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 1 of 3

Topic list

This week, we will be looking at the following topics:

- ***Topic 1: The living brain***
- Topic 2: Model organisms
- Topic 3: Focused journal club

Click **Next** to continue

Welcome

Neuroimaging as a treatment option

Real-time fMRI neurofeedback

Lecture overview

Part 1

Co-evolution of structural and functional neuroimaging

Part 2

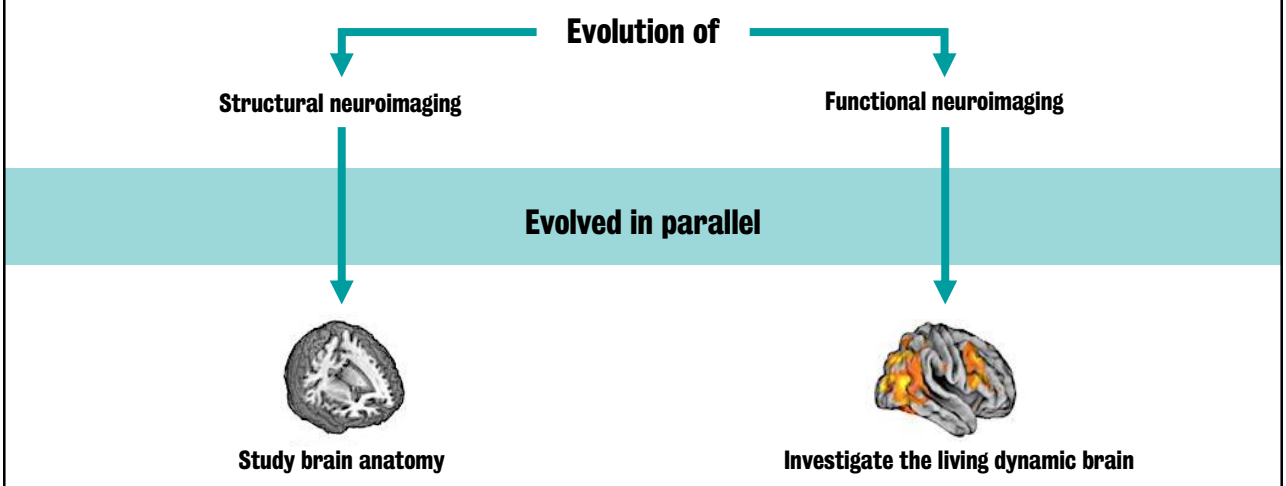
Functional neuroimaging techniques

Part 3

Functional magnetic resonance imaging (fMRI) in detail

Part 1

Introduction to part 1



Pre-neuroimaging: structural (1)

Early anatomists

(384 – 322 BCE)
Brain seen as a secondary organ

Aristoteles

2nd century
Brain viewed as the siege of the mind

Galen
(Greek physician)

14th – 17th century
Revived interest in anatomy studies

Da Vinci

Early form of structural brain imaging

Cavalcanti et al. (2009)

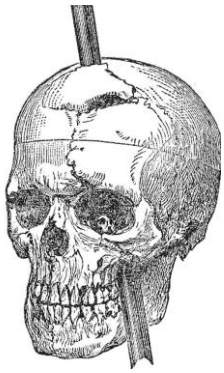
Pre-neuroimaging: structural (2)

Characteristics of lesion studies:

Study:
functional deficits after brain damage.

Invaluable tool in the understanding of:
the relationship between brain and behaviour.

Main drawback:
information for the precise location of the lesion was only available after patient's death.

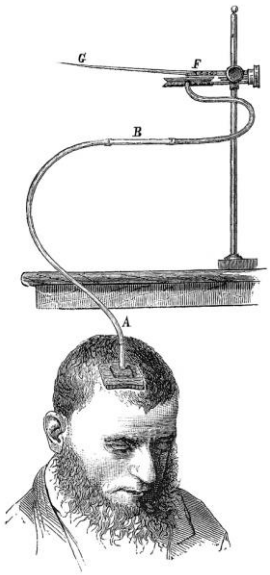


Pre-neuroimaging: functional (1)

Angelo Mosso

19th century
Italian physiologist

Pioneer of functional brain imaging

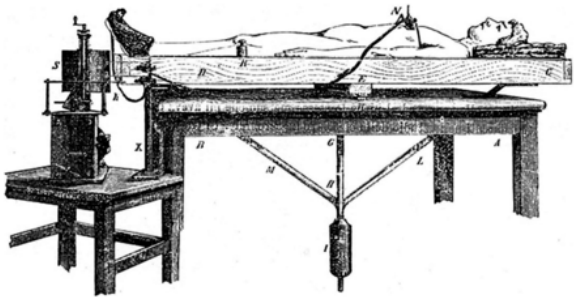


Linking brain pulsations to brain activity

Zago et al. (2009)

Pre-neuroimaging: functional (2)

Weighing brain activity with the balance



Weighing brain activity with the balance: Angelo Mosso's original manuscripts come to light.

Sandrone et al. (2013)

The machine that tried to scan the brain – in 1882.

Benderev (2014)

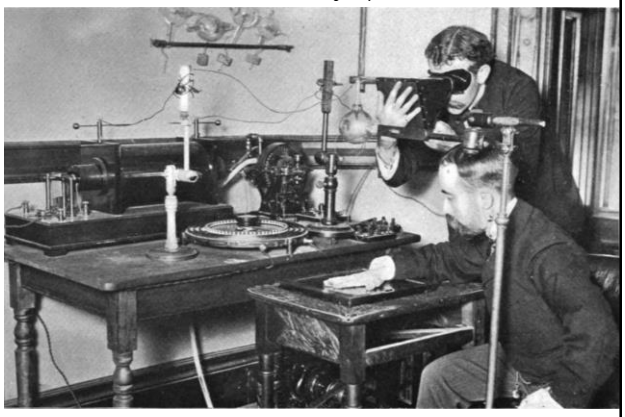
Bendrev (2014); Sandrone et al. (2013)

Early days: structure (1)

Wilhelm Röntgen
German physicist

First medical X-ray

Crookes tube X-ray experiment



Early days: structure (2)

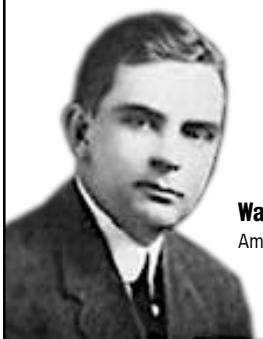
X-rays started to get used for medical diagnostics.

Main drawback:
lack of X-ray contrast within the skull.

Derived techniques were invented:

ventriculography and
pneumoencephalography

(1919)



Walter Dandy
American neurosurgeon

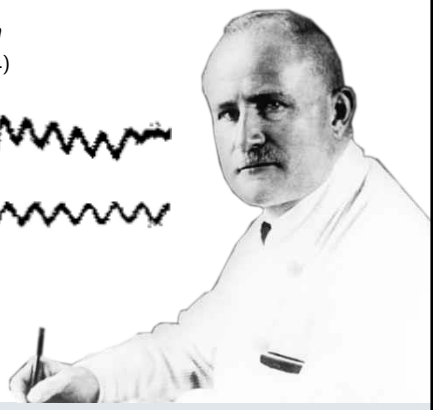
Pneumoencephalography

Early days: function (1)

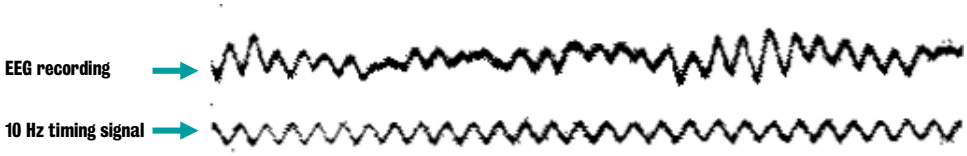
Measuring brain functioning in real time was made possible in the early 20th century with the invention of **electroencephalography (EEG).**

Hans Berger

German psychiatrist and physiologist



First published electroencephalogram of a human
(1924)



Early milestones of EEG history include:

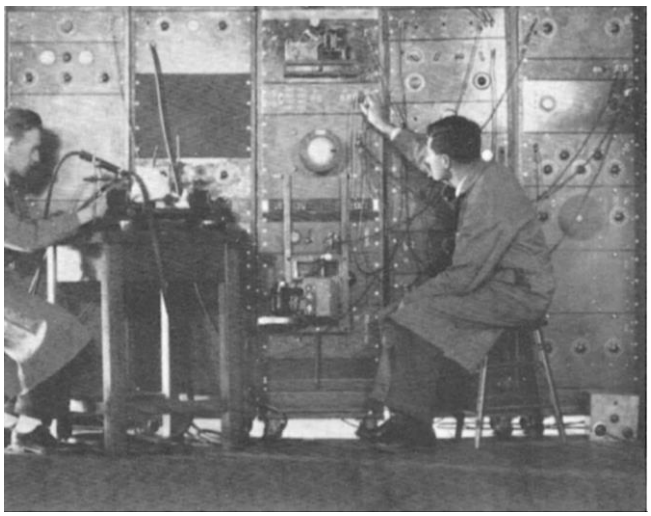
- the first measure of epileptic spikes (1934)
- the characterisation of the several stages of sleep (1953)

Early days: function (2)

Main use of EEG in a clinical setting:

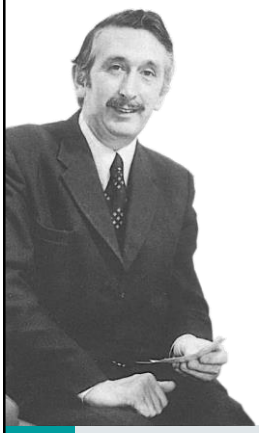
- detect and characterise epileptic seizures
- combined with fMRI, it is used to identify the whole network of brain regions involved

EEG equipment used in 1930s

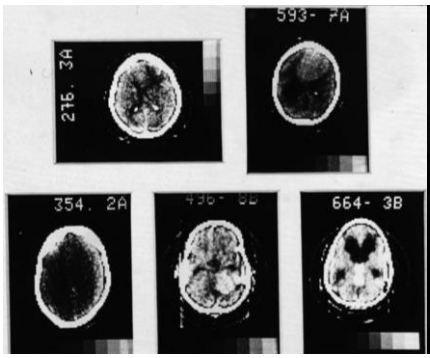


Stone & Hughes (2013)

1970s: structure (CT scan)



First CT scan, Atkinson Morley's Hospital



World's first whole-body CT scanner, 1973

Godfrey Hounsfield
English electrical engineer

Developed the first commercial CT scanner (1967)

CT: computed tomography
Also called:
- X-ray CT
- computerised axial tomography (CAT)

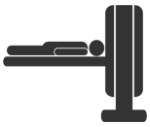
Filler (2010); Sittig et al. (2006)

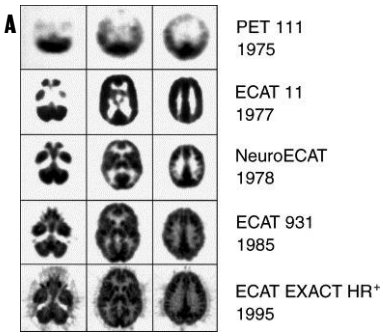
1970s: function (PET scan)

Positron Emission Tomography (PET)

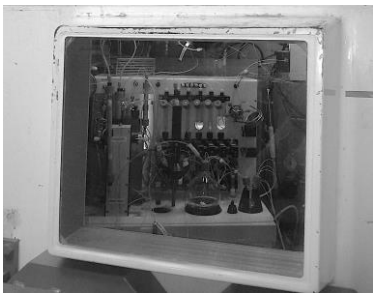
How does it work:

PET is a nuclear medicine technique which involves tagging an active molecule with a short-lived radioactive tracer and then injecting it in the body. Tissue tracer concentration and location can be computed by detecting the GAMMA rays emitted as a byproduct of the decay of the radioactive tracer.





Radioactive tracers decay quickly and thus need to be produced onsite in a cyclotron.



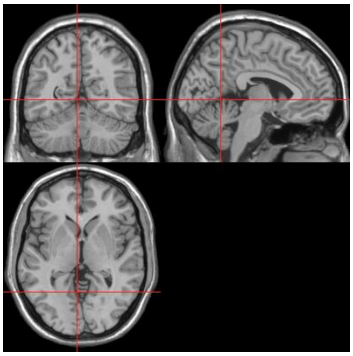
Paans et al. (2002)

Today: structure (MRI)

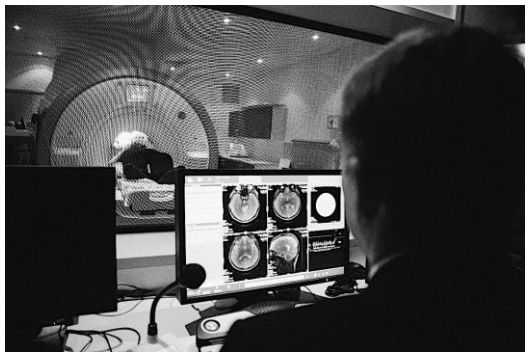
Magnetic Resonance Imaging (MRI) › Workhorse of today's neuroimaging research

Used to study brain structure in different ways:

- higher resolution anatomical scanning
- looking at microstructural changes with diffusion tensor imaging (DTI)
- mapping white matter tracks in the brain



High-resolution anatomical scanning



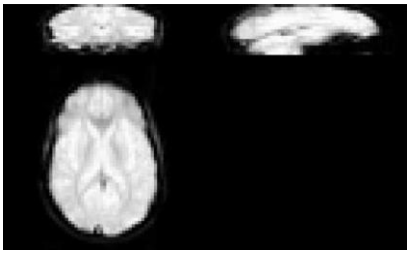
MRI scanner

Today: function (fMRI)

Functional magnetic resonance imaging (fMRI)

fMRI scanner

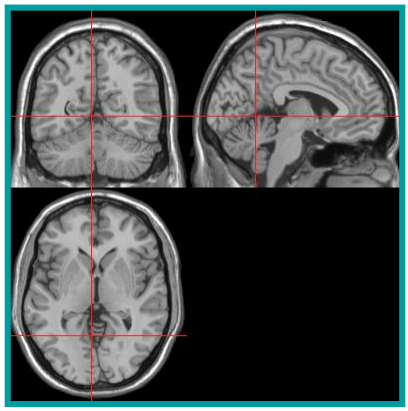
Measures dynamic changes every couple of seconds in the whole brain during experimental tasks (task-based fMRI) or at rest (resting state fMRI).



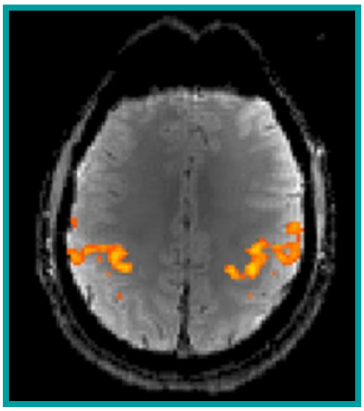
Example of raw fMRI data

Today: structure vs function

MRI scanners are versatile tools.



Typical volumetric scan for diagnostics



Functional activations overlaid on raw fMRI data

Difference in image quality is due to variation in spatial and temporal resolution.

Structural imaging:
- takes minutes to acquire > low temporal resolution
- great amount of details > high spatial resolution

fMRI – dynamic imaging:
- takes seconds to acquire > high temporal resolution
- poor amount of details > low spatial resolution

End of part 1