

# Erleben und Informationsverarbeitung in veränderten Bewusstseinszuständen

Eine neurowissenschaftliche Sicht



**Manuel Schabus<sup>\*,+</sup>**



<sup>\*</sup>Laboratory for Sleep, Cognition and Consciousness Research,  
Division of Physiological Psychology, University of Salzburg

<sup>+</sup>Centre for Cognitive Neuroscience Salzburg, Salzburg, Austria

[www.sleepscience.at](http://www.sleepscience.at)



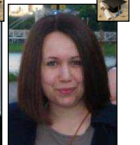
## Team

**Laboratory for Sleep, Cognition and  
Consciousness Research**

**Univ.-Prof. Manuel Schabus**  
**Ass.-Prof. Kerstin Hödlmoser**

**MSc. Renata del Giudice**  
**Mag. Dominik Heib**  
**Mag. Julia Lechinger**  
  
**BSc. Adriana Michalak**  
**BSc. Tomasz Wielek**  
**Mag. Christine Blume**

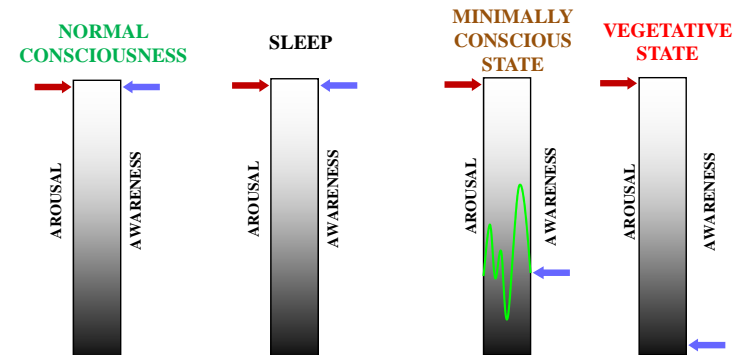
**BSc. Małgorzata Wiśłowska**  
**Bsc. Daniel Körner**  
**Bsc. Maria-Teresa Gnjezda**



## Inhalt

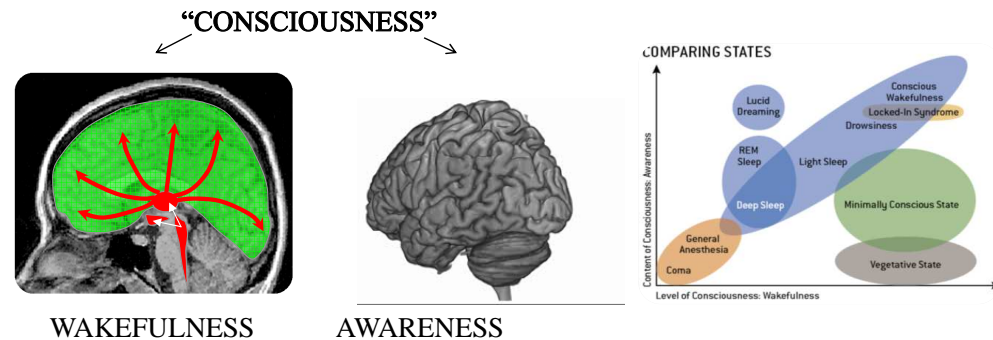
- I.** Definitionen des Bewusstseins
- II.** Spontane Oszillationen & Gehirnaktivität
- III.** Zirkadiane Rhythmik im “Wachkoma”
- IV.** Informationsverarbeitung in veränderten Bewusstseinszuständen
  - ✓ Wachkoma
  - ✓ Schlaf

## Wachkoma-Zustände (Disorders Of) Consciousness States



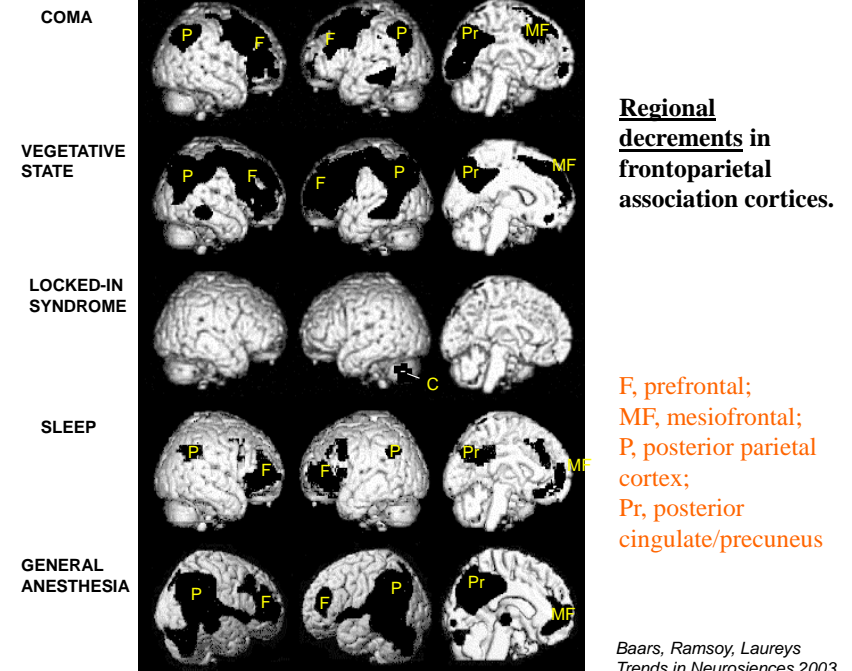
- **Behavioral assessment** remains the **gold standard** to monitor level of consciousness in patients with DOC.

# Neuronale Bewusstseins-Korrelate



- Neuroscientific Evidence for Consciousness and DOC

# Bewusstseins- Analogien



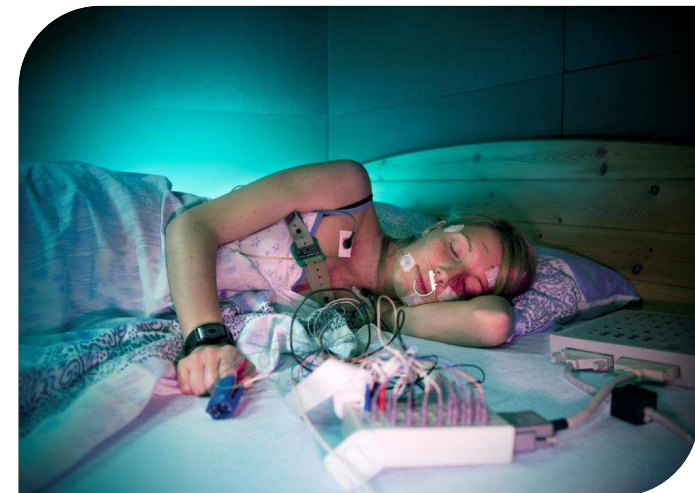
## Wachkoma & Schlaf Disorders Of Consciousness & Sleep



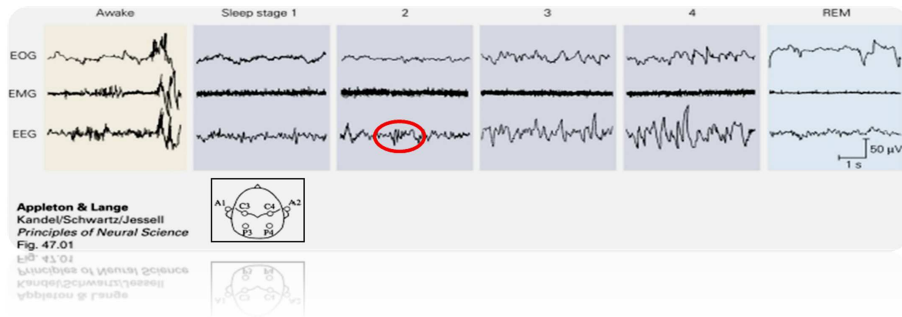
Cooperation partners:

- Albert-Schweitzer-Klinik (OA Dr. Pichler, Graz)
- “Apalliker Care Unit” im Geratriezentrum am Wienerwald (Prim. Dr. Donis, Wien)
- Christian Doppler Krankenhaus (Primar Dr. Trinko, Salzburg)
- Hospital Hermanos Ameibeiras (Havana, Cuba) - Prof. Dr. Calixto Machado

## I. Spontane Gehirnaktivität



# Gehirnoszillationen im EEG



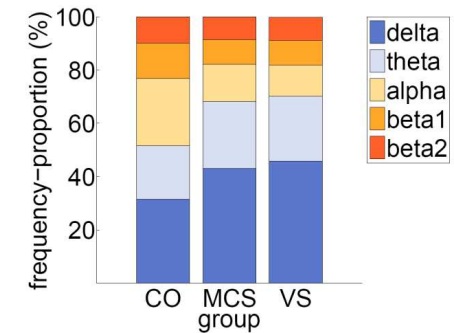
- Sleep spindles are related to fading of C but also learning
- Sleep architecture appears more complex in MCS than VS/UWS (Cologan, Schabus et al., 2010; Cologan et al., 2013) incl. spindles

# Gehirnoszillationen im Wachkoma

Attempt to develop **individual** and **quantitative markers** for diagnosis and prognosis.

## Advantage:

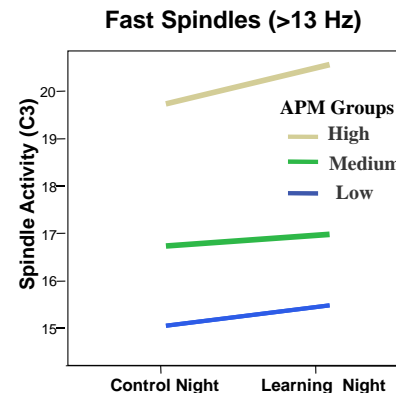
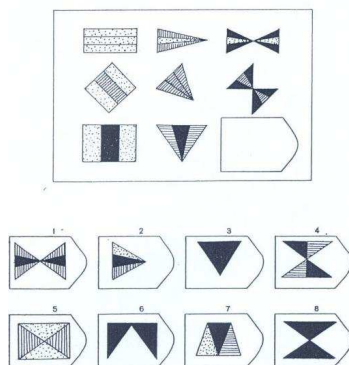
Resting state EEG is **independent** of the patient's will to cooperate and does not rely on specific abilities!



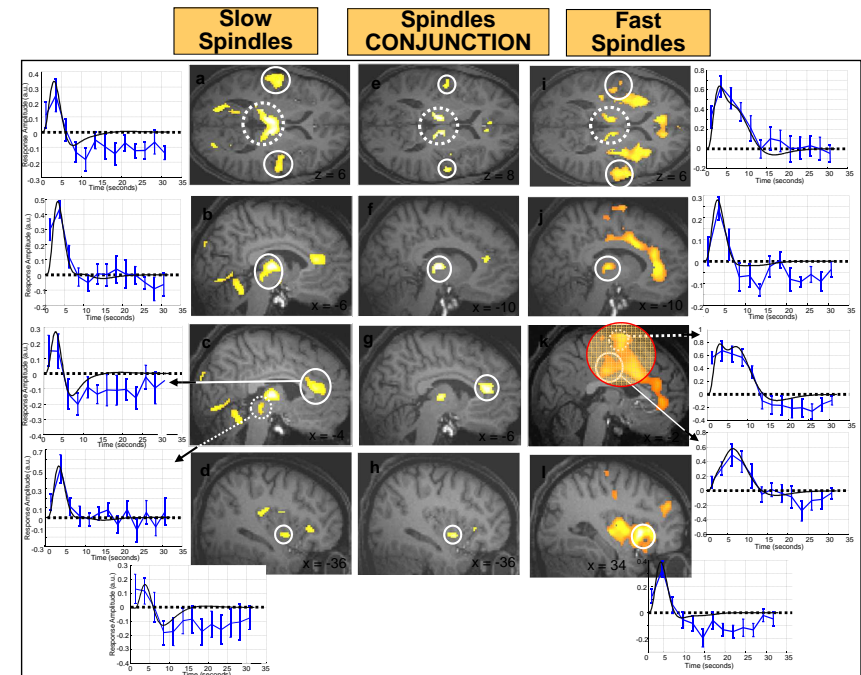
Fellinger,...& Schabus, (2011)

# Schlaf-Spindeln und „Intelligenz“

- General Cognitive Ability („g“) measured with Raven's Advanced Progressive Matrices (APM)



Schabus, M. et al. (2006). Sleep spindle-related activity in the human EEG and its relation to general cognitive and learning abilities. *European Journal of Neuroscience*, 23(7), 1738-1746.

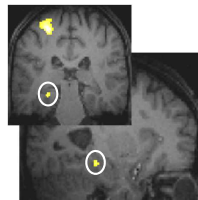
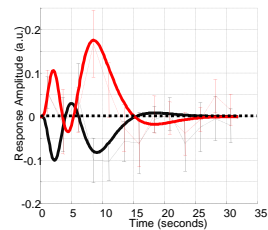


Schabus, M., et al. (2007). Hemodynamic cerebral correlates of sleep spindles during human non-REM sleep. *Proceedings of the National Academy of Sciences USA*, 104(32), 13164-13169.

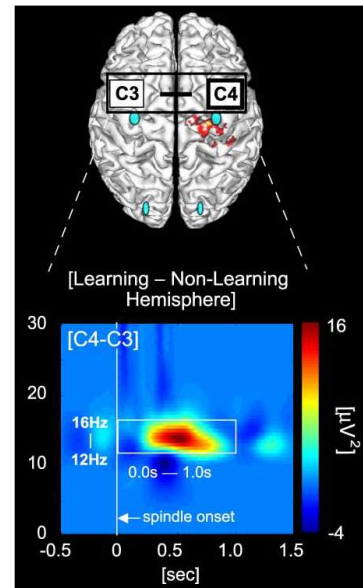
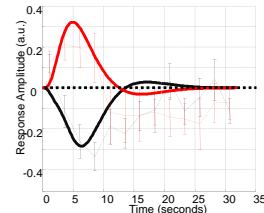


# Gehirnplastizität im Schlaf

## Hippocampus



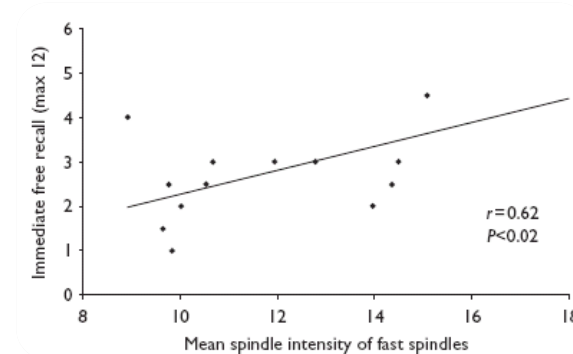
## Mesial Prefrontal Cortex



Nishida & Walker, PLoS One, 2007

Schabus et al., PNAS, 2007

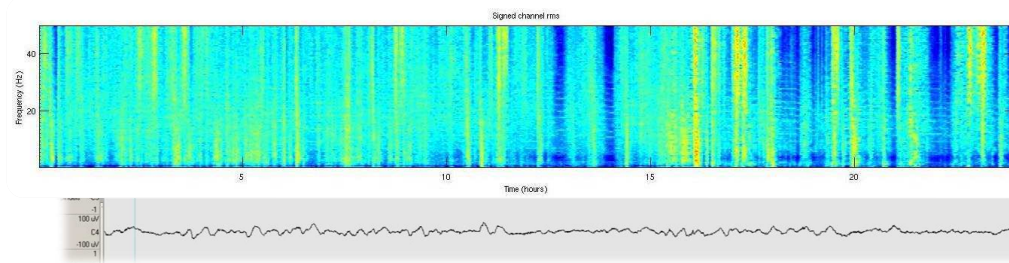
# Gehirn-Pathologien und Spindelabnahme



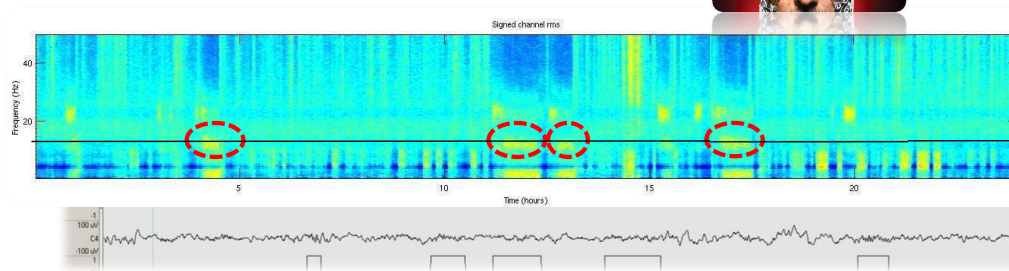
Lower spindle activity relates to lower memory performance in Alzheimer's Disease (e.g., Schabus et al., 2006; Rauchs et al., 2008)!

→ Even ipsilateral deviations after hemispheric strokes (e.g., Gottselig et al., 2002)

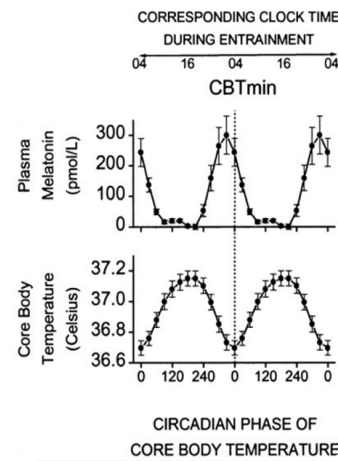
## VS/UWS without SWS, REM, Spindles, Circadian Rhythm



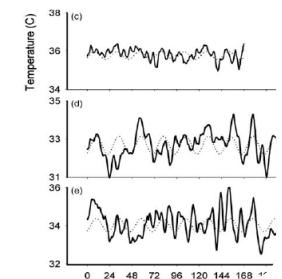
## MCS with SWS, REM, Spindles and high arousal index



## II. Zirkadianik im Wachkoma?

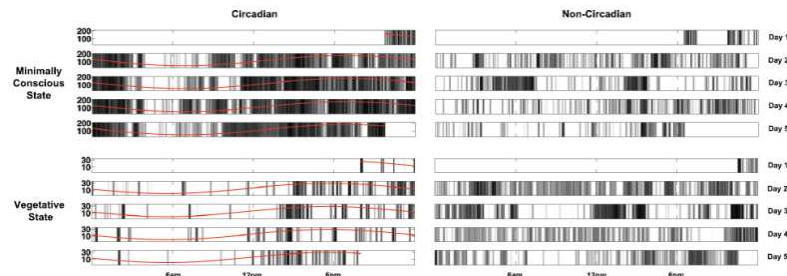


Wyatt et al. (1999)



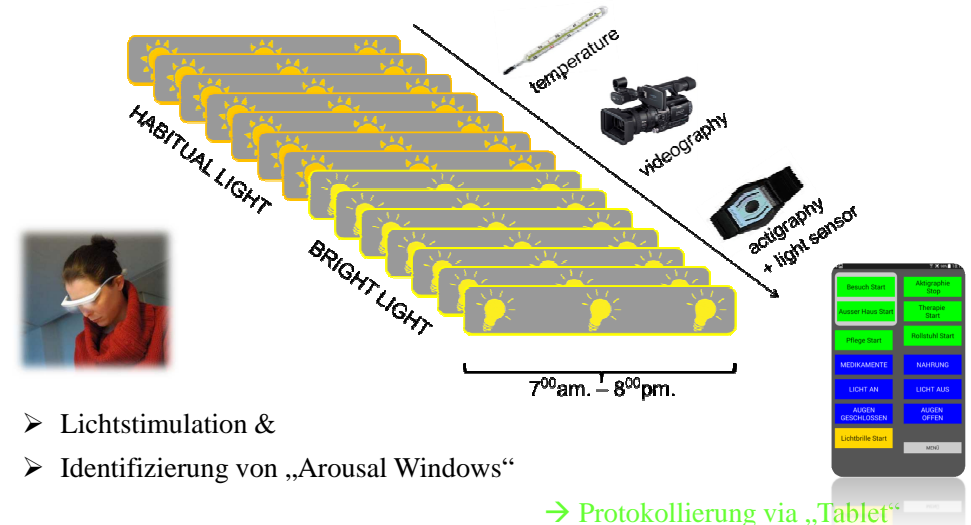
Bekinschtein et al. (2009)

# Aktivitätsniveau im Wachkoma?



**Figure 1** Actigraphy data from four representative patients. Each panel shows intensity of activity across each recording day. Red lines indicate the fit of the circadian rhythm. Note the periodic structure of the activity of the two patients with significant rhythms (left), compared with those without (right). Patients 19, 21, 52 and 45 are shown (clockwise from top-left). Log activity data smoothed across five minutes is plotted for clarity of visualization.

## Interventionen



- Lichtstimulation &
- Identifizierung von „Arousal Windows“

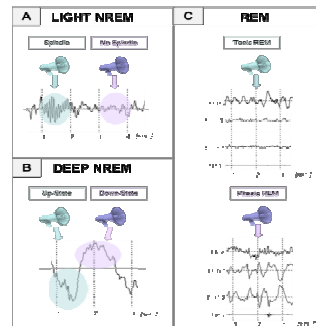
→ Protokollierung via „Tablet“

## III. Informationsverarbeitung über Bewusstseins-Zustände

In **DOC**:



In **healthy SLEEP**:



Stimulus-Material:

- Emotional-relevante Eigennamen
- bzw. Kinderreime

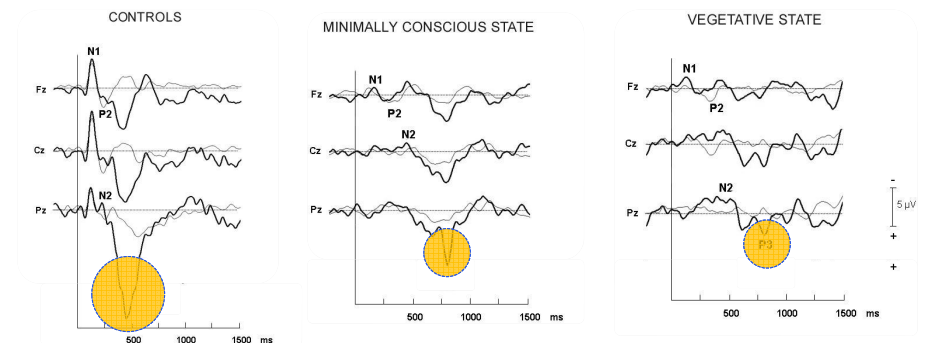
In **Newborns**:



## Informationsverarbeitung im Wachkoma

Sequences of 8 equiprobable first names:  
the own name and 7 non-familiar first names

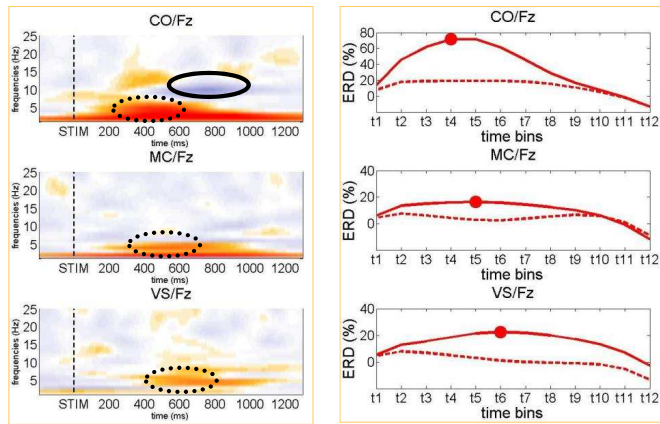
Helmut Simon Patrick Hector Helmut Manuel



Perrin, Schnakers, Schabus et al, Arch Neurol, 2006

# Zeit-Frequenz Analysen

(extended analyses from Schnakers, Perrin, Schabus et al., 2008)



12 controls (CO)

13 minimally conscious patients (MC)

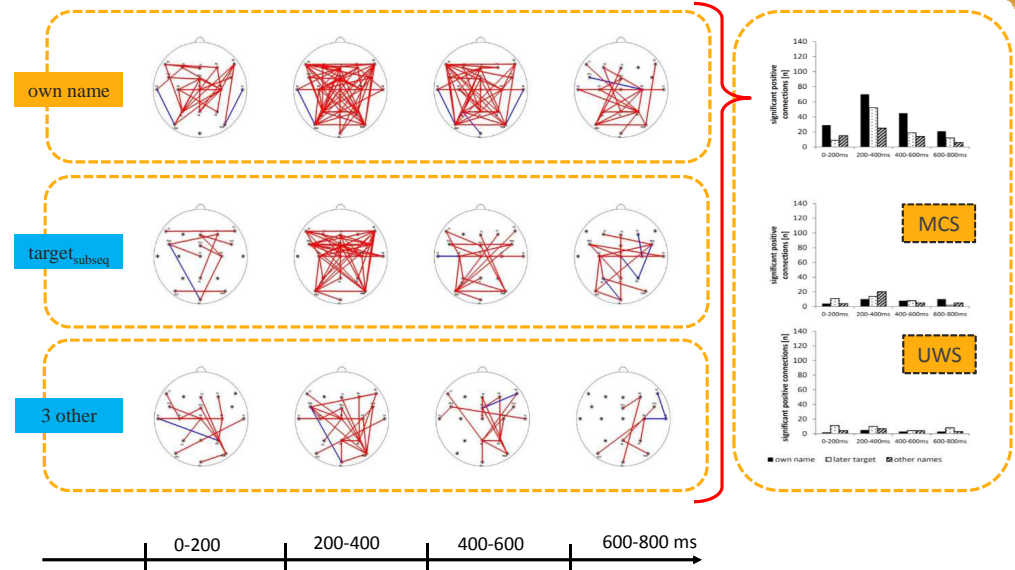
8 vegetative state patients (VS)

Event-related theta synchronisation to counted own vs. other names even in VS patients, yet delayed!!

Fellinger,... & Schabus (2011)

# “Phase Connectivity” Measures

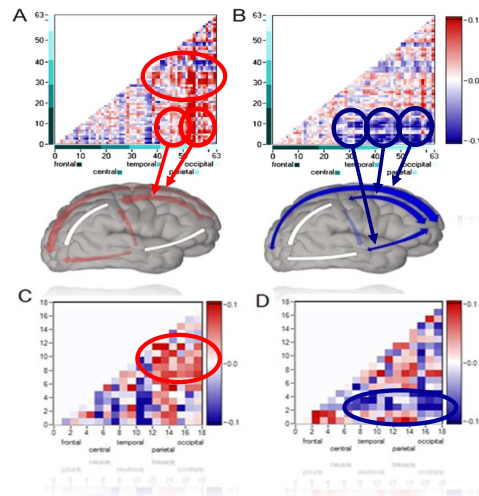
Large-scale delta connectivity: passive – healthy controls



# EEG Signal Complexity

(Effective Connectivity & Machine Learning Approaches)

– work in progress



Symbolic transfer entropy (STE) in consciousness (A), anaesthesia (B) and disorders of consciousness (C + D; modified from Jordan et al., accepted). While MCS (C) looks more similar to conscious wakefulness (A), VS/UWS (D) looks similar to propofol induced unconsciousness.



Thul, Lechinger, .. & Schabus (2015)

# Implikationen

→ Kritischer Blick auf das „Bewusstsein“

- Störungen des Bewusstseins
- Schlaf-Wach bei Gesunden
- „vorsprachlichen“ Babys

→ „Wachkoma“ und deren Diagnose/Prognose besser verstehen

- Mögliche Unterstützung der Genesung & „Arousal-Window“ Identifikation

...den Kern dessen besser zu verstehen der uns „menschlich“ macht...





LAB for SLEEP &  
CONSCIOUSNESS  
RESEARCH

## Bewusstsein

UNIVERSITY OF SALZBURG PHOTOGRAPHED BY L. CAPUTO

