Analysis of Human Brain Connectivity from Multi-Modal Imaging

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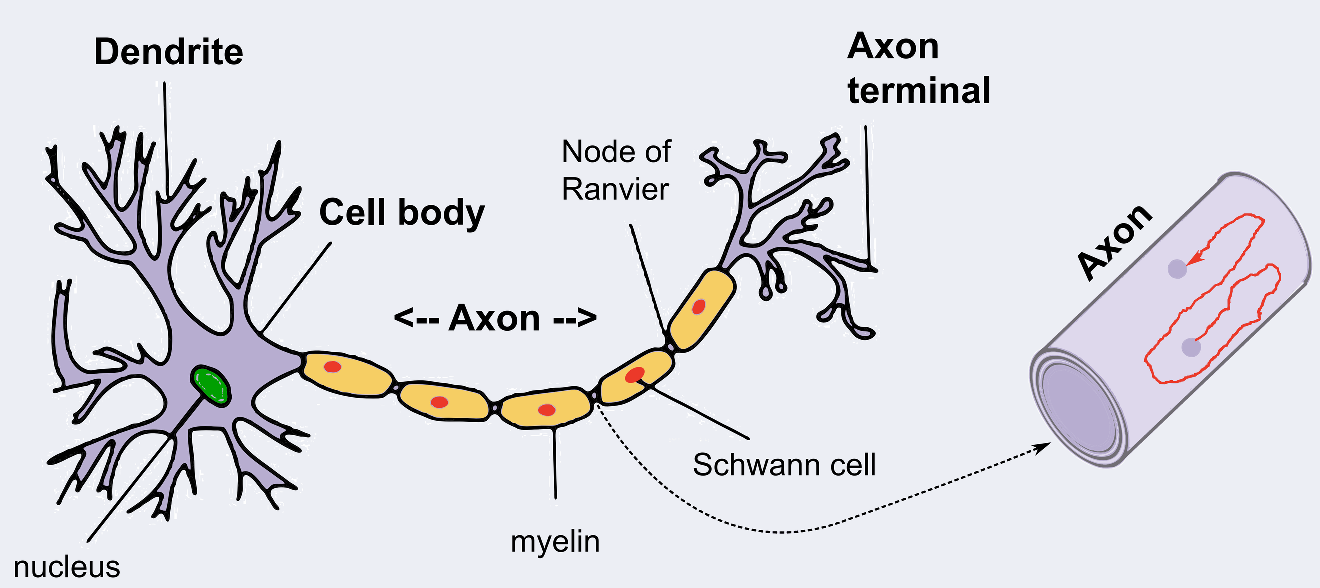
Introduction

- Human brain is arguably the most complex system in the universe.
- Finding the connections between various regions of the cortex helps to
  - understand the property of the brain under cognitive tasks such as memory and language.
  - understand the biological basis of psychiatric disorders such as Autism and Attention Deficit Hyperactivity Disorder (ADHD).
- We use two imaging techniques to measure the brain connectivity: Diffusion Tensor Imaging (DTI) and functional MRI (fMRI) .

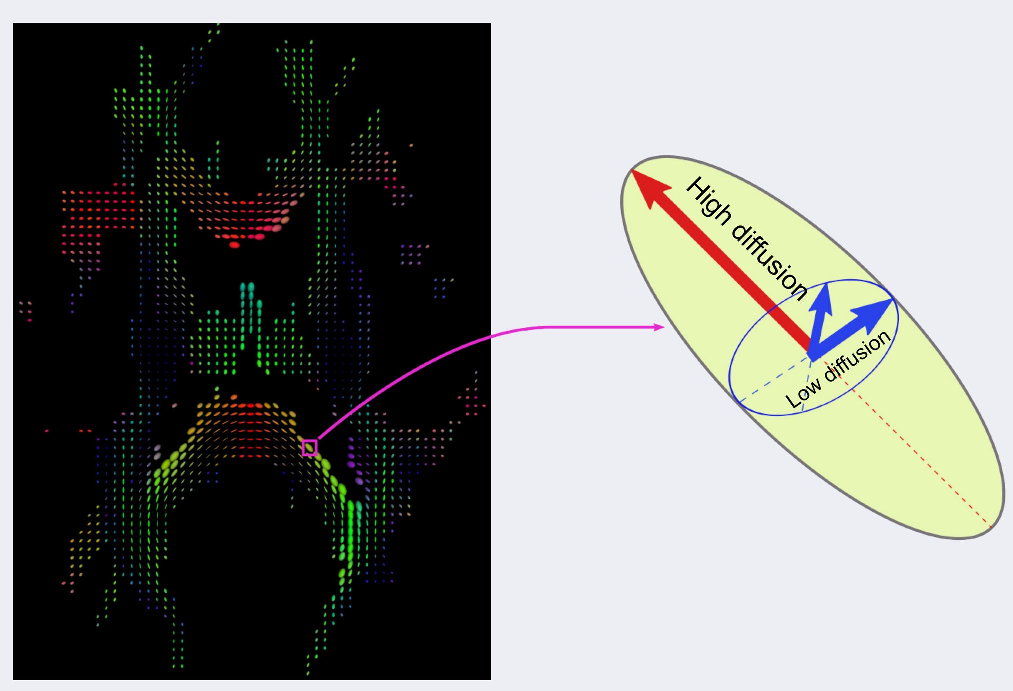
Diffusion Tensor Imaging

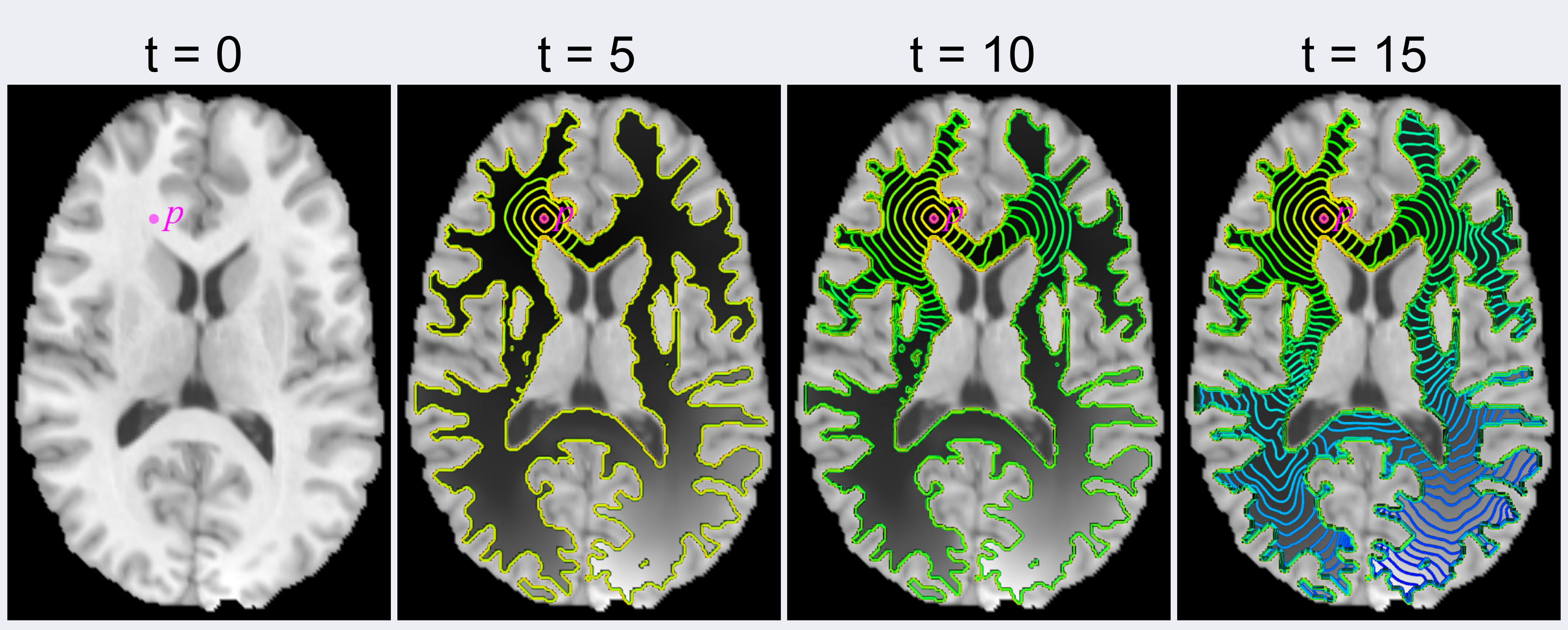


Neuros are connected by axons in white matter.

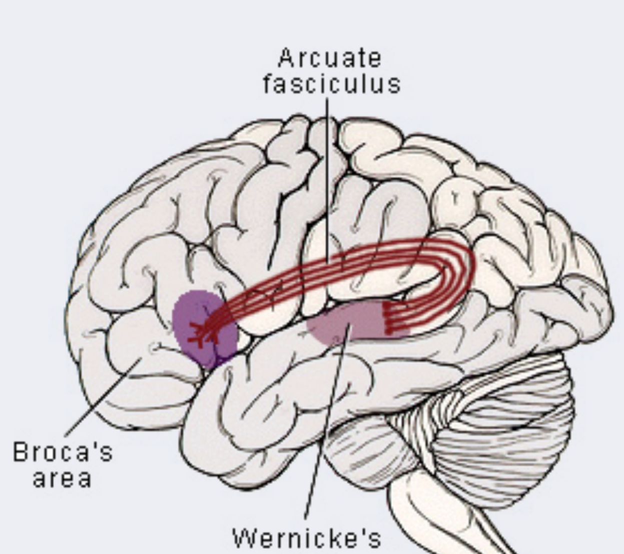
DTI is contructed by measuring the water diffusion inside axons.

Each voxel of DTI is visualized by an ellipsoid.



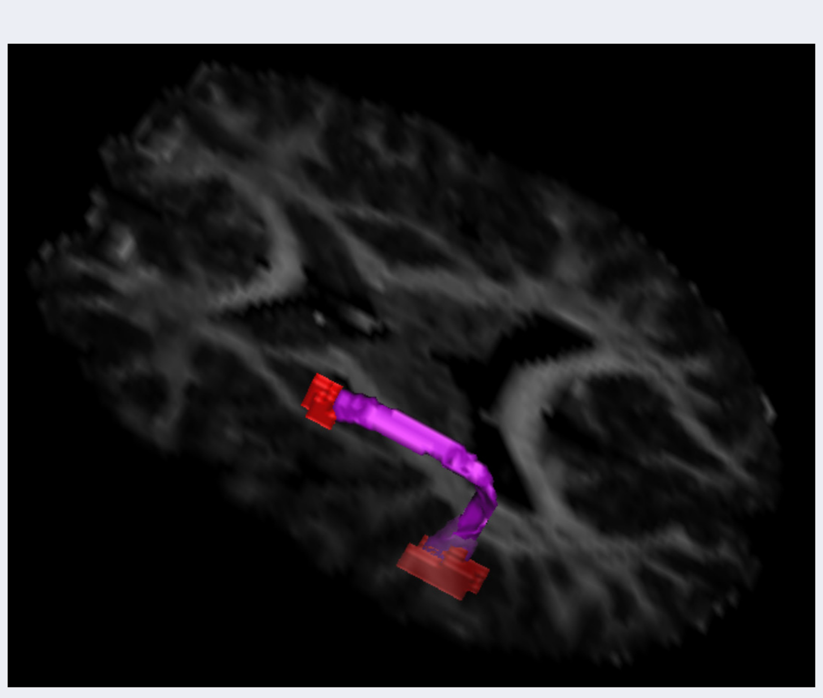


Starting from point p, we compute a timeofarrival function and this function can be used to represent the probability of the brain connectivity.

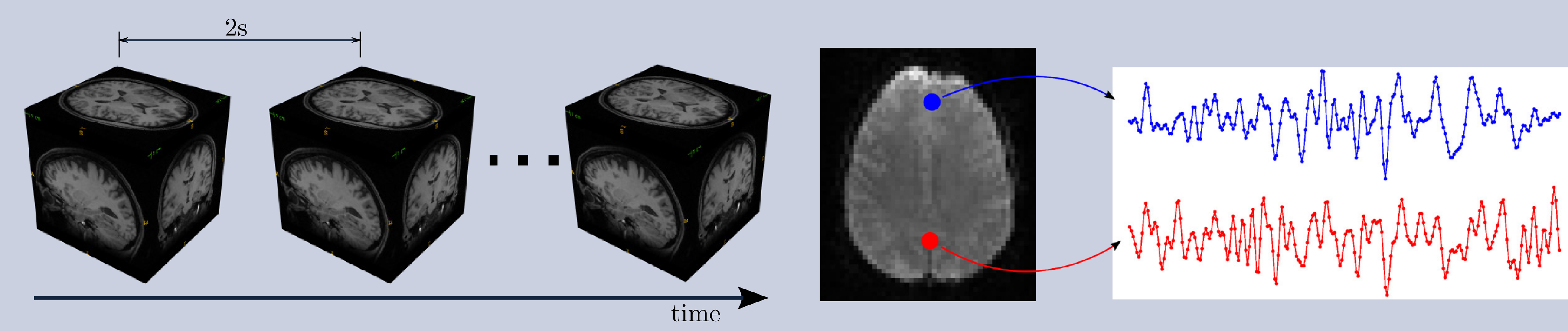


- A key diagnostic feature of autism is impairment in communication
- The arcuate fasciculus is a white matter tract crucial in language

- Is the arcuate fasciculus different in autism?
- Extract arcuate fasciculus automatically. (Joint work with Janet Lainhart from Dept. of Psychiatry).

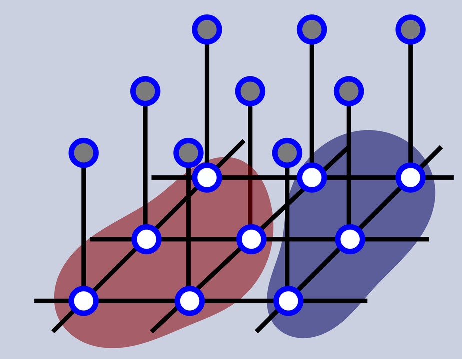


Functional MRI

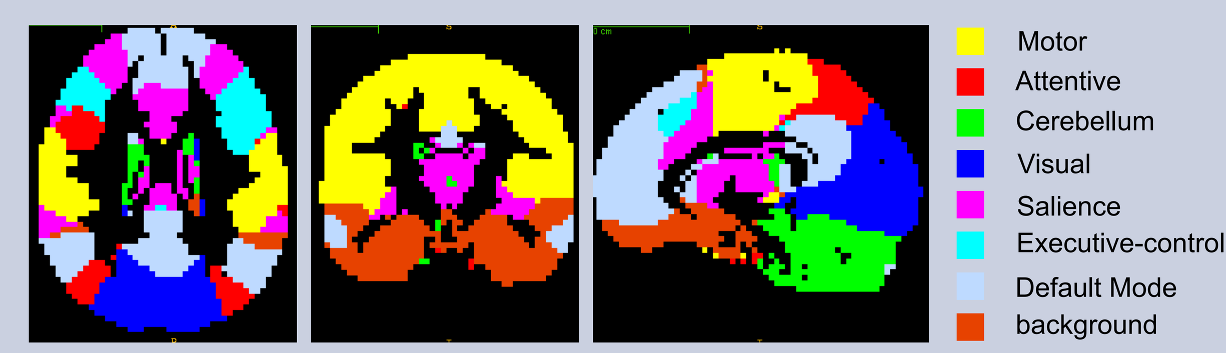


In resting-State functional MRI, subjects lie in the scanner but do not perform any cognitive task. The singal changes represent the intrinsic activity of the brain, ranther than the external stimuli.

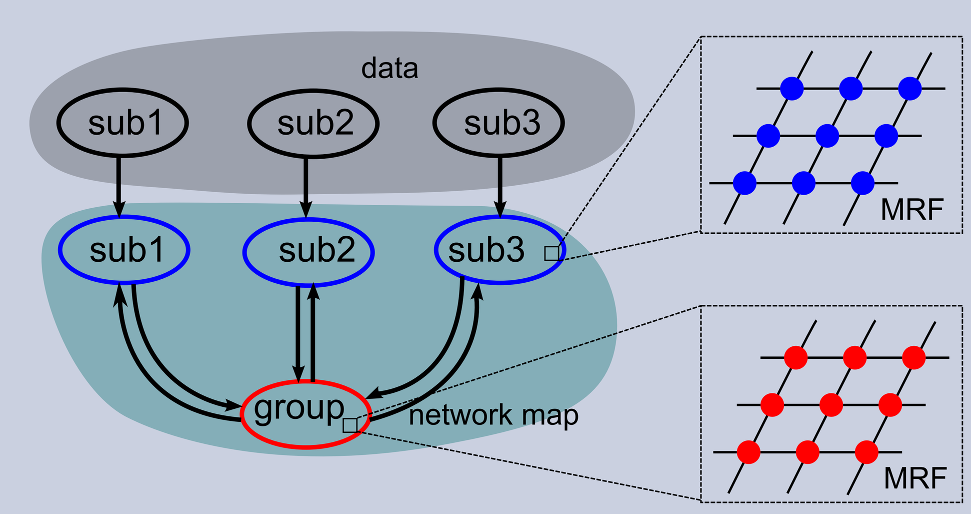
Functional connectivity is measured by linear correlation between the time courses of two voxels, i.e. how they are synchronized over time.



Segmentation of fMRI image based on a generative model.

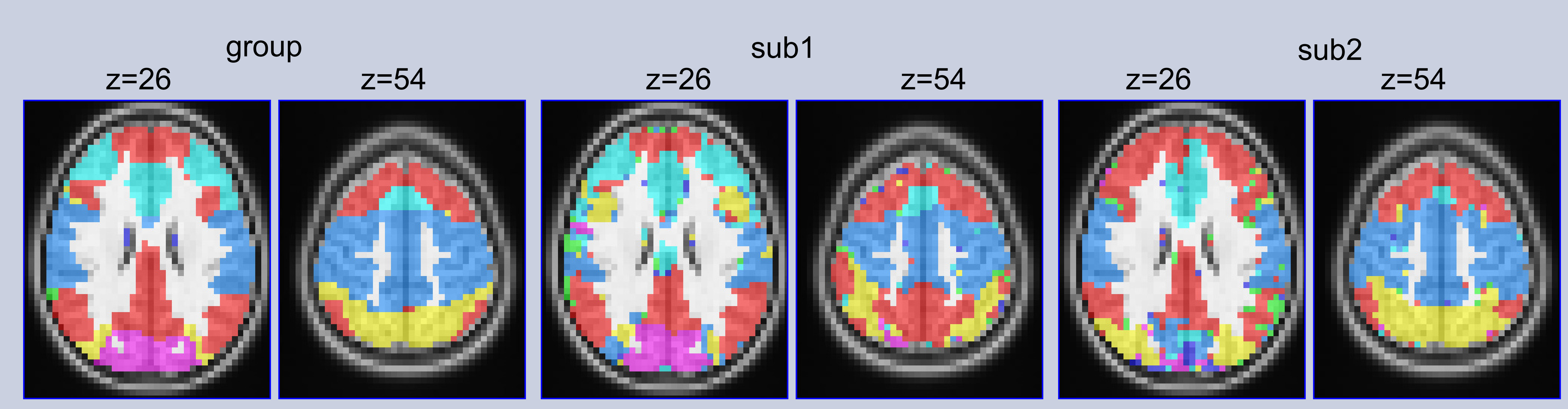


The spatial patterns of the clusters match the known functional networks.

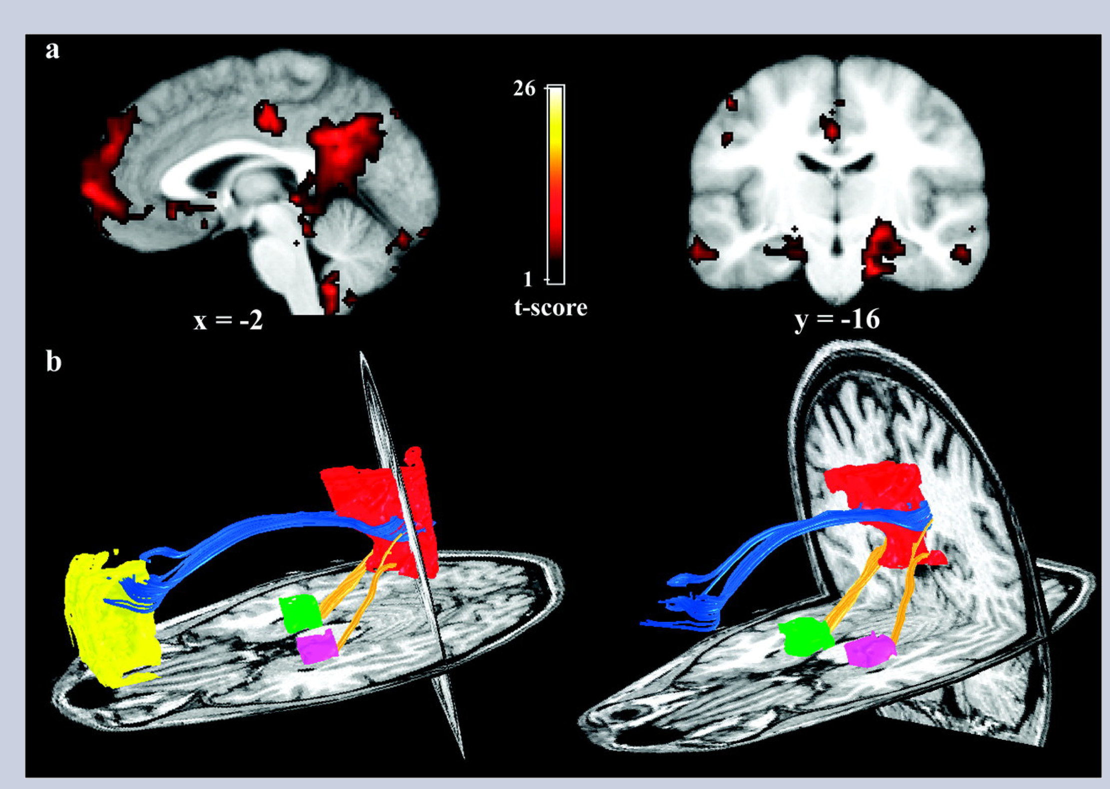


What about a group of subjects? A hierarichical model helps.

- Adding the links between group and subjects.
- The within-subject spatial coherence is represented by Markov Random Field.



Functional networks found from 66 health control subjects of ADHD dataset.



Fusion of DTI and fMRI helps deeper understanding of brain network.

Source: Greicius, Cerebral Cortex, 2009.