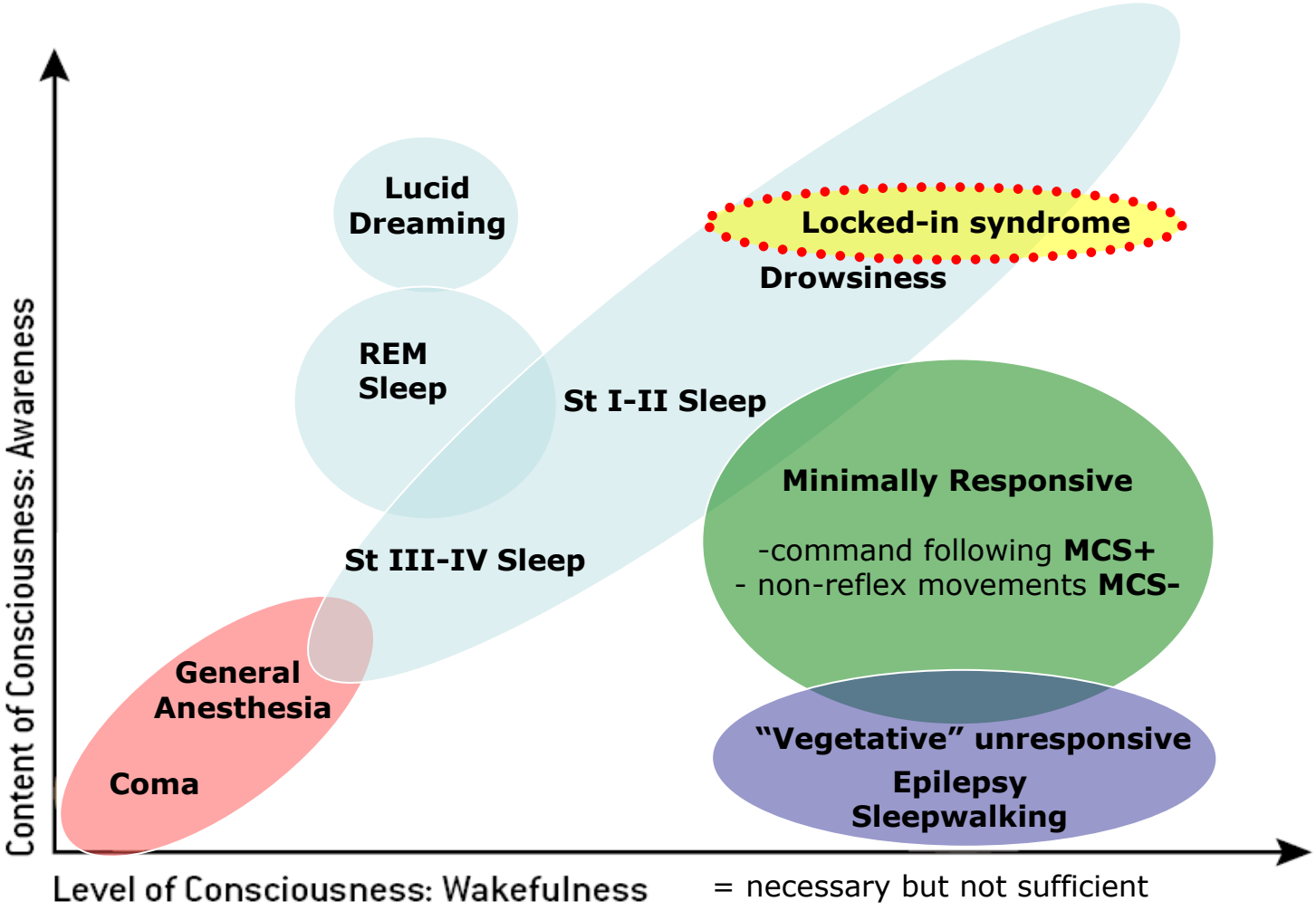
Can science explain consciousness? Lessons from coma & related states

Charlotte MARTIAL
PhD student
University Hospital
& University of Liège
Belgium

cmartial@ulg.ac.be
www.comascience.org

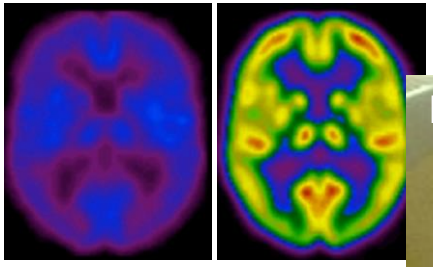
Arousal & awareness

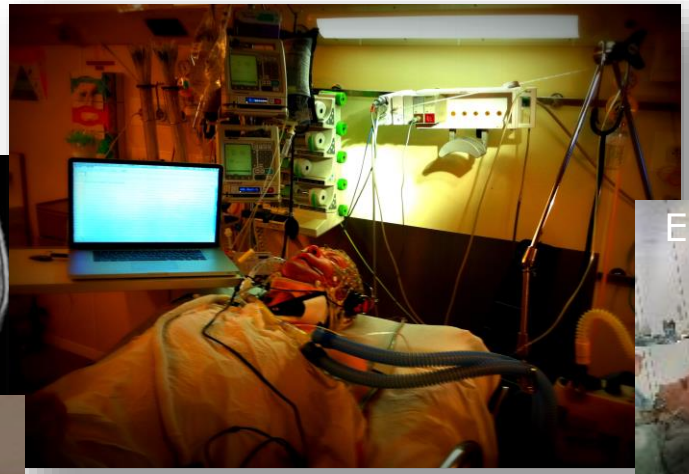


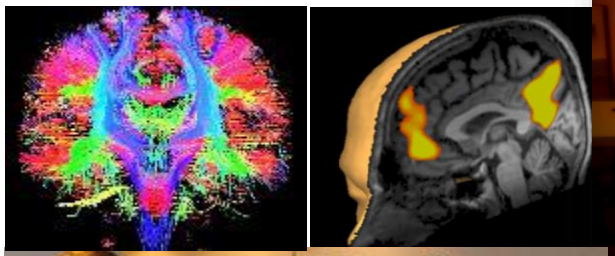
Laureys, 2005
Laureys et al, 2008

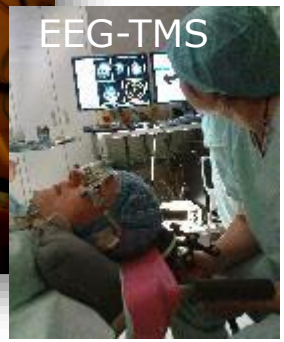
Measuring brain activity

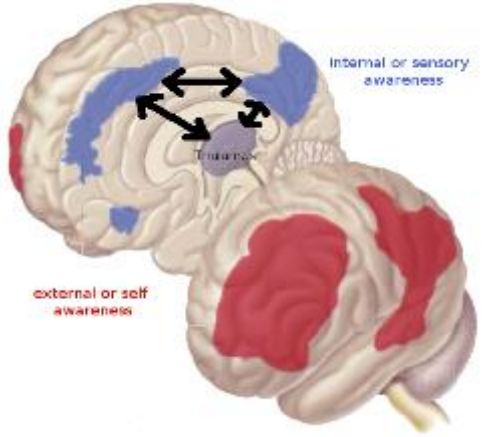
Altered states of consciousness
- Pathological : coma
- Pharmacological: anesthesia
- Physiological: hypnosis



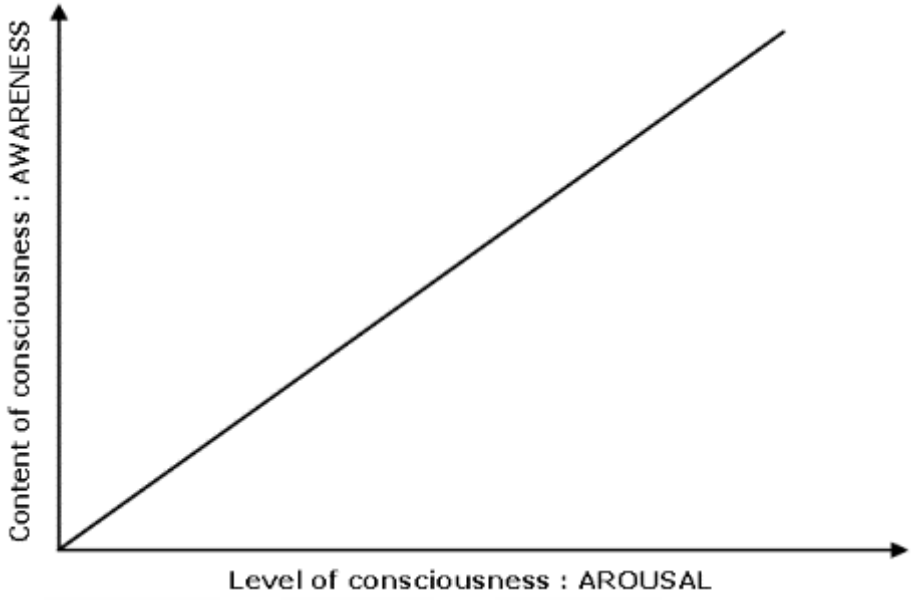


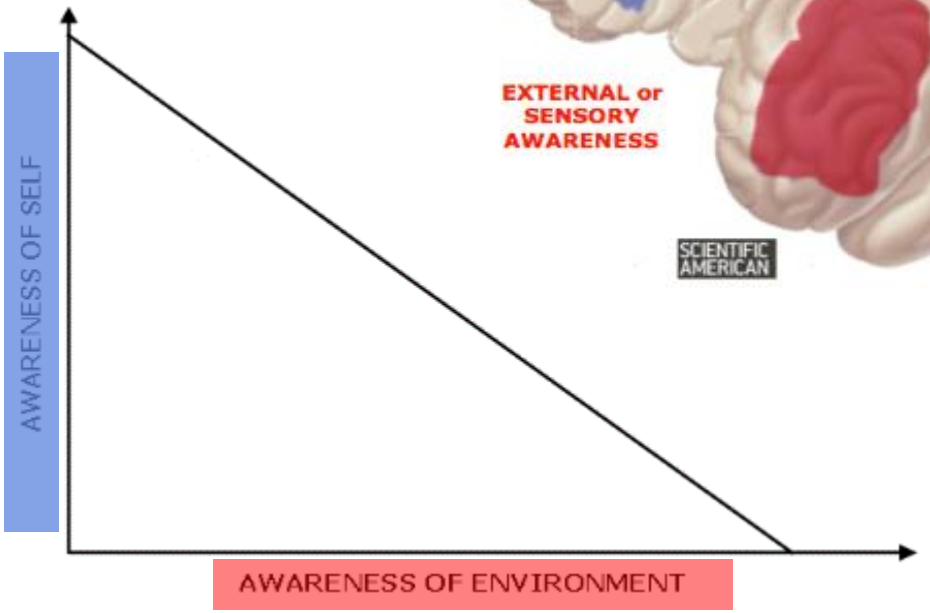


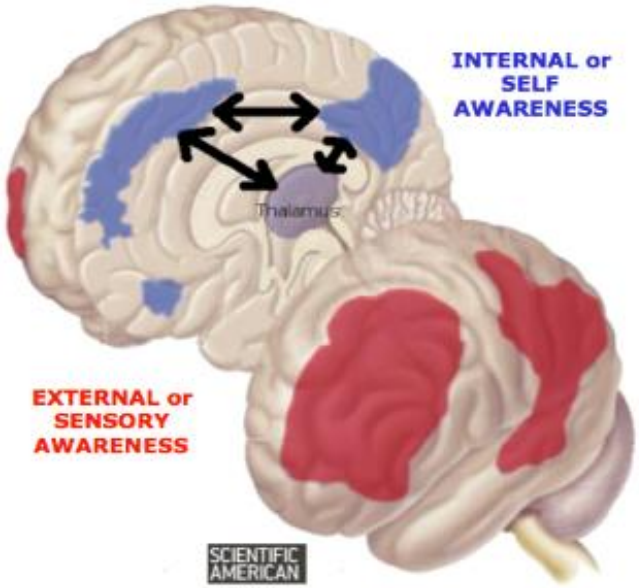




Measuring awareness

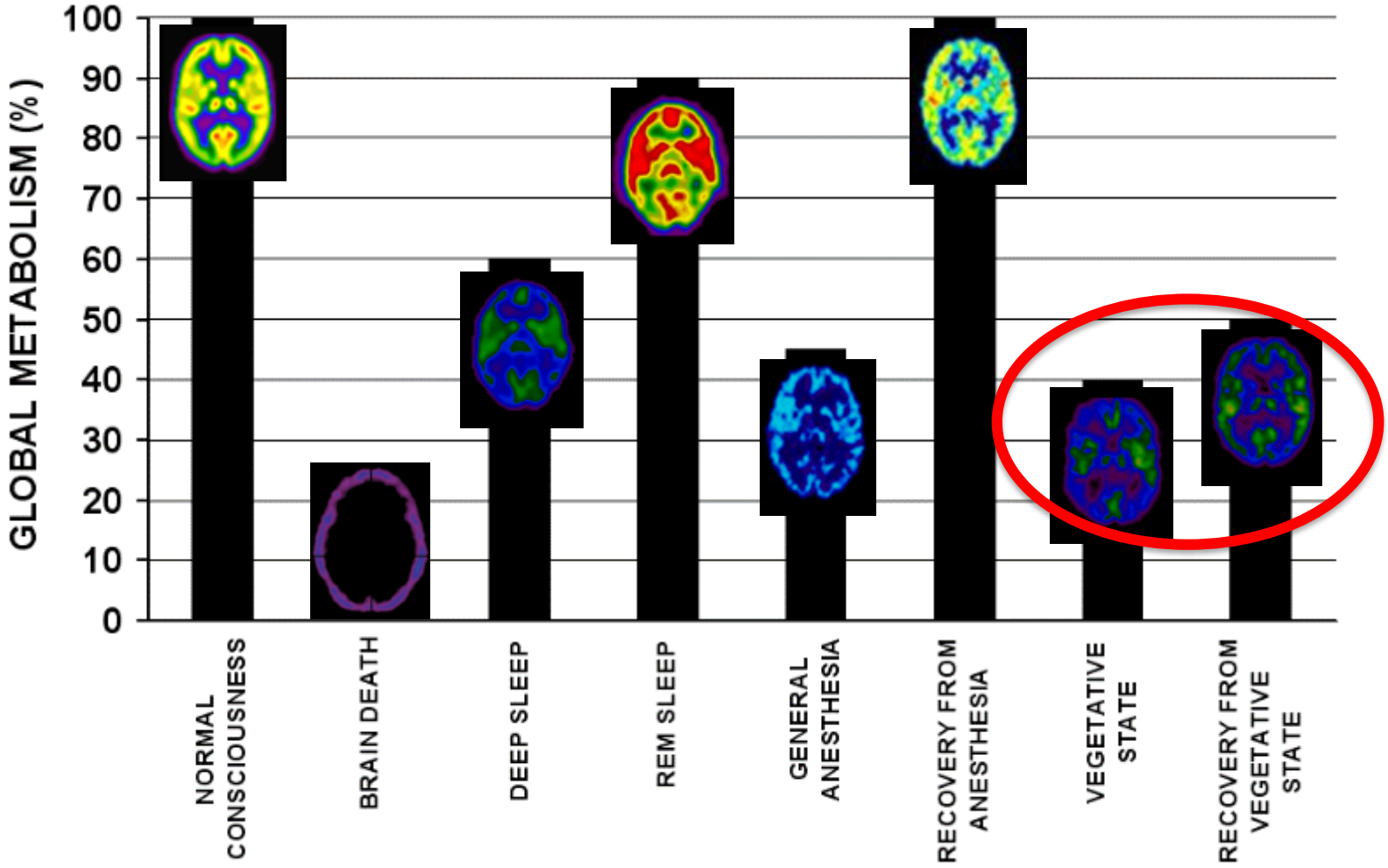






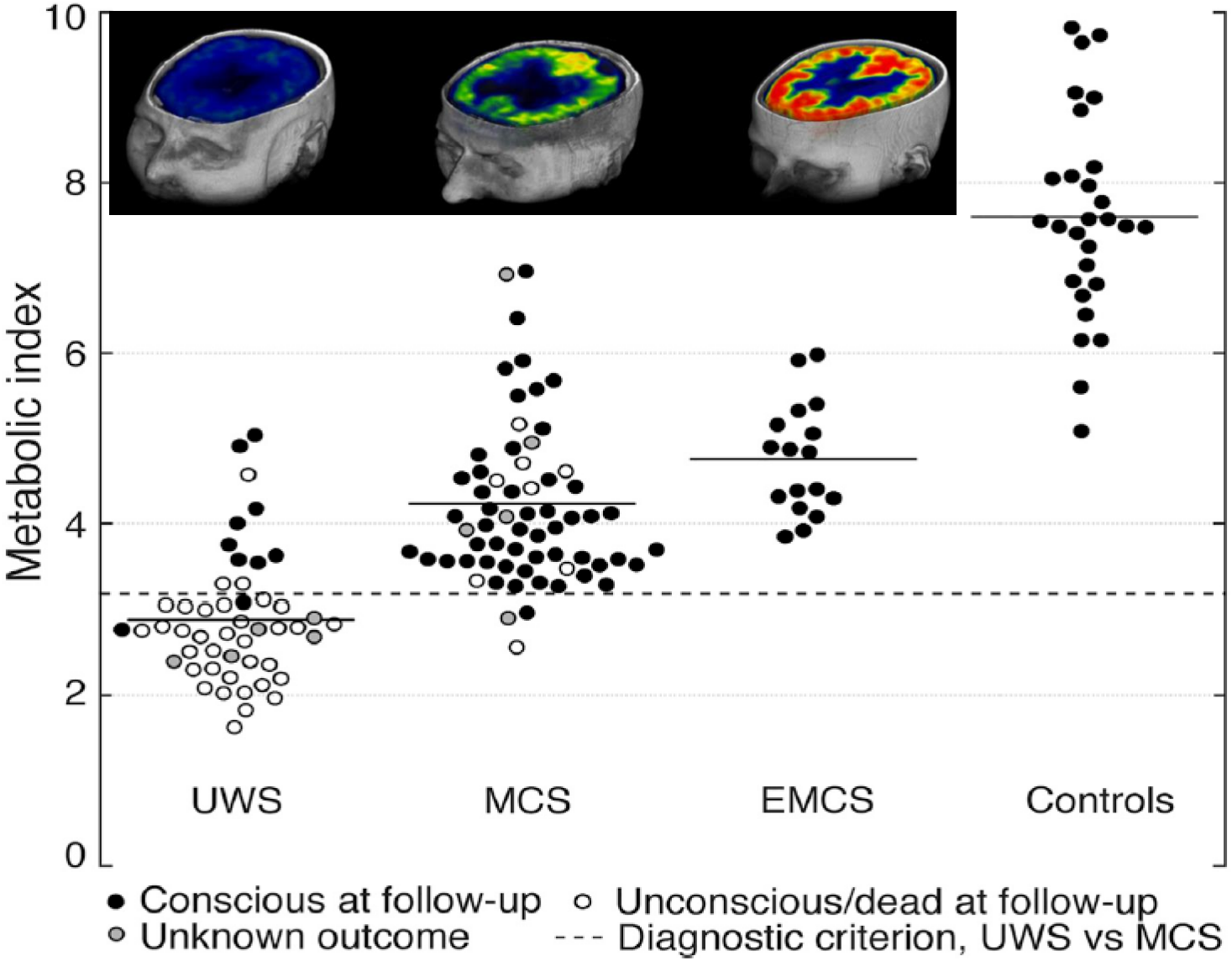
Boly et al, 2009
Vanhaudenhuyse & Demertzi et al, 2011

Consciousness ≠ global brain function



Laureys et al., Lancet Neurology, 2004

PET = diagnostic & prognostic markers



→ 42% of normal activity represents the minimal energetic requirement for the presence of conscious awareness

Stender et al, 2016

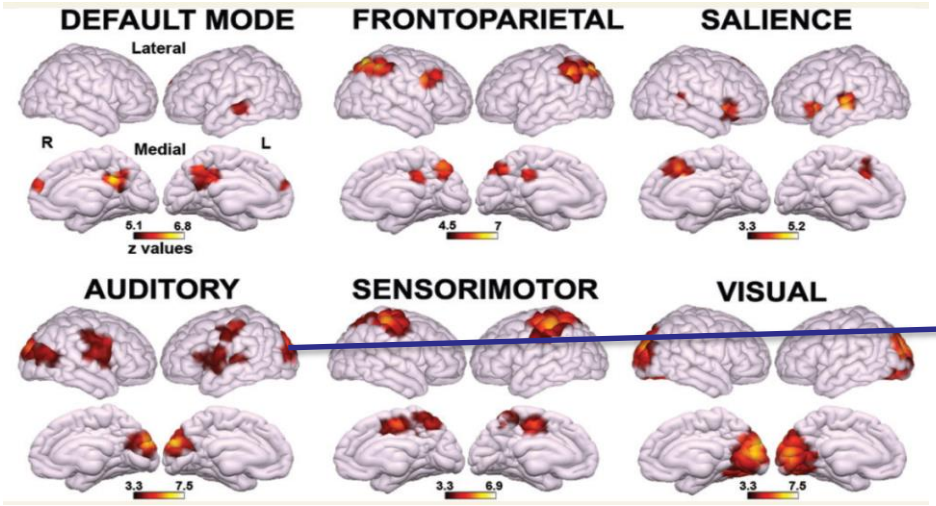
Classifying "resting" fMRI

doi:10.1093/brain/awv169 BRAIN 2015: 138; 2619–2631 | 2619

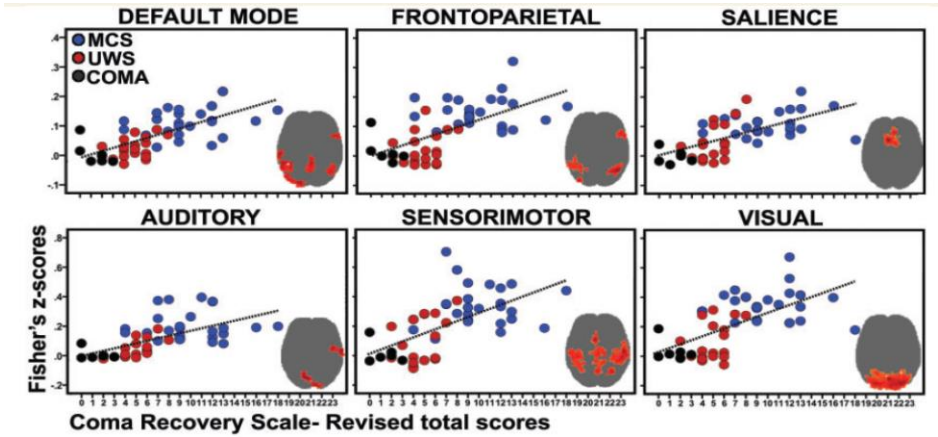
BRAIN
A JOURNAL OF NEUROLOGY

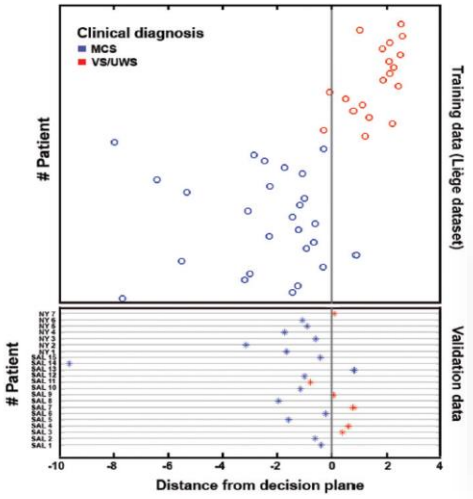
Intrinsic functional connectivity differentiates minimally conscious from unresponsive patients

Athena Demertzi,[1,*] Georgios Antonopoulos,[1,*] Lizette Heine,[1] Henning U. Voss,[2] Julia Sophia Crone,[3,4,5] Carlo de Los Angeles,[6] Mohamed Ali Bahri,[7] Carol Di Perri,[1] Audrey Vanhaudenhuyse,[8] Vanessa Charland-Verville,[1] Martin Kronbichler,[3,4] Eugen Trinka,[5] Christophe Phillips,[7] Francisco Gomez,[9] Luaba Tshibanda,[10] Andrea Soddu,[11] Nicholas D. Schiff,[12,13] Susan Whitfield-Gabrieli[6,*] and Steven Laureys[1,*]



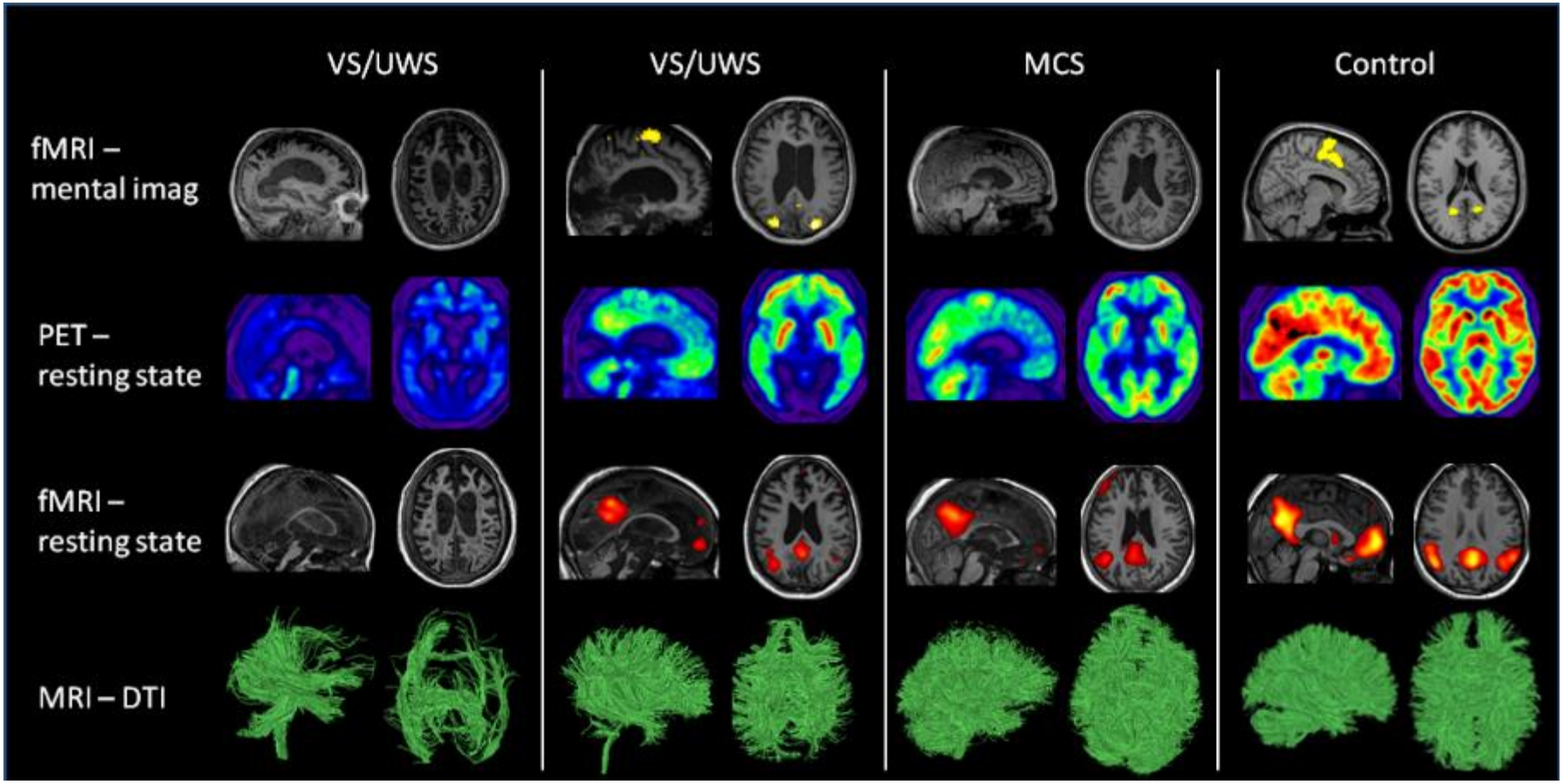
support vector machine classifier



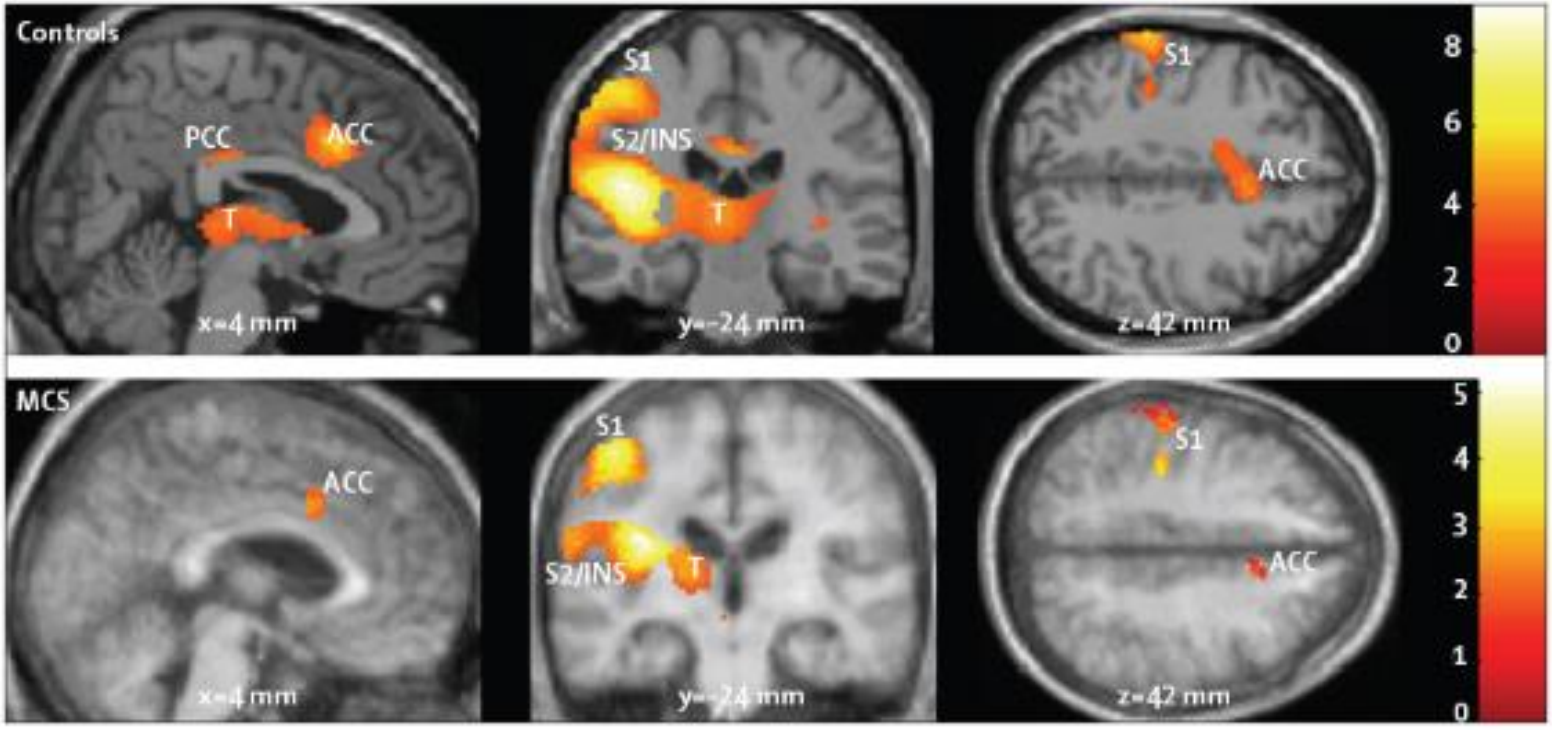


Vanhaudenhuyse et al, Brain, 2010
Demertzi et al, Brain, 2015

Diagnosis & prognosis



Pain



MCS patients activate the same areas as healthy controls, meaning that the stimulus can be integrated and processed

Laureys et al., Neuroimage, 2002
Boly et al., 2008

Diagnostic error after coma

n=103 post-comatose patients

- 45 clinical consensus diagnosis ‘vegetative state’
- 18 signs of awareness (Coma Recovery Scale)

30-40% potential misdiagnosis

JFK COMA RECOVERY SCALE - REVISED ©2004
Record Form

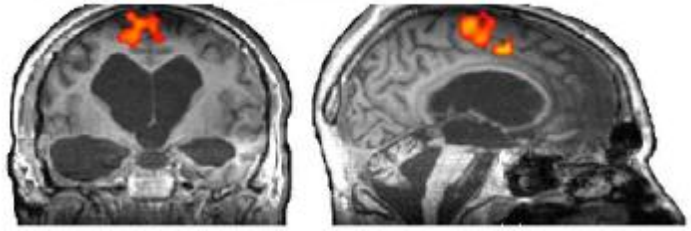
Patient: Date:								
AUDITORY FUNCTION SCALE								
4 - Consistent Movement to Command *								
3 - Reproducible Movement to Command *								
2 - Localization to Sound								
1 - Auditory Startle								
0 - None								
VISUAL FUNCTION SCALE								
5 - Object Recognition *								
4 - Object Localization: Reaching *								
3 - Visual Pursuit *								
2 - Fixation *								
1 - Visual Startle								
0 - None								
MOTOR FUNCTION SCALE								
6 - Functional Object Use †								
5 - Automatic Motor Response *								
4 - Object Manipulation *								
3 - Localization to Noxious Stimulation *								
2 - Flexion Withdrawal								
1 - Abnormal Posturing								
0 - None/Flaccid								
OROMOTOR/VERBAL FUNCTION SCALE								
3 - Intelligible Verbalization *								
2 - Vocalization/Oral Movement								
1 - Oral Reflexive Movement								
0 - None								
COMMUNICATION SCALE								
2 - Functional: Accurate †								
1 - Non-Functional: Intentional *								
0 - None								
AROUSAL SCALE								
3 - Attention								
2 - Eye Opening w/o Stimulation								
1 - Eye Opening with Stimulation								
0 - Unarousable								
TOTAL SCORE								

Schnakers et al, 2009
Stender et al, 2014

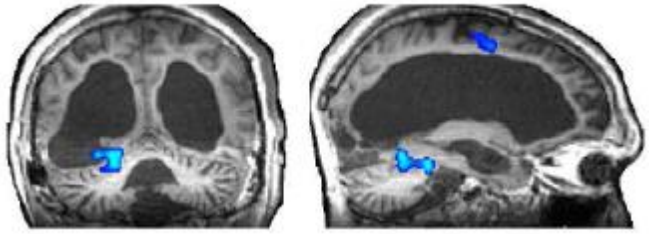
fMRI-based communication

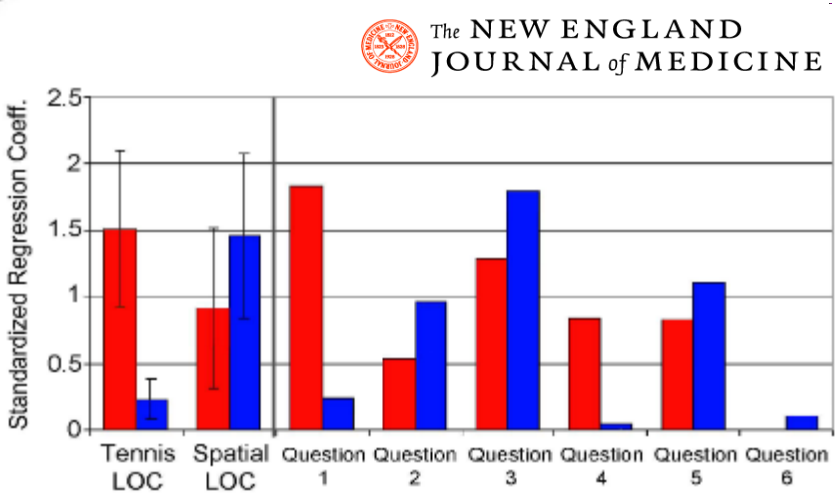
Imagine Tennis to answer 'YES'
Imagine Navigating to answer 'NO'

Is your father's name Alexander ?



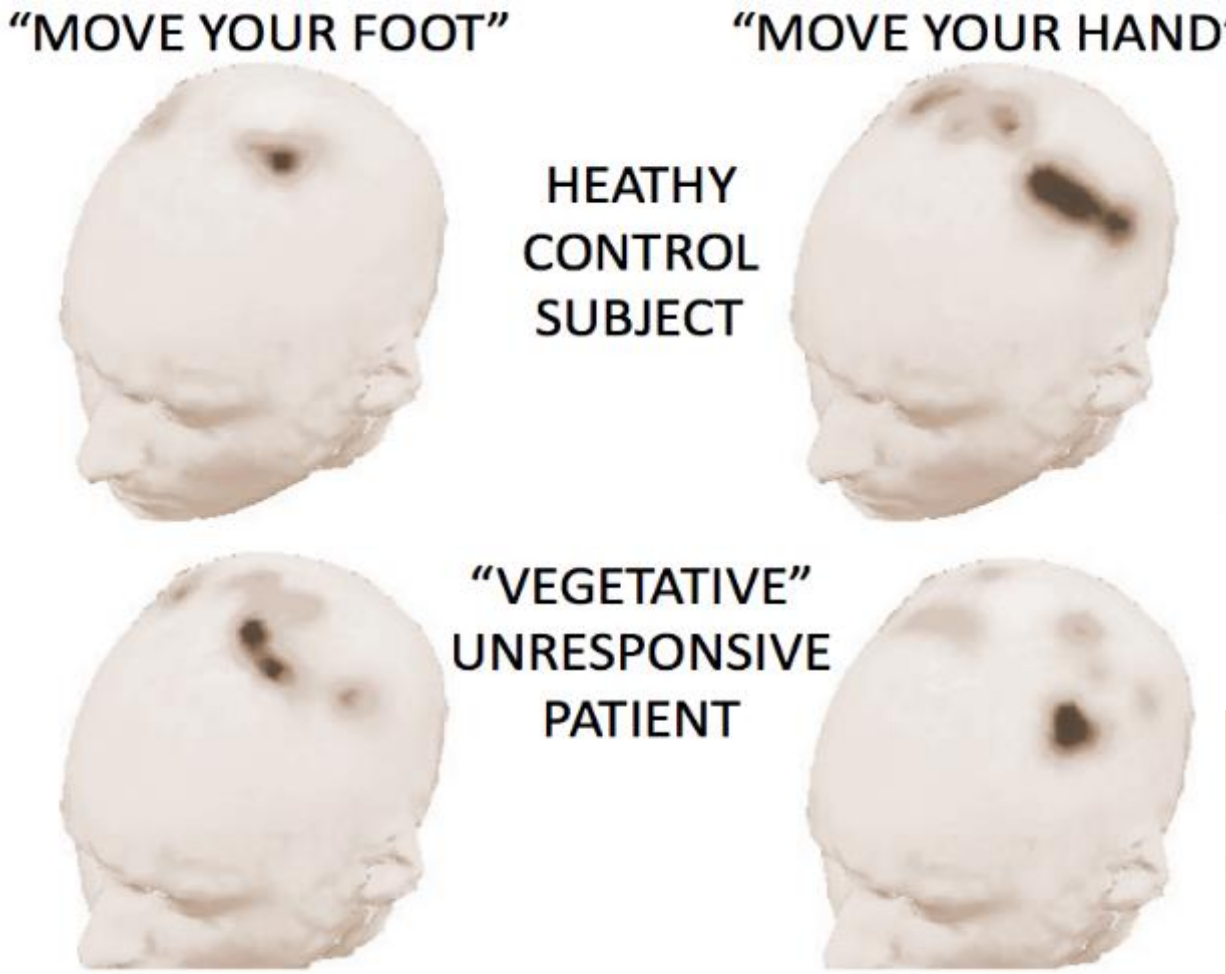
Is your father's name Thomas ?





Monti & Vanhaudenhuyse et al, 2010

EEG-based communication



Noirhomme et al, 2015
Lesenfants, Habbal et al, 2014

Quality of life

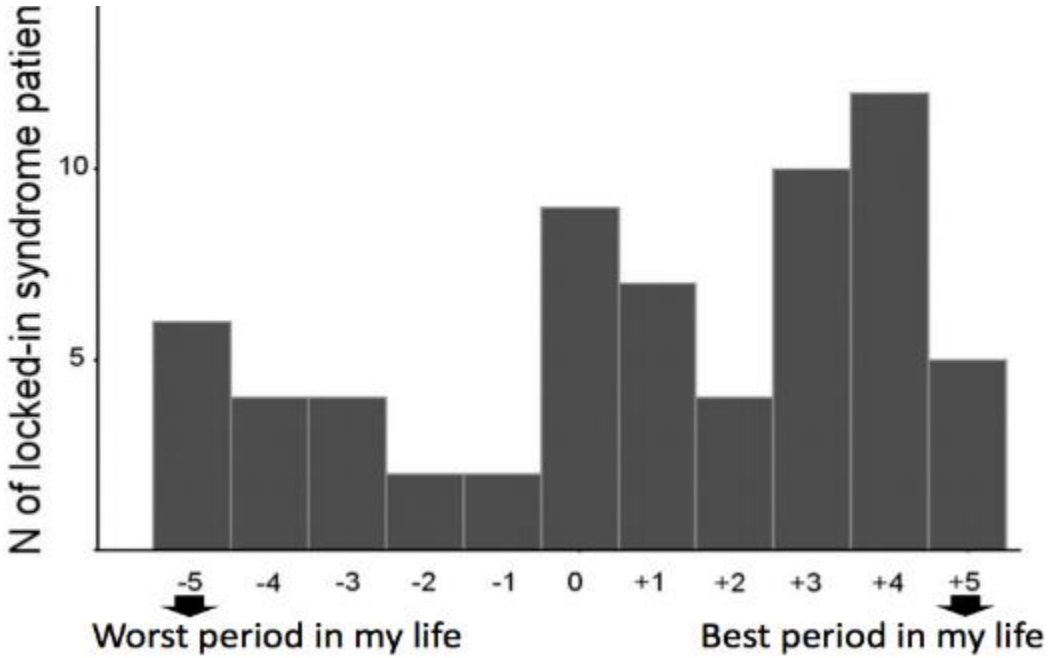
Open Access Research

BMJ open

A survey on self-assessed well-being in a cohort of chronic locked-in syndrome patients: happy majority, miserable minority

Marie-Aurélie Bruno,[1] Jan L Bernheim,[2] Didier Ledoux,[1] Frédéric Pellas,[3] Athena Demertzi,[1] Steven Laureys[1]

ALIS
Association du Locked-in Syndrome



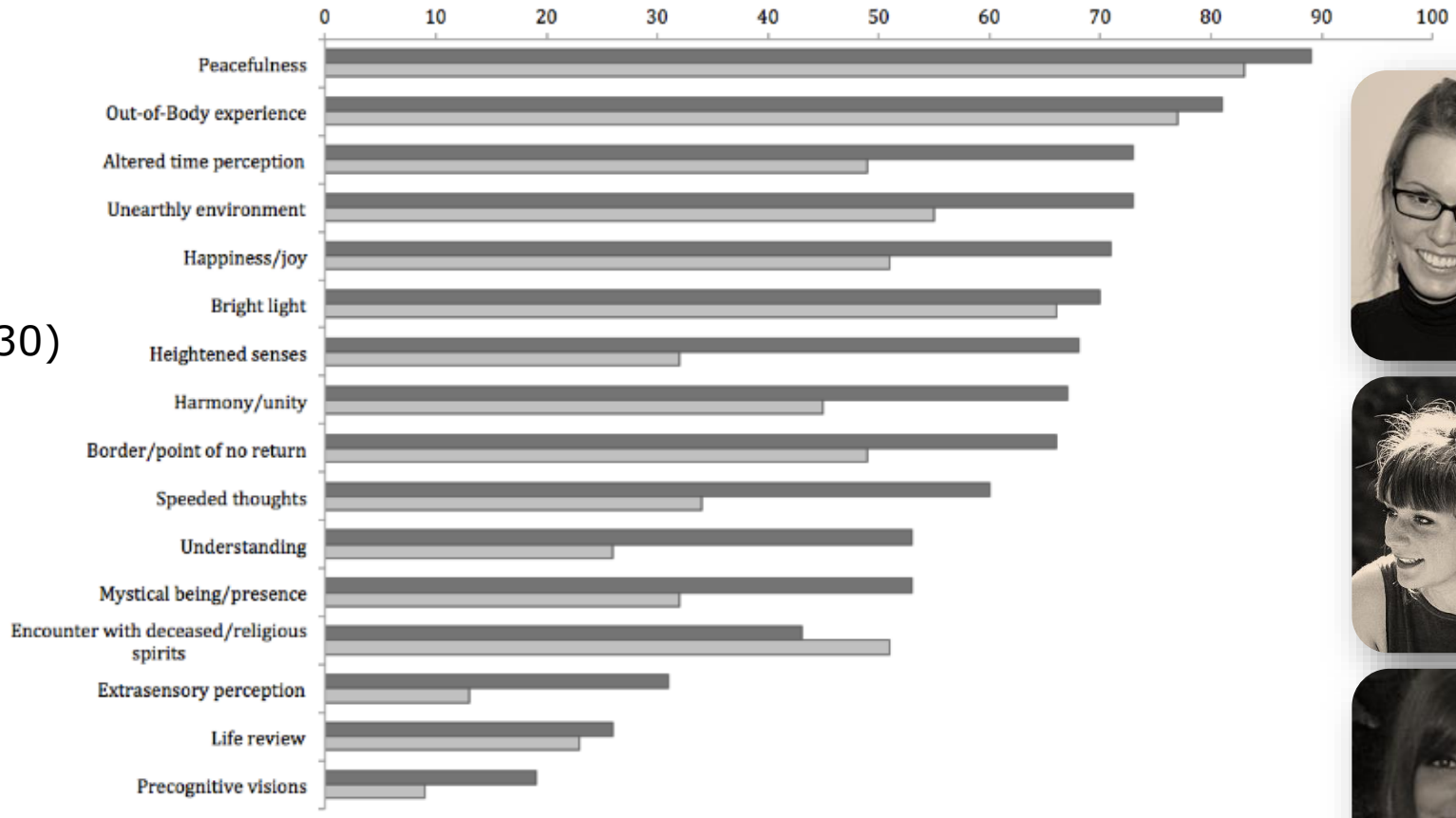
Bruno et al, *BMJ Open*, 2011

Near-death experiences

99% positive
1% negative

140 coma
- anoxic (45)
- traumatic (30)
- other (65)

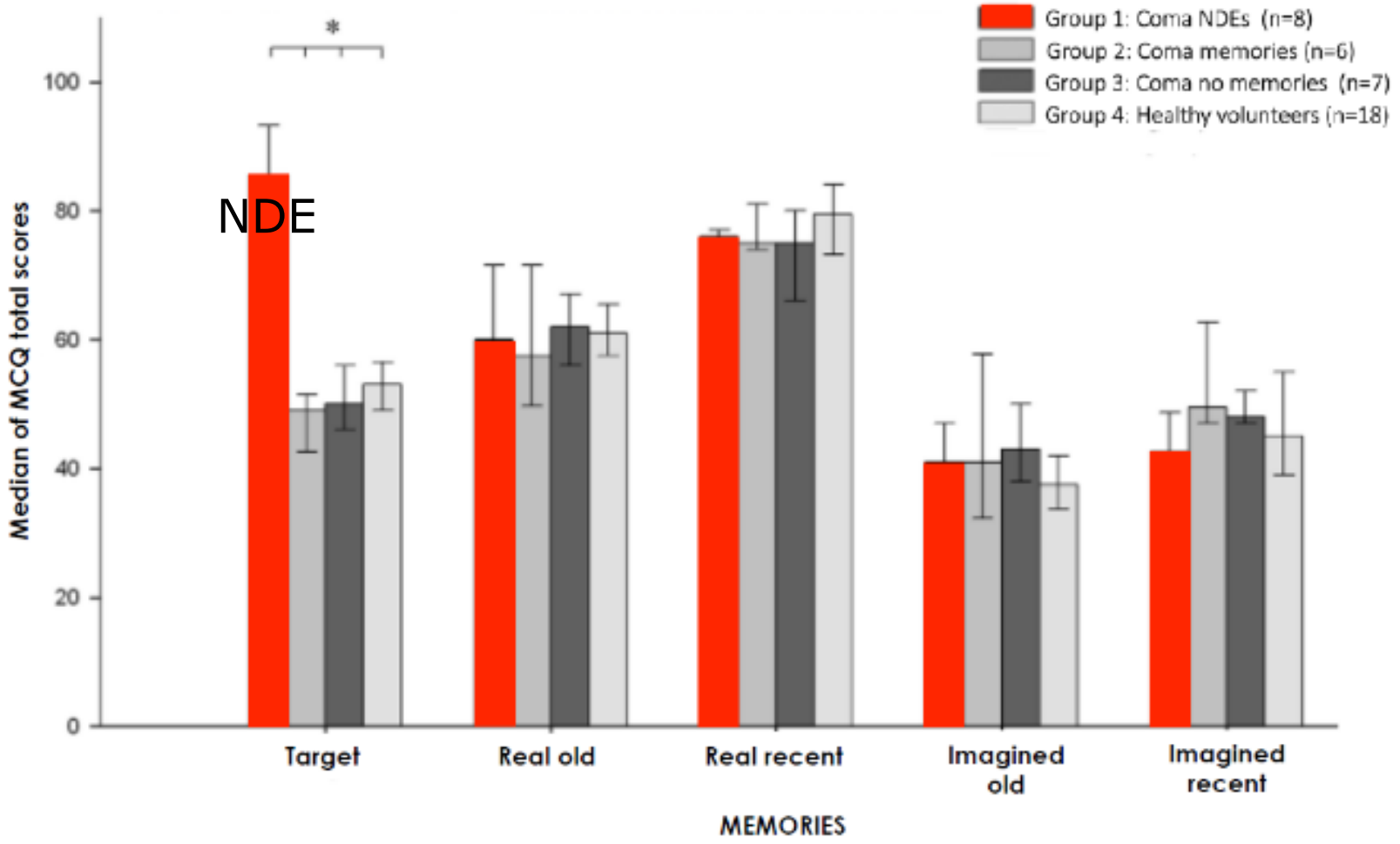
50 non-coma



Temporality of features

Charland-Verville et al, 2014
Martial et al., submitted

Near-death experiences memories

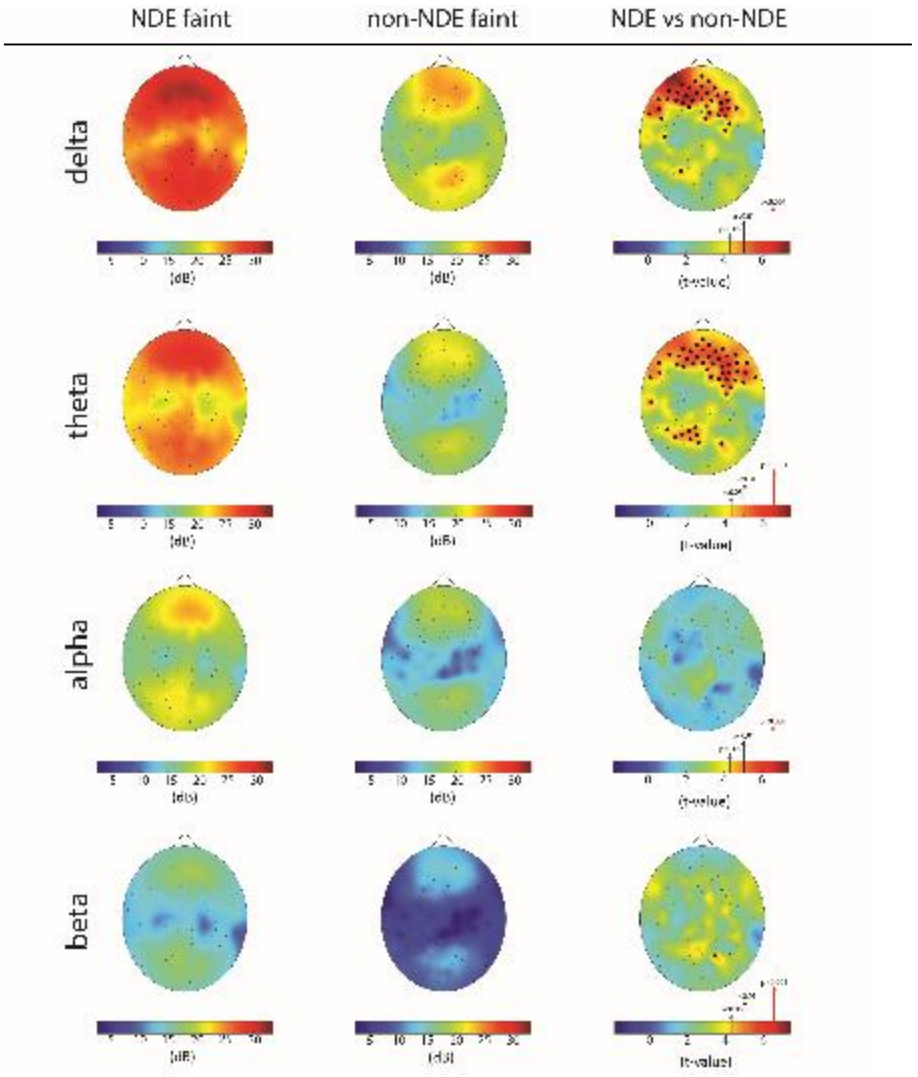


Thonnard et al, 2013

Near-death experiences

Brain function in syncope-induced near death experiences in normal healthy volunteers

43% reported a NDE as defined by the Greyson NDE scale



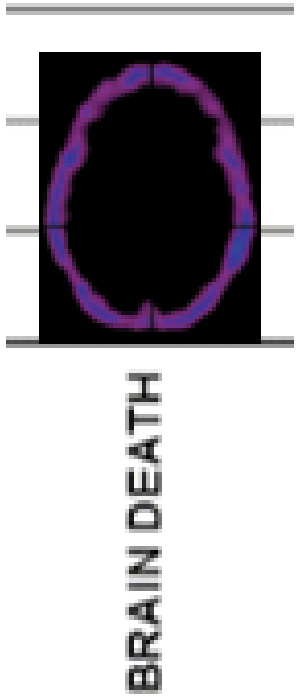
Charland-Verville* & Piuralli*, Martial, et al., in preparation

“Clinical” death VERSUS brain death

↓

Sometimes confusion!

! Remember that not a single patient who showed clinical criteria of brain death has ever recovered consciousness !



Conclusion

Human conscious awareness

≈ emergent property of collective critical neural network dynamics, involving a frontoparietal global workspace

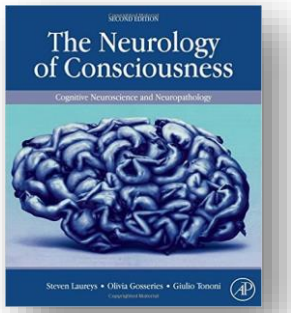
≈ still not fully explained

Diagnostic use

≈ 40% misdiagnosis

Prognostic use

≈ multimodal imaging



Contact:

cmartial@ulg.ac.be
coma@ulg.ac.be