Sleep & Memory

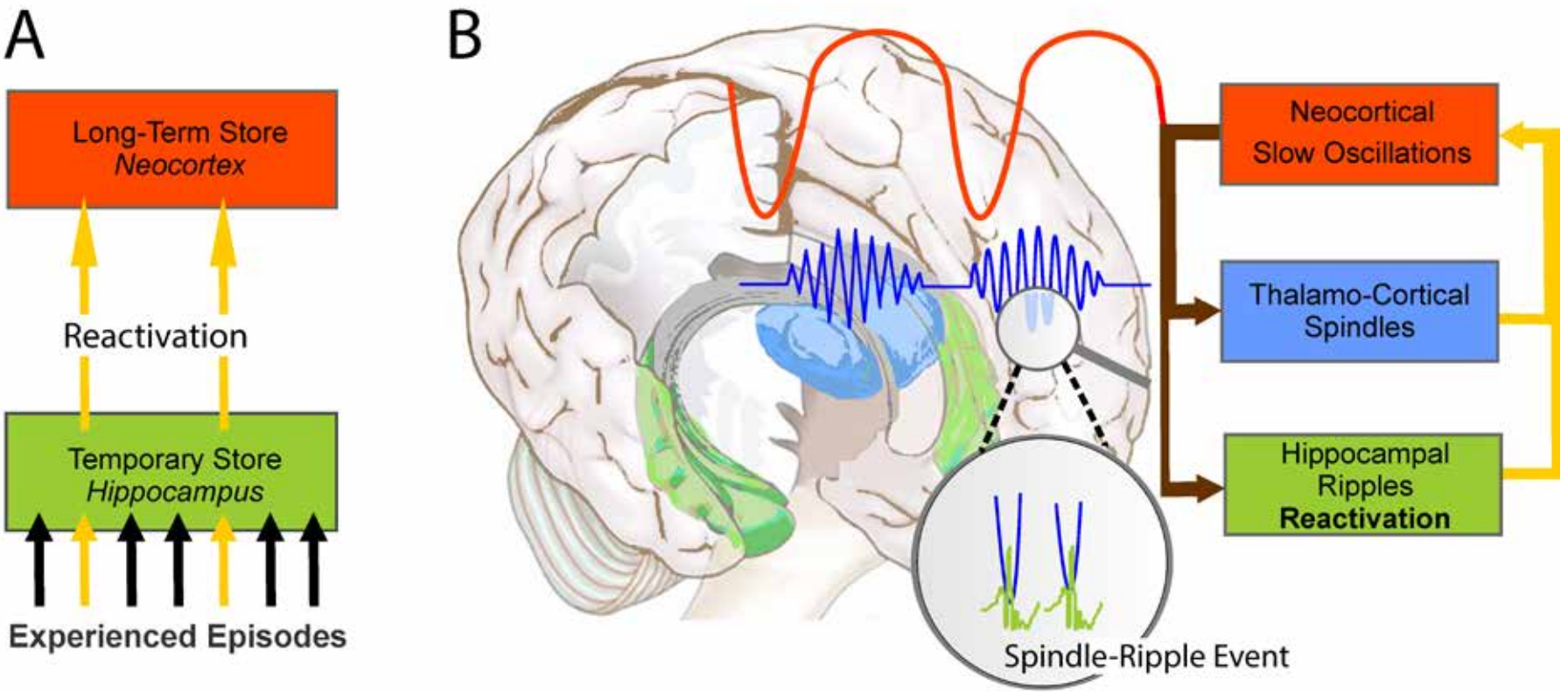
Time: Wed, 10:15 to 12:00

Prof. Dr. Björn Rasch, Division of Biopsychology
University of Zürich

Content

- 19.2. Introduction sleep and memory
- 26.2. Sleep and memory: historical studies
- 5.3. The two stage hypothesis: NonREM vs. REM sleep and memory
- 12.3. The two stage hypothesis: NonREM vs. REM sleep and memory II
- 19.3. Oscillations, sleep and memory
- 26.3. Memory reactivation during sleep
- 2.4. Downselection vs. active system consolidation during sleep I
- *9.4. cancelled (CNS Boston)*
- 16.4. Downselection vs. active system consolidation during sleep II
- *23.4. Easter Holiday*
- 30.4. Sleep and memory in children and adolescence: Implications for education
- 7.5. Sleep and memory in aged adults
- 14.5. Sleep and memory in anxiety disorders and depression
- 21.5. Sleep, stress and traumatic memories
- 28.5. Exam

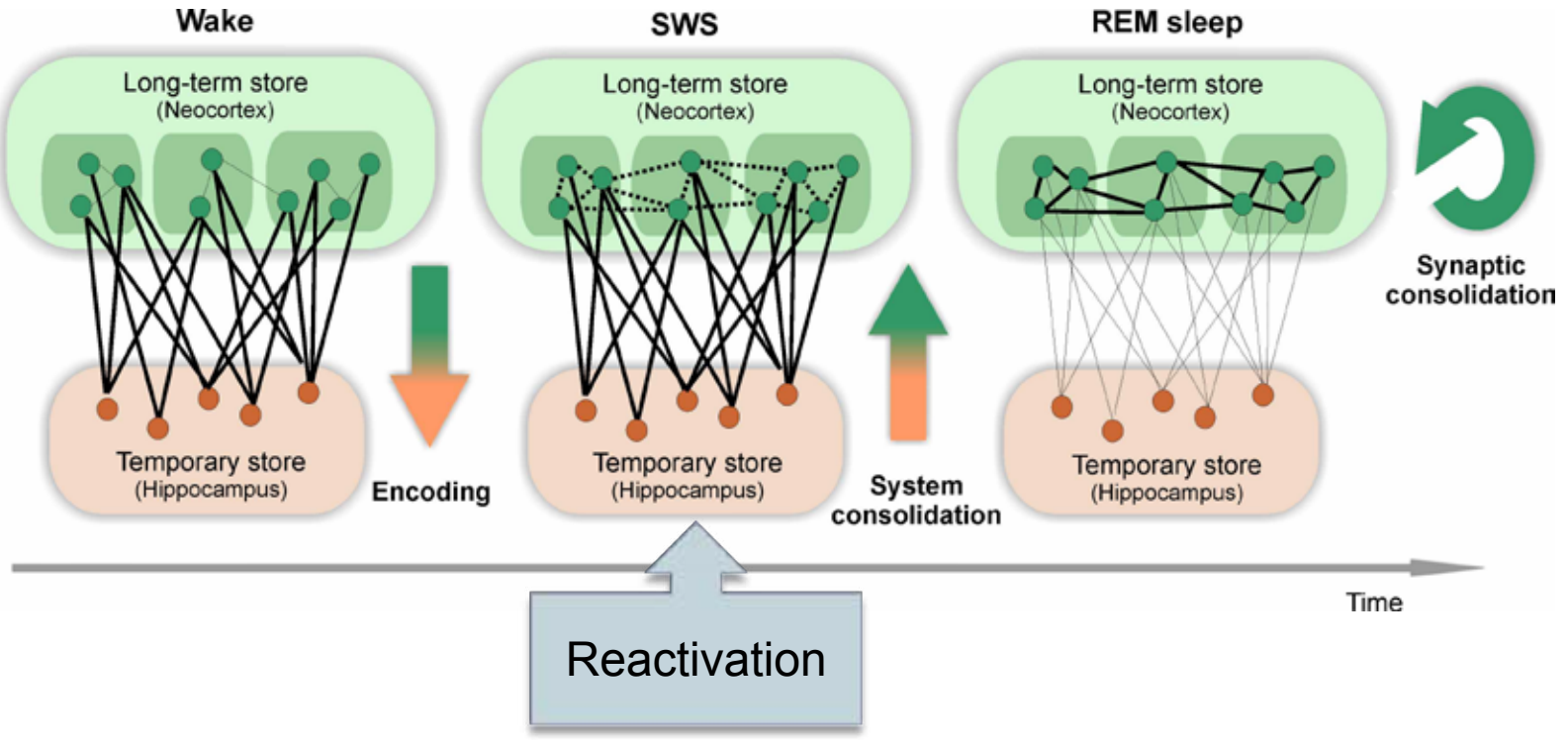
Active system consolidation hypothesis



Rasch & Born, 2013

Active system consolidation hypothesis

- Sequential contribution of sleep stages to memory



Diekelmann & Born, 2010, *Nat. Rev. Neurosci.*

Reactivations during sleep

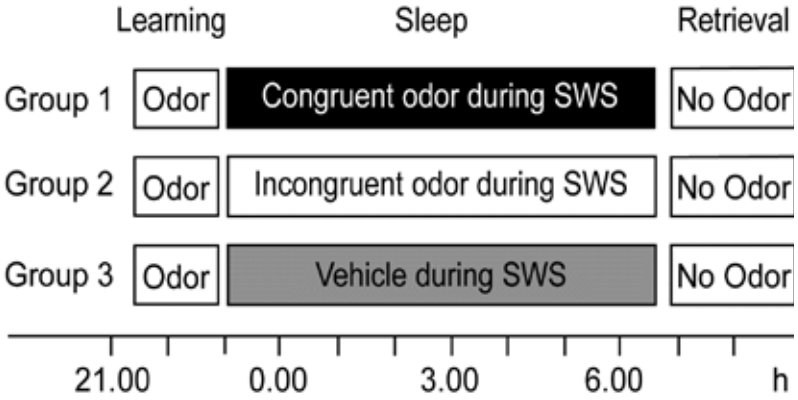
- Memories are replayed during sleep…
  - … but is replay relevant for memory consolidation?

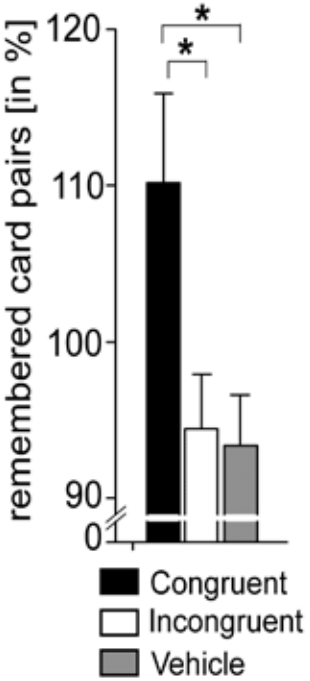
- Hypothesis:
  - Reactivating memories during sleep increases memory consolidation during sleep

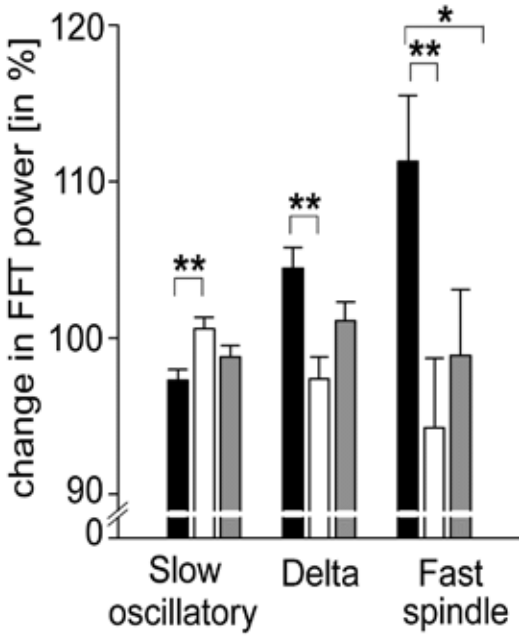
  - How to reactivate memories during sleep?

Oscillatory correlates of reactivation

- Odor-induced memory reactivation during SWS



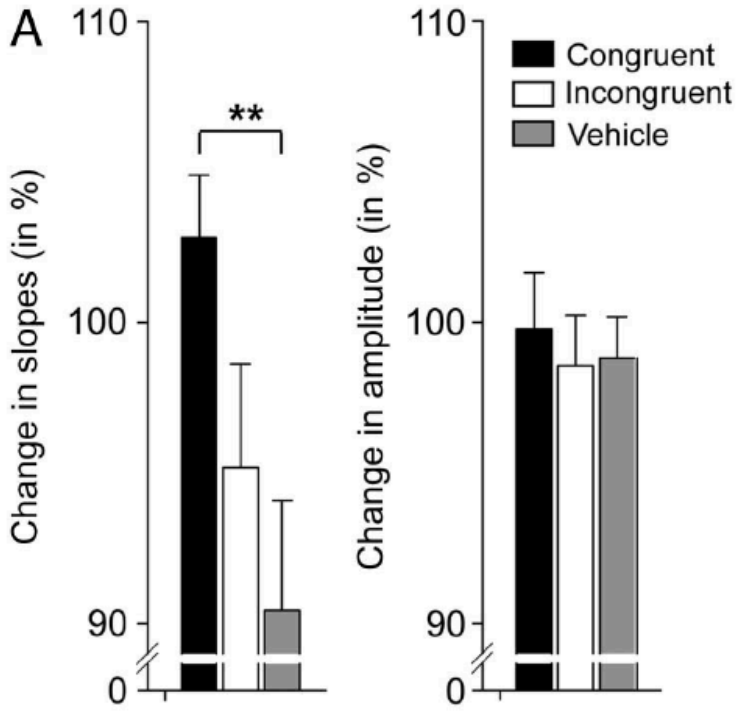


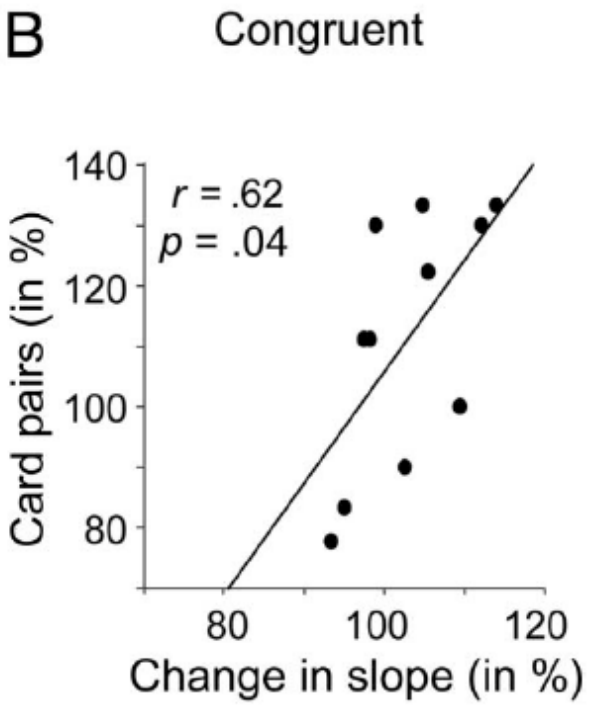


Rihm, Diekelmann, Born & Rasch, *J. Cogn. Neurosci., 2014*

Oscillatory correlates of reactivation

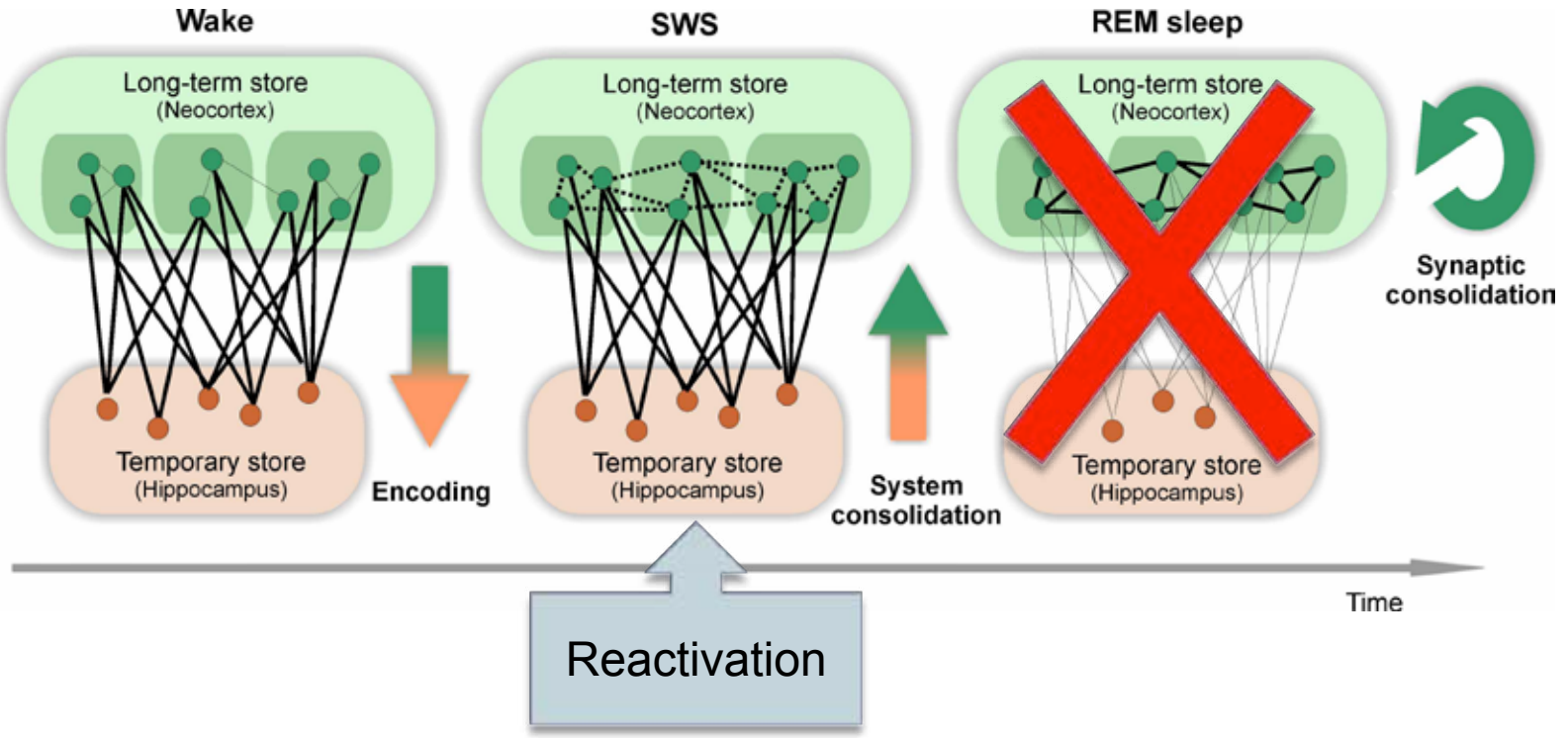
- Odor-induced memory reactivation during SWS





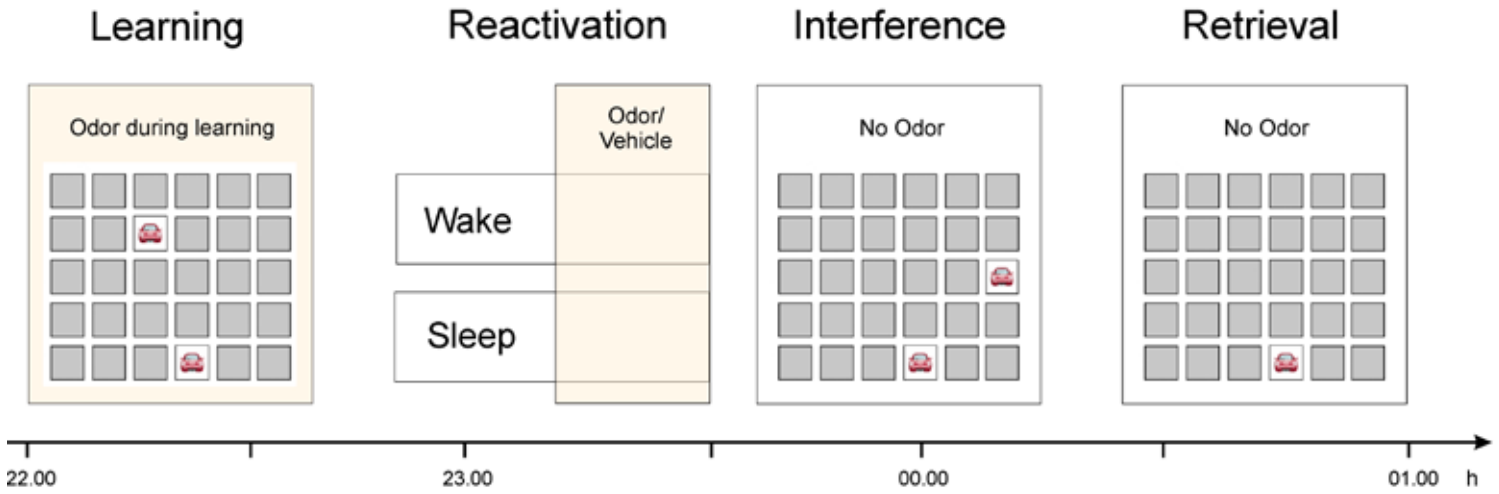
Memory consolidation during sleep

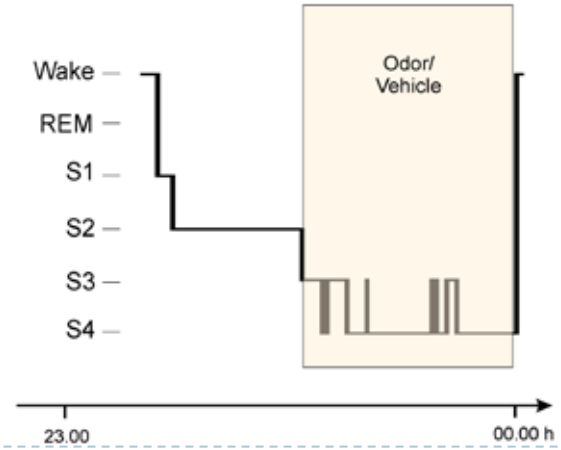
- Is REM sleep after reactivation during SWS necessary for improving memories?



Diekelmann & Born, 2009, *Nat. Rev. Neurosci*.

REM necessary for reactivation?

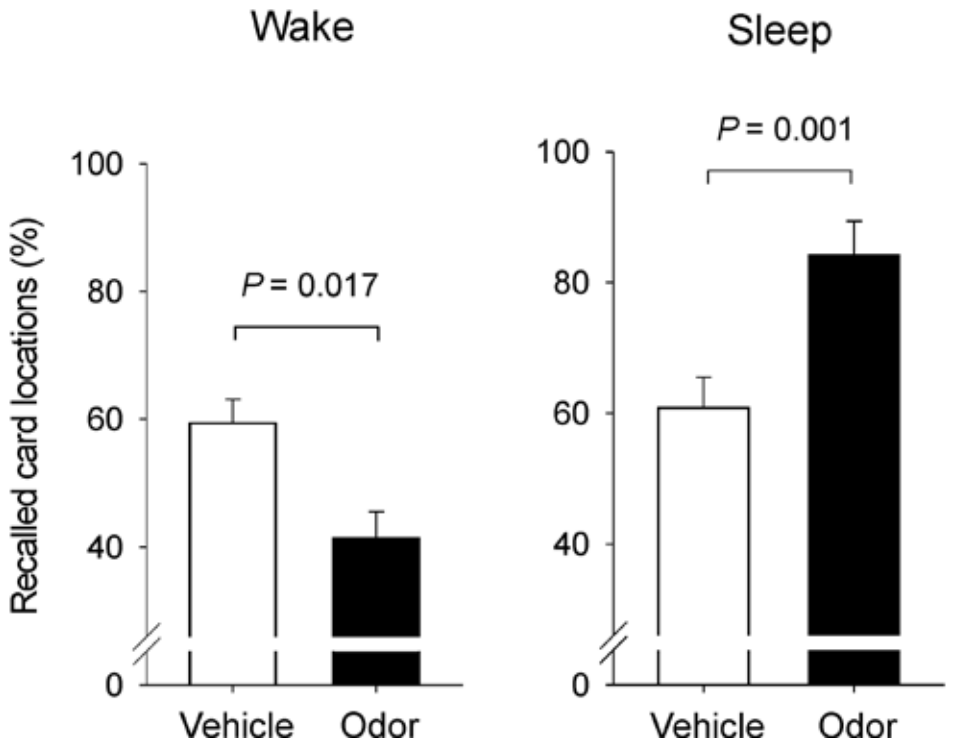




No REM sleep after reactivation during SWS.

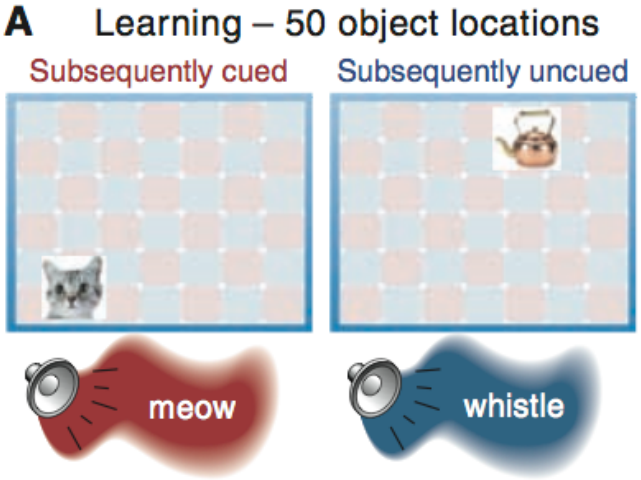
Diekelmann, Büchel, Born & Rasch, *Nature Neuroscience* 2011

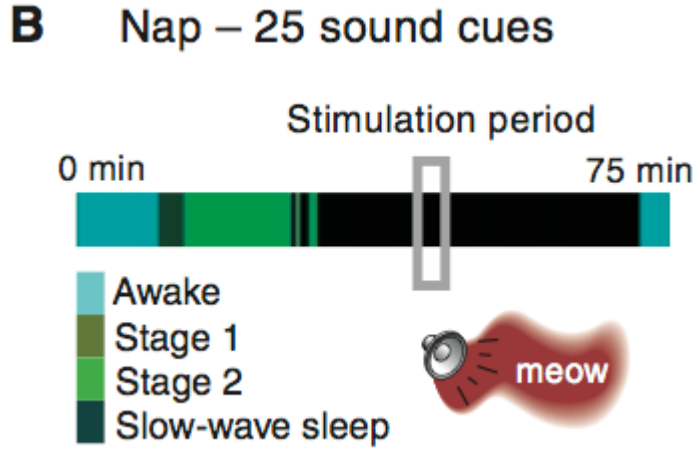
REM necessary for reactivation?

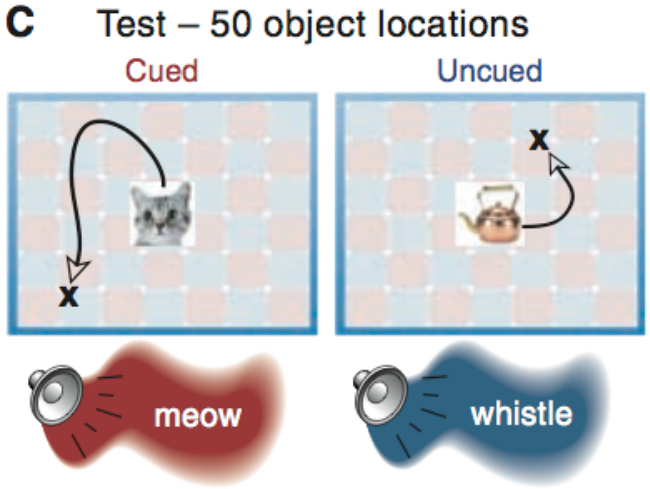


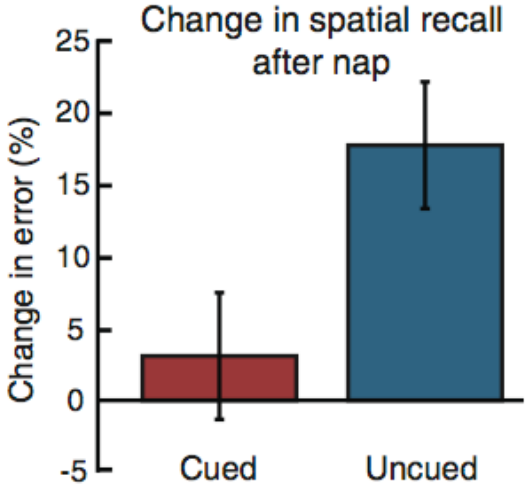
Diekelmann, Büchel, Born & Rasch, *Nature Neuroscience* 2011

Reactivations during SWS





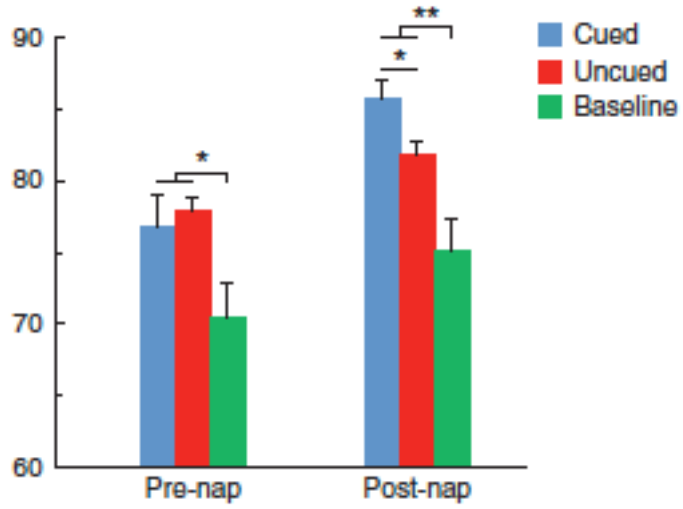




Rudoy et al., 2009, *Science*

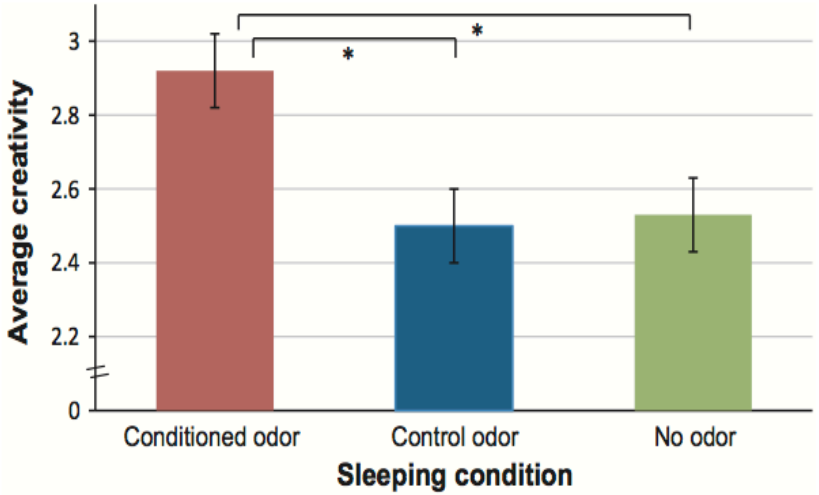
Cueing memory during sleep

- Motor skills



Antony et al., 2012, *Nat. Neurosci.*
Gais et al., *under revision*

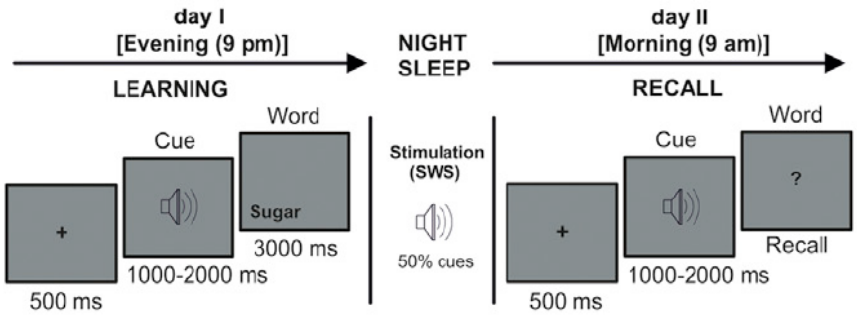
- Creativity
  - "How to motivate people to do voluntary work?

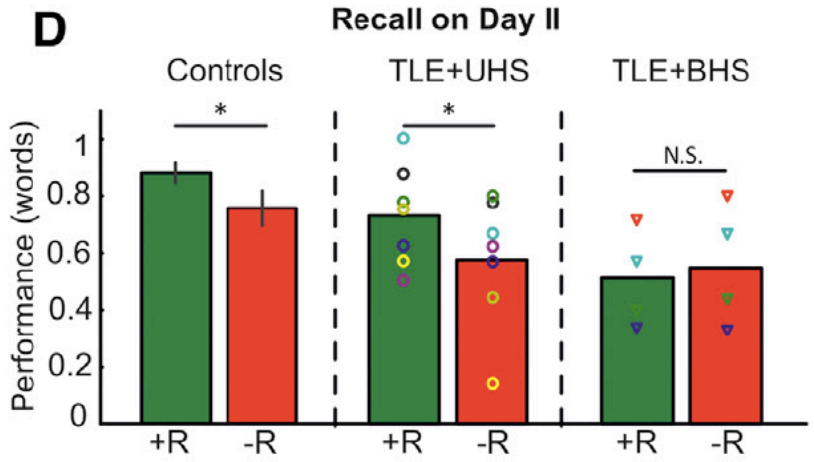


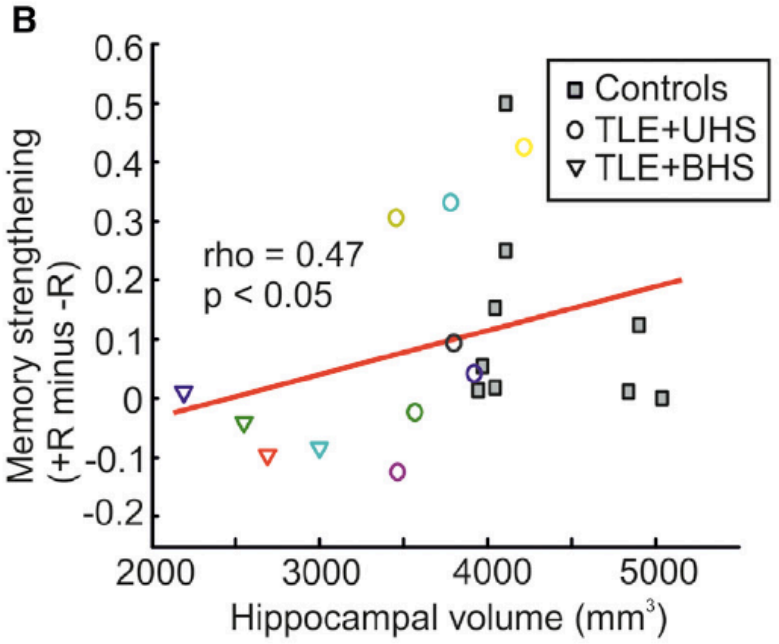
Ritter et al., *J. Sleep Res.*, 2012

Hippocampus-dependency of cueing

- Epileptic patients with unilateral (UHS) or bilateral (BHS) hippocampal sclerosis

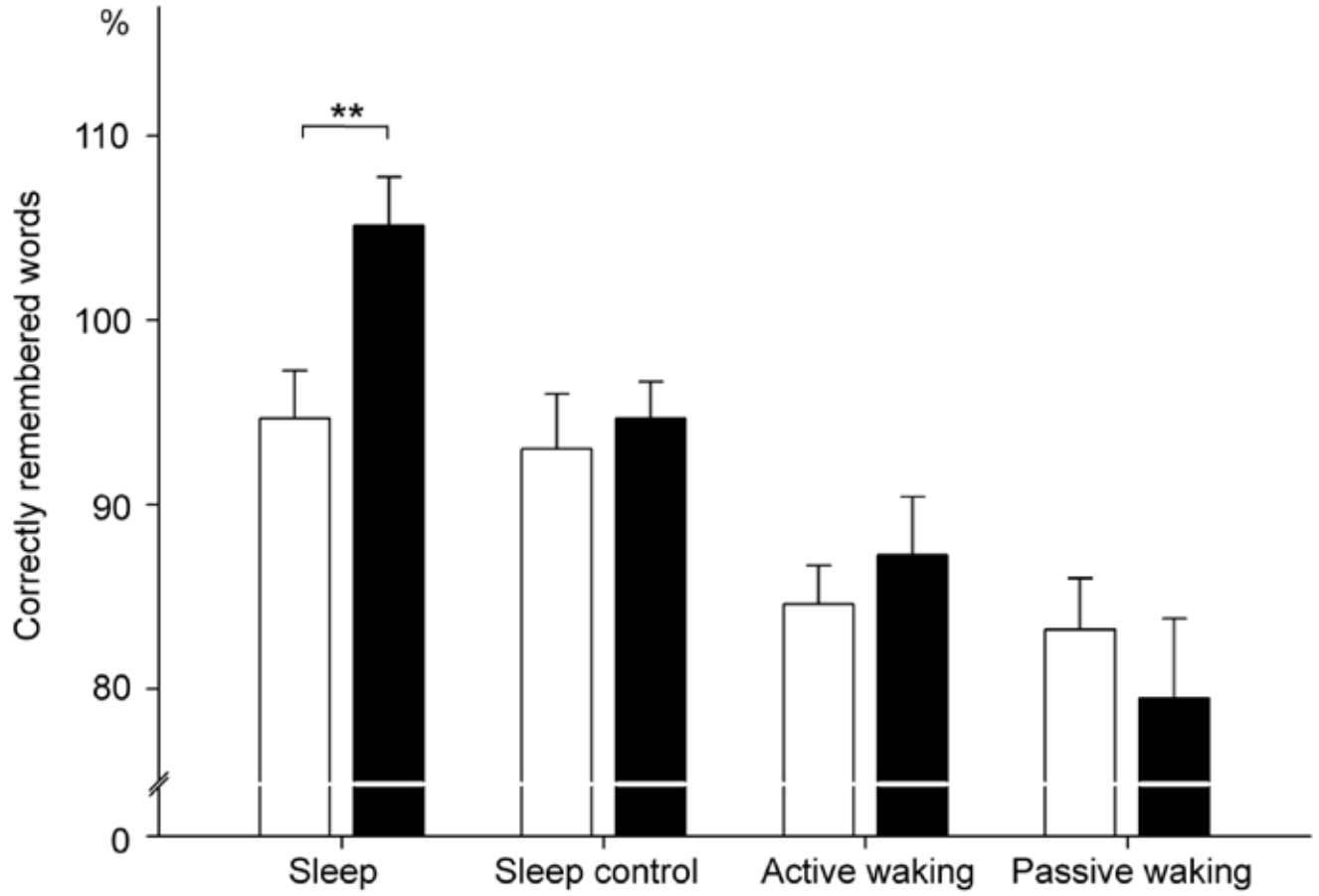






Fuentemilla et al., 2013, *Current Biol*.

Reactivation of foreign vocabulary



Schreiner & Rasch, Cerebral Cortex, *under revision*

Summary

- Memories are reactivated during NonREM sleep
  - Hippocampal place cells in rats / hippocampus in humans
  - Cueing reactivation during NonREM sleep imroves memory
    - Odors or sounds
    - Dutch vocabulary
  - Cueing success depends on the integrity of the hippocampus

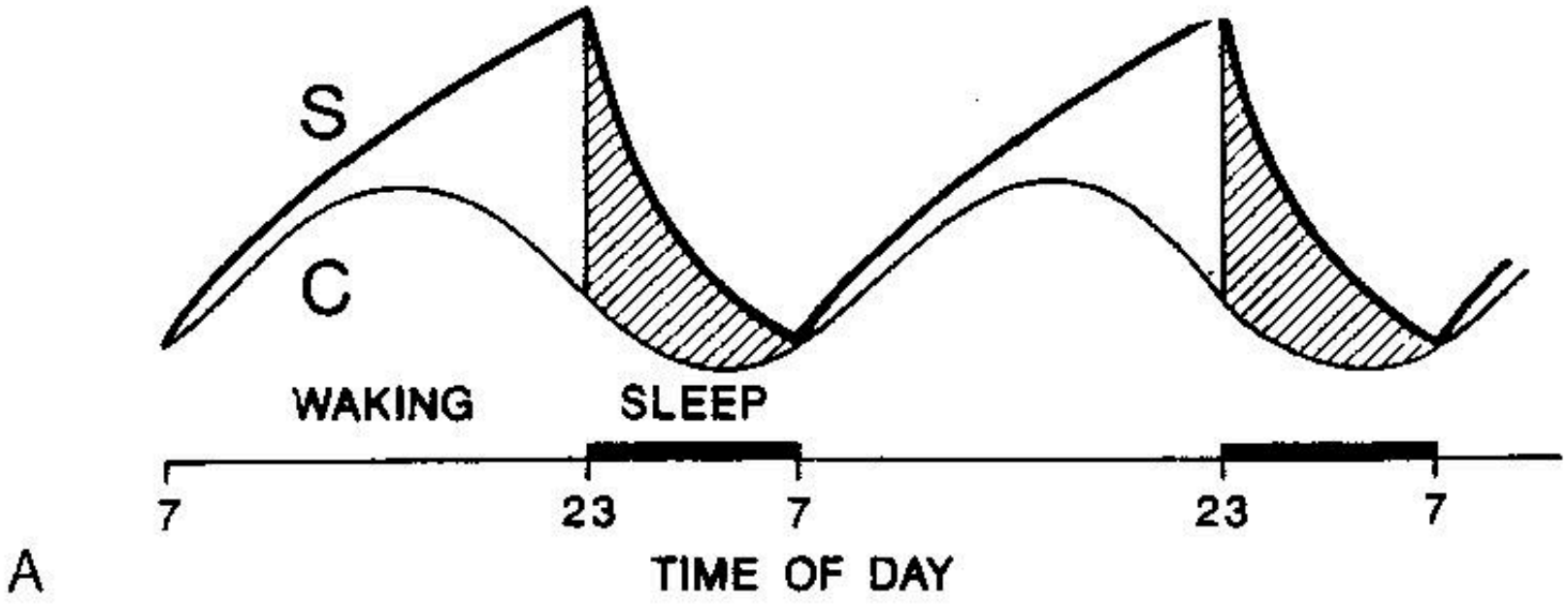
- REM sleep is not necessary
  - Immediate stabilization of reactivated memories during NonREM sleep

Synaptic Downscaling Hypothesis

- Assumes that sleep plays a role in downscaling of synapses
  - Wakefulness (= learning) potentiates synaptic strength
    - Increase in net synaptic strength
  - Sleep downscales synaptic strength
  - No functional role of "reactivations" assumed
  - Memory enhancement is by-product of downscaling
    - None-selective effect on memory
- Based on 2-process model of sleep regulation

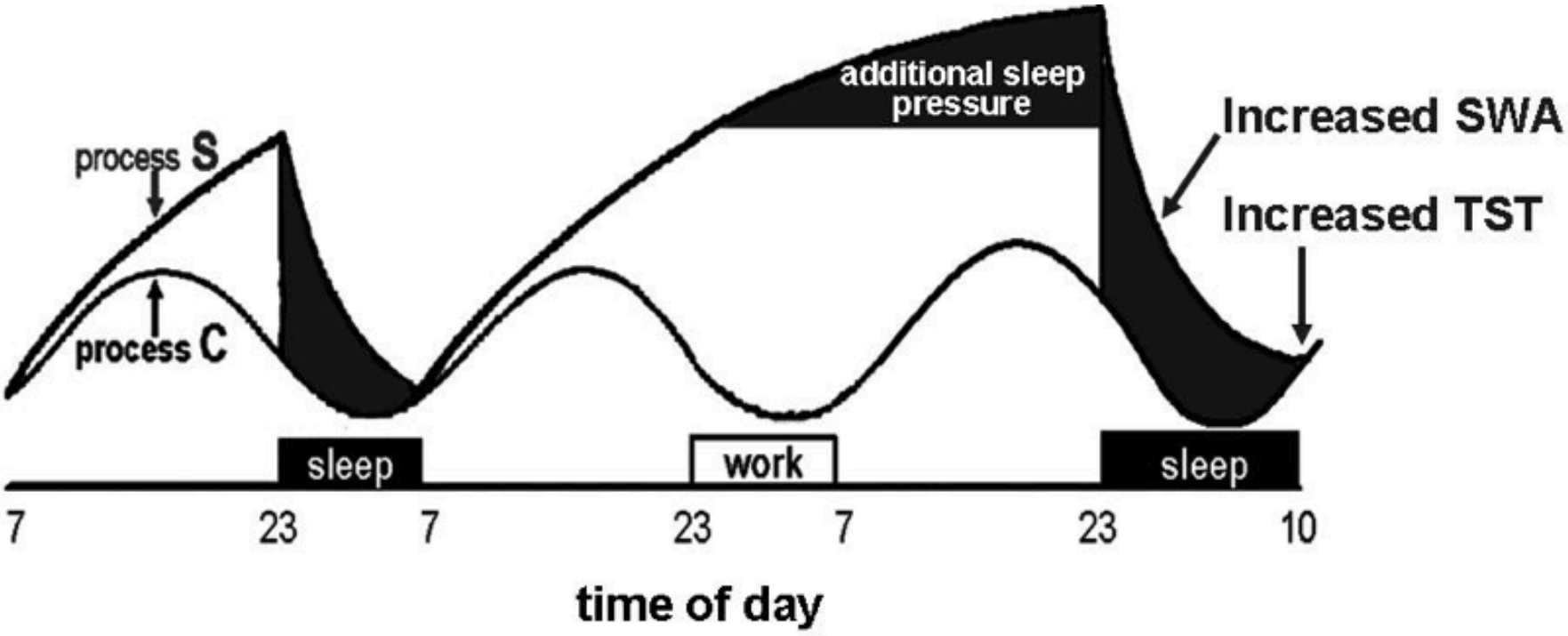
Sleep regulation

- The 2-process model of sleep regulation
  - Alexander Borbely, Universität Zürich
  - Process S: Homeostatic sleep pressure
  - Process C: Circadian component



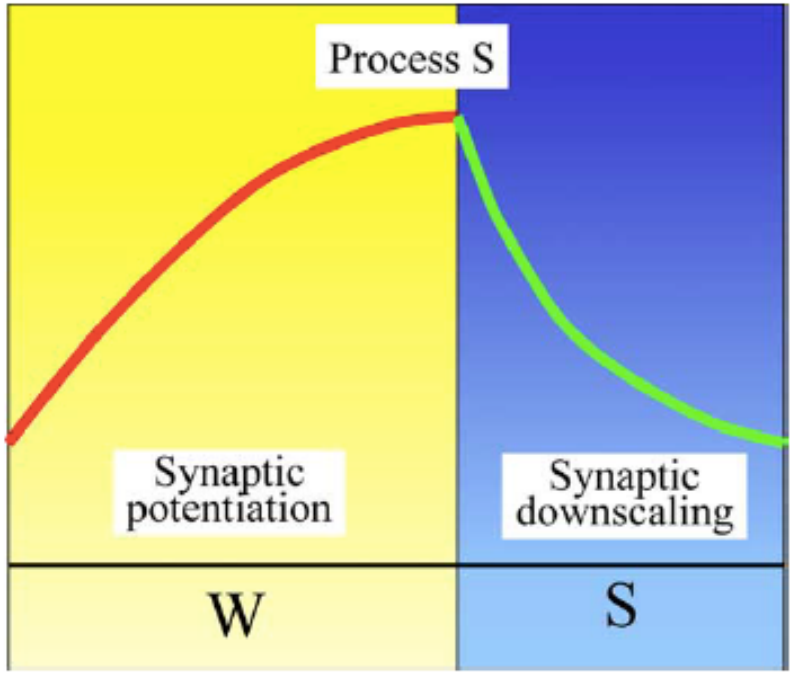
Sleep regulation

- The 2-process model and sleep deprivation
  - Increased sleep pressure



The synaptic downscaling hypothesis

- G. Tononi & C. Cirelli
  - Madison Wisconsin

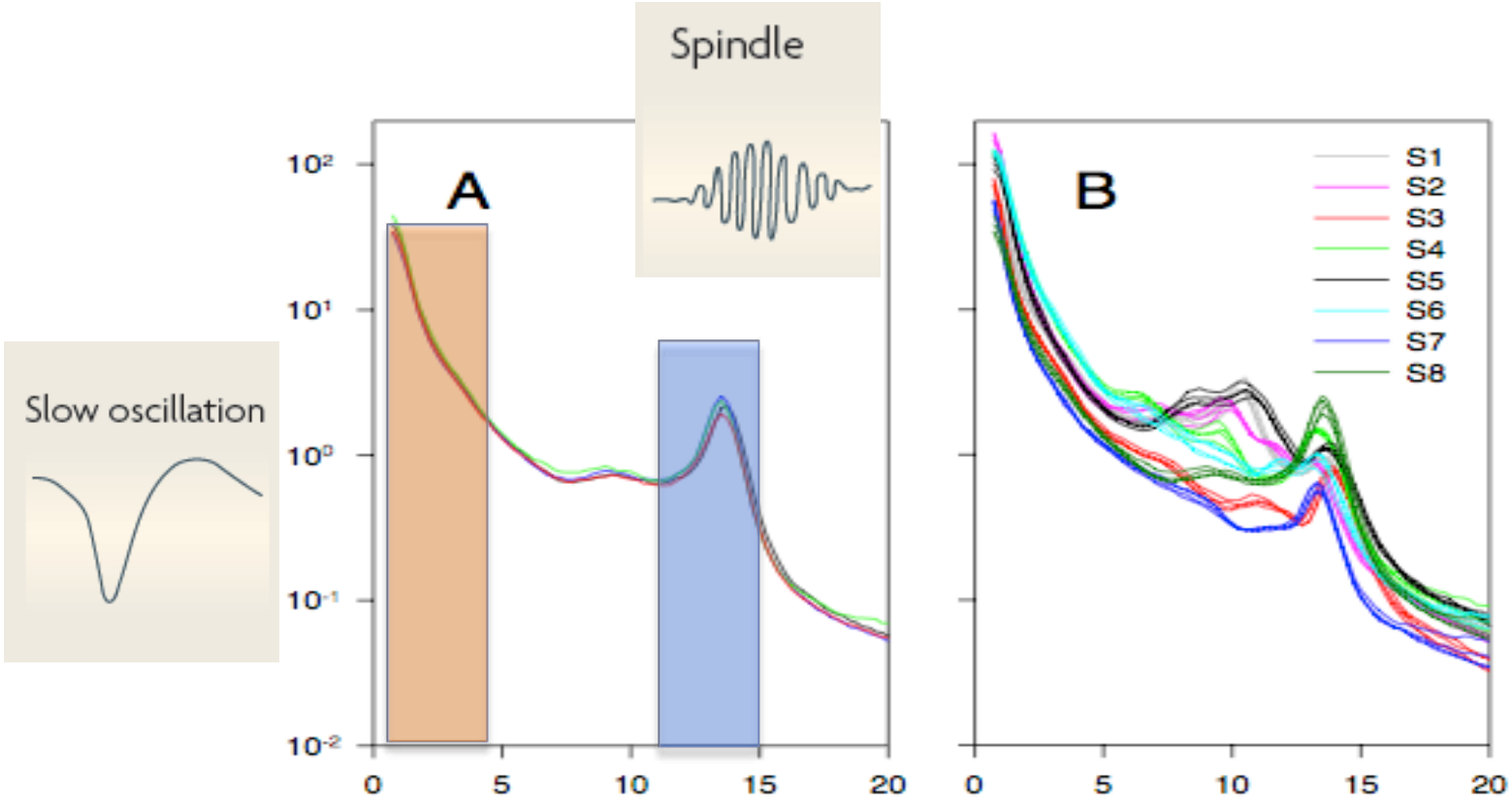


- Measure of synaptic downscaling during sleep:
  - Slow-wave activity (SWA)

Tononi & Cirelli, 2006, *Sleep Med Rev*

Excursus: Oscillations

- Powerspectrum during NonREM sleep

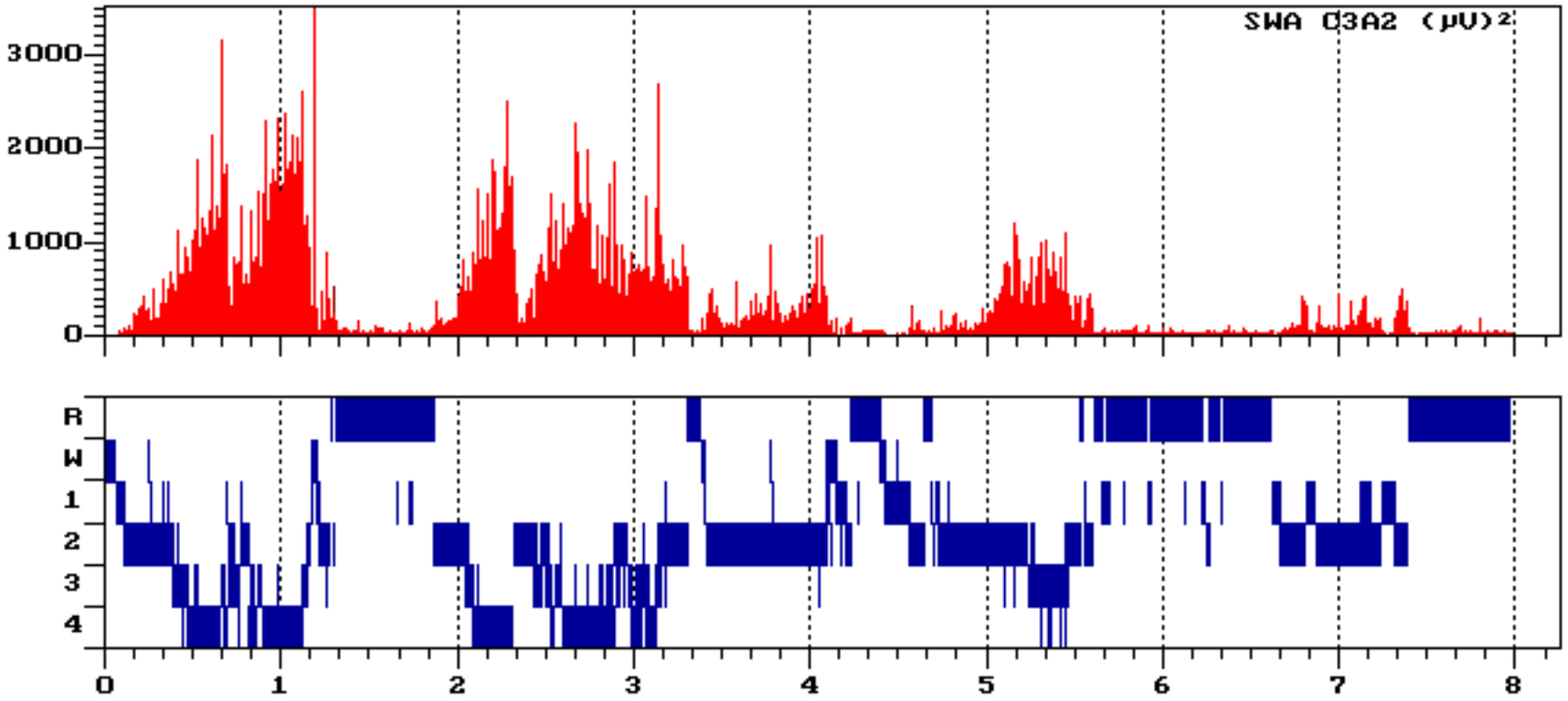


Slow Wave Activity
SWA: 0.5 – 4.5 Hz

Sleep Spindles
11 – 15 Hz

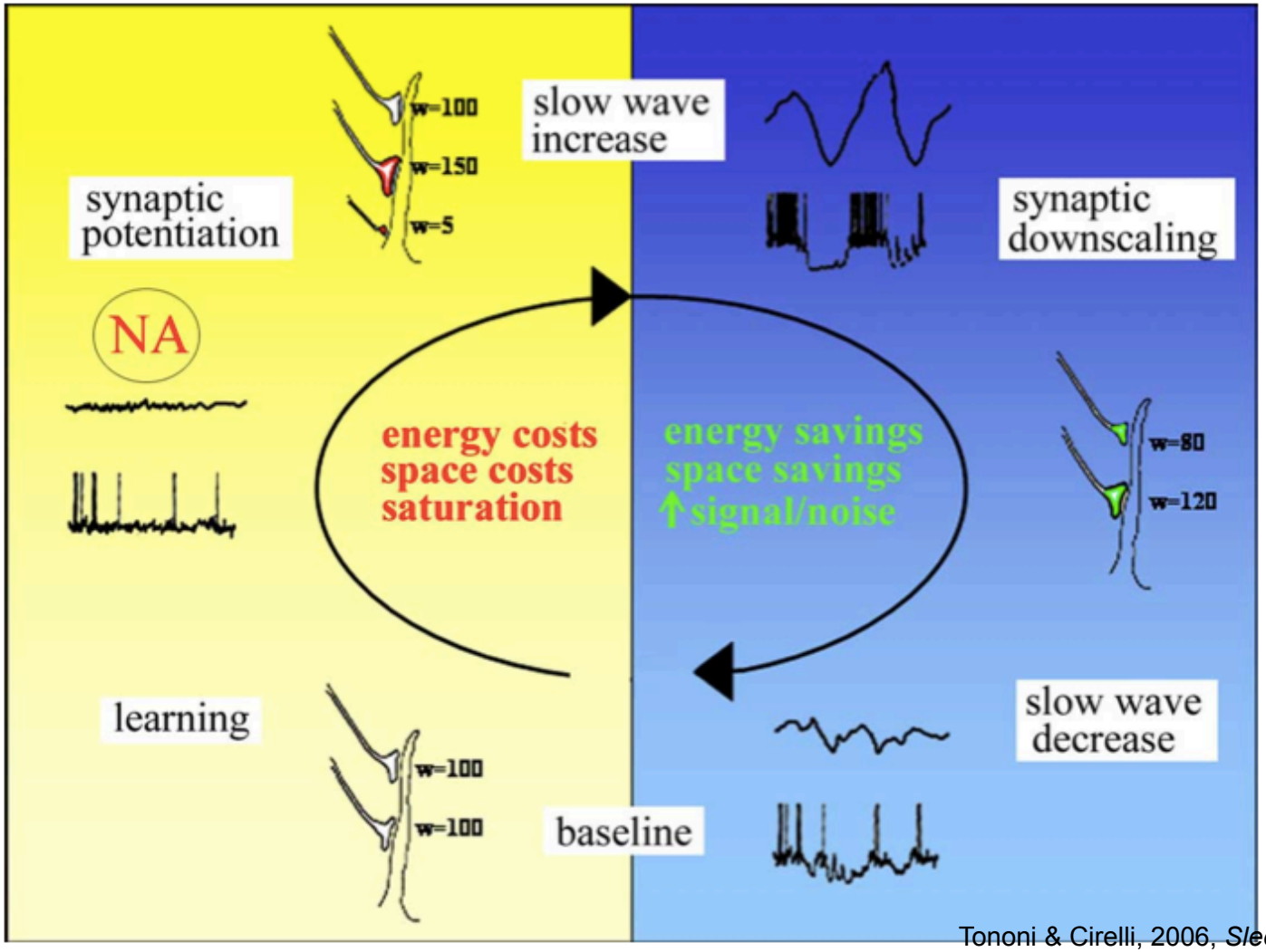
Buckelmüller et al., 2006, Neuroscience

SWA during a night of sleep



http:/www.pharma.uzh

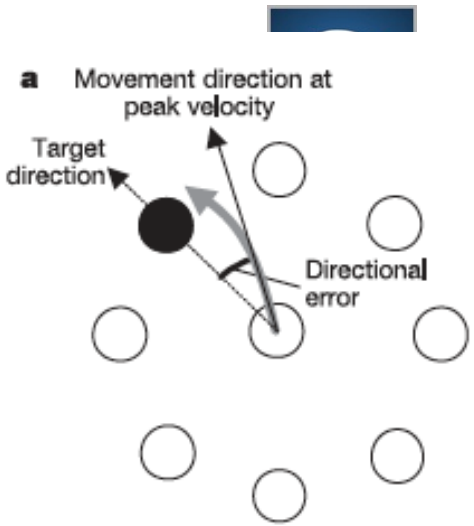
The synaptic downscaling hypothesis

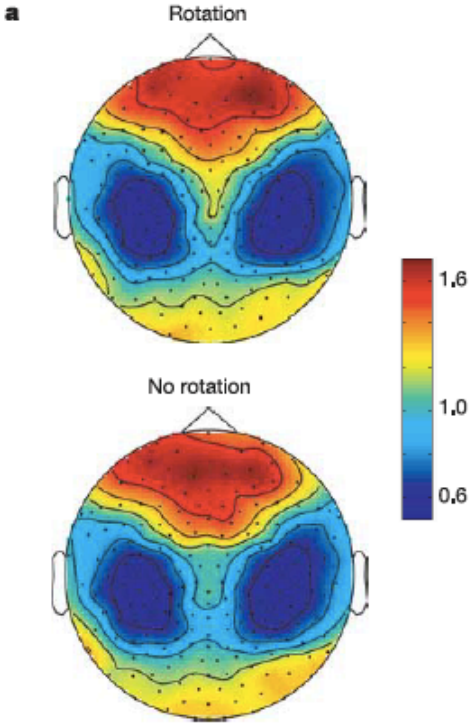


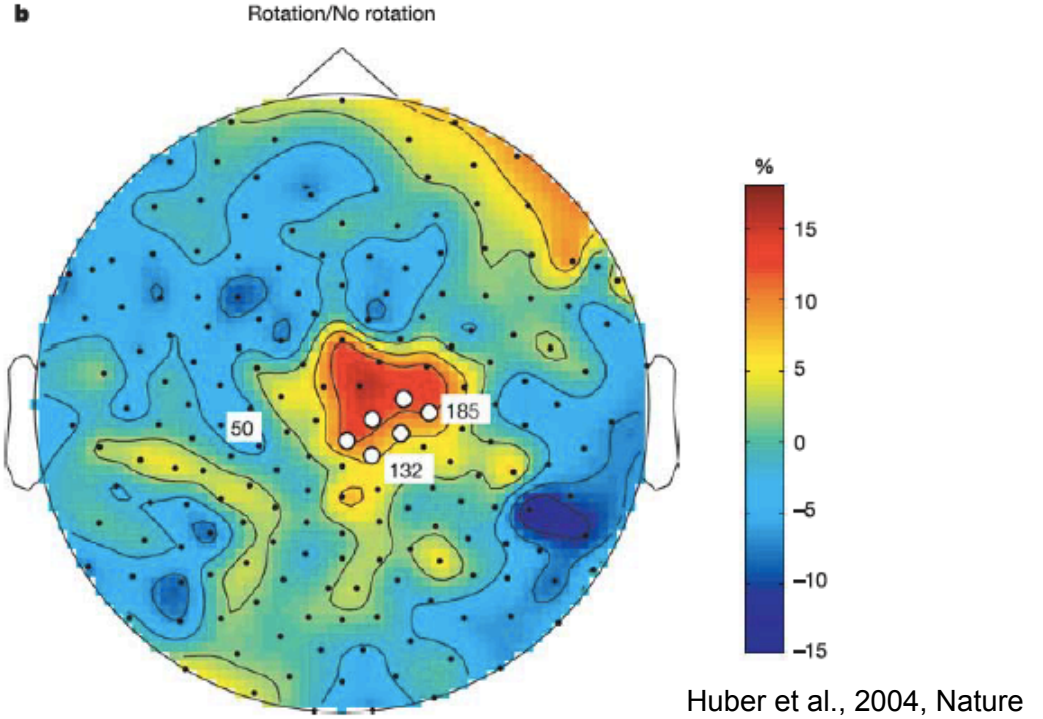
Tononi & Cirelli, 2006, *Sleep Med Rev*

Slow oscillations and memory

- Learning before sleep increases slow wave activity
  - Specific to brain region involved in learning



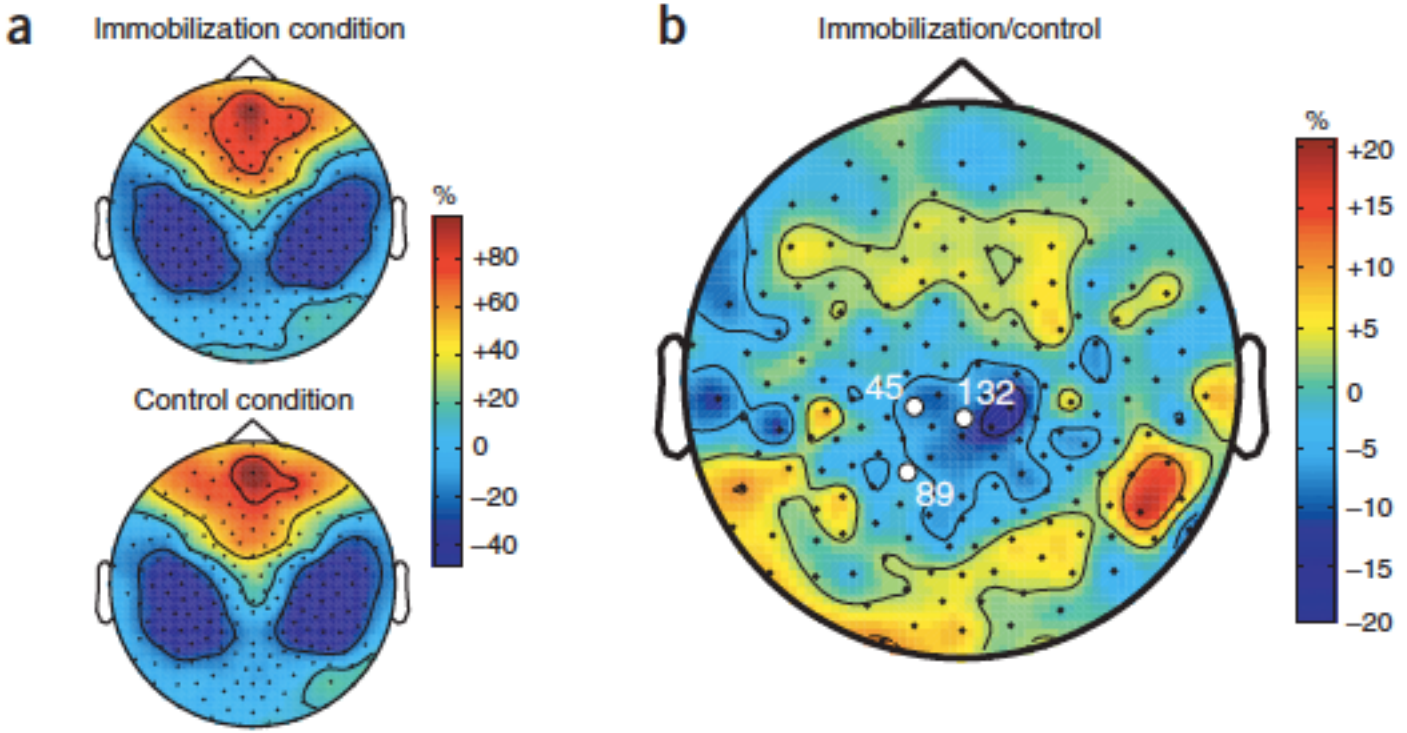




Huber et al., 2004, Nature

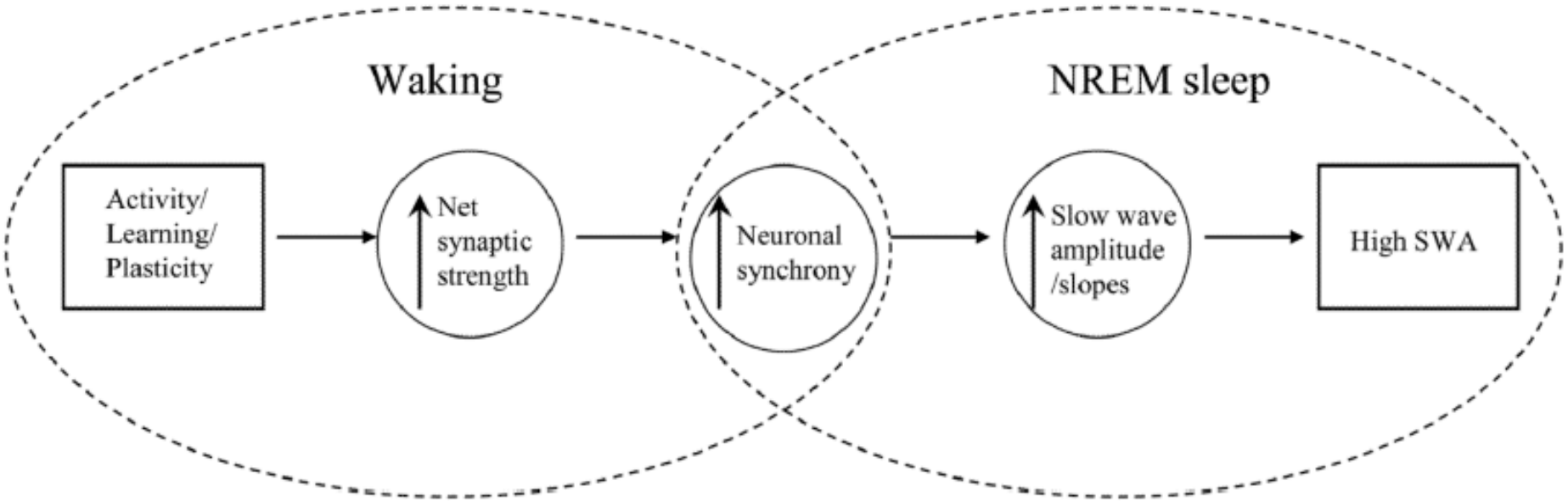
Slow oscillations and memory

- Immobilization of right arm before sleep reduces slow wave activity



Huber et al., 2006, Nature Neuroscience

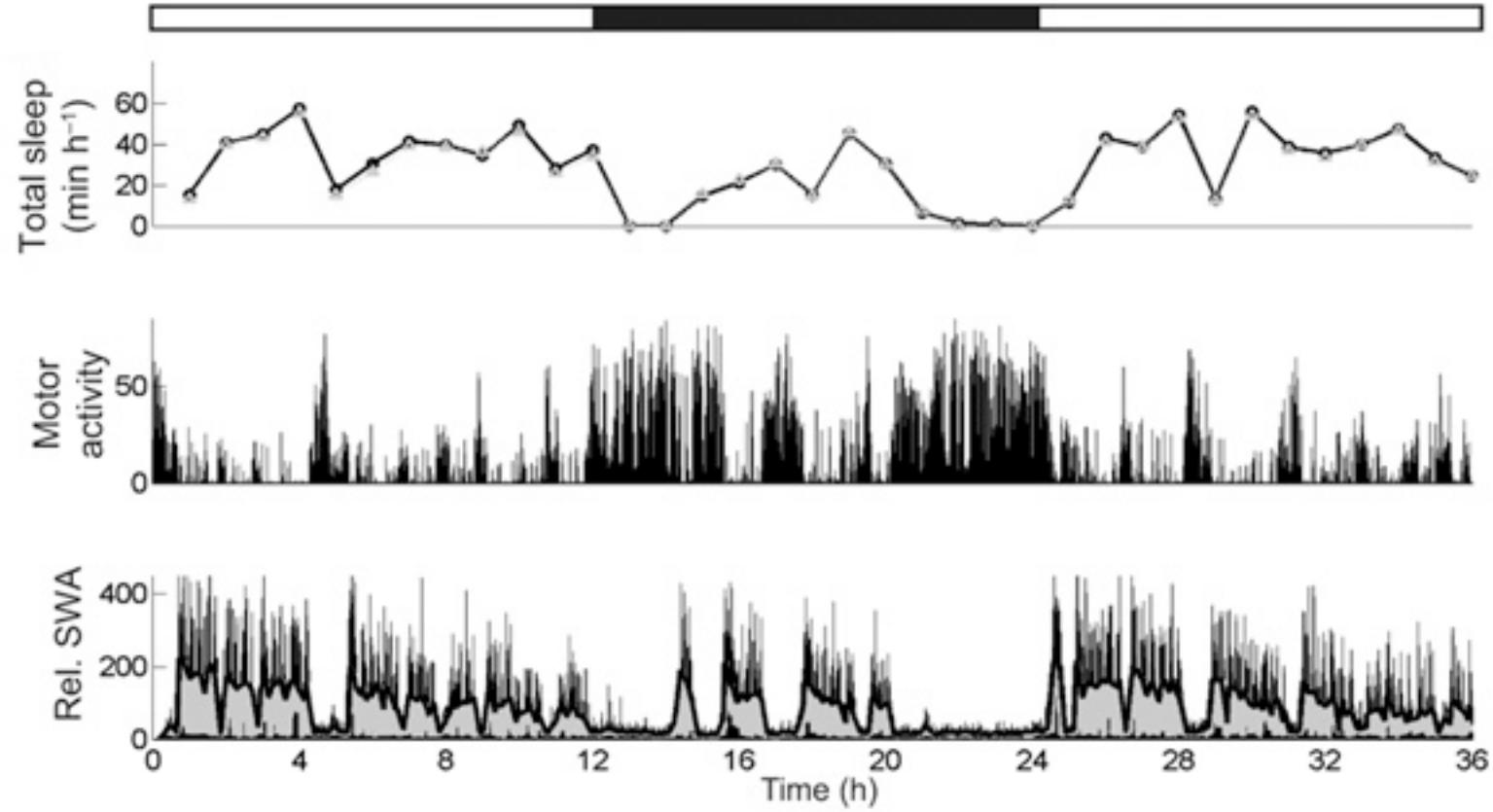
The synaptic downscaling hypothesis



Vyazovskiy et al., 2011, Prog. Brain Res.

Synaptic growth and sleep

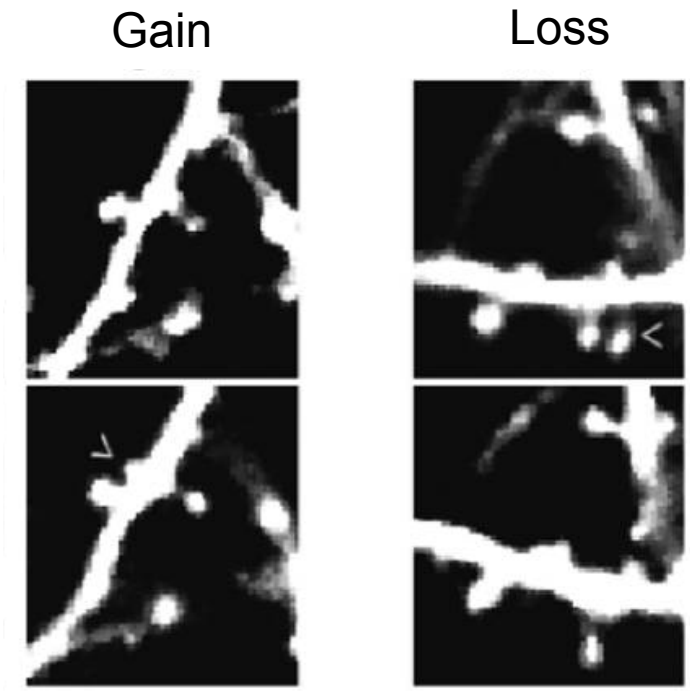
- Motor activity and SWA in rats

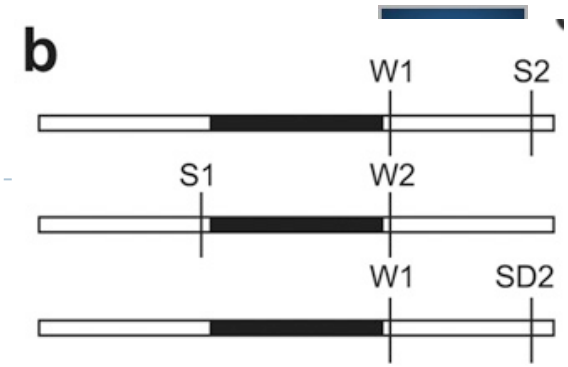


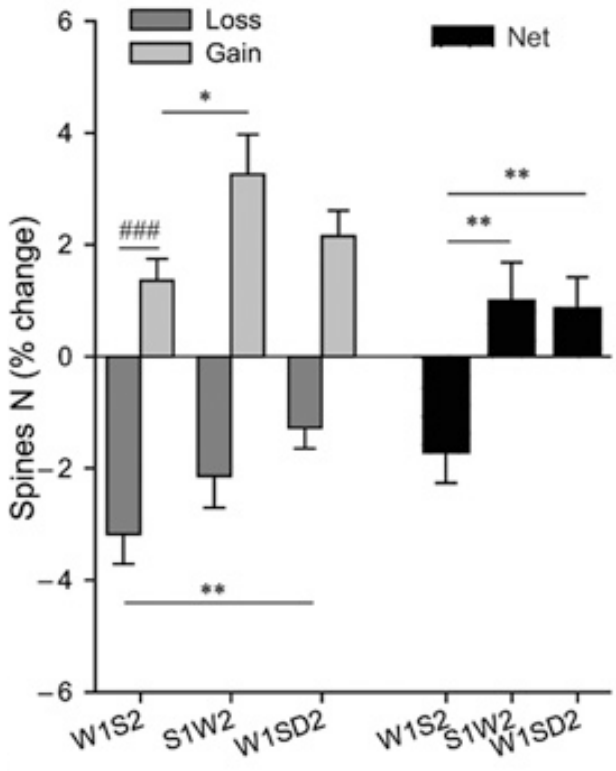
Maret et al., 2011, Nat. Neurosci.

Synaptic growth and sleep

- Synaptic spines
  - Net increase across waking
  - Net decrease across sleep

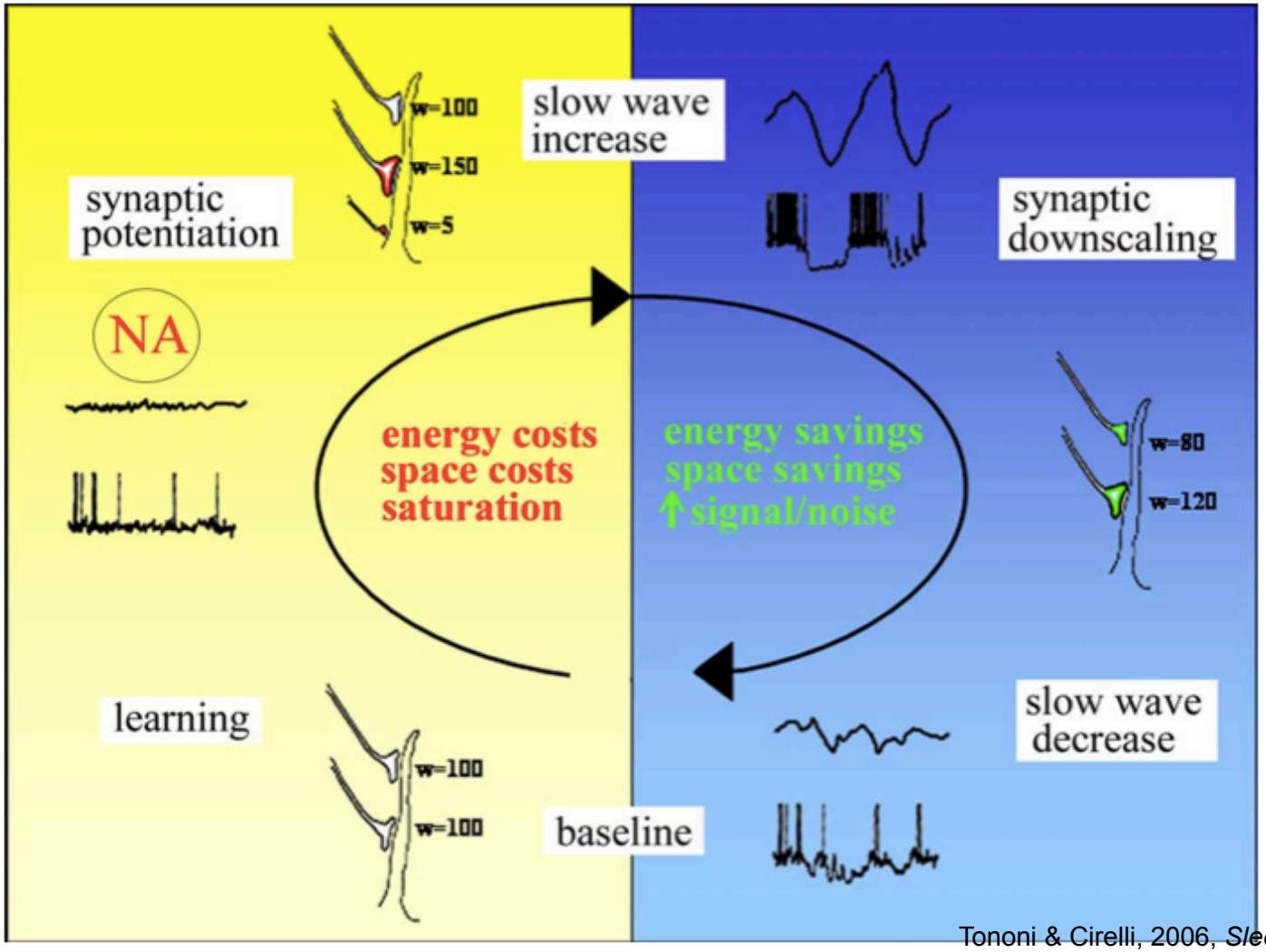






Maret et al., 2011, Nat. Neurosci.

The synaptic downscaling hypothesis



Tononi & Cirelli, 2006, *Sleep Med Rev*

Summary IV

- Synaptic Downscaling Hypothesis
  - G. Tononi & C. Cirelli, Madison Wisconsin
- Assumes that sleep plays a role in downscaling of synapses
  - Wakefulness (= learning) potentiates synaptic strength
  - Sleep downscales synaptic strength
  - No role for "reactivation"
- Slow wave activity (SWA) is a marker of synaptic downscaling
  - Learning induces local increases in SWA
  - Progressive reduction of SWA during sleep reflects reduced need for downscaling across sleep

Thank you for your attention.