



## UvA-DARE (Digital Academic Repository)

### Manipulating memory during sleep

van Poppel, E.A.M.; Talamini, L.M.

**DOI**

[10.1016/j.sleep.2019.11.1110](https://doi.org/10.1016/j.sleep.2019.11.1110)

**Publication date**

2019

**Document Version**

Final published version

**Published in**

Sleep Medicine

[Link to publication](#)

**Citation for published version (APA):**

van Poppel, E. A. M., & Talamini, L. M. (2019). Manipulating memory during sleep. *Sleep Medicine*, 64(Supplement 1), S398-S399. <https://doi.org/10.1016/j.sleep.2019.11.1110>

**General rights**

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

**Disclaimer/Complaints regulations**

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

## Memory

### MANIPULATING MEMORY DURING SLEEP

E.A.M. van Poppel<sup>1,2</sup>, L.M. Talamini<sup>1</sup>. <sup>1</sup> *Psychology, University of Amsterdam, Amsterdam, Netherlands*; <sup>2</sup> *Cognitive Biopsychology and Methods, University of Fribourg, Fribourg, Switzerland*

**Introduction:** Targeted Memory Reactivation (TMR) is the deliberate reactivation of a memory trace by presenting learning-related cues during sleep. TMR is thought to selectively enhance memory consolidation during Slow-Wave Sleep (SWS). The hallmark of SWS is the slow-wave, characterized in the electro-encephalogram (EEG) as a wave with amplitude >75

$\mu\text{V}$  and frequency around 1 Hz. The slow-wave reflects global synchronous neuronal depolarisation and increased excitability in the so-called up-state, followed by a widespread neuronal hyperpolarisation in the down-state. In this study, our aim was to present learned stimuli during either a slow-wave up- or down-state. Our expectations were that stimuli cued during the up-state would enhance vocabulary memory the most, since the up-state is associated with neuronal depolarisation and increased excitability.

**Materials and methods:** 65 Native Dutch speakers participated in the study. They learned 120 Danish nouns before sleep. We developed a closed-loop method that allows targeting stimuli to any oscillatory phase by modelling and predicting the oscillatory brain activity. We used this method to predict either up- or down-states in slow-waves. In the “Up” group ( $N=23$ ), half of the learned words were aurally cued again during predicted slow-wave up-states. In the “Down” group ( $N=19$ ), half of the learned words were cued during predicted slow-wave down-states. The “Sham” group ( $N=23$ ) did not receive any cues during the night. Auditory TMR started at the beginning of SWS and continued for 3 hours. The following morning, participants had to retrieve all 120 words in a cued recall test.

**Results:** Our results show that memory for words cued in the up-state of a slow-wave was improved, i.e. on average participants knew more of the cued words after sleep ( $107\%\pm 12\%$ ) compared to the uncued words ( $99\%\pm 10\%$ ,  $p=.03$ ). Moreover, we are the first to show that memory traces seem to deteriorate when cued in a slow-wave down-state ( $95\%\pm 11\%$ ) compared to uncued words ( $102\%\pm 10\%$ ,  $p=.04$ ). The sham group knew on average the same amount of words after sleep compared to the learned amount before sleep ( $100\%\pm 8\%$ ). Event-Related Potentials (ERPs) show an induced slow-wave-like pattern after cueing at the beginning of a slow-wave up-state, which is not present in an ongoing “sham” slow-wave. Presenting a cue at the beginning of a down-state seems to disrupt this pattern, resulting in a phase shift of the induced slow-wave-like pattern. Time-frequency analysis reveals an early enhancement in the fast spindle/beta power range (14–21 Hz) for the up-state cued words compared to the down-state cued words. Interestingly, both TMR cued groups show more SWS ( $17\%\pm 6\%$ ) compared to the sham group ( $11\%\pm 7\%$ ,  $p=.01$ ).

**Conclusions:** Applying TMR in an ongoing slow-wave up-state enhances post-sleep memory, whereas reactivation in the slow-wave down-state depresses memory. Thus, by taking into account the oscillation phase of the slow-wave, it is possible to manipulate the fate of a memory trace during sleep. These results open perspective for exciting future research, such as strengthening deliberate memory traces with a device wearable at home when learning, or even deteriorating memory traces in PTSD patients.