

Imaging in Disorders of Self-Consciousness

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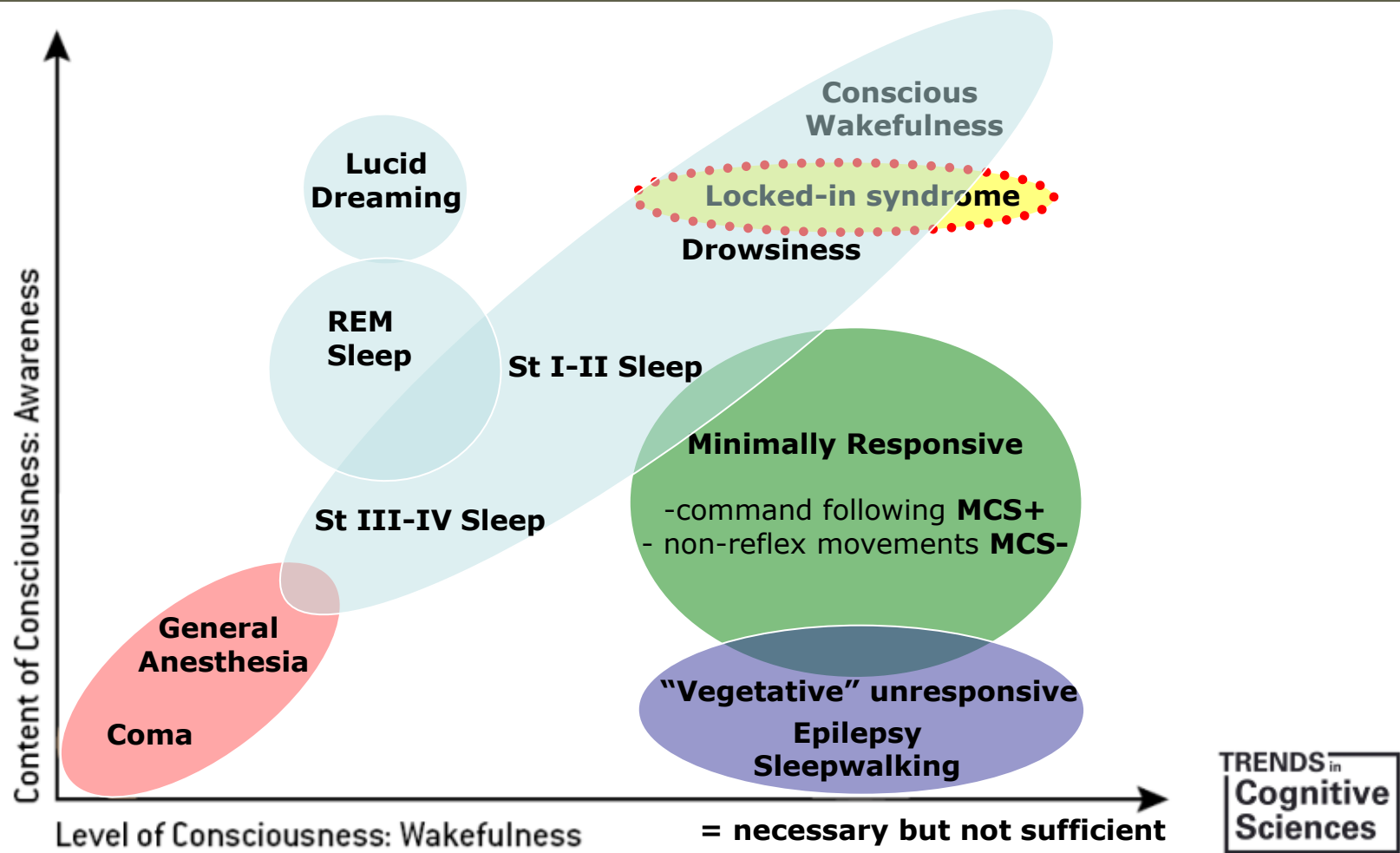
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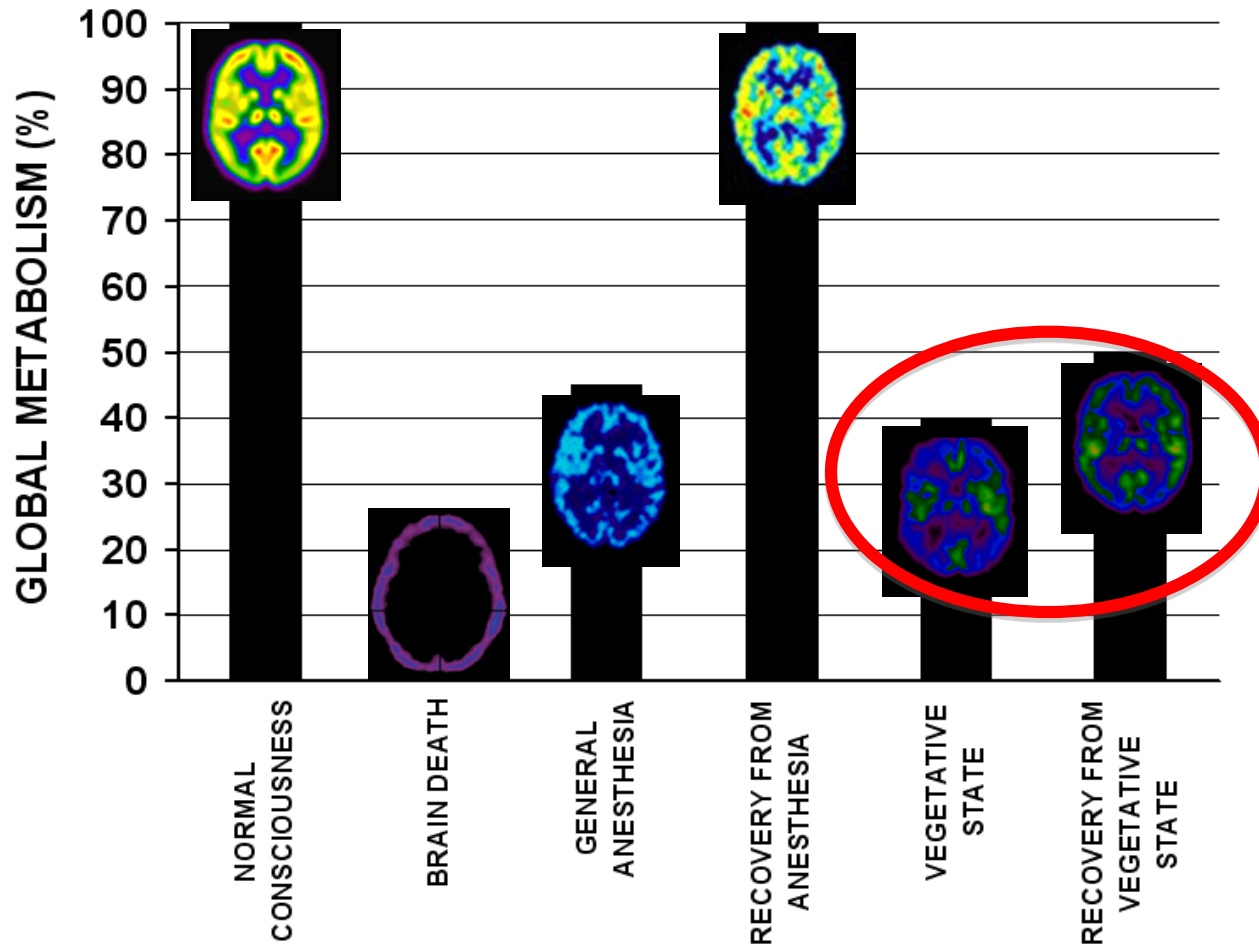
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Reducing consciousness to 2D



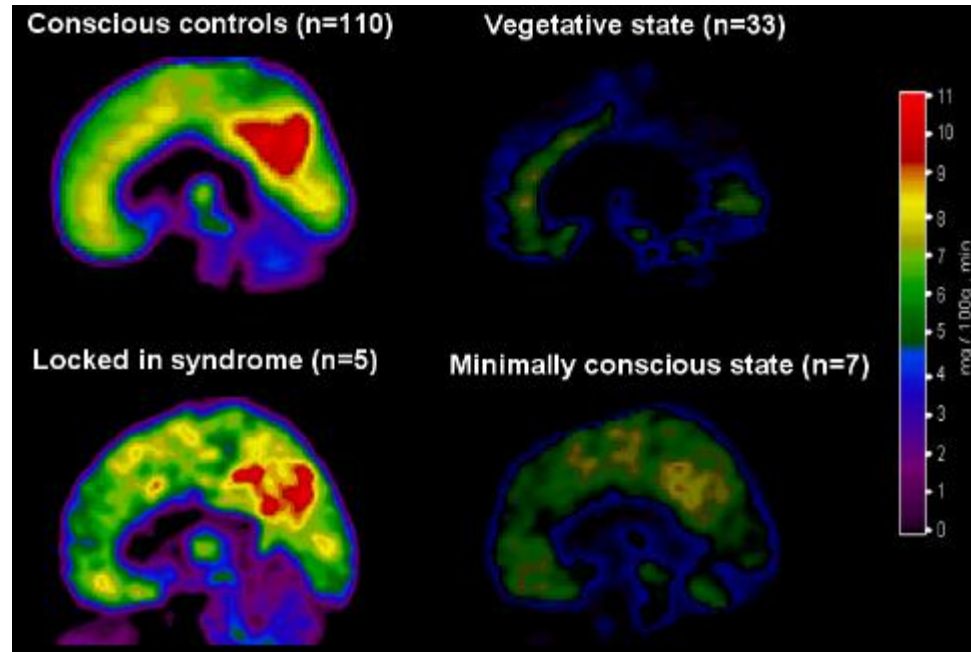
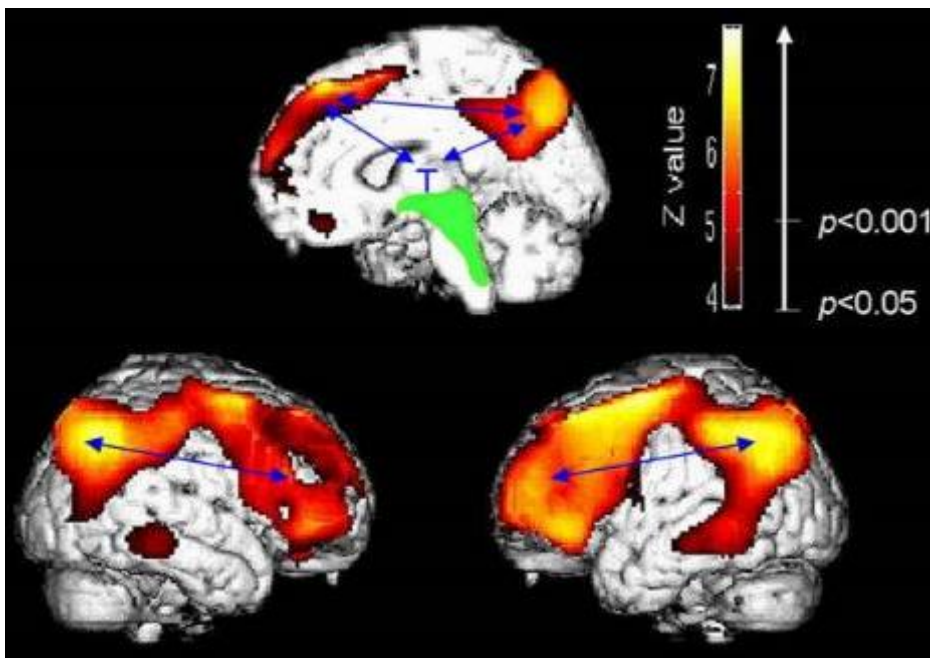
Consciousness \neq global brain function



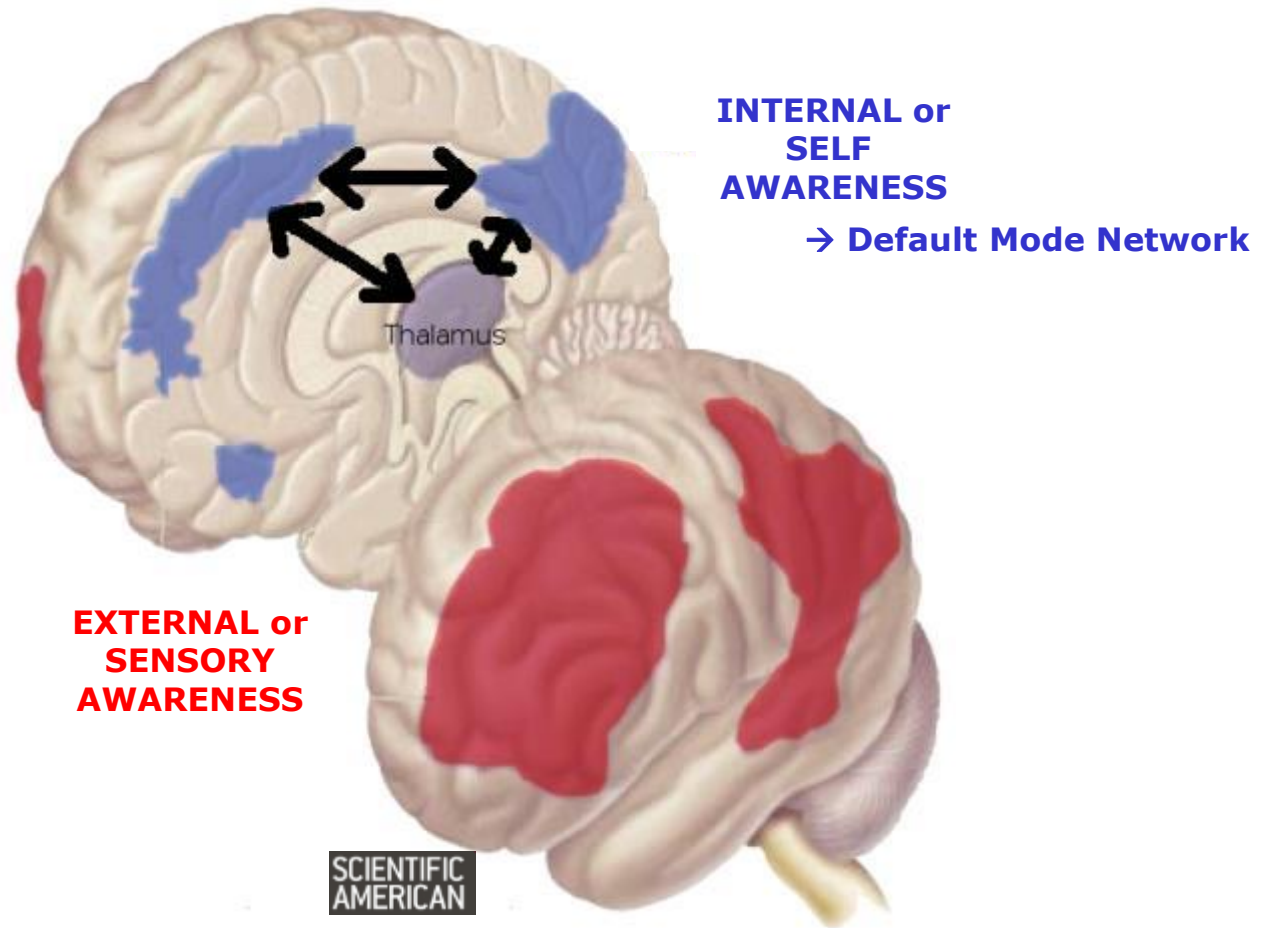
Consciousness \approx network functioning

Areas systematically dysfunctional in “vegetative” state & recovering activity after recovery of consciousness

Precuneus seems a critical hub



Two awareness networks



Diagnostic error after coma

103 post-comatose patients

- 45 clinical consensus diagnosis 'vegetative state'
- 18 showed signs of awareness

 **40% potential misdiagnosis**

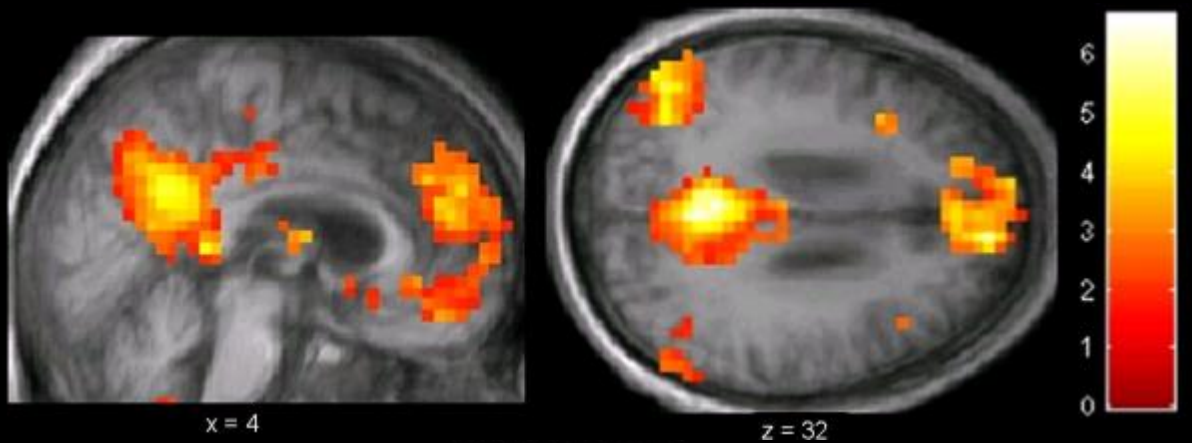
Solution: Coma Recovery Scale Revised (CRS-R)

Limitations of the CRS-R:

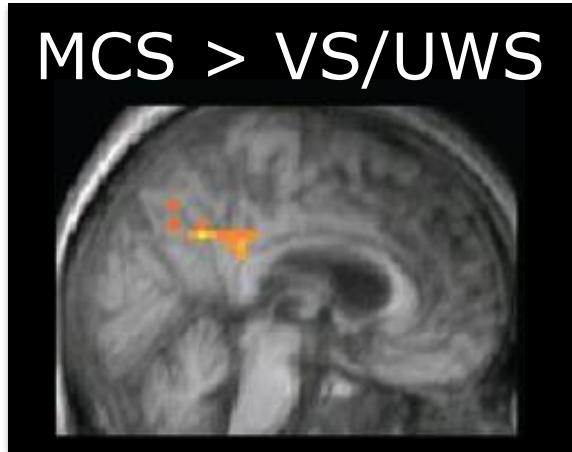
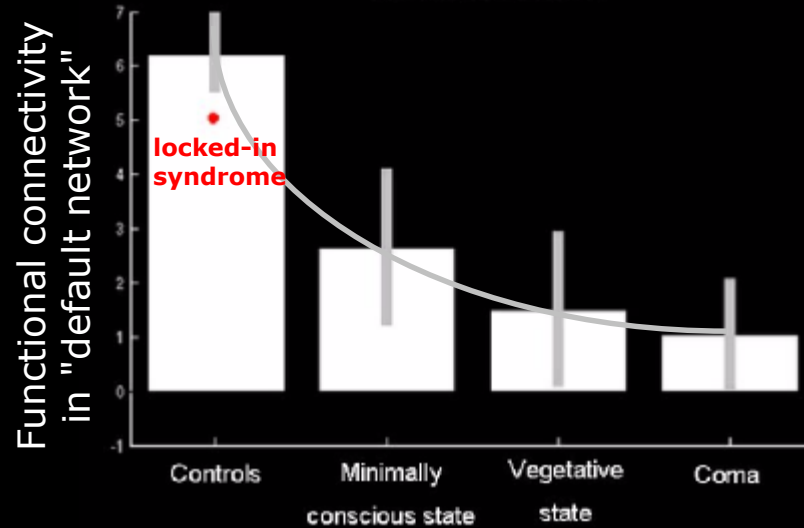
- Patients suffering from aphasia or lack of motivation on of the patient
- Motor abilities

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										

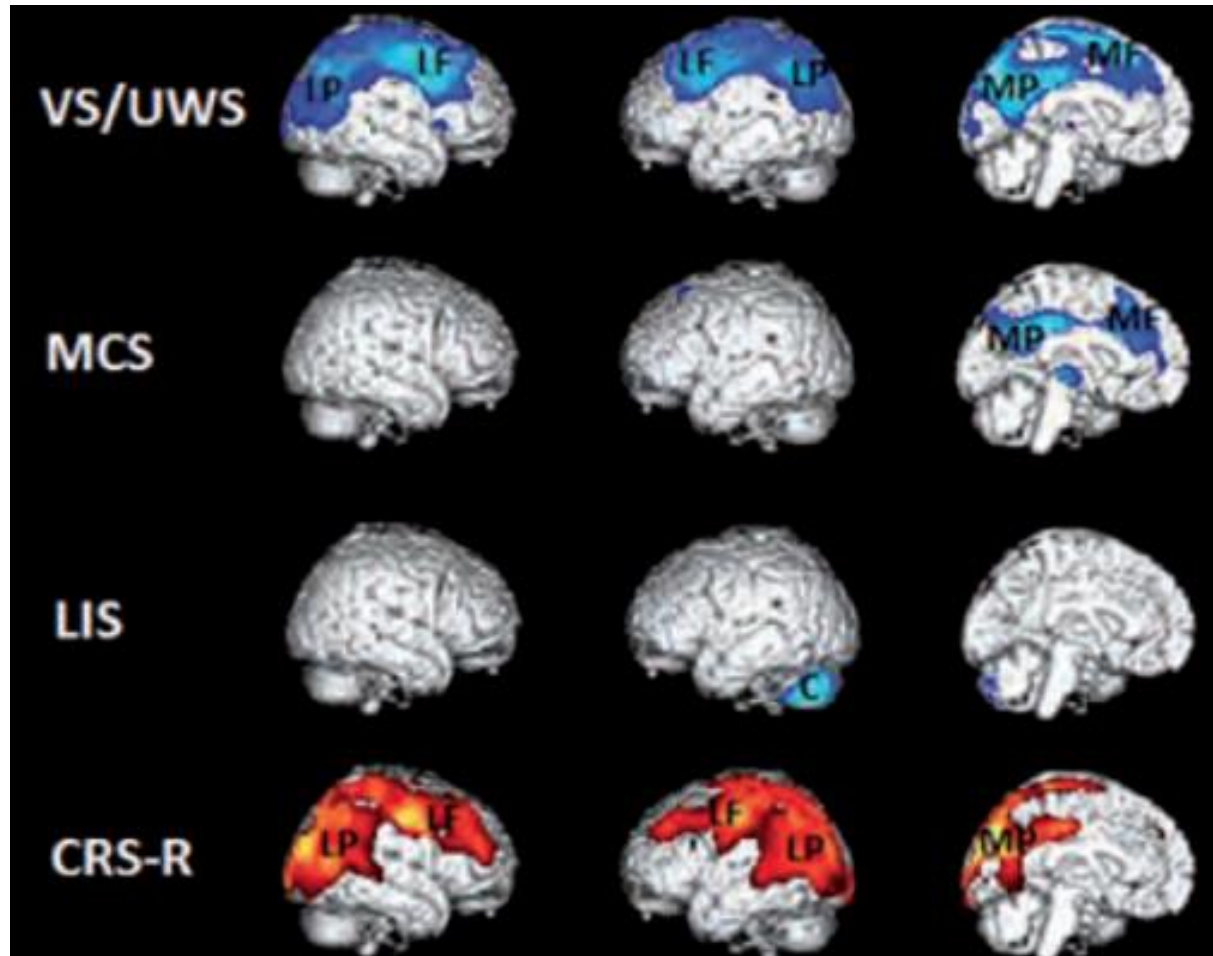
Resting connectivity: fMRI



Precuneus connectivity was found to be significantly stronger in MCS as compared with VS/UWS



Resting state metabolism: FDG-PET



CRS-R vs FDG-PET vs fMRI

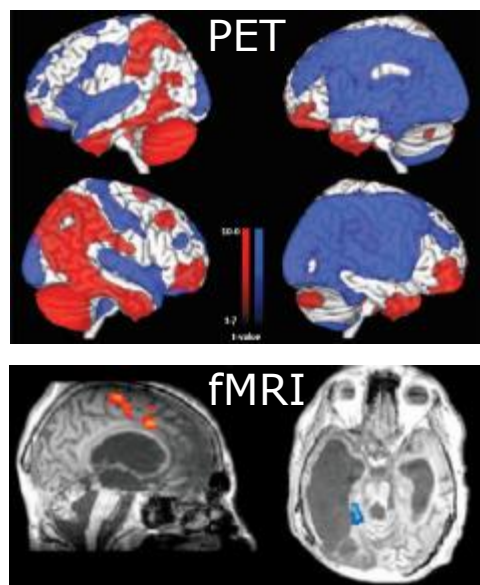
Coma Recovery Scale-Revised results			
	UWS	MCS	Total
Clinical consensus diagnosis			
VS/UWS	33 (37%)	18 (20%)	51 (57%)
MCS	2 (2%)	36 (40%)	38 (43%)
Total	35 (39%)	54 (61%)	89 (100%)
¹⁸F-FDG PET			
VS/UWS	24 (21%)	5 (4%)	29 (26%)
MCS	12 (11%)	71 (63%)	83 (74%)
Total	36 (32%)	76 (68%)	112 (100%)
Mental imagery fMRI			
VS/UWS	25 (36%)	23 (33%)	48 (69%)
MCS	3 (4%)	19 (27%)	22 (31%)
Total	28 (40%)	42 (60%)	70 (100%)

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

Table 2: Diagnostic results by modality

35% clinical misdiagnosis

32% CRS-R misdiagnosis



fMRI-based communication

Healthy Controls

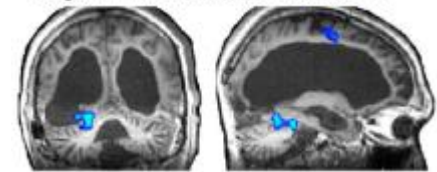
L25 TBI

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

Is your father's name Alexander ?



Is your father's name Thomas ?

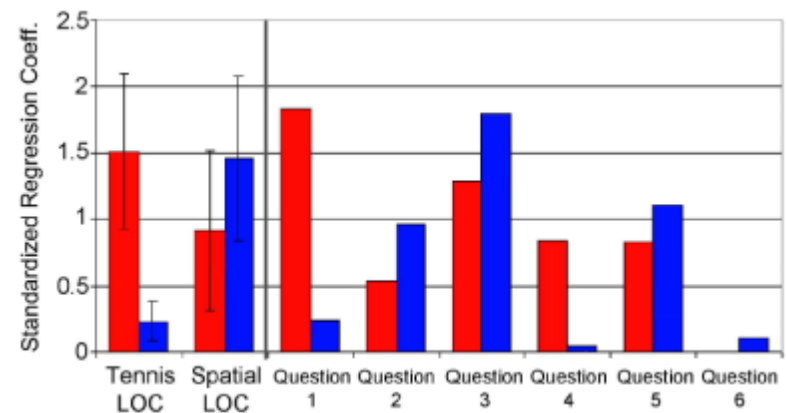


C04 TBI

L23 TBI

C06 TBI

L22 TBI



EEG-based communication

"MOVE YOUR FOOT"

"MOVE YOUR HAND"

HEALTHY
CONTROL
SUBJECT

"VEGETATIVE"
UNRESPONSIVE
PATIENT



www.thelancet.com



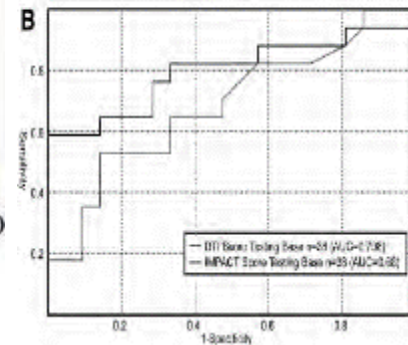
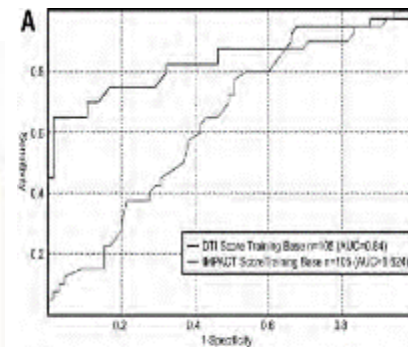
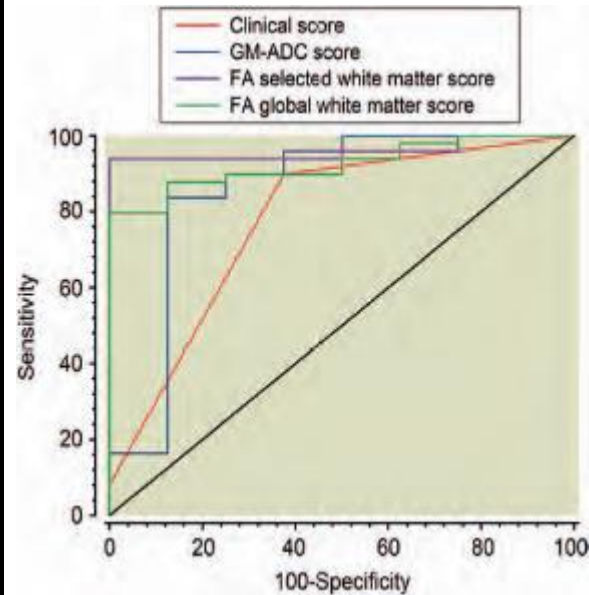
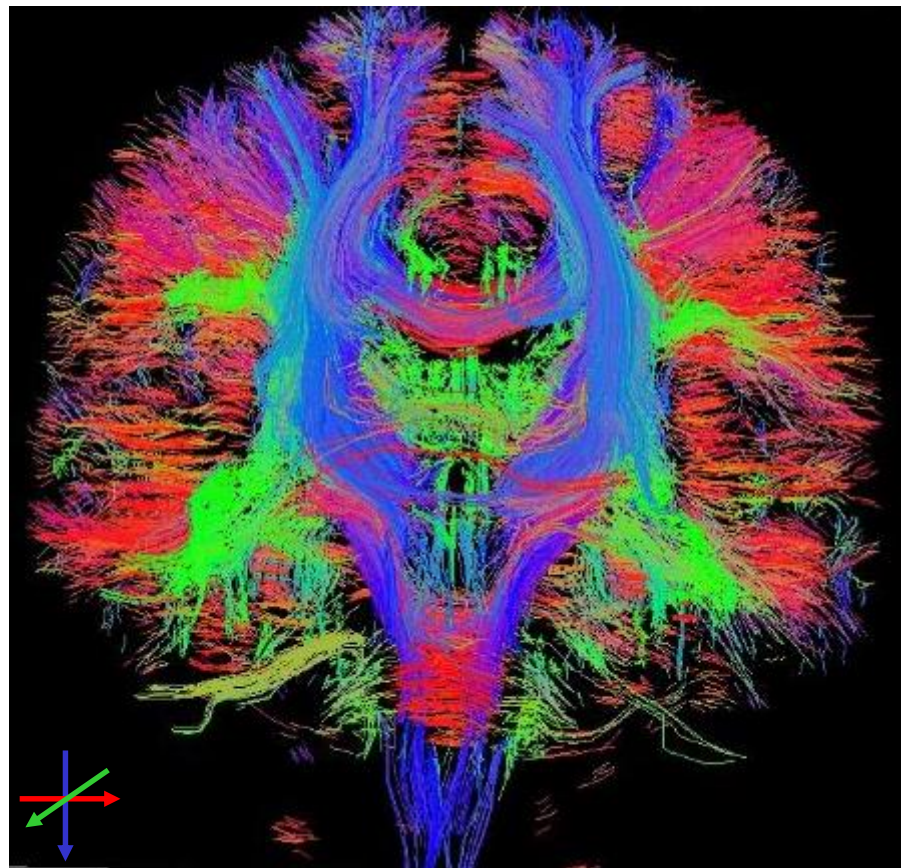
Cruse et al, *Lancet* 2012
3/16 VS/UWS (19%)

Cruse et al, *Neurology* 2012
7/23 MCS (30%)

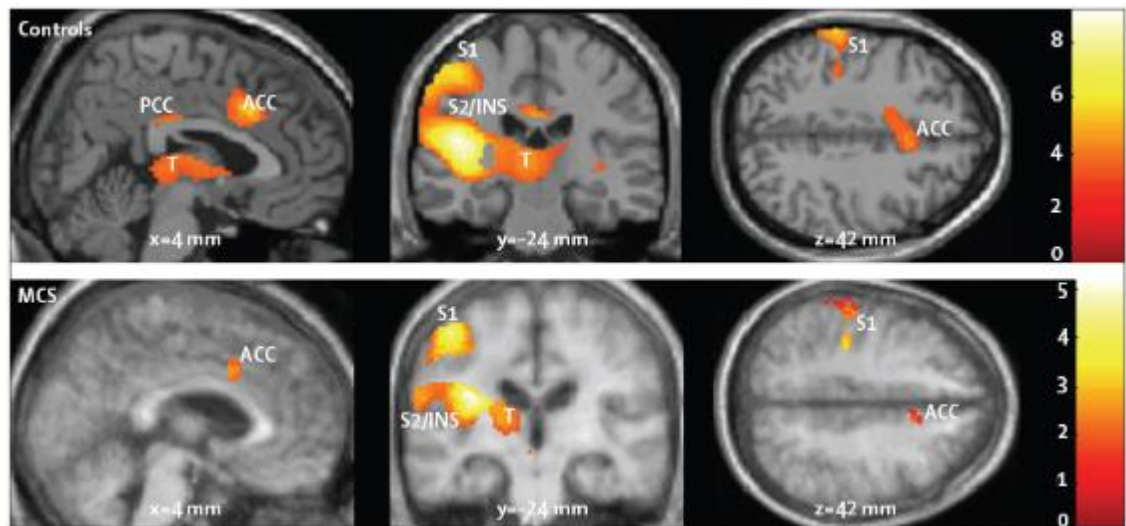
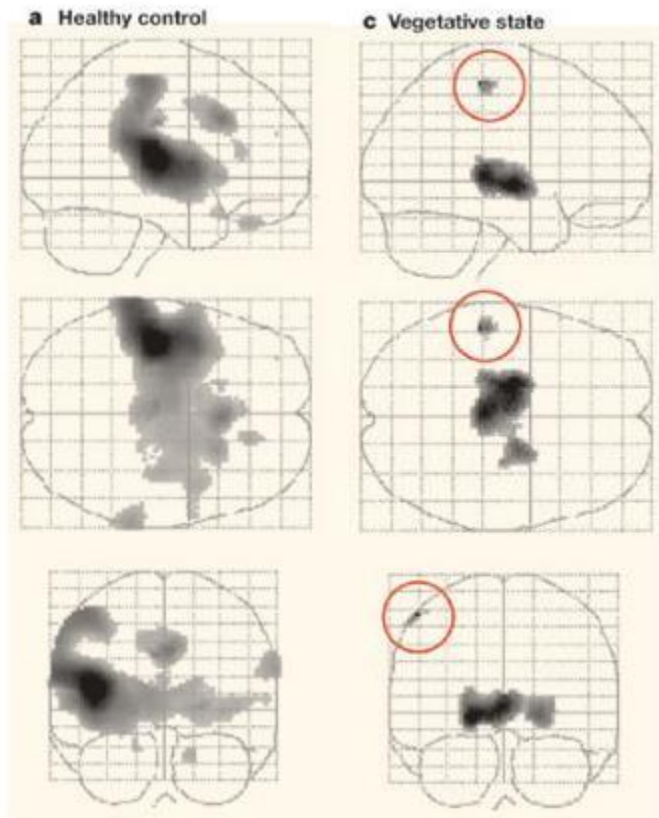
also see Goldfine et al, *Lancet* 2013

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Prognosis: MRI - DTI



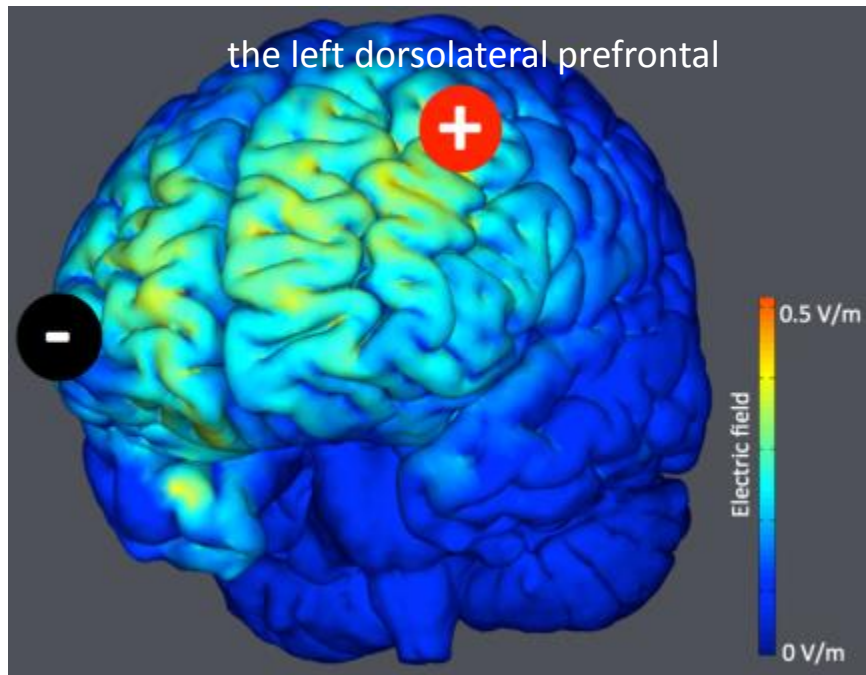
Pain in UWS and MCS



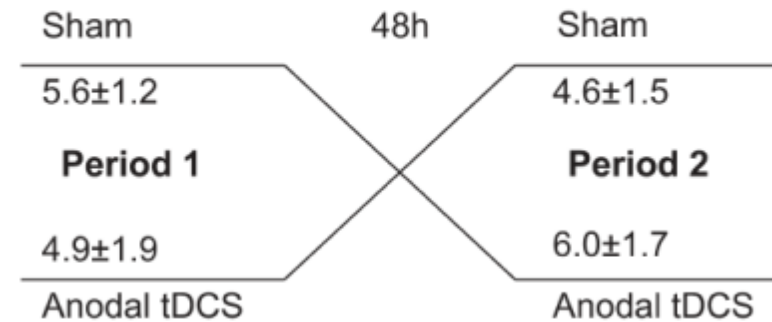
MCS patients activate the same areas as healthy controls, meaning that the stimulus can be integrated and processed

Stimulation: Frontal cortex (tDCS)

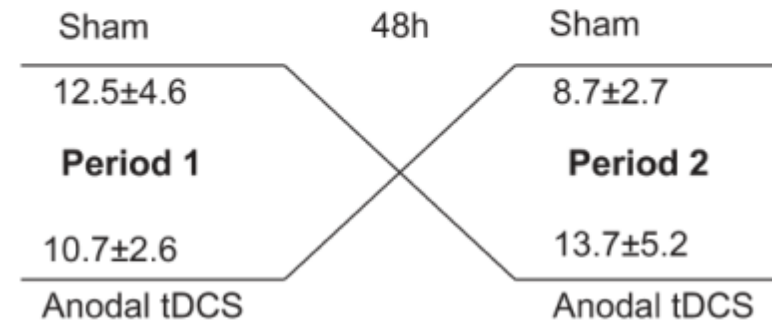
Transcranial Direct Current Stimulation (tDCS)



VS/UWS - CRS-R



MCS - CRS-R



Conclusion

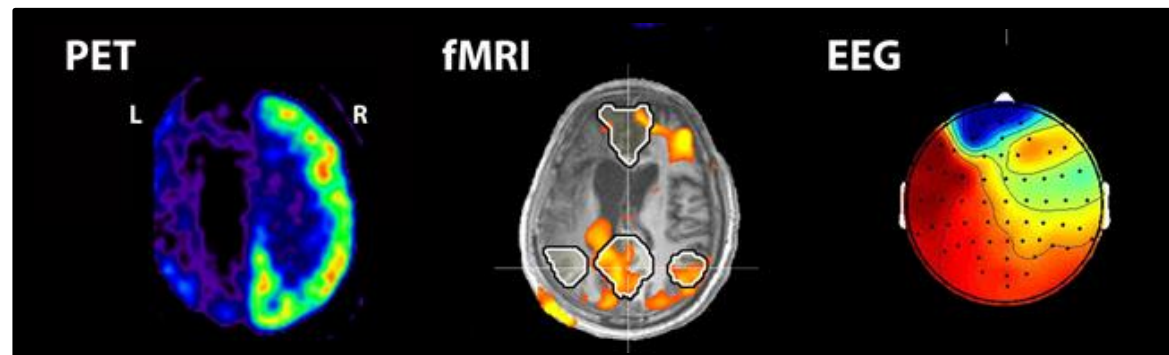
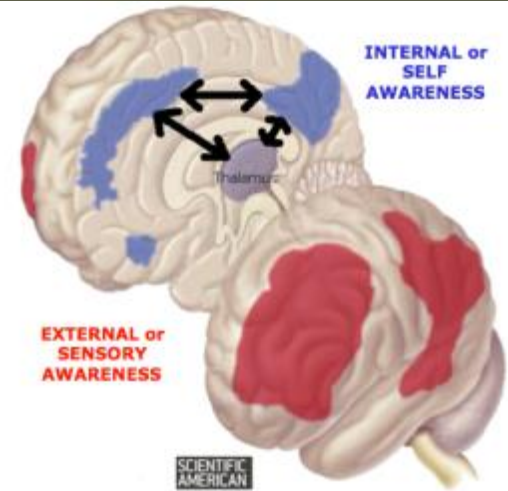
Human conscious awareness

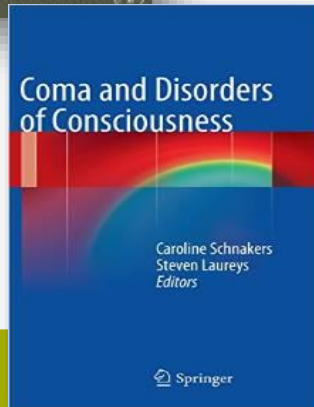
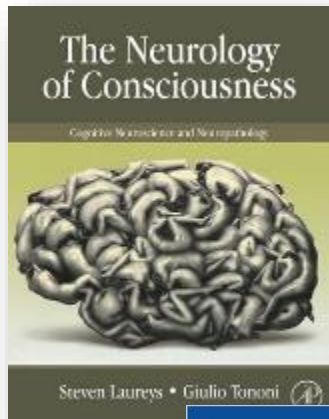
≈ emergent property of collective
critical neural network dynamics

Awareness can be subdivided into
internal and external awareness
supported by different networks

Diagnosis

CRS-R as gold standard
Neuroimaging
Neurophysiology





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FREEDOM TO RESEARCH



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