Repetitive subconcussions impact executive functioning: evidence from ERP and cognitive motor performance

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Introduction

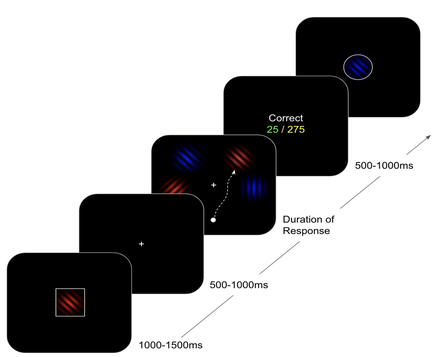
- Administration of repeated standardized subconcussions in a rodent model have been shown to create significant neuromotor dysfunction that can have consequences for cognitive motor performance (e.g., Lavender et al., 2020).
- Through electroencephalography (EEG), neural activity in the form of event-related potentials (ERPs)-like P3-associated with task switching capability and cognitive flexibility (e.g., Shen et al., 2020), can measure markers of cognitive impairment.
- The P3 is typically smaller and has an increased latency in individuals with history of repetitive mTBI compared to healthy individuals (e.g., Parks et al., 2015).
- The current study paired neurometric assessment of subsets of executive functioning with behavioral measures of movement fluidity to determine if these may be viable indicators of cognitive deficits resulting from repetitive and prolonged exposure to subconcussions.
- It was hypothesized that decreased amplitude and increased onset latency as well as decreased task switching capability during the performance of the experimental task would be observed for participants who had had greater exposure to repetitive subconcussions.

Methods

Participants

- N = 15 undergraduate student athletes.
- M_{age} = 19.46, SD_{age} = 1.46
- 6 female, 9 male
- Participants were divided into the groups low-impact and high-impact based on level of exposure to subconcussions.

Combined Simon & Flanker Visual Search Task



Methods

EEG Task

- Participants used a mouse moving in either expected or unexpected direction on the screen to select the cue stimulus among three distractors.
- Cue stimulus was presented at the center of the monitor for 1000-1500 ms. The cue stimulus was a Gaussian Gabor patch varying in color (red or blue), orientation (0°, 45°, 90°, or 135°), and border (square or circle).
- Border of cue stimulus indicated whether cursor movement would be "normal" or "adapted", indicating whether mouse would move in an expected or unexpected direction, respectively.
- Fixation cross was presented for 400-800 ms before bilateral presentation of target stimulus matching the cue and three distractor stimuli.

Electroencephalography

- P3 ERP was derived from the parietal (Pz) electrode from 250-600 ms post-cue stimulus onset, in accordance with previous task switching literature (e.g., Kieffaber &Hetrick, 2005)

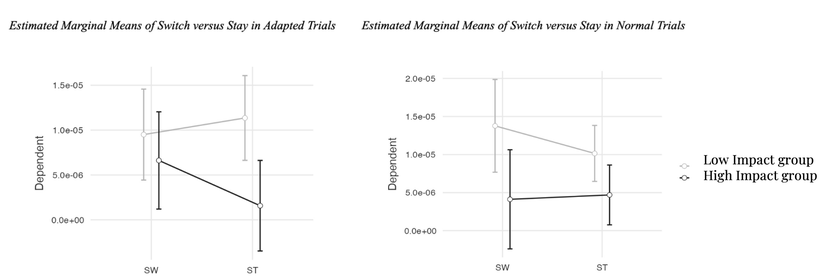
ERP Analyses

2 Group (low-impact, high-impact) x 2 Switch Type (switch, stay) x 2 Movement Type (normal, adapted) repeated measures ANOVA.

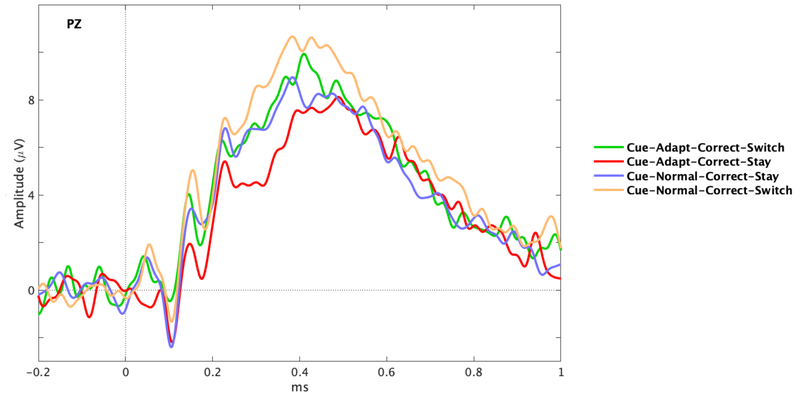
P3 amplitudes were entered into two 2 Group x 2 Switch Type mixed measures ANOVAs separately for Normal and Adapted movement types.

Results: P3 ERP & Task Switching

significant interaction between Group and Switch in the adapted trials, $F(1,13)=10.27$, $p<.01$, $n_p^2=0.44$, only high-impact group evidenced an increased P3 amplitude on Switch compared with Stay trials.



ERP Waveform



Results: P3 ERP & Movement Type

normal movement trials had significant main effect of group, $F(1,13)=6.11$, $p<.05$, $n_p^2=0.32$.

amplitude of the P3 component was significantly smaller in the high-impact group (M=4.41, SE=2.23) as compared to the low-impact group (M=12.0, SE=2.09).

adapted movement trials had main effect of group reaching marginal significance, $F(1,13)=4.07$, $p= 0.065$, $n_p^2=0.23$

Discussion

- Increase in P3 amplitude in switch trials for participants in the high impact group may be representative of increased allocation of neural resources for task performance, replicating previous research on decreased executive functioning capability as a result of repetitive exposure to mTBI (e.g., Ledwidge & Molfese, 2016)
- P3 amplitudes were smaller and had increased onset latency in the high-impact group, replicating previous research on individuals with mTBI (e.g., Broglio et al., 2009)
- These results suggest that prolonged repetitive exposure to subconcussions may be related to long term cognitive motor deficits which are observable through executive functioning tasks combined with ERPs.