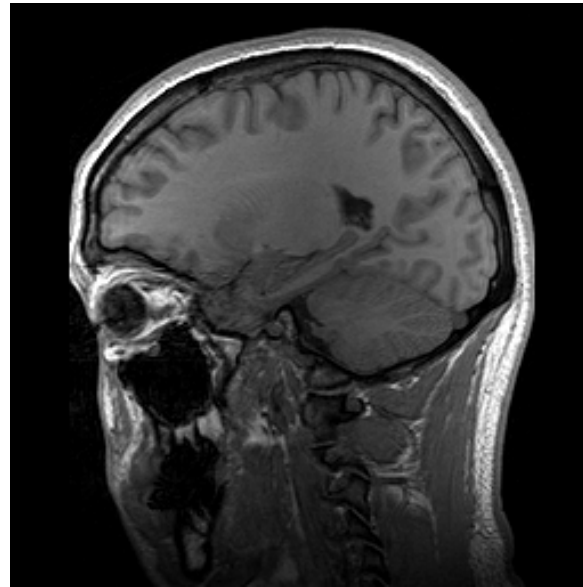
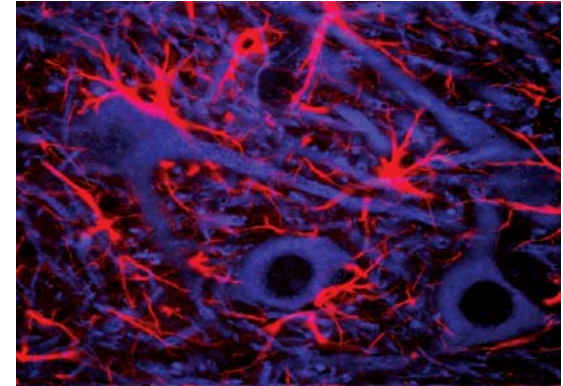


NEUROSCIENCE



Barbora Cimrová

Neuroscience



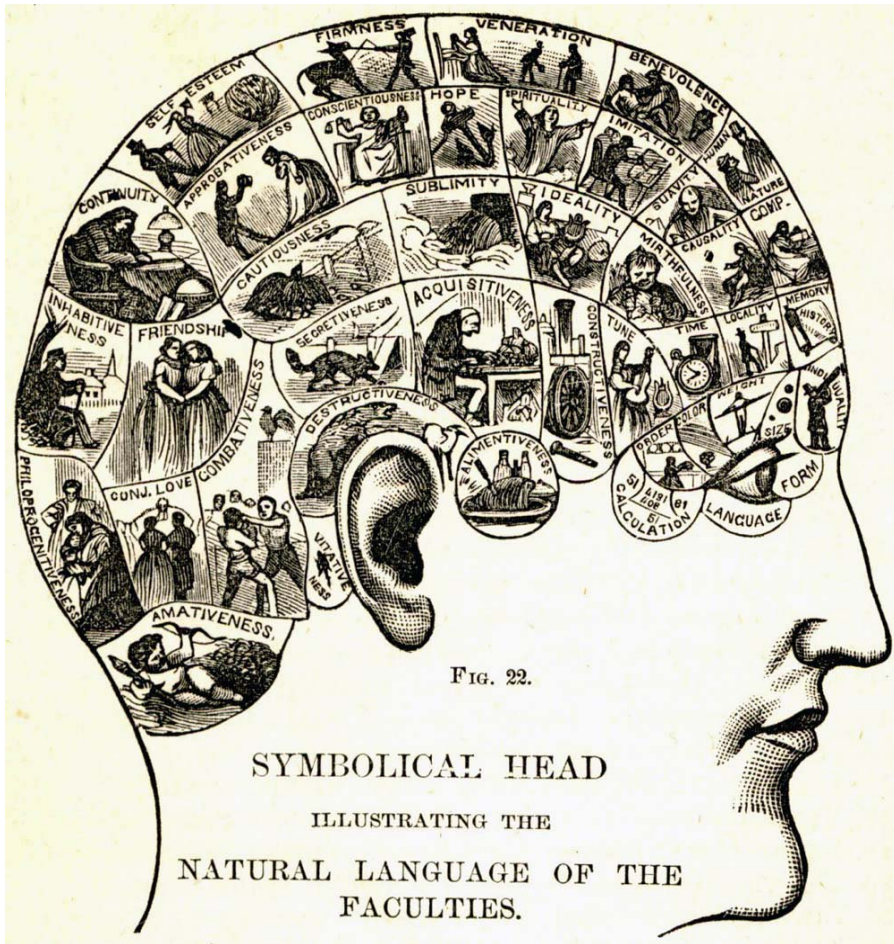
- is the scientific **study of the nervous system (NS)**
- structure, organization, function of its parts and its functioning as a whole unit
- traditionally: branch of biology
- an interdisciplinary science
- collaborates with other fields such as chemistry, medicine and allied disciplines, linguistics, mathematics, philosophy, physics, psychology, computer science, engineering.

*“Whether judged in molecular, cellular, systemic, behavioral, or cognitive terms, the **human nervous system** is a **stupendous piece of biological machinery**.*

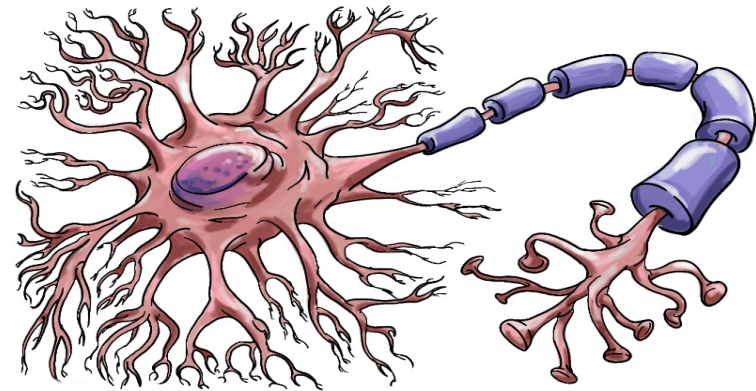
Given its accomplishments — all the artifacts of human culture, for instance — there is good reason for wanting to understand how the brain and the rest of the nervous system works.”

Purves et al. (2004) Preface in
NEUROSCIENCE: 3rd Edition, Sinauer
Associates, Inc., Sunderland, MA U.S.A.

Mind-body problem



Phrenology (Gall, 19th century)

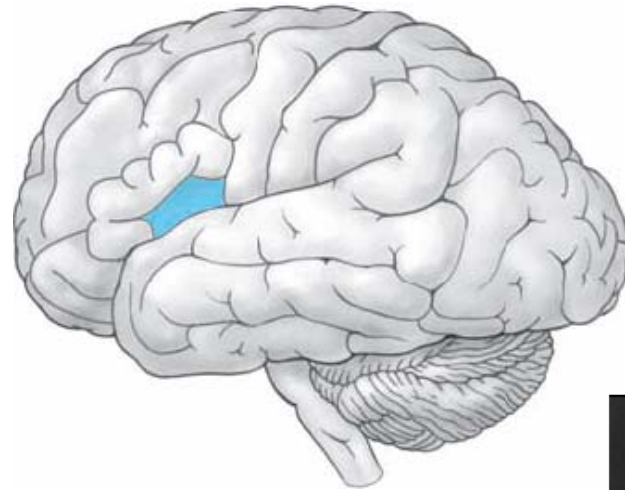


Experimental Approaches to Brain Function

- brain damage and its consequence
- experiments on animals
- functional brain imaging techniques
- methods that can reversibly disable particular brain area

Localization and Lateralization of Language

Paul Broca (1824–1880):



- 1) a behavior, such as language, is controlled by a specific brain area
- 2) destroying the area selectively destroys the behavior

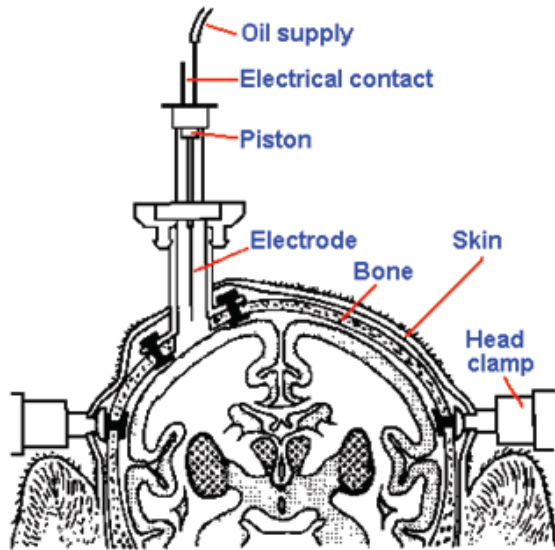
Broca's aphasia – inability to produce speech

<https://www.youtube.com/watch?v=6CJWo5TDHLE>

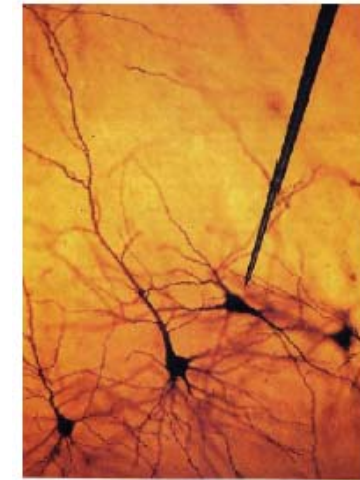


Experimental Approaches to Brain Function

- brain damage and its consequence
- **experiments on animals**
- functional brain imaging techniques
- methods that can reversibly disable particular brain area

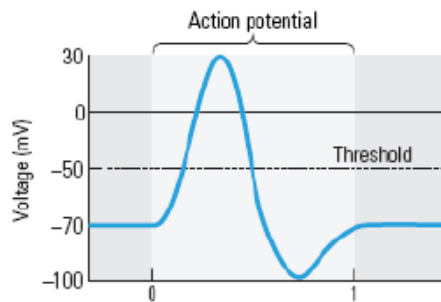


single-cell recording



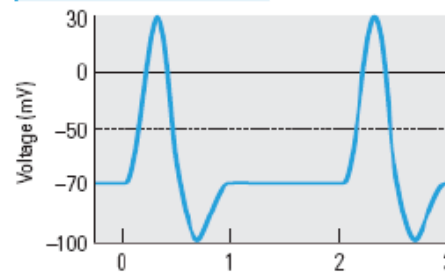
(A)

A single action potential occurs in 1 millisecond.



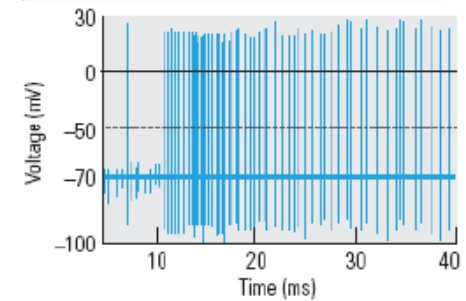
(B)

Two action potentials occur in 3 milliseconds.



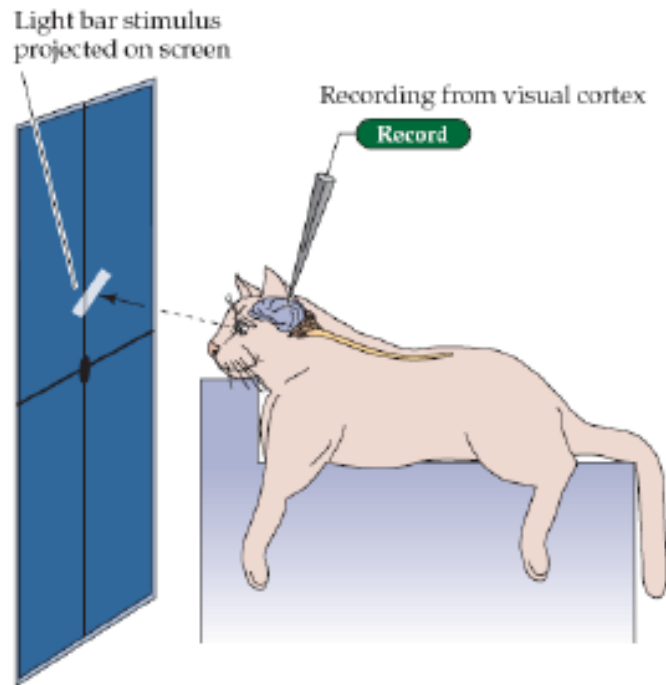
(C)

A changing pattern of activity can be seen with the occurrence of many action potentials in a 40-millisecond period.

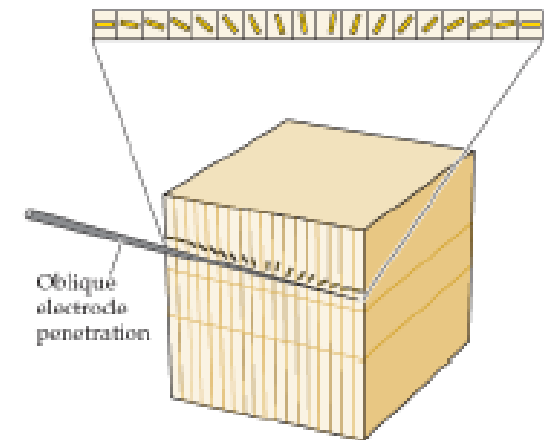


Simple cells in primary visual cortex

(A) Experimental setup



- Hubel a Wiesel, 1968
- 1981 Nobel prize



<https://www.youtube.com/watch?v=8VdFf3egwfg>

Experimental Approaches to Brain Function

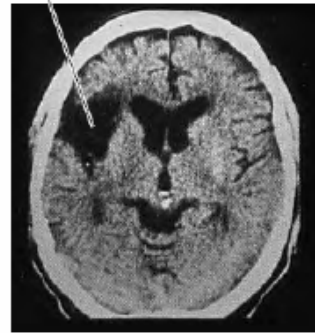
- brain damage and its consequence
- experiments on animals
- **functional brain imaging techniques**
- methods that can reversibly disable particular brain area

Brain Imaging Techniques

- structural

- CT

- MRI

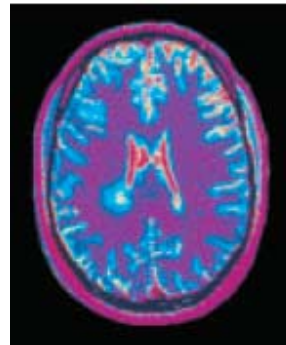


- functional

- fMRI

- PET

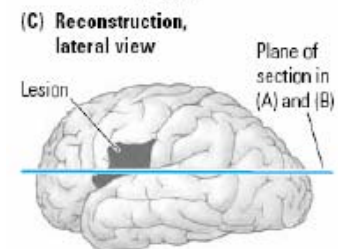
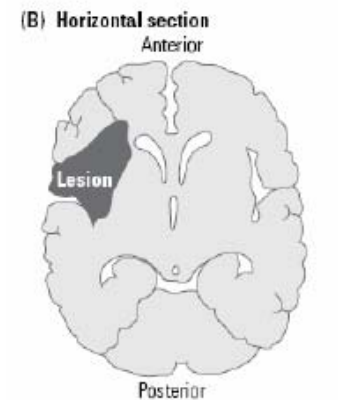
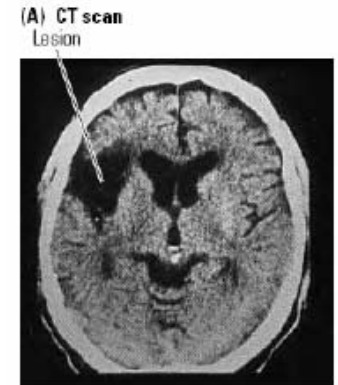
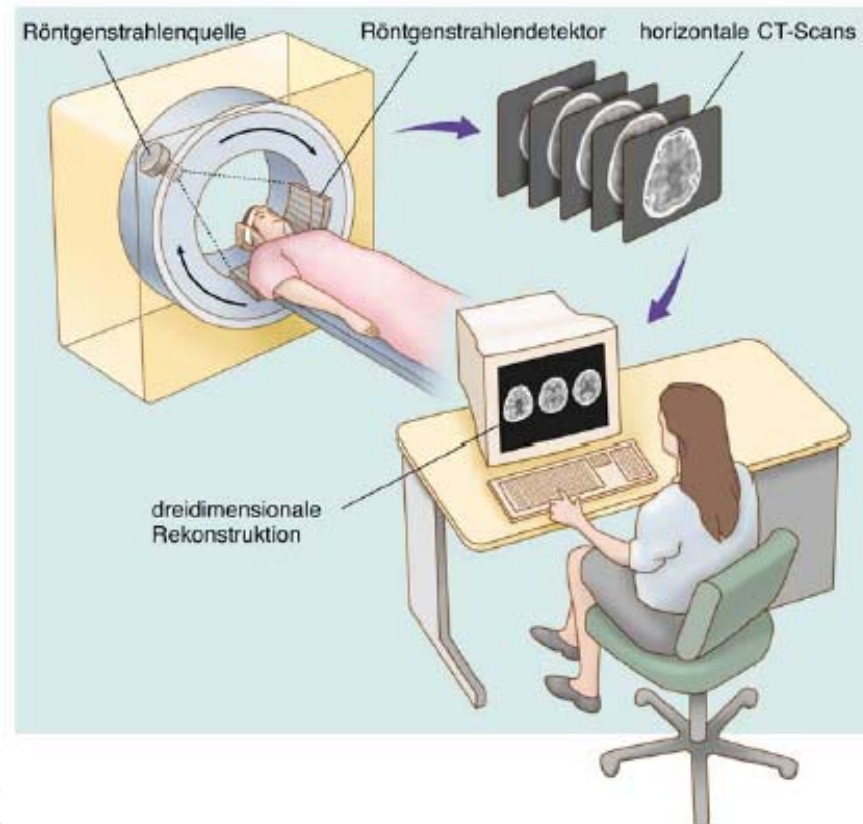
- EEG





CT – computed tomography

- **fast** (< 5 minutes)
- not very expensive => **available**
- **invasive**



- narrow X-ray beam is detected by sensitive
- CT scanner rotates (from 0° to 180°)
- Computer then calculate the radiodensity of each point within the slice plane, producing a tomographic image

MRI – magnetic resonance imaging

1

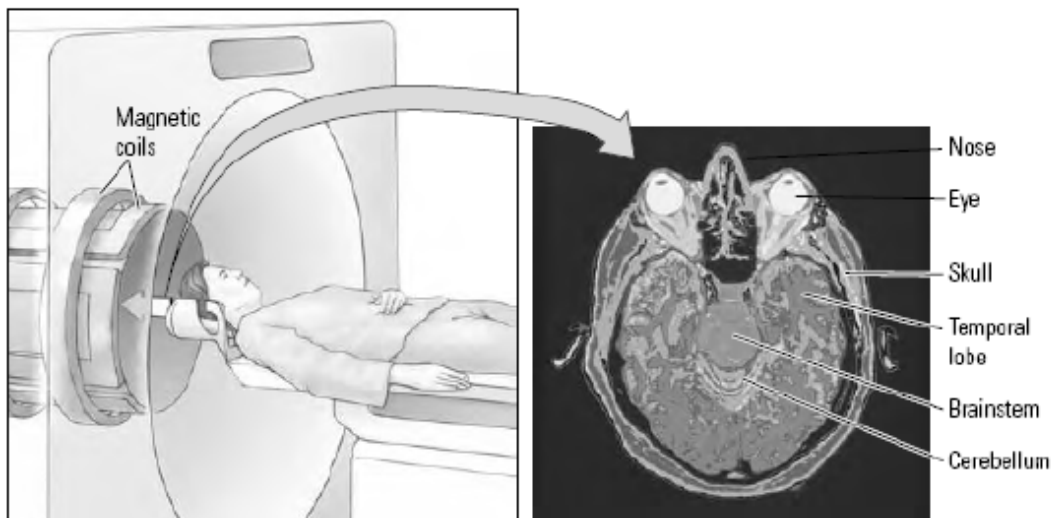
The subject is placed in a long metal cylinder containing two sets of magnetic coils arranged at right angles to each other.

2

A radiofrequency coil (not shown) surrounds the head and is designed to perturb the static magnetic fields that produce MRI.

3

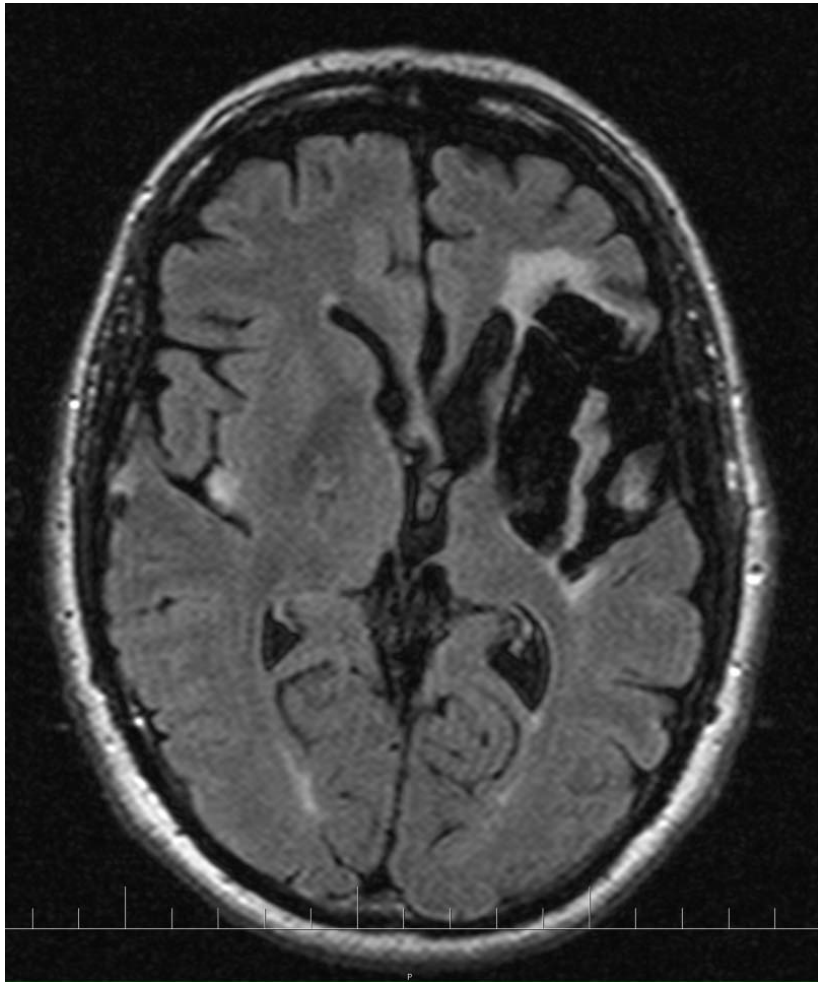
The resulting MRI is a horizontal slice through the head.



- high spatial resolution (mm)
- noninvasive
- expensive
- slow
- noisy

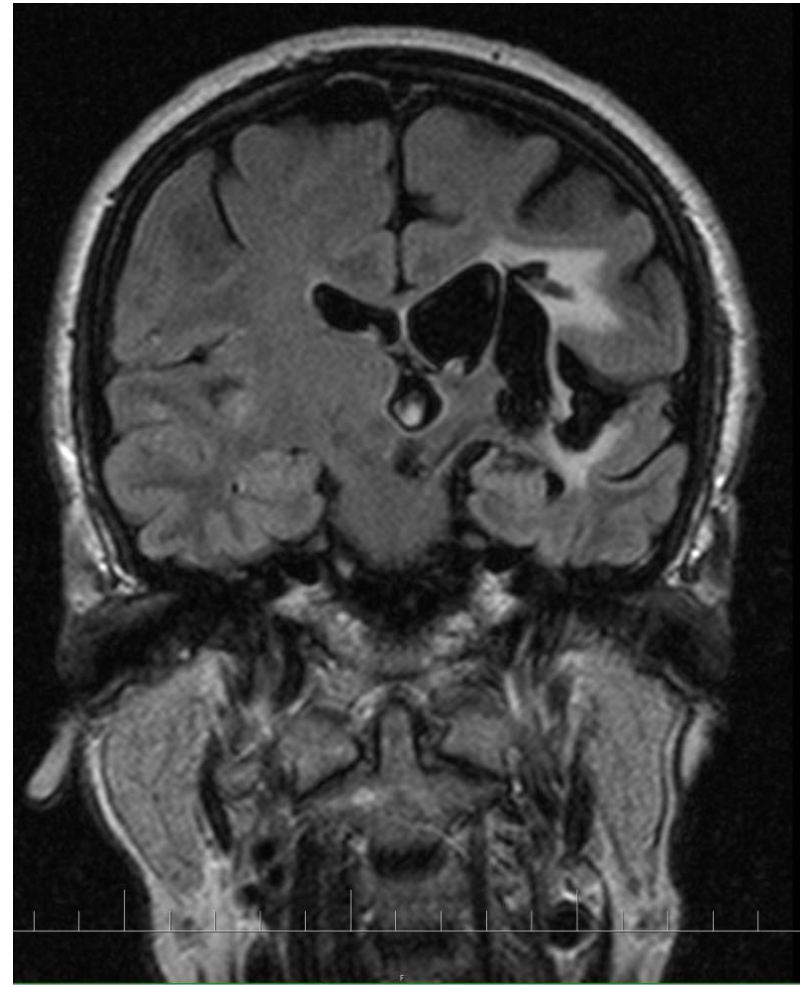


Front



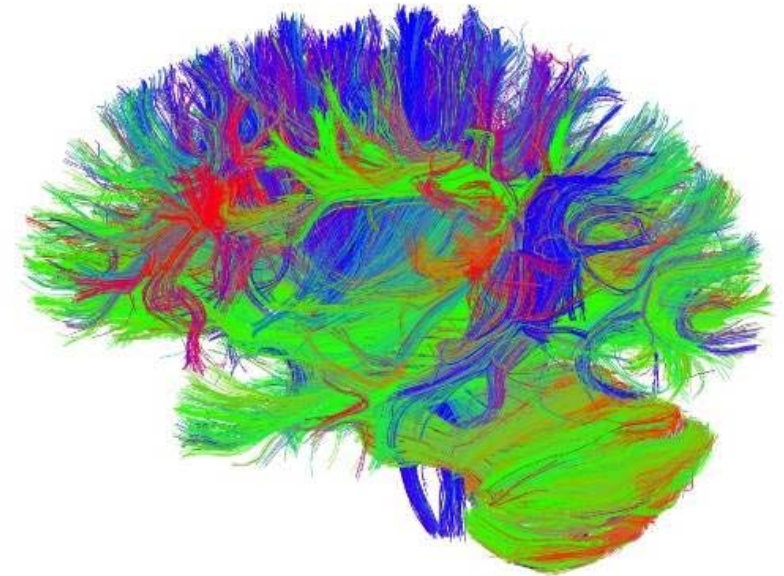
Right

Left

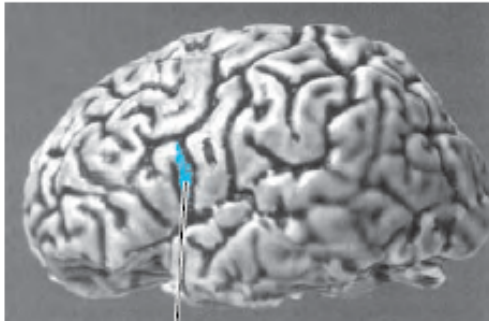




insideinsides.blogspot.com

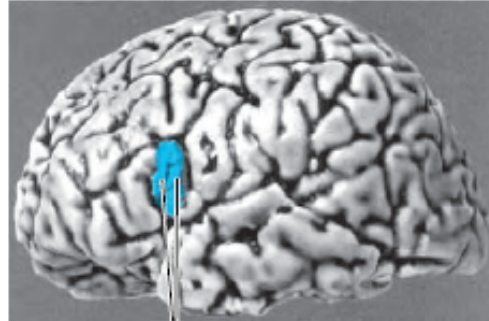


Individual A



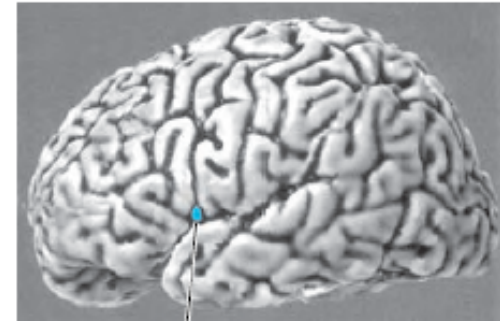
Pars opercularis with one gyrus

Individual B



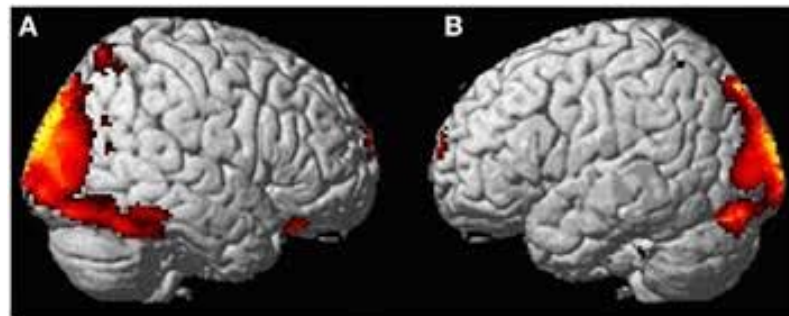
Pars opercularis with two gyri

Individual C

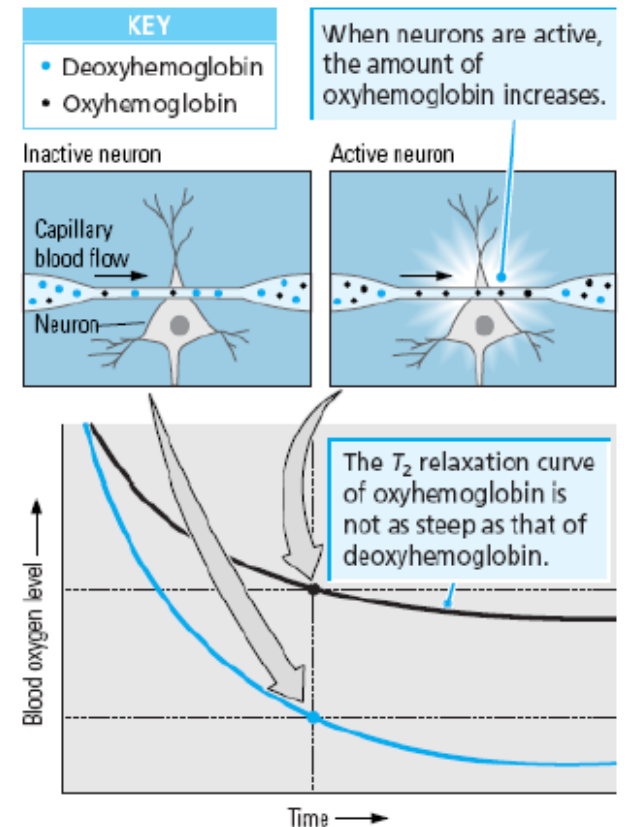


Pars opercularis hidden in sulcus between gyri

fMRI – functional magnetic resonance imaging



- variant of MRI allowing to see changes of activity in time
- detects differences in the level of oxyhaemoglobin vs. deoxyhaemoglobin, (resulting from neuronal activity)



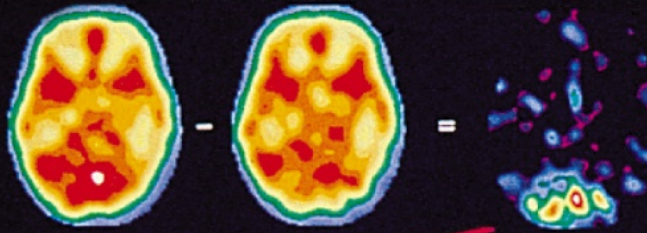
Blood oxygen-level-dependent signal (BOLD) haemodynamic response function

MITTELUNG ÜBER DIE PROBANDEN

visuelle Stimulation

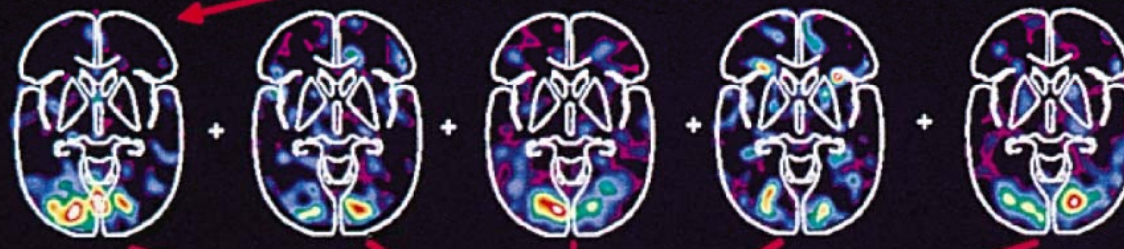
Kontrolle

Differenzbild



anatomische Standardisierung

individuelle Differenzbilder



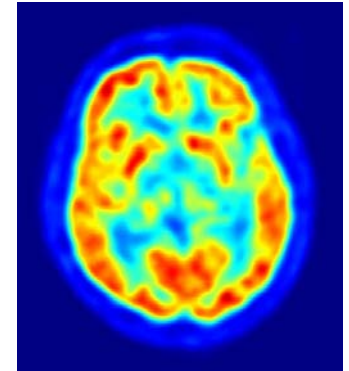
gemittelttes Differenzbild

Mind reading (image reconstruction from fmri)



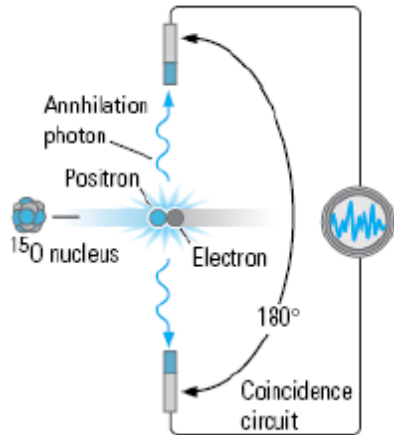
https://www.youtube.com/watch?v=1_yaQTR3KHI

PET – positron-emission tomography



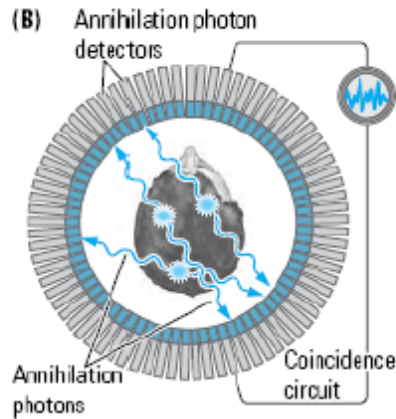
(A)

A positron released by an unstable nucleus of ^{15}O meets an electron and their mass is converted to two annihilation photons traveling at 180 degrees from each other.



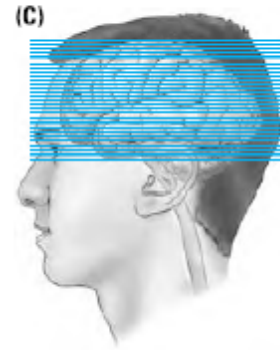
Opposing radiation detectors record the event when struck simultaneously by annihilation photons.

(B)



Multiple radiation detectors are arranged about the subject's head.

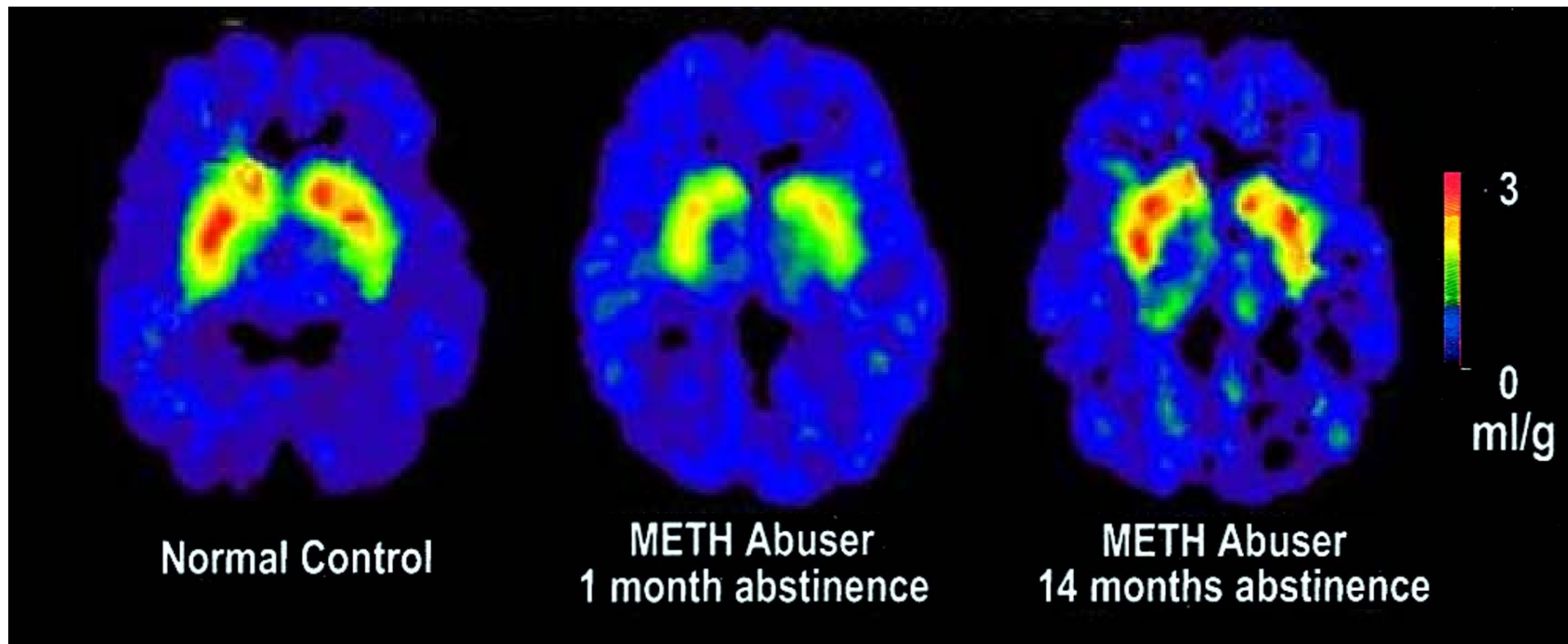
(C)



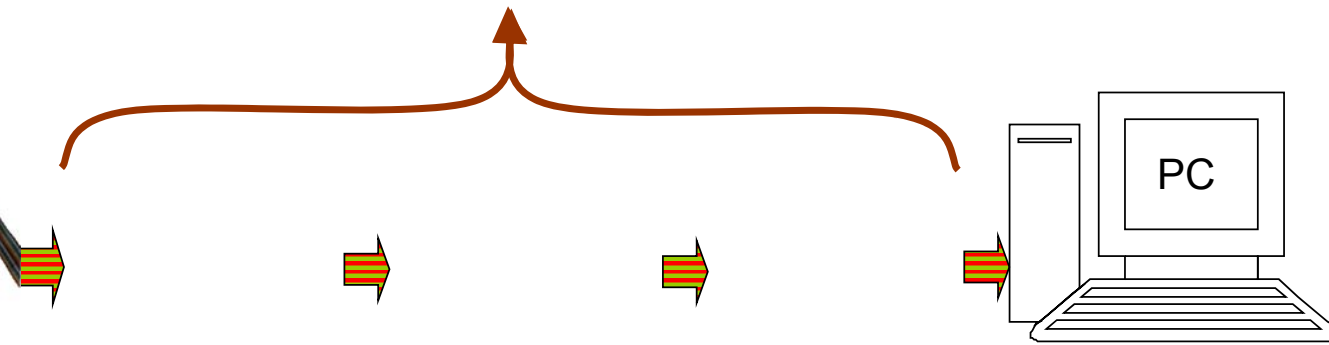
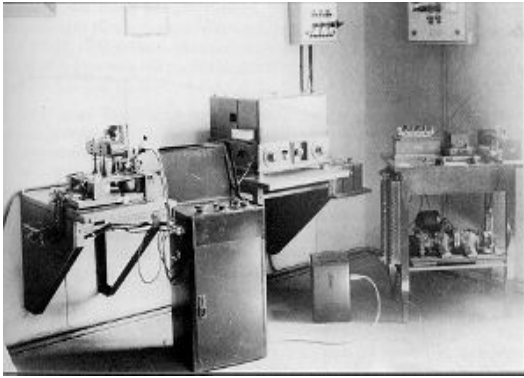
As many as 63 images are recorded simultaneously, in parallel horizontal slices.



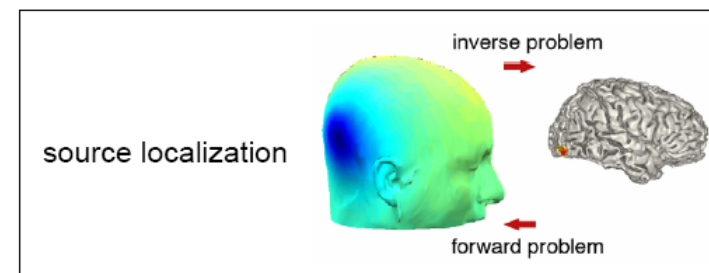
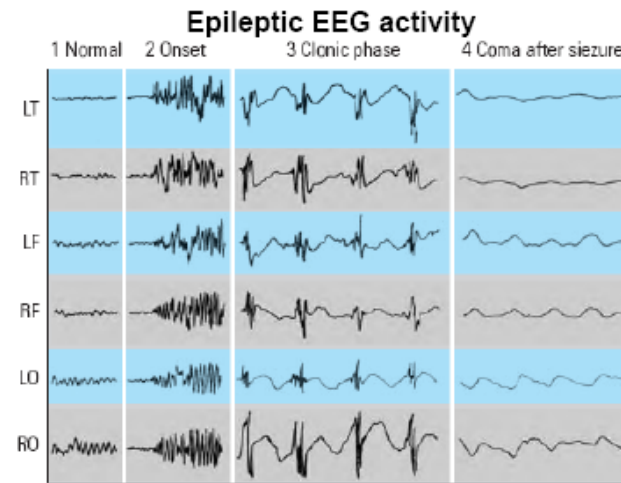
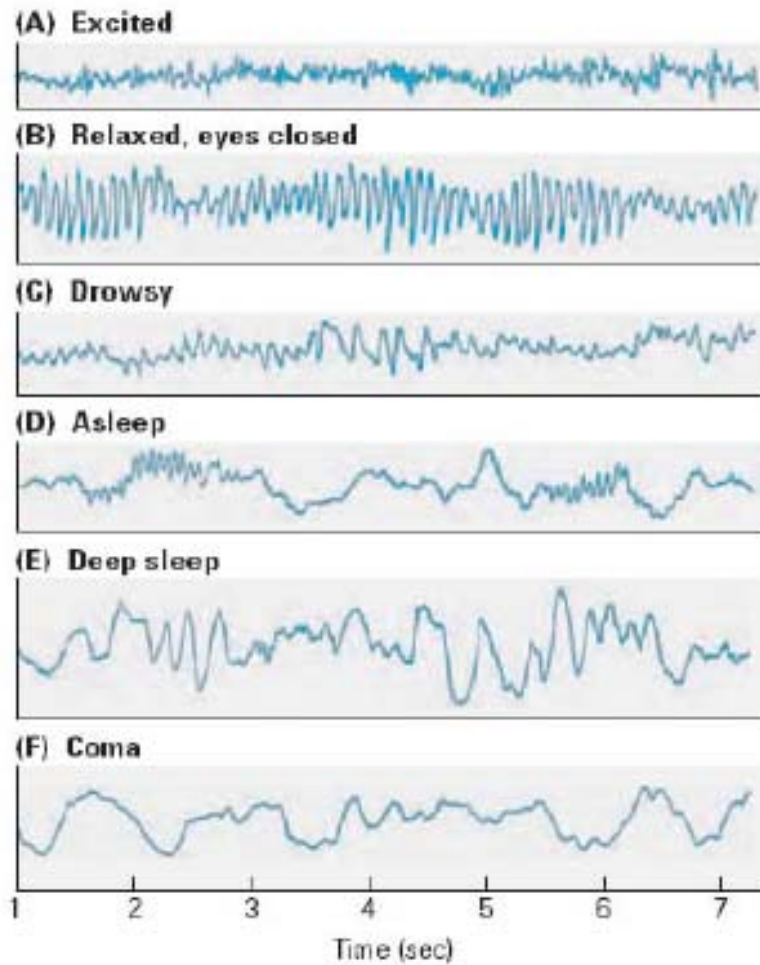
**Brain images of the distribution volume
of [11C]d-threo-methylphenidate (binding to the dopamine transporter)
in a control and a METH abuser.**



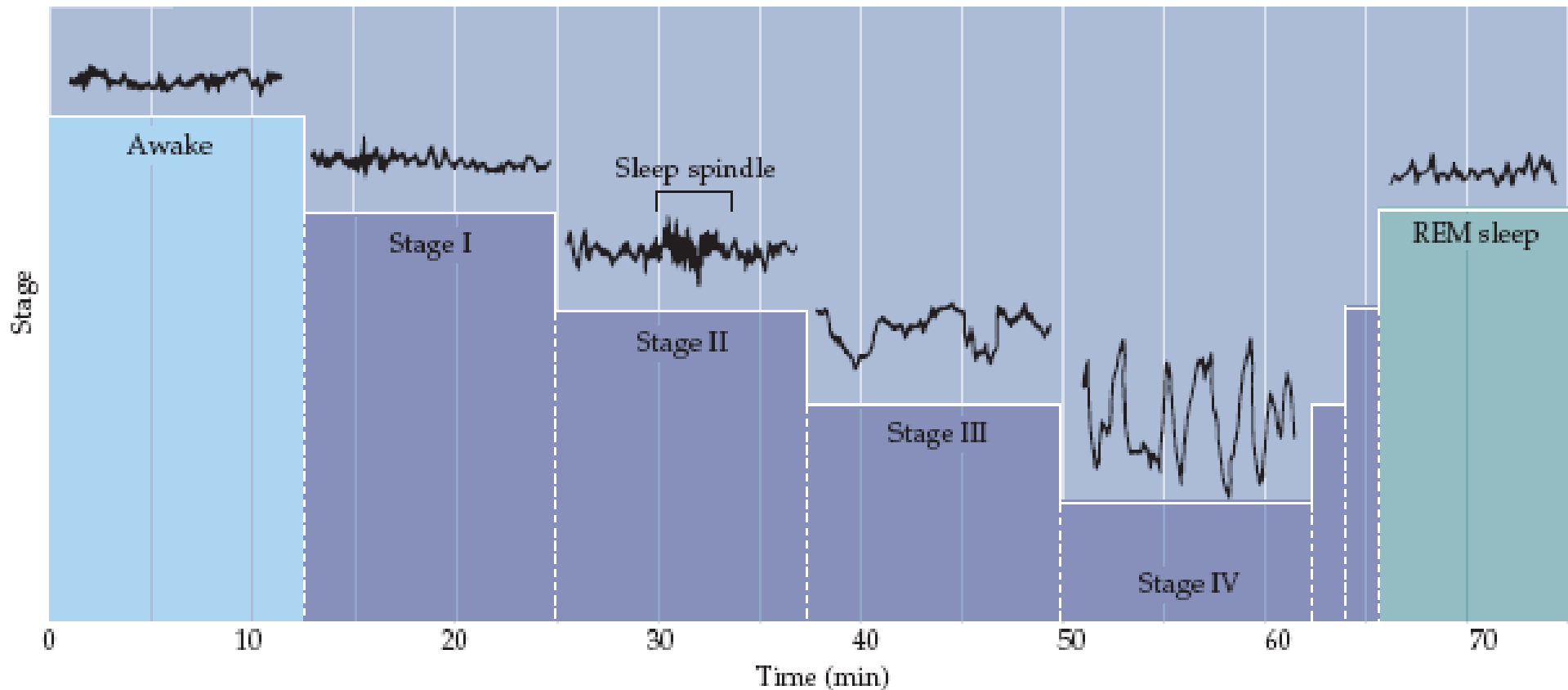
Electroencephalography



EEG activity in different states of vigilance

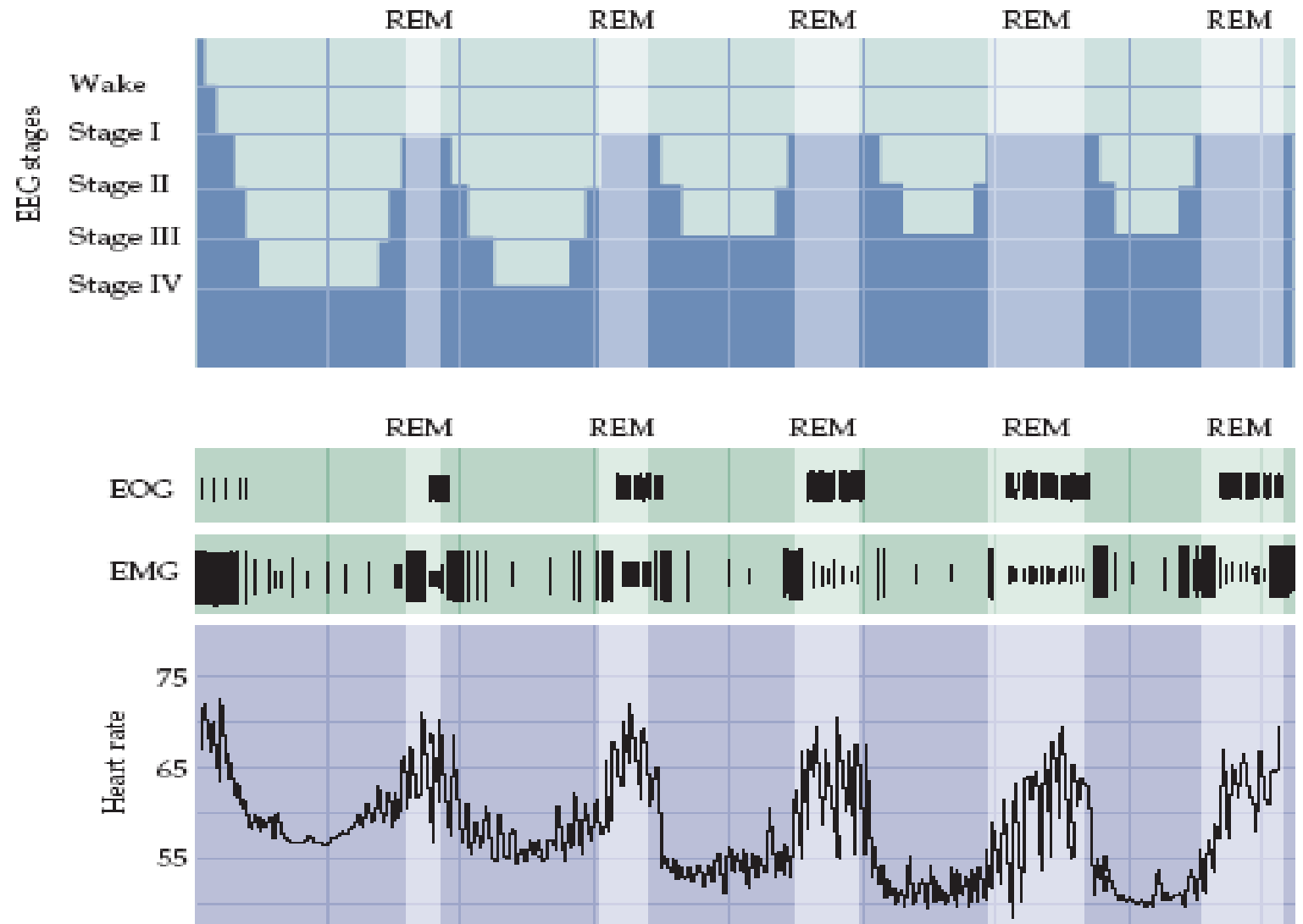


EEG recording during the first hour of sleep

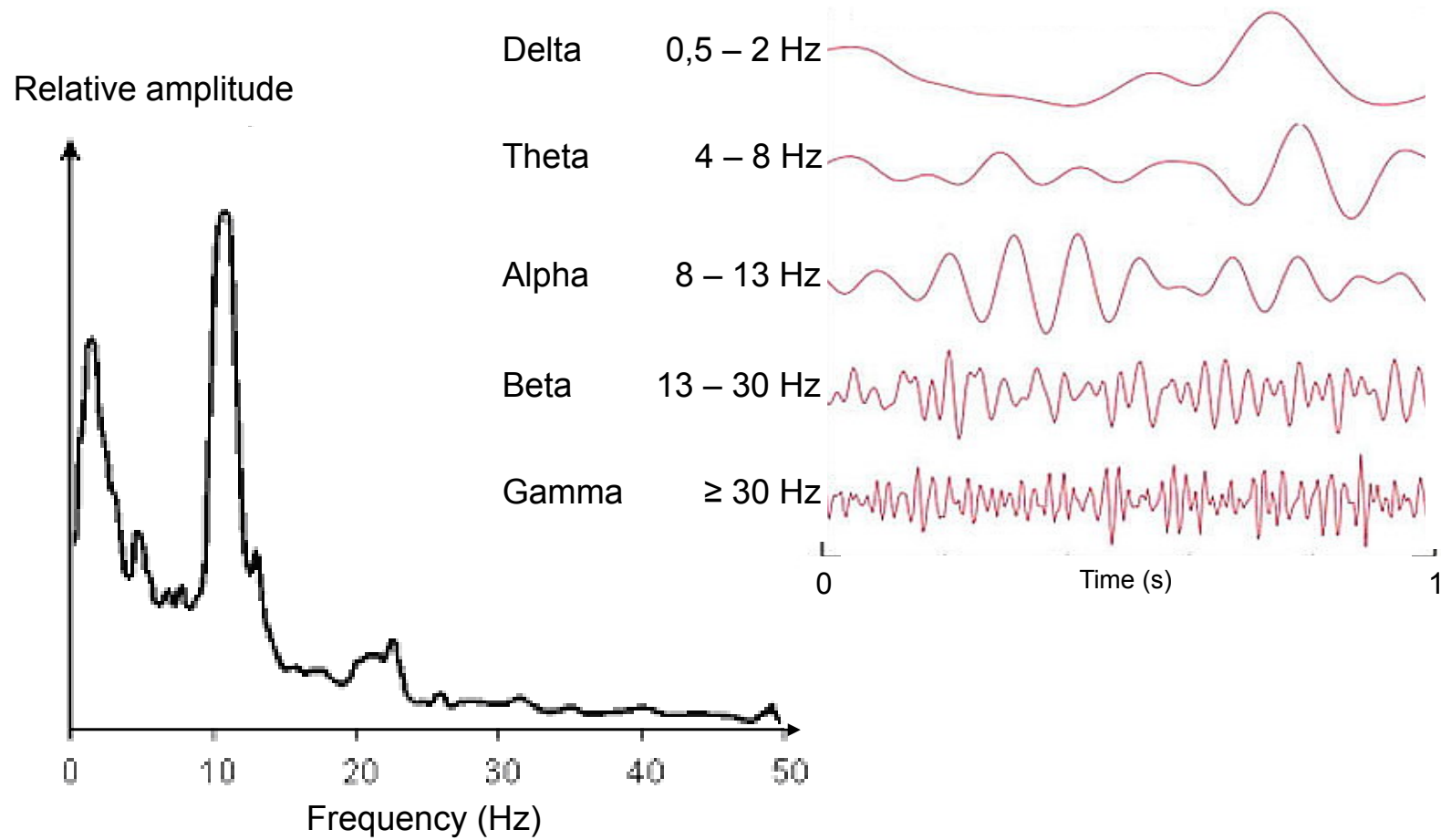


Adjusted according to Hobson, 1989

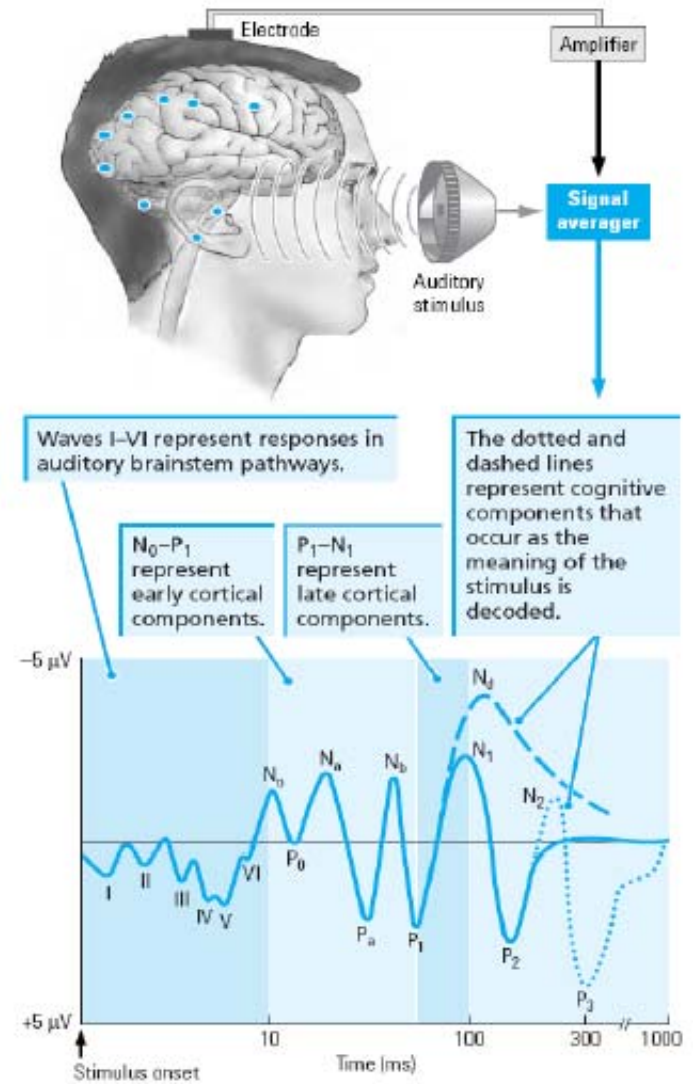
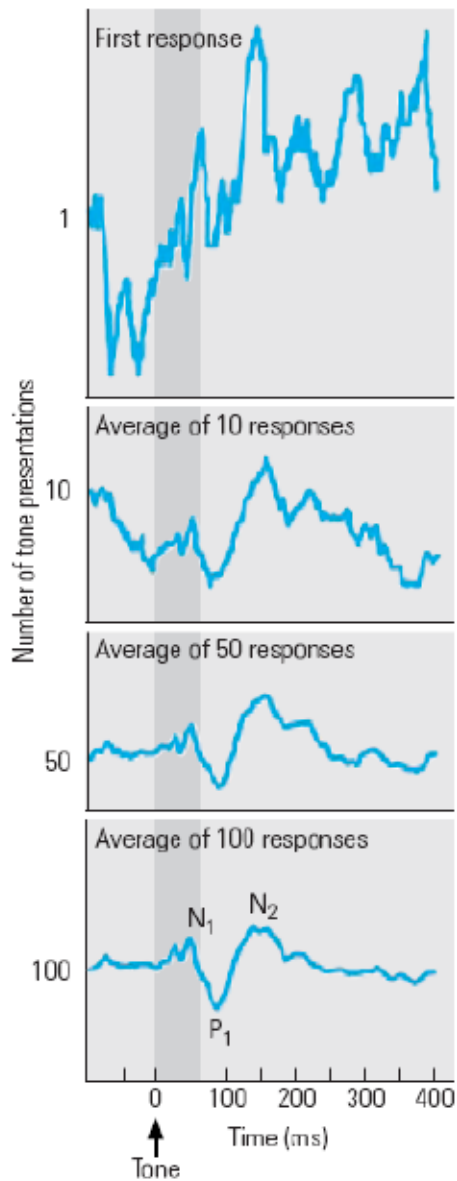
Sleep cycle



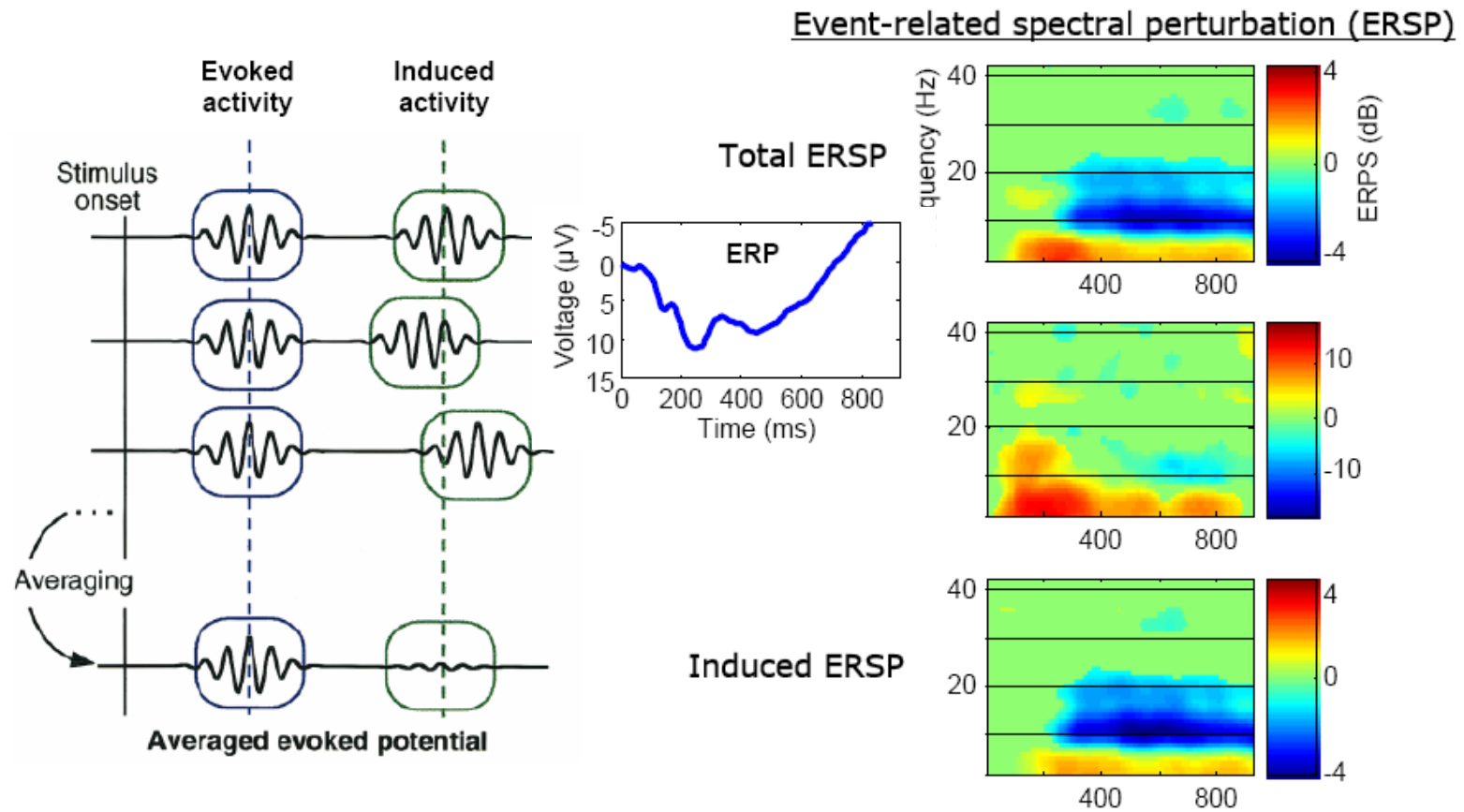
Spectral analysis



EEG evoked potentials



Evoked and event-related potentials



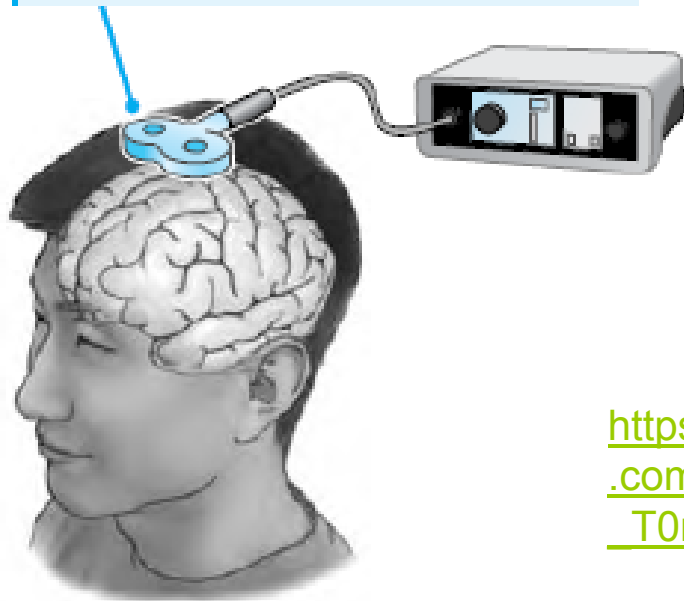
Tallon-Baudry 1999

Experimental Approaches to Brain Function

- brain damage and its consequence
- experiments on animals
- functional brain imaging techniques
- methods that can reversibly excite or disable particular brain area

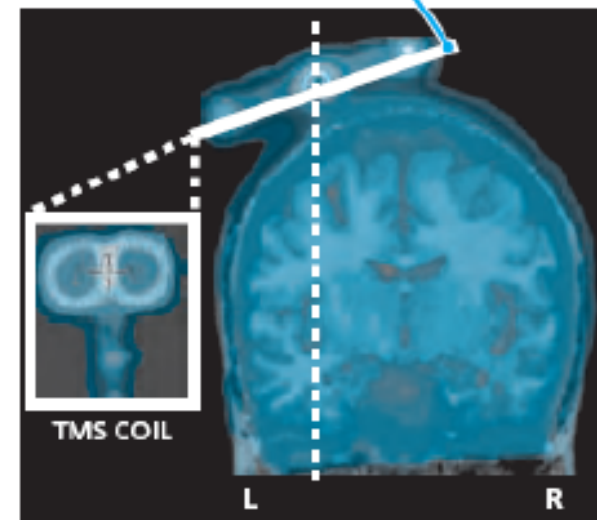
TMS – transcranial magnetic stimulation

A transcranial magnetic stimulator (TMS) is placed over a region of the cortex.

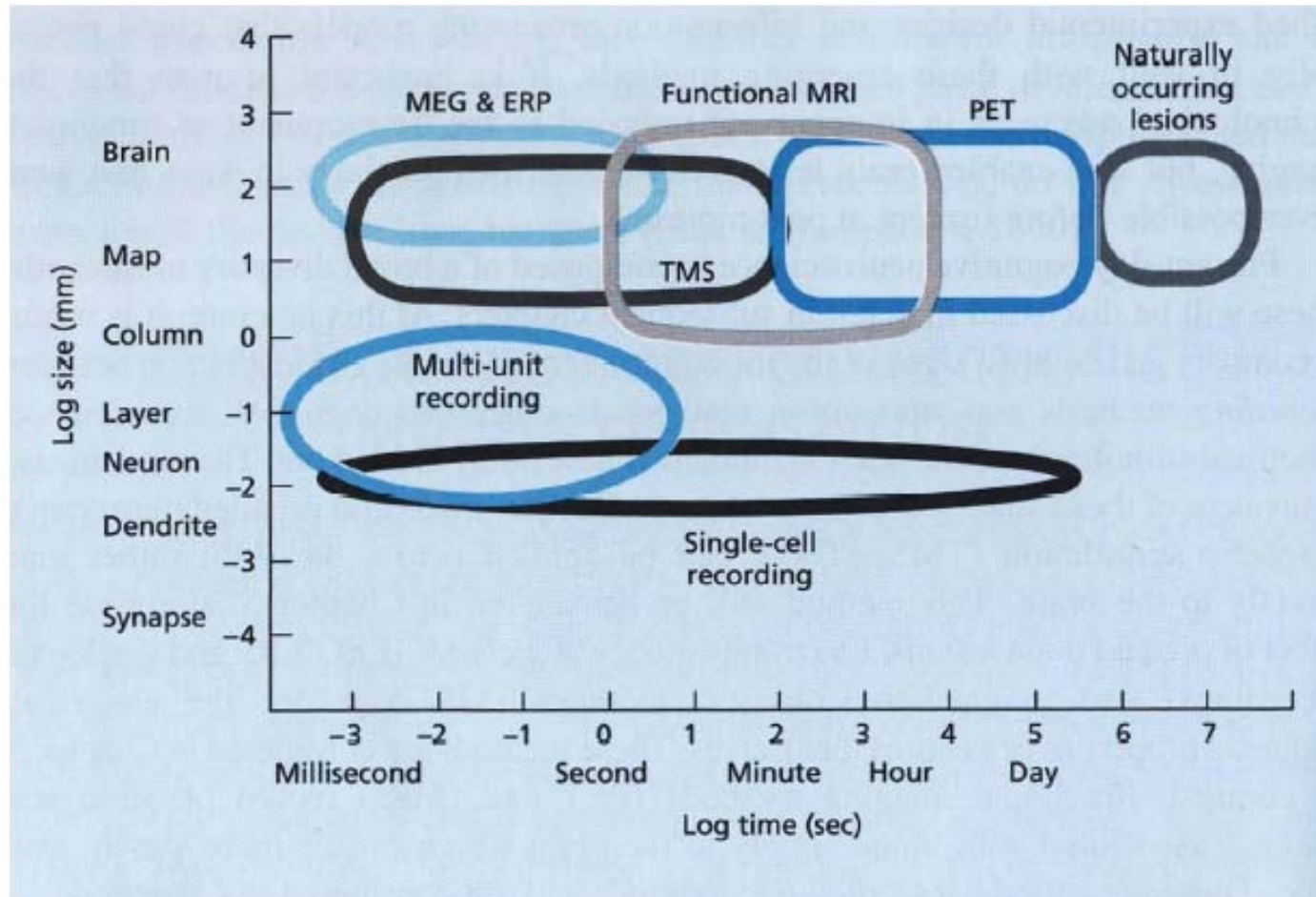


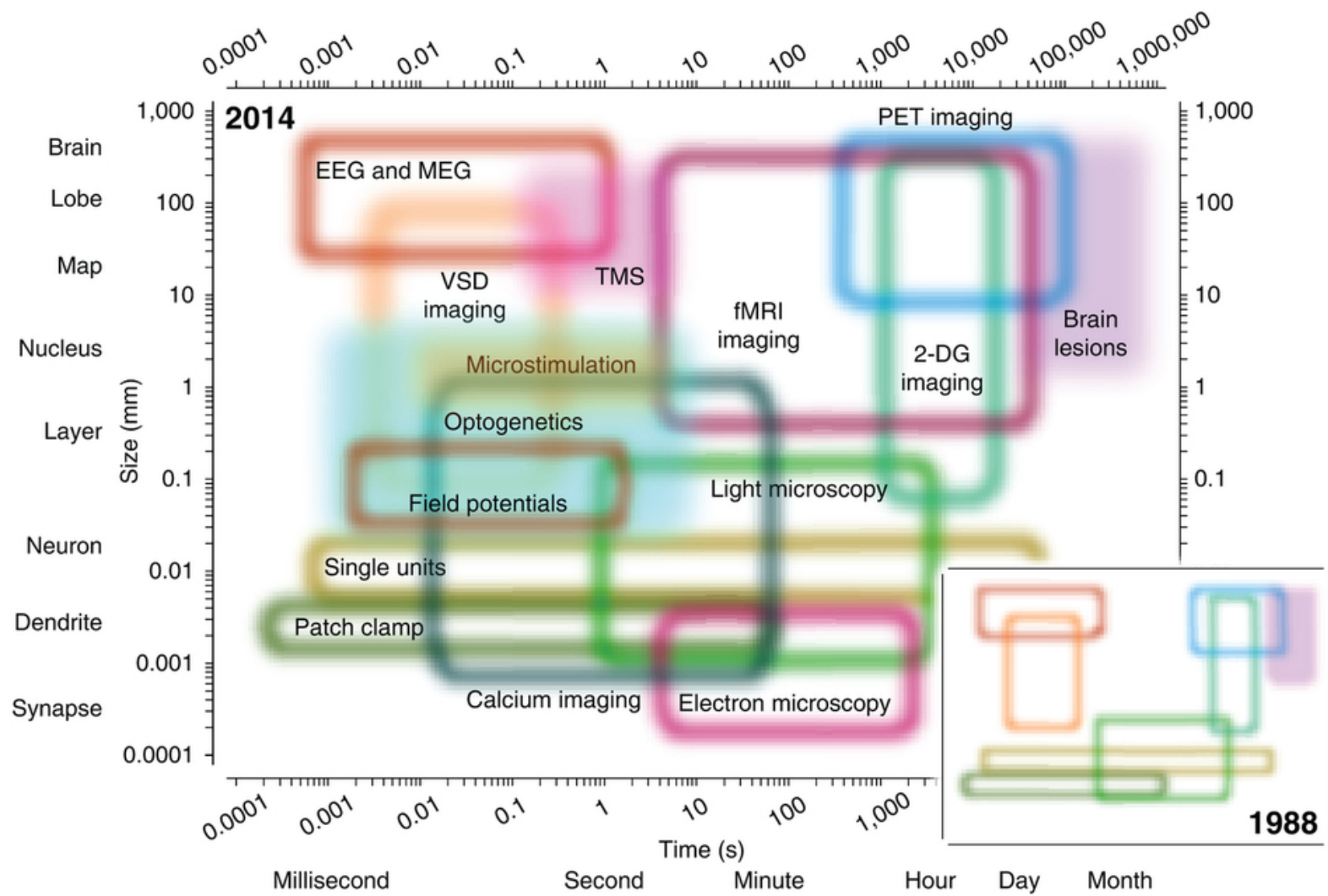
https://www.youtube.com/watch?v=FMR_T0mM7Pc

The TMS coil, shown here in composite MRI/PET scan photograph, interferes with brain function in the adjacent area, indicated by the dotted line.



Time and space resolution





Thank you for your attention

