Extracting Features from/for "other" data

London, PRoNTo course

May 2018

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Overview

- Introduction
- PET data
- Diffusion-weighted MRI
- MEG/EEG data
- Conclusion

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Data format

Input for (current version of) PRoNTo:

- any data in NIfTI image format
- in 2D or 3D format

Goal:

If not already an image, turn data into a NIfTI image!

(Future: other formats accepted)

https://nifti.nimh.nih.gov/

Overview

- Introduction
- PET data
  - Principles
  - Radiotracers and applications
- Diffusion-weighted MRI
- MEG/EEG data
- Conclusion

PET imaging

- Based on radioactive decay of radiotracer
- Radiotracer tracks a specific physiological process in the brain
- Typically clinical applications, e.g. Alzheimer or Parkinson diseases (AD or PD)
- 1 (or few) scan(s) per subject

➔ "Subject prediction" problem

FDG-PET image

Fluorodeoxyglucose (FDG) PET image

➔ Local glucose in-take

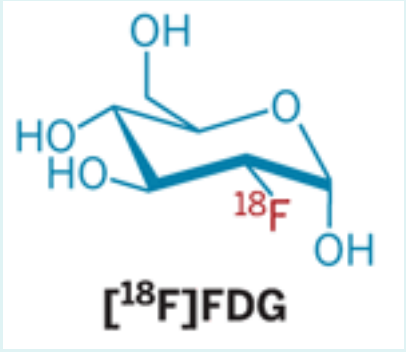
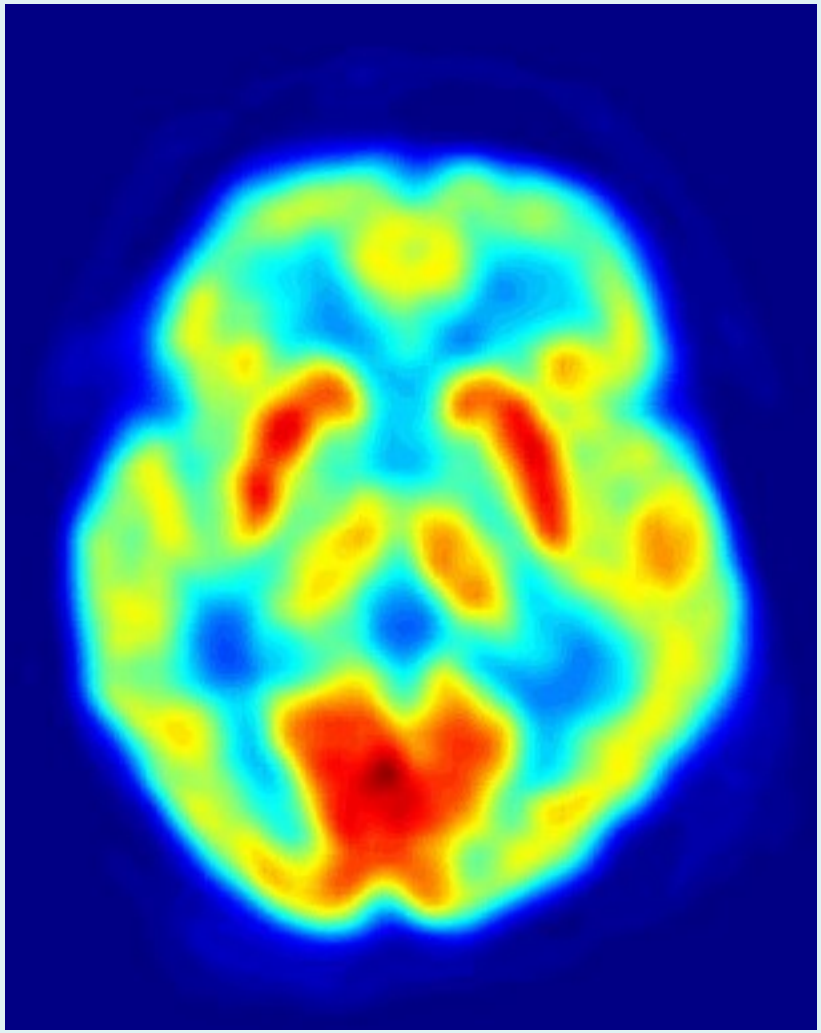
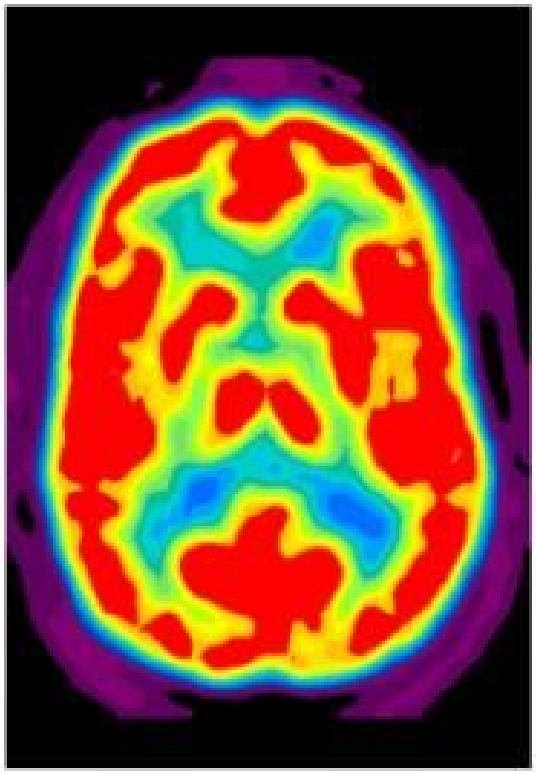


Image characteristics:

- physiological information
- blurry, i.e. limited anatomical information

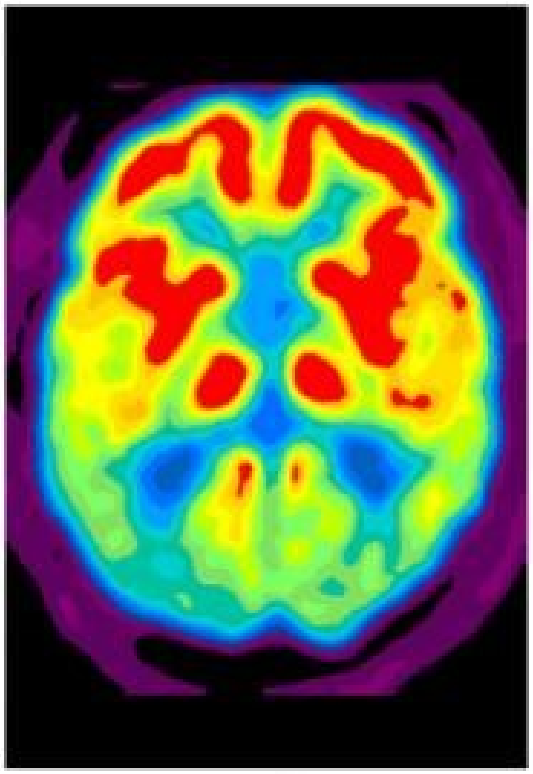


FDG-PET application



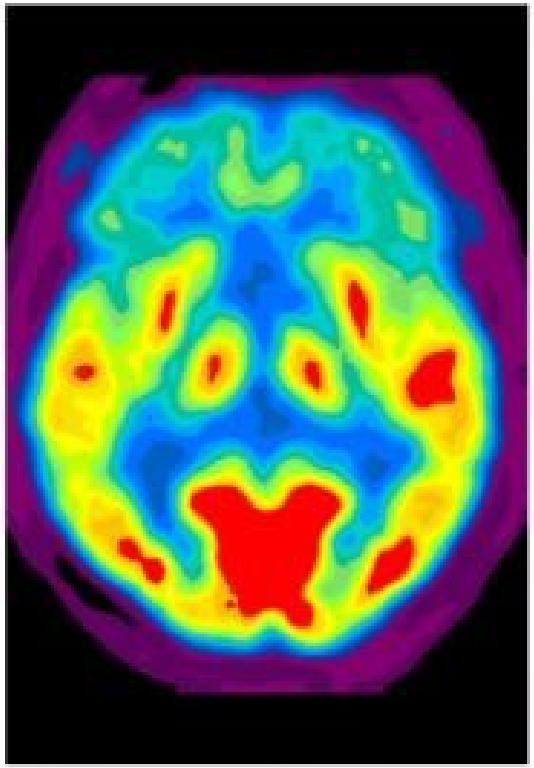
Normal

Consistent metabolic activity throughout the cerebral cortex



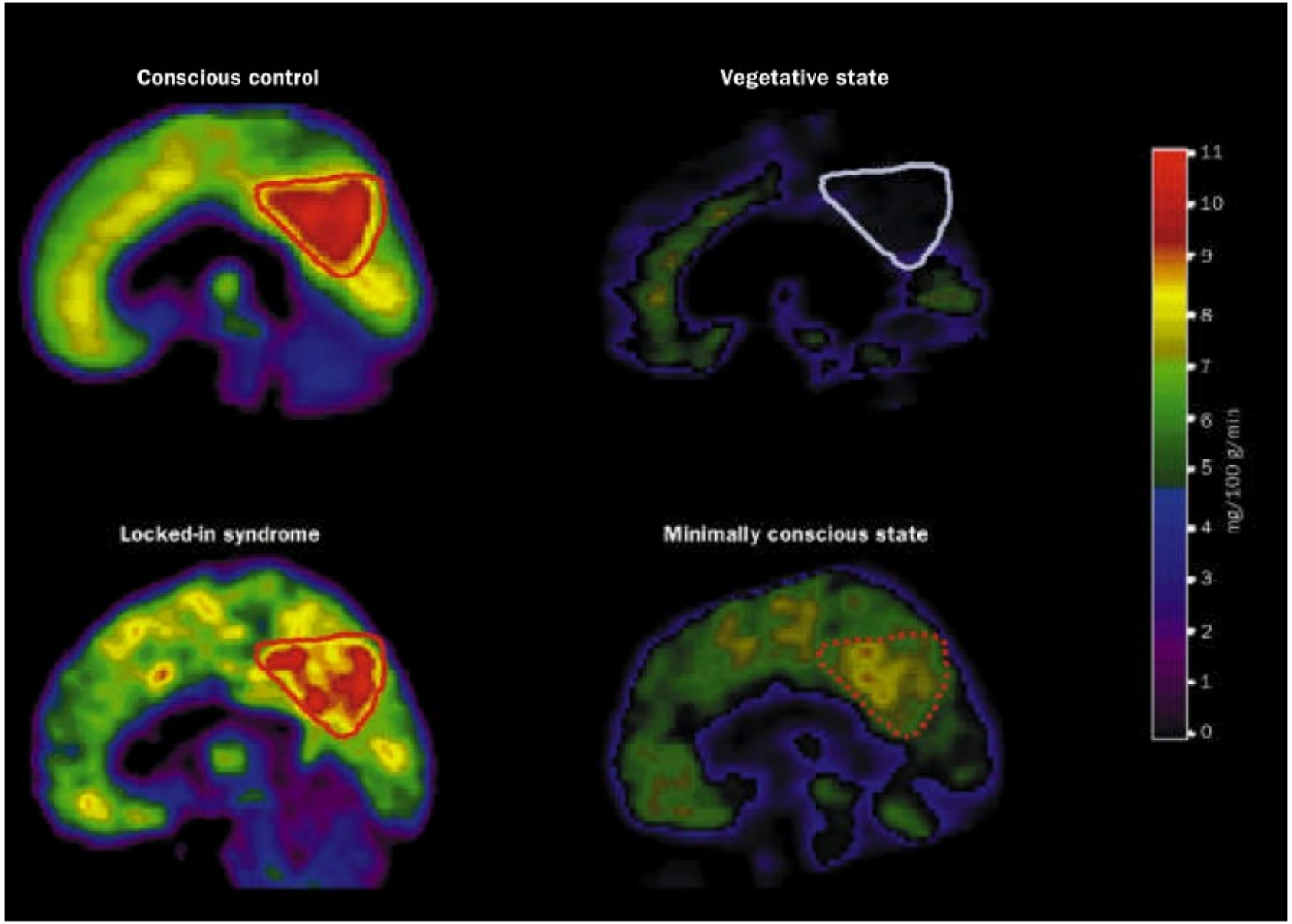
Alzheimer's Dementia

Reduced metabolic activity in the temporal and parietal lobes



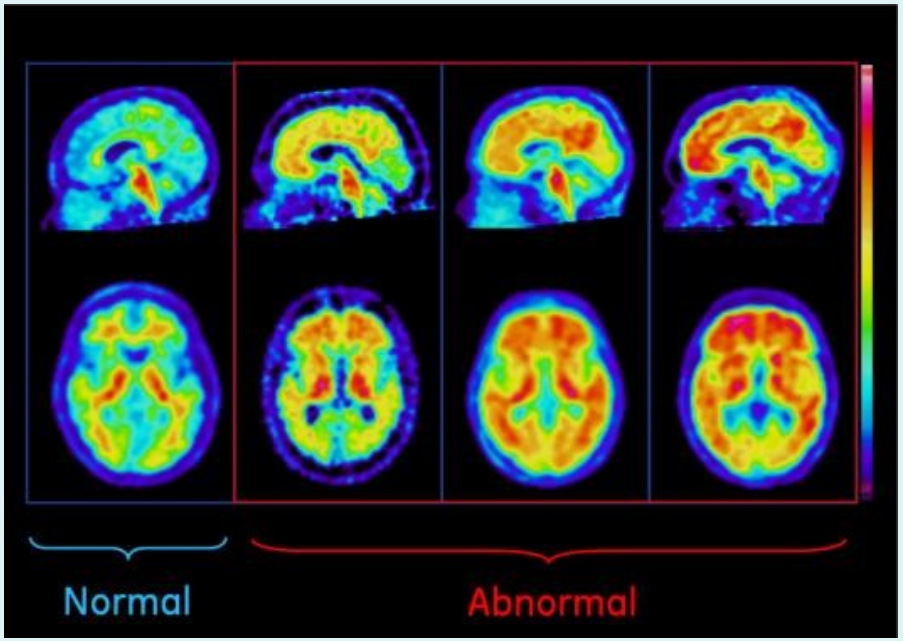
Frontal Lobe Dementia (Pick's Disease)
Reduced metabolic activity in the frontal lobe

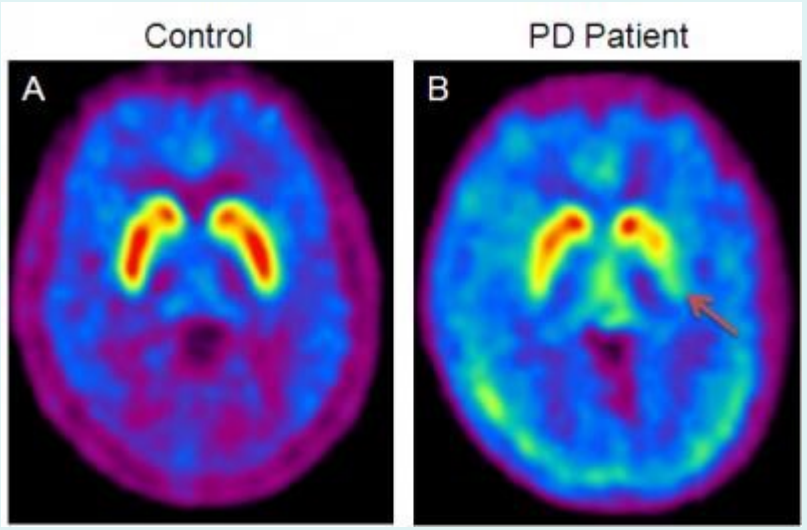
FDG-PET application



Other radiotracers

- Flutemetamol plaque beta-amiloid ➔ AD
- Fluorodopa for dopaminergic system ‘nigrostrial tractus’ ➔ PD
- Fallypride antagonist to dopamine receptors D2/D3 ➔ PD





PET imaging specificities

Things to worry about:

- Spatial alignment, i.e. normalization
  ➔ easier with sMRI
- Intensity scaling and quantitative values
  ➔ local/extended disease effect ?
- Region of interest
  ➔ limited “activated” area, still an “image”?

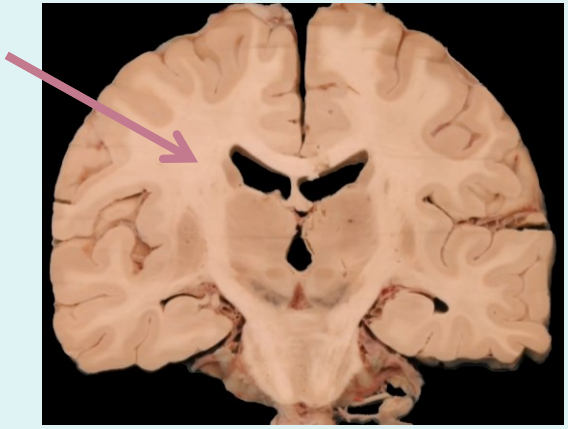
Overview

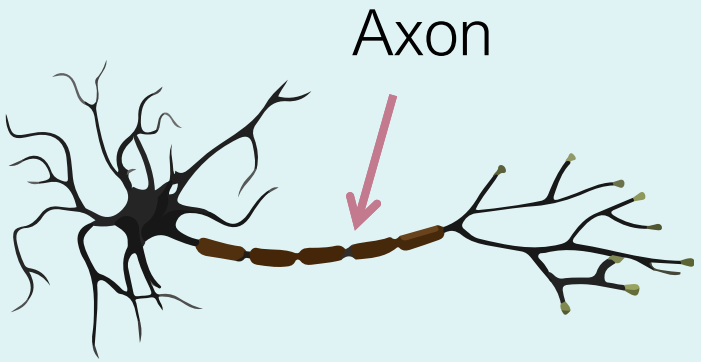
- Introduction
- PET data
- Diffusion-weighted MRI
  - basics
  - DTI & NODDI
  - connectomics
- MEG/EEG data
- Conclusion

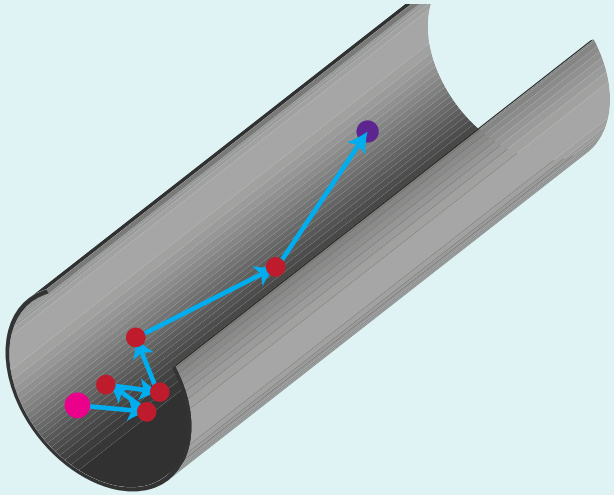
DW-MRI

Signal $\propto$ water diffusion in brain tissue.

White matter





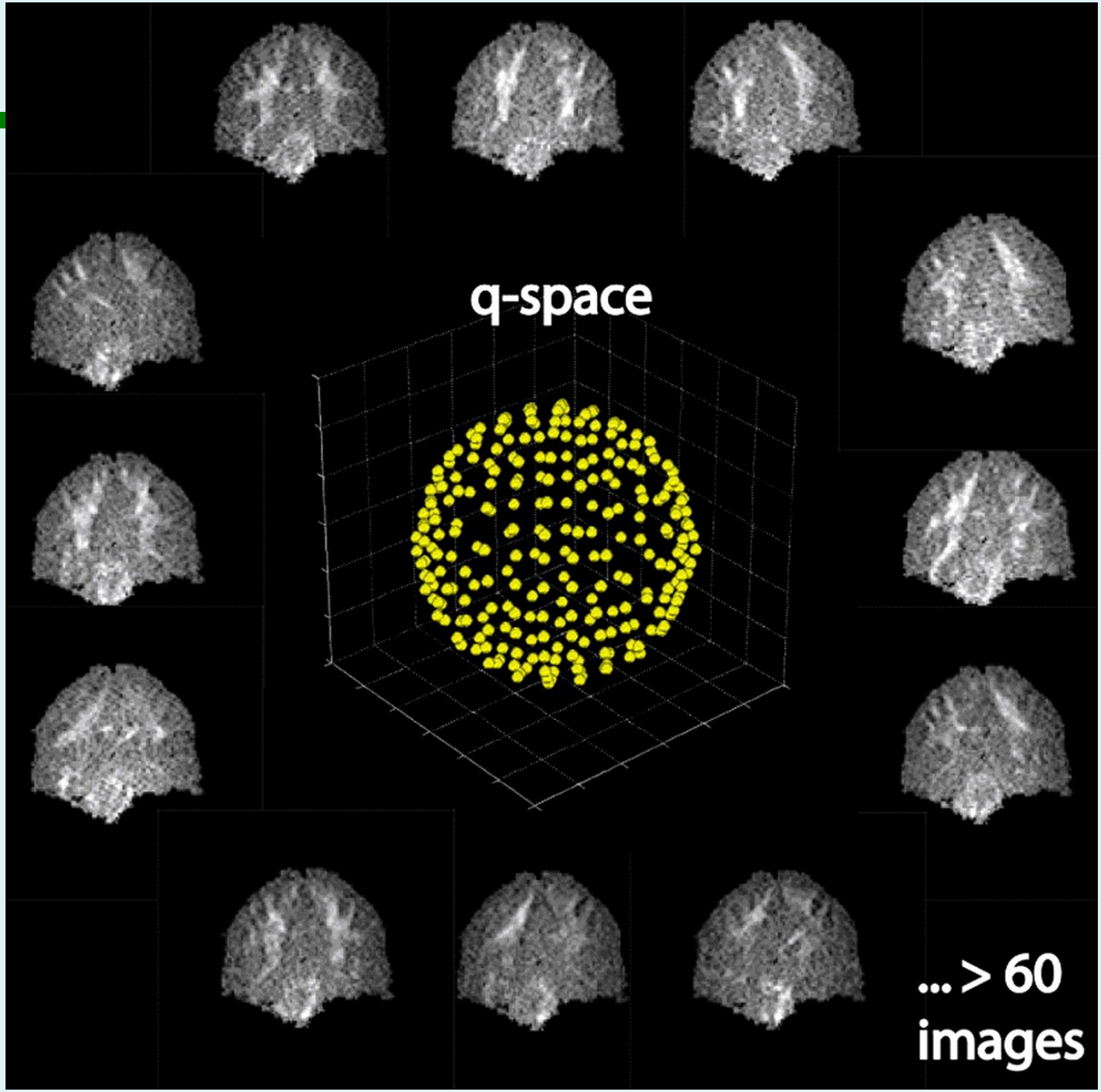


DW-MRI

Signal $\propto$ water diffusion in brain tissue.

Raw data:

- N (>20) images
- 1 image = signal attenuation due to water-diffusion in 1 direction
- some images without diffusion (ref. signal)


q-space
... > 60
images

DW-MRI

Signal $\propto$ water diffusion in brain tissue.

Raw data:

- N (>20) images
- 1 image = signal attenuation due to water-diffusion in 1 direction
- some images without diffusion (ref. signal)

➔ Fit a model to the data

➔ One (or few) parametric image(s)

➔ "subject prediction" problem

Diffusion Tensor Imaging, DTI

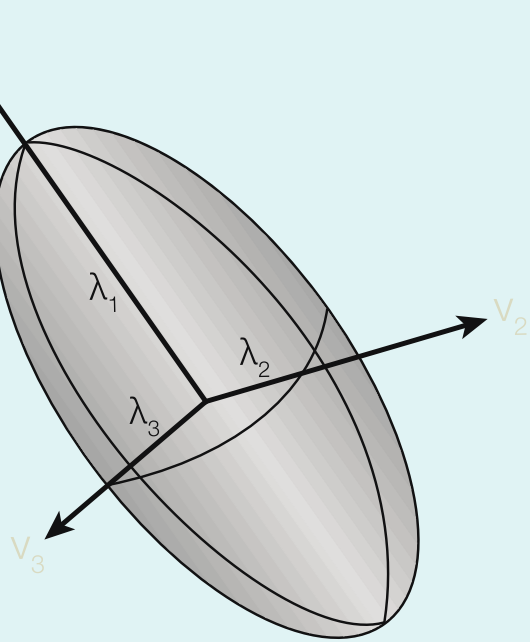
Fit a tensor model at each voxel

➔ 6 parameters per voxel

$$\begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{xy} & D_{yy} & D_{yz} \\ D_{xz} & D_{yz} & D_{zz} \end{bmatrix}$$

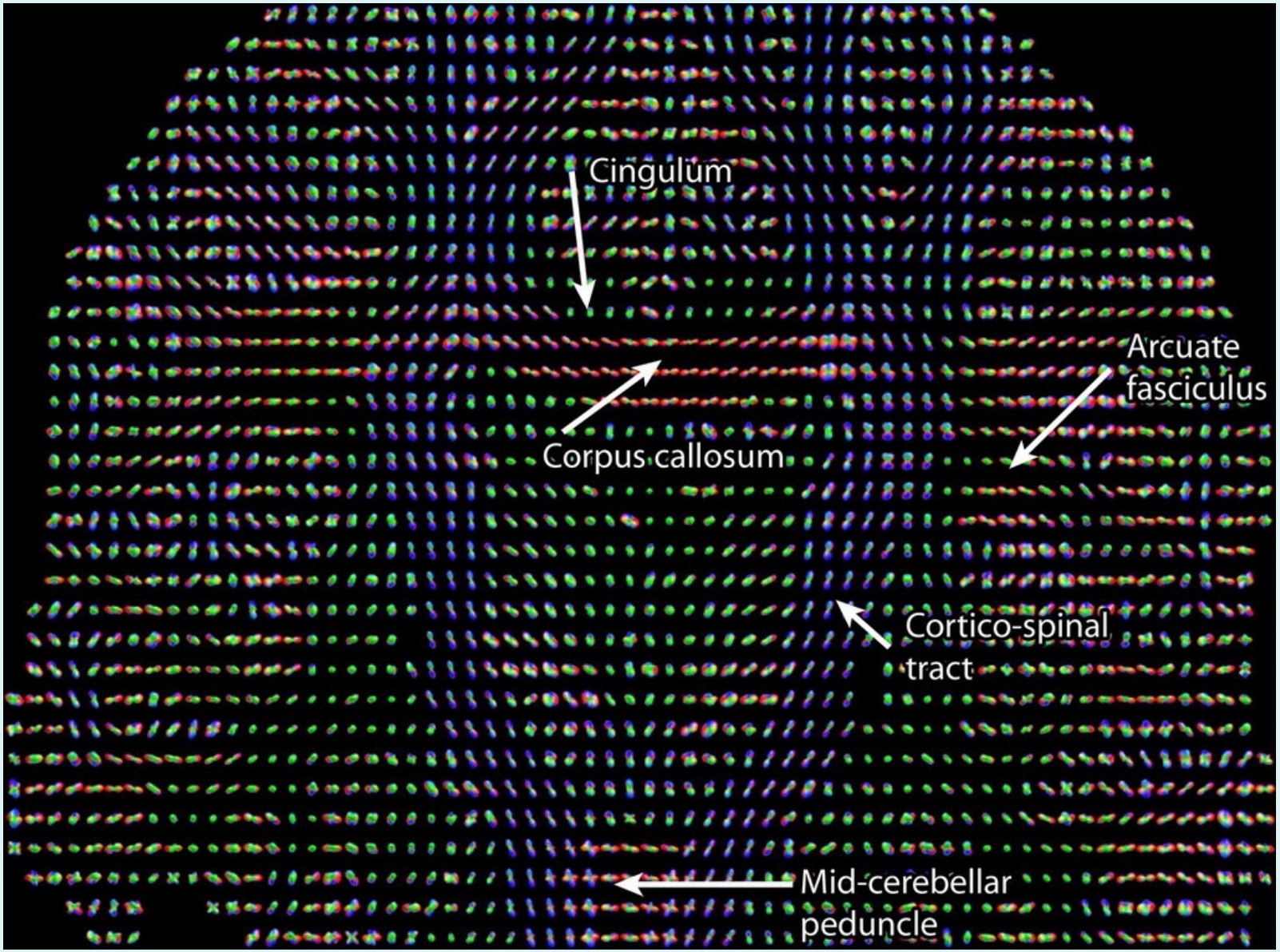
Derive scalar map(s)

➔ “interpretable” values



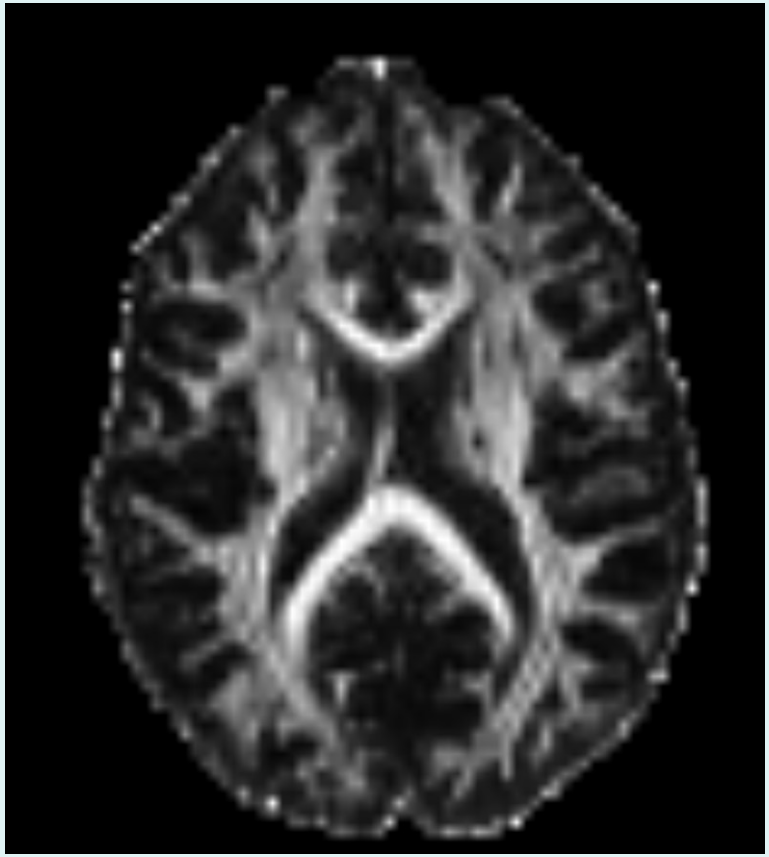
Tensor ellipsoid

Other models…



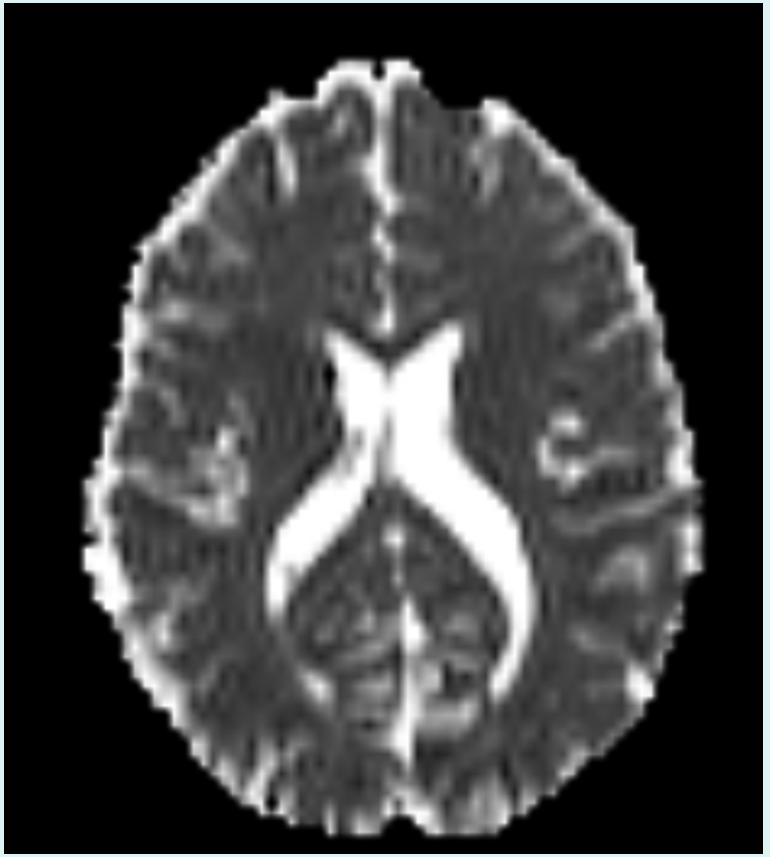
Diffusion Tensor Imaging

Fractional anisotropy



Reflects directionality
of diffusion

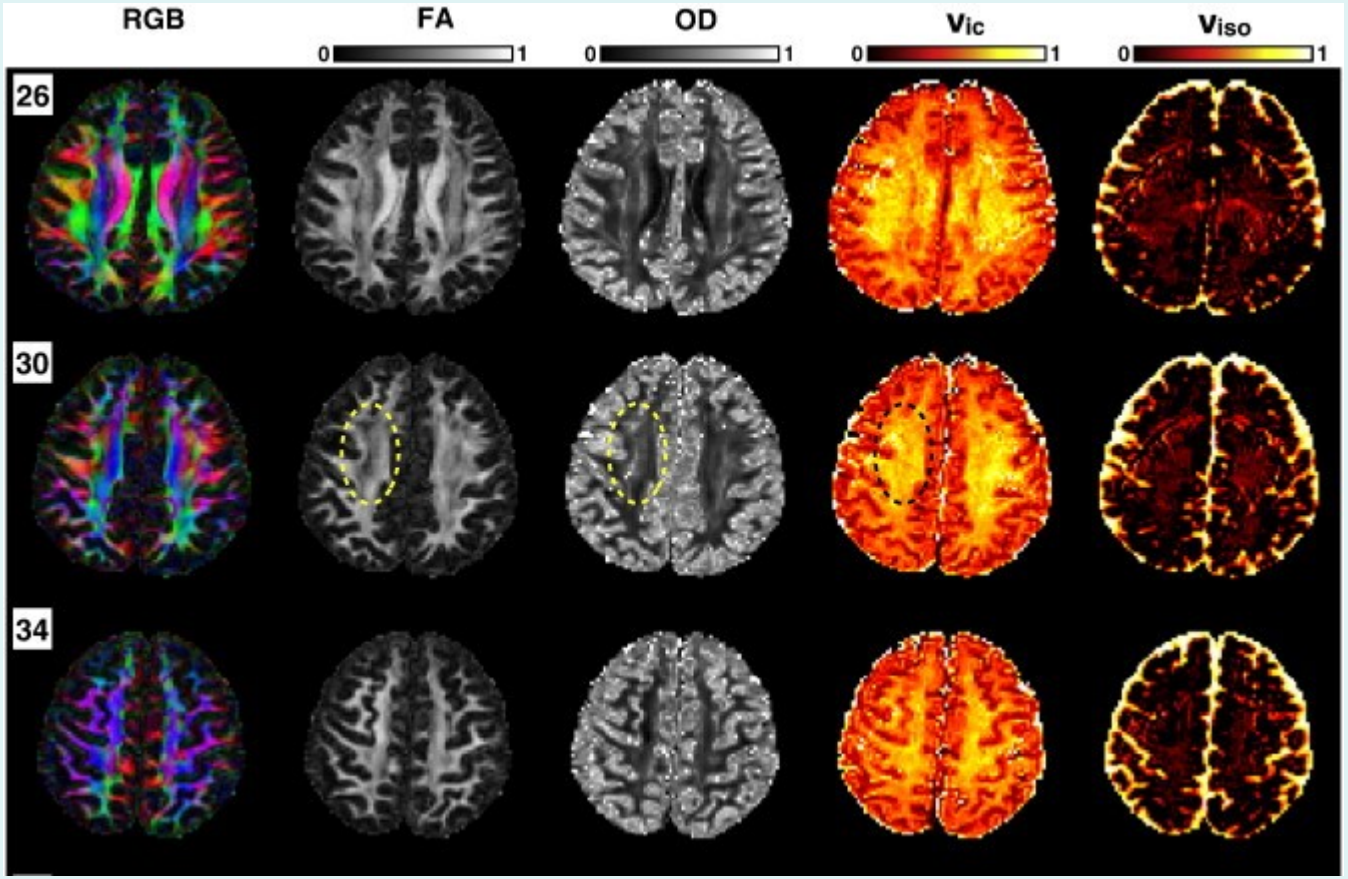
Mean diffusivity



Reflects strength
of diffusion

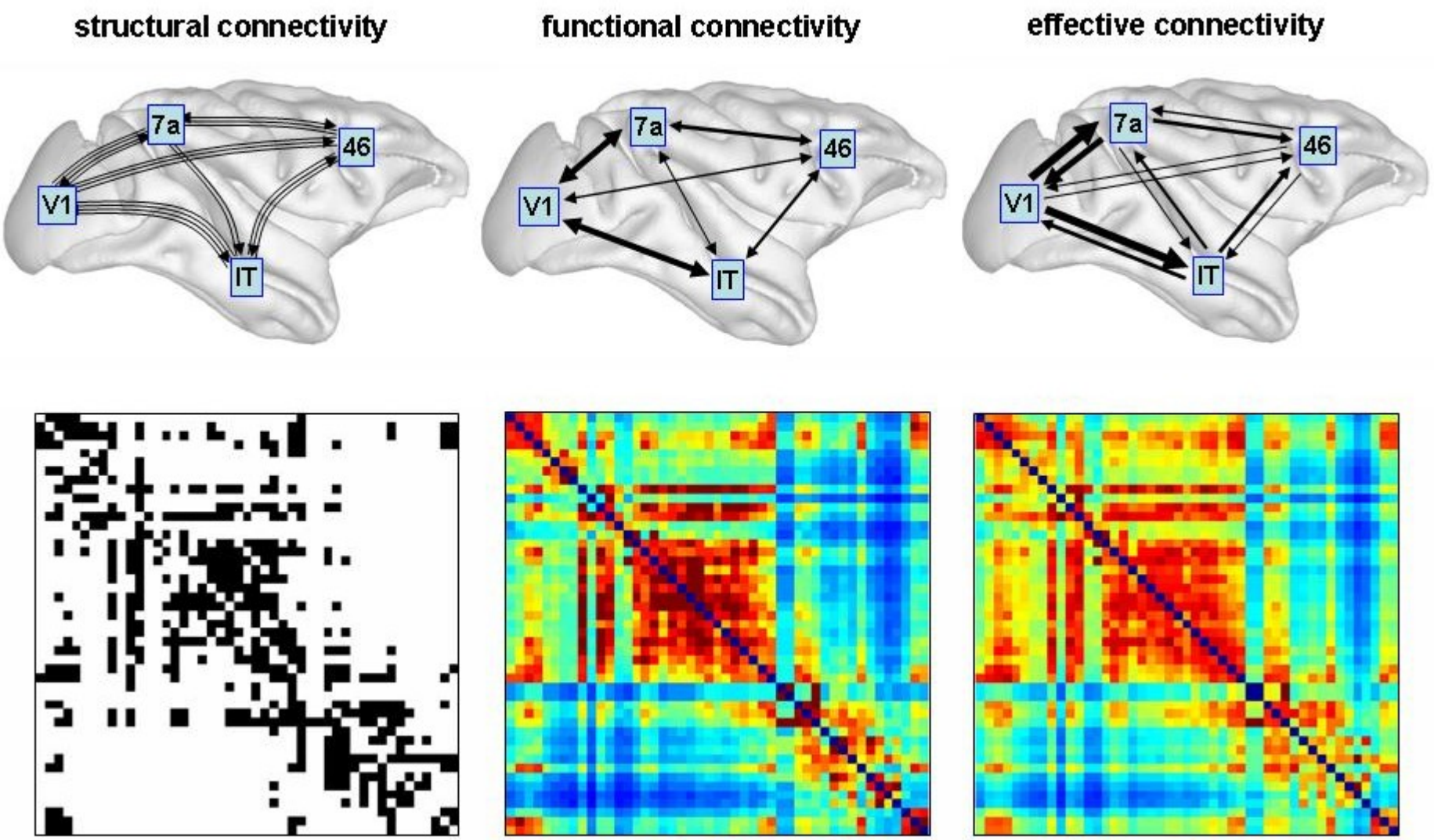
Neurite orientation dispersion and density imaging (NODDI)

RGB-encoded principal direction $\boldsymbol{\mu}$, FA, orientation dispersion index OD, intra-cellular volume fraction v_{ic}, and isotropic (CSF) volume fraction v_{iso}



G. Zhang et al., Neuroimage, 2012

Connectomics



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  - Data representation
  - Experimental considerations
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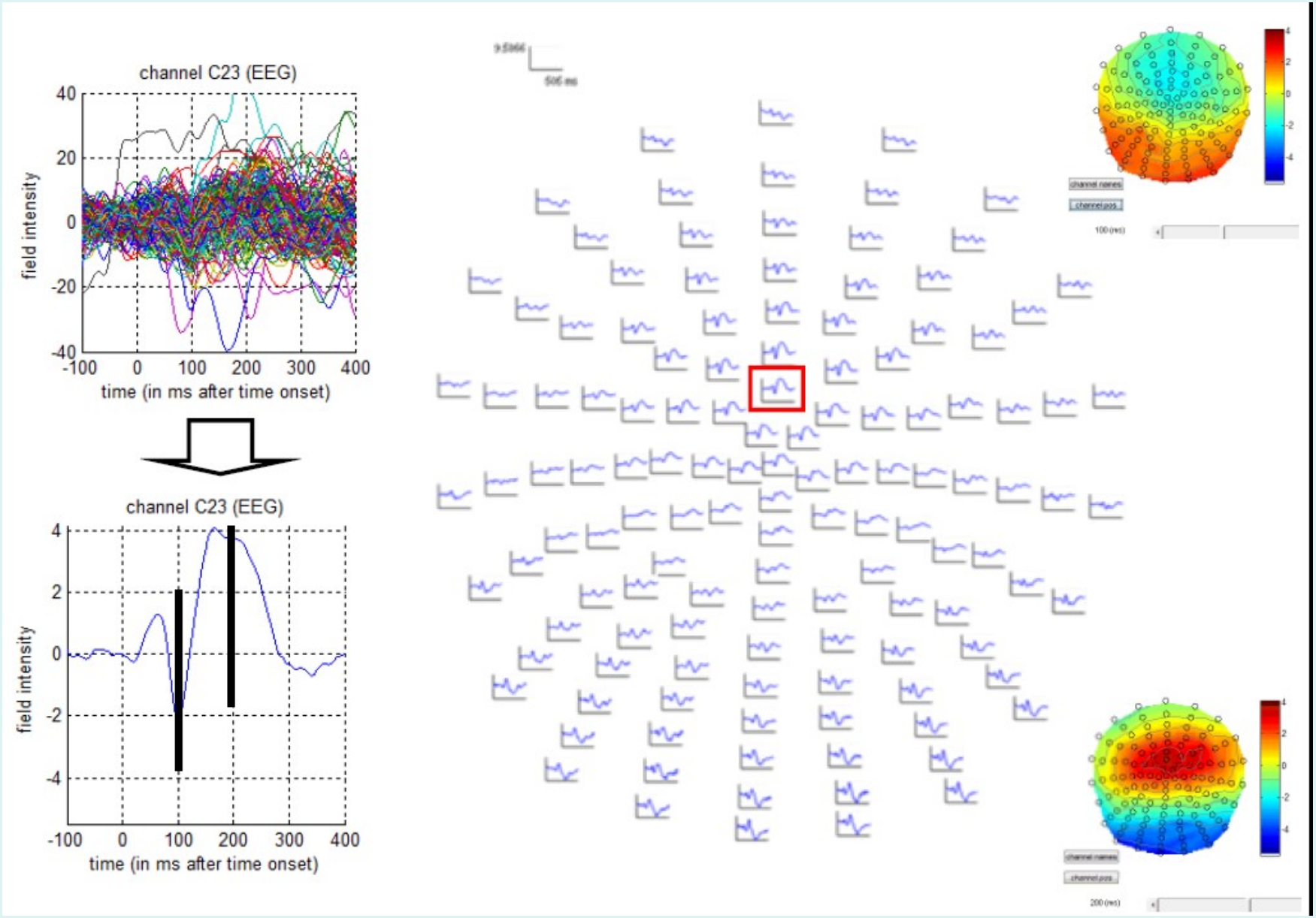
MEG/EEG data

Similar questions to fMRI:

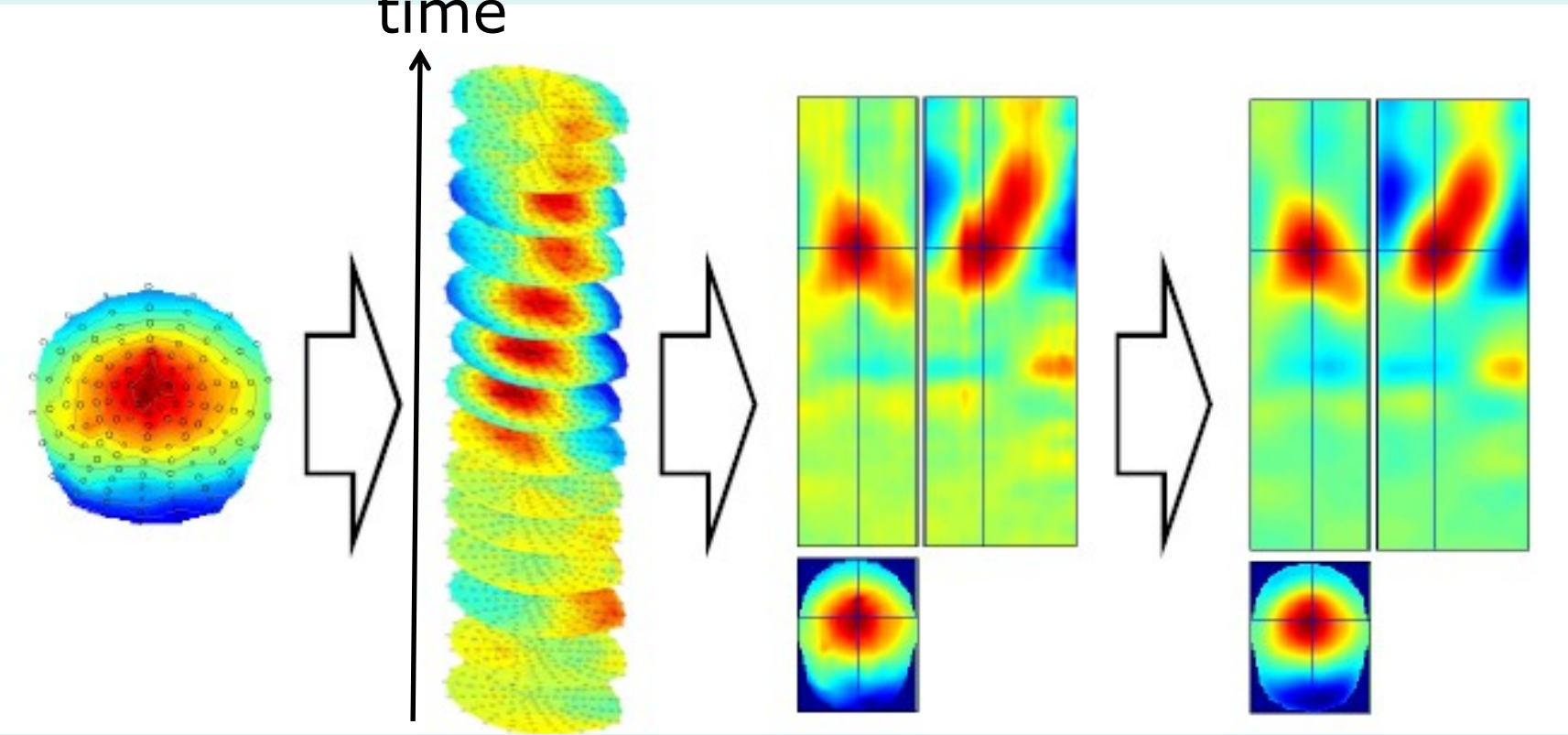
- Brain decoding problem, based on individual event response
- Subject prediction problem, based on summary maps

➔ turn MEG/EEG data into images!

EEG data example



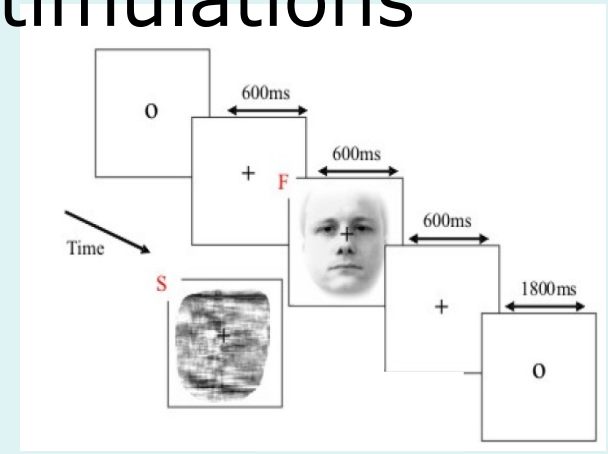
Time x scalp image



(SPM does it for you…)

Example of experiment

ERP, 2 conditions with visual stimulations "scrambled vs. faces".



Single subject:

➔ for each stimulus, "was the subject seeing a face or a scrambled image ?"

Multiple subjects:

➔ with average ERP per subject, "was the subject in group A or group B?"

Other ideas

- Contrast conditions

➔ Specific effect of interest

- Use time-frequency decomposition

➔ 3D image `channel x time x frequency`

- For resting EEG/MEG, use synchrony measure over `channel x time`

- …

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Conclusions

1 sample = 1 image

- What is your question of interest?
- At what level of inference ?
- What is the experimental design?
- How much data is/will be available?

- After “preparing” my data, how can I turn them into images?

Thank you for your attention!

Any question?