ABNS

Parietal lobe (attention, touch, saccade planning)

occipital lobe — Vision: perception of features, categories and location

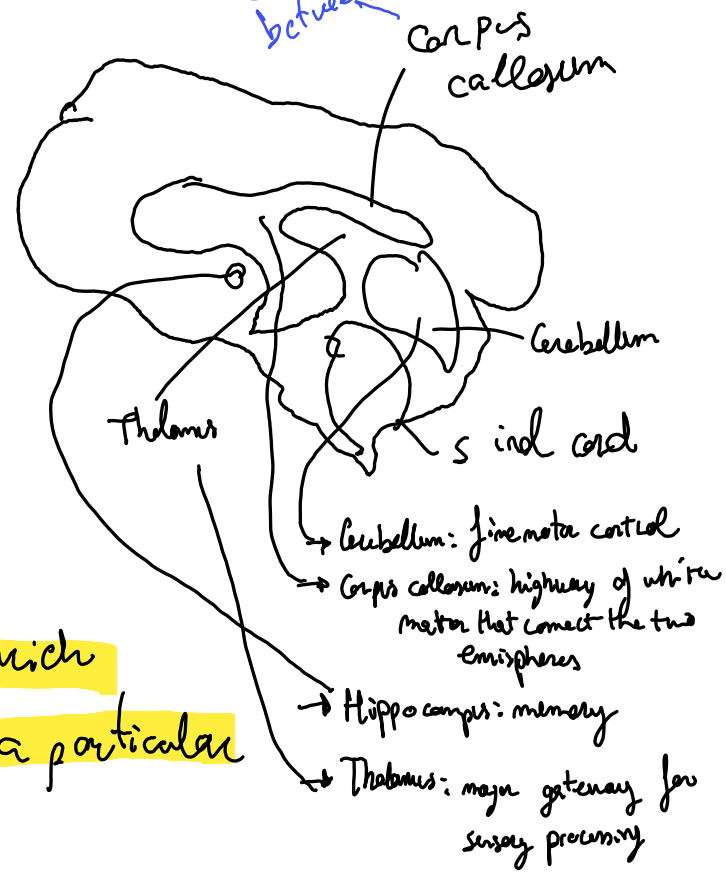
Frontal lobe

(planning, execution, higher level cognition
- language processing
- language production)

Temporal lobe

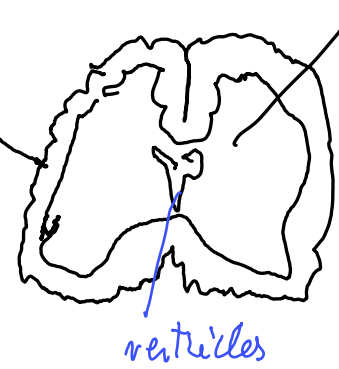
(auditory processing: • hearing • language)

shares informations between the two emispheres



→ Cerebellum: fine motor control
→ Corpus callosum: highway of white matter that connect the two emispheres
→ Hippocampus: memory
→ Thalamus: major gateway for sensory processing

There are NO areas which are strictly connected to a particular capability



GREY MATTER

- high density of cell bodies with relatively fewer myelinated axons
- sensing, processing, cognition
- includes not only the celebral cortex but also cerebellum, basal ganglia, thalamus, and several other regions
- involves the majority of cognitive processing
- related also for neurological and psychiatric conditions

WHITE MATTER

- mainly composed by long range pathways that connect different parts of the brain
- no computation or processing, just networking
- dynamically changes during learning
- loss of myelin lead to neurological and psychiatric symptoms
- related to brain functionalities and is object of study for identifying potential targets for interventions in various neurological and psy... disorders

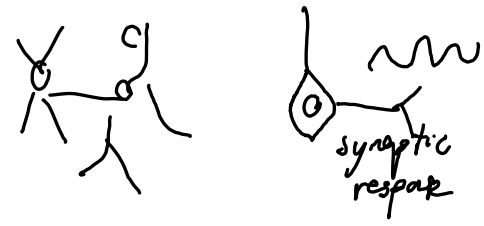
How to study the brain

Systems and pathways:

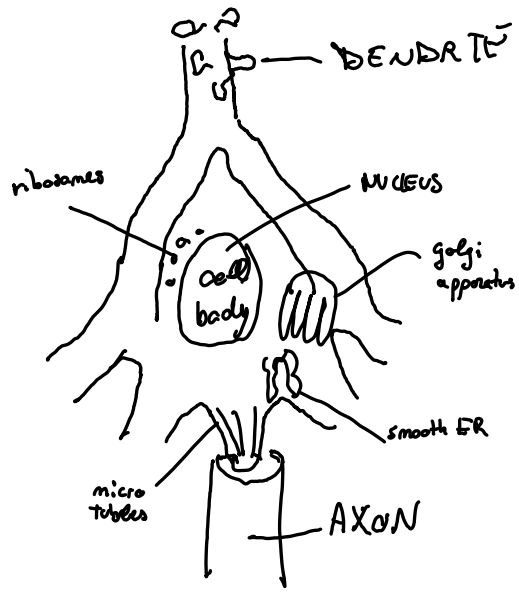
- large scale NW for specific function (sensorymotion, cognition) and his topographically distribution

Circuits and neurons

- network of interconnected neurons that underlie information processing



NEURONS — consists of
- dendrites
- cell body
- an axon

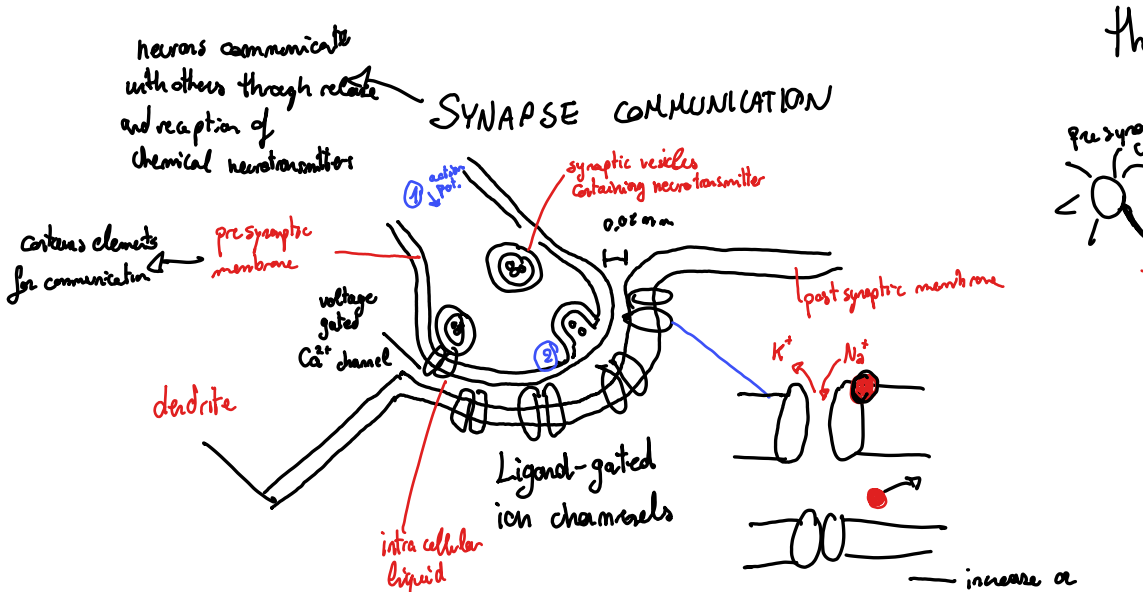


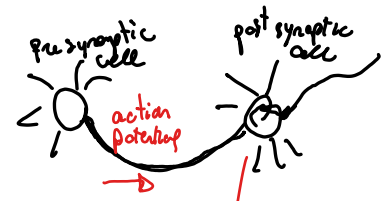
Synapses: connections between neurons and occurs on a neuron's dendrites

chemical, NOT electrical

FIRE:

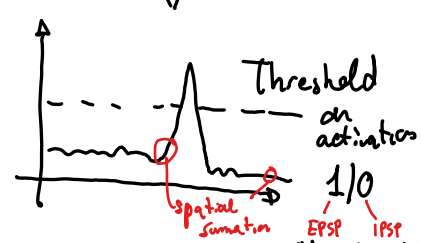
A neuron will fire (generating an action potential) depending on # of signals it receives on its dendrites and their strength which are summed in the neuron's body





When action potential reaches the presynaptic terminal, it triggers the opening of

1. voltage-gated calcium channels
2. vesicles release neurotransm.



potentiate
• inhibitory ---

SYNAPSES MANAGEMENT

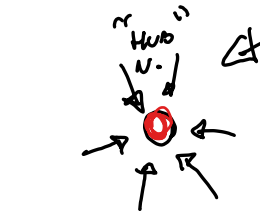
"adaptation plasticity"

STRENGTHENED

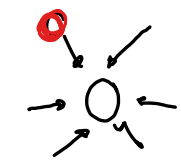
PRUNED

• weak and ineffective

NEURON SURVIVE RULE



• more chances to survival



• low chances of survival

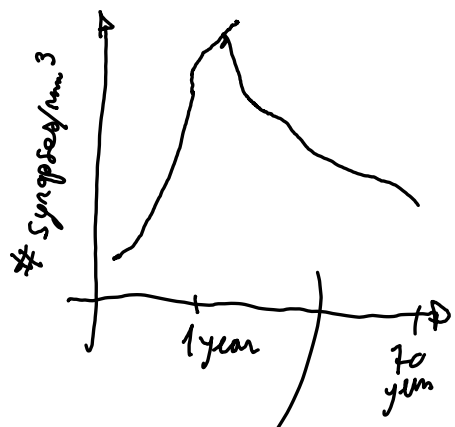
"size of brain triplicate from child to adult"

→ NO ADDITION OF NEURONS

→ • > # Synapses (connections)

• myelination of existing axons

• > dendritic branching



PS:

+ blind people have more grey matter

↓

NOT PRUNED SYNAPSES

+ Synesthesia

HOW TO STUDY THE BRAIN

1. EEG (electroencephalography)
2. Structural imaging
3. fMRI (functional magnetic resonance)
4. Diffusion weighted imaging

→ In neuroscience, an experiment or study is a systematic investigation of a research question or hypothesis that involves designing and conducting studies that involves manipulating variables of interest and collecting and analysing data from participants

↓

Conclusions: analyze collected data from participants and testing statistical significant differences between groups or conditions

↳ to relate to statistical estimation methods to distinguish chances to evidences

METHODS TO EXTRACT DATA

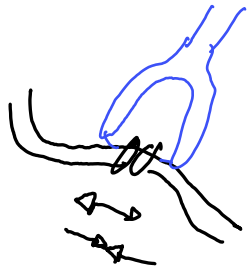
fMRI: . spatial resolution (mm, t) GOOD
- temporal resolution → slow (seconds) → due to sluggish hemodynamic response that fMRI measures

TMS (: transcranial magnetic stimulation):
- spatial res: poor (cm^2 t) depending on location and coil's size } used for understanding importance of areas
- temp res: fast (<ms)

Induced lesions:
- spatial res: widely depends
- temp. res: slows effects of lesions takes day/weeks to appear

MEG: (magnetoencephalography)
- spat. res: (<mm) depending on sensor } measure magnetic field generated by brain
- temp res: (<ms) super fast

Patch clamp: (recording from ion channels in cell membrane)
- spatial res: (< µs) } → directly from cell data
- temp res: (< 1ms)



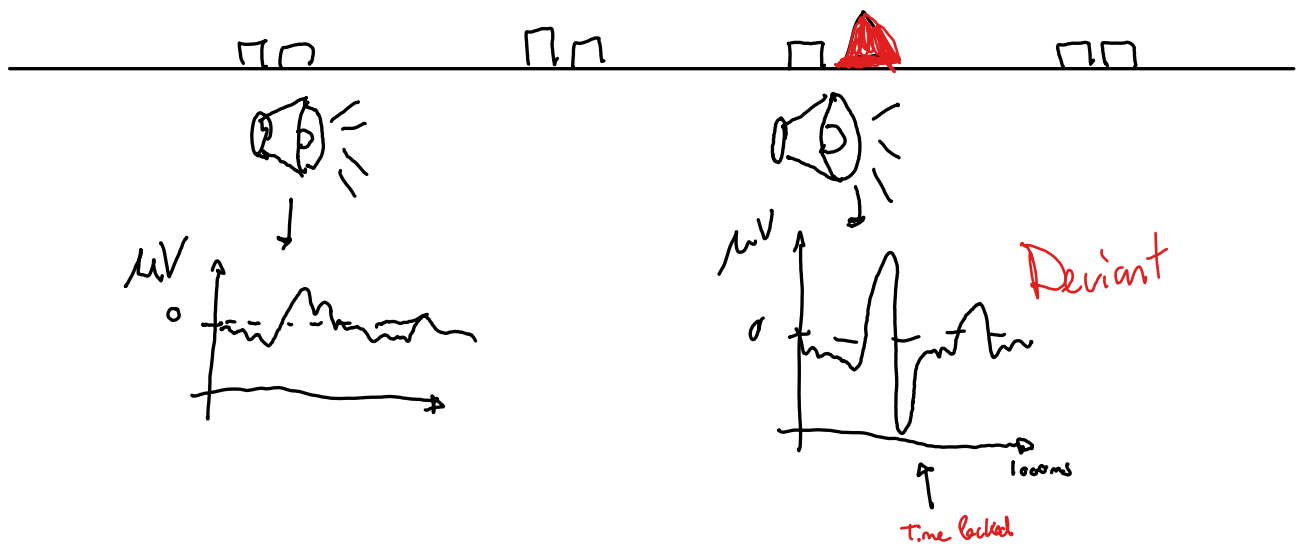
5ms

EEG: (cheap)
- bad for spatial res
- good for time series

EEG → to → ERP (Evoked-Response-Potential) → 1ms resolution

↓

quantifies electrical brain responses to events/stimuli based on time-locked EEG patterns



Problem of EEG: Noise

↳ The impact of noise of ERP scales down as a function of $\sqrt{N}$ (N = #samples)

since noise is stochastic, after several epochs it will be compensated!

↓

→ We need a lot of data

→ CONS: People get habituated

EEG on sleep

↳ is capable of expressing also important insights in form of frequency characteristic (cycling rate)

↓ divided into "bands"

Delta (0-4Hz)

Theta (4-8Hz)

Alpha (8-12) → • related to relaxation
• reduced communication between cortex and thalamus
• suppressed when attention is externally oriented

Beta (12-30)

Gamma (30-80)

High Gamma (80-150)

STRUCTURAL IMAGING → collect 3D images of the brain

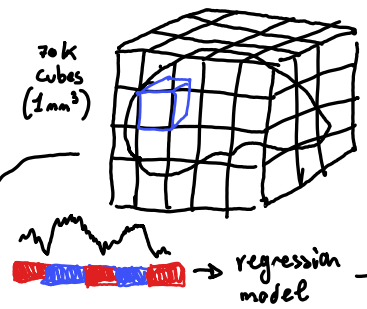
↳ useful for:
- grey matter volume
- density of grey matter in some regions

3D → 2D ←
- cortical thickness
- surface areas of some parts

FUNCTIONAL MRI → capable of observing which parts of the brain work when we do things like thinking of perceiving.
(work = involved in metabolic activity (proxy for neural activity))
(activity of neurons requires more energy → metabolic rate)

PRINCIPLE:
1. use a big magnet to affect protons in the brain and then measure behavior while they return in the original state
2. analysis of protons' patterns we can identify the areas that are more active
   ↳ detects changes in neural activity, not absolute magnitudes

TIME SERIES



→ regression model → predict human response on a particular stimulus (β values) weights

we usually study each voxel independently (ind. assumpt.)
↓
MASSIVELY UNIVARIATE ANALYSIS
- done along with preprocessing (spatial smoothing)
- Amplitude is very significant
- baseline signal level does not provide information on amplitude
  we need at least two conditions to detect changes
  ↓ we have to check variation

we can also pool together voxel-level estimates to reach group-level conclusions

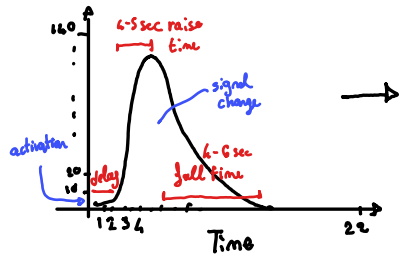
NOISE CAUSES →
- scanner drift
- head motion
- physiological noise

↓
we need to know statistics of noise
↓
→ usually poorly characterised
→ we can use regression to predict noise
→ we obtain equations involving terms for noise and signal

HEMODYNAMIC RESPONSE FUNCTION (HRF)

↓

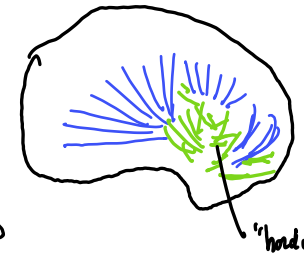
related to the weakness of the fMRI: altered response to a stimulus because oxygen arrives with delay affecting result



→ filter used to suppress the effect of hemodynamic response

DIFFUSION WEIGHTED IMAGING

(aka
- Diffusion MRI
- Diffusion Tensor imaging)



"hardwired connections"
related to functional connectivity

- used to examine the structure of white matters fibers
- information of strenght and direction of diffusion comes from each voxel