Studying gray and white matter changes in working memory networks due to repetitive head impact in children

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Introduction

- Should parents allow their children to play tackle football?
- Rapid brain development within the multiple demand (MD) network in late childhood (ages 8-12)[1]
  - MD network supports working memory (WM) and executive function (EF)
- Prior work shows long-term disturbances in EF in former tackle football players compared to non-contact athletes[2]
- Working memory deficits are some of the most common in pediatric TBI[3]
- **What happens with perturbations of gray/white matter in critical periods when children rapidly improve EF skills?**
- Tackle football starts at age 8, allowing opportunity to test causality of gray & white matter mechanisms of MD network

Research Questions

- **Does the MD network show blunted development due to football-related neurotrauma?**
- **Are these developmental differences reflected behaviorally?**

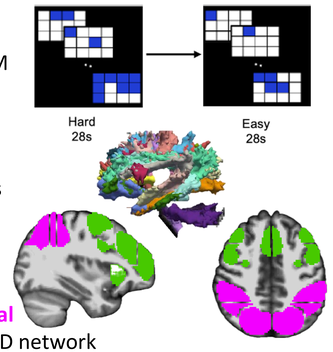
Methods

Participants:

N=25 (10 football players, 15 control), motion matched, age mean (sd) = 10.4 (1.3), min = 7.7, max = 12.2. Two timepoints (before & after initial football season)

MD fMRI task:

Task designed to measure WM skills and measure activation in the MD network[4]



- Two runs per timepoint

DTI: Maps white matter tracts

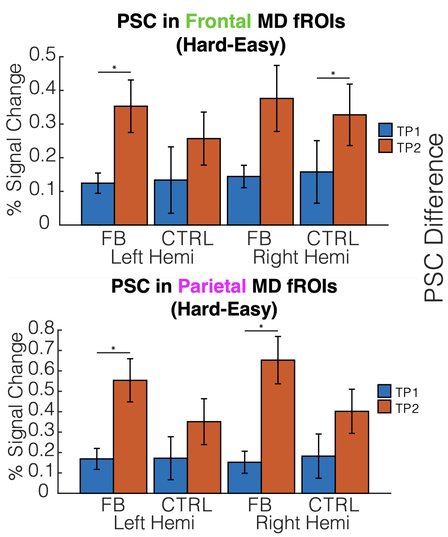
Processing:

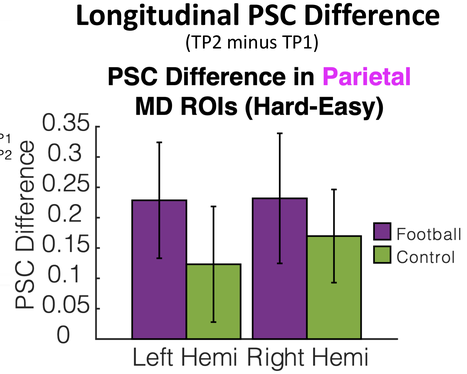
- TRACULA DTI processing[5]
  - Extracted FA measures
- Defined frontal and parietal subject-specific fROIs of MD network
- Calculated percent signal change (PSC) per MD task condition (Easy & Hard) within each fROI

Analysis:

- Surface group analysis measuring changes in sulcal depth
- TBSS analysis on DTI FA data[6]
- T-tests and ANOVAs on PSCs for MD fROIs
- T-tests and ANOVAs on MD task accuracy and reaction time

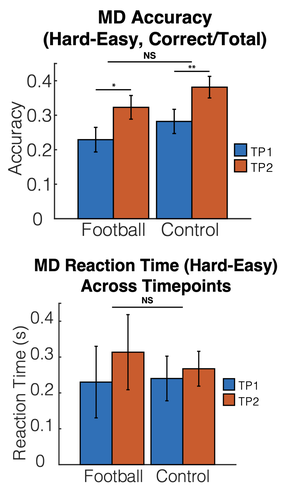
MD fROI Percent Signal Change Across Time





Football players show increased activation in **parietal** MD fROIs bilaterally. This longitudinal difference in activation is significant for football players but not for controls

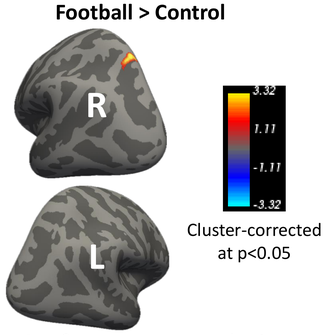
Longitudinal Task Accuracy and Reaction Time



Difference in longitudinal change in accuracy and reaction time is non-significant between groups

Gray Matter Changes within MD Network

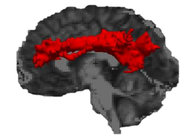
Football > Control



Cluster-corrected at p<0.05

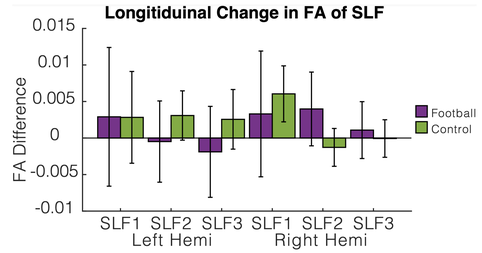
Surface group analysis indicates a cluster in left **SPS** where football players have a slightly deeper sulcus than controls after a season of tackle football

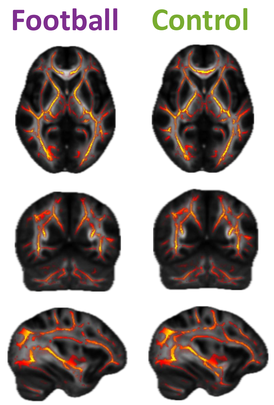
Superior Longitudinal Fasciculus Integrity Changes



Location of the SLF

p<0.1 cluster-corrected, TP2-TP1 control > football





Conclusions

- In contrast to controls, football players show increased activation in **frontal** and **parietal** MD fROIs after the initial season of tackle football, suggesting greater effort on the task, but do not show greater improvement in task performance than controls
- Whole-brain analysis shows greater sulcal depth longitudinally within the superior **parietal** sulcus in children who played football than in controls
- Both controls and football players showed increases in FA of the SLF over time with slightly less growth in football players

Future Directions

- Explore whether football players show continued gray and white matter differences at a third timepoint to see if differences prevail, and whether behavioral differences emerge in EF or working memory
- Head impact dose-response effects on gray & white matter, executive function, and working memory

References & Acknowledgements

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