Introduction to Electroencephalogram(EEG)

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Abstract

The following text includes summary of the Electroencephalogram basics that were covered in the EEG basics playlist by Jeremy Moeller. It explains the model of EEG and the functioning of it. Moreover it also describes the different methods and patterns used to read the EEG data and the facilities provided to collect and organise data read by the EEG device using a software and its usage in clinical neurology.

Basic EEG terminology

EEG data is recorded by placing of electrodes at predefined locations on the scalp of the subject. These locations are determined by the 'International 10-20 system' which ranges from nasion to inion and 2 opposite pre-aruicular points anterior to each ear. It basically divides the forehead into 3 main divisions known as Frontal, Central and Parietal respectively, which are further divided into subdivisions on the basis of their locations like odd numbered(FP1, C3, P7 etc) for the left and even numbered(F4, T8, O2) for the right, and 'z' suffixed (Cz, Fz, Pz) for the central regions.

How EEG is recorded

EEG data is sent through a differential amplifier. A differential amplifier is a device that takes in two inputs and produces the relative difference between them.(See Figure 1)

As seen in Figure 1, the two inputs are images which are somewhat similar with slight differences in them. The differential amplifier eliminates the similarities and only gives the difference between them as the output(relative output not absolute).

Figure 2 represents the polarity rules of reading EEG data. The peak 'above' for input1-input2 data is read as input 2 is +ve w.r.t. input1 OR input1 is -ve w.r.t. input2. And if a channel has the same sign throughout the chain then it can be concluded that it has the same sign absolutely. such channels show reversing of peaks in their consecutive channels this is called 'phase reversal'.

Representation of EEG data

EEG data is recorded by analysing the output of the differential amplifier, taking two different electrodes(FP1, F3 etc) at a time as input. This output is called a 'Channel' a.k.a 'Derivation'. Such Channels are combined together to form a single waveform called 'Chain'. Different selections of chains allow different interpretations of EEG data known as 'Montages'. One such method is called Anterior-Posterior Bipolar Montage in which the chain is made from the leftmost branch(from Fp1 to O1 vertically) as if we are looking the top of the subject and the subject is facing right. Figure 3 describes this montage. Some other types of montages are as follows:

-> Transverse Bipolar Montage - In transverse montage, the subject is viewed from above when the subject is facing front. At this stage the channels are taken horizontally for eg, one chain is from the left ear to the right. It is useful to read the central activity during sleep.

-> Common Reference Montage - One of the electrodes are taken as reference and the channels are made with other electrodes w.r.t. this reference.

-> Common Average Montage - similar to Common reference montage but instead of other electrodes, the second input is the average data of all the remaining electrodes. There's a phenomenon known as reference contamination, in which when a charge is concentrated on some area then it affects the reading of other normal electrodes due to which originally average reading might seem below average due to this excess charge.

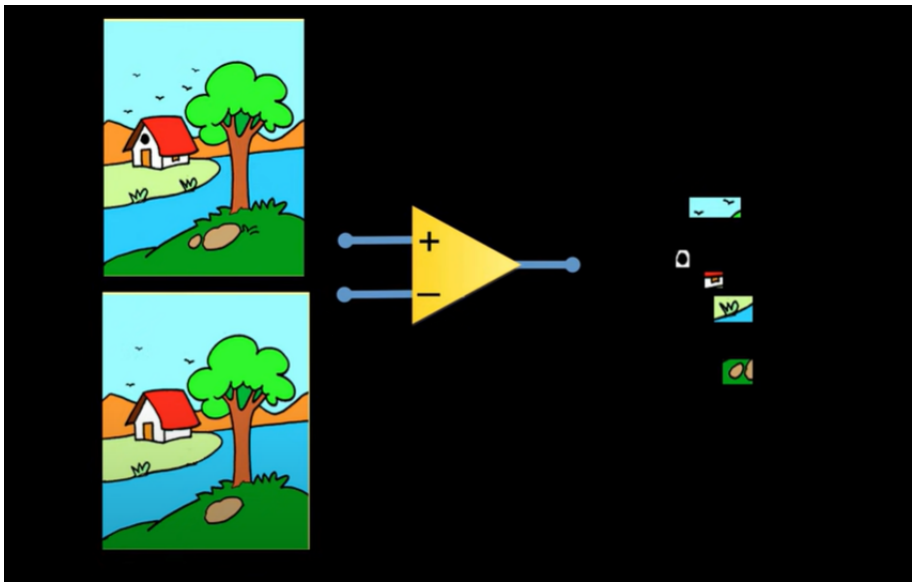

Figure 1: Reading of differential amplifier

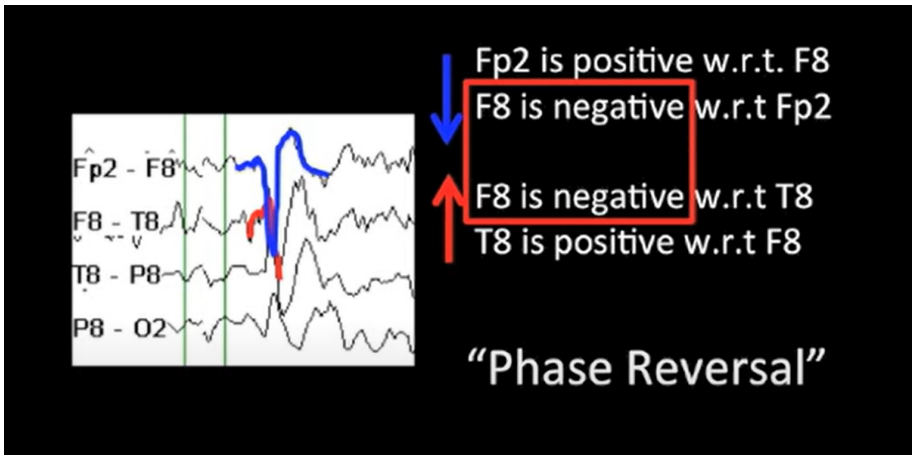

Figure 2: Polarity Rules

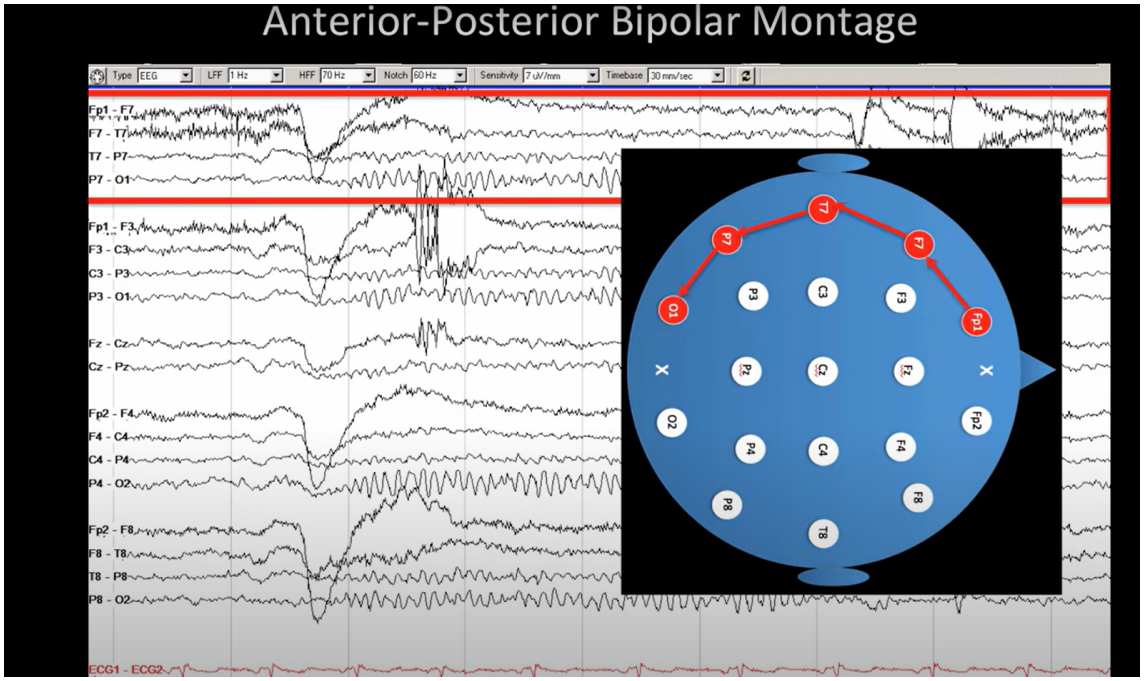

Figure 3: Anterior-Posterior Bipolar Montage

-> Laplacian Montage - An initial electrode is selected as input1 and input2 is the average data of its nearest neighbours. For central electrode its nearest neighbours are 4 along the sides. This montage is very useful to eliminate reference contamination. However it cannot be used where abnormalities are widely distributed.

EEG reading of Eye blink

The eye is considered as a dipole. The retina is taken as negative charge and cornea is taken as positive charge. When the eye blinks, there is a reflex action known as 'Bell's phenomenon' in which the eye ball moves upwards. This creates concentration of positive charge near the FP1 channel. So Fp1 +ve than F3 and so on creates a waveform detected in the EEG data processing.

Figure 4 shows the waveform detected due to the blink of eye which creates peak down in the EEG data in all chains except the central Fz-Pz chain. The amplitude of the peak is determined w.r.t. the distance of +ve cornea from channel. FP1>F3, F3>C3 and so on.

Interpreting EEG data

EEG data consists of different waveforms of different frequencies. Delta(<4Hz), Theta(4-7Hz), Alpha(8-13Hz), Beta(13-30Hz), Gamma(>30Hz).

There are two types of filters to filter unwanted frequencies so that the data is as smooth as possible. LFF(Low Frequency Filter) - filters specified low frequency; high frequencies pass easily through this. HFF(High Frequency Filter) - filters specified high frequency; low frequencies pass easily through this.

Sensitivity is defined as the amplitude of the waveform per unit length of the peak of waveform where the wave is plotted. Low sensitivity means larger peak of the waveform plotted, however the absolute amplitude of the waveform remains unchanged.

Normal Awake EEG

Figure 8 depicts the EEG reading of awakening process. Initially when eyes are closed, we cam observe alpha rhythm. Later on eye opening due to which there is peak up(at the time of blink(closed), it was peak down), and when eyes are open the alpha rhythm is blocked by movement, then there

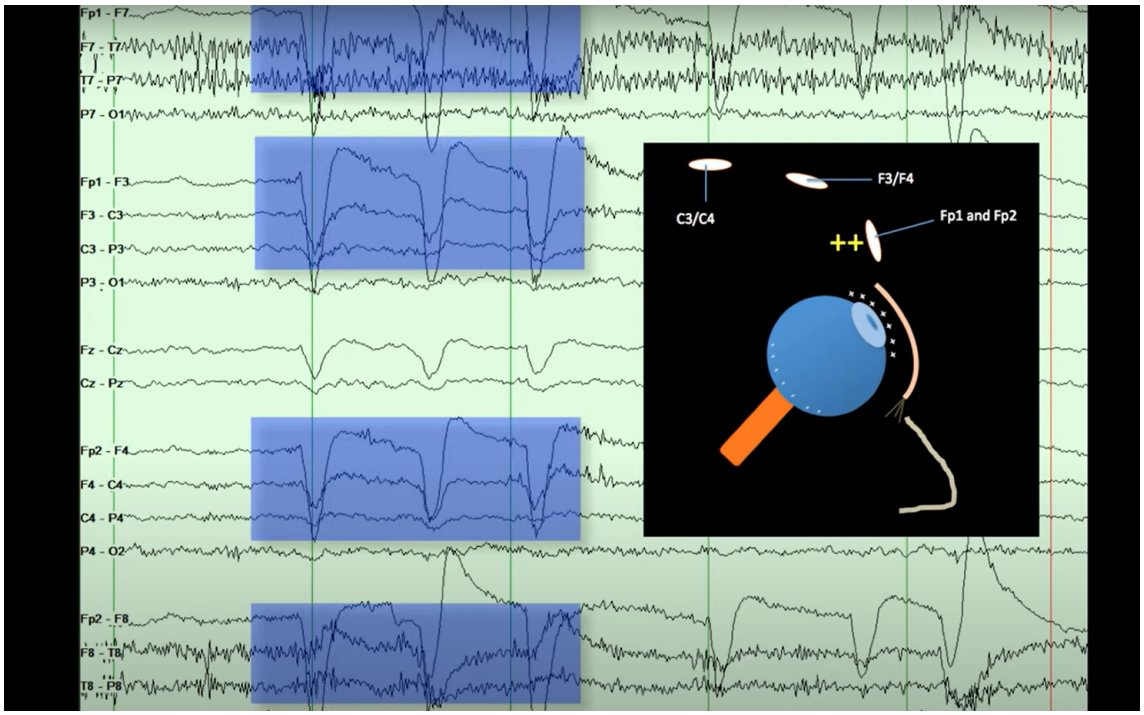

Figure 4: EEG reading of eye blink

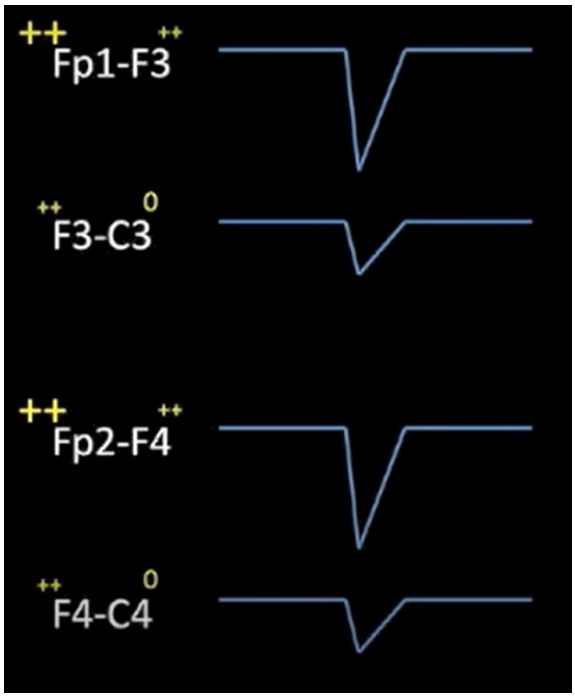

Figure 5: Polarity of waveform due to eye blink

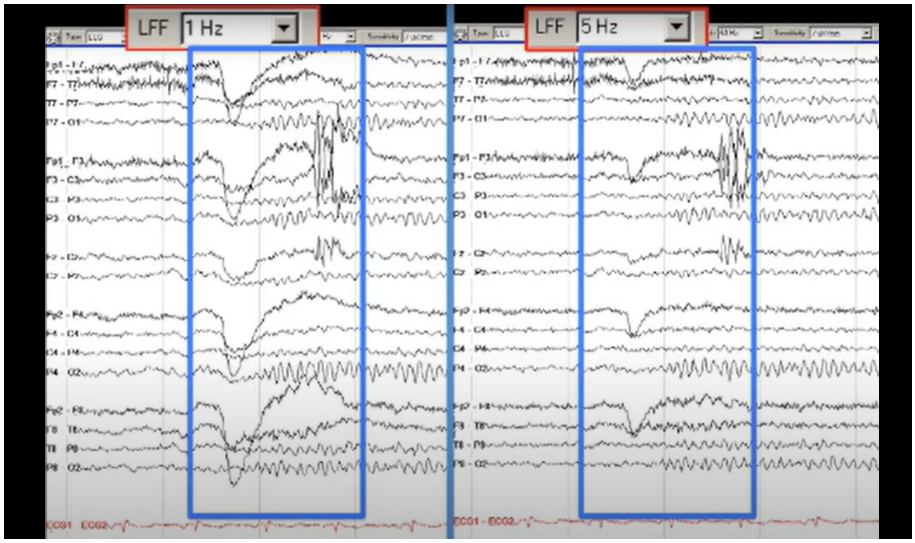

Figure 6: Low Frequency Filter

Figure 7: High Frequency Filter

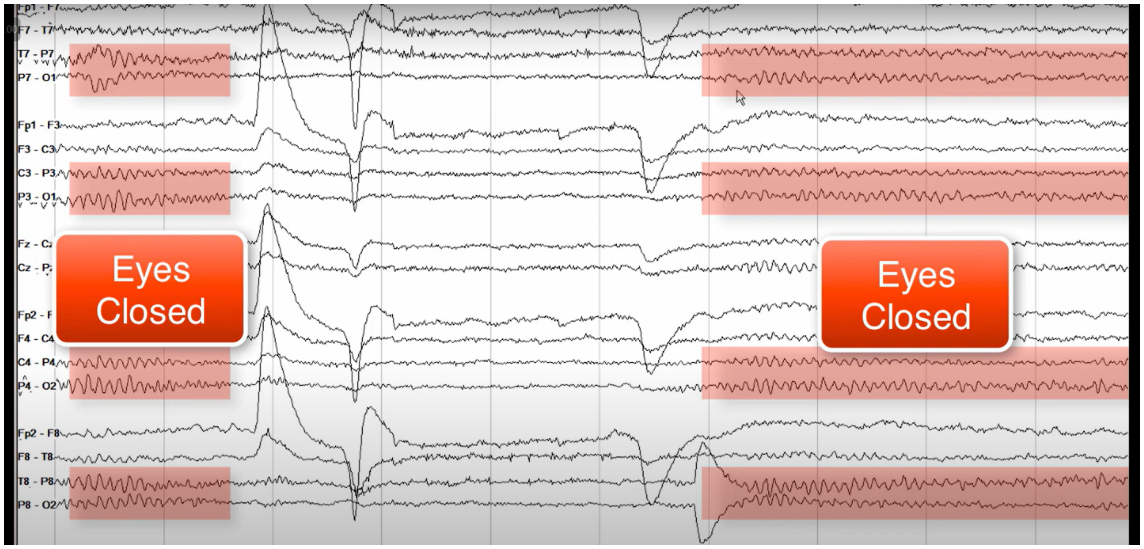

Figure 8: Normal Awake EEG

is eye closure (peak down), and then Lateral rectal spike, followed by alpha rhythms when eyes are closed.

1 Conclusion

Hence the content covered some basic terminologies of EEG, patterns used to read EEG data and clinical implications of it, it also covered the methods to represent EEG data and defects in them.

2 References

https://youtube.com/playlist?list=PLxaiR6teSdjoEZWaDWm28A9QjFN7eguApsi=2lZnX1bA2Sy41yYW