Sleep and Hippocampal Development during Early Childhood

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Introduction

• In early childhood, memory performance is enhanced by an afternoon nap (Kurzdorf & Spencer, 2013).
• This process is thought to reflect consolidation of memories from hippocampus to the cortex supported sleep spindles (Rasch & Born, 2013).
• Additionally, in early childhood, the nap benefit has been associated with spindle density (Kurzdorf, Duclos, & Spencer, 2013; Schabus et al., 2008).
• It is critical to study these processes during early childhood because memory improves and the hippocampus shows age-related changes.

(Riggins et al. 2015; Riggins et al., 2018).

Purpose: Investigate relations between the nap benefit on memory, spindle density, and hippocampal volume.

Methods

Participants

• Participants are part of an ongoing longitudinal study.
• Preliminary analyses included 31 habitual nappers who provided usable data (Mage=3.87 years, 19 female).

Experimental Design

• Children participated in three visits, approx. one week apart.

Nap visit
Children nap per their usual routines

Wake visit
Children play quietly for the duration of their typical nap

MRI Structural scan

Polysonmography (PSG)

• Spindles were identified in the 9-15 Hz range at C3 during nREM2 and spindle density was calculated manually (Kurzdorf, Duclos, & Spencer, 2013).

Behavioral Memory Task

Encoding

Immediate recall (IR)

Adjusted Sleep Change Score = (Sleep IR – Sleep DR)/Sleep IR

Structural MRI Data

• A T1-weighted structural MRI scan (9 mm³) was obtained using a Siemens 3T scanner with a 32-channel coil.
• Hippocampal volumes were extracted via Freesurfer v6.0 (Fischl, 2012) and refined using ASAT (Automated Segmentation Adapter tool, Wang et al., 2015).
• Hippocampal subregions (head, body, tail) were defined using standard anatomical landmarks (DeMaeter et al., 2013; Riggins et al., 2015).

Results: Brain – Sleep Change Score

Left, but not right, hippocampal volume was negatively associated with nap benefit on memory (i.e., adjusted sleep change score) when controlling for age, sex, and ICV.

Results: Brain – Sleep Spindles

Left hippocampal tail volume was positively associated with spindle density when controlling for age, sex, and ICV. No other significant relations were observed.

Discussion

• Children with a larger hippocampus
  • Benefited less from the nap on a memory task
  • Demonstrated greater sleep spindle density.

• Together, these findings reveal relations between memory, nap physiology, and hippocampal volume during early childhood.
• These findings may suggest that children with larger hippocampi produce greater spindles density and are less dependent on the nap benefit for memory.

• Future Directions: Given these findings, we plan to investigate these relations in children who have transitioned out of their nap and those who have not using our longitudinal sample.

References


https://doi.org/10.1073/pnas.1306418110


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https://doi.org/10.1093/sleepphys/27.3.1479

Take-Home Message

Children with a larger hippocampus demonstrated greater spindle density and benefited less from the nap. This may be an early indicator of a transition out of the afternoon nap.

Acknowledgements

Thank you to the families that participated in this research study. We would also like to thank the members of the Neurocognitive Development Lab and the Somneuro Lab for assistance with data collection and analysis. Support for this research was provided by NIH (HD094758) and NSF (BCS 1749280) to TR and RS.

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