



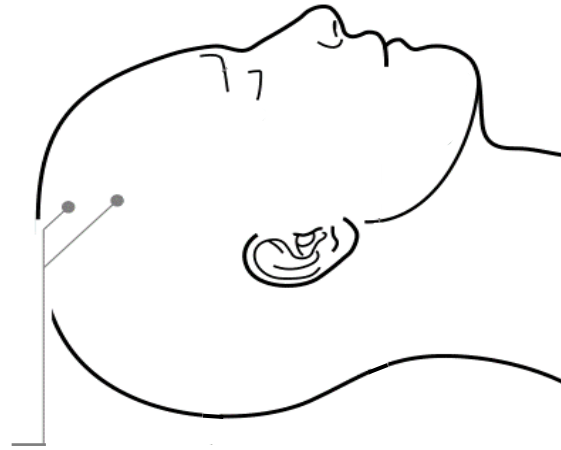
# Spontaneous EEG and Sleep



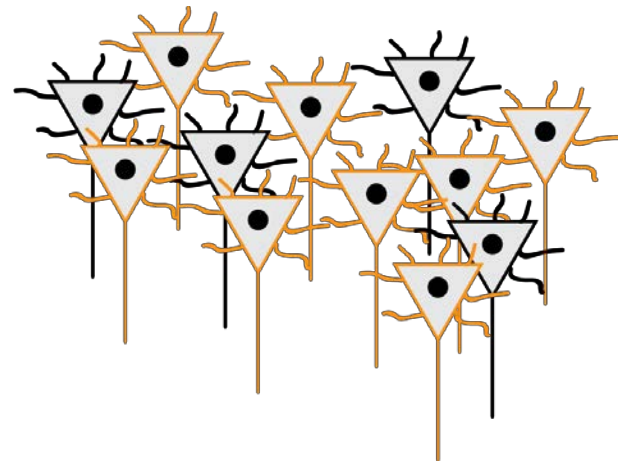
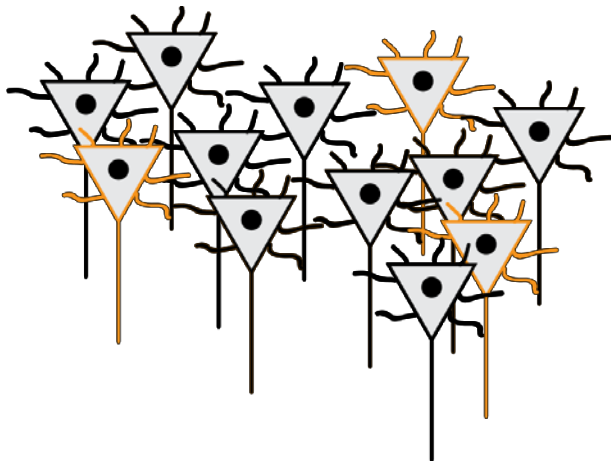
## Agenda

- Recording methods
- Oscillations on different time scales
- Examples: functions of sleep

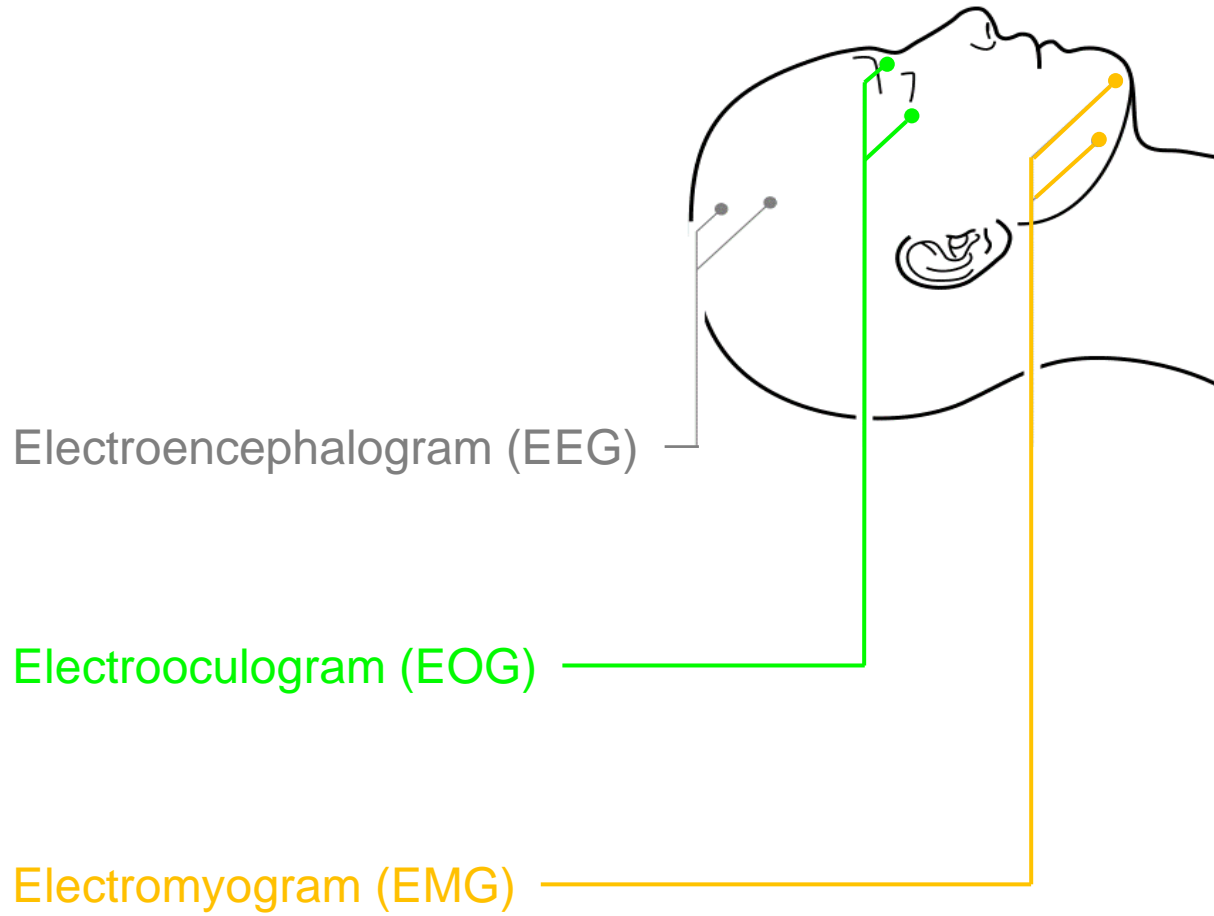
# Polysomnography



Electroencephalogram (EEG)



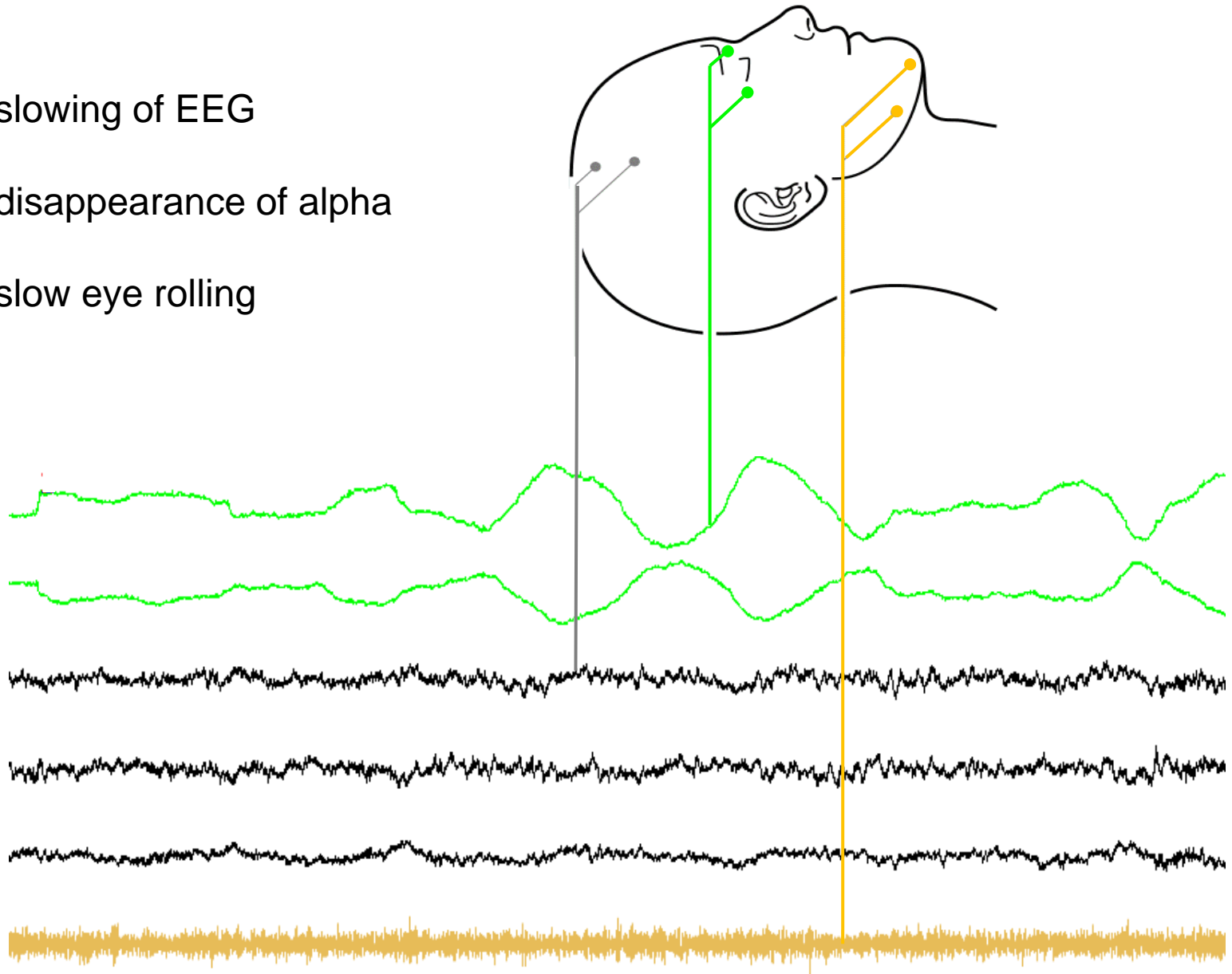
# Polysomnography





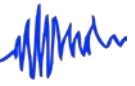
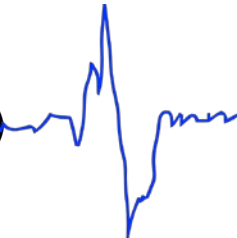
## Sleep stages: N1

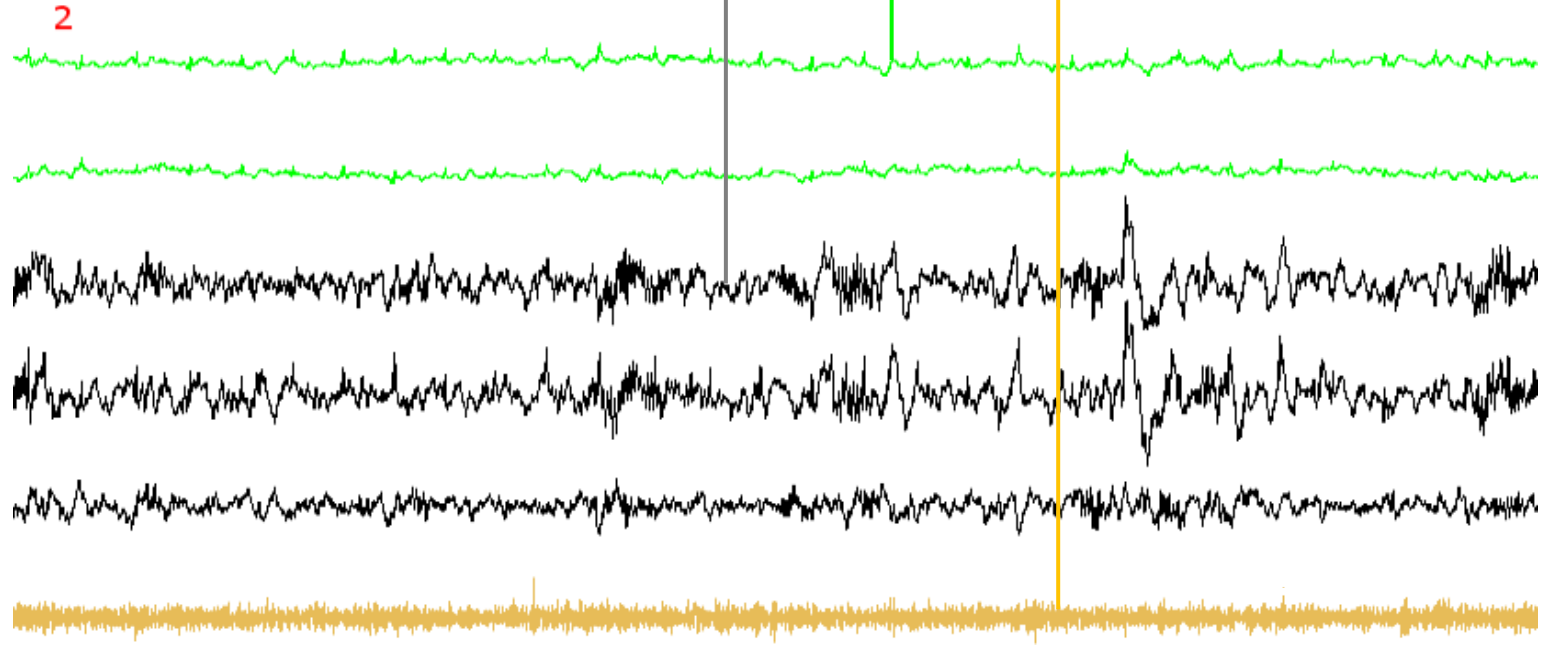
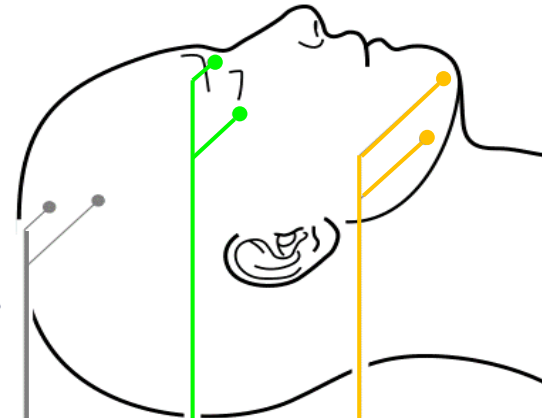
- slowing of EEG
- disappearance of alpha
- slow eye rolling





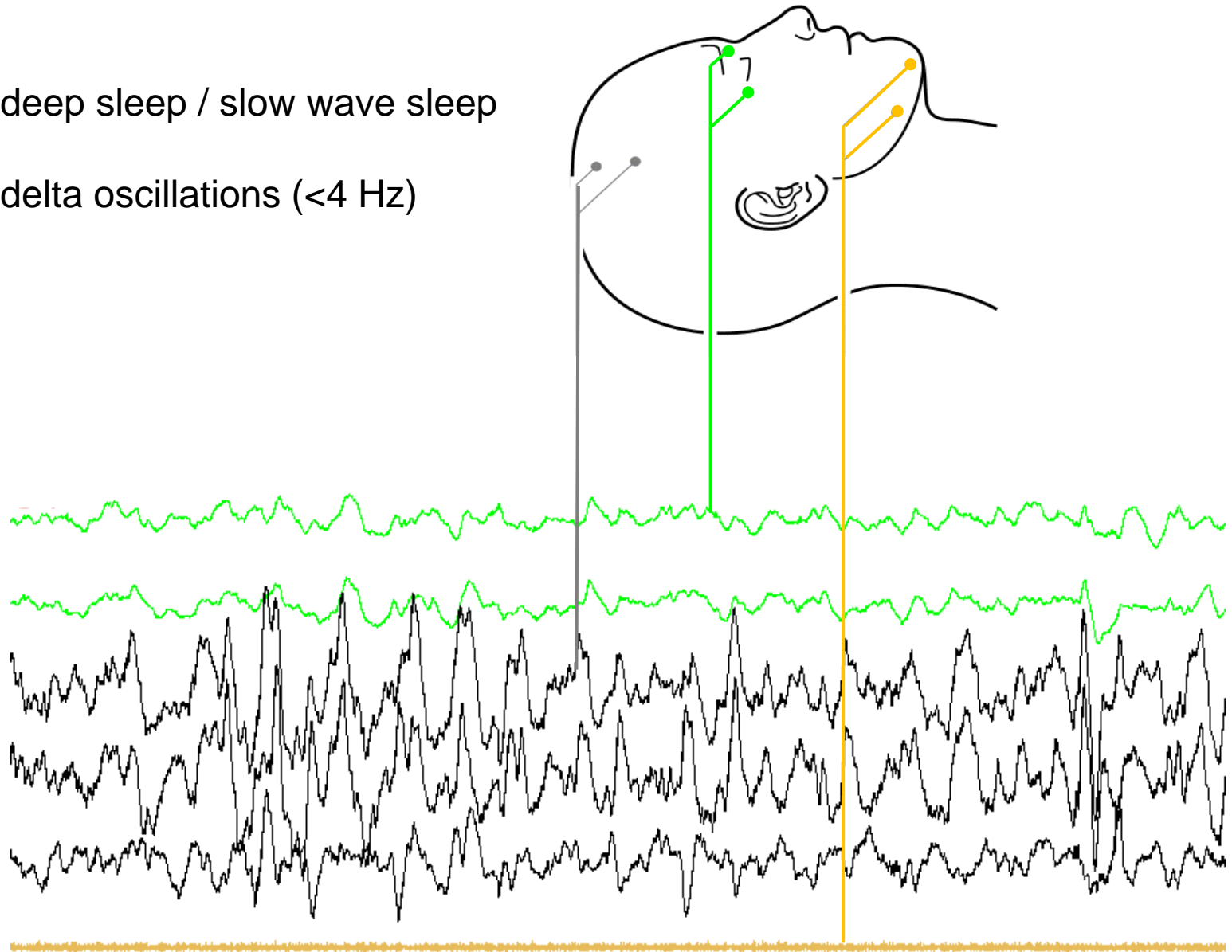
## Sleep stages: N2

- sleep spindles (10-16Hz) 
- K-complexes (0.5-1Hz) 



## Sleep stages: N3

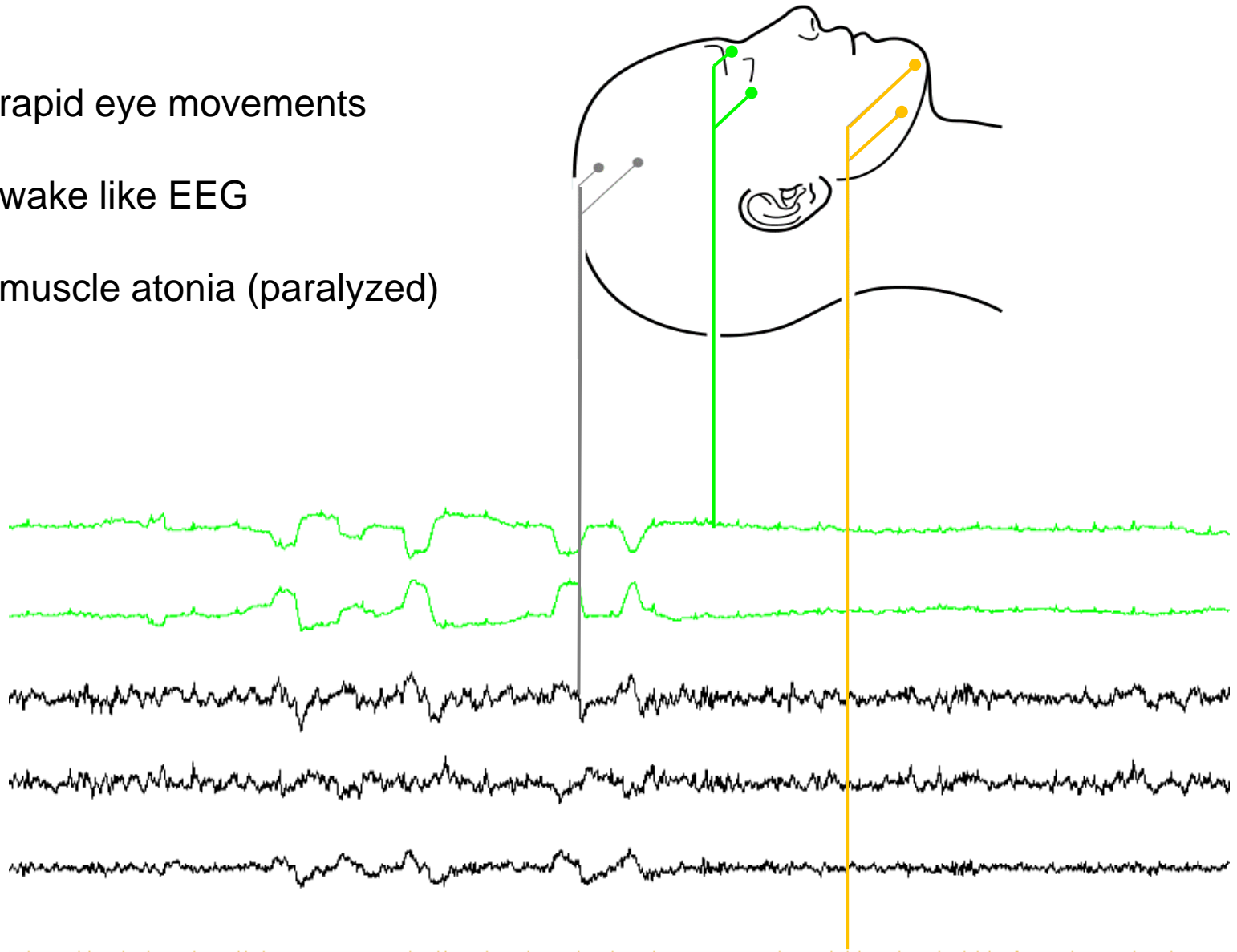
- deep sleep / slow wave sleep
- delta oscillations (<math><4\text{ Hz}</math>)





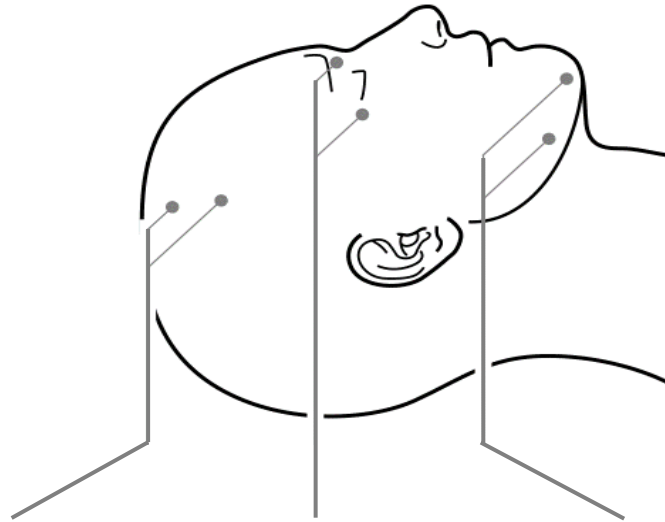
## Sleep stages: REM

- rapid eye movements
- wake like EEG
- muscle atonia (paralyzed)



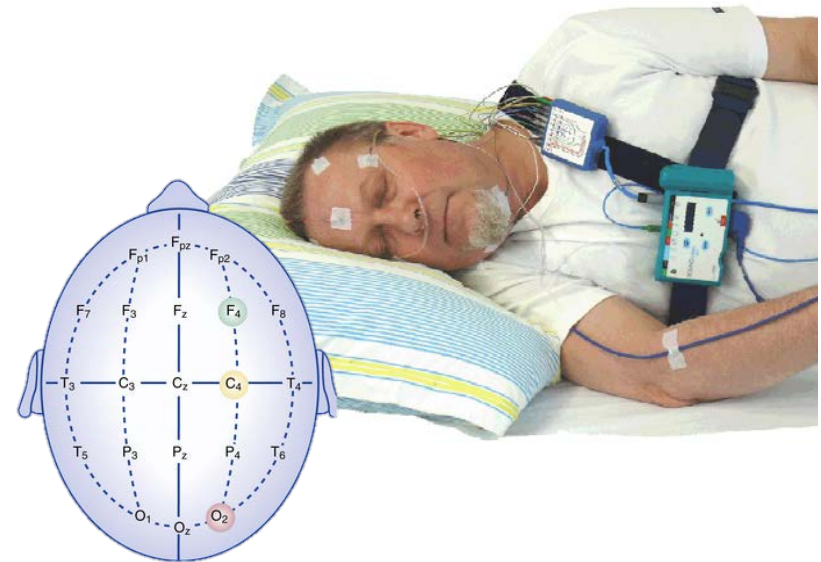
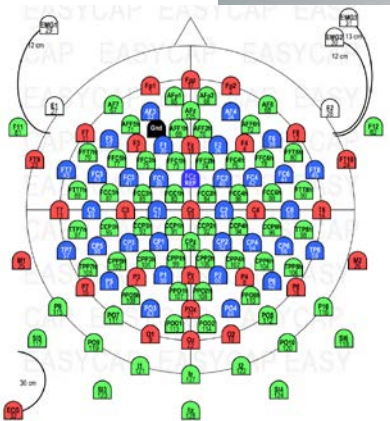
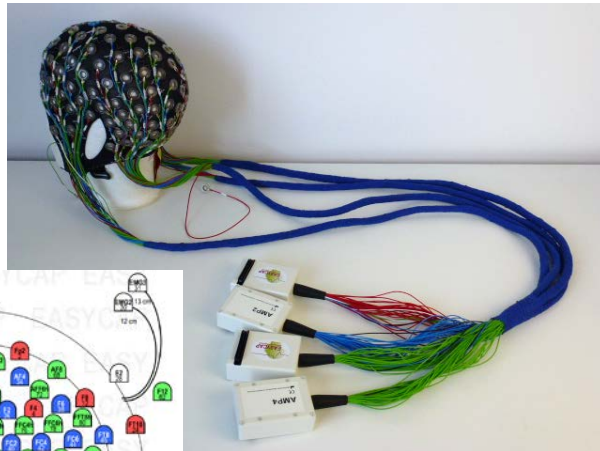


# Sleep stages: overview

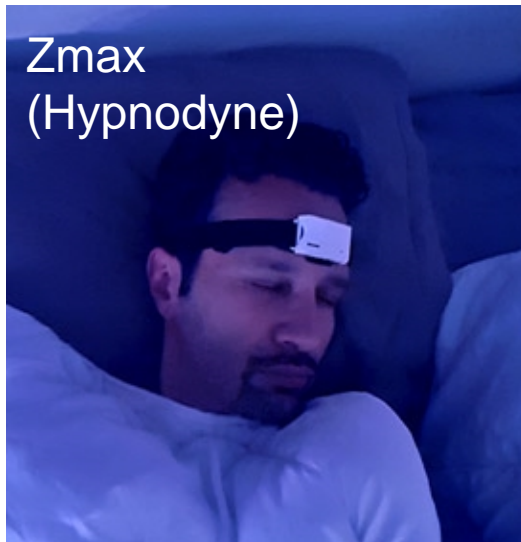
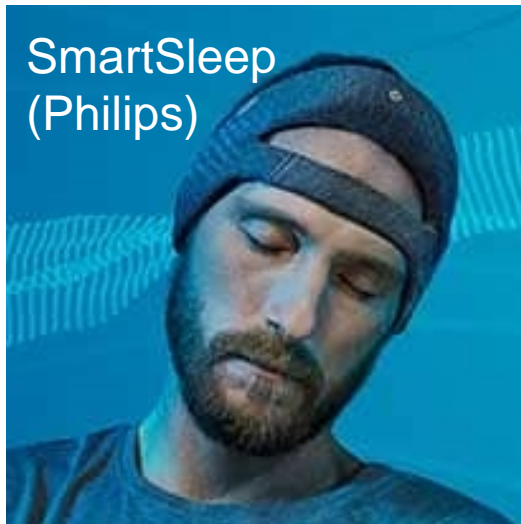


	Brain / EEG	Eyes / EOG	Muscles / EMG
wake			
REM			
N1			
N2			
N3			

# Sleep EEG: lab vs. home recordings



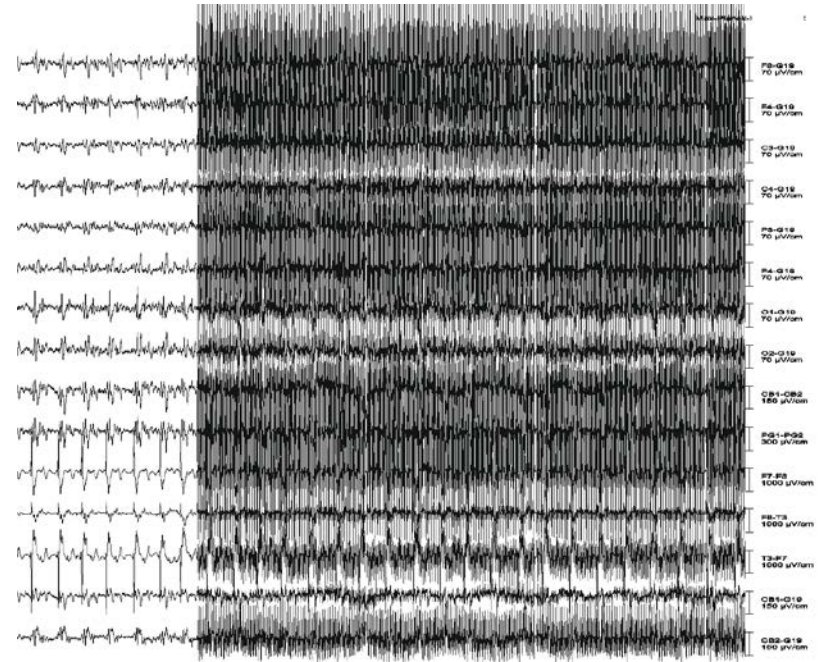
# Sleep EEG headbands



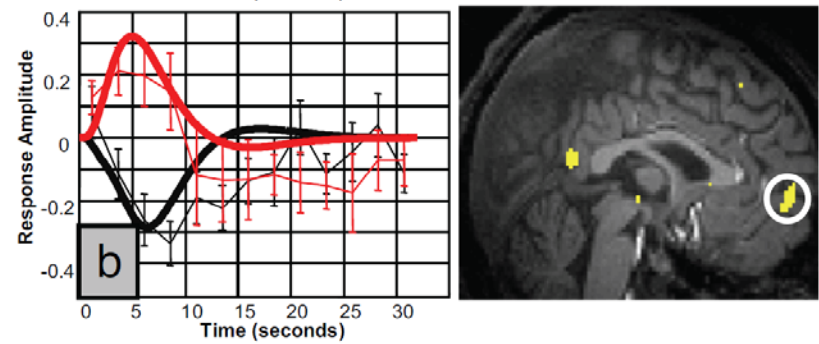
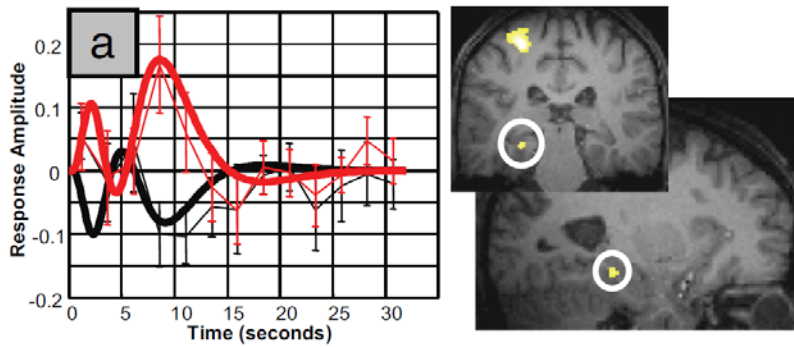
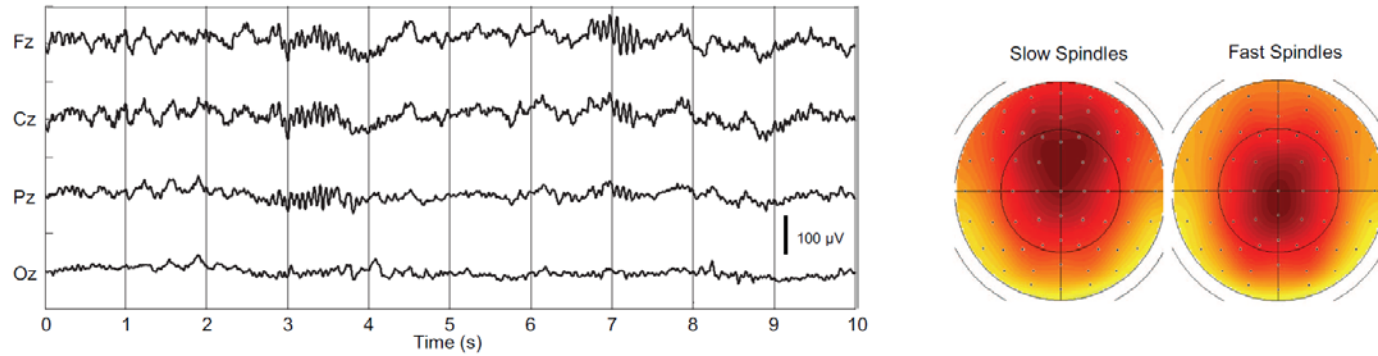
Aurora Dreamband  
(iWinks)



# Combined EEG/fMRI

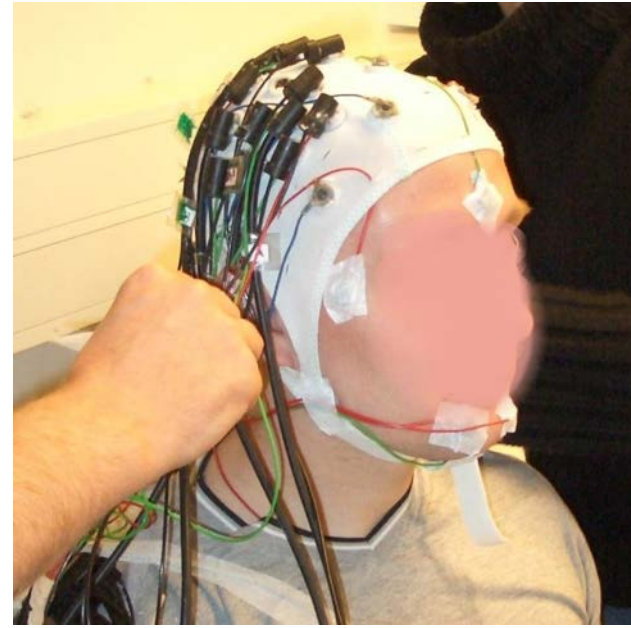
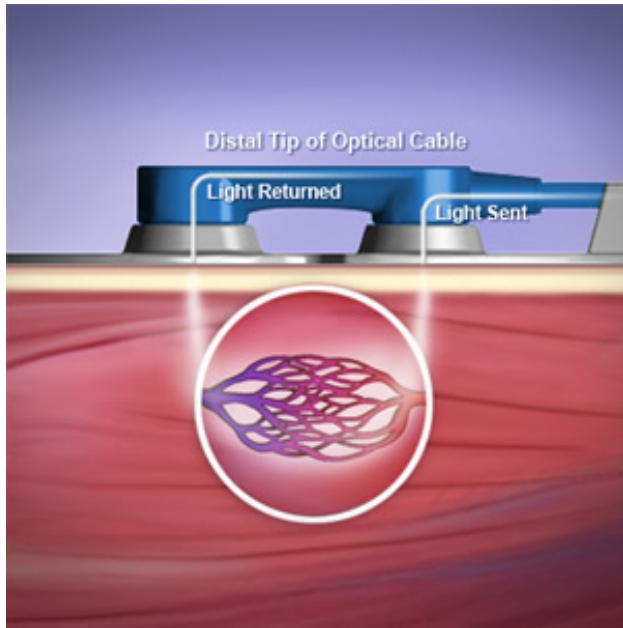


# Combined EEG/fMRI: sleep spindles



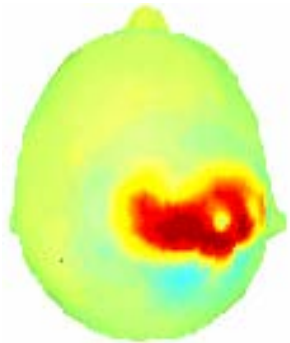


# Combined EEG/NIRS

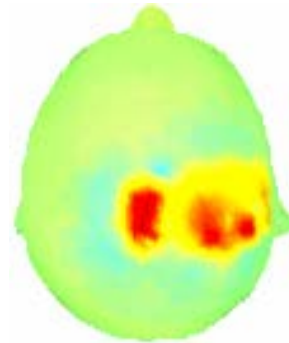




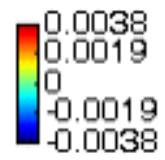
real hand movements



dreamed hand movements



HbO



# Spontaneous EEG and Sleep



## Agenda

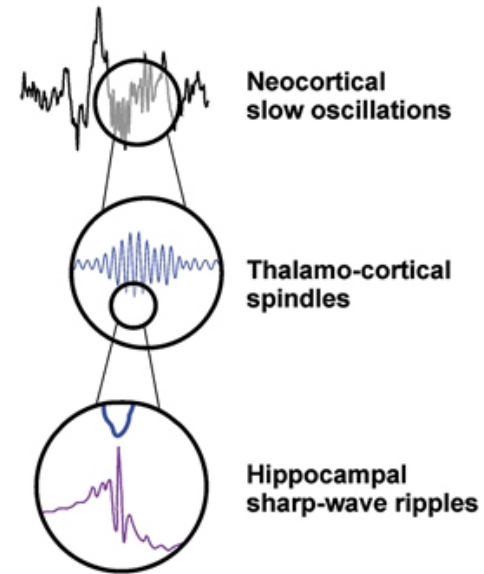
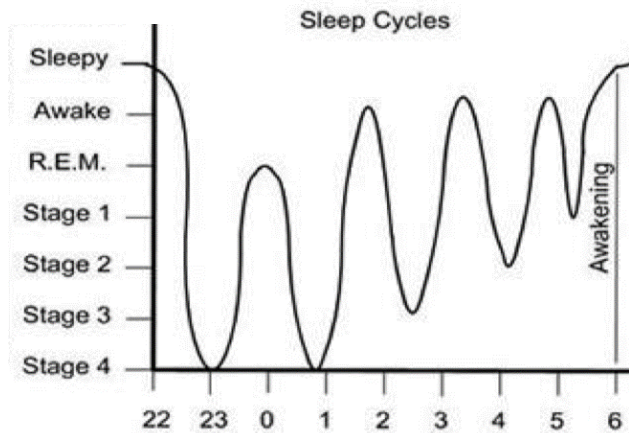
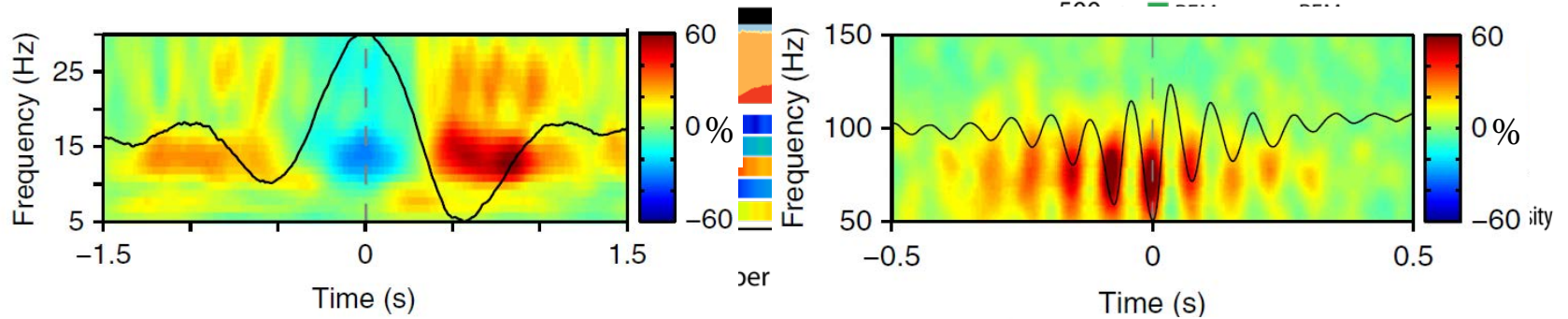
- Recording methods
- Oscillations on different time scales
- Examples: functions of sleep



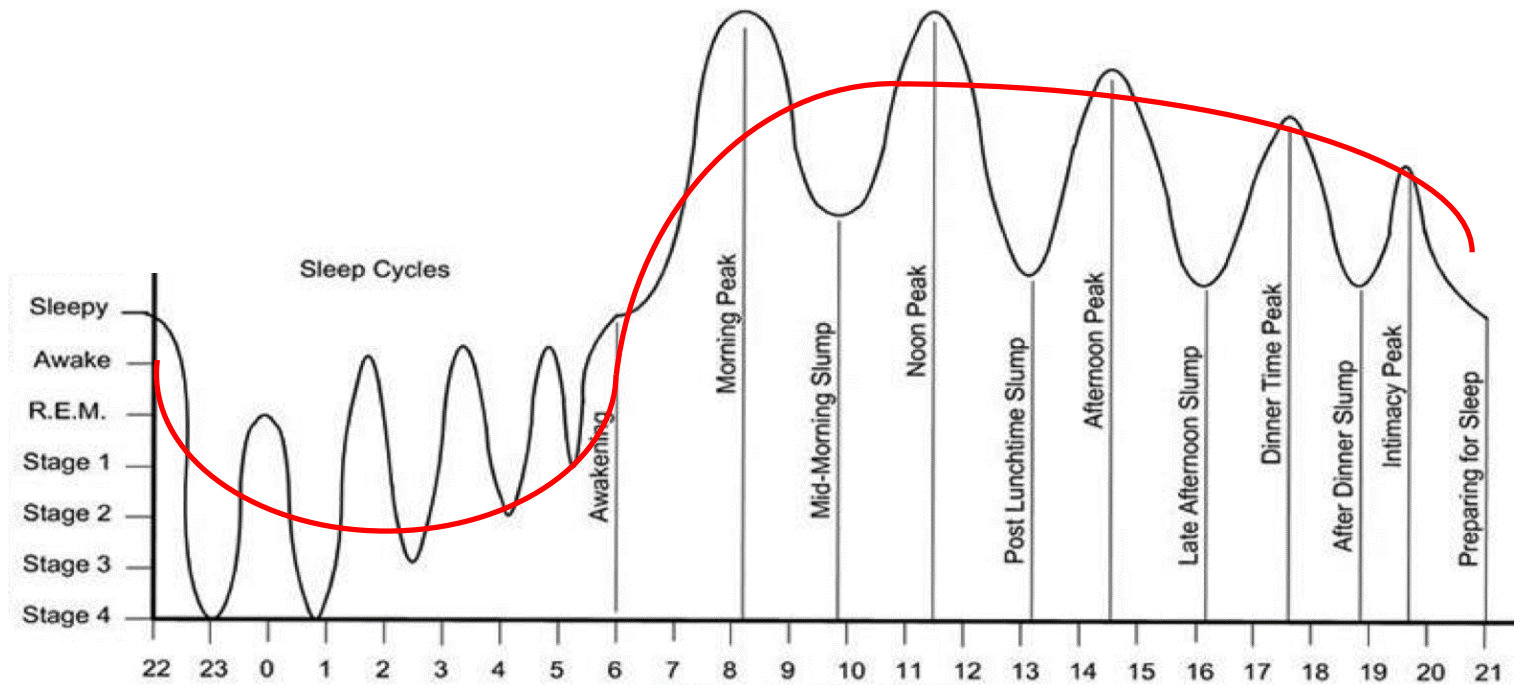
# Sleep: nested oscillations



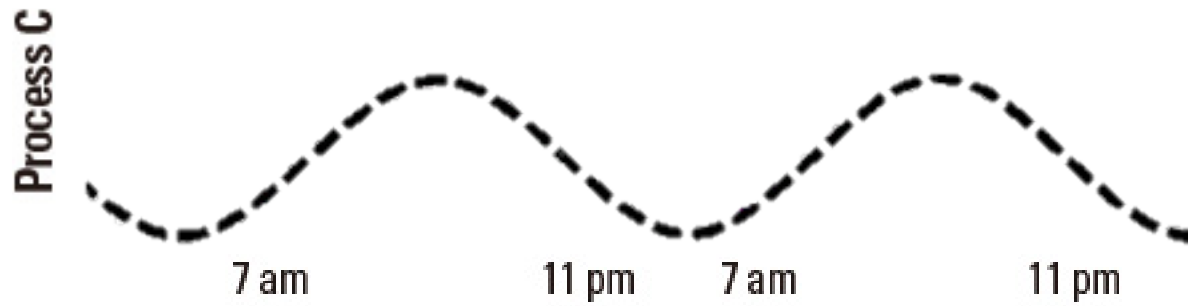
# Sleep: nested oscillations



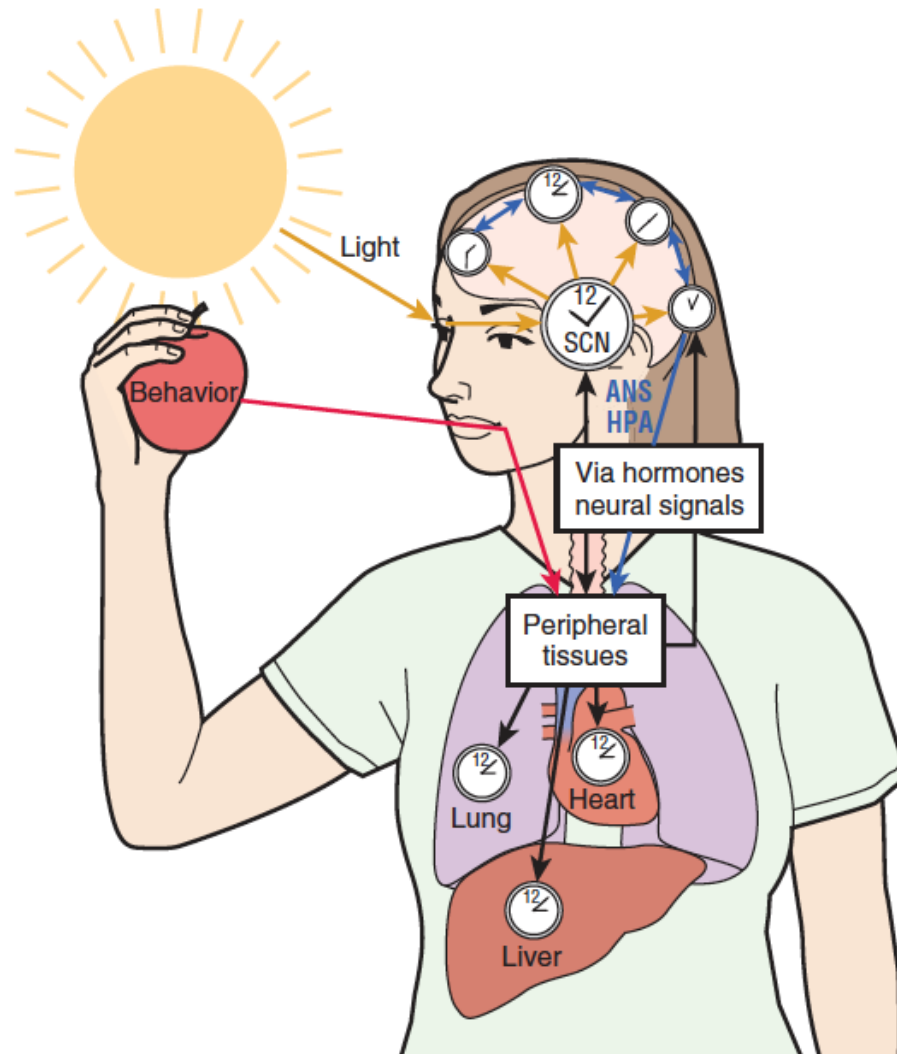
# Sleep: ultradian oscillations



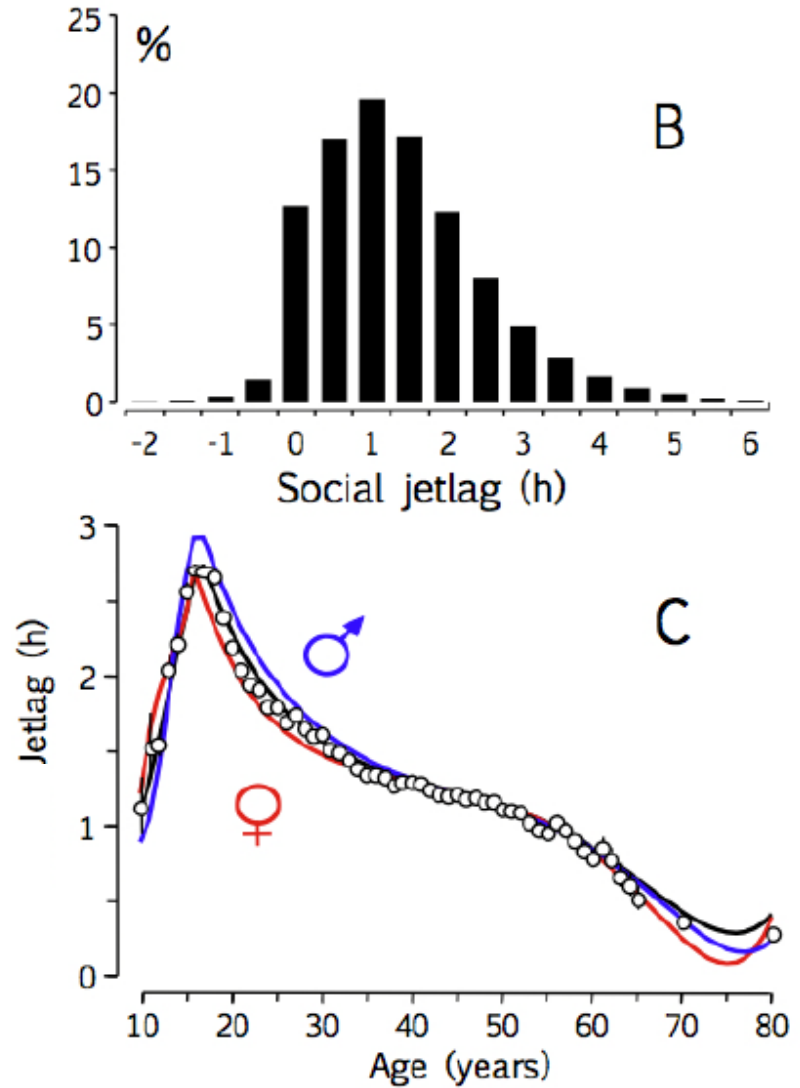
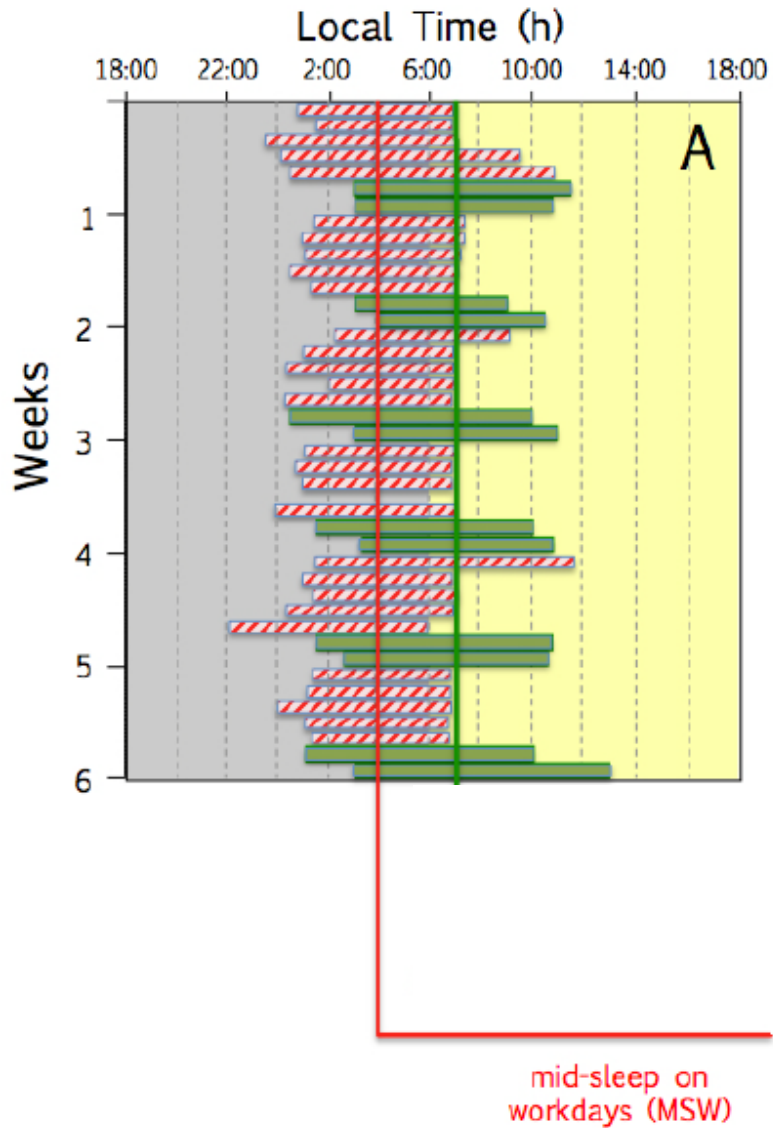
# Sleep: circadian oscillations



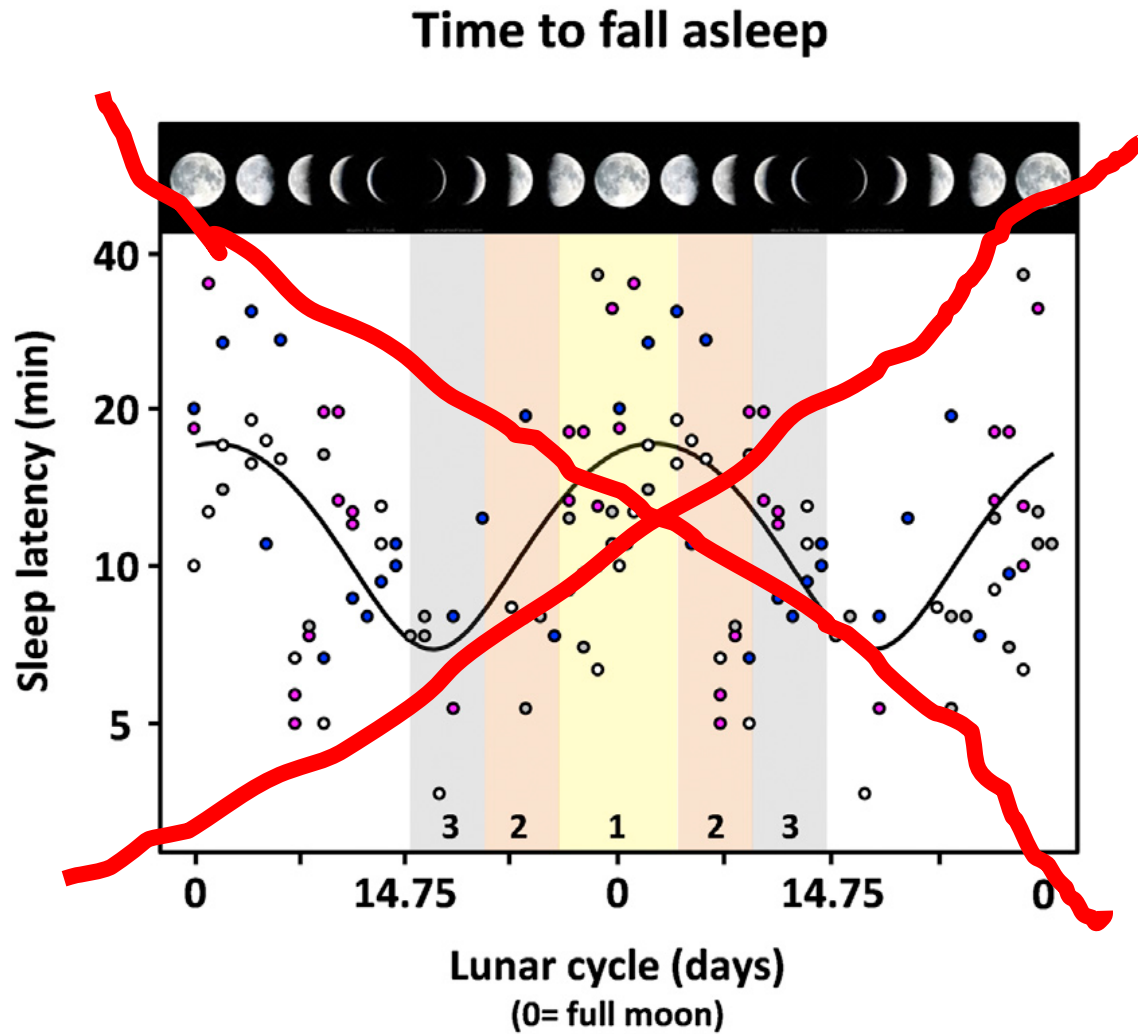
# Sleep: synchronization through light



# Sleep: weekly oscillations



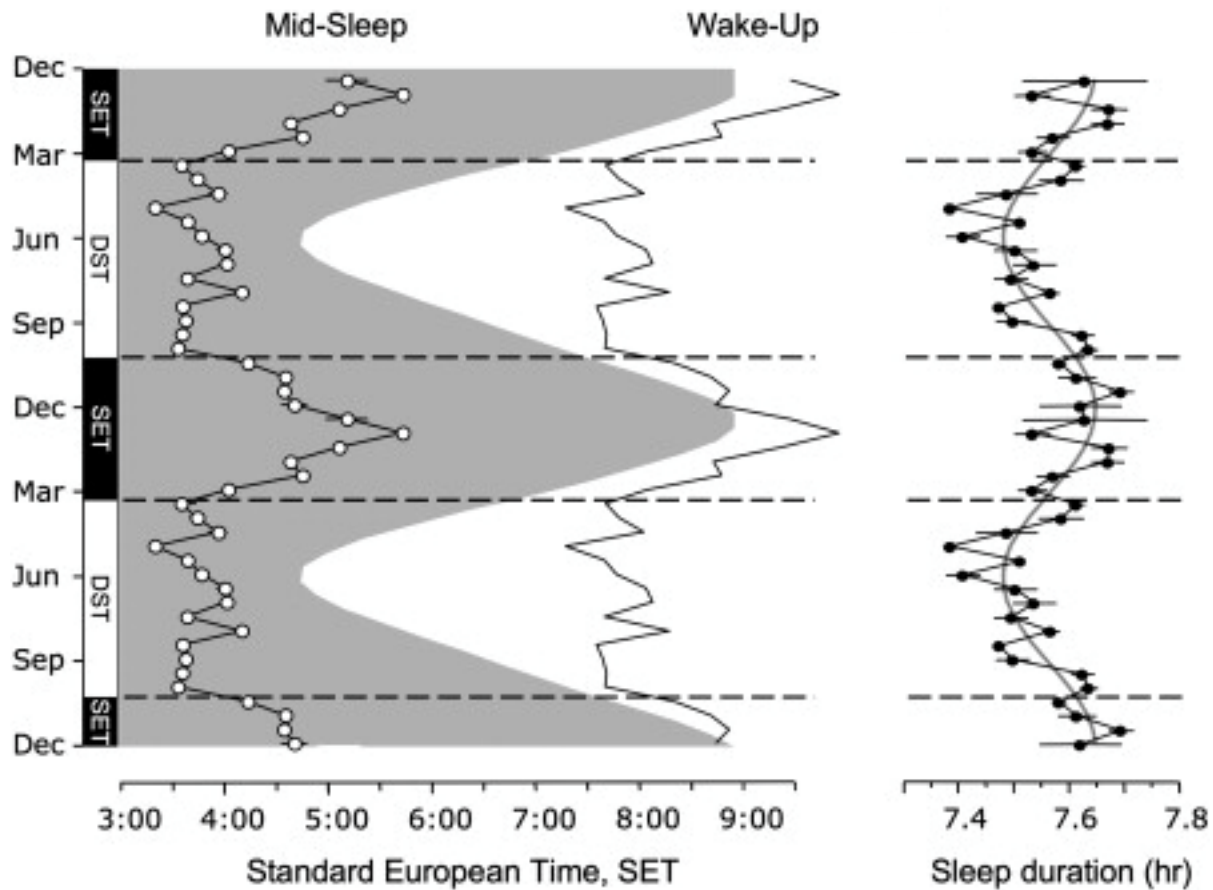
# Sleep: monthly oscillations?



Cajochen et al., 2013  
but: Cordi et al., 2014

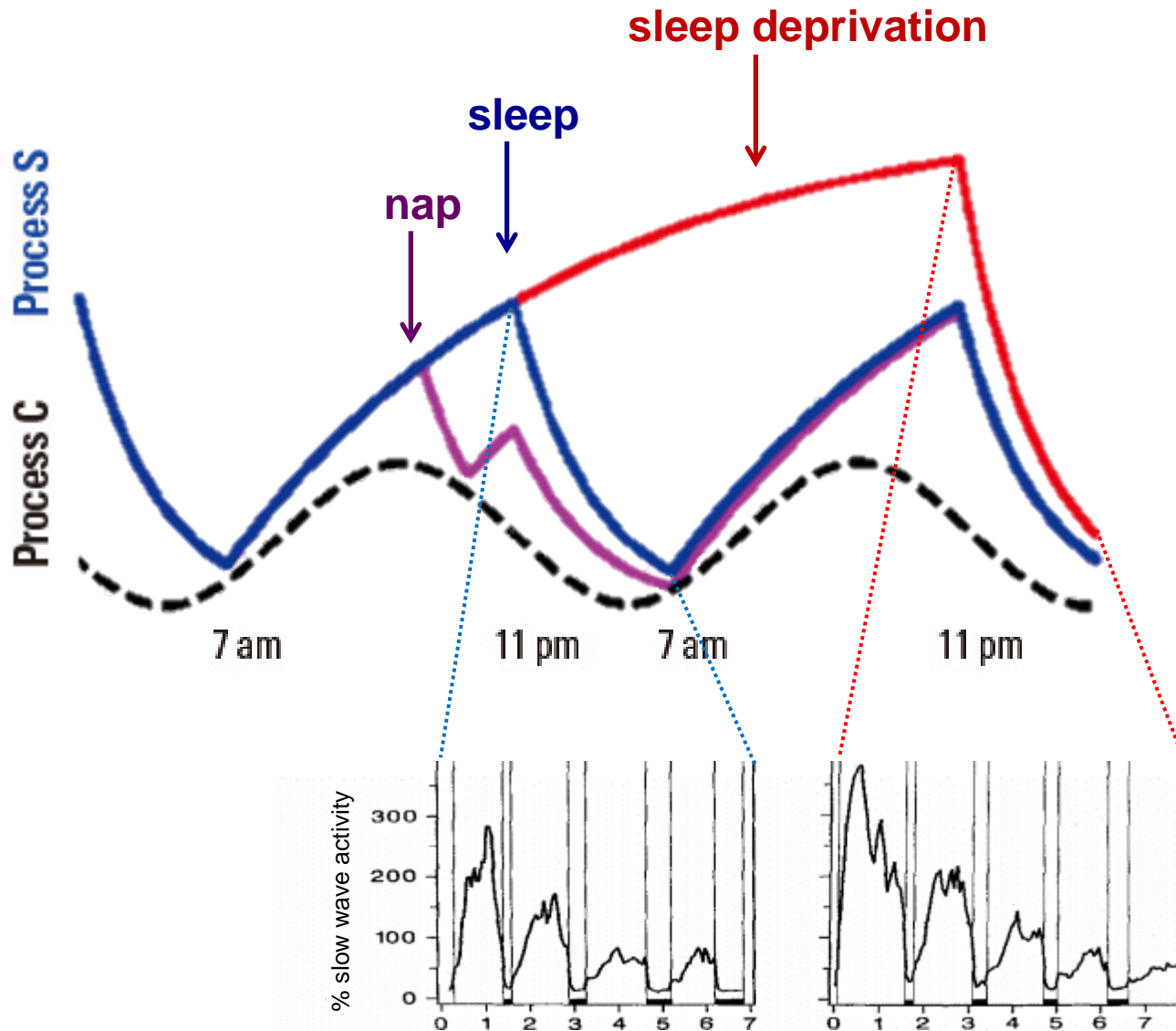


# Sleep: annual oscillations

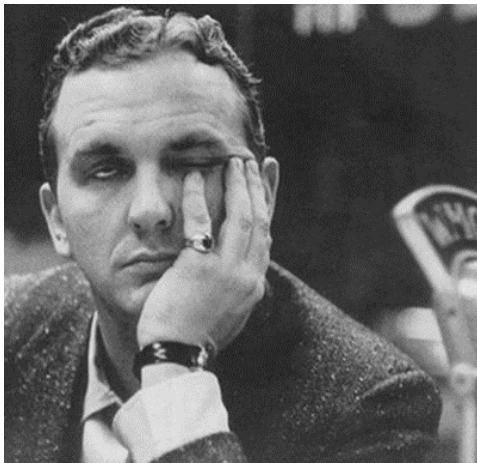
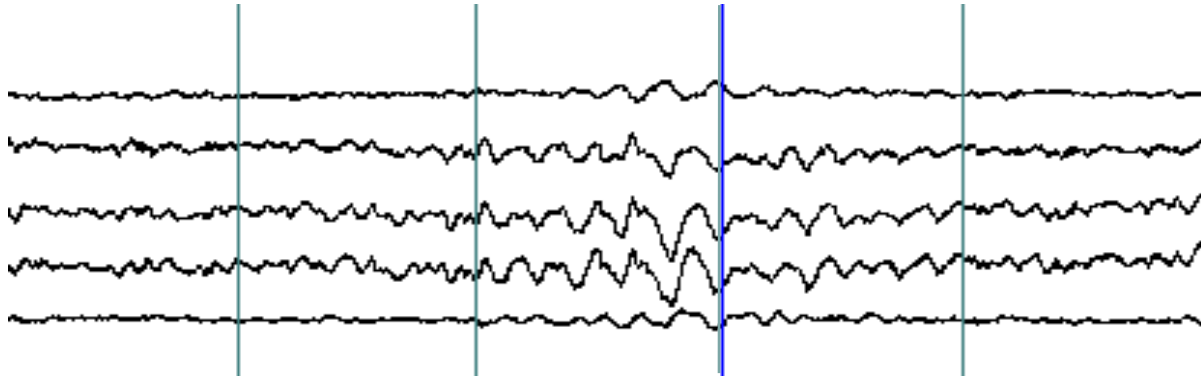




# Sleep regulation: two-process model



# Sleep pressure

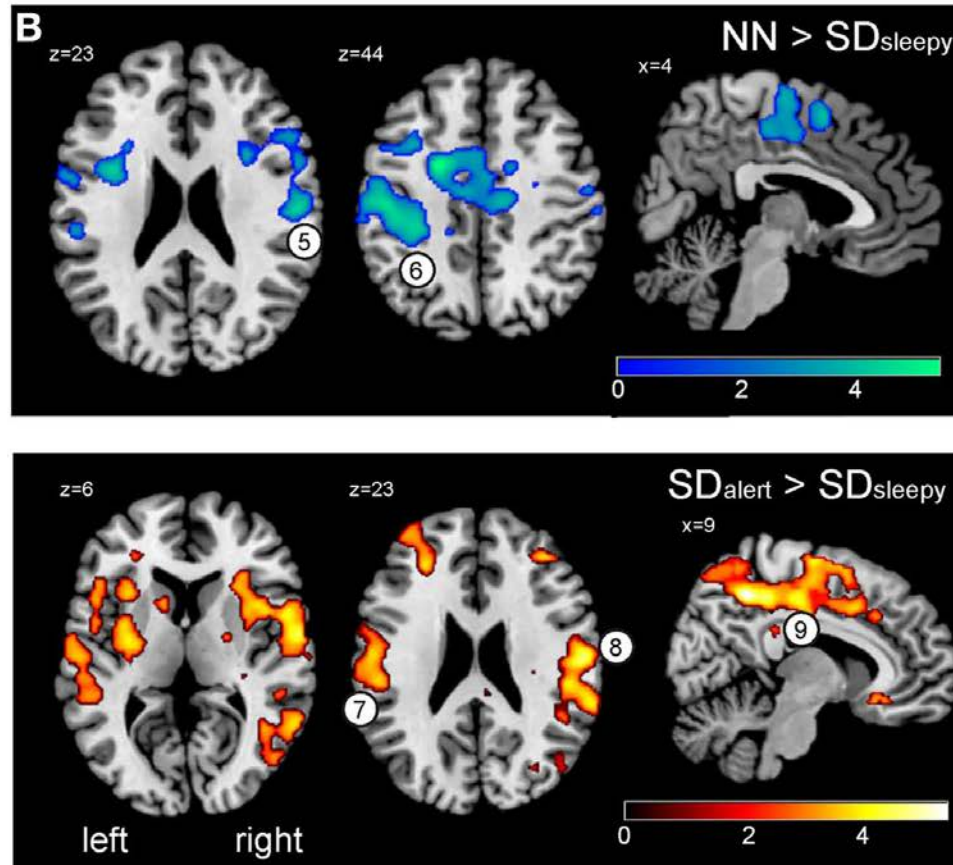


– microsleeep

– local sleep



# Combined EEG/fMRI: vigilance measurement





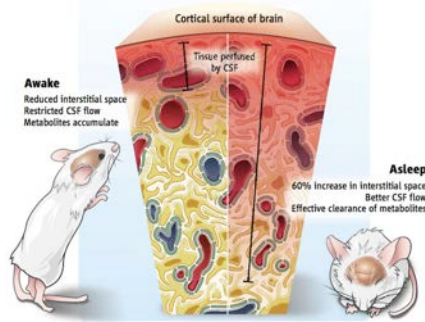
## Agenda

- Recording methods
- Oscillations on different time scales
- Examples: functions of sleep

# Sleep: more than a substitute for coffee!



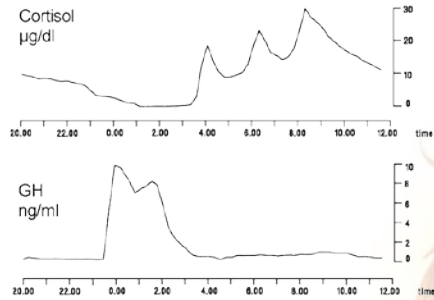
brain clearance



memory



hormones



emotions



immune system



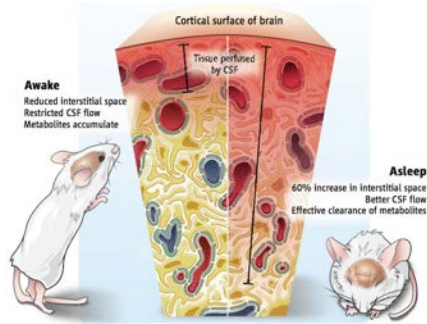
simulation



# Sleep: more than a substitute for coffee!

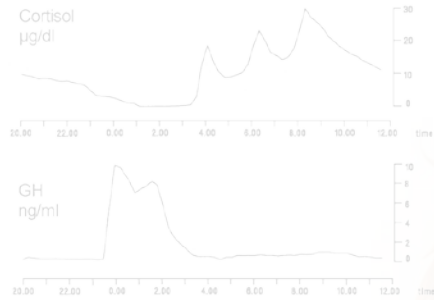


brain clearance



memory

hormones



emotions

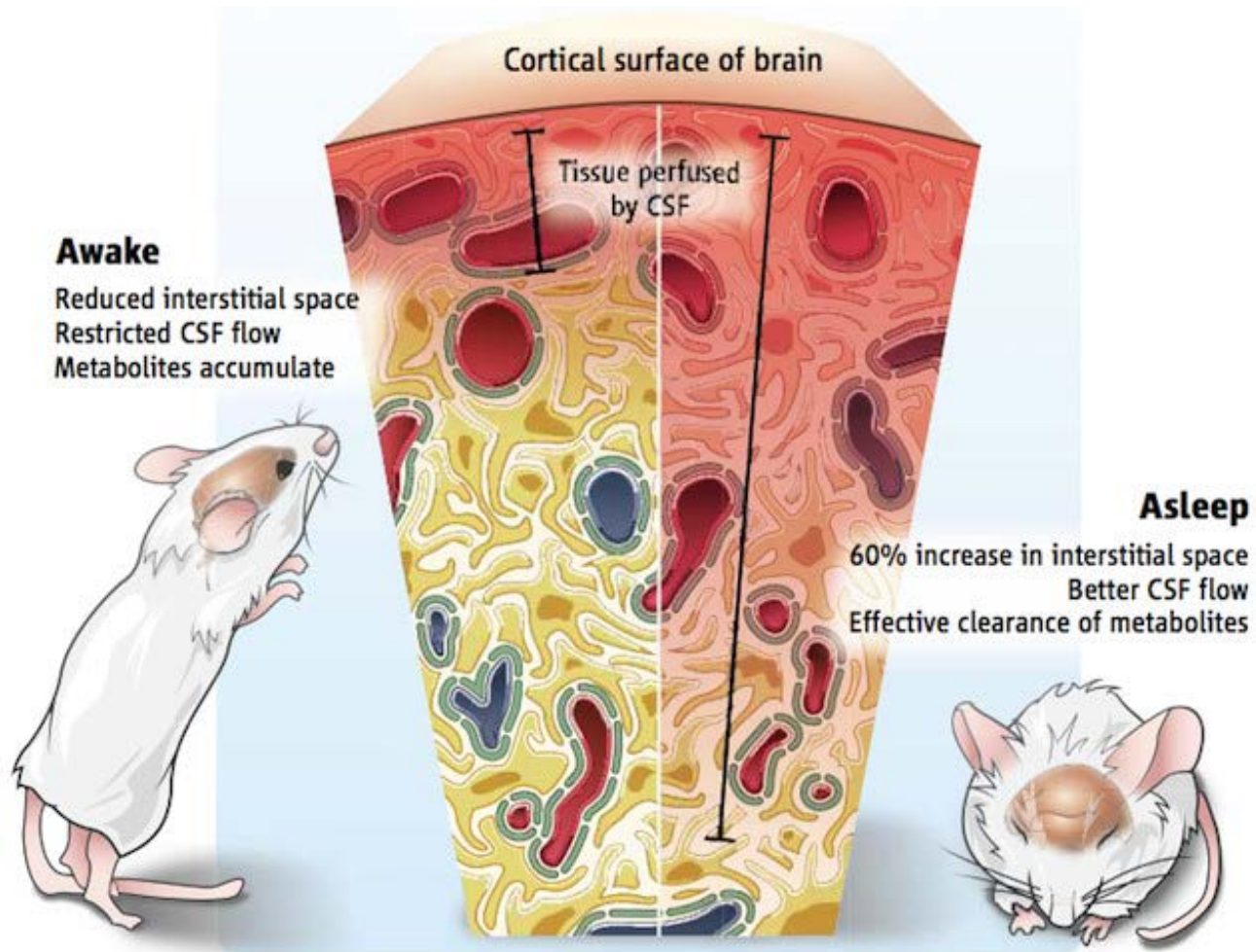
immune system



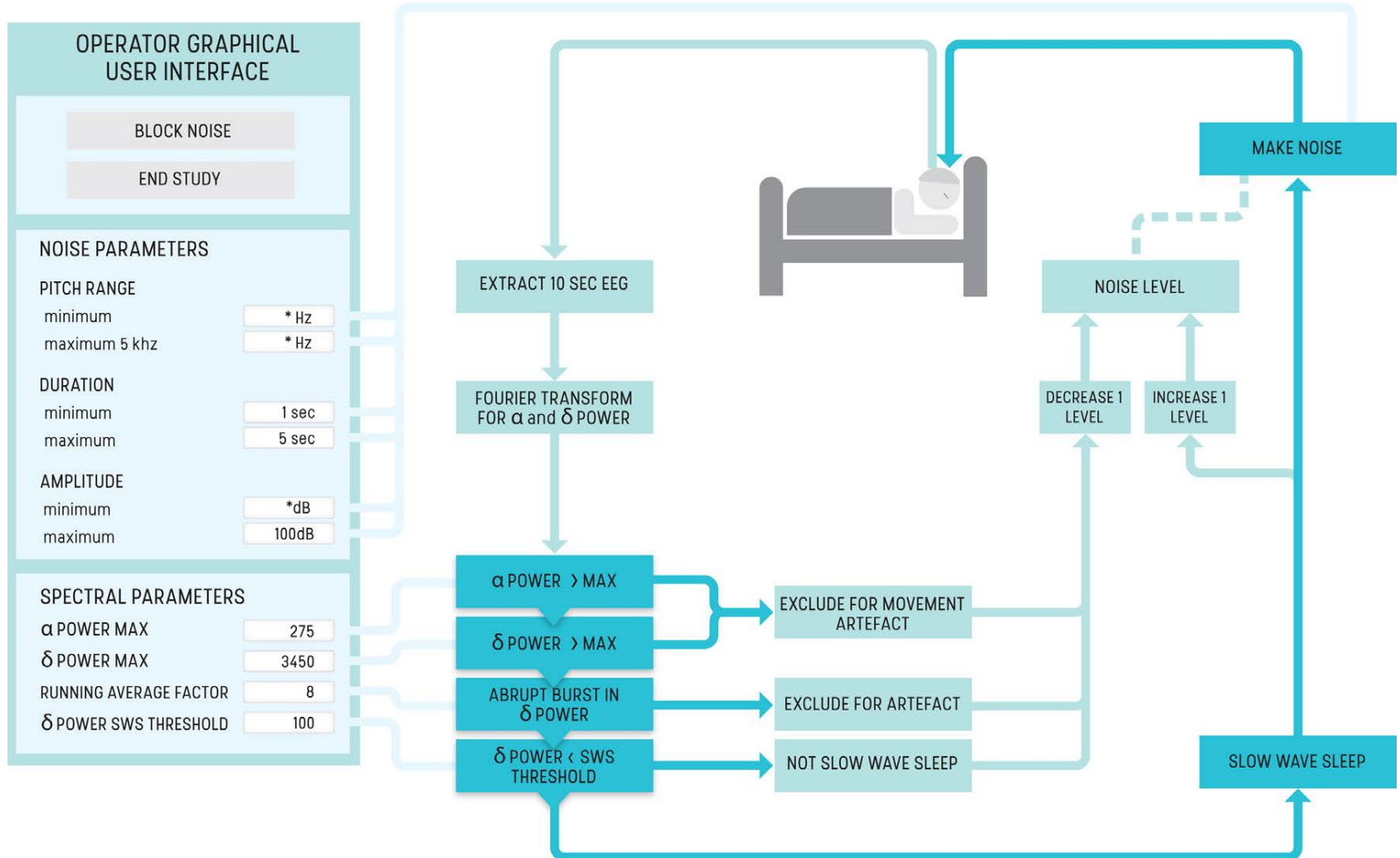
simulation



# Brain clearance function of sleep

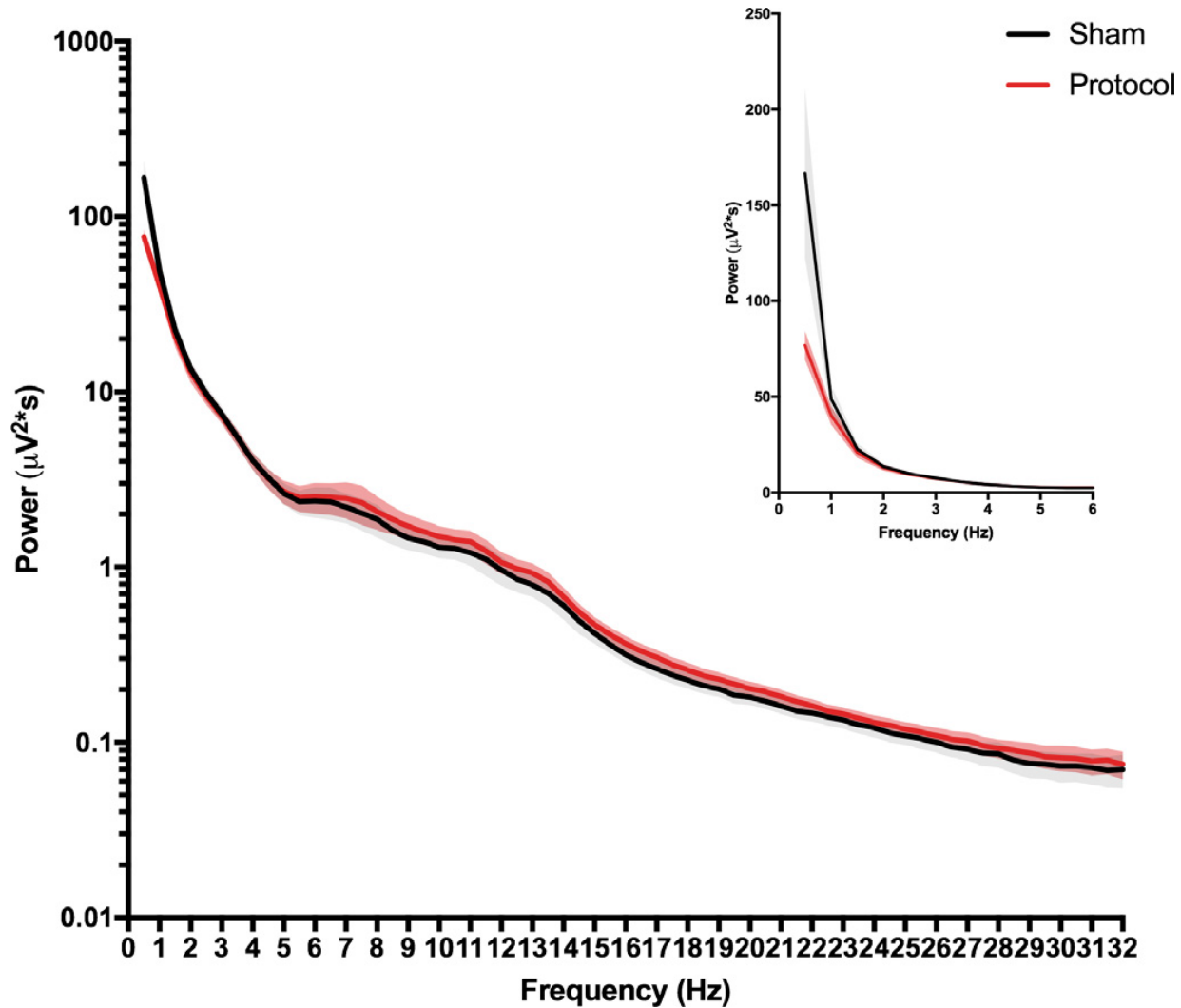


# Brain clearance function of sleep



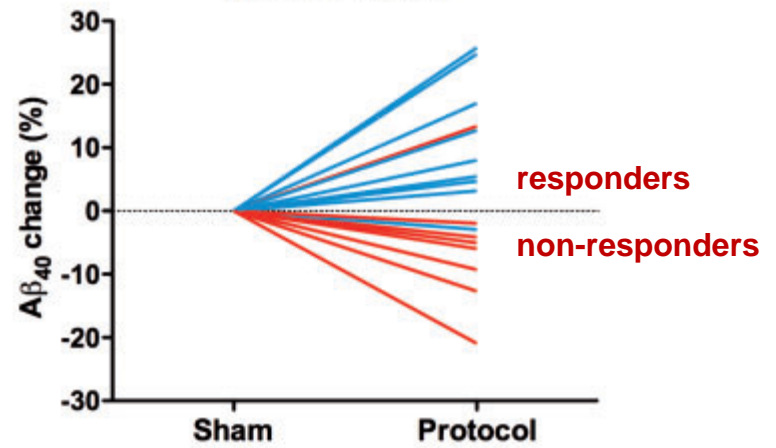
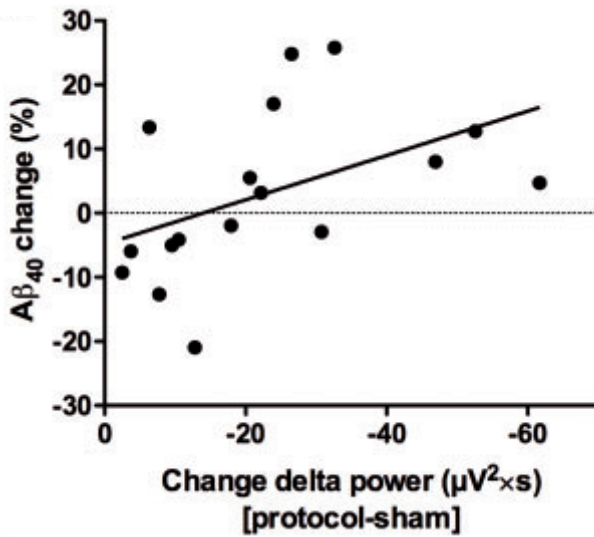


# Brain clearance function of sleep





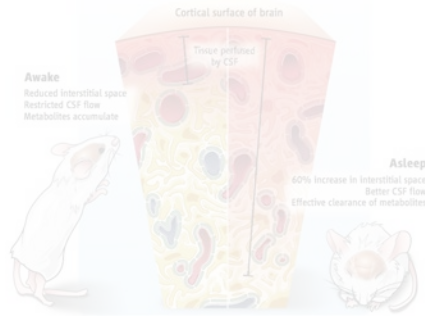
# Brain clearance function of sleep



# Sleep: more than a substitute for coffee!



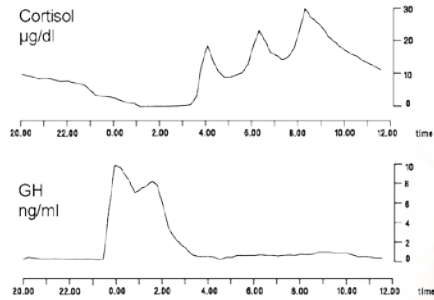
brain clearance



memory



hormones



emotions



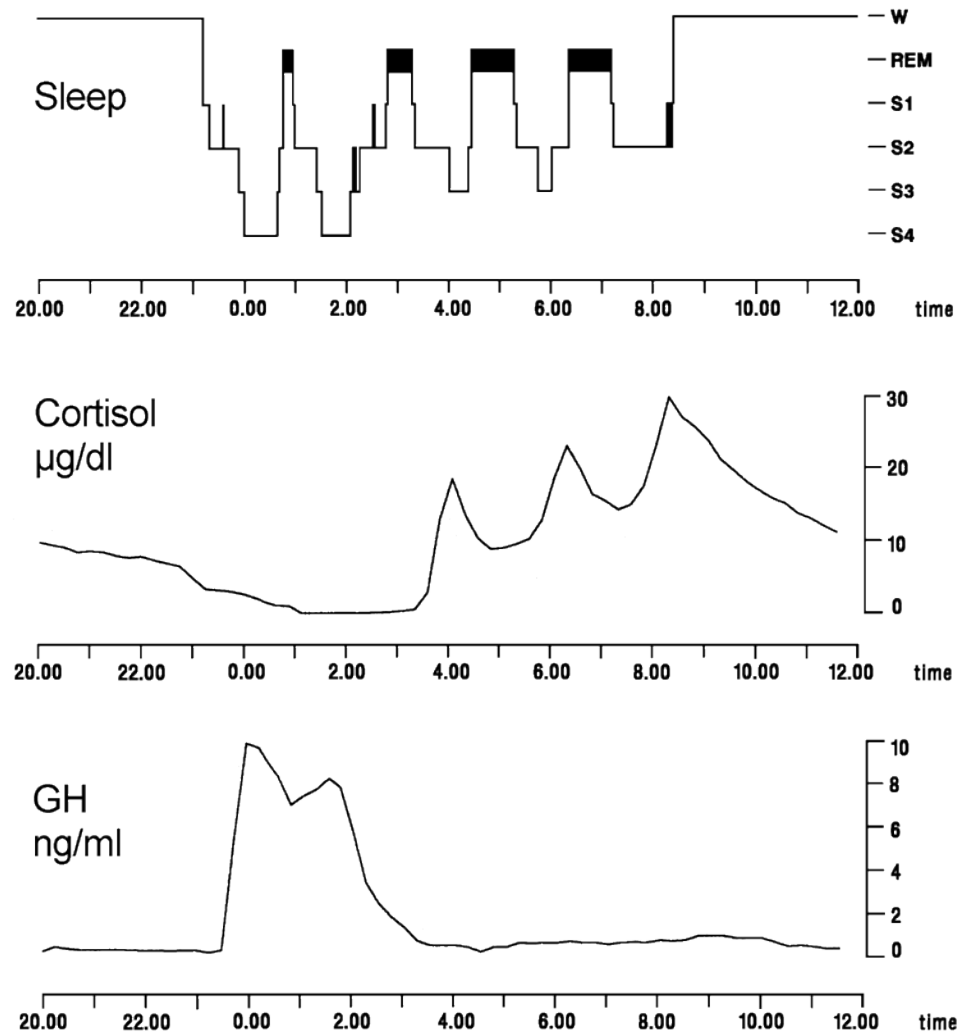
immune system



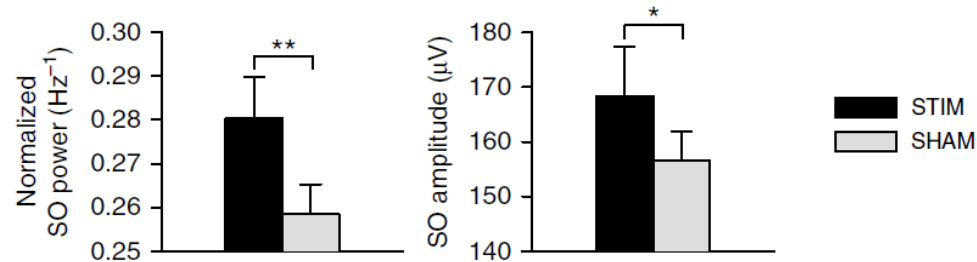
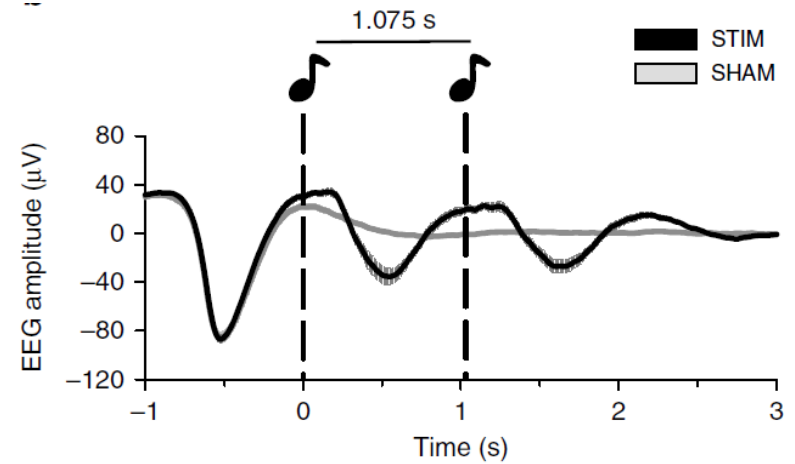
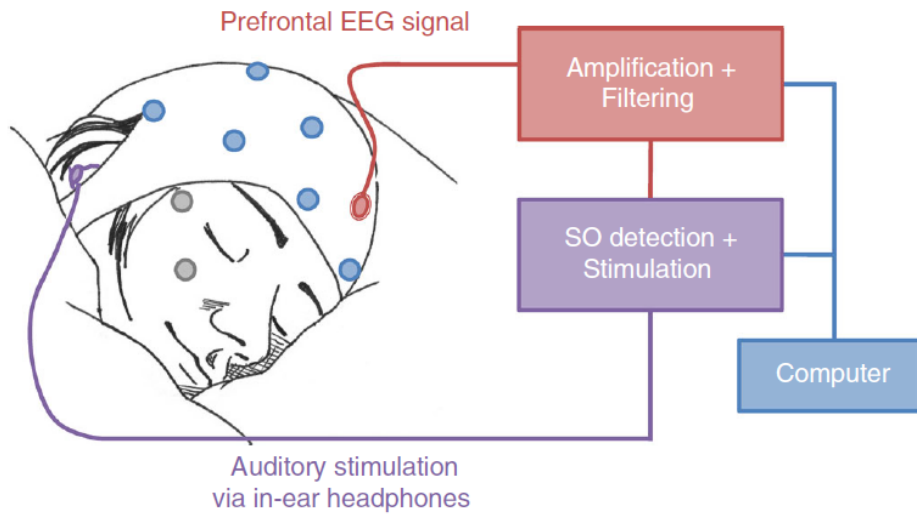
simulation



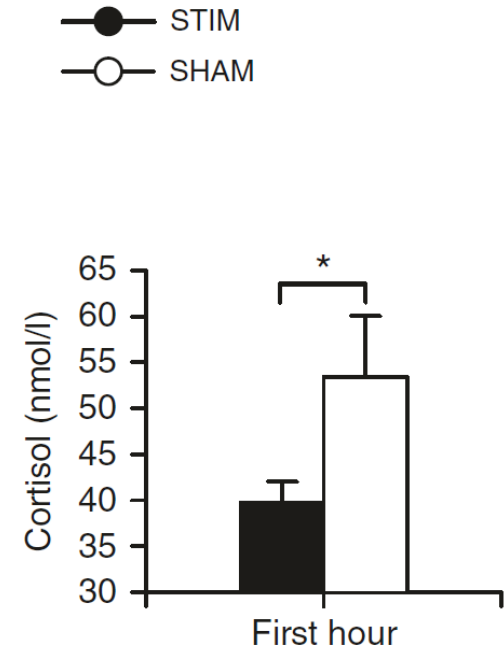
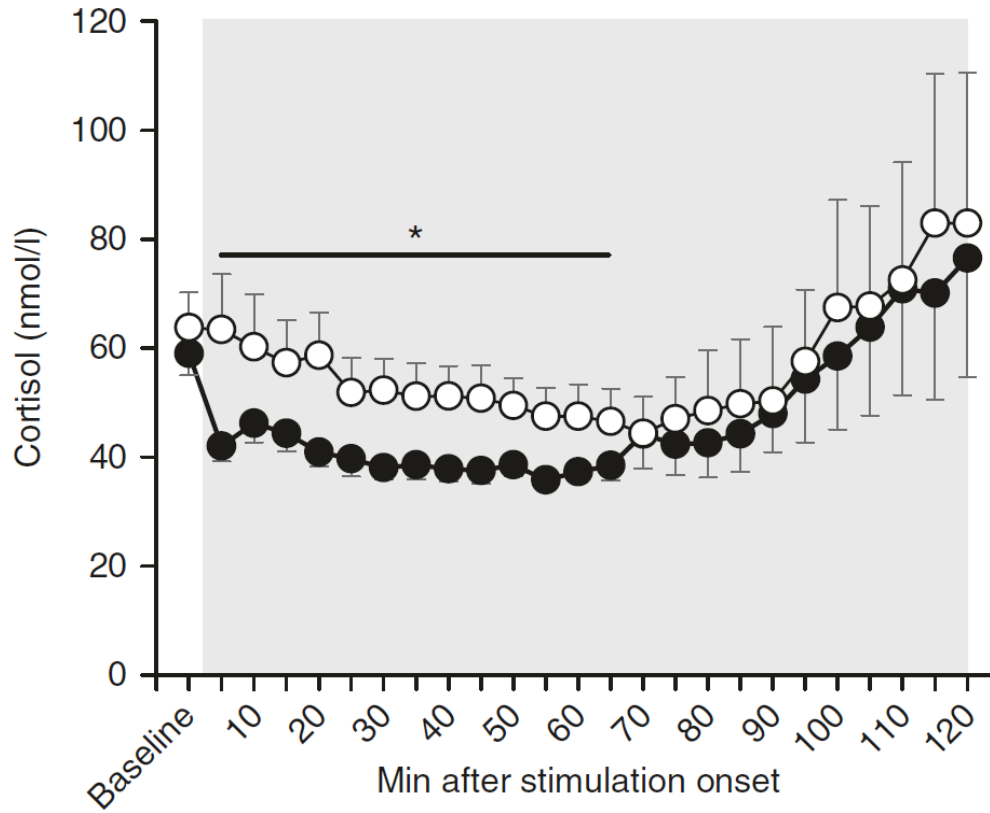
# Endocrine function of sleep



# Endocrinological function of sleep



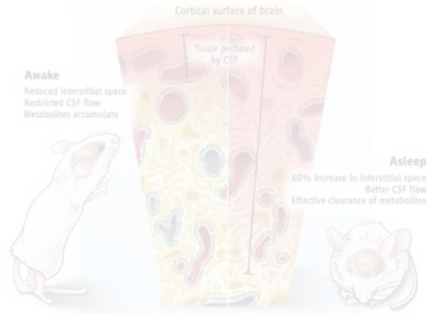
# Endocrinological function of sleep



# Sleep: more than a substitute for coffee!



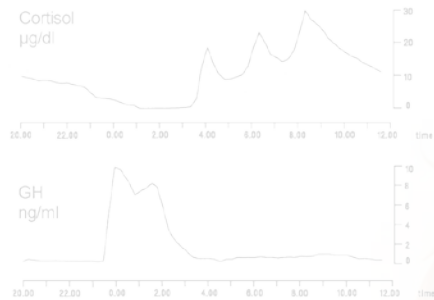
brain clearance



memory



hormones



emotions



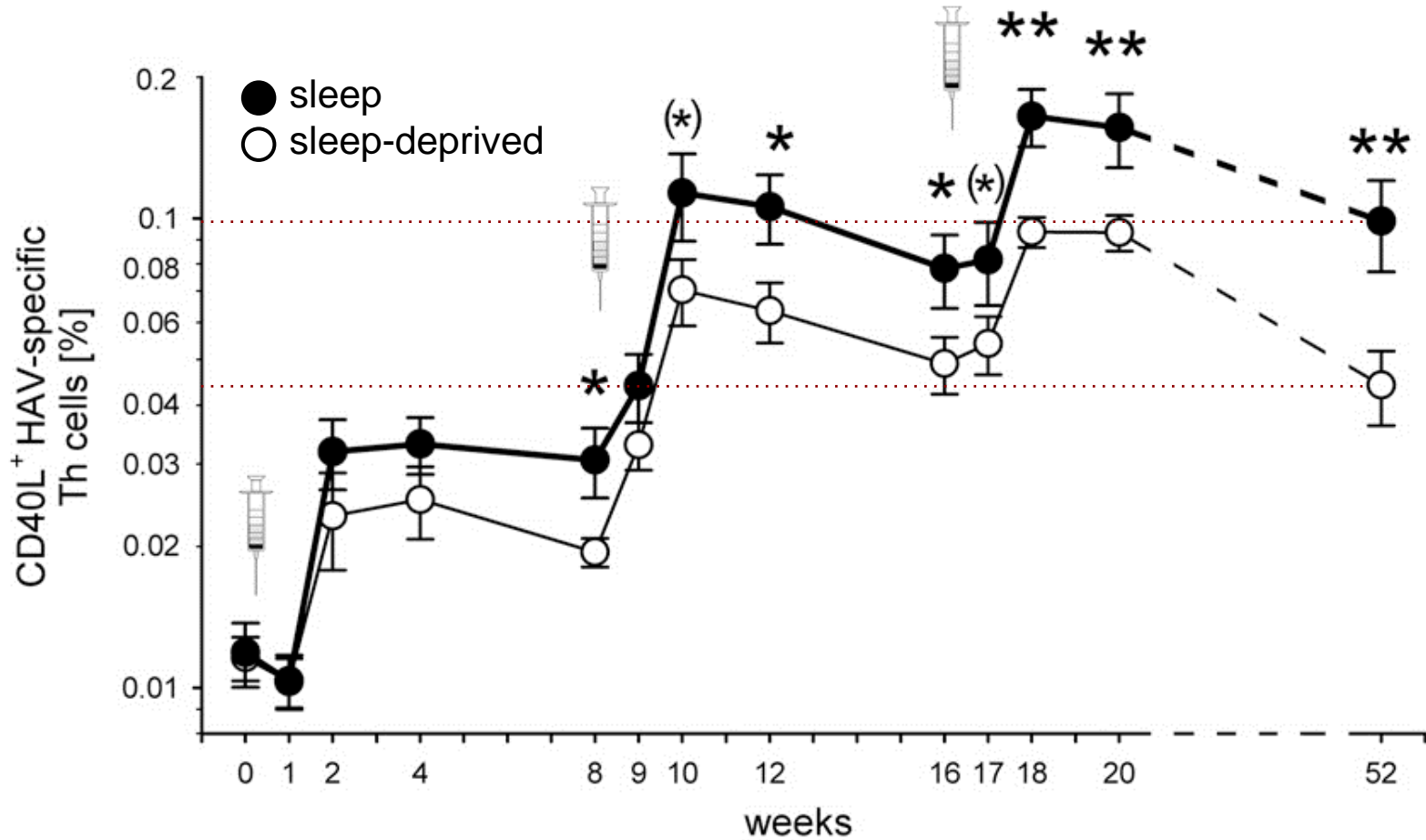
immune system



simulation



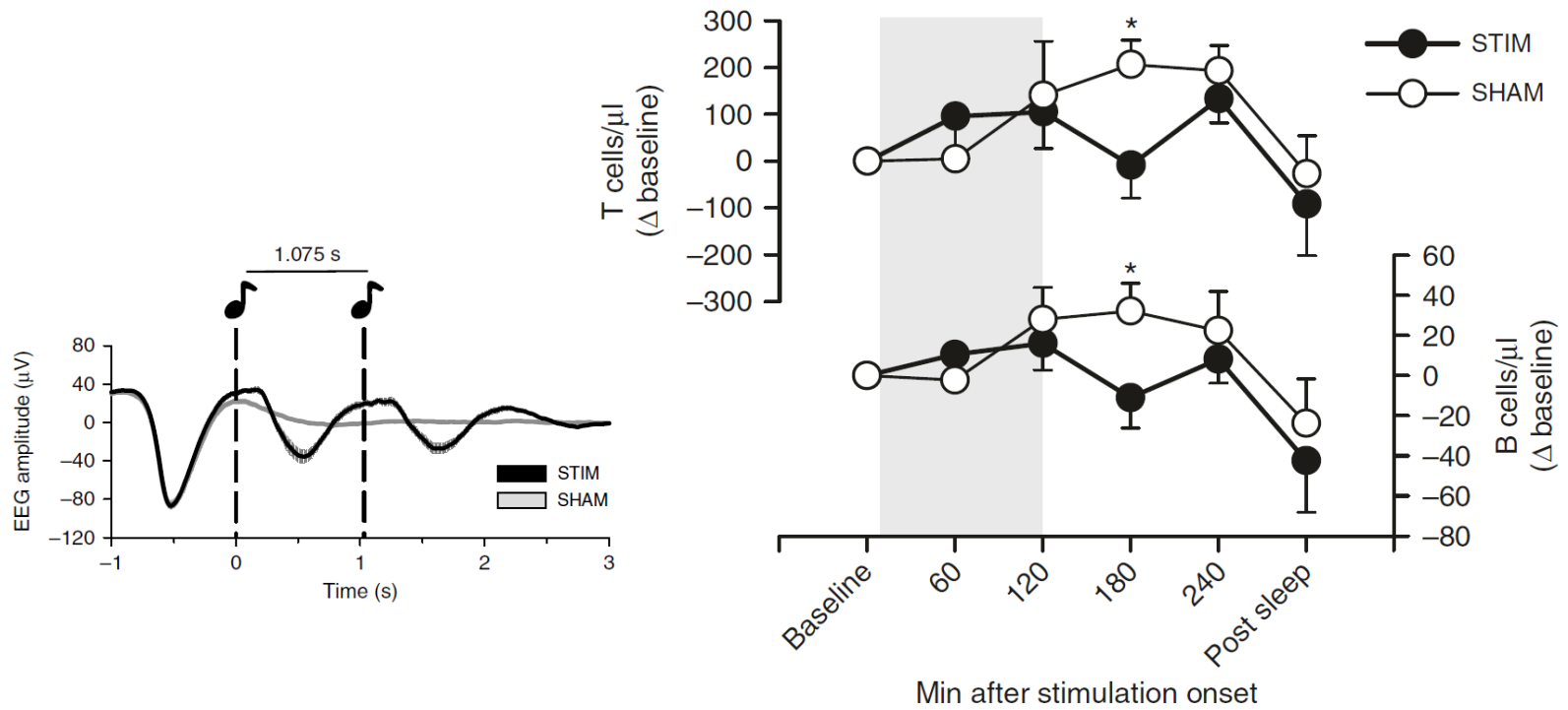
# Immunological function of sleep



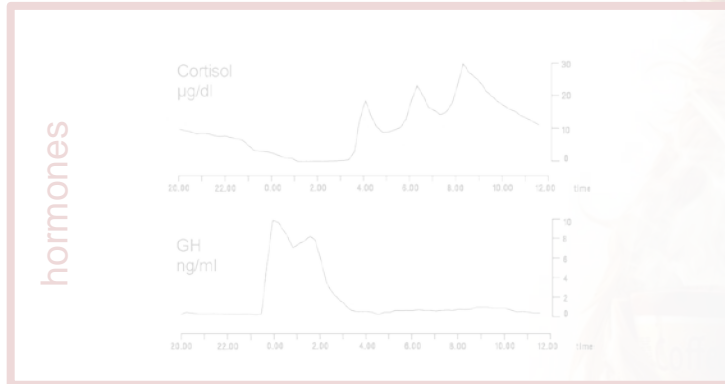
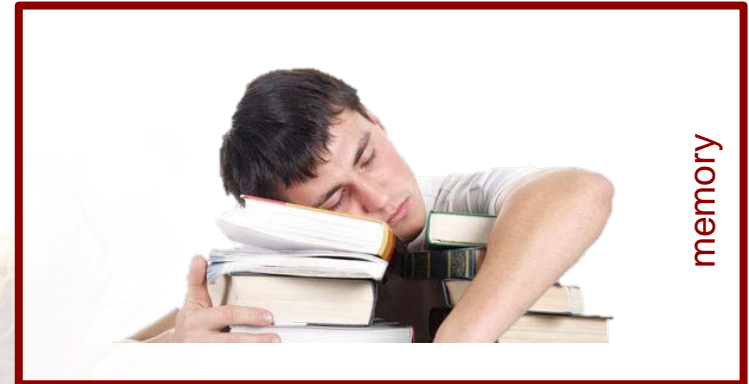
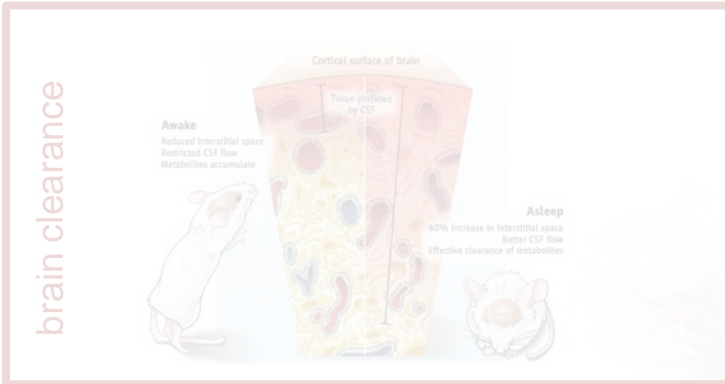




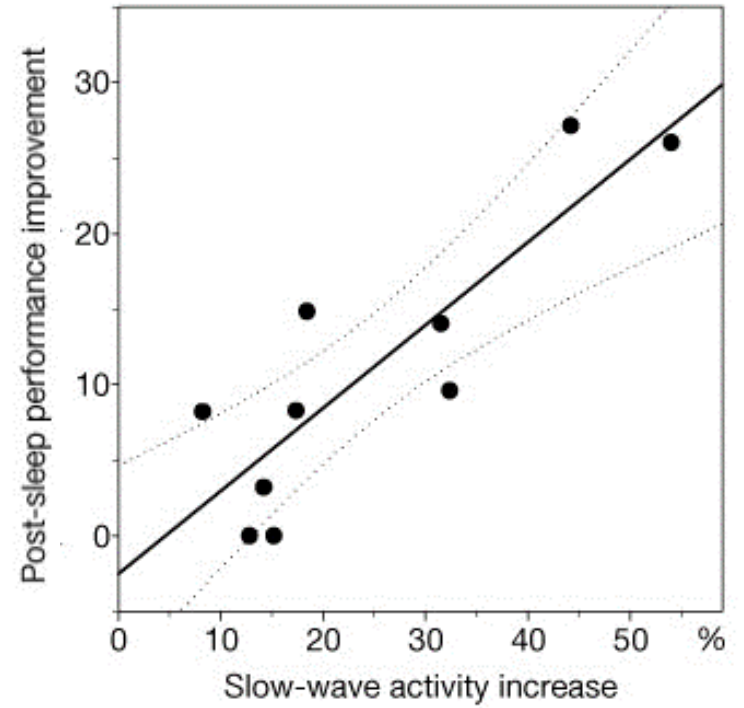
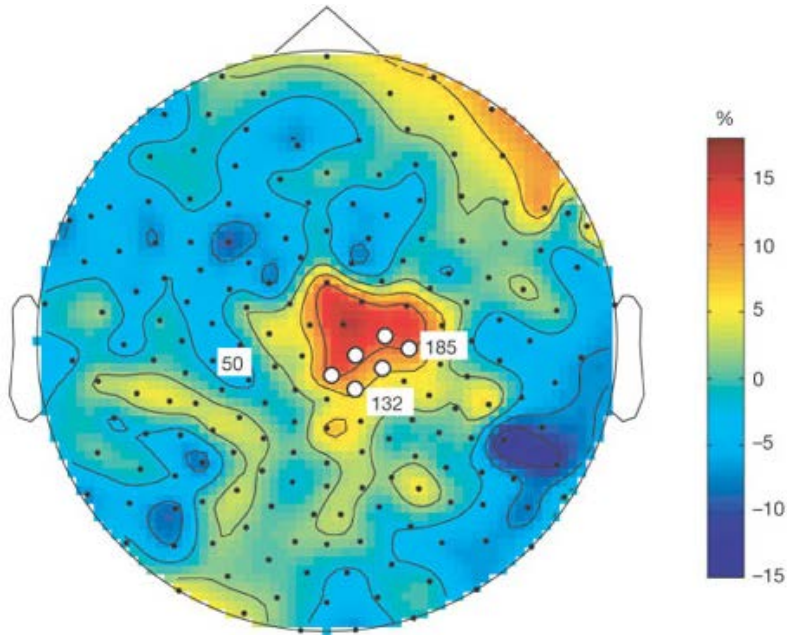
# Immunological function of sleep



# Sleep: more than a substitute for coffee!

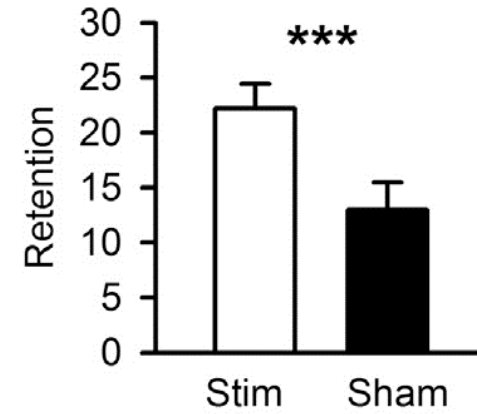
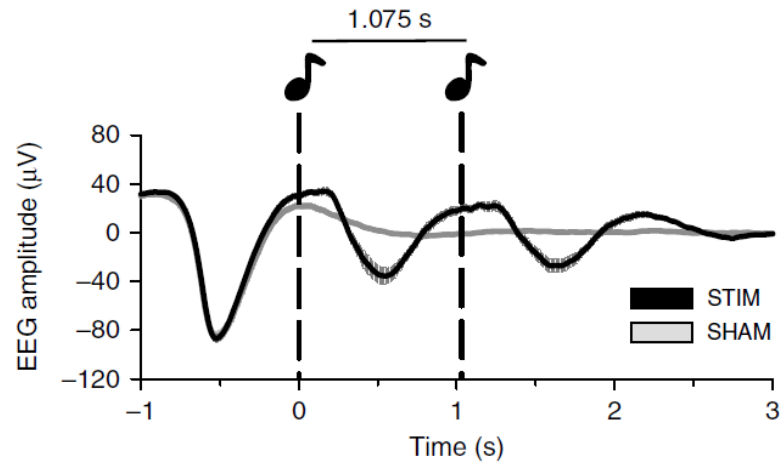


# Slow wave activity

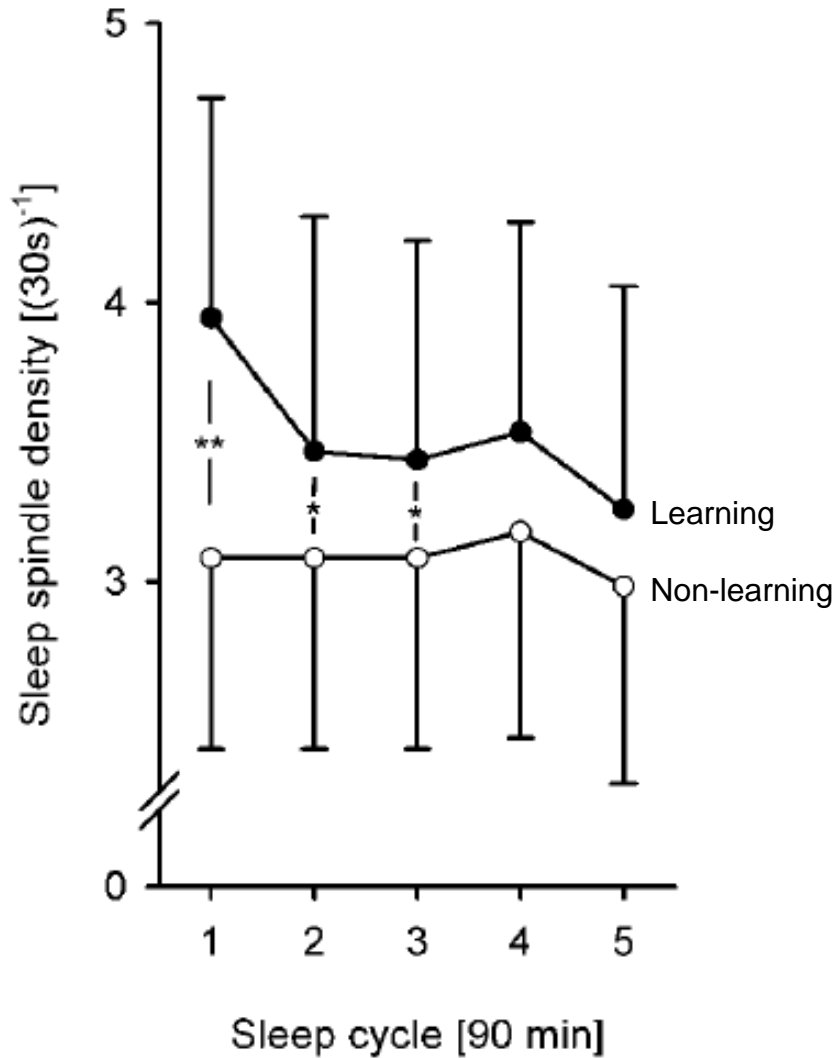




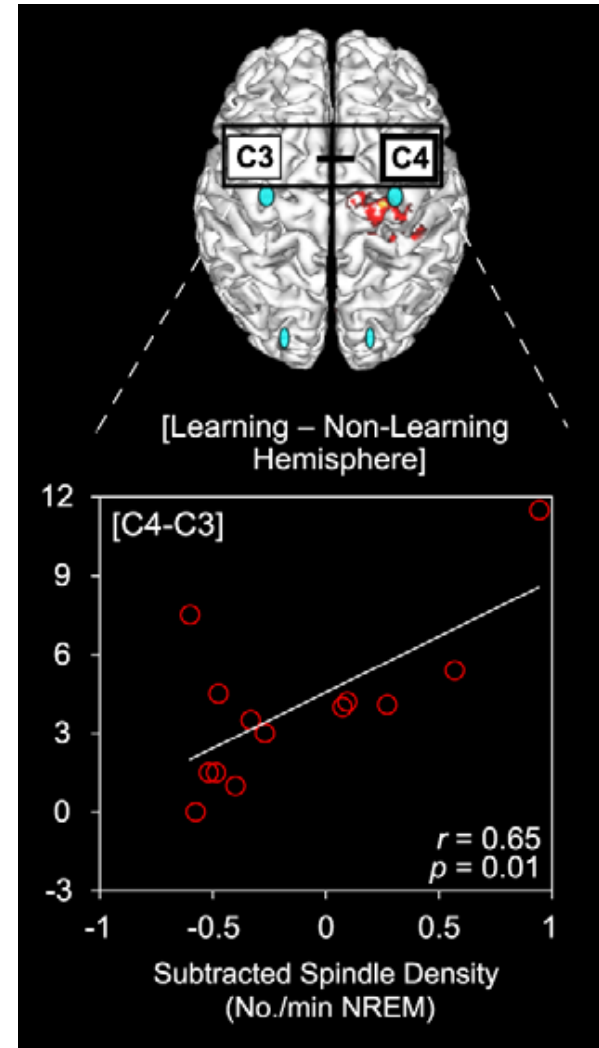
# Slow wave activity



# Sleep spindles



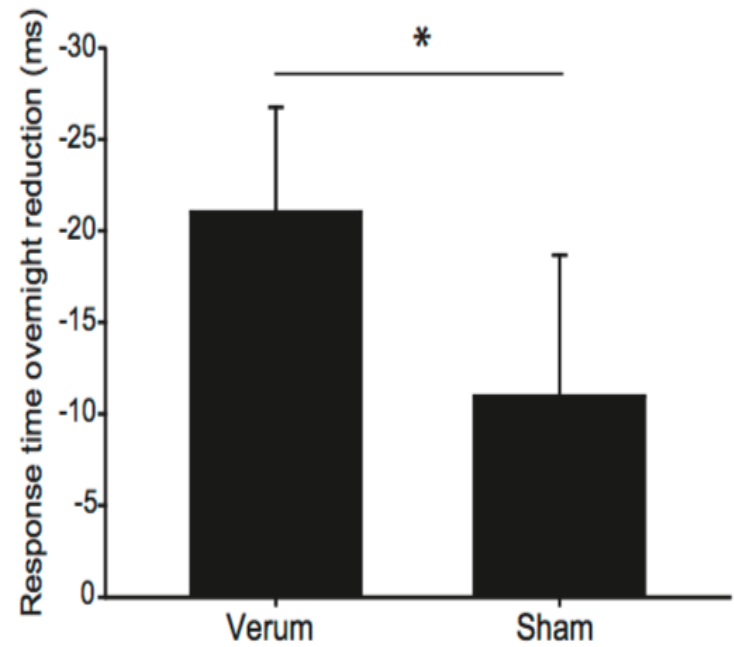
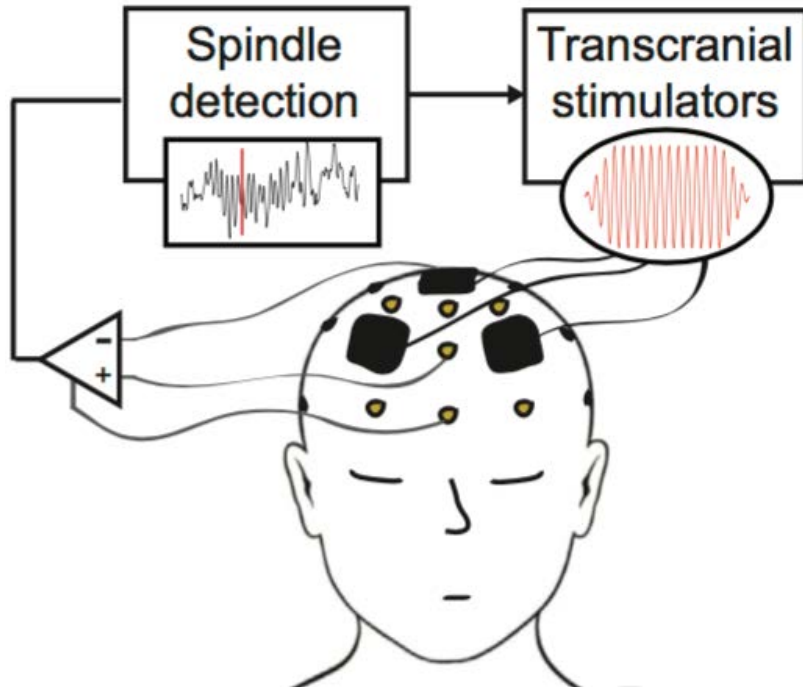
Gais et al., 2002



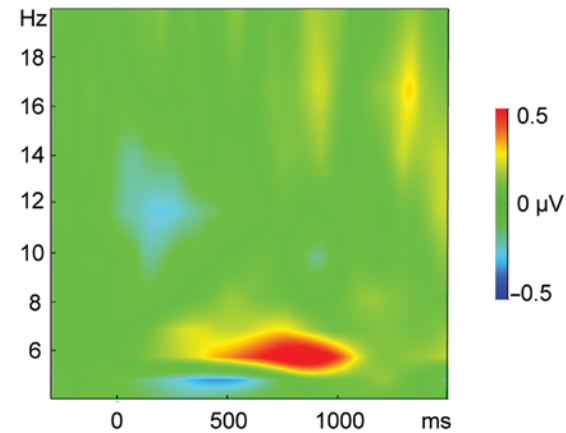
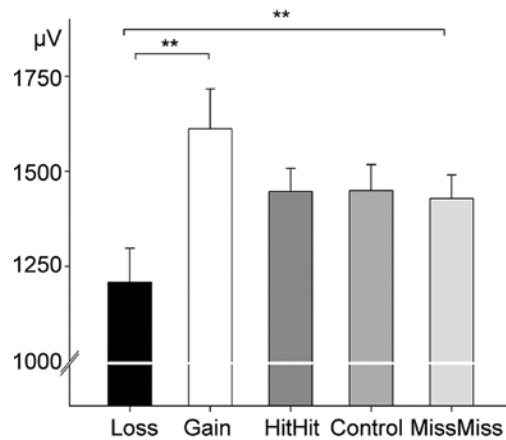
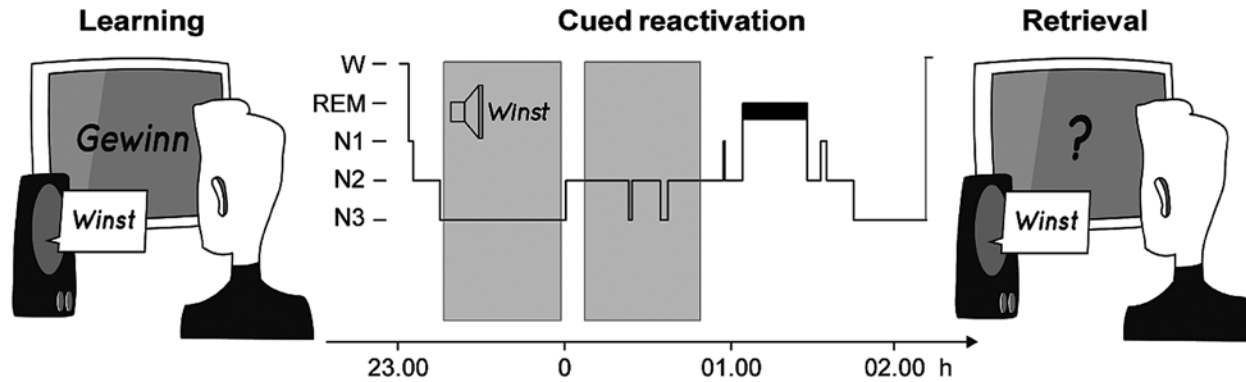
Nishida & Walker, 2007



# Sleep spindles



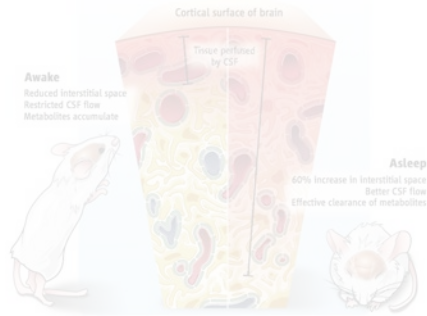
# Cued memory reactivation



# Sleep: more than a substitute for coffee!



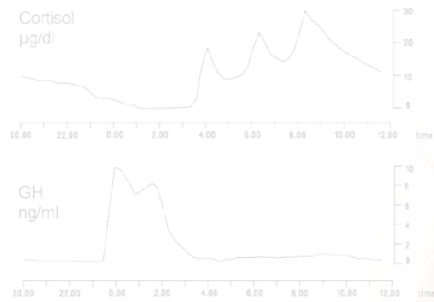
brain clearance



memory



hormones



emotions



immune system



simulation



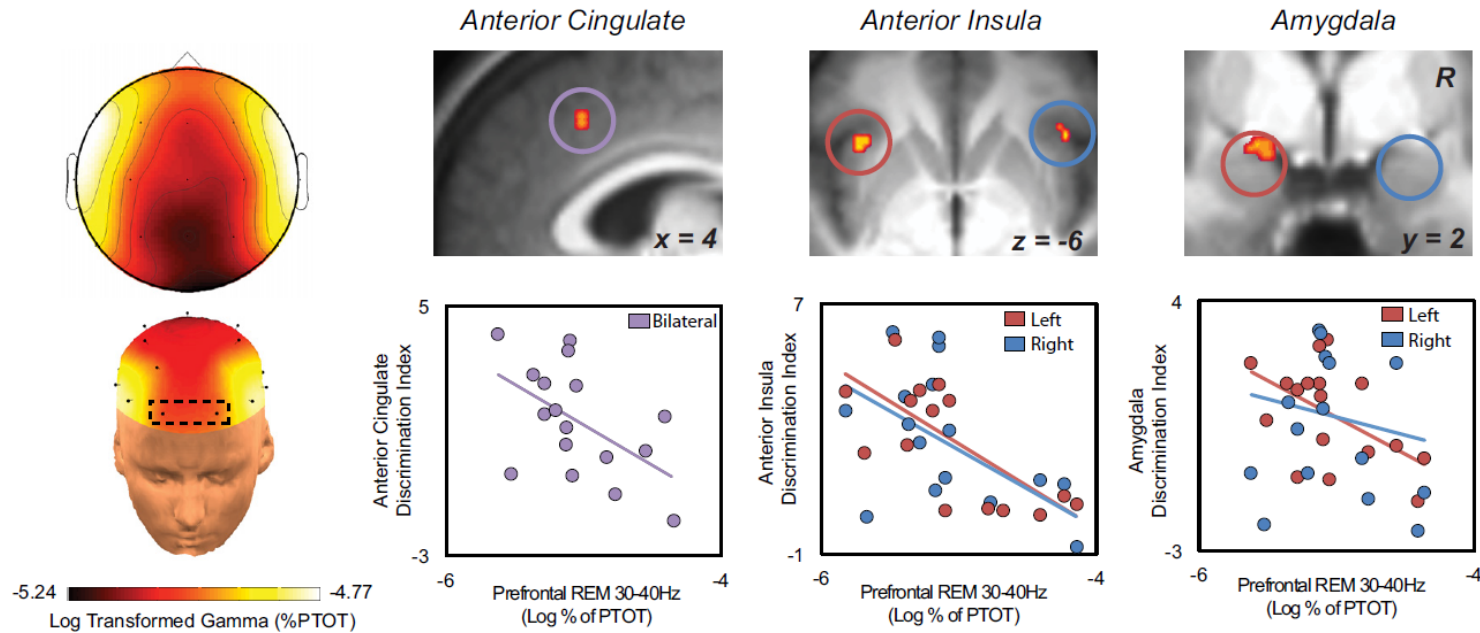


# Emotional function of sleep

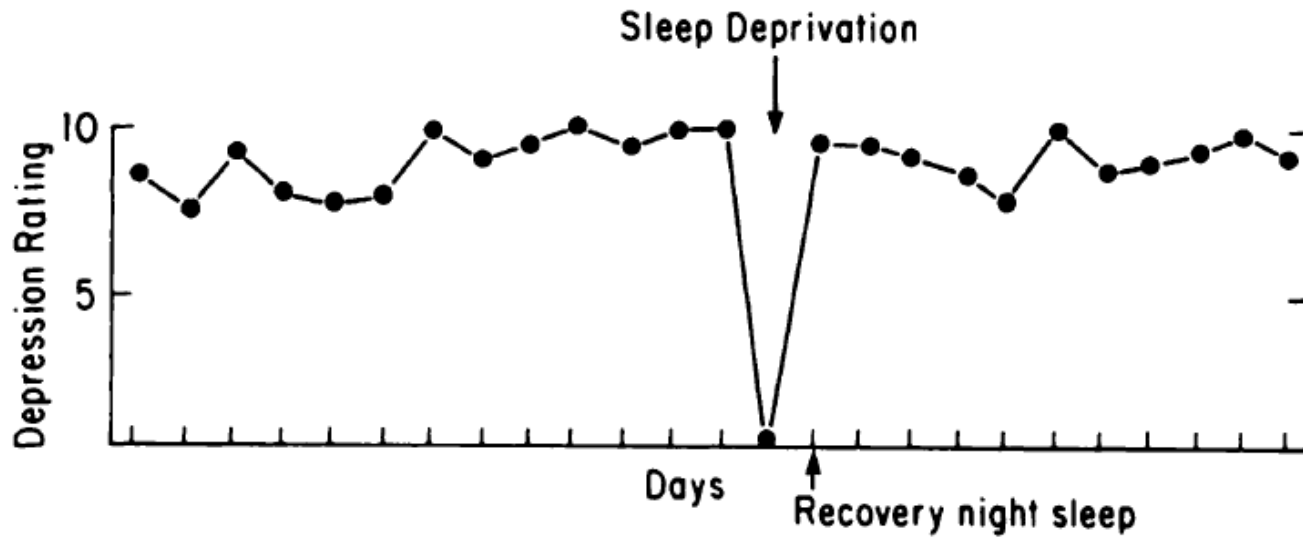


Not Threatening

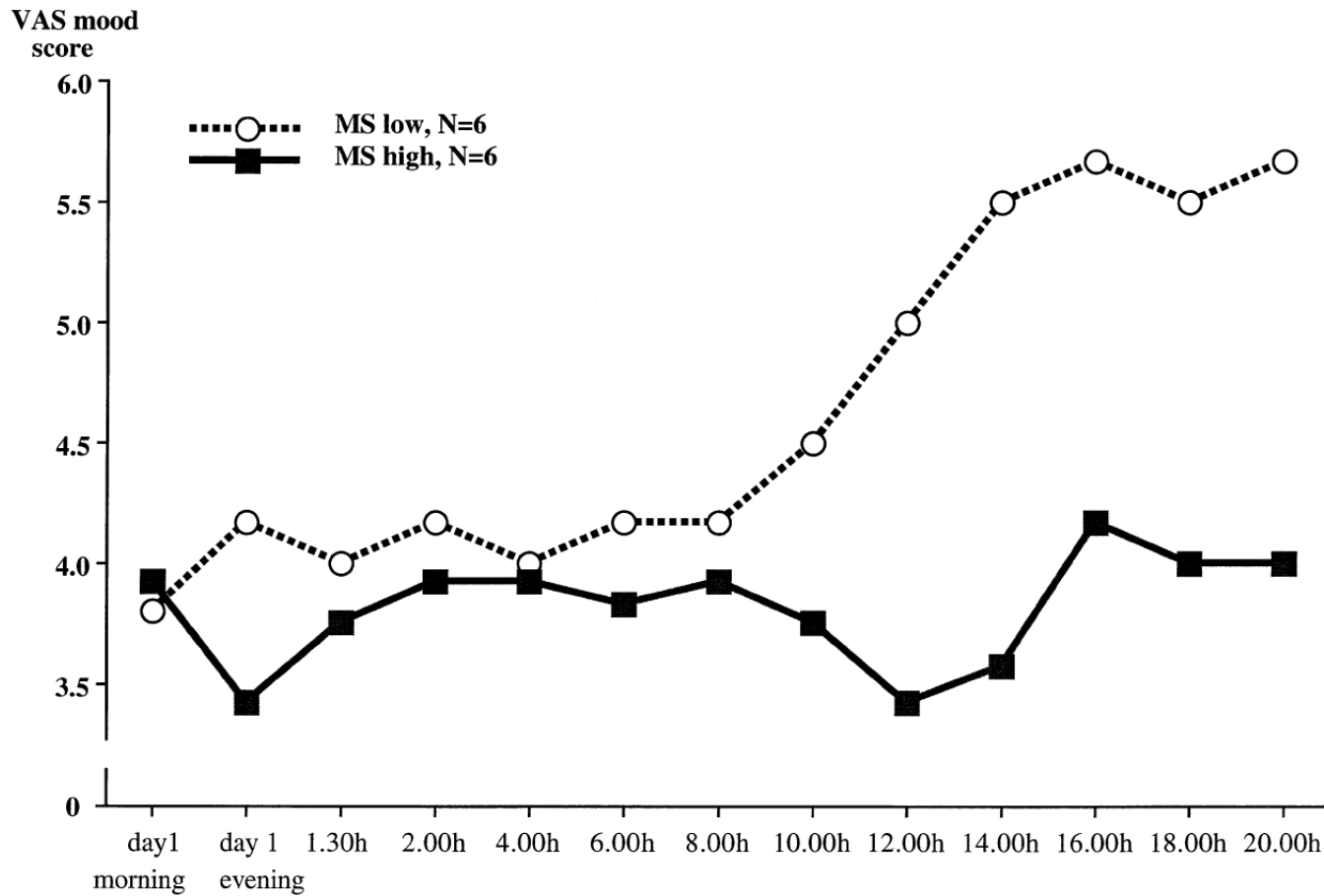
Threatening



# Depression and sleep deprivation



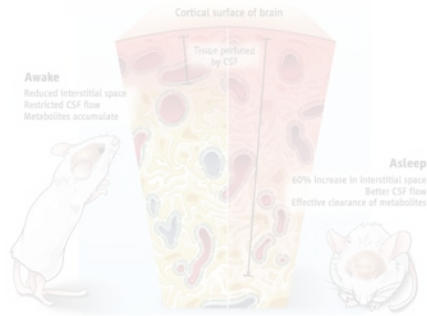
# Depression and sleep deprivation



# Sleep: more than a substitute for coffee!



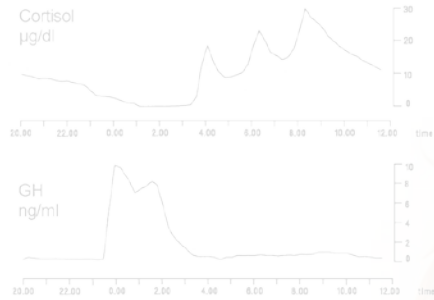
brain clearance



memory



hormones



emotions



immune system



simulation

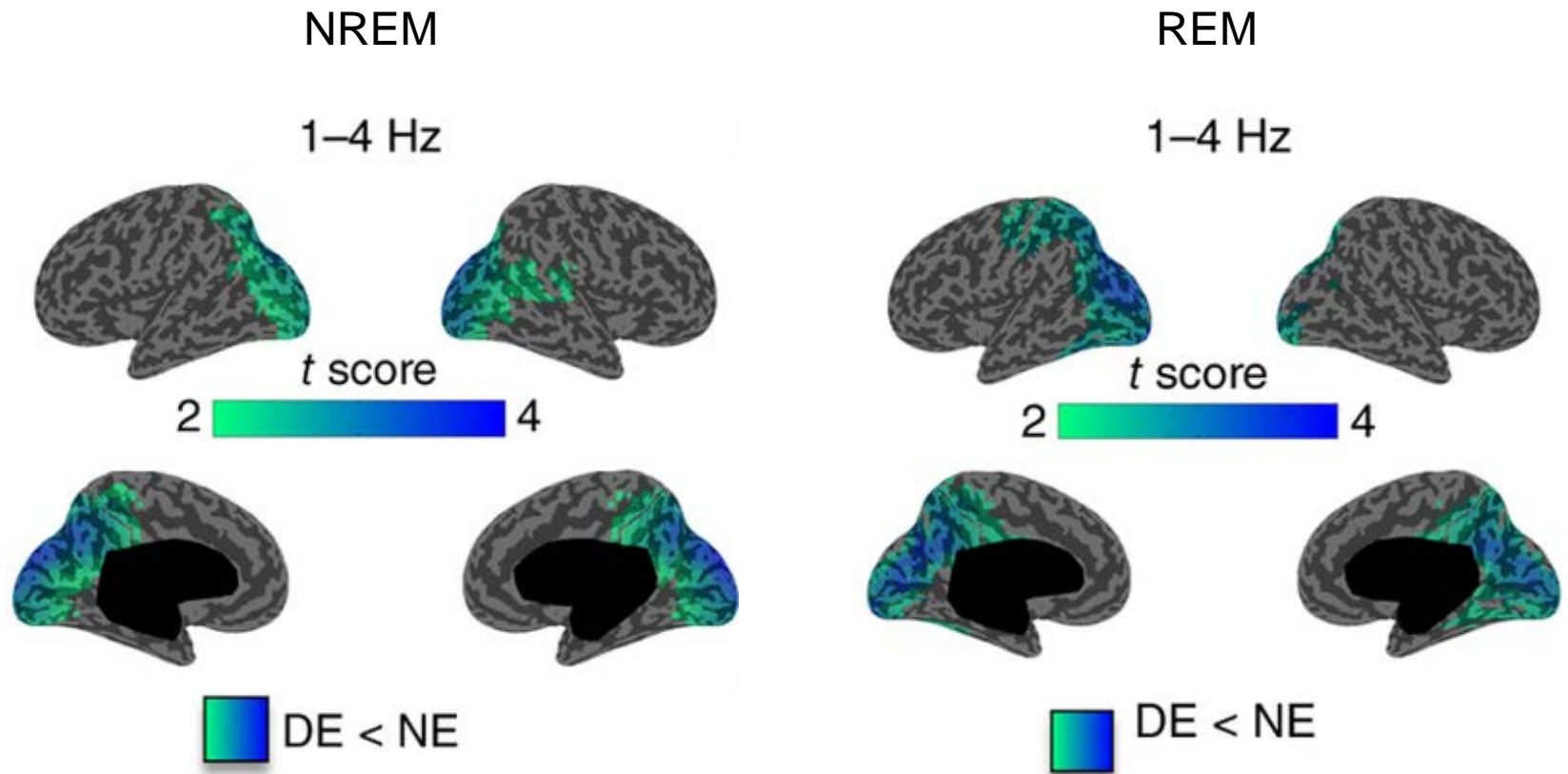








# Dream experience vs. no experience

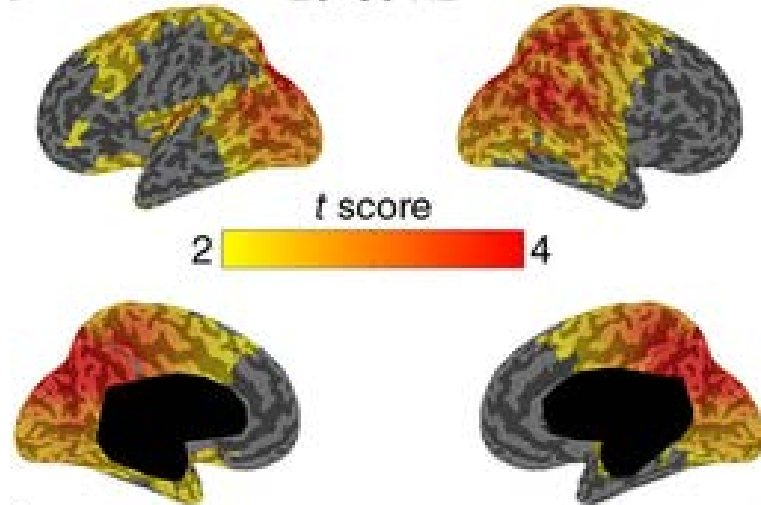


# Dream experience vs. no experience



NREM

20–50 Hz



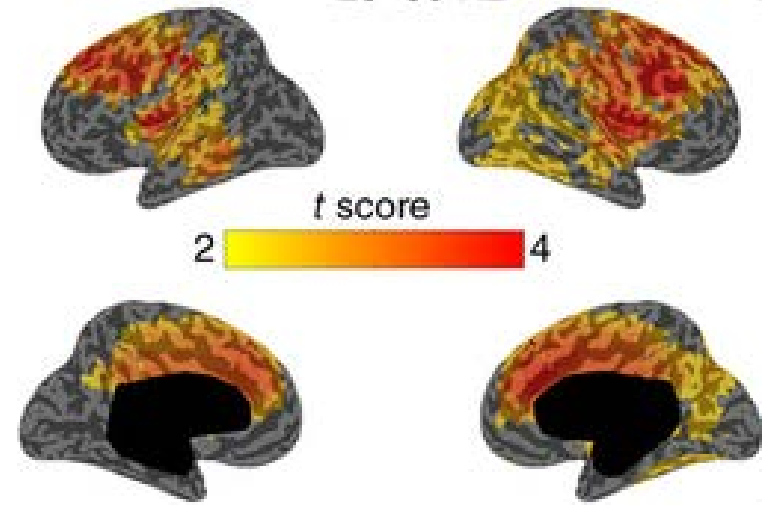
t score

2 4

DE > NE

REM

25–50 Hz



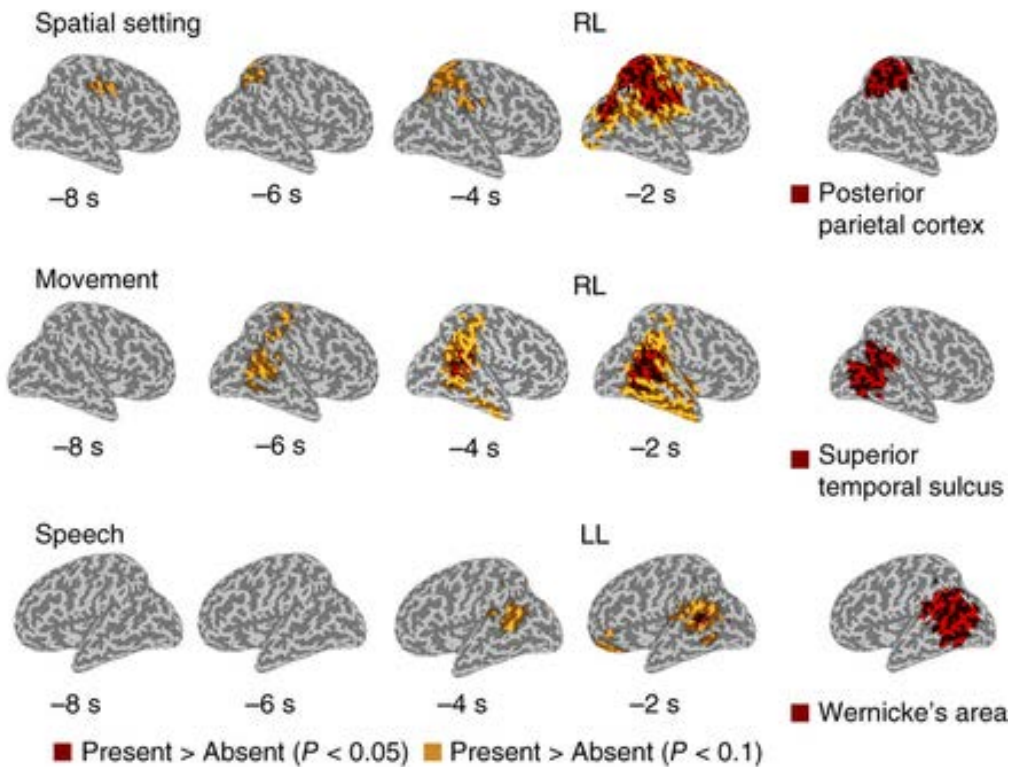
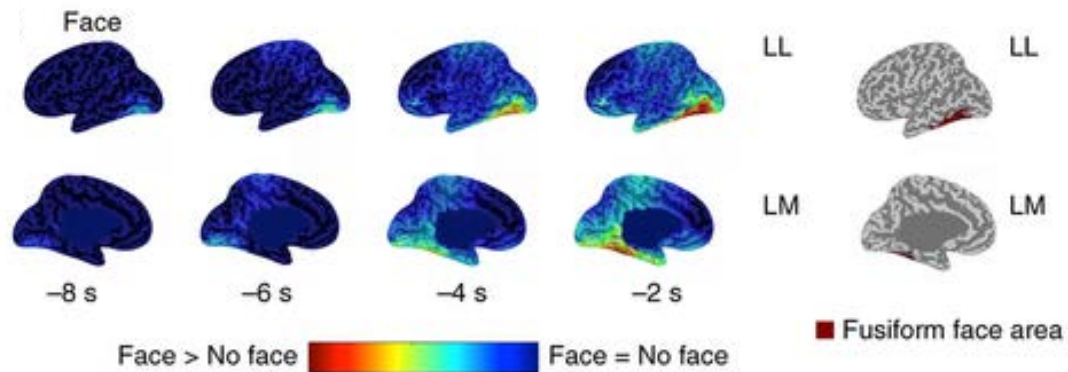
t score

2 4

DE > NE



# Dream content

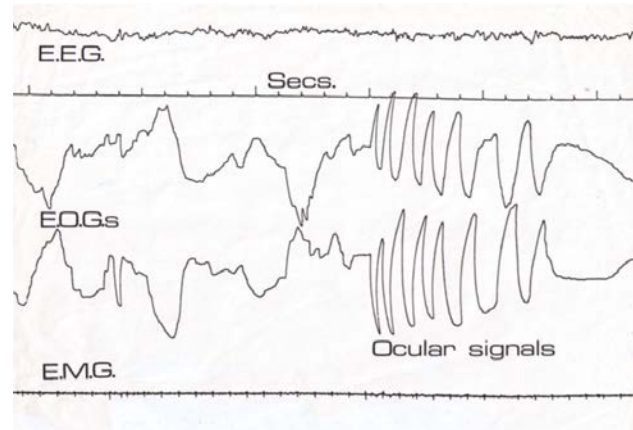




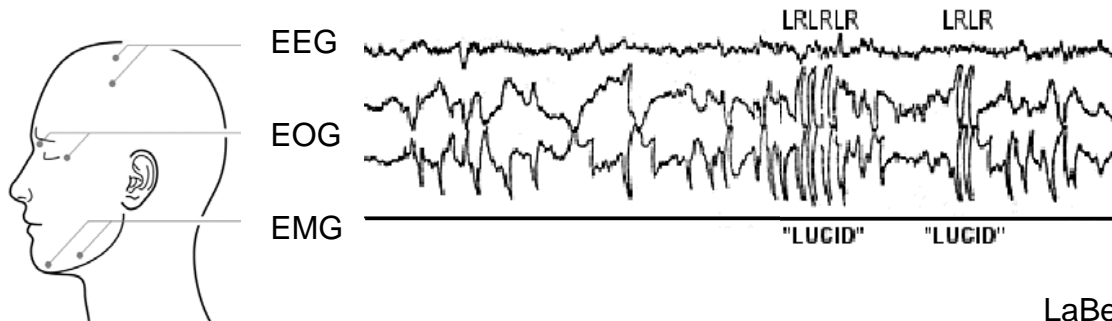
...am I  
dreaming?



# Lucid dreaming



Hearne, 1978

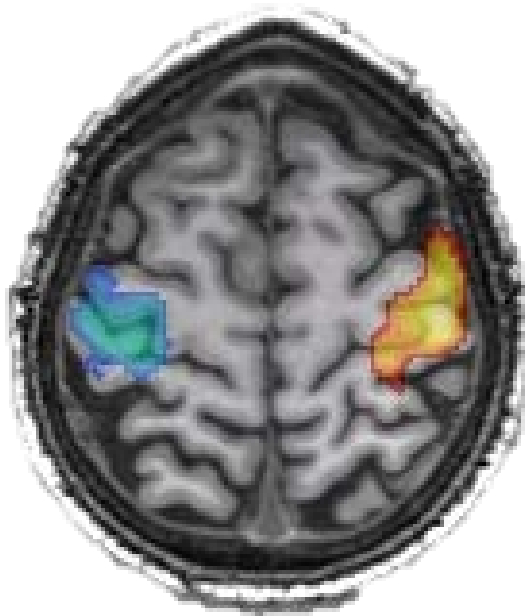


LaBerge et al., 1981

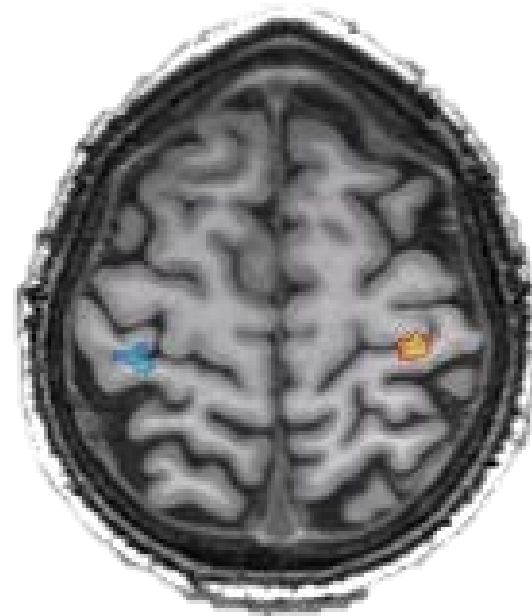


# Neural correlates of dream content

real hand movement



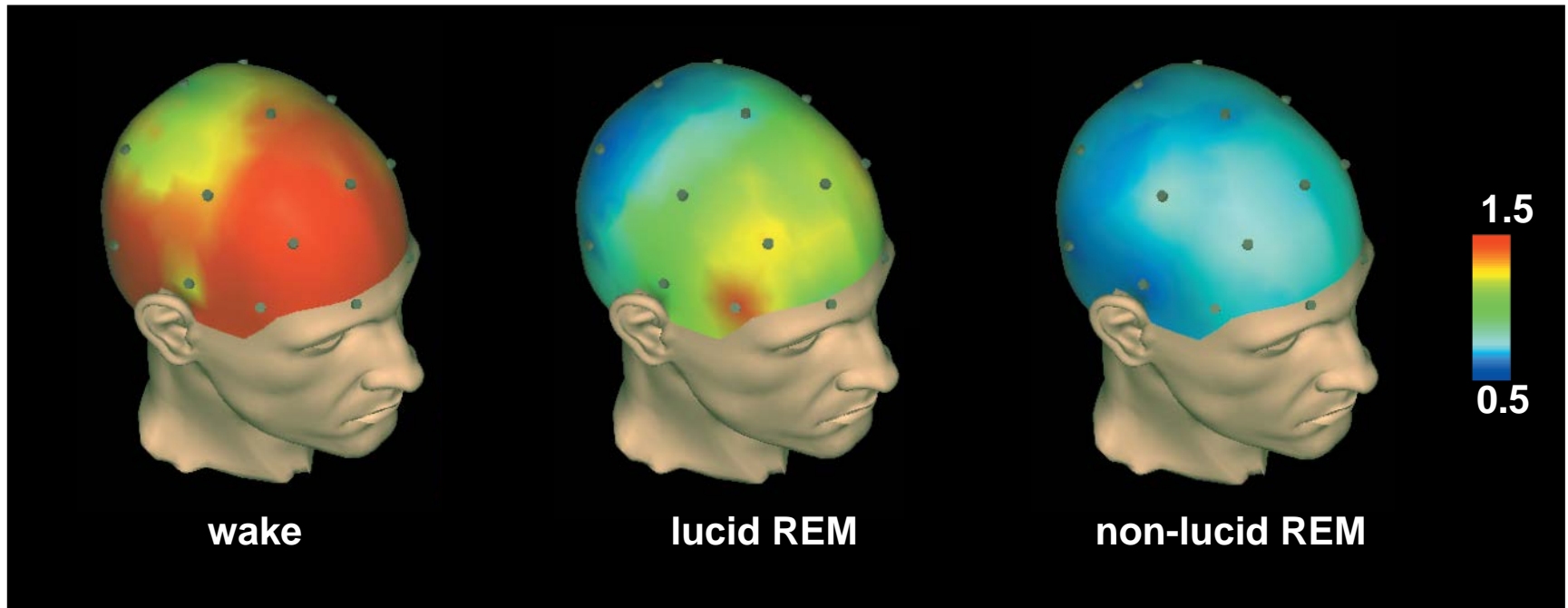
dreamed hand movement





# Neural correlates of lucid dreaming

40 Hz gamma power

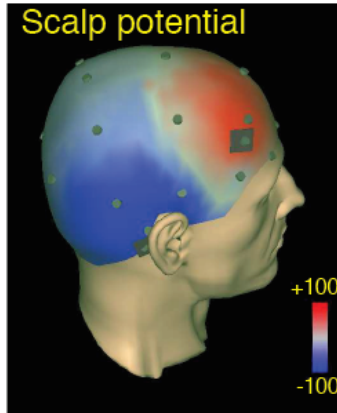
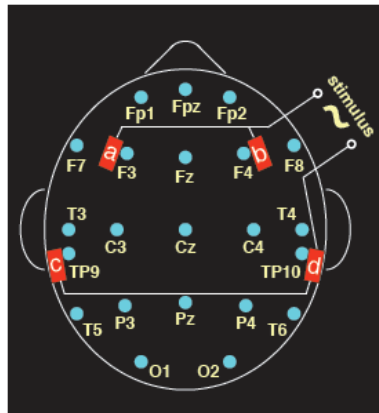






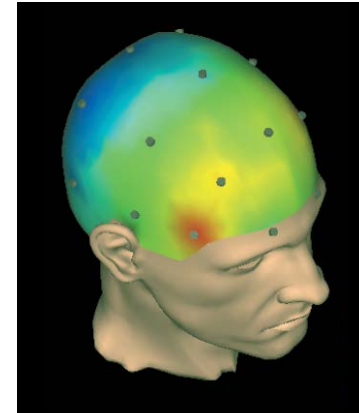
# Neural correlates of lucid dreaming

transcranial alternating current stimulation (tACS)

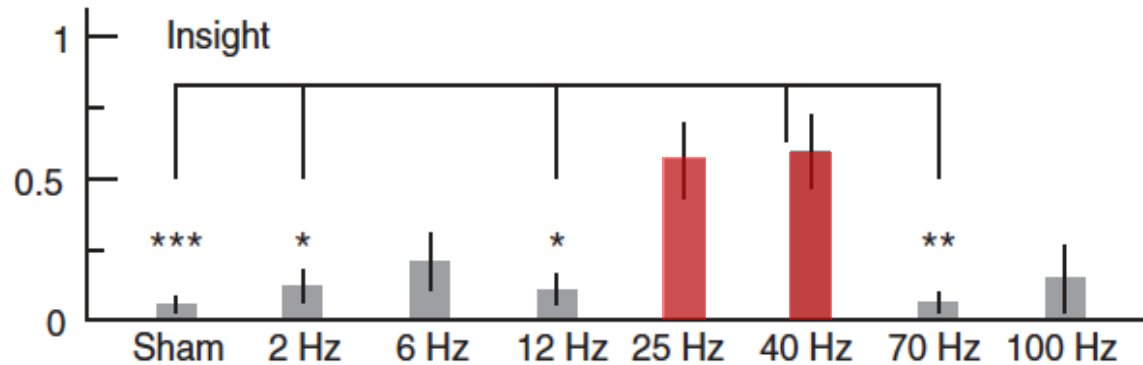


Voss et al., 2014

40 Hz: lucid REM



Voss et al., 2009



Voss et al., 2014

## Conclusions



- Spontaneous EEG activity harbors important information
- In particular sleep before, during, after experiment!
- Cascade of nested oscillations
- Options to manipulate spontaneous oscillations