

Fondamenti di bioingegneria

***Laurea in
Ingegneria Informatica, Biomedica e delle
Telecomunicazioni***

Fabio Baselice



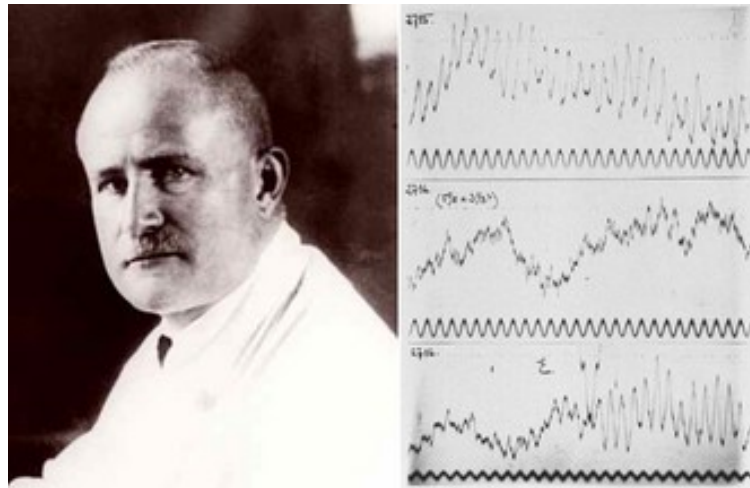
Argomenti

- Il sistema nervoso centrale (CNS)
- Elettroencefalogramma (EEG)
- Magnetoencefalogramma (MEG)

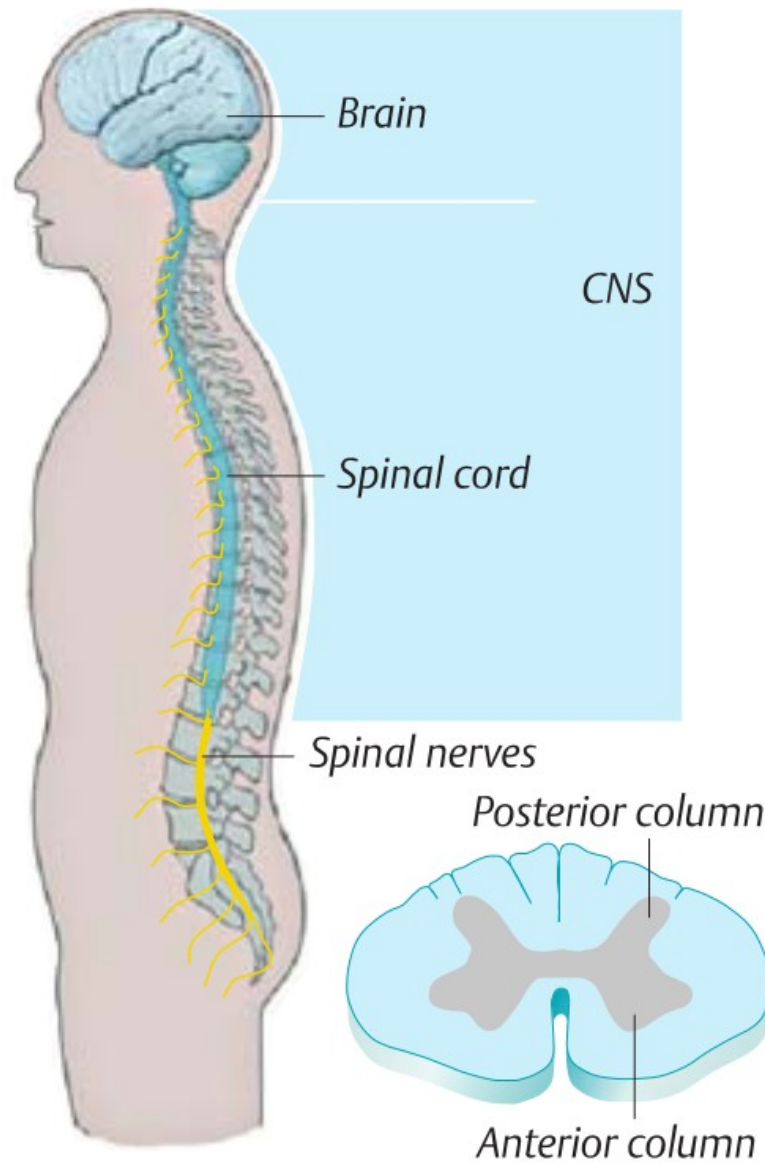
Cenni storici

Richard Caton (1875) – Pubblicazione dei primi risultati sulla registrazione dell'attività bioelettrica cerebrale di animali.

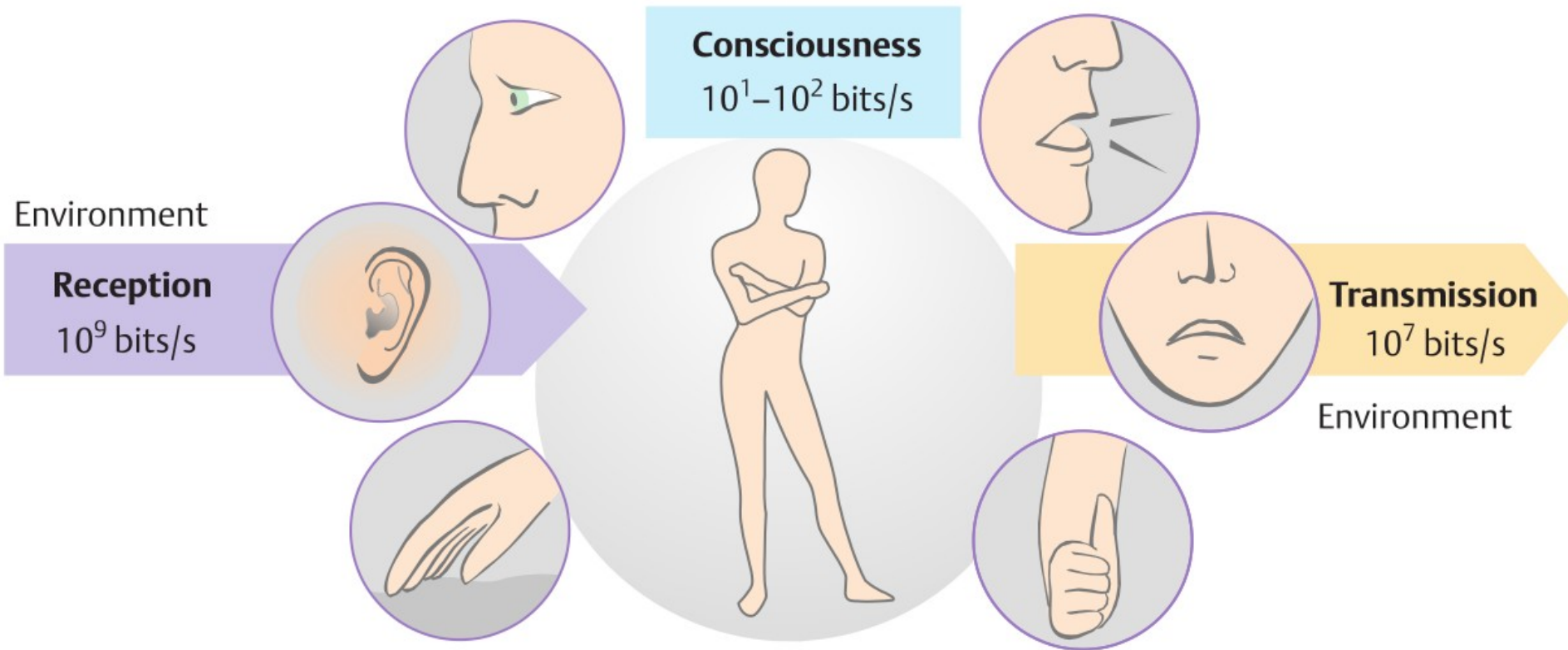
Hans Berger (1924) – Prima registrazione dei segnali elettrici cerebrali sull'uomo.



Cenni di anatomia

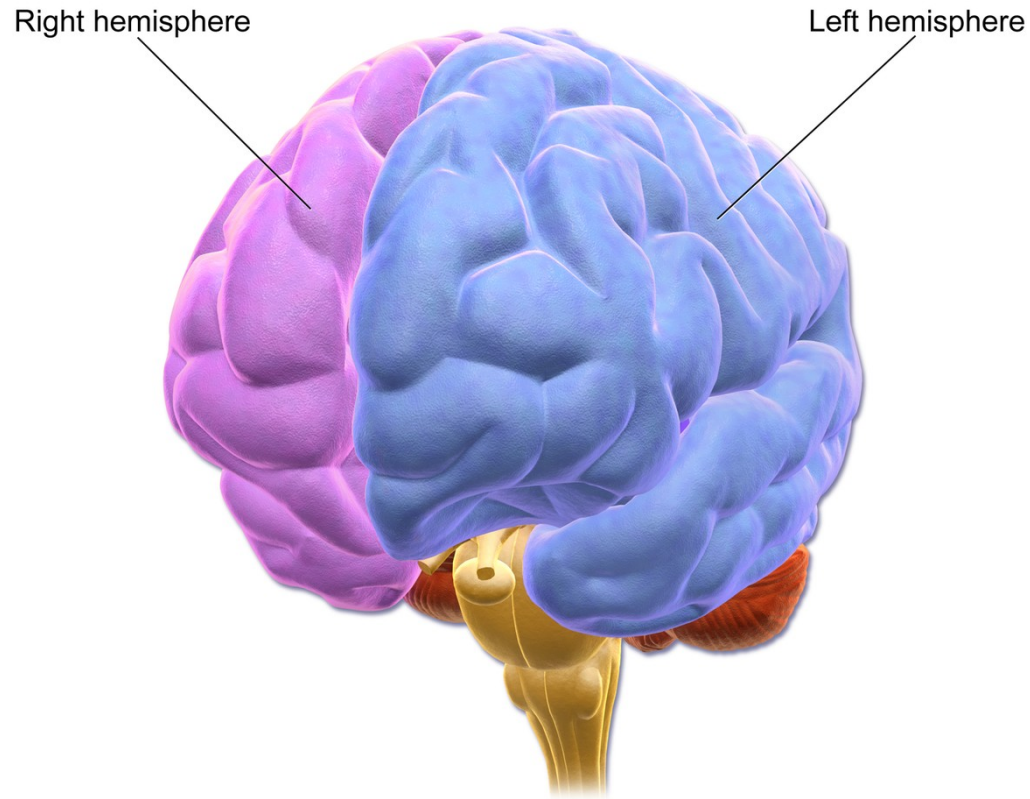


Cenni di anatomia

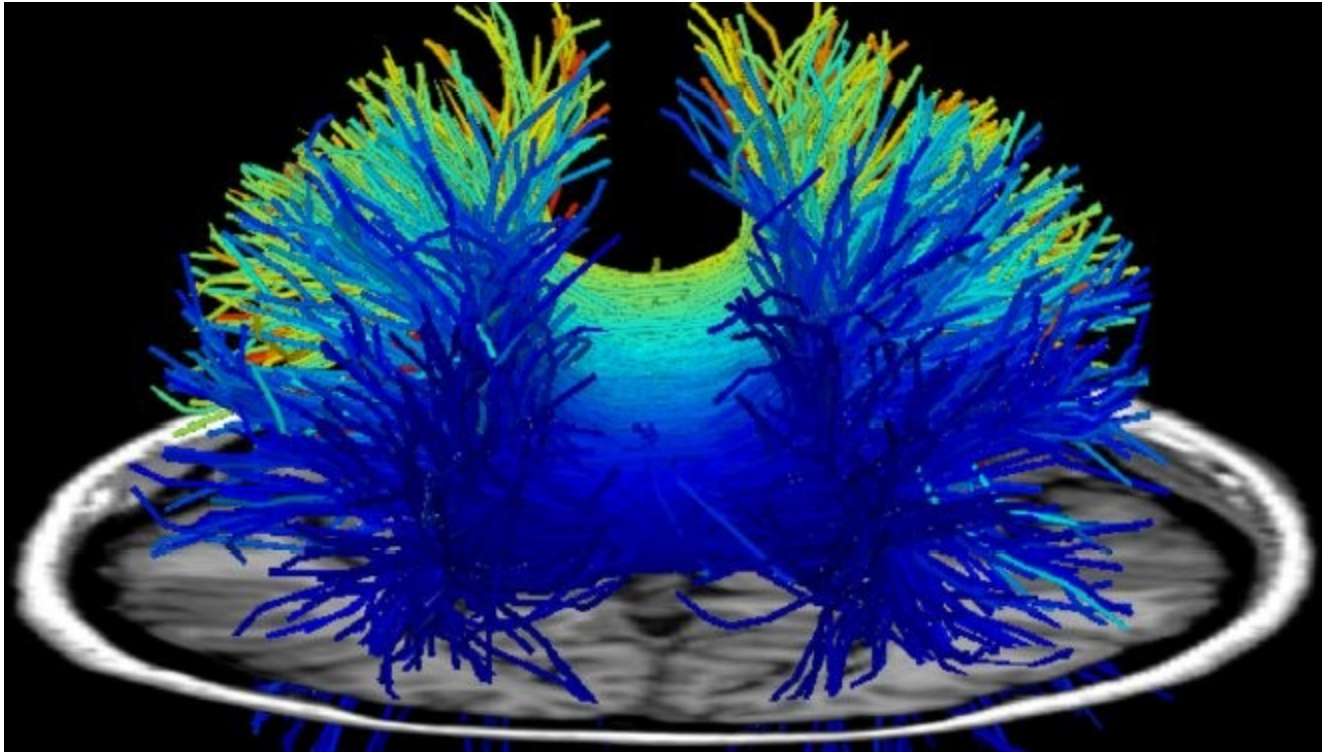


Cenni di anatomia

Cerebral Hemispheres

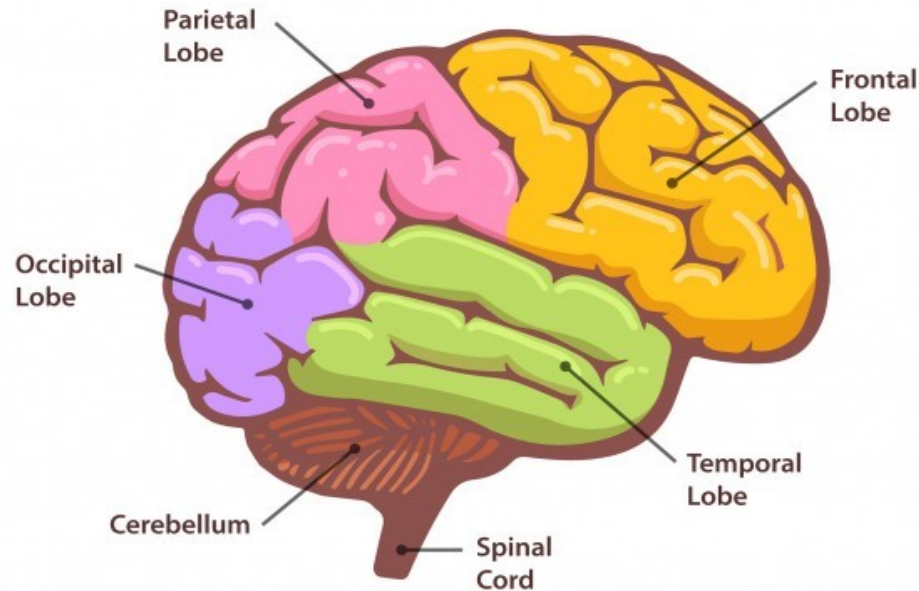


Cenni di anatomia



Corpo calloso

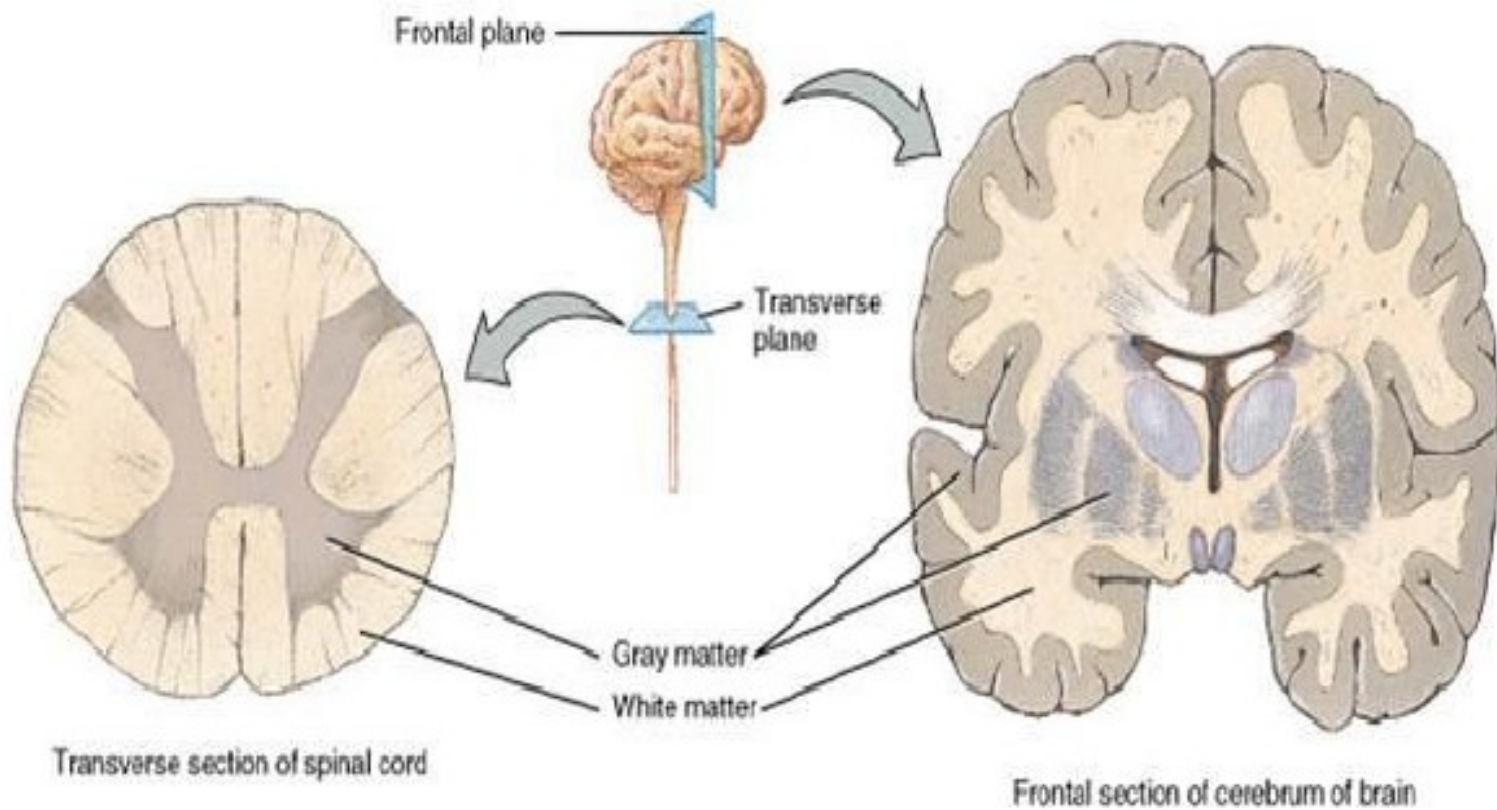
Cenni di anatomia



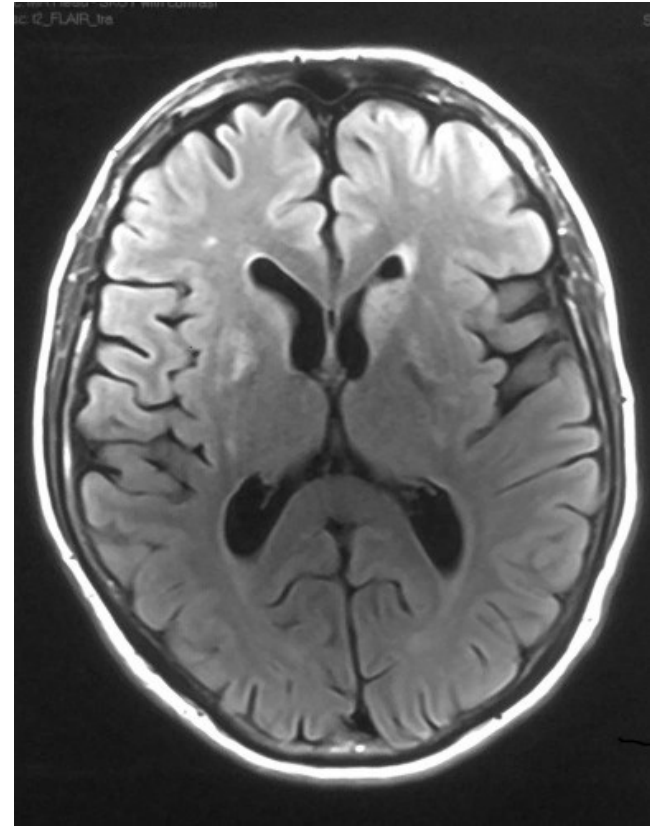
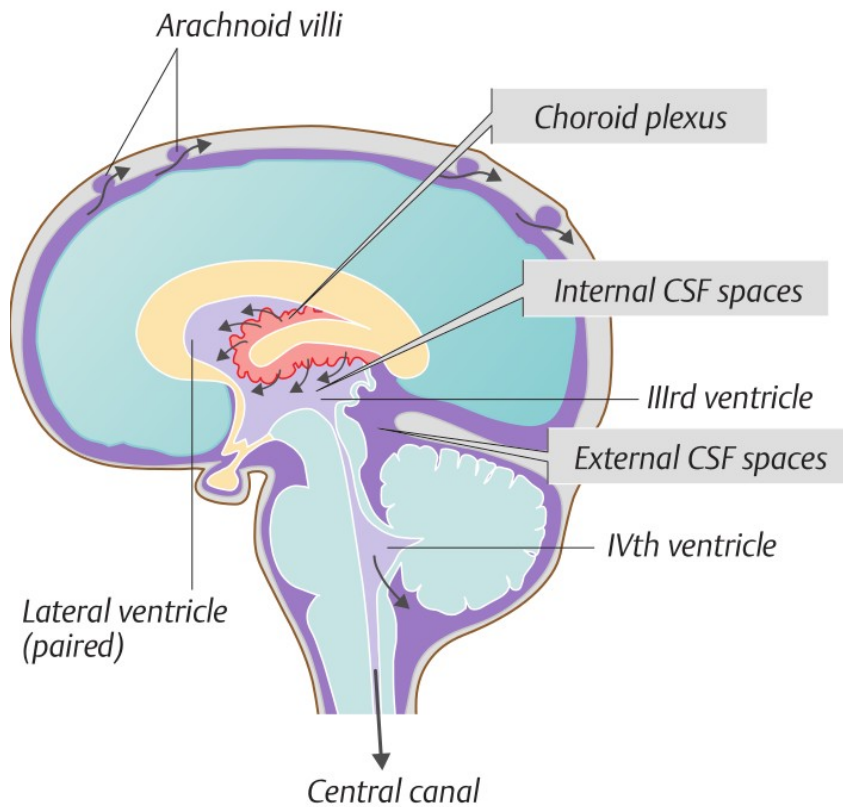
Parts of the Human Brain

Encefalo: cervello, cervelletto e tronco encefalico.
Sistema talamo-corticale e nuclei della base

Cenni di anatomia

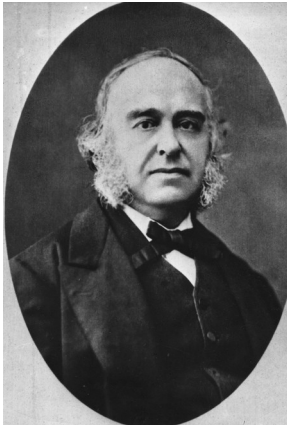


Cenni di anatomia



Funzionamento cerebrale

Localizzazione

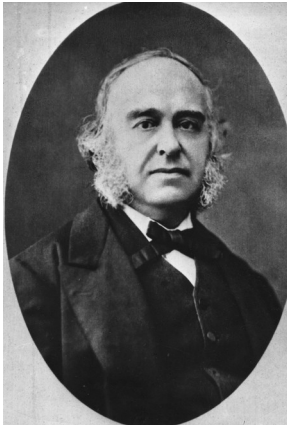


Paul Broca

Area del linguaggio

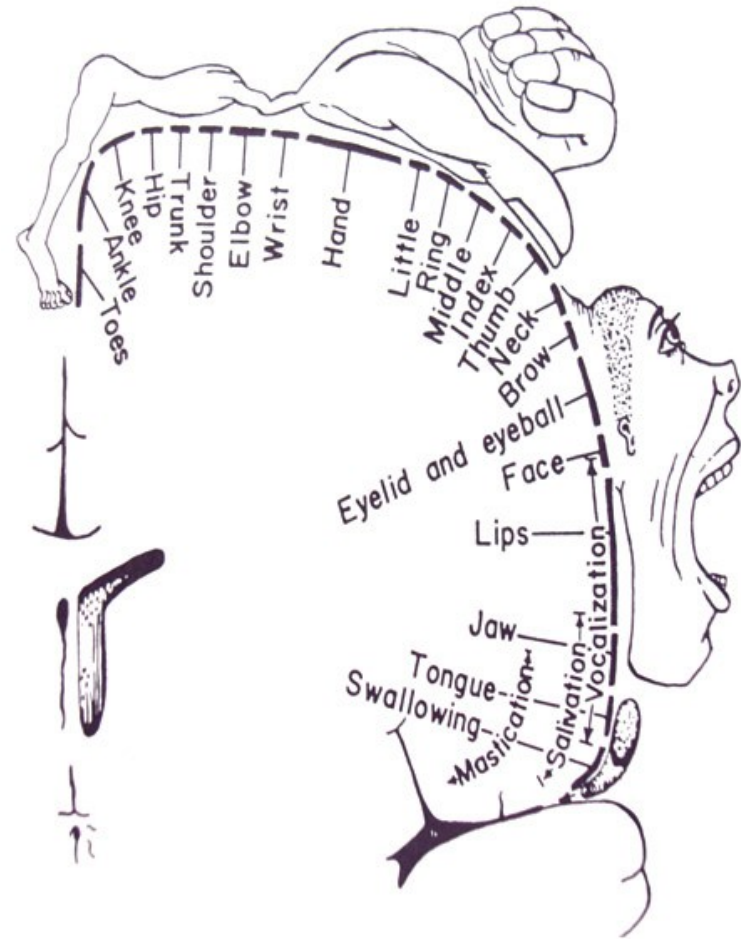
Funzionamento cerebrale

Localizzazione



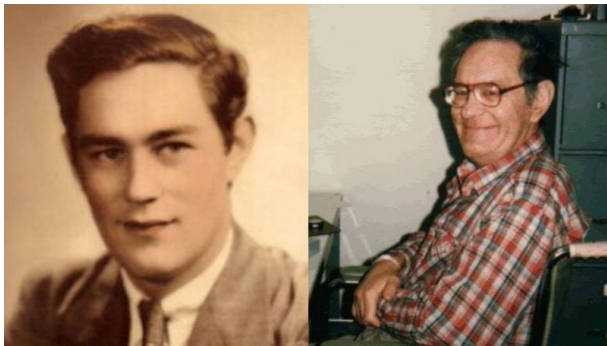
Paul Broca

Area del linguaggio



Funzionamento cerebrale

Rete



Henry Molaison

USA, 1953



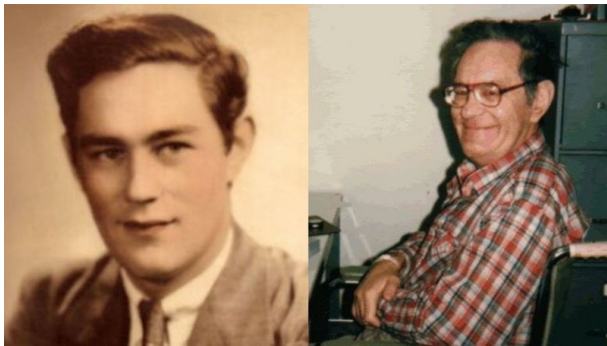
2019

Caenorhabditis elegans.

302 neuroni, 8000 sinapsi

Funzionamento cerebrale

Rete



Henry Molaison

USA, 1953



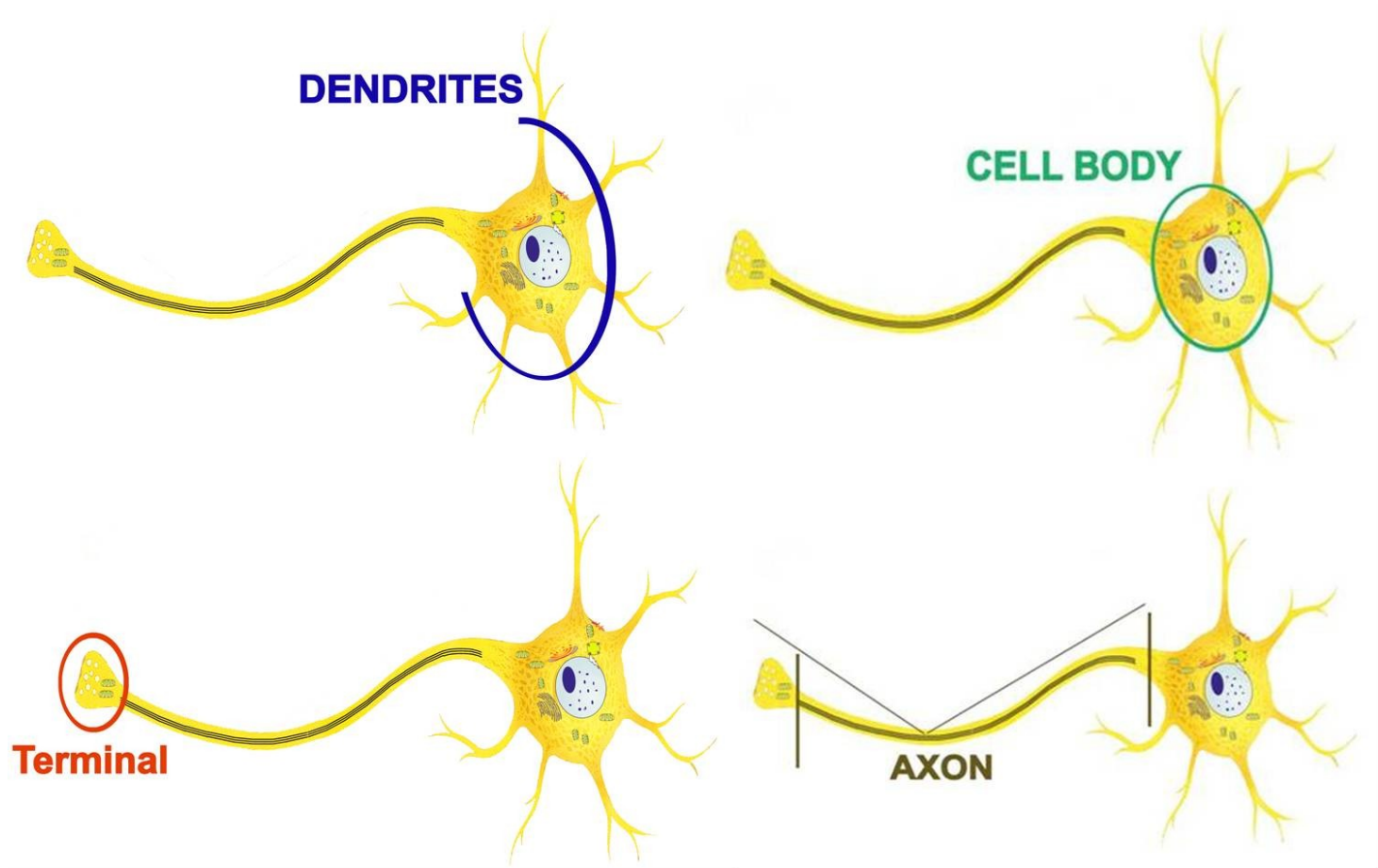
2024

Drosophila melanogaster

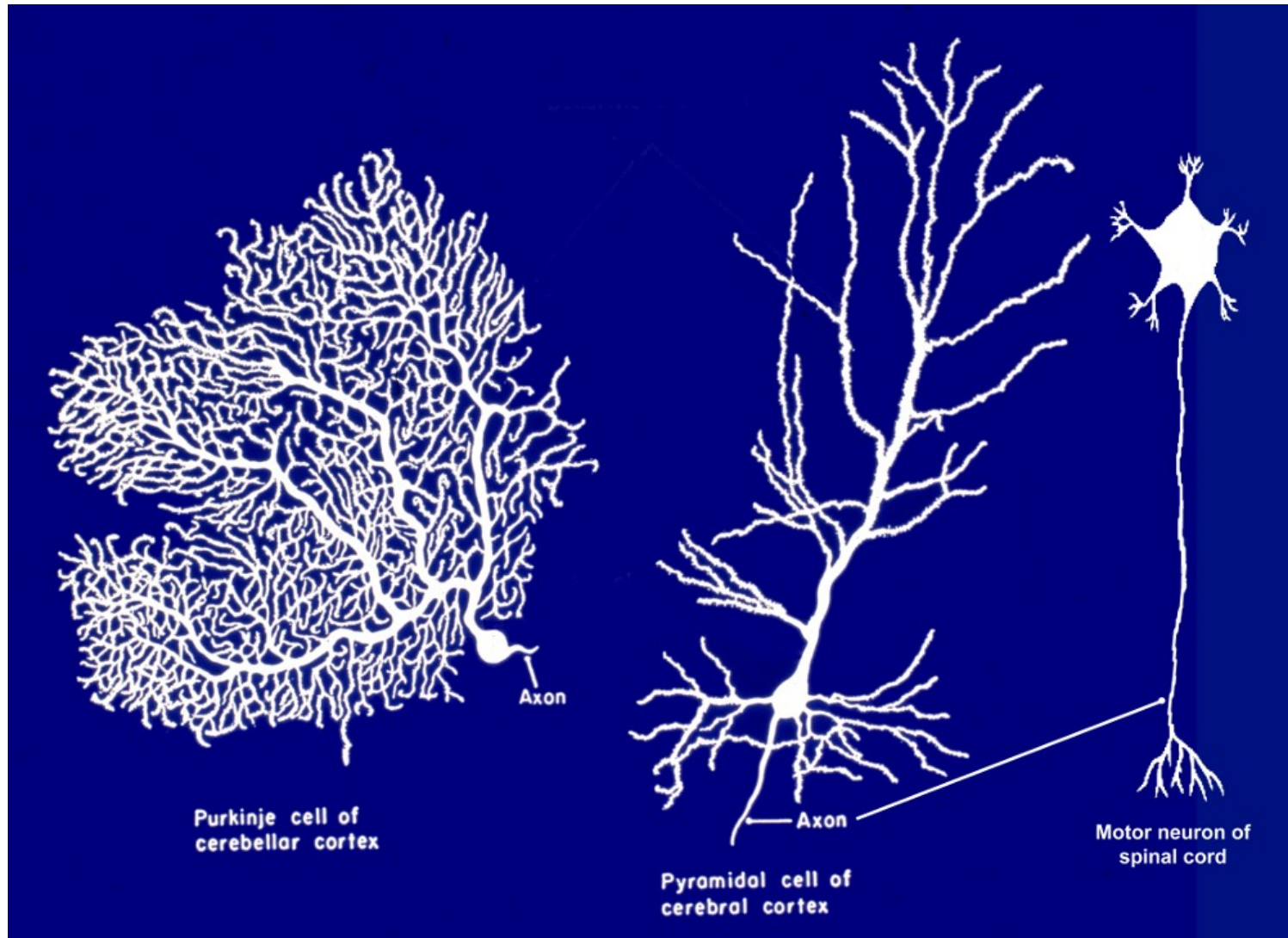
139.255 neuroni, 50M sinapsi

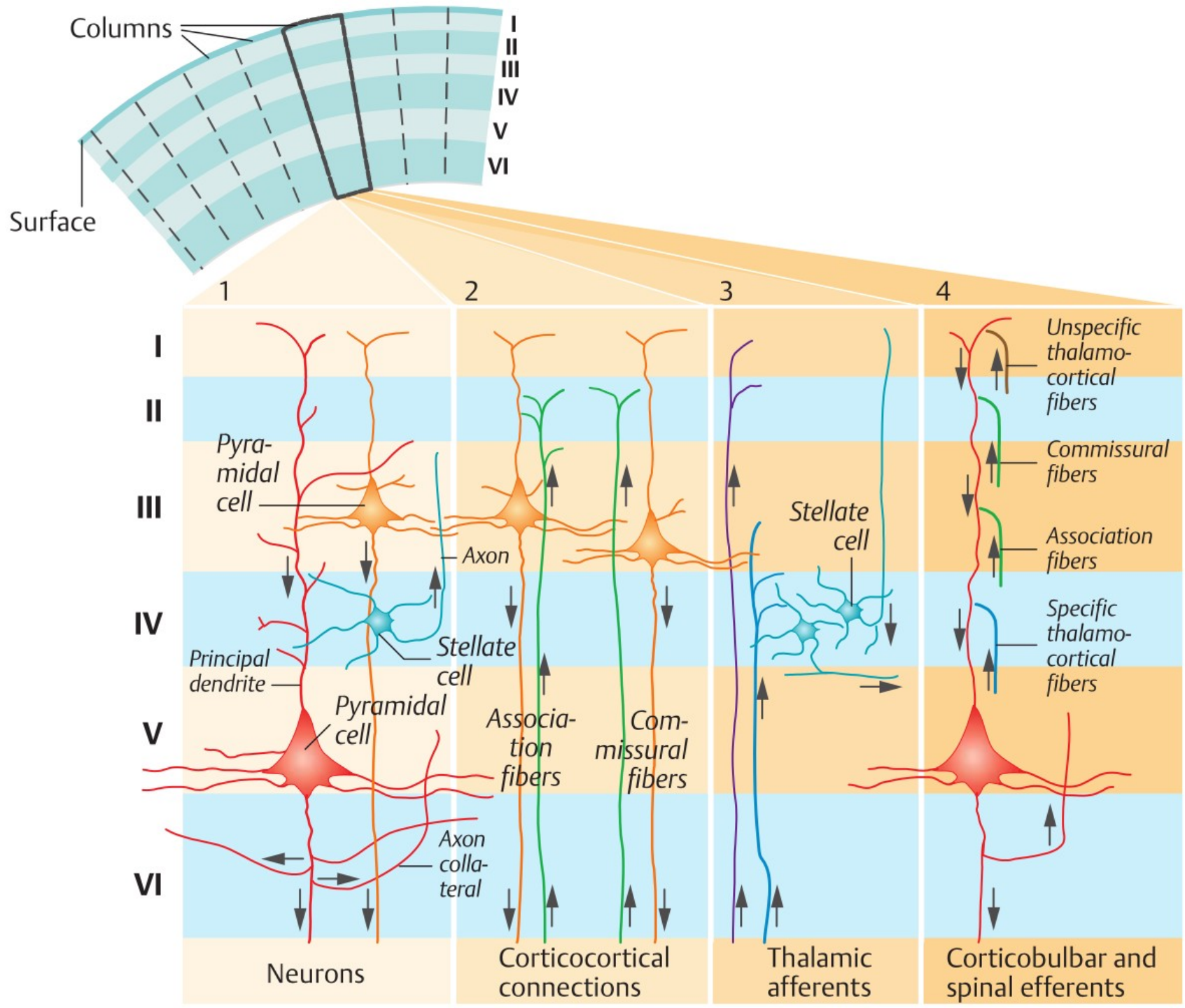


Cenni di anatomia



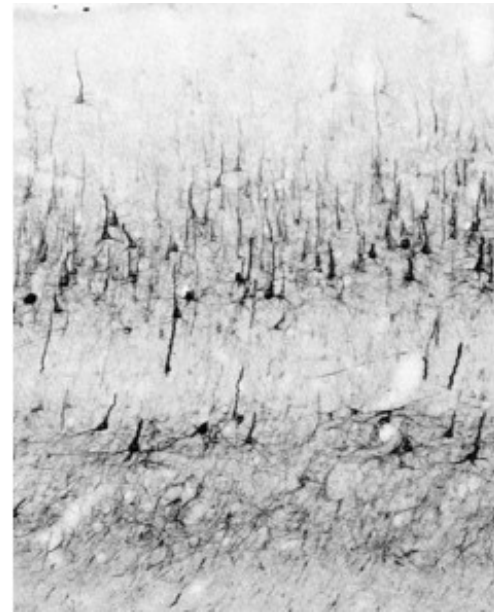
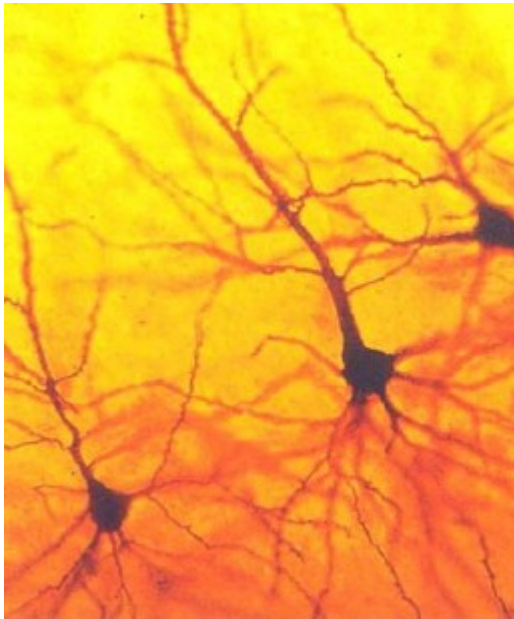
Cenni di anatomia



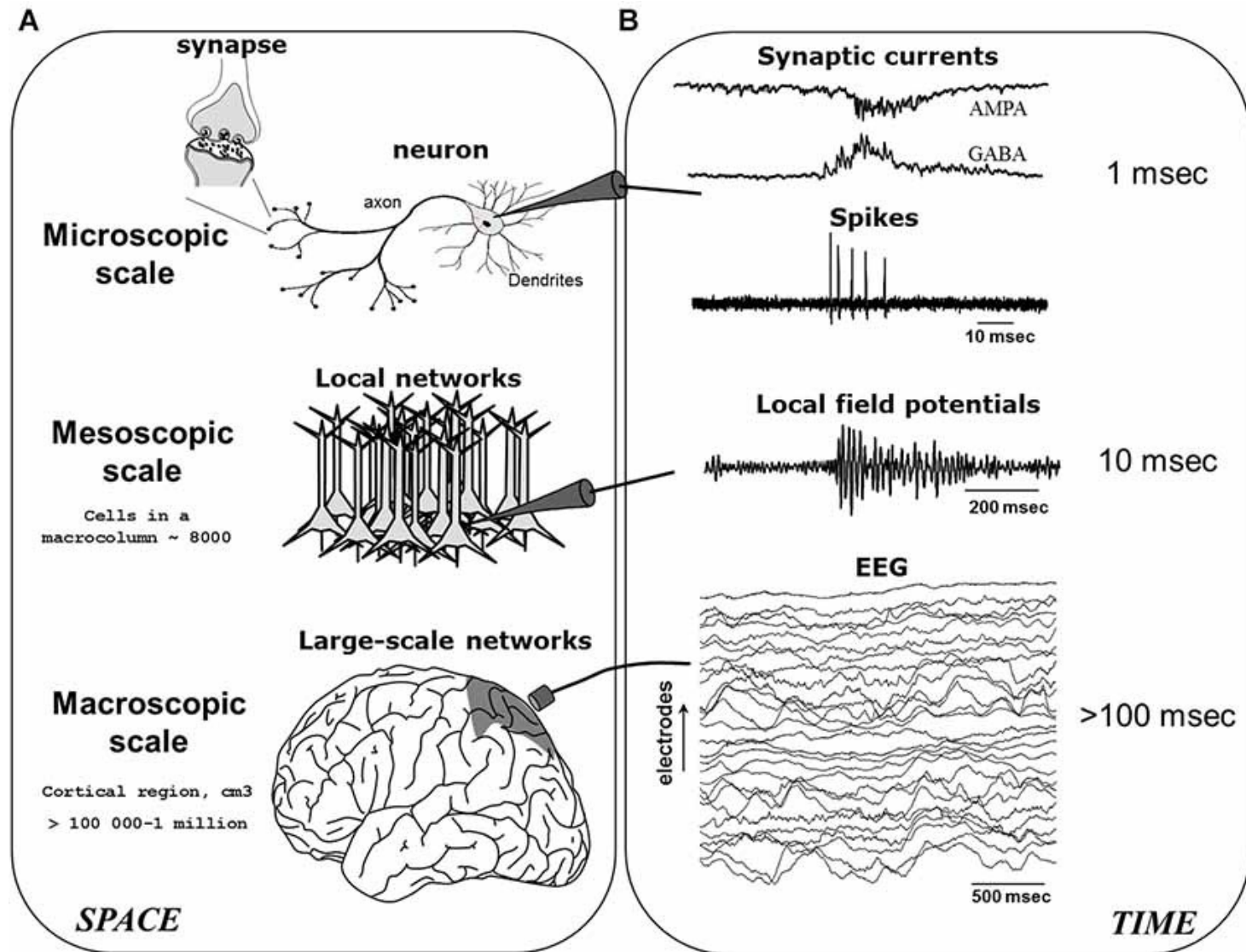


EEG

L'elettroencefalogramma (EEG) rileva l'attività elettrica spontanea della corteccia cerebrale data dalla somma dell'attività sincrona di migliaia di milioni di neuroni piramidali che presentano un orientamento simile nello spazio.

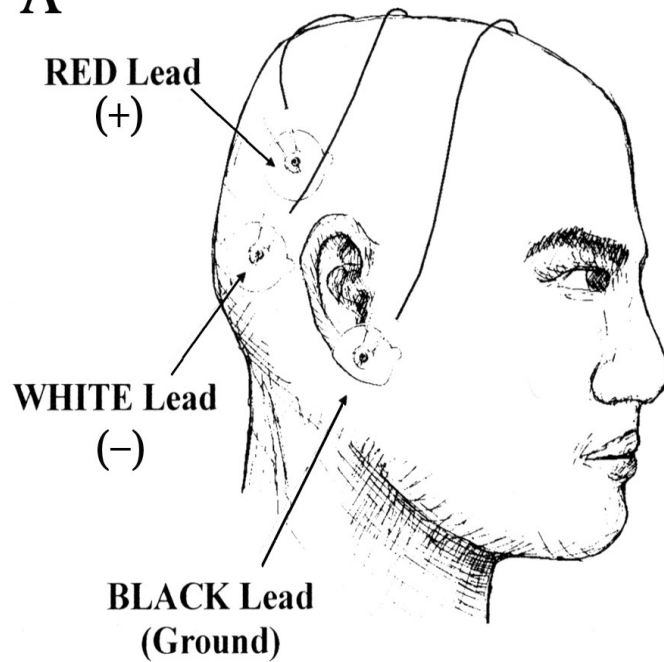


EEG

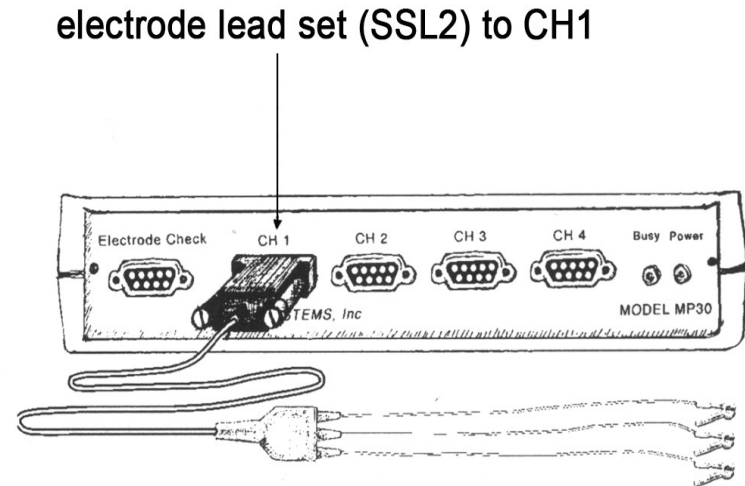


EEG

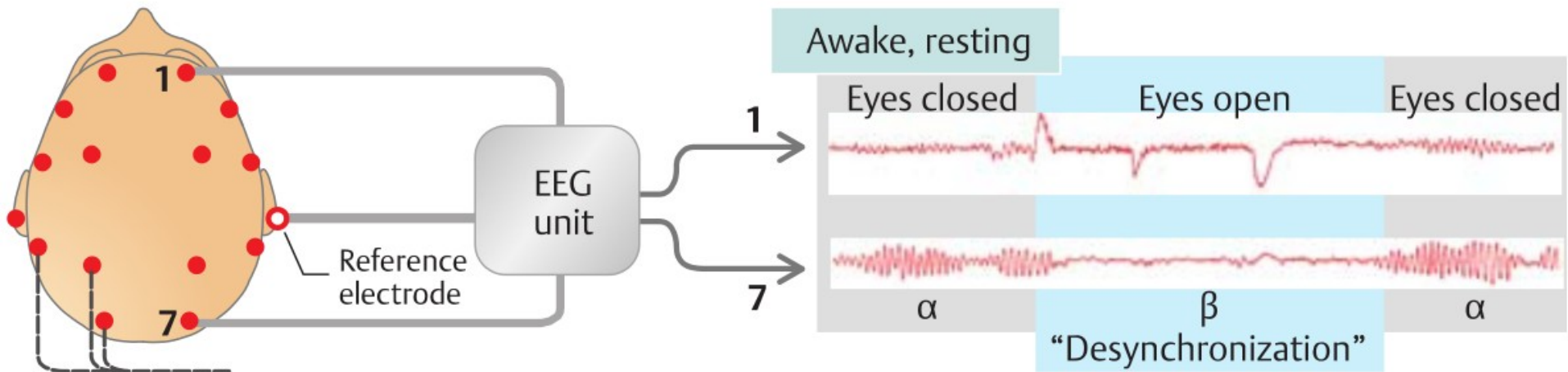
A



B



EEG



EEG

Il sistema di registrazione dei segnali EEG è chiamato Elettroencefalogramma, ed è costituito da una unità di acquisizione (elettrodi) di segnali misurati sullo scalpo, da una unità di elaborazione dei segnali e da una unità di visualizzazione e memorizzazione dei dati.



Elettrodi a coppetta

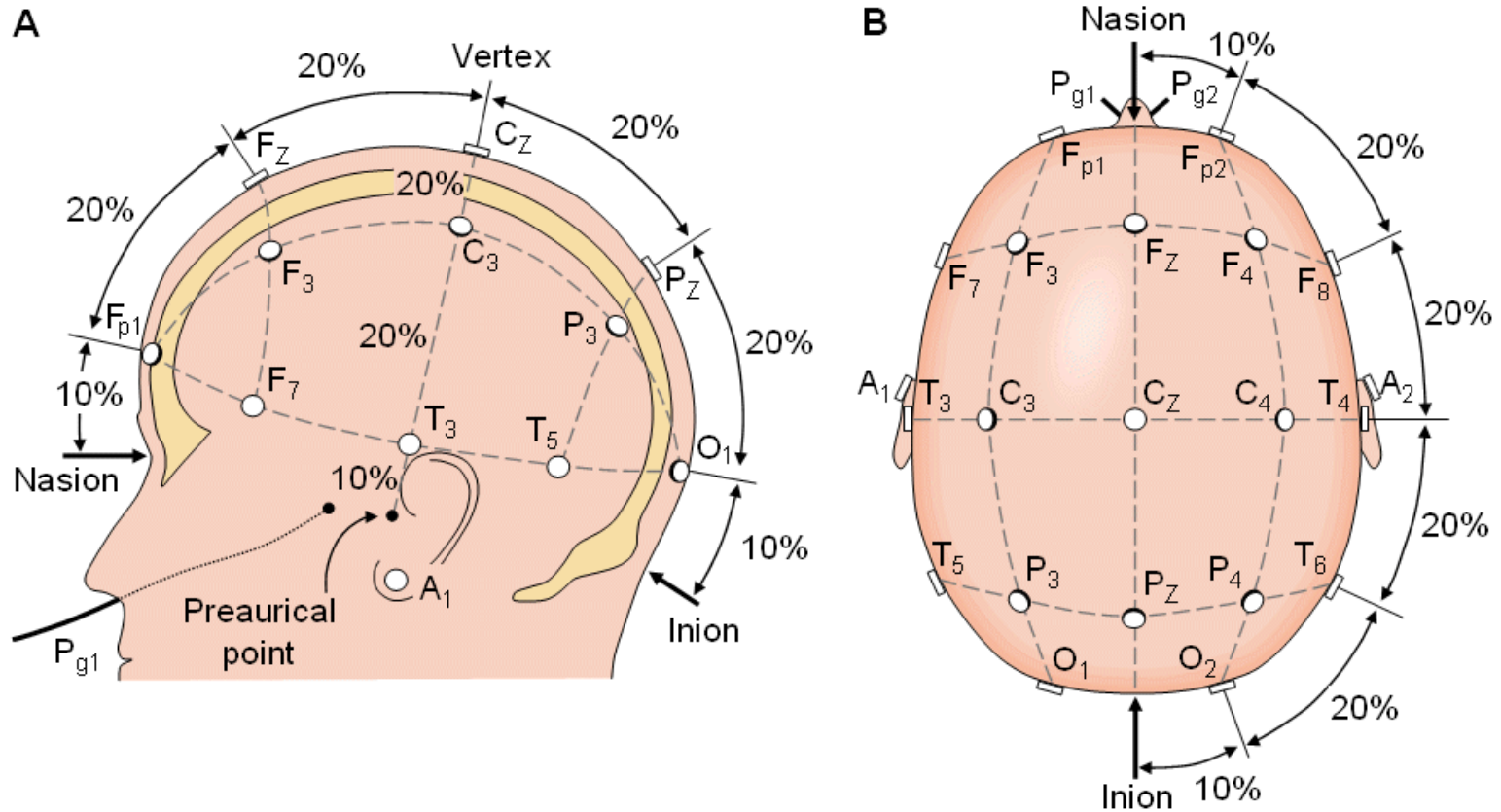


Elettrodi monouso



Elettrodi ad anello

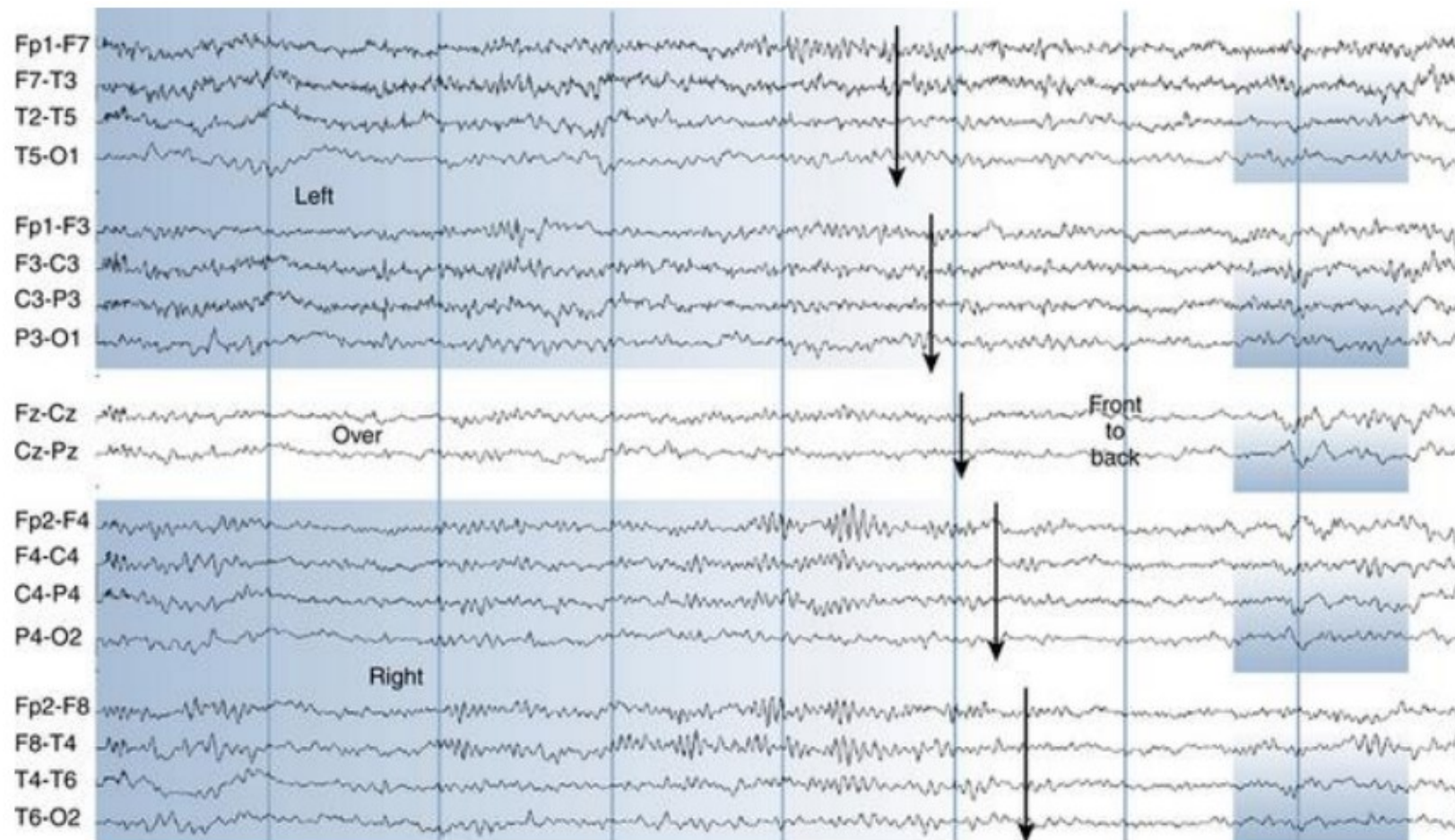
Sistema internazionale 10/20



Sistema internazionale 10/20

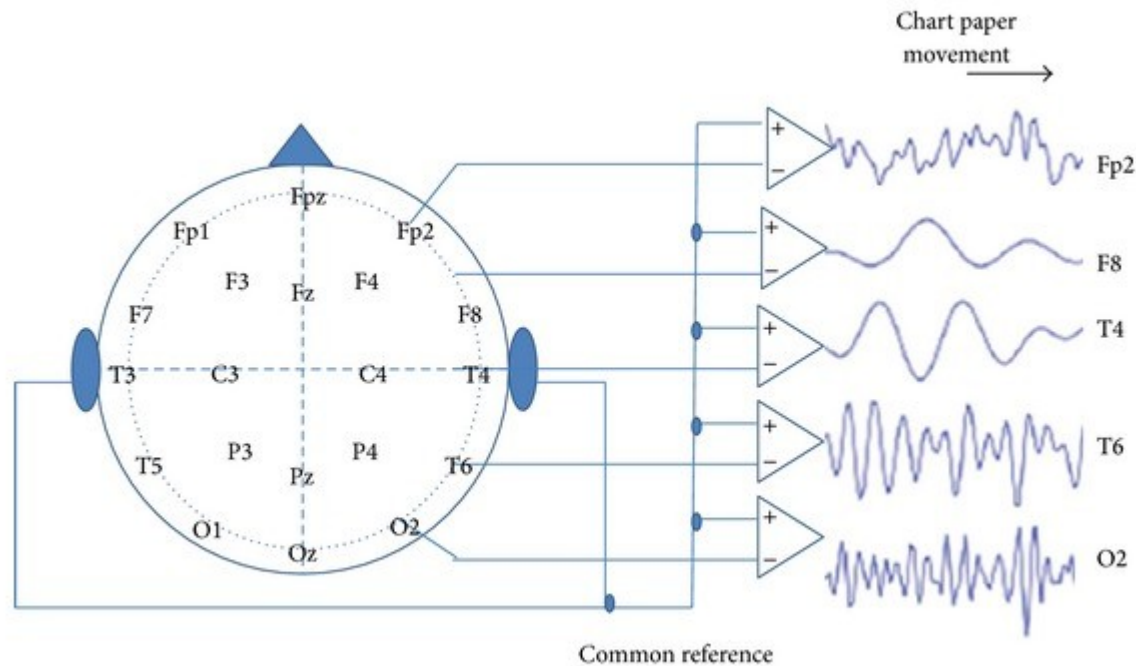


Esempio di segnale registrato



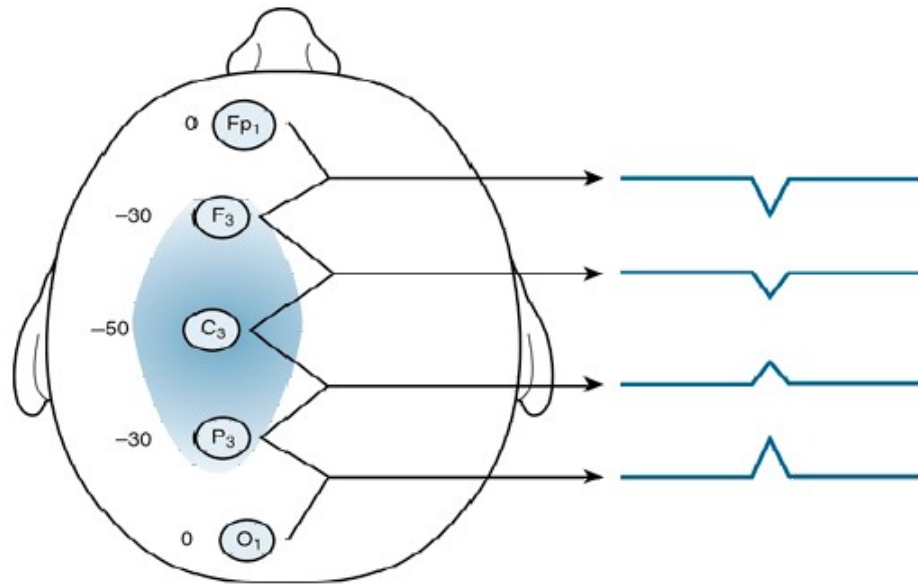
Configurazione referenziale

Ogni canale misura ed amplifica la differenza tra un elettrodo applicato sullo scalpo del paziente (sito elettricamente attivo) e l'elettrodo di riferimento (sito elettricamente neutro, es. punta del naso, lobo dell'orecchio, ...)

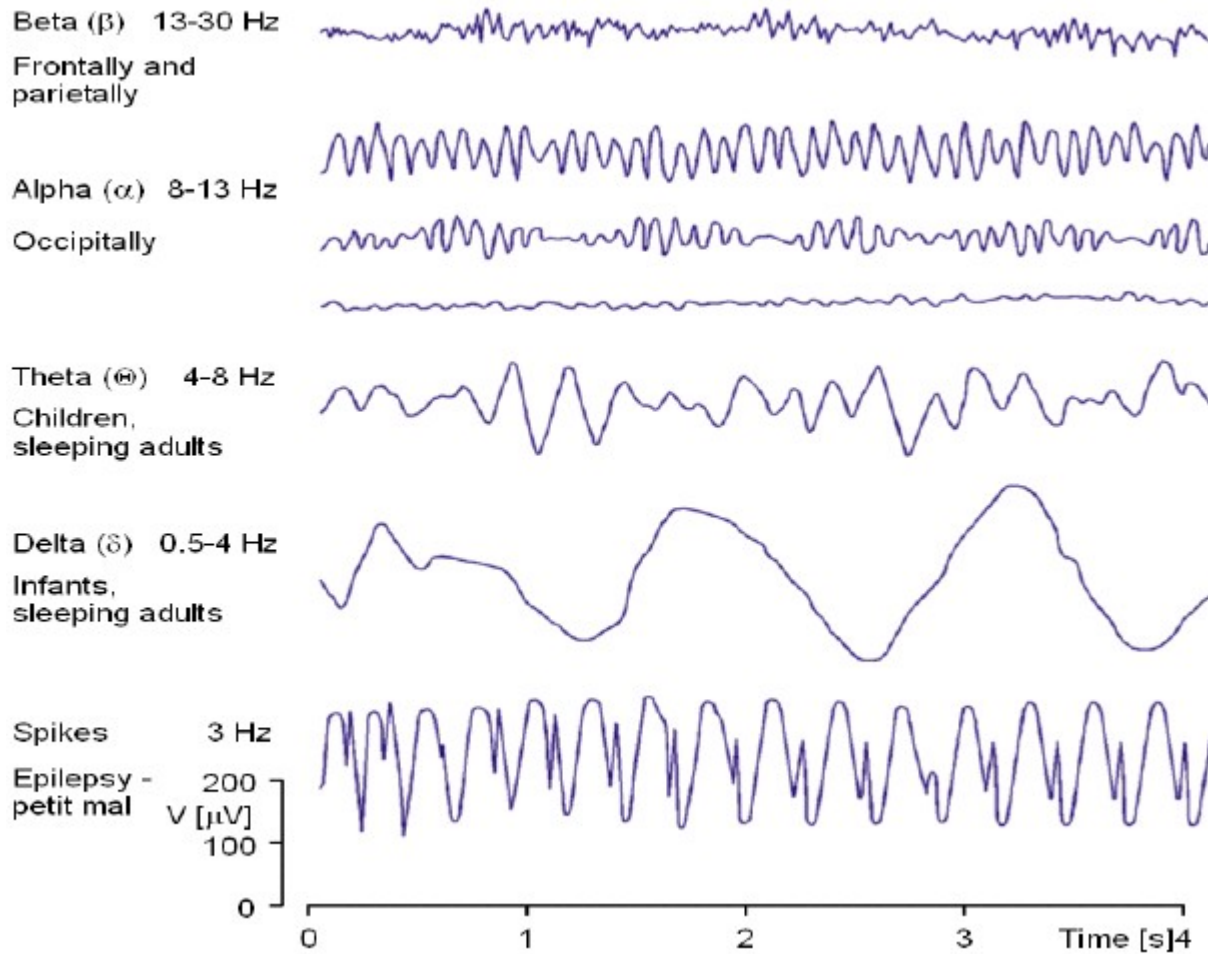


Configurazione bipolare

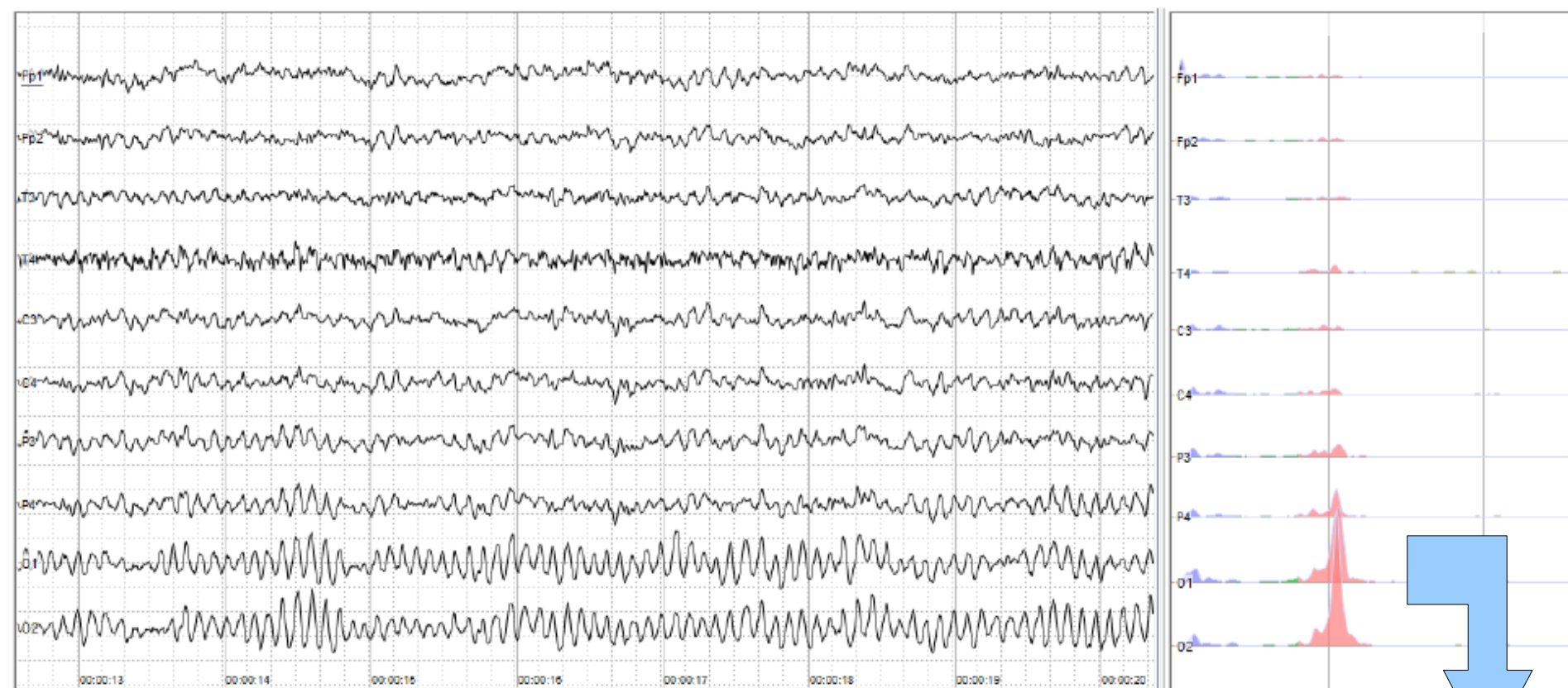
Ogni canale misura ed amplifica la differenza tra elettrodi adiacenti, entrambi applicati sullo scalpo del paziente (su siti elettricamente attivi).



Ritmi elettroencefalografici



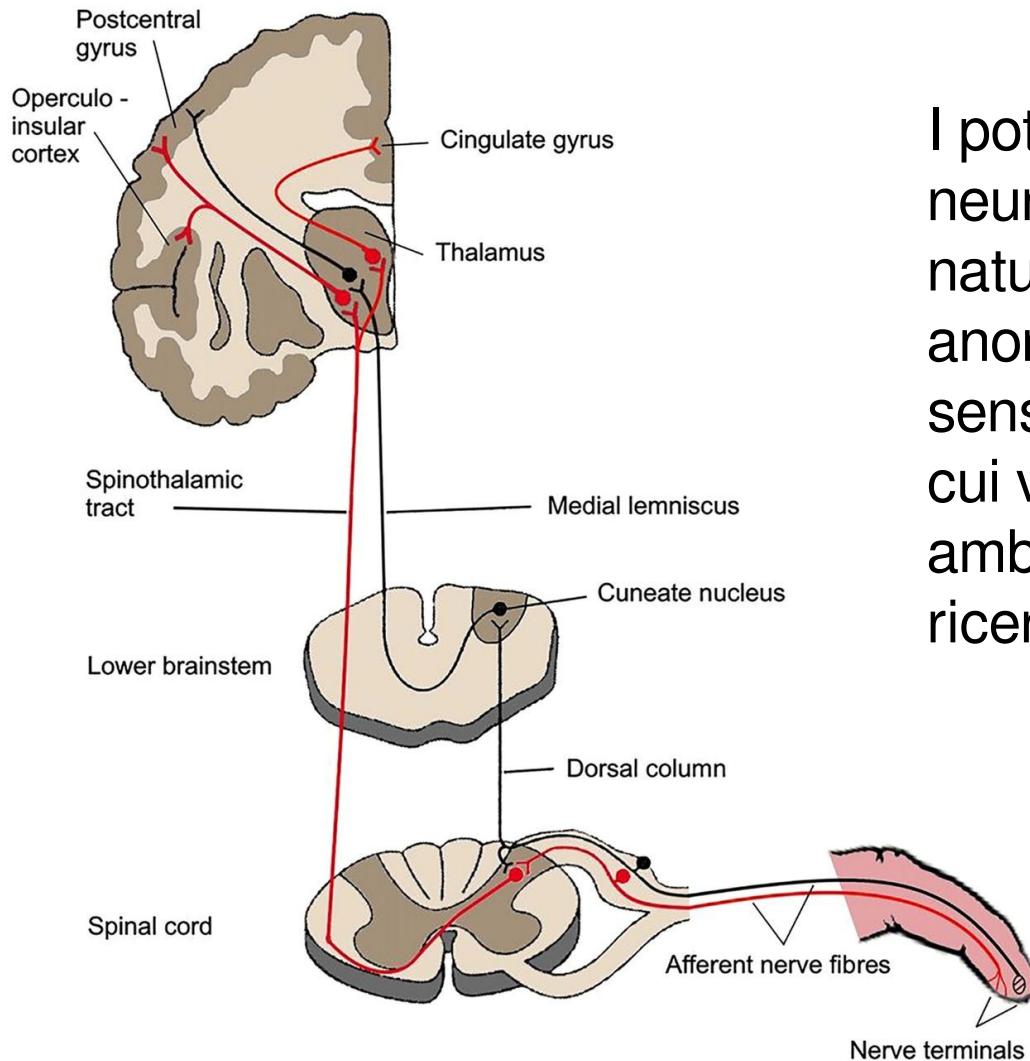
Ritmi elettroencefalografici



Ritmo alfa

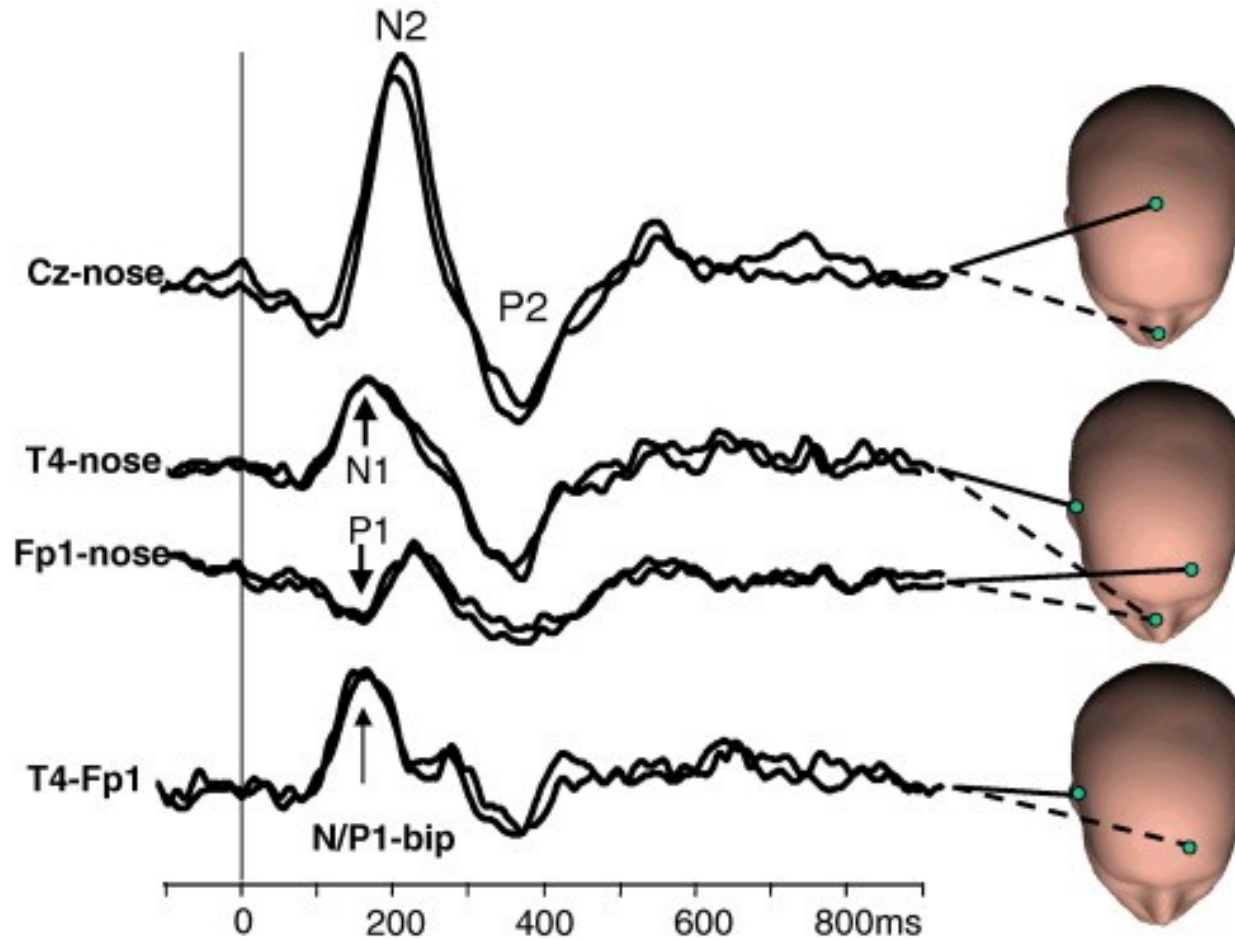
Regione occipitale destra

Potenziale evocato

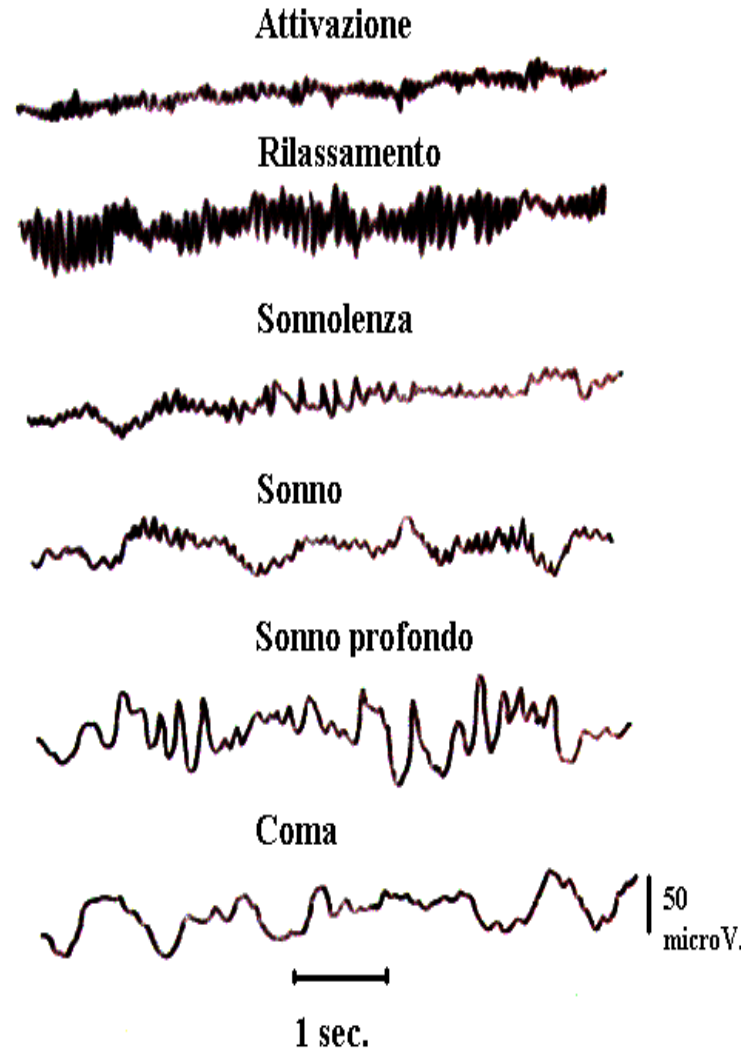


I potenziali evocati sono risposte neurali legati a stimoli di varia natura. Sono degli indicatori di anomalità nel sensore sensoriale e motorio, motivo per cui vengono utilizzate sia in ambito clinico che in ambito di ricerca.

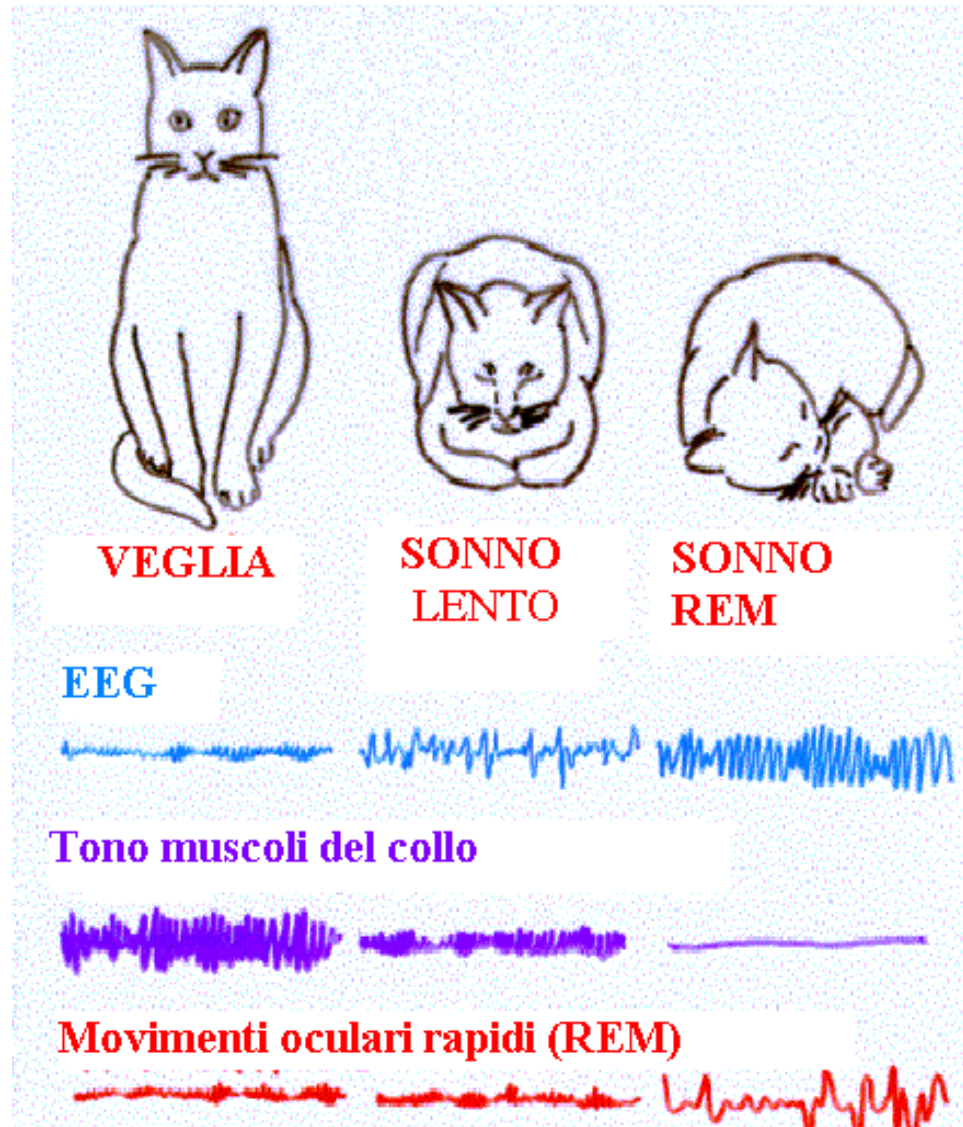
Potenziale evocato



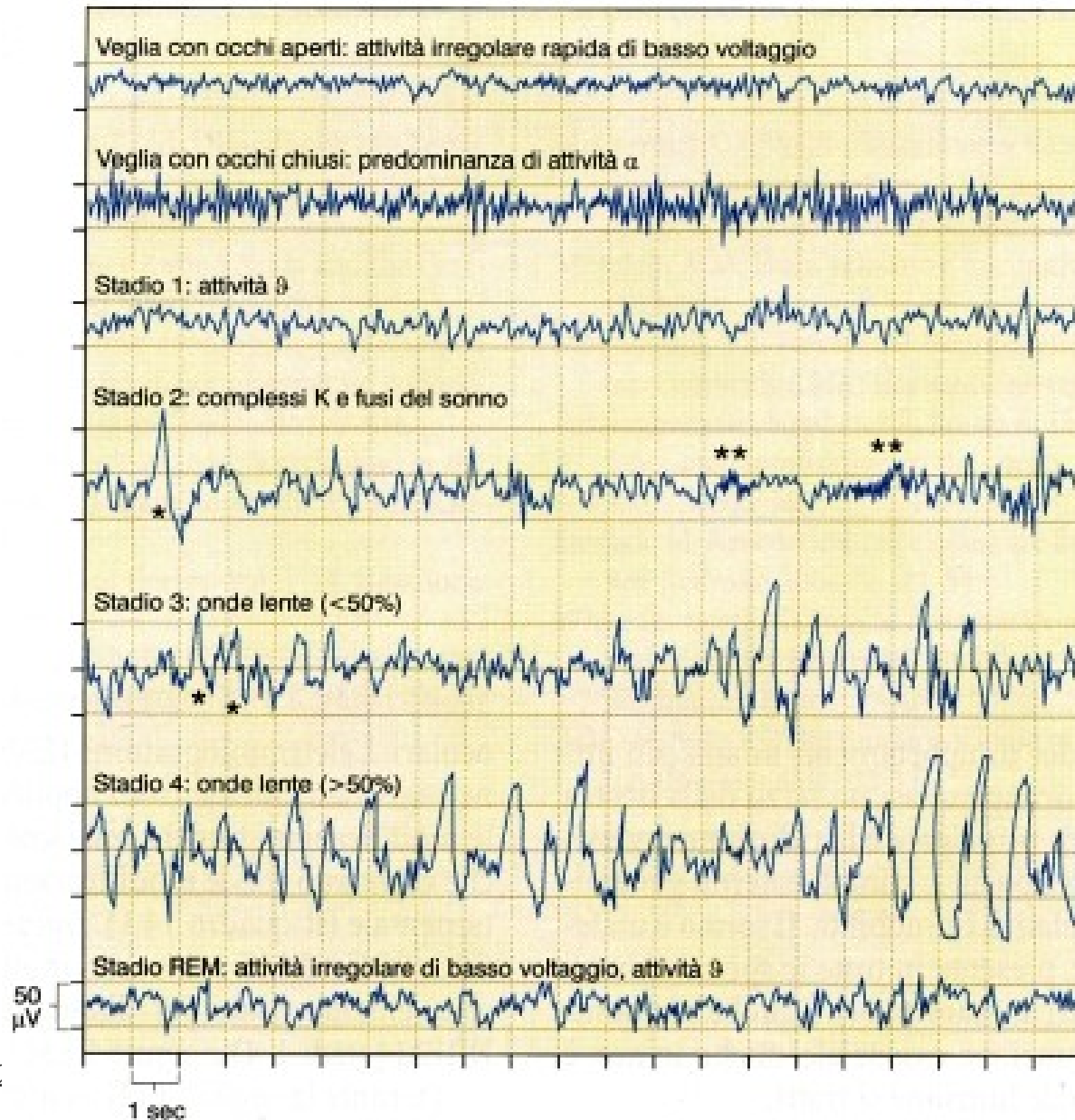
Sonno



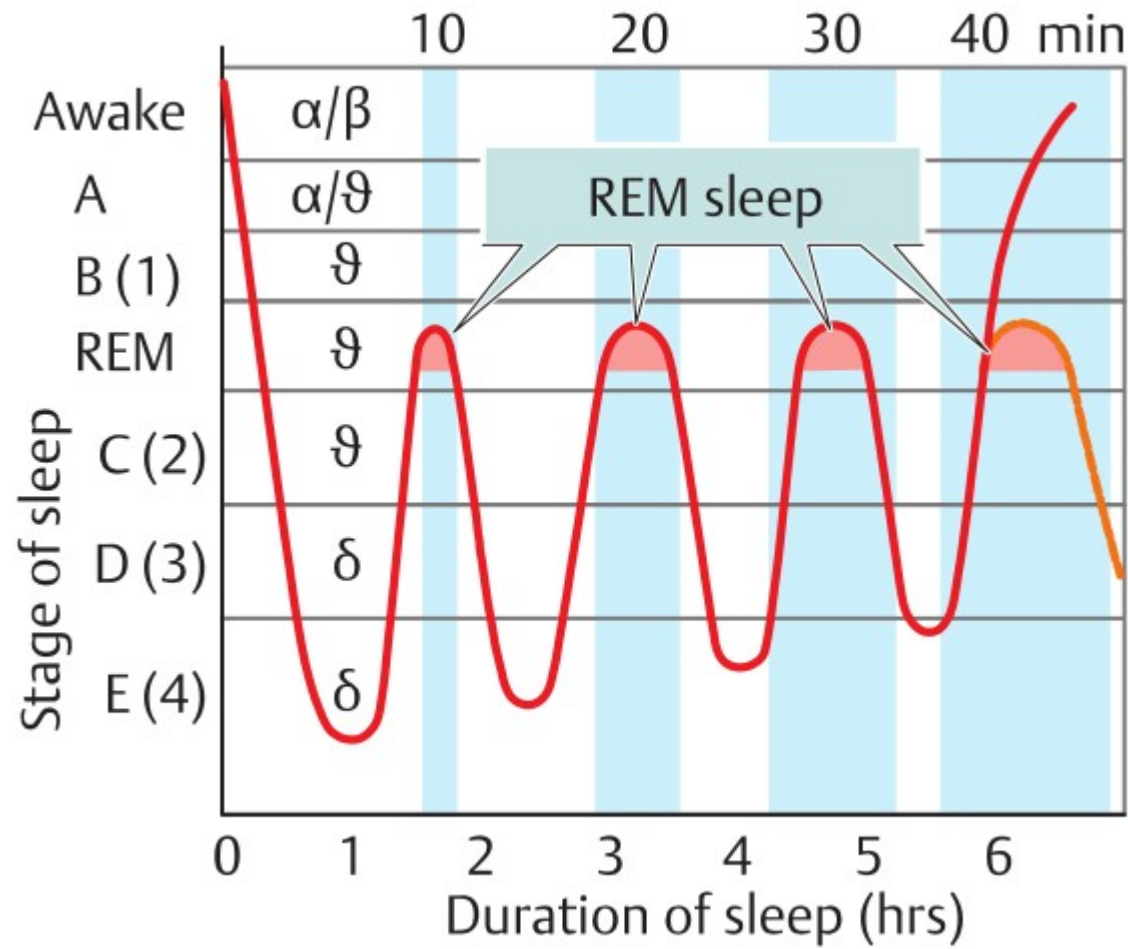
Sonno



Sonno

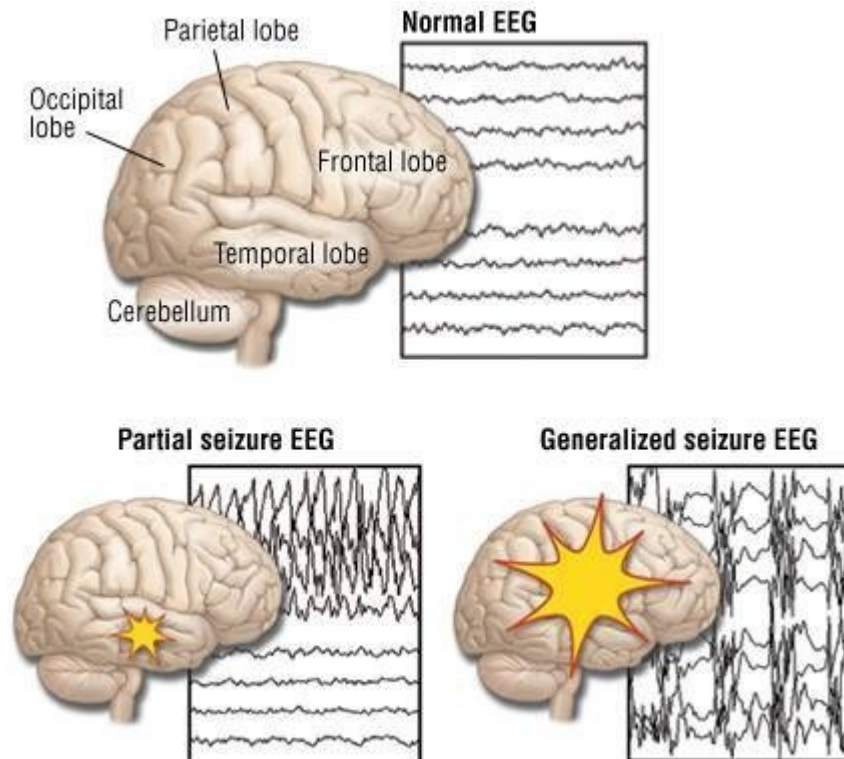


Sonno



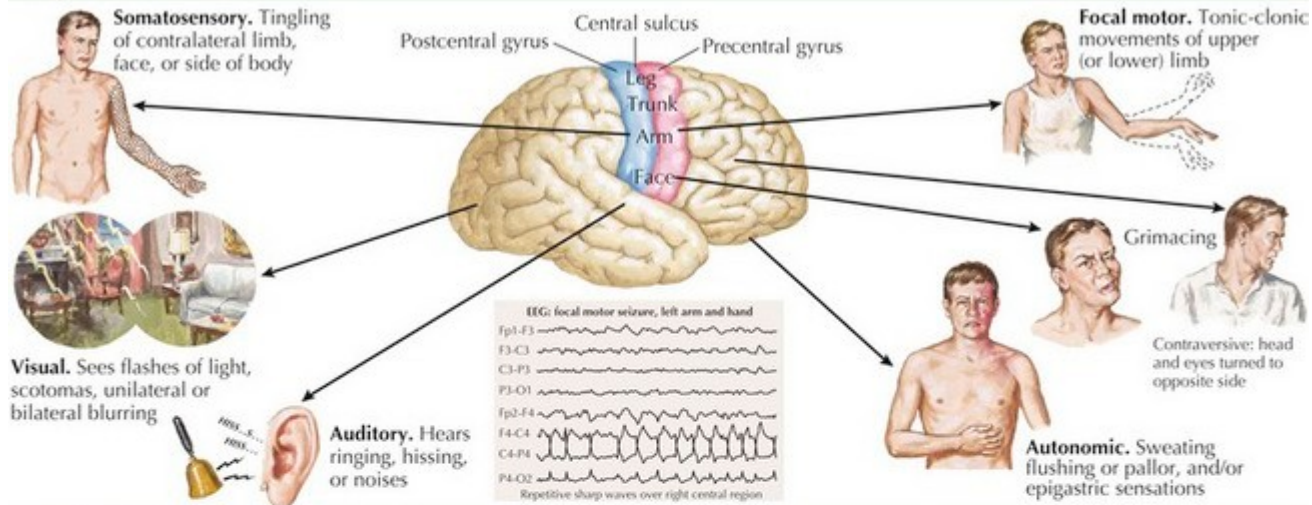
Epilessia

L'epilessia è caratterizzata da un'eccessiva attività incontrollata di una parte o dell'intero cervello. In questo caso, si parla di epilessia parziale o di epilessia generalizzata, rispettivamente.



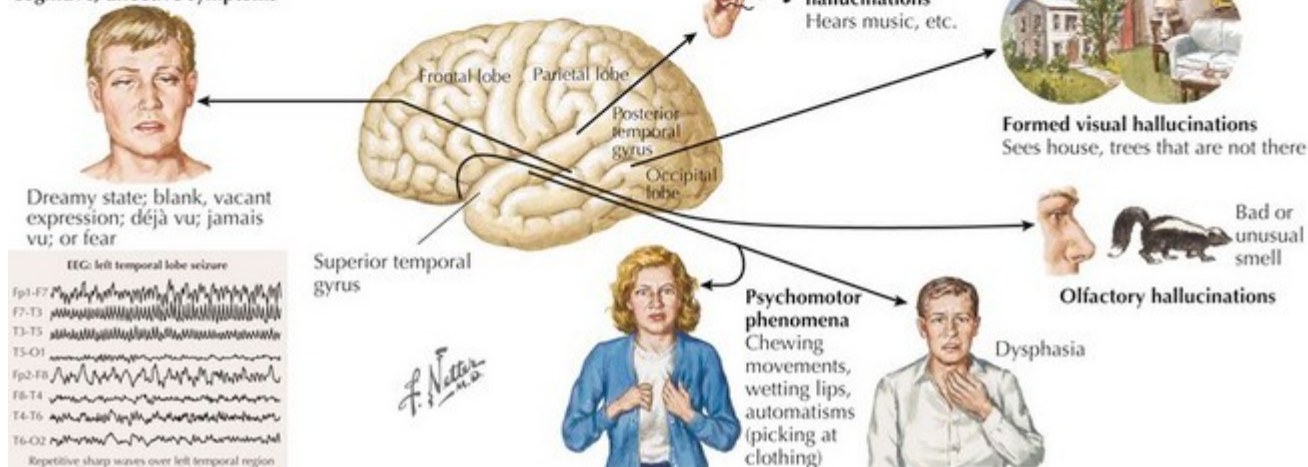
Epilessia – crisi parziale

Simple Partial Seizures

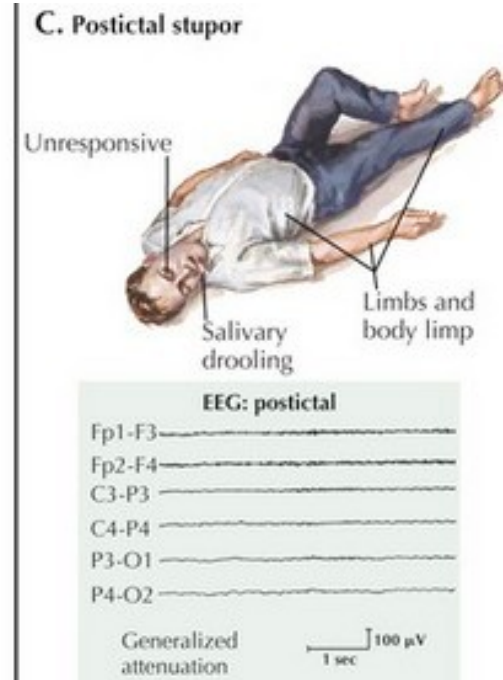
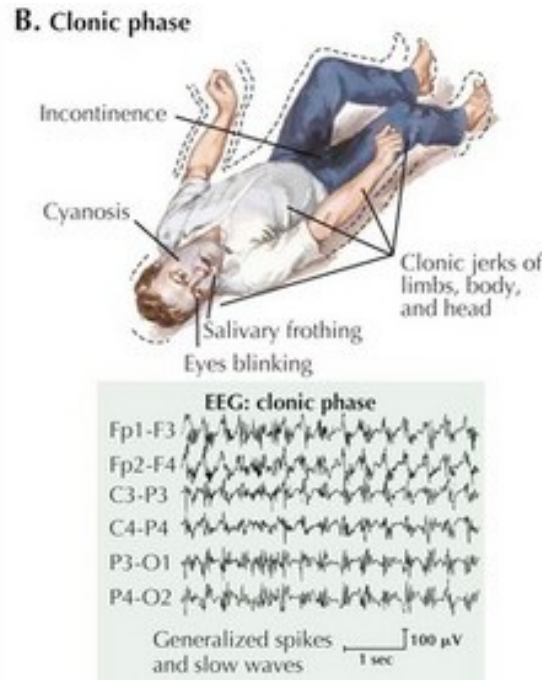
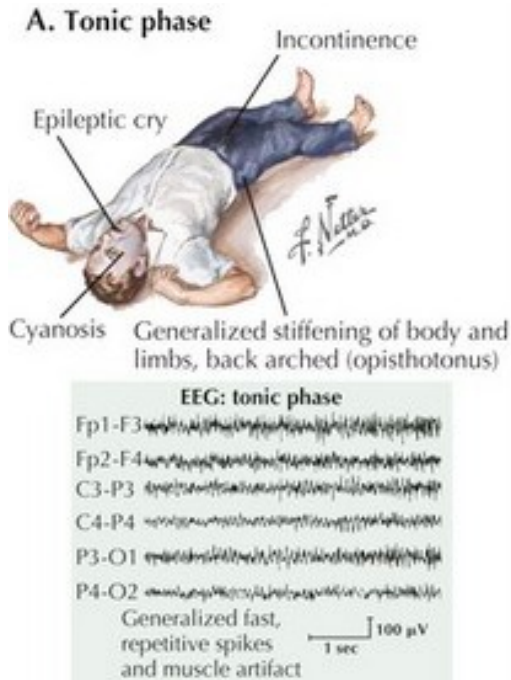


Complex Partial Seizures

Impairment of consciousness: cognitive, affective symptoms



Epilessia – crisi generalizzate



Grand mal (convulsiva), petit mal (non convulsiva)

Magnetoencefalogramma (MEG)



Magnetoencefalogramma (MEG)

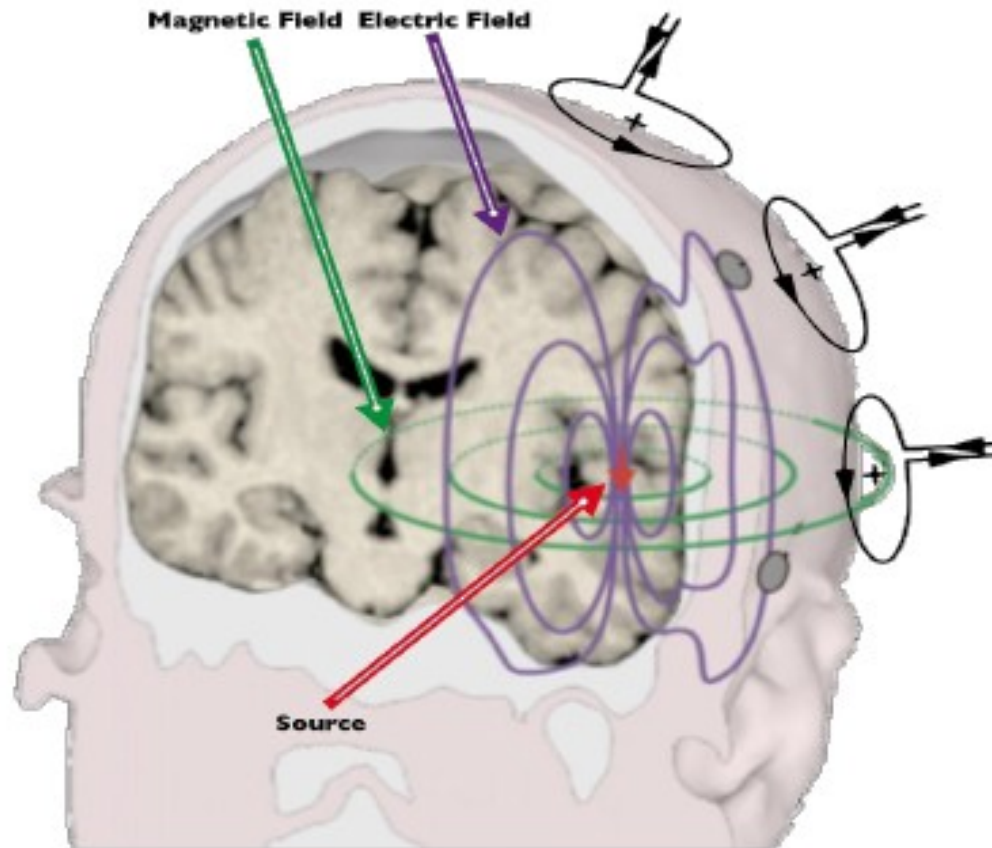
La magnetoencefalografia (MEG) è un sistema diagnostico di imaging che misura la variazioni temporali dei campi magnetici legati all'attività cerebrale.



Magnetoencefalogramma (MEG)

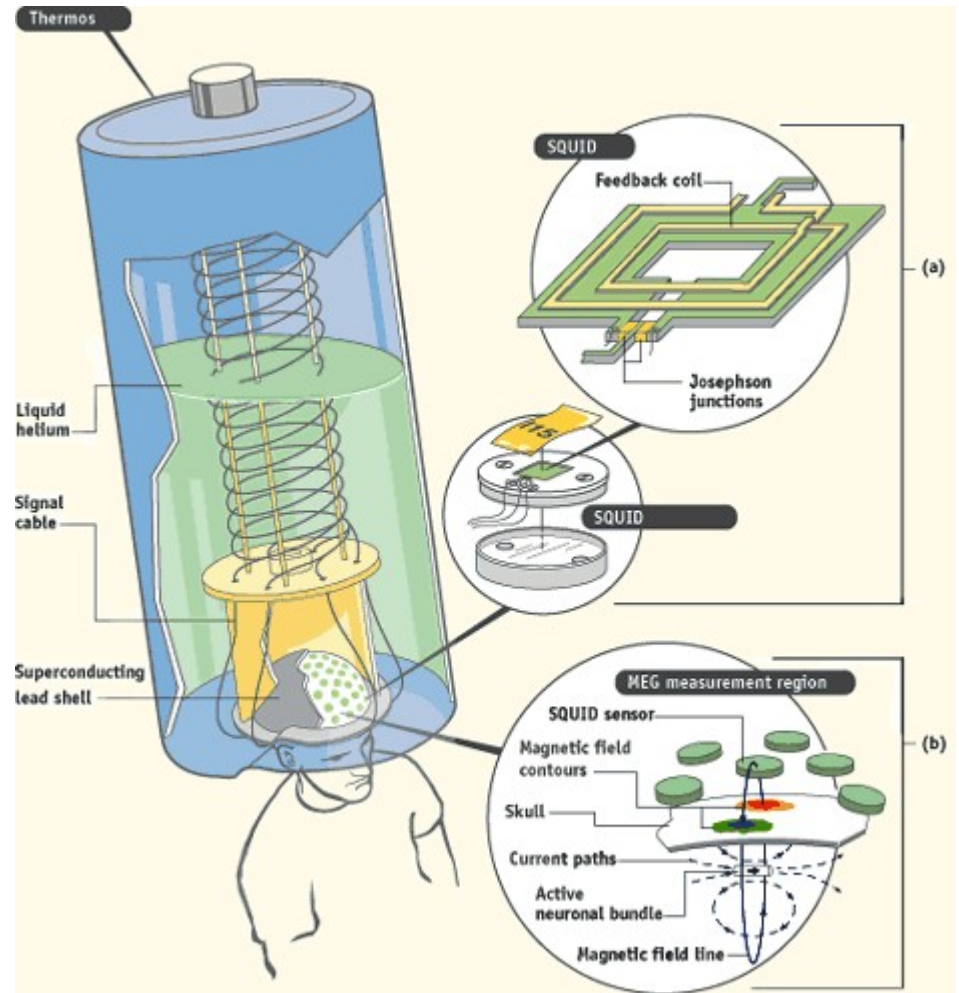


Magnetoencefalogramma (MEG)

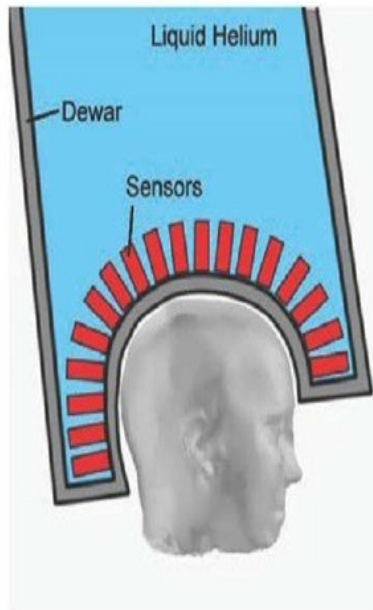


Sorgenti

Magnetoencefalogramma (MEG)

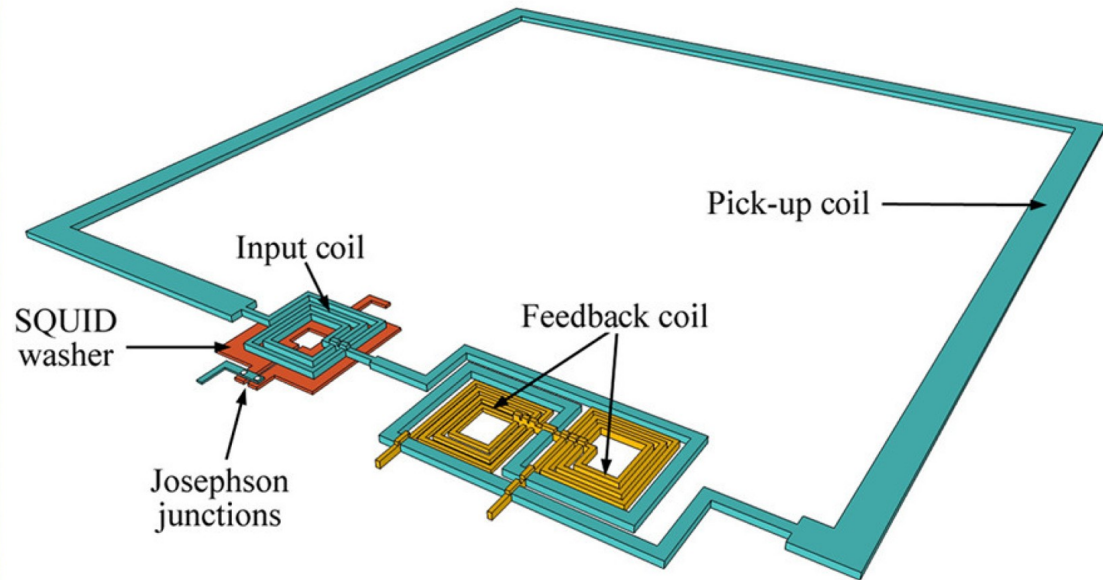
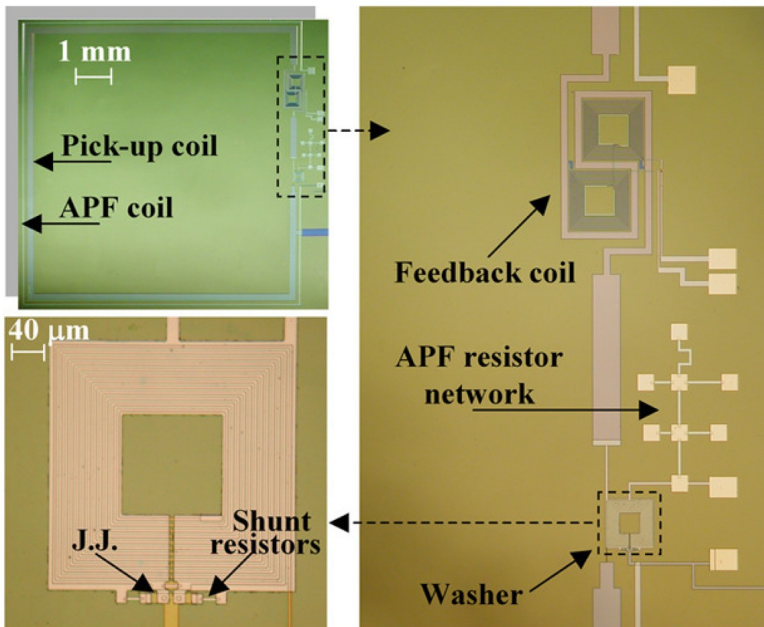


Magnetoencefalogramma (MEG)



Per funzionare il sistema richiede temperature molto basse.
Per questo motivo si riempie il dewar di elio liquido ($t < -269^{\circ}\text{C}$).

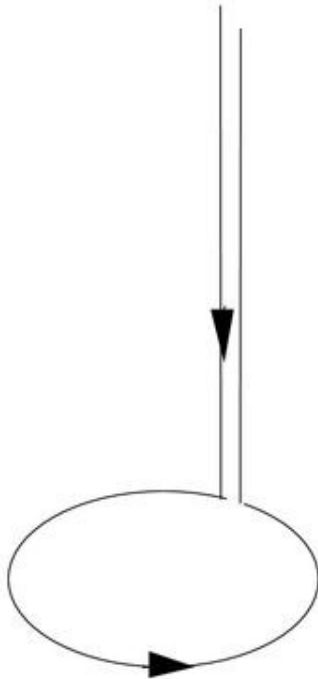
Sensori



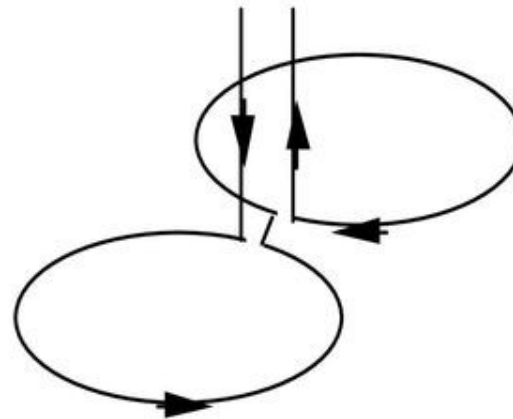
SQUID - Superconductor Quantum Interference Devices

Sensori

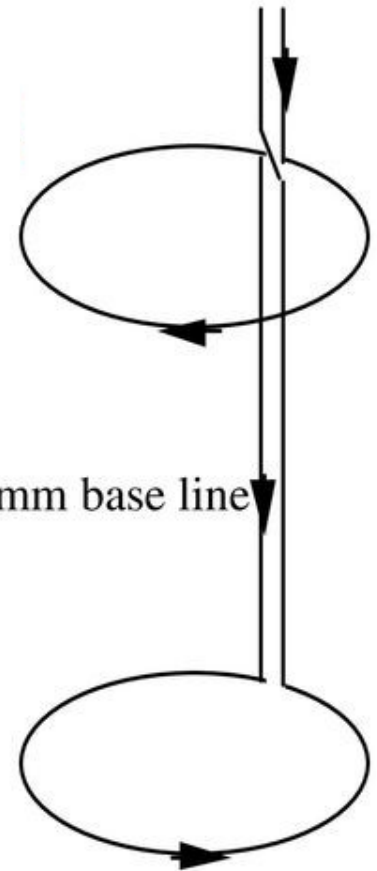
Magnetometer



Gradiometer

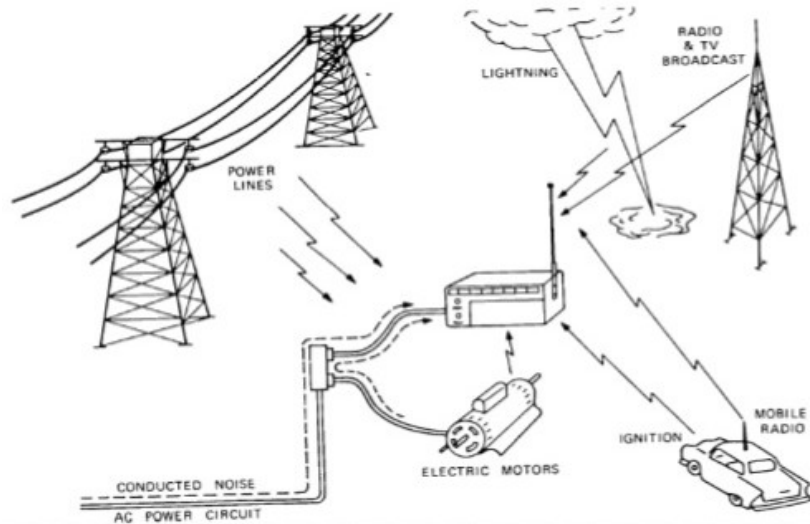


Planar type

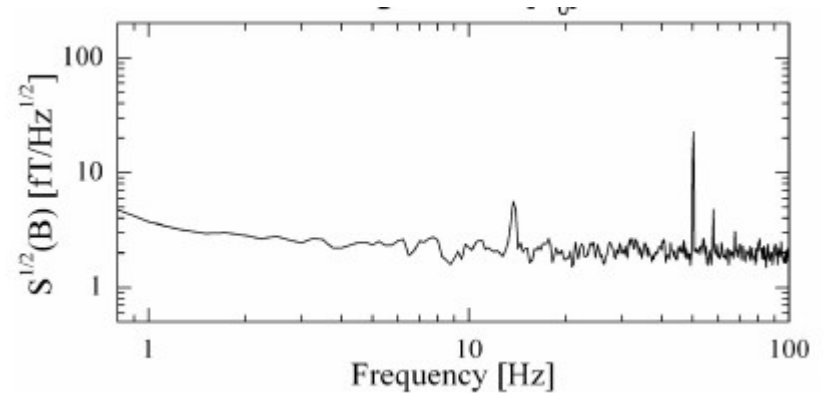


Axial type

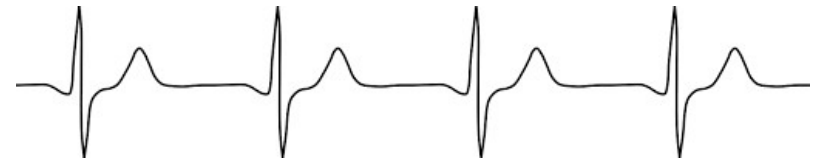
Rumore



Ambientale



Sensori



Fisiologico

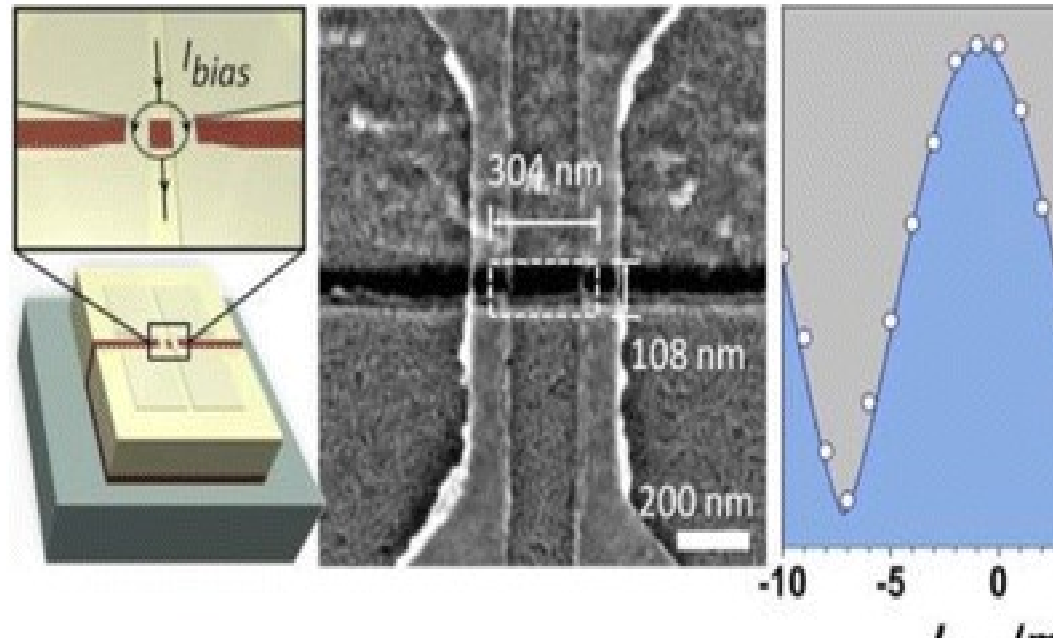
Rumore ambientale - Schermaggio



David Cohen,
MIT, 1969.

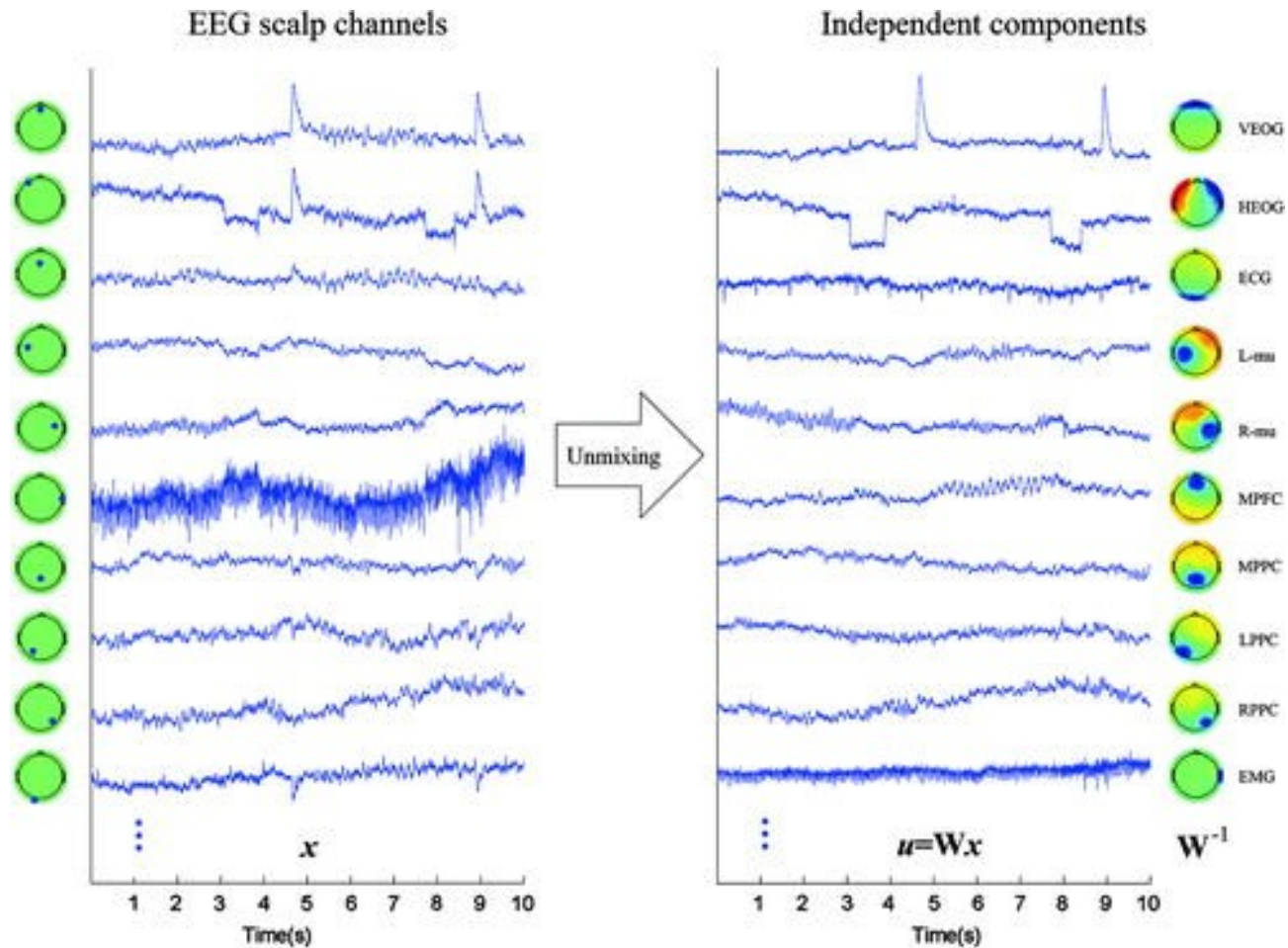


Rumore dei sensori



SQUID di nuova generazione (es. 3D).

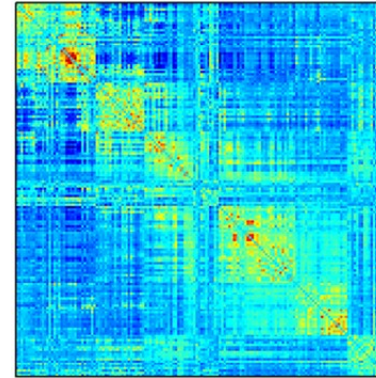
Rumore fisiologico - Algoritmi



Catena di elaborazione



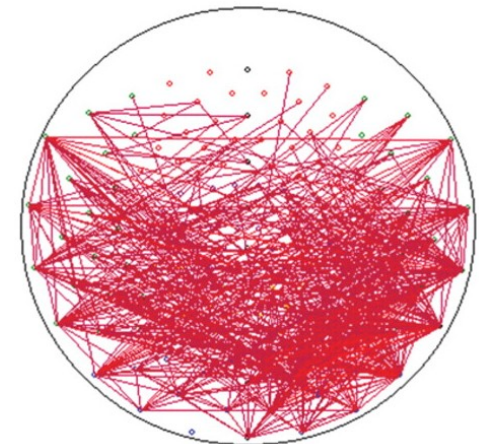
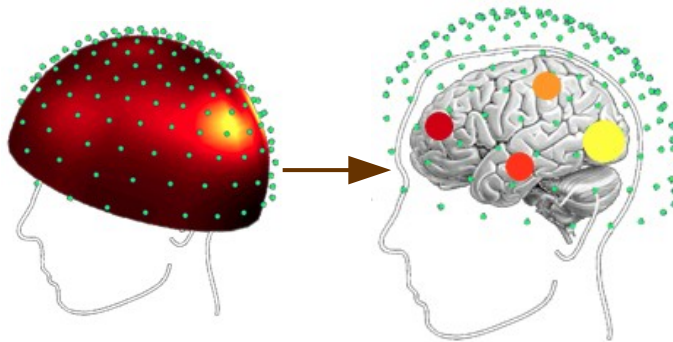
Data
Acquisition



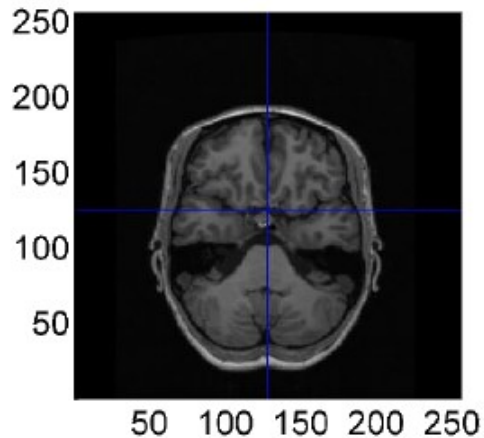
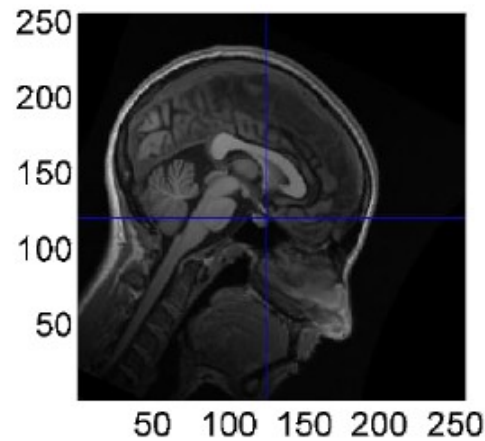
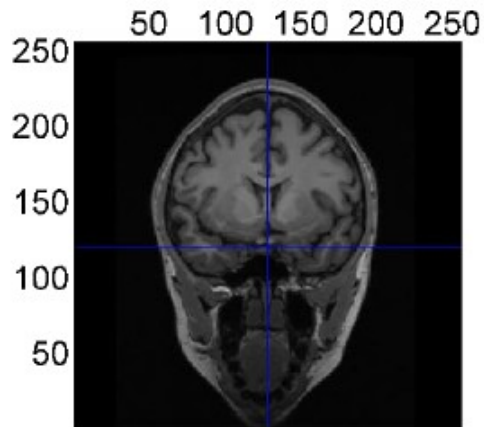
Focusing

Connectivity
measurement

Graph
analysis



Catena di elaborazione

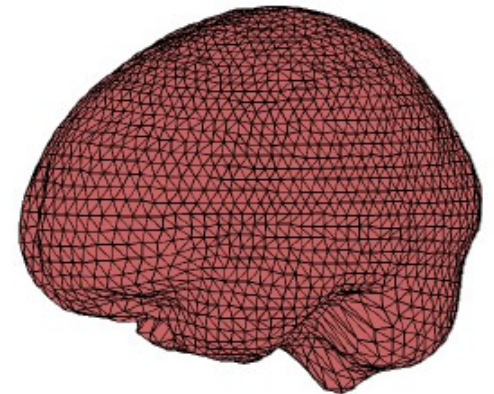


voxel 7896192, indices [128 125 121]
itab coordinates [-0.5 26.5 32.5] mm

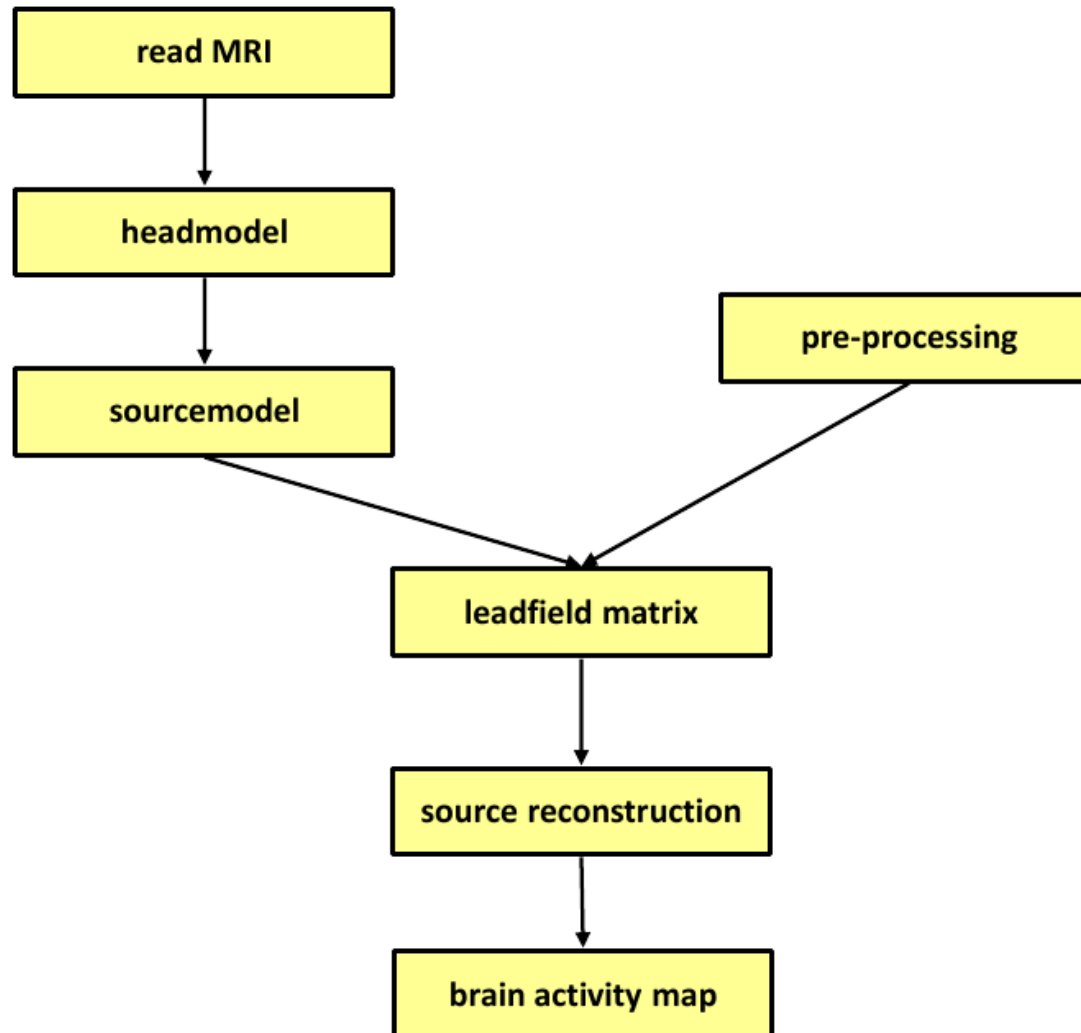
atlas label: NA



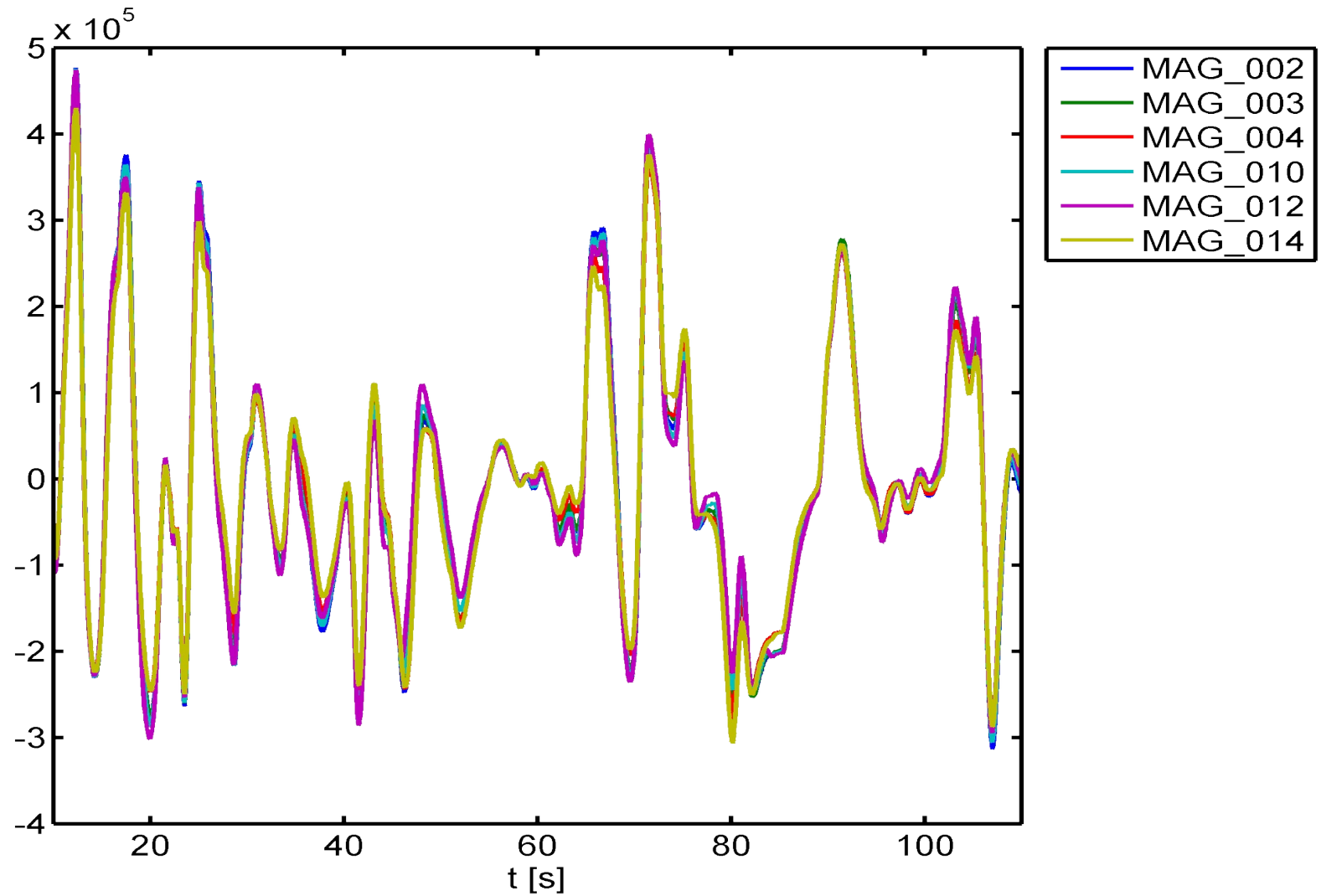
Headmodel



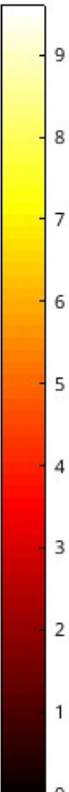
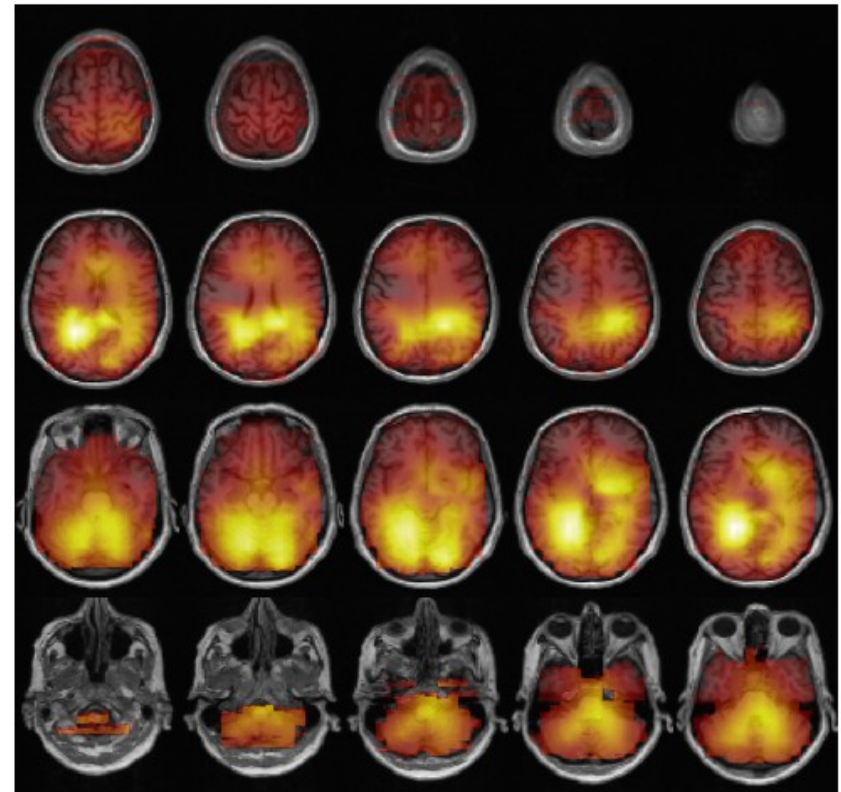
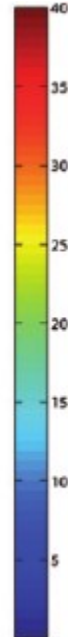
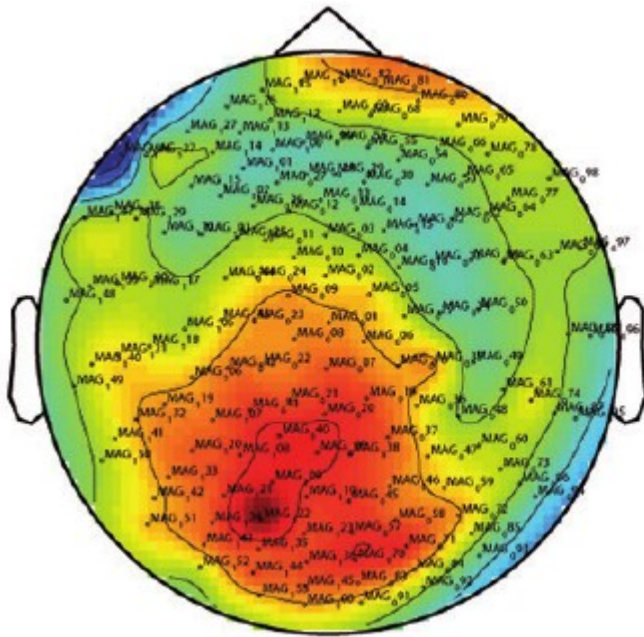
Catena di elaborazione



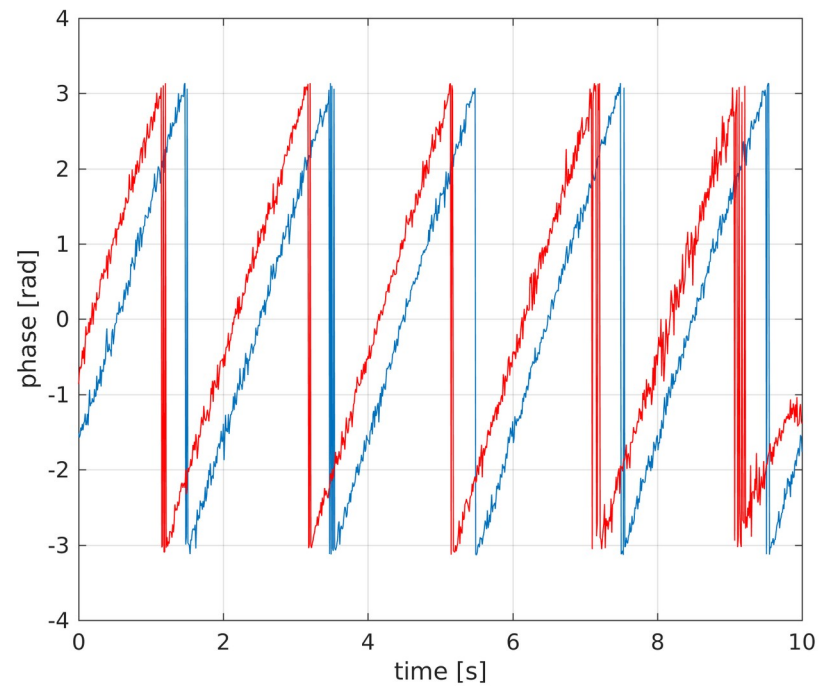
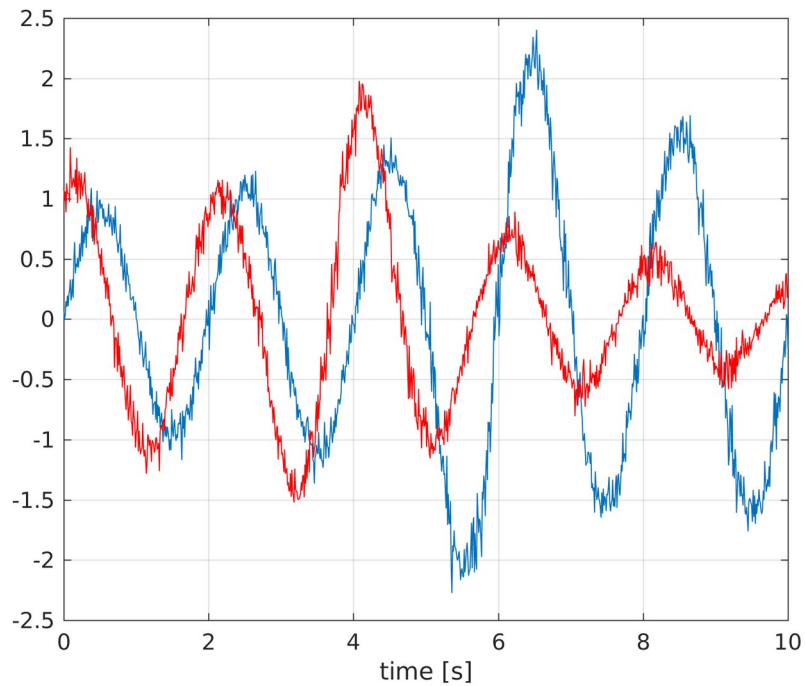
Catena di elaborazione



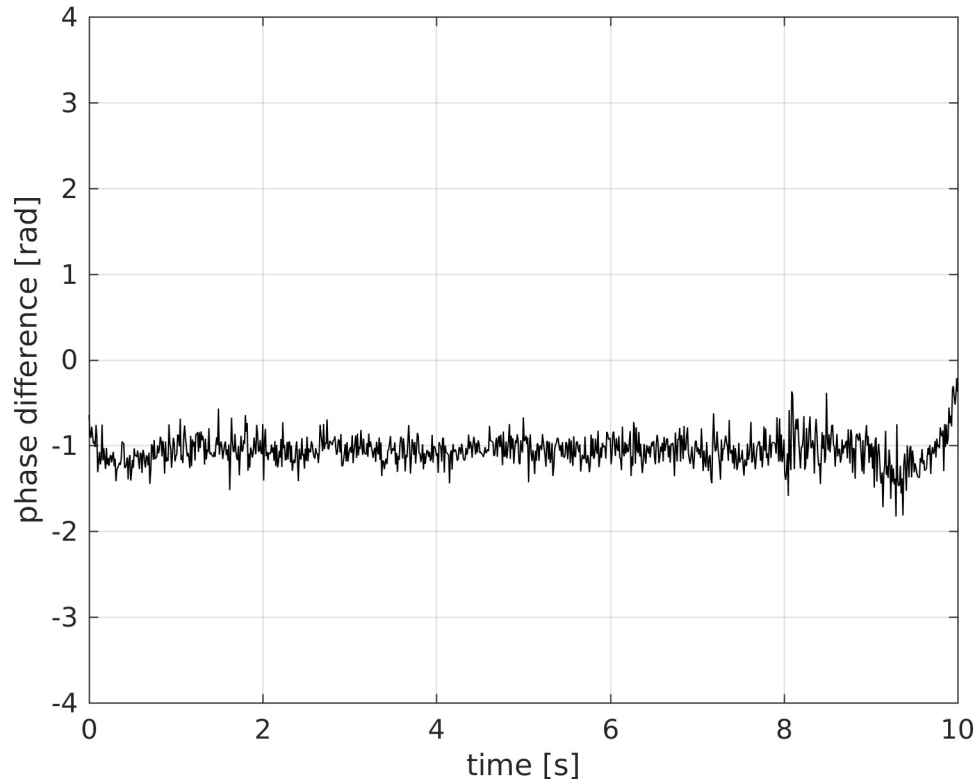
Catena di elaborazione



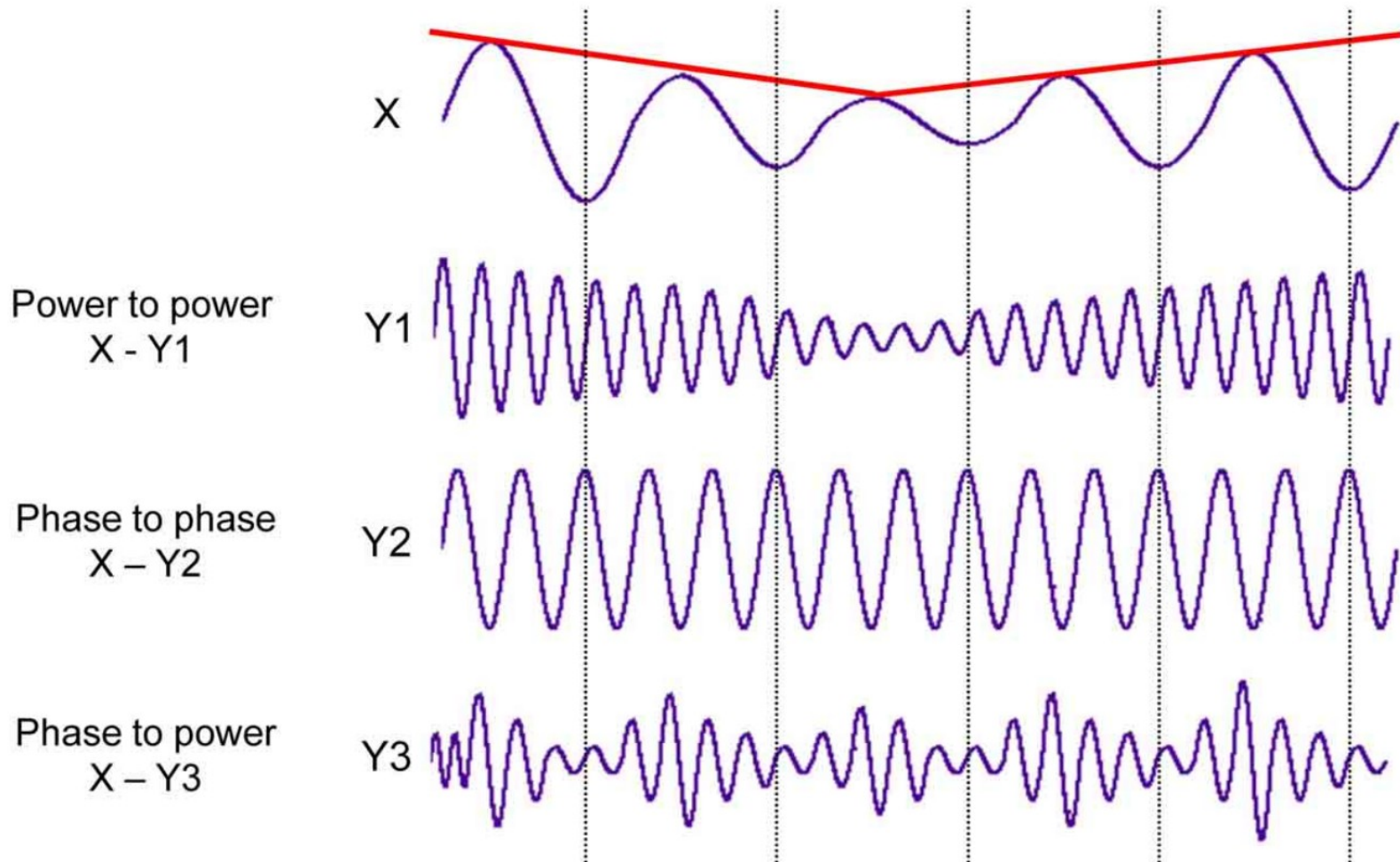
Accoppiamento



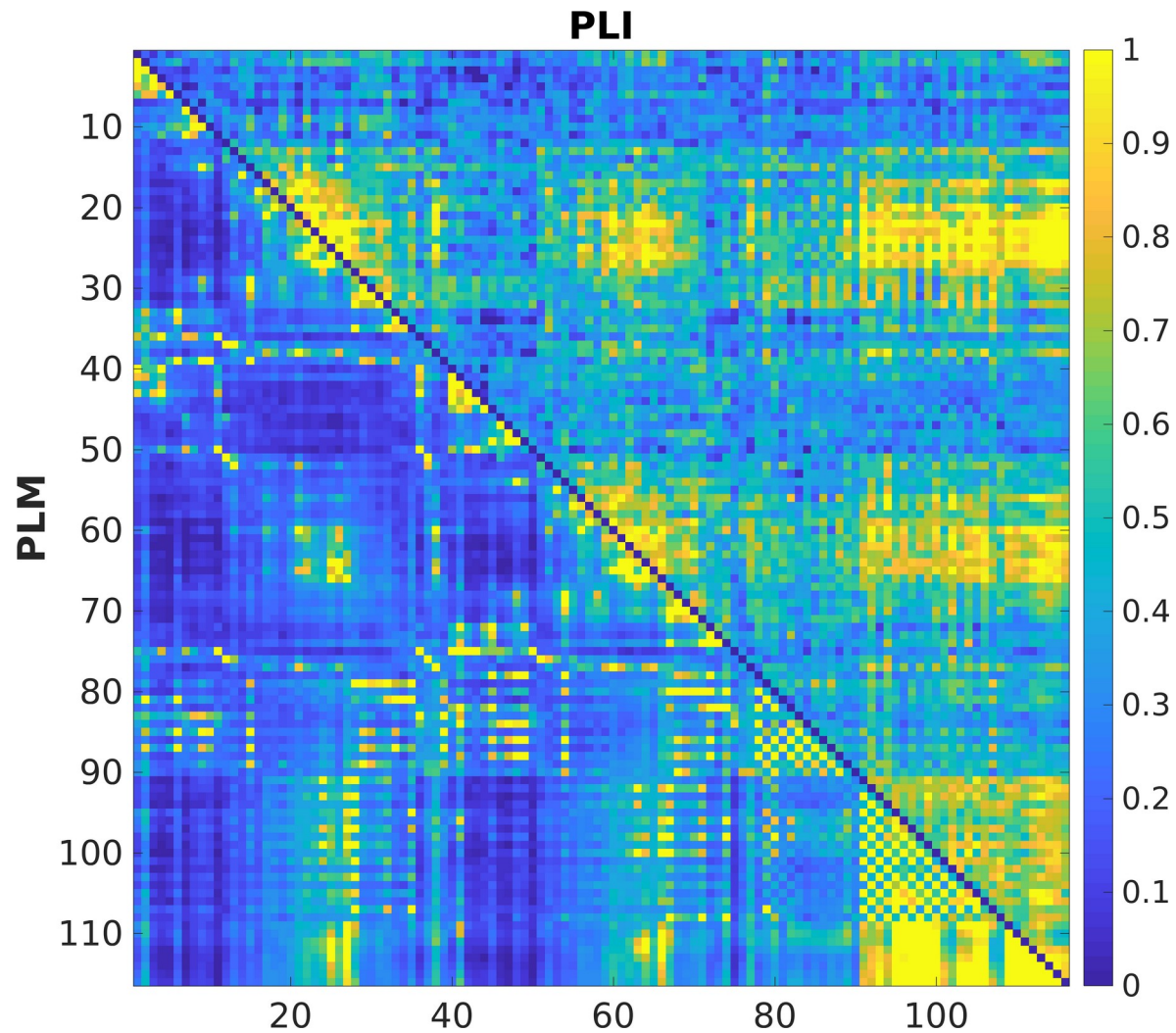
Accoppiamento



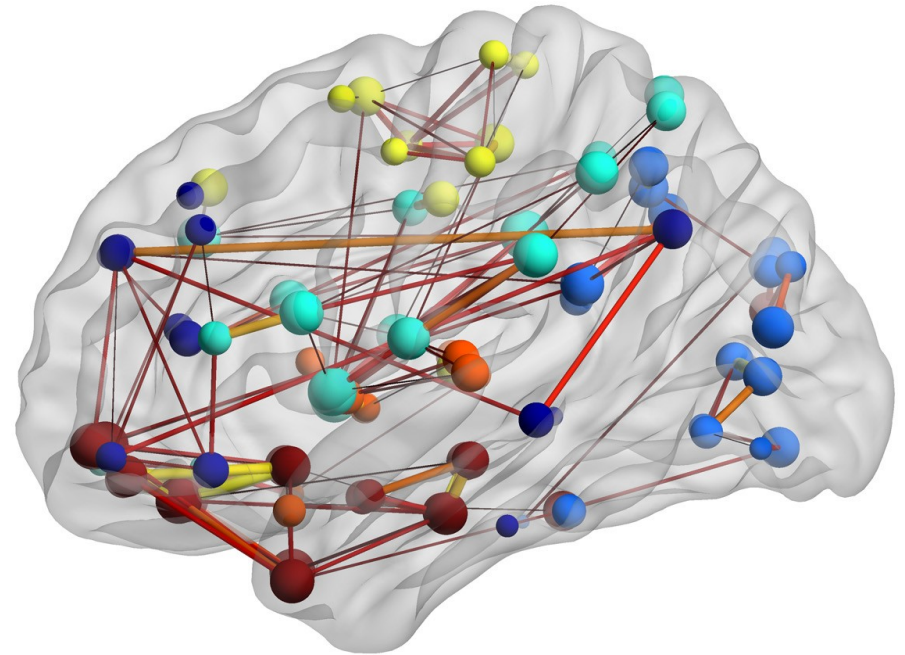
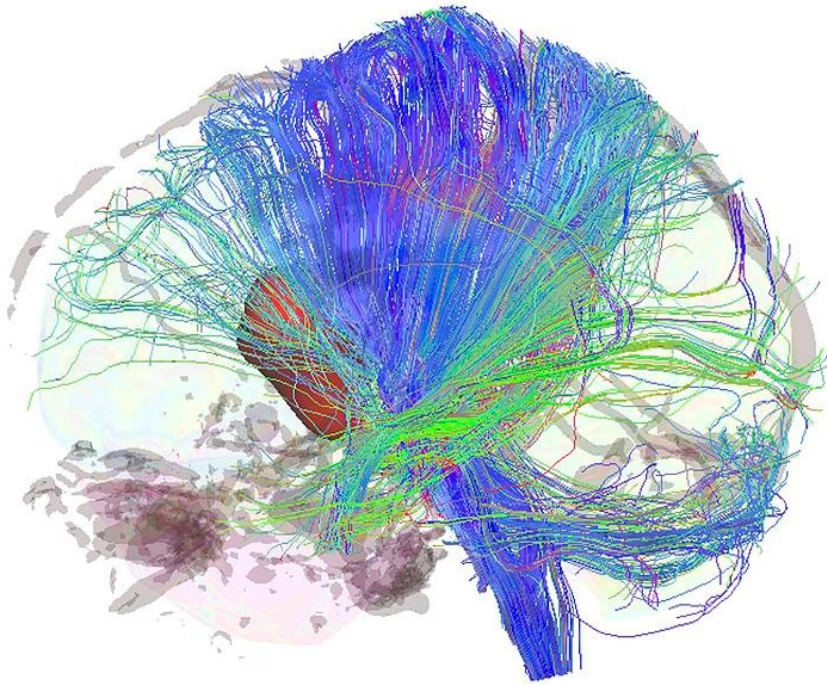
Accoppiamento



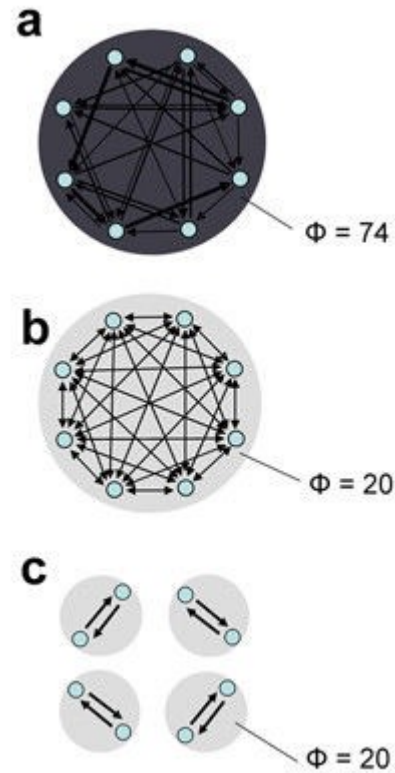
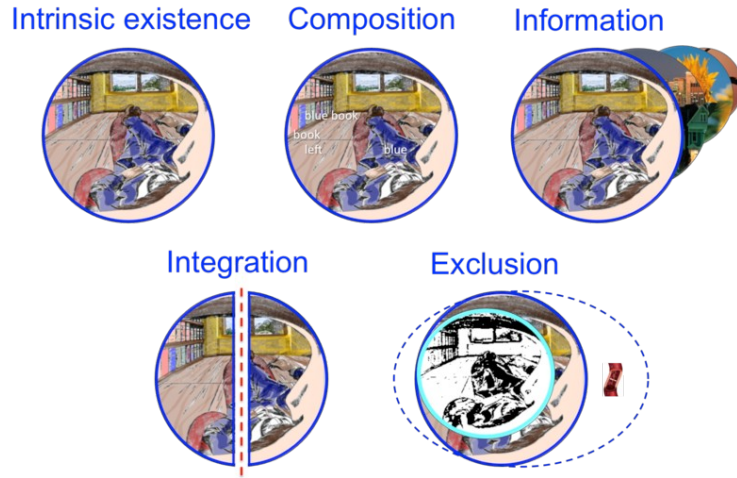
Connettività



Rete di connettività cerebrale



Coscienza



Giulio Tononi
Credit: Courtesy of the Author

Integrated Information Theory