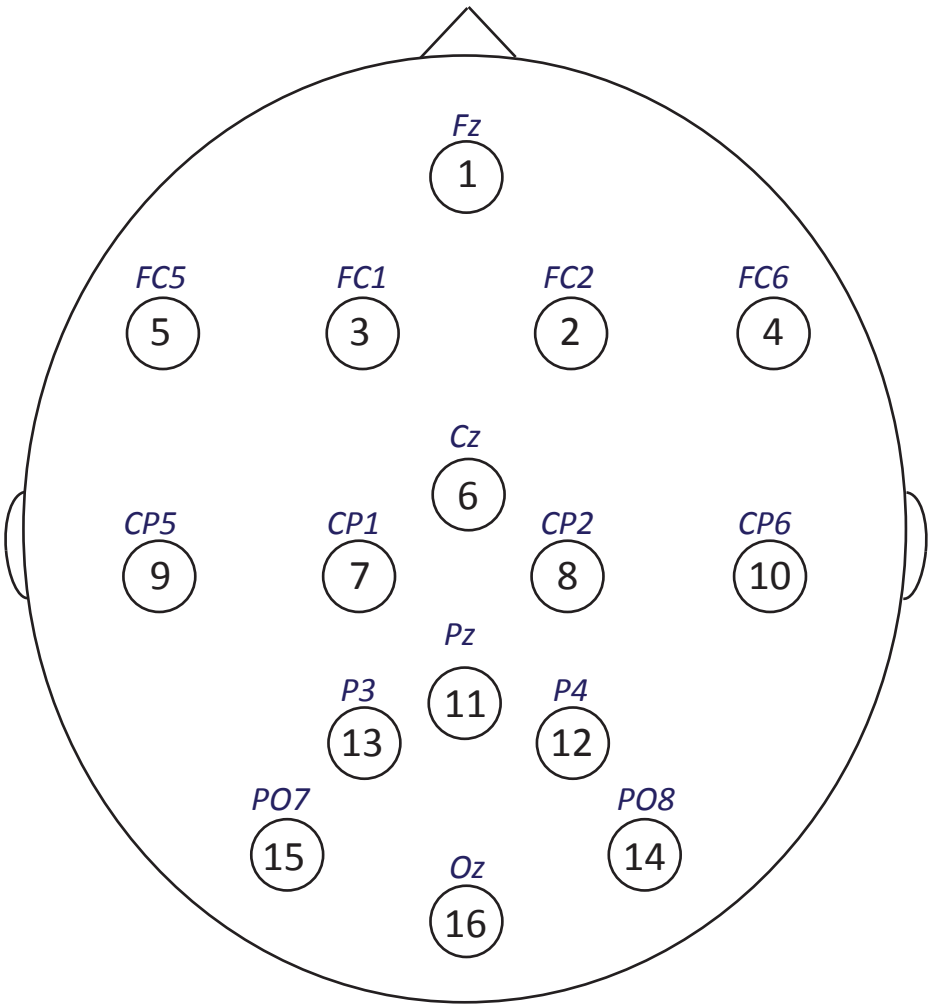
COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Lab Instruction 4
Auditory Oddball Paradigm

Brain Computer Interface Lab
ECBM 4090



Event Related Potentials: Auditory Oddball Experiment

In this experiment, we will explore event related potential (ERP) by designing an auditory oddball task.

The **oddball paradigm** is an experimental paradigm used in ERP research, where presentations of sequences of repetitive **standard** audio/visual stimuli are infrequently interrupted by a **deviant** stimulus. The subject is asked to react by silent counting or button pressing to incidents of target/deviant stimuli (hidden as rare occurrences) amongst a series of more common/standard stimuli (that often require no response). A negative ERP component called N200 (or N2) is typically evoked around 200ms after the onset of deviant stimulus. Additionally, a positive ERP component, known as P300, occurs around 300ms after the stimulus onset and has been found to be larger after target stimuli (the stimulus that subject is paying attention to–in this case deviant stimuli).

In this experiment, we will explore the following questions:

1) What is the shape and magnitude of the ERP for a) standard sounds and b) deviant sounds?
2) Which electrodes show a stronger ERP response?
3) Does the ERP depend on the subject's attention? If yes, how?

To create the oddball experiment, you need Simulink to play sounds at regular intervals. You will need to create a trigger signal to mark the beginning of the standard sounds and deviant sounds and save the triggers in sync with the EEG signal. You can use the trigger to separate target from non-target stimuli.

Setup:

1. Electrodes: Since we are interested in creating a scalp map of the ERP, we will use **all electrodes** in this experiment.
2. Filter: Bandpass 0.1Hz to 60Hz. Notch at 60Hz. Make sure to leave sufficient time for the EEG signal to settle before beginning the recording of experimental trials.

Task 1: Creating the sound and storing triggers to a .mat file

1. Create the sound.
    a. Create a Simulink s-function to play a 100ms tone (a sinusoid) at a frequency of 500Hz every 0.7 seconds.
    b. Hint: To create a sound duration d, frequency f, and sampling rate fs:

```
T = (1:d*fs)/fs;
W = sin (2*pi*T*f);
```

2. Create a trigger signal.
    a. S-functions can have an output port which can be accessed from their Simulink block. Create a trigger signal using the output of the s-function (**block.OutputPort(1).Data**) that will indicate every time you play a sound.
        i. Hint: The output of the s-function block (block.OutputPort(1).Data) is updated **only** at the end of the s-function's execution. Therefore, if you make several

changes to this variable during the execution of the s-function, the output will reflect only the very last change.

ii. Hint: You can define global variables that maintain their value from different calls to the s-function. Use the following format:

Define the variable in the start() function:

```
function Start(block)
global tmp;
tmp = 0;
```

and access it in the output function:

```
function Output(block)
global tmp;
tmp = tmp+1;
disp(tmp);
```

b. Connect your trigger to the scope and add it as an input to the To File module. The trigger will be saved to file in sync with the EEG data.

3. Collect at least 400 repetitions of the tone. If breaks are needed, collect the repetitions in two or more separate experiment blocks, and **make sure to save to different files**. In this case, you will need to concatenate the trials across different blocks in MATLAB.

Report: Open the recorded EEG files in MATLAB. Find the onset of the tones as indicated by the trigger signal you generated and saved. For each electrode, create the Event Related Potential (ERP) by averaging the EEG waveform across all trials. Include 100ms before and 600ms after the onset of the tone. Show the ERPs for each channel in one plot. Determine which electrodes have the strongest ERP response and show the average ERP over those electrodes. (3 pts)

Task 2: Designing the oddball paradigm:

In the previous task, you generated a tone and were able to estimate the ERP response. Here, we will create two tones, one that occurs frequently (standard), and one that occurs rarely (deviant). The subject will count the number of deviant sounds. Your task is to compare the ERP response between the standard and the deviant.

1. Generate a standard tone and a deviant tone.
   a. Modify the Simulink function to randomly choose between a 500Hz and 900Hz tone in each trial, with one tone being played less frequently.
   b. The probability of 500Hz = 0.85, and the probability of 900Hz = 0.15.
      i. Use rand(1) function in MATLAB.
      ii. Play 500Hz if rand(1) is less than 0.85. Otherwise play 900Hz.

2. Modify the trigger code to create different values for each tone so that you can later separate the responses to standard and deviant in MATLAB.

3. Collect data.
    a. Ask the subject to count the number of times the deviant stimulus occurs.
        i. The P300 wave occurs more reliably and with a larger amplitude if the subject is actively engaged in the task of detecting the targets.
        ii. The P300 wave amplitude also varies with the improbability of the targets.
    b. Collect at least 400 trials, separated into blocks as needed. Your average signals look better the more data you collect. **Make sure not to overwrite the same file!**

4. Run the experiment again, but ask the subject to ignore the stimuli. This can be accomplished by playing a video *without audio* for the subject to attend to.
    a. Collect at least 400 trials, separated into blocks as needed. **Make sure not to overwrite the same file!**

Report: Open the "with attention" EEG file (Task 2.3) in MATLAB and repeat the analysis from Task 1 by plotting the average ERPs overall and the average ERPs over the electrodes with the strongest response. This time, separate the trials with frequent tones from those with infrequent tones. Plot the average ERP responses to the frequent and infrequent tones on the same figure and compare the waveforms. Plot the scalp map of each ERP at 0, 100, 200, and 300ms after the onset of the tone. Use topoplot.m from EEGLAB and BCI.locs on Courseworks. Describe the differences you see between the standard and deviant ERPs and topoplots. (7 pts)

Homework: Compare the "with attention" and "without attention" ERPs

- Open the "with attention" and "without attention" EEG files in MATLAB.
- Plot the average ERP responses to the frequent and infrequent tones for the "with attention" and "without attention" conditions for all electrodes and determine the electrodes with the strongest response (5 pts)
- Plot the average ERP responses to the frequent and infrequent tones for the "with attention" and "without attention" cases, averaged over the strongest electrodes (2 pts)
- Describe the differences you see between the averaged standard and deviant ERPs for the "with attention" and "without attention" conditions. Specifically, compare the MMN and P300 components. (2 pts)
- Based on prior research, which ERP component should you use to determine if the subject was paying attention? Does this match your experimental data? (1 pt)