KING'S College LONDON

INSTITUTE OF PSYCHIATRY,
PSYCHOLOGY & NEUROSCIENCE

Module:
Techniques in Neuroscience

Week 1:
Understanding the brain: Who we study, how and why?

Dr Vincent Giampietro

Topic 1:
The living brain
Part 2 of 3

Part 2

Introduction to part 2

Functional imaging
(mapping brain activity)

Main technologies currently used

Described and contrasted on:

- **spatial resolution**
- **temporal resolution**
- **level of tolerance needed**

Electroencephalography (EEG) (1)

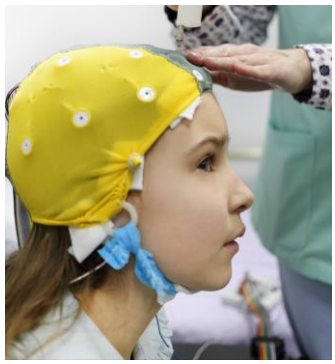
EEG

Characteristics:
- non-invasive
- records brain activity
- signal is picked up by multiple electrodes in different locations

Advantages:
- cheap
- somewhat portable
- measures brain activity at the millisecond scale

Disadvantages:
- signal is measured only on the surface of the scalp leading to lack of localisation of brain function, especially in the deep brain

Electroencephalography (EEG) equipment and recording



Electroencephalography (EEG) sensors are covered with gel to make sure they have good contact.

Electroencephalography (EEG) (2)

Spatial resolution

lowest | low | high | highest

Temporal resolution

lowest | low | high | **highest**

Tolerance needed

low | medium | high

Magnetoencephalography (MEG) (1)

MEG

Characteristics:

- closely associated to EEG, but measures changes in magnetic field
- subject has to position their heads in MEG helmet
- liquid helium is used to cool down the sensitive magnetic sensors
- low spatial resolution (especially to deep brain)
- high temporal resolution

MEG scanner

Magnetoencephalography (MEG) (2)

Spatial resolution

lowest | low | high | highest

Temporal resolution

lowest | low | high | **highest**

Tolerance needed

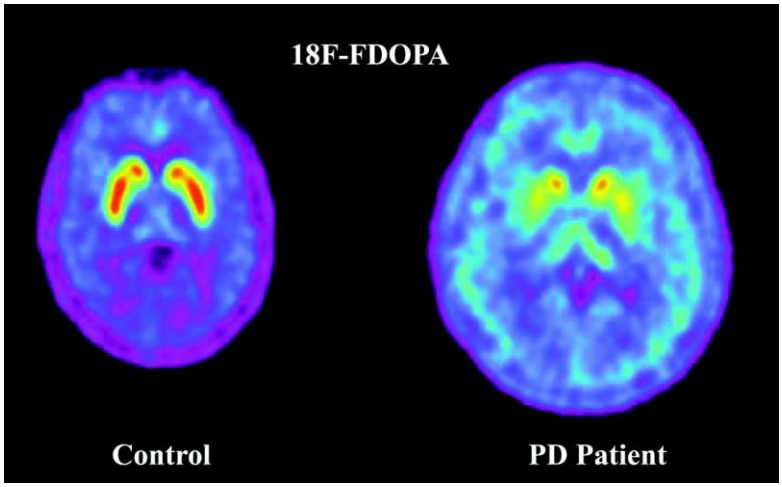
low | **medium** | high

Positron emission tomography (PET) (1)

PET

Characteristics:

- invasive neuroimaging technique
- use of radiopharmaceuticals to measure physiological processes
- possible to compute tissue tracer concentration
- one of the most commonly used tracer is fluorine-18 (F-18) fluorodeoxyglucose (FDG)



PET scan using 18F-FDOPA to characterise the distribution of dopamine in the brain of healthy subject (left) and of a patient of with Parkinson's disease (right)

Positron emission tomography (PET) (2)

Spatial resolution

lowest | low | **high** | highest

Temporal resolution

lowest | low | high | highest

Tolerance needed

low | medium | **high**

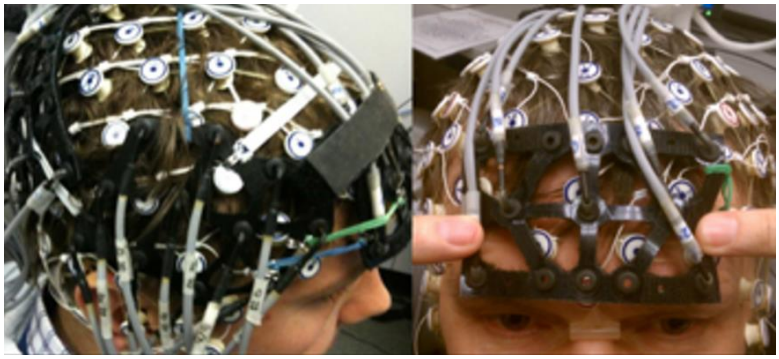
Functional near infrared spectroscopy (fNIRS) (1)

fNRIS

Characteristics:
- non-invasive optical imaging technique
- detects changes in brain activity through neurovascular coupling with the use of near-infrared light
- based on the BOLD effect: **B**lood **O**xygenation **L**evel **D**ependent

Limitations:
- near-infrared light does not penetrate deep through the skull or brain
- limited spatial resolution

But, particularly suited for the infant brain.



Sample NIRS probe configuration

Functional near infrared spectroscopy (fNIRS) (2)

Spatial resolution

lowest | **low** | high | highest

Temporal resolution

lowest | low | **high** | highest

Tolerance needed

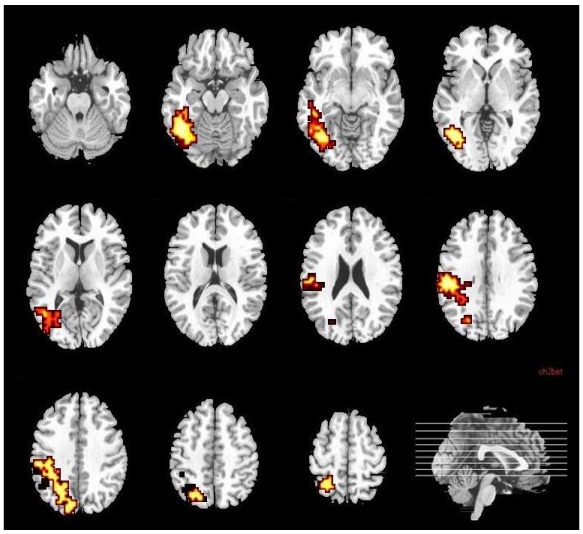
low | medium | high

Functional magnetic resonance imaging (fMRI) (1)

fMRI

Characteristics:

- based on the BOLD effect: **B**lood **O**xygenation **L**evel **D**ependent
- based on the fact that oxy- and deoxyhaemoglobin have different magnetic properties
- indirectly measures brain activity from regional changes in magnetism
- used to study a wide range of psychiatric and neurological disorders
- also used to study healthy brain processes



Brain activity measured by fMRI

Functional magnetic resonance imaging (fMRI) (2)

Spatial resolution

lowest | low | high | **highest**

Temporal resolution

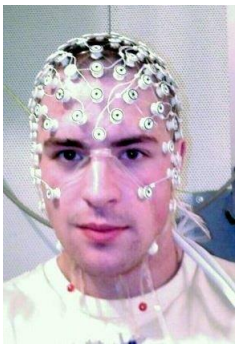
lowest | **low** | high | highest

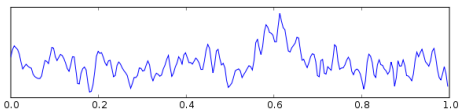
Tolerance needed

low | **medium** | high

Comparing the methods (1)

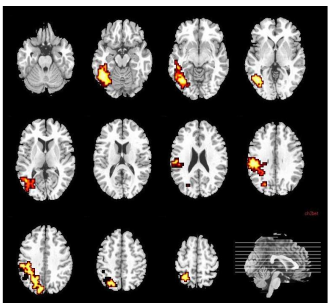
EEG

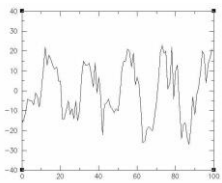




2s

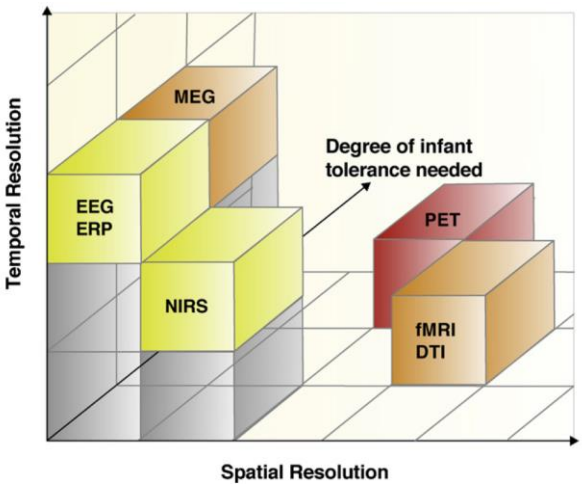
fMRI





5min

Comparing the methods (2)



Comparison of neuroimaging methods in terms of spatial resolution, temporal resolution and degree of (infant) tolerance needed

Illuminating the developing brain: the past, present and future of functional near infrared spectroscopy

Lloyd-Fox et al. (2010)

Lloyd-Fox et al. (2010)

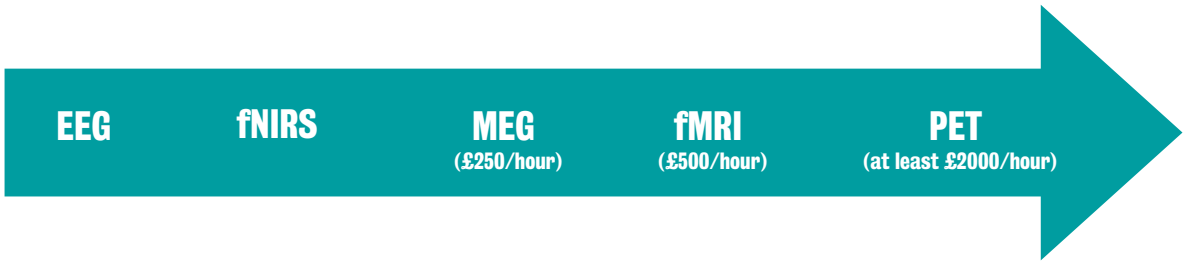
Comparing the methods: price (1)

Equipment/infrastructure costs

EEG → fNIRS → MEG → fMRI → PET

Comparing the methods: price (2)

Running costs



End of part 2