Decreased Cortical Thickness is Associated With Higher Executive Functioning in Children as Seen Through Longitudinal Development

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INTRODUCTION

- Working memory is a type of executive function or goal-directed behavior that requires encoding, maintenance and updating of information in mind.
- Developmentally, working memory has protracted maturation over infancy and childhood.
- Working memory has been linked to structural brain measures like cortical thickness distributed across the frontal, parietal, and temporal lobes.
- Developmentally, cortical thickness across lobes rapidly increases and then stabilizes or decreases in later childhood.
- Previous studies have linked cortical thickness with working memory ability but did not consider the contributions of longitudinal brain development over infancy and childhood to later working memory ability.
- The frontal lobe is strongly associated with higher order thinking; however, the parietal lobe is also the dorsal pathway of information which important for spatial processing. Similarly, the temporal lobe carries information through the ventral pathway such as object recognition.

OBJECTIVE

To determine if early developments in cortical thickness is relevant for predicting executive function through a working memory task (n-back task).

RESULTS

Figure 1. Cortical Thickness Correlated with N-back D-prime Performance

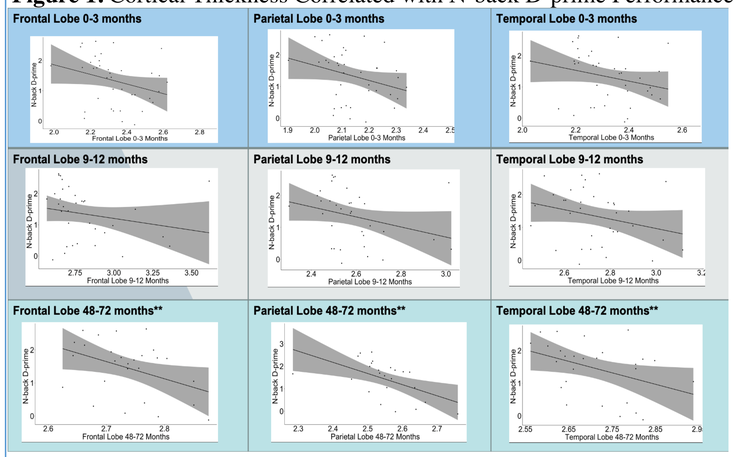
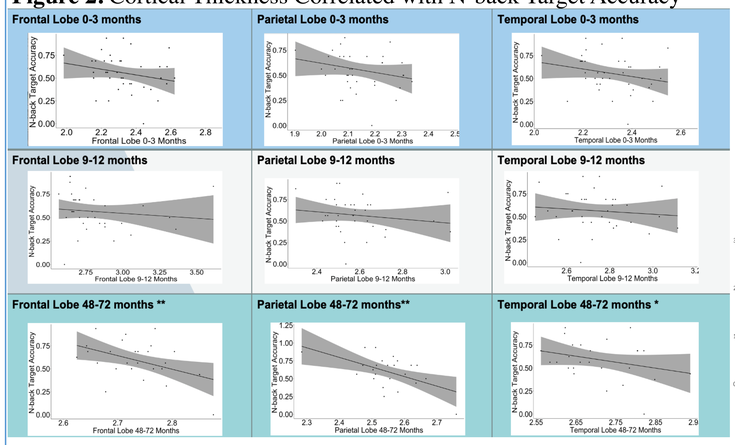
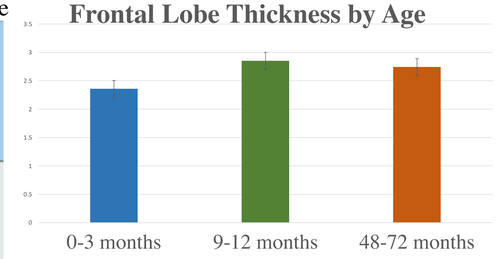
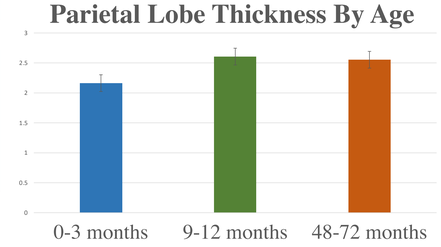


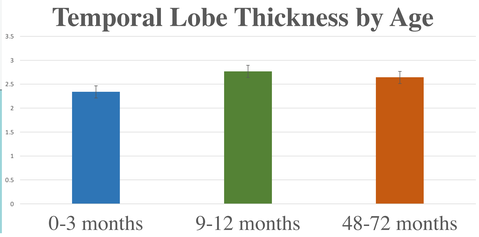
Figure 2. Cortical Thickness Correlated with N-back Target Accuracy





Strongest correlation at last time periods for all three lobes when cortical thickness is compared with n-back D-prime analysis (Figure 1). The Frontal and Parietal lobes were significant for n-back Target Accuracy correlations (Figure 2).





MATERIALS AND METHODS

MRI and Data Collection:

MRI scans collected at 11 possible time periods, using Infant-specific processing pipeline (iBEAT)

Then separated into three main time periods: Age 0-3 months, Age 9-12 months , Age 48-72 months

Participants: 46 at first time periods (0-3 months), 43 at second time point (9-12 months), 28 at last time point (48-72 months)

N-back Task:

Participants must recognize one specific stimulus (a letter, number, or symbol) in a sequence and then recall the same number later depending on what "n" is

2-back Data Collection:

Working memory data taken through the n-back task at pre-adolescence (8-10 years)

-Target Accuracy: Considers overall accuracy during the fMRI task not accounting for false-alarms

-D-prime: Is calculated by taking the difference of the z-transformed hit rate (correct matches) from the z-transformed false-alarm rate (incorrect non-matches) (Woodburn et al., 2017)

Statistical Analysis: Correlation plots with Cortical Thickness measurements and n-back test and linear regressions controlling for age and sex

CONCLUSIONS

Decreased Cortical Thickness for all three lobes at the last time point was correlated to working memory at pre-adolescent measures (n-back D-prime only)

-Significant for frontal and parietal lobes (at last time period), but trending for the temporal lobe (Figure 2)

-Strong Negative Correlation

Likely cause: Synaptic Pruning

Initial burst of synaptic connectivity affecting gray matter measurements, followed by a steep decrease, indicating pruning of synapses and related gray matter, accompanied by greater myelination of existing connections (Sakai, 2020)

Limitations and Future Directions

Participants in fMRI machine during n-back task instead of at computer

Age range of participants (larger compared to previous timepoints)

Dropped participants throughout the longitudinal study for various reasons

ACKNOWLEDGEMENTS

CIRCLE Lab:

- Dr. Margaret Sheridan, PhD
- Dr. Adam Bryant Miller, PhD
- Mac Woodburn, MS
- Lucy Laurie

Thesis Advisor:

- Dr. Margaret Sheridan

Funded by NIH R21HD096232 & NCTRACS - 27101 14101 429801

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