Effects of concussion history and football exposure on working memory performance in retired National Football League and college football players

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Background

· Previous research on sport-related concussions has identified the potential for detrimental effects of concussion that persist after acute concussion recovery.
· In studies of retired athletes, a history of sport-related concussions has been linked with an increased likelihood of memory complaints, depressive symptoms, dementia, and early-onset Alzheimer's Disease as compared to age-matched individuals with no history of concussions.
· Aside from concussions, football players have been shown to receive many sub-concussive episodes that are not captured by their concussion history and may instead be reflected by their overall level of football exposure.
· The current study was designed to compare the long-term effects of concussion history and football exposure on working memory performance to examine whether the unique concussive episode or amount of time spent playing football accounted for functional abnormalities during a memory task.

Methods

Participants

· Sixty-three former college football ("low exposure)" and professional National Football League players ("high exposure") between ages 52 and 65, who had received anywhere from 0-27 concussions in their careers.
- The "low exposure, low concussion" group included participants with 0 or 1 reported concussions who had only played college football (n=16).
- The "low exposure, high concussion" group included participants with more than 3 reported concussions who had only played college football (n=16).
- The "high exposure, low concussion" group included former NFL players with 0 or 1 reported concussions (n=16).
- The "high exposure, high concussion" group included former NFL players with more than 3 reported concussions (n=15).
- NFL and college players were matched on age, position played (i.e., offensive lineman, quarterback, wide receiver, etc.), and concussion history.

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

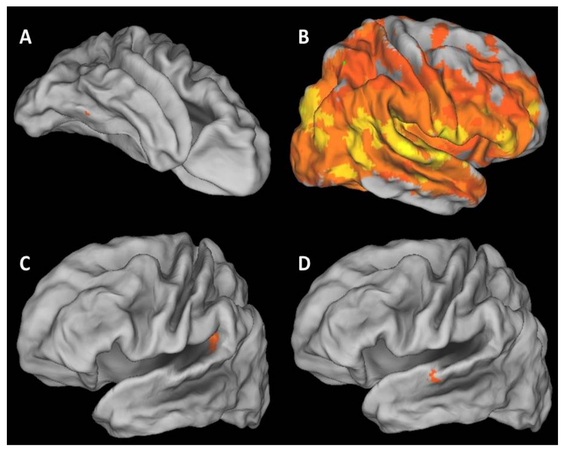
Results

Behavioral Results

· The four groups did not differ in terms of mean accuracy performing each task (main effect of concussion F(1)=0.00, p=.97; main effect of exposure F(1)=0.18, p=.68), or mean response reaction time (main effect of concussion F(1)=0.18, p=.67; main effect of exposure F(1)=0.68, p=.41).

Univariate Imaging Results

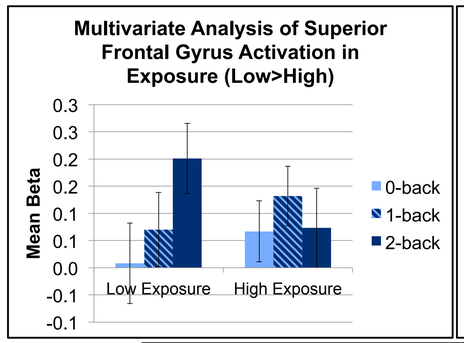
· Across univariate contrasts, significant main effects of concussion were observed in all 3 contrasts (1-back>0-back, 2-back>0-back, 2-back>1-back), but a main effect of exposure only emerged in 1 contrast (2-back>0-back).
· Regions activated more by the low concussion (1-back>0- back), and the low exposure (2-back>0-back) groups are regions more traditionally associated with N-back task performance, while regions activated more by the high concussion group (2-back>0-back and 2-back>1-back) are regions not traditionally associated with N-back task performance.

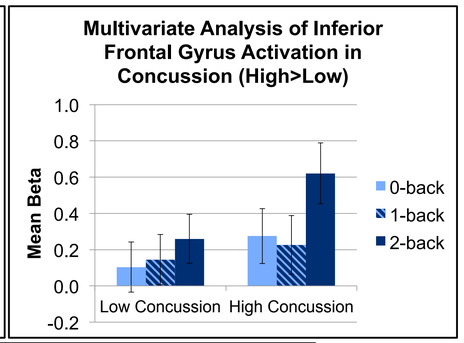


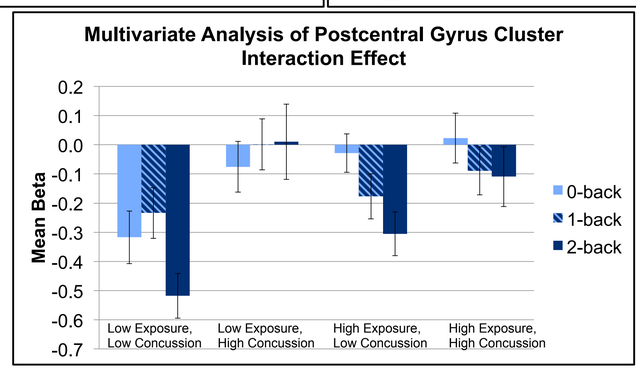
Topographical maps of fMRI cluster activation by univariate contrast: (A) 1-back>0-back contrast in which the highlighted areas were recruited more by the low concussion group than the high concussion group; (B) 2-back>1-back contrast in which the highlighted areas were recruited more by the high concussion group than the low concussion group; (C) 2-back>0-back contrast in which the highlighted areas were recruited more by the high concussion group than the low concussion group; and (D) 2-back>0-back contrast in which the highlighted areas were recruited more by the low exposure group than the high exposure group.

Parametric Imaging Results

· Parametric analyses were also conducted to identify any clusters that showed a significant increase or decrease in activity across the three levels of working memory load.
· Results showed that while there were regions that showed such a trend based on the main effect of exposure (4 clusters in total), and an interaction between concussion and exposure (3 clusters in total), there were a far greater number of clusters showing this trend based on a main effect of concussion (34 clusters in total).
· Within the main effect of exposure, the parametric increase in recruitment tended to be more evident in the low exposure group within regions traditionally associated with N-back task performance.
· The main effect of concussion showed a sharper increase in recruitment of regions between 2-back and 1-back tasks in regions diffusely spread throughout the brain (not just related to the N-back task).







Discussion

· All groups were equivalent on working memory accuracy and reaction time measures. As such, the observed neural differences are not due to task difficulty effects.
· Within each of the univariate contrasts, as well as parametric analyses, concussion history accounted for more neural recruitment differences than did exposure history.
· These functional recruitment differences can be interpreted as differences in neural efficiency, such that high concussion and high exposure groups are recruiting less efficient neural networks to complete the task.
· These findings suggest that both football exposure and concussion history may contribute to differential neural recruitment in a working memory task, but concussion history plays a larger role than does exposure alone.
· Our results provide evidence towards the critical role of the distinct concussive episode, above and beyond that of non-concussive/sub-concussive impacts sustained through football exposure alone, in the memory changes experienced by retired football players.

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