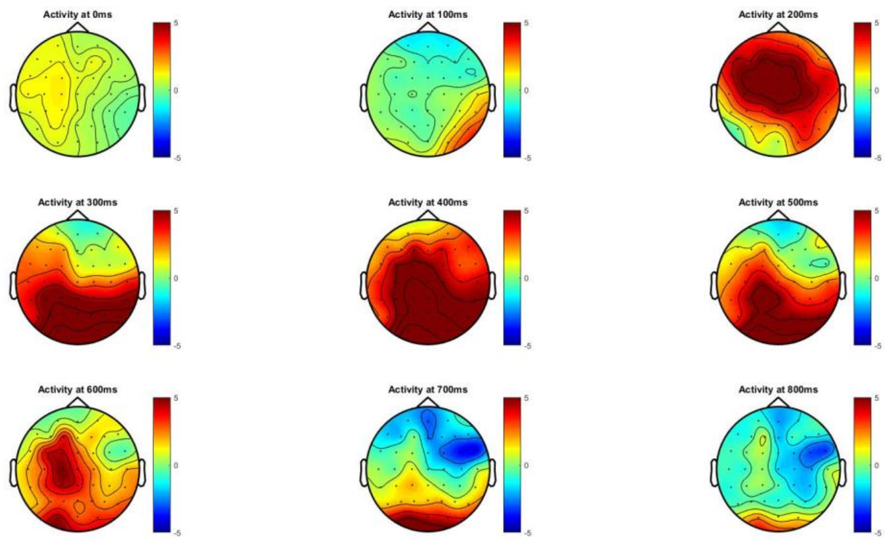
Brain Computer Interfaces (Fall 2017, ELE 594)

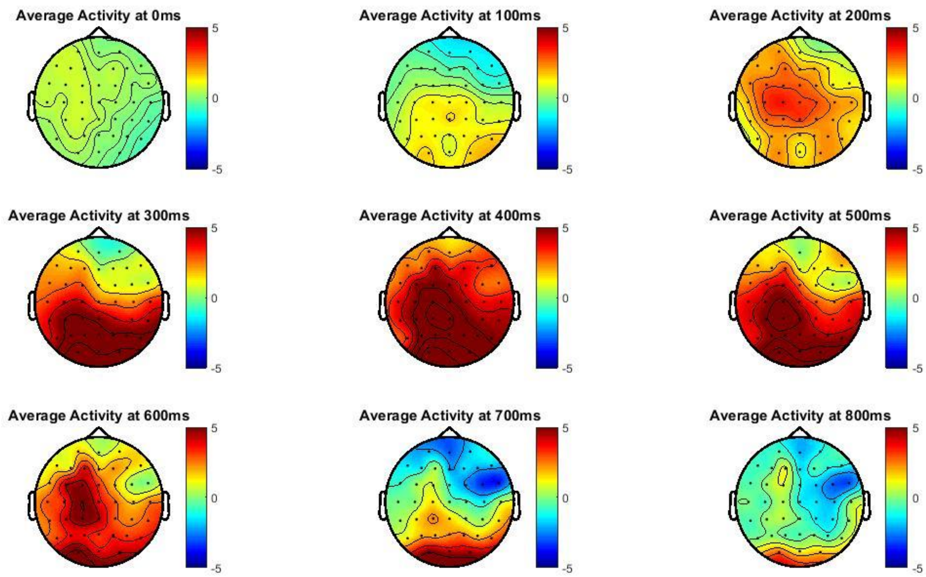
1st Homework Solutions

Question 1-a):

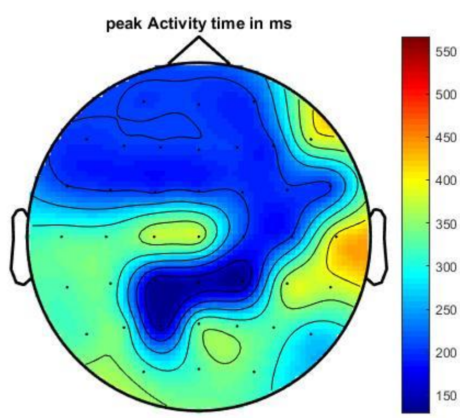
The window of interest (0 to 800ms) was extracted and averaged over the 99 trials



To increase SNR, at each time point activity was averaged from 20 ms before until 20 ms after:



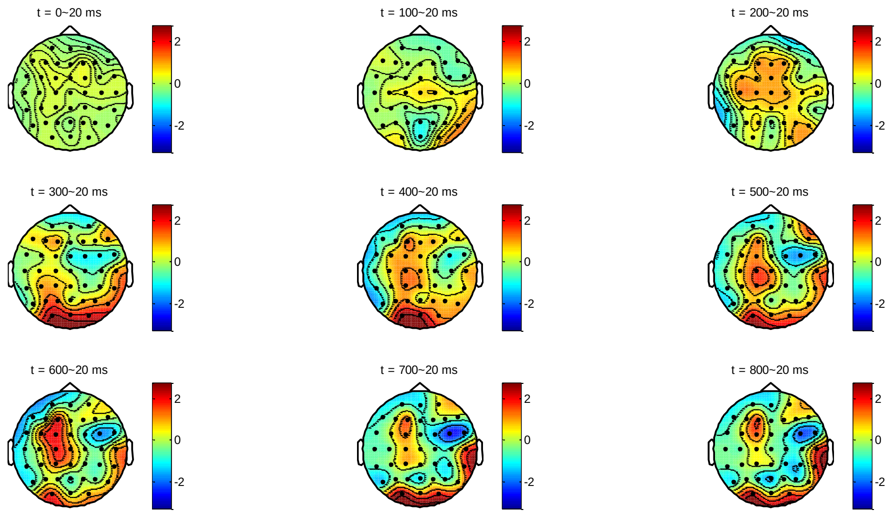
Question 1-b):



In this question, Topoplot was used in a brilliant way in order to display the time peak of the ERP in every channel, this means we are looking at time course of peaks across different brain locations. Central parts of parietal lobe show the earliest peak responses (around 100 ms) and right temporal shows the latest peak responses (around 400-500 ms).

Question 1-c):

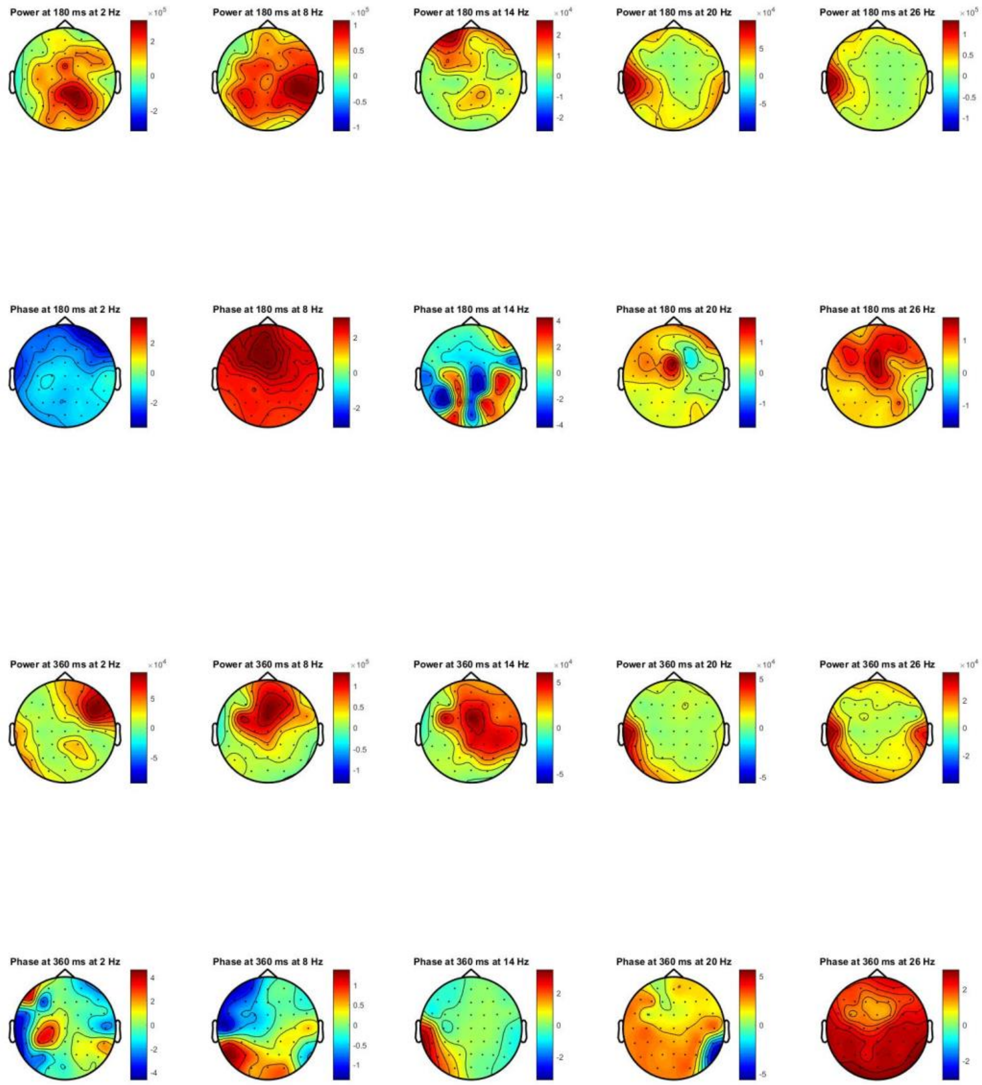
In this Question, we applied a Large Laplacian filter. To do so, neighbor electrodes were identified based on the given criteria, then the corresponding weights were calculated. The weight of each neighbor electrode was somehow inversely proportional to the distance separating it from the electrode of interest, relative to the distance separating it to all the other neighbor electrodes

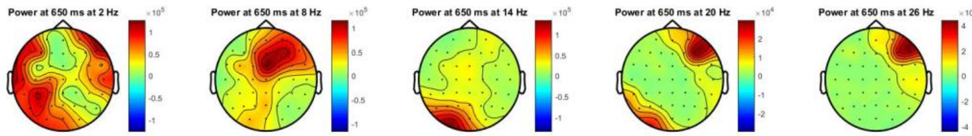


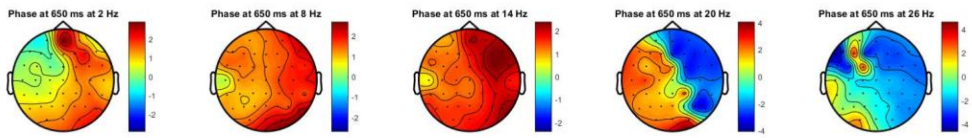
Large Laplacian clearly produced more localized plots by subtracting the activity of the neighboring channels.

<u>Question 2):</u>

A family of complex wavelets at 5 frequencies from 2 Hz to 30Hz was created. The Morlet wavelet was simply created by multiplying a complex sine wave at each of the frequencies with a Gaussian window (4 cycles). After creating our family of Wavelet filters, we convolved the EEG data with each filter. To do so, both waves where transformed to the frequency domain using fft, then multiplied together then the Inverse fft was applied to transform the data back into the time domain, the necessary data trimming was performed. After this step, Both Power and Phase were calculated and stored as indicated. The plots show the data after convolution with each of the wavelet frequencies at 180 ms, 360 ms and 650 ms from the stimulus onset.


Power at 180 ms at 2 Hz
Power at 180 ms at 8 Hz
Power at 180 ms at 14 Hz
Power at 180 ms at 20 Hz
Power at 180 ms at 26 Hz
Phase at 180 ms at 2 Hz
Phase at 180 ms at 8 Hz
Phase at 180 ms at 14 Hz
Phase at 180 ms at 20 Hz
Phase at 180 ms at 26 Hz
Power at 360 ms at 2 Hz
Power at 360 ms at 8 Hz
Power at 360 ms at 14 Hz
Power at 360 ms at 20 Hz
Power at 360 ms at 26 Hz
Phase at 360 ms at 2 Hz
Phase at 360 ms at 8 Hz
Phase at 360 ms at 14 Hz
Phase at 360 ms at 20 Hz
Phase at 360 ms at 26 Hz

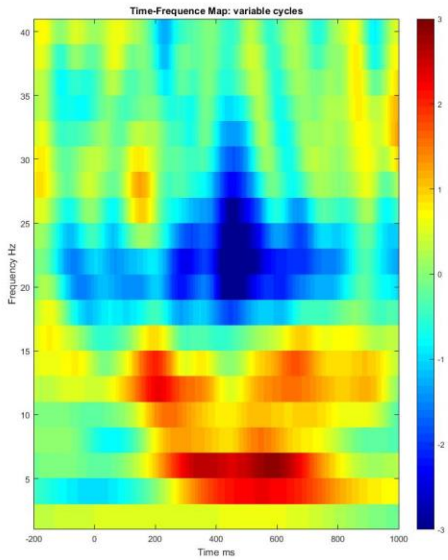


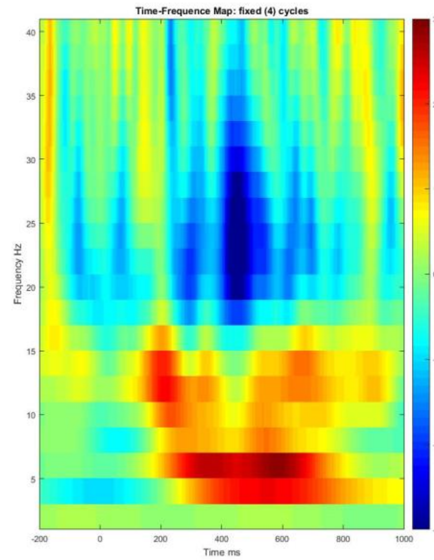


It can be seen that the most dominant frequency components of data are around 8 Hz. In 180 ms after stimulus onset, it is more localized in both the middle right and left parts of the brain, then at 360 ms the activity is propagating to the frontal part and remains there at 650ms. For the phase plots we cannot see any coupling between phases and amplitudes. The phase and amplitudes plots would have similar dynamic if there is only a coupling between them.

<u>Question 2 (Optional Part):</u>

In this Part, channel FCz is specified, and frequencies from 2Hz to 40 Hz are considered. The effect of various cycles [3 10] Hz has being investigated. Small cycles are used for lower frequencies and then it keeps rising with the frequency until it reaches the 10 cycles with the 40Hhz. Average Power is computed over all trials and baseline correction was applied as required. Feature maps were built for both cases fixed cycle (4) and variable cycles as a function of the frequency as below:





By increasing the number of cycles the frequency precision is increasing while the temporal precision is decreasing. The left plot shows more localized frequencies but lower temporal localization in the higher frequency bands since they are the one who used the larger number of cycles (left plot). On the contrary on the right plot, there is low-frequency precision (but higher temporal precisions) in the higher frequencies which uses the same length of cycles (4).