Alpha Desynchronization Increases During Dynamic Visual Assessments Within One Year of Mild Traumatic Brain Injury

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ABSTRACT

BACKGROUND: Mild Traumatic Brain Injuries (mTBI) can lead to visual processing deficits, including decreased visual acuity, visual field impairment, eye movement dysfunction- including vergence, saccadic, smooth pursuit movements and an increase in mental workload during visual tasks. Previous studies have shown a general relationship between visual tracking performance and brain function, whereas brain-specific studies, as measured via electroencephalogram (EEG), indicated head-injury correlational differences between mTBI patients and healthy controls. Specifically, mTBI patients demonstrated decreased alpha activity with a corresponding, subsequent, increase in theta activity and an overall increase in cognitive effort during visual-tracking and motor tasks. The purpose of this project was to examine the relationship between brain activity and visual-motor deficit in participants with a recent mTBI compared to healthy controls. We hypothesized that participants with recent mTBIs (within the previous 13 months) would exhibit alpha desynchronization and perform worse on dynamic vision tests compared to healthy controls. **METHODS:** To test these hypotheses, data from 10 concussed participants (age: 20.2 ± 1.87 yrs, post-injury: 8.0 ± 3.96 months) and 17 healthy participants (age: 20.7 ± 1.68 yrs) wore a 32-channel dry EEG cap while completing a series of RightEye dynamic vision tests. Participants' eye movements were tracked using an SMI Red-RE eye tracker, while MATLAB was used to analyze alpha and theta power within spectral analysis. **RESULTS:** The mTBI group demonstrated a significant ($p < .05$) increase in alpha desynchronization during discriminant reaction time and smooth pursuit tasks. **CONCLUSIONS:** These findings indicate that mTBIs results in increased cognitive workload in brain regions that negatively impact visual motor control and neurological functions during visual discrimination tasks within 1-year post-injury. Furthermore, the results demonstrate the need to assess the long-term impact of concussions on the visual-motor system

PURPOSE

The purpose of this project is to examine the relationship between brain activity and visual-motor deficit in participants with a recent mTBI compared to healthy controls.

MATERIALS & METHODS

- Data from 10 concussed participants (age: 20.2 ± 1.87 yrs, post-injury: 8.0 ± 3.96 months) and 17 healthy participants (age: 20.7 ± 1.68 yrs) were analyzed.
- Concussion history was self-reported. All concussed individuals had been diagnosed with mild TBI within the last 13 months.
- Each subject was fitted with a 32-channel dry g.tec EEG cap and neuronal activity was recorded using g.Recorder software (Guger Technologies, Austria) and analyzed in MATLAB programming (*MathWorks, USA*).
- All participants completed the Dynamic Vision Test (RightEye, LLC, MD, USA) consisting of smooth pursuits (circular, horizontal, vertical), saccades (horizonal, vertical), fixations, and reaction time tasks (choice, discriminate).

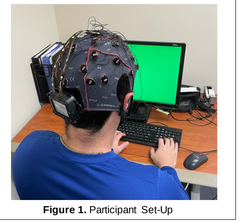

Figure 1. Participant Set-Up

RESULTS

Repeated Measures ANOVA

- Analysis was conducted on the influence of concussed status and brain region on absolute power in both the alpha and theta frequencies for three visual tasks: circular smooth pursuit (CSP), choice reaction time (CRT), and discriminate reaction time (DRT).
- Significant main effects for region and interaction effects between region and group were demonstrated and are shown below with an asterisk.

Table 1. Repeated Measures ANOVA Significance for Absolute Power in the Alpha Frequency

Task	Region	Region * Group
Circular Smooth Pursuit	<.001*	.028*
Choice Reaction Time	.007*	.181
Discriminate Reaction Time	.149	.282

Table 2. Repeated Measures ANOVA Significance for Absolute Power in the Theta Frequency

Task	Region	Region * Group
Circular Smooth Pursuit	.003*	.014*
Choice Reaction Time	<.001*	.047*
Discriminate Reaction Time	.004*	.033*

Multivariate ANOVA

- MANOVAs were conducted on the influence of concussed status on neuronal activity and oculomotor metrics generated from the Dynamic Vision Test.
- The MANOVA on CSP metrics in the alpha frequency revealed a significant multivariate effect, Wilks' lambda, $\Lambda = .000$, $F(25,1) = 553.81$, **$p = .034$.**
- Other tasks included in Multivariate ANOVA were not significant.

Connectivity Plots

- Produced using coherence for both alpha and theta frequencies for CSP, CRT, and DRT.
- Plots using alpha frequency showed little connectivity differences between concussed and healthy individuals.
- Plots using theta frequency showed less connectivity in concussed individuals compared to healthy individuals (*Figure 2*).

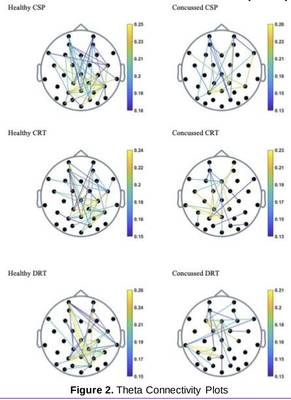

Figure 2. Theta Connectivity Plots

		Right Frontal	Right Frontal-Central	Left Parietal	Right Parietal	Left Parietal-Occipital	Right Parietal-Occipital
CSP	C	0.56 (0.91)*	0.43 (0.66)*	0.42 (0.7)*	0.42 (0.7)*	0.39 (0.68)	0.35 (0.76)*
	H	1.86 (1.62)*	2.62 (3.03)*	1.56 (1.23)*	1.56 (1.23)*	1.86 (3.03)	1.4 (1.17)*
DRT	C	0.41 (0.98)	0.27 (0.53)*	0.24 (0.52)	0.24 (0.52)	0.22 (0.44)*	0.29 (0.83)
	H	1.12 (0.58)	1.99 (2.09)*	2.08 (3.96)	4.99 (12.36)	1.14 (0.74)*	2.88 (5.62)
VSP	C	0.7 (1.23)*	0.48 (0.77)*	0.3 (0.43)*	0.4 (0.63)*	0.4 (0.61)	0.56 (0.97)
	H	1.29 (0.98)*	1.64 (2.27)*	1.31 (1.16)*	1.07 (0.78)*	1.56 (1.61)	1.2 (1.13)
HSP	C	0.42 (0.72)*	0.33 (0.55)*	0.36 (0.6)*	0.33 (0.57)*	0.52 (0.91)	0.4 (0.74)
	H	1.28 (0.94)*	1.61 (2.09)*	0.91 (0.57)*	1.45 (1.59)*	0.98 (0.52)	1.13 (1.12)

Table 3. * indicates significant difference ($p < 0.05$) in alpha wave event-related-synchronization/desynchronization

DISCUSSION

- **The results indicate the combination of circular smooth pursuit assessment and neuronal activity in the alpha frequency have the potential to be a successful diagnostic tool for TBIs.**

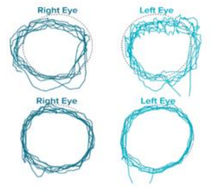

Figure 3. Circular Smooth Pursuit of concussed individual (top) and healthy individual (bottom).

- Differences in connectivity in the theta frequency may be indicative of neuronal dysfunction in the anterior cingulate, the region of the brain responsible for theta rhythm.
- The ANOVA results indicate a difference in power between regions of the brain during most tasks and an interaction effect between concussed status and power in some tasks.
- The data in Table 3 shows statistically significant alpha desynchronization during smooth pursuit and discriminate reaction tasks.
  - This data indicates that mTBI results in increased cognitive workload and dysfunctional internal processing during discrimination tasks within one-year following injury.
- Neural monitoring during dynamic visual tasks can be used to assess neural damage or injury during the diagnosis and progression of Mild Traumatic Brain Injuries.

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