LMU KLINIKUM DER UNIVERSITÄT MÜNCHEN
CAMPUS GROSSHADERN
INSTITUTE FOR STROKE AND DEMENTIA RESEARCH (ISD)

Standard electrode positions and reference systems

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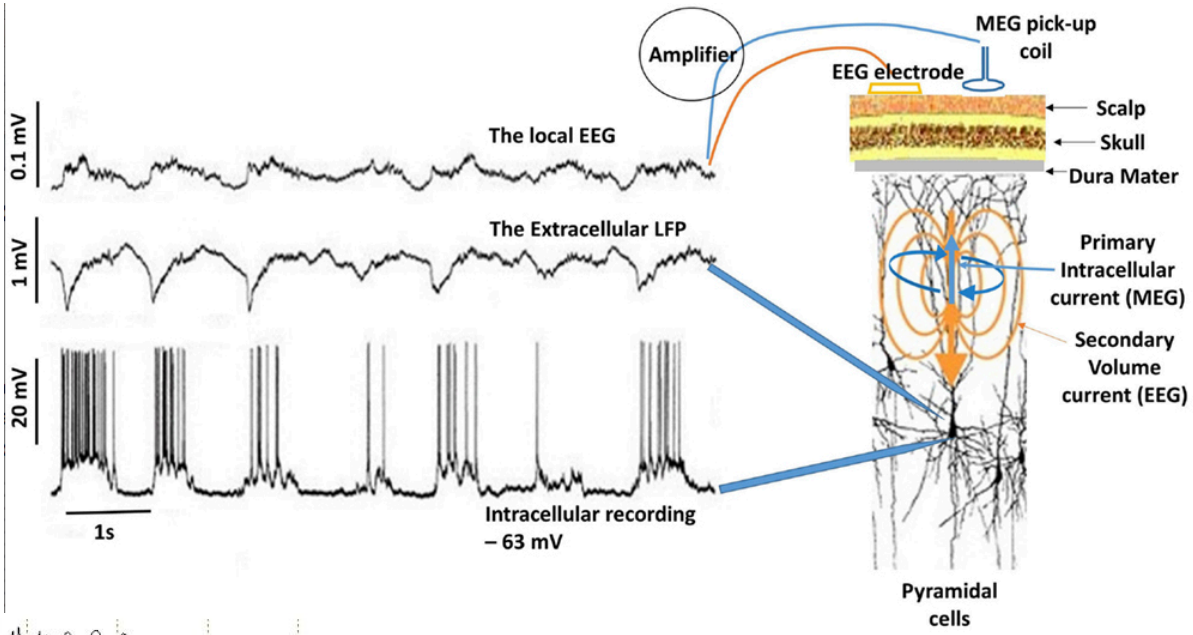
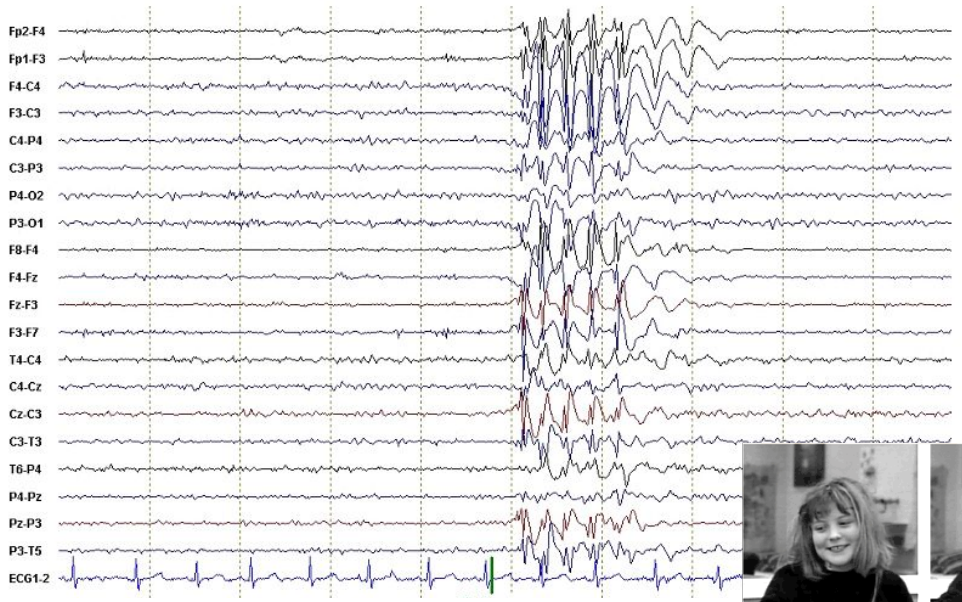
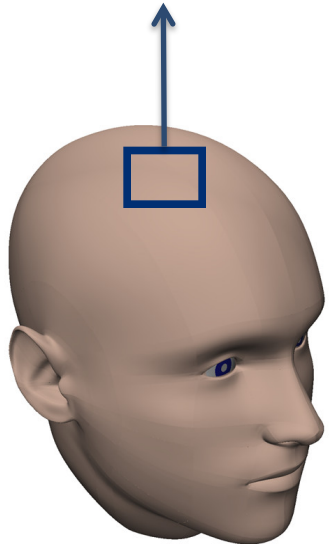
Funded by:
Solorz-Żak Research Foundation

EEG - overview

- **What is recorded?**
  - Electrical activity of the cortex
  - Voltage fluctuations from ionic current within neurons



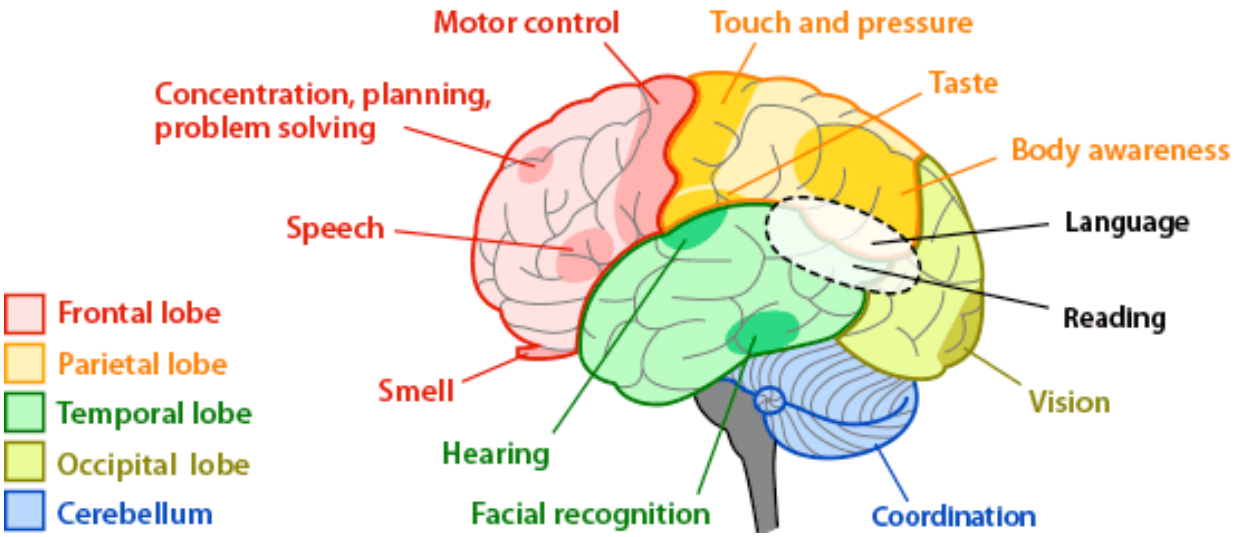




EEG - challenges

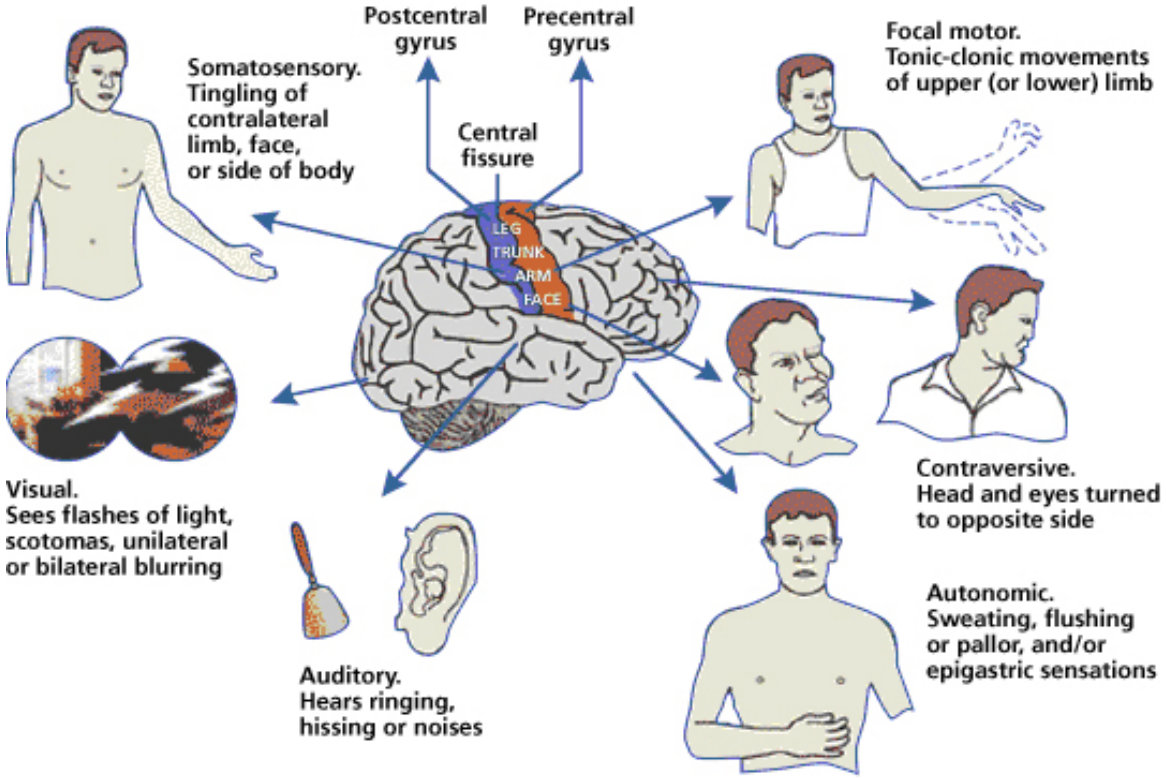
- In order be **comparable** between subjects and sites and to fulfill clinical and scientific requirements, the EEG signal should be **recorded in a standardized manner**

- **Science:** Different brain regions are involved in different cognitive processes



EEG - challenges

- In order be **comparable** between subjects and sites and to fulfill clinical or scientific requirements, the EEG signal should be **recorded in a standardized manner**
- **Clinic:** Different brain regions are involved in different etiologies of neurological disorders (epilepsy→ epilepsy surgery)

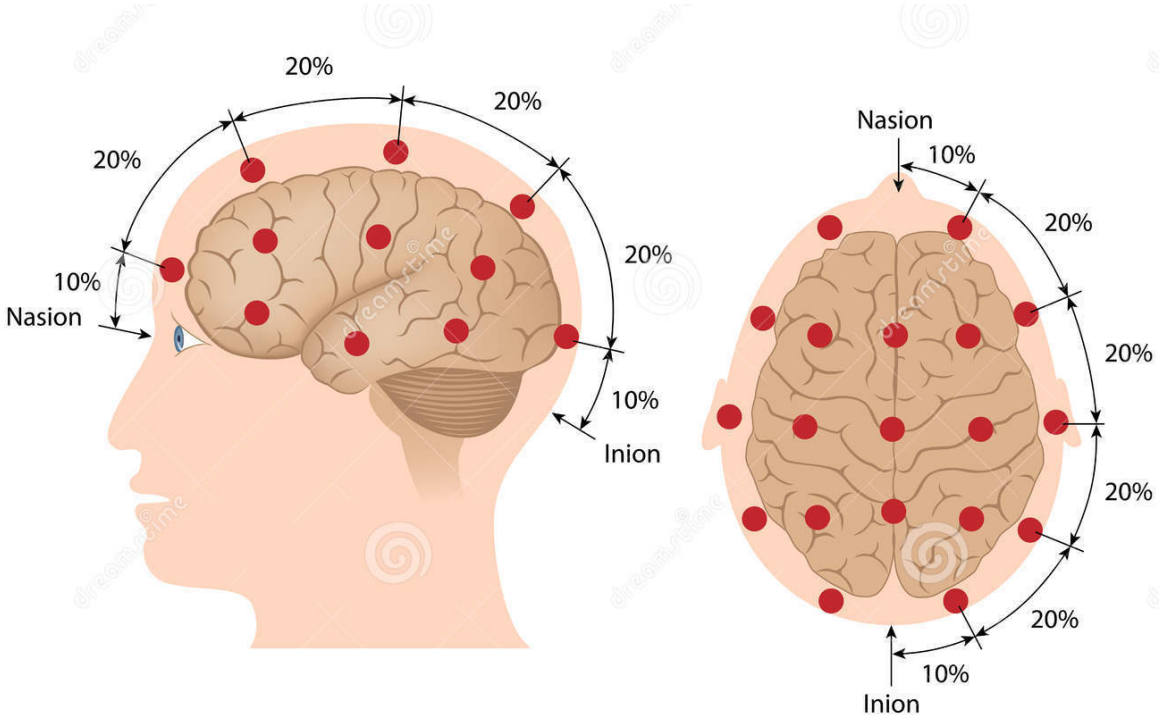


EEG - challenges

- A standardized EEG electrode positioning system is required

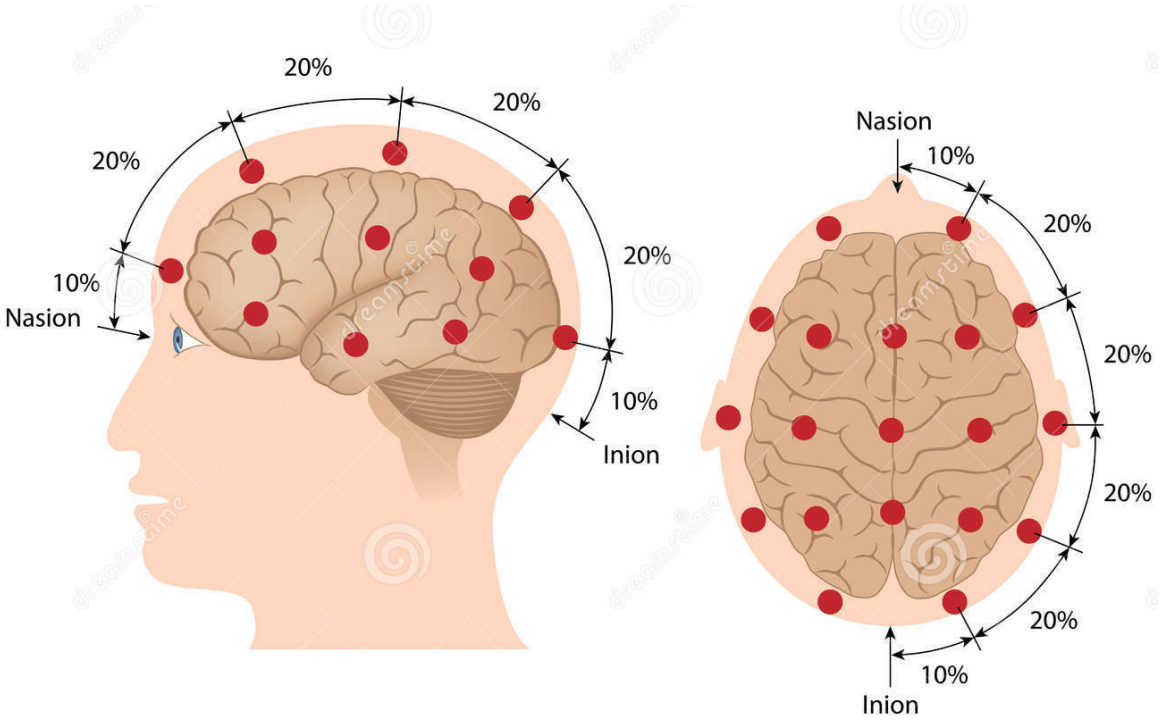
The 10-20 System of Head Measurement and Electrode Placement

- Standardized placement system of EEG electrodes established in 1958 by H. Jasper, a canadian psychologist
- Meant to facilitate communication and comparison of results
- Provides for adequate coverage of all parts of the head/brain



The 10-20 System of Head Measurement and Electrode Placement

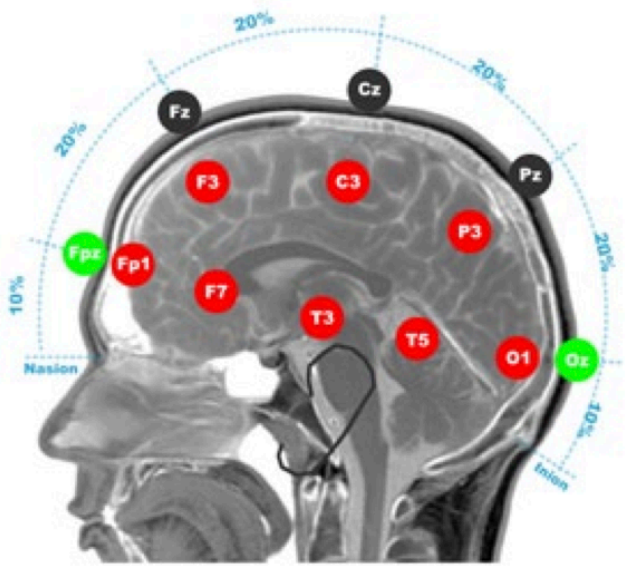
- The numbers ’10’ and ‘20’ refer to the distances between adjacent electrodes
- Usually, 21 (19 active + ground & reference) electrodes are used, but others can be added to improve spatial resolution



The 10-20 System of Head Measurement and Electrode Placement

Terminology:

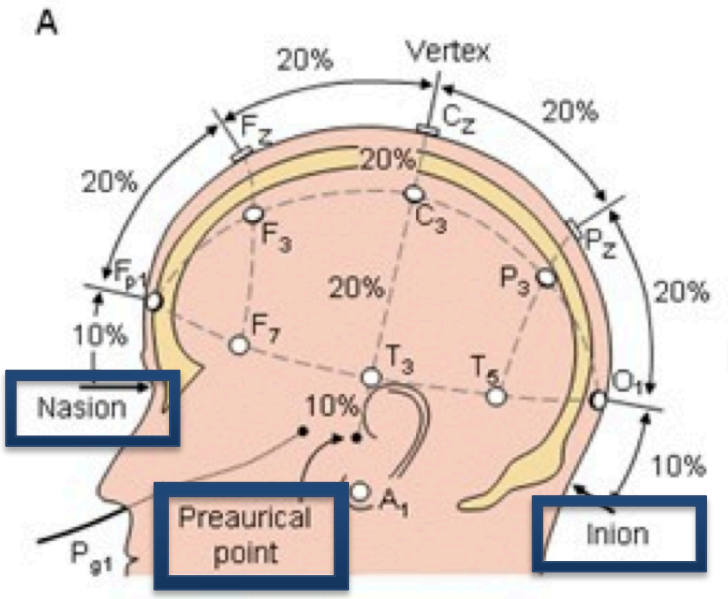
- Each electrode has a **letter** to identify the lobe and a **number** to identify the hemisphere location
- **Even** numbers (2,4,6,7) refer to electrodes on the right hemisphere
- **Odd** numbers (1,3,5,7,) refer to electrodes on the left hemisphere
- Electrodes along the mid sagittal plane have the **subscript "z"**

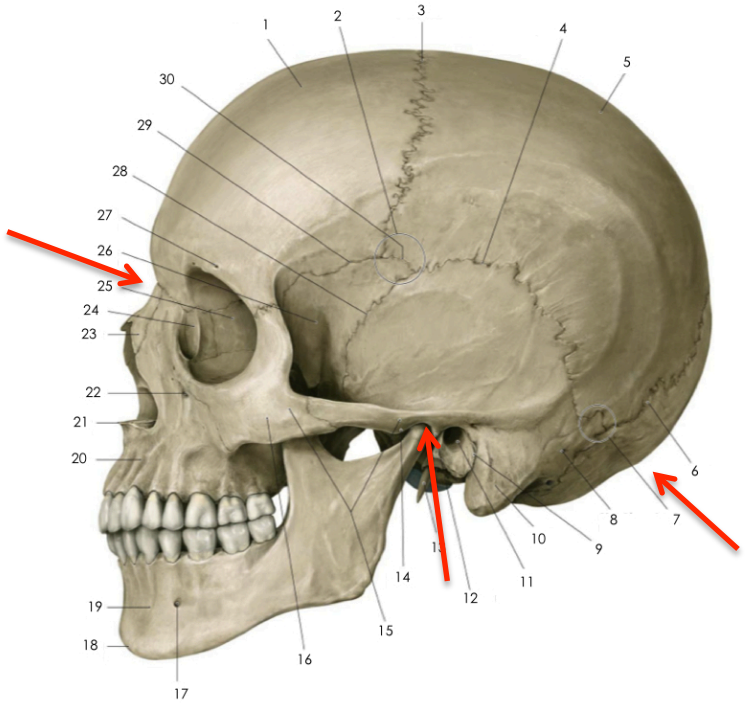


Electrode	Lobe
F	Frontal
T	Temporal
C	Central *
P	Parietal
O	Occipital

The 10-20 System: Basic steps

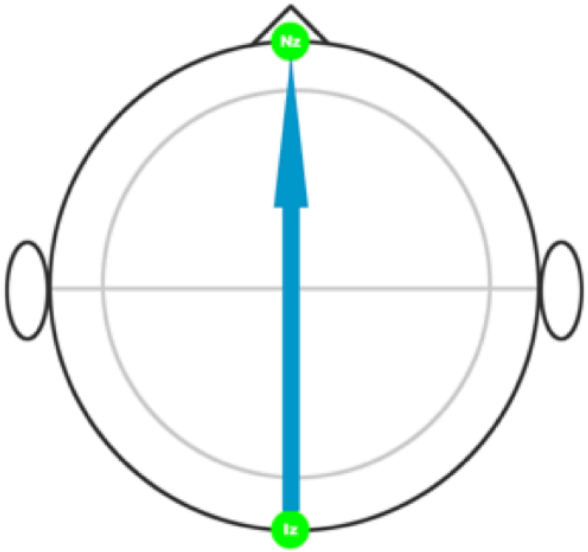
- Step 1: Four anatomical landmarks are used to position the electrodes

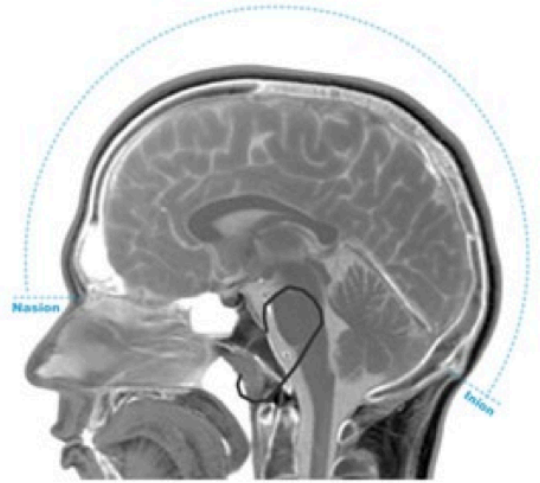




The 10-20 System: Basic steps

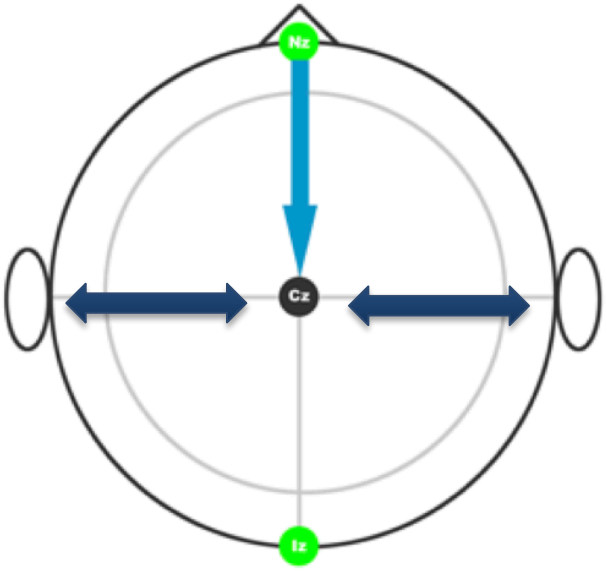
- Step 1: Measure over the center line of the scalp, from the Nasion (bride of the nose) to the Inion (external occipital pretuberance)

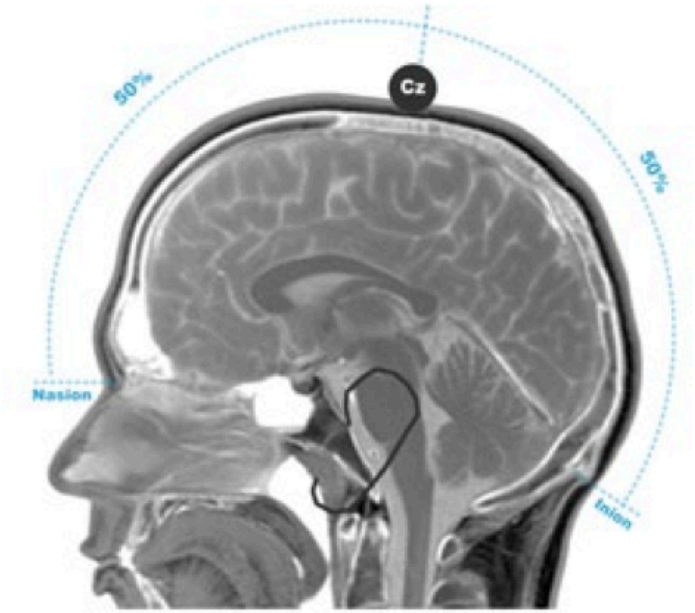




The 10-20 System: Basic steps

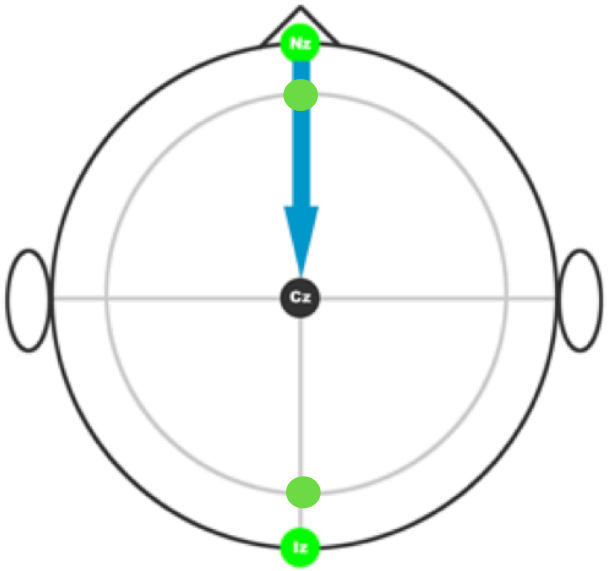
- Step 2: Measure and mark 50% of your total. This is the preliminary Cz mark

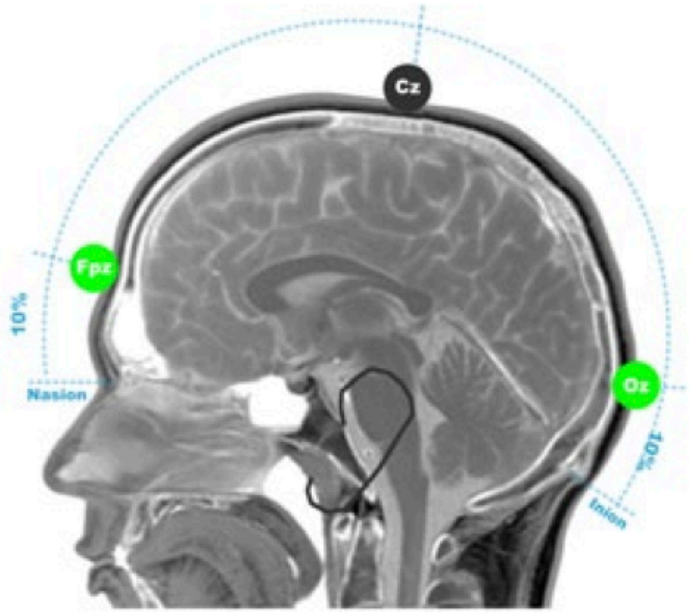




The 10-20 System: Basic steps

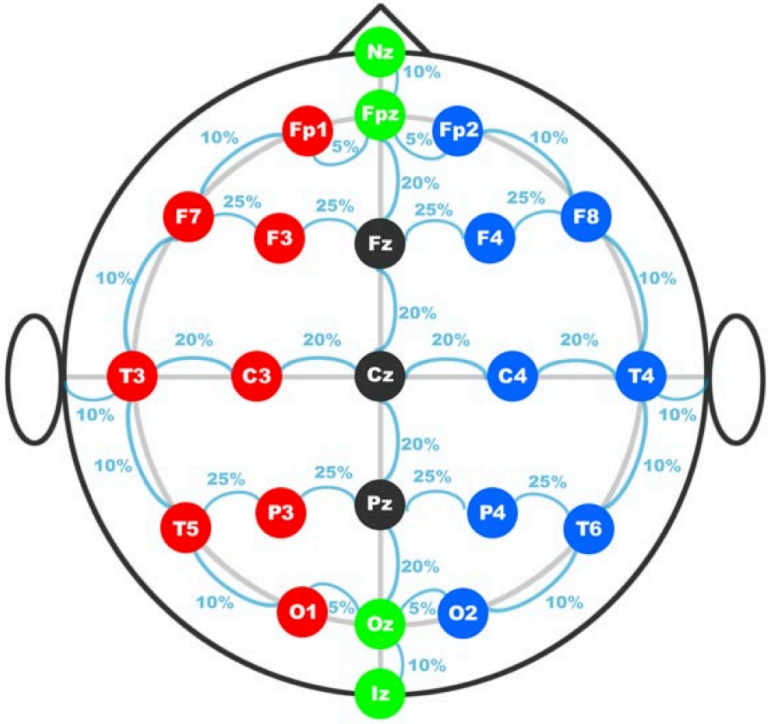
- Step 3: Measure and mark 10% up from the Nasion and 10% up from the Inion. These are the preliminary Fpz and Oz marks





The 10-20 System: Basic steps

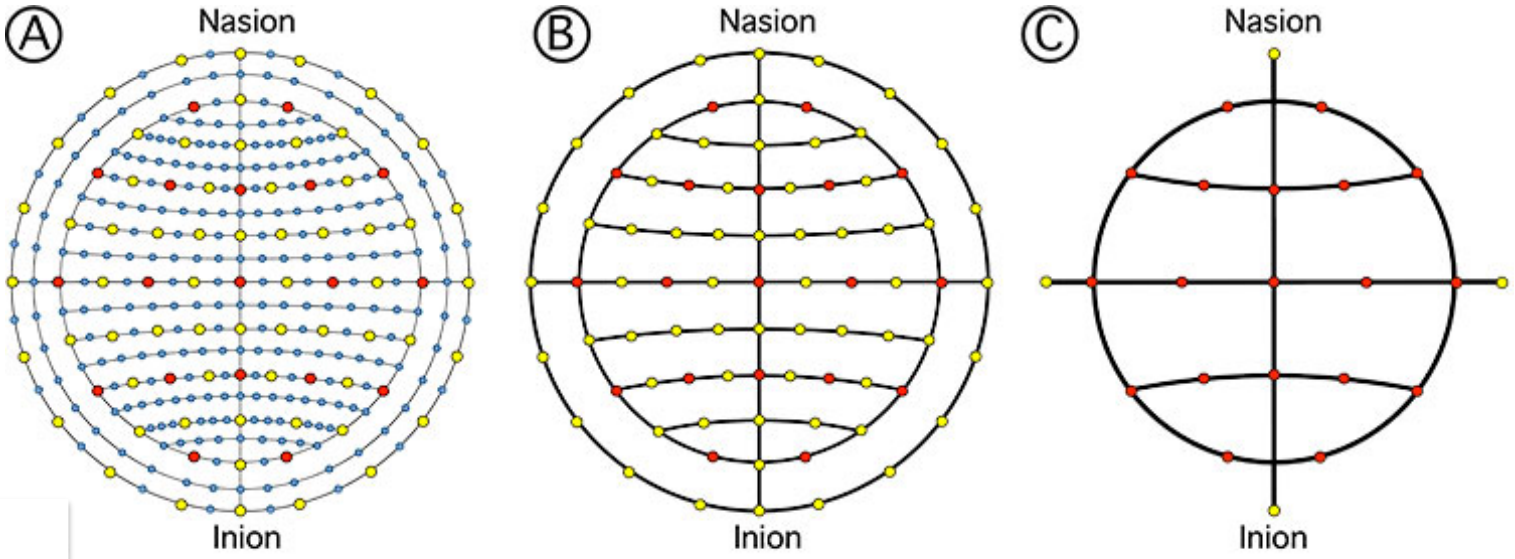
- Today EEG-caps are used commonly, thus placing individual electrodes is done only in exceptional cases



=> What if I the spatial resolution is not high enough for my purposes?

Extending the 10-20 system

- In a standard 10-20 setup, 21 electrodes are used
- Other electrodes can be added, to
  - Increase spatial resolution (> 256 electrodes are possible)
  - Record from specific areas of interest
  - Monitor other electrical activity (e.g. ECG, EMG, eye movement)



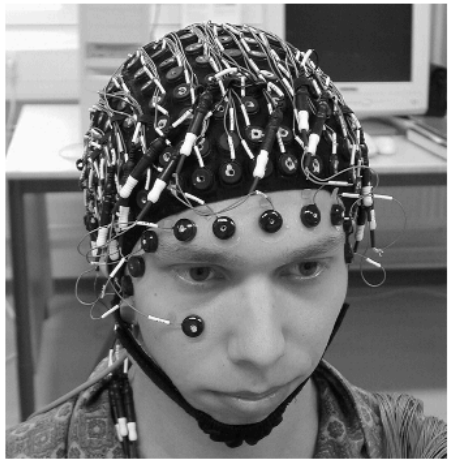
10-5 10-10 10-20

Extending the 20-10 system

- How does a higher number of electrodes improve spatial resolution?

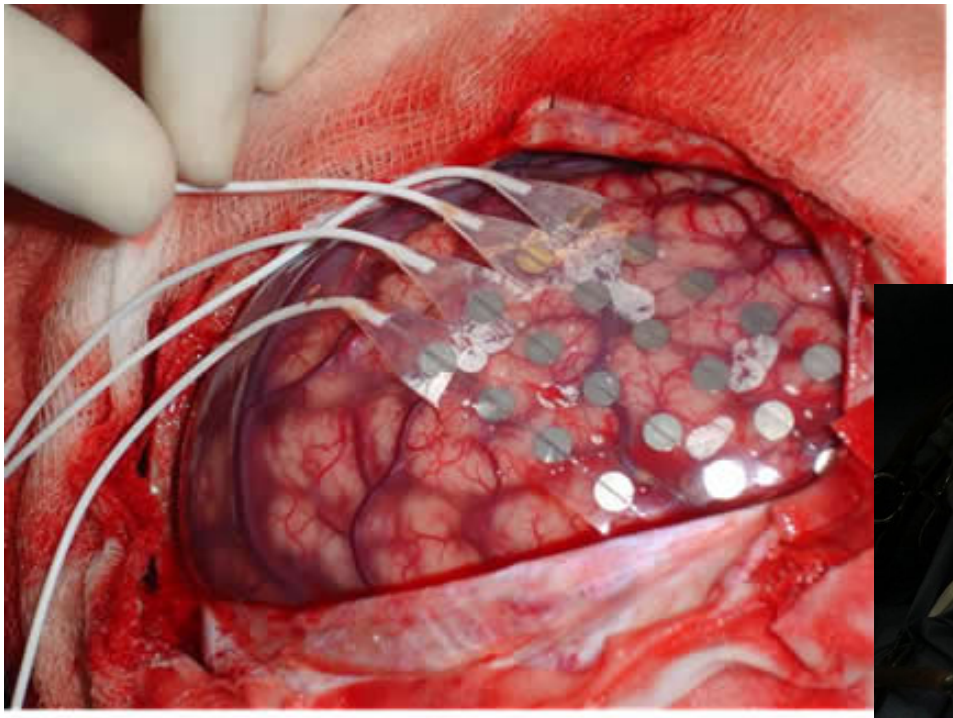
- Mean interelectrode distance (Gevins, 1994)
  - Classical 10-20 system: 6 cm
  - …64 electrodes: 3.3 cm
  - …128 electrodes: 2.25 cm
  - …256 electrodes: 1.6 cm

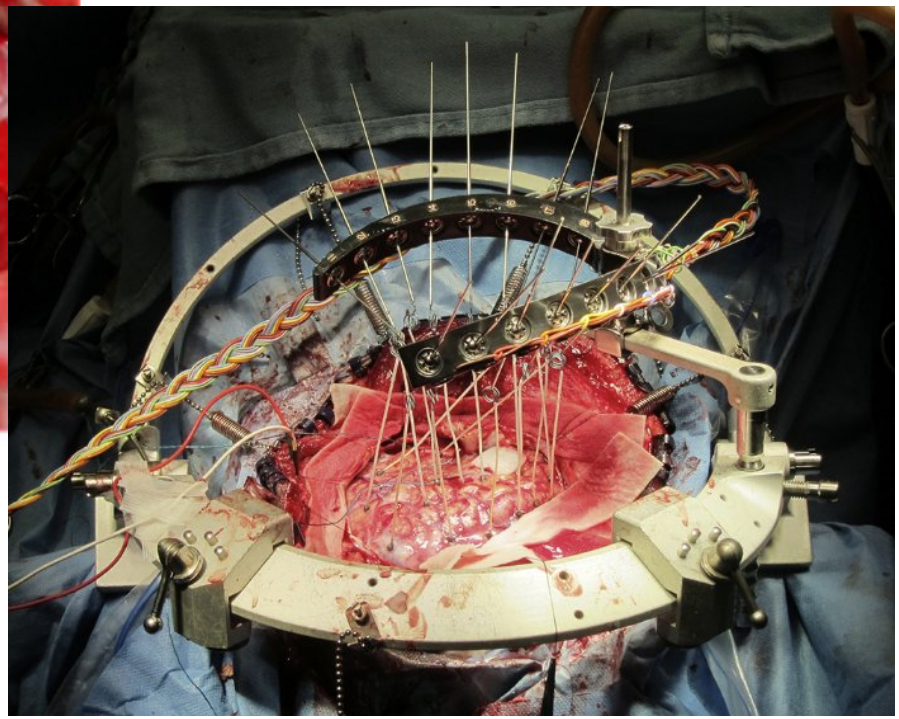
124-channel



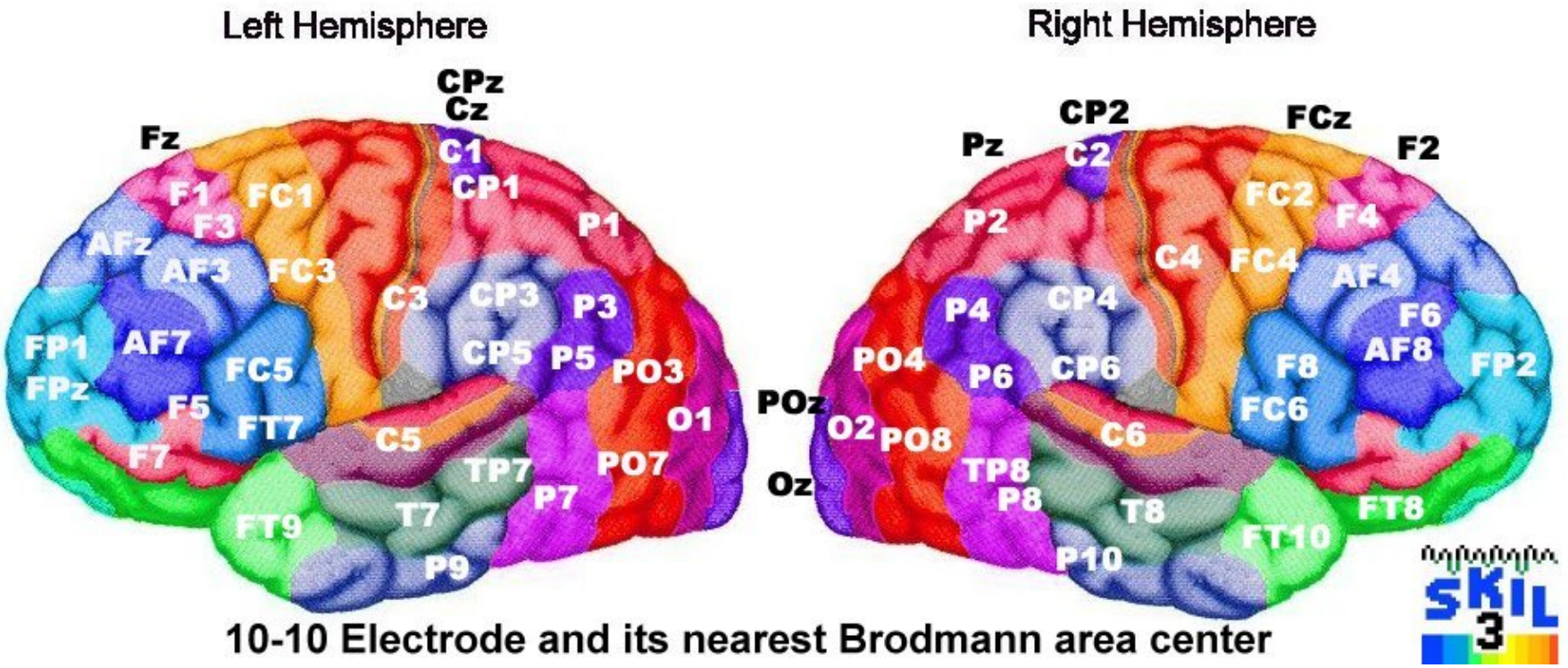
256-channel

If more than 256 electrodes still aren’t enough





Standardized electrode positioning and underlying brain regions



⇒ Clinical purpose: Detect the origin of a seizure

⇒ Scientific purpose: Investigate brain regions/networks and their involvement in cognitive processes/neurological disorders

The EEG signal

- Electric potentials are only defined with respect to a reference electrode, i.e. an arbitrarily chosen “zero level”

- The EEG signal represents a difference in voltage between an active electrode and a reference

- The choice of the reference may depend on the purpose of the recording

EEG Referencing

- Ideally, the reference
  - would be affected by global voltage changes in the same manner as all other electrodes
    - Unspecific activity is substracted out by referencing (e.g. slow voltage shifts due to sweating)
  - should not pick up signals that are not intended to be recorded (i.e. ECG)
    - Hence It should be placed in an presumed “inactive” zone

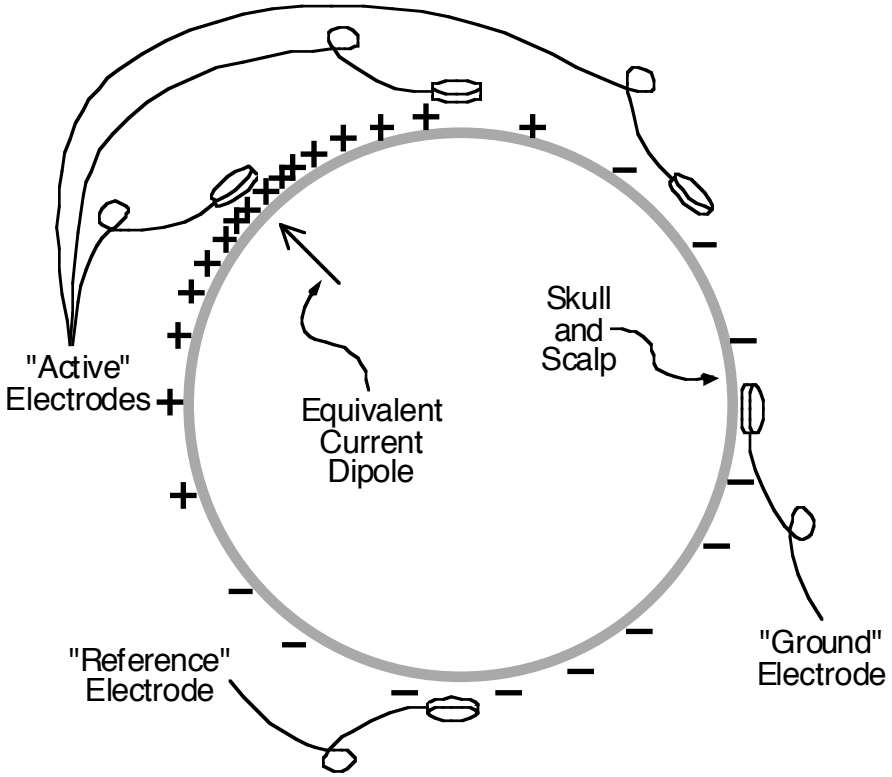
Referencing montages in EEG

- **Common reference**
  - All electrodes use the same reference (e.g. mastoid, earlobe, Cz, Nose)
  - **But:** unilateral Reference electrodes can introduce asymmetries

- **Average reference**
  - Average between two electrodes (e.g. left and right earlobe or mastoids)
  - Common average reference: Global mean of all electrodes
  - Local average reference: Mean of the 4 or 8 surrounding electrodes

Common referencing methods in EEG

- In Addition to the active and reference electrode, typical EEG systems also use a ground electrode



Voltage is measured between ACTIVE and GROUND (A - G)

Voltage is measured between REFERENCE and GROUND (R - G)

Output is difference between these voltages

(A - G) - (R - G) = A - R

It's as if the ground does not exist

Any noise in common to A and R will be eliminated

Luck, 2005

Thanks for your attention

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Solorz-Żak Research Foundation