Relations between working memory and cortical thickness in frontal and parietal regions in early childhood

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Introduction

- Working memory (WM) changes rapidly in early childhood, but it remains unclear how cortical regions that support these abilities in adults relate to WM changes in children.
- Cortical thickness may be a useful measure in investigating this association, as age-related changes in cortical thickness may support improvements in cognitive abilities as a result of synaptic pruning and increased myelination (Sowell et al., 2004).
- However, only limited research has investigated how cortical thickness relates to WM abilities in childhood. For example, Kharitonova and colleagues (2013) found that thickness in superior parietal cortex (SPC), but not anterior cingulate cortex (ACC), related to WM. However, SPC did not mediate the relation between age and WM.
- **The present study extends this research by investigating the relation between performance on a digit span task and cortical thickness of specific areas related to WM: ACC, SPC, superior frontal cortex (SFC), and middle frontal cortex (MFC).**

Methods

Participants

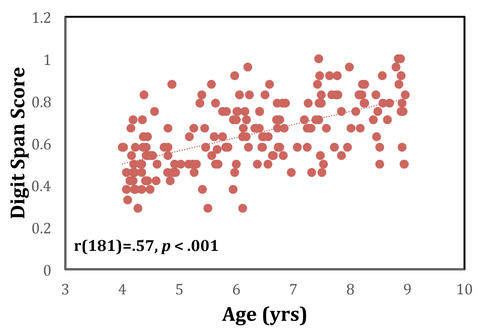
- 181 children aged 4-8 years (*M*= 6.27, *SD* = 1.49 years, 92 females) completed the study.
- Participants were part of a larger study examining the development of episodic memory in early childhood.

MRI Data

- T1-weighted high resolution (1mm^3) anatomical images were acquired from a Siemens 3T scanner with a 32-channel coil at the Maryland Neuroimaging Center using a standard structural MRI scan sequence.
- Freesurfer v5.1 (Fischl, 2012) was used to calculate cortical thickness volumes and total gray matter volume. The Desikan-Killiany atlas was used for cortical parcellation (Desikan et al., 2006).
- Boundary lines between CSF, gray matter, and white matter were visually inspected to ensure accuracy. Manual edits were made when necessary.

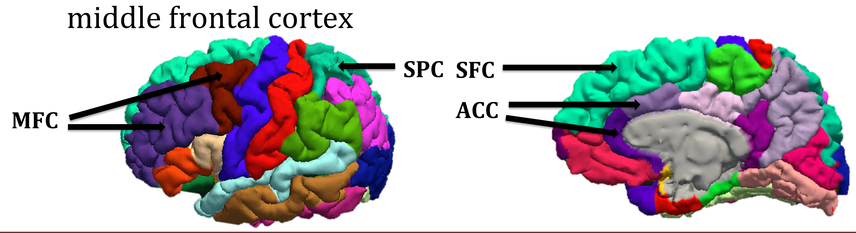
Results: Age-Digit Span Associations

- Participants completed a forward digit span task (Gathercole & Adams, 1993).
- Participant's Digit Span Score was measured as the proportion of sequences correctly recalled.
- A bivariate correlation showed that Digit Span Score was significantly and positively correlated with age.



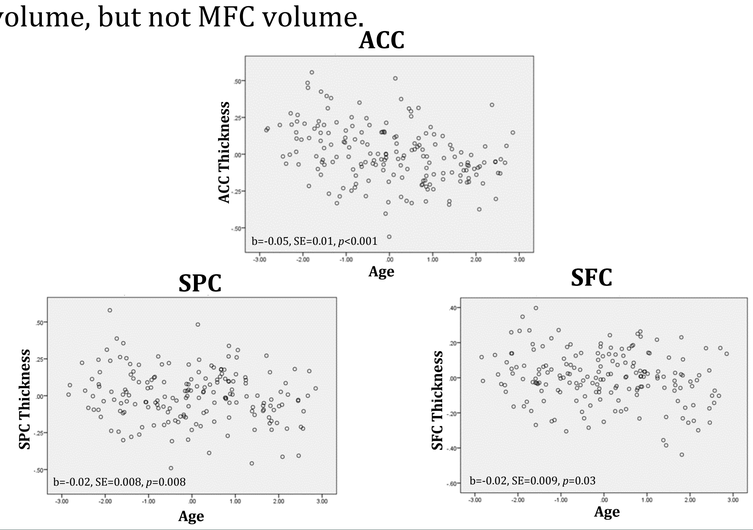
Methods: MRI Data

- The following ROIs were created by averaging cortical thickness values for areas of interest:
  - **ACC**: left/right rostral anterior cingulate cortex and caudal anterior cingulate cortex
  - **SPC**: left/right superior parietal cortex
  - **SFC**: left/right superior frontal cortex
  - **MFC**: left/right rostral middle frontal cortex and caudal middle frontal cortex



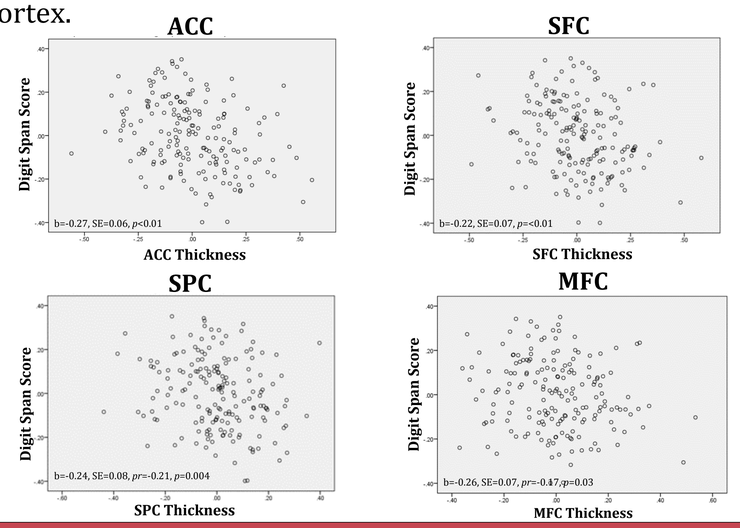
Results: Age-Cortical Thickness Associations

- Associations between age and cortical thickness were explored.
  - Separate linear regressions were run entering age as the predictor and each ROI as the dependent variable.
  - Covariates: Total gray matter volume and gender.
  - Age was a significant predictor of ACC volume, SPC volume, SFC volume, but not MFC volume.



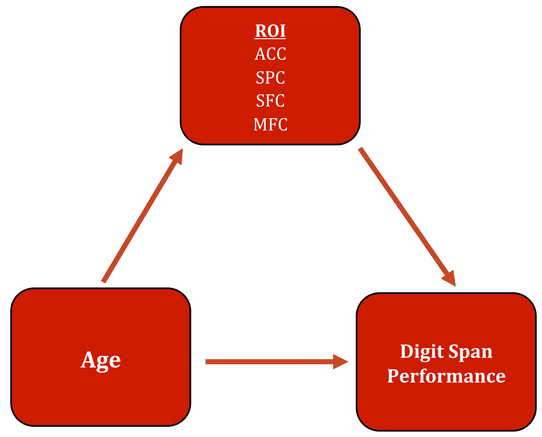
Results: Cortical Thickness-WM Associations

- Associations between cortical thickness and digit span performance were examined next.
  - Separate linear regressions were run entering each ROI as the predictor and Digit Span Score as the dependent variable.
  - Covariates: Total gray matter volume and gender.
  - Cortical thickness in each ROI was a significant predictor of Digit Span Score, such that those with a thinner cortex in the specified areas performed better than those with a thicker cortex.



Results: Mediation Analysis

- A mediation model was tested using Hayes' SPSS Process macro (Hayes, 2013). Separate models were run with age as the predictor, each ROI as the mediator, and Digit Span Score as the dependent variable. Significant mediation was observed for the model with ACC as the mediator. Specifically, there was a significant indirect effect of age on Digit Span Score through ACC thickness, b = 0.008, SE=0.01, CI [0.0019, 0.0191].



Discussion

- These results suggest that even in early childhood, there are associations between WM abilities and thickness in cortical areas known to support WM in adults.
  - Age was negatively associated with the thickness of ACC, SPC, SFC, but not MFC.
  - Thickness in each ROI was negatively associated with WM as measured by Digit Span.
- Consistent with Kharitonova's findings (2013), our results support a relation between SPC and WM, but did not support a mediation. However, our results did suggest that ACC is not only associated with WM, but mediates the relation between age and WM.
- Future research should focus on investigating longitudinal changes in these cortical areas as they relate to WM to increase the present understanding of the relation between cortical thickness and improvements in WM during childhood.

Acknowledgements

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References

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