Relations Between Autobiographical Memory and Hippocampal Subregion Volume in Early Childhood

Lisa Cox, Oyindamola Adedipe, & Tracy Riggins
University of Maryland, College Park

Neurocognitive Development Lab

Introduction

- Autobiographical memory is the ability to remember personally significant past events. It is closely related to, but distinct from, episodic memory and autonoetic consciousness, which is often described as 'mental time-travel' or the ability to re-experience an event through memory.
- The ability to form and retain autobiographical memories improves throughout childhood (e.g., Bauer & Larkina, 2016).
  - Research has identified ~8 years of age as a point in which recall of early memories becomes more reliable and consistent (e.g., Peterson et al. 2011).
- fMRI research suggests that the hippocampus is involved in autobiographical memory retrieval in both 8- to 11-year-old children and adults (Bauer et al., 2016).
- However, fMRI studies are challenging to conduct with children younger than 8 years. Another way to examine relations between autobiographical memory and the hippocampus is through structural imaging.
- In young children and adults, *episodic* memory has been linked to the volume of the hippocampus, which differs along the longitudinal axis (e.g., Riggins et al., 2016; DeMaster et al., 2013).
- The goal of this study was to examine the relation between hippocampal volume and autobiographical memory in early childhood, and to investigate whether hippocampal subregions are differentially related to autobiographical memory.

Methods

Participants

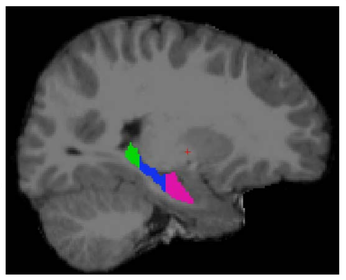
- 46 participants (21 male) between the ages of 4-8 years are included.
- Participants underwent an autobiographical memory interview (AMI) as well as a magnetic resonance imaging (MRI) scan.

Materials

- Audio recordings of the AMI were transcribed using the Child Language Analysis (CLAN) program and transcription guidelines (MacWhinney, 2000). Mean Length of Utterance (MLU), a measure of linguistic productivity, was calculated using CLAN.
- Transcriptions were segmented and tagged manually using the General Architecture for Text Engineering (GATE) (Cunningham, Maynard & Bontcheva, 2011).

MRI Data Collection and Processing

- A T1-weighted structural MRI scan (.9 mm^3) was obtained using a 32-channel coil on a Siemens 3T Trio scanner while participants watched a movie.
- T1 images were reconstructed and segmented using Freesurfer v5.1 (surfer.nmr.mgh.harvard.edu; Fischl, 2012) and Automatic Segmentation Adapter Tool (ASAT, nitrc.org/projects/segadapter; Wang et al., 2011).
- The hippocampus was divided into head, body, and tail subregions using standard anatomical landmarks (Weiss et al., 2005; Riggins et al., 2015) and adjusted for Intracranial Volume (ICV) (Raz et al., 2005) derived from FSL.



Autobiographical Memory Interview (AMI)

Event Selection

The AMI was adapted from Bauer & Larkina, 2016. Participants' parents were asked to provide two recent events in the child's life. They were told to choose events that were specific, unique, and less than a day long.

Administering the Interview

The interview had three phases:

- Free recall:

  What do you remember about going to the beach?

  I played in the waves with my brother.

  That's interesting… what else do you remember?

- Prompted recall:

  Your parent said you built sandcastles at the beach. Tell me what you remember about that.

- Specific prompts

  Who else was at the beach? Where was the beach?

This procedure was repeated for the second event.

Scoring the Autobiographical Memory Interview

Scoring Procedure

- Transcribed interviews were scored using a modified version of the Autobiographical Interview Scoring Manual (Levine et al., 2002).
- This method distinguishes between episodic and non-episodic memory, and has previously been shown to be sensitive to age-related changes (Willoughby et al. 2012).
- In addition to the quantitative scores provided by summing event details, scorers provided an episodic richness rating,(0-6 scale), again according to Levine et al. (2002) guidelines.

Text Segmentation and Tagging

- Text was segmented into information-bearing details, which were generally full clauses.
- Each segment was classified as either an event-internal detail or an event-external detail according the Levine et al. (2002) system.
- For our variable of interest, we summed all event-internal details over all three phases of the interview (free recall, prompted recall, and specific prompts) for both events to obtain a measure of *total episodic recall* for these autobiographical events.

Event-Internal	Examples	Event-External	Examples
Event	"I kicked the ball"	Semantic	"She is older than me"
Perceptual	"The hat was blue"	Semantic Time*	"It was Halloween"
Emotional/Thought	"I was excited"	Date*	"It was August fifth"
Coarse-grained Location*	"We were at a park"	Semantic Location*	"Disneyland is in Florida"
Fine-grained Location*	"I sat next to her"	Repetition	"It was fun… I had fun."
Coarse-grained Time*	"It was a few months ago"	Other	"Are we done yet?"
Fine-grained Time*	"First I played, then I slept"	*Changed from Levine et al. (2002)	

*RSR: What can you tell me about your first rock concert? .
*CHI: I saw Heart .
*CHI: It was at Wolftrap .
*CHI: Really &-um really far away .
*CHI: But it was fun .
*CHI: A lot of fun .

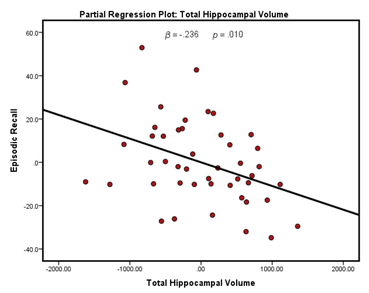
Free Recall Start
Event
Coarse-grained Location
Emotion
Repetition

Behavioral Results

- Episodic memory recall correlated with age, $r(44) = .462$, $p = .001$.
- Episodic memory recall also correlated with mean length of utterance (MLU), even after controlling for age, $r(43) = .729$, $p<.001$.
- Children produced more episodic details than semantic details, $t(45) = -7.352$, $p<.001$.

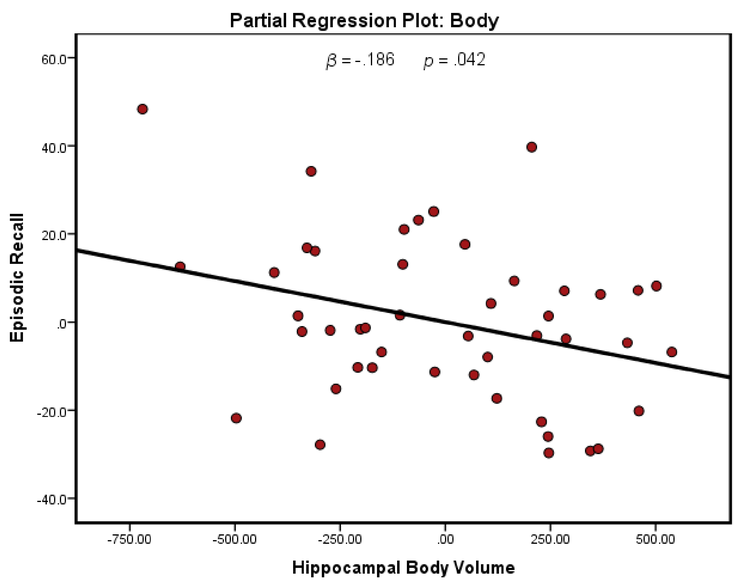
Total Hippocampal Volume Results

- After controlling for age, gender, and MLU, lower total ICV-adjusted hippocampal volume predicted better episodic memory recall, $R^2 = .717$, $F(4,45) = 25.978$, $p < .001$.



Hippocampal Subregion Results

- A multiple linear regression including age, gender and MLU, as well as hippocampal head, body, and tail volumes showed smaller body volume predicted greater episodic recall scores ($R^2 = .732$, $F(6,39) = 17.769$, $p < .001$).
- Tail volume showed a similar, marginally significant trend ($p<.10$), whereas head volume showed no relation to episodic recall.



Discussion

Behavioral

- Autobiographical memory, as assessed by the number of episodic details, increased as a function of age.
- Given that our task was intended to prompt children to talk about episodic, autobiographical memories, we expected children to provide more episodic details than semantic information, which is consistent with our results.

Hippocampus

- We found that total hippocampal volume is related to autobiographical memory recall in children. Specifically, the greater the number of details recalled, the smaller the overall volume.
- Analyses of hippocampual subregions suggest this association is driven by the hippocampal body.
- Previous research has shown that in both adults and children, the longitudinal axis of the hippocampus is differentially related to episodic memory. This study builds on that finding by suggesting that this is true not just for episodic memory as measured in the laboratory, but for episodic details from significant life events.
- Our results support the pattern observed with episodic memory in both adults and children where 'bigger' does not always mean 'better' (De Master et al., 2013). Smaller hippocampal volume overall and hippocampal body volume in particular led to better performance on autobiographical memory recall.

Future Directions

- Preliminary analyses also indicated that there may be sex differences, but the sample size was too small to fully address these differences. We intend to investigate whether these differences exist with our full sample of nearly 200 children.
- The head and tail of the hippocampus are thought to be differentially related to coarse-grained and fine-grained detail in memory, especially with respect to location and time (Poppenk et al., 2013). Our modifications to the Levine et al. (2002) AMI coding system will be used to investigate whether this is true in young children.
- Many of the children in this sample are part of a longitudinal cohort. We will investigate whether there are changes in the relations between hippocampal volume and autobiographical memory in the same children over time.

References

- Bauer, P. J., & Larkina, M. (2016). Predicting remembering and forgetting of autobiographical memories in children and adults: A 4-year prospective study. Memory, 24(10), 1345-1368.
- Bauer, P. J., Pathman, T., Inman, C., Campanella, C., & Hamann, S. (2017). Neural correlates of autobiographical memory retrieval in children and adults. *Memory*, *25*(4), 450-466.
- Cunningham, H., Maynard, D., & Bontcheva, K. (2011). *Text processing with gate*. Gateway Press CA.
- Cunningham, H., Maynard, D., Bontcheva, K., Tablan, V., Aswani, N., Roberts, I., ... & Heitz, T. (2011). Developing language processing components with gate version 6 (a user guide). *University of Sheffield, Department of Computer Science*.
- DeMaster, D., Pathman, T., Lee, J. K., & Ghetti, S. (2013). Structural development of the hippocampus and episodic memory: developmental differences along the anterior/posterior axis. *Cerebral cortex*, *24*(11), 3036-3045.
- Levine, B., Svoboda, E., Hay, J., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: dissociating episodic from semantic retrieval. *Psychology and Aging*, *17*, 677-689.
- Fischl, B. (2012). FreeSurfer. *NeuroImage*, *62*(2) 774–781. doi:10.1016/j.neuroimage.2012.01.021
- MacWhinney, B. (2000). The CHILDES Project: Tools for Analyzing Talk. 3rd Edition. Mahwah, NJ: Lawrence Erlbaum Associates.
- 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), 1092-1105.
- Poppenk, J., Evensmoen, H. R., Moscovitch, M., & Nadel, L. (2013). Long-axis specialization of the human hippocampus. *Trends in cognitive sciences*, *17*(5), 230-240.
- Raz, N., Lindenberger, U., Rodrigue, K. M., Kennedy, K. M., Head, D., Williamson, A., . . . Acker, J. D. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex*, *15*, 1676–1689. doi:10.1093/cercor/bhi044
- Riggins, T., Blankenship, S. L., Mulligan, E., Rice, K., & Redcay, E. (2015). Developmental differences in relations between episodic memory and hippocampal subregion volume during early childhood. *Child Development*, 86(6), 1710-1718.
- Riggins, T., Geng, F., Blankenship, S. L., & Redcay, E. (2016). Hippocampal functional connectivity and episodic memory in early childhood. *Developmental Cognitive Neuroscience*, 19, 58-69.
- Wang H, Das SR, Suh JW, Altinay M, Pluta J, Craige C, Yushkevich PA (2011): A learning-based wrapper method to correct systematic errors in automatic image segmentation: Consistently improved performance in hippocampus, cortex and brain segmentation. *NeuroImage*, *55*, 968–985.
- Weiss, A. P., Dewitt, I., Goff, D., Ditman, T., & Heckers, S. (2005). Anterior and posterior hippocampal volumes in schizophrenia. *Schizophrenia Research*, *73*, 103–112. doi:10.1016/j.schres.2004.05.018
- Willoughby, K. A., Desrocher, M., Levine, B., & Rovet, J. F. (2012). Episodic and semantic autobiographical memory and everyday memory during late childhood and early adolescence. *Frontiers in psychology*, *3*.

Acknowledgements

We would like to thank the families for participating in this study and members of the Neurocognitive Development Lab for assistance with this project, particularly Jacob Hansen, Shane Wise, Kelsey Canada, and Morgan Botdorf.

This research was supported by the National Institutes of Health HD07951.