Long-Term Effects of Concussion and Contact History on Cognitive Function in Middle-Adulthood

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Background

- Young adults with a history of multiple concussions show deficits in attention, working memory, and inhibition, while older adults with a history of multiple concussions show deficits in inhibition, language, and long-term memory[1]
- Few studies have specifically examined cognitive and neural functioning in former athletes with a history of concussions in middle-adulthood[2]
- Past studies that have examined long-term memory in former athletes have traditionally used clinical memory tasks (i.e., HVLT) or cued recall tasks that include items that exhibit some sematic relationship[3]
- Research questions for the present study:
  o **Will former athletes with a history of concussions show a cued recall deficit relative to those with no history of concussions?**
  o **Will former athletes with a history of multiple concussions benefit from a semantic relationship between words in a pair to the same degree as former athletes with no history of concussions?**
  o **Will former athletes with a history of concussions show compensatory neural activity during encoding of word pairs?**
  o **How will the functional connectivity between a hippocampal memory network and the default mode network relate to performance on the memory task?**

Methods

Participants
- Twenty-two former college football (*n*=19) and non-contact athletes (*n*=3) between age 35 and 45, who participated in NCAA athletics between 1999-2001
  o Football and non-contact athletes were matched on age, position played (i.e., offensive lineman, quarterback, wide receiver, etc.), and exposure to head impacts
  o Football players were stratified as having sustained 3 or more concussions (FC+; *n*=11) or 0-1 concussions (FC-; *n*=8)
  o Non-contact athletes (C-) participated in non-contact sports, and did not report a history of concussions

Measures
- Associative Cued Recall (ACR) Task
- fMRI BOLD Percent Signal Change
- 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
  o Hippocampal Network (8 ROIs)[4]
  o Default Mode Network (4 ROIs)[5]
 o Hippocampal-Default Mode Connections

Procedure
- ACR task
  o Paired Associate Learning Paradigm
  o Low and No Association word pairs
  o Block design (4 blocks)
  o Each block contained only 1 type of task (i.e., only low association pairs), and blocks alternated task type
  o Task order and word pairs were counter-balanced
  o Scan images acquired during encoding
  o Cued recall completed after each block, while participant remained in the scanner
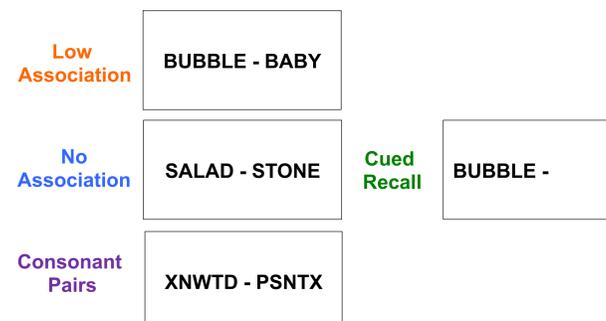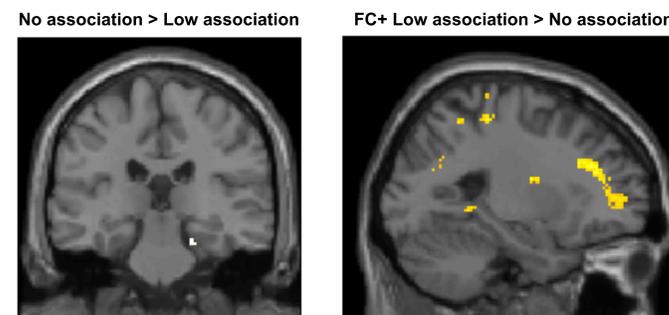
Results

ACR Task Performance
- All participants showed a benefit of semantic relatedness between the cue and target (Low association > No association)
- Participants who played football in college (FC+ and FC-) performed worse on the task than non-contact athletes (C-)
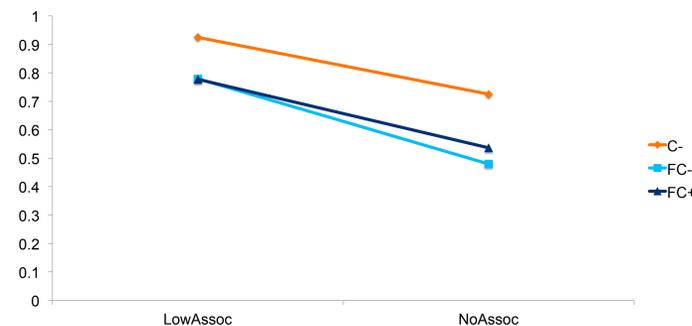

Univariate fMRI Analyses
- **Main effect of semantic relatedness:** one cluster within the parahippocampal gyrus recruited more during low association condition than no association condition
- **Main effect of concussion:** one cluster in left lateral temporal lobe recruited more by no concussion groups (FC- and C-) than concussion group (FC+)
- **Main effect of football:** one cluster in cingulate recruited more by football (FC+ and FC-) than non-football (C-), and one cluster in STG recruited more by non-football (C-) than football (FC+ and FC-)
- **Main effect of semantic relatedness by group:**
  o **FC-:** some clusters in frontal lobe recruited more during no association condition than low association condition
  o **FC+:** 67 clusters throughout the brain recruited more during low association condition than no association condition

No association > Low association   FC+ Low association > No association

Low Association   BUBBLE - BABY

No Association   SALAD - STONE   Cued Recall   BUBBLE -

Consonant Pairs   XNWTD - PSNTX

Functional Connectivity Analysis

- **DMN strength:** No effect of group or condition on DMN connectivity
- **Hippocampal network strength:** No effect of group or condition on hippocampal network strength
- **Between-network connectivity:** No effect of group on between-network strength, but significant decoupling between DMN and HC during memory task relative to consonant pairs
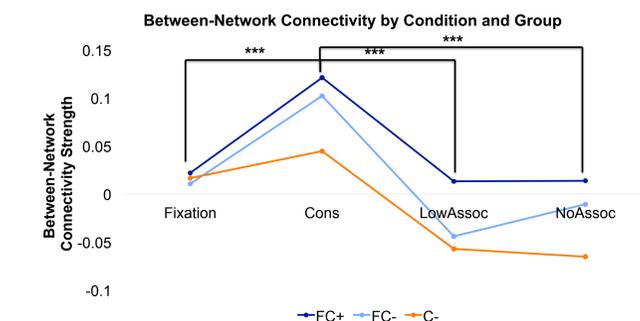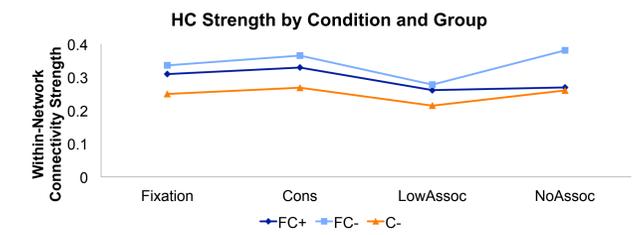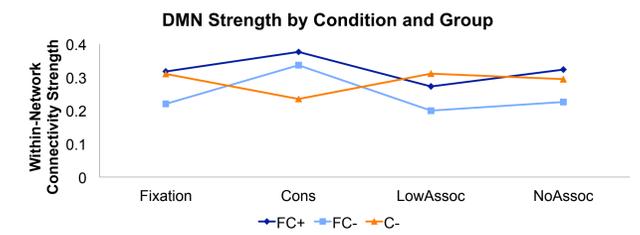
Discussion

- Preliminary results suggest that football history may be a stronger predictor of memory deficits in middle-adulthood, but concussion history may explain more functional neural inefficiencies during memory encoding
- Further, while connectivity analyses did not reveal group differences in network-based connectivity metrics, univariate analyses revealed widely differing neural recruitment during memory encoding, suggesting these two metrics of neural efficiency may capture differing, but complementary aspects of neural recruitment during a task

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