Effects of the stimulation of alpha oscillations on the Default Mode Network in correlation with PTSD and Anxiety

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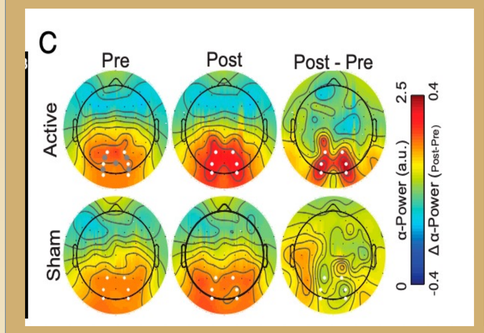
Introduction

Post Traumatic Stress Disorder (PTSD), is a mental health disorder that is triggered by traumatic events. Neural synchronizations in the brain are what align neural activity across brain regions and promote the temporal lobe functions, such as memory and auditory processes. Of the listed oscillations, alpha, beta, gamma, and delta, this research mainly focuses on the alpha oscillations in the brain and how it differs between people with PTSD versus those without. The lab uses electroencephalography (EEG) and Functional MRI (fMRI) technology in order to determine these differences (Clancy, Kevin J, et al, 2). Alpha oscillations usually range from about 8-12 hertz and since we are interested in the frequency of this firing, the data is transferred through a Fourier transformation system. Using discrete bands, we observe how it affects the Default-Mode-Network (DMN). For people with Post Traumatic Stress Disorder, the DMN is known to be atypically active at these times and has shown an increase in activity of these alpha oscillations through stimulation. By analyzing these discrete bands after transcranial stimulation, and through fMRI scans to see a more detailed picture of the brain, we can determine how the DMN is affected by these processes.



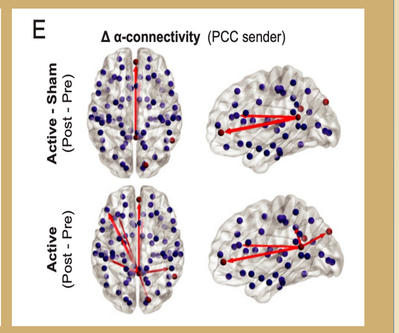


Fig C. demonstrates the increase in intensity of alpha oscillations in the pre stimulation phase versus the post stimulation phase. As you can see, the area that increases in intensity of redness shows an increase in the alpha oscillation frequency. You can also see this in the SHAM part of the stimulation, where the intensity of alpha power increases post-stimulation. Fig E. represents the alpha power connectivity in a whole brain map of tACS advancement. The red lines represent the prior DMN ROIs (release low frequency oscillations throughout the brain), and the blue dots which show the Brodmann areas (part of the brain that is responsible for motor movement.

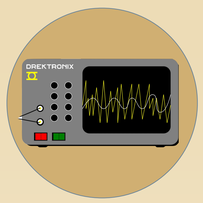
Methods

Pre/Post Stimulation RS (resting state) recordings

- The participant will look at a non-moving cross for 5 to 10 minutes in order to elicit DMN activity.
- A healthy participant would have an active DMN and an inactive Salience Network (SN)- the part of the brain that moderates internal or external processing- while anxious participants may have weak DMN activity with unusually high SN activity.
- This allows us to record the aberrant activity in the DMN and the SN that is implicated in PTSD.

tACS/Sham Stimulation

- Alpha frequency stimulation was administered with a sinusoidal node oscillating at 10 hertz using the tACS system.
- Electrodes were placed over the midline occipital-parietal sites and were used to administer the alpha oscillations that ranged in this cortex.
- The tACS/SHAM stimulation was administered for 20 minutes where the participant would perform a small task in order to enhance tACS efficiency.
- The SHAM stimulation is used to show that the tACS is causing a change in activity, rather than some confound.

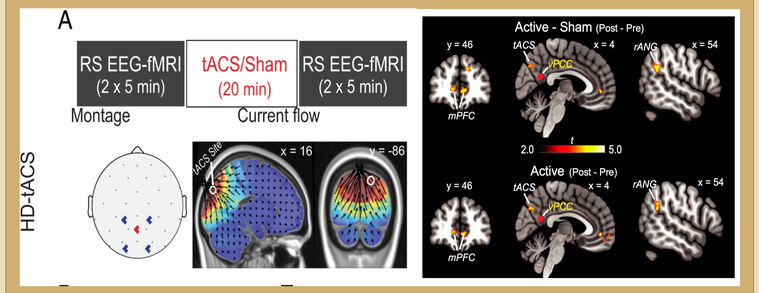


EEG Acquisition and Analysis

- EEG data was collected simultaneously with the fMRI data.
- The alpha oscillation frequency was calculated using the multitaper spectral estimation technique.
  - This technique is basically the Fourier transformation system mentioned earlier.
- Through the EEG data we are able to determine the alpha oscillation frequency.

References

Results



The participants underwent RS EEG-fMRI recordings before and after the tACS SHAM stimulation. During this process, an increase in the right posterior alpha power of the brain was observed. This also included the right posterior to frontal (P->F) alpha connectivity in the Active group from pre to post stimulation. A similar trend occurred when examining the effect of the tACS on source level (DMN) alpha P ->F connectivity (Clancy, Kevin J, et al, 6).

Conclusions

When combining the tACS/SHAM stimulation with the EEG-fMRI, we demonstrated that the tACS of the alpha oscillation source in the occipital-parietal cortex strengthened alpha oscillations and BOLD alpha-frequency connectivity within the default mode network. Through the Fourier Transformation system, we can obtain the discrete bands from the EEG data which shows alpha oscillations increasing upon stimulation, further solidifying the fact that the default mode network and its functions is affected by the stimulation of these oscillations within individuals with PTSD.