Personalized rTMS guided by qEEG provide improved outcome in a patient suffering from concussion, depression, and anxiety following a surfing accident

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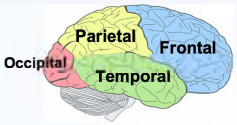
Introduction

- The effectiveness of the current management practice for concussion (i.e., mild traumatic brain injury, and its sequalae, post-concussion syndrome) has been in dispute and there have been considerable research efforts in search for alternative methods.
- Recent studies pointed to repetitive transcranial magnetic stimulation (rTMS) as a promising new tool for concussion treatment (Koski et al., 2015; Cavinato et al., 2012; Xia et al., 2017; Leung et al., 2016).
- It is thought that high frequency pulses (5 Hz and higher) produced by rTMS increase cortical excitability and thereby improve cognitive functions.
- In particular, the amplitude of alpha frequency oscillations during resting period corresponds to alpha reactivity, with larger alpha at rest associated with better cognitive performance (Klimesch et al., 2003).
- **These alpha bands are only observed when frequency is adjusted to the individual.**

Characteristics of an ideal qEEG tracing



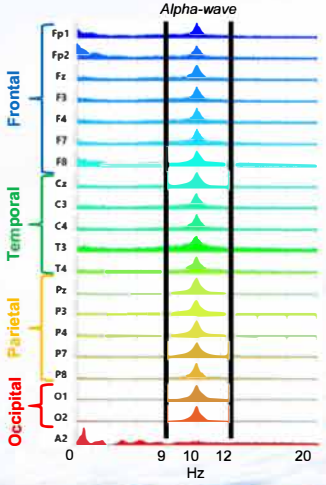
Ideal qEEG characteristics

- *Narrow peak of alpha-wave complex at around 10 Hz*
- *Synchrony of alpha-waves across cerebral cortex between 9-12 Hz*
- *Minimal "noise" outside of 9-12 Hz region*

EEG power spectral acquisition

- *EEG recordings were acquired before PrTMS® and once every 5 treatments.*
- *Approximately 4 minutes of EEG time-series data was converted to the frequency-domain to produce a power spectrum with 0.1 Hz resolution and encompassing 2 – 20 Hz.*
- *A proprietary frequency algorithm (PeakLogic, Inc. San Diego) identified the alpha band and continually adjusted this frequency according to successive EEG power spectral acquisitions and clinical response.*

Ideal Brain Wave Pattern
Alpha-wave

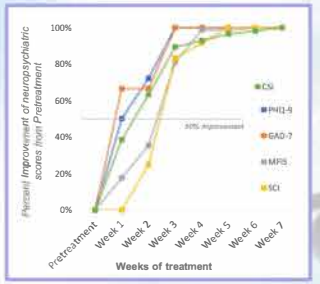


Case Presentation

A previously healthy Caucasian man in his 20s presented for a near drowning episode following a surfing accident. The patient was found to be cyanotic and unresponsive after being pulled out of the water and received CPR for 5 min. He arrived at the ED in severe distress with O2 saturation at 60%, was admitted to the ICU and treated for acute respiratory failure, hypoxia, pulmonary edema, and lactic acidosis. He otherwise showed no signs of other injuries and was discharged when his pulmonary status improved; later during follow up in neurology clinic, however, the patient had persistent neurocognitive symptoms, confusion, sleep dysregulation, fatigue, severe anxiety, and depression. *The patient was seen and received daily rTMS for 8 weeks with personalized alpha frequency, as determined quantitative EEG (**qEEG-guided PrTMS®**).* Neuropsychiatric assessments and repeat qEEG were performed at least every week.

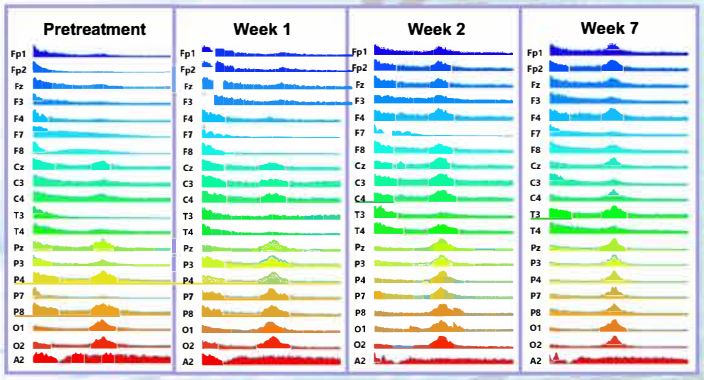
Results

Clinical improvement across all measured domains during treatment period



- *During the treatment period, the patient's neuropsychiatric scores in concussion, depression, anxiety, fatigue, and sleep condition were measured weekly via standardized assessment tools, CSI, PHQ-9, GAD-7, MFIS, and SCI respectively.*
- *After one week of treatment (**week 1**), there was over **50% clinical improvement** in **depression (PHQ-9) and anxiety (GAD-7)** scores.*
- ***Concussion (CSI) score** also reached the threshold of 50% clinical improvement by **week 2**.*
- ***All measures** reached the threshold of 50% clinical improvement by **week 3**.*

qEEG tracing showing improved synchrony across cortex during treatment period



- ***Prior to treatment**, there were marked **decreases in alpha frequency amplitude** in the frontal, temporal, and parietal regions.*
- *By **week 2-3** of treatment, there were **activation of alpha-waves** in almost all regions.*
- *By **week 7** of treatment, the **alpha-wave peaks narrowed and synchronized** across cerebral cortex*

Current treatment approaches available for post-concussive symptoms have limited data regarding effectiveness

Treatment	Effectiveness	Reference
Psychoeducational	A number of controlled studies suggest that early education and reassurance are beneficial	*Al Sayegh et al., 2010 Borg et al., 2004 Mittenberg et al., 2001*
Cognitive Rehabilitation	Controversial; good support only in military veteran population	*Cooper et al., 2015 Prince and Bruhns, 2017*
Psychotherapy/CBT	May be more effective than cognitive rehab; limited data supporting specifictreatment effectiveness in the setting of concussion	*Tiersky et al., 2005 Al Sayegh et al., 2010 Potter et al., 2016*
Pharmacological	Medications are targeted for specific symptoms (ex. antidepressants for depression, anxiolytic for anxiety, etc) and have limited data supporting specific treatment effectiveness in the setting of concussion	*Fann et al., 2001 Perino et al., 2001*
Hyperbaric chamber	RCT studies have not consistently shown benefit	*Miller et al., 2015 Hoge and Jonas, 2015*

Conclusions

- The EEG tracings from pretreatment showed decreased alpha waves in the frontal and somatosensory areas of the brain, suggesting severe brain dysfunction likely due to hypoxia, head impact on the reef (as his helmet was shattered), or both.
- Over the next few weeks of treatment, there were activation of alpha wave distribution, peak narrowing of alpha-waves, and improved synchrony across cerebral cortex.
- Remarkably, the timing of this **synchrony coincided with clinical improvement** in concussion, depression, anxiety, fatigue, and sleep condition as measured by CSI, PHQ-9, GAD-7, MFIS, and SCI respectively.
- These results indicate that **qEEG-guided PrTMS®** was associated with clinical recovery from concussion and improved mental health condition and level of functioning.
- This study provides further crucial evidence of the promising implications for the use of this **novel, noninvasive, personalized approach to effectively treat concussion and its constellation of mental health** comorbidities such as anxiety, depression, confusion, and other neurocognitive impairments.
- Further studies comparing the effects of qEEG-guided PrTMS® on concussion to a placebo group are warranted to determine the extent of its effectiveness over the recovery course.

References

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