Cortical Thickness in the Cognitive Control Network, Task Switching, and Bilingualism

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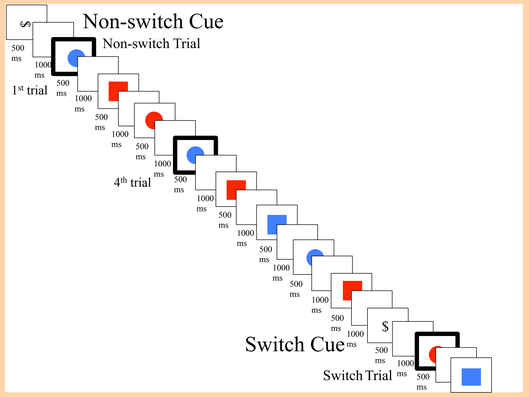
Introduction

- Cortical thickness in certain regions of the brain seems to be related to cognitive control abilities
  - Anterior cingulate cortex (ACC)
  - Inferior parietal lobule (IPL)
  - Inferior frontal gyrus (IFG)
  - Dorsolateral prefrontal cortex (DLPFC)
- This has been found in various populations including ADHD children, aging and memory-impaired adults, and typically-developing, monolingual children and adults [1,2,3,4,5]
- The cortical thickness and cognitive control relationship has not been examined in bilinguals, although bilinguals may have differences in both cognitive control [see 6] and grey matter density compared to monolinguals [7,8]

Methods

- Participants: Forty-five Spanish-English bilinguals
- Language background variables:
  - Age of English acquisition measured by a questionnaire. Range from 0-17 years (mean age=7.23 , SD=3.52)
  - English and Spanish proficiency measured by Woodcock Language Proficiency Battery-Revised sentence comprehension and vocabulary subtests (mean Spanish proficiency=77.02, SD=10.33; mean English proficiency=75.25, SD=6.97)
- Shape-color task:
  - Instructed to press the right or left key based on a sorting rule (color or shape) in response to red/blue circles/squares
  - After 8-19 trials, saw a nonverbal cue to switch (switch cue) or continue with the same rule (non-switch cue)
  - Completed 162 trials per run for 5 runs inside the MRI scanner (Functional scans not included in the analyses presented here)
- Two T1 MPRAGE anatomical scans were taken with a 0.48mm x 0.48mm x 1mm voxel size



Design of the shape-color task

Acknowledgments

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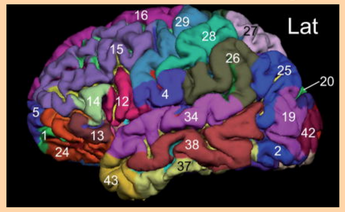
Analyses

- Dropped incorrect responses from reaction time (RT) analyses
- Dropped time out responses from accuracy analyses
- Four behavioral calculations
  - RT switch cost = First switch trial RT – First non-switch trial RT
  - Accuracy switch cost = First non-switch trial accuracy – First switch trial accuracy
  - RT cue cost = First trial RT – Fourth trial RT
  - Accuracy cue cost = Fourth trial accuracy – First trial accuracy
- Cortical thickness calculated by collaborators at the University of California, Riverside using surface-based morphometry through the FreeSurfer software
- Regression equations for thickness in each ROI predicting each behavioral calculation

Atlas used for regions of interest (ROIs)[9]



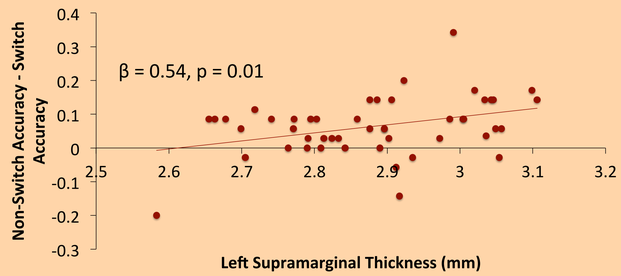
Descriptive Results

- One participant removed for low response rate (22.96% response rate)
- RT switch cost: mean = 33.71ms, SD = 44.38ms
  - Switch RT: mean = 671.70ms, SD =154.37ms
  - Non-Switch RT: mean = 638.00ms, SD =134.25ms
- RT cue cost: mean = 80.31ms, SD = 51.49ms
  - First Trial RT: mean = 654.90ms, SD =142.95ms
  - Fourth Trial RT: mean = 454.4ms, SD = 97.33ms
- Accuracy switch cost: mean = 6.38%, SD =8.66 %
  - Switch accuracy: mean = 80.68%, SD =11.96 %
  - Non-Switch accuracy: mean = 87.07%, SD =14.22 %
- Accuracy cue cost: mean = 2.59%, SD = 7.50%
  - First trial accuracy: mean = 83.88%, SD = 12.41%
  - Fourth accuracy: mean = 86.47%, SD = 10.00%

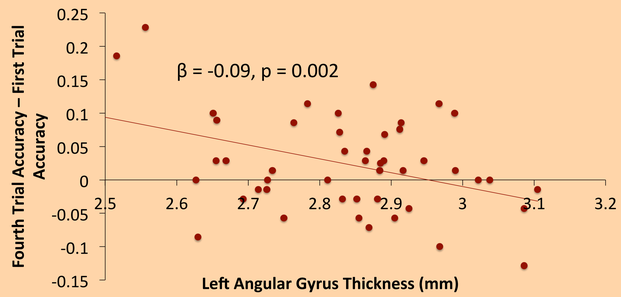
ROI	Mean	Standard Deviation
Left Dorsolateral Prefrontal Cortex Thickness	2.45	0.12
Right Dorsolateral Prefrontal Cortex Thickness	2.42	0.15
Left Anterior Cingulate Cortex Thickness	2.81	0.17
Right Anterior Cingulate Cortex Thickness	2.93	0.15
Left Opercular Gyrus Thickness (Part of the IFG)	2.96	0.15
Right Opercular Gyrus Thickness (Part of the IFG)	2.96	0.17
Left Triangular Gyrus Thickness (Part of the IFG)	2.96	0.16
Right Triangular Gyrus Thickness (Part of the IFG)	2.92	0.17
Left Supramarginal Gyrus Thickness (Part of the IPL)	2.88	0.13
Right Supramarginal Gyrus Thickness (Part of the IPL)	2.91	0.15
Left Angular Gyrus Thickness (Part of the IPL)	2.83	0.16
Right Angular Gyrus Thickness (Part of the IPL)	2.84	0.13

Regression Results

Accuracy Switch Cost and Left Supramarginal Thickness



Accuracy Cue Cost and Left Angular Gyrus Thickness



- No other significant or nearly significant regressions with cortical thickness and RT or accuracy costs

Conclusions

- Left IPL cortical thickness related to accuracy during the task
  - Left supramarginal cortical thickness predicts accuracy cue costs
  - Left angular cortical thickness predicts accuracy switch costs
  - Appears to be a dissociation between working memory and task switching that may have neural underpinnings
  - Left IPL has previously been associated with bilingualism[7,8]
  - Cortical thickness in this region could be a mechanism connecting language experience with cognitive control
- ACC, IFG, and DLPFC not significantly related to performance
  - Task differences: ACC correlations found in bilinguals performing flanker task [10]
  - Developmental difference: Frontal areas thin throughout the lifespan, but cognitive control abilities peak in young adulthood [11,12]
- Future research should examine the relationship between cortical thickness and cognitive control in both bilinguals and monolinguals

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