Relations between source memory performance and hippocampal subfield volume in early childhood

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Introduction

- Episodic memory shows significant improvement during early childhood (e.g., Hamond & Fivush, 1991; Peterson, Warren, & Short, 2011)
  - Specifically, children's ability to remember details of an event (such as who taught them a specific fact or where they learned it) shows rapid developmental change between 5-7 years (Riggins, 2014).
- The hippocampus is thought to play a critical role in episodic memory, specifically the ability to recall event details (Scoville &Milner, 1957), even in children as young at 7 years of age (Ghetti & Bunge, 2012).
- The hippocampus is an anatomically and functionally heterogeneous structure made up of subfields (CA1-4, dentate gyrus, and subiculum).
  - Subfields are thought to follow different developmental trajectories during childhood. The dentate gyrus, has been argued to have the most post protracted developmental course, with maturity emerging between 5- 7 years (Lavenex & Lavenex, 2013; Serres, 2001).
  - Hippocampal subfields also show relations with memory performance that vary as a function of age.
    - For example, a recent study showed that CA1 volume is negatively correlated with memory in young children but positively correlated with memory in adults (Schlichting et al., 2017).

Methods

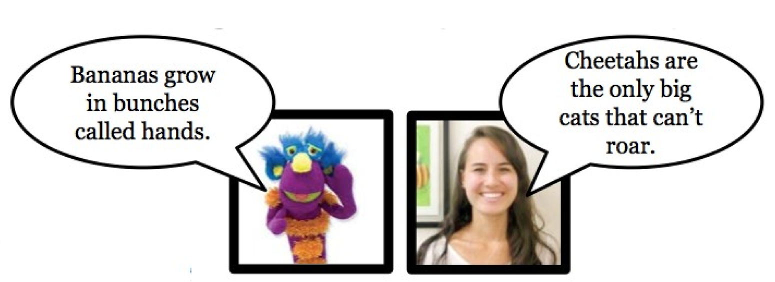
Participants

- The present study included data from 148 4- to 8-year-old children (75 males, 73 females).
- Given previous literature suggesting differential relations between subfield volumes and age (Schlichting et al., 2017), a median split was used to create 2 groups.
  - Younger Children: 4.0-6.15 years (mean = 4.91, SD = .69), n = 75
  - Older Children: 6.15-8.92 years (mean = 7.35, SD = .85), n=73
- Children participated in two different sessions spaced 1 week apart
  - Visit 1: Source Memory - Encoding
  - Visit 2: Source Memory - Retrieval and structural MRI

Behavioral Task

- Source Memory Paradigm:

(adapted from Drummey & Newcombe, 2002; Riggins, 2014)



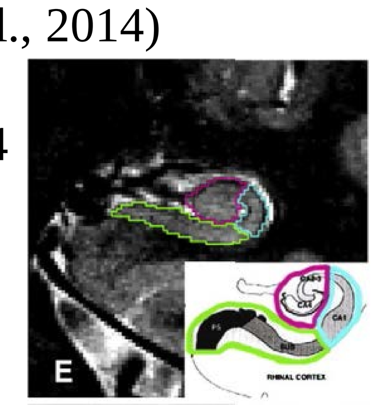
- Each child was presented with 12 novel facts.
- Half from an adult, and half from a puppet.
- One week later, children were asked to recall the fact and and the source of the fact, if not prompts were given and recognition was assessed.
- Memory performance was indexed by the proportion of questions for which the participant was able to remember the fact (fact recall or fact recognition) and both the fact and the source of the fact (source memory) correctly.

MRI Data Collection

- An ultra-high resolution (.4mm x .4mm x 2 mm) T2-weighted structural MRI scan was acquired using a 32-channel coil on a Siemens 3T Trio scanner.

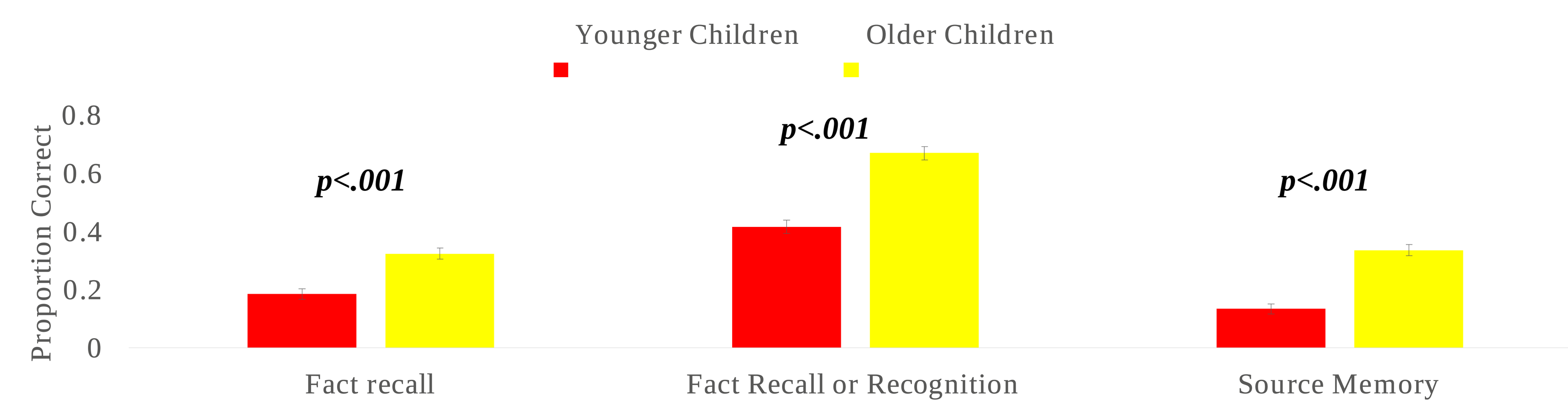
MRI Data Processing and Analysis

- Volumes for the following hippocampal subfields were extracted using a protocol adapted from Joie et al., 2010 and the Automatic Segmentation of Hippocampal Subfields software (ASHS, Yushkevich et al., 2014)
  - "Early developing": CA1
  - "Late developing": dentate gyrus, CA2, CA3 and CA4
    - These volumes were combined together for the present study, and will be referred to as DGCA234
- FSL was used to compute intracranial volume (ICV), which was used to control for differences in head size between participants.



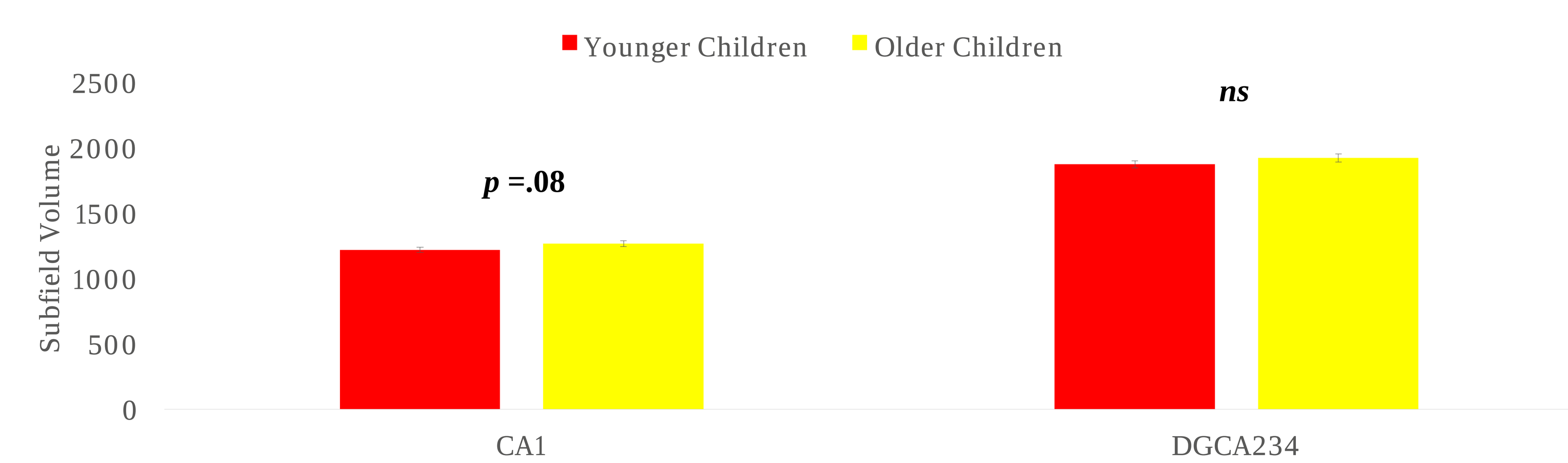
Results: Source Memory

Memory for the facts and the source from whom the facts were learned was better in older compared to younger children, *ps* <.001

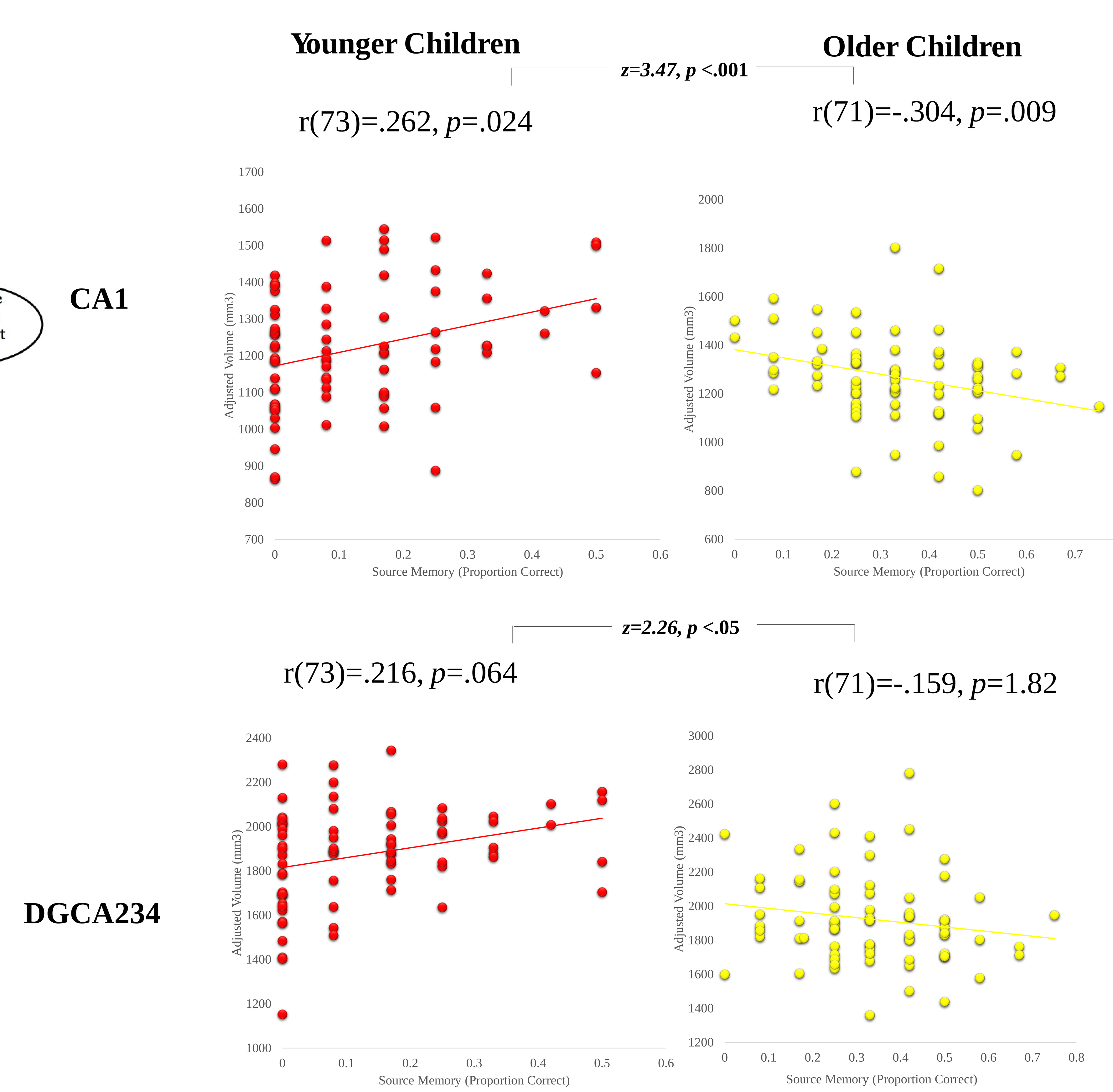


Results: Hippocampal Subfields

Adjusted volume of CA1 was marginally larger in older children, *p* =.08. DGCA234 did not differ between groups.



Results: Brain-Behavior Relations



Discussion

- Results revealed that:
  - Memory for facts and the source from whom the facts were learned was better in older compared to younger children.
    - This is consistent with previous research (e.g., Riggins, 2014).
  - CA1 was significantly positively correlated with source memory in younger children but significantly negatively correlated with source memory in older children.
    - This shift is similar to previous findings regarding relations between memory and CA1 volume in the hippocampal head in individuals aged 6-30 years. Specifically, in this study younger children showed a negative relation between memory and CA1 volume whereas adults showed a positive correlation (Schlicting et al., 2017).
  - DGCA234 was marginally positively correlated with source memory in younger children but was not related with source memory in older children.
    - However, the two correlation coefficients were significantly different from each other, suggesting differential relations between groups.
- Based on previous research suggesting similar periods of developmental change, we expected the dentate gyrus would relate to source memory. However, this relation was only observed in younger children. In contrast CA1, showed a significant relation with source memory performance in both younger and older children.
- Future research will investigate these brain-behavior relations further by examining how they differ along the longitudinal axis of the hippocampus and in the left versus right hemispheres.

References

- Drummey, A. B., & Newcombe, N. S. (2002). Developmental changes in source memory. *Developmental Science*, 5(4), 502–513. doi:10.1111/1467-7687.00243
- Ghetti, S., & Bunge, S. A. (2012). Neural changes underlying the development of episodic memory during middle childhood. *Developmental Cognitive Neuroscience*, 2, 381–395. doi:10.1016/j.dcn.2012.05.002
- Hamond, N. R., & Fivush, R. (1991). Memories of Mickey Mouse: Young children recount their trip to Disney World. *Cognitive Development*, 6, 433–448. doi:10.1016/ 0885-2014(91)90048-I
- Joie R, Fouquet M, Mézenge F, Landeau B, Villain N, Mevel K, ... Chételat G. (2010). Differential effect of age on hippocampal subfields assessed using a new high-resolution 3T MR sequence. *NeuroImage*, 53(2), 506-14. doi:10.1016/j.neuroimage.2010.06.024
- Lavenex P., & Banta Lavenex P. (2013). Building hippocampal circuits to learn and remember:insights into the development of human memory. *Behavioural Brain Research*, 254, 8 21.doi:10.1016/j.bbr.2013.02.007
- Peterson, C., Warren, K. L. & Short, M. M. (2011). Infantile amnesia across the years: a 2-year follow-up of children's earliest memories. *Child Development*, 82(4), 1092-105.doi:10.1111/j.1467-8624.2011.01597.x
- Riggins, T. (2014). Longitudinal investigation of source memory reveals different developmental trajectories for item memory and binding. *Developmental Psychology*, 50(2), 449-59. doi:10.1037/a0033622
- Serres, L. (2001). Morphological changes of the human hippocampal formation from midgestation to early childhood. In C. A. Nelson & M. Luciana (Eds.), *The handbook of developmental cognitive neuroscience* (pp. 45– 58). Cambridge, MA: MIT Press
- Schlichting, M. L., Guarino, K. F., Schapiro, A. C., Turk-Browne, N. B., & Preston, A. R. (2017). Hippocampal Structure Predicts Statistical Learning and Associative Inference Abilities during Development. *Journal Of Cognitive Neuroscience*, 29(1), 37-51. doi:10.1162/jocn_a_01028
- Yushkevich, P. A., Pluta, J., Wang, H., Ding, S.L., Xie, L., Gertje, E., Mancuso, L., Kliot, D., Das, S. R. &Wolk, D.A. (2014). Automated Volumetry and Regional Thickness Analysis of Hippocampal Subfields and Medial Temporal Cortical Structures in Mild Cognitive Impairment, *Human Brain Mapping*, 36(1), 258-287. doi:10.1002/hbm.22627

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