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EEG Primer

Sándor Beniczky

- Basic EEG technology:
  - Electrodes and montages
- How to assess EEG systematically:
  - Background activity
  - Interictal EEG patterns
  - Ictal EEG patterns
- Sensitivity & specificity:
  - avoiding false positives & false negatives.

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Basic EEG technology
Outline

- **Where is the EEG signal generated?**
- **EEG electrodes**
- **EEG Montages**

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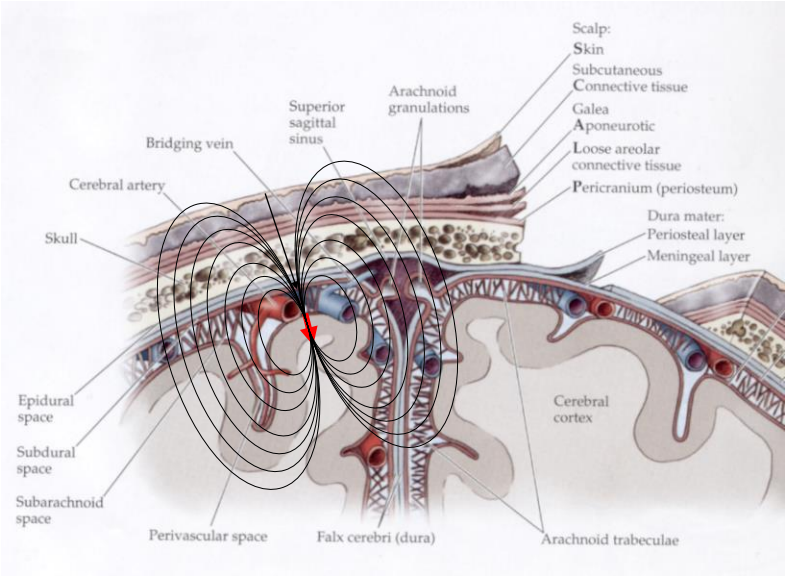

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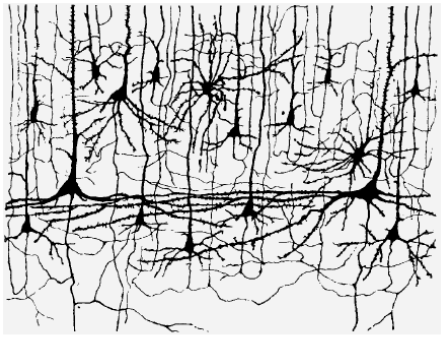
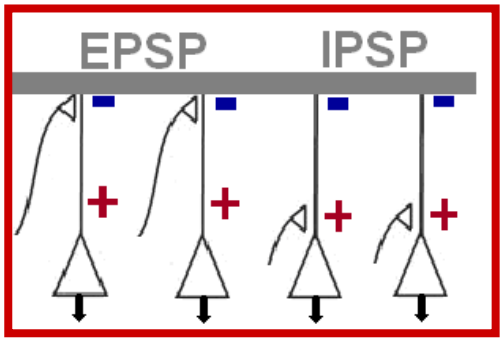
Where is the EEG signal generated?

- PSP (mainly)
- dendrites



A Neuronal network in the cerebral cortex, silver impregnation (according to *Cajal*)



Reading EEG in the clinical practice: empiric!

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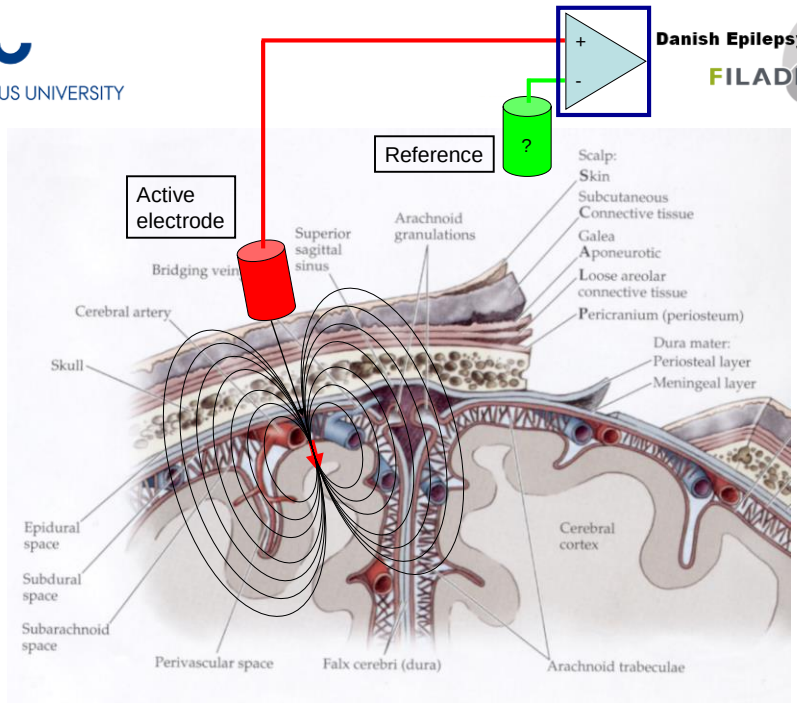

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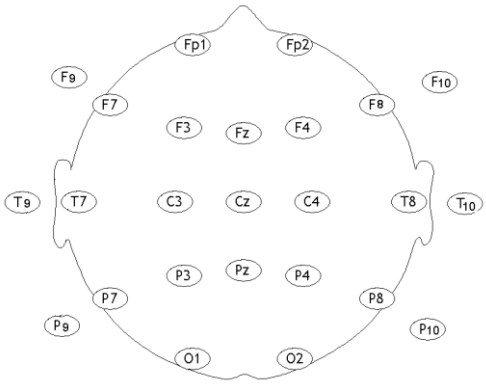
IFCN electrode array



Seeck et al., Clin Neurophysiol. 2017

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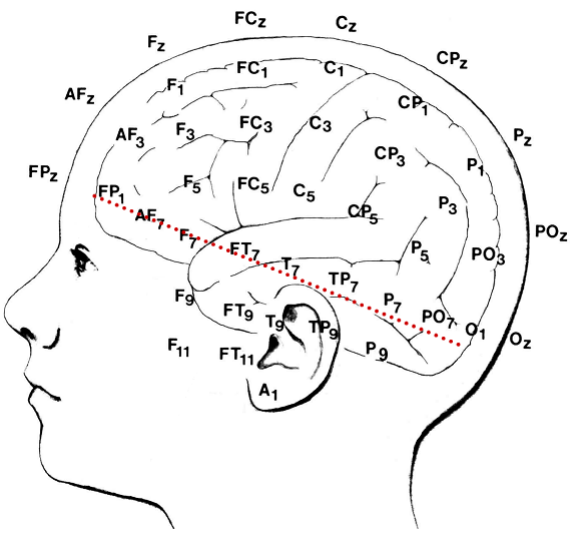

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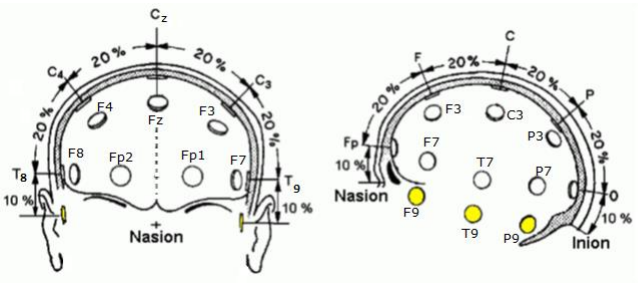

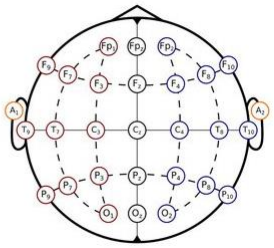

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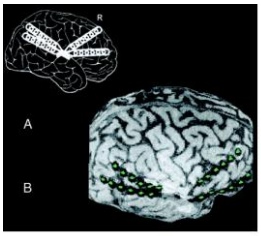
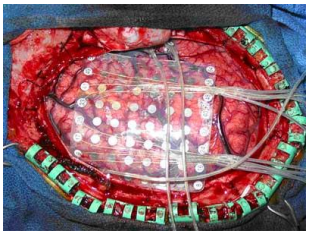
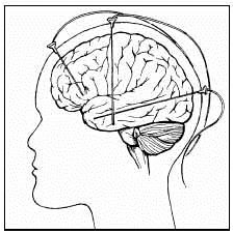
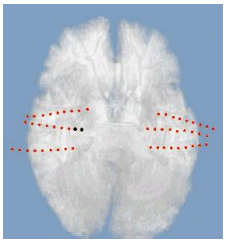
Intracranial electrodes









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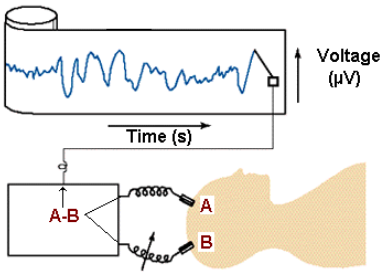
EEG channel



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Montages

- Connecting scalp-electrodes:
  - Two-by-two:
    Bipolar montages
  - Each electrode to the same reference electrode:
    Referential montage

- Calculating (computing) the reference electrode (potential):
  - **Common average**
  - **"Reference-free" montage (BESA)**
  - **Current source density (CSD)**
  - **Source derivation; source montages**

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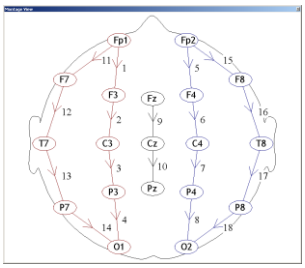
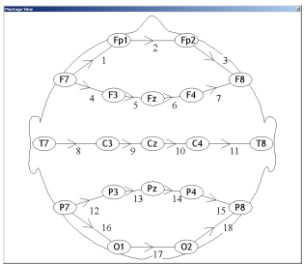
Bipolar montages: chains of electrode-pairs

- Longitudinal bipolar



- Transversal bipolar



(Fp1-CRR)-(F3-CRR) = Fp1-CRR-F3+CRR = Fp1-F3

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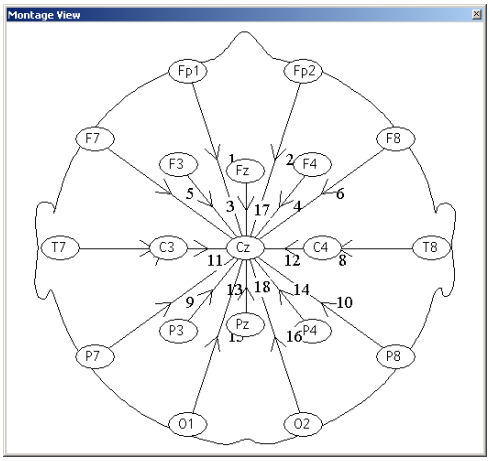
Referential montages:

- All electrodes are connected to the same (real, existing) scalp-electrode
- This electrode is usually:
  - Cz
  - A1
  - A2
  - A1-A2



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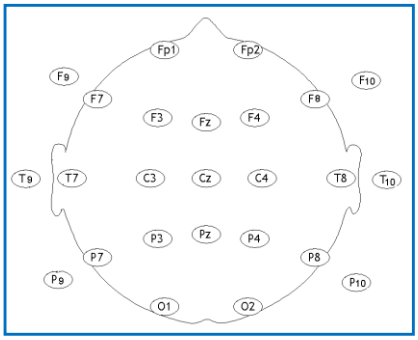
Common Average:

Reference= (Fp1+Fp2+…O2)/25

For example 25 electrode setting: 1/25 = 4%

One scalp-electrode only contributes to 2%

of the signal in the channel (for bipolars the reference contributes 50%)



Charges rearranged on the scalp, but the sum of it=0.

Average of all electrodes: neutral (inactive) reference

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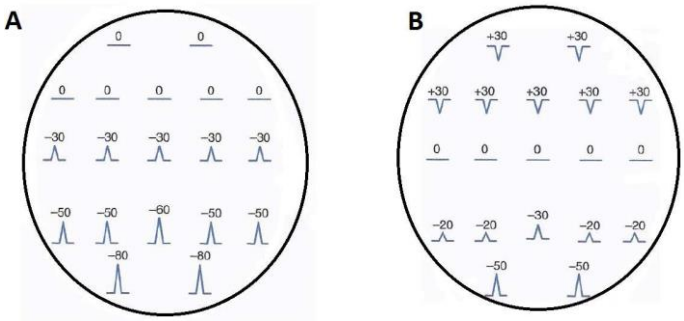
Erroneous concepts on how potentials are induced on the scalp and how they are reflected in common average montage:



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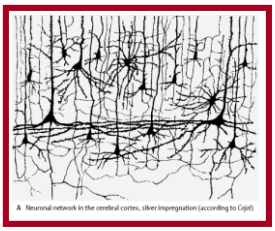
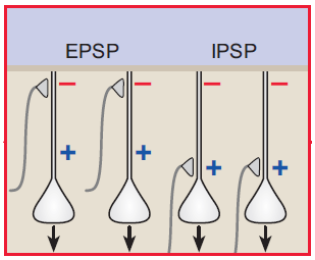
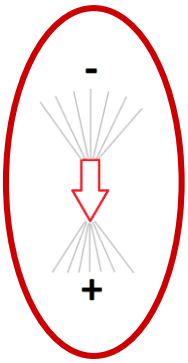
Signal generation







Interictal Epileptiform Discharges: summation of many dipoles

Return currents

- Negative potential - at the cortical surface
- Positive potential - in the opposite direction

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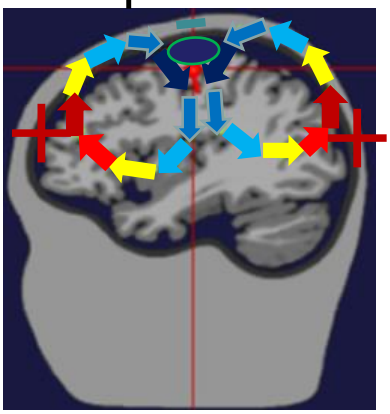
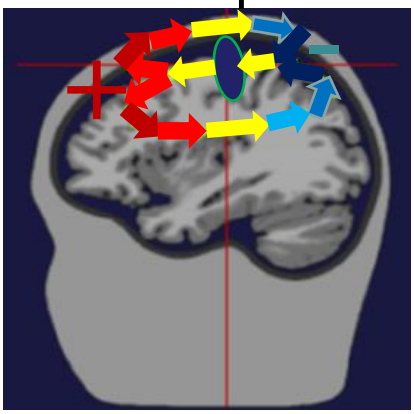
Signal generation:

Both negative and positive potentials on the scalp





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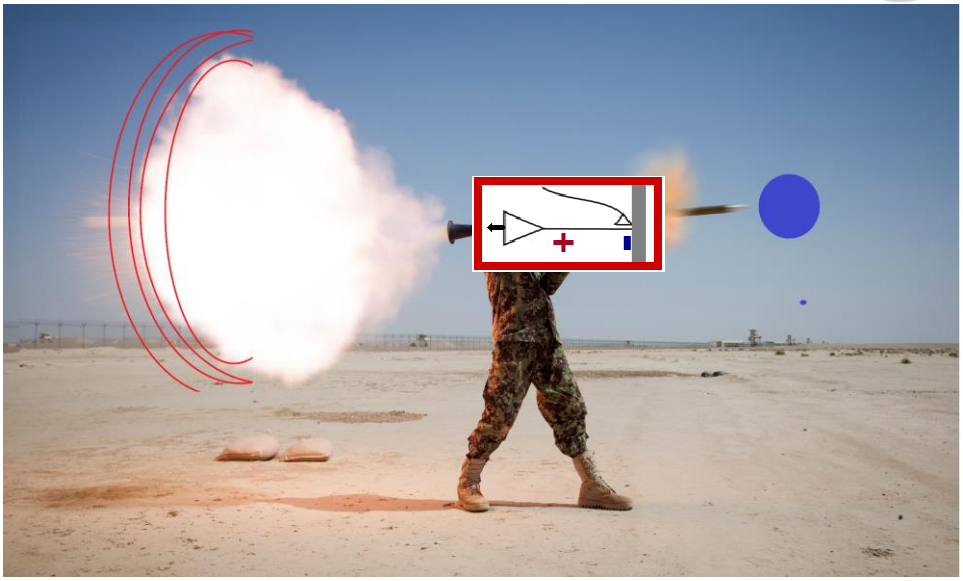

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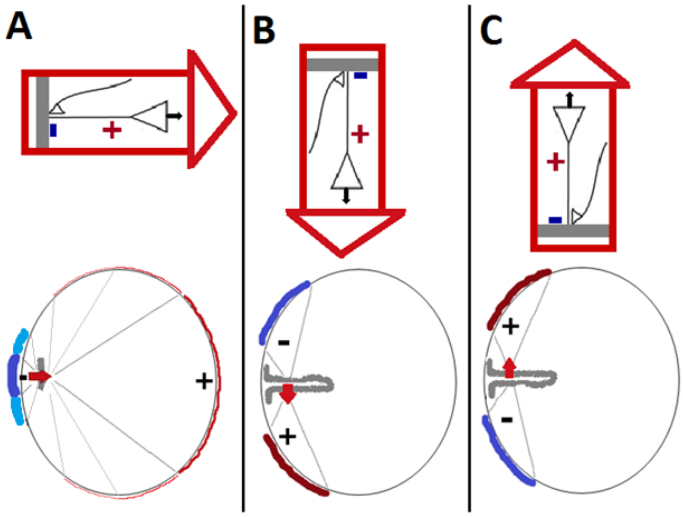

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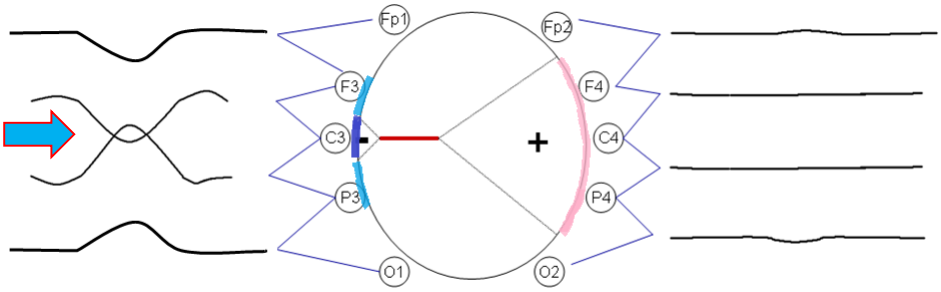
Radial dipole – longitudinal bipolar

Negative Phase-reversal



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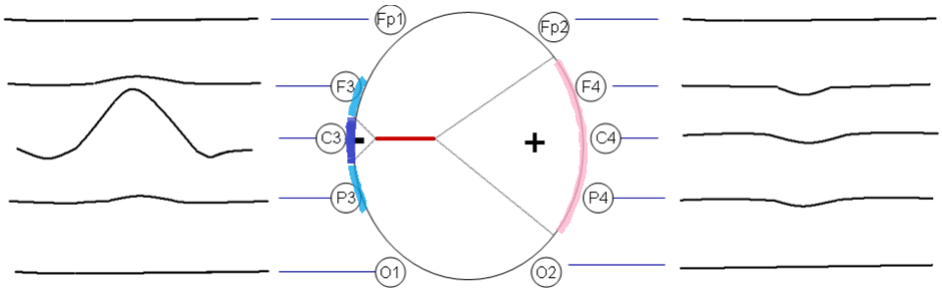
Radial dipole – common average



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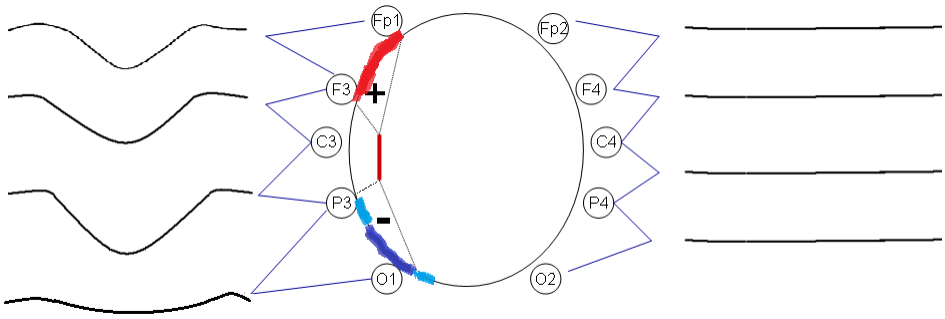
Horizontal tangential dipole - longitudinal bipolar



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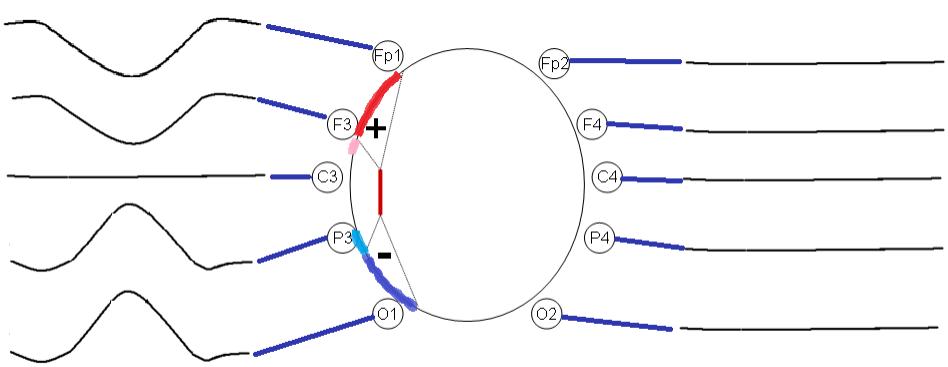
Horizontal tangential dipole – common average



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Advantages and disadvantages of different montages

Montage	Advantages	Disadvantages
Bipolar	- usually localizes well the negative peak - quite reliable to show side-difference - shows well the artefacts / eye-movement; salt-bridge between electrodes	- only 2-by-2 comparisons - distortion of actual wave-form - poor detection of widespread sources - longitudinal: might miss vertical dipoles - transversal: might miss horizontal tangential dipoles
Common average	- good representation of the waveform - comparison of all electrodes - visualization of diffuse abnormities - visualisation of the positive potentials of the dipole	- a salt-bridge between 2 adjacent electrodes will not be noticed - upward-shift of the zero-voltage line (especially if the electrodes in the inferior temporal chain are not included in the array) - if several electrodes are rhythmically active, it might mislead those who are not familiar with this montage

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Polygraphic (non-EEG) channels

- ECG:
  - Differential diagnosis
  - Identification of artifacts (ECG artifact, pulse artifact)
- Surface-EMG
  - Characterization of motor seizures

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