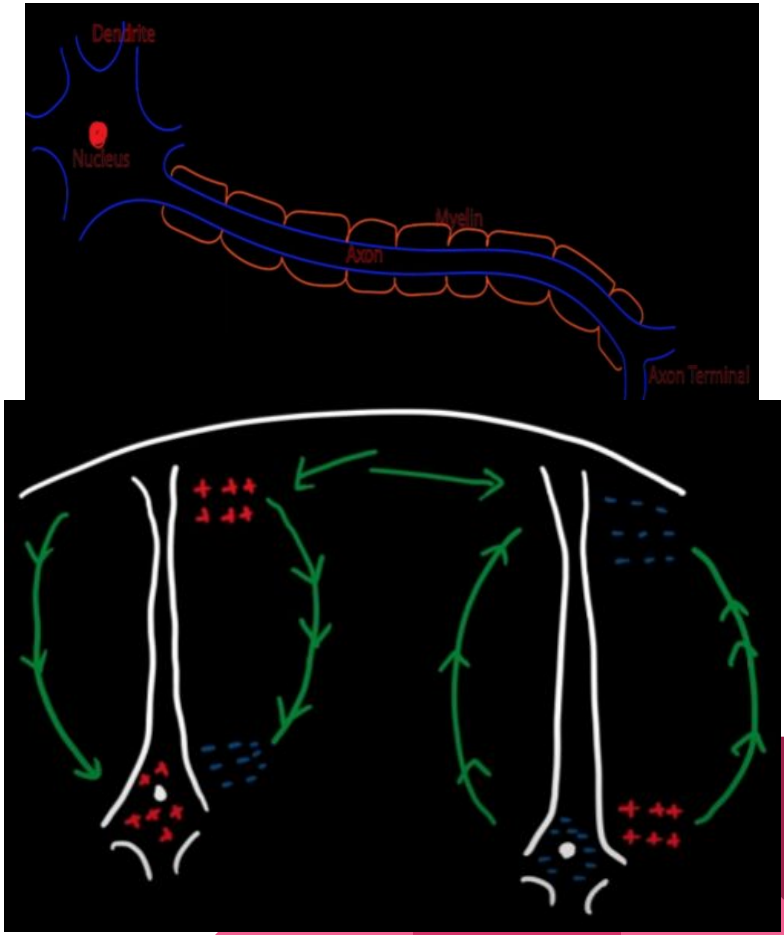
Electroencephalogram (EEG) Signals

Zachary Gros, Stephon Legnon

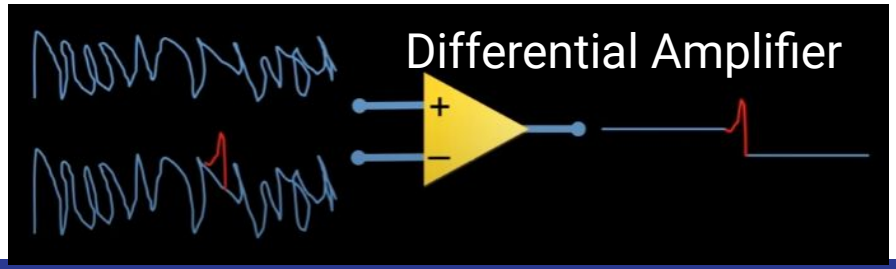
Generation of EEG Signals

Electroencephalography (EEG) signals are generated from the electrical activity of cortical pyramidal neurons within the brain's cerebral cortex (the brain's outermost layer). The detectable activity is the electrical signals emitted by the communication of two neurons. The sending neuron emits either an excitatory (+) or inhibitory (-) signal to the receiving neuron which then copies the signal's charge. Then, the extracellular space around the neuron builds up an opposing charge around the receiving neuron's nucleus. Additionally, the extracellular space near the axon terminal of the receiving neuron builds up a charge of the same charge as the neuron. With opposing charges occurring along the neuron, current will then begin to flow between the two ends of the neuron.



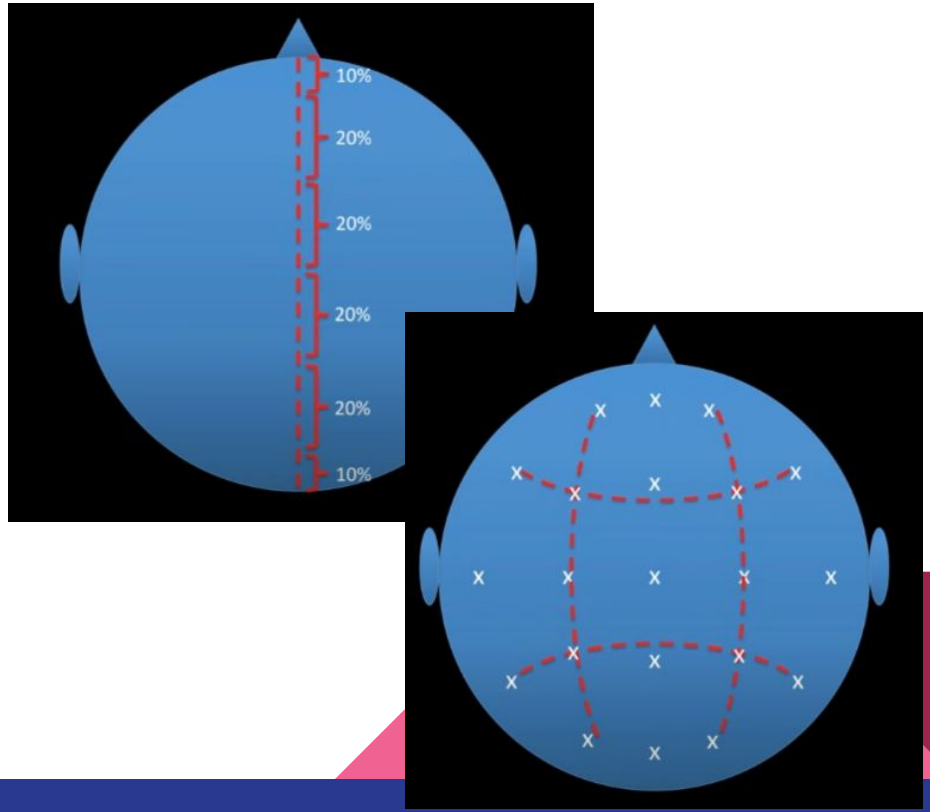
How EEG Signals are Recorded

As stated in the previous slide, the neurons that make up the neuron groups responsible for generating EEG signals are located in the third and fifth layers of the brain's cerebral cortex. Given that the cerebral cortex is the outermost layer of the brain, the generated EEG signals can be recorded by placing electrode along the scalp of a patient in which these electrodes record EEG signals using a differential amplifier. The differential amplifier detects two electrical inputs from two neurons and outputs the difference between the two inputs. This technology is very useful for recording and displaying miniscule differences in electrical signals.



Standard Electrode Placement Scheme for Recording EEG Signals

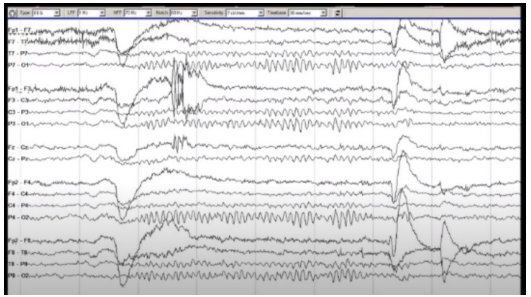
The standard electrode placement scheme for recording EEG signals is first constructed by placing electrodes in 10-20% increments beginning from the nasion located at the bridge of the nose to the inion located at the back of the head as shown in the leftmost diagram. This is repeated perpendicular to the original line. Then, electrodes are placed along the circumference of the head in 10% increments with electrodes being placed along the intersections of the parasagittal lines running across the head as shown in the diagram to the right.



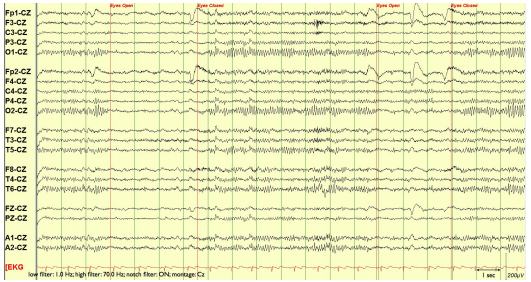
Montage Schemes

EEG montages are different ways to visualize EEG recordings. They involve capturing the differences between signals from various electrodes and comparing these signals on a graph. Some different types of montages are bipolar, reference, and laplacian montages. Bipolar montages compare the signals of adjacent electrodes along a specified path from the front to the back of the head, creating a chain of signals. These chains are recorded across multiple pathways and displayed collectively on a chart. Reference montages, on the other hand, involve comparing individual electrodes or groups of electrodes to a single reference electrode or a chain of electrodes. Laplacian montages focus on comparing a specific electrode's signal to the average of its nearest neighboring electrodes.

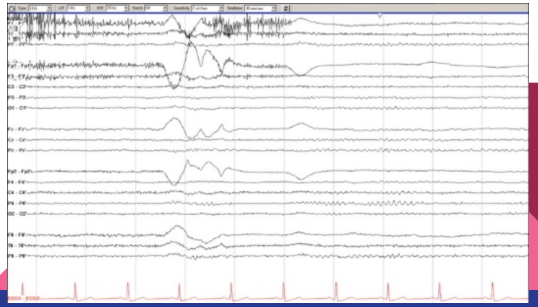
Bipolar Montage



Reference Montage

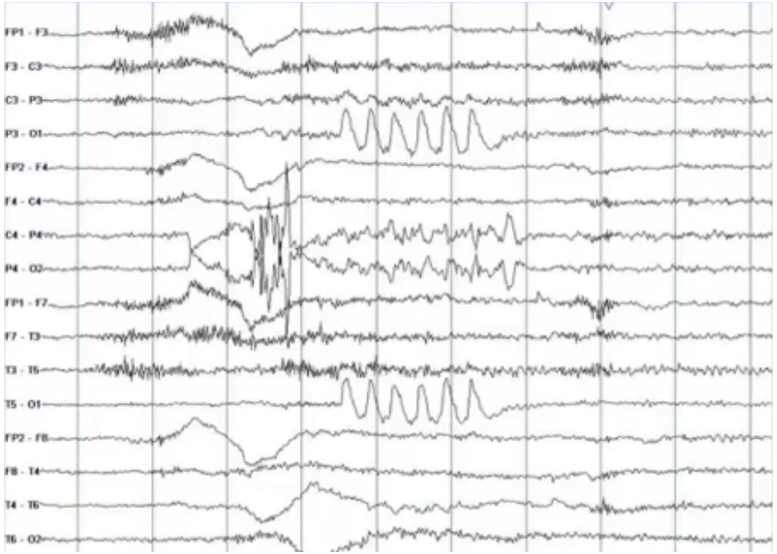


Laplacian Montage



Generation of the eyes-movement artifact

The eye can be thought of as having a positive and a negative end. When the eye moves toward a particular electrode on the scalp, it generates a spike of positive electricity, leading to an artifact in the EEG output. For example, during Bell's phenomenon, when a person blinks, the eye automatically moves upward, creating a change in positive charge at the electrodes near the front of the eye. This upward movement can be particularly pronounced in electrodes located above the eye. As a result, there is a larger negative reading in the surrounding electrodes due to the increased positive charge at the targeted electrode, which can complicate the interpretation of the EEG data.



EEG with eye movement artifact