University of Tehran

Faculty of Engineering

Department of Electrical Engineering and Computer Engineering

Introduction To Cognitive Neuroscience

Assignment 3

810102559

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Introduction

Today we will be using eeg data, recorded from 64 channels to investigate an hypothesis, that n170(A negative spike in 170ms after stimulus onset) is more selective to face stimuli then house dolls. But we will use rigorous and informative proofs, plots and statistical analysis to show this.

Preprocessing

The first step is to clean the highly messy data. Eeg data because of its non-invasive methods can record many things other then the brain signal, that are considered noise. We used eeglab for this step because of its rich and old history.

1- After importing our data to eeglab

2- importing the events using the 64th row of the data

3- importing channel locations using the the thetha and phi coordinates of the official Easy-Cap documentation, Figure 1.

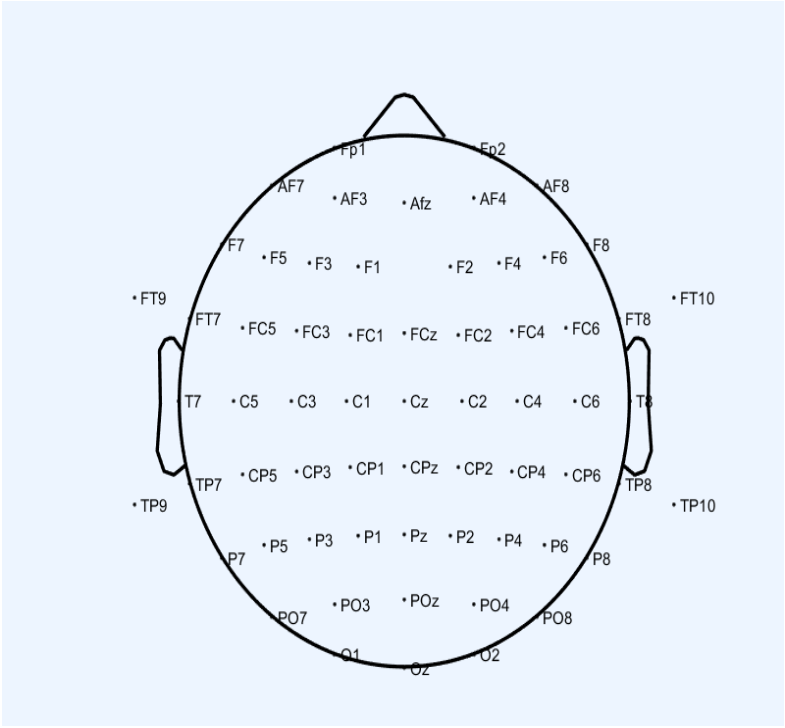


Figure 1: Channel Locations Visualized

4- Resampling the data from 1000hz to 256hz to reduce data size.

5- highpass filter(1hz) to eliminate baseline drifiting noises, Figure 2.

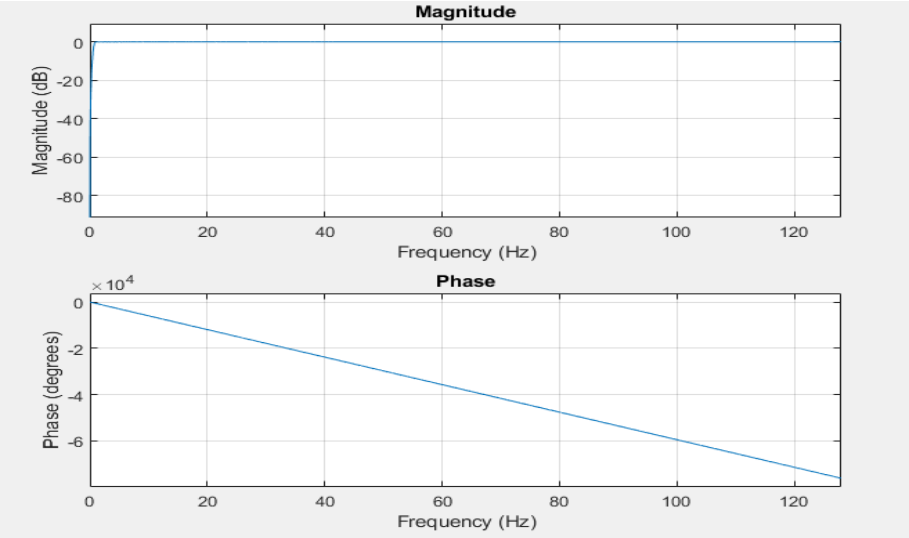


Figure 2: High pass filter Plot

6- Notch filter between 49hz and 51 to take care of city wide line noise(Asia is 50hz), Figure 3.

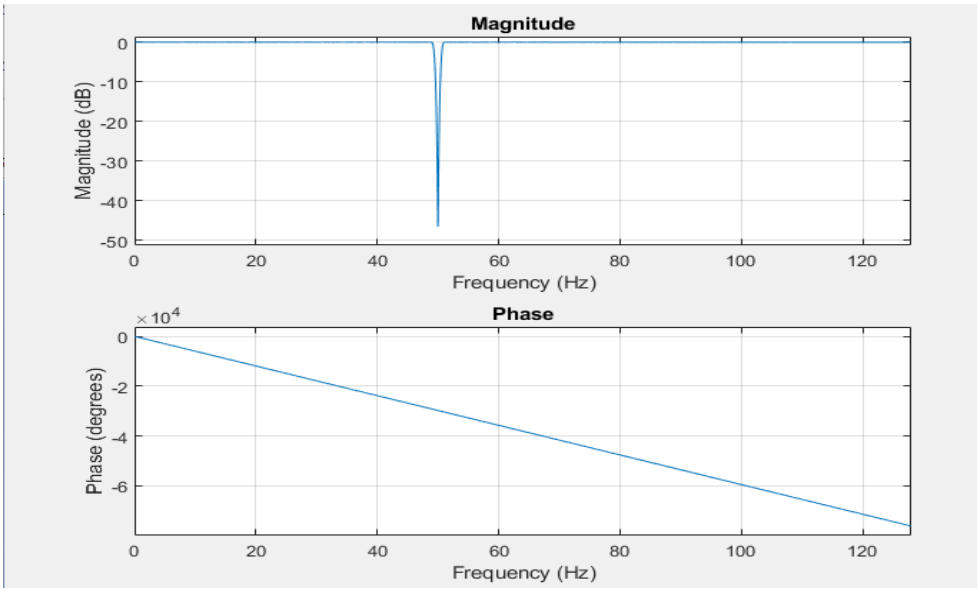


Figure 3: Notch Filter Plot

7- Using asr and clean_rawdata function from, we removed channels that were flat for more then 7 seconds, the minimum acceptable correlation was 0.6 and max acceptable high frequency noise was std was 4, an average of 10 channels were removed per subject, example Figure 4.

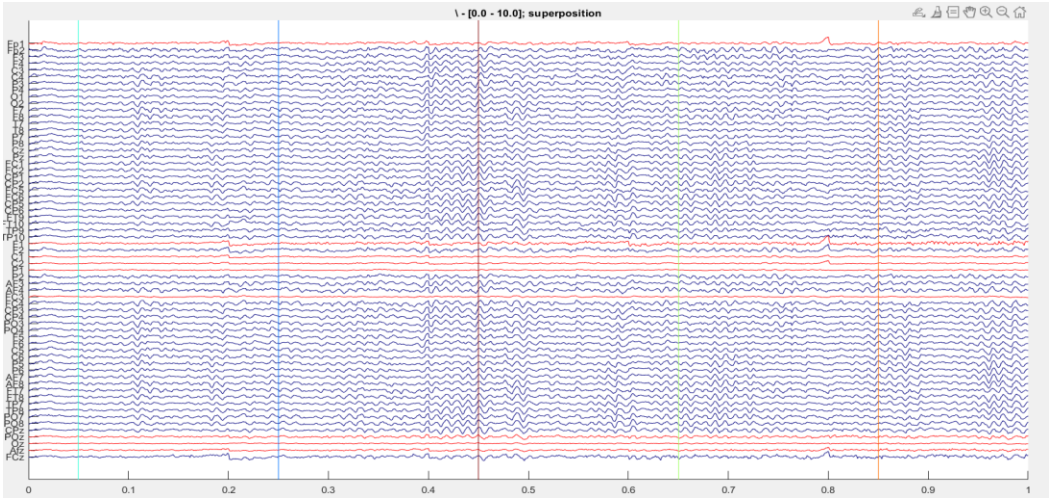


Figure 4: Channel's removed for a subject

8- We then interpolated the removed Channels back so that when averaging, because of the missing data it won't be biased to other channels, also to retain full rank and have the full channel count for averaging.

9- Used Makuto's full rank average reference, because when we average reference, the average of all the electrodes becomes zero, this means now we have n – 1 degrees of freedom, and one of the electrodes values can be calculated using all the other electrodes(Linearly dependent), causing the rank of the data to decrease and this causes problems, so we add the original reference channel(Fz), as a zero filled channel, then we average reference, then we remove it.

10- we epoched between -0.2 and 0.6, so we can have a little bit of the next epochs In each epoch for mvpa.

11- we then removed some epochs by hand, Circa Example Figure 5.

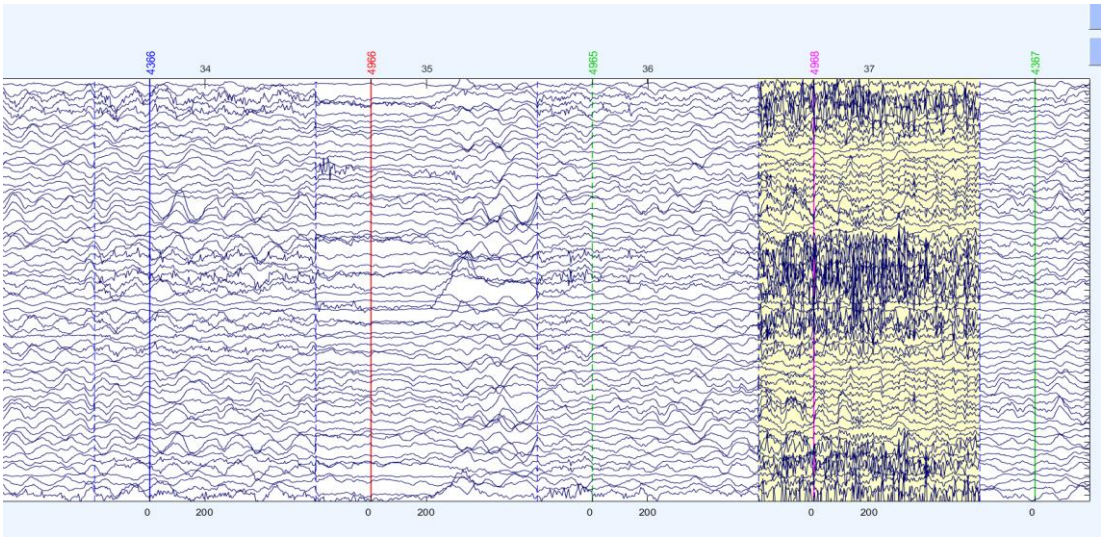


Figure 5: Bad Epoch Example

12- And at the end we removed the basline from -200 ms before to reduce common average brain activiy(e.g thinking about tomorrows dinner) noise.

ERP

Ok so now back to our hypothesis, We want a steeper negative peak at 170ms for faces then house. After Calculating the erp and plotting it, in figure Figure 6 and Figure 7, it clearly Shows that Face has way higher Negative peak at 170ms and house has random behavior around that. But eyes can deceive us, that's why we need to prove this using statistical testing, we do a cluster permutation test to see if our result is actually significant from a random null distribution, as seen in Figure 8, around n170 the difference between face erp and house erp is significant.

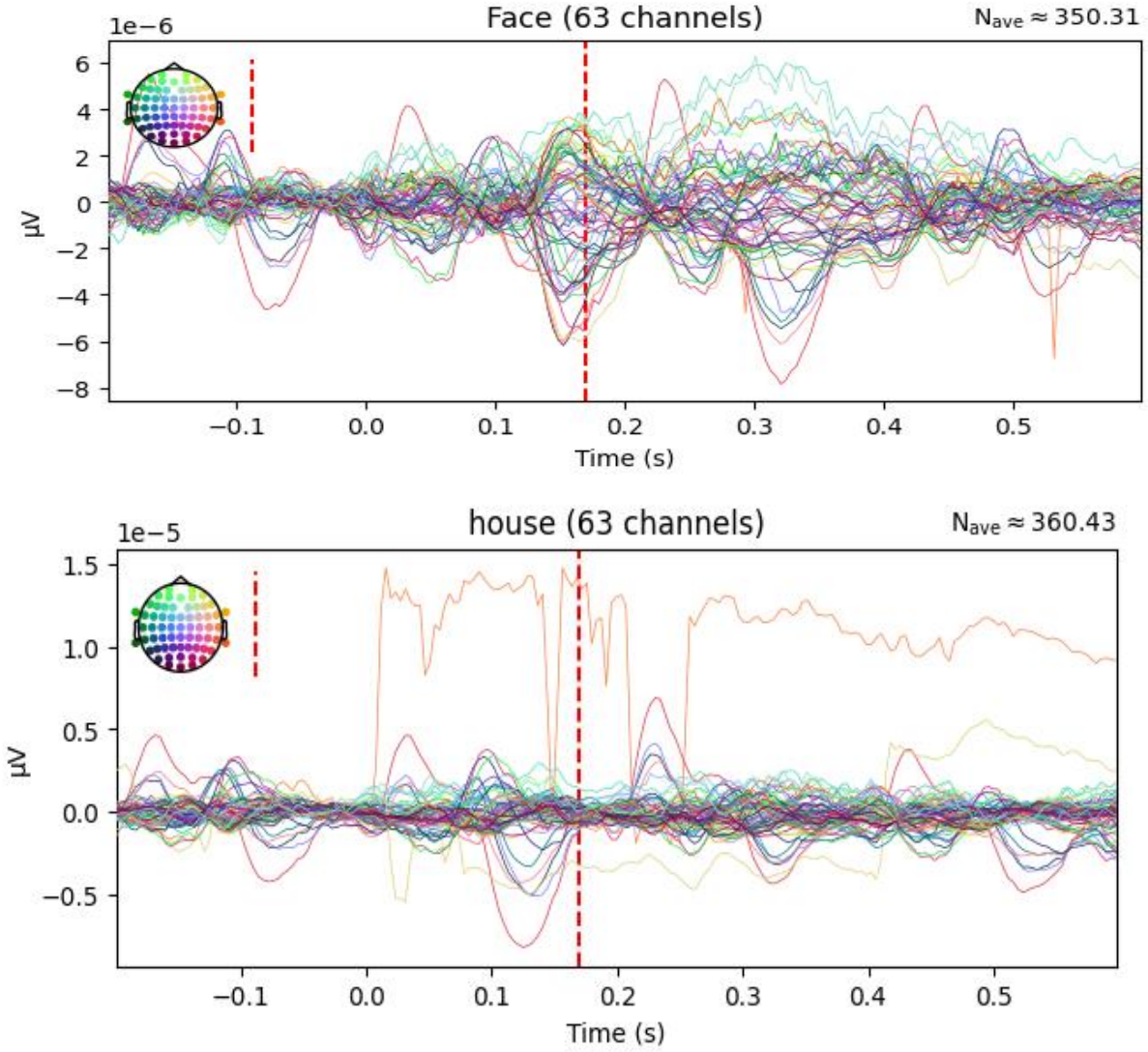


Figure 6: ERP for faces vs houses

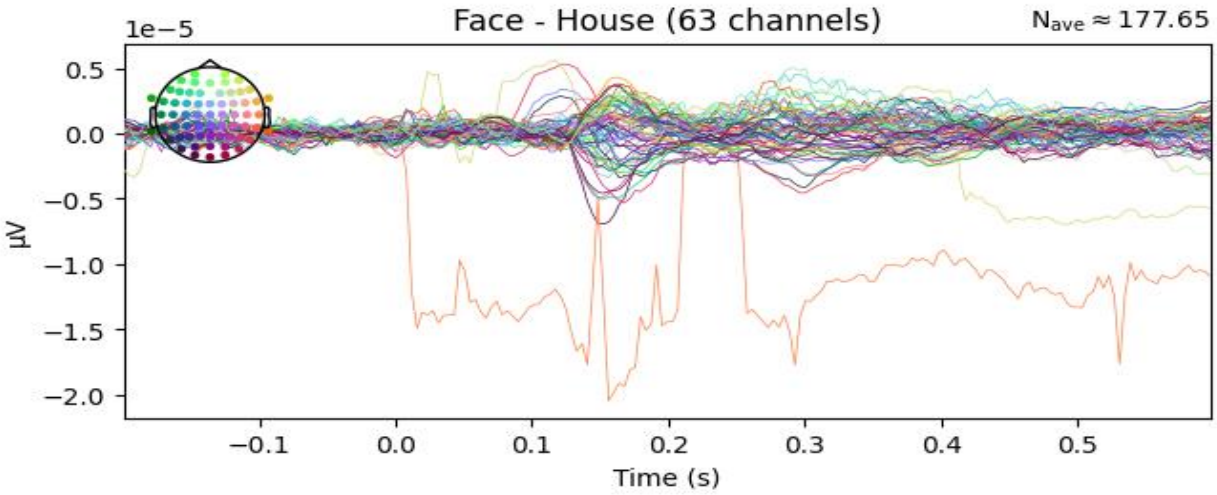


Figure 7: Difference between ERPs of face and house

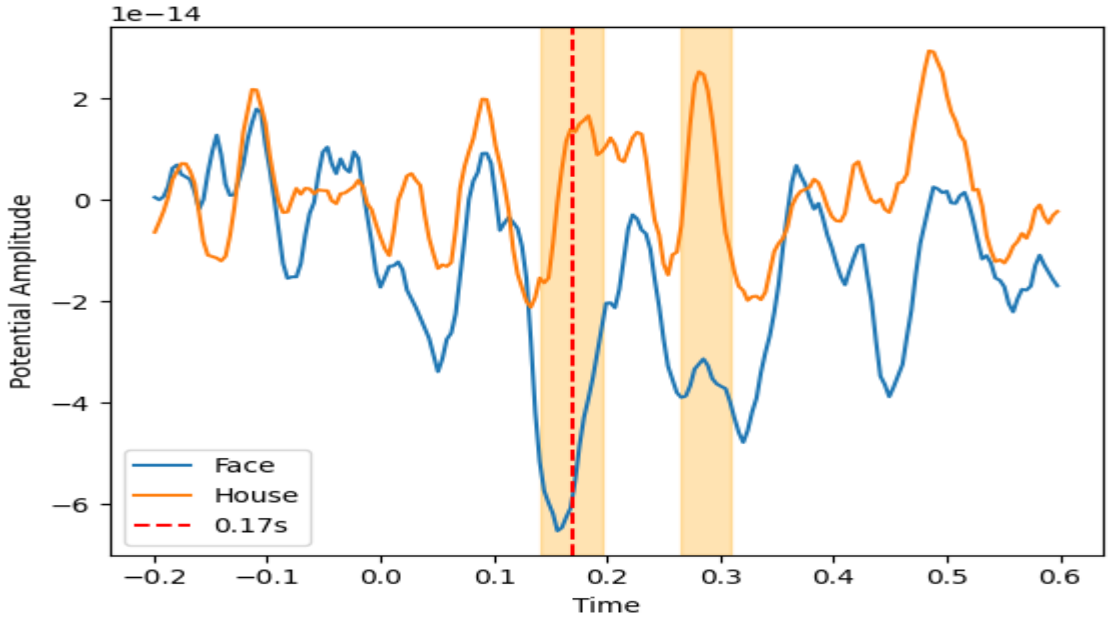


Figure 8: Statistical Testing for ERP

Time-Frequency Analysis

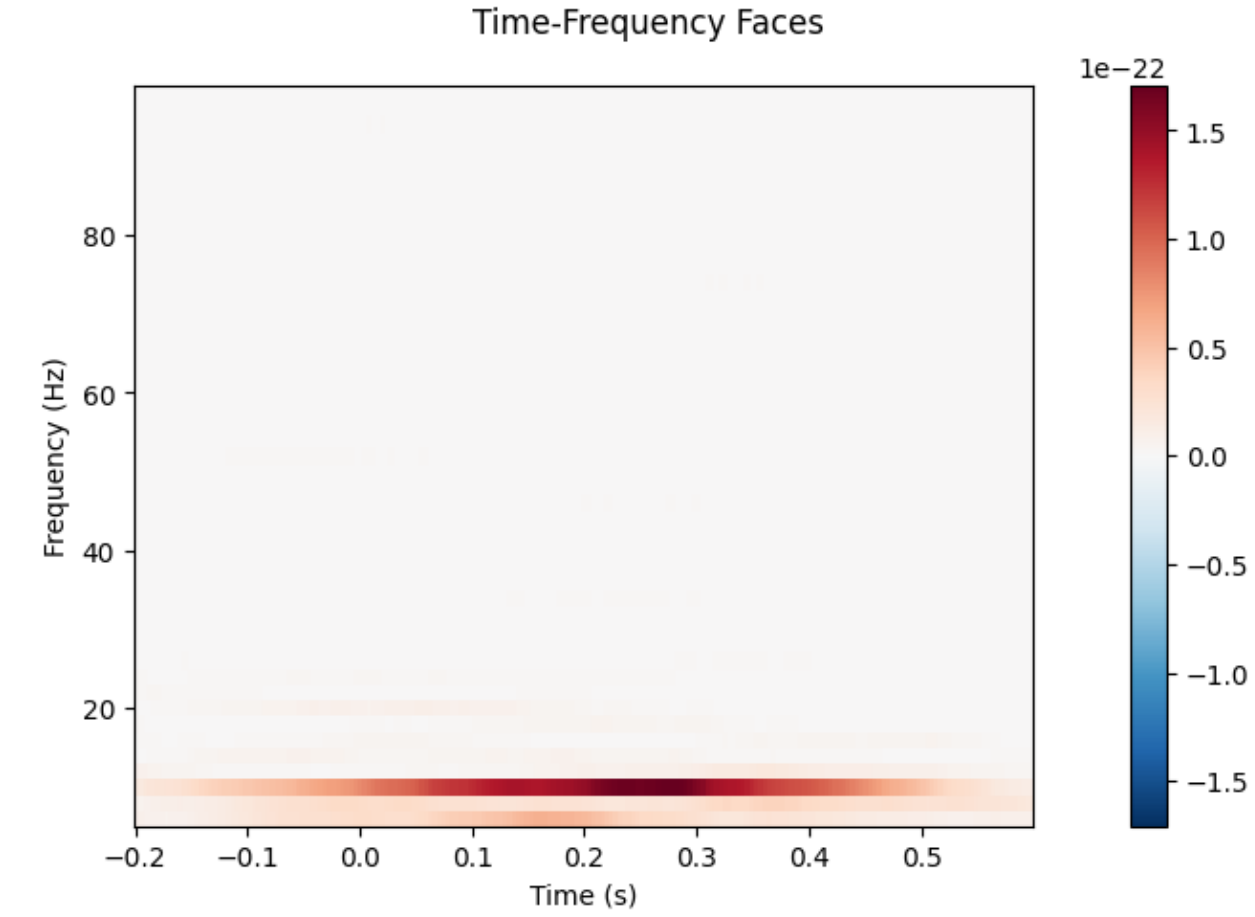
Different frequency bands correlate with different perceptual activites. In Figure 9 Face has higher acitivty in the alpha band in between 0 and 0.2 , this is because face is a way more socially salient stimuli and alpha increases more for these type of stimuli also these might be for face selective regions activites because of n170, but gamma has higher power for house, this is because house is a less recognized and more complex stimuli and might need more ventral stream processing for it.

Delta (0.5–4 Hz): This is for slow processing, often seen in sleep or passed out subjects.

Theta (4–8 Hz): This is for more working memory and is shown for both face and houses, as the brain process things with memory, also its shown in sequential processing.

Beta (13–30 Hz): This is for more prediction and Sensorimotor integration

Gamma (30-100+hz): This is for more feature binding(Color, edges, shapes and etc), and more comlex object recognition.


Time-Frequency Faces
1e−22
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
80
60
40
20
Frequency (Hz)
−0.2
−0.1
0.0
0.1
0.2
0.3
0.4
0.5
Time (s)

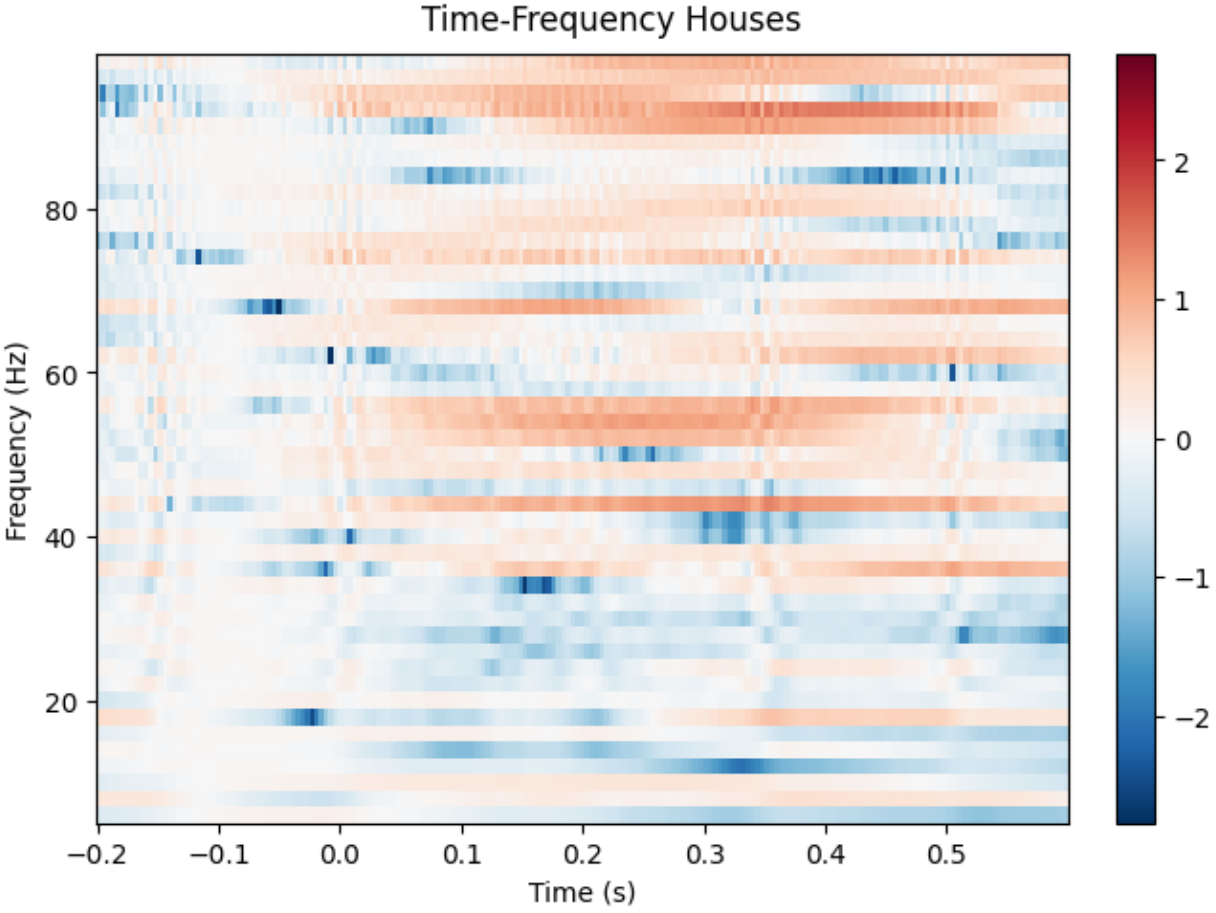

Time-Frequency Houses
2
1
0
−1
−2
80
60
40
20
Frequency (Hz)
−0.2
−0.1
0.0
0.1
0.2
0.3
0.4
0.5
Time (s)

Figure 9: Time Frequency map for both Face and houses

MVPA

Temporal MVPA:

In this section we see if in what time point can a classifier decode face vs house stimulus. As you can see in figure Figure 10, around n170, where it is expected for the brain to respond to face stimuli and not to house stimuli, we have way above chance level accuracy, but just as the wise Obi-Wan Kenobi says "Your eyes can deceive you, don't trust them", We need to conduct a statistical test, so we conduct another permutation cluster test, we even put the threshold at 5 so its very much sensitive, and as we see the area that is significantly above the chance level, Is n170!!!!

So the answer the question in the assignment, yes face and dollhouse can be reliably distinguished using eegpaterns, and a specific time point is more informative, around 170ms!!

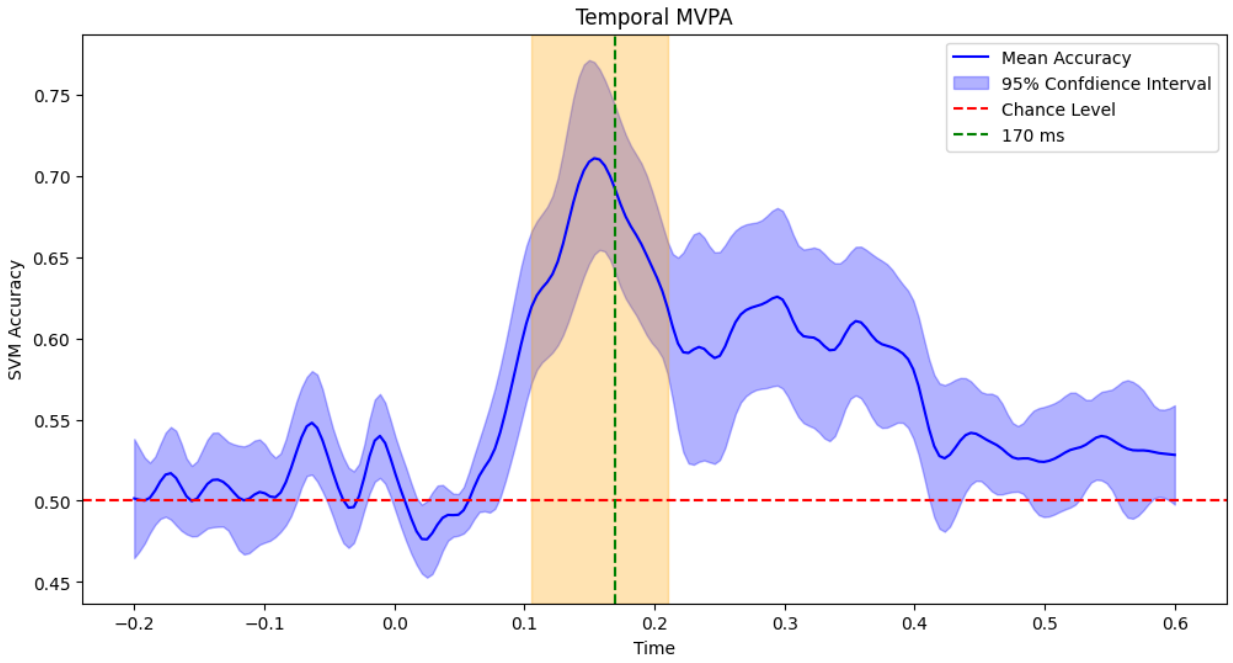


Figure 10: SVM accuracy for temporal mvpa

Spatial MVPA:

Now we want to see which electrode, or brain region is more responsible for n170, as you can see in Figure 11 The back and of the head is used, as the back of the head is usually for object recognition and visual perception, and according to https://en.wikipedia.org/wiki/N170, n170 is right lateriezed, and you can see that in the figure where the lower right is more active. So again to answer the question, yes some other spatial scalps do have more information(lower back right of the head) and it can distinguish between the two stimuli.

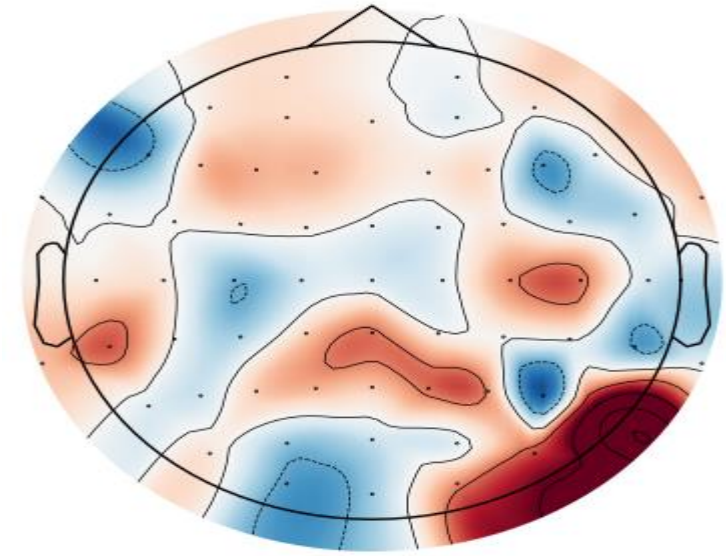


Figure 11:Spatial accuracy

Time Time Genralization:

Now we did time time generalization. Figure 12 shows that visual processing int the earlier stages is higher, around 0.1-0.2(Which is where n170 is)

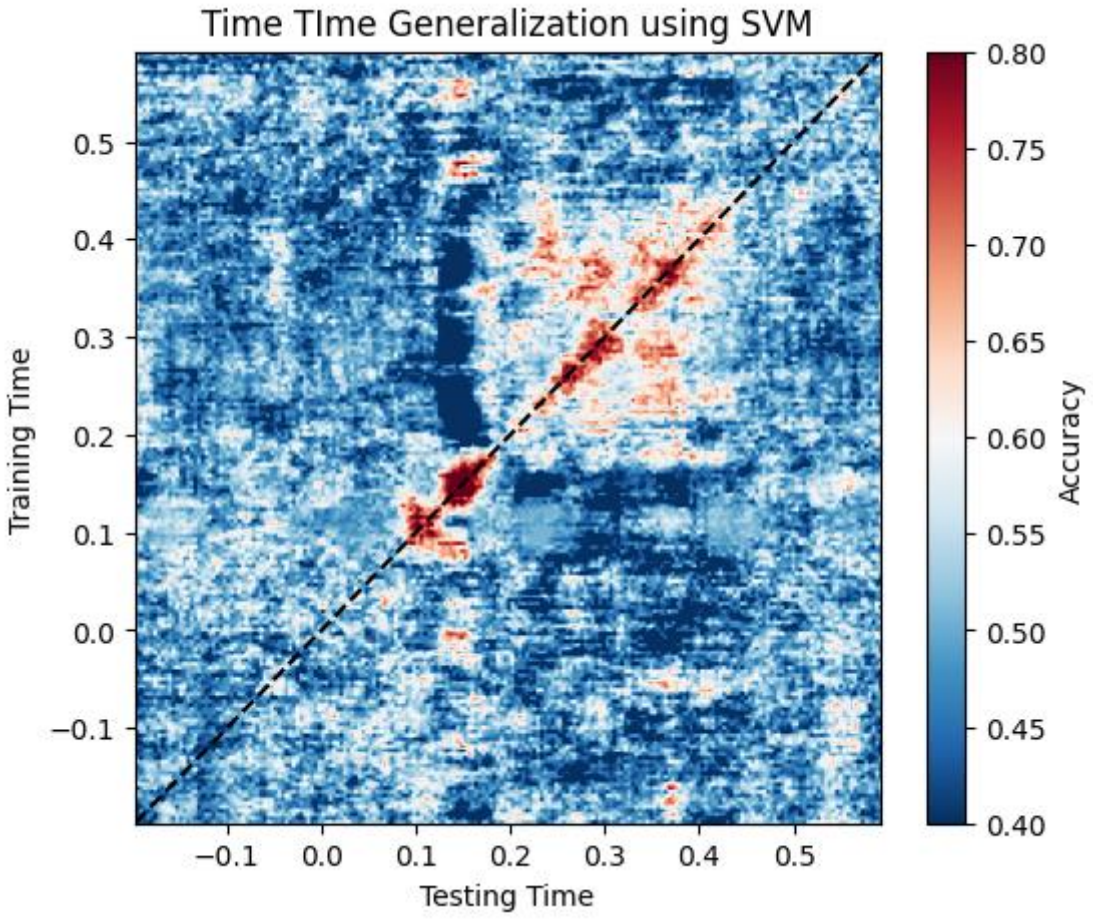
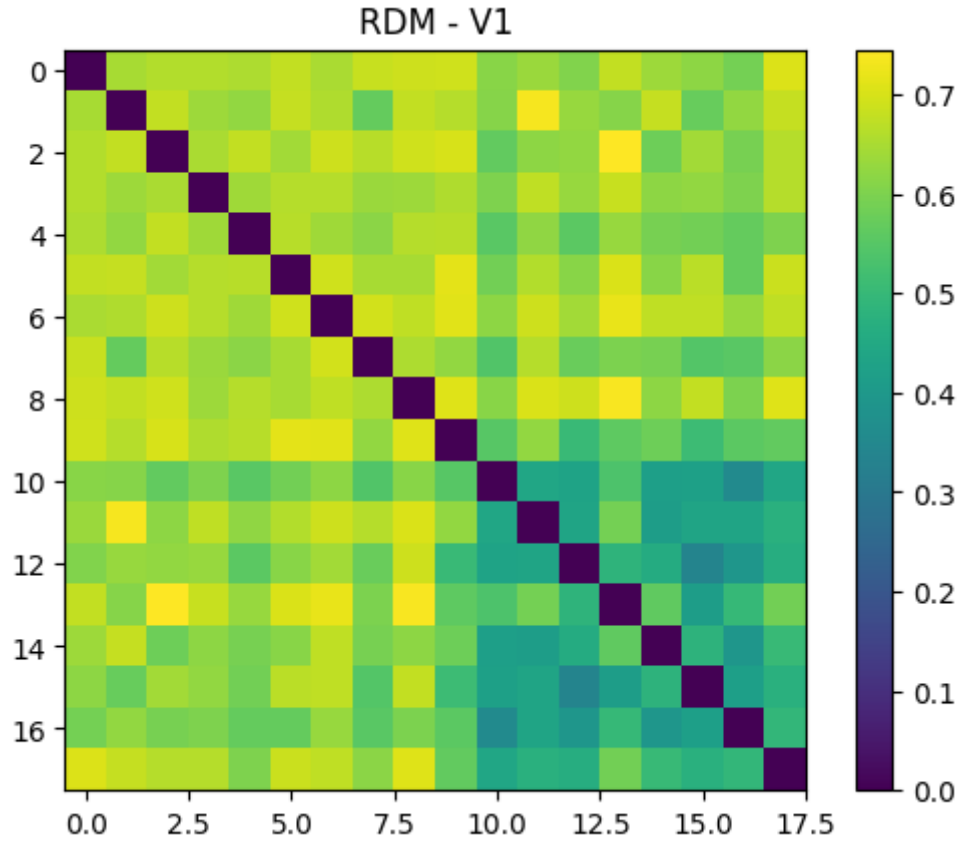
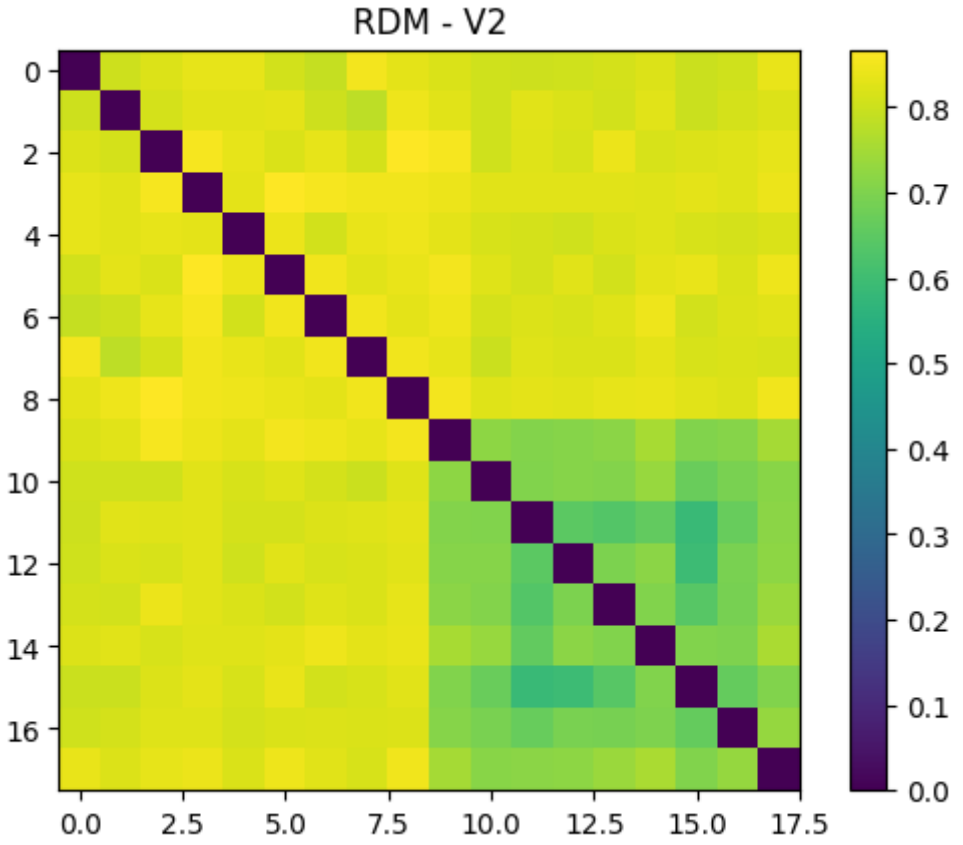


Figure 12:Time Genralization matrix

RDM and RSA

Now we conduct rdm to compare a neural network architecture which has tried to model the ventral stream processing, with our eeg data, which can only be done with rdm. After we have calculated the rdm using the 18 stimuli in our eegdata in each time window, just like the mvpa, we then forward pass our 18 stimuli images to our cornet-s model, and extract their features, in different levels Figure 13 and then do a correlation between each time slice(Average between the 10 subjects) and the cornets, to see in which time slices, does the modeld brain network, has higher correlation with the actual brain data.


RDM - V1
0
2
4
6
8
10
12
14
16
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0


RDM - V2
0
2
4
6
8
10
12
14
16
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

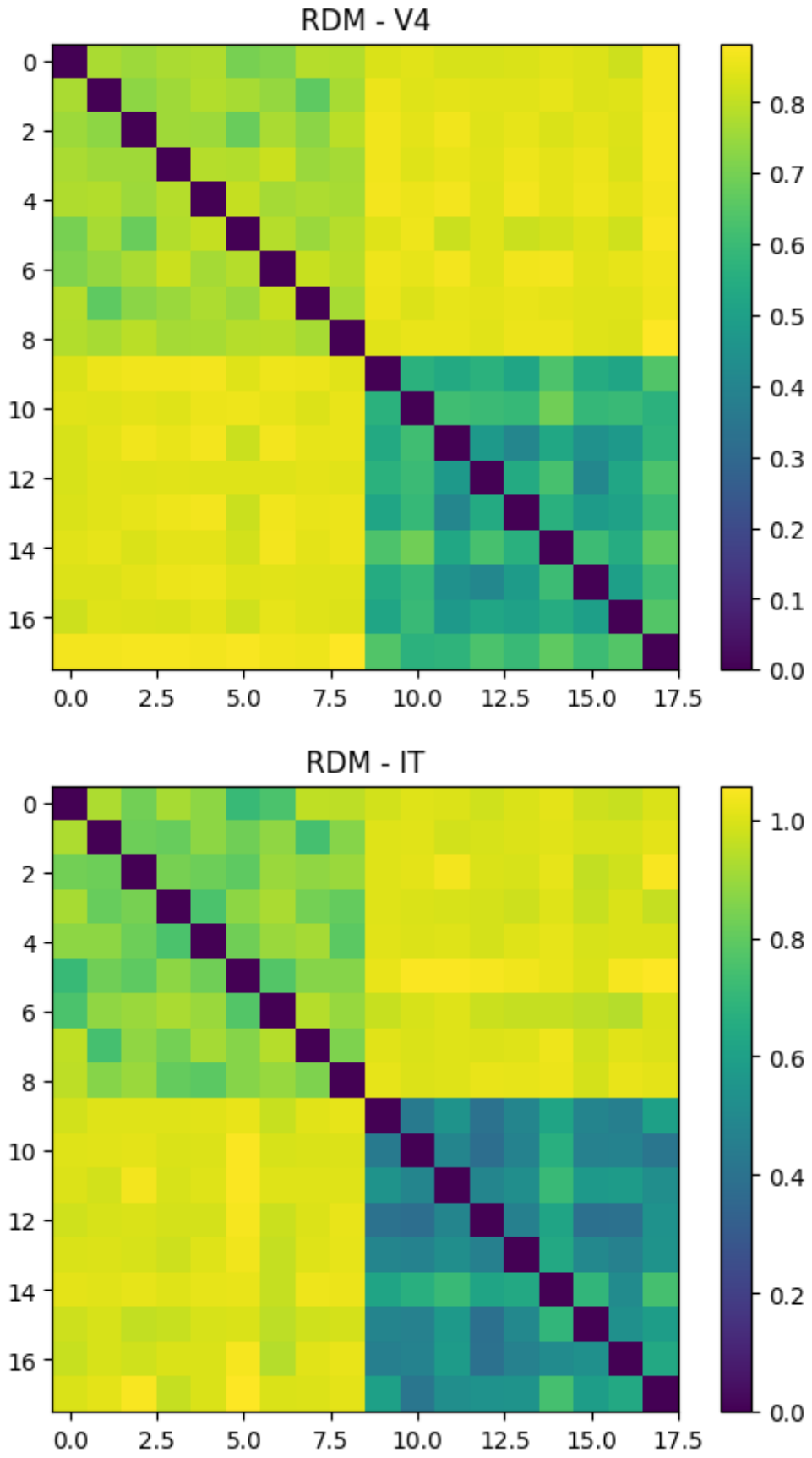


Figure 13:RDM for differnet layers of cornet

And the result in Figure 14 shows very important insights, firstly according to the official wiki page shown earlier, the fusiform in IT is more responsible for the n170, as shown in the figure IT has the highest correlation(specially around n170).

But this thing also has insights in how the ventral system works. In around 40ms v1 is more active, just like our real brain where v1 is the first step and lowest level of visual processing, then v2 has the highest accuracy, then it goes into v4, and well it which it has the highest correlation.

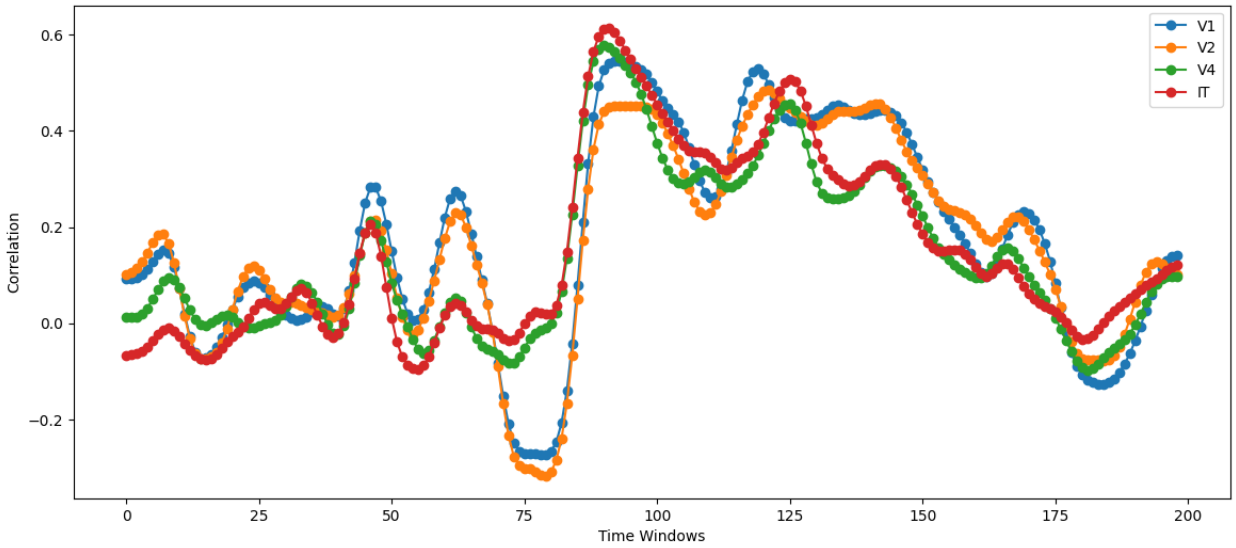


Figure 14: Different layers of cornet Correlation

And now we have conducted many evidence that our hypothesis that the brain processes n170, face stimuli more against house stimuli.

Thank you for your patience.

-Roshak