

Neural correlates  
of **unconsciousness**

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# Defining (un)consciousness

By "**consciousness**" I mean those states of sentience or awareness that typically begin when we **wake up** in the morning from a dreamless sleep and continue throughout the day until we **fall asleep** again.

- John **Searle**

"Many definitions of consciousness have been proposed, none of which completely avoids an element of **tautology** or **self-reference**"

Giacino et al., 2014

## Unconsciousness

Natural or artificial state identified through  
**absence of consciousness.**

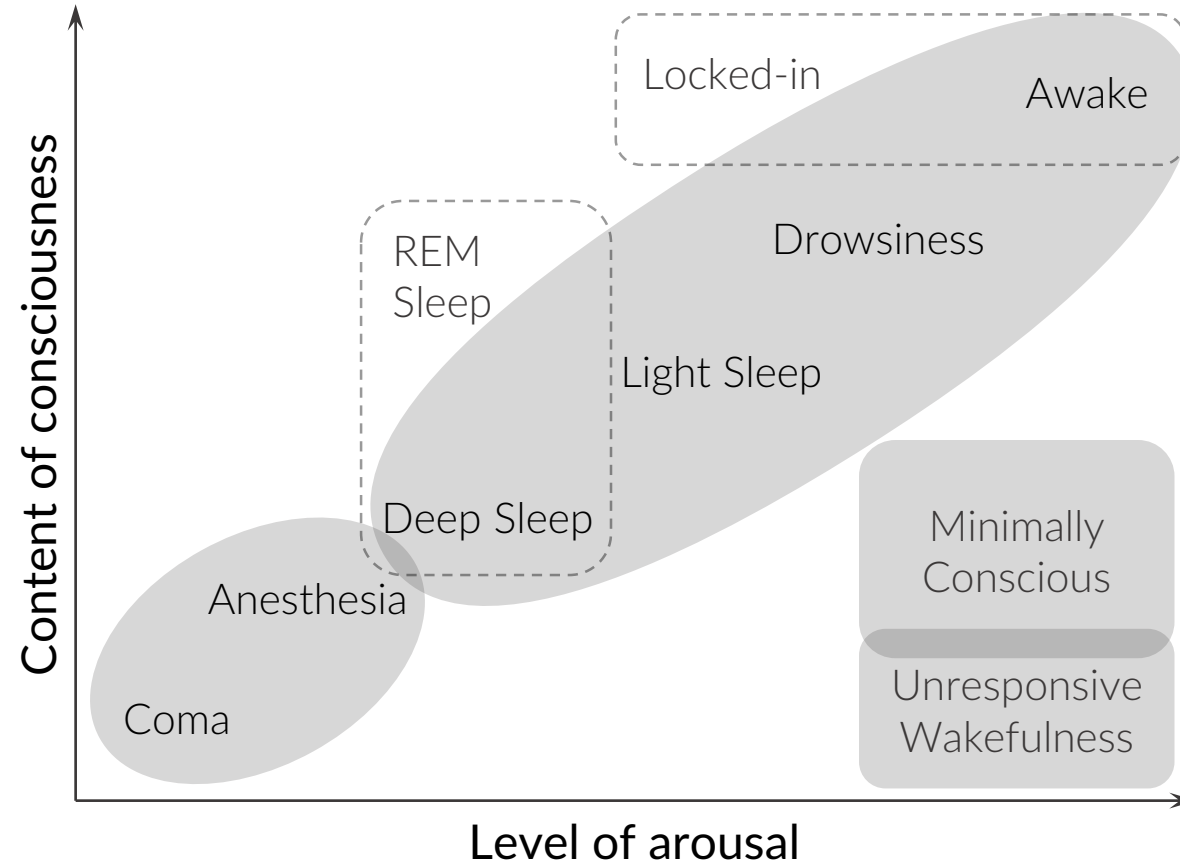
**Giacino, J. T., Fins, J. J., Laureys, S., & Schiff, N. D.** (2014). Disorders of consciousness after acquired brain injury: the state of the science. *Nature Reviews Neurology*, 10(2), 99-114.

# Dimensions of consciousness

## Further readings:

**Laureys, S.** (2005). The neural correlate of (un) awareness: lessons from the vegetative state. *Trends in cognitive sciences*, 9(12), 556-559.

**Boly, M., Seth, A. K., Wilke, M., Ingmundson, P., Baars, B., Laureys, S., ... & Tsuchiya, N.** (2013). Consciousness in humans and non-human animals: recent advances and future directions. *Frontiers in psychology*, 4, 625.

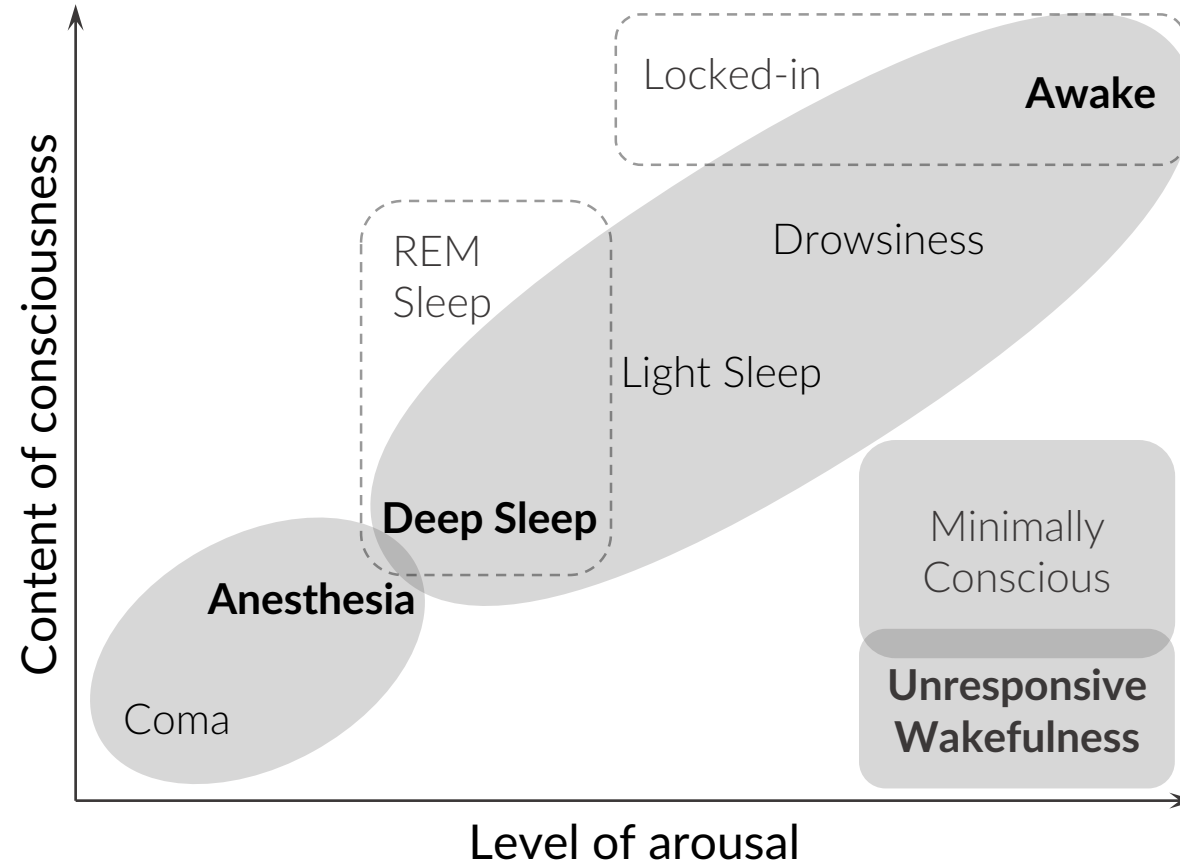


# Dimensions of consciousness

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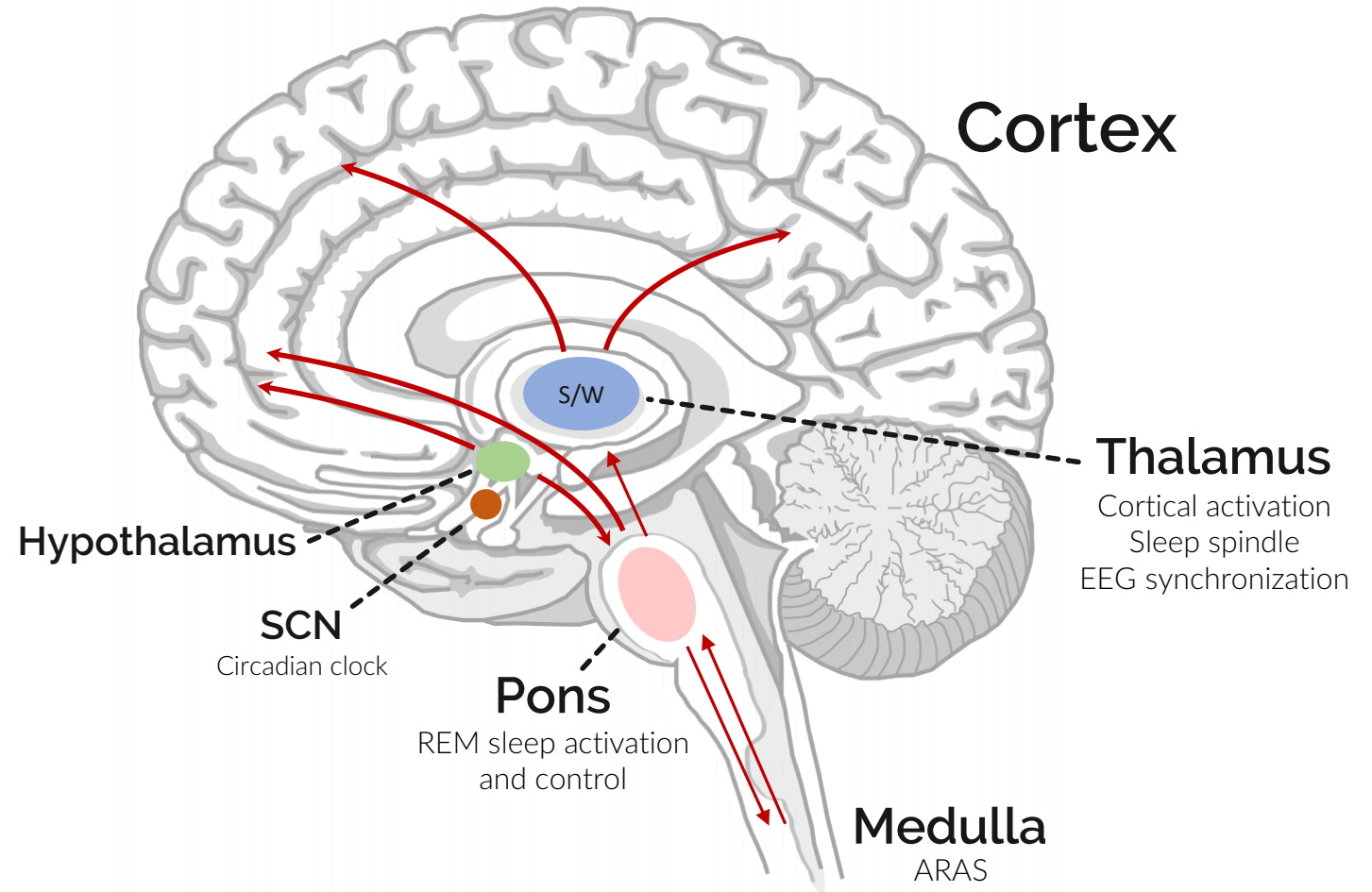
# Neural mechanisms of arousal

**ARAS** – Ascending Reticular Activating System

**SCN** – Suprachiasmatic nucleus

Based on:

**Neurobiology of Sleep**, in: Chapter 1:  
Normal Sleep  
<http://sleepdisorders.sleepfoundation.org/chapter-1-normal-sleep/neurobiology-of-sleep/>



# Many stages of sleep

## Frequency composition

## Distinct neural events

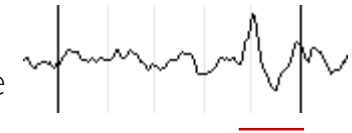
Strong **Alpha** waves (8 – 13 Hz)  
**OCCIPITAL** regions

Awake

N1

Dominant **Theta**  
waves (4 – 7 Hz)

Vertex  
Sharp Wave



N2

K-complex



Dominant **Delta**  
waves (0.5 – 3 Hz)  
**FRONTAL** and **CENTRAL** regions

Sleep spindle



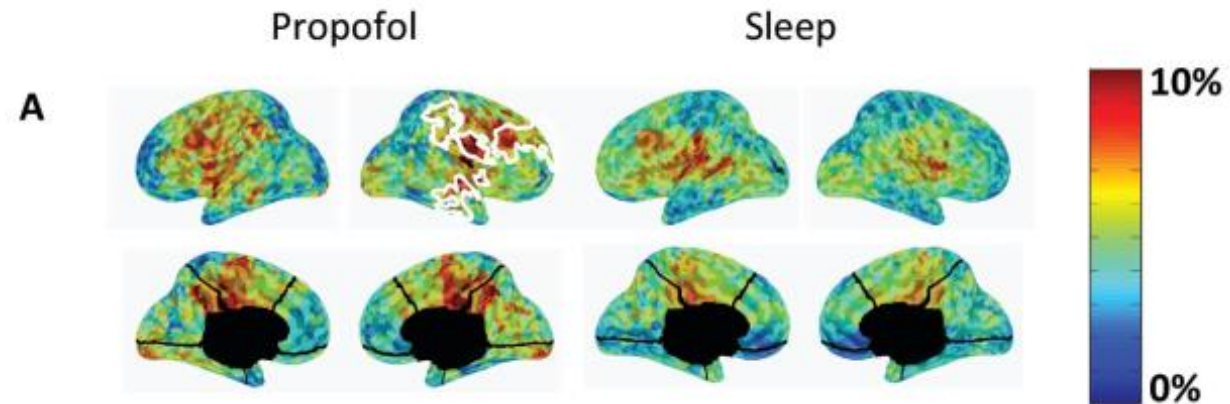
N3

Berry, R. B., Brooks, R., Gamaldo, C. E., Harding, S. M., Marcus, C. L., & Vaughn, B. V. (2012). The AASM manual for the scoring of sleep and associated events. Rules, Terminology and Technical Specifications. Darien, Illinois, American Academy of Sleep Medicine.

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# Anesthetic sedation

## Propofol induced unconsciousness



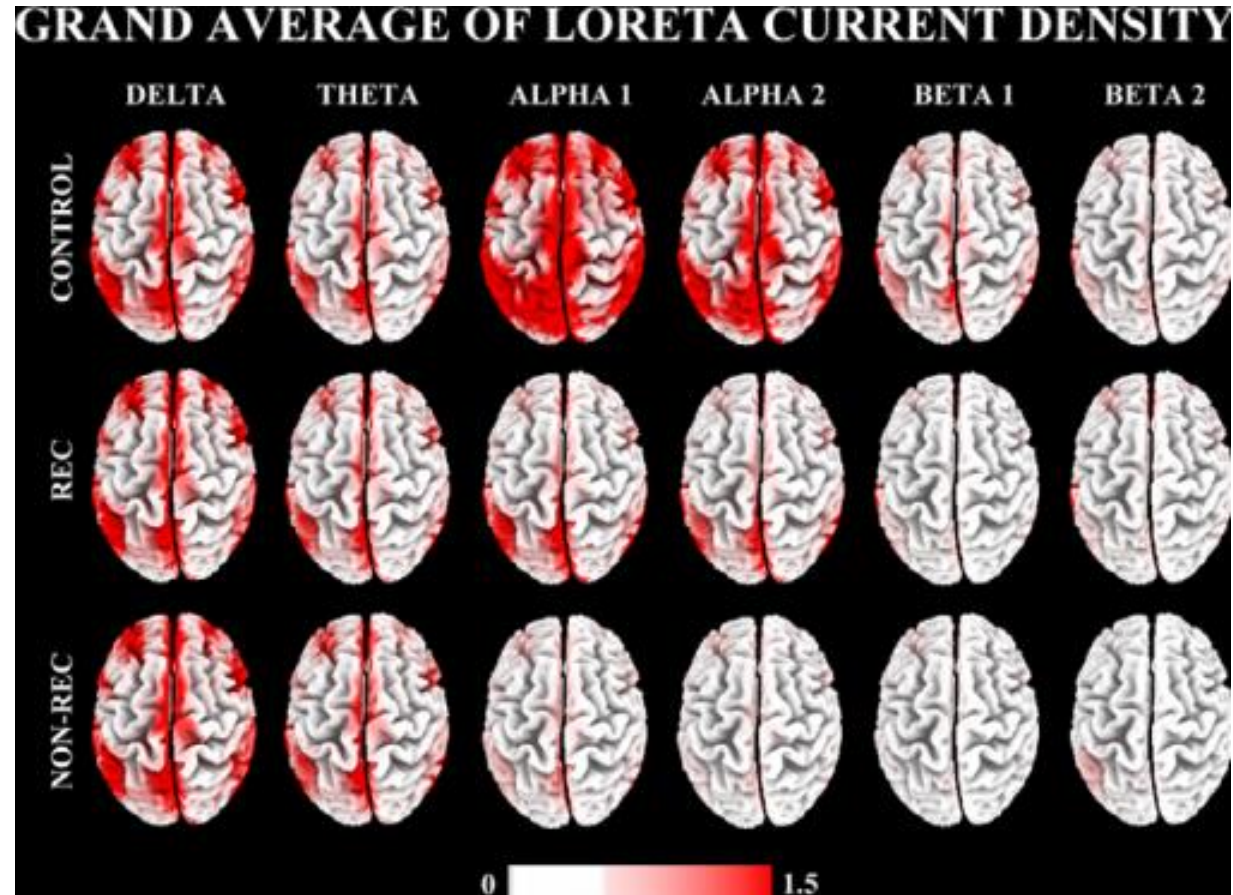
Murphy, M., Bruno, M. A., Riedner, B. A., Boveroux, P., Noirhomme, Q., Landsness, E. C., ... & Tononi, G. (2011). Propofol anesthesia and sleep: a high-density EEG study. *Sleep*, 34(3), 283-291.

### Changes in spectral content:

- Strong increase in **Delta** and higher **Alpha**
- Similar topography (predominantly **ACC**, **PCC** and Insula)

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# Disorders of consciousness

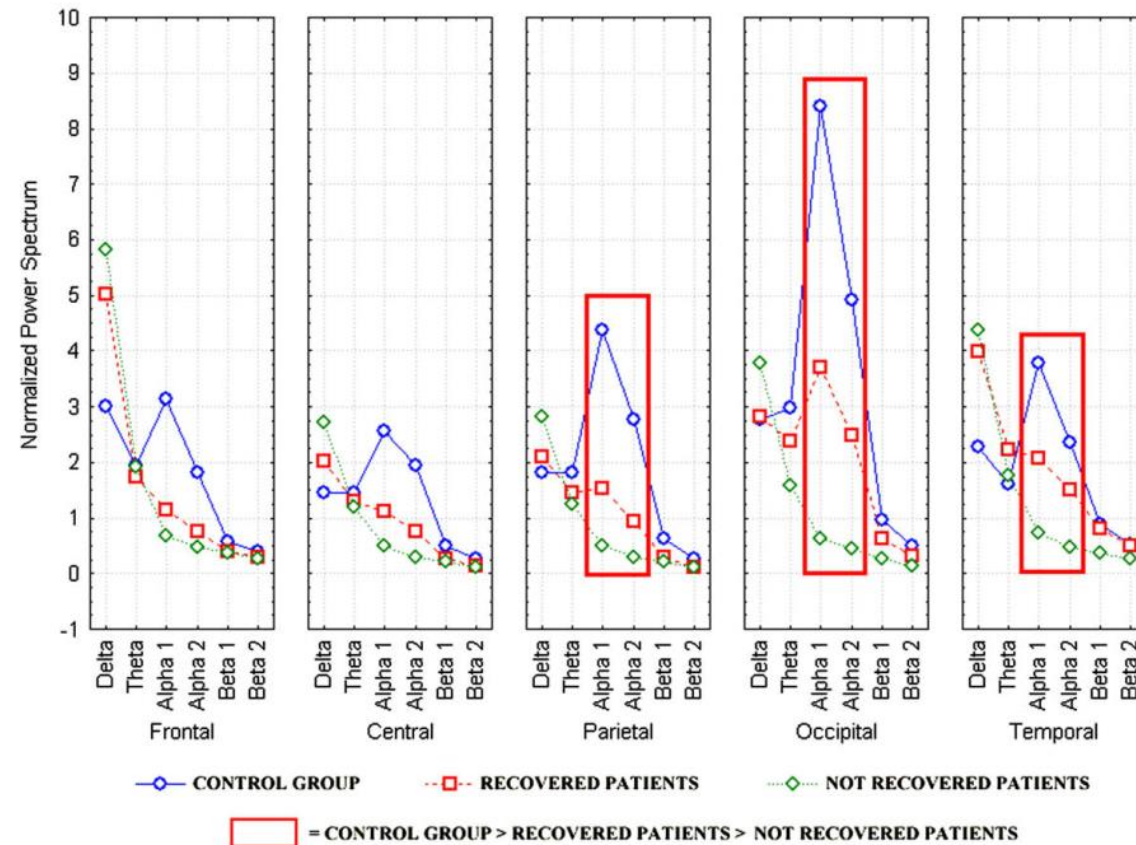


**Babiloni, C., Sarà, M., Vecchio, F., Pistoia, F., Sebastiano, F., Onorati, P., ... & Rossini, P. M. (2009).** Cortical sources of resting-state alpha rhythms are abnormal in persistent vegetative state patients. *Clinical Neurophysiology*, 120(4), 719-729.



# Disorders of consciousness

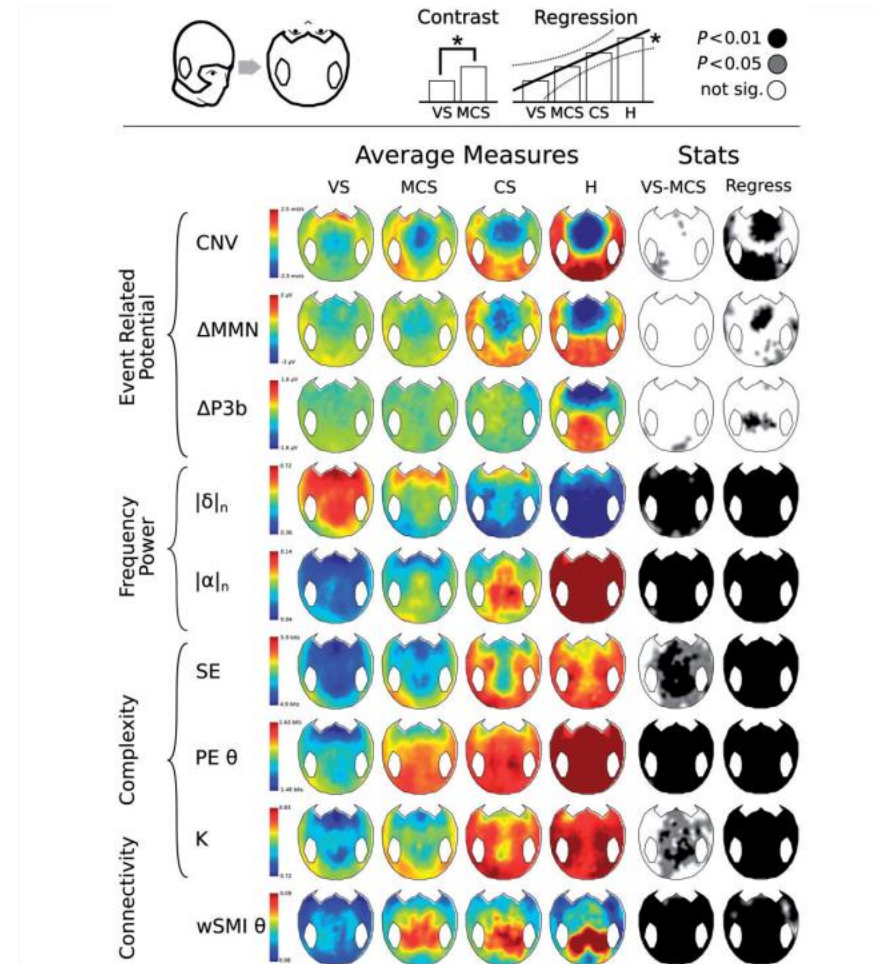
STATISTICAL ANOVA INTERACTION AMONG GROUP, BAND AND ROI



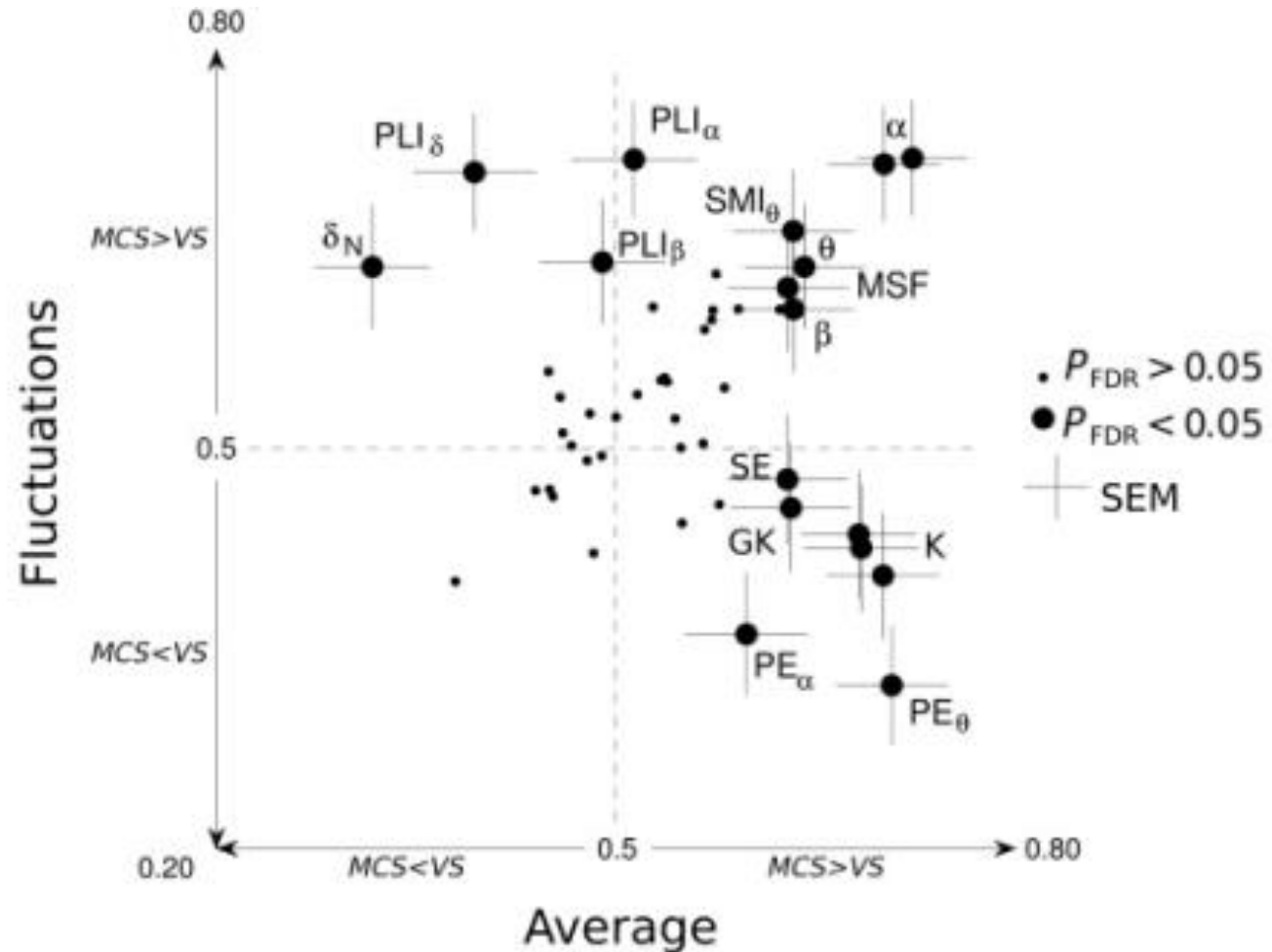
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# Disorders of consciousness

Sitt, J. D., King, J. R., El Karoui, I., Rohaut, B., Faugeras, F., Gramfort, A., ... & Naccache, L. (2014). Large scale screening of neural signatures of consciousness in patients in a vegetative or minimally conscious state. *Brain*, 137(8), 2258-2270.



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# Where do we go from here...

## Machine learning approaches

**Phillips, C. L.**, Bruno, M. A., Maquet, P., Boly, M., Noirhomme, Q., Schnakers, C., ... & Luxen, A. (2011). "Relevance vector machine" consciousness classifier applied to cerebral metabolism of vegetative and locked-in patients. *Neuroimage*, 56(2), 797-808.

## Brain-Computer Interfaces (BCI)

**Lulé, D.**, Noirhomme, Q., Kleih, S. C., Chatelle, C., Halder, S., Demertzi, A., ... & Thonnard, M. (2013). Probing command following in patients with disorders of consciousness using a brain-computer interface. *Clinical Neurophysiology*, 124(1), 101-106.

Data suggests a unified view of neural correlates of **un**consciousness.

## Obstacles to overcome:

1. Comparable high-quality datasets
2. Localization difficulties
3. Generalization of findings
4. **Automatization** and **prediction**



Thank You for your **awareness** 😊

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**slides:** [github.com/mkoculak/kkk9/koculak\\_slides.pdf](https://github.com/mkoculak/kkk9/koculak_slides.pdf)



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