Oscillations and effective connectivity in human corticothalamic networks

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-Characterize EEG oscillations triggered by TMS
in healthy, awake subjects

-Measuring cortical effective connectivity
in different models of unconsciousness

-Characterize EEG oscillations triggered by TMS in healthy, awake subjects

-Measuring cortical effective connectivity in different models of unconsciousness

-Characterize EEG oscillations triggered by TMS in healthy, awake subjects

-Measuring cortical effective connectivity in different models of unconsciousness

Bedside assessment of consciousness by evaluating the patient's ability to interact with the external environment

CRS-R

COMA RECOVERY SCALE-REVISED

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Administration and Scoring Guidelines

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Center for Head Injuries
Edison, New Jersey

JFK
Johnson Rehabilitation Institution
Affiliated with JFK Medical Center
SOLARIS HEALTH SYSTEM

Updated 11-1-05

JFK COMA RECOVERY SCALE - REVISED ©2004

Record Form

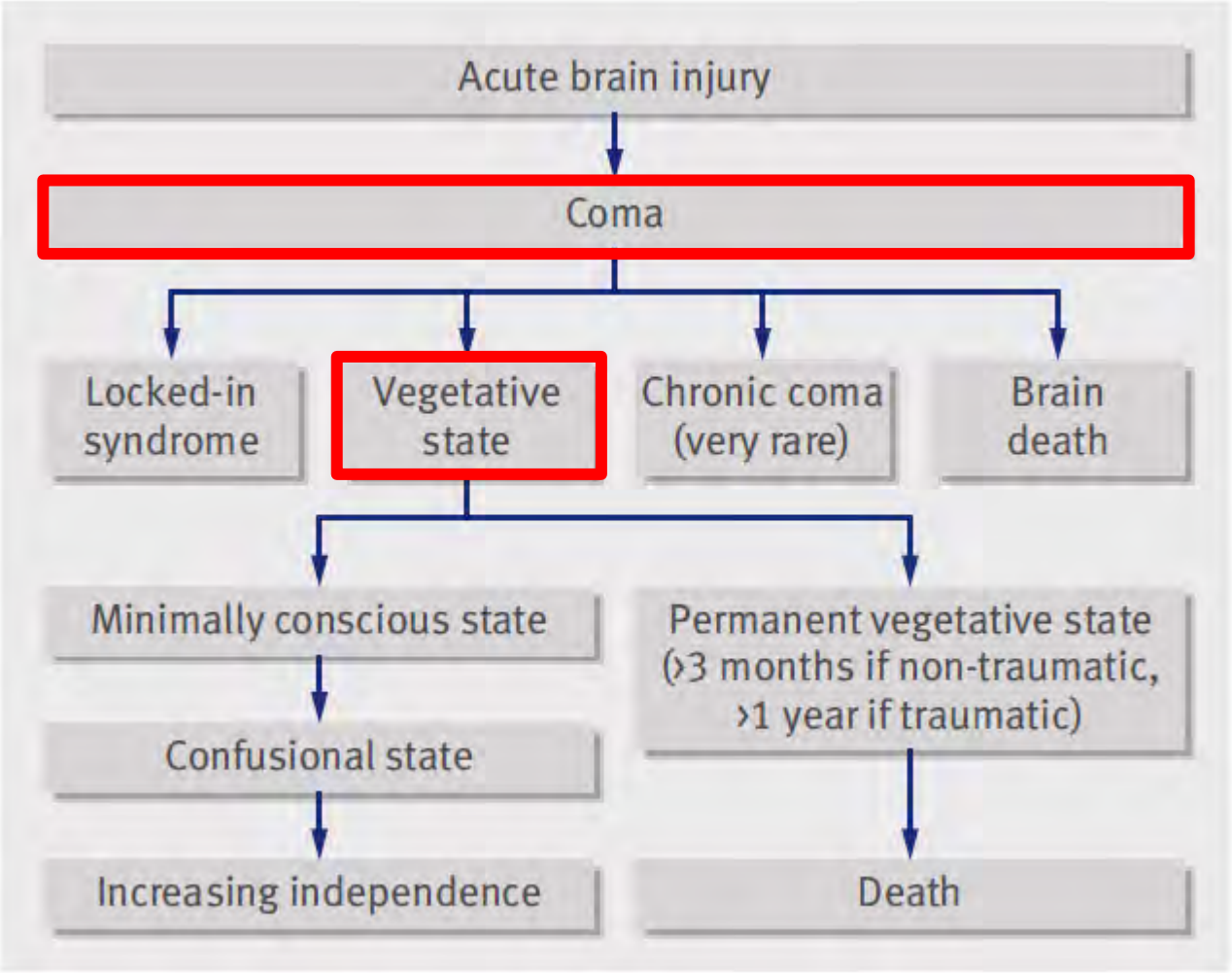
This form should only be used in association with the "CRS-R ADMINISTRATION AND SCORING GUIDELINES" which provide instructions for standardized administration of the scale.

Patient:	Diagnosis:	Etiology:
Date of Onset:	Date of Admission:	

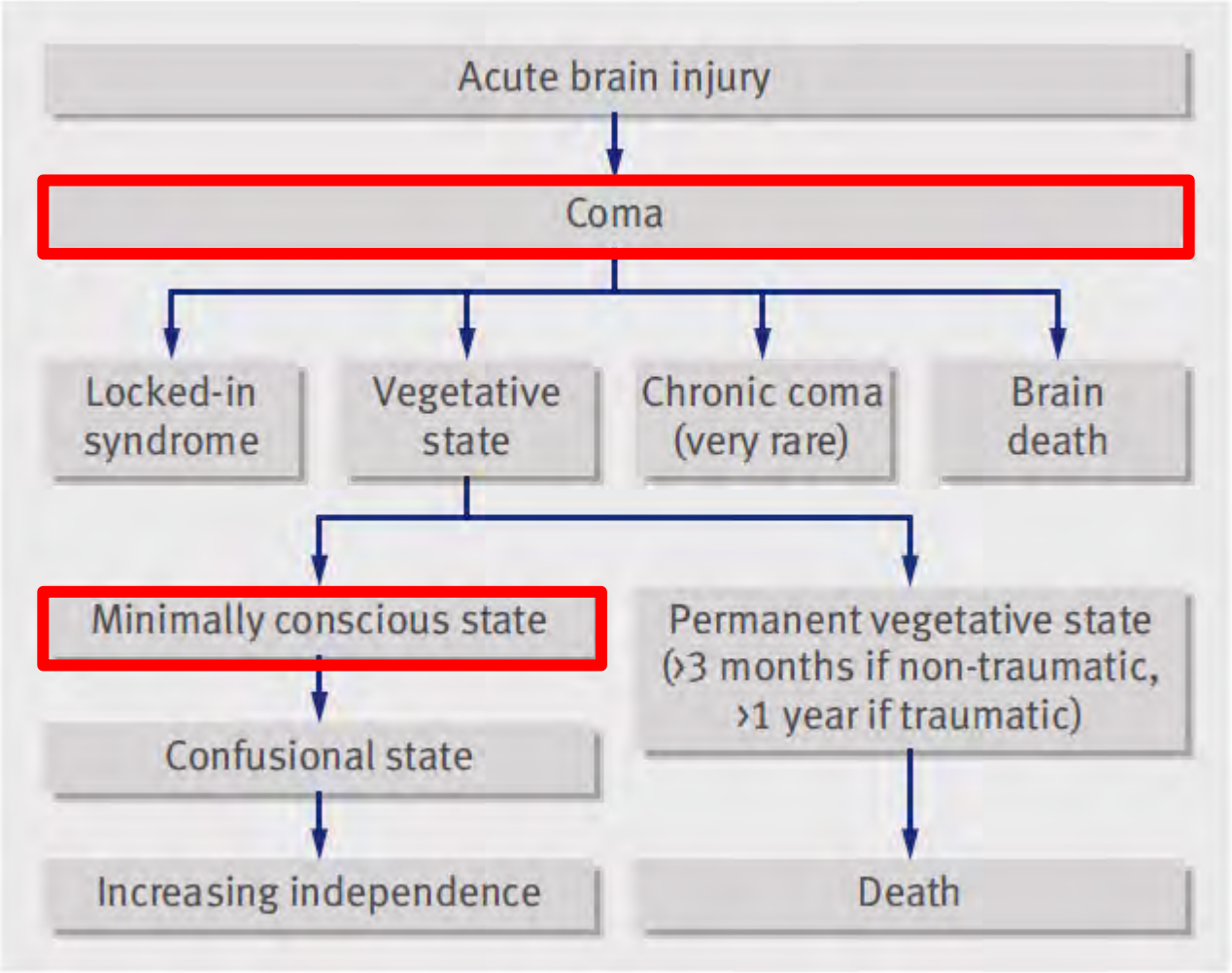
Date																
Week	ADM	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AUDITORY FUNCTION SCALE																
4 - Consistent Movement to Command *																
3 - Reproducible Movement to Command *																
2 - Localization to Sound																
1 - Auditory Startle																
0 - None																
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																

Denotes emergence from MCS †
Denotes MCS *

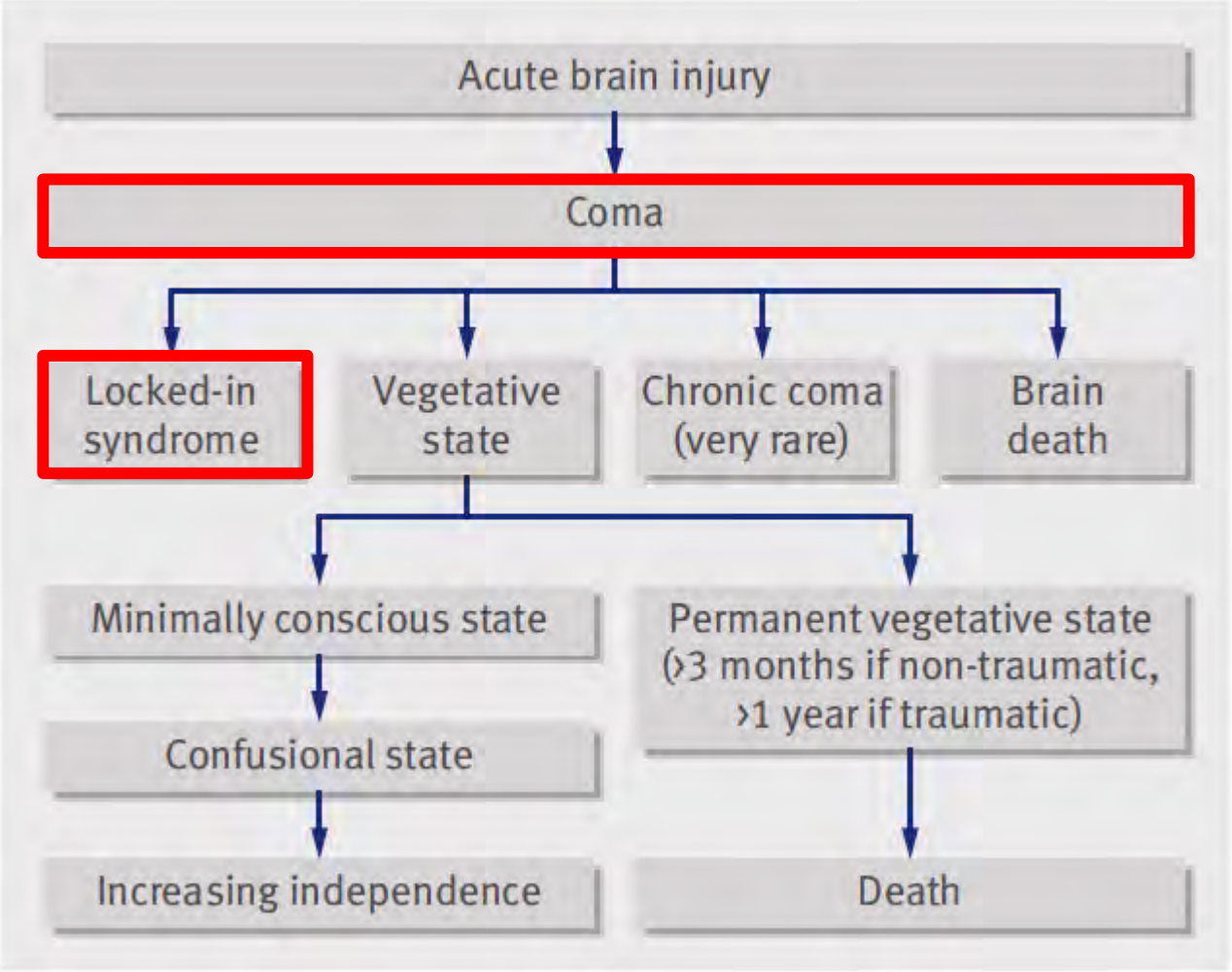
Vegetative State: the patient recovers sleep/wake cycles, yet there is no functional communication with the external world



Minimally Conscious State: the patient shows inconsistent signs of interaction with the external world, yet no functional communication

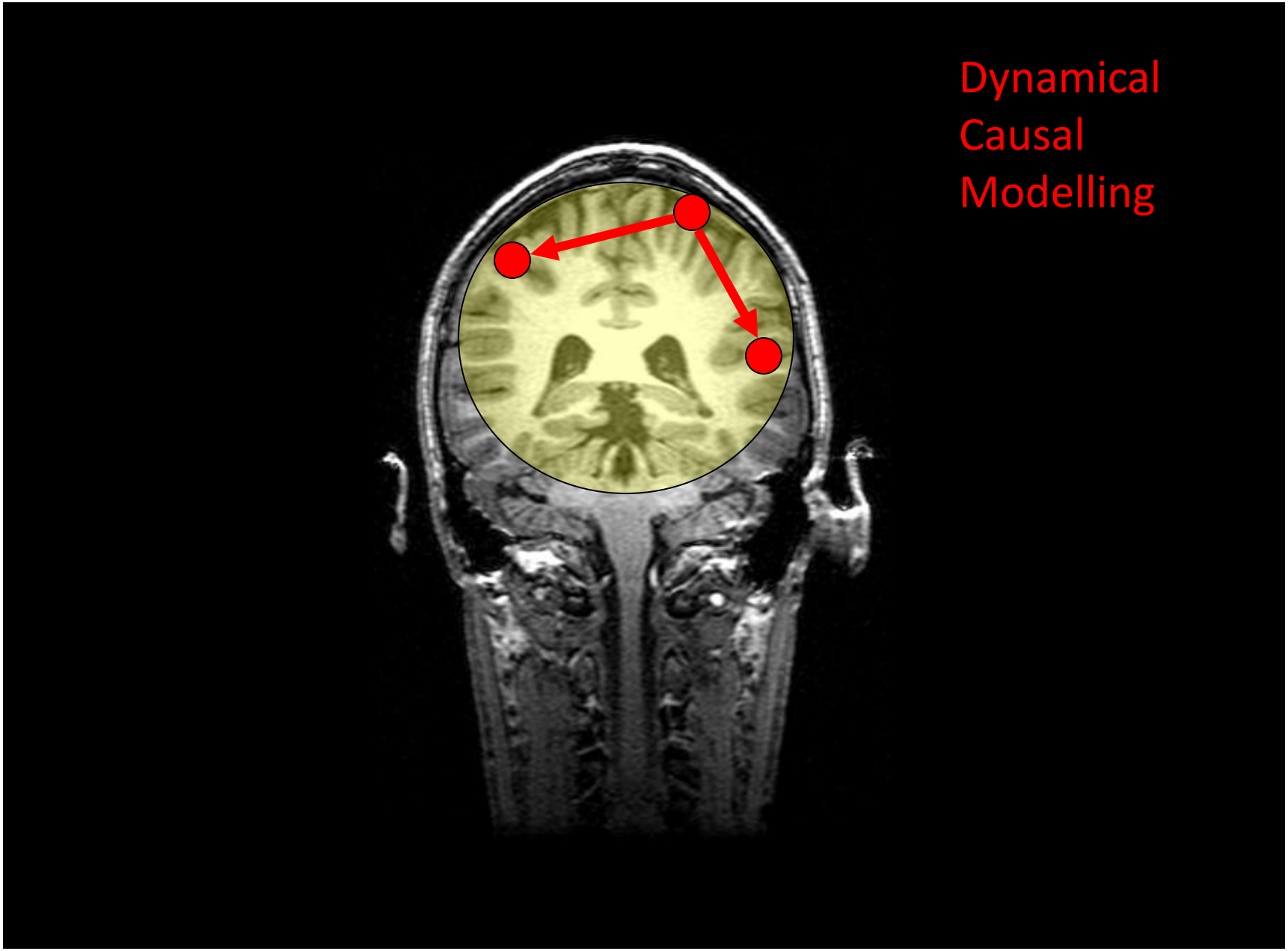


Locked-In Syndrome: the patient is fully conscious, yet her/he cannot functionally communicate due to lesions of the motor pathways

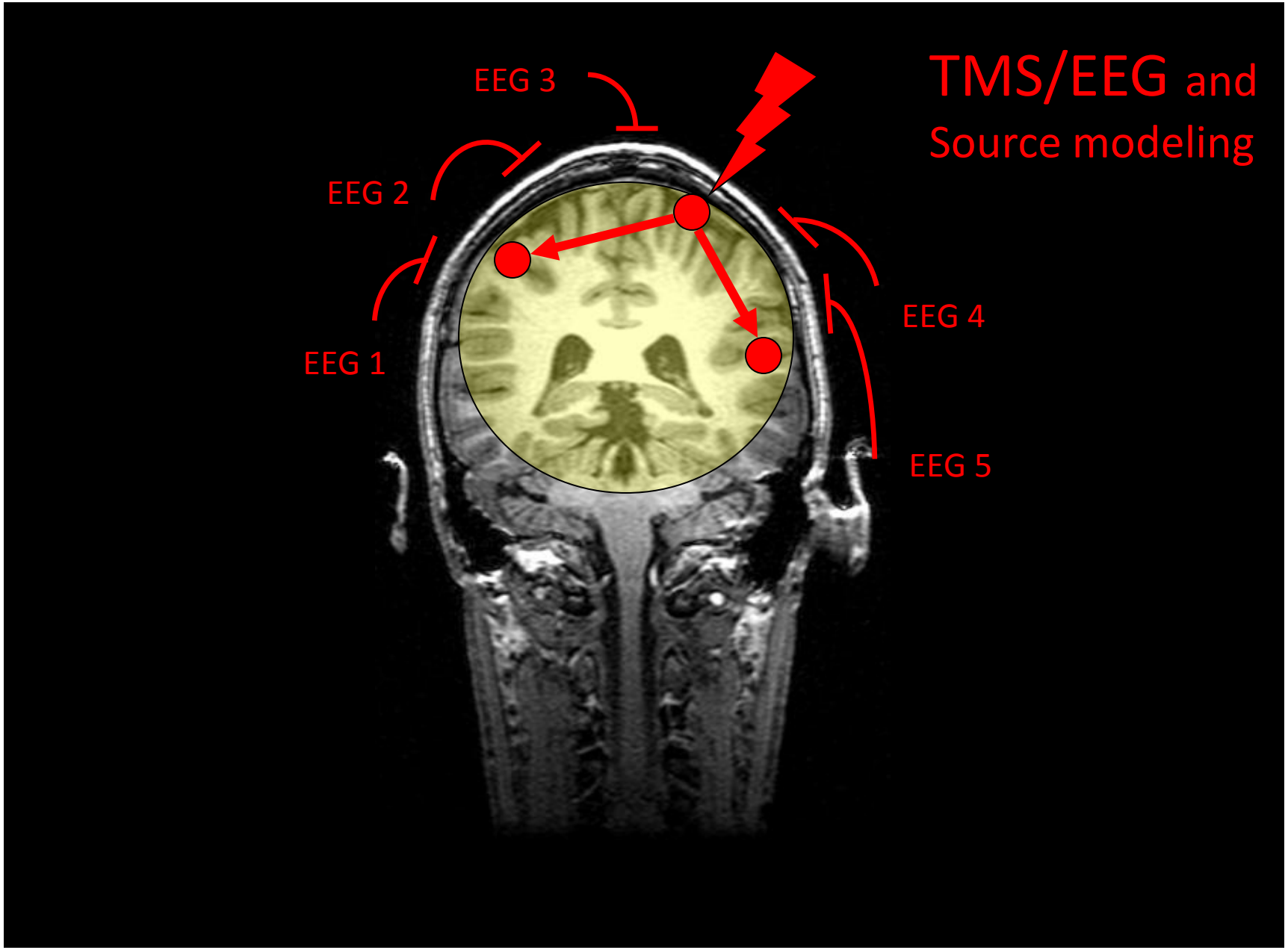


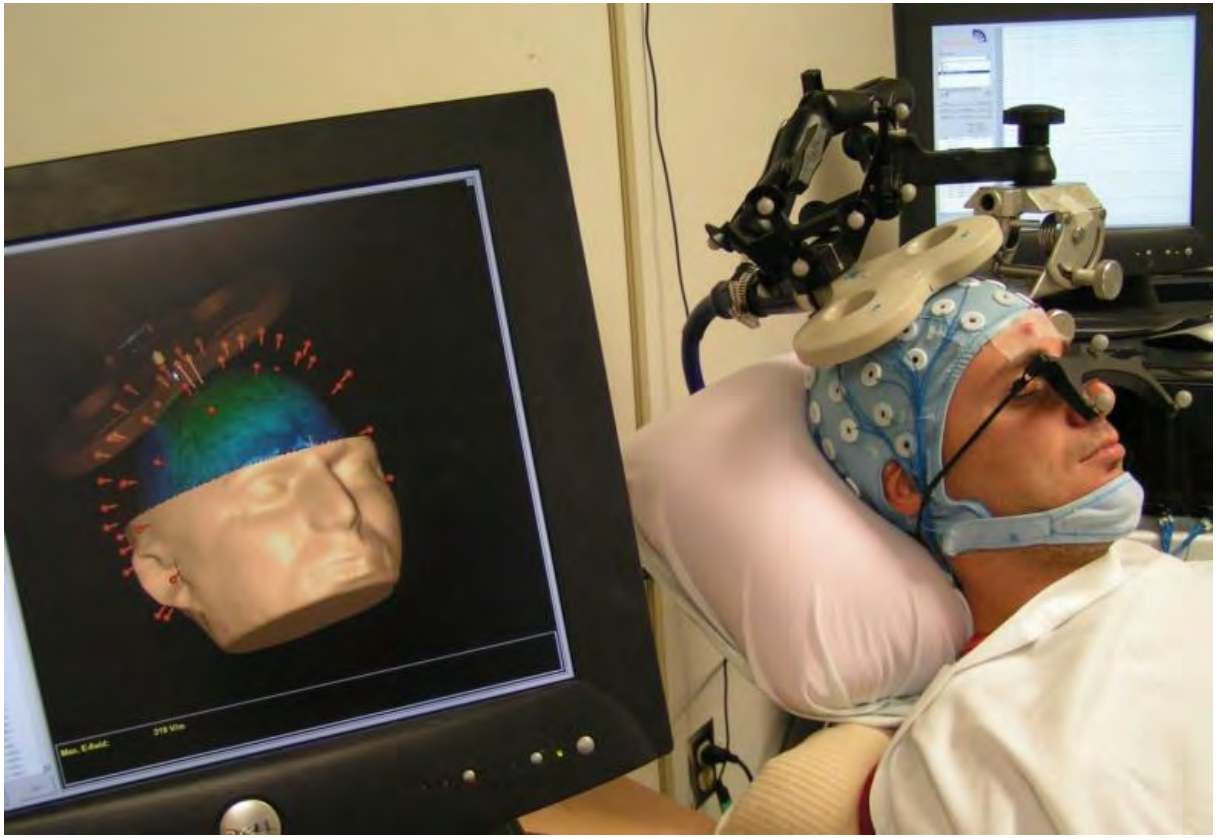
INTRACORTICAL COMMUNICATION

INTRACORTICAL COMMUNICATION

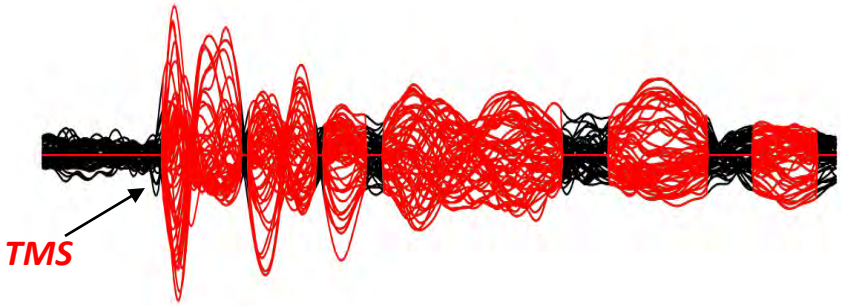


INTRACORTICAL COMMUNICATION

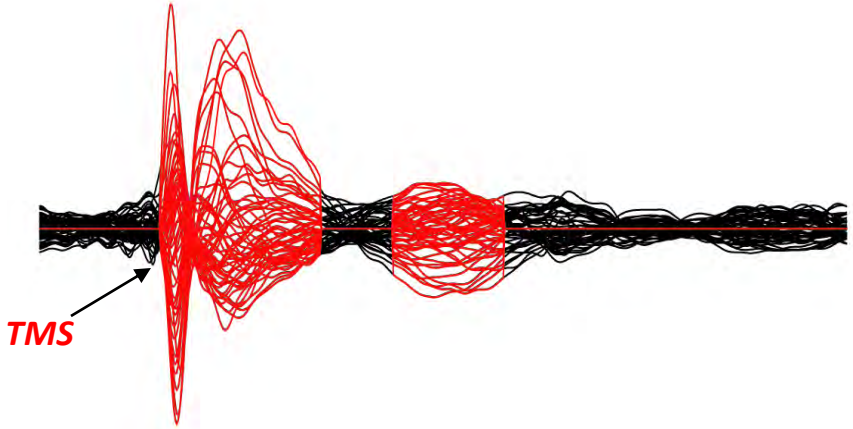


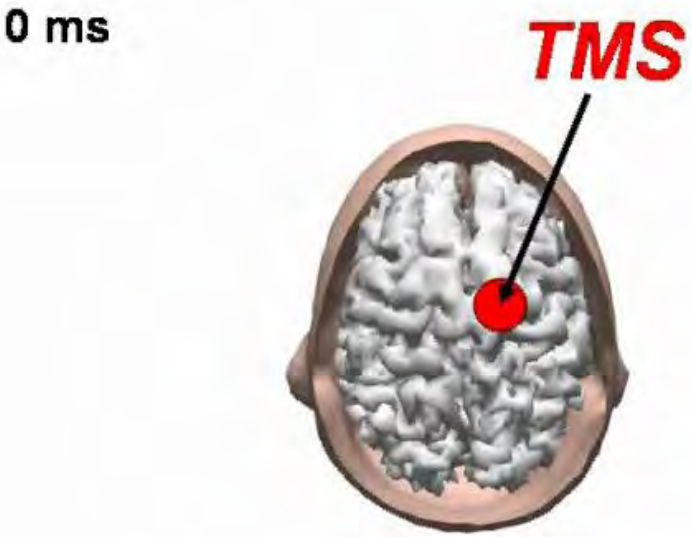


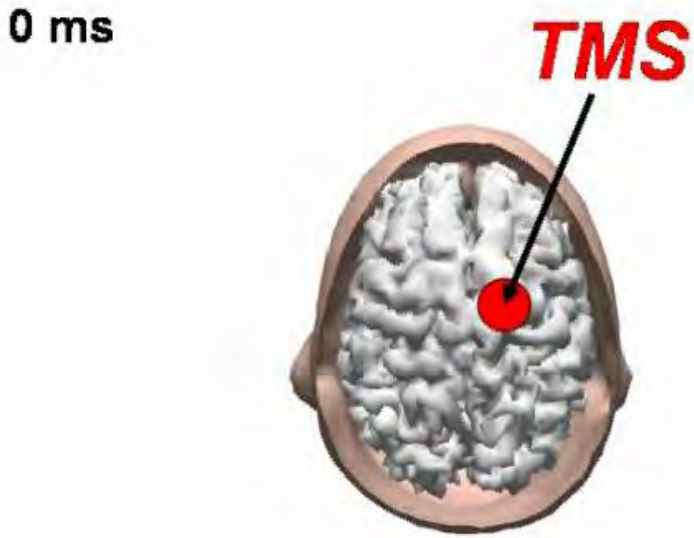
Wakefulness



Sleep

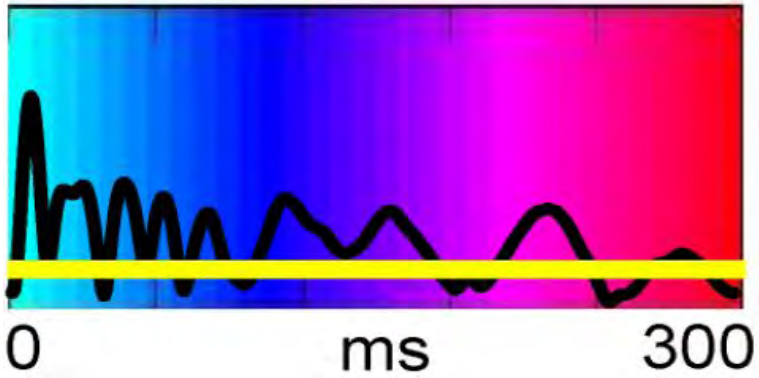




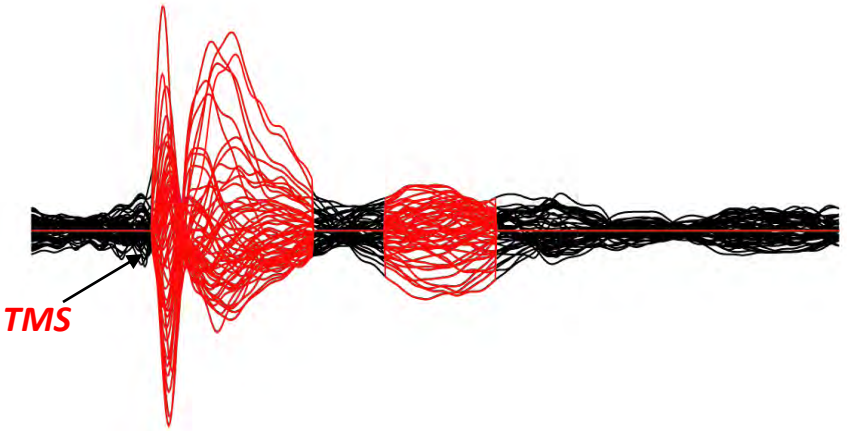


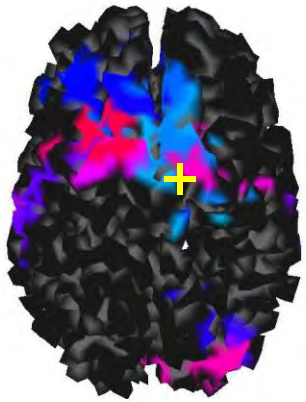
Massimini et al., Science 2005

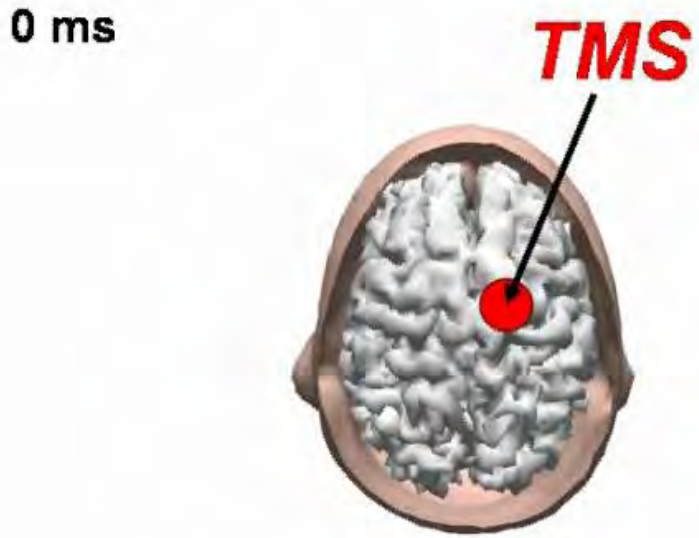
Wakefulness



Sleep

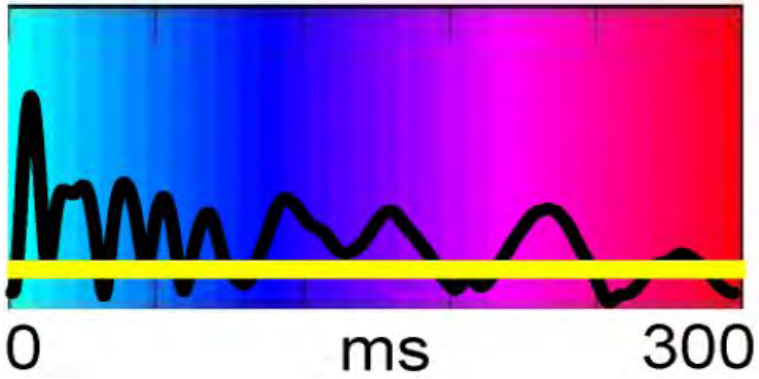


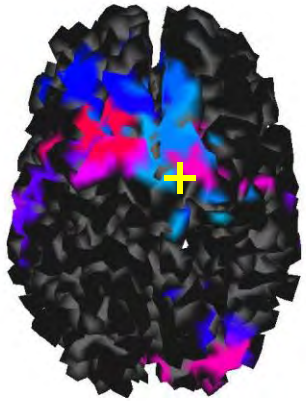




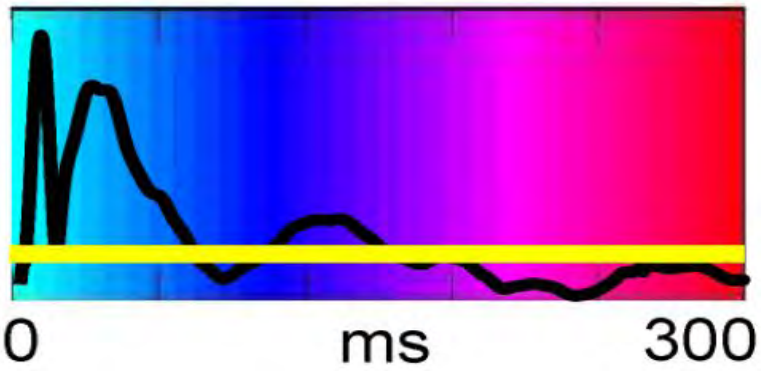
Massimini et al., Science 2005

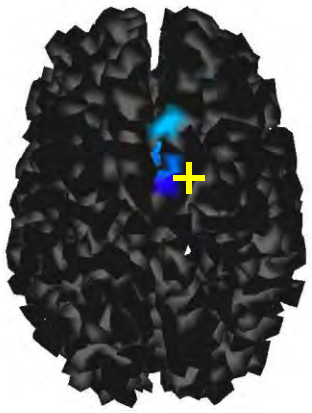
Wakefulness



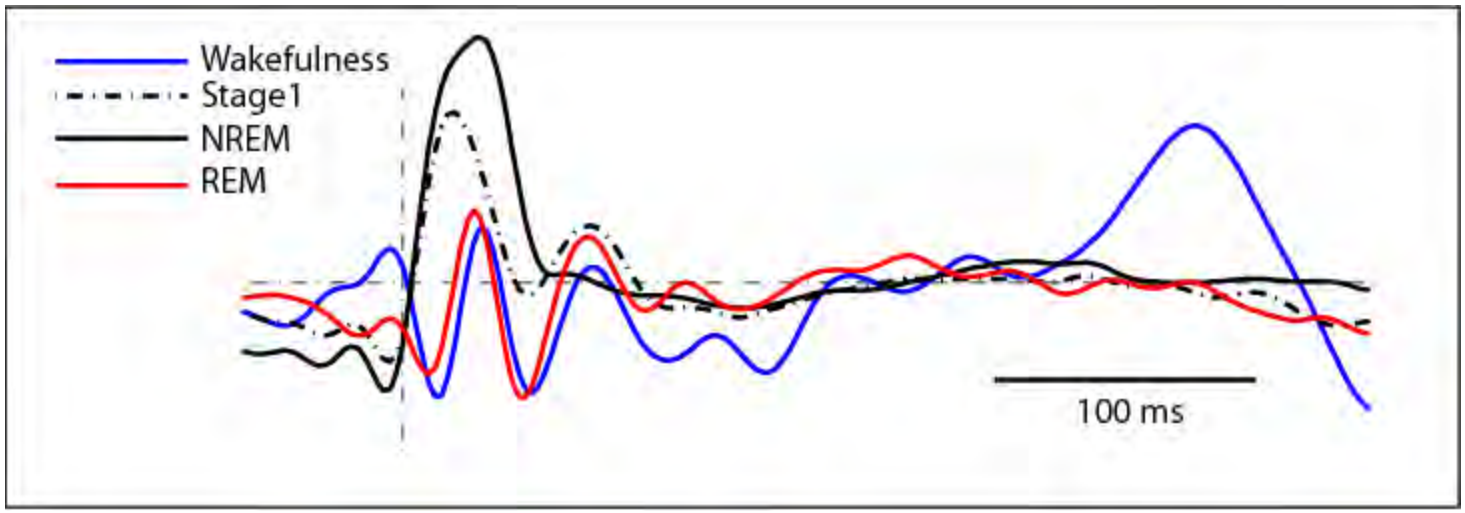


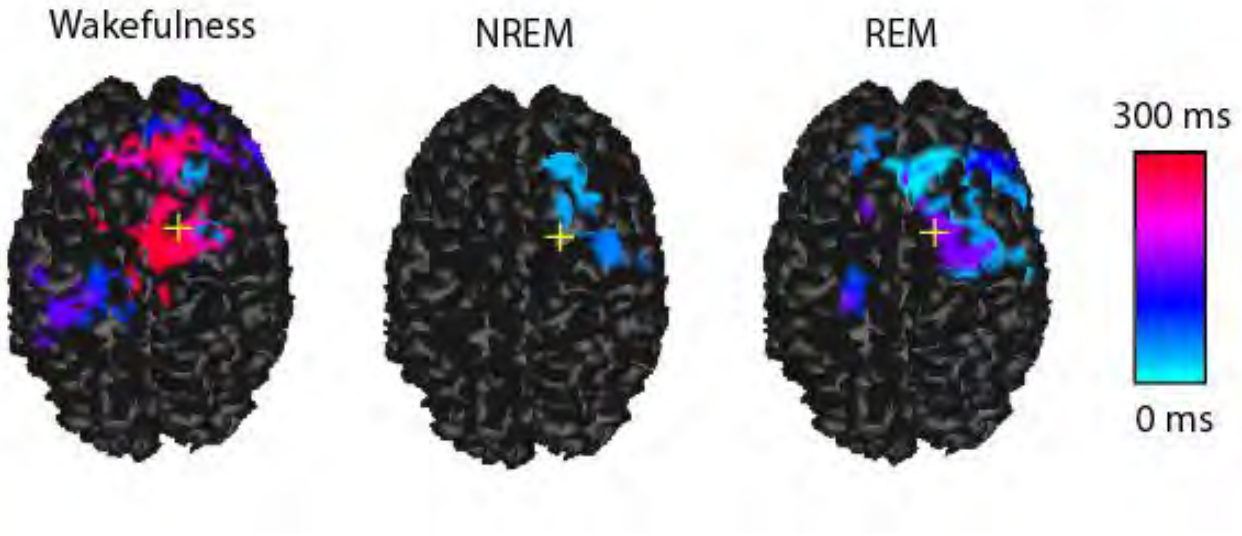
Sleep





Massimini et al., Science 2005



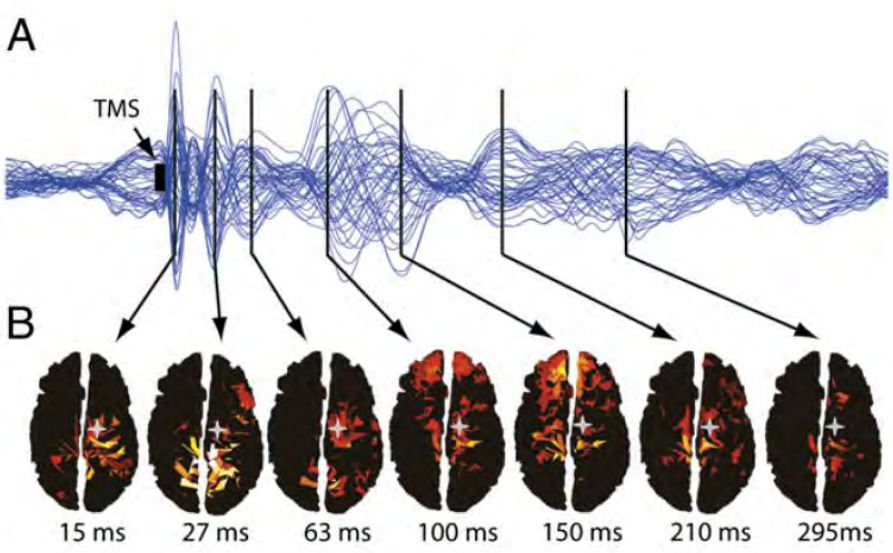


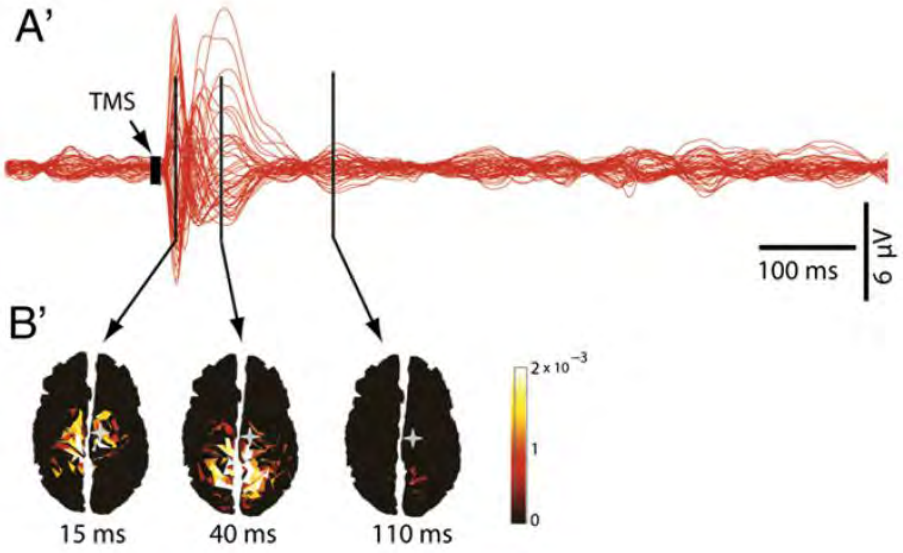
Massimini et al., *Cogn. Neurosci, 2010*

Ferrarelli et al., PNAS 2009

Wakefulness

Anaesthesia (Midazolam)

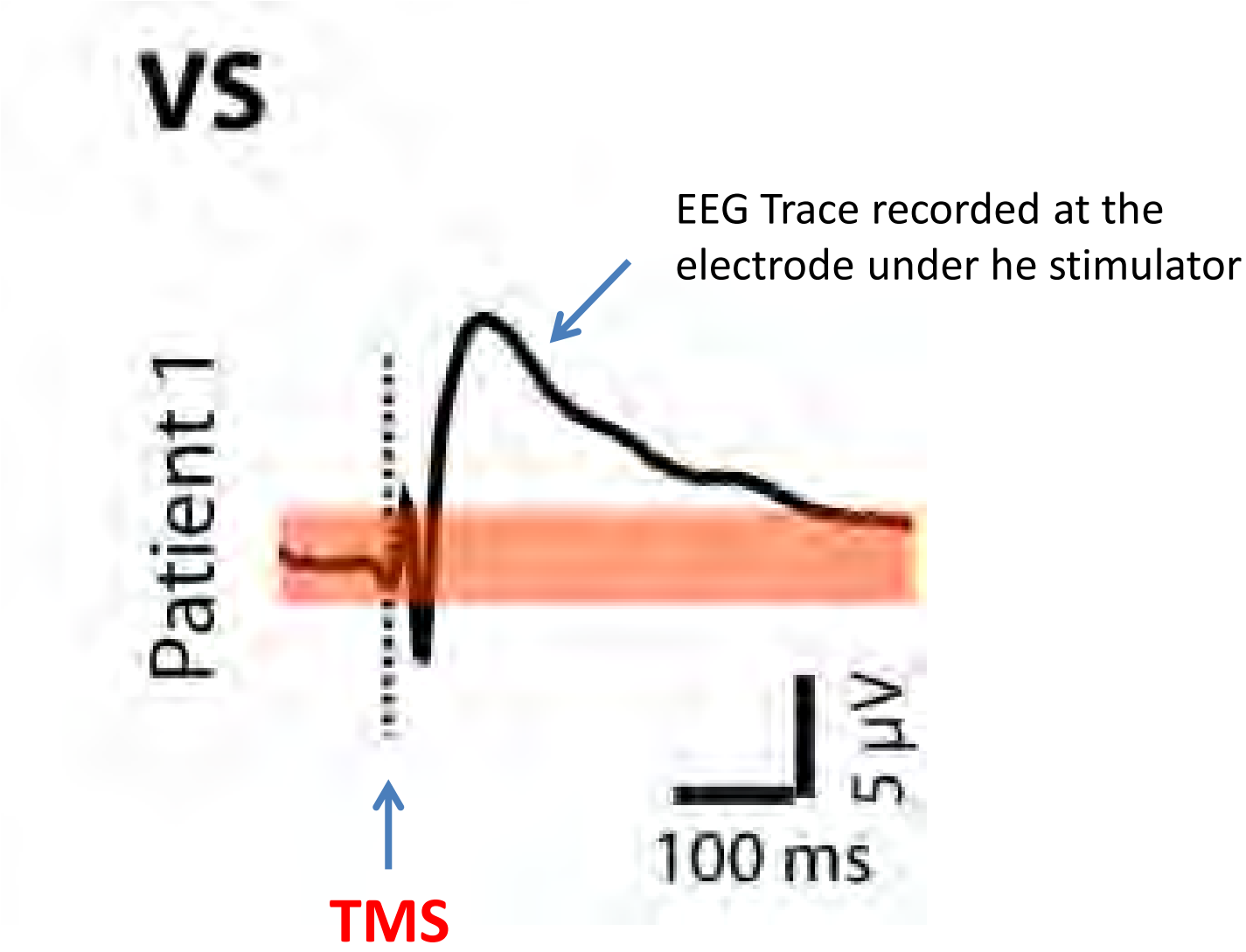




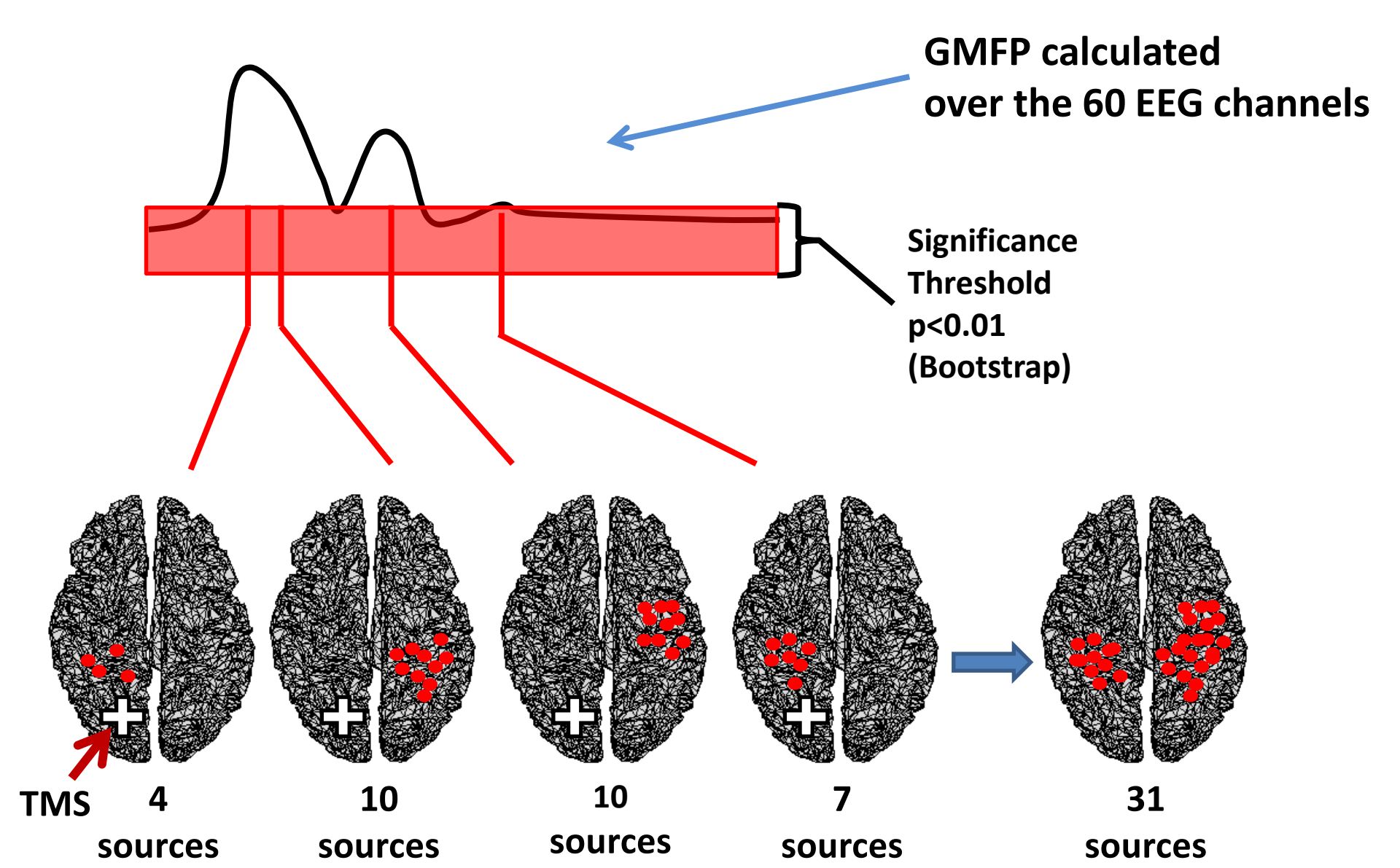
Transcranial Magnetic Stimulation
combined with EEG
and source modelling
in non-communicating
brain-injured patients:

Vegetative State (**VS**) and
Minimally Conscious State (**MCS**)
Locked-In Syndrome (**LIS**)

Vegetative State
(vigilance without awareness)



Rosanova, Gosseries et al., Brain 2012

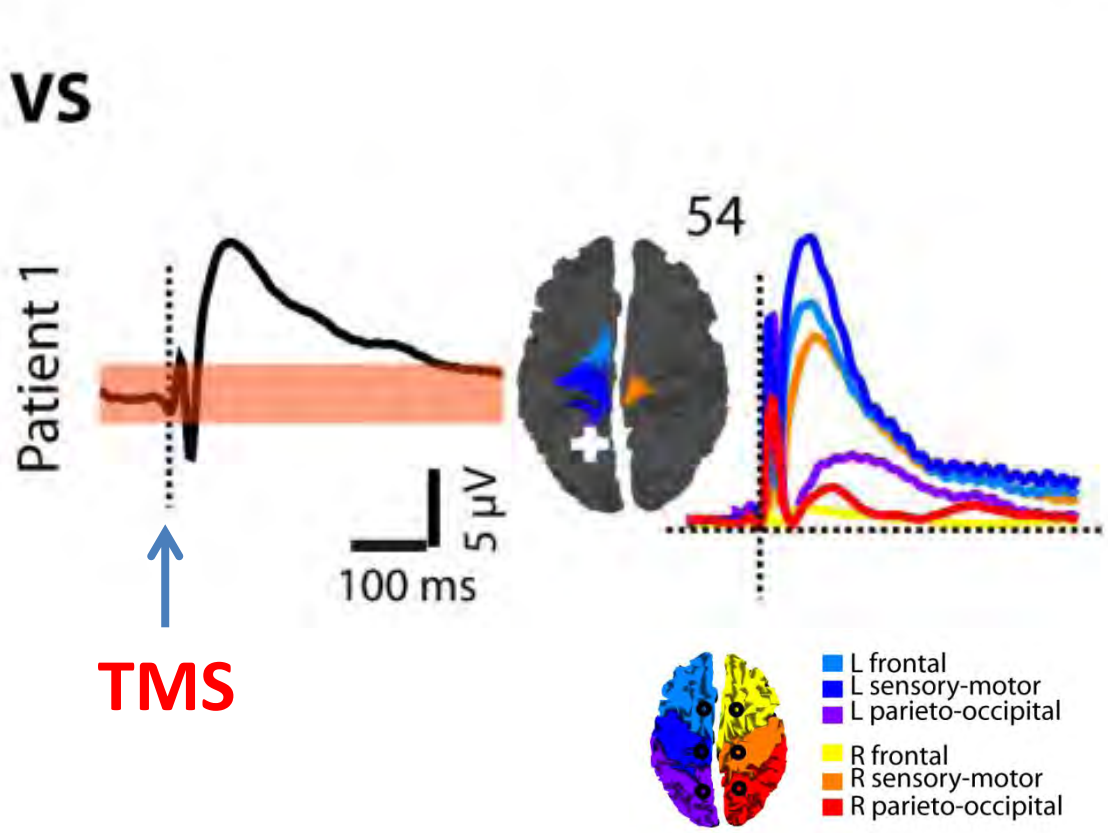


Source Modelling was computed by means of Minimum Norm Estimate (MNE)

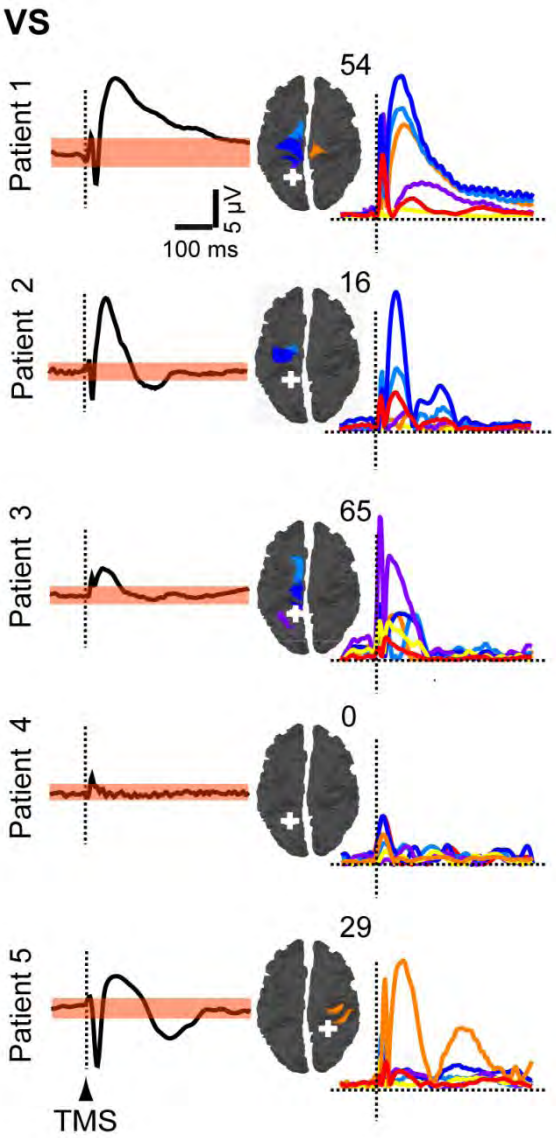
31
sources

L frontal
L sensory-motor
L parieto-occipital

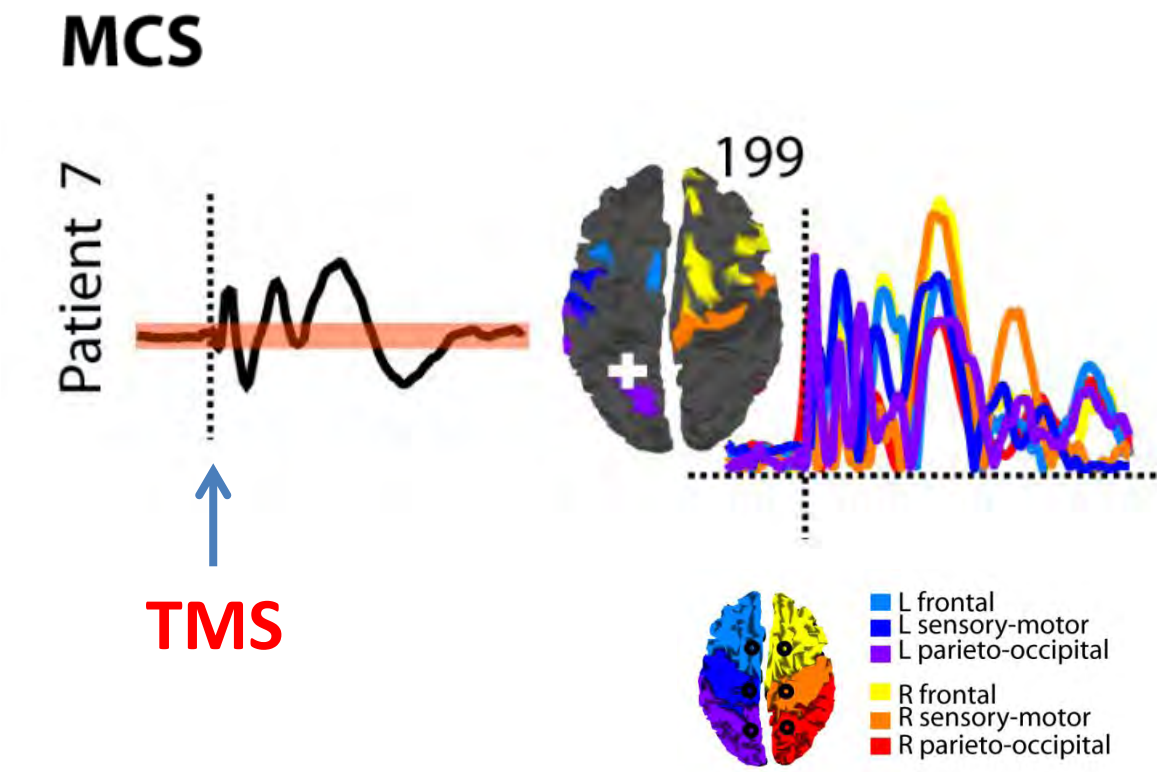
R frontal
R sensory-motor
R parieto-occipital



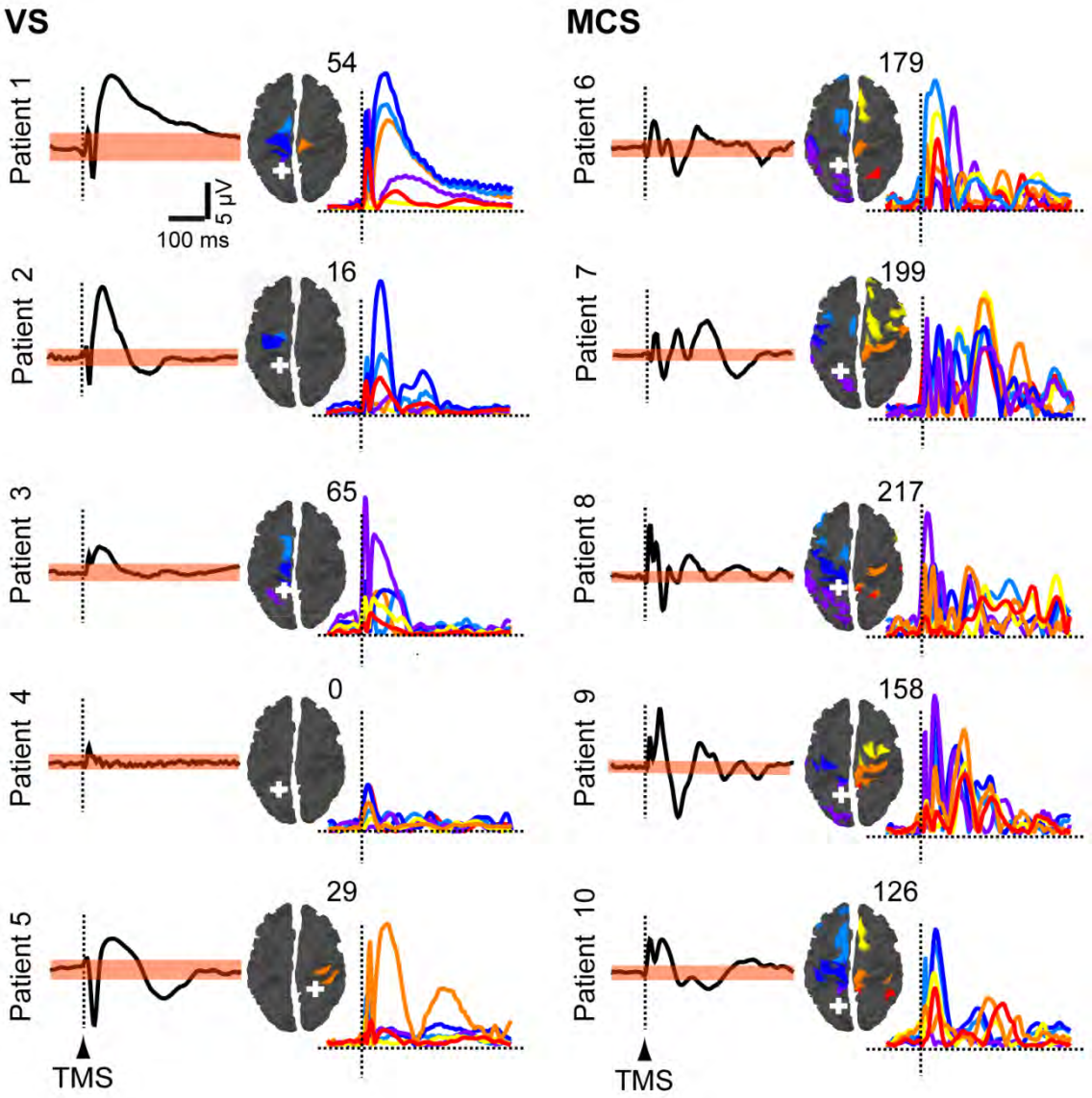
Rosanova, Gosseries et al., Brain 2012



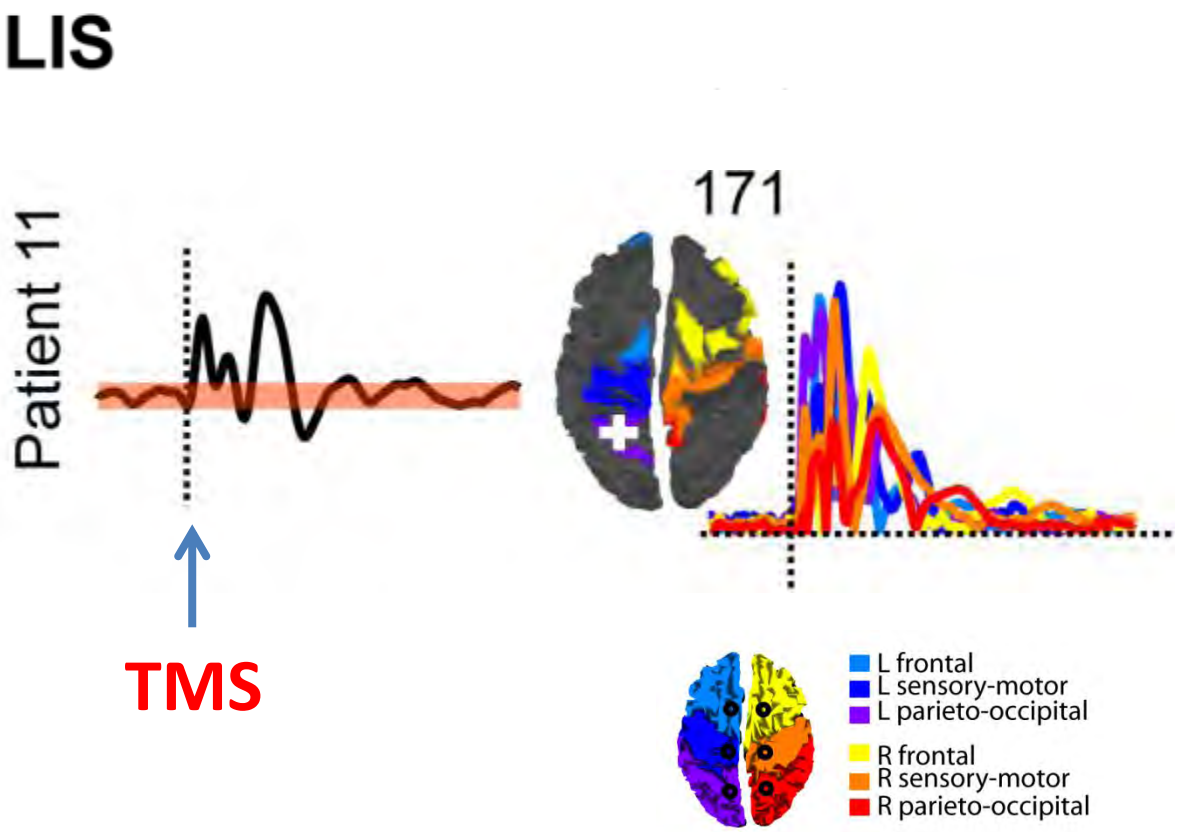
Rosanova, Gosseries et al., Brain 2012



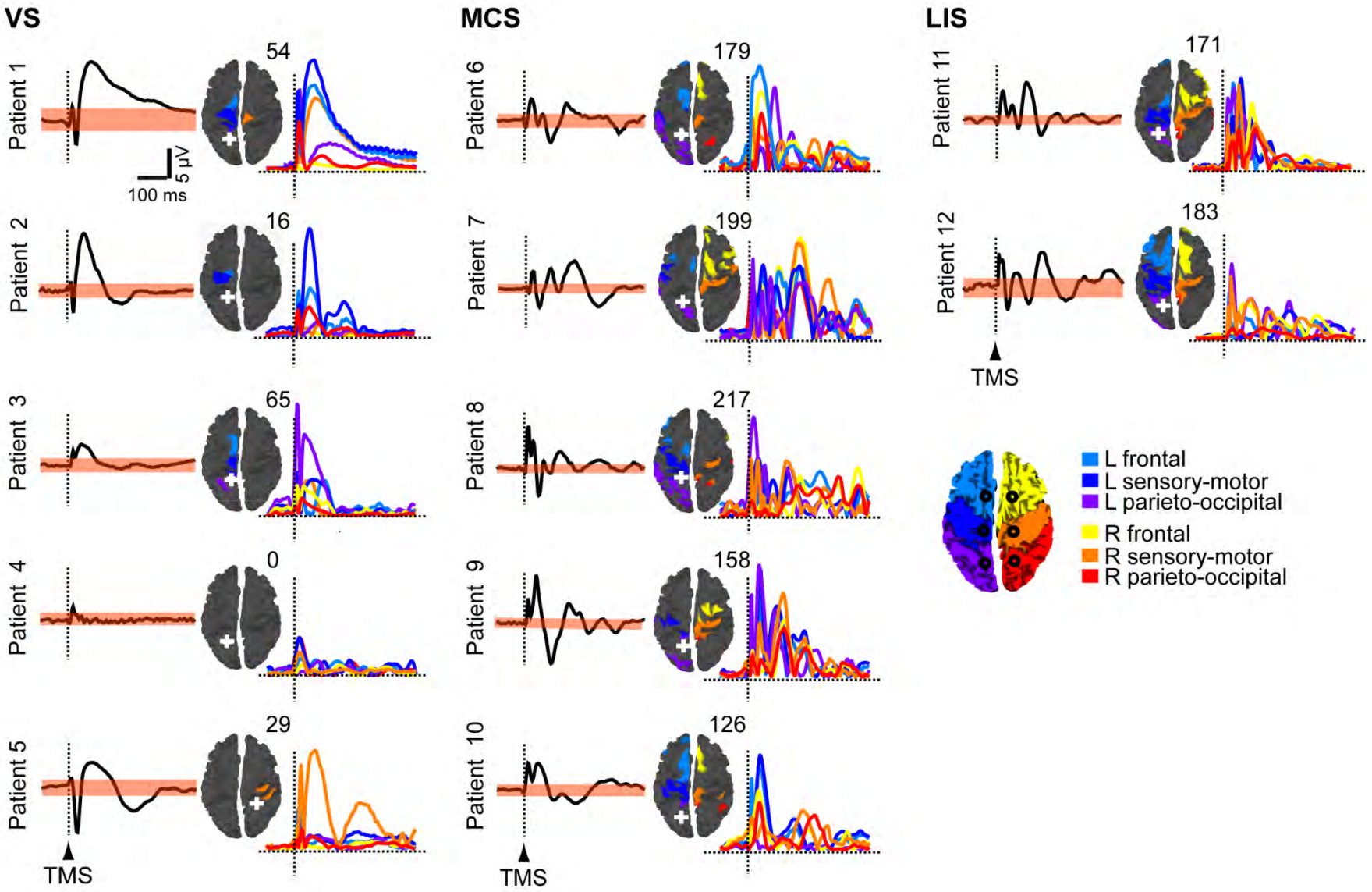
Rosanova, Gosseries et al., Brain 2012



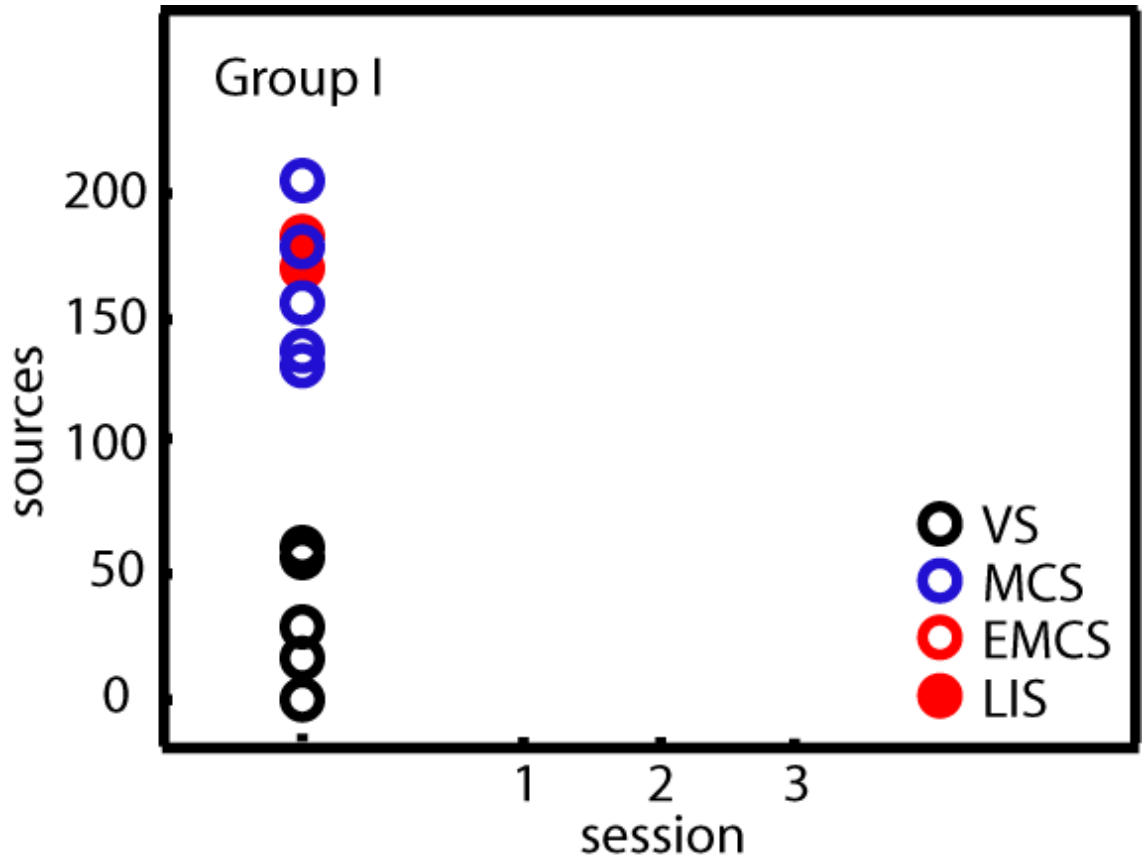
Rosanova, Gosseries et al., Brain 2012



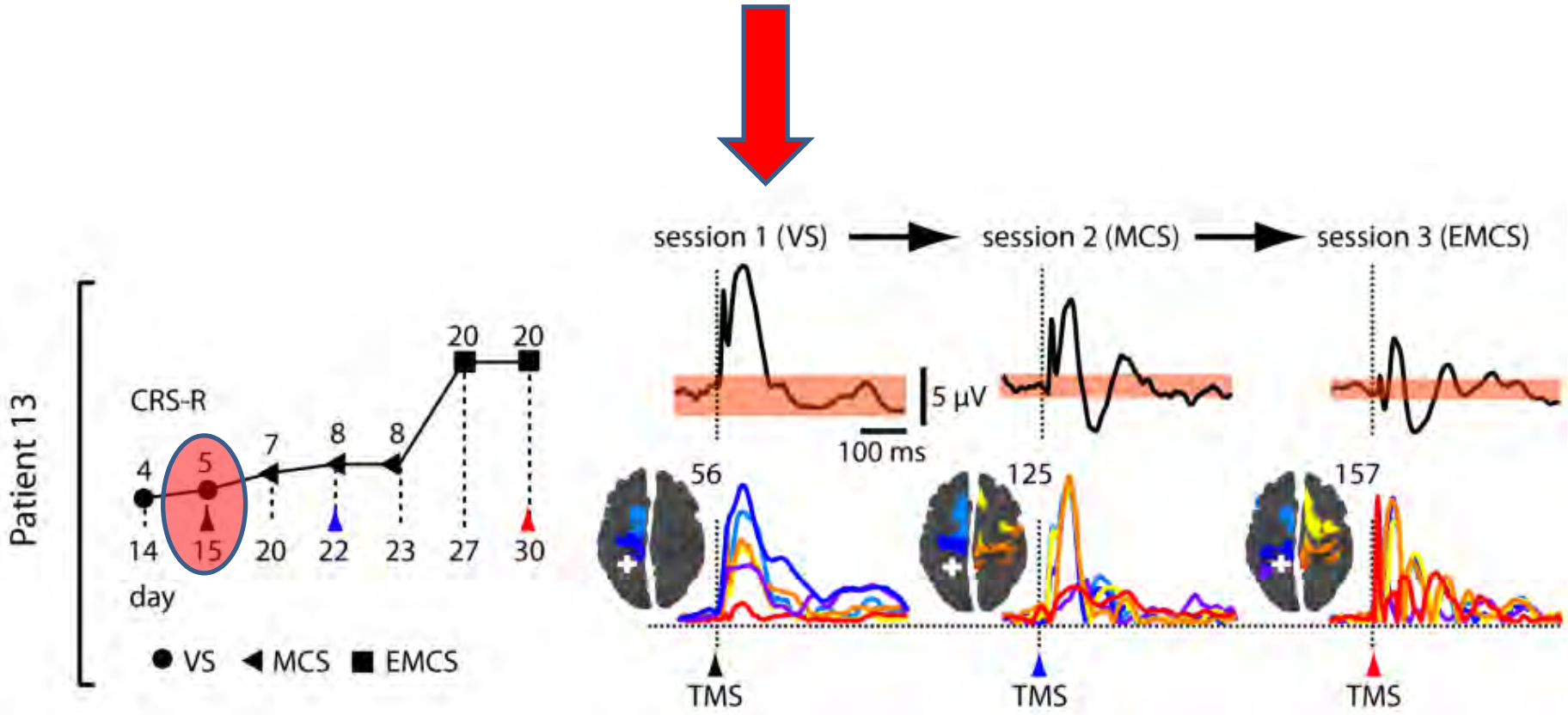
Rosanova, Gosseries et al., Brain 2012



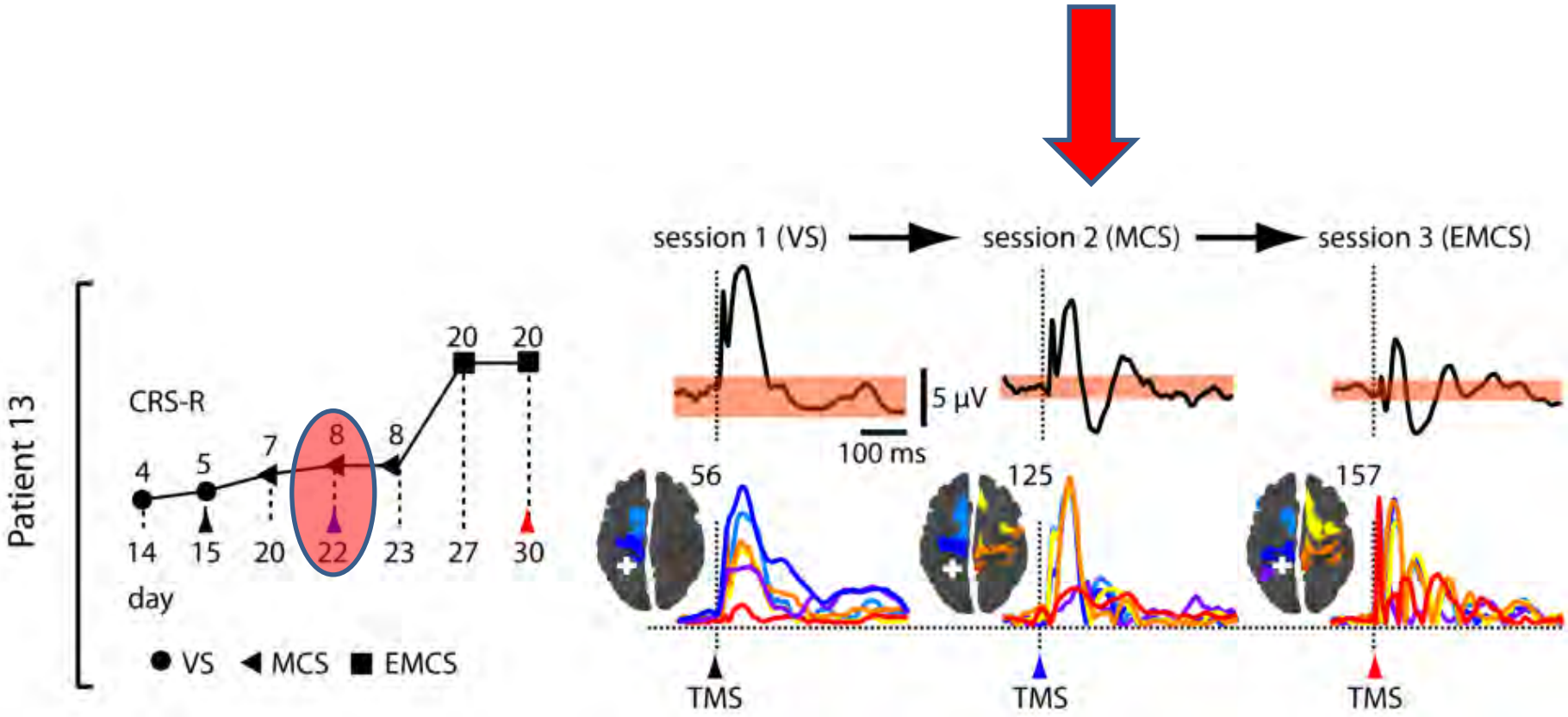
Rosanova, Gosseries et al., Brain 2012


Group I
200
150
100
50
0
sources
1
2
3
session
VS
MCS
EMCS
LIS

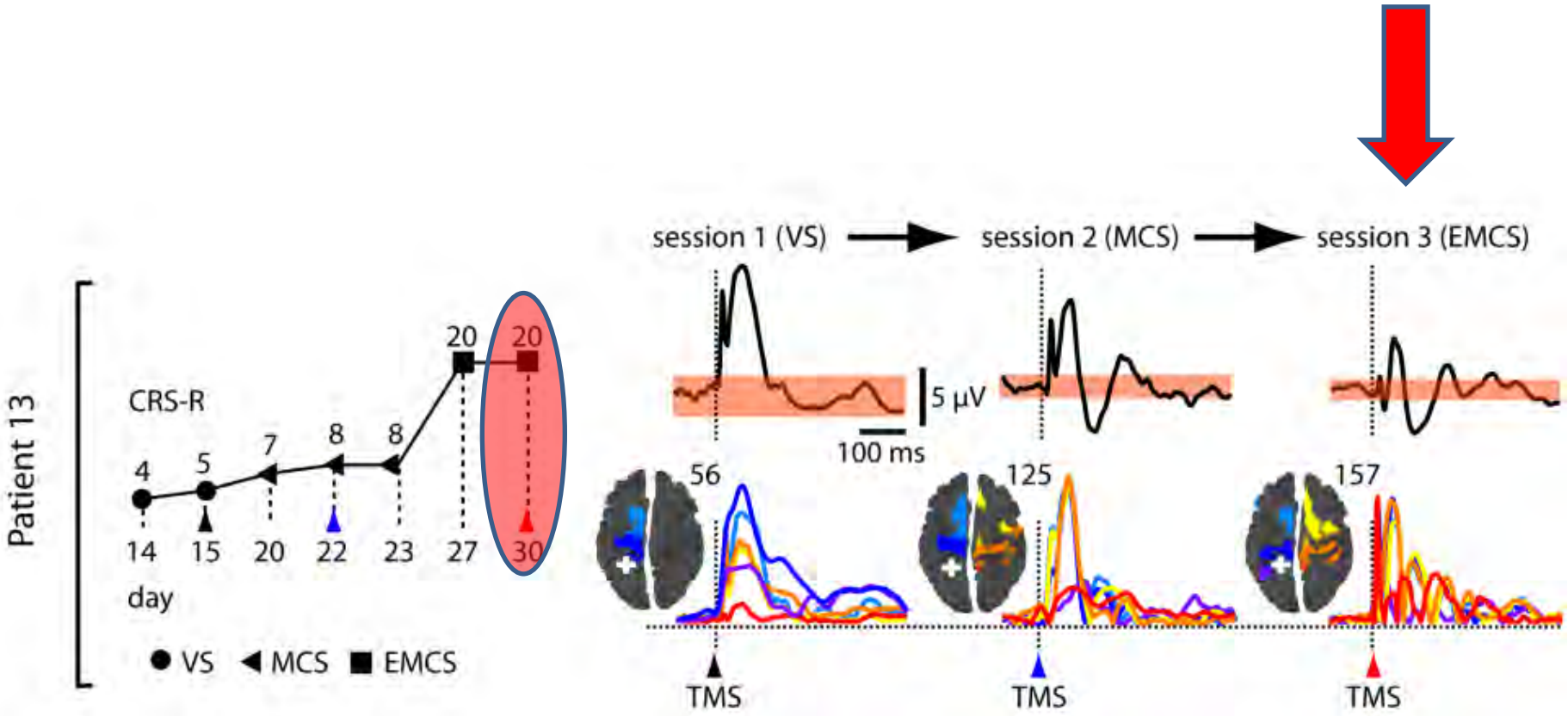
Longitudinal measurements in acute patients



Rosanova, Gosseries et al., Brain 2012

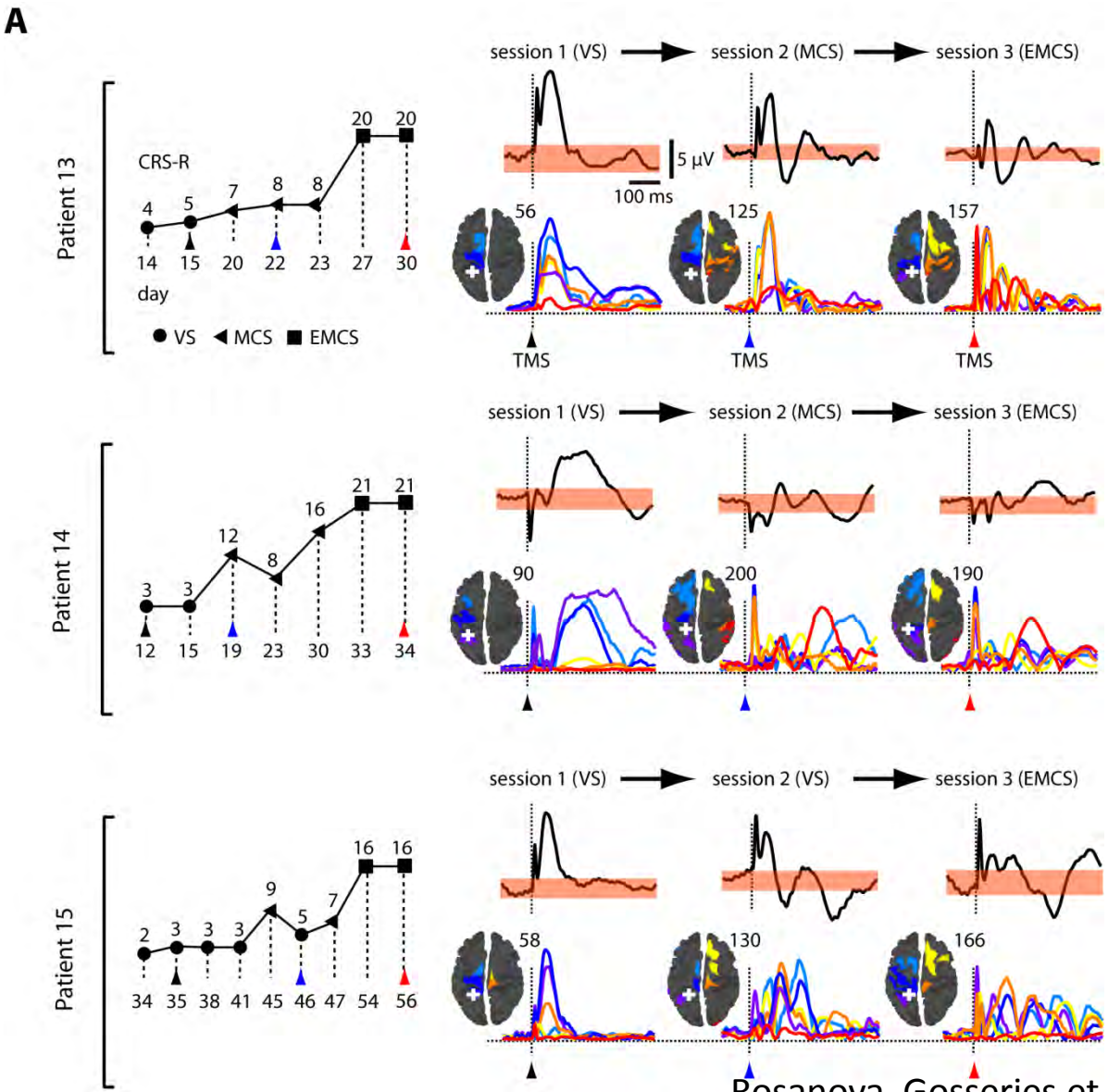


Rosanova, Gosseries et al., Brain 2012



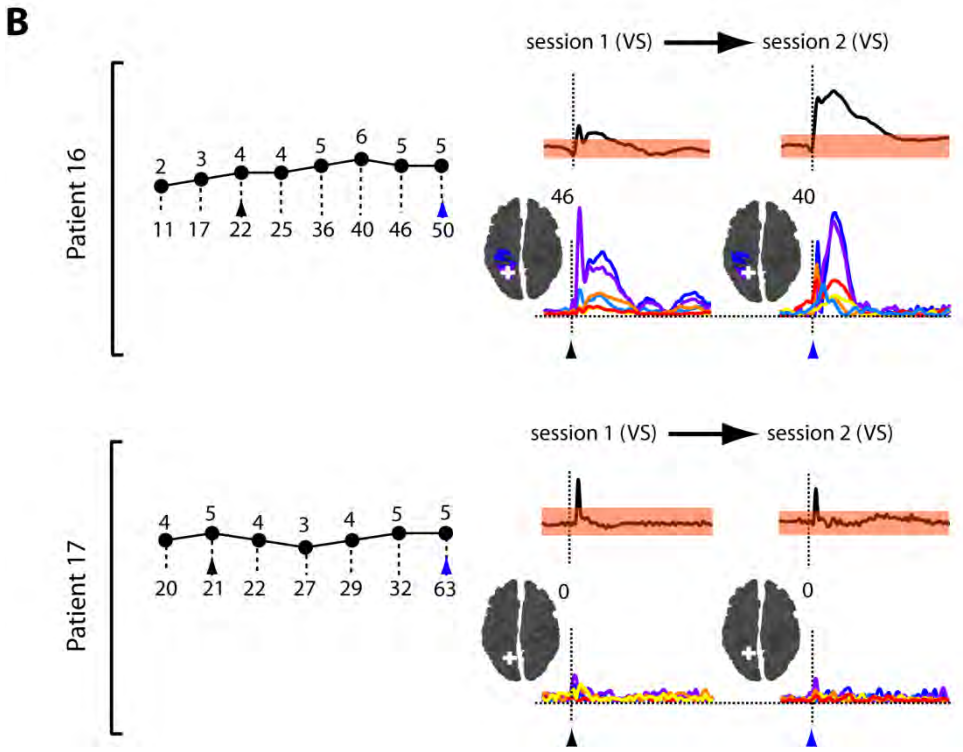
Rosanova, Gosseries et al., Brain 2012

Longitudinal measurements in the three patients who recovered consciousness



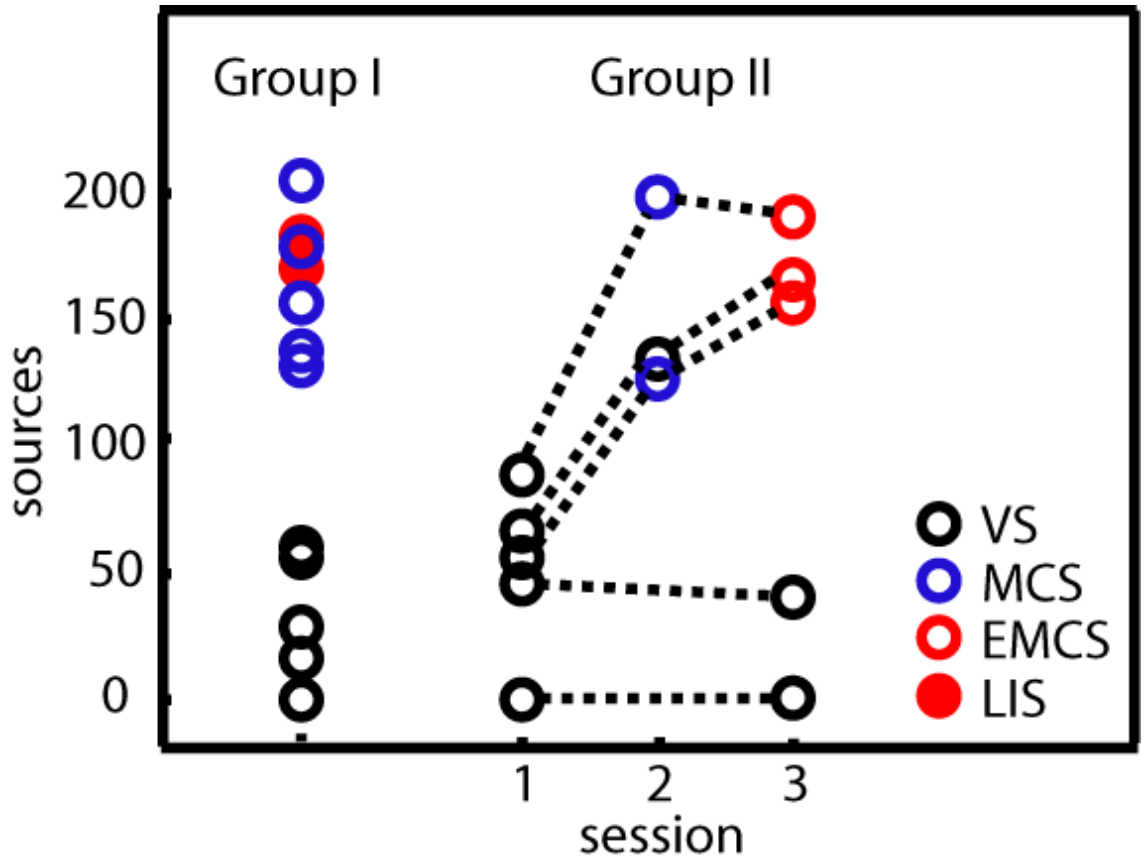
Rosanova, Gosseries et al., Brain 2012

Longitudinal measurements in the two patients who did not recover consciousness



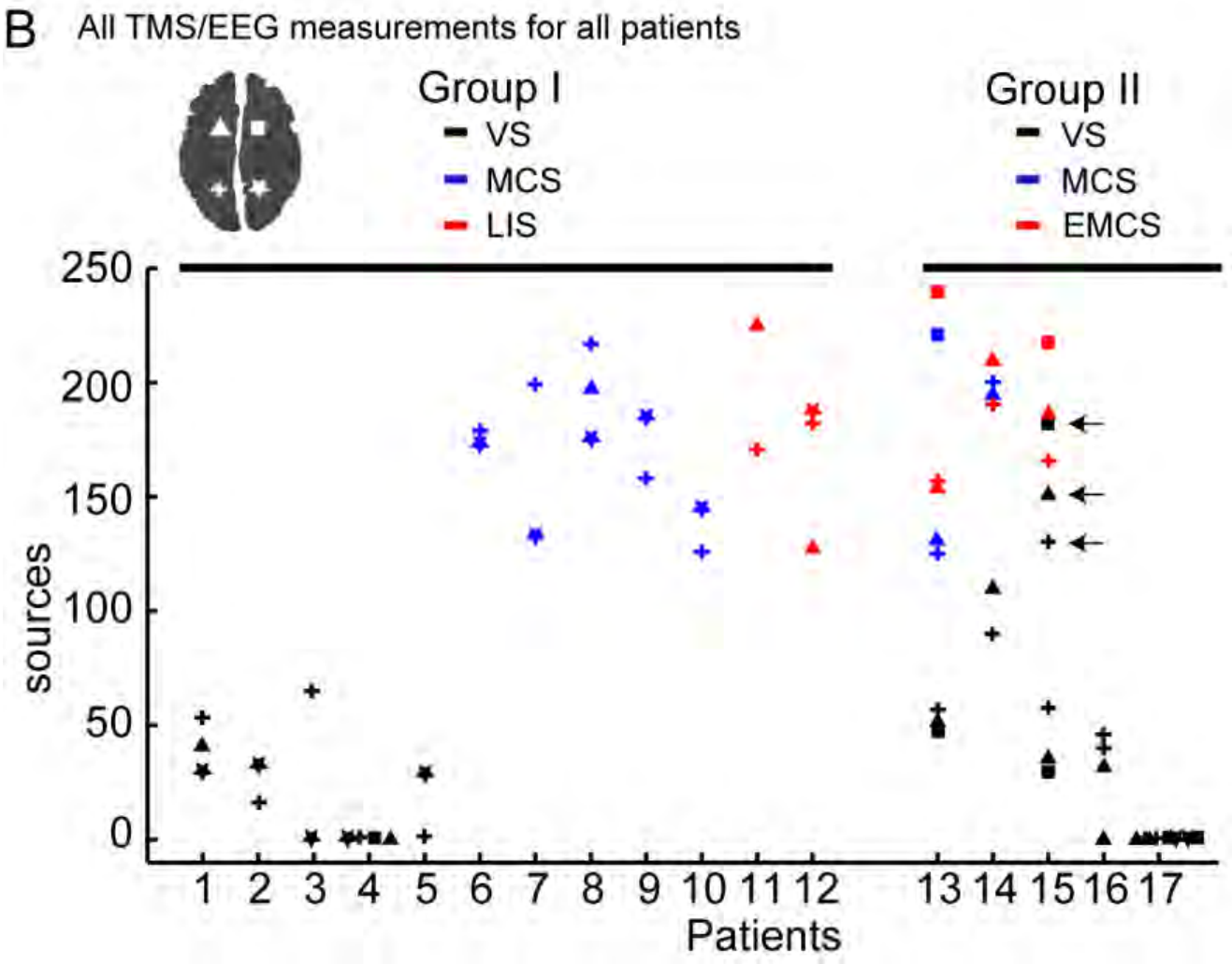
Rosanova, Gosseries et al., Brain 2012

Effective connectivity values for all patients in sessions where left parietal cortex was stimulated



Rosanova, Gosseries et al., Brain 2012

Effective connectivity values for all patients and in all sessions (also right parietal and frontal areas)



Rosanova, Gosseries et al., Brain 2012

Perturbational Complexity

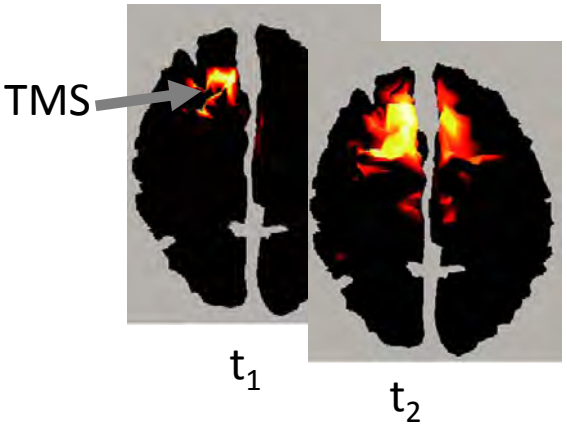
non-parametric statistics at the source level

TMS

t_1

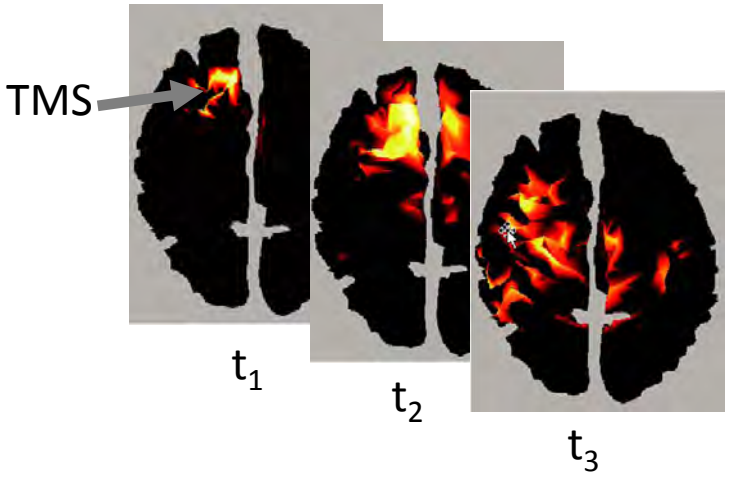
Perturbational Complexity

non-parametric statistics at the source level



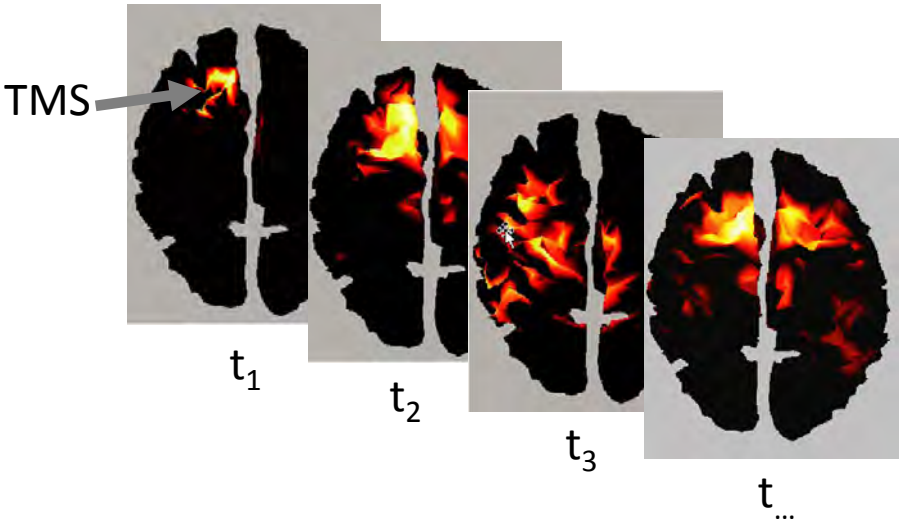
Perturbational Complexity

non-parametric statistics at the source level



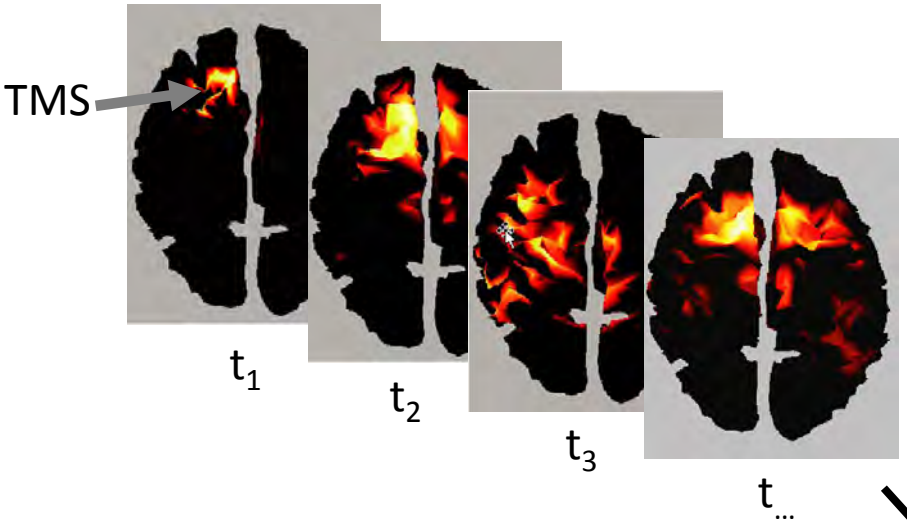
Perturbational Complexity

non-parametric statistics at the source level

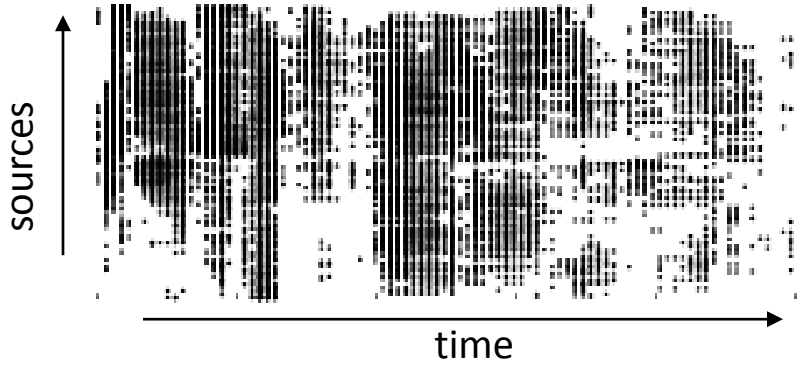


Perturbational Complexity

non-parametric statistics at the source level

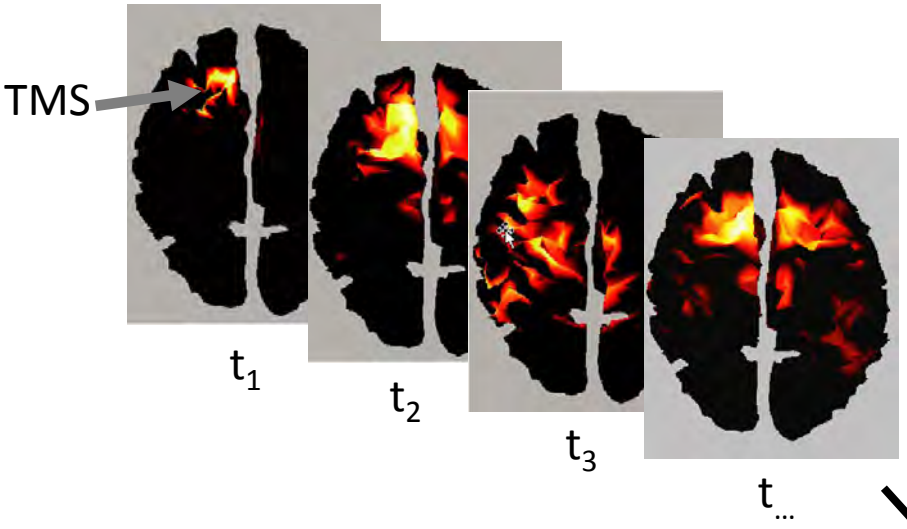


binary matrix of significant activation

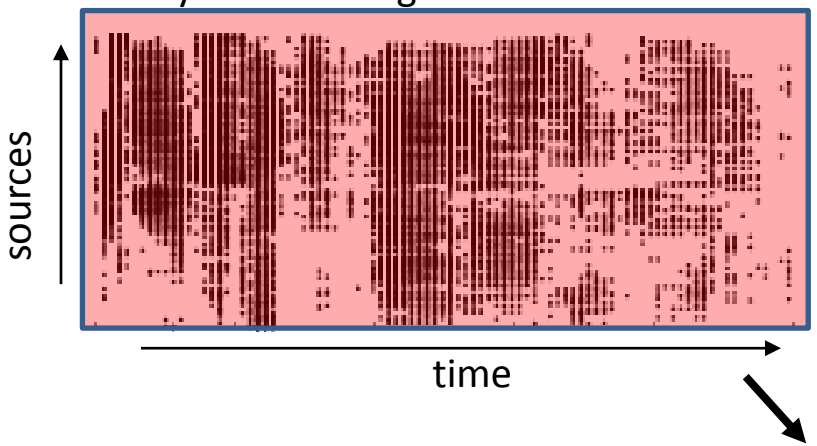


Perturbational Complexity

non-parametric statistics at the source level



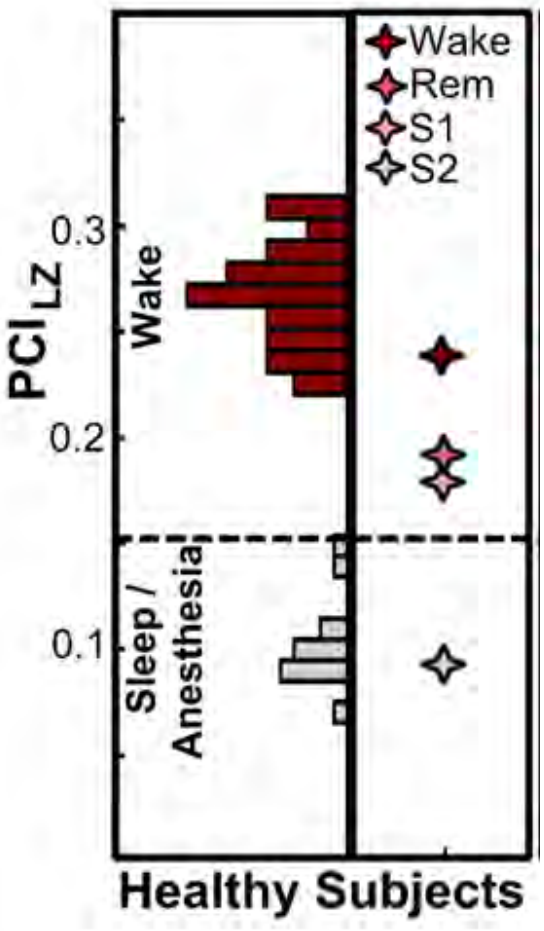
binary matrix of significant activation



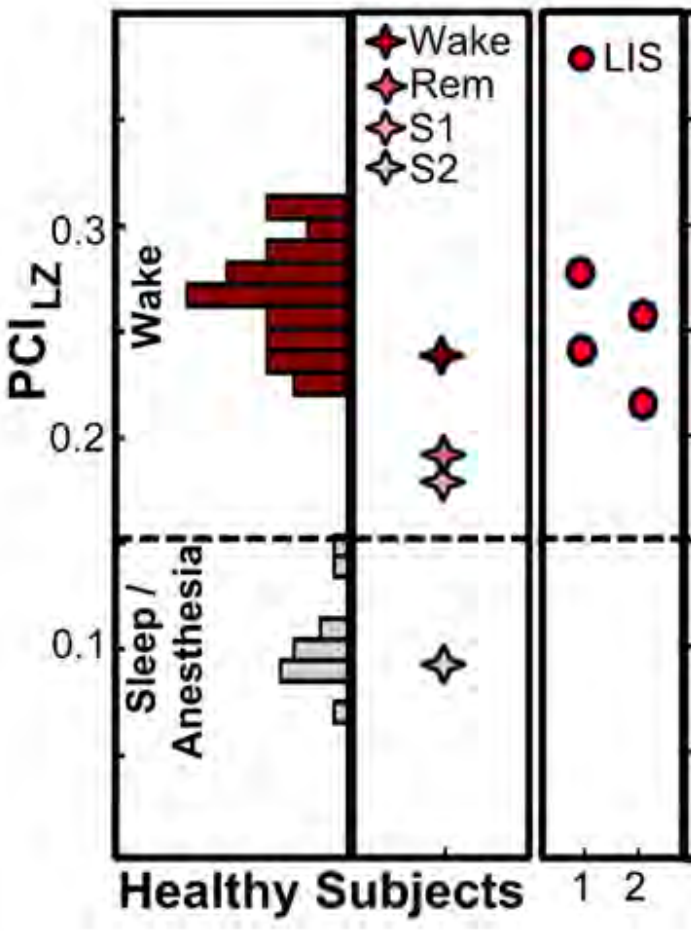
BITS

(Lempel-Ziv-Welch Complexity)

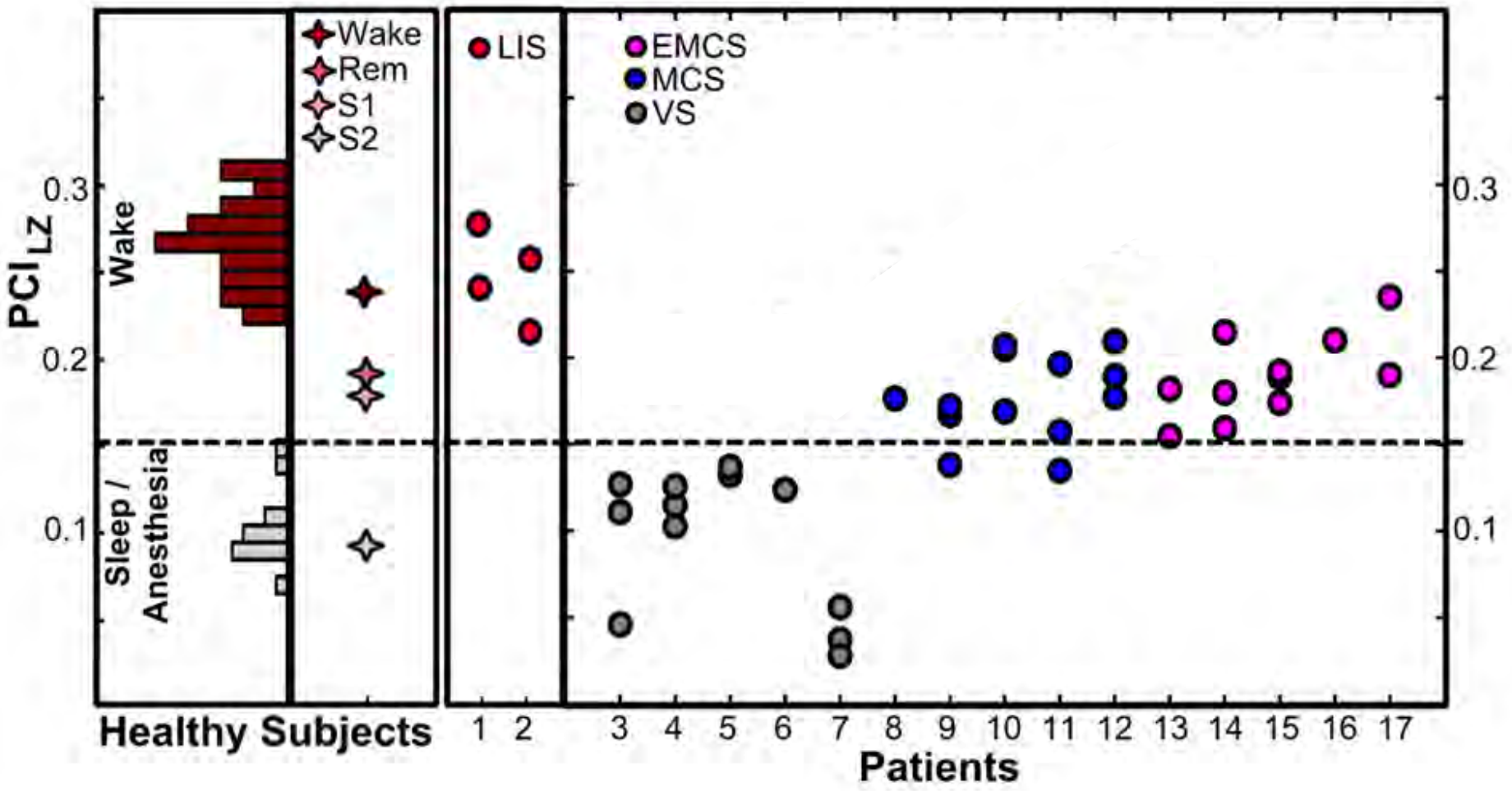
Perturbational Complexity



Perturbational Complexity

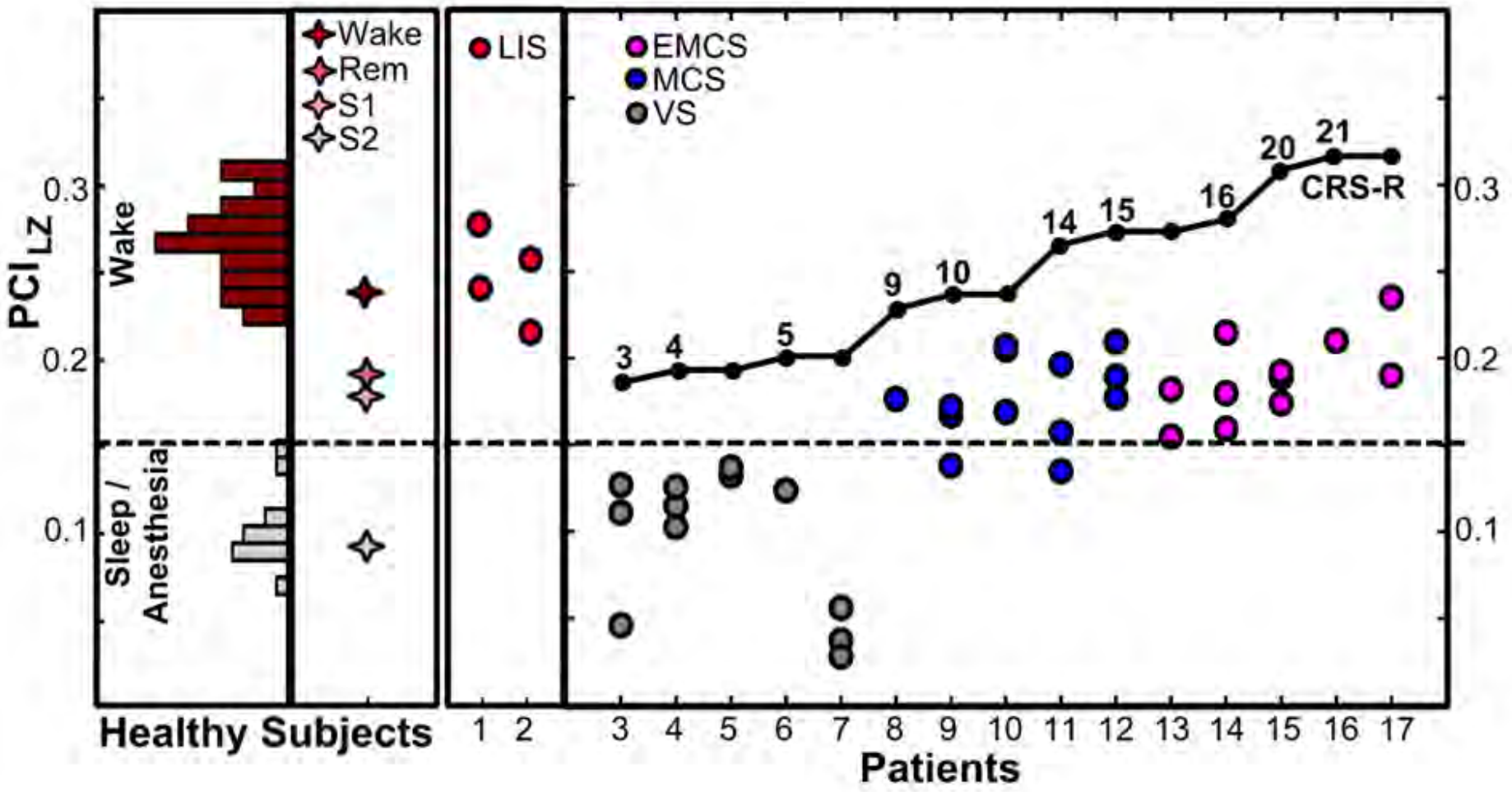


Perturbational Complexity



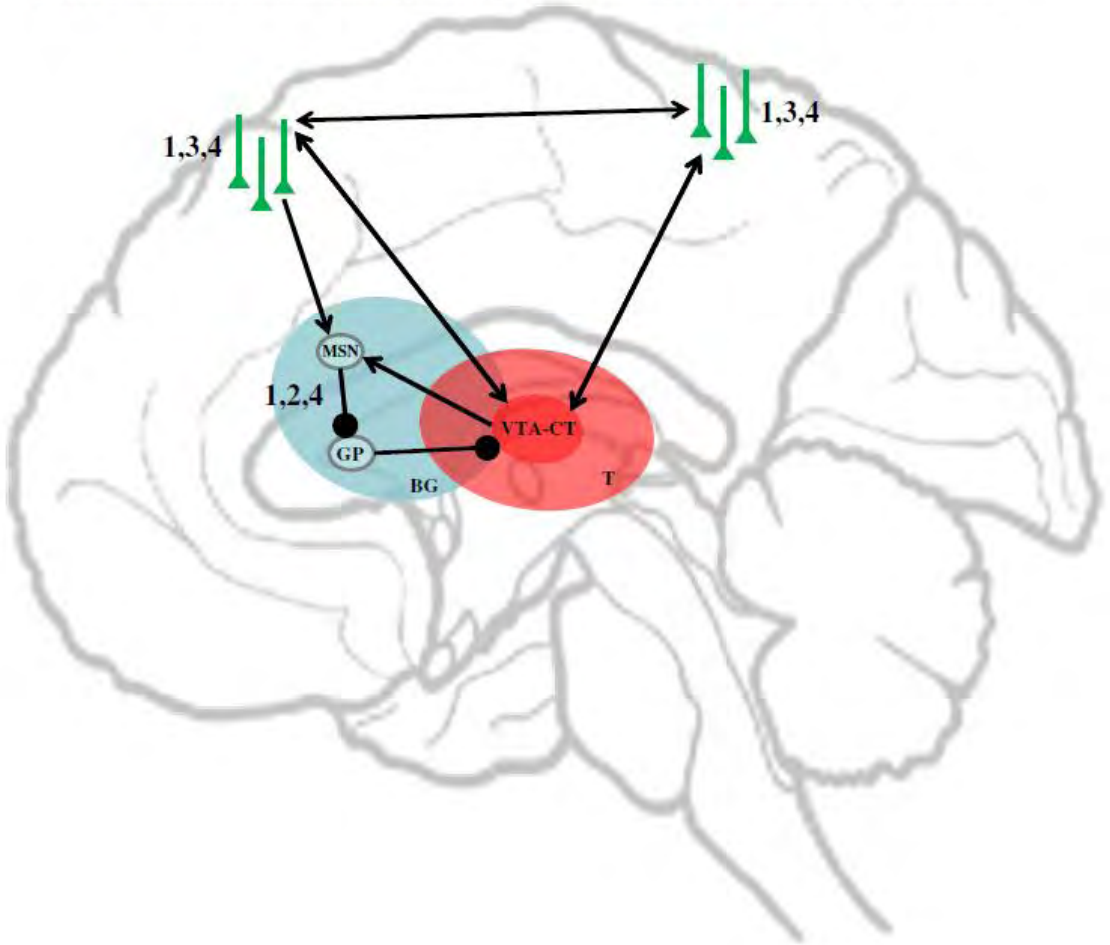
Casali et al., *in preparation*

Perturbational Complexity



Casali et al., *in preparation*

Possible mechanisms of action of central thalamic DBS in the injured brain



Shah and Schiff, *Eur J Neurosci* 2010

Thanks!

MILAN:

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Andrea Pigorini

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Matteo Fecchio

Simone Sarasso

Marcello Massimini

MADISON:

Fabio Ferrarelli

Michael Murphy

Michael Peterson

Brady Riedner

Giulio Tononi

LIEGE:

Melanie Boly

Olivia Grosserie

Marie-Aurelie Bruno

Pierre Boveroux

Steven Laureys

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STSM – COST 2009
Pur 2009 (Univ Milan)
Prin 2008 (Italian Gov)