The Brain & brain data

Mads Jensen, PhD

mads@cas.au.dk

Contents

Practical information

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.
- A paper can be maximum 7 normal pages
  - code goes in an appendix
  - Figures does not count.

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.
- A paper can be maximum 7 normal pages
  - code goes in an appendix
  - Figures does not count.
- Introduction and discussion/conclusion is combined maximum of 7 normal pages.

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.
- A paper can be maximum 7 normal pages
  - code goes in an appendix
  - Figures does not count.
- Introduction and discussion/conclusion is combined maximum of 7 normal pages.
- A normal page is 2400 characters *including* spaces and in-text references.

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.
- A paper can be maximum 7 normal pages
  - code goes in an appendix
  - Figures does not count.
- Introduction and discussion/conclusion is combined maximum of 7 normal pages.
- A normal page is 2400 characters *including* spaces and in-text references.
- The reference list does *not* count for the pages limits.

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.
- A paper can be maximum 7 normal pages
  - code goes in an appendix
  - Figures does not count.
- Introduction and discussion/conclusion is combined maximum of 7 normal pages.
- A normal page is 2400 characters *including* spaces and in-text references.
- The reference list does *not* count for the pages limits.
- Citation style is APA7

The exam questions

- Open questions
- Philosophical questions?

Topic	Question
The brain	• Describe a cognitive function? • Discuss the use of fMRI and EEG/MEG for action selection?
Electrophysiology	• What are the pros and cons of EEG vs MEG? • How are ERPs related to brain structures and functions of the mind?
Oscillations	• How can oscillations be used to investigate and cognition? • Link oscillations to a cognitive function. This can be in term of frequencies and/or cortical location(s) etc.
MVPA	• Why use MVPA for statistical assessment of EEG data? • Pros and cons of linear vs non-linear MVPA models for brain imaging data
Neural Networks	• Are neural networks better than MVPA for analysis of neuroimaging data? • Can Neural networks be used to model cognition?

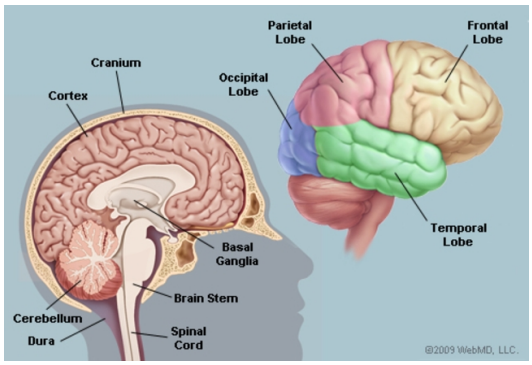
The brain

The brain

Neurons, connections, and organised chaos!

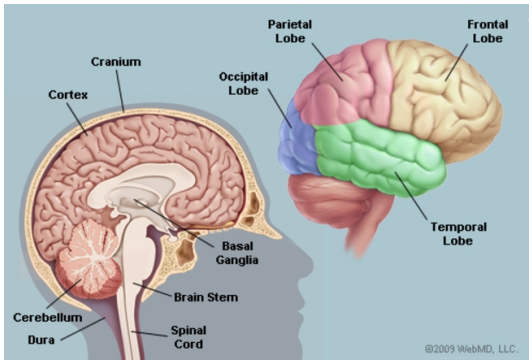
The brain

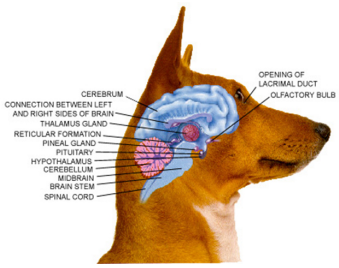
Neurons, connections, and organised chaos!



The brain

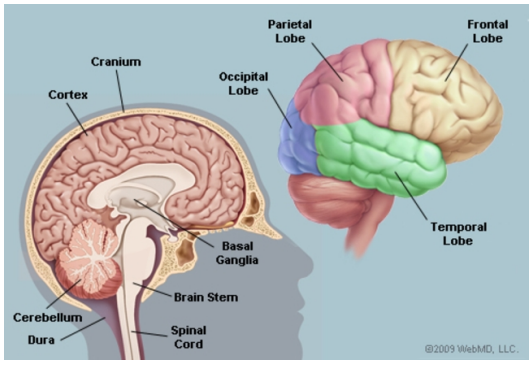
Neurons, connections, and organised chaos!

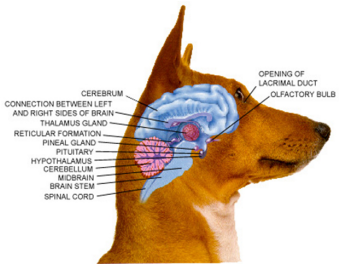


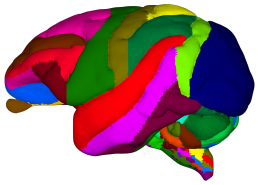


The brain

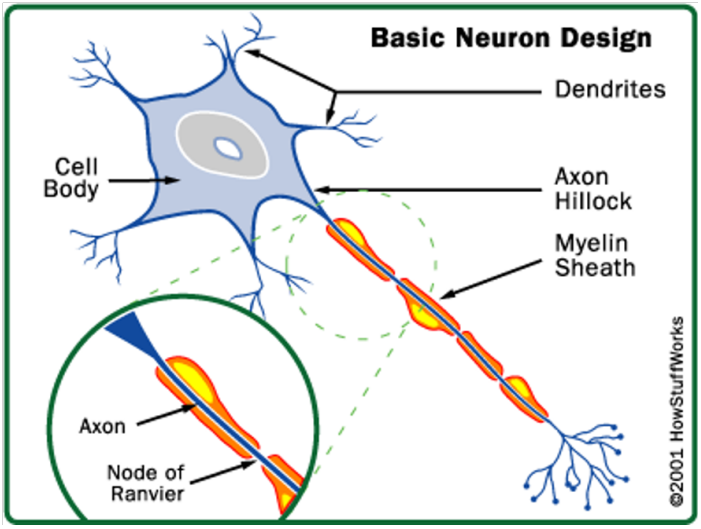
Neurons, connections, and organised chaos!



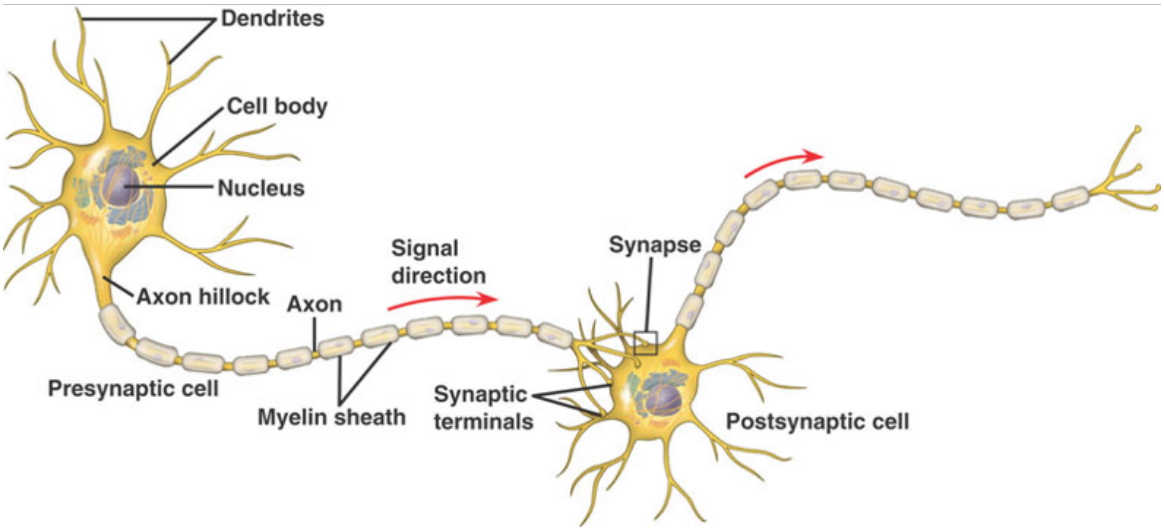




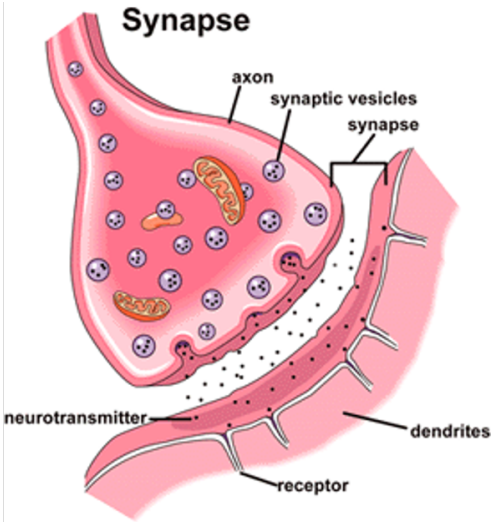
Neurons



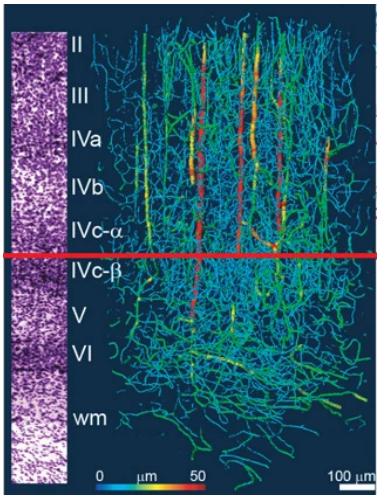
Neurons



Neurons

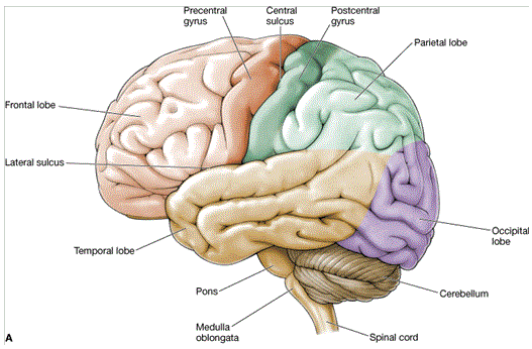


Cortical columns

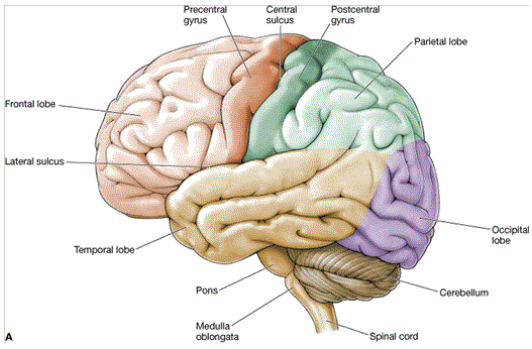


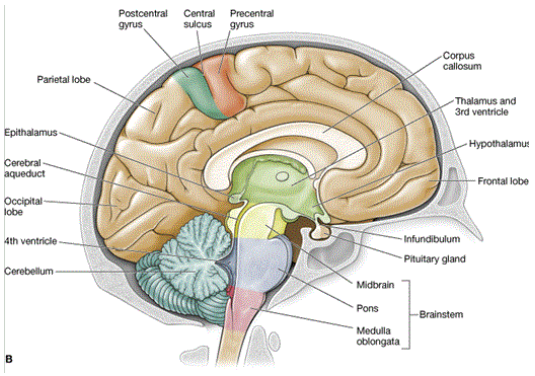
(Figure from Logothetis, 2008)

Gross anatomy



Gross anatomy

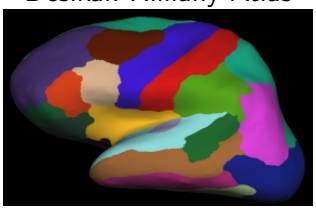




Cortical parcellation

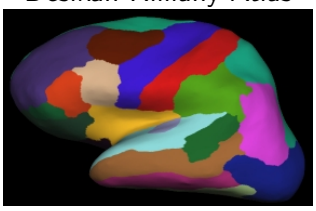
Cortical parcellation

Desikan-Killiany Atlas

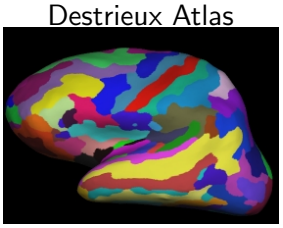


Cortical parcellation

Desikan-Killiany Atlas

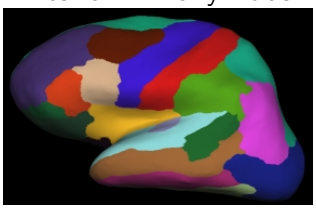


Destrieux Atlas

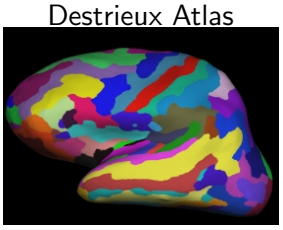


Cortical parcellation

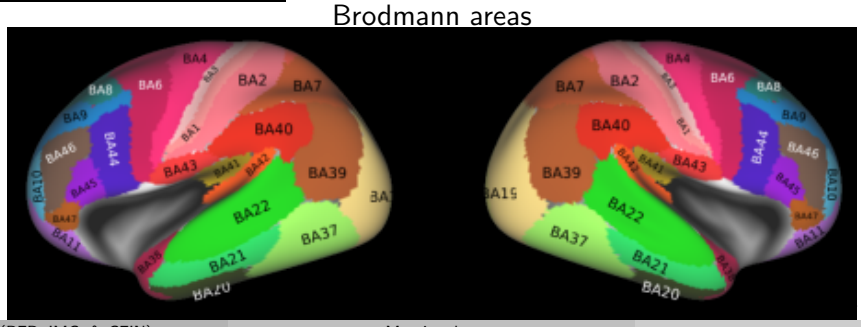
Desikan-Killiany Atlas



Destrieux Atlas

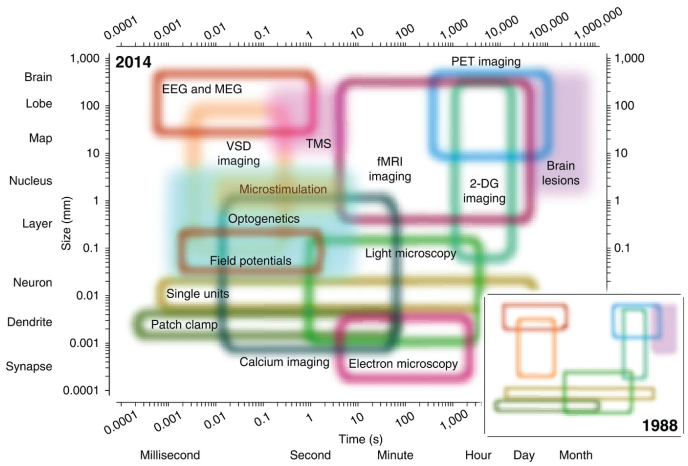


Brodmann areas



Brain data: the big picture

Overview

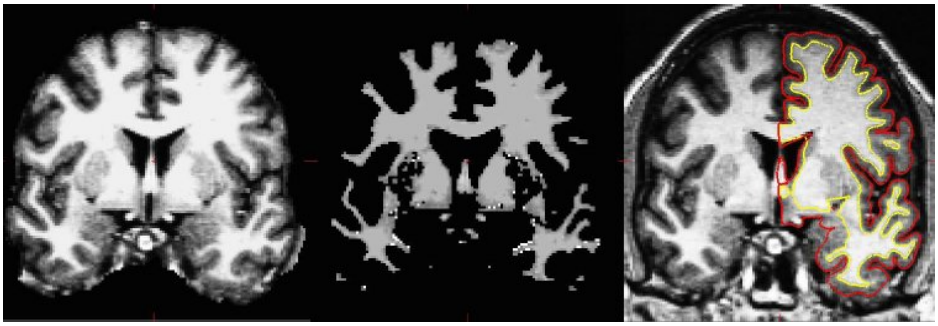


(Figure from Sejnowski et al., 2014)

Types of data

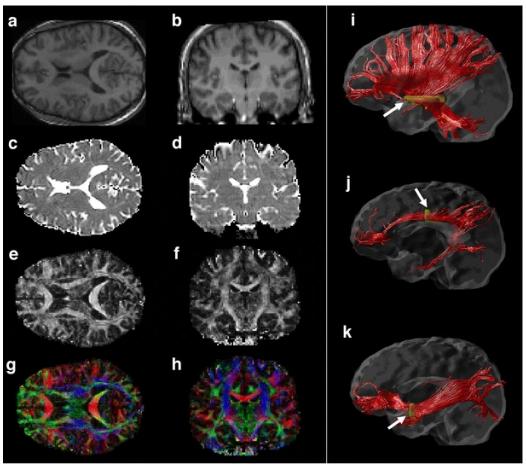
- Anatomical vs functional data
- Spatial or temporal precision

Structural images



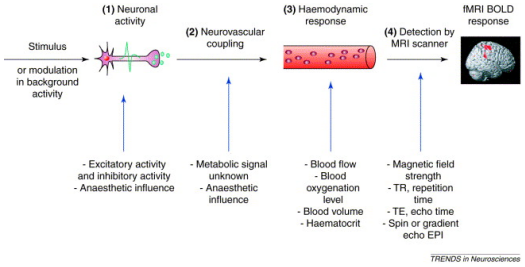
(Figure from http://surfer.nmr.mgh.harvard.edu/fswiki/FreeSurferAnalysisPipelineOverview)

Diffusion Tensor Imaging (DTI)



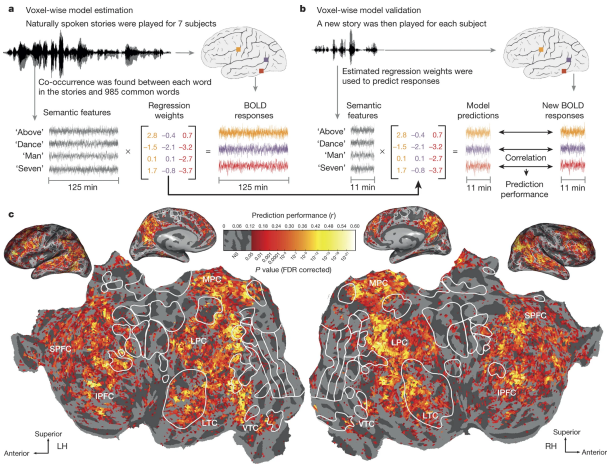
(Figure from Assaf & Pasternak, 2008)

Blood oxygenation level-dependent (BOLD) signal



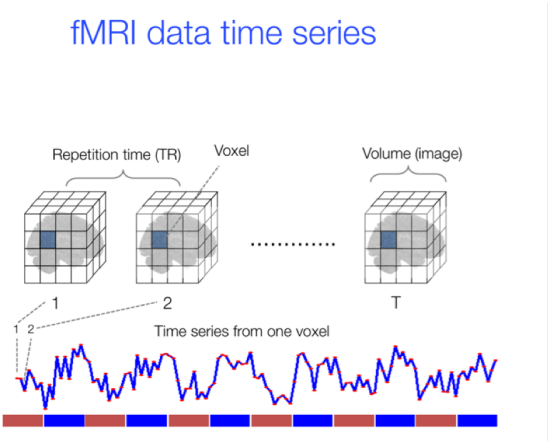
(Figure from Arthurs & Boniface, 2002)

Cortical surface vs voxels



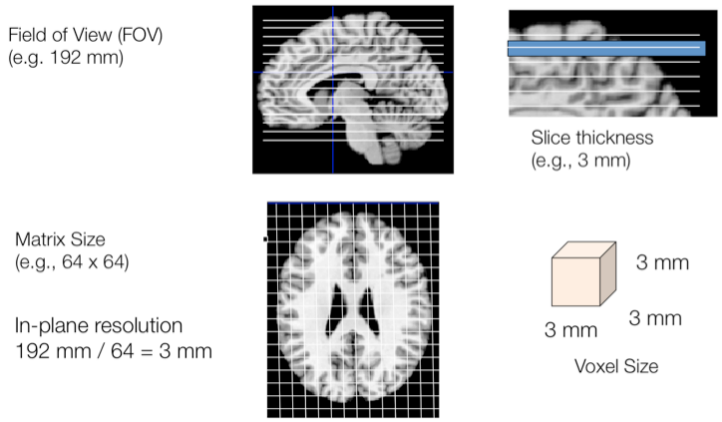
(Figure from Huth et al., 2016)

Cortical surface vs voxels



(Figure from https://leanpub.com/principlesoffmri/read)

Cortical surface vs voxels



(Figure from https://leanpub.com/principlesoffmri/read)

Brain data

What is that is special about brain data?

Brain data

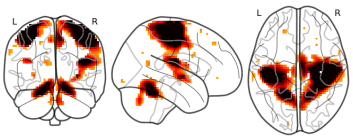
What is that is special about brain data?

- Dependence in one or more dimensions

Brain data

What is that is special about brain data?

- Dependence in one or more dimensions
  - Structural MRI dependence in space

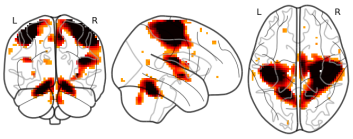


Nilearn, (see Abraham et al., 2014)

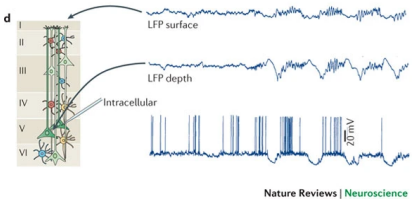
Brain data

What is that is special about brain data?

- Dependence in one or more dimensions
  - Structural MRI dependence in space
  - Local field potential dependence in time



Nilearn, (see Abraham et al., 2014)



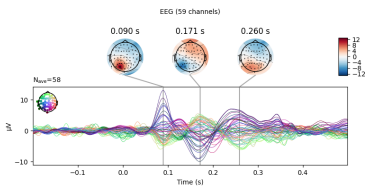
From Buzsaki et al (2012)

Brain data

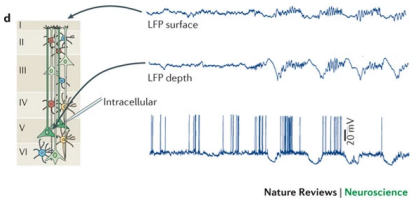
What is that is special about brain data?

- Dependence in one or more dimensions
  - Structural MRI dependence in space
  - Local field potential dependence in time
  - MEG/EEG dependence in space *and* time

Nilearn, (see Abraham et al., 2014)



MNE-python, (see Gramfort et al., 2013)

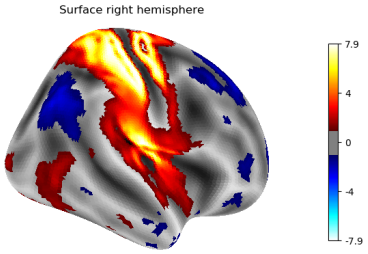


From Buzsaki et al (2012)

Brain imaging modalities

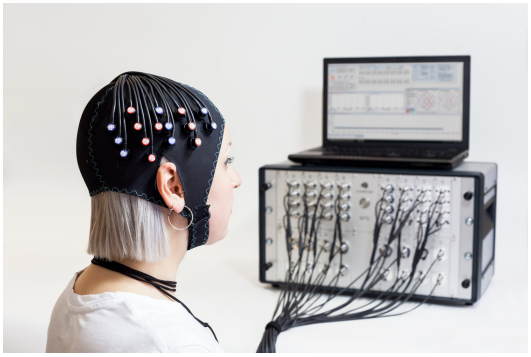
Functional magnetic resonance imaging (fMRI)

Functional magnetic resonance imaging (fMRI)



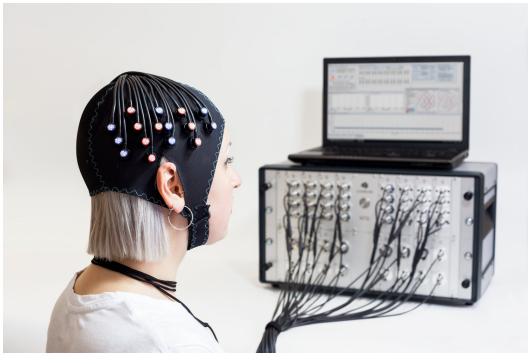
from Nilearn
https://nilearn.github.io/auto_examples/01_plotting/plot_3d_map_to_surface_projection.html

Functional near-infrared spectroscopy (fNIRS)

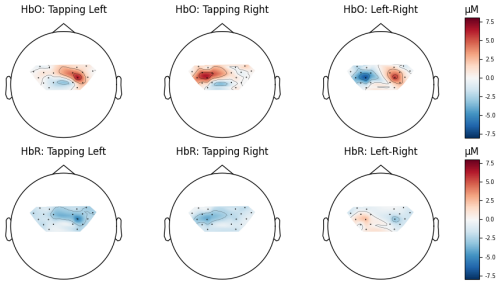


From wikipedia

Functional near-infrared spectroscopy (fNIRS)

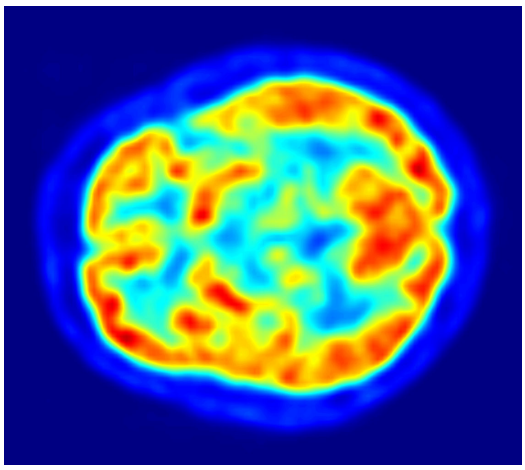


From wikipedia



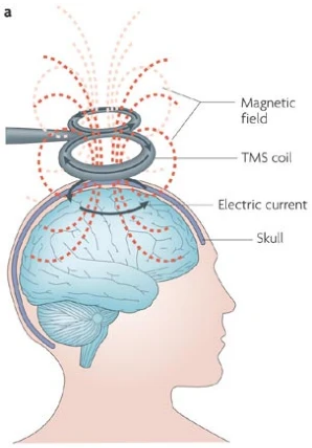
from mne-python
https://mne.tools/stable/auto_tutorials/preprocessing/plot_70_fnirs_processing.html

Positron emission tomography (PET)

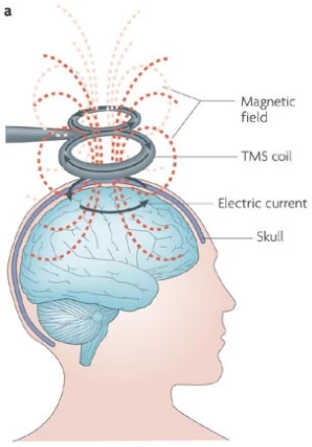


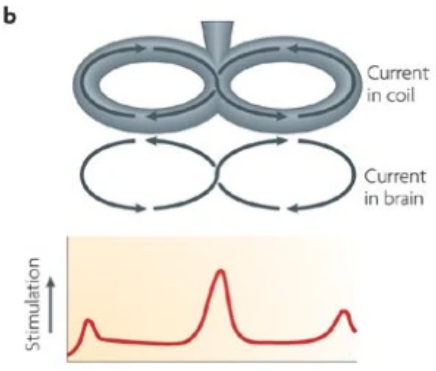
Affecting the cortex

Transcranial magnetic stimulation (TMS)



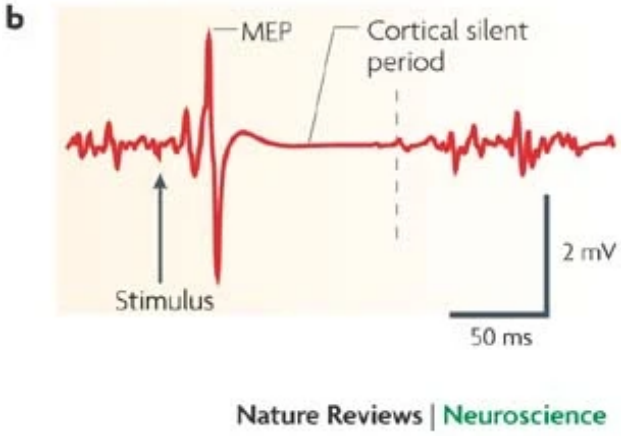
Transcranial magnetic stimulation (TMS)





(From Ridding & Rothwell, 2007)

Transcranial magnetic stimulation (TMS)



(From Ridding & Rothwell, 2007)

Questions?

References I

Abraham, A., Pedregosa, F., Eickenberg, M., Gervais, P., Mueller, A., Kossaifi, J., Gramfort, A., Thirion, B., & Varoquaux, G. (2014). Machine learning for neuroimaging with scikit-learn. *Frontiers in Neuroinformatics*, *8*, 1–10. https://doi.org/10.3389/fninf.2014.00014

Arthurs, O. J., & Boniface, S. (2002). How well do we understand the neural origins of the fMRI BOLD signal? *Trends in Neurosciences*, *25*(1), 27–31. https://doi.org/10.1016/S0166-2236(00)01995-0

Assaf, Y., & Pasternak, O. (2008). Diffusion Tensor Imaging (DTI)-based White Matter Mapping in Brain Research: A Review. *Journal of Molecular Neuroscience*, *34*, 51–61. https://doi.org/10.1007/s12031-007-0029-0

Buzsáki, G., Anastassiou, C. A., & Koch, C. (2012). The origin of extracellular fields and currents — EEG, ECoG, LFP and spikes. *Nature Reviews Neuroscience*, *13*, 407–420. https://doi.org/10.1038/nrn3241

References II

Gramfort, A., Luessi, M., Larson, E., Engemann, D. A., Strohmeier, D., Brodbeck, C., Goj, R., Jas, M., Brooks, T., Parkkonen, L., & Hämäläinen, M. (2013). MEG and EEG data analysis with MNE-Python. *Frontiers in neuroscience*, *7*, 267. https://doi.org/10.3389/fnins.2013.00267

Huth, A. G., de Heer, W. A., Griffiths, T. L., Theunissen, F. E., & Gallant, J. L. (2016). Natural speech reveals the semantic maps that tile human cerebral cortex. *Nature*, *532*(7600), 453–8. https://doi.org/10.1038/nature17637

Logothetis, N. K. (2008). What we can do and what we cannot do with fMRI. *Nature*, *453*, 869–78. https://doi.org/10.1038/nature06976

Ridding, M. C., & Rothwell, J. C. (2007). Is there a future for therapeutic use of transcranial magnetic stimulation? *Nature Reviews Neuroscience*, *8*, 559–567. https://doi.org/10.1038/nrn2169

References III

Sejnowski, T. J., Churchland, P. S., & Movshon, J. A. (2014). Putting big data to good use in neuroscience. *Nature Neuroscience*, *17*(11), 1440–1441. https://doi.org/10.1038/nn.3839