

Electroencephalography: basic biophysical and technological aspects important for clinical applications

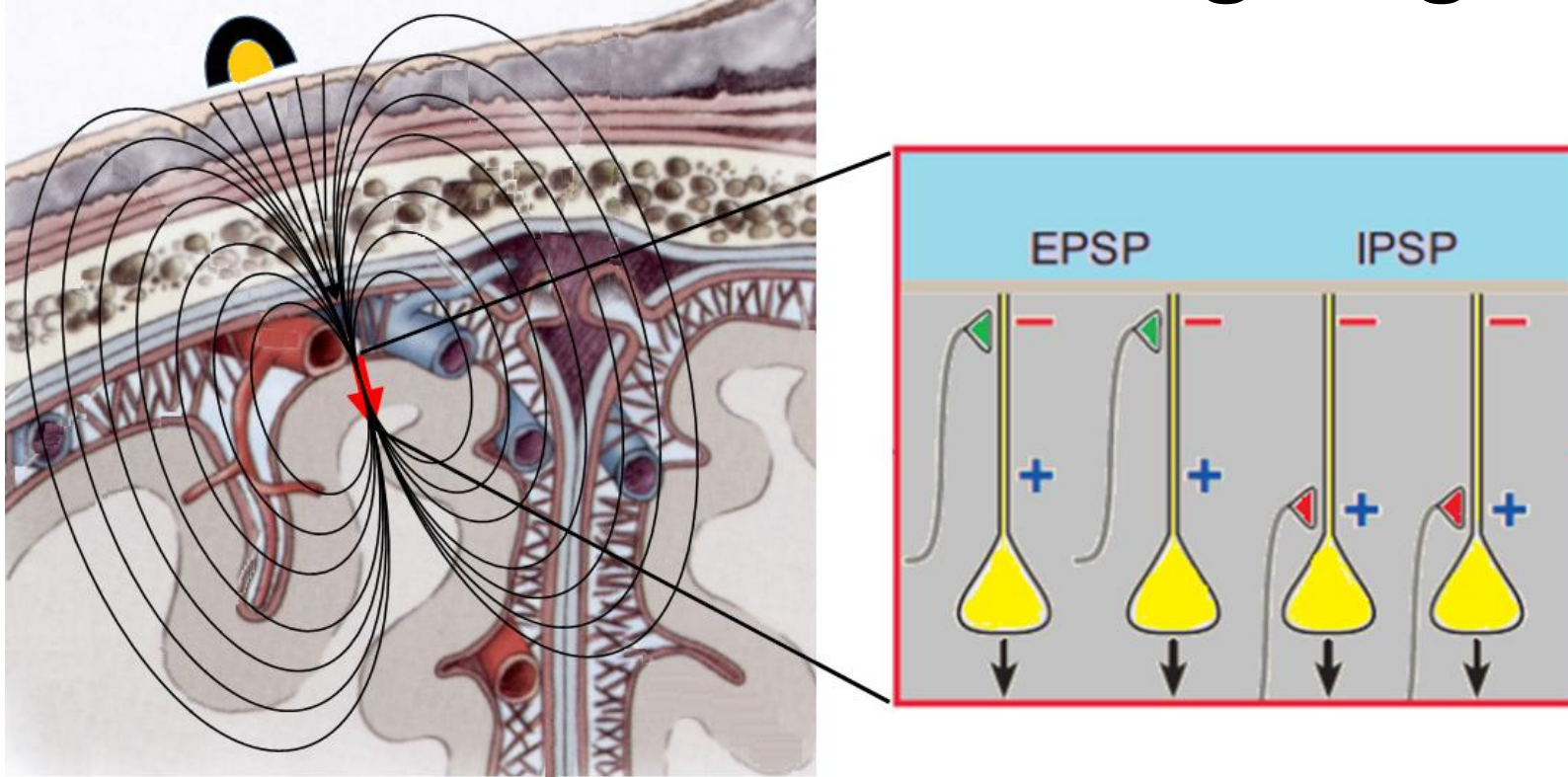
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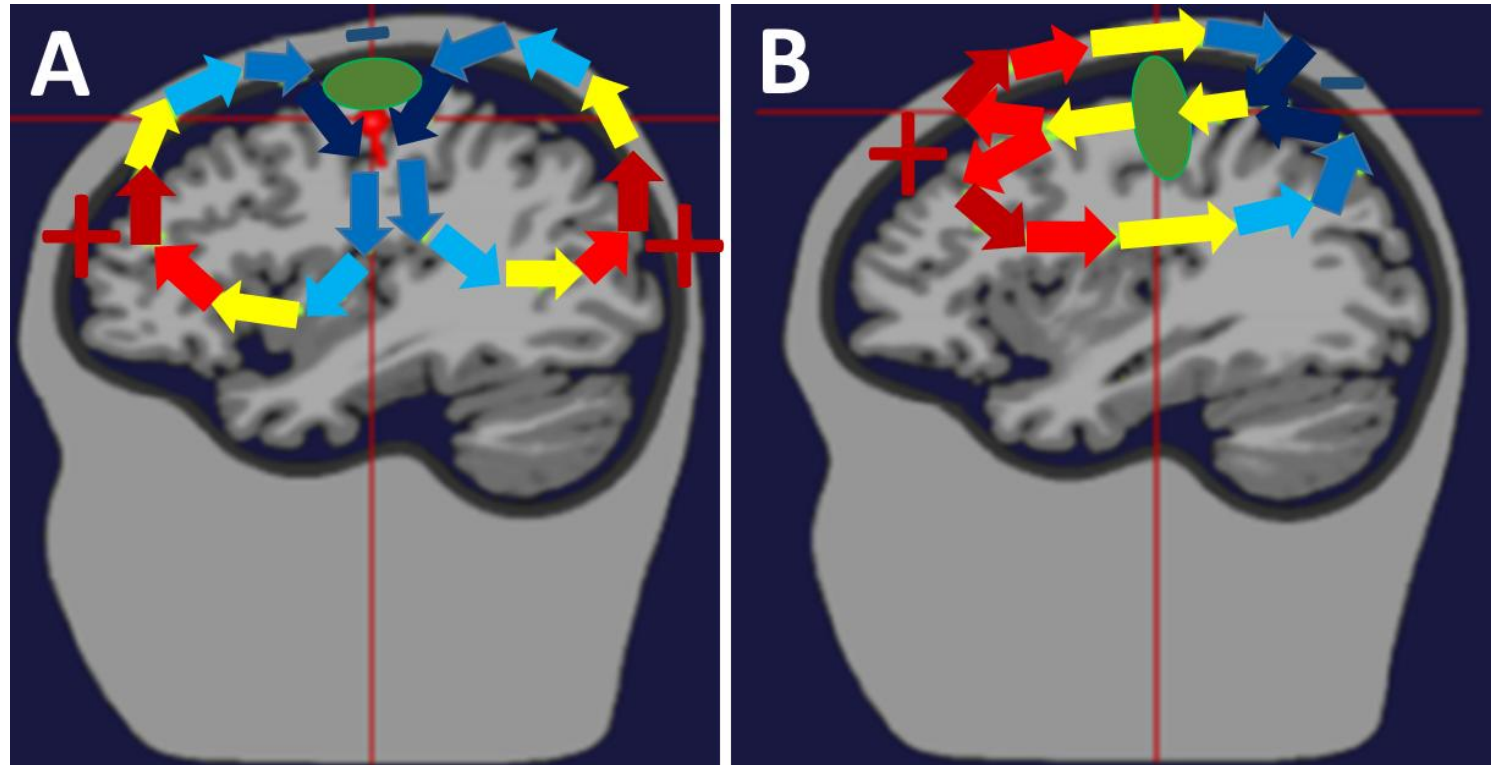
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Neuronal mechanisms of EEG signal generation



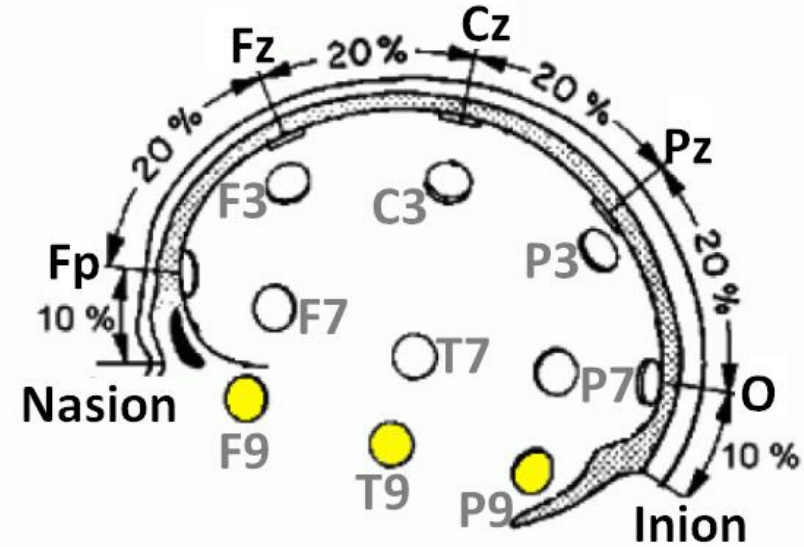
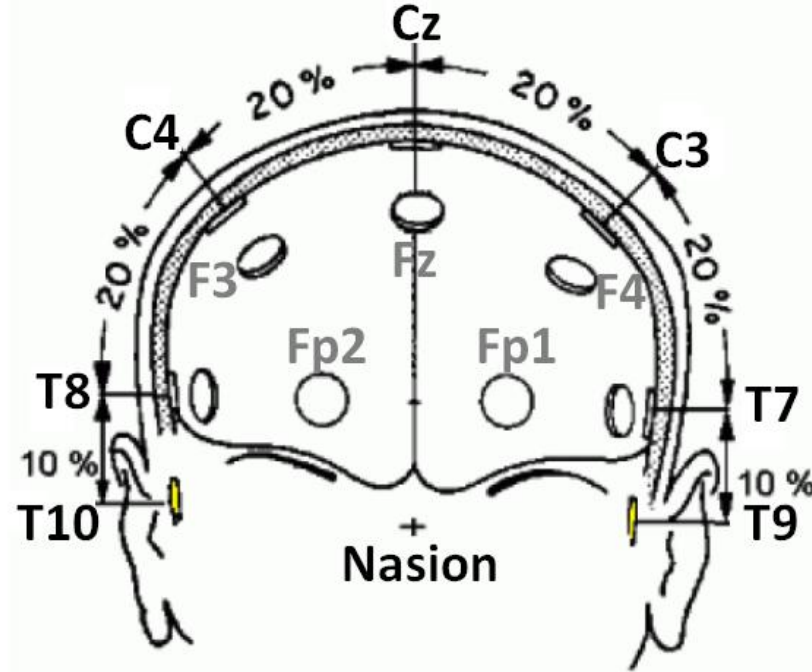
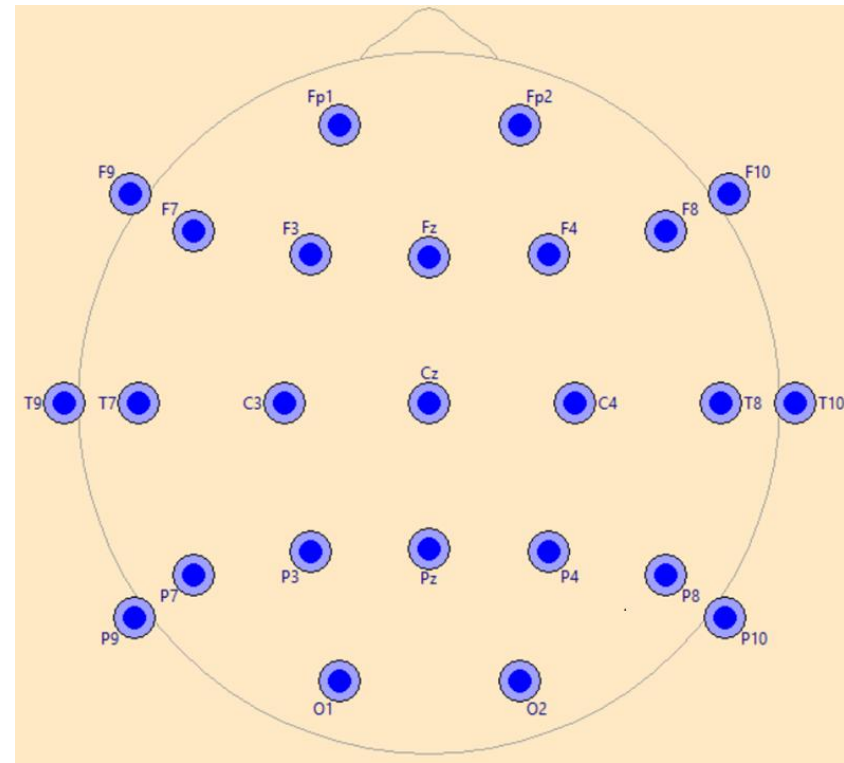
EEG signals are generated by the transmembrane ion currents in the pyramidal neurons (cortical layers IV-V). The black ellipsoids symbolize the volume conduction of the return currents in the tissue between the generator (red arrow) and the recording EEG electrode (cup containing conductive paste) on the scalp. The box to the right is a schematic representation of the local field potentials in the cortical generator. Excitatory post-synaptic potentials (EPSP, in green) have extracellular negativity at the synapse (active sink) due to the influx of Na^+ ions, and extracellular positivity at the passive source, due to the compensatory current. Inhibitory post-synaptic potentials (IPSP, in red) have extracellular positivity (active source) due to the influx of Cl^- or efflux of K^+ ions, and extracellular negativity at the passive sink, due to the compensatory currents.

Current flow generated by cortical sources



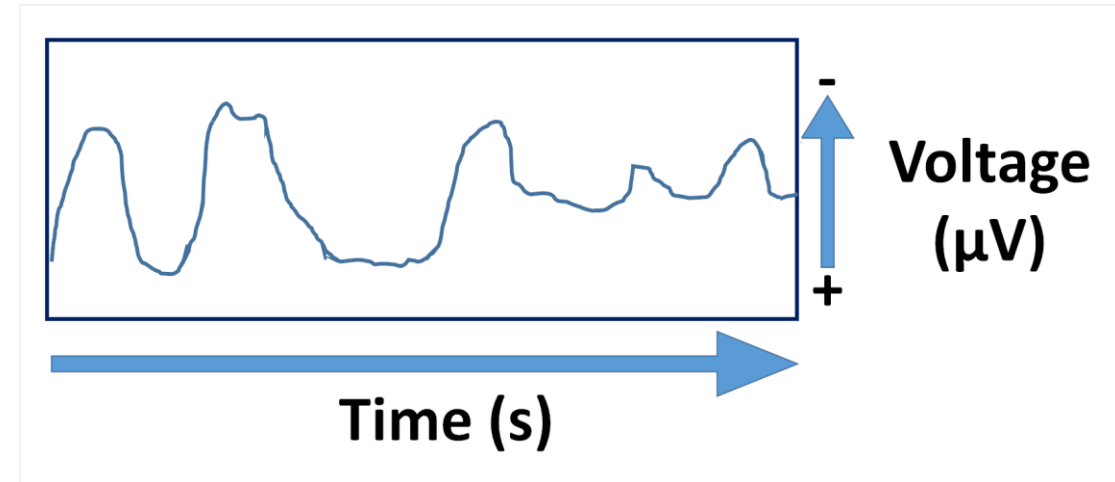
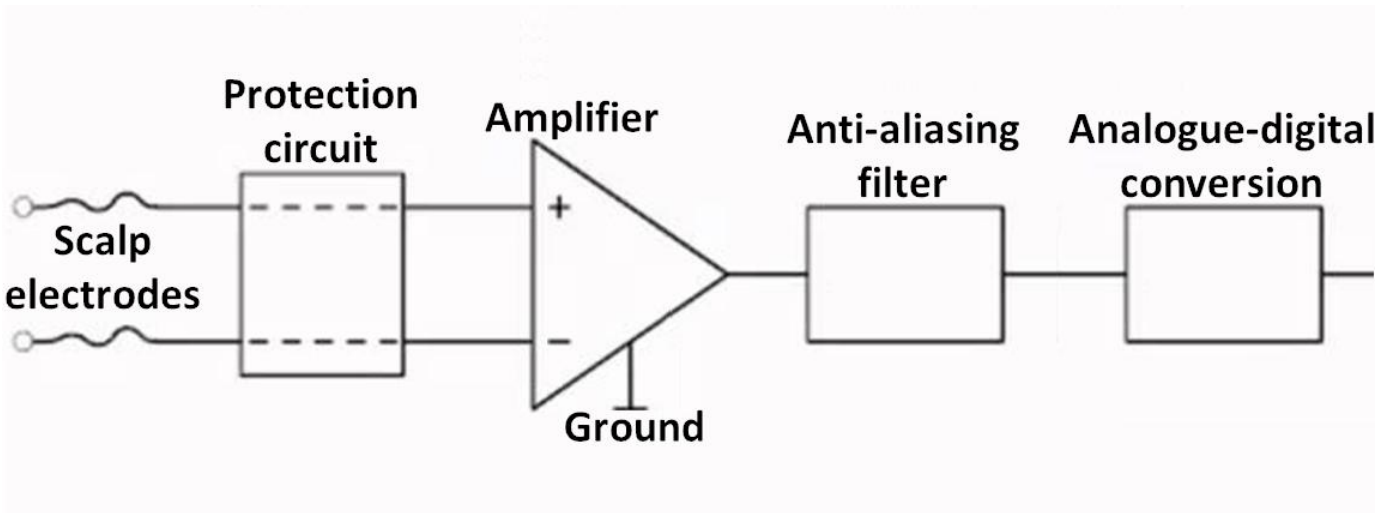
Cortical sources are depicted as green ellipsoids, at the center of the red cross-hair, with radial (A) and tangential (B) orientation. A: When the cortical source is on the convexity (radial orientation), the return currents generated along the apical dendrites have the direction shown in the figure, causing a relatively circumscribed area of negative potentials on the scalp, overlying the source. The rest of the scalp has low amplitude, diffuse positive potentials. B: When the cortical source is in the wall of a sulcus (tangential orientation), the return currents are parallel with the surface, as shown in the figure. This results in two areas with opposite polarity on the scalp. The negative polarity is in the direction of the cortical surface of the generator. The color scale in the arrows indicate the polarity: red – positive, blue – negative, yellow, transition between them.

The standard 25 electrode array of the International Federation of Clinical Neurophysiology



The landmarks and measuring of the 10 and 20% distances for standard electrode placement. A: coronal plane; the distance is measured between the preauricular points (T9 and T10). B: sagittal plane; the distance is measured from nasion to inion. The electrodes highlighted in yellow represent the inferior temporal chain ("low row").

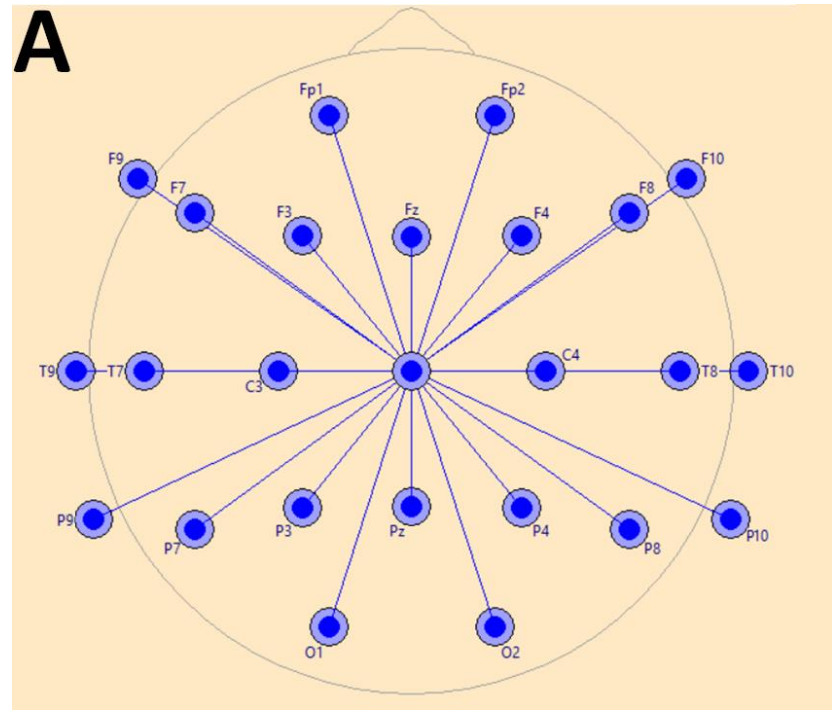
Schematic representation of the EEG amplifier & display of the signals



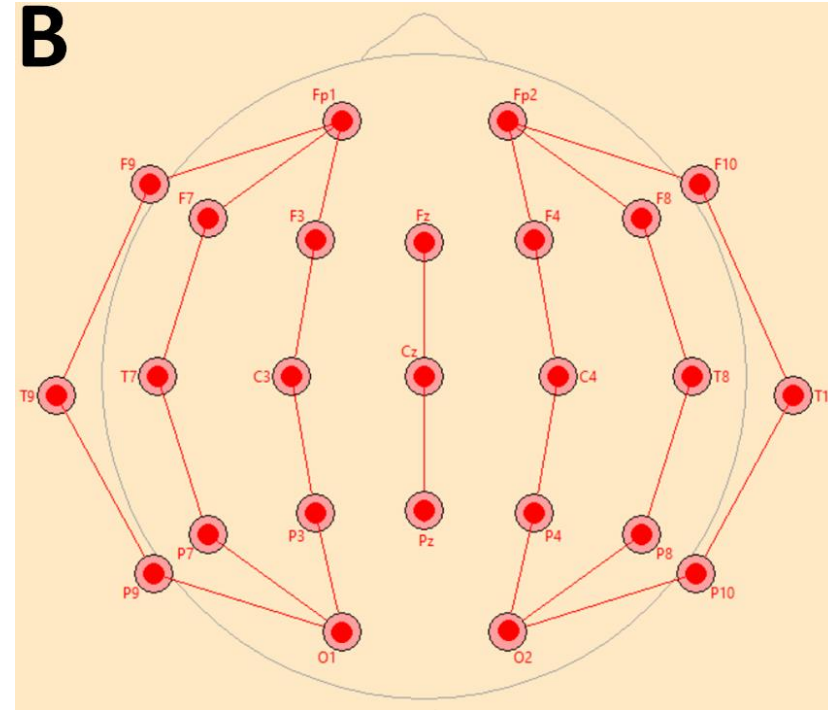
Each EEG channel is displayed as an oscilloscope: time runs from left to right and voltage is plotted on the vertical axis.

By convention, in EEG, the negative values are upwards and the positive values are downwards on the vertical axis.

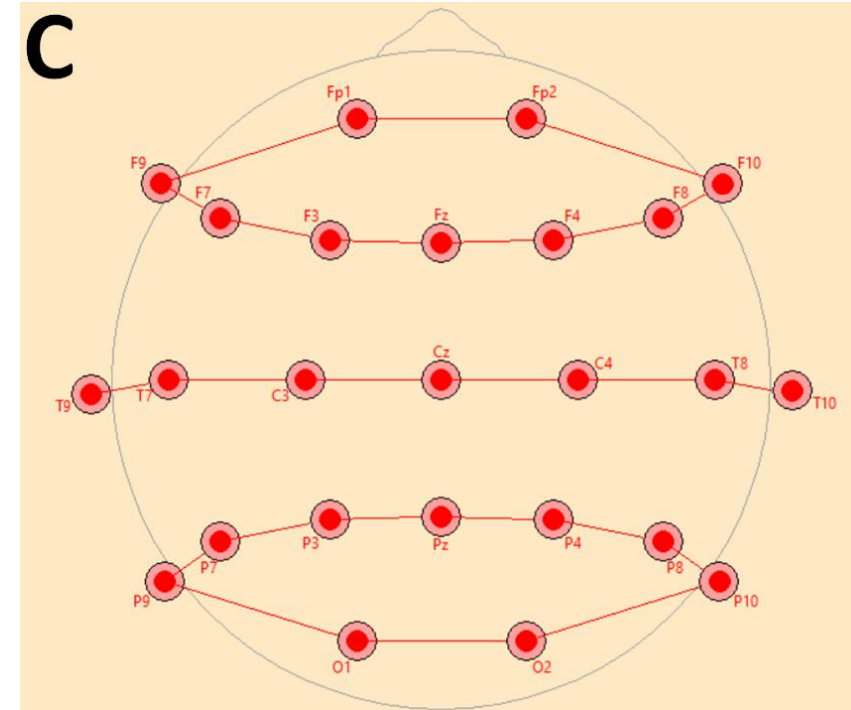
EEG montages that use scalp electrodes as reference



A: referential montage (to Cz).

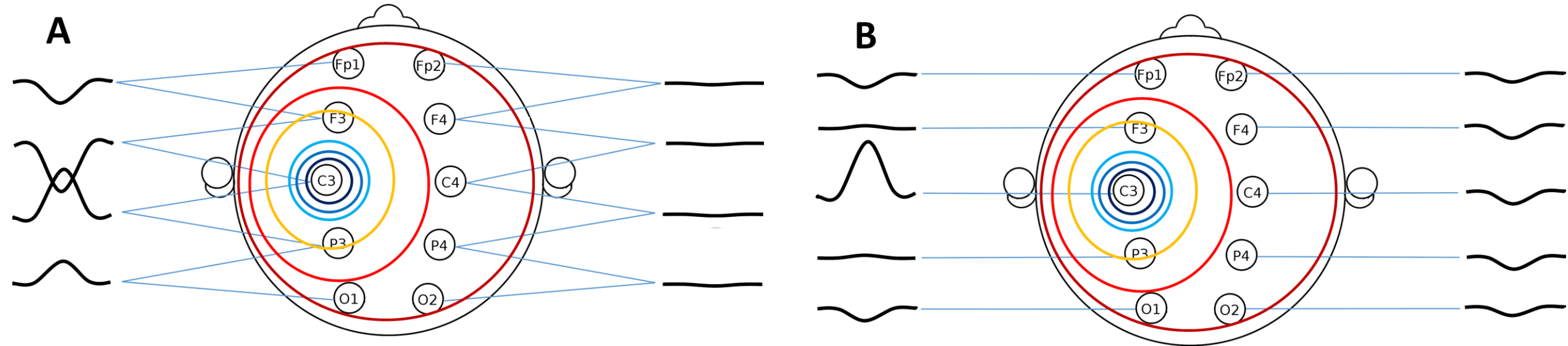


B: longitudinal bipolar montage.



C: transversal bipolar montage.

Schematic representation of EEG traces recorded from a signal generated by a cortical source with radial orientation

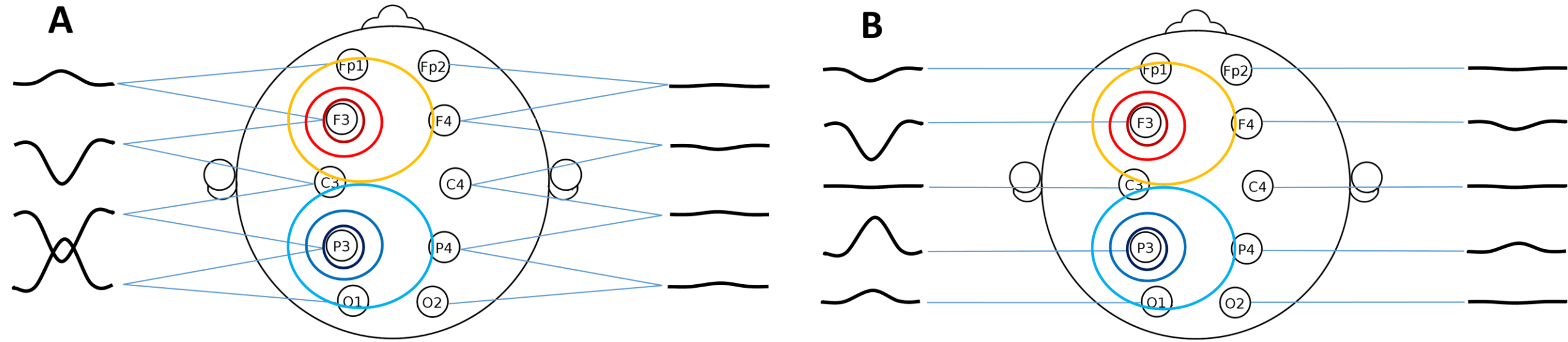


A: longitudinal bipolar montage.

B: common average montage.

Color code for the topographic distribution on the scalp: blue – negative, red – positive potentials, yellow – transition between them.

Schematic representation of EEG traces recorded from a signal generated by a cortical source with tangential orientation (the anterior wall of the central sulcus).

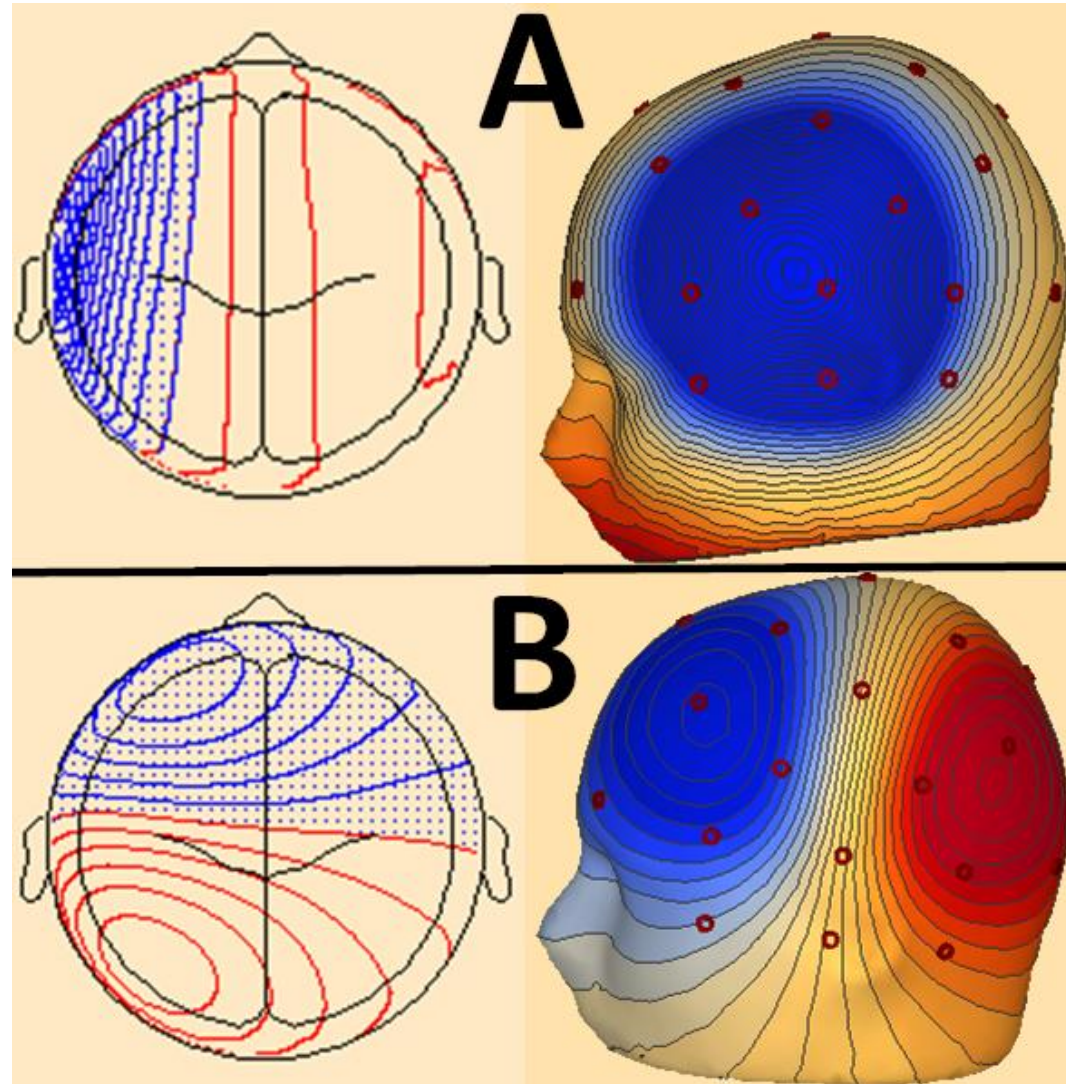


A: longitudinal bipolar montage.

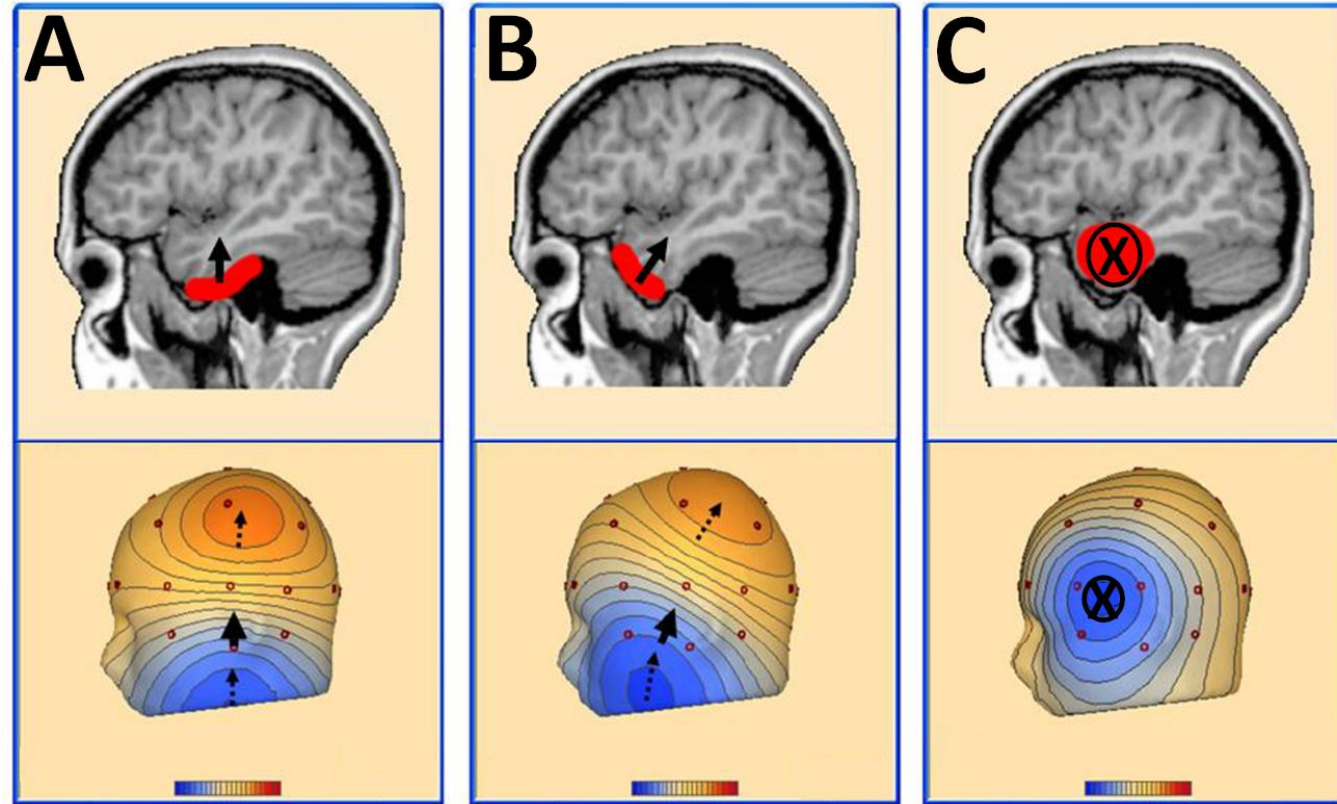
B: common average montage.

Color code for the topographic distribution on the scalp: blue – negative, red – positive potentials, yellow – transition between them.

Voltage maps showing topographic distributions of negative (blue) and positive (red) potentials, generated by cortical sources with radial (A) and tangential (B) orientation.



Voltage maps corresponding to signals generated in different regions of the left temporal lobe



A: basal; B: polar; C: lateral.

In the upper row, the cortical areas generating the signals are highlighted in red. In the lower row, the arrows show the location and the orientation of the cortical sources – tangential in A and B, radial in C.