Need for personalized phase-matched transcranial alternating current stimulation?

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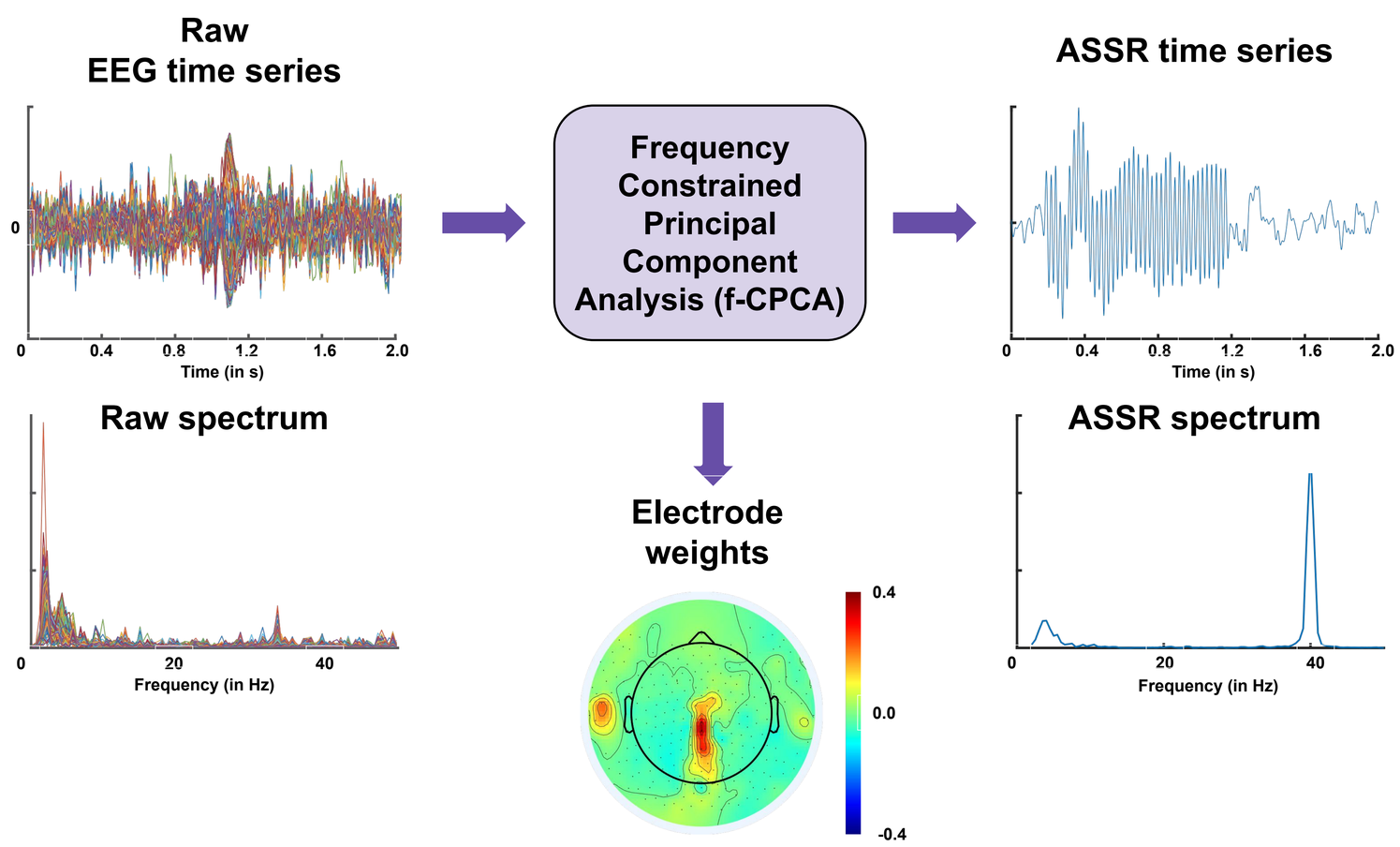
Introduction

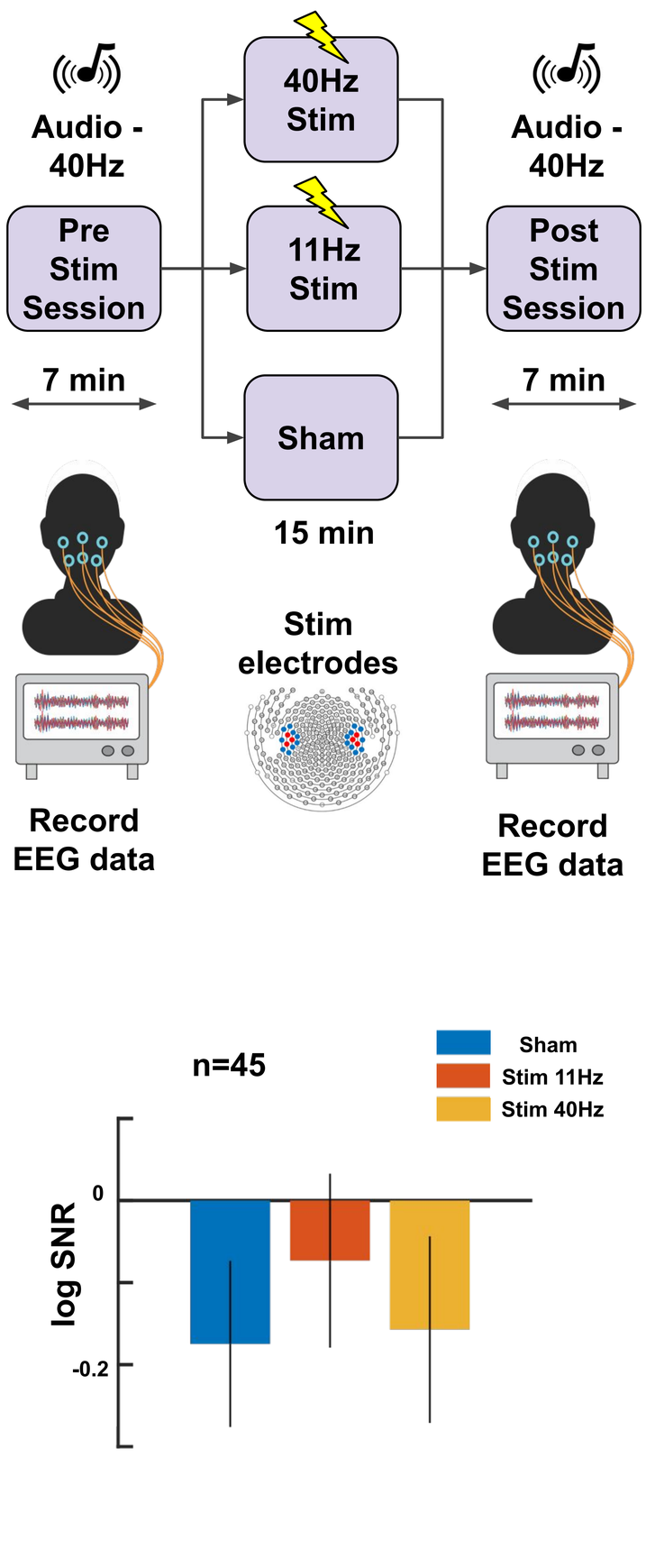
Transcranial Alternating Current Stimulation (tACS) is a non-invasive neuromodulation technique that delivers low-intensity alternating currents through scalp electrodes, producing weak electrical fields in the brain to augment ongoing neural activity.

TACS has been increasingly used in intervention studies to directly link brain oscillations and cognitive processes (Feurra, M, et al. 2011). But, the results have been inconsistent (Kasten, F.H., et al. 2019).

The current project aims to start at the basics with tACS and demonstrate reliable physiological effects of tACS.

More specifically, the project aims to study the effects of 40Hz tACS on a Auditory Steady-State Response (ASSR) at the same frequency (40Hz in this experiment).





Methods

A total of 45 healthy adult human participants took part in the tACS study, 15 in each condition. In the pre-stimulation block (Pre Stim), the participants listened to a 40Hz auditory tone for 7 minutes, played in both ears using earphones. This was followed by 15 minutes of high-definition tACS at 40Hz, and again 7 mins of 40Hz auditory tone in the post stimulation block (Post Stim).

Among the 45 total participants, 15 were stimulated at 40Hz, 15 others were stimulated 11Hz to control frequency-specific effects, and the remaining 15 underwent a sham stimulation. Participants' EEG was recorded in both the Pre and Post Stim blocks.

We used a novel dimensionality reduction technique called frequency-Constrained Principal Analysis (f-CPCA) that constrains the EEG variance based on the frequency of oscillations and extracts components specific to the frequency of interest (here 40Hz).

f-CPCA based components for the ASSR signal at 40Hz were extracted for each block. The ASSR signal-to-noise ratio (SNR), power at 40Hz divided by power in the neighbouring frequencies (35 - 45Hz) was computed. We checked whether the difference between the Post Stim and Pre Stim ASSR SNRs varied across stimulation types (Sham vs 11Hz vs 40Hz).

Results

.A univariate ANOVA was performed with the stimulation type as an independent variable. We did not find any significant differences between the different stimulation conditions.

Conclusion

The lack of effect of tACS on ASSR signals could be due to various factors: 1. heterogenous brain states during stimulation, i.e. differences in phase of tACS with the ASSR oscillations (Fiene, M., et al. 2020), 2. individual variability in brain anatomy (Krause, B., et al. 2014).

In the next set of experiments, we aim to control for the phase of the tACS signal as well as estimate participant-specific electrode montage for stimulation.

References

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