The sleeping brain's response to verbal and non-verbal memory cues

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Background

- Sleep is thought to actively support memory consolidation through reactivation of newly formed memories.
- Mediated by oscillations of slow-wave sleep, these memory traces are reorganised into stable representations (Klinzing et al., 2019).
- One way to investigate memory reactivation during sleep is by re-exposing the sleeping brain to stimuli that are linked to newly formed memories – this paradigm is known as targeted memory reactivation (Schreiner et al., 2015; Cairney et al., 2018).

Aims

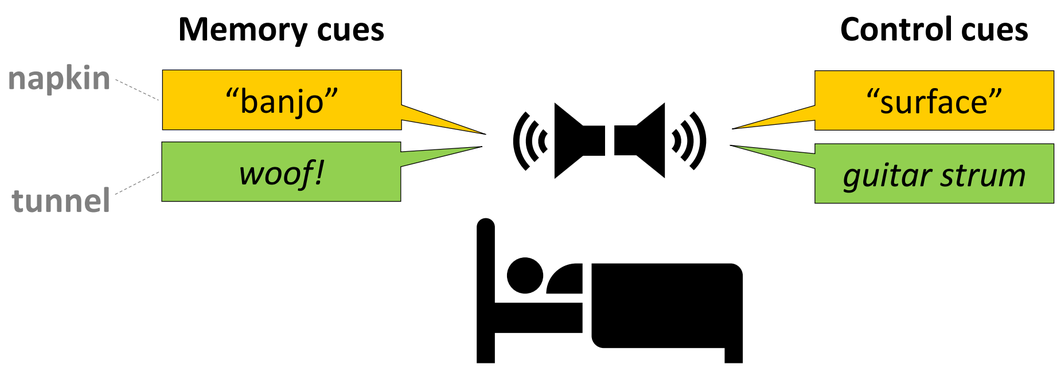
Using secondary data (behavioural data published in Cairney et al., 2017), we explored differences in evoked sleep oscillations between:

1. Memory cues and control cues.
2. Verbal and non-verbal memory cues.
3. Verbal memory cues presented by the same or a different speaker.

Methods

- 51 participants (males, mean age ± SD: 20.61 ± 1.97).
- In the first session, participants associated visually-presented words with spoken words (verbal) and environmental (non-verbal) sounds.
- A subset of the verbal and non-verbal cues were then replayed during overnight slow-wave sleep. In addition, previously unheard control cues were presented ("surface" and *guitar strum*).
- For a subset of the participants (N=23), the speaker for the verbal cues was changed.

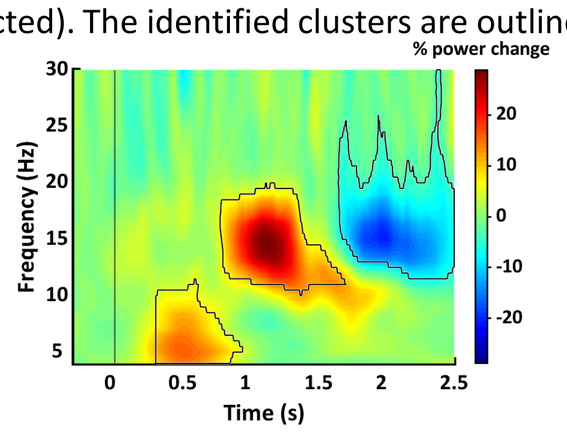
Figure 1. Cue examples. Memory and control cues consisting of verbal or non-verbal information were presented during overnight sleep, one at a time (ITI = 5 s).



Results

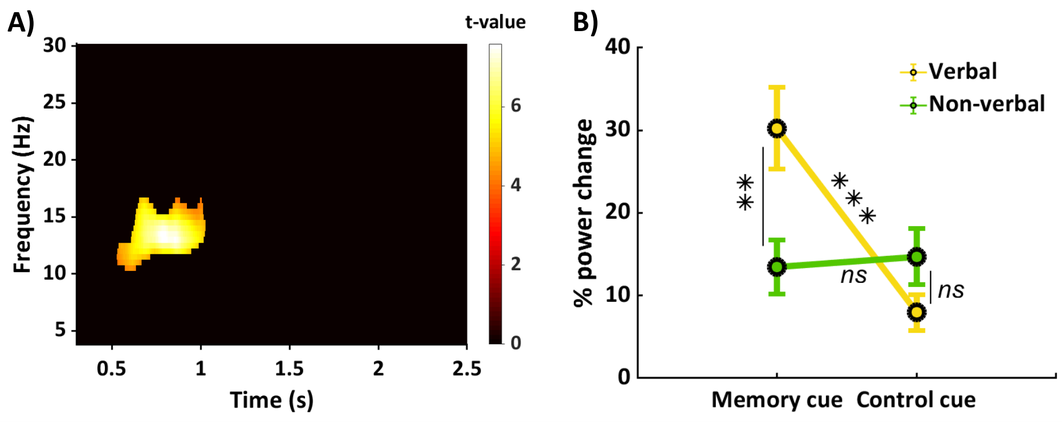
- Cluster-based permutation analyses showed no significant oscillatory differences when changing the speaker (p >.050). Data were collapsed across this manipulation for all other analyses.
- Overall, memory cues and control cues evoked significantly different oscillatory responses (memory > control, p <.010). The identified clusters showed increases in theta (~4-11.5 Hz, d = .44) and spindle frequency bands (~10-20 Hz, d = 0.47), and later decreases in spindle/beta band (~11.5-30 Hz, d = - 0.38).

Figure 2. Memory > Control cues. Grand average time-frequency differences (baseline-corrected). The identified clusters are outlined.



- Verbal and non-verbal cues evoked significantly different memory-related responses (2x2 factorial design, Verbal$^{memory > control}$ > Non-verbal$^{memory > control}$, p <.050). The identified cluster showed an increase in the spindle band (~10.5-16 Hz, d =.27, **Figure 3A**). Post-hoc tests of the cluster revealed a power increase for verbal memory cues compared to control and non-verbal memory cues (**Figure 3B**).

Figure 3. Verbal > Non-verbal cues (memory > control). A) Threshold t-value map (p <.05, corrected). **B)** Average (±SE) of the cluster by cue type. ** = p <.010, *** = p <.001, *ns* = p >.050 (Bonferroni corrected).



Conclusions

- In line with previous findings, memory cues evoke increases in theta and spindle power, which have been linked to memory consolidation (Schreiner et al., 2015; Schechtman et al., 2019).
- Verbal and non-verbal memory cues might differentially evoke spindle-mediated memory processes. Spindles have been effective for stimulus decoding (Cairney et al., 2018), but this is the first study to link spindle power with verbal (vs. non-verbal) memory cues.
  → Spindles may reflect the type of memory which is reactivated.

References

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