

# Neuroimaging nei disturbi di coscienza

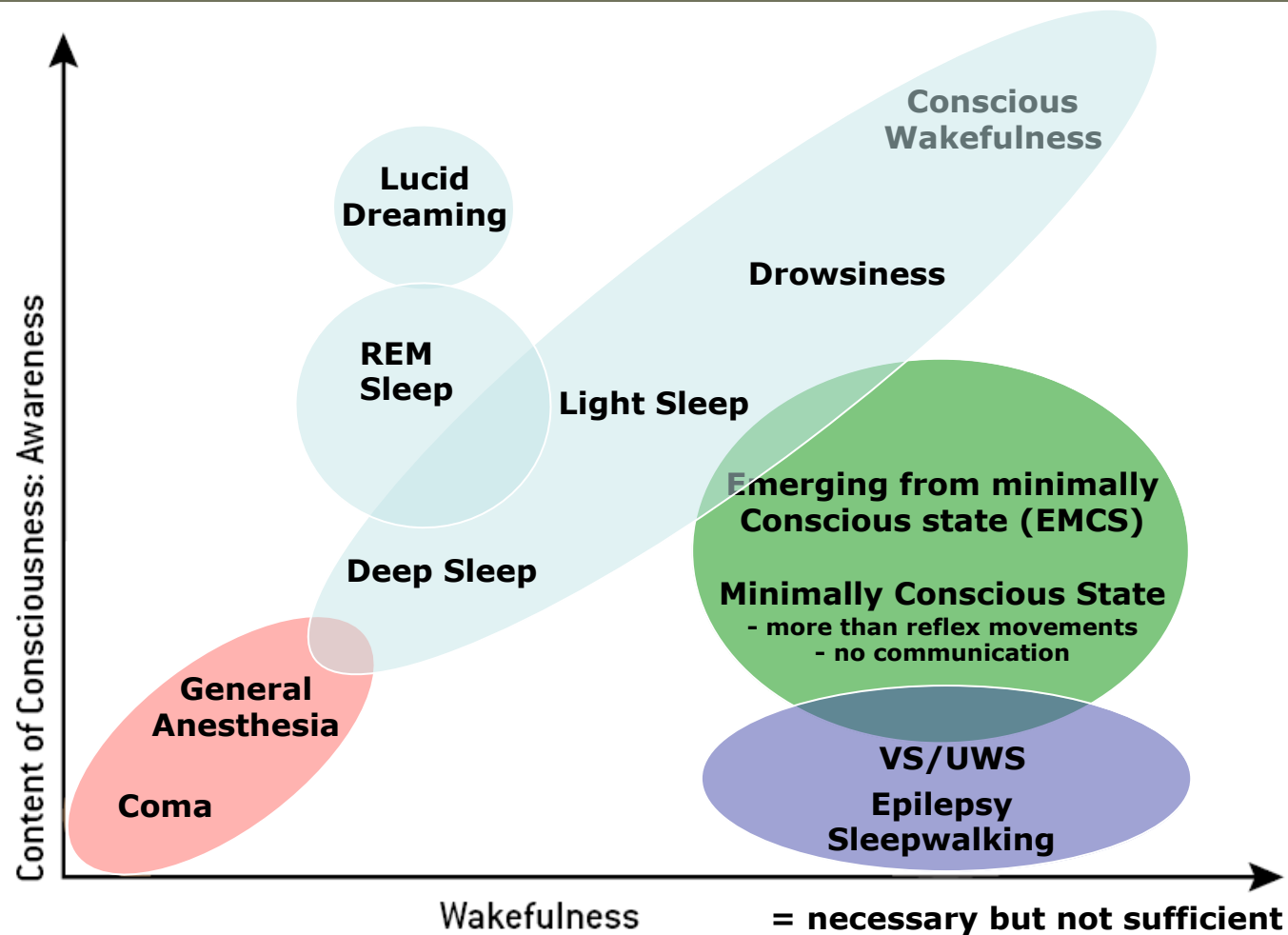
**Carol Di Perri**  
**MD PhD**

Arezzo 18th November 2017

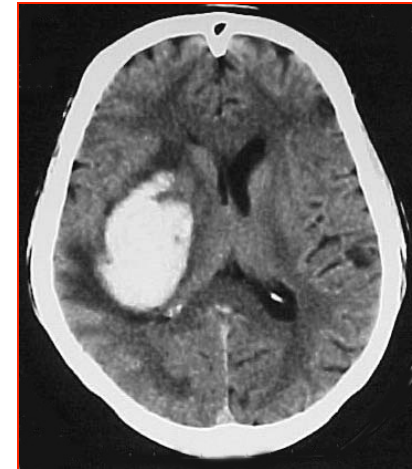
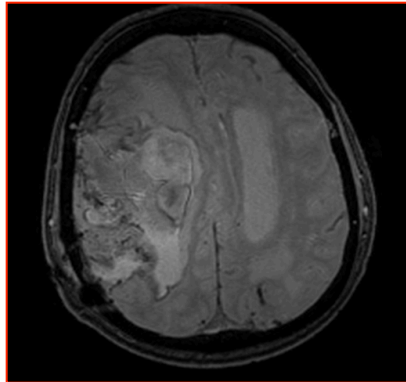
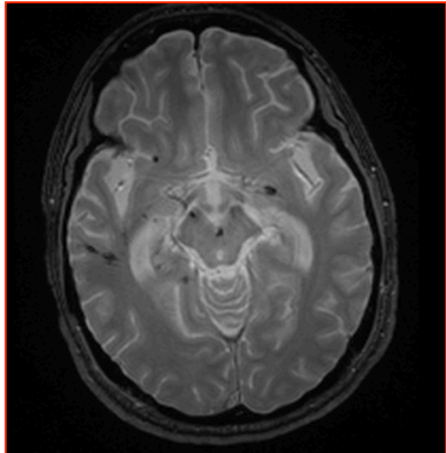
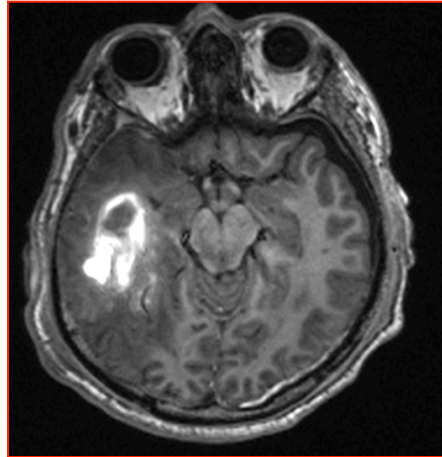
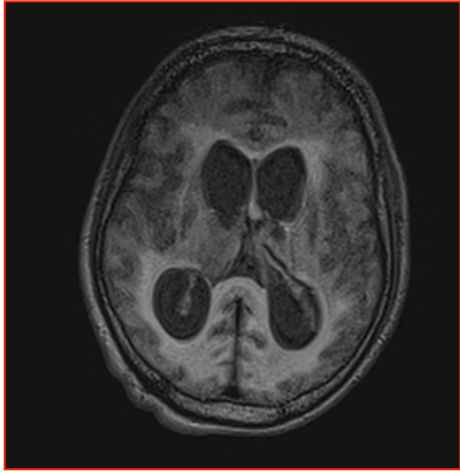


[www.comascience.org](http://www.comascience.org)

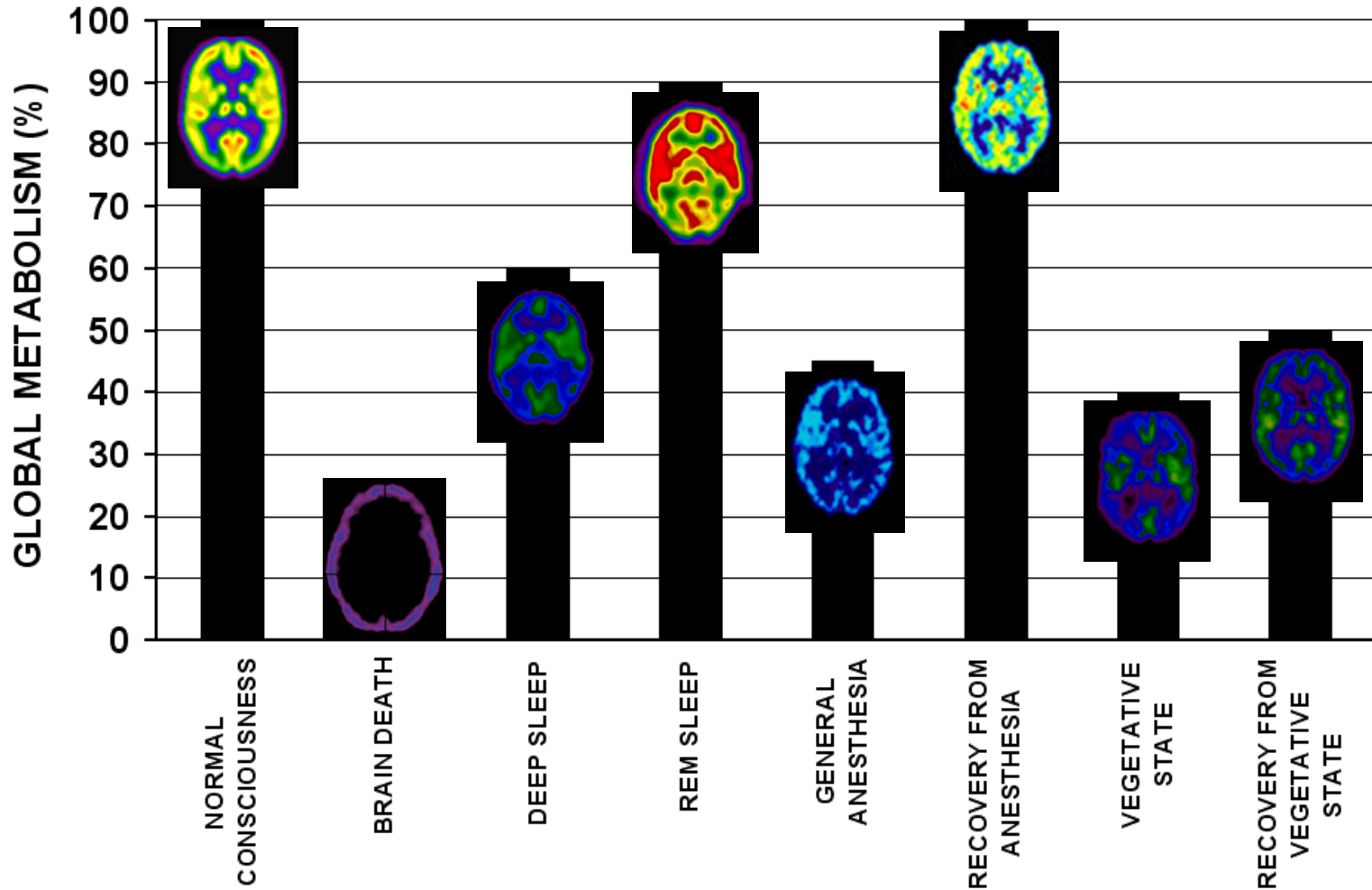
# Reducing consciousness to 2D



# *Conventional Imaging*



# Awareness $\neq$ whole brain

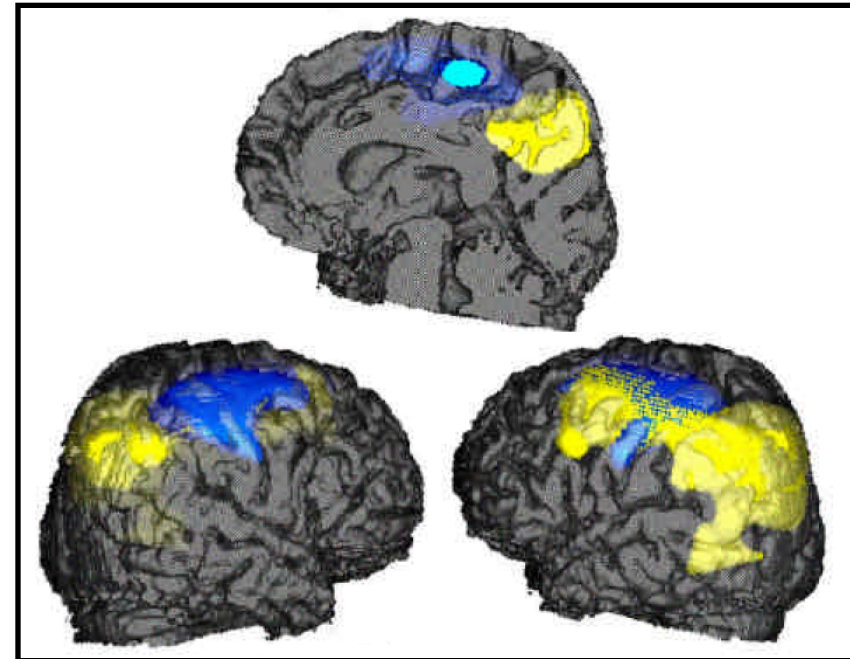
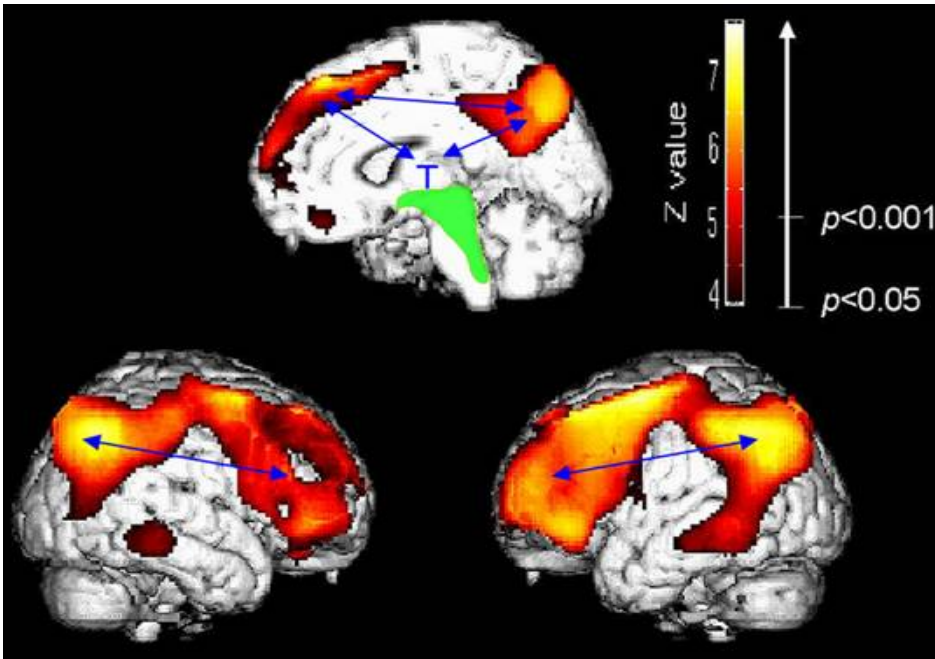




# Awareness $\approx$ frontoparietal

areas that are systematically dysfunctional in the VS/UWS

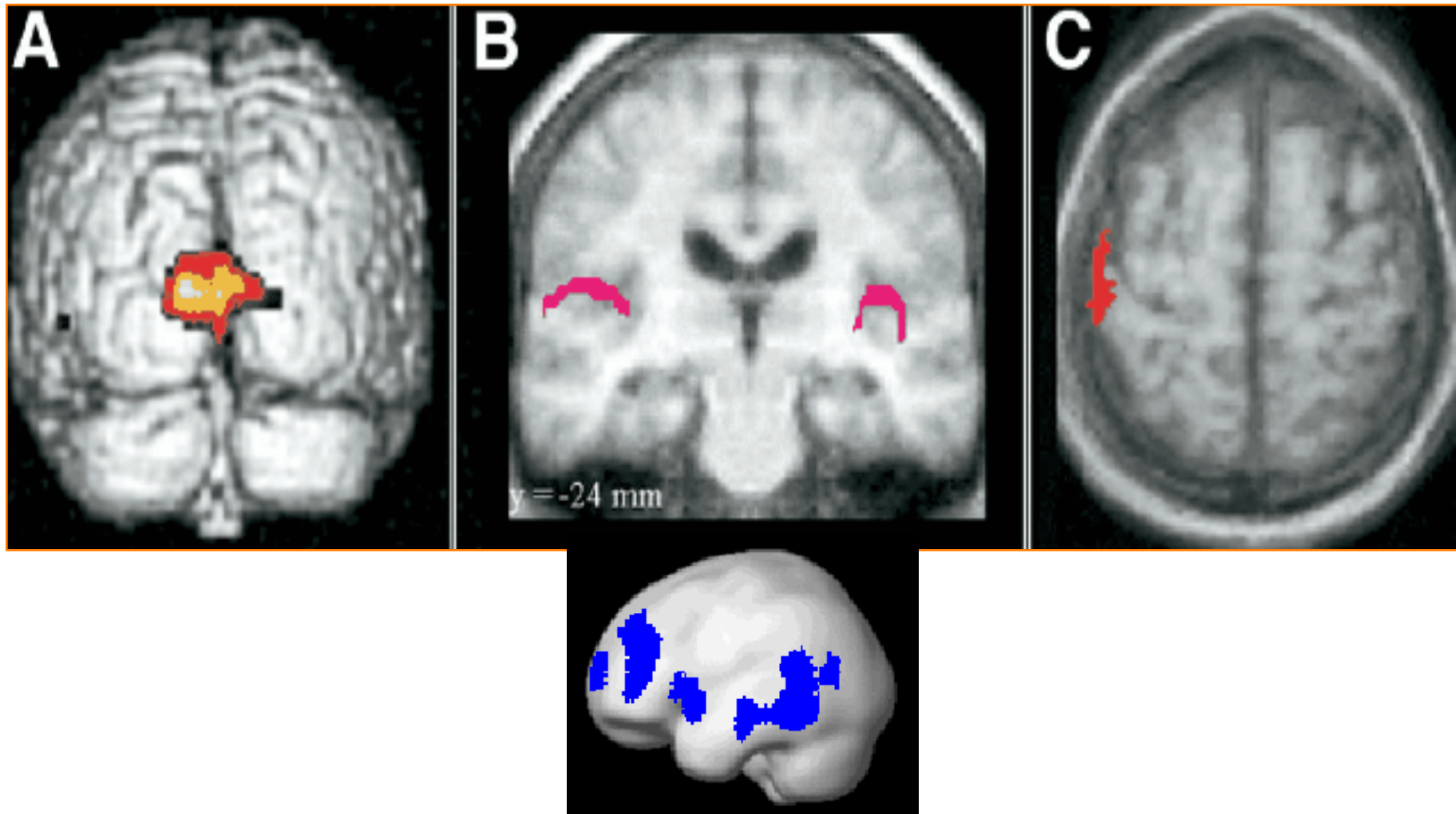
areas that recover metabolism after recovery from the VS/UWS



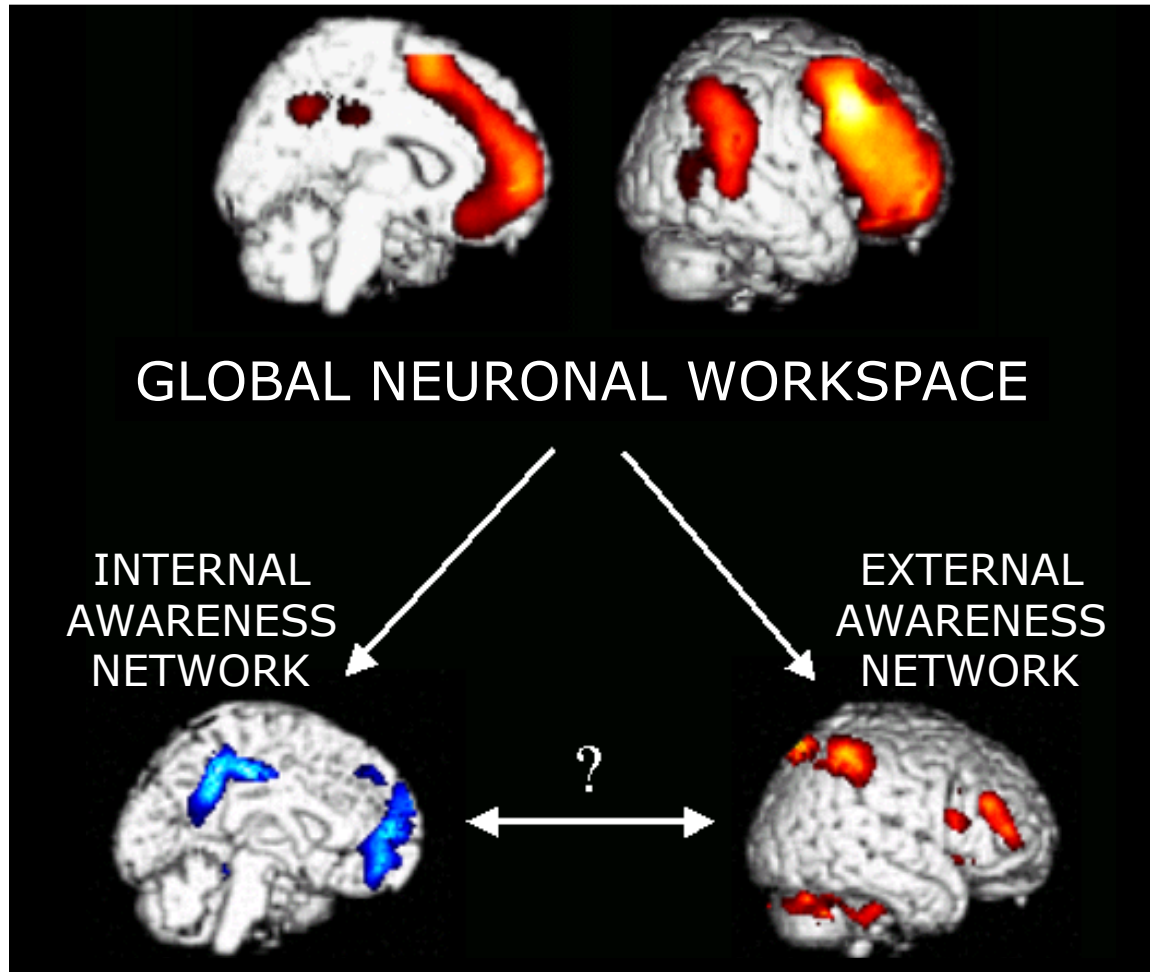
Laureys et al, *Neuroimage* 1999  
Laurey et al, *Lancet* 2000

Laureys et al, *J Neurol Neurosurg Psychiatry*, 1999

# *Do Patients in a VS/UWS feel or hear?*



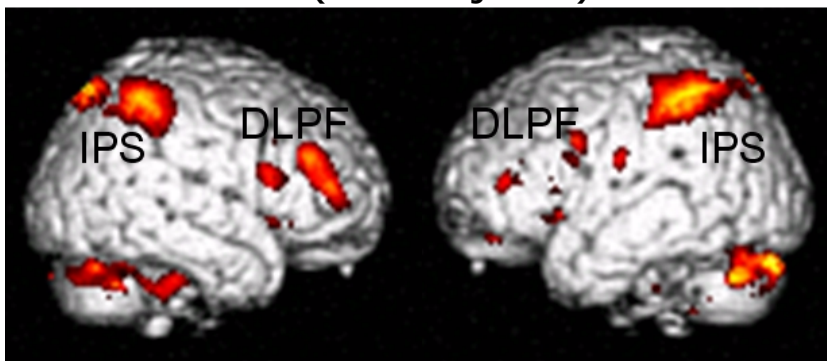
# Two awareness networks



# External and internal awareness

## NEURAL CORRELATE OF EXTERNAL (SENSORY) AWARENESS

Peri-luminal laser stimulation on the hand (24 subjects)

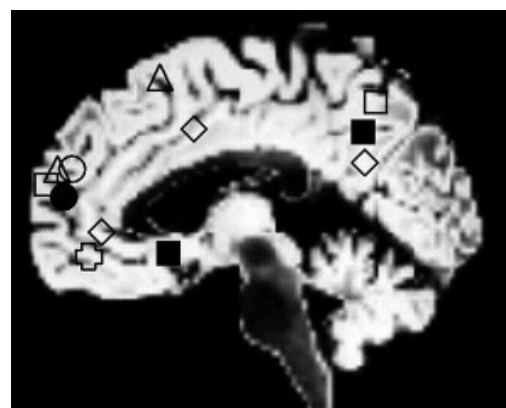


perceived ( $433 \pm 23$  mJ) >  
unperceived ( $438 \pm 21$  mJ)

Boly et al, *PNAS* 2007  
(also Dehaene et al, *Nat Rev Neuroci* 2001;  
Rees et al, *Nat Rev Neuroci* 2001)

## NEURAL CORRELATE OF INTERNAL (SELF) AWARENESS

Auto-referential stimuli



### OWN NAME

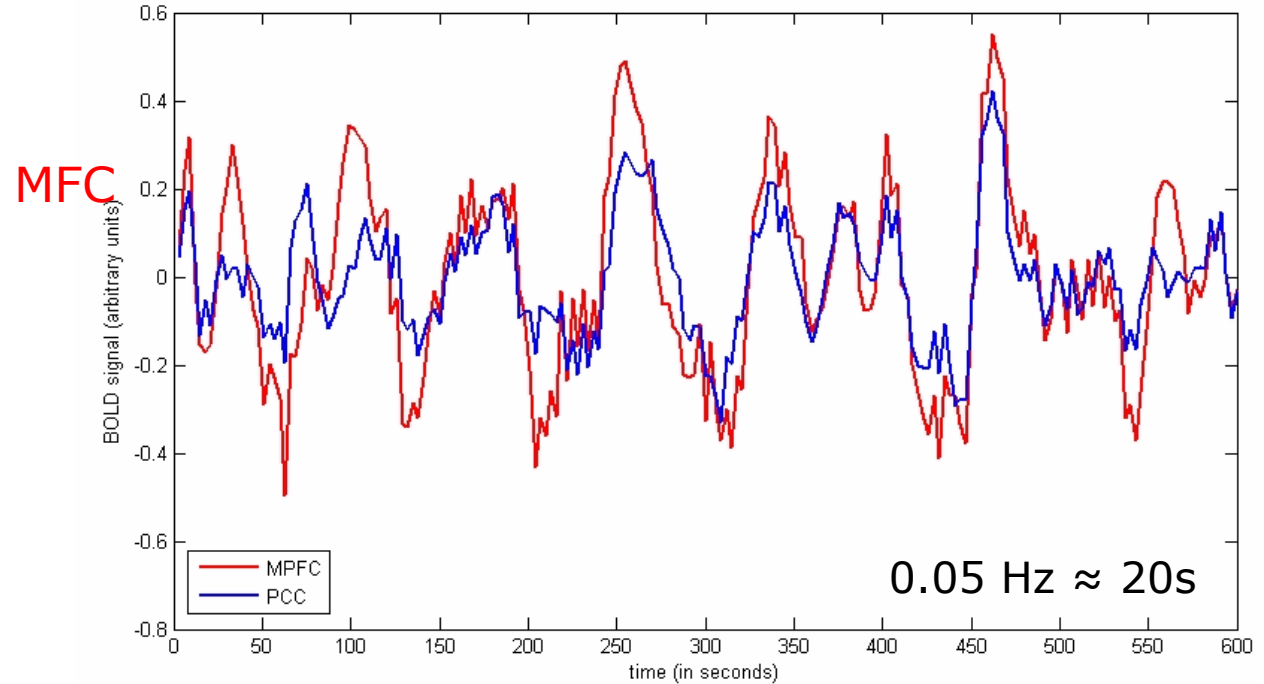
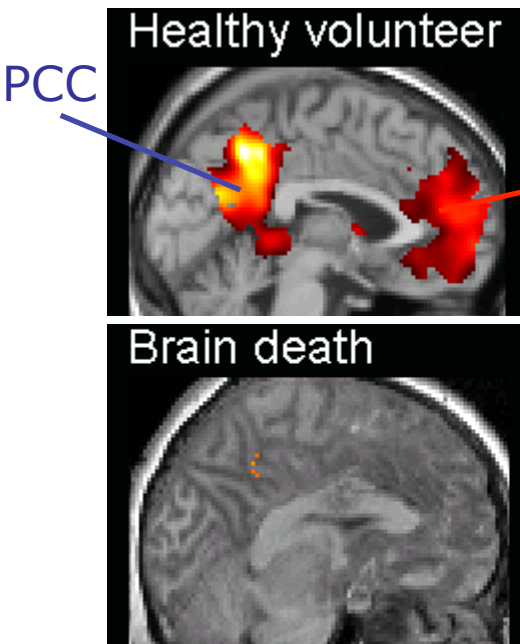
- 15 controls: Perrin et al. 2005
- △ 16 controls: Kampe et al. 2003
- 3 controls: Staffen et al. 2006
- 1 MCS patient: Laureys et al. 2004
- 1 VS patient: Staffen et al. 2006

### OWN FACE

- ⊕ 12 controls: Platek et al. 2006
- ◇ 6 controls: Kircher et al. 2001

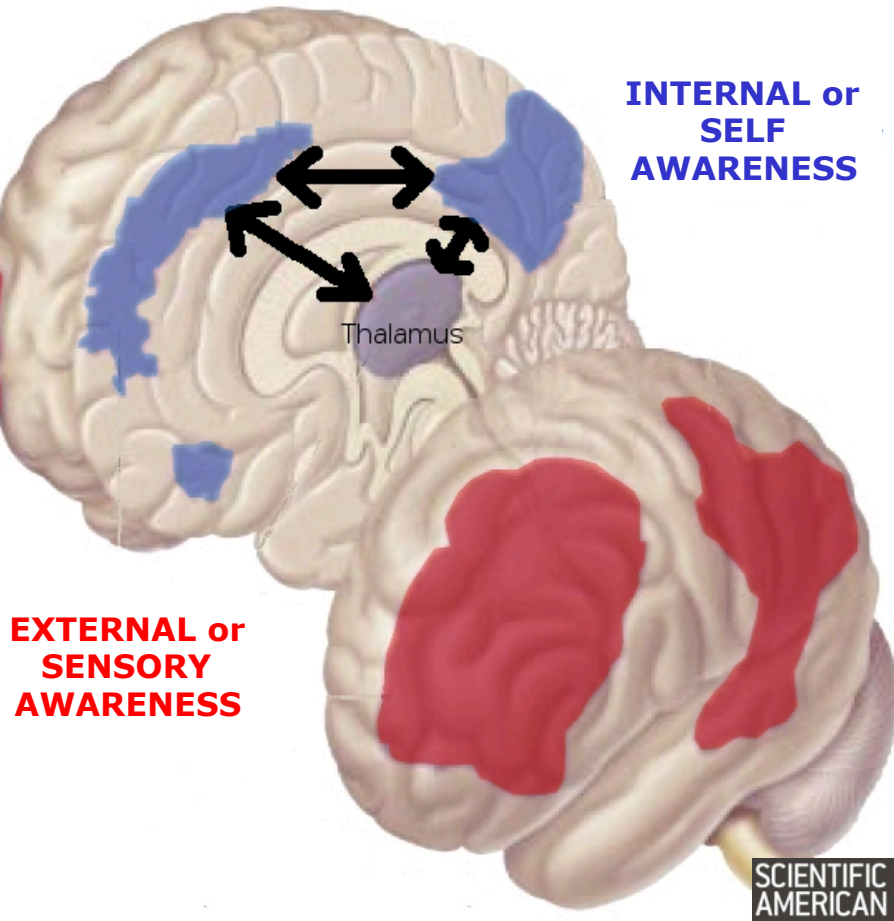
Laureys et al, *Consciousness & Cognition* 2007  
(also Mason et al, *Science*, 2007;  
Golland et al, *Neuropsychologia* 2008)

# “Resting state” default brain activity



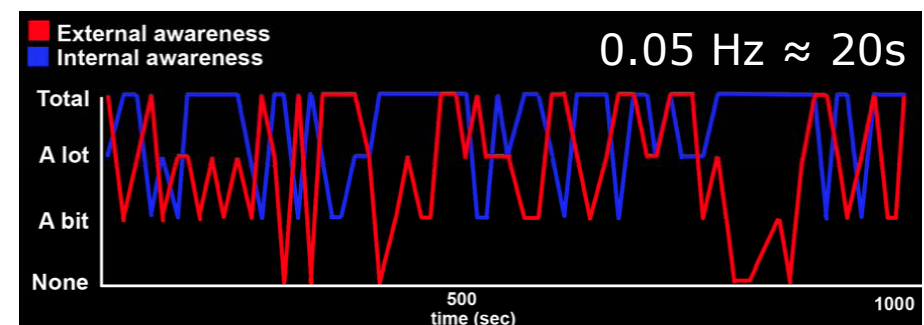
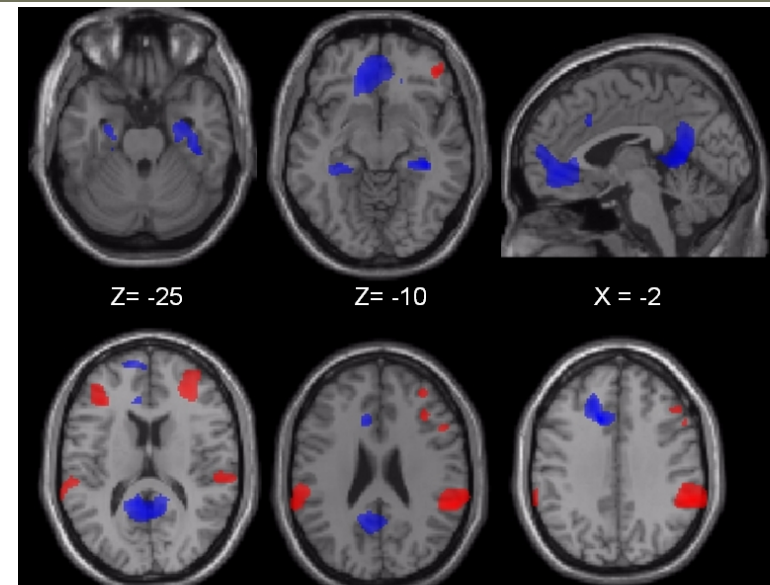
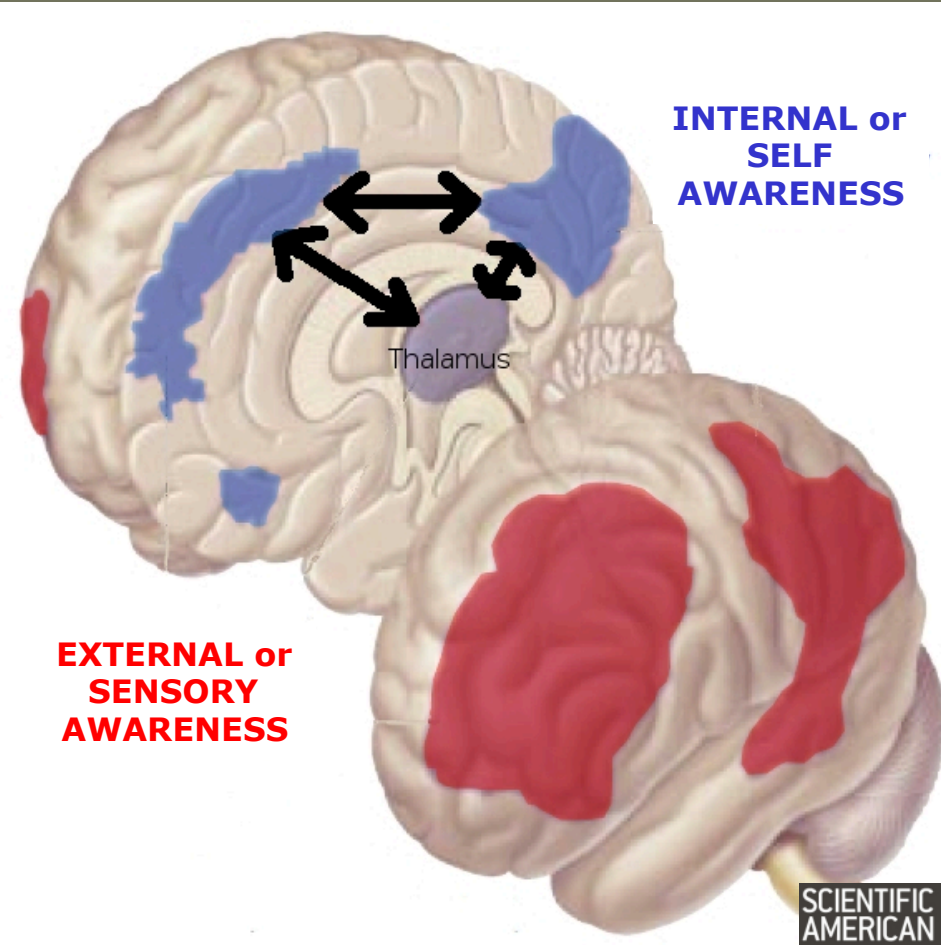


# Two awareness networks



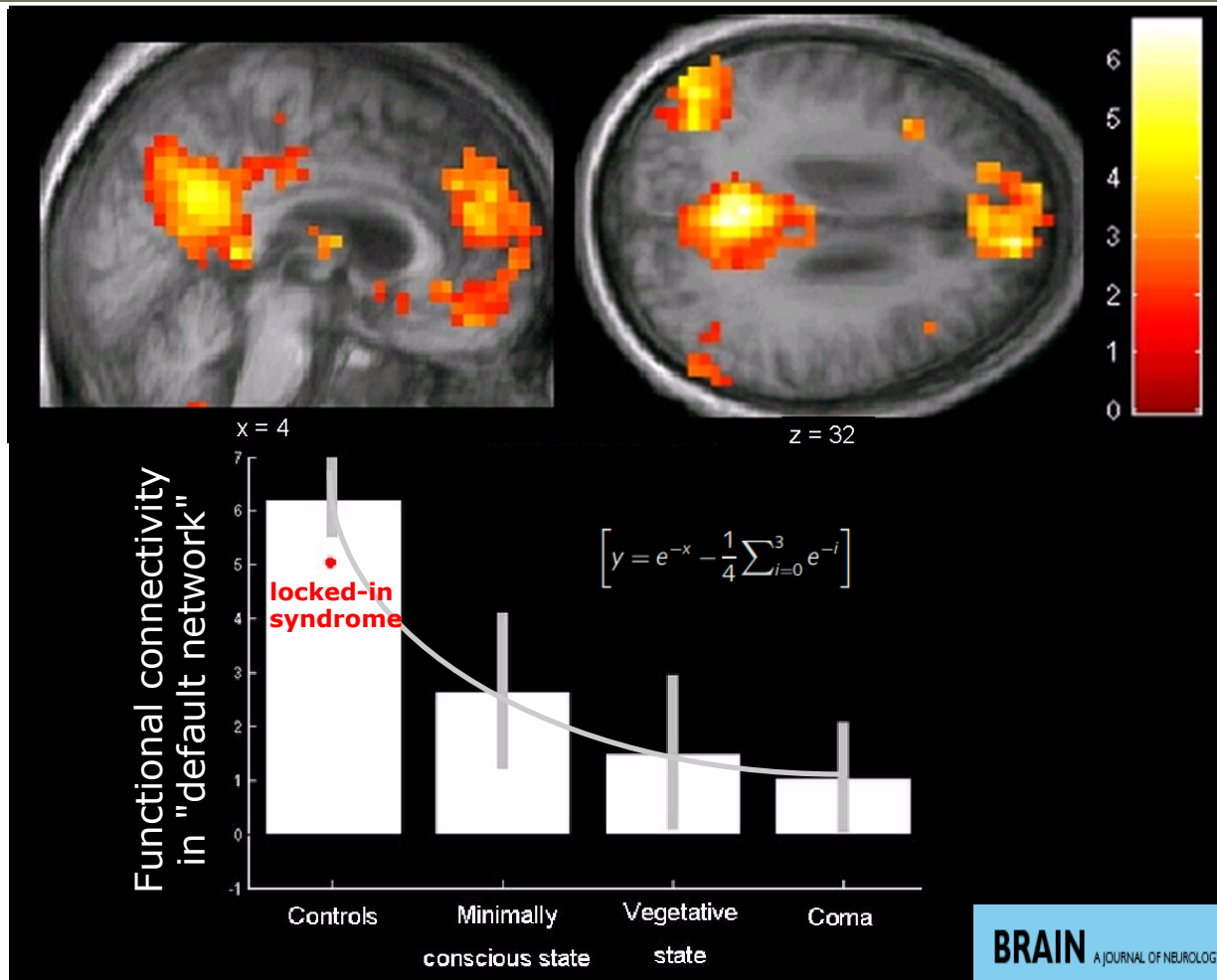


# Two awareness networks

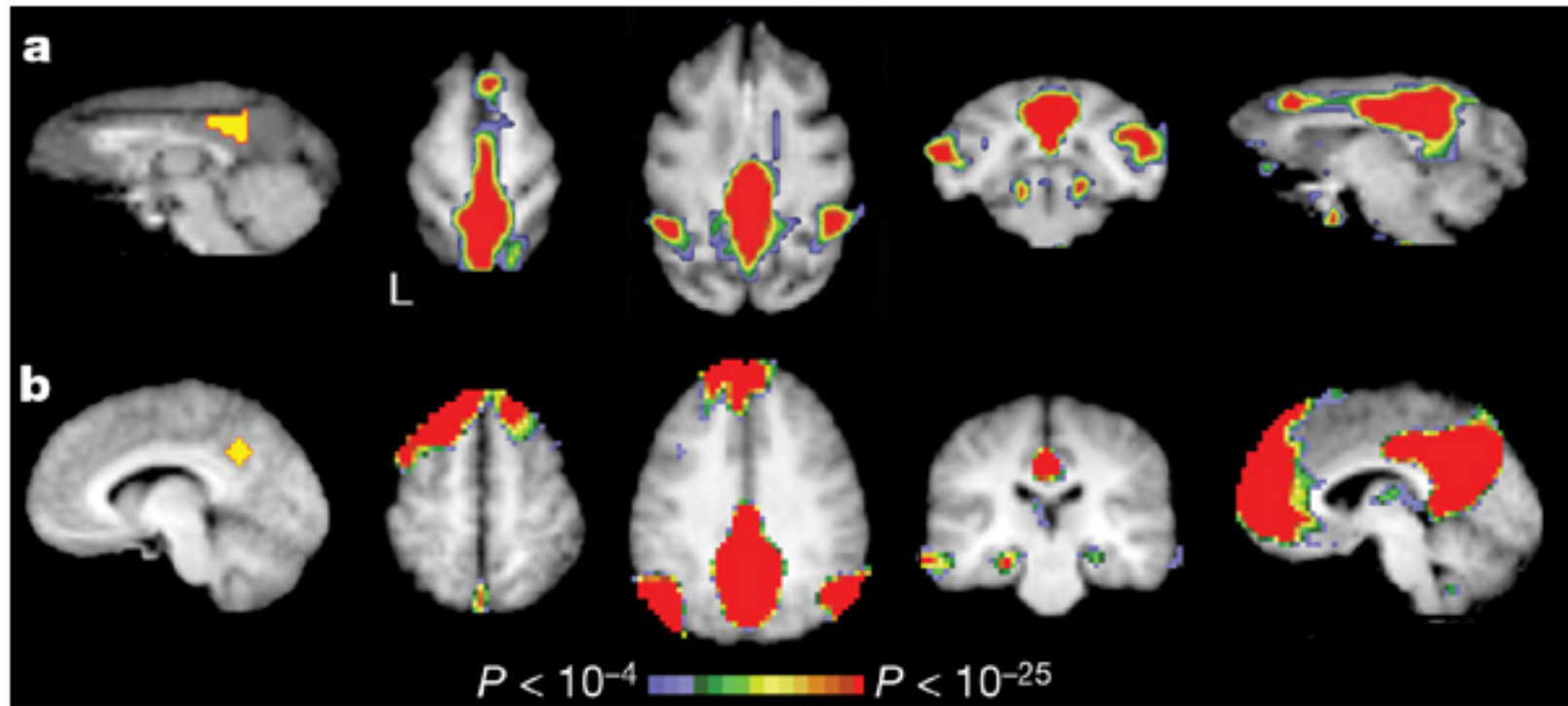


Journal of  
Cognitive Neuroscience

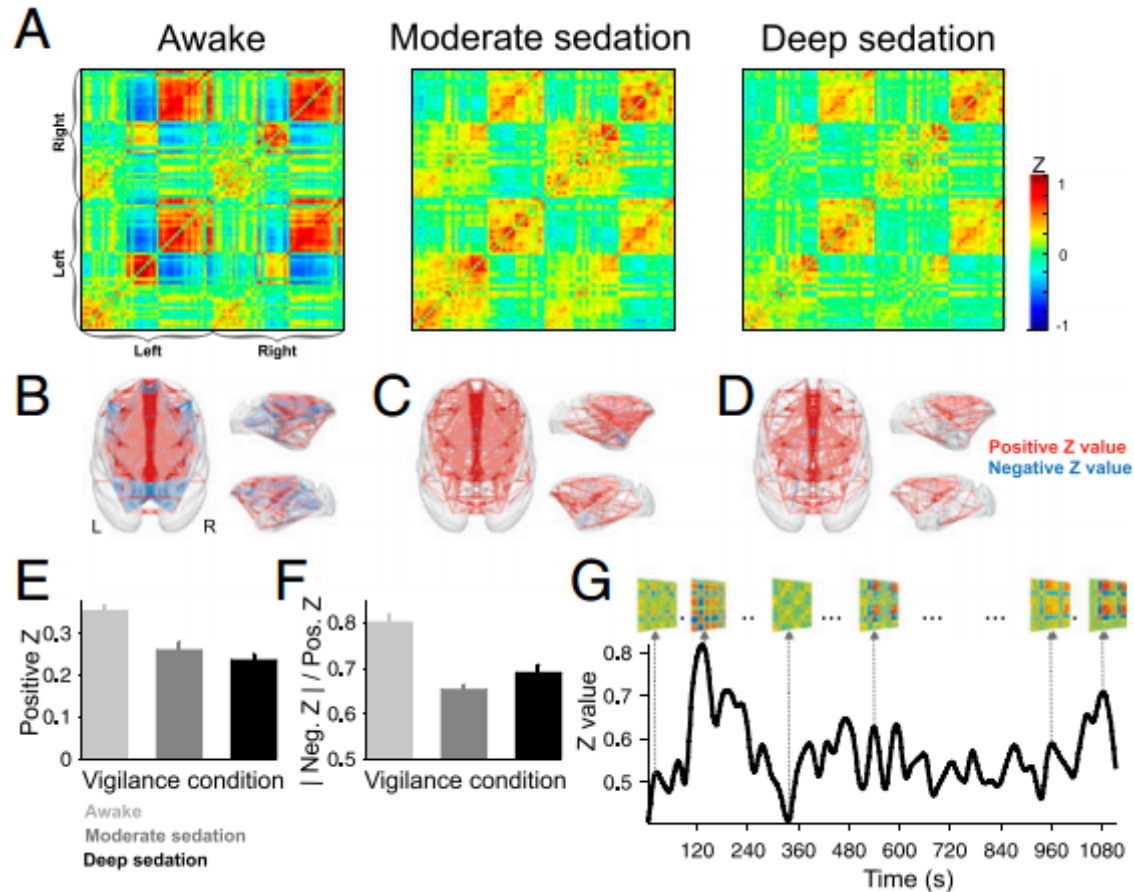
# "DMN" and consciousness



# More than correlation?



# Anticorrelation



## Limbic hyperconnectivity in VS/UWS

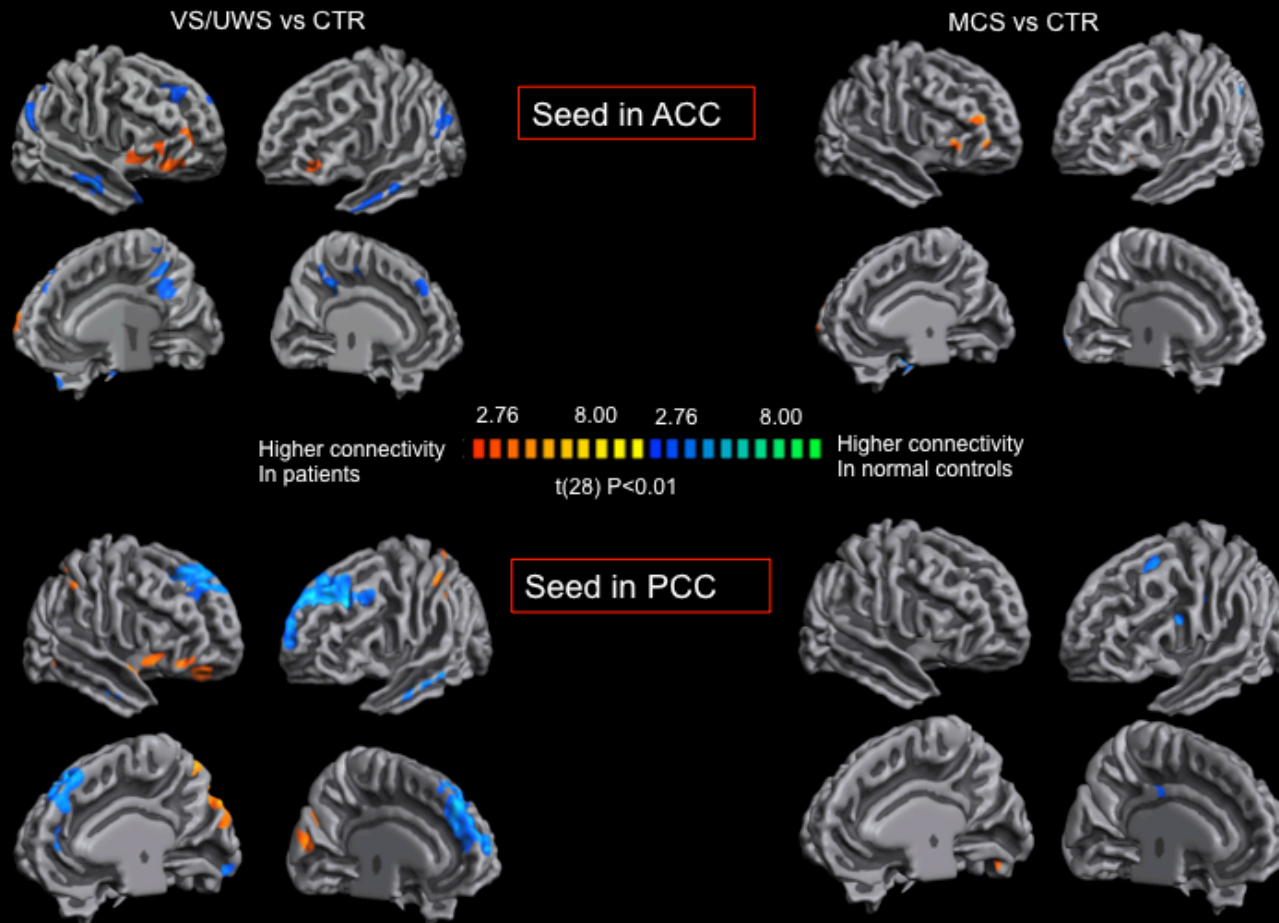
**Aim:** investigate the hypothesis that DOC might not be simply a function of DMN hypoconnectivity, but rather a more complex, dysfunctional brain connectivity structure

**Population:** 11 VS/UWS and 7 MCS, 18 healthy controls

**Analysis:** Resting state- fMRI -Inferential and non inferential analyses (ICA and seed-based)

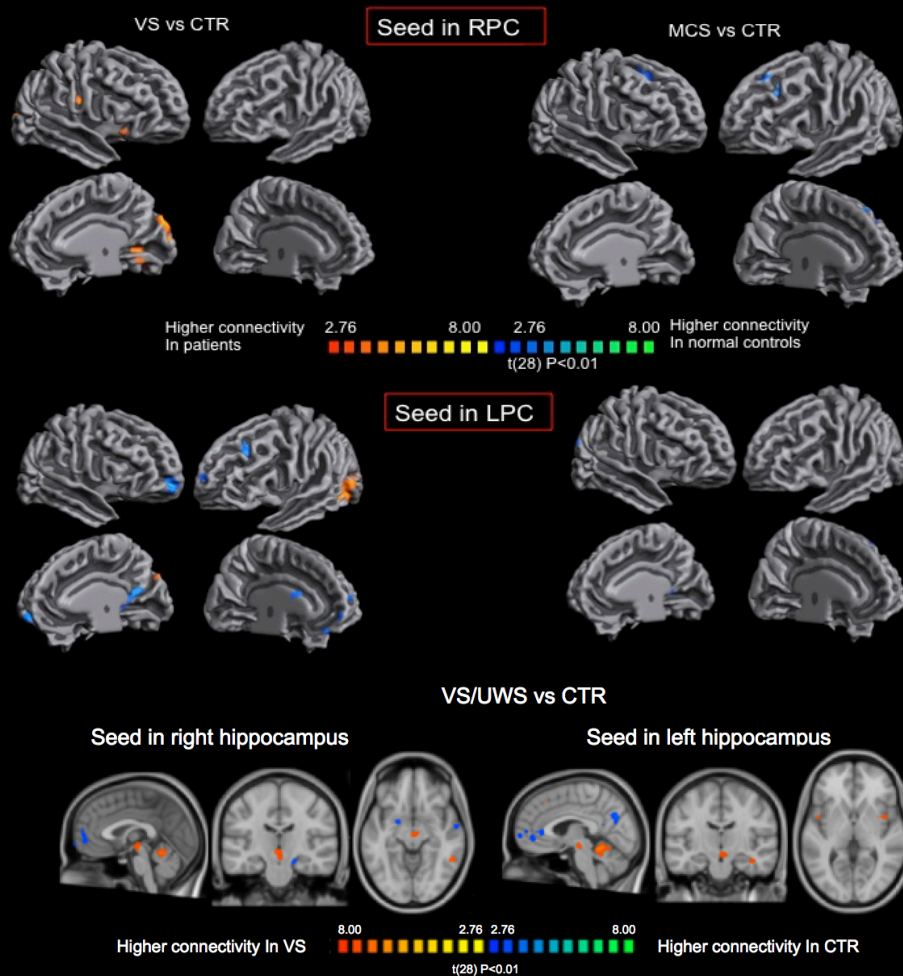


# Limbic hyperconnectivity in VS/UWS





# Limbic hyperconnectivity in VS/UWS



# The neural correlates of EMCS patients

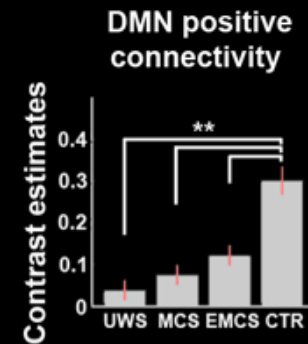
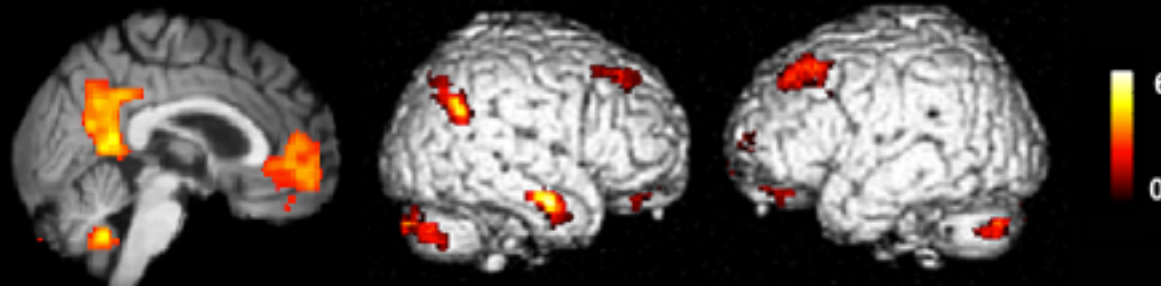
**Aim:** to investigate the role of **DMN anticorrelation** (DMN negative connectivity) in different levels of consciousness

**Population:** 58 post-comatose patients (21 VS/UWS, 24 MCS, **13 EMCS**) and 35 controls

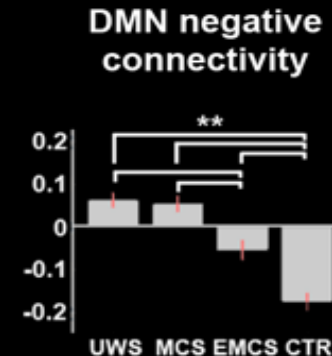
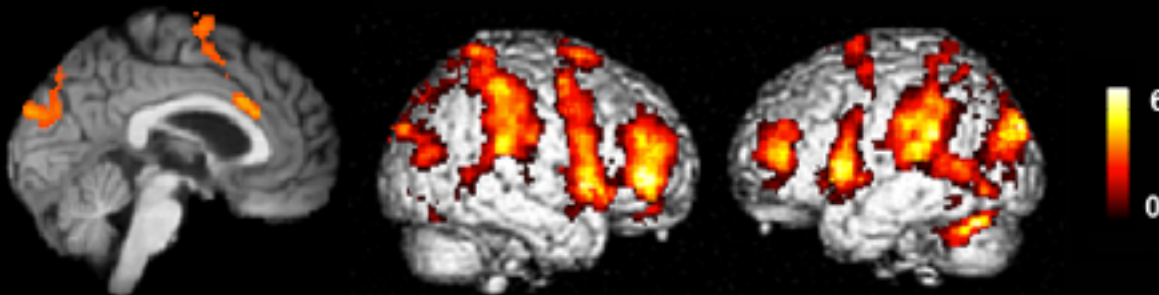
**Analysis:** DMN positive and negative connectivity,  
PET: to test the hypothesis that the identified differences in connectivity would be of neuronal origin.  
VBM: to exclude the influence of structural deformation on functional connectivity

# The neural correlates of EMCS patients

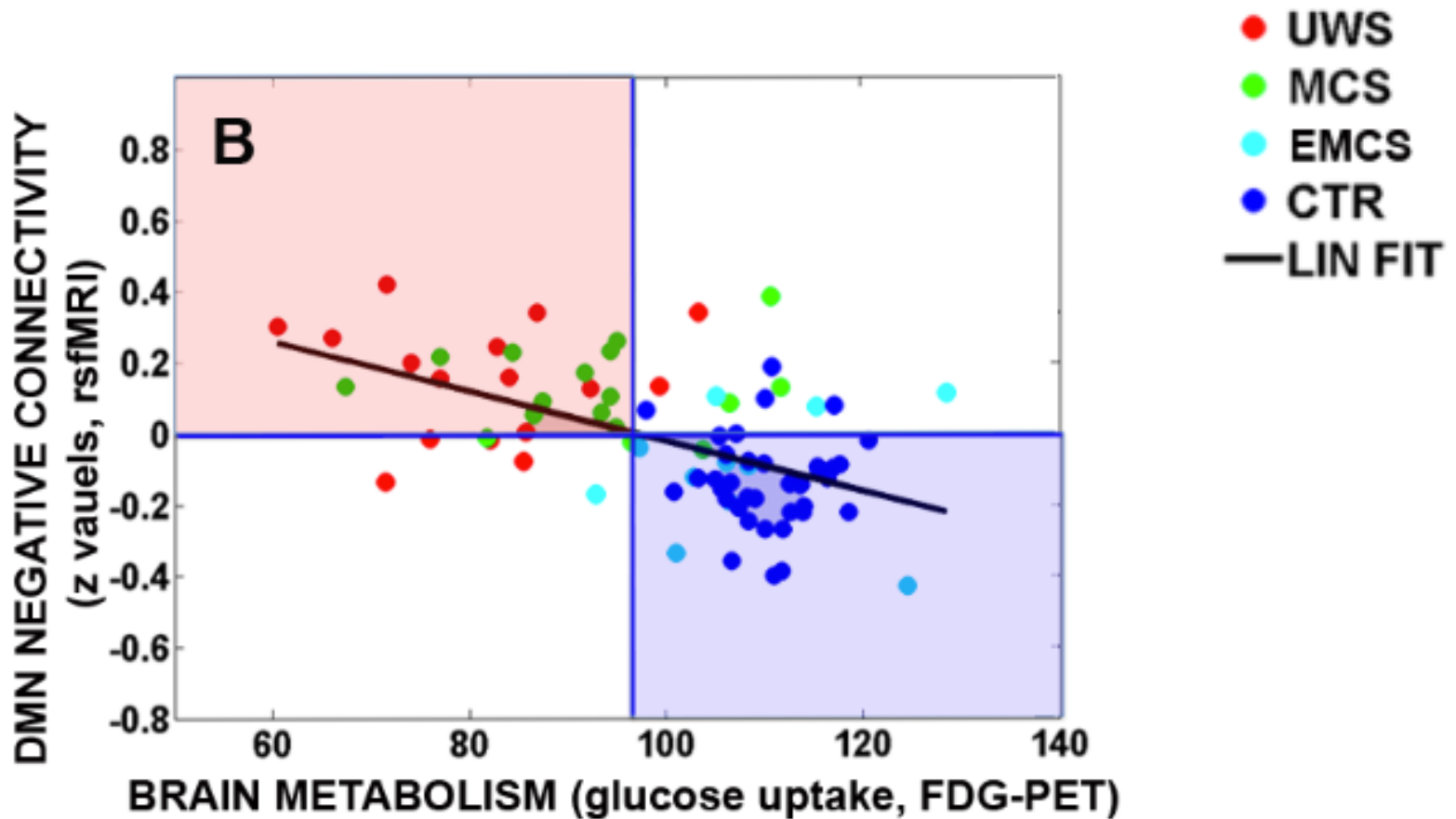
## a. DMN positive connectivity



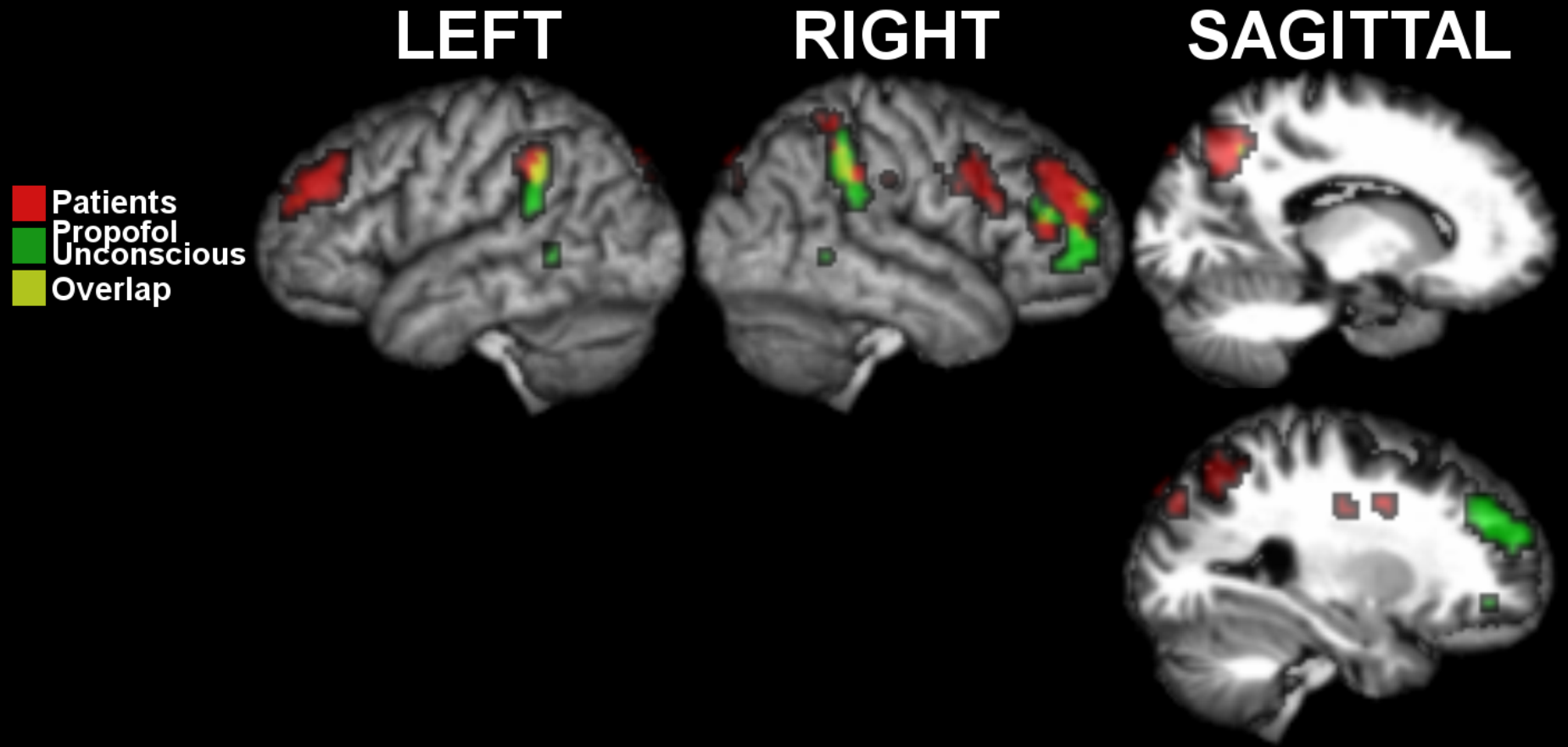
## b. DMN negative connectivity



# The neural correlates of EMCS patients



# The neural correlates of EMCS patients



# Anticorrelation

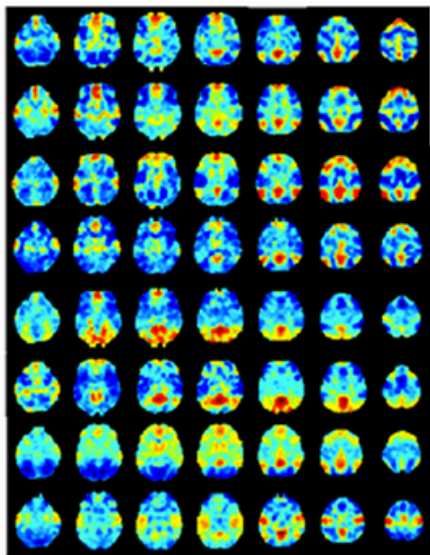


*“... the difference between cacophony and symphony does not necessarily relate to the number of musicians playing, or the decibel level, or the processing of the musical score: the difference is coordination in time.”*

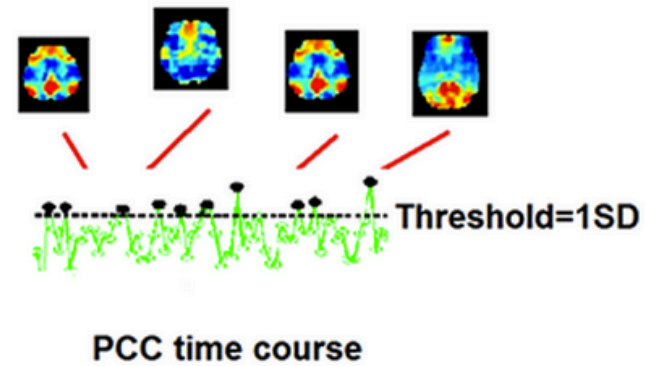
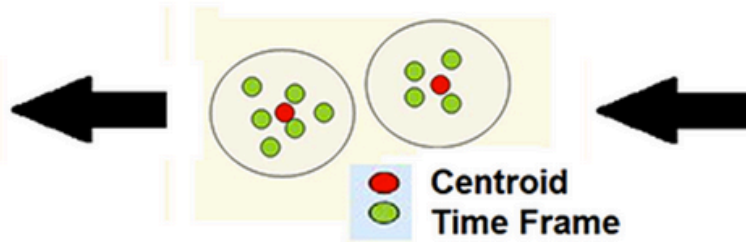


# CAPs in patients with DOC

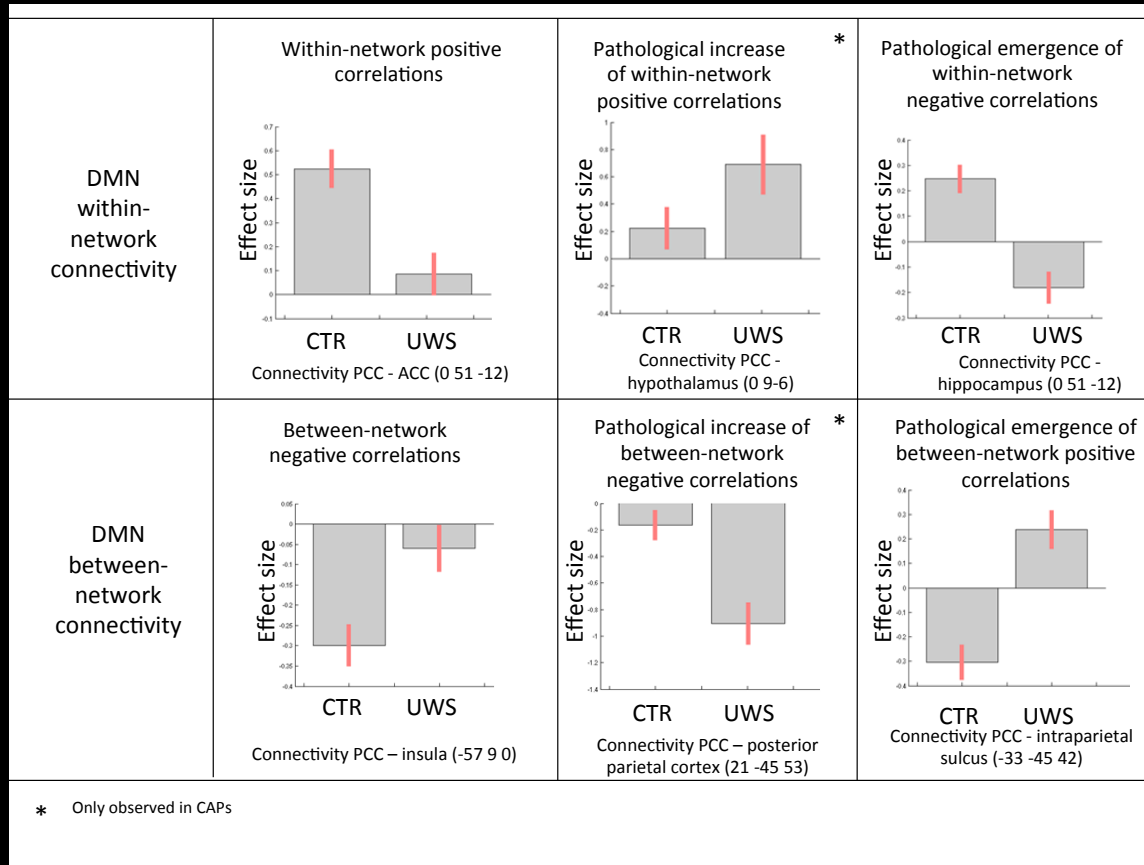
## PCC Co-activation patterns



## K-means (Centroids fixed)



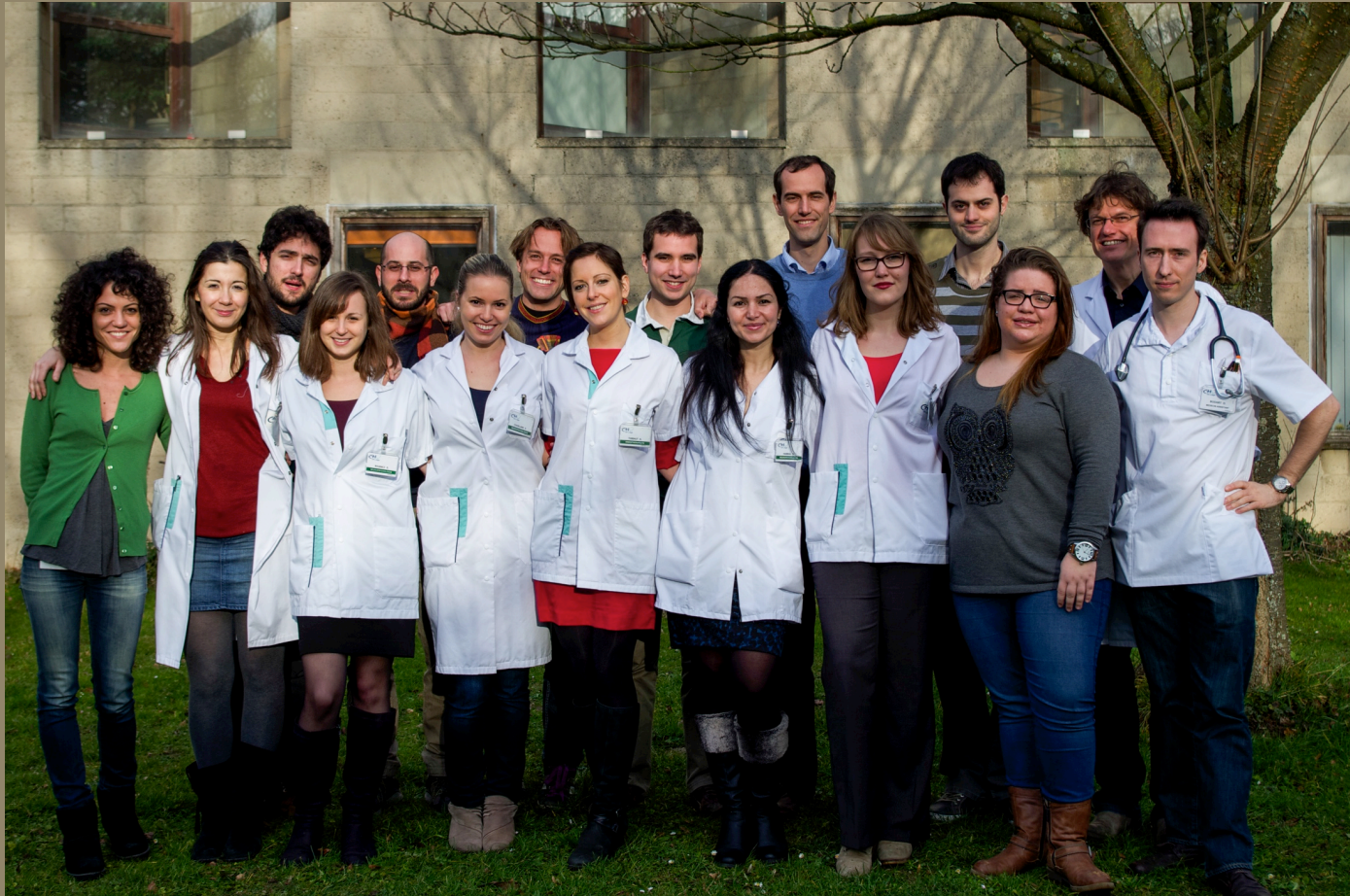
# CAPs in patients with DOC



# Take home message

- Impaired consciousness= a multifaceted dysfunctional connectivity architecture of the brain where altered within-network and between-network connectivity are all involved
- Functional connectivity is only an aspect of the brain function. A multimodal imaging and neurophysiological approach is mandatory to have an holistic vision of the disease in general and single patient in particular
- Next challenge will be to apply these neuroimaging techniques at single subject level, as required by clinical practice

# Thank you for your attention !!



[www.comascience.org](http://www.comascience.org)