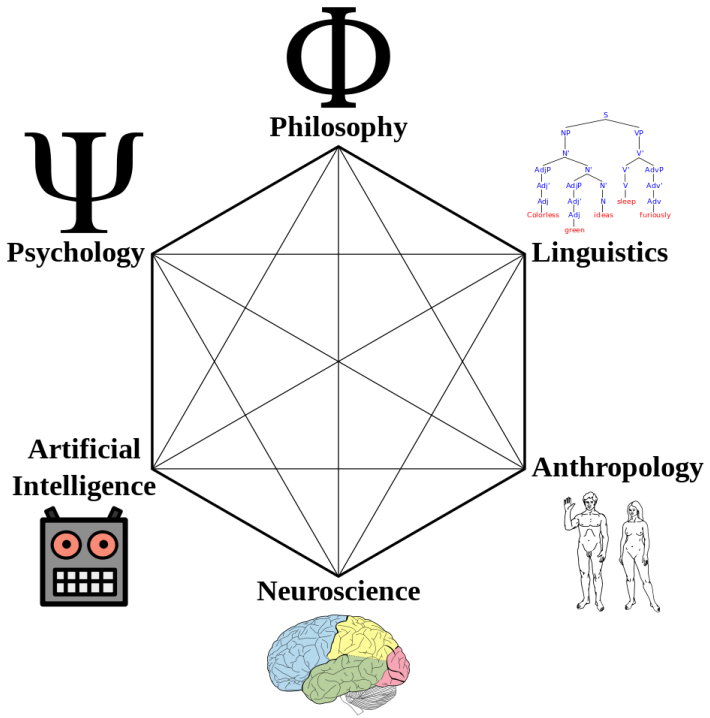
Non-Invasive Functional NeuroImaging Methods



Electroencephalography (EEG)
and
Mangnetoencephalography (MEG)

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History

EEG

Year	Significance for EEG
1875	Caton records brain potentials from cortex
1883	Marxow discovers evoked potentials
1929	Berger records electrical activity from the skull
1936	Gray Walter finds abnormal activity with tumors
1957	The toposcope (imaging of electrical brain activity)
1980	Color brain mapping (quantitative EEG)

MEG

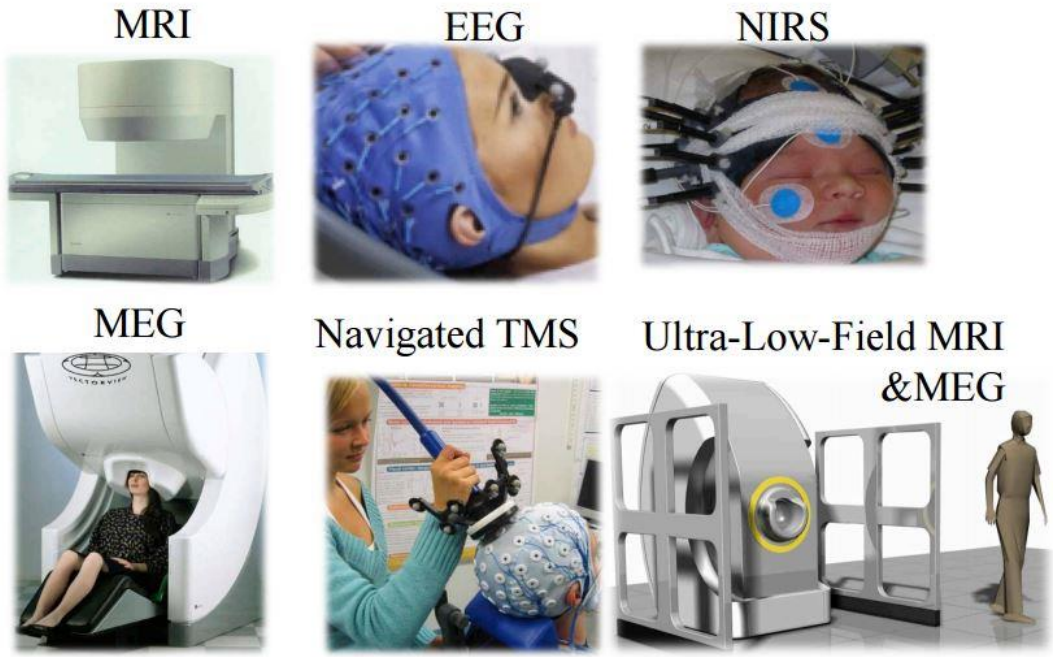
Year	Significance
1969	Cohen, Edelsack, Zimmerman – First magnetocardiogram with a SQUID
1971	Cohen records first unaveraged MEG recording
1974-75	First visually evoked MEG recordings by Cohen
1978	Brenner records somatosensory evoked fields. Pickup coil only 7mm from scalp.
1982	Tonotopy of the auditory cortex.

Reasons for rapid development of Cognitive NeuroScience field?

- Theoretical advances in neuroscience.
- Non-Invasive Neuroimaging techniques.
- Advances in data analysis techniques.

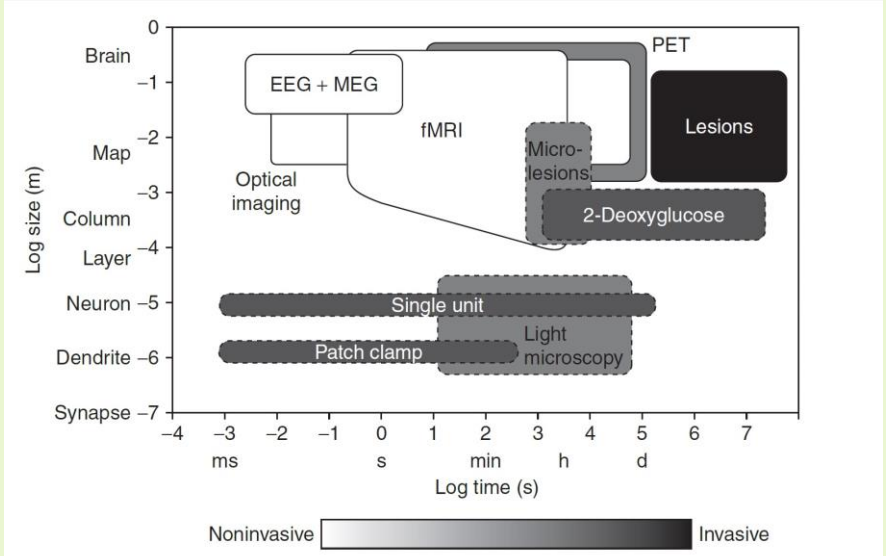
Non-Invasive NeuroImaging Techniques

- Non-invasive neuroimaging refers to techniques that produce images of brain without requiring surgery, incision of the skin, or any direct contact with the inside of the body.[3]
  - These techniques help in quantification of brain activity of healthy people when they engage in perceptual and cognitive tasks.
  - Also useful in localization (mapping) of lesion sites.



Classes of NeuroImaging Techniques

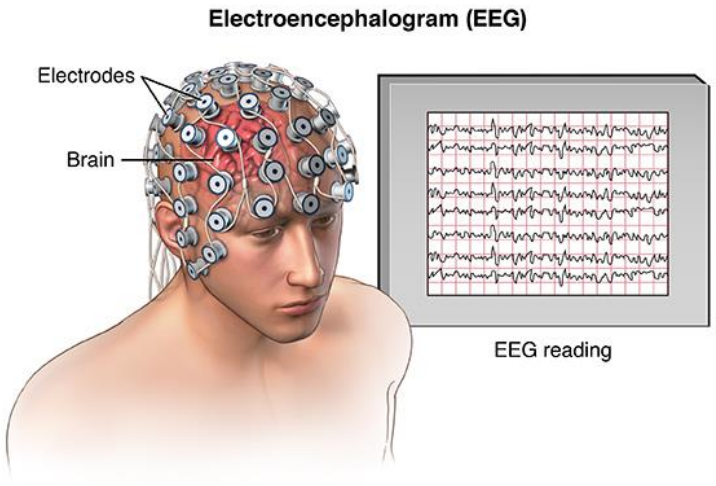
Spatial vs. Temporal resolution

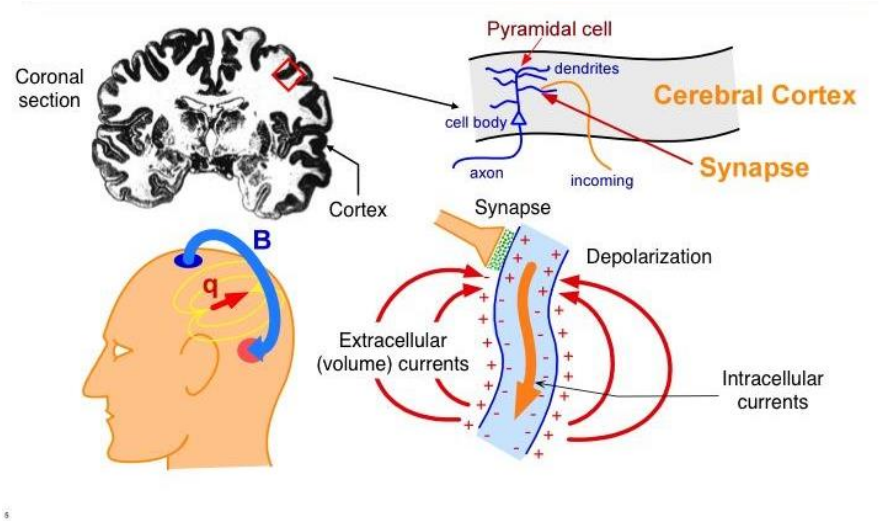


- **Types :** [4]
  - **Anatomical Techniques :**
    - CT, MRI, Diffusion Tensor Imaging
  - **Functional Techniques** : based on measuring neural activity.
    - Directly measuring - EEG & MEG
    - Indirectly measuring - PET, f-MRI, NIRS

Introduction to EEG and MEG

- EEG is an non-invasive, electrophysiological monitoring method to record the electrical activity of the brain.
- MEG, also an non-invasive technique, allows us to record magnetic fields produced by electrical currents occuring in the brain which is useful for mapping brain activity.





Source:

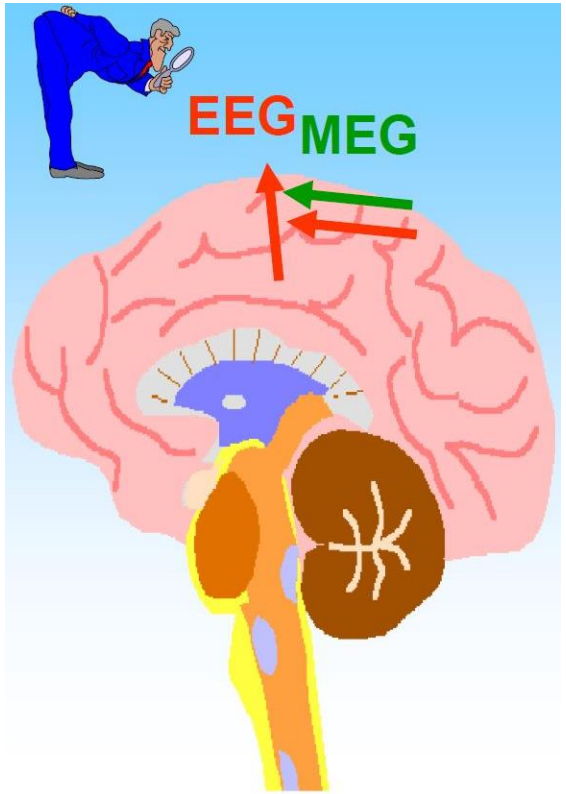
http://www.hopkinsmedicine.org/healthlibrary/test_procedures/neurological/electroencephalogram_eeg_92,P07655/

http://ilabs.washington.edu/what-magnetoencephalography-meg

Electrophysiological basis of EEG and MEG signals

1 % of synchronously active neurons produce 95% of the scalp EEG

- The EEG and MEG signals are generated by synchronous postsynaptic currents in the pyramidal neurons of the cerebral cortex.[5]
- EEG is sensitive to radial and tangential sources.
- MEG is the magnetic counterpart of EEG. MEG is sensitive only to tangential sources.



Instrumentation of EEG and MEG

EEG

Modern EEG systems come with caps of 64 or even upto 256 electrodes.

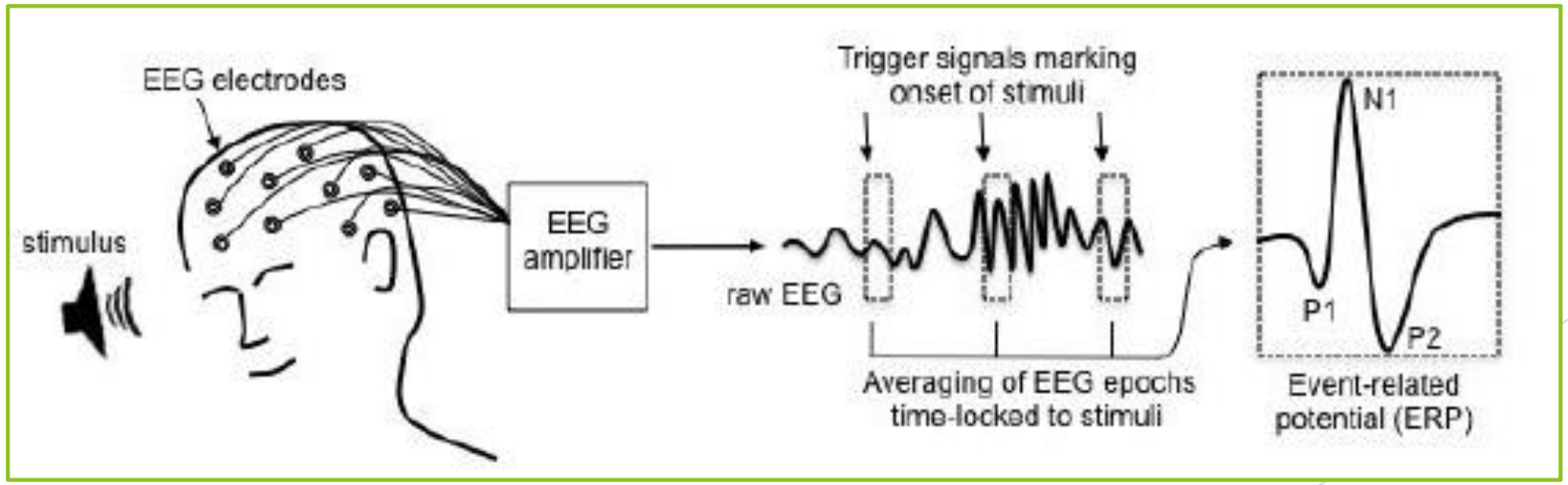
MEG

Modern neuromagnetometer contain helmet-shaped arrays of more than 300 SQUID* sensor that, for operation, have to be immersed in liquid helium at temperature 4 K (-269 °C)

*Superconducting **QU**antum **I**nterference **D**evices

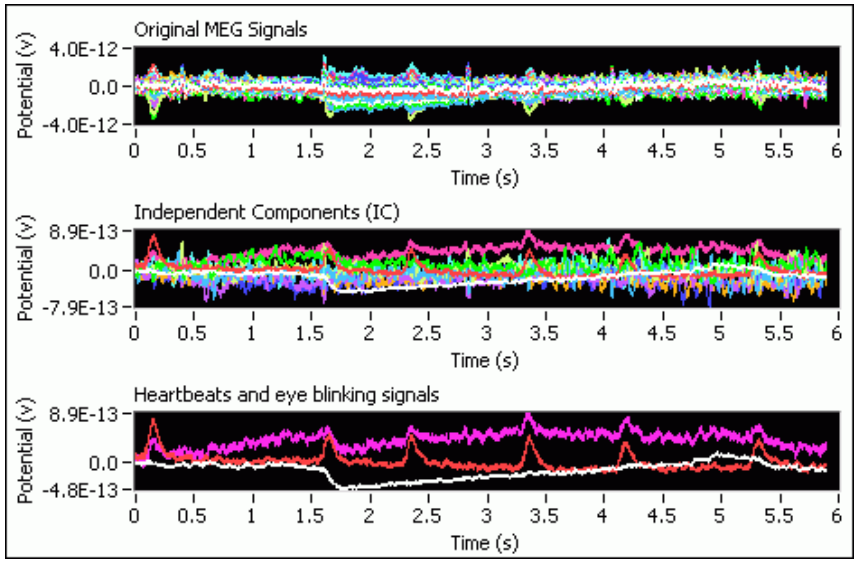
Analysis of signals

- EEG Signals
  - Event related potentials
    - As signal to noise ratio is comparatively higher, the averaging process helps preserve the source signal.
  - Binding problem
    - How different areas of brain react to the same stimuli.
  - Forward and Inverse Problems
    - Given the primary currents, what is the electromagnetic field?
    - Given the measured electromagnetic field, what are the primary currents?



Signal Analysis contd..

- MEG Signals
  - Efficiently interpreted by source models
  - Beamforming
    - It is a technique where whole brain is scanned by sequential application of spatial filters that only allow a specific activity with maximum gain suppressing the others.

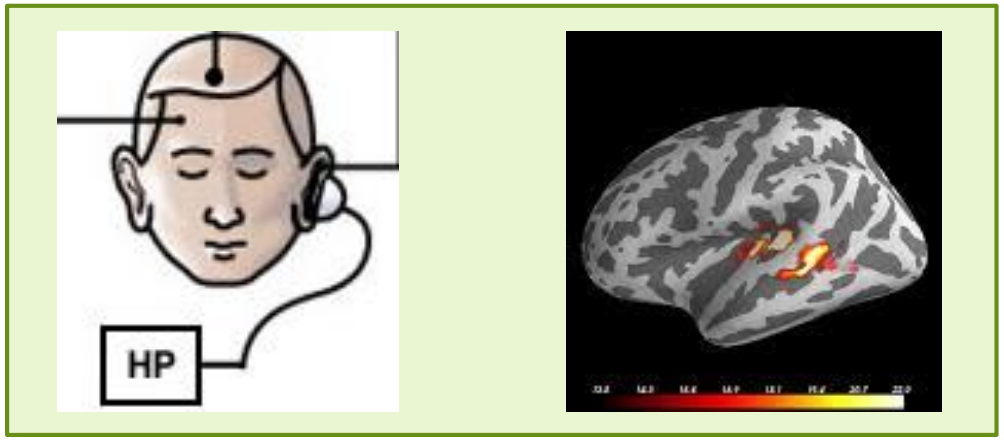


Comparison of EEG and MEG signals.

- EEG requires a reference electrode whereas MEG doesn't, infact, MEG doesn’t need any electrodes.
- MEG signals decay much faster than EEG.
- MEG recordings have achieved in increased accuracy of source localization.

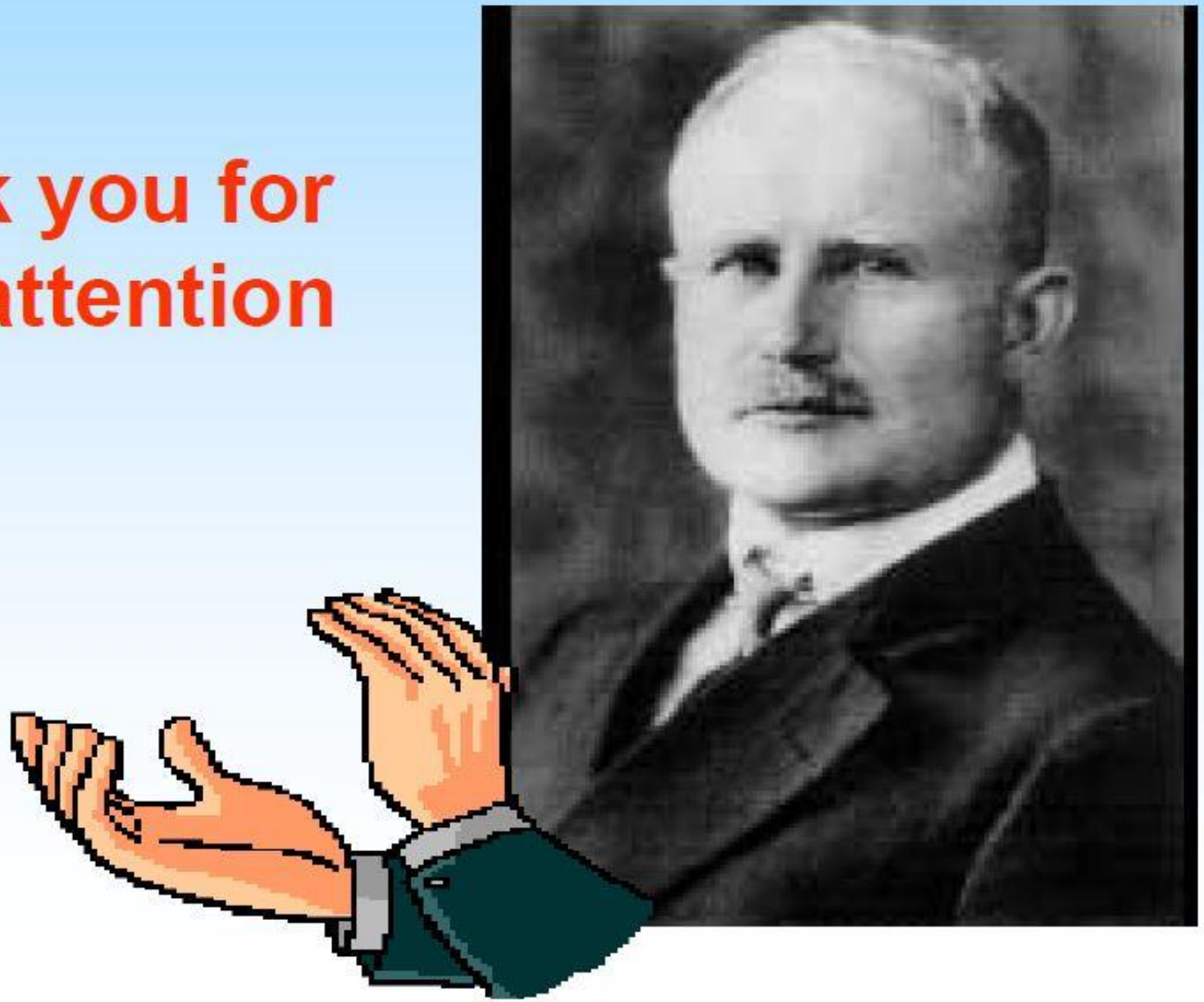
Contribution to the Study of Cognition

- Neuroimaging research enrich our understanding of the neural basis of wide variety of cognitive abilities. Helping in unraveling the mysteries of higher cognitive functions.



- Memory!
  - helping in decoding how the information is organized and stored.
- Help in gaining insight into the etiology of neurobehavioral disorders, for surgical planning, and to assess functional recovery after brain damage.

Thank you for your attention



The father of EEG: H. Berger

Reference

- [1] Cognitive Neuroscience https://en.wikipedia.org/wiki/Cognitive_neuroscience
- [2] Introduction to Cognitive Neuroscience, Iiro P. Jääskeläinen
- [3] Neuroimaging http://web.stanford.edu/group/hopes/cgi-bin/hopes_test/neuroimaging/
- [4] S A Bunge, I Kahn, Cognition: An Overview of Neuroimaging Techniques
- [5] Hari, R., 1990. The neuromagnetic method in the study of the human auditory cortex.
- [6] http://maki.bme.ntu.edu.tw/wp-content/uploads/2013/01/RistoIlmoniemi_slides.pdf