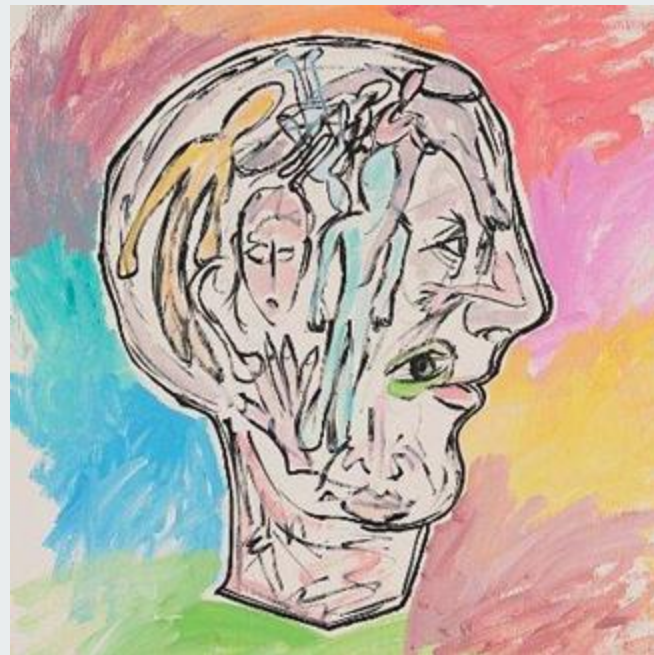# Neuroimaging, An Overview

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04 Dec 2024
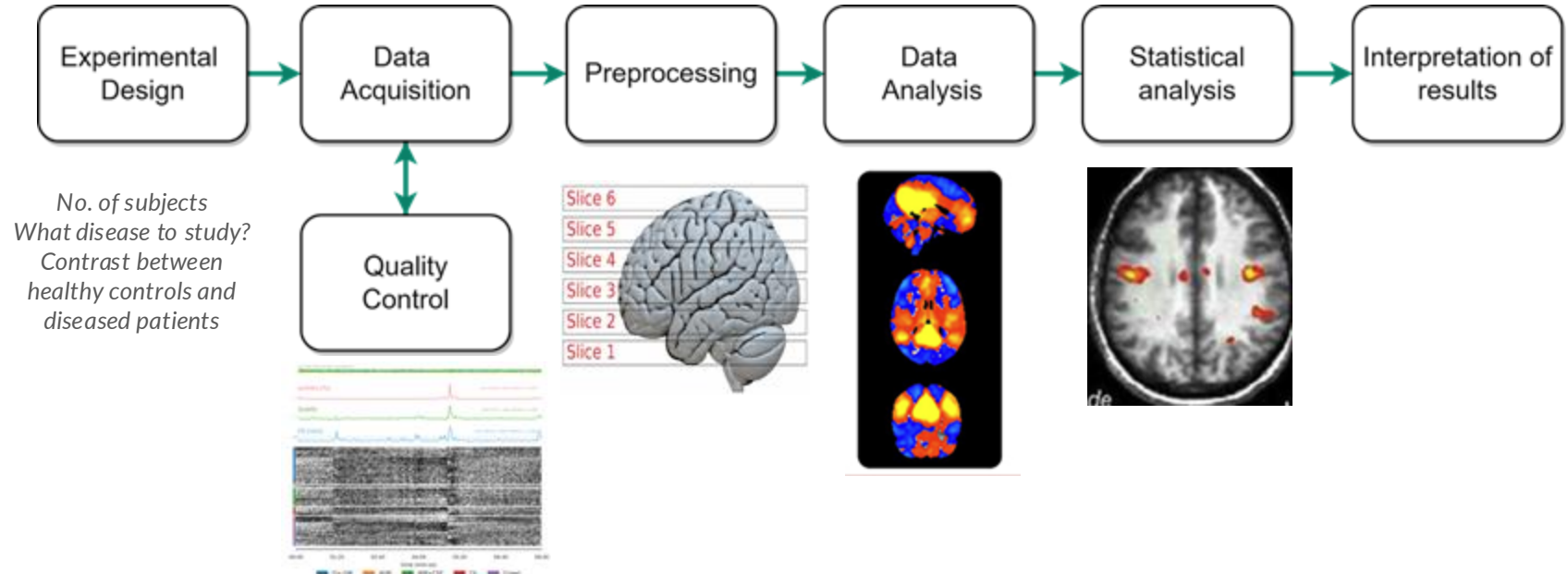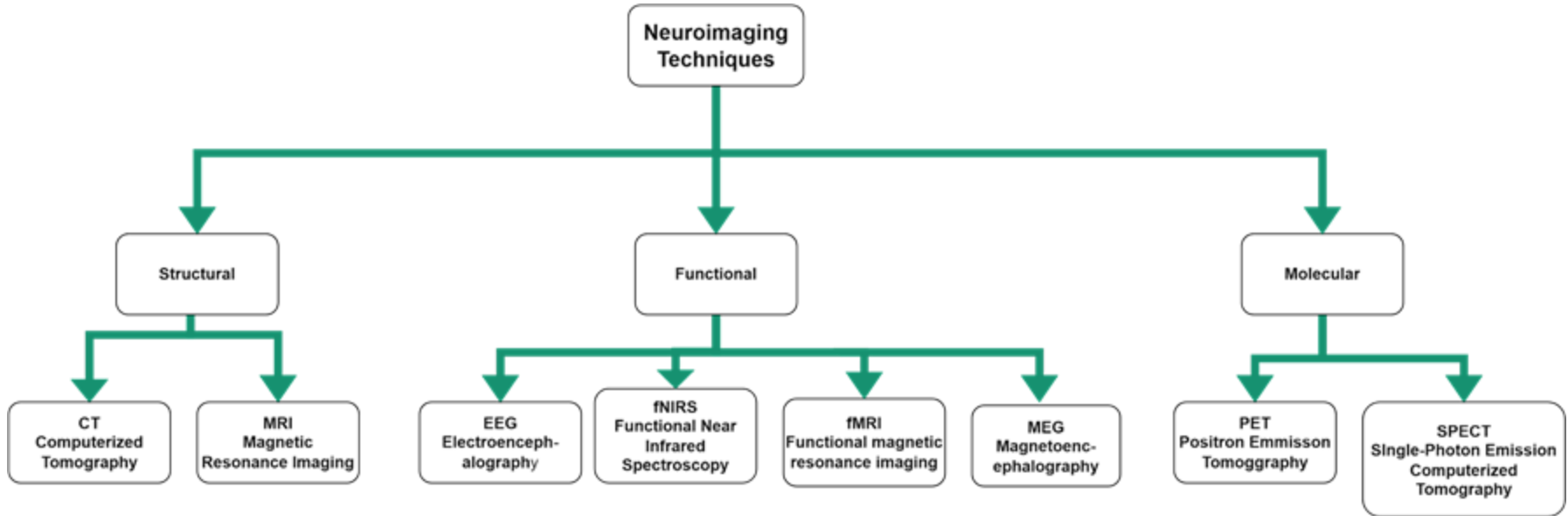
Outline

- Introduction
- Types of Neuroimaging
  - Structural
  - Functional
  - Multimodal
- Summary
  - Data formats
  - Data analysis

What does a typical Neuroimaging study look like?

Experimental Design → Data Acquisition → Preprocessing → Data Analysis → Statistical analysis → Interpretation of results

Data Acquisition ↕ Quality Control

No. of subjects
What disease to study?
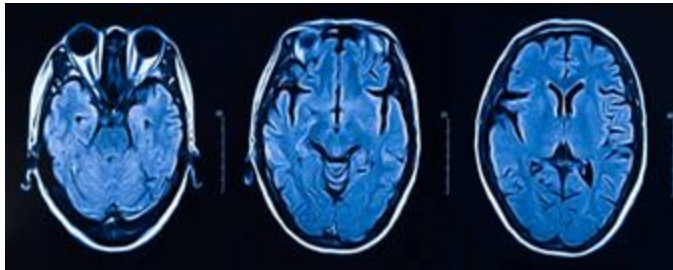*Contrast between healthy controls and diseased patients*

Different Modalities

Adapted from Mihai Teleanu et. al 2019 Nanomaterials accessed on 22.11.22

Structural Neuroimaging

Useful for medical applications where spatial resolution is important
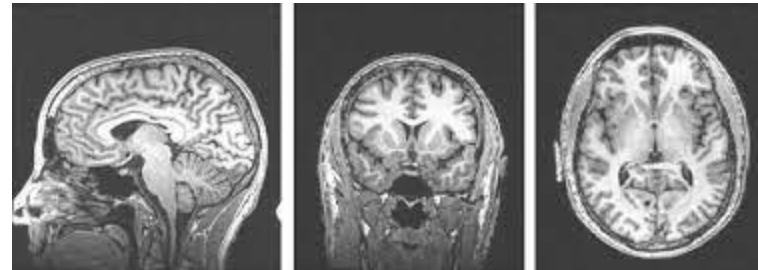
CT scan [1]

Faster scans, better view of tissue structure, organs and bones, works with X-ray radiation
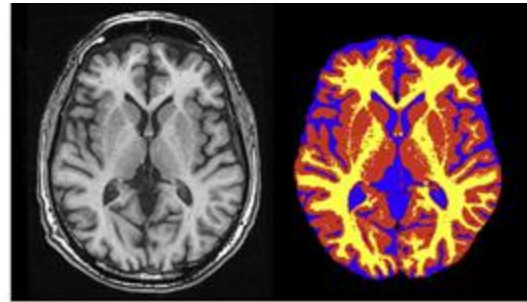
Structural MRI scan [2]

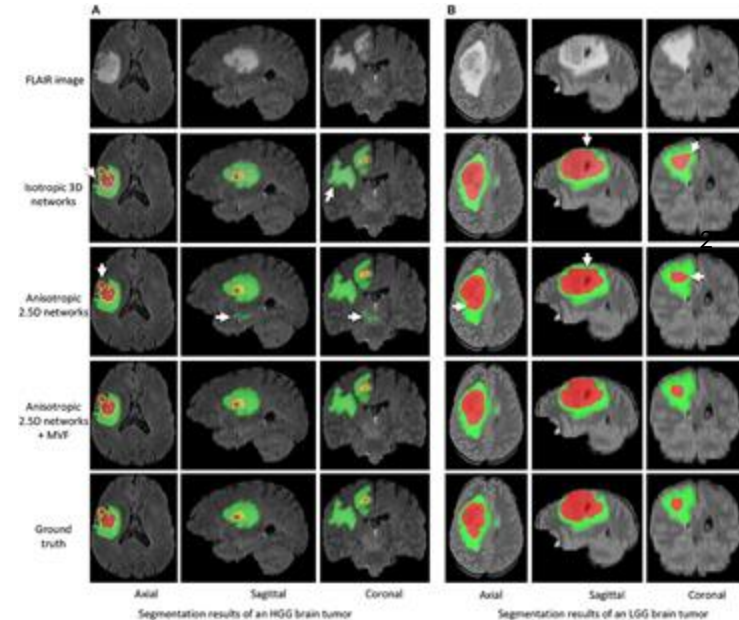Better spatial resolution, safety from radiation, better soft tissue contrast

Image (1) from link and Image (2) from link, accessed on 24.11.22

Structural MRI: Difficult problems

Segmentation

1

Separating image into white matter (yellow), gray matter (red) and cerebrospinal fluid (blue)
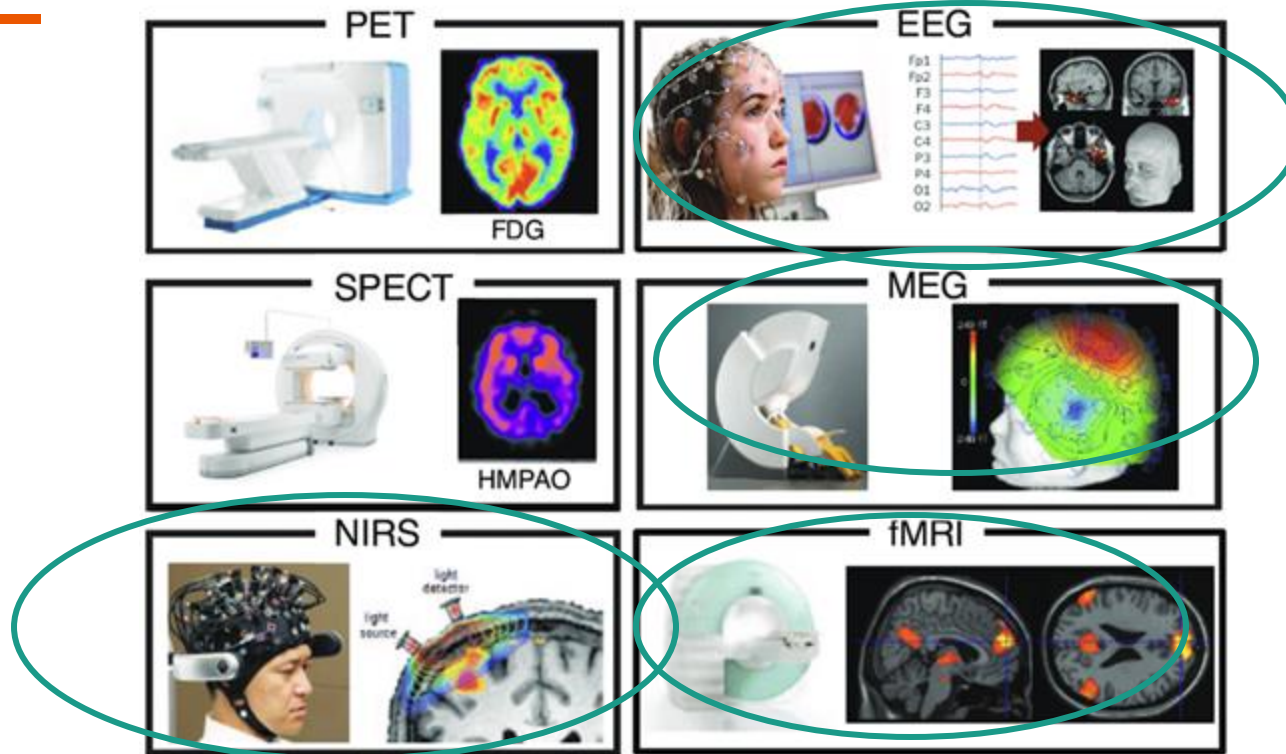

2

2

Determining the boundaries of a tumor
Edema (green), core (red), enhancing core (yellow)

Image (1) from link and Image (2) from link, accessed on 24.11.22

Functional Neuroimaging

Image from Strobe 2015

What are we trying to measure?

Brain Signals: indirect vs direct

TRENDS in Biotechnology

Image from Min et. al 2010 Trends in Biotech, accessed on 11.11.22
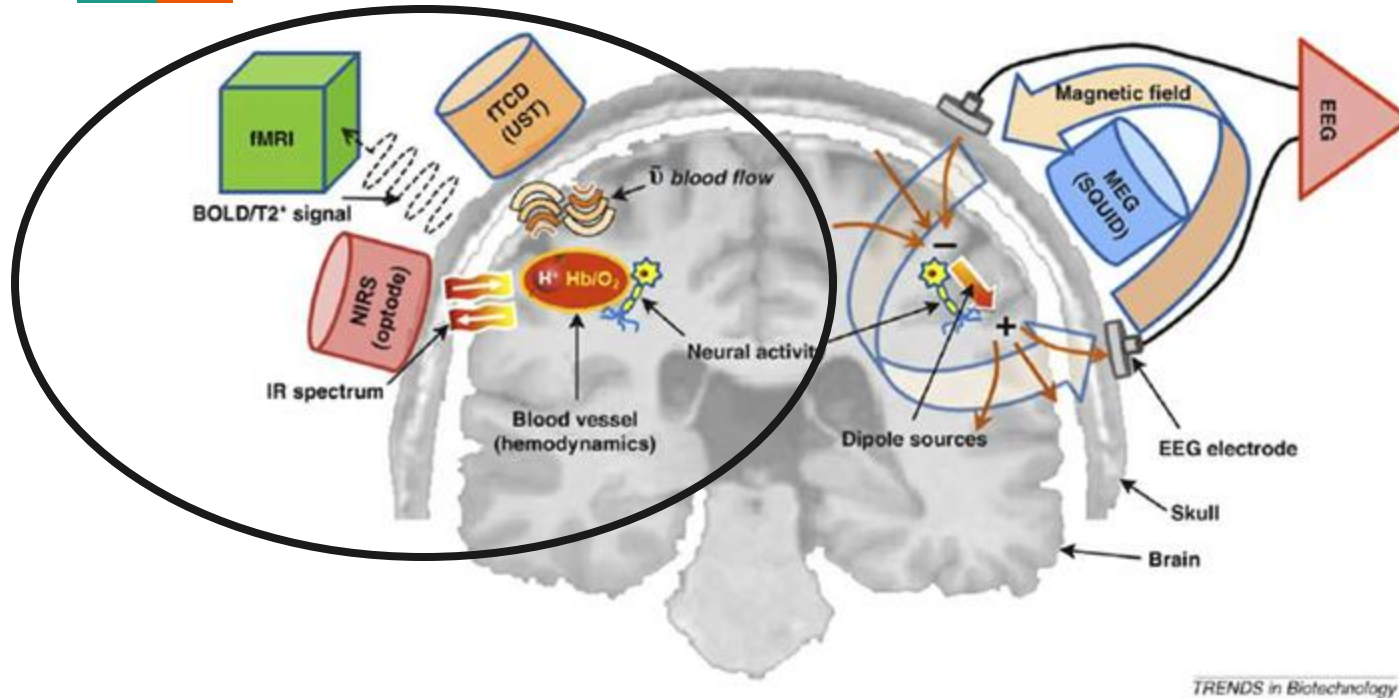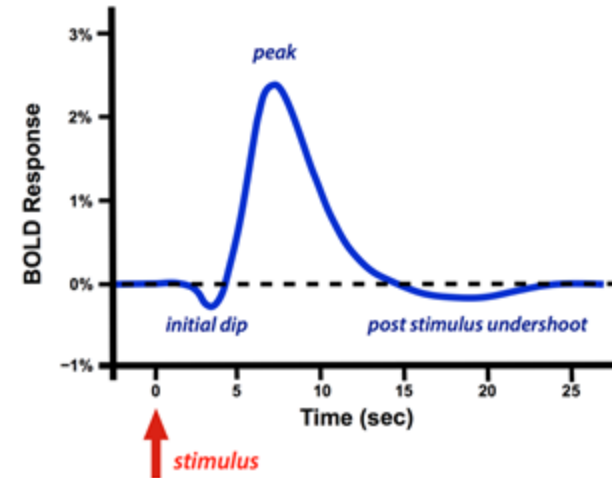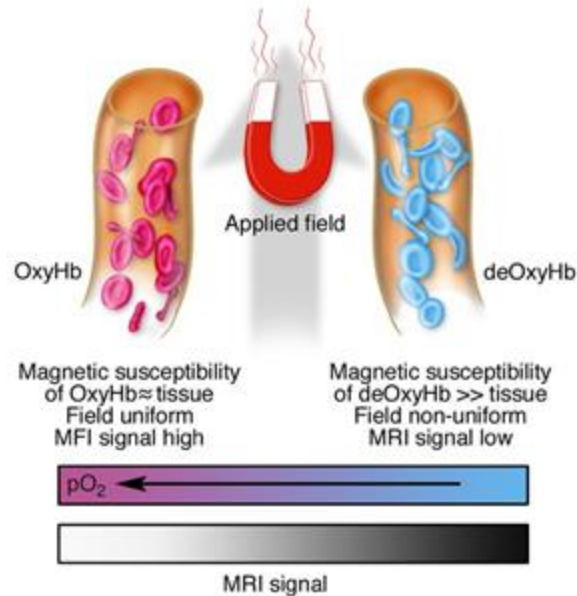
Oxygen Levels

Blood Oxygen Level Dependent (BOLD) Signal

Image (1) from link and Image (2) from Andy's Brain Book, accessed on 24.11.22

fMRI, fNIRS...
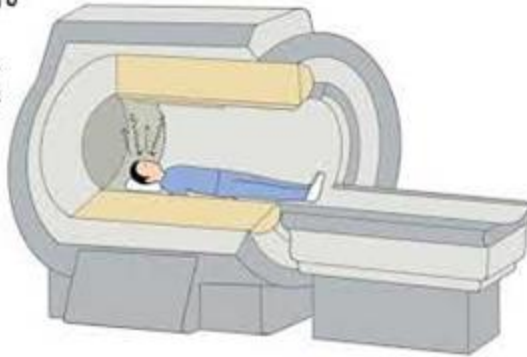
fMRI: Difficult problems, big data

Number of voxels	~10e5
Time	0.5h = 1800 s
Array size per session	60 x 60 x 30 x 1800
Number of sessions	3
If longitudinal, then number of time points	3
Total dimensions (per subject)	60 x 60 x 30 x 1800 x 3 x 3
Number of subjects	50

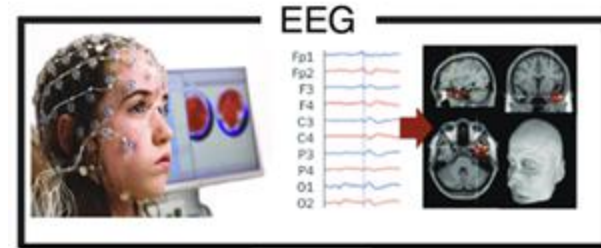I. Discovering spatial maps with coherent temporal dynamics

Image from Khosla, Ngo et. al 2019 Mag Reson Imaging, accessed on 24.11.22

Brain Signals: indirect vs direct

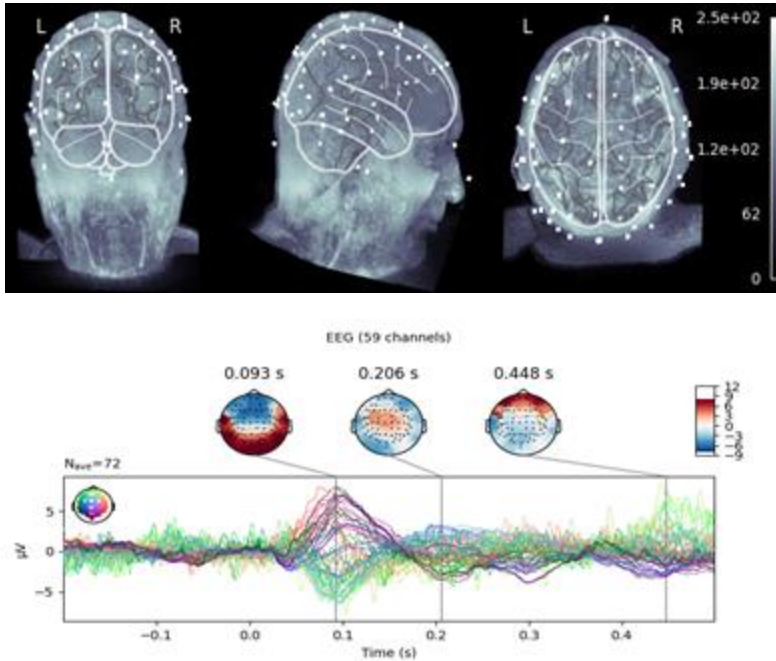Image from Min et. al 2010 Trends in Biotech, accessed on 11.11.22
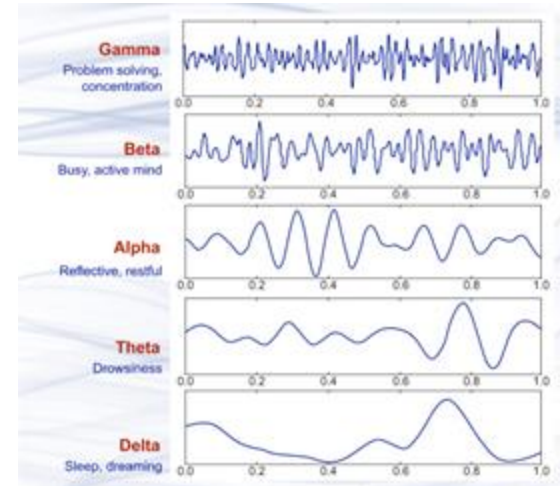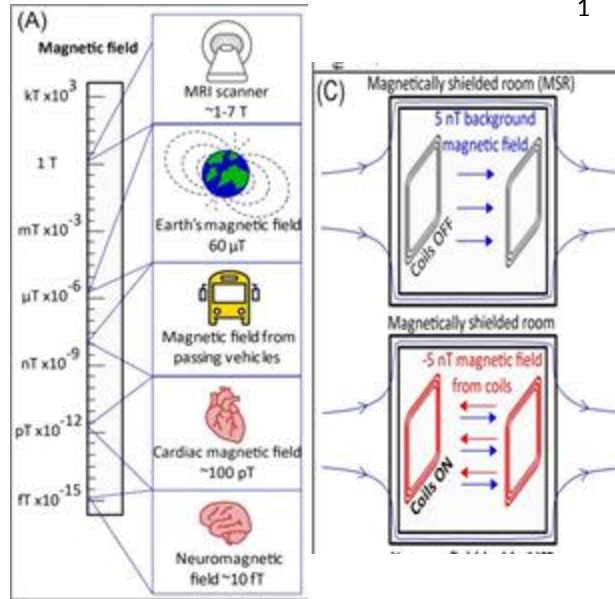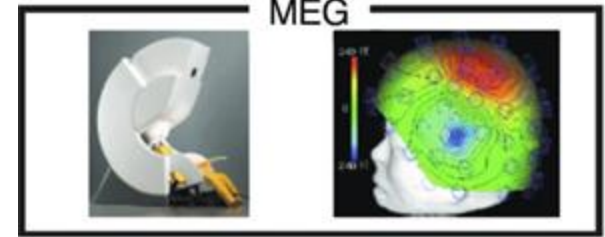
13
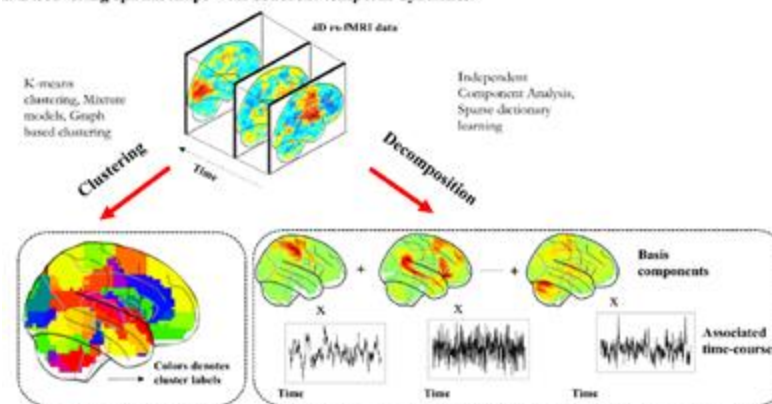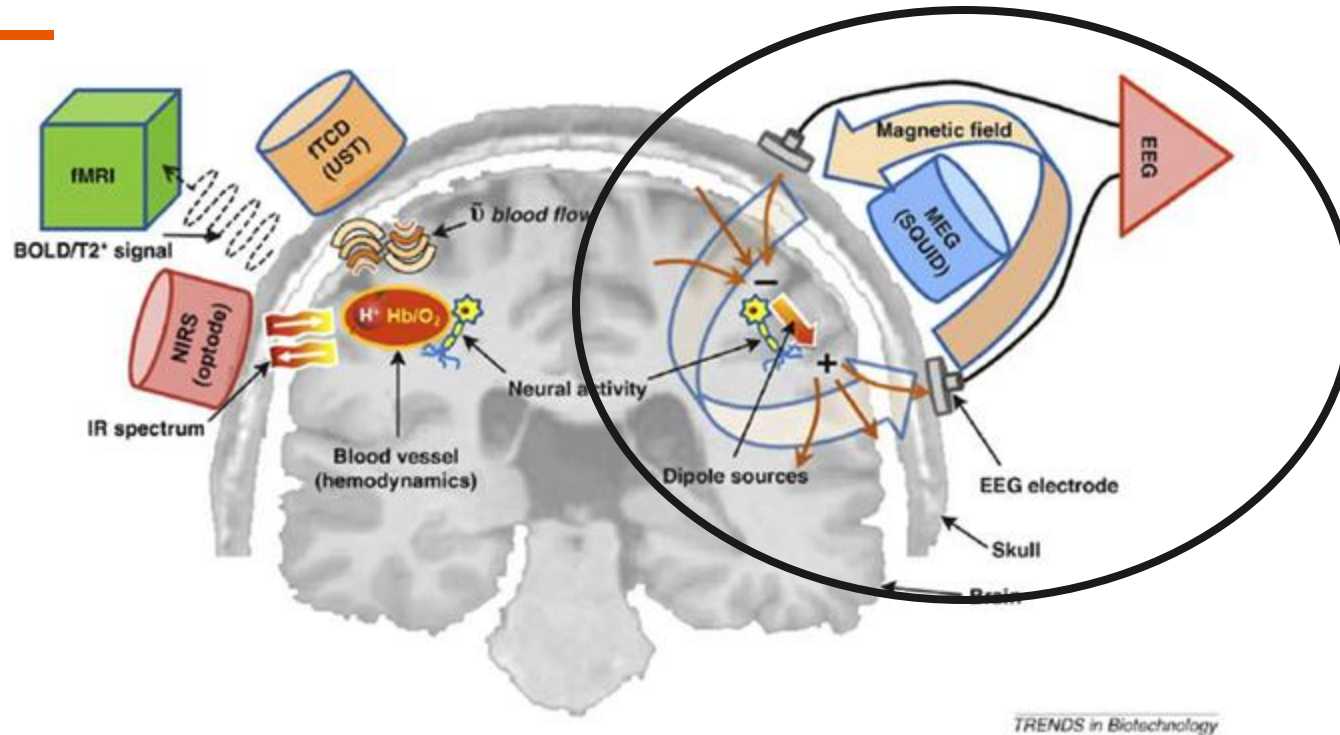
Electrical Activity: EEG

1

2

3

Image (1) and (2) from mne docs, Image (3) from Abhang et. al 2016 Elsevier

# Magnetic Activity: MEG

MEG

1

2

3

Magnetically shielded room

First ever MEG device invented by MIT physicist David Cohen

Image (1) from Brookes et. al 2022 Trends in Neuroscience, Image (2) and (3) from wikicommons

Magnetic Activity: OPM-MEG

Images from Brookes et. al 2022 Trends in Neuroscience

Data challenges: EEG and MEG

Image from Pantazis, Adler 2021 Sensors, accessed on 25.11.22
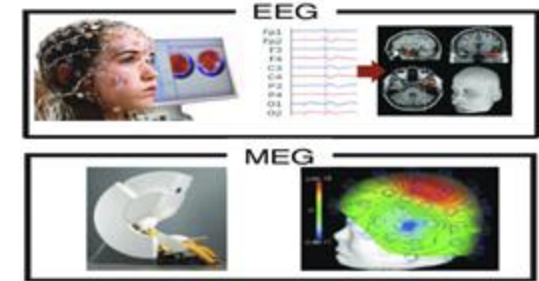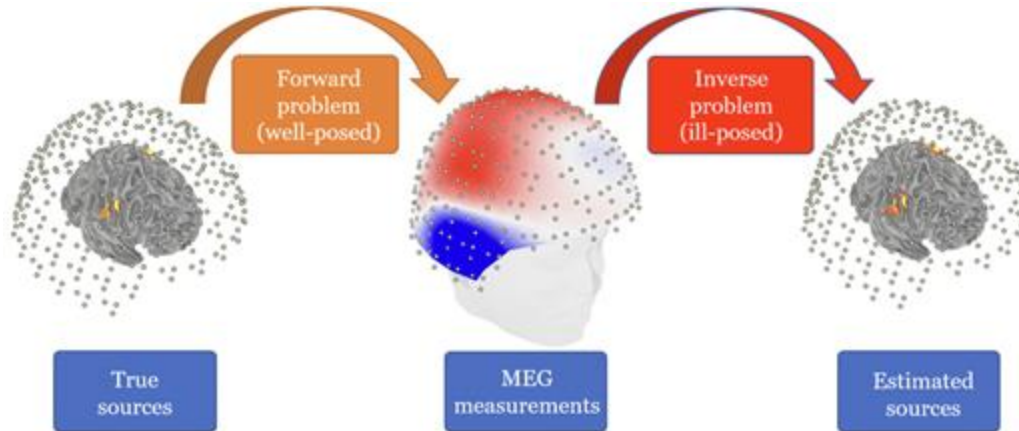
Spatio-Temporal Resolution in functional Neuroimaging
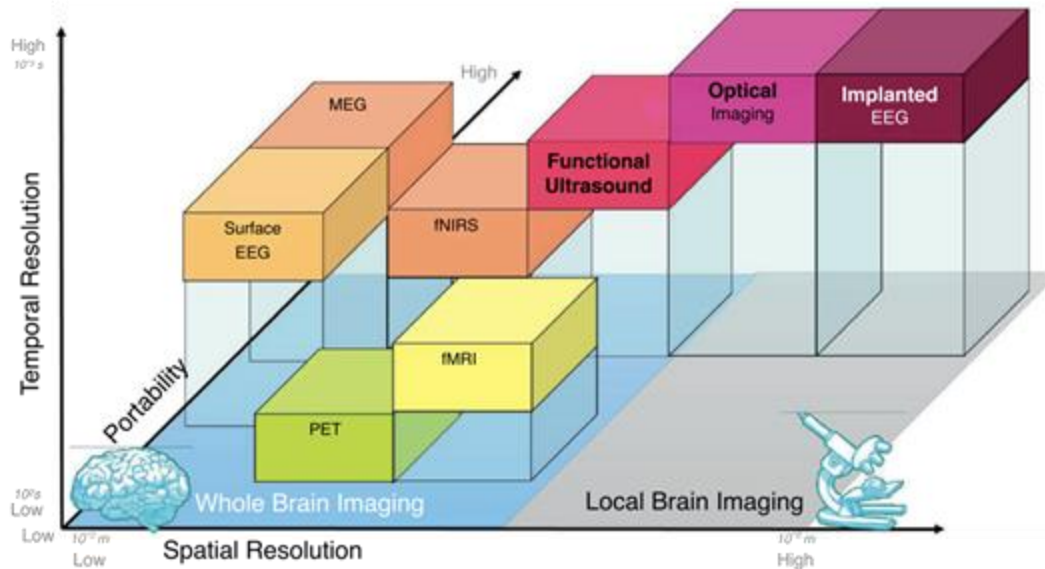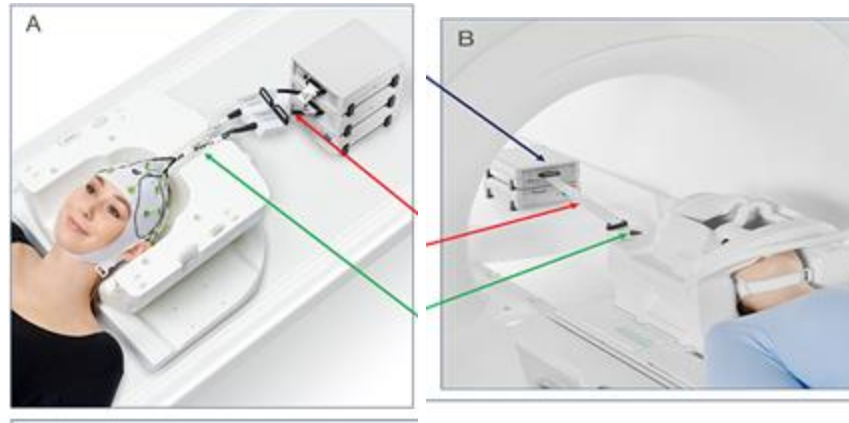

Image from Deffieux et. al 2018 Opinion in Neurbiol. ,accessed on 11.11.22
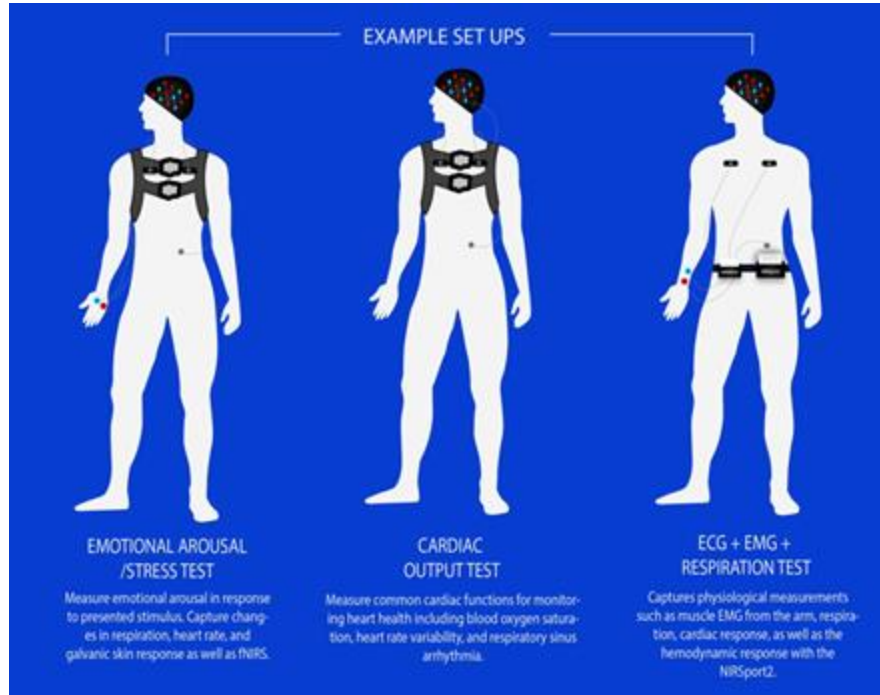
MultiModal Neuroimaging

EEG-fMRI

EEG-fNIRS

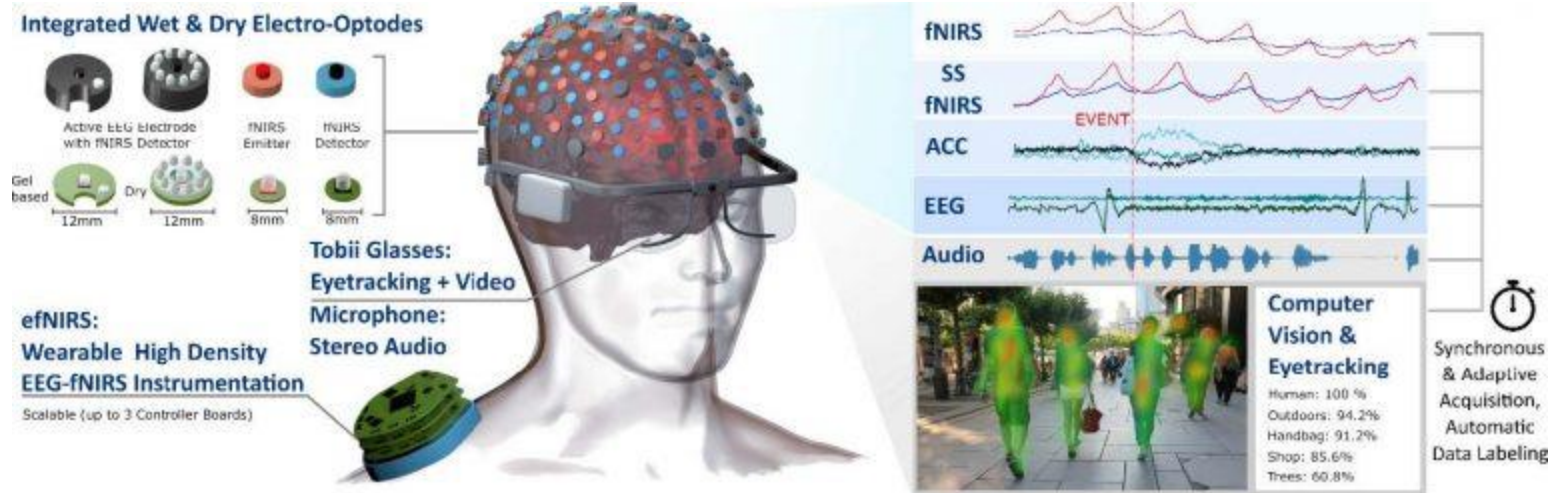Image (1) from Brain Products and Image (2) from NIRx ,accessed on 11.11.22

Mobile Neuroimaging – out of the lab

Images from NIRx ,accessed on 11.11.22

Brain Computer Interfaces

Images from Luhmann et. al 2020 BMC ,accessed on 11.11.22
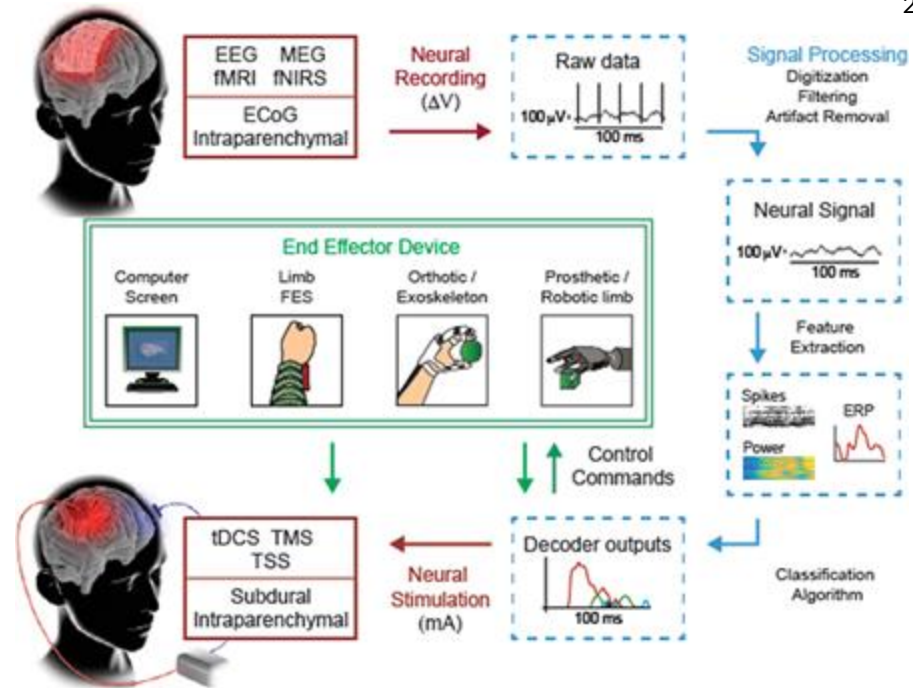
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Brain Computer Interfaces + Machine Learning

Image (1) link, Image (2) from Bockbrader et. al 2018 PM&R ,accessed on 11.11.22

Neuroimaging: Data formats

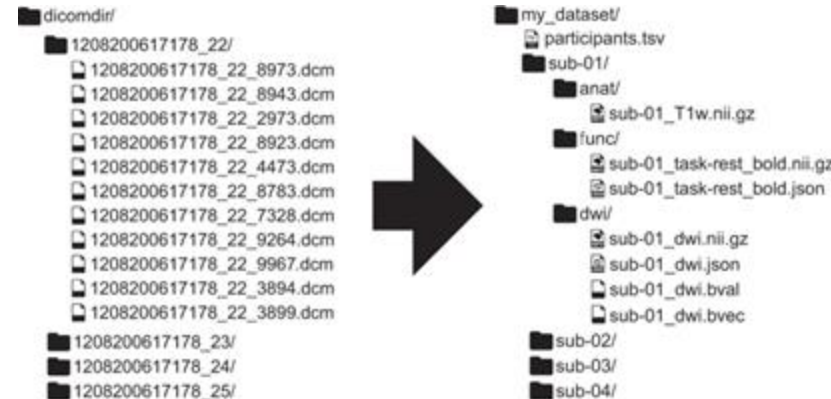Image (1) and (2) from bids docs, Image (3) from link, accessed on 25.11.22

Neuroimaging: Data Analysis

Tasks	Modality	Packages
Quality Control	fMRI/sMRI	MRIQC
	EEG/MEG/fNIRS/ OPM-MEG	MNE, BrainStorm
Preprocessing	fMRI	fMRIPrep
	EEG/MEG/fNIRS/ OPM-MEG	MNE python
Machine Learning	All	Converting data into numpy arrays from all the preprocessing packages, then std. ML

Thank you for your attention!