

Mechanisms of targeted memory reactivation during sleep: he role of pre- and post-cue spindles

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Short bursts of activity called sleep spindles (11-16 Hz, 0.5-2 s) may New memory traces become reactivated during post-learning sleep

targeted memory reactivation3 to investigate this link contribute to this process? However, we lack temporally-precise evidence linking spindles and memory reactivation. Here we used

Wake classifier training

Sound - picture over-learning

Encoding

Test w/ feedback

Picture - spatial location learning

Encoding

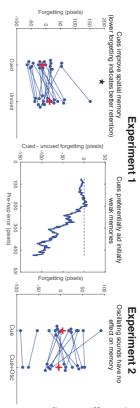
Guess

Feedback

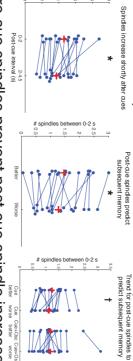
After the nap: 81% recalled During learning: each pair retrieved 2x.

eading to their stabilization

Sound cues during sleep improve spatial memory



Post-cue spindles predict subsequent memory Experiment 1 **Experiment 2**

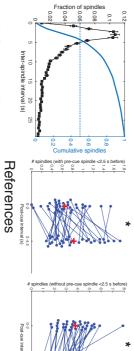


Pre-cue spindles prevent post-cue spindle increases Inter-spindle intervals suggest spindle incidence subject to refractory period Lack of pre-cue spindles allows

large increase in post-cue spindle

Condition 1 - early sounds

Condition 2 - late sounds



²Schreiner, T, Lehmann, M, & Rasch, B (2015) Auditory feedback blocks memory benefits of cueing during Antony, JW & Paller, KA (2017) Contributions of the hippocampus to declarative memory consolidation during sleep. The Hippocampus from Cells to Systems, Eds Hannula, D. & Duff, M. p. 245-80

Post-nap spatial and sound-picture tests

Acknowledgements

Exp 1: Cued half of the sounds associated with each category (e.g., [moow], [vloin]), Mean: 7.2, 17 ange: 2.8-9.2 cues per tem Exp 2: Cued ALL sounds, with half followed by 2s, 15 Ft amplitude-modulated white noise. Mean: 6.6, range: 2.7-10.9 cues per item.⁴

REM

Stimulation period

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Nap (90 min)

Pre-nap test

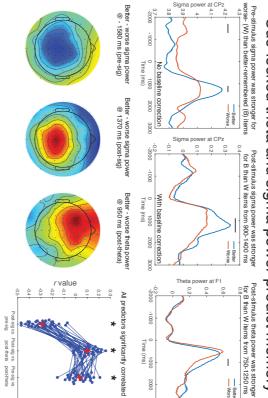
Guess

Feedback

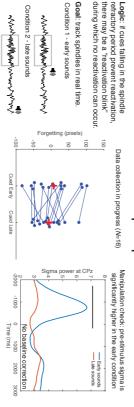
Pre-nap erroi

This work is supported by the NSF BCS grant 1533511 to KAP and KAN and the CV Starr Fellowship to JWA. ⁴Antony, J.W., & Paller, K.A. (2017). Using oscillating sounds to induce sleep spindles. Sleep **40**: zsw068. Available online ³Rudoy, JD, Voss, JL, Westerberg, CE, & Paller, KA (2009) Strengthening individual memories by reactivating 2016 Nov 28. https://doi.org/10.1093/sleep/zsw068 them during sleep. Science 326, 1079.

Cue-locked theta and sigma power predict memory



Real-time follow-up experiment



Take-home messages

- 1) Sleep cues benefit memory
- Post-cue spindles predict subsequent memory²
- Three EEG measures signal successful memory reactivation pre-stimulus sigma power, post-stimulus sigma power, and post-stimulus theta power
- Due to spindle refractoriness, pre-cue spindles may negatively predict subsequent memory — an idea we are examining in a real-time experiment