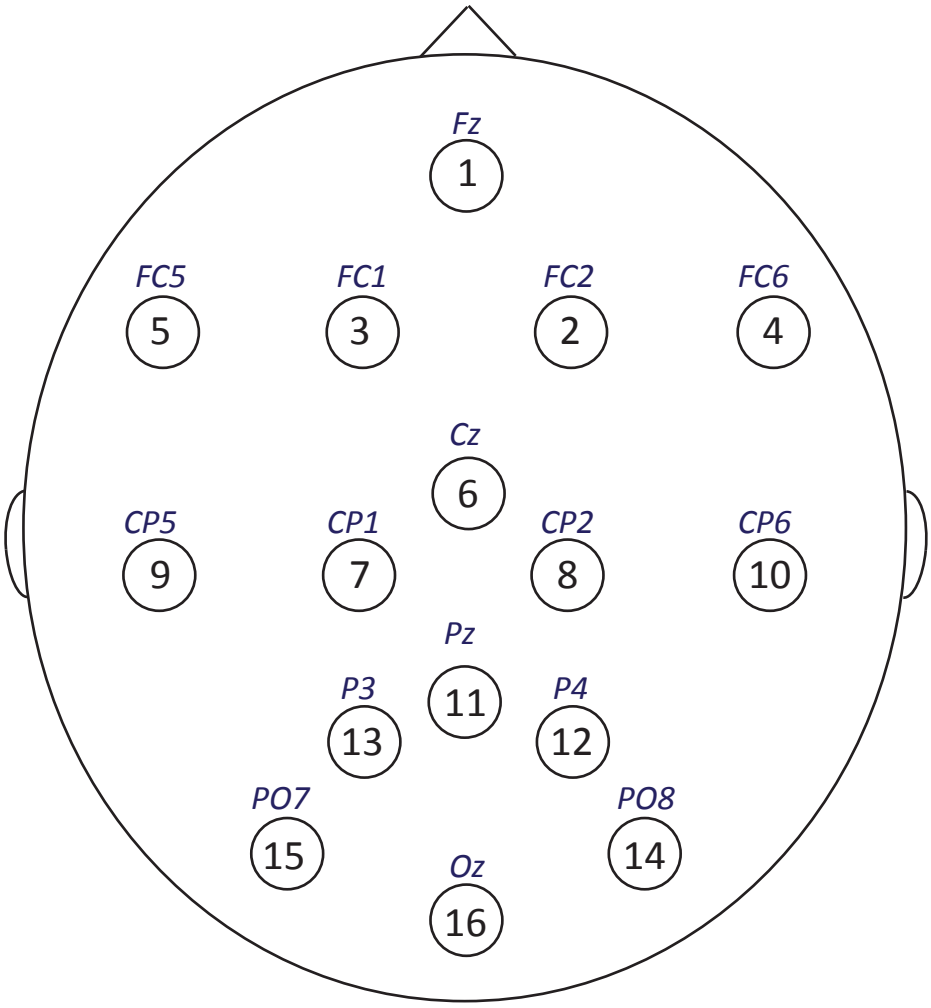
COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Lab Instruction 8
Steady State Visually Evoked Potentials

Brain Computer Interface Lab
ECBM 4090



Steady State Visually Evoked Potentials (SSVEP) are natural responses to visual stimulation at specific frequencies. When the retina is excited by a visual stimulus ranging from 3.5 Hz to 75 Hz, the brain generates electrical activity at the same frequency as the visual stimulus (or at multiples of that frequency).

This technique is used widely in EEG research on vision. SSVEPs are useful because they have a high signal-to-noise ratio and are relatively immune to artifacts. They provide a way to characterize preferred frequencies of neocortical dynamic processes. SSVEPs are also commonly used in BCI application because they are highly reliable detectable responses and can be used to measure subject's attention.

In this project, we will present flashing visual stimuli at different frame rates and record EEG responses as the subject visually attends to the stimuli. We will study SSVEPs by measuring the magnitude of the neural response at the modulator frequency (f_m). Unlike ERPs but similar to ASSR, SSVEP is *not* a time-locked response and is measured in the *spectral* domain.

Setup:

1. Electrodes: **Fz, Cz, Pz, P3, P4, PO7, PO8, Oz.**
2. Filter: Bandpass 0.5Hz to 60Hz. Notch at 60Hz.
3. Visual stimuli can be downloaded from Courseworks (framerate12/24/30.avi).

Experiment 1: Measuring SSVEP at various frequencies

1. Collect EEG data responses to visual stimuli at a frame rate of 12Hz.
    a. Start recording the EEG signal.
    b. Begin the stimulus ~10 seconds after the recording onset.
    c. Make sure the movie covers a large area on the monitor and ask the subject to visually focus on the flashes.
    d. Remember to discard the first 10 seconds of the data in your analysis.

2. Repeat this process for 20Hz and 30Hz visual stimuli. **Save each EEG condition to separate files!**

Report: Frame rate 12 means that each frame (black or white) is shown for 1/12 second. What is the frequency of the visual stimuli (how many full cycles per second) when the frame rate is 12Hz, 20Hz, and 30Hz? (3 pts)

Experiment 2: Online decoding of the SSVEP response

1. Create a Simulink module for online decoding.
    a. Build a module similar to the one you used in the ASSR Attention to compare response power in two frequencies: 20Hz and 30Hz.
    b. Your module should estimate the ratio of low-passed envelope of the EEG response at these two frequencies.
    c. Display the relative magnitude of the 20Hz and 30Hz SSVEPs.

2. Collect EEG data in this paradigm.
    a. Play the 20Hz and 30Hz movies simultaneously on opposite sides of the display.
    b. Ask the subject to look at one video, then the other video, while monitoring the module output.
        i. Take screenshots during each attentional condition

Report: Are you able to detect the attended visual stimulus in real-time? Include screenshots of the SSVEP power during each attentional condition. (7 pts)

Homework: Use only Experiment 1 data!

Load the EEG signal in MATLAB. Start by taking the Fourier transform of each channel and averaging the FFT magnitude over all channels. Plot the average magnitude. (1 pt)

Question 1. If the length of the FFT is L, given the sampling frequency of your EEG signal (256Hz), which sample in FFT corresponds to each frame rate? Mark that frequency on the plots (you can zoom in to increase the resolution). (2 pts)

Next, display all channels at the modulator frequency.

Question 2. Create scalp maps showing the average magnitude of the SSVEP signal over all channels for all three stimuli used. Which stimulus generated the maximum response? Which scalp areas had the strongest SSVEP? (3 pts)

Question 3. Divide the strongest SSVEP case into 30s intervals and plot the normalized magnitude of the SSVEP signal as a function of the signal duration. At what duration can you reliably detect the presence of the SSVEP? (2 pts)

Question 4. From the data collected in the paradigm where you play 30Hz and 20Hz simultaneously and subject attends to only one of the two, plot FFT showing the SSVEP peaks for a) Attend 20Hz and distractor 30Hz and b) Attend 30Hz and distractor at 20Hz. What happens to 20Hz and 20 Hz peaks in FFT for condition a and b respectively? (2 pts)