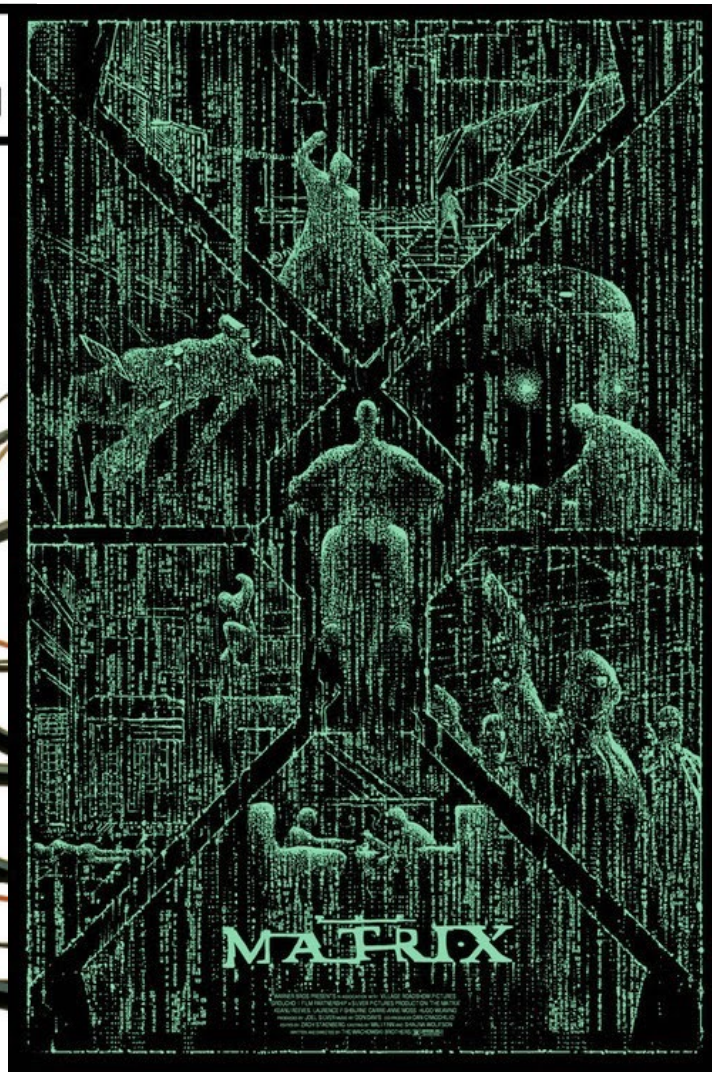
Full Body Movement and Embodiment

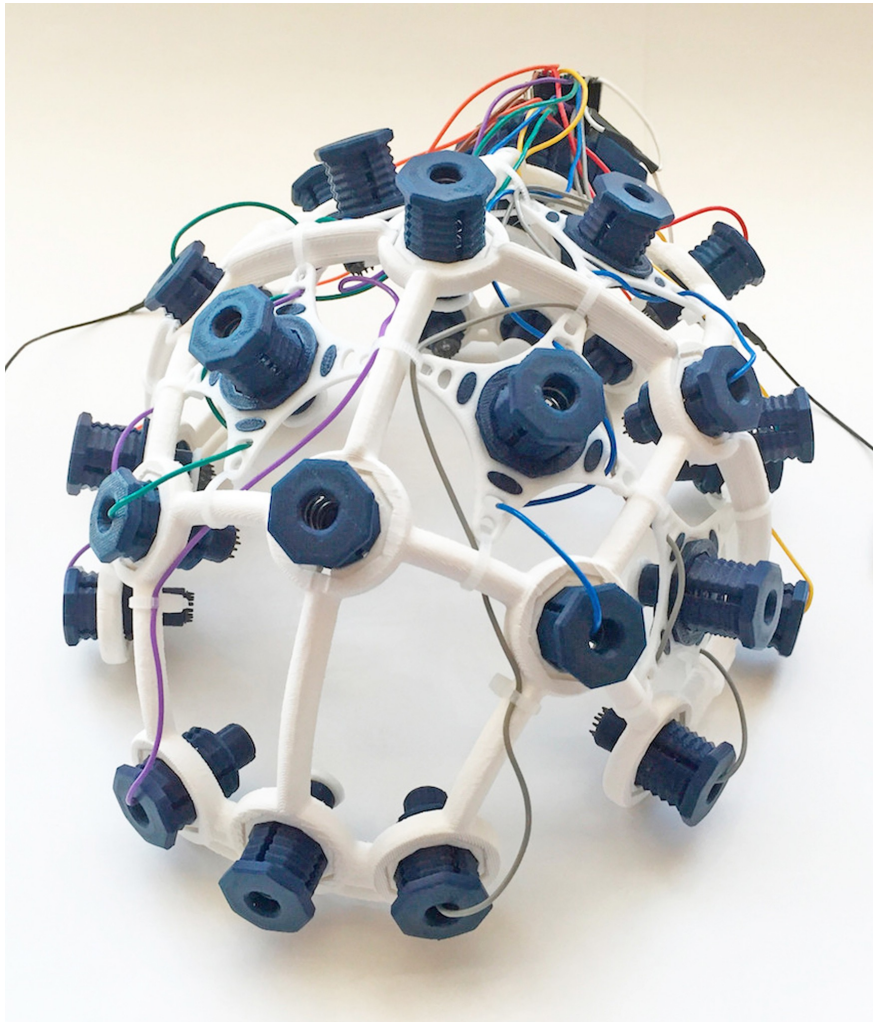




[4,5,6]

Electroencephalography (EEG)

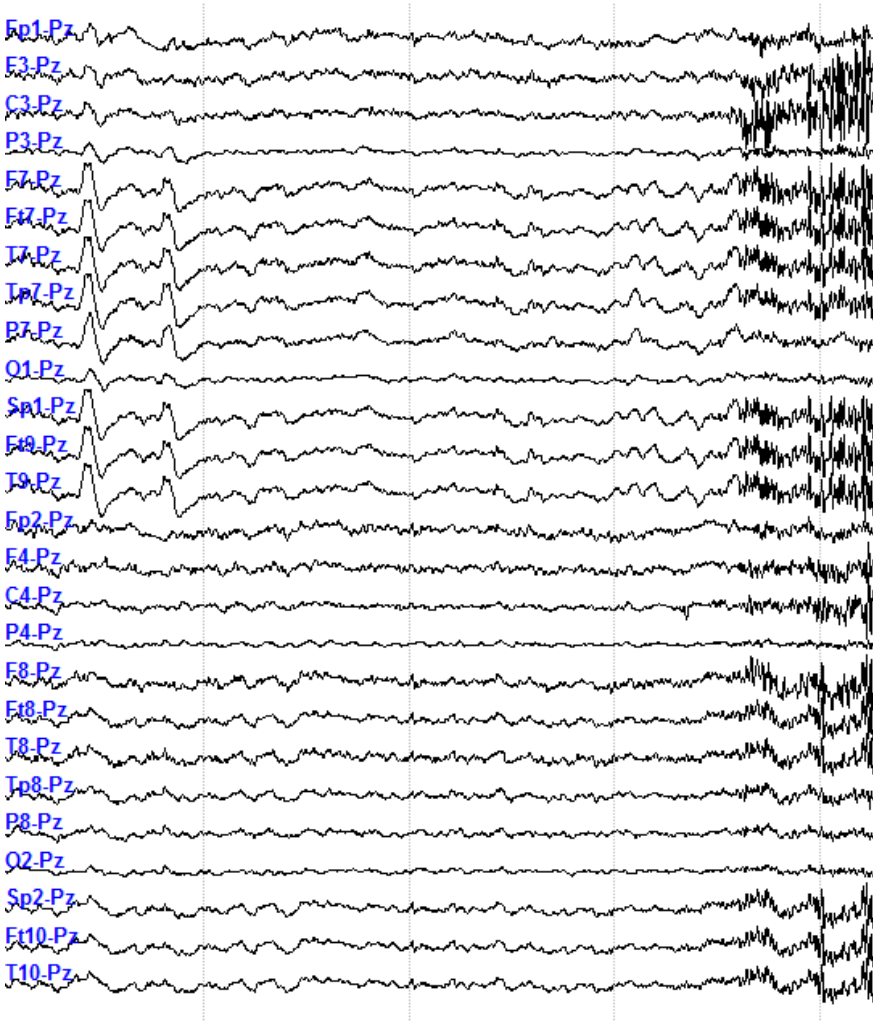
+ Electrophysiological monitoring method
+ Non-invasive
+ openbci.com



[1]

Electroencephalography (EEG)

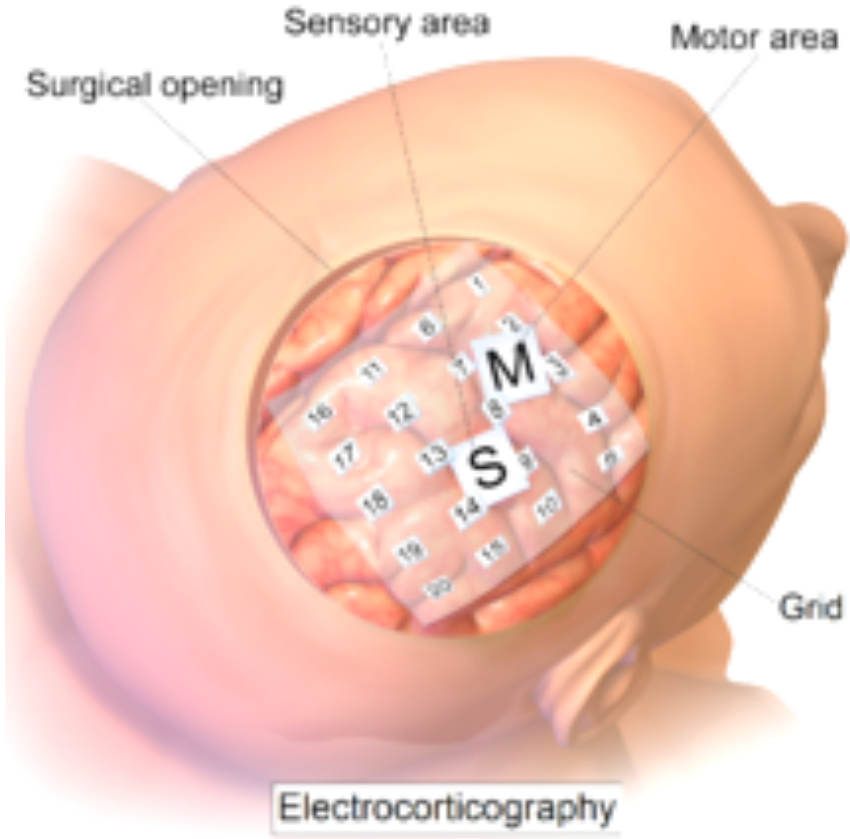
+ Segmentation into electrodes
+ Signal needs to penetrate skull
+ Mapping to region is inaccurate



[2]

Electrocorticography (EGOC)

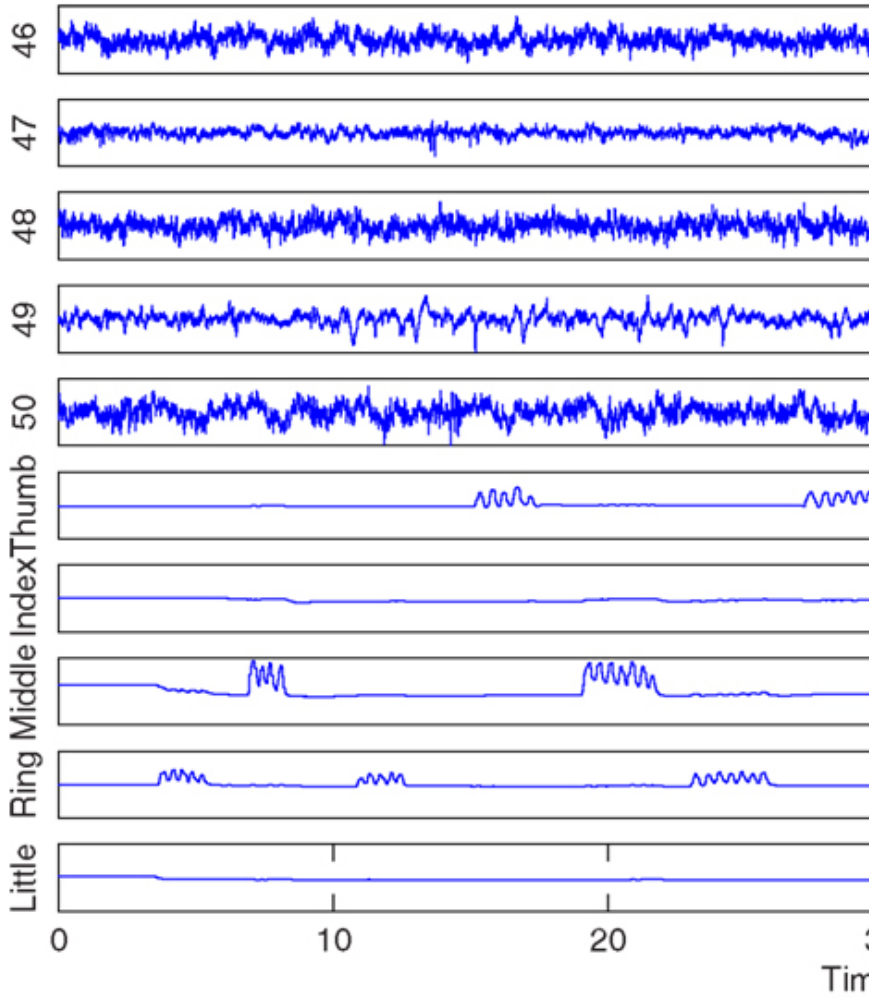
+ Invasive Implant
+ EEG direct on the cerebral cortex
+ Implant located on the region of interest



[2]

Electrocorticography (EGOC)

+ Lower Noise vs Signal ratio
+ Higher Spatial resolution
+ Direct mapping from signal to brain region



[2]

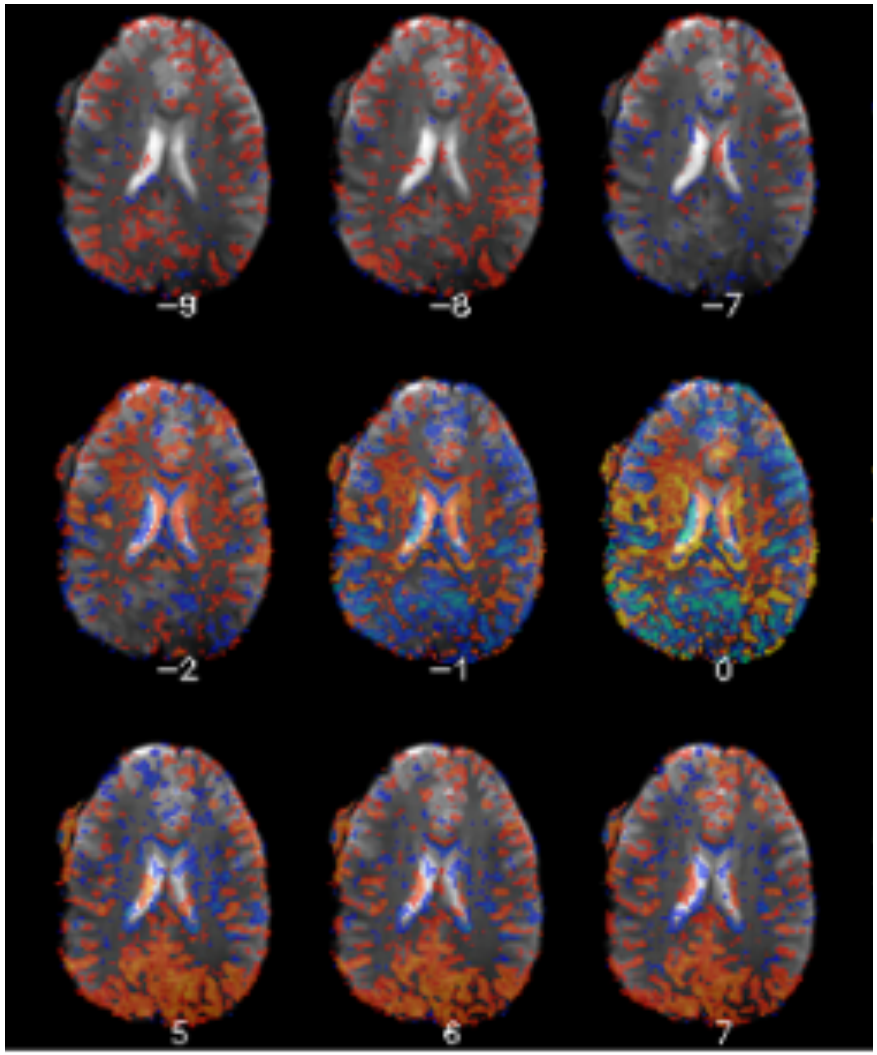
Functional Magnetic Resonance Imaging (f-MRI)

+ Stationary
+ Expensive machine
+ Non-invasive

[3]

Functional Magnetic Resonance Imaging (f-MRI)

+ Hemodynamic response
+ Oxygen consumption
+ Image data



[9]

Compare and Contrast

EEG	ECOG	f-MRI
Non invasive	Invasive	Non invasive
High Temporal	High Temporal	Low Temporal
Low Spatial	High Spatial	High Spatial
High Noise	Low Noise	High Noise
Cheap	Expensive	Expensive

Compare and Contrast

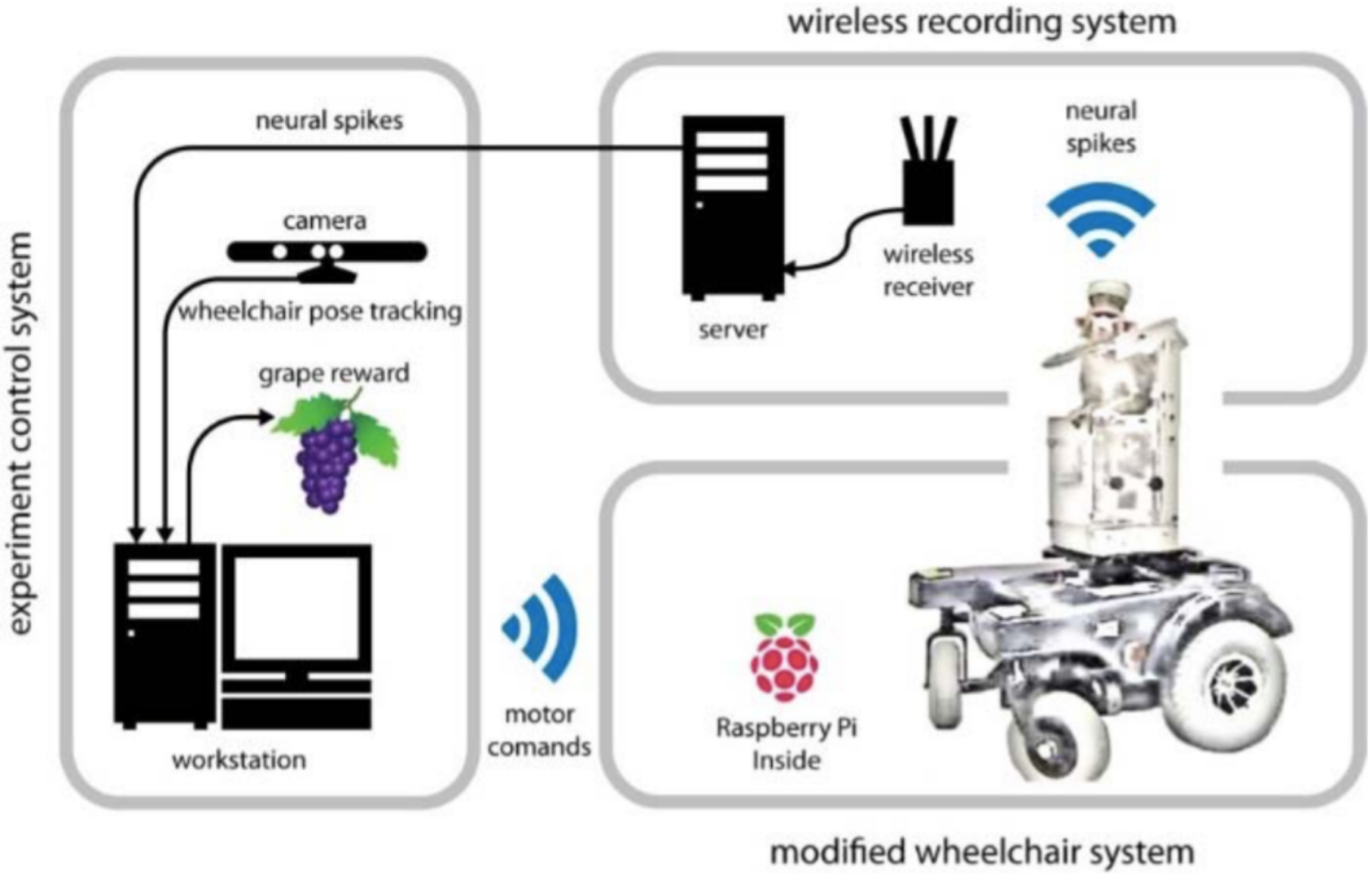
EEG	ECOG	f-MRI
Non invasive	Invasive	Non invasive
High Temporal	High Temporal	Low Temporal
Low Spatial	High Spatial	High Spatial
High Noise	Low Noise	High Noise
Cheap	Expensive	Expensive

Brain Computer Interfaces for Full Body Movement and Embodiment

Can M and K learn to navigate in a 2D space?

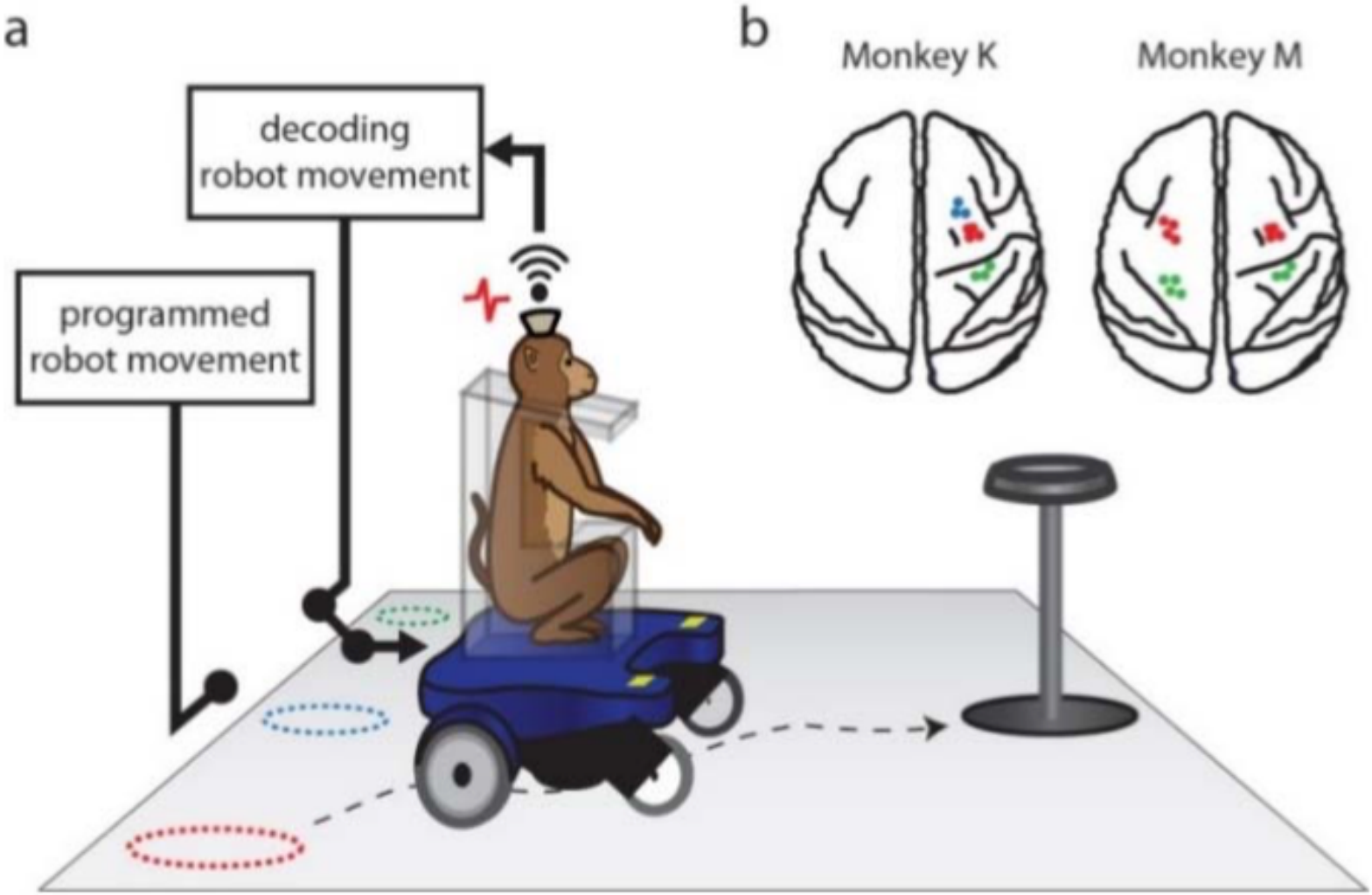
+ BCI have been established for limb movement [12]
+ Whole body navigation has been untested [10]
+ Chronically implanted with multichannel electrode arrays (EGOC) on two monkeys (M,K)

Experiment Setup I



[10]

Experiment Setup II



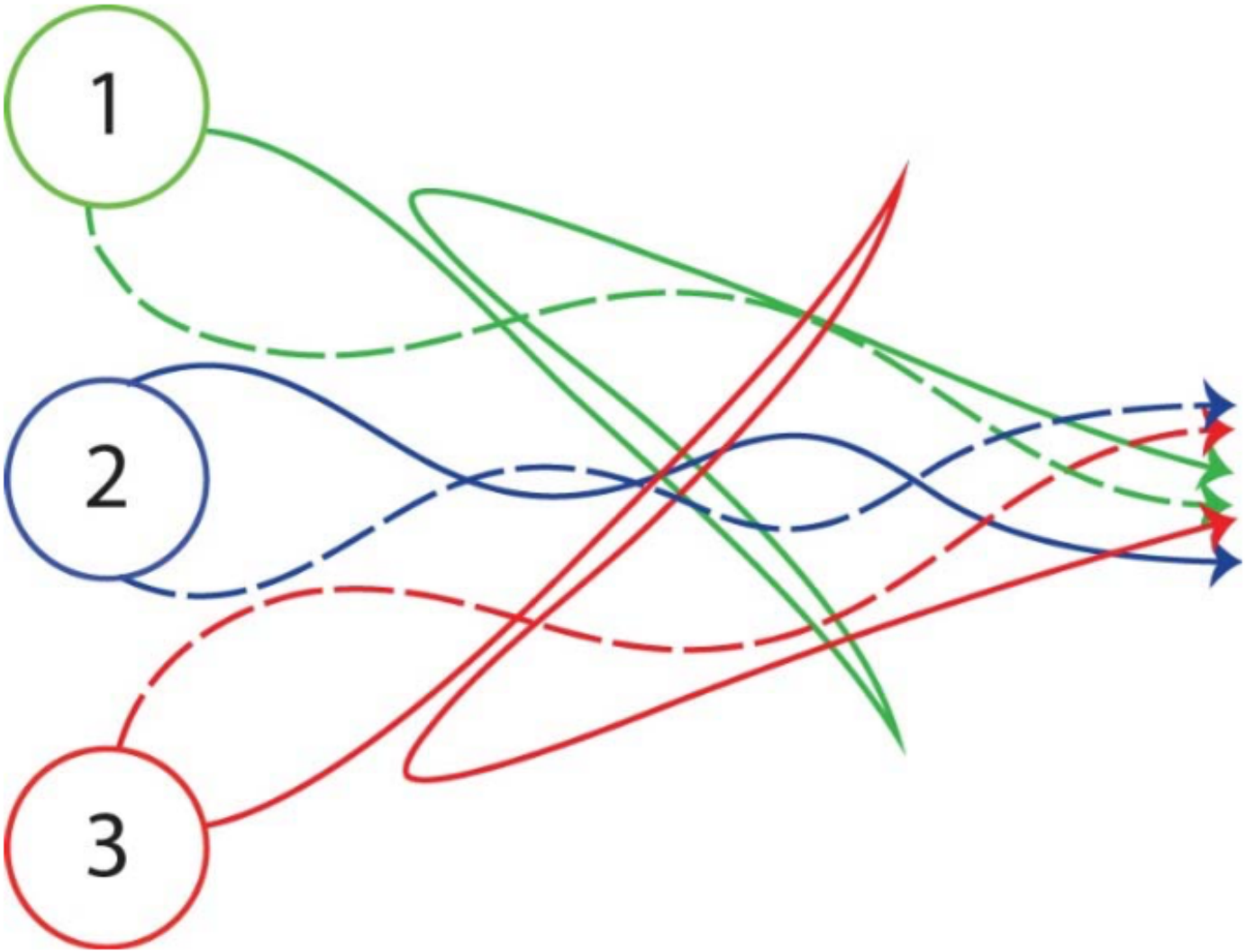
[10]

Classifier Training Method

+ 30 trials to train BCI decoder
+ Passive movements evoke somatosensory sensations
+ Generated commands from a 1s window divided into ten 100 ms bins

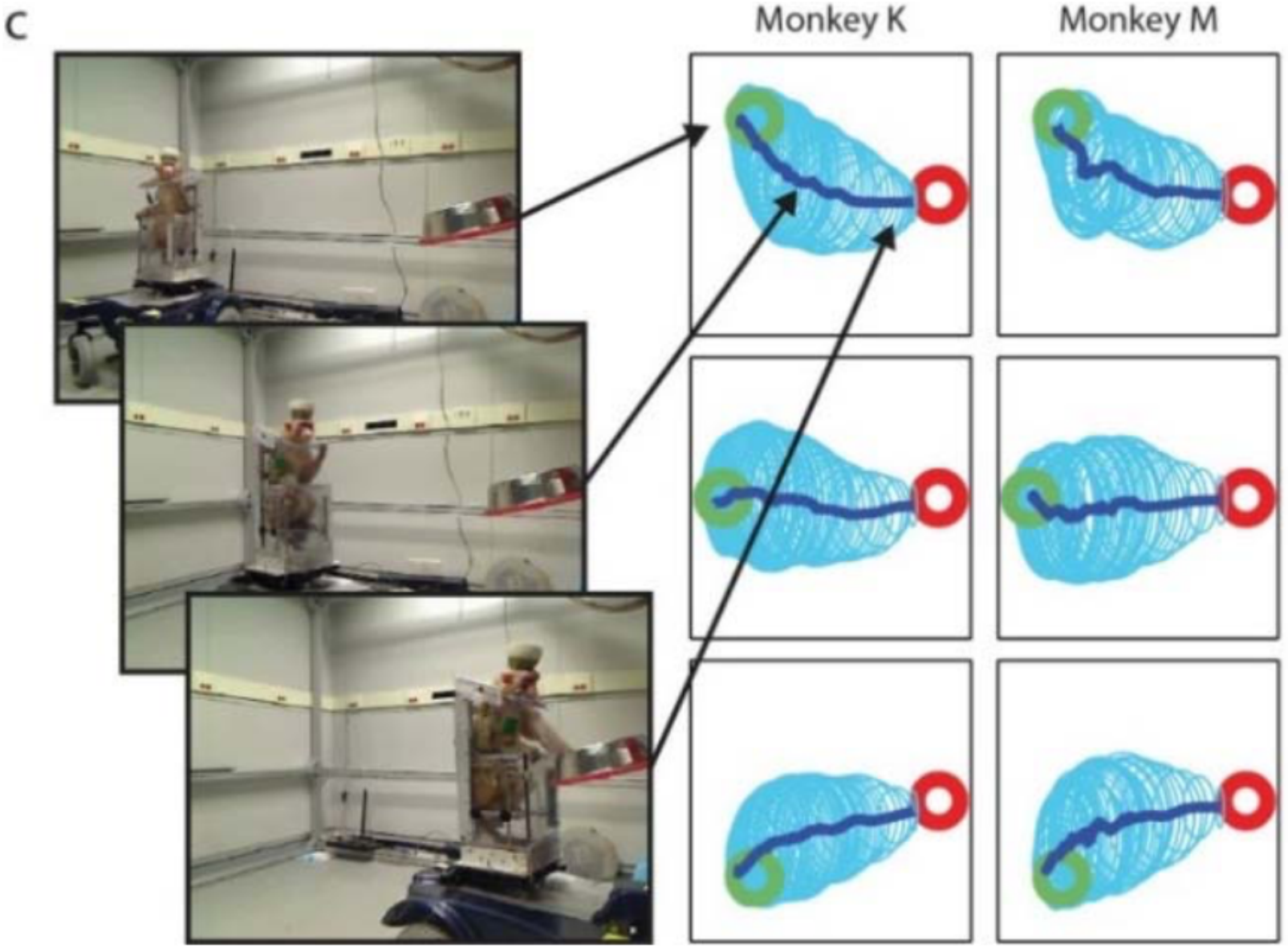
[10]

Classifier Training Course



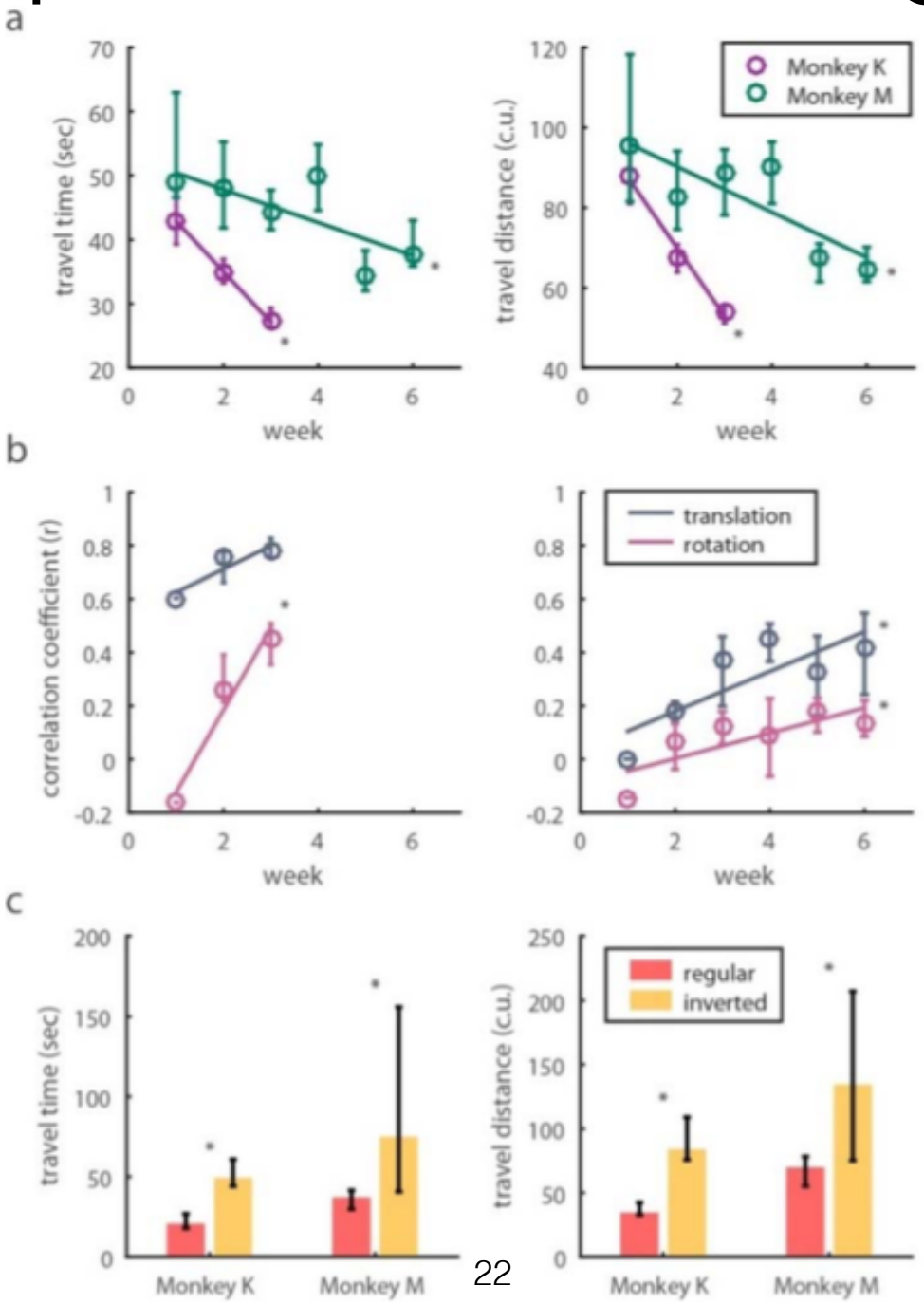
[10]

Experiment Findings I



[10]

Experiment Findings II



[10]

Video

https://www.youtube.com/watch?v=zPTvHG7XNxM

Whole Body Movement Findings

+ Cortical neuronal ensembles can directly control whole-body navigation in a mobile device such as a robotic wheelchair. [10]

+ Did the monkey really wanted to go there?

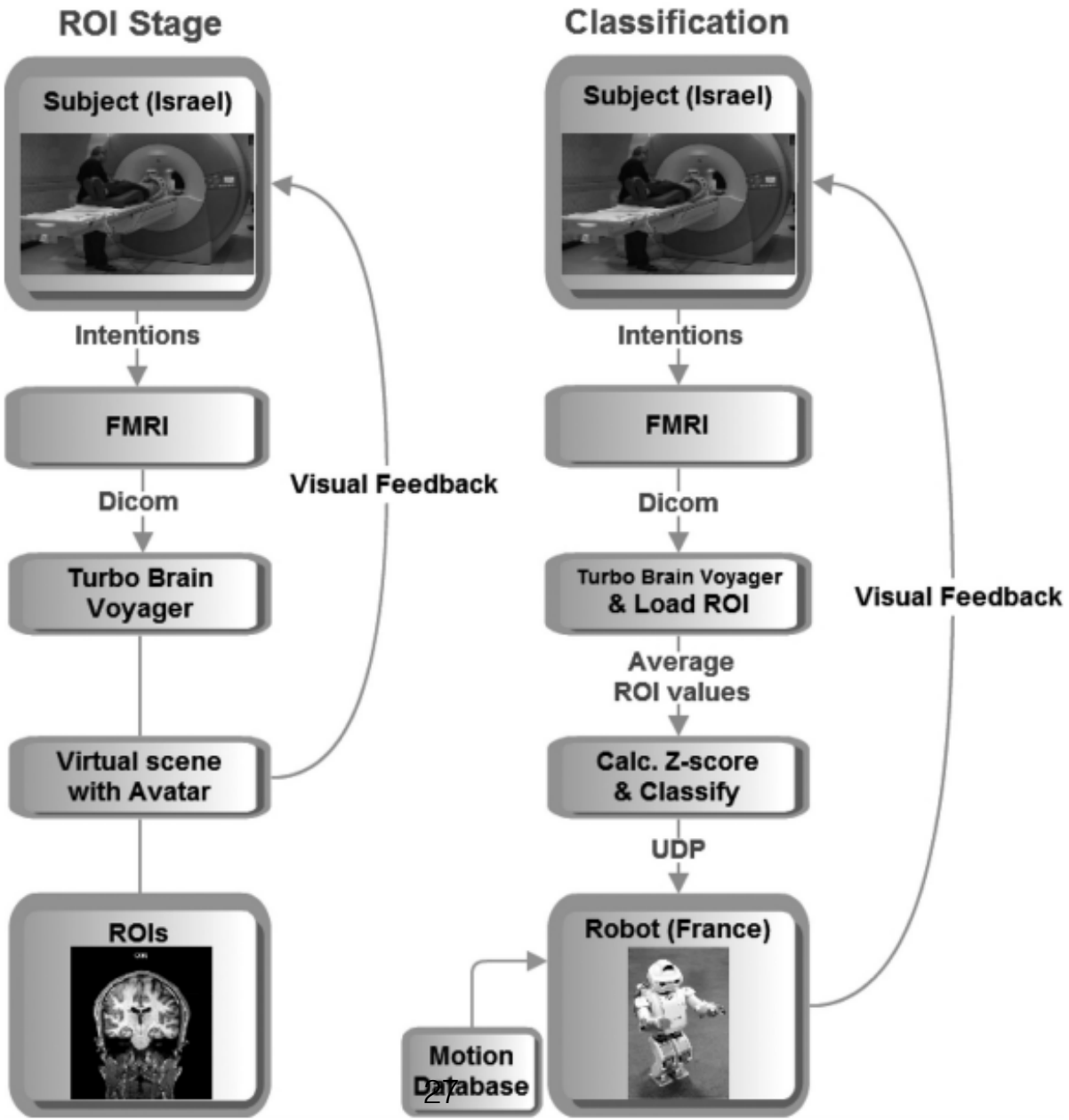
+ How much navigation was involved?

Brain Computer Interfaces for Full Body Movement and Embodiment

Can a BCI create the illusion of being somewhere else?

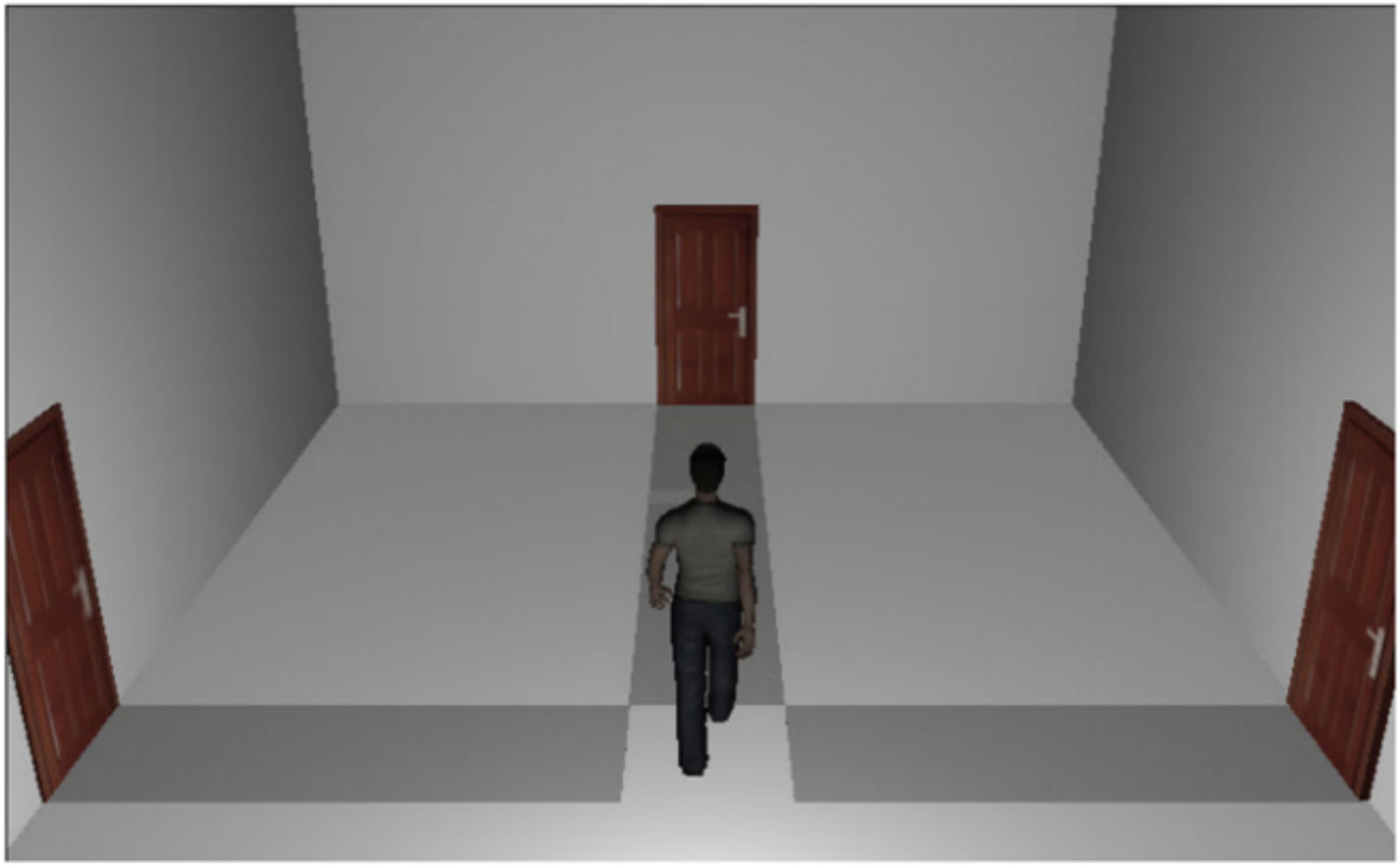
+ f-MRI computer brain interface with virtual feedback.
+ The subject is given the illusion of being embodied in an avatar.
+ Navigation only through screen and thought.

Classifier Training I



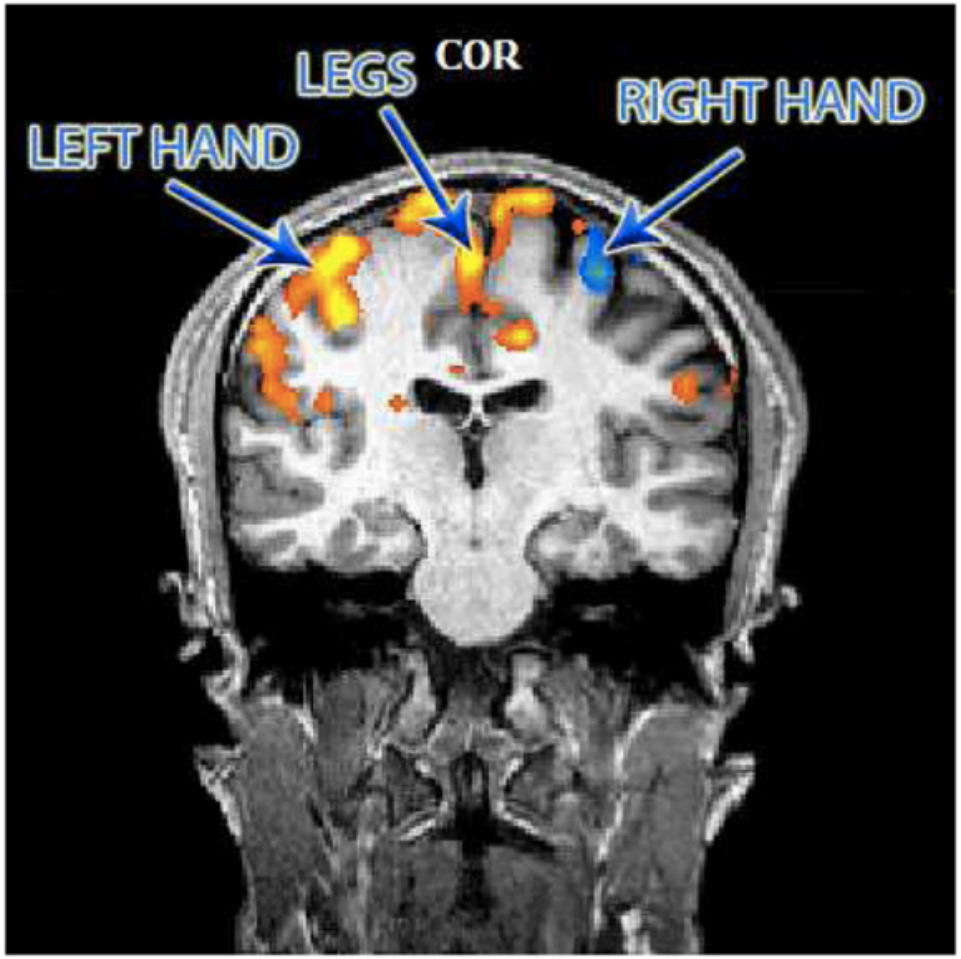
[11]

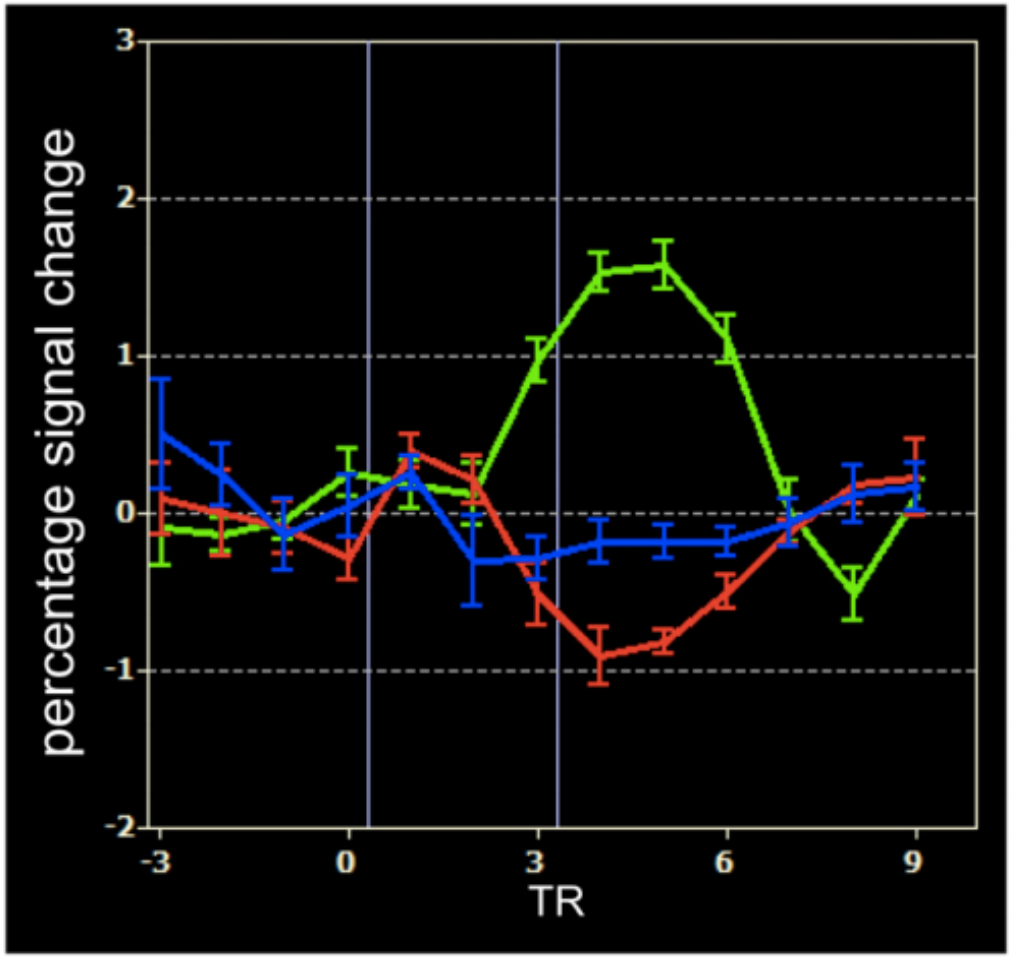
Classifier Training II



[11]

Classifier Training III





[11]

Classifier Training III

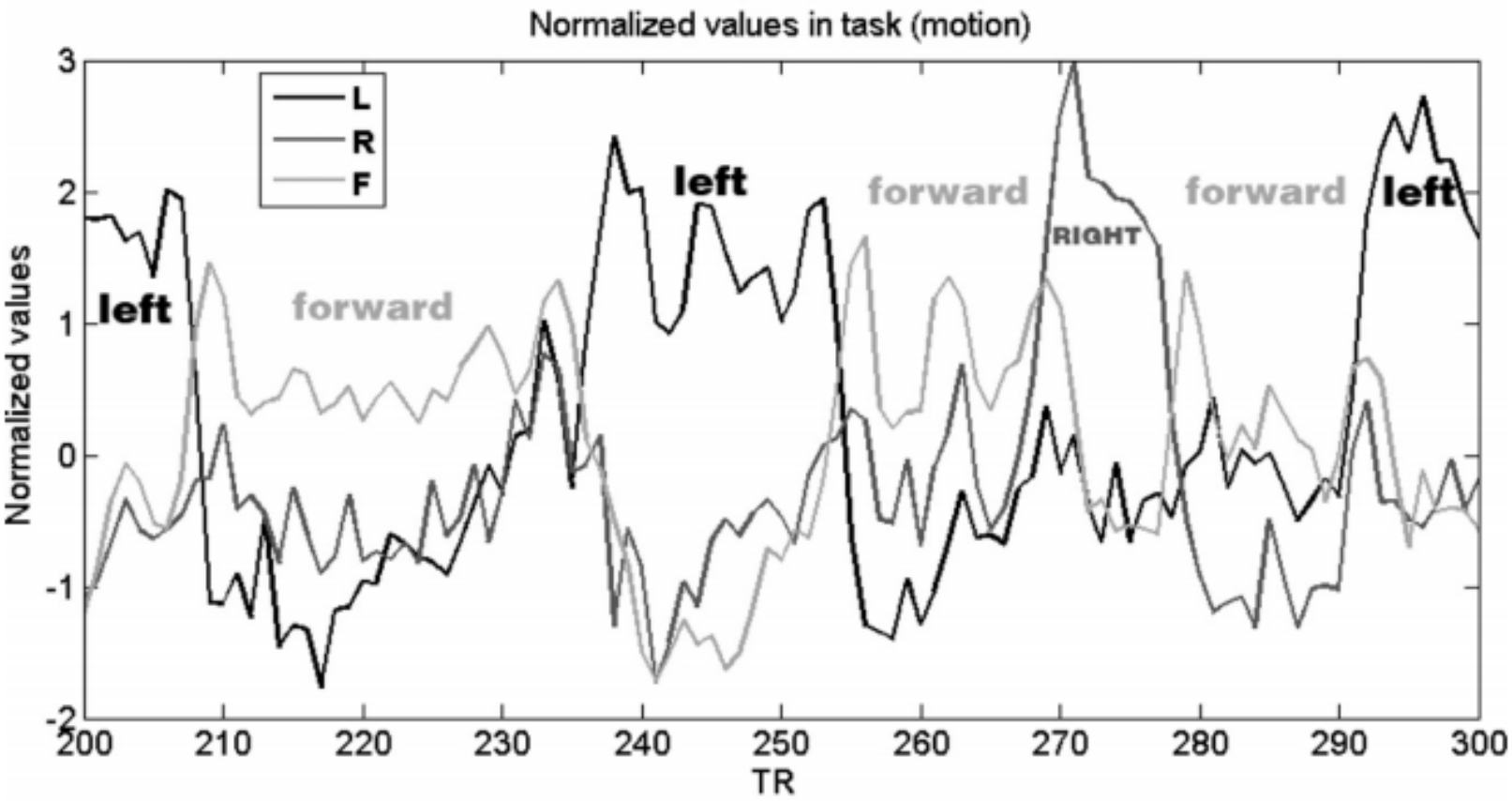


Figure 8. *Normalized activation levels of subject S1 in the three ROIs used to control the robot, during task, using motion.*

[11]

Video

https://www.youtube.com/watch?v=cXFmRzNZHqc&t=182s

Embodiment Findings

+ Subjects are able to perform a navigation task in a virtual environment using an fMRI-based BCI.
+ Test subject reported a ‘feeling of being in France’.
+ Tapping with finger appears the best approach to directing movement.

Conclusion

+ Basic capabilities for embodiment and full body movement
+ Subjects had the feeling of being embodied ‘in France’
+ Ethical questions arise naturally

[13]

References

[1] http://openbci.com/

[2] https://en.wikipedia.org/wiki/Electrocorticography#/media/File:Intracranial_electrode_grid_for_electrocorticography.png

[3] http://sites.psu.edu/siowfa15/wp-content/uploads/sites/29639/2015/10/fmri.jpg

[4] http://www.hollywood.com/movies/avatar-59102149/

[5]http://static.rogerebert.com/uploads/movie/movie_poster/ghost-in-the-shell-1996/large_vTXgUgB4KyntDSUezLljcm1Ol6N.jpg

[6] http://geektyrant.com/news/the-matrix-glow-in-the-dark-poster-by-kilian-eng

[7]http://cdn.vidible.tv/prod/2016-03/03/56d8ae48e4b0ade05e93fbc7_cv1.jpg

[8] http://www.nature.com/article-assets/npg/srep/2016/160303/srep22170/images_hires/m685/srep22170-f1.jpg

[9] https://fmrif.nimh.nih.gov/

[10]Direct Cortical Control of Primate Whole-Body Navigation in a Mobile Robotic Wheelchair Sankaranarayani Rajangam, Po-He Tseng, Allen Yin, Mikhail A. Lebedev, Miguel A. L. Nicolelis

[11] fMRI-Based Robotic Embodiment: Controlling a Humanoid Robot by Thought Using Real-Time fMRI, Ori Cohen, Moshe Koppel, Rafael Malach and Doron Friedman

[12] Moritz, CT, Perlmutter, SI, and Fetz, EE. "Direct Control of Paralyzed Muscles by Cortical Neurons." Nature, published online October 15, 2008.

[13] https://www.poparta.com/blog/wp-content/uploads/sites/3/2015/03/avatar-movie-wallpaper-widescreen-8-wallpaper-background-hd-avatar-2-delayed-again.jpeg