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

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Introduction

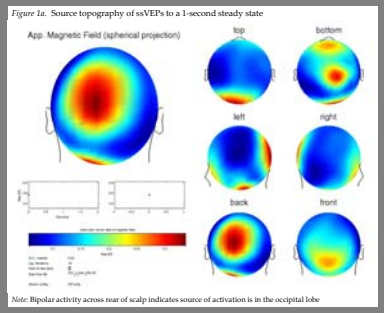
- Researchers are still conducting experiments to test the feasibility of measuring brain activation with the use of brain imaging devices
- Some critics have claimed that neuroscience is the "new phrenology" (Shepherd Ivory Franz, 1912) because they do not understand how to operate the equipment or 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
  - Six University of Georgia students participated for fulfillment of a research appreciation requirement (19-27 years old, 2 Females).
- 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.
- Electroencephalographic (EEG) data
  - Recorded vertex referenced using a 256-sensor Geodesic Sensor Net (Electrical Geodesics, Eugene, OR).
  - Bad sensors dropped from analysis and artifacts corrected using BESA 5.1.
  - Transformed to average reference and bandpass filtered from 1–30 Hz.

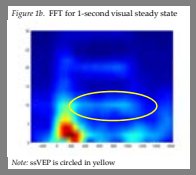
Results

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



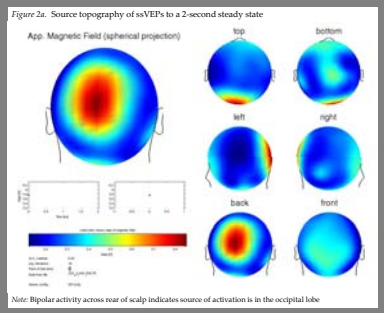
Note: Bipolar activity across rear of scalp indicates source of activation is in the occipital lobe

Figure 1b. FFT for 1-second visual steady state



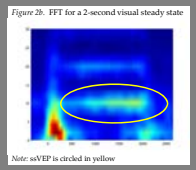
Note: ssVEP is circled in yellow

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



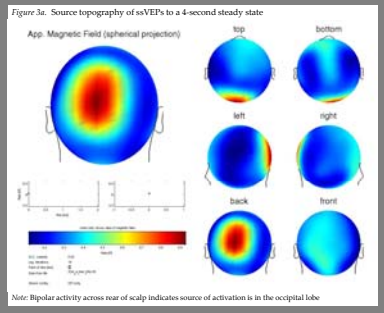
Note: Bipolar activity across rear of scalp indicates source of activation is in the occipital lobe

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



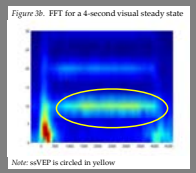
Note: ssVEP is circled in yellow

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



Note: Bipolar activity across rear of scalp indicates source of activation is in the occipital lobe

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



Note: ssVEP is 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. 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
  - Using a longer duration steady state stimulus produced a more clear band of activity. This 10 Hz activity is thicker than it was in the 1000 ms condition, demonstrating the greater power of producing a steady state with a 2000 ms oscillating stimulus.
- Figure 3: 4000 ms steady state
  - This longer duration results in a more definitive demonstration of the power of the duration of the oscillating stimulus. When the stimulus oscillated for only 1000 ms a thin band of ssVEP activity was recorded at 10 Hz. Increasing this steady state stimulus to 2000 ms produced a clearer, stronger 10 Hz ssVEPs. However, it was the 4000 ms steady state duration that produced the largest and most clear 10 Hz ssVEPs.
- The duration of the oscillating stimulus has a large effect on the power of the ssVEP that is recorded in an electroencephalogram.
- Minor spectral activity in higher frequencies may indicate presence of two distinct neural mechanisms (Mayville et al., 2001). On the other hand this could be an artifact of measuring activity from neurons tangential to sensors.

References

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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.

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