# Circular Smooth Pursuit Assessment and Neuronal Activity in the Alpha Frequency as Predictors of mTBI

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## INTRODUCTION

- An estimated sixty-nine million individuals suffer from traumatic brain injuries each year, contributing heavily to death and disability [1].
- Accurate and timely detection and diagnosis are essential to preventing debilitating and long term consequences.
- Many traditional diagnostic methods are subjective, unreliable, and rely on patient cooperation.
- Assessment of oculomotor control can identify dysfunction in neuronal activity indicative of a brain injury.
- Previous research has suggested that circular smooth pursuit and reaction time tasks can be used as biomarkers for TBIs [2].

## PURPOSE

The purpose of this project was to study the differences in brain activity and oculomotor control in concussed individuals compared to healthy individuals and determine if the combination of these metrics could predict head injury.

## 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 sustained their head injuries in 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 determinate 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.
- The MANOVA results for all other tasks were not significant.

### Discriminant Analysis

- Conducted to determine whether brain activity expressed by absolute power and visual performance measurements could predict the presence of a head injury.
- The overall Wilks' lambda was significant, $\Lambda$ = .075, $\chi^2(22)$ = 36.17, $p$ = .029.

### Connectivity Plots

- Connectivity plots were produced using coherence for both alpha and theta frequencies for all three tasks – CSP, CRT, and DRT.
- Plots using alpha frequency showed little to no connectivity differences between concussed and healthy individuals.
- Plots using theta frequency showed less connectivity in concussed individuals compared to healthy individuals (right).
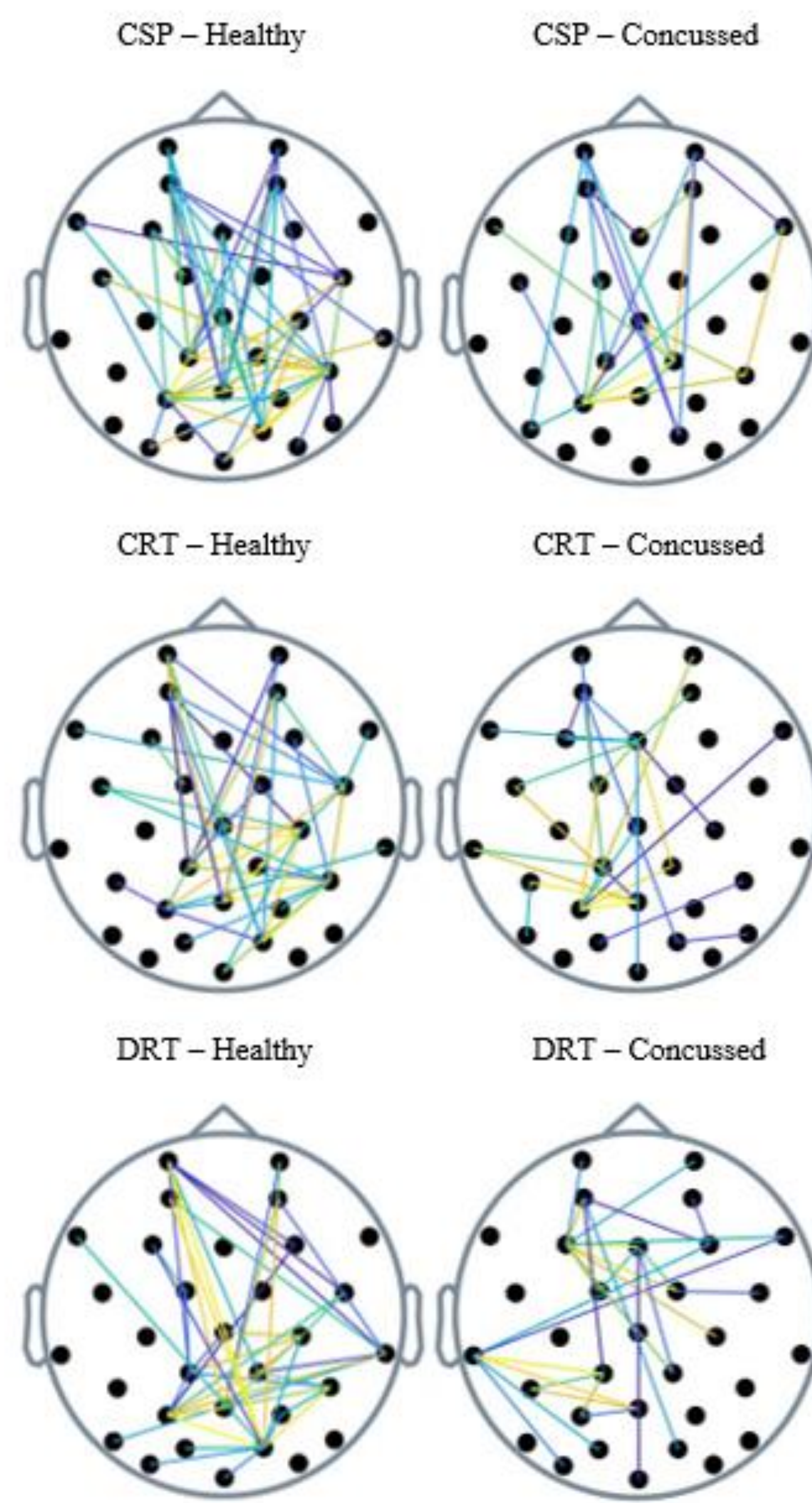
**Figure 2.** Connectivity Plots for Alpha Frequency

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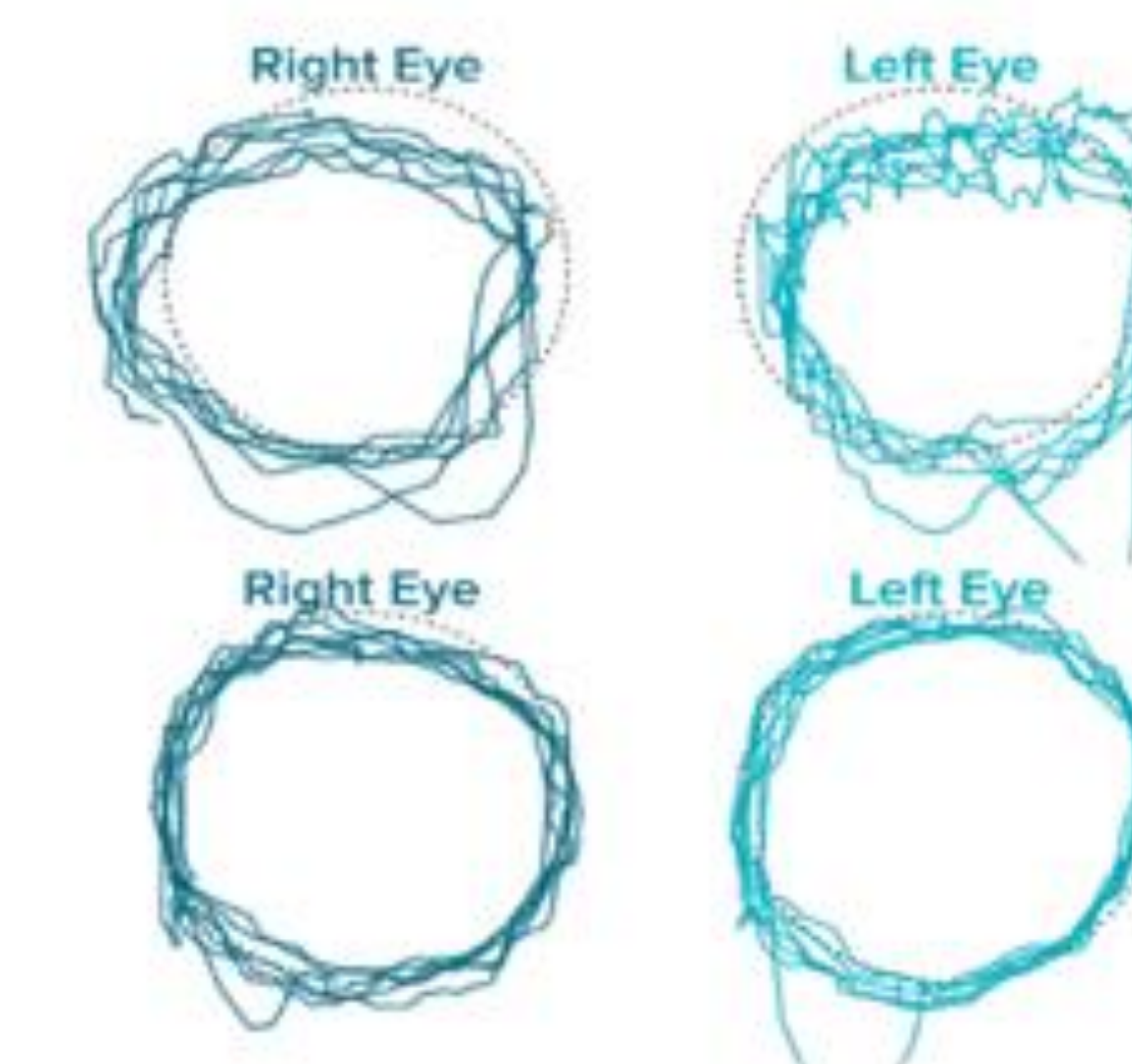
**Figure 3.** Circular Smooth Pursuit of concussed individual (top) and healthy individual (bottom).

## FUTURE WORK

More research should be conducted to understand the effects of post-injury length, severity of injury, and frequency of injury on the results.

## REFERENCES

[1] Dewan, M. et al. Journal of Neurosurgery. (2019). 130(4) 1080-1097.

[2] Hunfalvay, M. et al. Frontiers in Behavioral Neuroscience. (2020).

## ACKNOWLEDGEMENTS