Power of 10-Hz Steady State Visual Evoked Potentials in an Magnetooencephalogram as a Function of Steady State Duration

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Introduction

• Researchers are still conducting experiments to test the feasibility of measuring brain activation with the use of brain imaging devices

• Some critics have claimed that neuroscience is the "new phrenology" (Shepherd Ivory Franz, 1912) because they do not understand how to operate the equipment or understand the data.

• One primary criticism is that the data is often very noisy and the methods for correcting or removing the noisy artifacts can be questionable. Sometimes it is difficult to detect the target signal through the noise without a correction.

• By exposing participants to an oscillating stimulus you can record steady state visual evoked potentials (ssVEPs) oscillating at a known frequency, i.e. the stimulation frequency (Moratti et al., under review).

• When recording ssVEPs the surrounding neurons should also oscillate at the stimulation frequency. Under the assumption that many of the noisy artifacts that occur in this data are the result of neurons oscillating at varying frequencies, creating ssVEPs should allow the researcher to detect any differing activity as a result of some target manipulation.

• The purpose of this study is to test the hypothesis that creating ssVEPs results in a greater signal-to-noise ratio (SNR) in the recorded data.

• If increasing the SNR is possible through the creation of ssVEPs then it would be interesting to discover if the duration of the oscillating stimulus affects this SNR further.

• To test these hypotheses, participants were exposed to a 10 Hz oscillating stimulus at one of three different durations: 1000 ms, 2000 ms, or 4000 ms.

Methods

• Participants
  • Five University of Georgia students participated for fulfillment of a research appreciation requirement (19-27 years old, 1 Female).
• Steady state visual evoked response task
  • Steady State: Monochrome checkerboard oscillating at 10 Hz for one of three durations: 1000 ms, 2000 ms, or 4000 ms.
  • Transient Stimuli: White or Grey box appeared in the center of the monitor 500 ms before, 500 ms after, or 1000 ms after the offset of the steady state.
  • Participants were to make a button press when they observed the grey box.
• Magnetoencephalographic (MEG) data
  • Recorded using a CTF Omega whole-cortex MEG system with 143-channel channels (Omega 2000, VSM MedTech Inc., Port Coquitlam, Canada).
  • Bad sensors dropped from analysis and artifacts corrected using BESA 5.1.
  • Transformed to average reference and bandpass filtered from 1–30 Hz.

Results

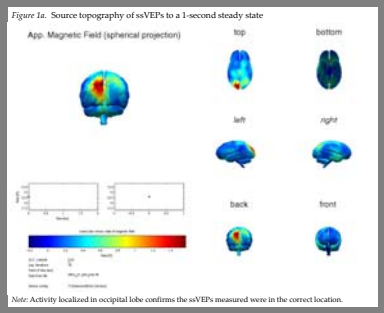

Figure 1a. Source topography of ssVEPs to a 1-second steady state

Note: Activity localized in occipital lobe confirms the ssVEPs measured were in the correct location.

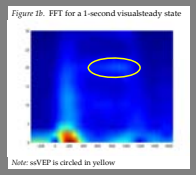

Figure 1b. FFT for a 1-second visualsteady state

Note: ssVEP is circled in yellow

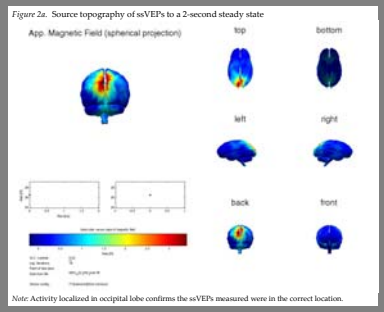

Figure 2a. Source topography of ssVEPs to a 2-second steady state

Note: Activity localized in occipital lobe confirms the ssVEPs measured were in the correct location.

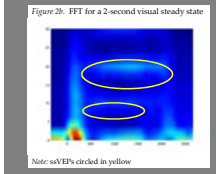

Figure 2b. FFT for a 2-second visual steady state

Note: ssVEPs circled in yellow

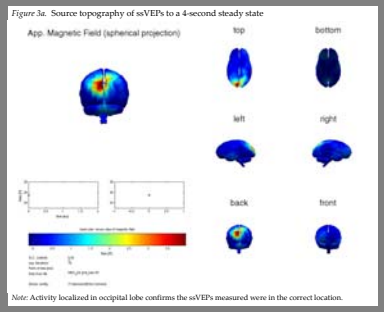

Figure 3a. Source topography of ssVEPs to a 4-second steady state

Note: Activity localized in occipital lobe confirms the ssVEPs measured were in the correct location.

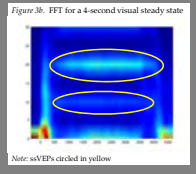

Figure 3b. FFT for a 4-second visual steady state

Note: ssVEPs circled in yellow

Discussion

• Figure 1: 1000 ms steady state
  • The 1000 ms steady state stimulus produced a thin line of activation at the 10 Hz level but greater activity it the high beta frequency range (20-30 Hz). While this line is thin, it does show that the manipulation was successful at inducing 10 Hz ssVEPs with a 1000 ms oscillating stimulus.

• Figure 2: 2000 ms steady state
  • Even using a longer duration steady state stimulus produced a clearer band of activity in the first harmonic. Discussion of the difference in these spectral peeks lies below.

• Figure 3: 4000 ms steady state
  • The longest duration steady state resulted in the most powerful ssVEP but again mostly in the higher frequencies.

• The duration of the steady state has a large effect on the power of the ssVEP that is recorded in a magnetoencephalogram, though the effect of a 10 Hz stimulus produces ssVEPs in the expected range as well as in higher frequencies.

•The activity in the higher frequencies could suggest two distinct neural mechanisms are operating (Mayville et al., 2001) to produce the spectral ssVEPs in the magnetoencephalograph. Interestingly, the spectral FFTs of the ssVEPs measured by an EEG do not show as much activity in this higher range but there is clear indication that another process is occurring there as well. This might indicate that the activity is an artifact of measuring tangential sources.

References

Franz, S. I. (1912). New phrenology. *Science, 35*, 321-328.

Mayville, Fuchs, Ding, Cheyne, Deecke, & Kelso. (2001). Event-related changes in neuromagnetic activity associated with syncopation and synchronization timing tasks. *Human Brain Mapping, 14*, 65-80.

Moratti, S., Clementz, B., Gao, Y., Ortiz, T., & Keil, Andreas. (under review). Neural mechanisms of evoked oscillations: Stability and interaction with transient events. *Human Brain Mapping*.

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