In the Name of God

Neuroscience of Learning, Memory, Cognition

Homework_3 Report

- EEG Signal Pre-Processing and Processing
- Apnea detection using EEG signals

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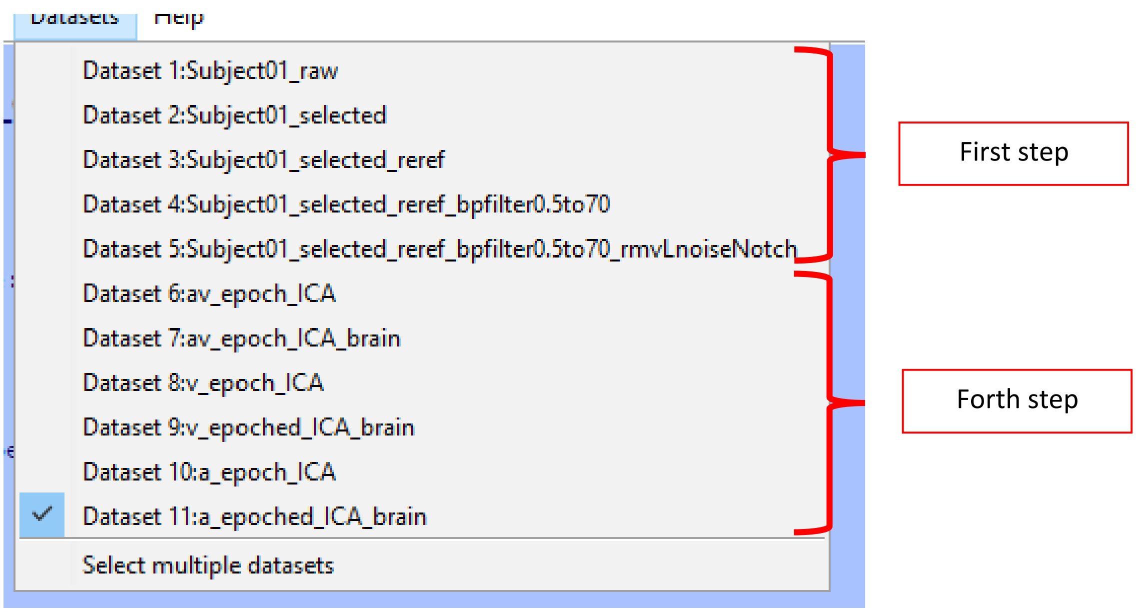
1- EEG Pre-Processing:

At first you should import the data`s in to the EEG LAB in the order below:

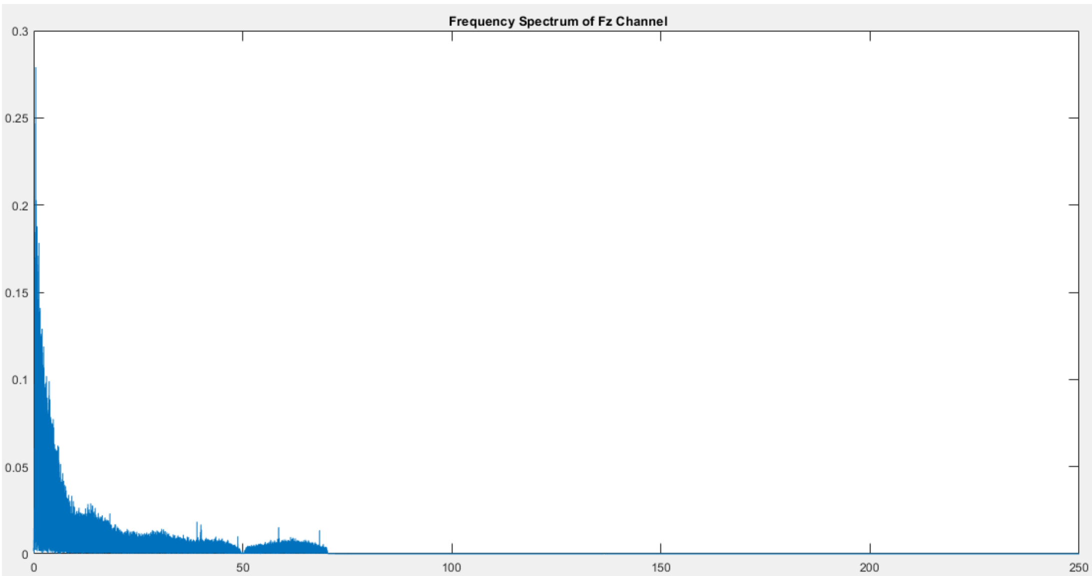


- If you don`t load these data`s in this order, you have to change the index of the ALLEEG struct in the code based on your order.

- Data files are available here if you want

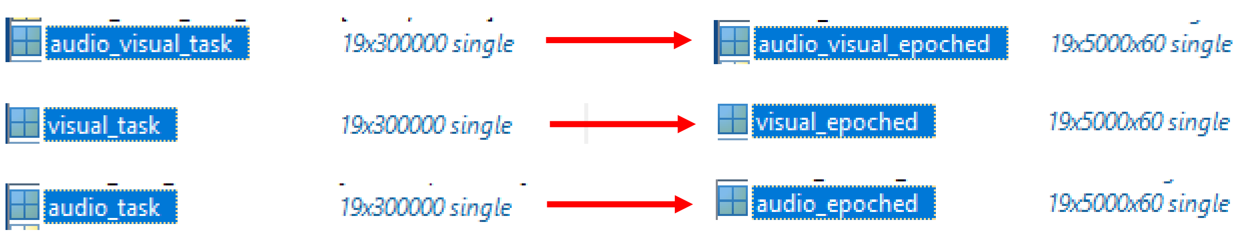
١,١ – Some filtering:

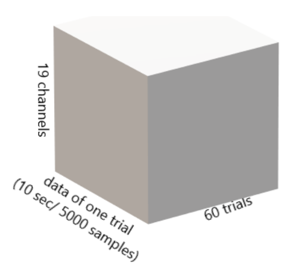
I`ve used a notch filter to remove the line noise. (remove 49-51 Hz) After Re_referencing the datas to their mean and applying a bandpass and notch filter, frequency spectrum of Fz channel is plotted by accessing ALLEEG(5).data.



1.2 – epoch:

Now we have to divide the data in to epochs. First step is to extract the tasks from the data using 20th column and then We will have a 19,5000,60 epoch for each task:





١.٣ – Remove noisy trails:

Now we remove trials that their frequency spectrum has a standard deviation more than 3.5:

noisy_trials_a_task	[31;58]
noisy_trials_av_task	[35;54]
noisy_trials_v_task	[35,46]

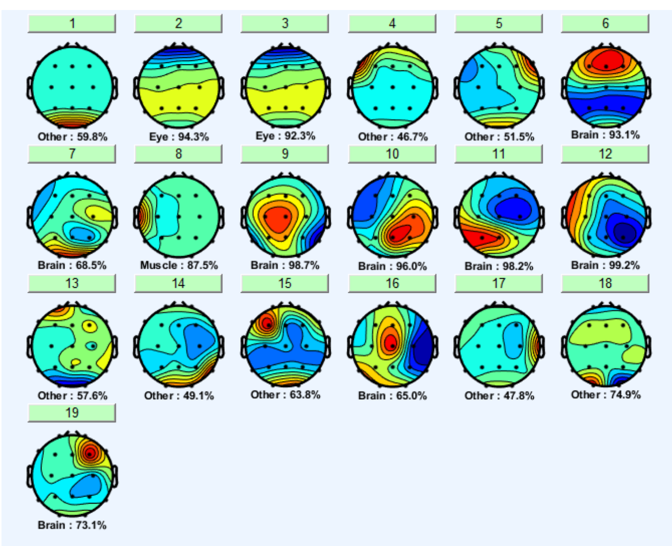
So 2 trials from each task will be removed:

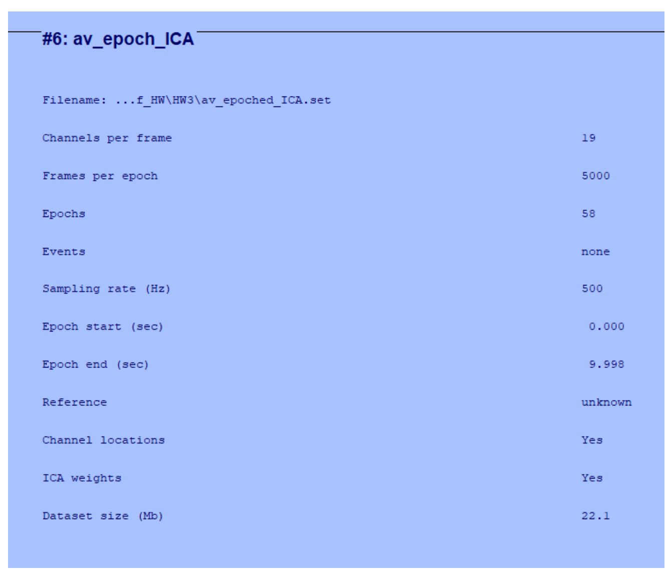
audio_visual_epoched	19x5000x58 single
visual_epoched	19x5000x58 single
audio_epoched	19x5000x58 single

1.4 – Remove artifacts:

After running ICA on each task`s epoch, we have the components:

- Audtiory_Visual_task components:

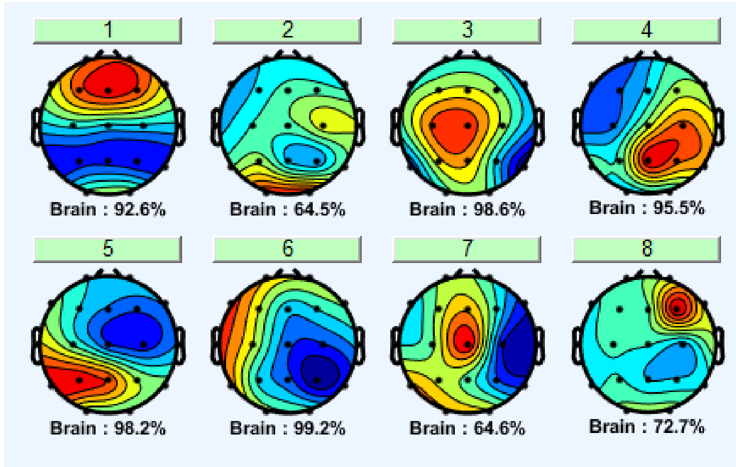




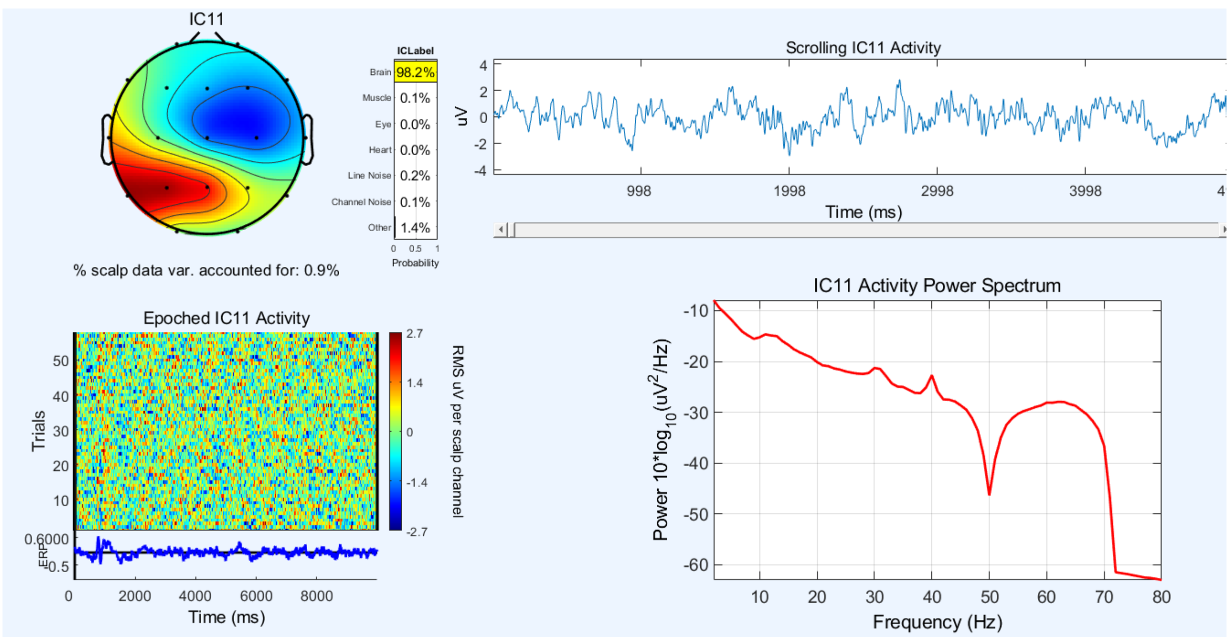
#6: av_epoch_ICA

Filename: ...f_HW\HW3\av_epoched_ICA.set	
Channels per frame	19
Frames per epoch	5000
Epochs	58
Events	none
Sampling rate (Hz)	500
Epoch start (sec)	0.000
Epoch end (sec)	9.998
Reference	unknown
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	22.1

We`ve got 8 brains and all the others will be removed:

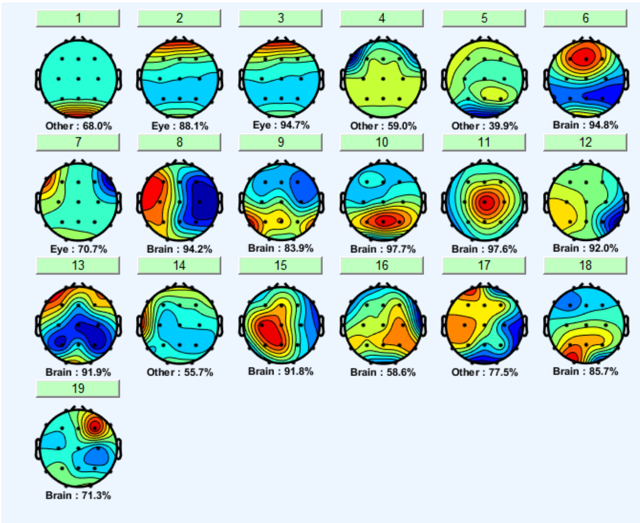


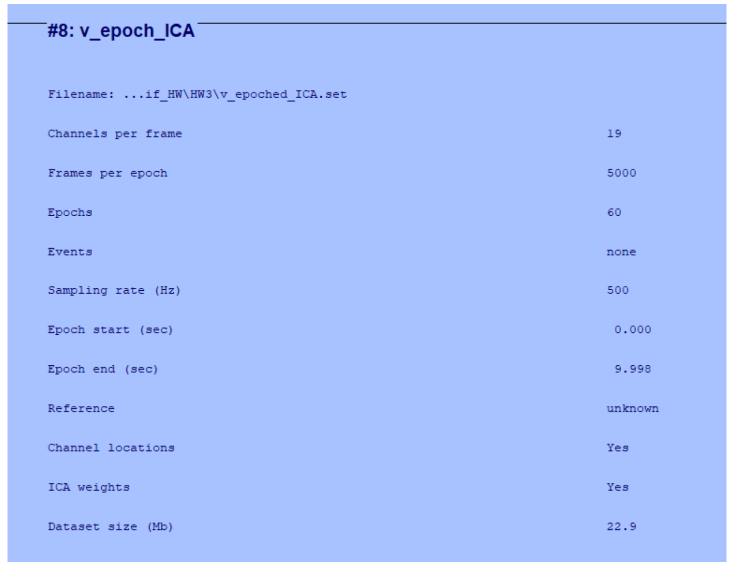
- Component 11 details:



We can see the power spectrum of a brain component which has a decay like a $\frac{1}{x}$ at first of it.

- Visual_task components:

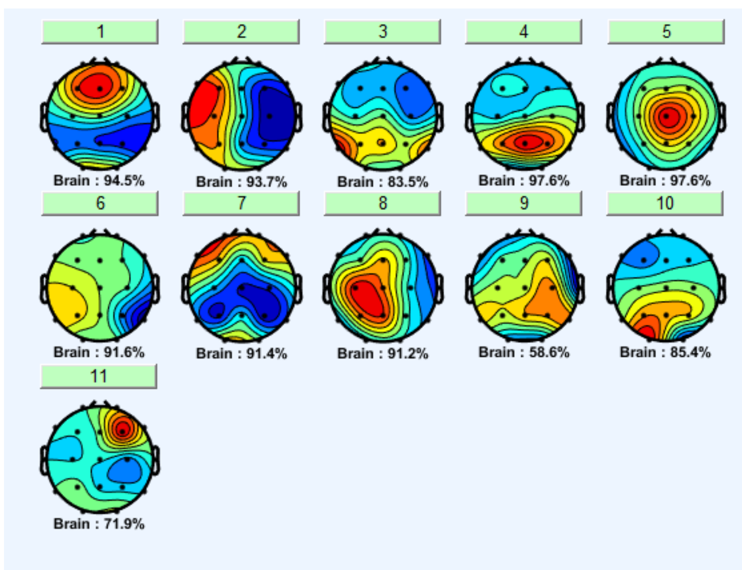




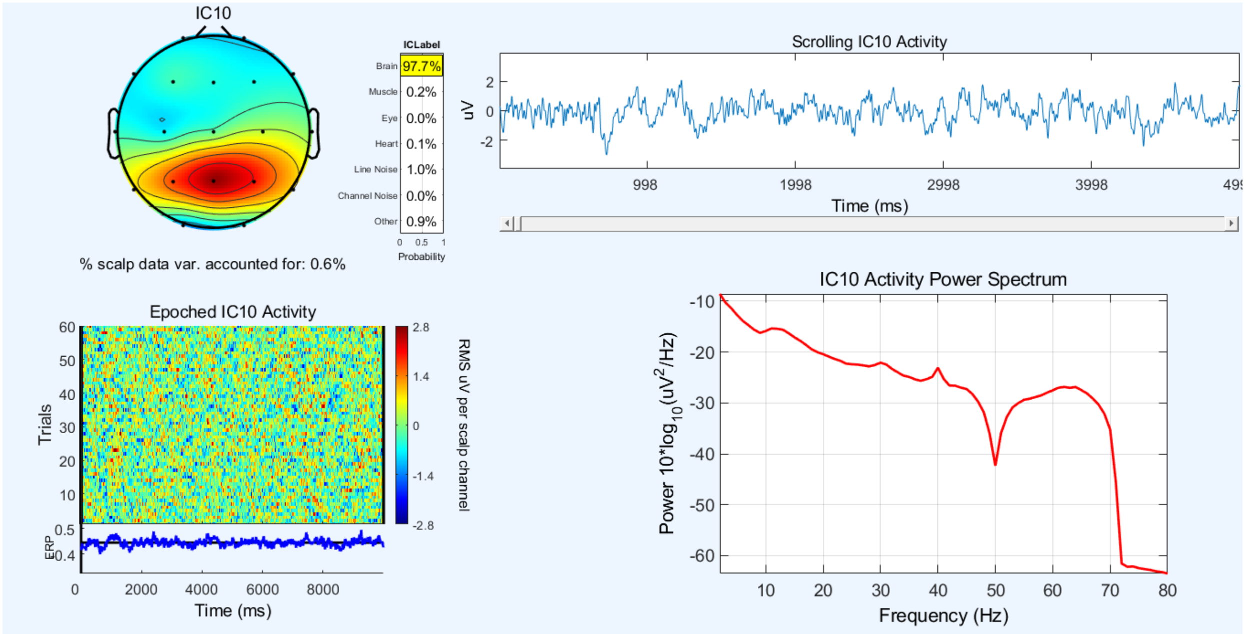
#8: v_epoch_ICA

Filename: ...if_HW\HW3\v_epoched_ICA.set	
Channels per frame	19
Frames per epoch	5000
Epochs	60
Events	none
Sampling rate (Hz)	500
Epoch start (sec)	0.000
Epoch end (sec)	9.998
Reference	unknown
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	22.9

We`ve got 11 brains and all the other components will be removed:

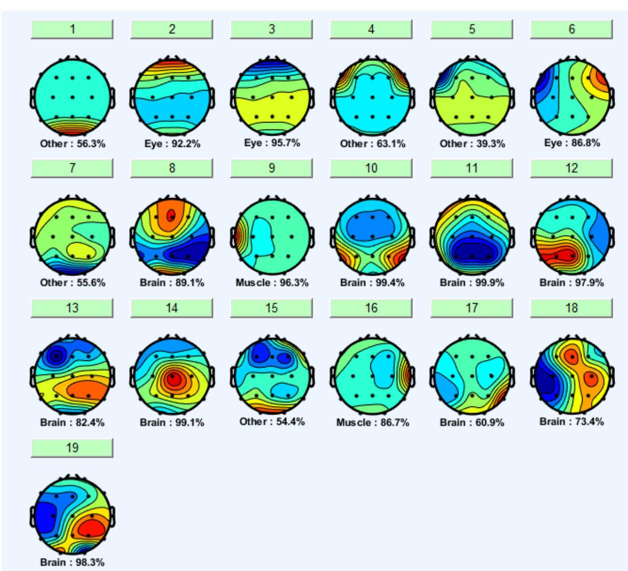


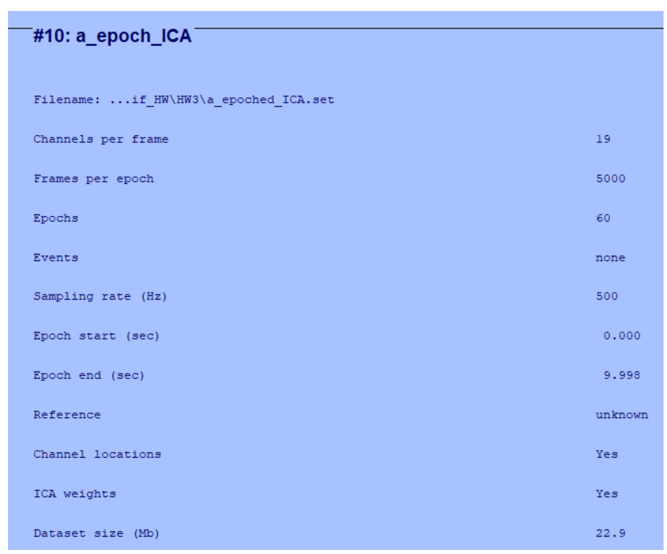
- Component 10 details:



We can see the power spectrum of a brain component which has a decay like a $\frac{1}{x}$ at first of it.

- Auditory_task components:

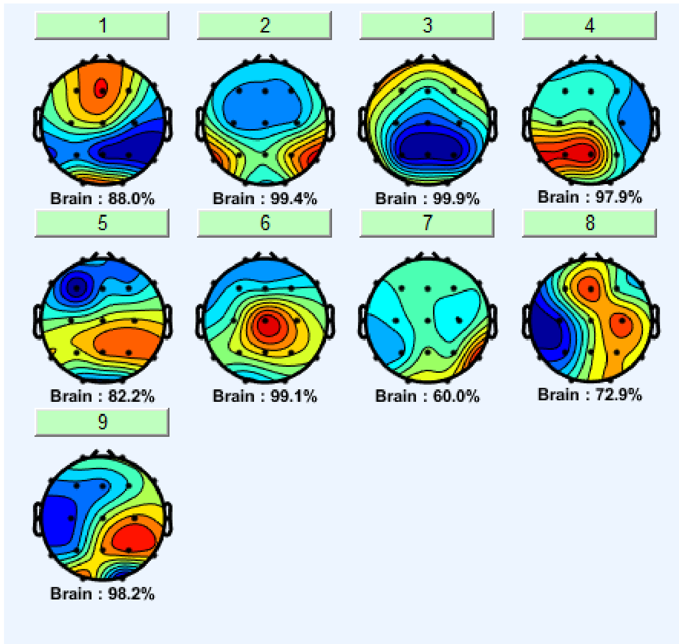




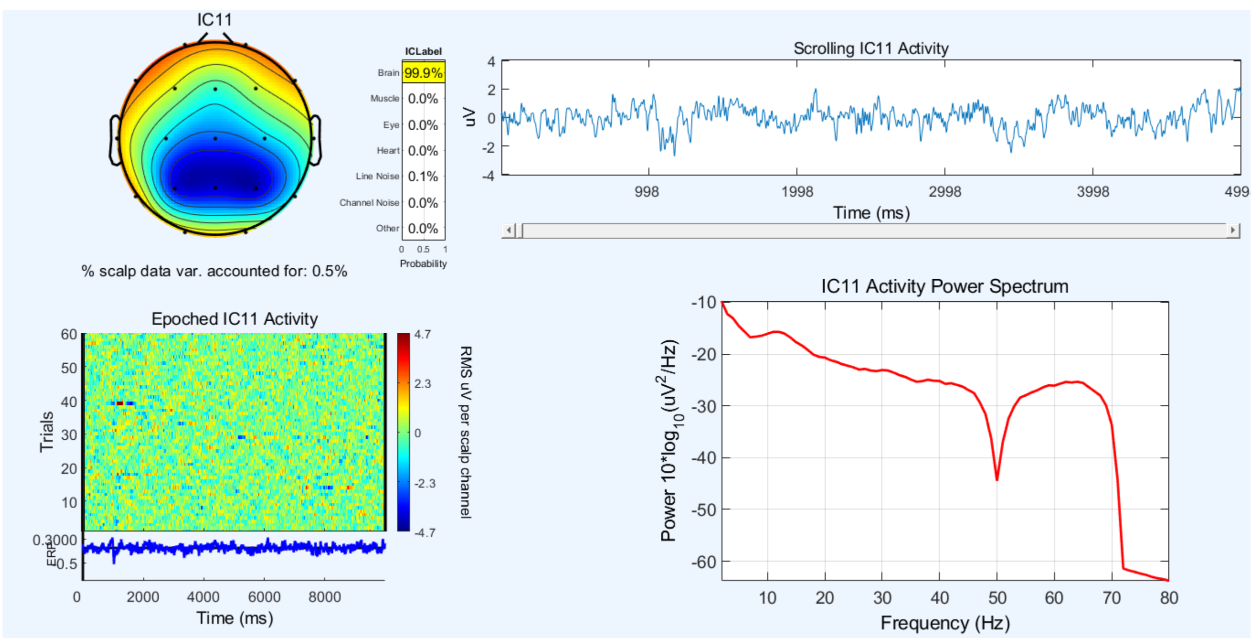
#10: a_epoch_ICA

Filename: ...if_HW\HW3\a_epoched_ICA.set	
Channels per frame	19
Frames per epoch	5000
Epochs	60
Events	none
Sampling rate (Hz)	500
Epoch start (sec)	0.000
Epoch end (sec)	9.998
Reference	unknown
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	22.9

We`ve got 9 brains and all the other components will be removed:



- Component 11 details:



We can see the power spectrum of a brain component which has a decay like a $\frac{1}{x}$ at first of it.

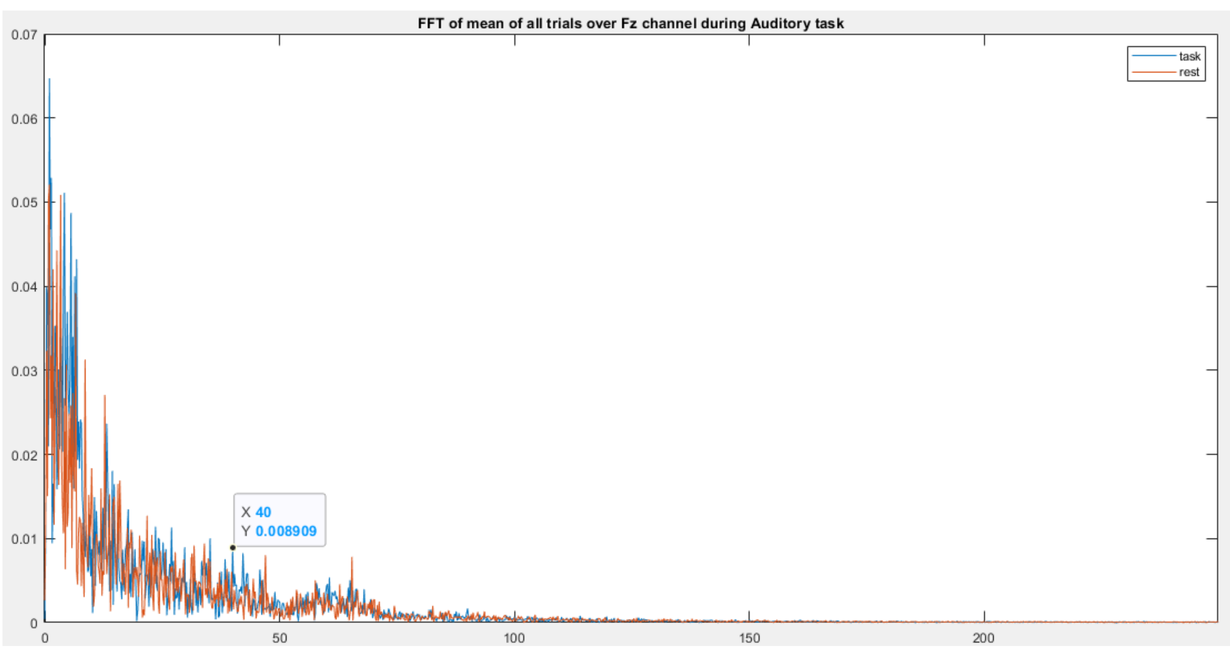
1.5 – EEG processing:

After the pre-processing, the data will be normalize using **zscore** and after that, we get the mean of trails on each channel. Before calculating the means, separating the rest and task state in our data is necessery. First 5 seconds of each trial a task is in progress and the second 5 seconds of each trial is rest state:

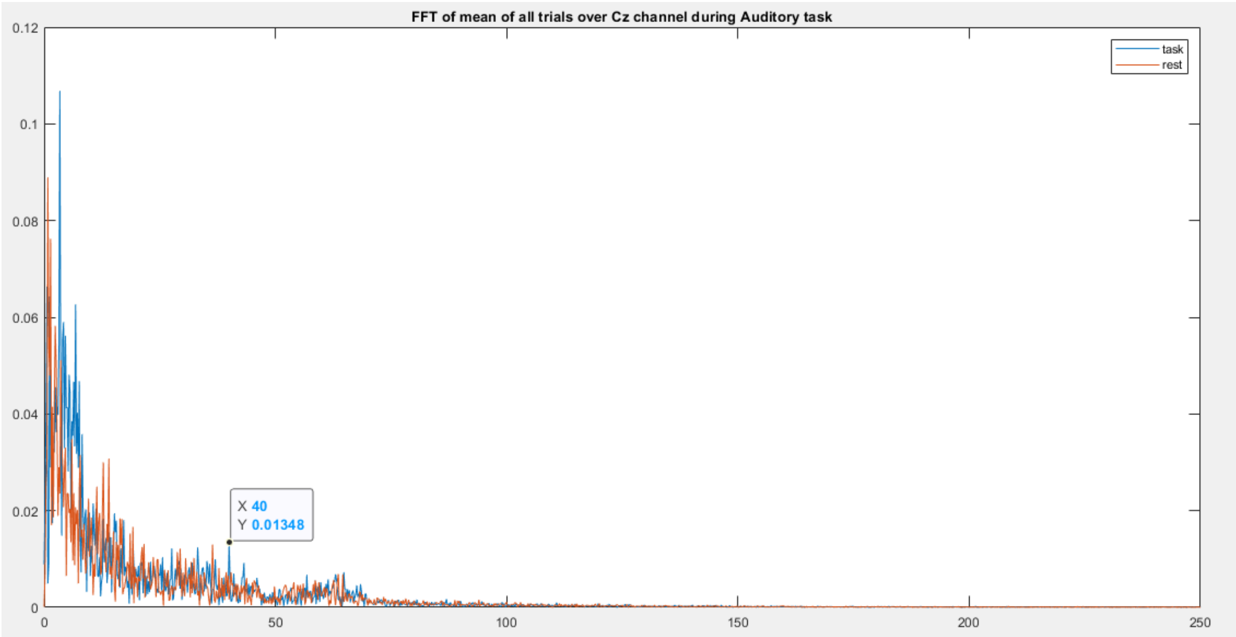
```
% av - task
avTask_stimuli = av_data(:,1:2500,:);
avTask_rest = av_data(:,2501:5000,:);

% v - task
vTask_stimuli = v_data(:,1:2500,:);
vTask_rest = v_data(:,2501:5000,:);

% a - task
aTask_stimuli = a_data(:,1:2500,:);
aTask_rest = a_data(:,2501:5000,:);
```

Since the brain`s response even to the same stimulus is different each time, we do the experiment more than once and at the end see the average result of trials.

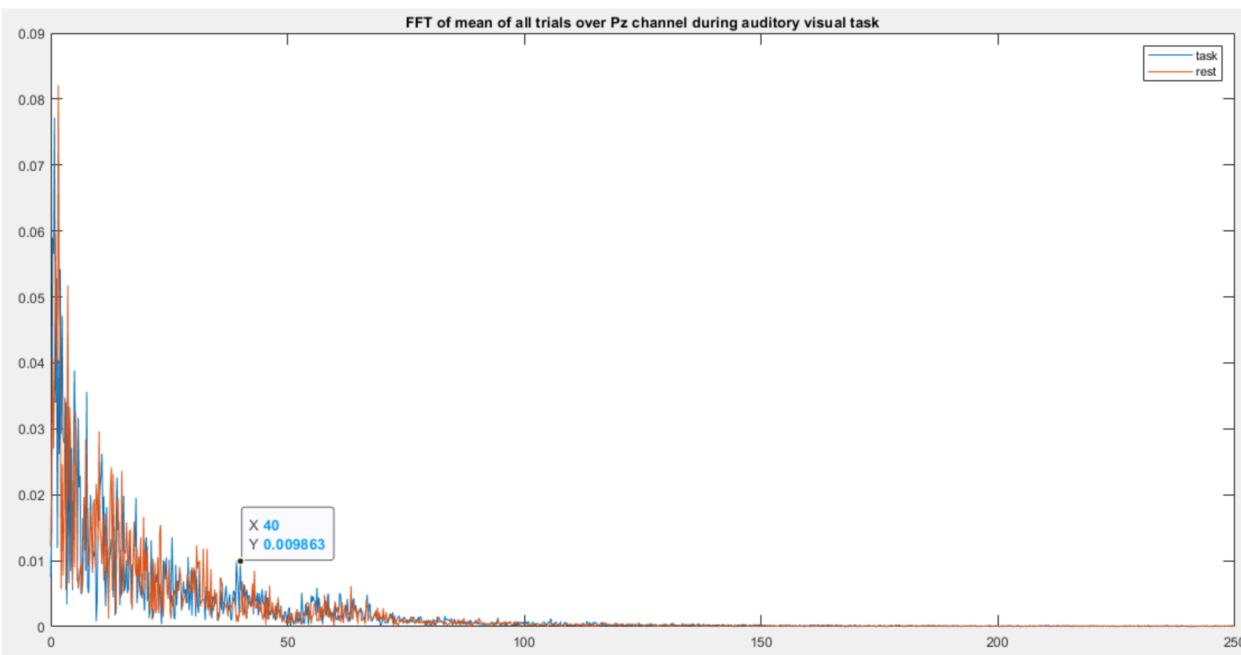
after getting the means, we would have three 19,2500 2d matrices for each task.



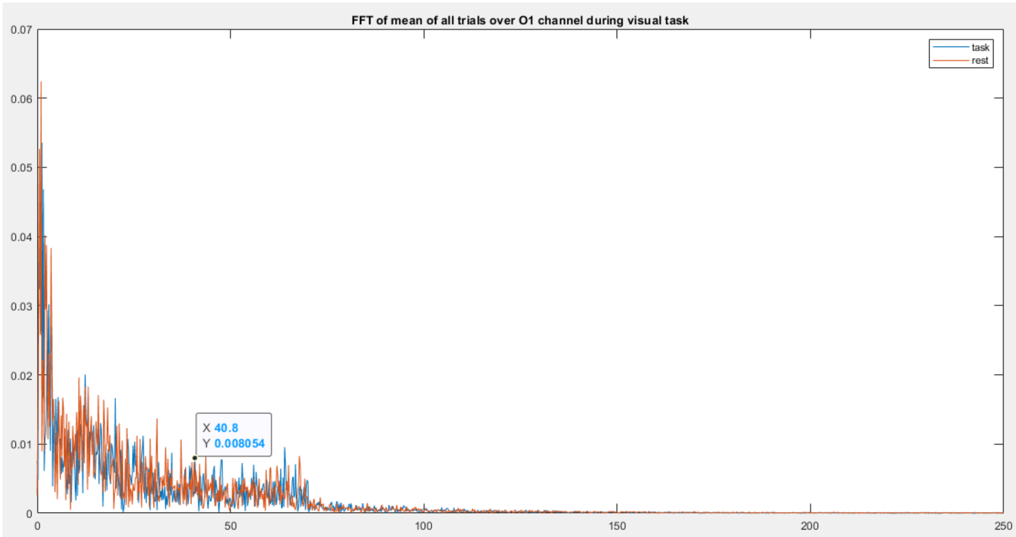
frequency spectrum of Fz channel of auditory task



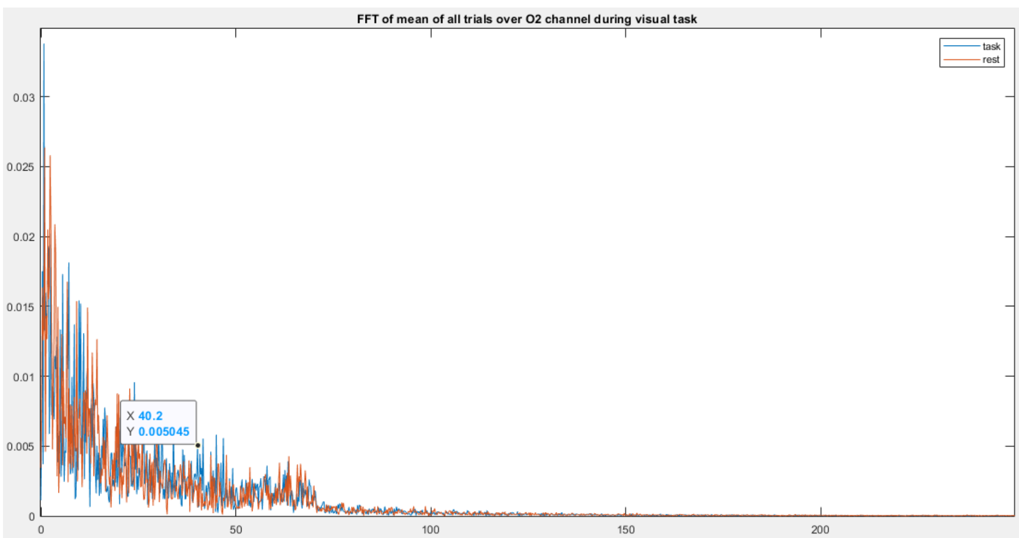
frequency spectrum of Cz channel of auditory task



frequency spectrum of Pz channel of auditory visual task



frequency spectrum of O1 channel of visual task



frequency spectrum of O2 channel of visual task

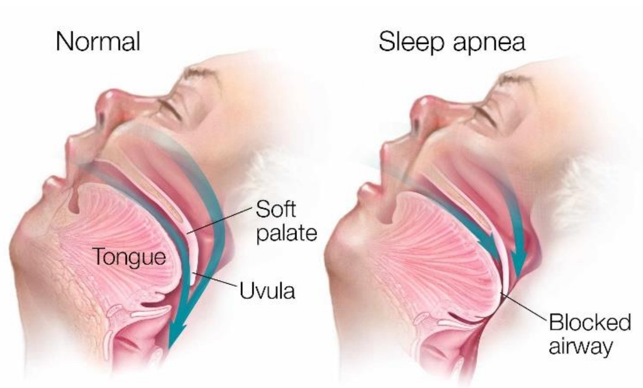
Actually in 40 Hz stimulus, we have the highest entertainment. experiments has shown that 40Hz stimulus, significantly reduce proteins associated with Alzheimer's disease in mice. So this 40 Hz stimulus is very important to us for treating and preventing Alzheimer in humans.

2 – Apnea Detection:

1.1 –

Sleep apnea is a serious disorder in caused by abnormal pauses in breathing. There are three main types of apnea:

- **Obstructive sleep apnea,** the more common form that occurs when throat muscles relax
- **Central sleep apnea,** which occurs when your brain doesn't send proper signals to the muscles that control breathing
- **Complex sleep apnea syndrome,** also known as treatment-emergent central sleep apnea, which occurs when someone has both obstructive sleep apnea and central sleep apnea



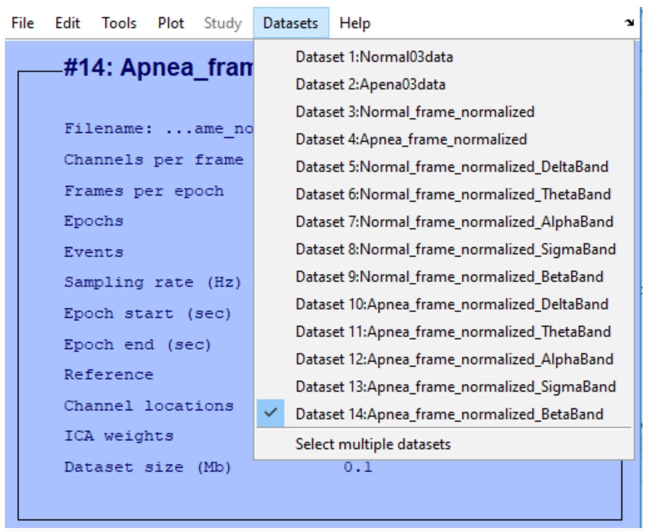
So a sleep technologist is needed to monitor and record sleep apena events. There`s been several researches to develop auto apnea detection using bio-signals but among them, the EEG has received much more attention. The question is why?

EEG signals reflect the electrical activity of the brain and sleep stages are related to electrical activity of the brain. So when apnea happens, it affect the EEG signals. Most of the methods for detecting apnea, is to classify apnea patients and healthy people. Extracting data from different frequency bands of EEG signal is very popular.

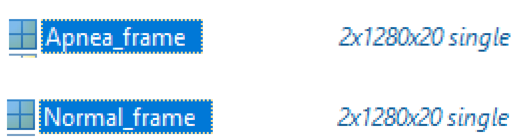
We get data from 2 channels with symmetric locations and in order to reduce the noise, average of the 2 channels in time domain will be used. The channels are C3-A2 and C4-A1. 5 different subjects are considered in this research with large differences in AHI. The average height, weight and age of these subject are 178.6 cm, 99.14 kg and 50.8 years. Duration of apnea event is something between 10 and 25 s in the most of the cases. To make sure that each frame only consists apnea or non-apnea event, the frame duration has been considered 10 s.

1.2 –

Import the data files in order below to run the code:



At first we extract our 20 10 sec frames from each data. So we have 2 3d matrices now, one for normal subject and one for apnea:



average of the channels for each data in time domain:

Apnea_avg	1x1280x20 single
Normal_avg	1x1280x20 single

Now the dc offset of the each frame will be removed by subtracting the averages of the samples in each frame:

```
% Averaging in time domain
% now we calculate the average of each frame in time domain for each channel
Normal_mean = mean(Normal_avg,2);
Apnea_mean = mean(Apnea_avg,2);

% pre-processing
% next we have to subtract the mean of each frame from each sample value in
that frame
Normal_frame_avg = Normal_avg - Normal_mean;
Apnea_frame_avg = Apnea_avg - Apnea_mean;
```

Then each frame will be normalized with reference to the maximum value of that frame.

1.3 – Band-limited signal extraction:

Now 5 channel bands including delta (δ) (0.25–4 Hz), theta (θ) (4–8 Hz), alpha (α) (8–12 Hz), sigma (σ) (12–16 Hz) and beta (β) (16–40 Hz) will be extracted from the data using some bandpass filters in EEGLAB. Data files are available here if you want.

1.4 – Proposed inter-band energy ratio feature:

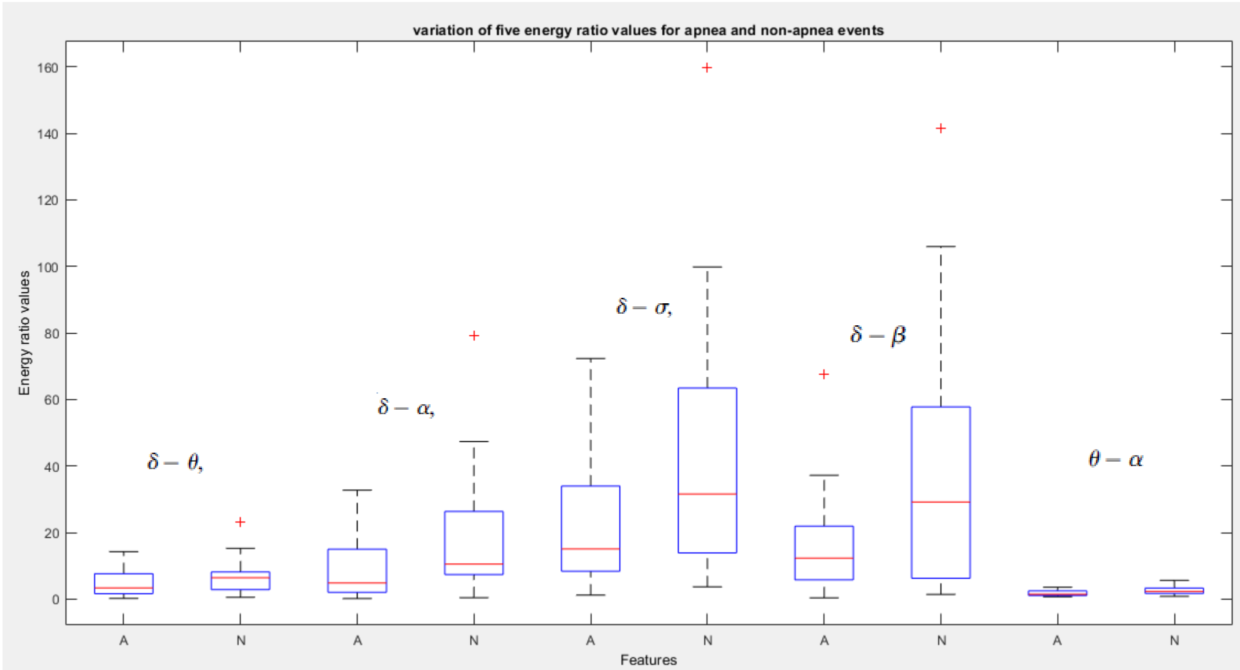
At first, energy of each band will be calculated for apnea and non-apnea data:

$$E_p = \sum_{n=1}^{N} \{x_p[n]\}^2,$$

Then the following ratios will be calculated :

$\delta - \theta$, $\delta - \alpha$, $\delta - \sigma$, $\delta - \beta$ and $\theta - \alpha$

$$R_{pq} = \frac{E_p}{E_q},$$



variation of five energy ratio values for apnea and non-apnea events
Energy ratio values
Features
$\delta-\theta,$
$\delta-\alpha,$
$\delta-\sigma,$
$\delta-\beta$
$\theta-\alpha$
160
140
120
100
80
60
40
20
0
A
N
A
N
A
N
A
N
A
N