Investigation of optimal tACS duration for alpha activity modulation based on resting-state electroencephalography

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INTRODUCTION

- Transcranial alternating current stimulation (tACS) is one of the non-invasive brain stimulation techniques to modulate neural activity by applying a weak electric current.
- Although the efficacy of tACS has been demonstrated in many previous studies, an optimal tACS duration has not yet been determined.
- Since long-term tACS may cause skin burns or phosphenes, it is necessary to consider an appropriate stimulation duration according to experimental paradigms.
- Thus, we investigated the optimal tACS duration for alpha activity modulation using resting-state electroencephalography (EEG).

METHOD

Experimental Condition

- Ten subjects opened (EO) and closed (EC) their eyes for 3 min before and after tACS.
- EEG data were measured from 61 scalp electrodes according to the international 10-20 system, but for analysis, only 15 electrodes (P5, P3, P1, Pz, P4, P6, P8, PO7, PO3, POz, PO4, PO8, O1, Oz, O2) in occipital area were used.
- To apply tACS, anode and cathode electrodes were attached to P8 and P7, respectively, and the tACS duration was randomly applied for 10, 20, and 30 min for three different days with minimum 7 days intervals.
- The tACS intensity was individually determined in such a way that we decreased by 0.25 mA from 2 mA to a minimum of 1 mA depending on the presence of pain and phosphene.
- Individual alpha frequency (IAF) was used as a stimulation frequency, which was determined using the Pz channel of EC EEG data measured before tACS.

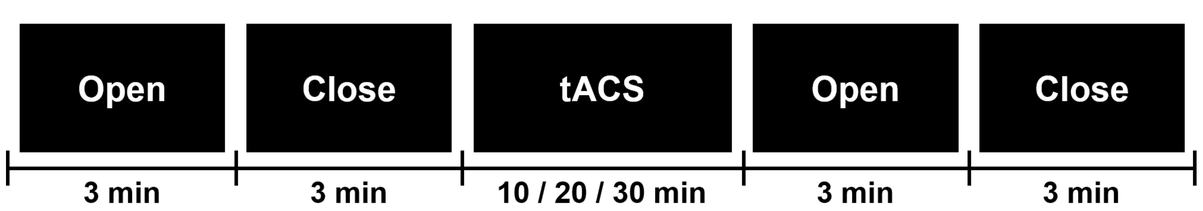

Figure 1. Experimental paradigm

Data Analysis

- EEG of EO data were used for data analysis and applied band-pass filter between 3.5 – 50.5 Hz, and applied adaptive filter to remove eye movement.
- In order to eliminate artifacts, the filtered EEG data were segmented into a length of 3 s and if an EEG segment contained severe physiological artifacts (± 75 μV), it was excluded from further analysis.
- The power spectral densities (PSDs) of the IAF ± 2 Hz were estimated using the occipital channels measured before and after tACS to confirm the alpha activity change.
- The statistical significance of PSDs changes in the IAF ± 2 Hz band before and after tACS estimated was investigated through two-sample t-test for each tACS condition.

RESULT

- Figure 2 shows the mean frequency power of difference between after for IAF ± 2 Hz band according to the tACS duration.
- It was confirmed that **the frequency power of IAF ± 2 Hz was increased after tACS** compared to before tACS for all three conditions.

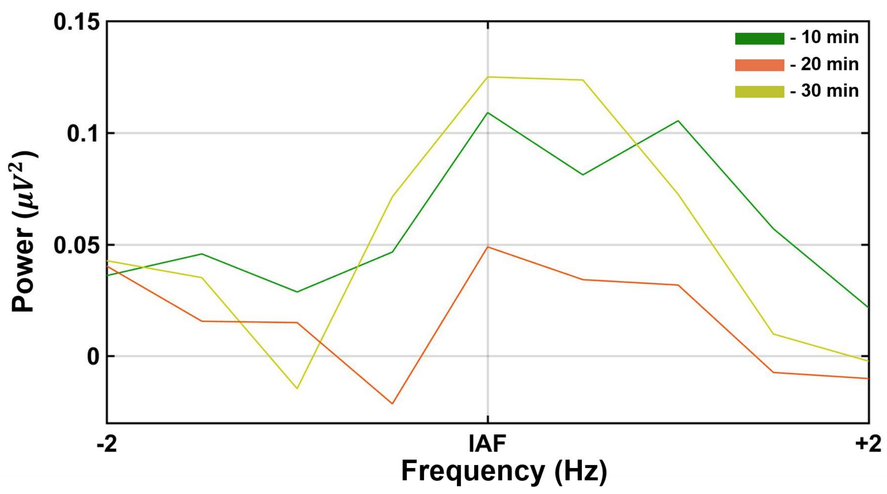

Figure 2. Mean frequency power of difference between after and before for IAF ± 2 Hz depending on the tACS duration.

- Figure 3 shows the mean frequency power for the IAF ± 2 Hz band in the occipital area according to the tACS duration.
- It was confirmed that **the alpha power increased after tACS regardless of the stimulation duration, and in particular the significant increase in IAF was observed for the stimulation durations of 10 and 20 min** (two-sample t-test, $p < 0.05$).

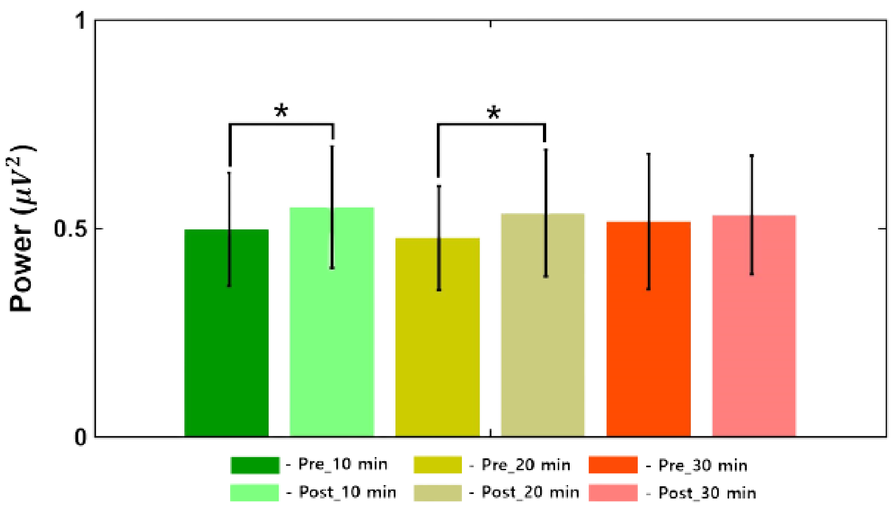

Figure 3. Changes in mean frequency power for the IAF ± 2 Hz depending on the tACS duration.

CONCLUSION

- In this study, we investigated the optimal tACS duration affecting EEG modulation based on resting-state EEG.
- **We demonstrated that alpha activity could be significantly modulated 10 min after tACS, but not after 30 min; an optimal tACS duration can be between 10 and 20 min for alpha activity modulation.**
- In further studies, we will investigate changes in EEG patterns before and after tACS on EC as well as EO condition.

ACKNOWLEDGEMENT

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