Lack of Decoupling Between Default Mode and Working Memory Networks Associated with No Behavioral Differences in Retired Football Players

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Background

- Recent studies have examined the relationship between age of first exposure to football and cognitive function, and have found that earlier exposure to football is associated with poor cognitive[1] and neural health outcomes[2].
- Because of the observed white matter abnormalities in those who began playing football earlier, neural connectivity patterns could be disrupted resulting in less efficient connections between neural regions.
- Recent studies have shown that as cognitive load increases, task-relevant networks "decouple" from the default mode network[3].
- However, older adults are less able to decouple task-relevant and task-irrelevant (i.e., default mode) networks as task demands increase[4].
- The current study was designed to assess the effect of age of first exposure to football on metrics of network connectivity in a sample of retired athletes.
- **Hypothesis: Athletes who began playing football at an earlier age will show reduced ability to decouple task-relevant (working memory) and task-irrelevant (default mode) networks as working memory task demands increase, and this lack of decoupling will be associated with poorer behavioral performance.**

Methods

Participants
- Sixty-two former college football and professional National Football League players between age 52 and 65, who had received anywhere from 0-27 concussions in their careers, and played post-high school football for anywhere from 3-20 years
  - NFL and college players were matched on age, position played (i.e., offensive lineman, quarterback, wide receiver, etc.), and concussion history

Measures
- Age of First Exposure (AFE): Participant's reported age of onset of participation in football
- Connectivity network average strength: graph theory metric of functional connectivity measuring strength of all connections among all regions in the networks of interest, divided by number of ROIs in each network to correct for differences in network size
  - Working Memory Fronto-Parietal Network (11 ROIs)[5]
  - Default Mode Network (9 ROIs)[6]
  - Working Memory-Default Mode Connections

Procedure
- N-back task
  - 0, 1, and 2 back memory task
  - Block design
  - 6 blocks
  - Each block contained only 1 type of task (i.e., only 0-back), and there were 2 consecutive blocks per task type
 - Task order was randomized
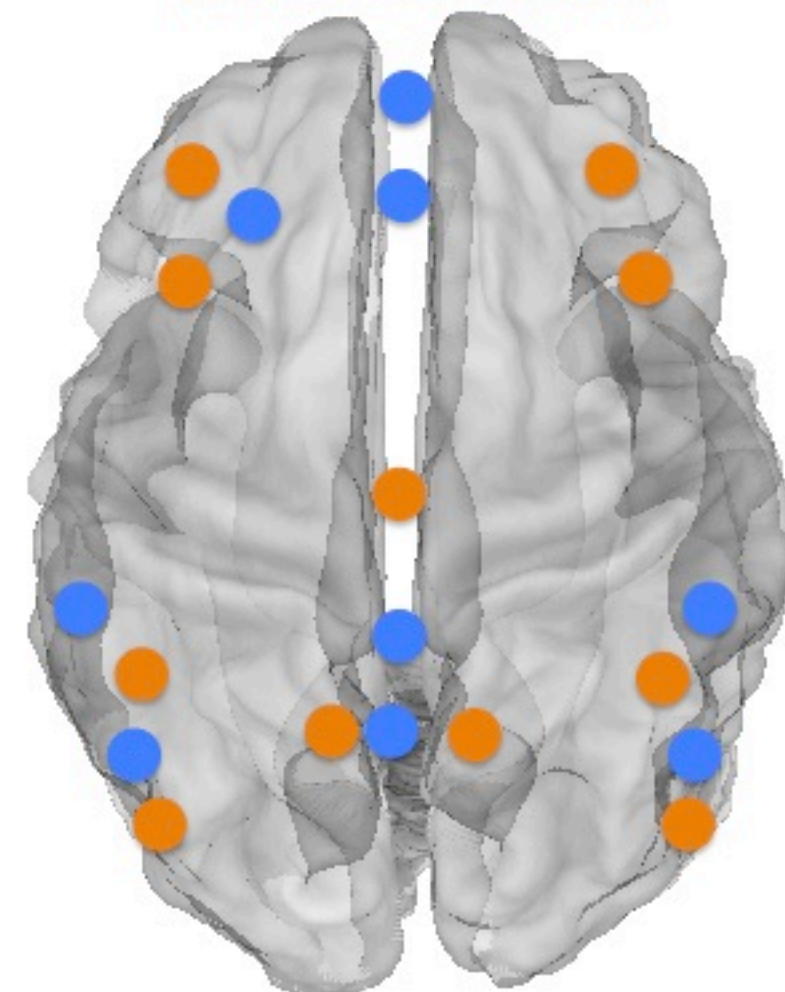
Results

Functional Connectivity Analysis
- Results from parametric analyses showed no relationship between task difficulty and connectivity within working memory or default mode networks, or the relationship between working memory and default mode networks
- Correlational analyses evaluating the relationship between task-relevant network connectivity and inter-network connectivity, however, revealed an unexpected positive relationship between working memory network connectivity, and connectivity between working memory and default mode networks (see top graph)
- Further, this relationship remained significant even after controlling for age of first exposure to football and age at time of visit

Behavioral Performance Analysis
- Analyses of behavioral data revealed no relationship between working memory performance and any metrics of network connectivity
- However there was a small negative correlation between age of first exposure to football and reaction time at each level of the task, suggesting that individuals who began playing football at a younger age showed slower reaction times at each level of the task (see bottom graph)
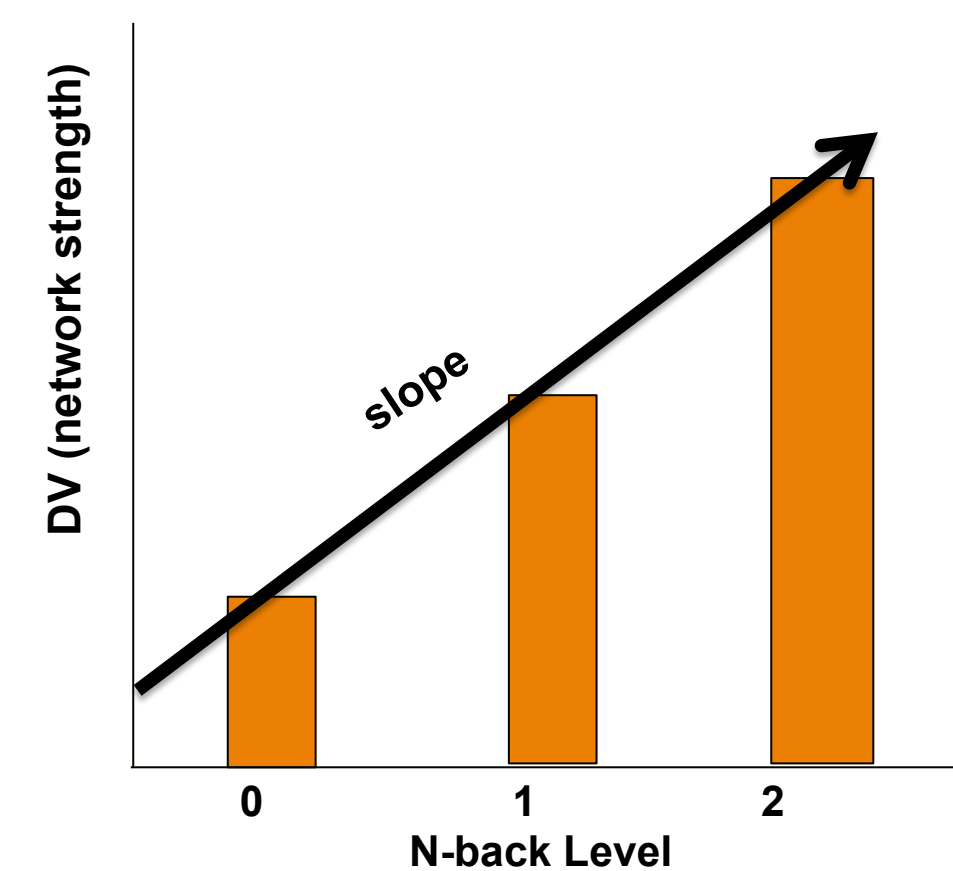

Coupling Between Working Memory and Default Mode Network ROIs

$R^2 = 0.73111$

Working Memory Network Slope / Between-Network Slope
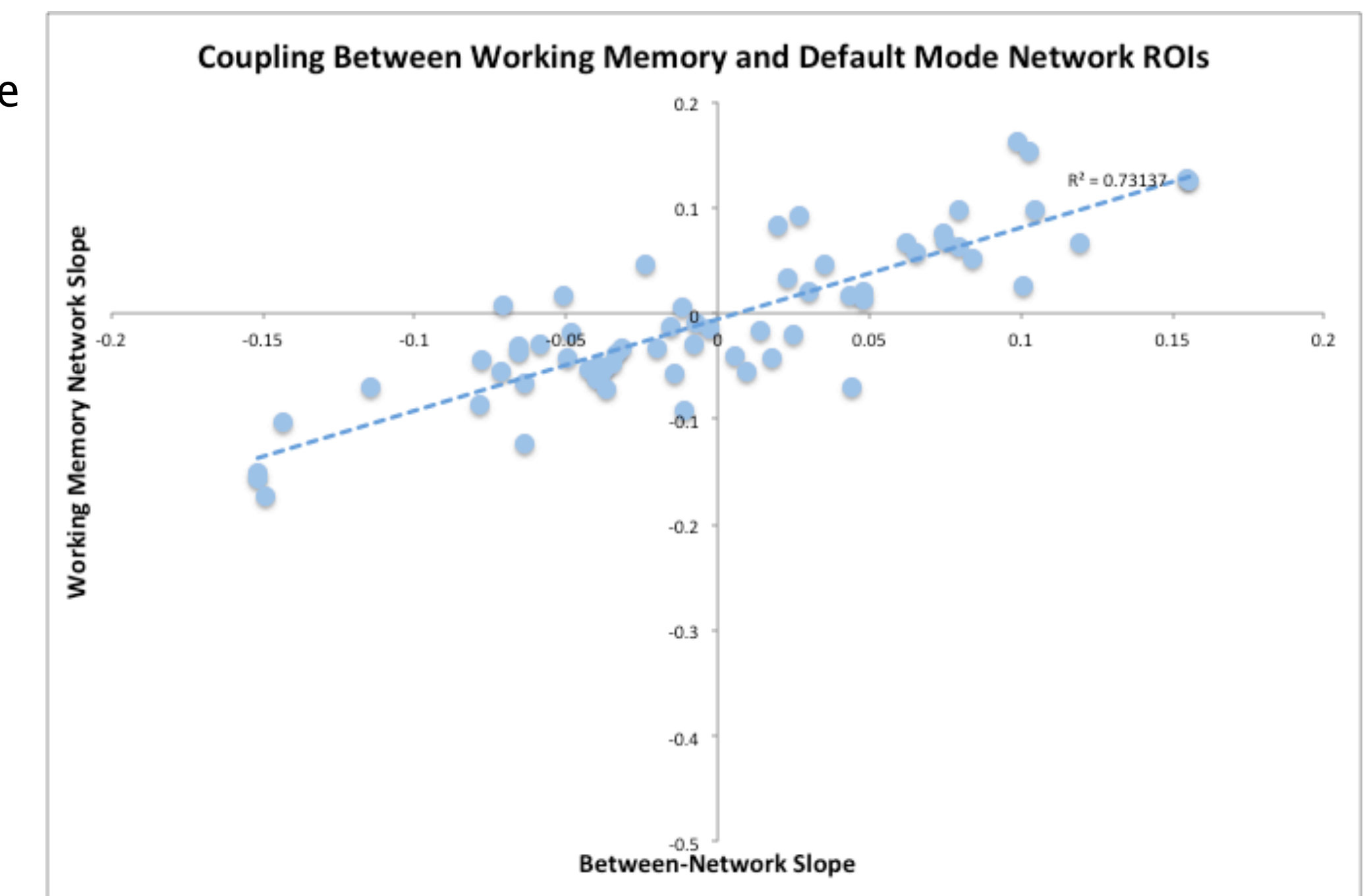
Fronto-Parietal Working Memory Network
(Dosenbach et al., 2007)

Default Mode Network
(Laird et al., 2009)

Parametric Analyses

DV (network strength)

slope

0   1   2
N-back Level

Discussion

- Results from analyses of functional connectivity revealed no evidence of decoupling between default mode and working memory networks as task difficulty increased, and no effect of age of first exposure to football on this relationship.
- Analyses of behavioral performance, however, revealed a negative relationship between age of first exposure and reaction times at each level of task difficulty.
- Behavioral results may reflect overall deficits in processing speed in those who began playing football at a younger age; individuals who may also be at risk for white matter abnormalities that could underlie such deficits.[2]

Age of First Exposure Negatively Correlated with Reaction Time

Reaction Time / Age of First Exposure to Football

0back_RT, 1back_RT, 2back_RT, Linear (0back_RT), Linear (1back_RT), Linear (2back_RT)
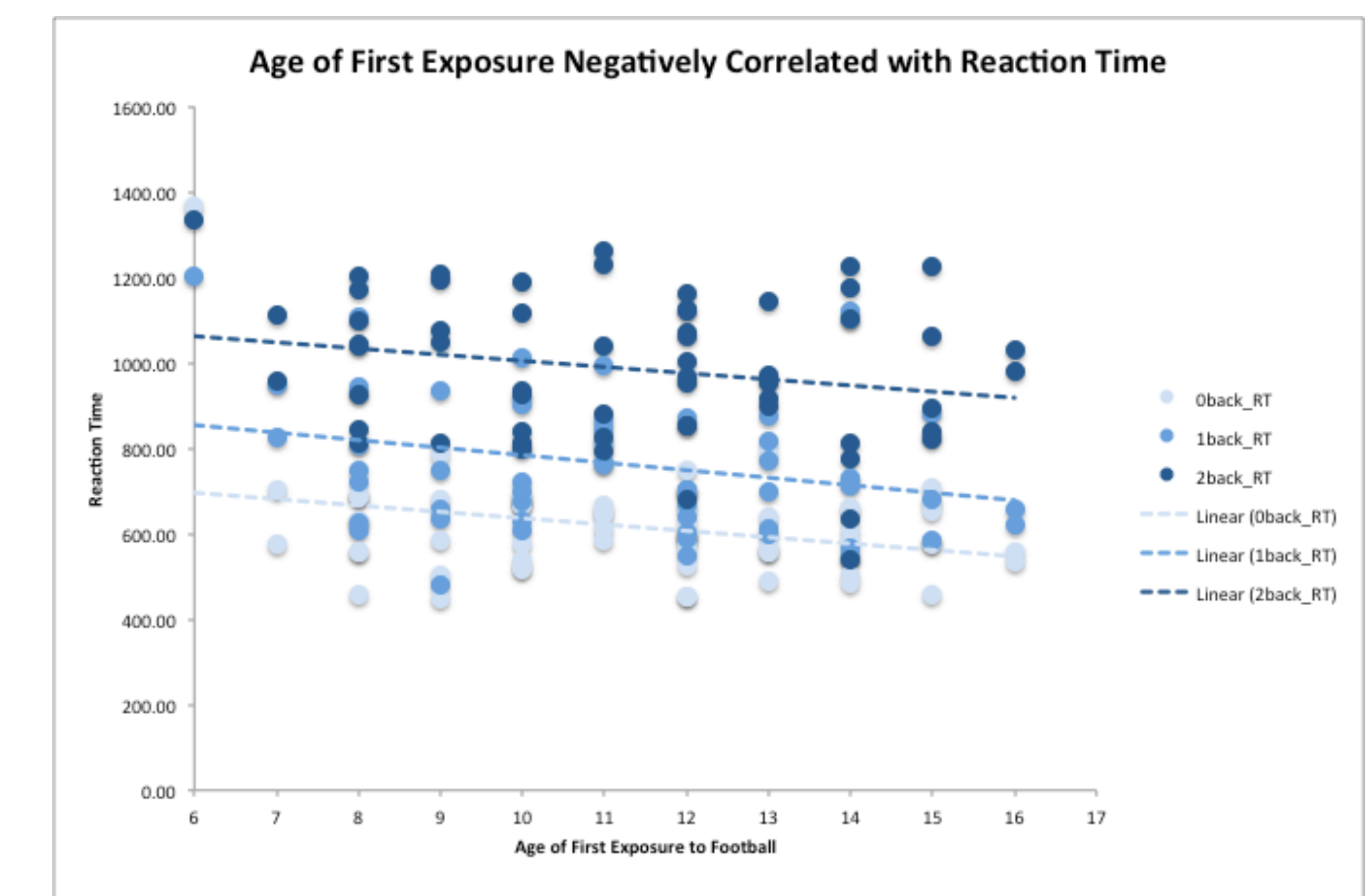
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