EXPLORING STEADY-STATE VISUAL EVOKED POTENTIALS WITH VIDEO STIMULI

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SSVEP Ergonomics

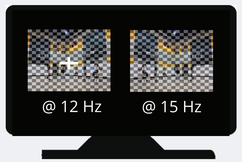
Steady-state visual evoked potentials (SSVEPs) are robust responses that can be detected using electroencephalography (EEG). Stimuli to generate SSVEPs are typically flashing LEDs or checkerboards, which are unpleasant to view for sustained periods of time. More ergonomic SSVEP stimuli could facilitate augmented reality systems, brain-computer interfaces, and biofeedback for attention training.

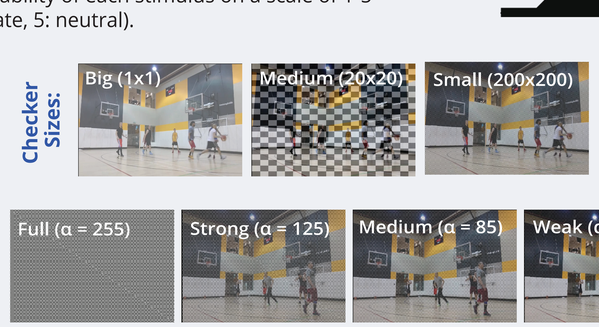
This work investigates if videos combined with semi-transparent flashing checkerboards provide a more ergonomic SSVEP paradigm that effectively classifies attention.

Methods

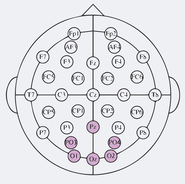
Experimental Setup

Nine participants were cued to attend to one of two 60s videos playing on a computer monitor, each flashing at a unique frequency (12 Hz/15 Hz) with varied checker sizes and opacities. After viewing a set of checkerboards, participants reported the desirability of each stimulus on a scale of 1-5 (1: hate, 5: neutral).





Signal Processing and Classification



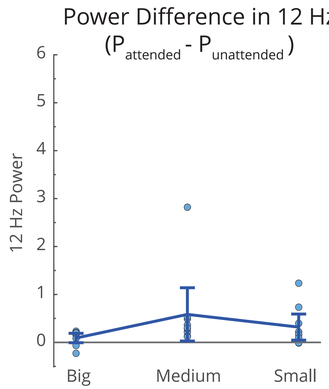
EEG data were bandpass filtered (0.5 Hz to 50 Hz) and epoched into three second increments. Artifacts were rejected using visual inspection and independent component analysis.

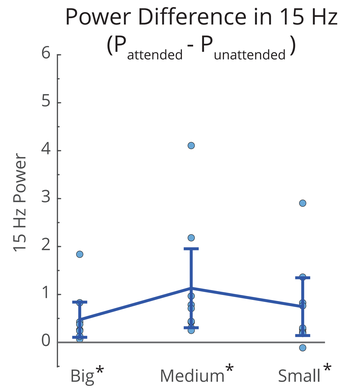
Bandpower was calculated over six posterior electrodes (Pz, PO3, PO4, Oz, O1, O2) in 0.5 Hz bins around each display frequency for bandpower plots.

A support vector machine using bandpower from all 32 channels was used to classify the frequency of the attended stimulus.

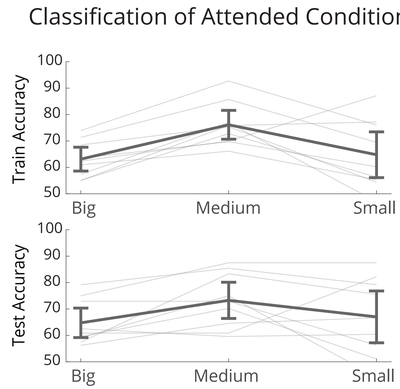
Error bars for all plots represent 95% confidence intervals. * indicates $p < 0.05$.

Varying Checker Size

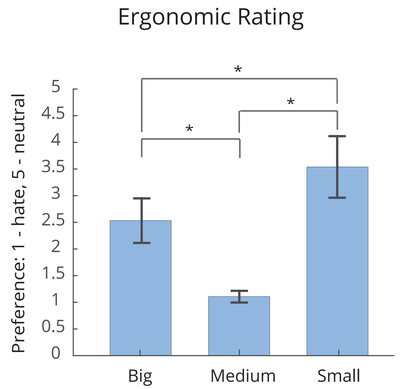




Power is higher for the attended versus unattended condition in both the 12 and 15 Hz bands ($F(1,16) = 8.73$, $p = 0.02$; $F(1,16) = 9.32$, $p = 0.02$, respectively).

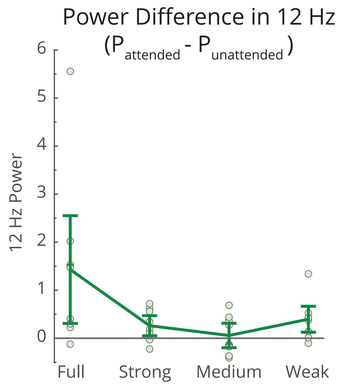


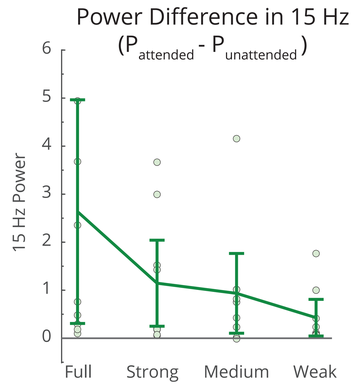
Classification accuracy follows a similar pattern to bandpower across checker sizes.



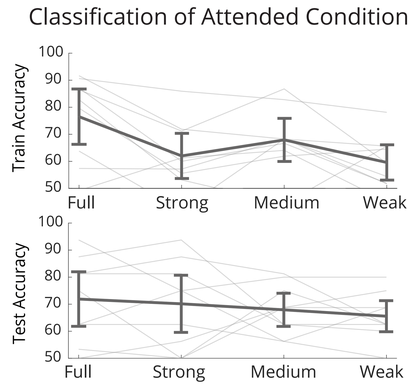
Preference voting varied significantly across checker size conditions.

Varying Checker Opacity

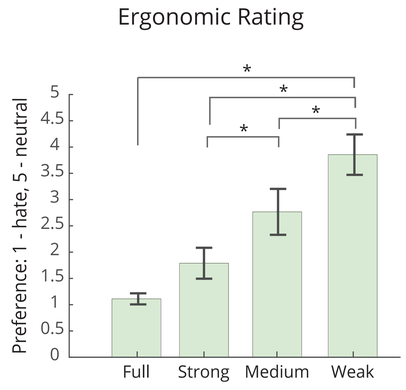




Attention condition interacts with stimulus opacity in both the 12 and 15 Hz bands ($F(3,24) = 4.77$, $p = 0.01$; $F(3,24) = 4.28$, $p = 0.01$, respectively). Power is higher for the attended versus unattended condition ($F(1,24) = 8.23$, $p = 0.02$; $F(1,24) = 5.49$, $p = 0.05$, respectively).



Classification accuracy decreases with reduced opacity.



There is an inverse linear ($R^2 = 0.82$) relationship between opacity and preference.

Video-checkerboard stimuli may be a feasible and more ergonomic alternative to traditional checkerboard stimuli.

We observed a decrease of 1.5% in classification accuracy with each 10% increase in ergonomic rating ($R^2 = 0.58$).