EEG Basics

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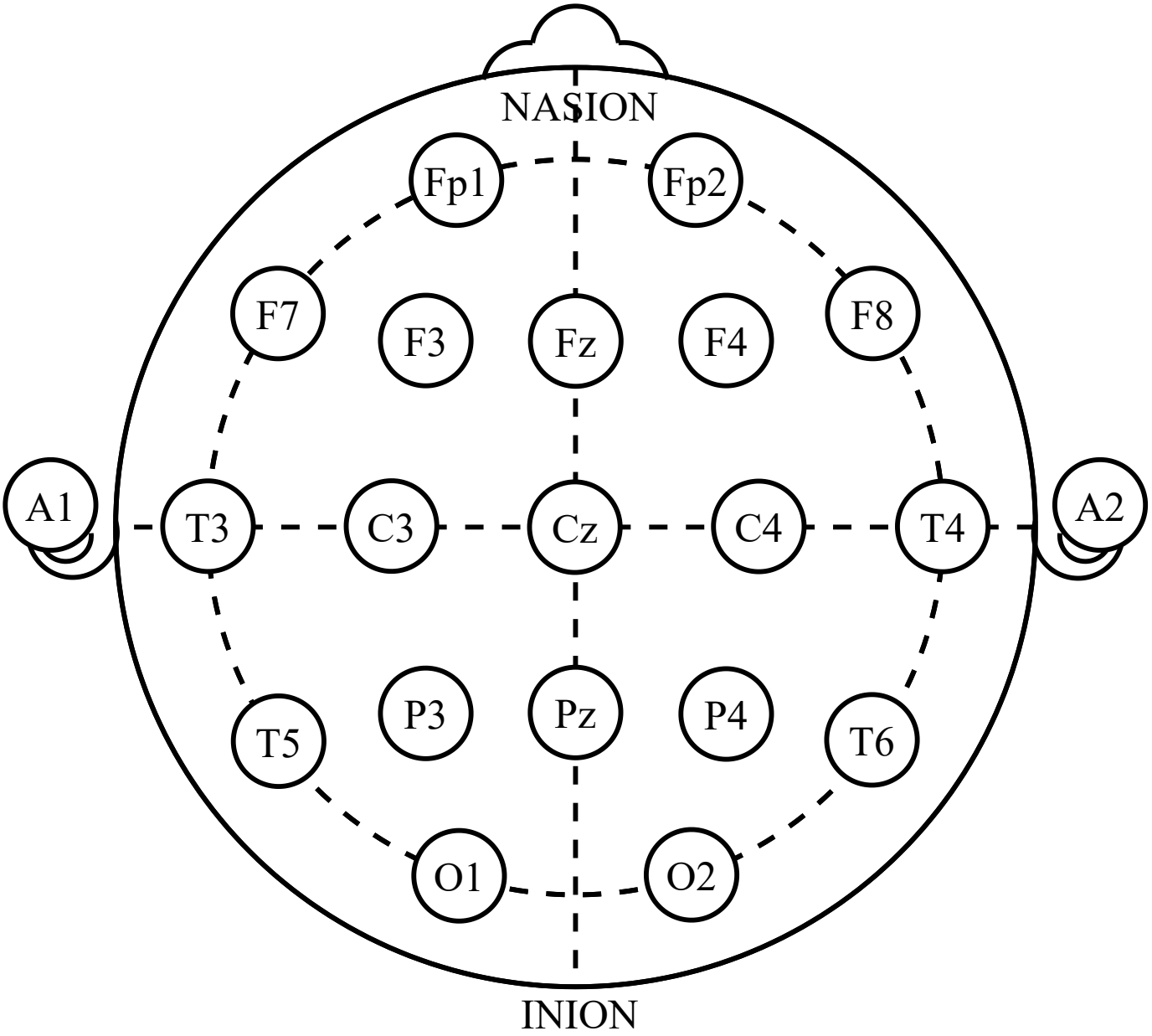
An electroencephalogram (EEG) is a test that measures electrical activity in the brain using electrodes attached to the scalp. Neurons communicate via electrical impulses and are active all the time, even during sleep. This activity shows up as wavy lines on an EEG recording.

International 10-20 system

The system by which the EEG electrodes are applied to the scalp of the person and then displayed on EEG recording.A standard method of measuring the head and placing the electrodes.
The numbers “10” and “20” refer to the distances between adjacent electrodes, which are either 10% or 20% of the total distance (front-back or right-left) of the skull. The total distance is based on the anatomical locations on the scalp: nasion and inion (front-back direction) and the two preauricular points (right-left direction).Odd numbers are on the left side and even numbers on the right side of the head.Lower numbers indicate the electrode is closer to midline.



How is EEG recorded ?

It is done using differential amplifier where it takes two inputs and gives their difference as output.Brain waves recorded on EEG have amplitudes in order of microvolts .

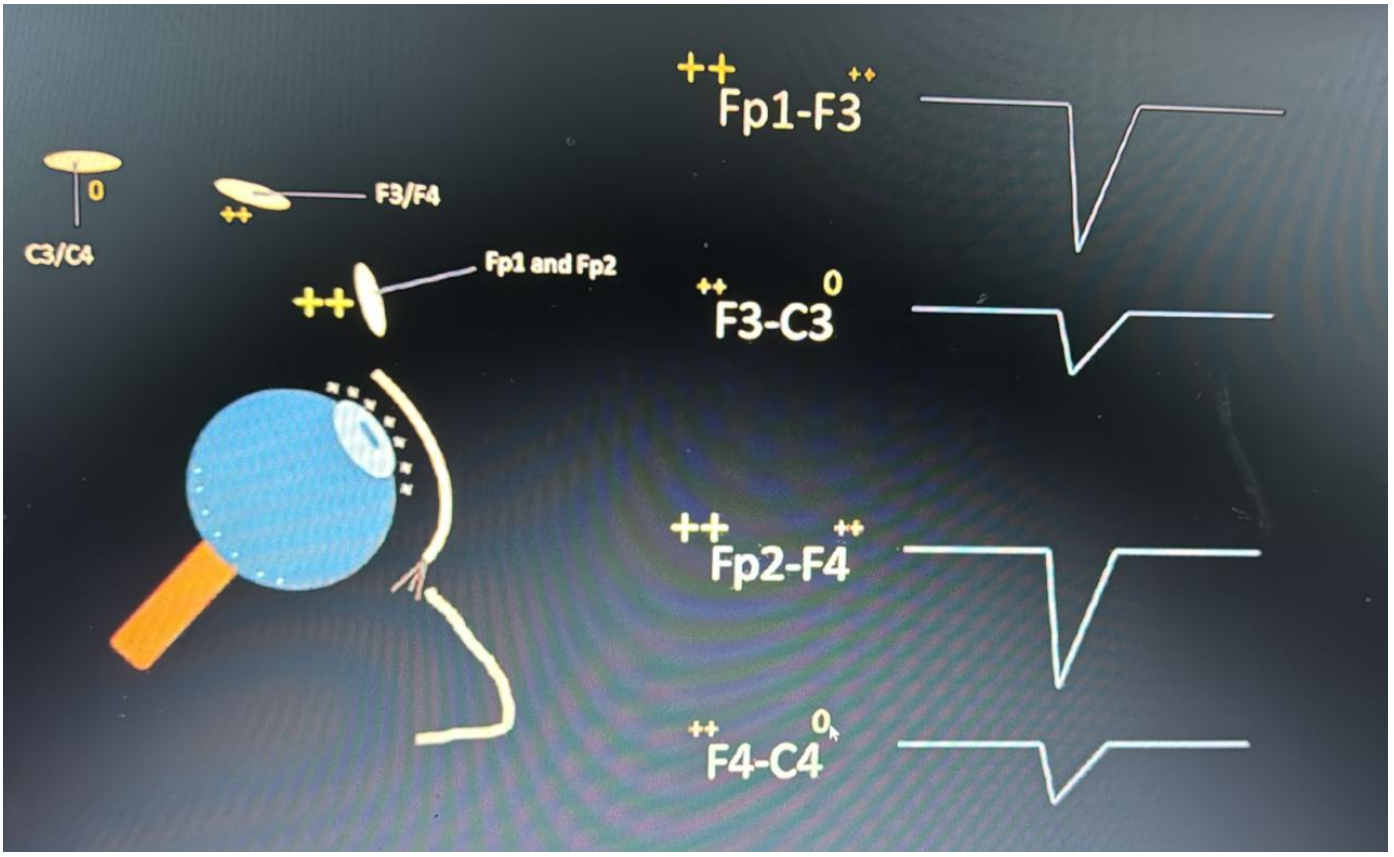
The differential amplifier allows us to filter out other ambient electromagnetic noise. The difference between the tracings can be considered as the actual brain wave. While the other movement we can consider ambient electromagnetic noise.The ability that the common wave forms are cancelled out while the differences remain is known as the common mode rejection ratio.

The tracing(input1-input2)is referred to as a channel.If there is an upward deflection in the channel, we say that input1 is negative w.r.t. input2.If there is a downward deflection in the channel, we say input1 is positive w.r.t. input2.

Eye movements on EEG

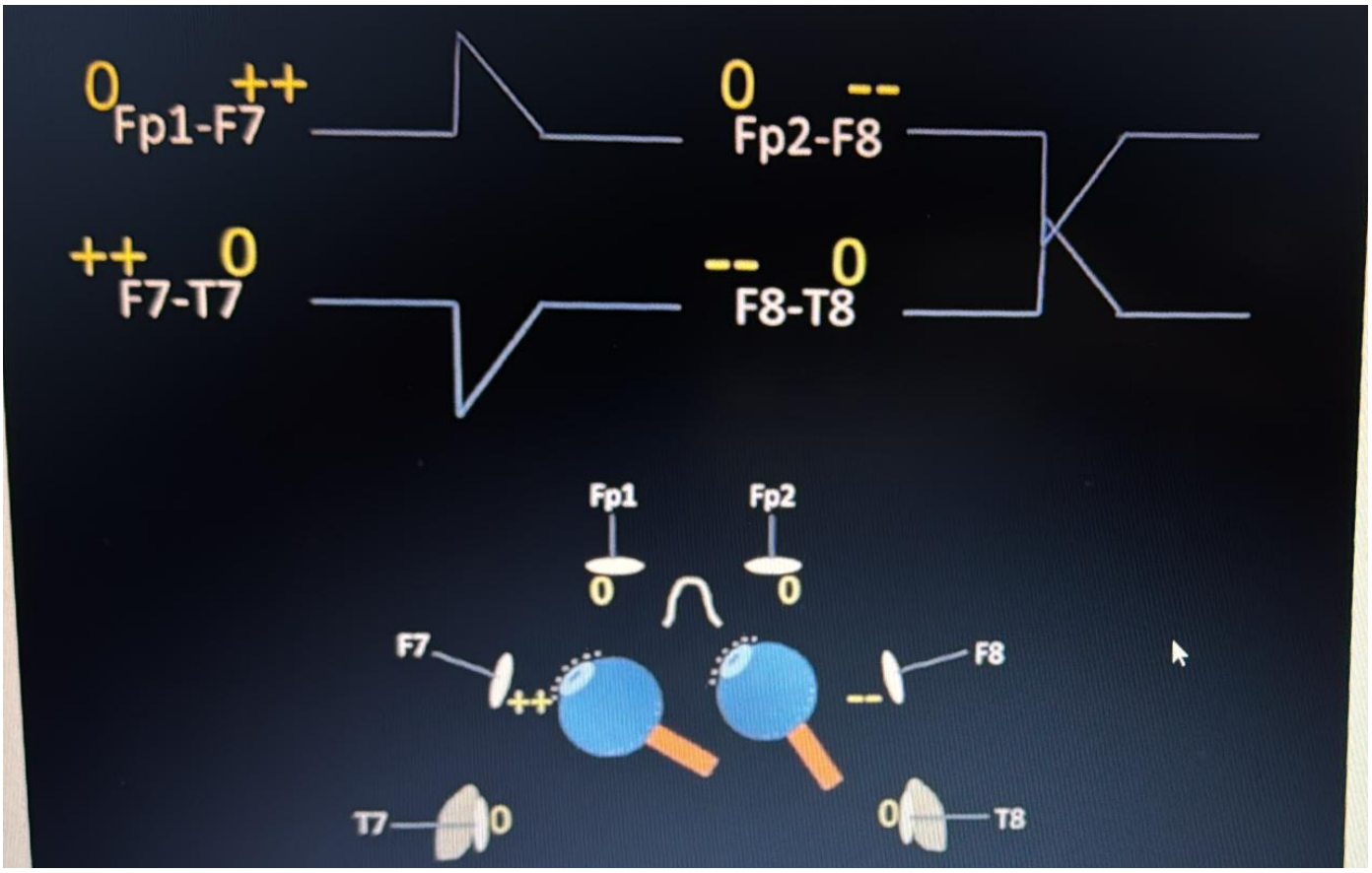
Blinking

The retina of the eye is relatively electronegative while the cornea is relatively electropositive.
When eye is blinked, the eyelid goes down while the eyeball moves upward into the head. This is known as Bell's phenomenaon. in this situation, the closest electrode would be Fp1 or Fp2 depending on the side of the head, which would see the greatest amount of positive charge from the electropositive cornea while C3 and C4 are so distant, they likely do not receive any charge from the eyeball.



Horizontal eye movement

In a left eye movement, the positive electrodes that are closest to these eye movements are F7 and T7 and the negative electrodes that are close to these eye movements are F8 and T8 and father away are Fp1 and Fp2.



In order for the eye to move to the left, the lateral rectus muscle has to contract which is very close to the F7 electrode. So the initial activity before the eye movement is a small negative charge secondary to the contraction of the lateral rectus, this is known as Lateral rectus spike which is sometimes mistaken for an epileptiform discharge.

How is EEG displayed?

Bipolar Montage

Bipolar EEG channels involve two adjacent scalp electrodes that capture the brain activity. The most common bipolar montage is the anterior-posterior bipolar montage. We put a number of chains together to generate a montage.

Common Reference Montage

In the common reference montage we compare signal at every electrode position on the head to a single common reference. One of the most common reference is the Cz montage.

Common Average Reference Montage

The common average EEG montage uses averaged potential of all the electrodes as the referential electrode and subtract it from the EEG signal at every electrode for every time point. Fp1 and Fp2 are very susceptible to eye movement while O1 and O2 are susceptible to head movement so they are generally excluded from the average reference montage.
Reference Contamination refers to the influence of the reference electrode on the recorded signals. Its placement and electrical characteristics can introduce artifacts into the EEG signal, which may distort the true brain activity being measured.

Laplacian Montage

In Laplace montage, we compare one electrode position to an average of its nearest neighbours which helps avoid reference contamination.
Laplacian montages are not good for broad electrical fields.(**K-complex**) which are observed during sleeping.

Waveforms in EEG

EEG recordings produce waveforms that are classified into different frequency bands, each associated with different states of brain activity.

1. Delta Waves (0.5-4 Hz): These are the slowest waves and are associated with deep sleep.
2. Theta Waves (4-8 Hz): Theta waves are slower than alpha waves and are often seen during drowsiness or light sleep.
3. Alpha Waves (8-12 Hz): Alpha waves are prominent during wakeful state when the mind is in a calm, idle state.
4. Beta Waves (12-30 Hz): Beta waves are associated with active, alert, and attentive states.
5. Gamma Waves (30-100 Hz): Gamma waves are the fastest brainwaves and are associated with memory recall, learning, and information processing.

Signals in EEG

Low-pass filter: A low-pass filter allows frequencies below a certain cutoff frequency to pass through while attenuating frequencies above that cutoff. It effectively removes high-frequency noise or components from the signal while preserving the low-frequency components.
High-pass filter: Conversely, a high-pass filter allows frequencies above a certain cutoff frequency to pass through while attenuating frequencies below that cutoff. It removes low-frequency noise or components from the signal while preserving the high-frequency components.
Diminished signal refers to a situation where the strength or quality of a signal is reduced, making it more difficult to detect or interpret.

Normal Awake

For normal wakefulness ,

- The low frequency filter is set to 1 Hz
- The high frequency filter is set at 70 Hz
- The notch filter is off
- The sensitivity is set to 7 microvolts/mm
- The time base is set to 30 mm/sec
- The montage is anterior-posterior bipolar montage which is common for routine EEG checkings

The characteristic of alpha rhythm which makes it of higher voltage with eye closure and attenuate with eye-opening is known as reactivity.
The normal range of amplitude of alpha rhythm is 20-50 microvolts.
The normal degree asymmetry of the right is higher voltage than that of left side(overall <50%)