Enhancing frequency-specific steady-state visual evoked potential (SSVEP) response using transcranial alternating current stimulation

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ABSTRACT

Steady-state visual evoked potential (SSVEP) based brain computer interface is one of the most researched type of BCI that uses neuronal response generated gazing at a visual stimulus in distinct frequencies. However, some population called "SSVEP illiteracy" who does not respond to the given visual stimuli is one of the major drawbacks of the system. In this study we have investigated whether it is possible to enhance the SSVEP response of a specific frequency by stimulating the visual cortex using transcranial alternating current stimulation (tACS). Total fifteen participants were recruited for the experiment. Each participant recorded the initial SSVEP response before tACS. After initial SSVEP session, participants were stimulated by tACS for 20 minutes. Finally, SSVEP response was recorded to compare the effect of tACS. In this study, we found that frequency-specific tACS increases the SSVEP response of the stimulating frequency while unaffecting the response of the non-stimulating frequencies. This study confirms that the frequency-specific tACS stimulation can effectively enhance the SSVEP responses which might be used to overcome SSVEP illiteracy

INTRODUCTION

- Steady-state visual evoke potential (steady-state visual evoked potential, SSVEP) based brain-computer interface (BCI) is one of the most researched type of BCI.
- However, some population called "SSVEP illiteracy" who does not respond to the given visual stimuli.
- In a recent study, transcranial direct current stimulation (tDCS) on visual cortex was found to increase the SSVEP response [1].
- In this study, we have investigated whether it is possible to enhance the SSVEP response of a specific frequency by stimulating the visual cortex using transcranial alternating current stimulation (tACS)

METHODS

Participants

•Total Participants 15 (Male : 12, Female : 3, Age : 26.25 ± 0.97)

• Participants had normal or corrected to normal vision.

Experimental Procedure

•1) Resting state EEG (eyes open, eyes closed, for 5 minutes, respectively)

•2) SSVEP EEG (12 different flickering frequencies)

•3) Individual tACS (anodal : O1, Oz, O2, and Pz, Cathodal : Cz)

•4) SSVEP EEG (12 different flickering frequencies)

•5) Resting state EEG (eyes open, eyes closed, for 5 minutes, respectively)

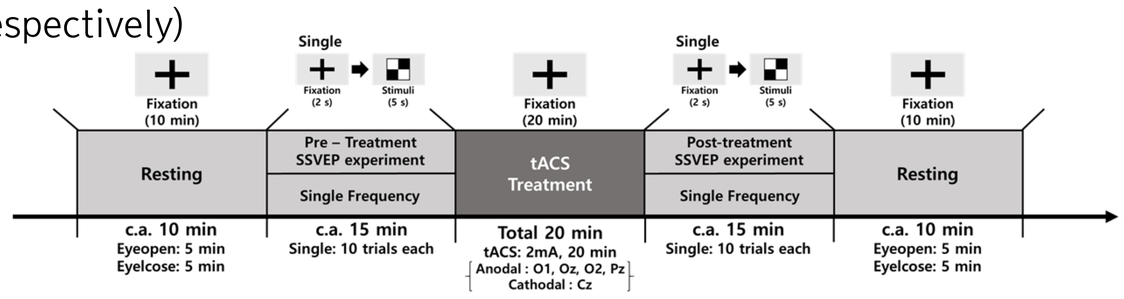

Fig 1 Whole experimental procedure

Preprocessing

- 1) Common average referencing
- 2) Baseline correction
- 3) Filtering (1 ~ 50 Hz bandpass filtering)
- 4) Epoching (0 ~ 5000 ms, stimulus onset)

Spectral Analysis

- Fast Fourier transform was adapted to recorded EEG data
- Abolute power and signal-to-noise ratio were extracted from spectral EEG data

Statistical Analysis

- Non-parametric statistical analysis was adapted to absolute power and signal-to-noise ratio
- Wilcoxon signed rank test was used for these parameters

RESULTS

Figure 2

- Before and after tACS SSVEP response

Figure 3

- SSVEP parameter's statistical result
- Stimulated frequency have significant difference power and SNR

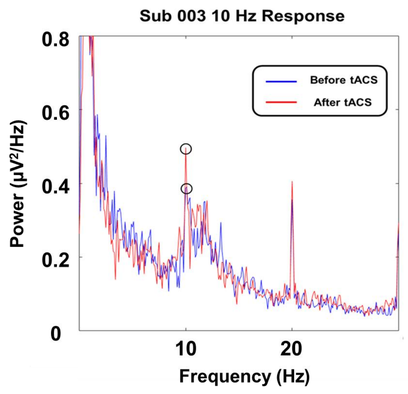

Fig 2 SSVEP response

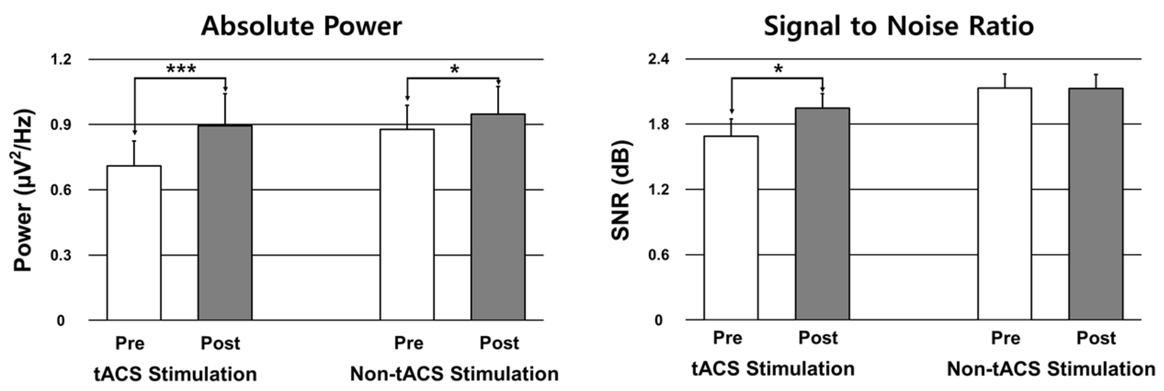

Fig 3 Absolute power and signal to noise ratio result

CONCLUSION

- In this study, we found that frequency-specific tACS increases the SSVEP response of the stimulating frequency while unaffecting the response of the non-stimulating frequencies.
- This study confirms that the frequency-specific tACS stimulation can effectively enhance the SSVEP responses which might be used to overcome SSVEP illiteracy.

REFERENCES

1. Kim, Do-Won, et al. "Can Anodal Transcranial Direct Current Stimulation Increase Steady-State Visual Evoked Potential Responses?." Journal of Korean medical science 34.43 (2019).

ACKNOWLEDGEMENT

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