

Sleep for Preserving and Transforming Episodic Memory

Marion Inostroza¹ and Jan Born
Annual Review of Neuroscience, 2013

Chirag Gupta

IIT, Kanpur

Overview

- ▶ Major breakthroughs in memory research indicate that sleep plays a pivotal role in memory consolidation.
- ▶ Questions researchers seek to answer -
 - ▶ To what extent does sleep help in memory consolidation?
 - ▶ What are the processes involved during various phases of sleep?
- ▶ This review looks at evidence for a specific involvement of sleep in active system consolidation.
- ▶ Various consolidation processes that happen during sleep talked about, experimental evidence provided.
- ▶ Paper not very organized, and a lot of interrelated ideas spread out in sections.

Few terms

Episodic Memory

Episodic memory is the memory of autobiographical events that can be explicitly stated. It is the collection of past personal experiences that occurred at a particular time and place.

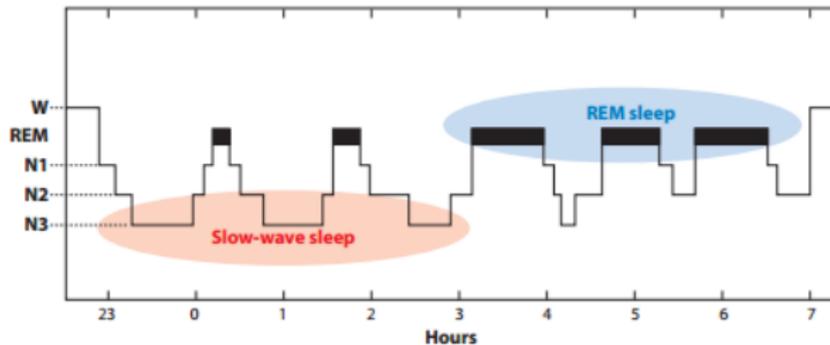
Rapid Eye Movement Sleep

Sleep is categorized as Rapid Eye Movement (REM) Sleep, and non-REM sleep. Each has its own characteristics, in terms of oscillations that occur in the neural circuitry. REM sleep is characterized by rapid random movements of eyes.

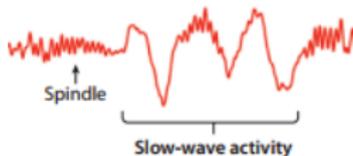
Slow wave sleep Sleep

This consists of stages 3 and 4 of non-REM sleep. This period of sleep is called slow wave sleep because the EEG activity is synchronized, producing slow waves with a frequency of less than 1 Hz and a relatively high amplitude.

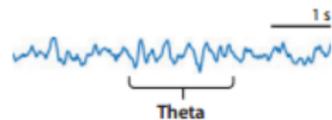
Waves during sleep



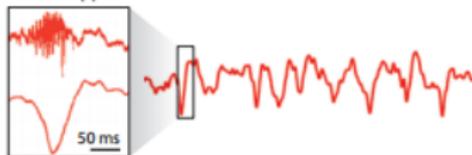
Slow-wave sleep



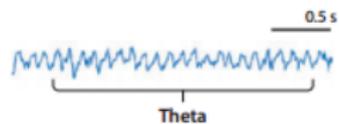
REM sleep



Sharp wave-ripple



Theta



Memory consolidation

Two stage model for memory-consolidation.

1. Incoming information fed into a temporary store.
(Hippocampus)
2. Hippocampal firing strengthens temporary memories. Also, from these temporary stores, some information gradually integrated with pre-existing knowledge into a long term store.
 - ▶ Extrahippocampal regions are typically neocortical regions.
 - ▶ Hippocampus is vital for short term memory.
 - ▶ Long term memory has more *de-contextualized* representations in extra hippocampal regions.

System Consolidation

Redistribution of hippocampal representations of memory to extrahippocampal neuronal networks, and the associated qualitative changes in memory content.

Effects of sleep

- ▶ This process of consolidation is carried out during sleep.
- ▶ Hippocampal firing strengthens episodic buffers.
- ▶ Temporary episodic memory encoded during waking hours transformed by neuronal reactivations during SWS into schema-like generic representations.
- ▶ Specificity in consolidation : Neocortical slow oscillations exert top-down control to *select* memories that are to be consolidated.
- ▶ Protection of newly encoded memories from being overwritten by temporally local information.

Support for system consolidation theory

Wilson and McNaughton, 1994

- ▶ Spike activity in hippocampal place cells while the rat was running along a track for food reward
- ▶ Same spike activity reactivated during subsequent SWS sleep!
- ▶ These reactivations occur at a faster pace, but in the same temporal order.

Yaroush et al. 1971, Fowler et al. 1973

- ▶ Beneficial effects of post learning sleep on declarative tasks such as the learning of nonsense syllables, words, and paired associate word, which rely majorly on hippocampal function.
- ▶ SWS is much more relevant for strengthening declarative memory than REM sleep.

Strengthening of contextual information

- ▶ Preferential strengthening of context over itemic memory, during sleep.
- ▶ Contextual features of episodic memory critically depend on hippocampal function.
- ▶ Most benefits of sleep for contextual aspects of episodic memory.

Study by **van der Helm et al. 2011**

- ▶ Participants learned two lists of words, while facing two different posters.
- ▶ Nap group vs. non-nap group.
- ▶ Nap group showed better memory for the poster associated with a word.
- ▶ Recognition of the words per se did not differ!

Transformation of memory representations during sleep

- ▶ De-contextualization of episodic memory information.
- ▶ Hippocampal information moves to extra-hippocampal regions during SWS.
- ▶ New information embedded into pre-existing schemas.
- ▶ Semantic and skill representations acquired that can be applied independent of their spatio-temporal context.

Fischer et al. 2006, Drosopoulos et al. 2011

- ▶ Participants asked to generate deliberately the sequence underlying an SRTT (Serial Reaction Time Task) trained under implicit conditions before a retention interval of sleep or wakefulness.
- ▶ Sleep subjects developed a significant amount of explicit sequence knowledge!

Perspective

Questions unanswered

- ▶ What is the role of top-down control in the consolidation process?
- ▶ How exactly does the bottom up transformation to abstract representations take place?
- ▶ What happens if schemas are not readily available, for example during early development?

Conclusion

This review of past research clearly establishes that sleep as a brain state is critical to the formation of memories. From a scientific point of view, the understanding of sleep will also be essential to a genuine appreciation of the underlying processes of memory.

References

Since this was a review paper, a plethora of previous publications have been cited by the authors. The review was self-contained, and there were no particular references that I had to go through to understand it.

A few particularly interesting experiments have been mentioned in the slides above, along with their references. The viewer is encouraged to look at those experiments if interested.