Exploring Relations Between Hippocampal Microstructure and Mnemonic Discrimination in Preschoolers

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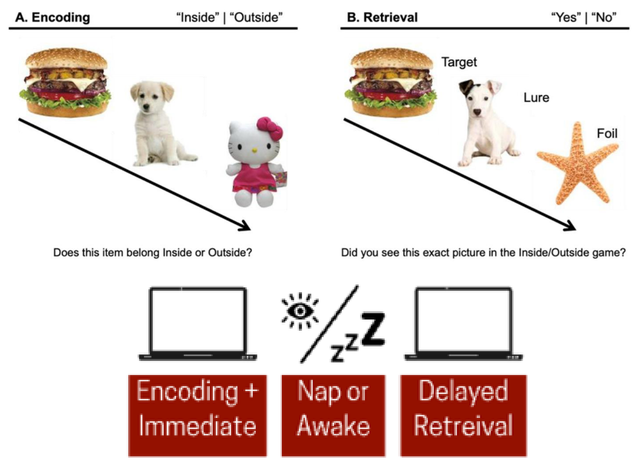
Introduction

- Assessments of hippocampal microstructure using diffusion weighted imaging (DWI) have been shown to predict memory performance over and above hippocampal macrostructure.[1]
- DWI looks at the diffusion of water molecules within tissue, better reflecting integrity. Fractional anisotropy (FA) quantifies the diffusion of water along the neuronal tracts, whereas mean diffusivity (MD) reflects the average diffusivity of water[2].
- Prior studies in children have shown a negative association between MD in the hippocampus and memory[1, 3, 4], but the relation between FA in the hippocampus and memory in children is not as clear because of the high content of gray matter, which is less directionally organized than white matter, and goes through stages of growth and development throughout childhood.[5]
- Additionally, sleep has proven to be important for memory performance, especially in young children[6]. Prior research has found differential relations between memory performance and hippocampal macrostructure depending on whether the child had napped or was kept awake[6, 7], suggesting sleep may influence the relation between hippocampal structure and memory.
- Limited work has addressed the relation between mnemonic discrimination and hippocampal microstructure in young children.
- We hypothesized that mnemonic discrimination ability and memory performance would be negatively related to MD in the hippocampus and positively related to FA in the hippocampus due to reduced diffusion because of organizational maturation in the hippocampus.

Methods

- Participants were 49 habitual nappers between the ages of 3 and 5.5 years (M = 3.92 , SD = 0.61, 26 F).
- Participants completed an episodic memory task (Mnemonic Similarity Task; MST[5] where they were shown pictures of objects and then tested on their memory both immediately afterward and again after either a nap or an equivalent period of wake. The order of nap or wake was randomized and each child completed both conditions.
- A lure discrimination index (LDI) was calculated by subtracting the percentage of incorrect lures from the percentage of correct targets. An item memory (IM) score was calculated by subtracting the percentage of incorrect foils from the percentage of correct targets.
- Diffusion-weighted MRI images were acquired a week after the memory assessment and then pre-processed using MRtrix 3.0. Binary hippocampal masks were created using Freesurfer 7.4.

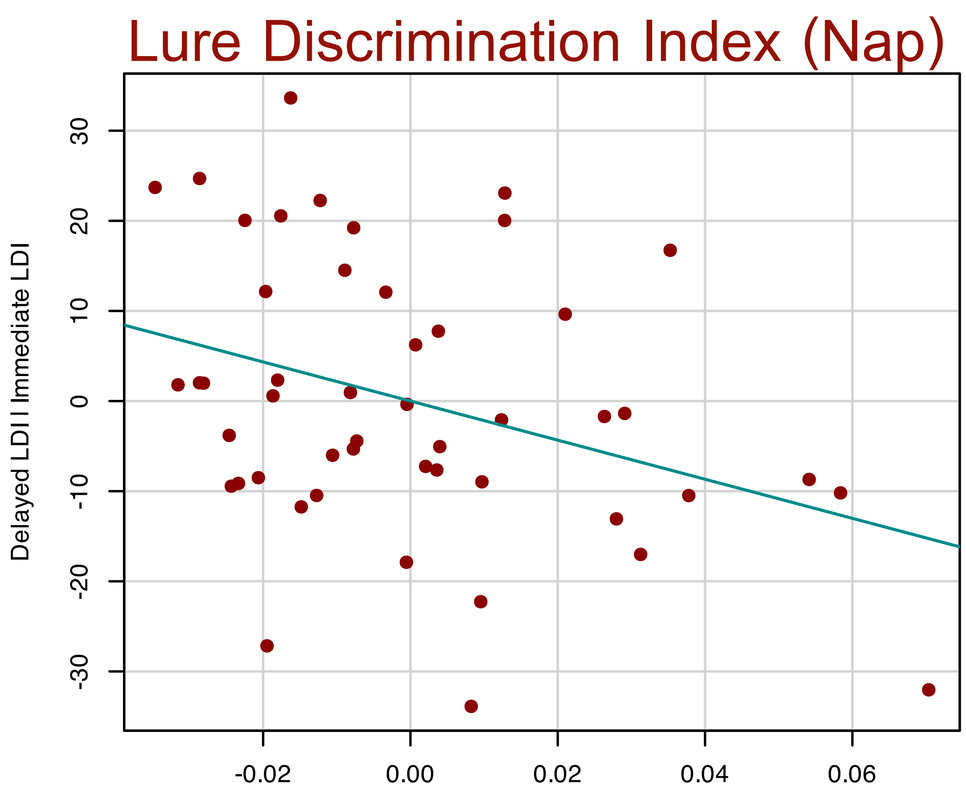


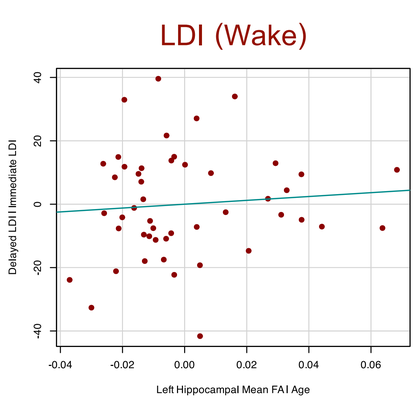
Analysis

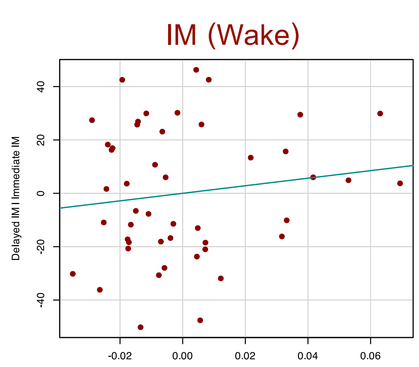
- Linear regressions were run to identify associations between delayed memory recall and each DTI metric (FD, MD) for each hippocampal hemisphere (left, right) controlling for immediate recall performance and age. These regressions were conducted on memory recall after the child had napped and after the child was kept awake. The Bonferroni method was used to correct for multiple comparisons.

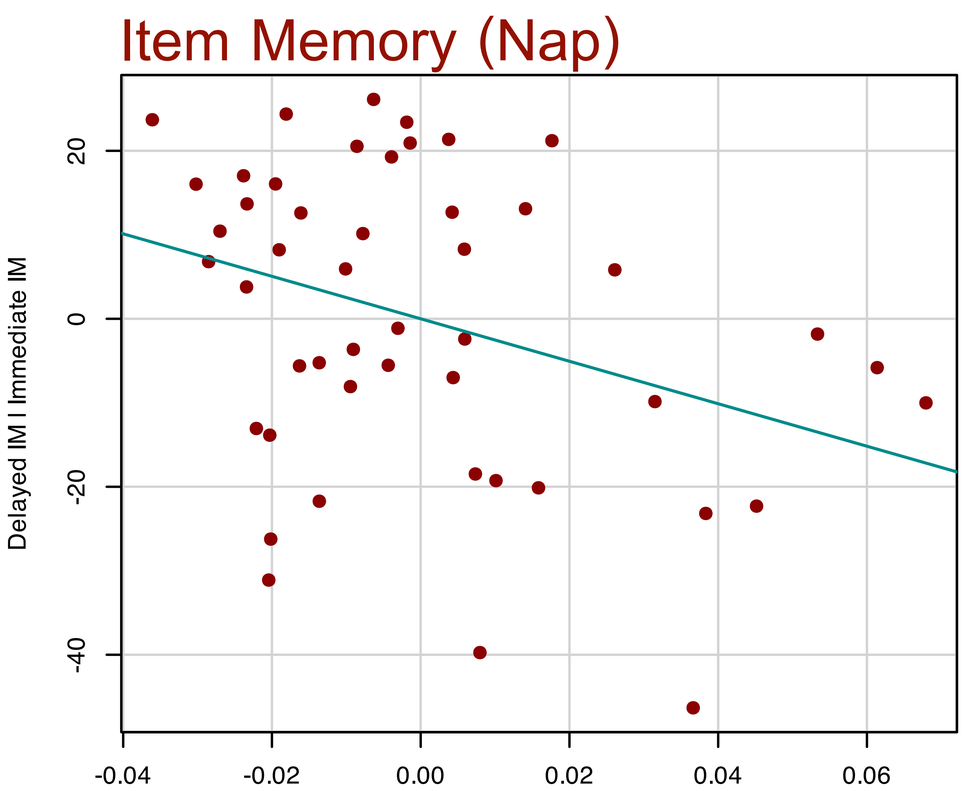
Results

- **LDI delayed retrieval following a nap** and **left hippocampal mean FA** were negatively related, $t(44) = -2.44$, $p = 0.019$, *uncorrected*, but this association did not survive Bonferroni correction.
- There was also a **negative** relation between **IM delayed retrieval following a nap** and **left hippocampal mean FA**, $t(45) = -2.49$, $p = 0.017$, *uncorrected*, but this association did not survive Bonferroni correction.
- No significant relations were found when the children were kept awake, with MD, or in the right hippocampus.









Conclusion

- Decreased left hippocampal mean fractional anisotropy was associated with better delayed memory recall after children napped, but not after they were kept awake.
- The differences in findings for the nap and awake conditions may indicate there are differences in the extent to which the hippocampus is involved in consolidation during periods of sleep compared to periods of wake in young children.
- Associations found only in the left hippocampus may indicate that different types of memory may recruit different hemispheres of the hippocampus; one study found that navigational memory in adults was associated with FA in the right hippocampus only[9].
- Decreased FA may be associated with better memory in the hippocampus due to the high density and low organization of the gray matter in the hippocampus, which may restrict diffusion along the tracts. Future studies should utilize more precise metrics, like NODDI, which account for the orientation, dispersion, and density of the neurons.

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