Modulating Working Memory with Transcranial Alternating Current Stimulation: Pilot Study for tACS as a Treatment for Age-Related Cognitive Decline

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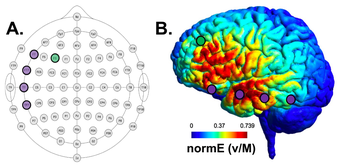
SUMMARY

- This study aims to investigate the effects of theta transcranial alternating current stimulation (tACS) on working memory (WM) performance, measured by cognitive tasks testing WM capacity and cognitive load. We are currently in the data collection phase of our study and plan to continue gathering data during the fall semester.

INTRO/BACKGROUND



(A) montage of electrode placement; **(B)** brain model of electrical current intensity of tACS. (anode=green; cathode = blue)

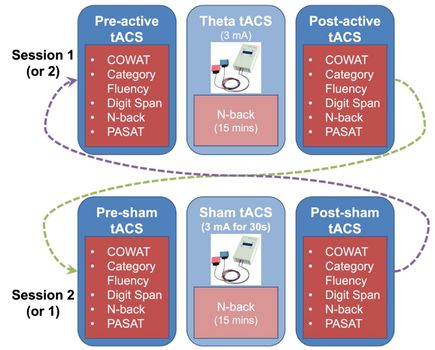
- tACS is a noninvasive brain stimulation (NIBS) technique that involves running a relatively weak, sinusoidal current through electrodes placed on the scalp.
- Past research has shown that NIBS can help improve working memory along with other cognitive processes such as language performance, learning, and cognitive control.
- Working memory (WM) is the ability to hold information for a short period of time. This largely applies to information that is no longer visually present. WM is important in daily tasks such as short-term memory, decision making, and problem solving.
- WM is mainly associated with the prefrontal cortex as well as the temporal lobe.
- WM tends to worsen as individuals get older and is significantly hindered in neurological diseases such as Dementia and Alzheimer's.
- WM can be thought of as a mechanism that works in two different modes. The first one is called the "updating" mode which takes in information/stimuli. The second mode is called "maintenance" which ensures that irrelevant information/stimuli does not interfere with the encoded information.

HYPOTHESIS/RESARCH GOALS

❖ In comparison to sham, active in-phase theta-tuned frontotemporal tACS will enhance WM performance and display particular improvements for tasks dealing with greater WM demands.

METHODOLOGY

- A double-blind, within group study was conducted for 10 healthy subjects (projected n=20).
- Prior to the experiment, subjects took a demographics survey, and sleep-quality questionnaire as well as the Edinburgh Handedness and Beck Depression Inventory to assess fitness.
- Counterbalanced in-phase frontotemporal theta-tuned tACS stimulation was administered over the course of 2 visits, one consisting of an active tACS condition and the other, sham condition, localized over the left frontotemporal cortex for a duration of 15 minutes (Figure 1).



- Subjects completed the N-back task before, during, and after stimulation and the Digit Span Task before and after stimulation to measure WM cognitive load and total WM capacity, respectively.
- A Repeated Measures ANOVA was conducted for each task to further analyze trends.

Digit Span Task

Subjects hear a sequence of digits and then have to type (recall) them into the computer. The number sequences ramp up all the way to 11 digits (forwards and backwards). 2 sequences were given per span.

Forward #1: 4 6 7 2 1 Type: 4 6 7 2 1

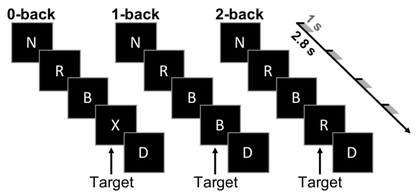
Forward #2: 2 3 1 9 6 Type: 2 3 1 9 6

Forwards and backwards trials were separated into 2 separate computerized tasks.

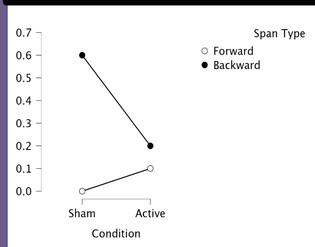
Backward #1: 3 4 8 7 1 Type: 1 7 8 4 3

Backward #2: 5 3 6 4 8 Type: 8 4 6 3 5

N-back Task

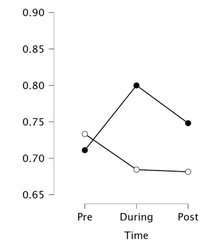


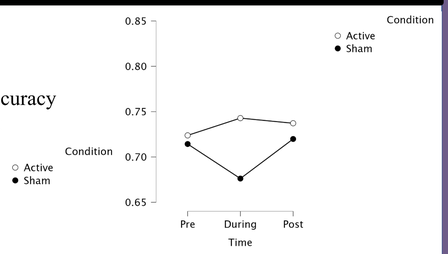
EARLY RESULTS



(A) Digit Span Accuracy for forward and backward spans

(B) Analysis of Accuracy for the 2-back task





(C) Analysis of Accuracy for the 3-back task

EARLY RESULTS CONTD.

- Participants were more accurate when doing the 3-back during active. stimulation relative to sham, than the 2-back (p=0.029)
- No significant correlation between sham/active conditions or time period were noted.
- A slight improvement in Active compared to Sham for the forward spans was observed. However, backward span performance declined under stimulation.
- Lasting effects of theta tACS (post) were not achieved.

CONCLUSION/NEXT STEPS

- Given the differential increase in WM performance for the N-back task in comparison to the digit span task under active stimulation, it can be inferred that theta tACS deals more exclusively with the updating processes of visuospatial working memory.
- The unusual trend in forward/digit span improvements may be attributed to the current limited subject pool, with clearer data points to be attained in the future as we continue to run subjects.
- Moving forward, the 3-back task will be used exclusively regardless of baseline performance in order to reach desired stimulation effects and avoid stagnant improvement due to ceiling effects.
- Our primary focus moving forward is implementing the Neuroelectric 32-channel Starstim device to simultaneously record stimulation and EEG for quantitative analysis.

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