



What kind of consciousness is retained in noncommunicating states?

Consciousness: Nature/Culture
Max Planck for Human Development
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Human Brain Project

James S. McDonnell Foundation

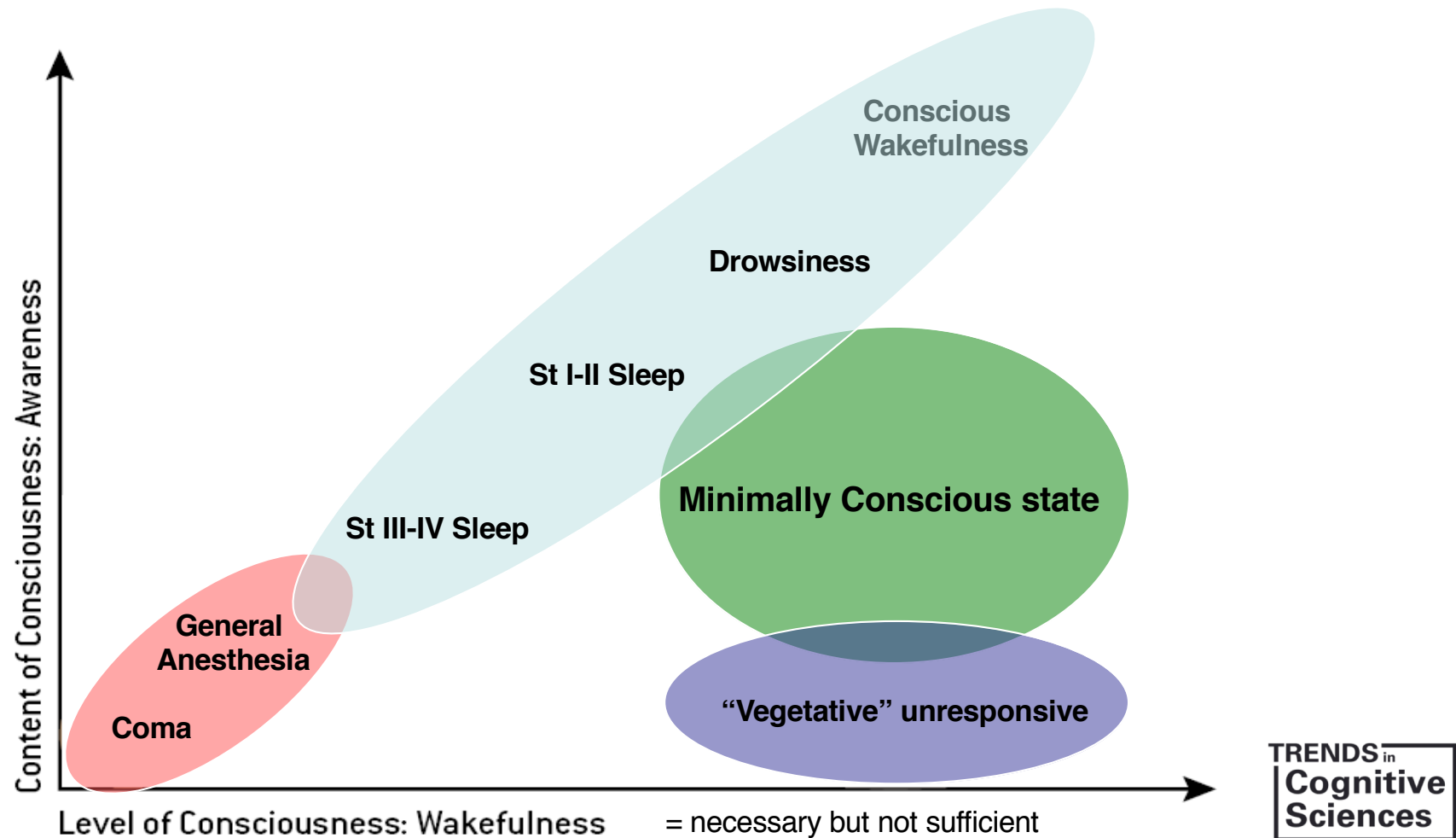


Patients cannot express themselves

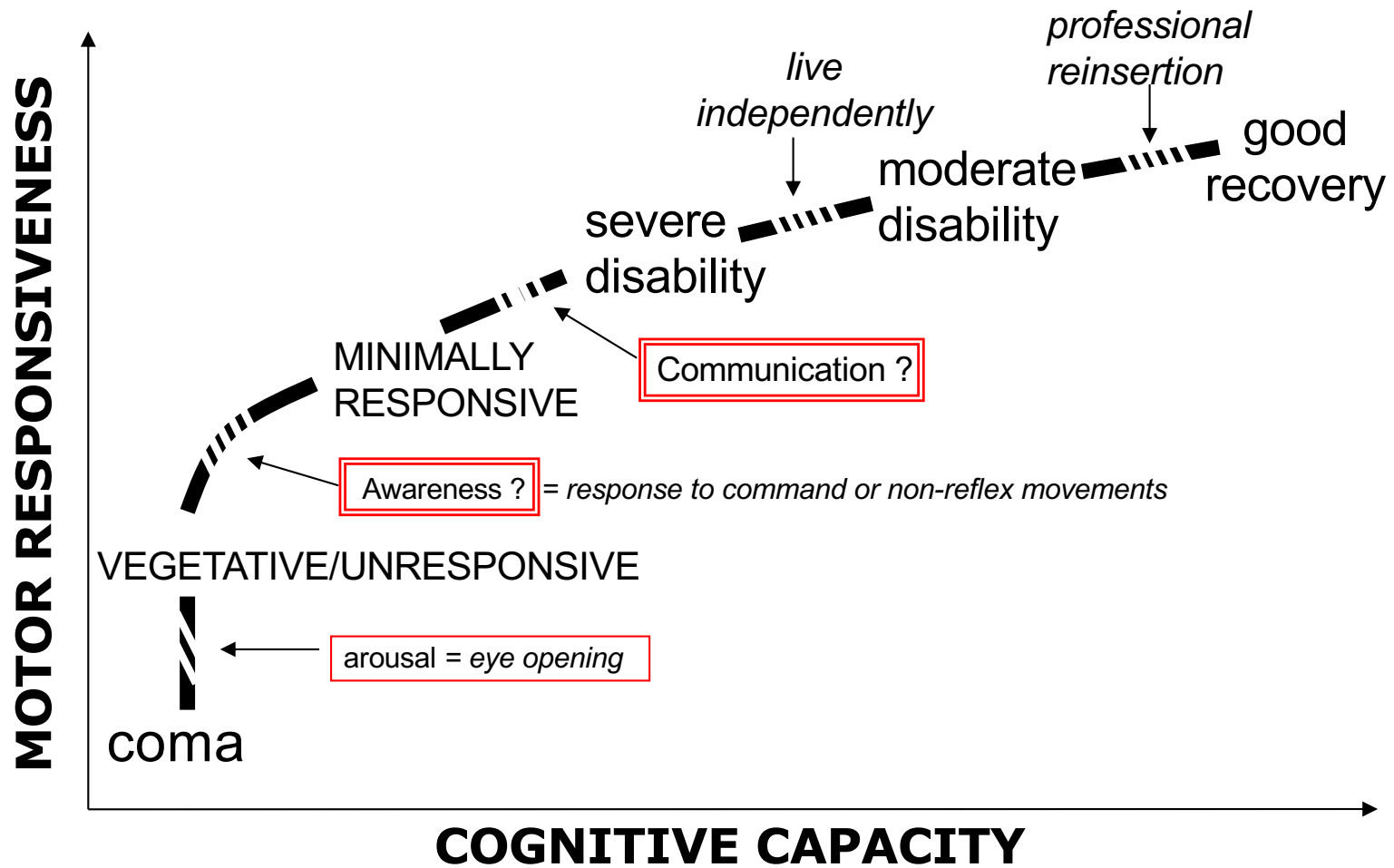


Hable con ella 2002, Pedro Almodóvar

A clinical definition



Behavioural signs of C



Gold standard?

Standardized assessment

n=103 post-comatose patients

45 Clinical diagnosis of VS
18 Coma Recovery Scale MCS

↳ 40% misdiagnosed

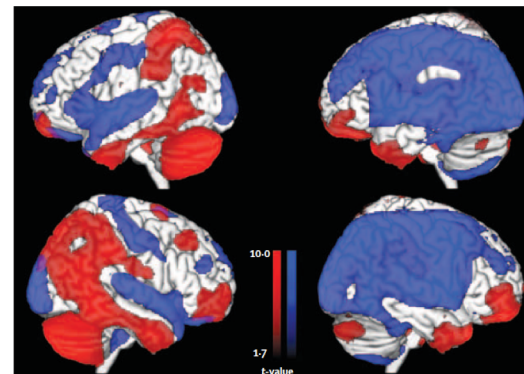
Schnakers et al, *Ann Neurol* 2006; *BMC Neurol* 2009

PET Neuroimaging

	Coma Recovery Scale-Revised results		
	UWS	MCS	Total
Clinical consensus diagnosis			
¹⁸F-FDG PET			
VS/UWS	24 (21%)	5 (4%)	29 (26%)
MCS	12 (11%)	71 (63%)	83 (74%)
Total	36 (32%)	76 (68%)	112 (100%)

UWS=unresponsive wakefulness syndrome. MCS=minimally conscious state.

Table 2: Diagnostic results by modality

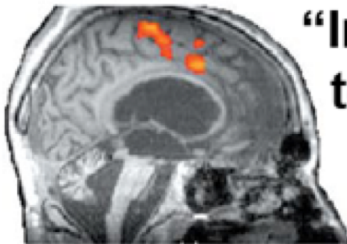
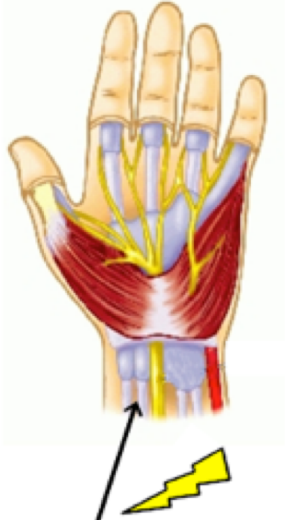
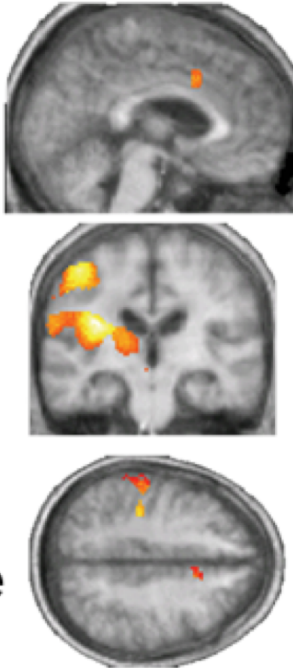


Stender & Gosseries et al, *Lancet* 2014

Neuroimaging paradigms

Owen et al, Science 2006
Monti & Vanhaudenhuyse et al, NEJM 2010

Boly et al, Lancet Neurol 2008

Active paradigms	Passive paradigms
 <p>“Imagine playing tennis”</p>	 <p>median nerve</p> 

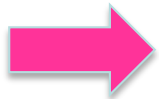
Heine, Di Perri, Soddu, Laureys, Demertzi
In: *Clinical Neurophysiology in Disorders of Consciousness*, Springer-Verlag 2015

Demertzi & Laureys, In: *I know what you are thinking: brain imaging and mental privacy*, Oxford University Press 2012

Some numbers

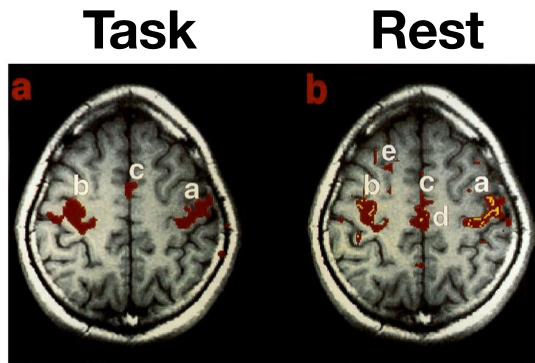


- The human brain is approximately 2% of the weight of the body
- 80% of this energy consumption is used to support neuronal signaling
- Stimulus and performance-evoked changes in brain energy consumption <5%

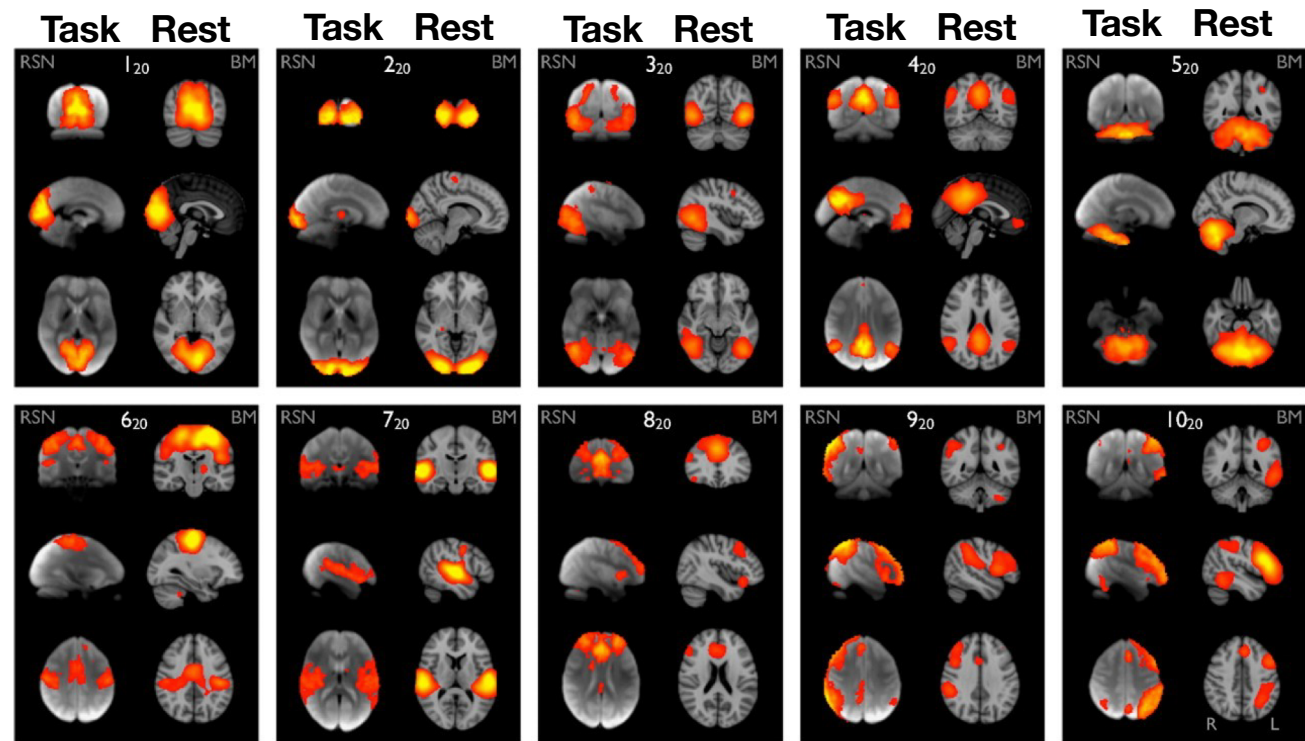


While conscious awareness is energetically inexpensive, it is dependent upon a very complex, dynamically organized, non-conscious state of the brain that is achieved at great expense

Intrinsic functional organization

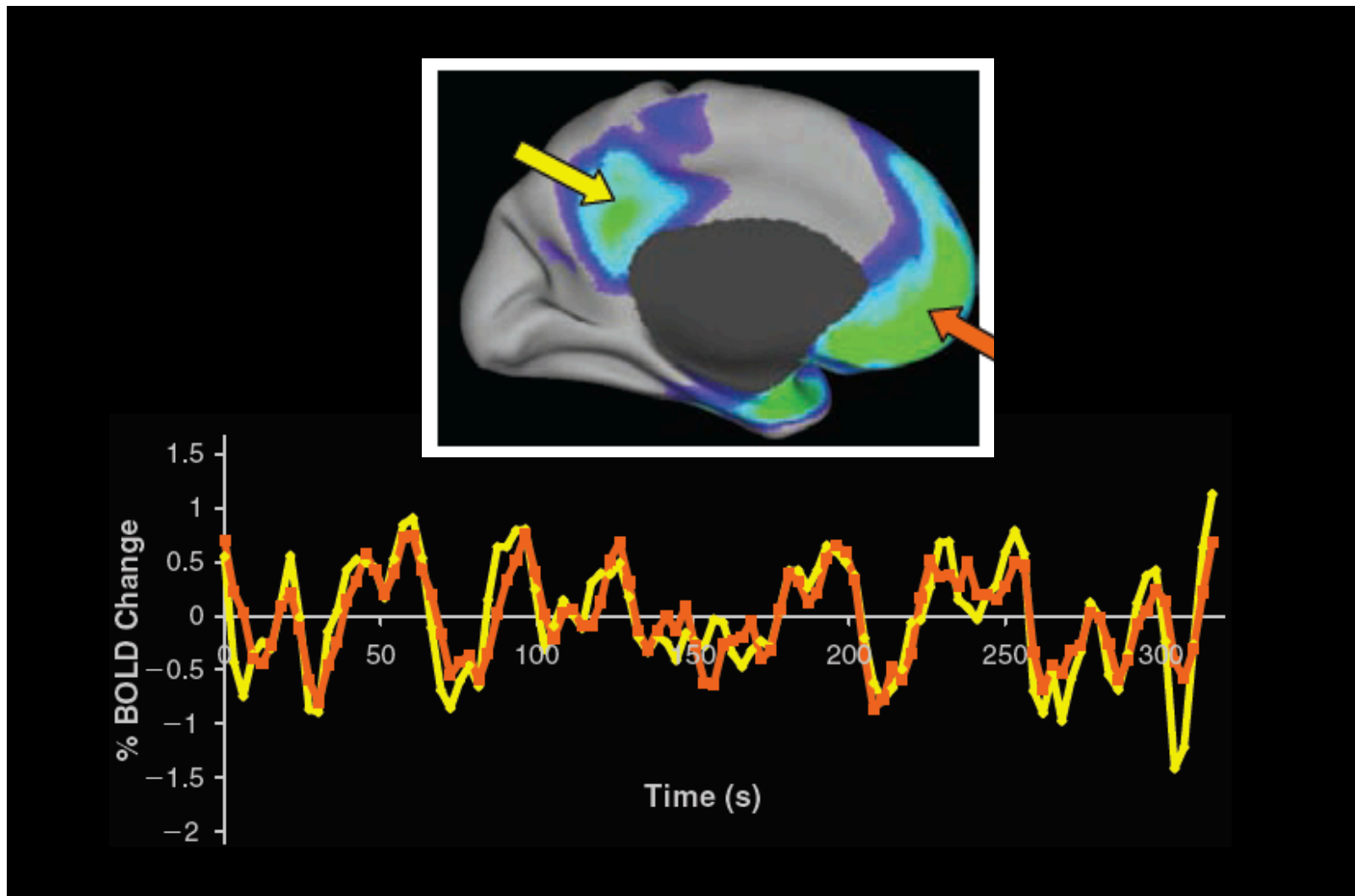


Biswal et al., *Magn. Reson. Med.* 1995



Smith et al, *PNAS* 2009

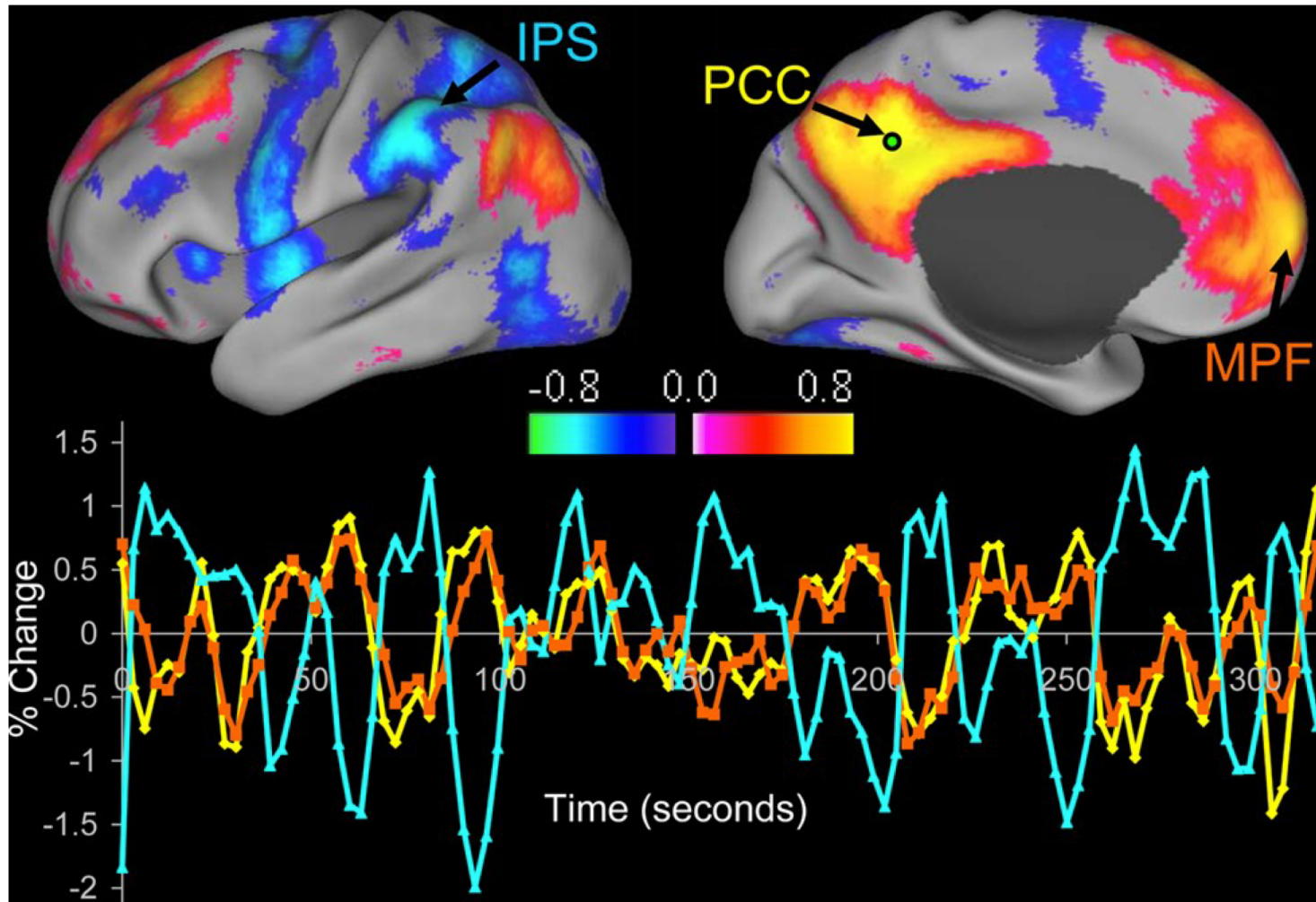
Default mode network (DMN)



Raichle & Snyder, Intrinsic Brain Activity and Consciousness.

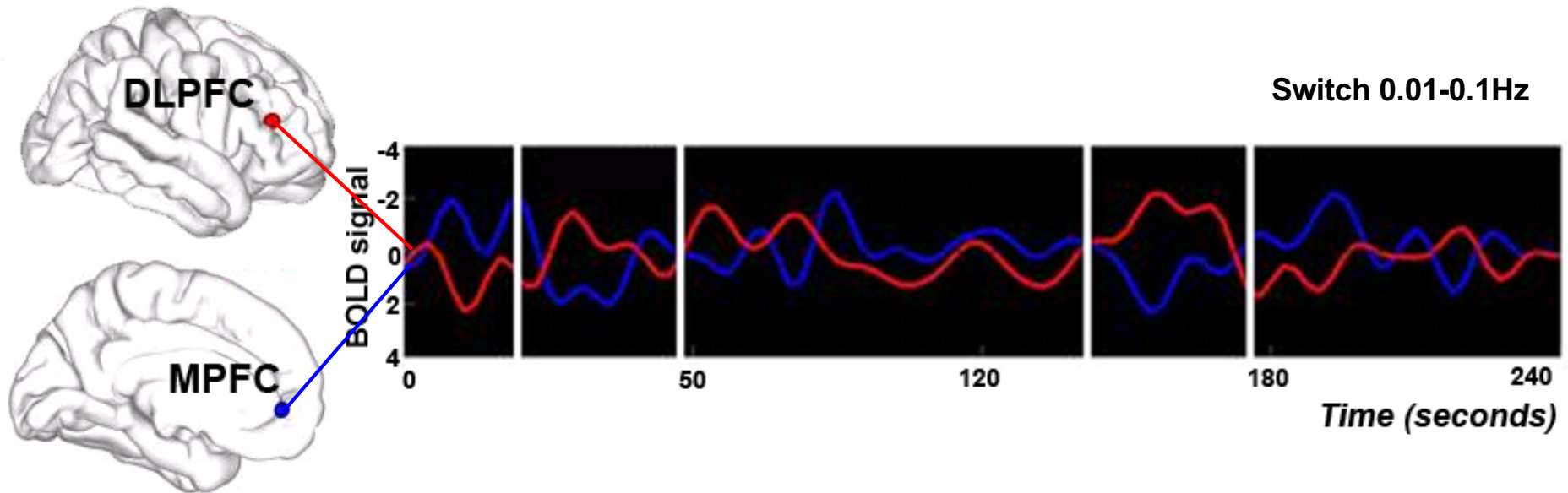
In: Laureys S, Tononi G, editors. The Neurology of Consciousness. Oxford: Elsevier Academic Press; 2009. p. 81-48

DMN anticorrelations



DMN anticorrelations

External awareness
or anticorrelated network



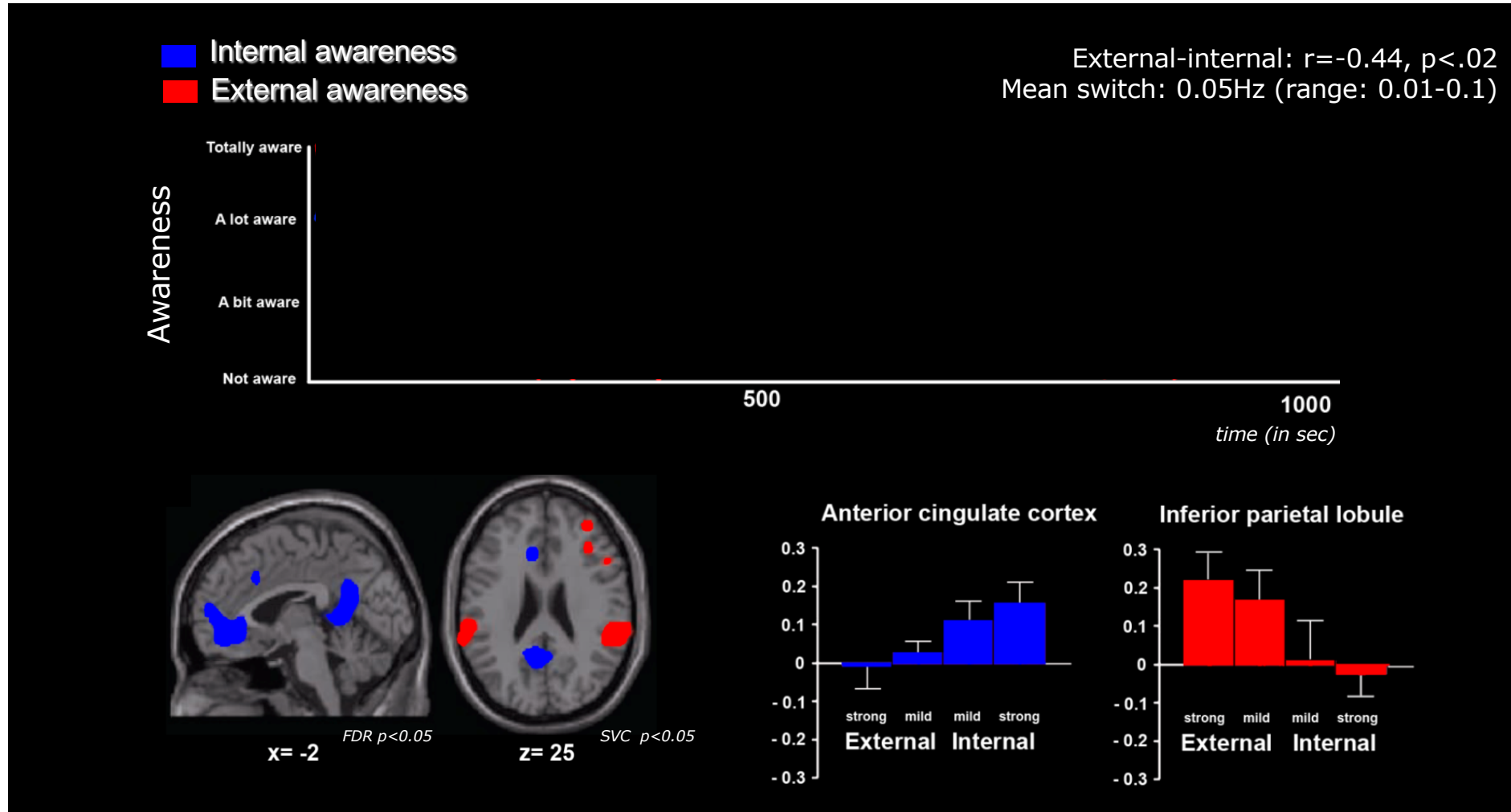
Internal awareness
or Default mode network

Demertzi & Whitfield-Gabrieli. in: *Neurology of Consciousness* 2nd ed. 2015

Demertzi et al, *Front Hum Neurosci* 2013

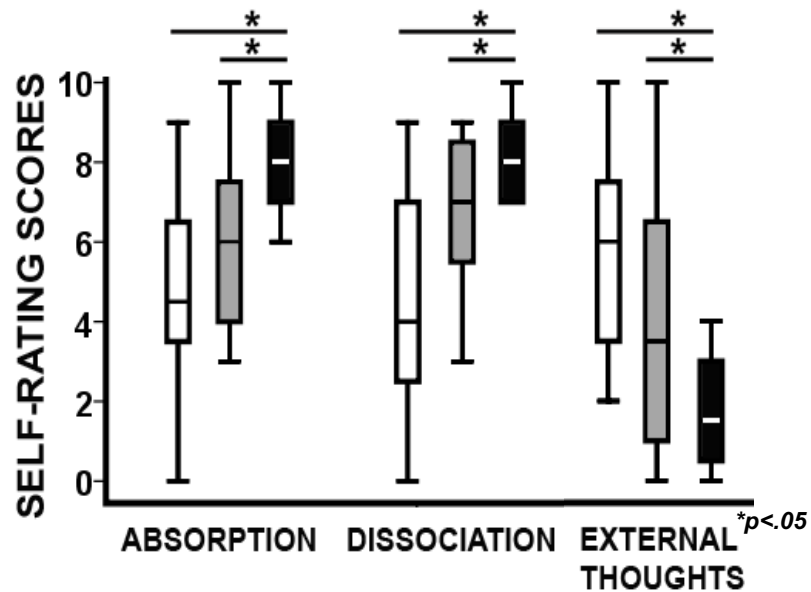
Demertzi, Soddu, Laureys. *Curr Opin Neurobiology* 2013

Cognitive-behavioral relevance

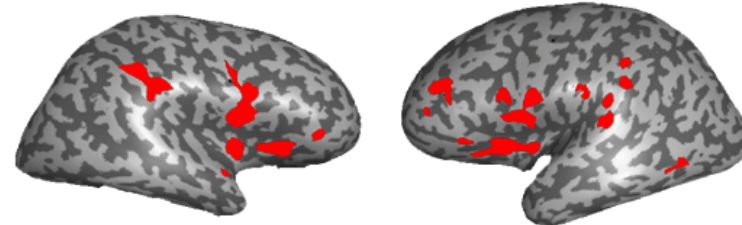


Effect of awareness

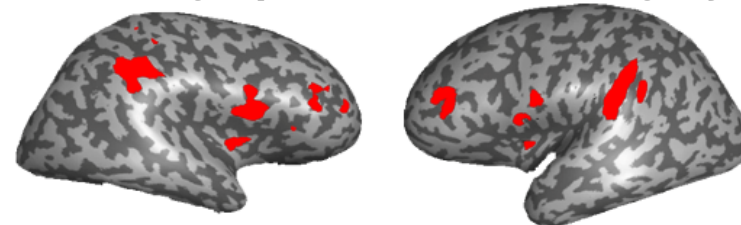
- Normal consciousness
- Autobiographical mental imagery
- Hypnosis



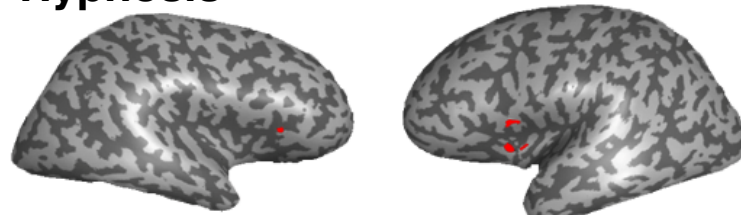
Normal consciousness



Autobiographical mental imagery

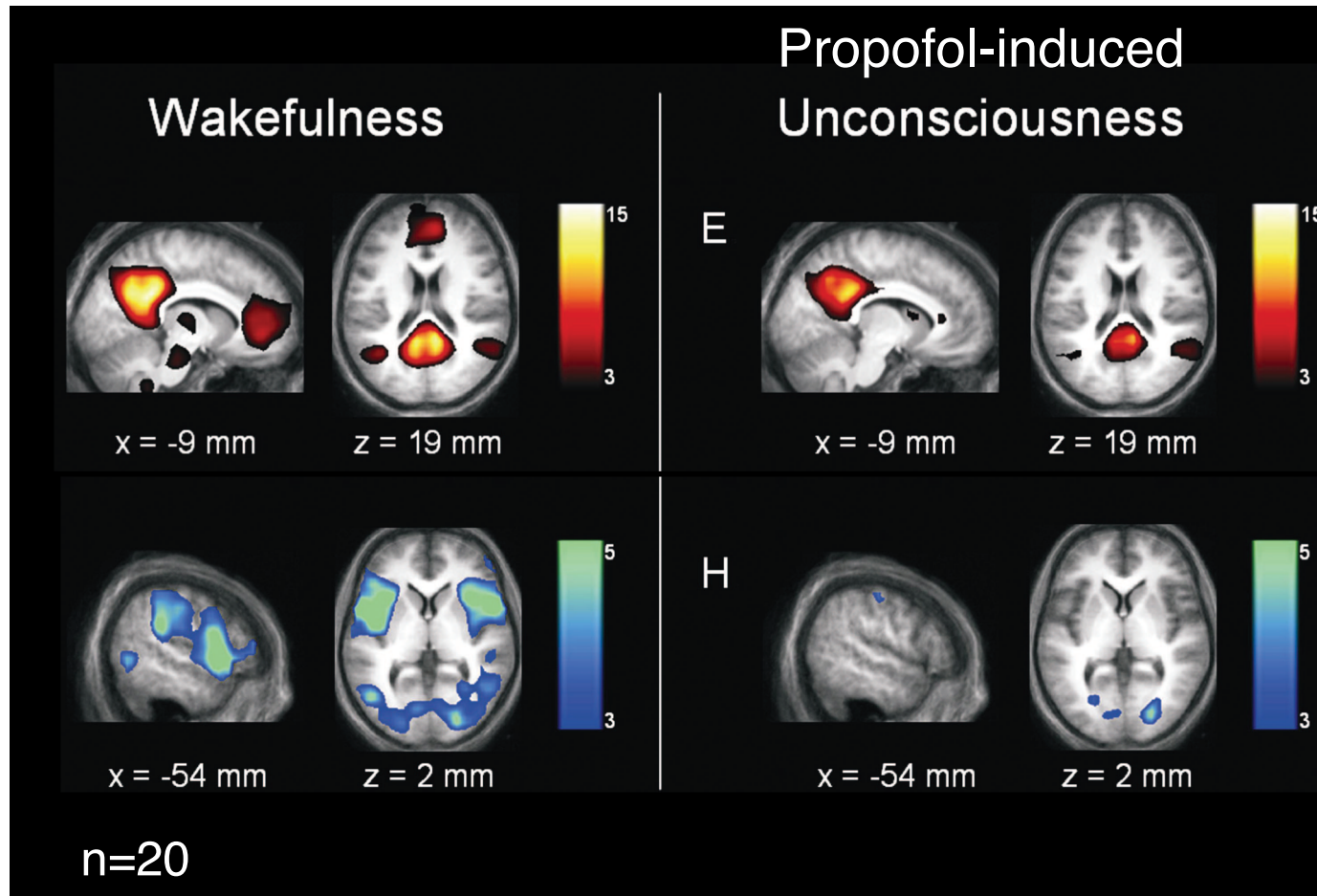


Hypnosis



p<0.05 corrected for multiple comparisons

Effect of arousal



Effect of environment

SCIENTIFIC REPORTS

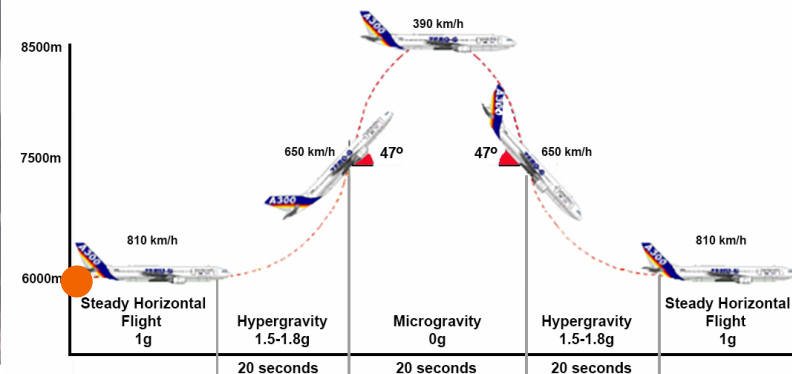
www.nature.com/scientificreports/



Parabolic flight



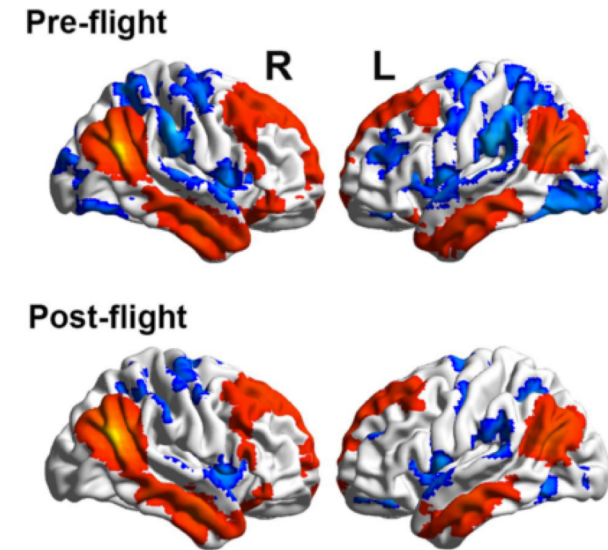
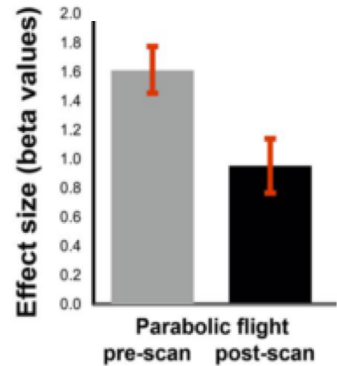
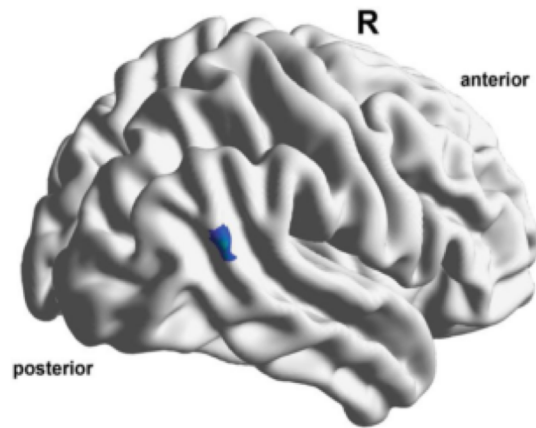
European Space Agency



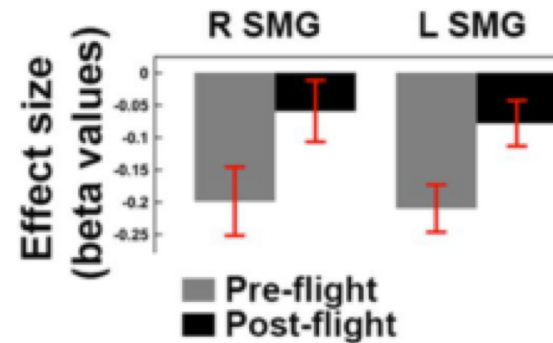
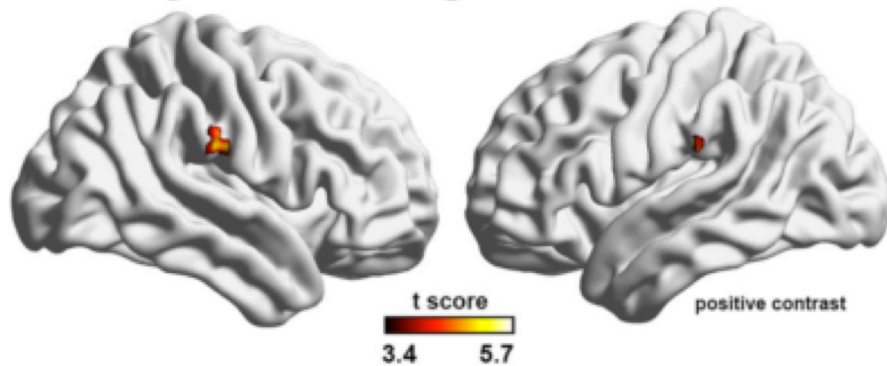
Parabolic flight trajectory

Angelique Van Ombergen¹, Floris L. Wuyts¹, Ben Jeurissen², Jan Sijbers², Floris Vanhevel³, Steven Jillings¹, Paul M. Parizel³, Stefan Sunaert⁴, Paul H. Van de Heyning¹, Vincent Dousset⁵, Steven Laureys⁶ & Athena Demertzi^{6,7}

Effect of environment

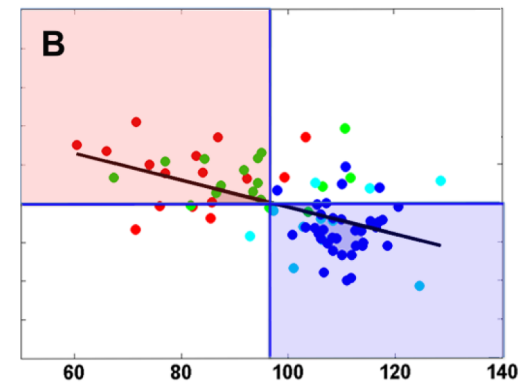
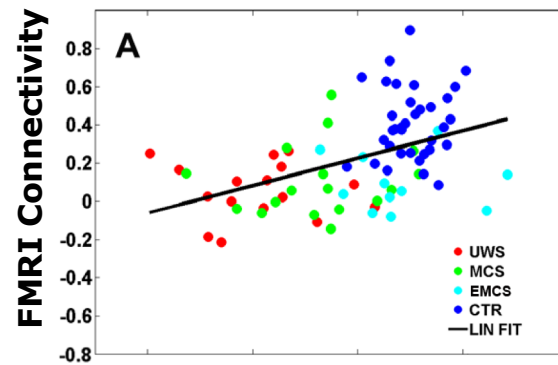
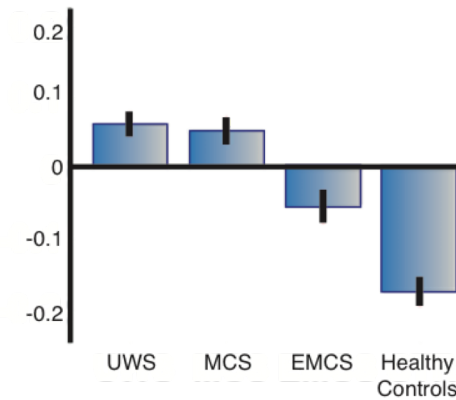
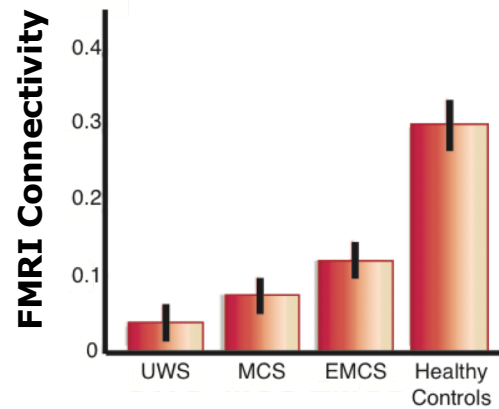
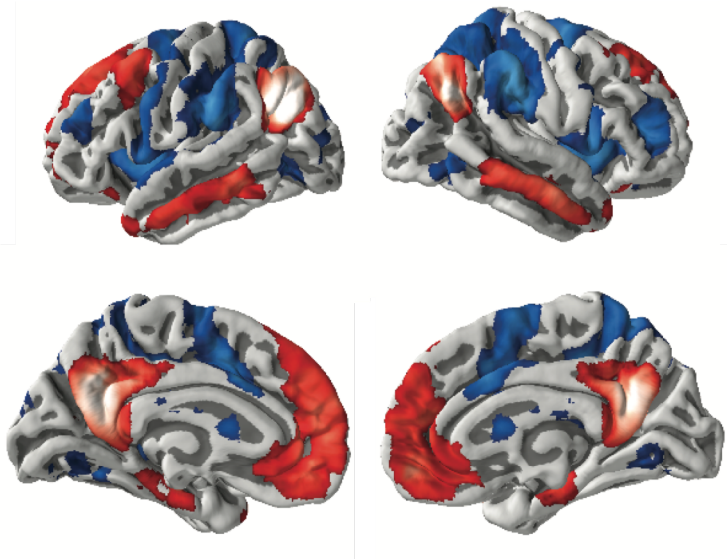


Post – Pre flight



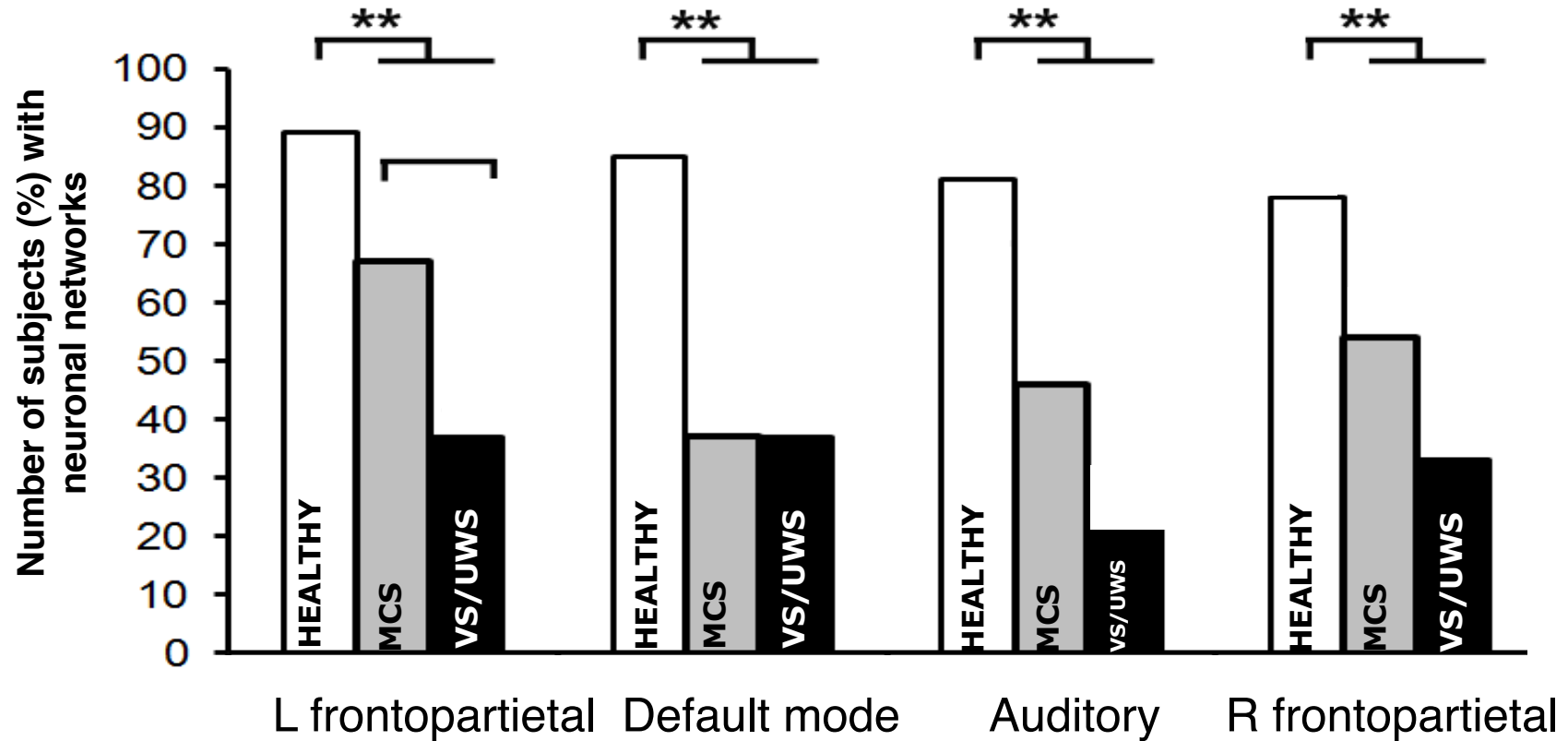
Effect of pathology

DMN CORRELATIONS DMN ANTICORRELATIONS



Brain metabolism

Networks are disrupted in low global states of C

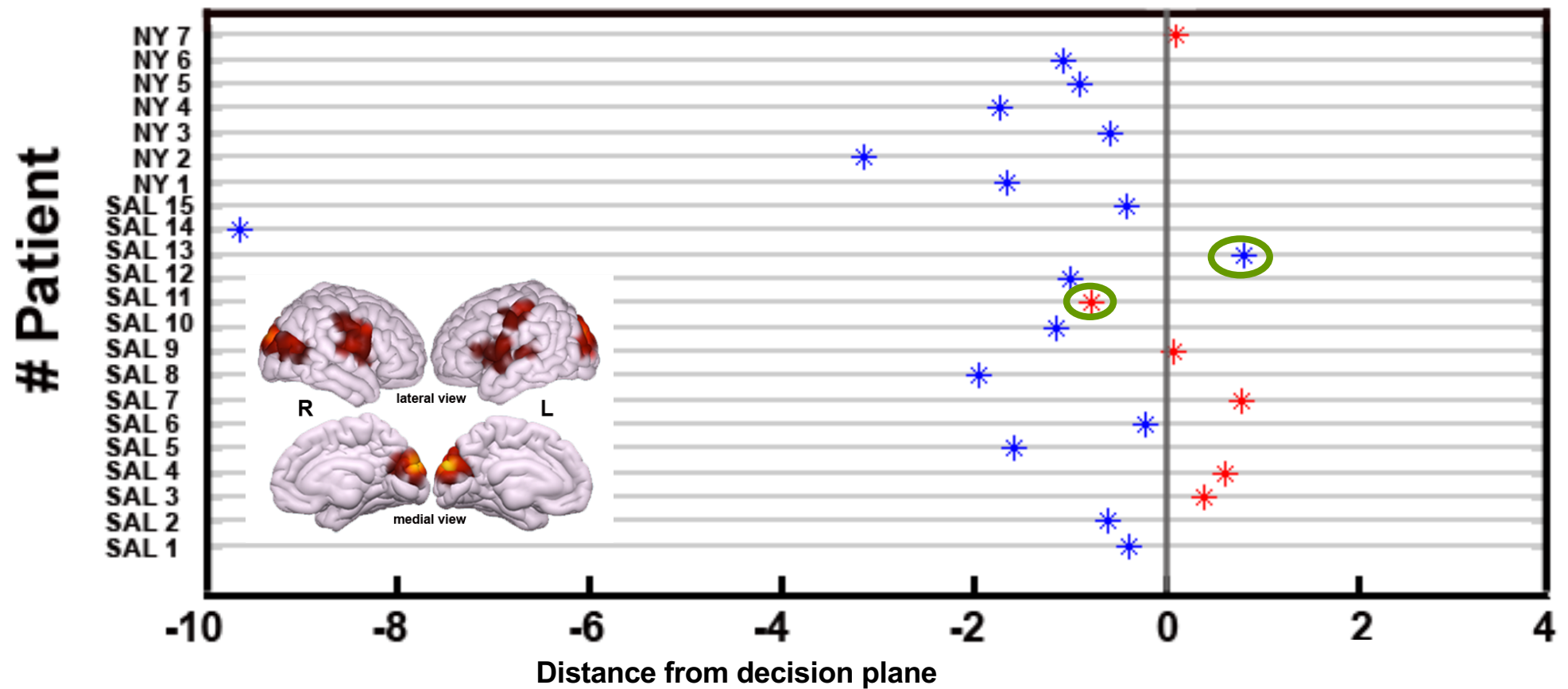


Feature	Accuracy	TPR healthy	TPR patients	Selected RSNs
Healthy vs. all patients				
Neuronality	85.3	.82	.87	Auditory, DMN

Consciousness \approx Connectivity

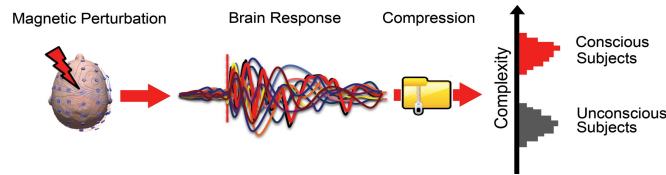
Classification MCS

Classification VS/UWS

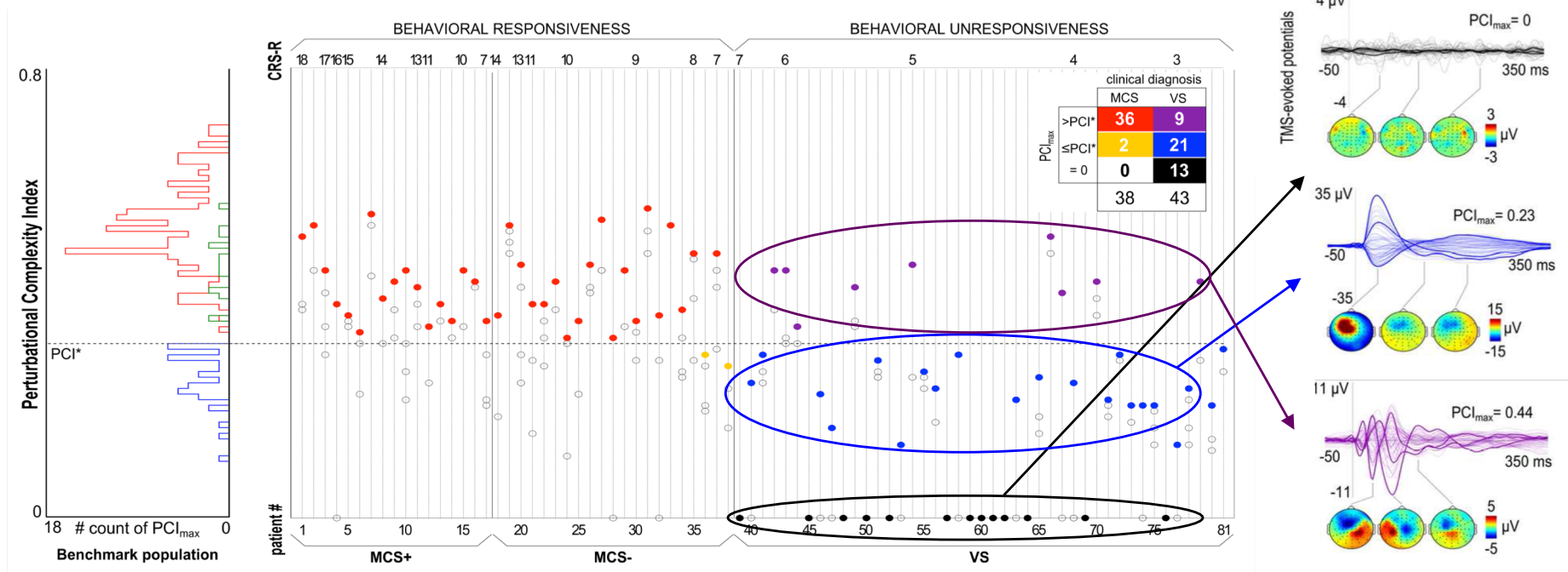


Consciousness \approx Complexity (stimulation)

Transcranial magnetic stimulation and electroencephalography



Perturbational complexity index

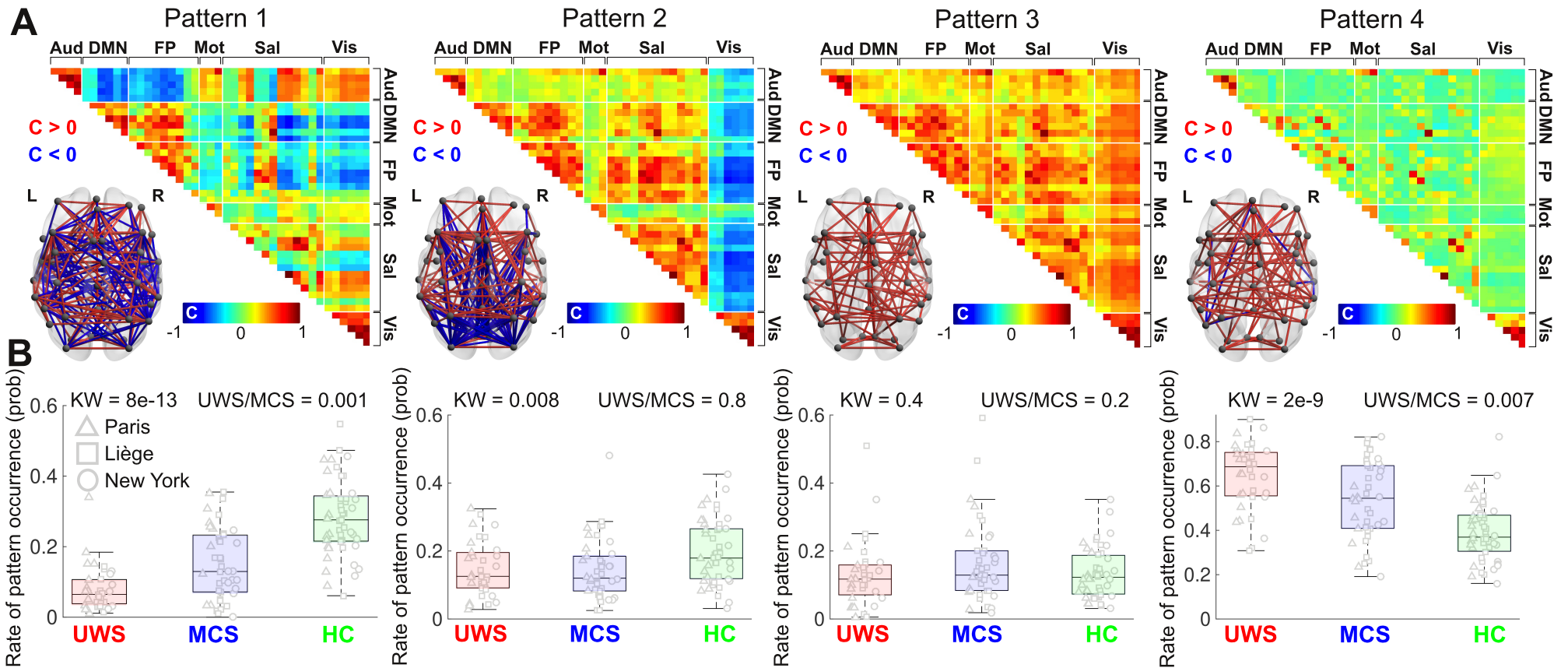


Consciousness \approx Complexity (rest)



James S. McDonnell Foundation 

Grant Type: Collaborative Activity Award, Phase I & II (2008-2017)



Demertzi & Tagliazucchi, Dehaene, Deco, Bartfeld, Raimondo, Martial, Fernández-Espejo, Rohaut, Voss, Schiff, Owen, Laureys, Naccache, Sitt. *Science Advances* (accepted)

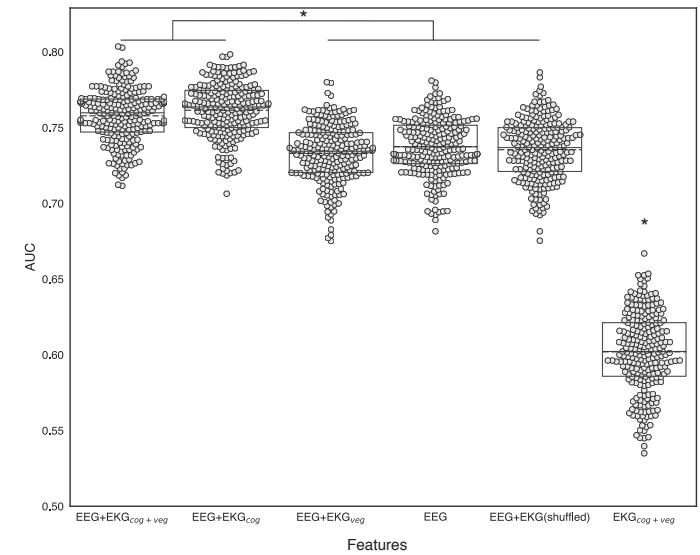
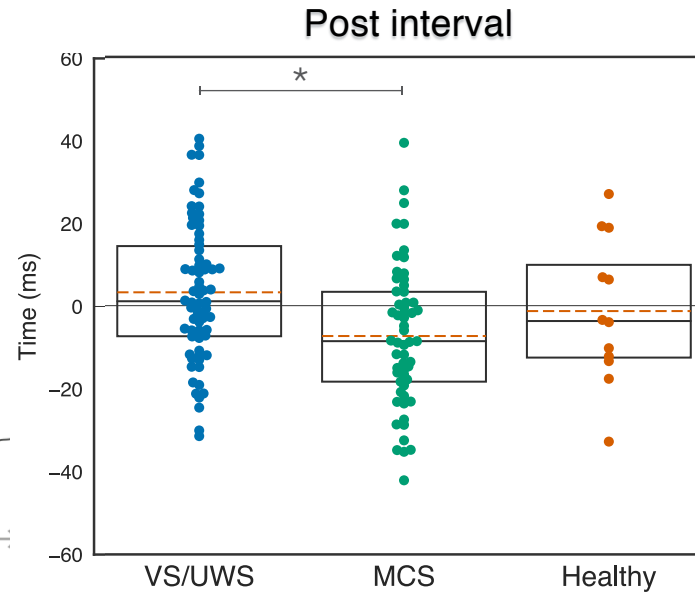
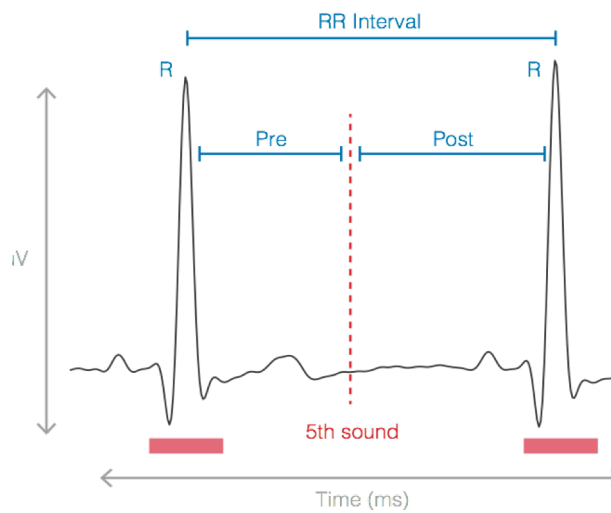


Consciousness \approx Prediction

Listen to the heart

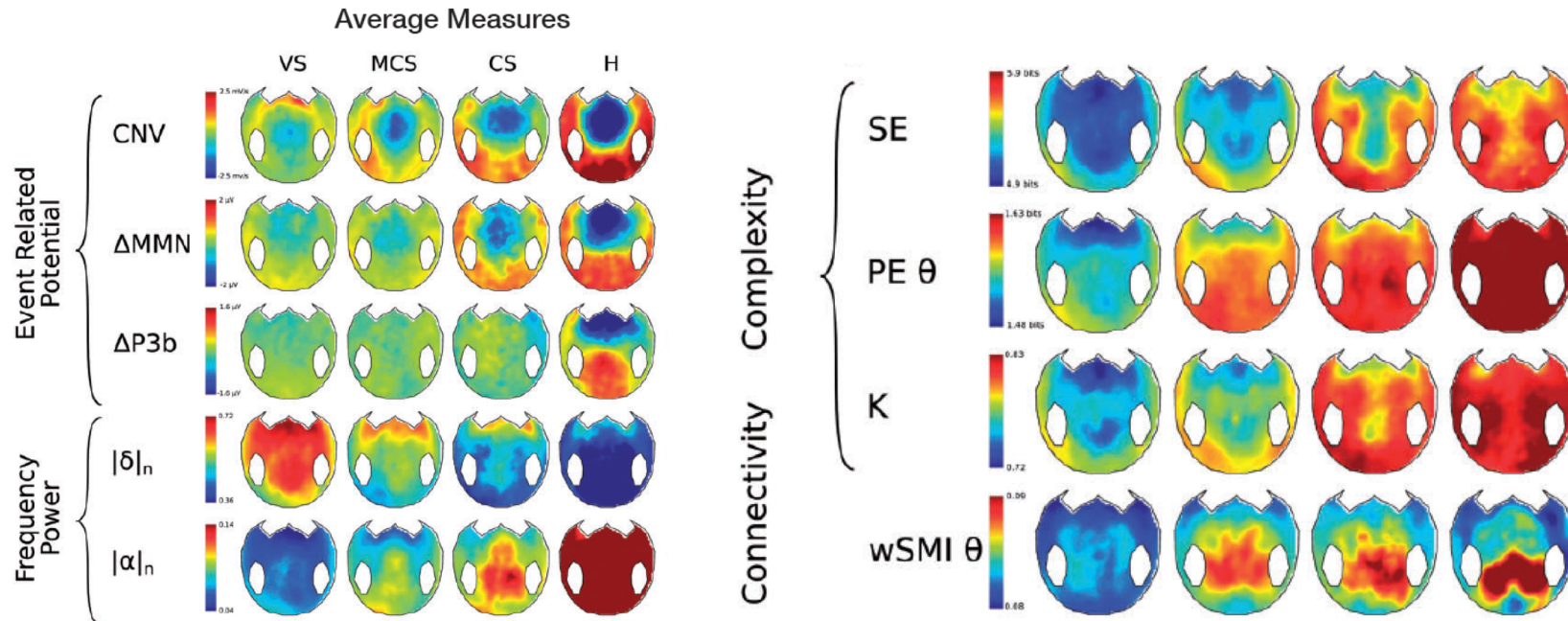


Auditory oddball paradigm



Consciousness \approx Complexity & Prediction

EEG automated machine learning



Probability of being (minimally) conscious

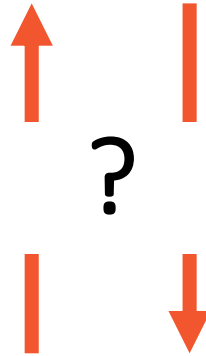


Patients cannot express *themselves*



Hable con ella 2002, Pedro Almodóvar

SELF



CONSCIOUSNESS

WHICH SELF IN UNCONSCIOUSNESS?



social

COMMON VIEW: no self

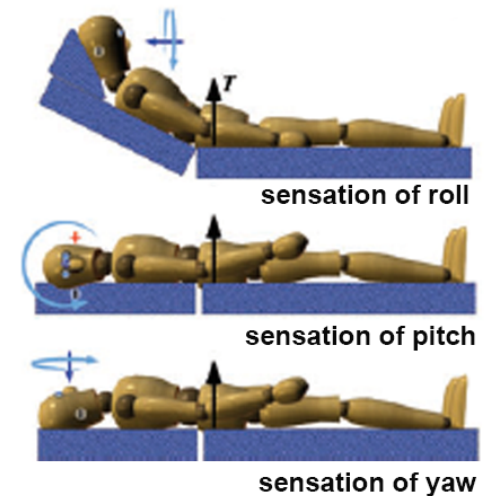
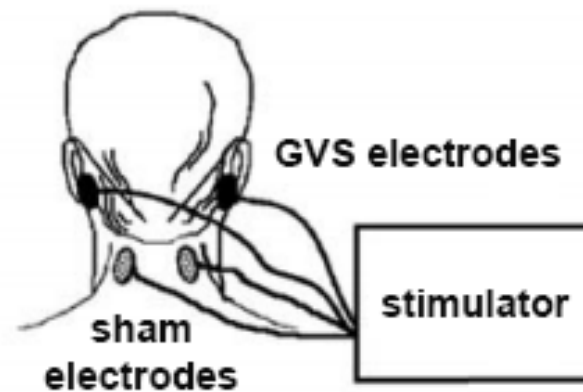
HYPOTHESIS: yes self

MODEL: Embodiment

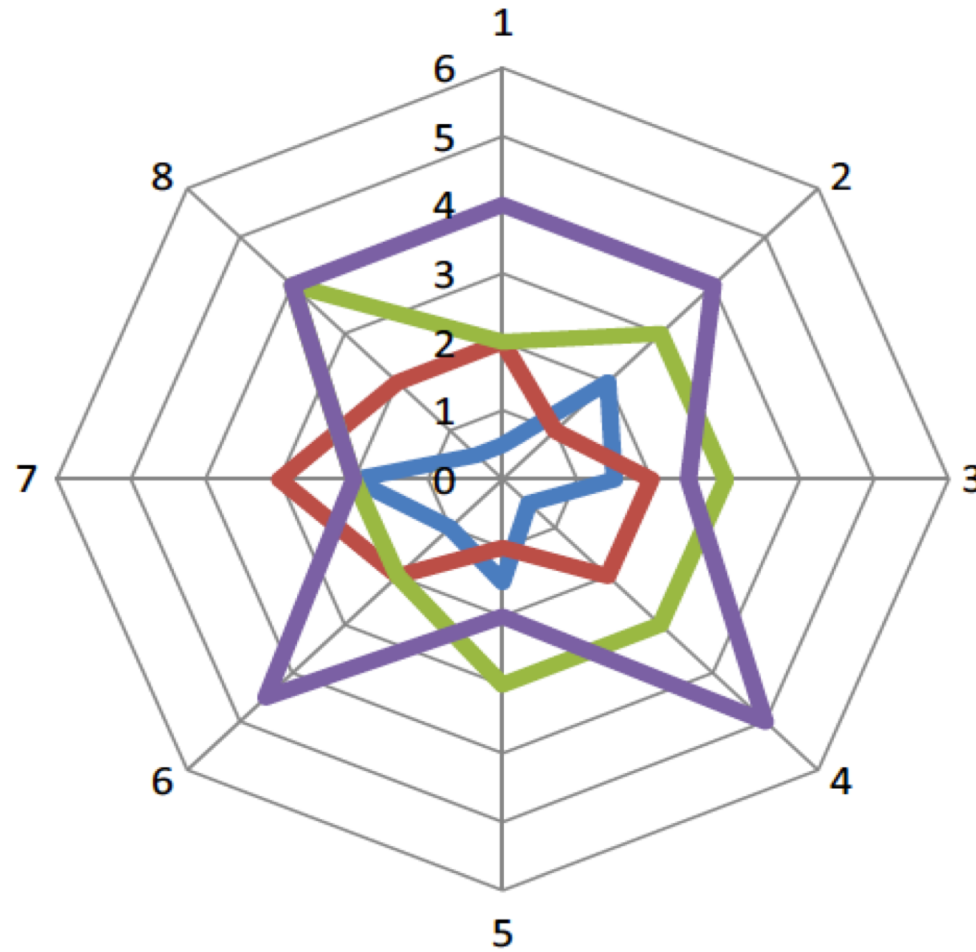
narrative

HOW: Probe balance

minimal



Defining Consciousness

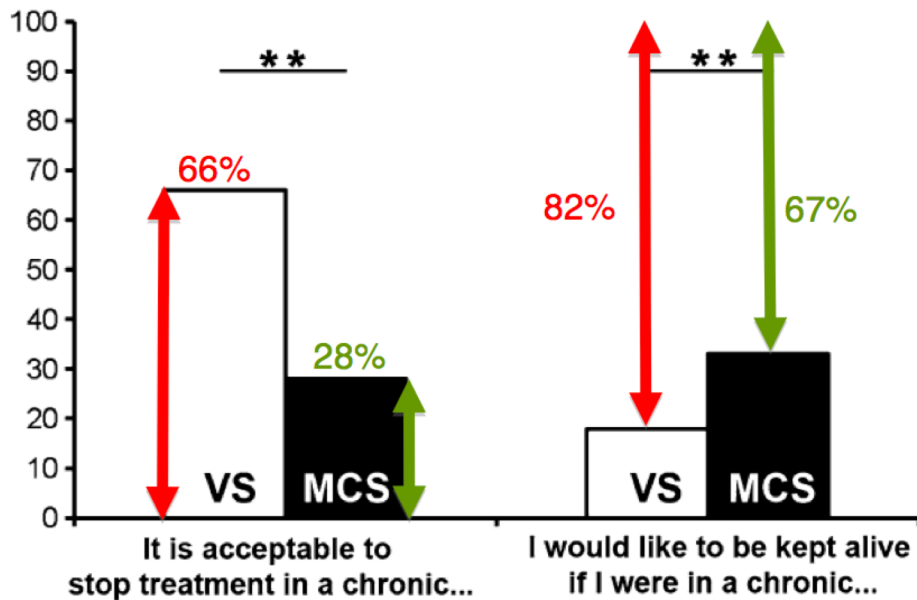


Why does it matter?

Consciousness has a moral significance

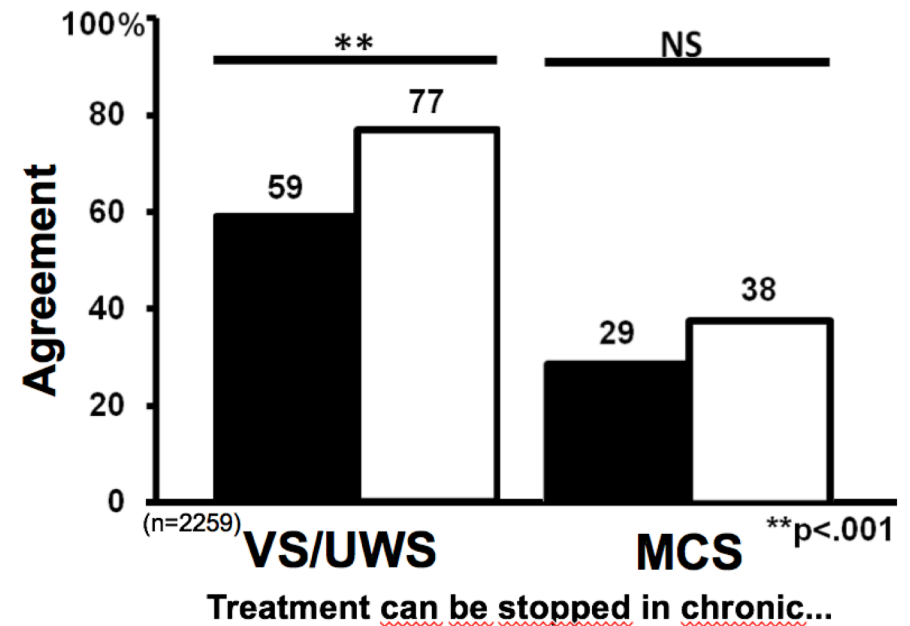


2,475 medical professionals



Demertzi et al, *J Neurol* 2011

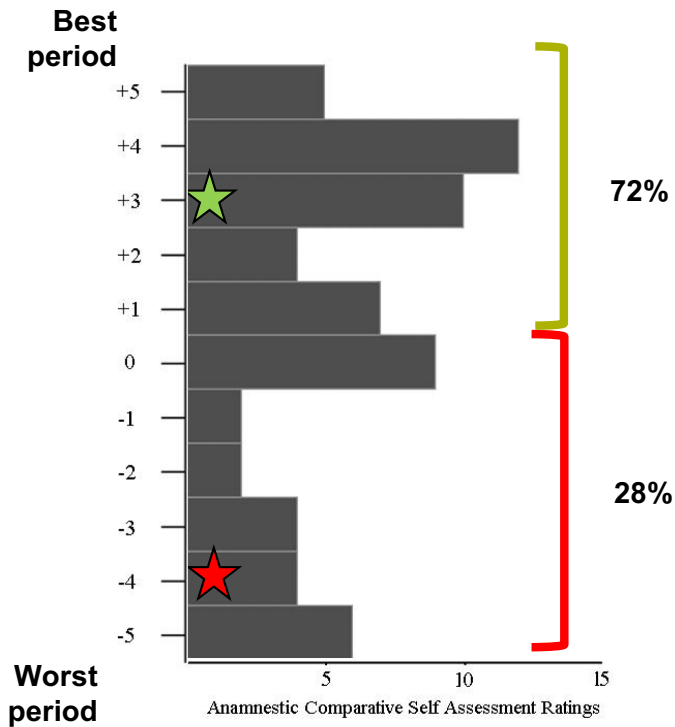
■ Feel pain
□ Do not feel pain



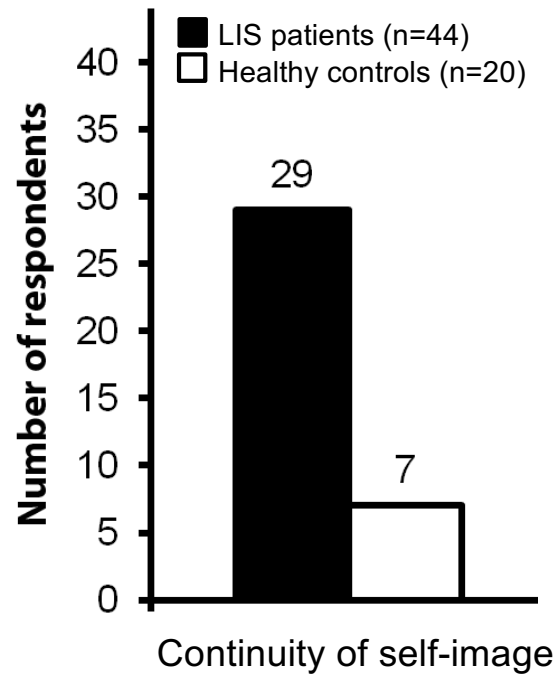
Demertzi & Racine et al, *Neuroethics* 2012



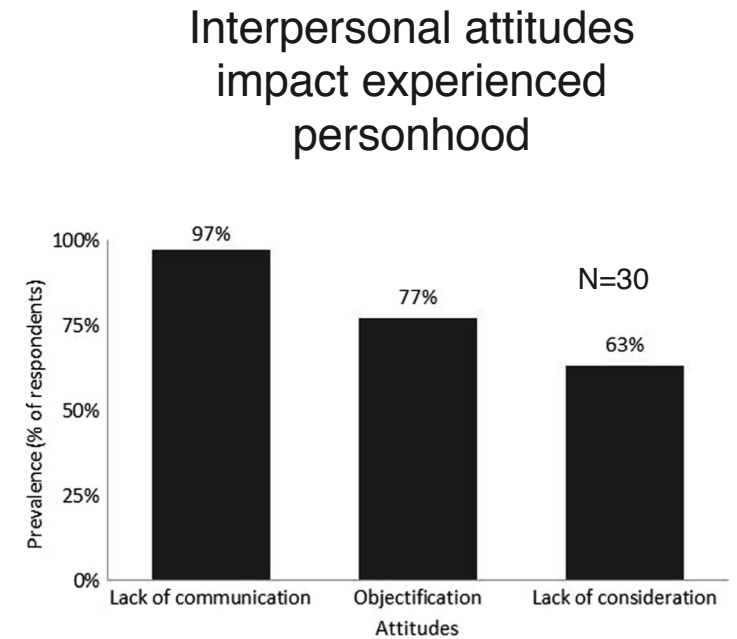
Quality of life



Bruno et al, *Br Med J Open* 2011



Nizzi & Demertzi et al, *Conscious & Cogn* 2012



Nizzi, Blandin, Demertzi *NeuroEthics* 2018

Taken together...



Consciousness needs a brain which:

- is intrinsically organized
- shows complexity
- shows dynamic flexibility
- is able to predict its environment and itself

Consciousness carries a moral significance

Consciousness is an inter-personal structure

Thank you for your attention!

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 ADemertzi

