Enhancing steady state visually evoked potentials with tACS: precise frequency control with LCD glasses

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Introduction:

In previous research we showed that steady state visually evoked potentials (SSVEPs) can be enhanced with frequency matched sawtooth wave tACS.

The high signal-to-noise ratio of SSVEPs greatly simplifies the problem of artefact removal.

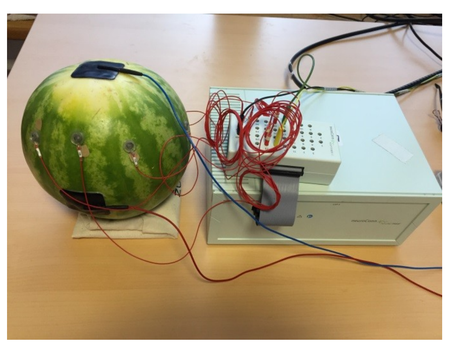
However, SSVEPs on a screen are limited to multiples of the refresh rate of the screen.

Here we create SSVEPs using LCD glasses which can be made to flicker at any frequency.

Additionally, SSVEPs can be created from any real world scenes.

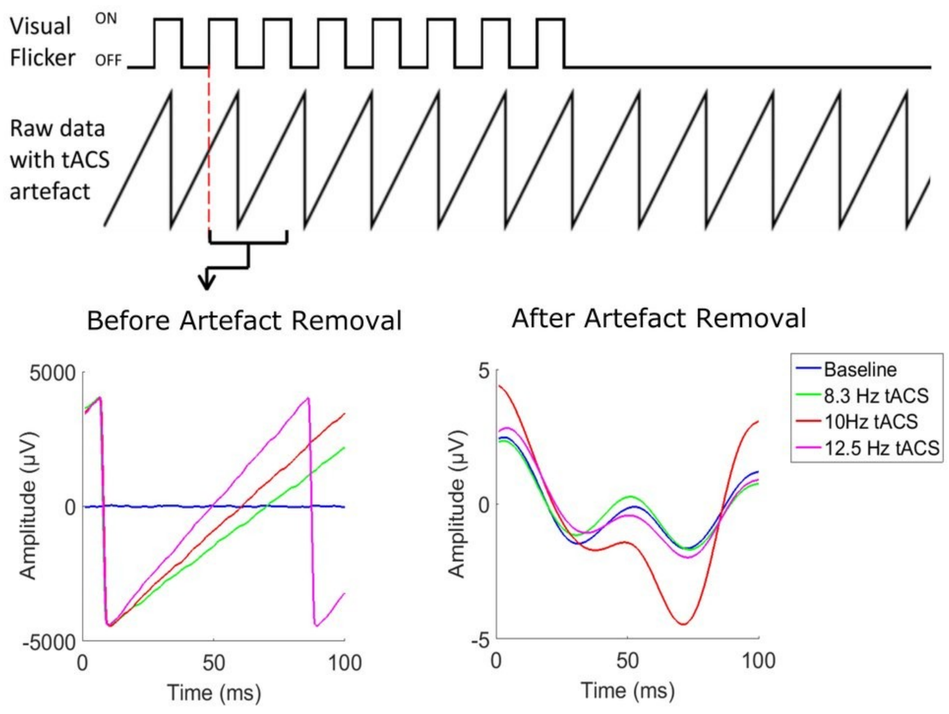
Now we can have precise control over the relative difference in frequency of the tACS and visual flicker.

LCD glasses

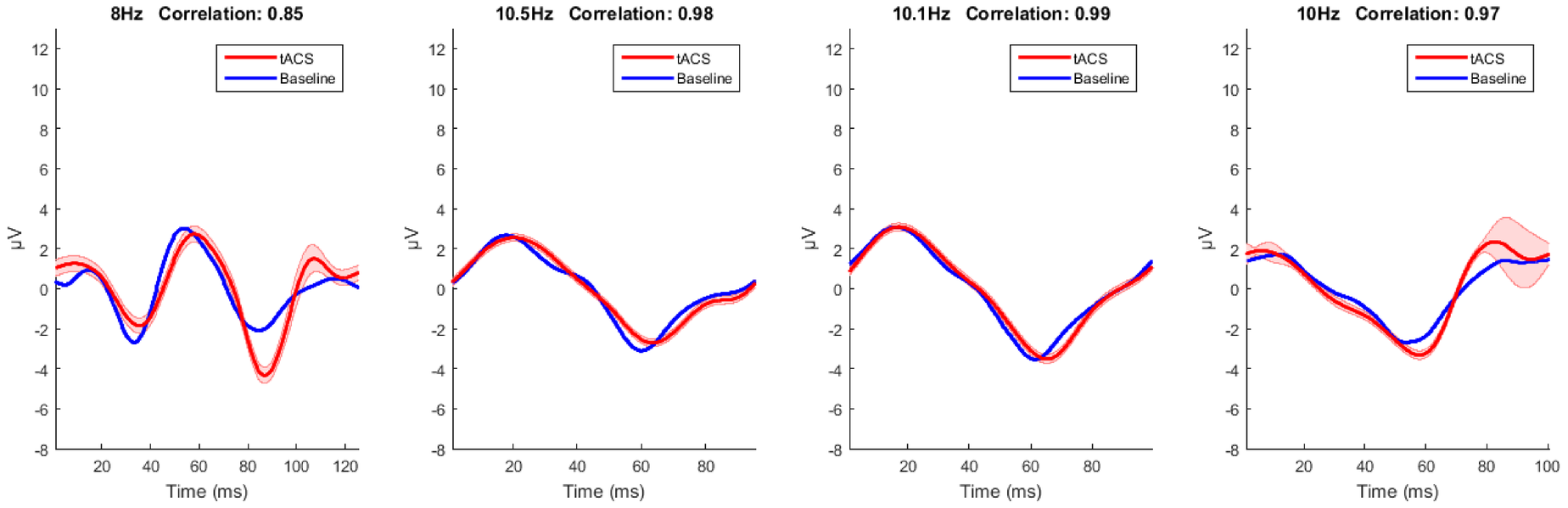


tACS test on watermelon

Previous work: (Dowsett *et al.* 2020)



Dowsett, J., Herrmann, C. S., Dieterich, M., & Taylor, P. C. (2020). Shift in lateralization during illusory self-motion: EEG responses to visual flicker at 10 Hz and frequency-specific modulation by tACS. European Journal of Neuroscience, 51(7), 1657-1675.

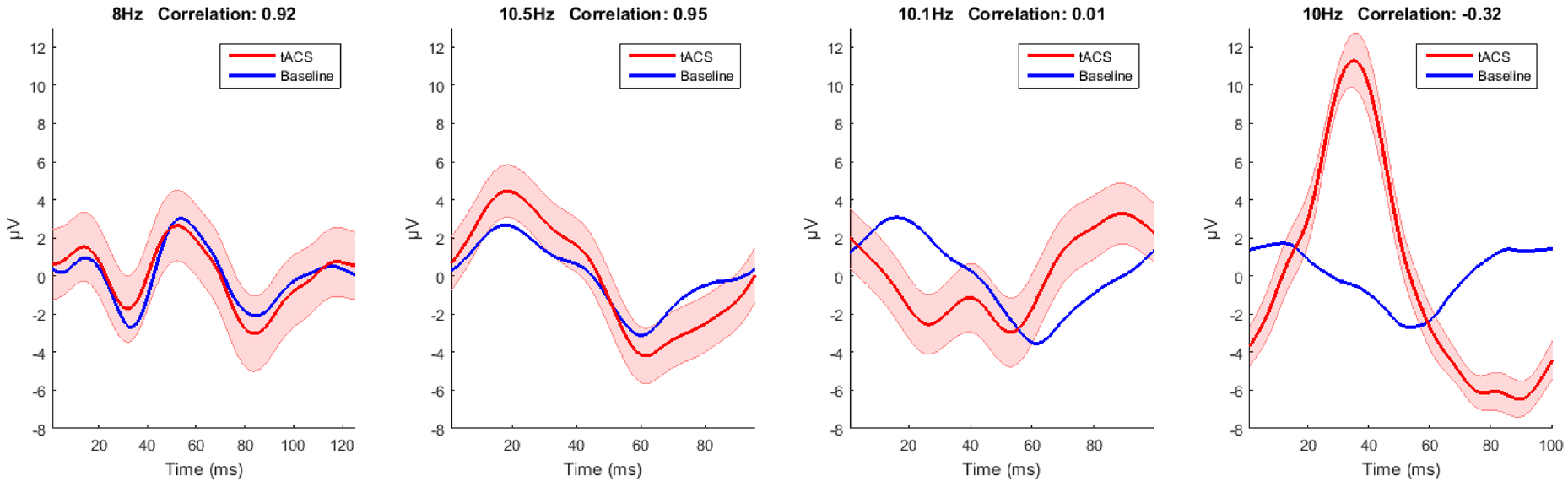


Test with a watermelon

10 Hz sawtooth wave tACS and simulated SSVEPs at 8, 10.5, 10.1 and 10 Hz.

In all cases tACS artefact can be removed and the SSVEP recovered.

The amplitude of the tACS artefact was similar in size to that seen in human participants.



Test with a human participant

10 Hz sawtooth wave tACS and SSVEPs from LCD glasses at: 8, 10.5, 10.1 and 10 Hz.

10 Hz tACS has no effect on 8 Hz flicker.

10 Hz tACS with 10.5 Hz flicker shows a slight increase amplitude.

10.1 Hz flicker shows a shift in phase.

Frequency matched tACS and flicker shows a significant increase in amplitude and a phase shift relative to the baseline SSVEP.

Conclusions:

The control condition with a watermelon, and the more distant frequencies (8Hz flicker and 10 Hz tACS), demonstrate that the tACS artefact can be removed successfully.

Precise frequency control over the flicker frequency and the tACS might allow us to specifically target either the phase or the amplitude of SSVEPs in future experiments, and to study any subsequent behavioural effects.

Future work will investigate differences in tACS phase, waveform shape, and the exact amplitude of stimulation required to enhance SSVEPs.

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DFG Deutsche Forschungsgemeinschaft

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