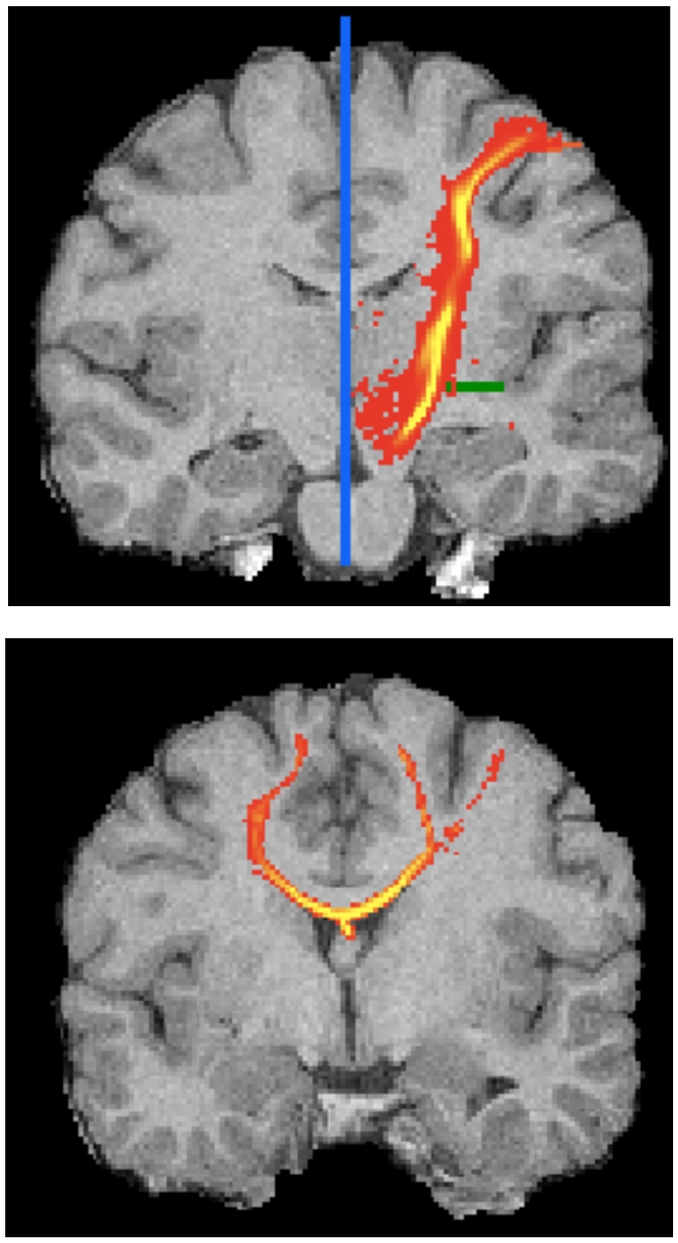
ProbtrackX outputs

Known white matter tracts

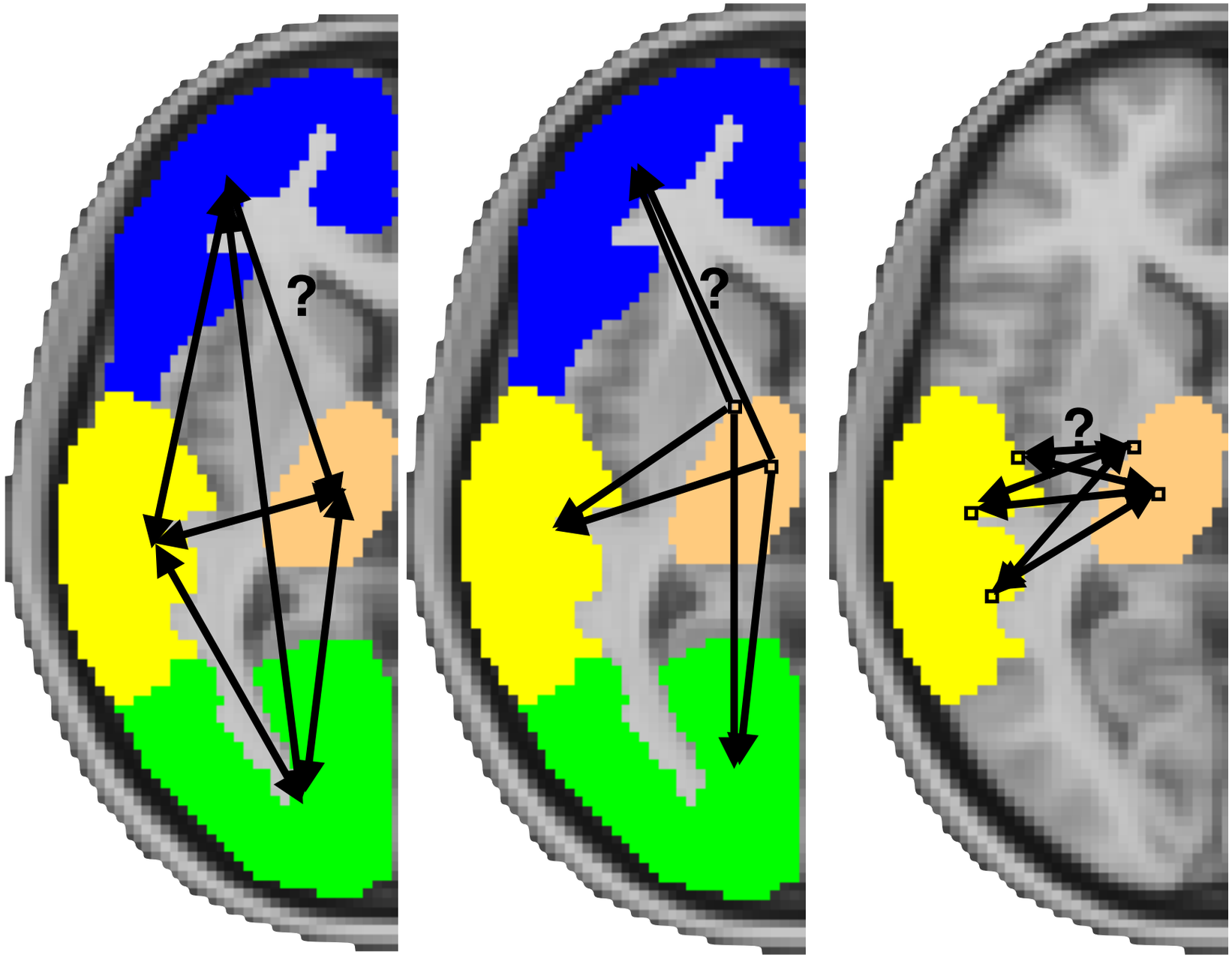


Connectivity matrices

ROI by ROI

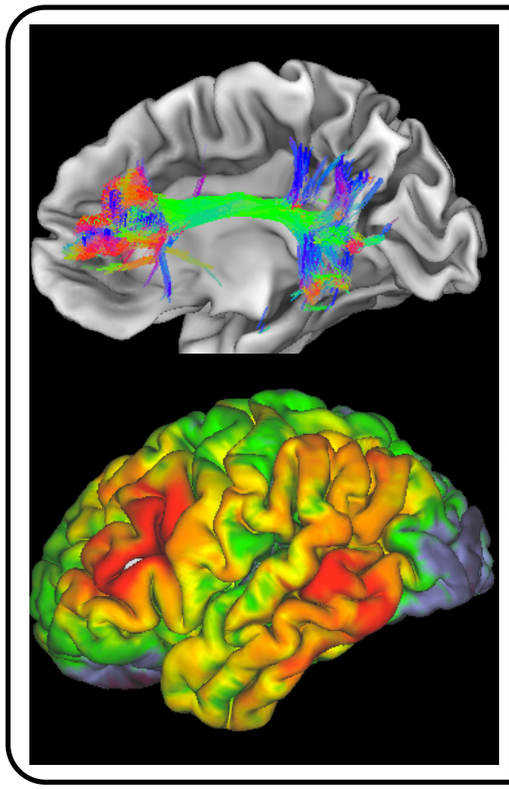
voxel by ROI

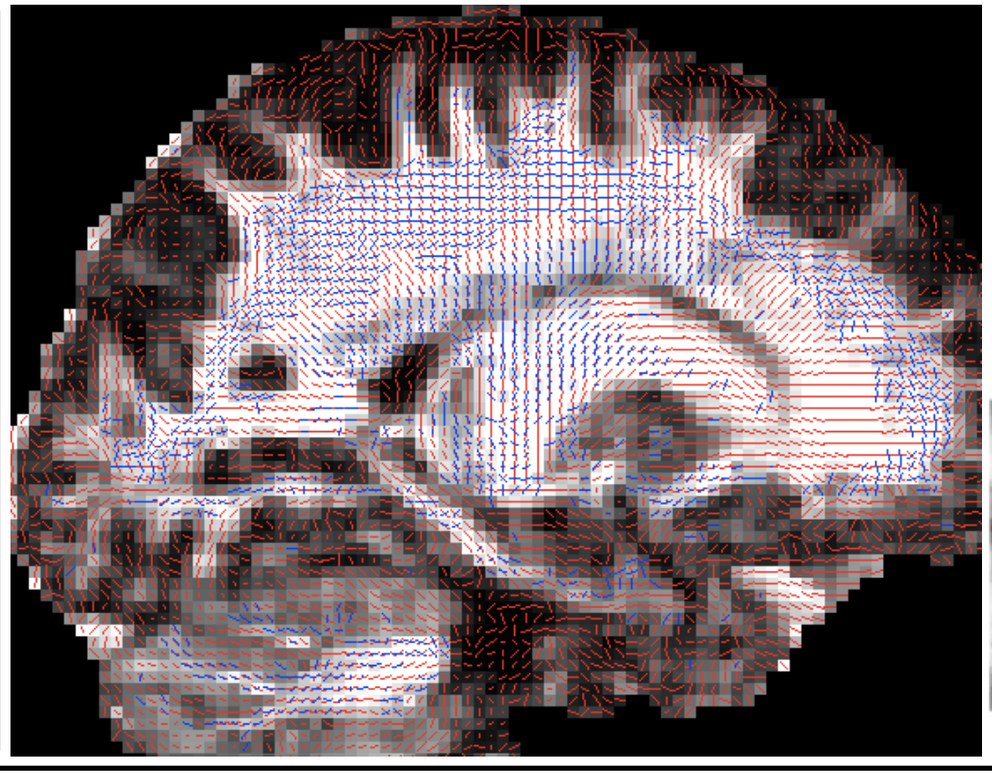
voxel by voxel

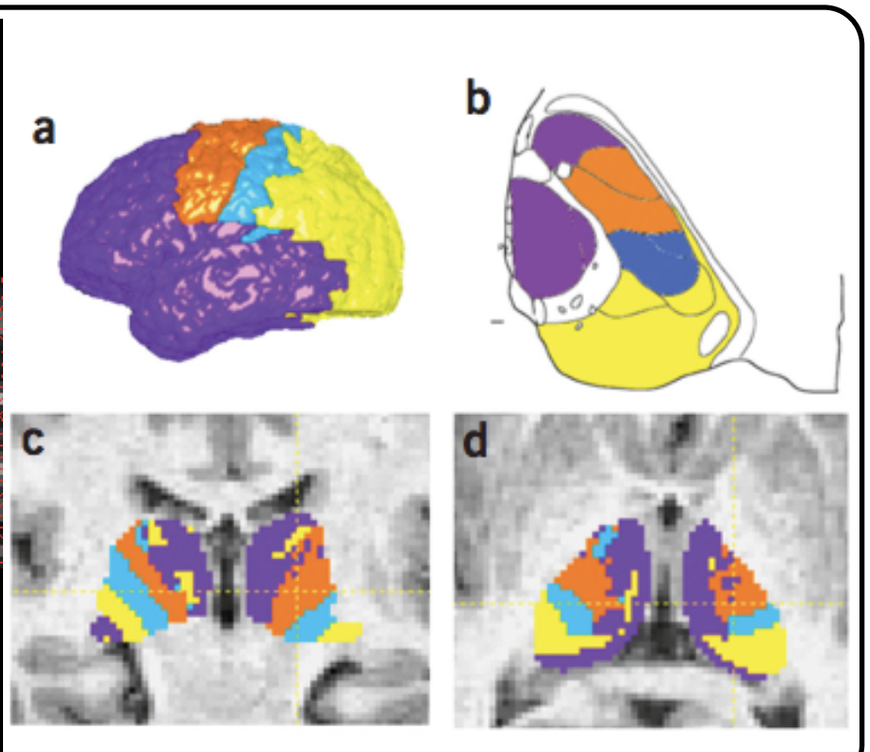


Diffusion Tractography

- Goal of tractography
- Estimating Fibre Orientations - BEDPOSTX
- Probabilistic Tractography - PROBTRACKX
- ProbtrackX outputs
- Tractography limitations







What is a quantitative measure of connectivity?

- Number of axons connecting 2 areas?
- Proportion of axons from a seed that reach a target?
- "Integrity" of the connecting white matter …
  - Effective conductivity?
  - Degree of myelination?
  - Packing density?
- What are we measuring?
  - The probability that the **dominant** path through the diffusion field passes through this region.

Connection Probabilities

- They may reflect "*Connection Strength*"

- But they do also reflect other uninteresting factors, such as:

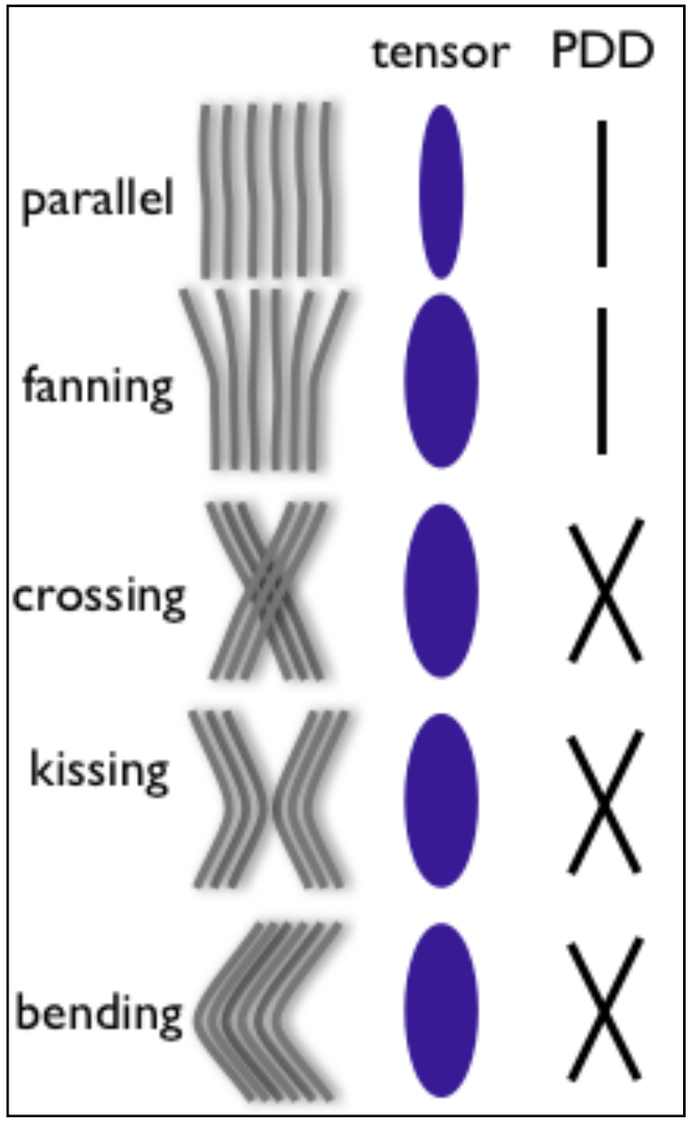
  Connection length: Longer connections have smaller probability than shorter ones

  Geometric complexity: Probabilities of connections that go through regions of complex structure will be smaller than connections than go through more coherent regions

  Resolution of the spatial grid: Probabilities change if we change the size of "bins" for displaying the spatial histogram

Can we trust tractography?

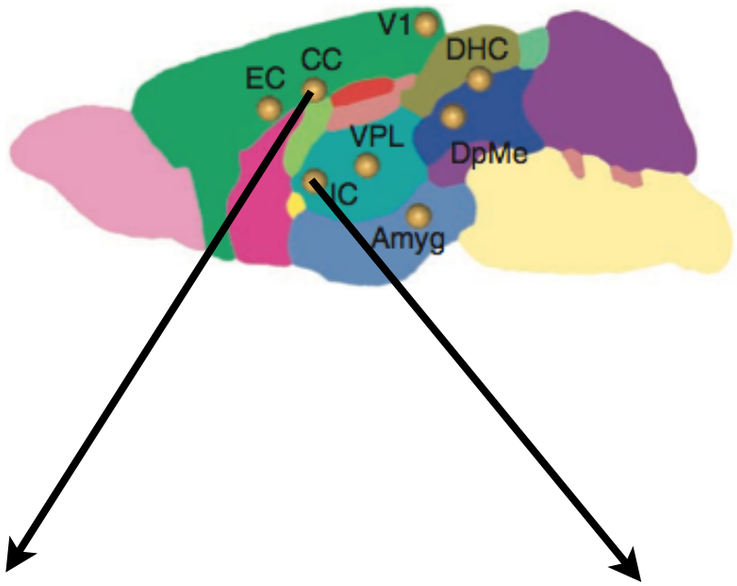
Is the direction of least hindrance to diffusion a good proxy for fibre orientation?

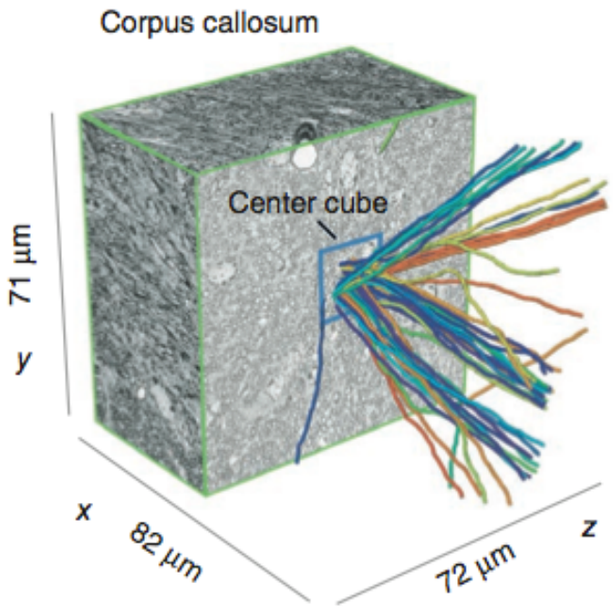


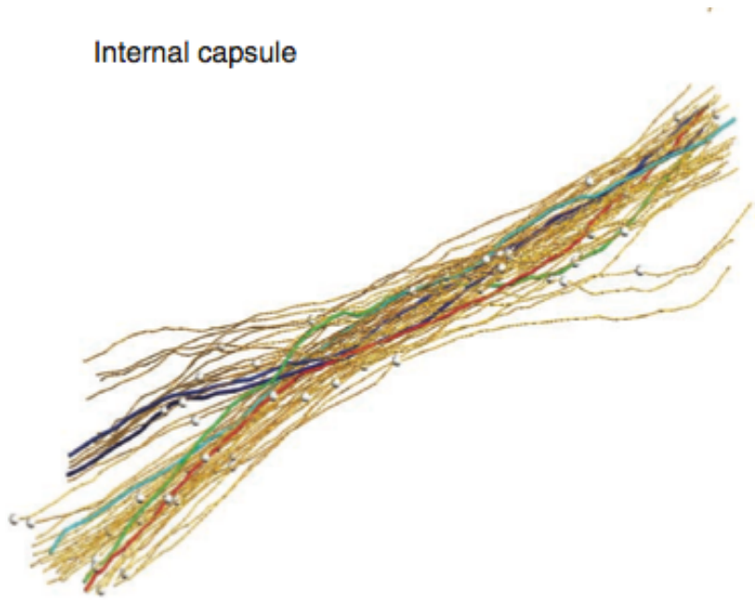
mapping between axon geometry and diffusion profile can be ambiguous

Jbabdi & Johansen-Berg (2011)

White matter organisation can be surprising

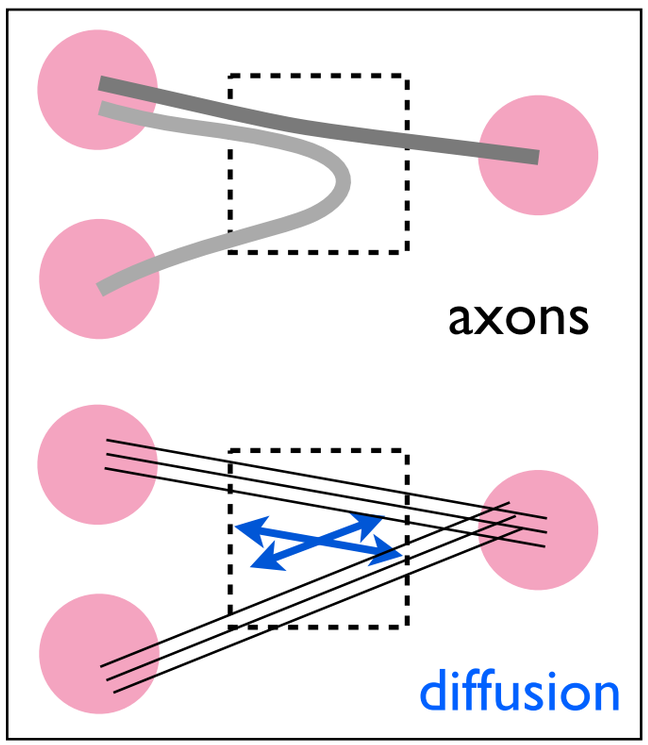




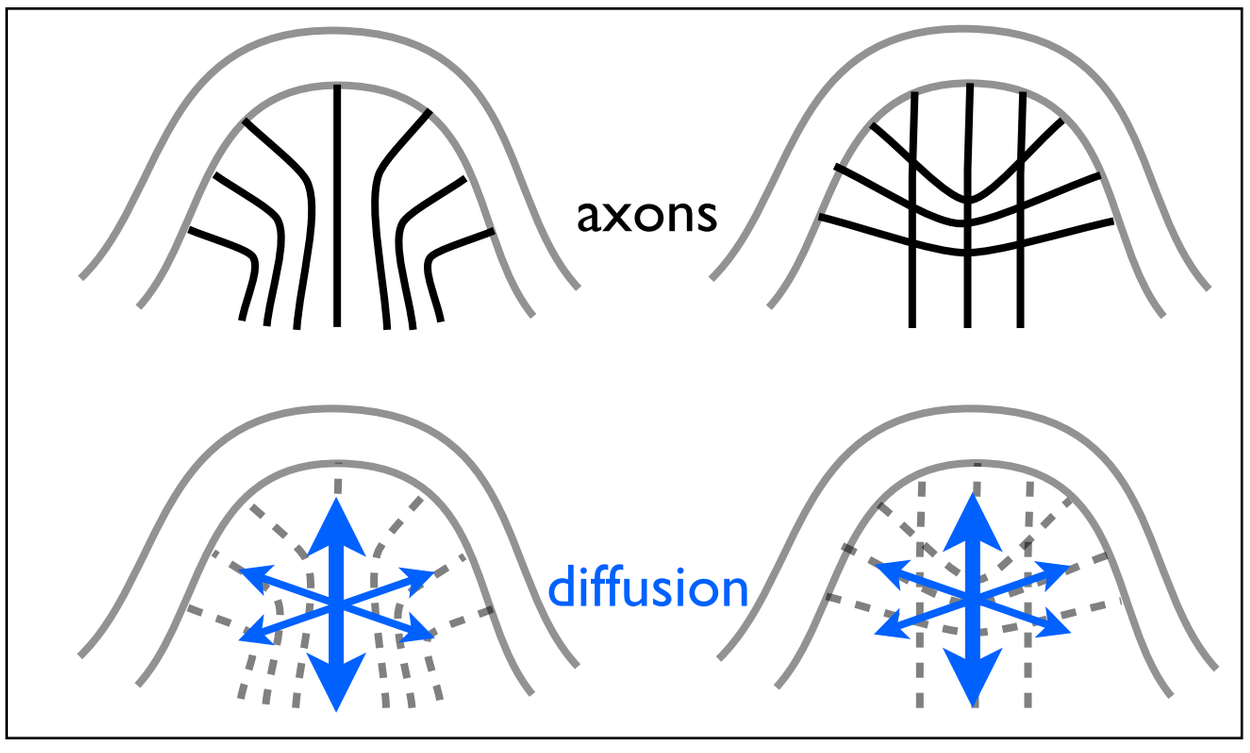


Whole mouse brain Electron Microscopy!
Mikula Binding Denk, Nature Methods 2012

Can we trust tractography?



In the white matter:
jumping between tracts



Near the cortex
ambiguities/biases

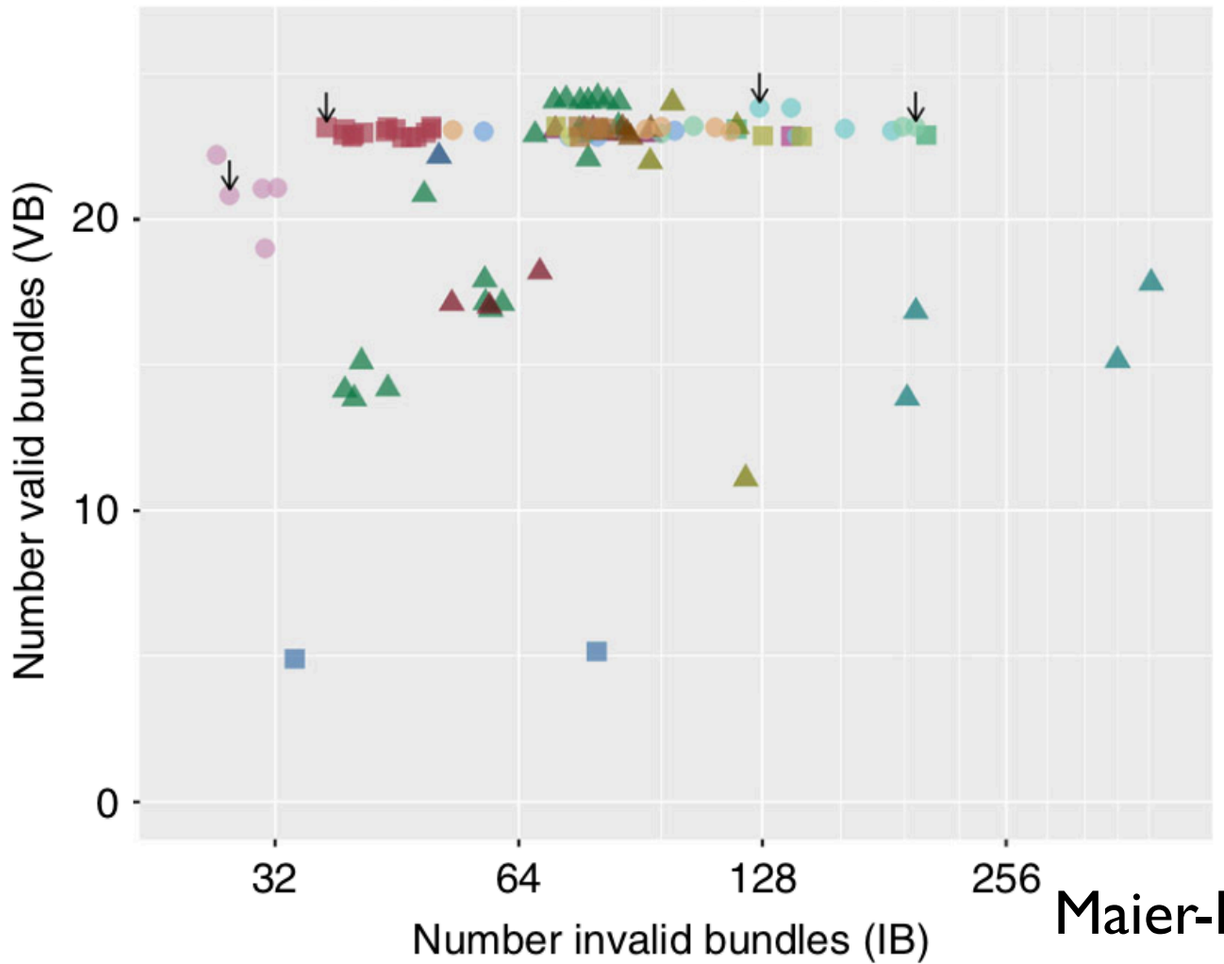
Jbabdi & Johansen-Berg (2011)

Many false positives in tractography

25 synthetic WM tracts (based on real data)

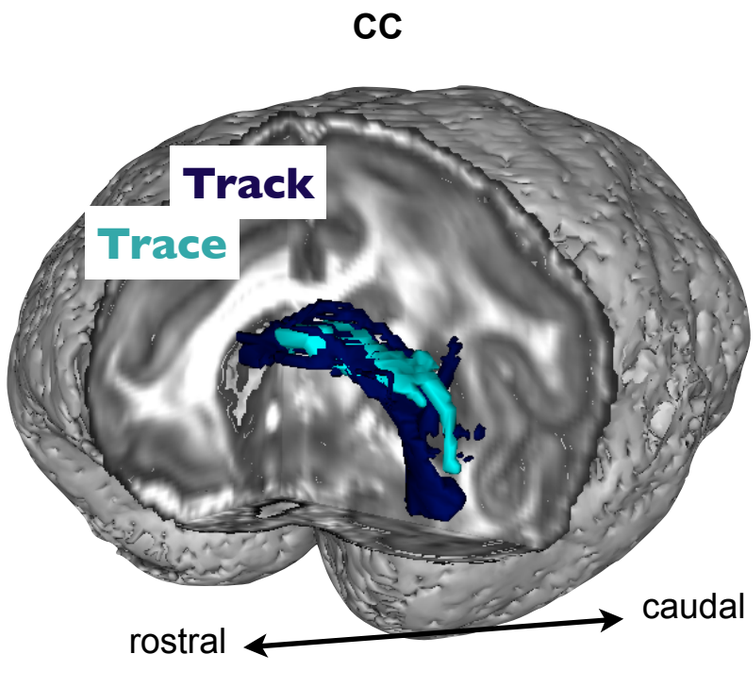
Simulated diffusion data

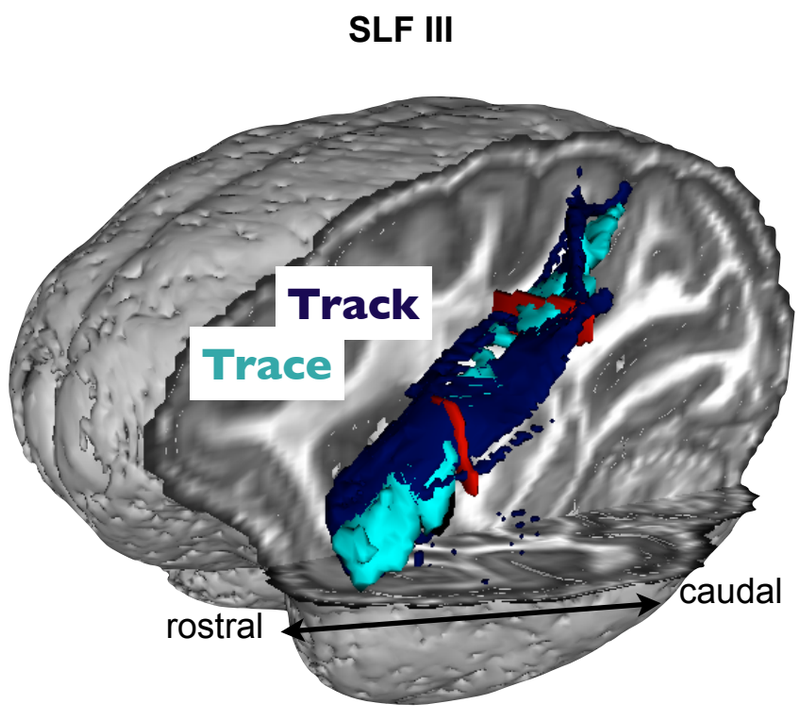
Bundle detection

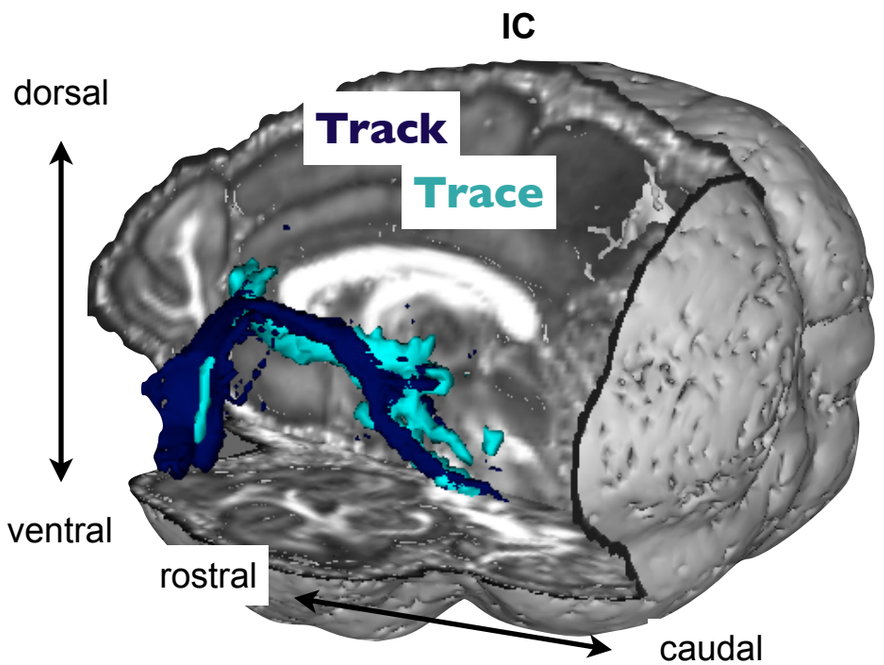


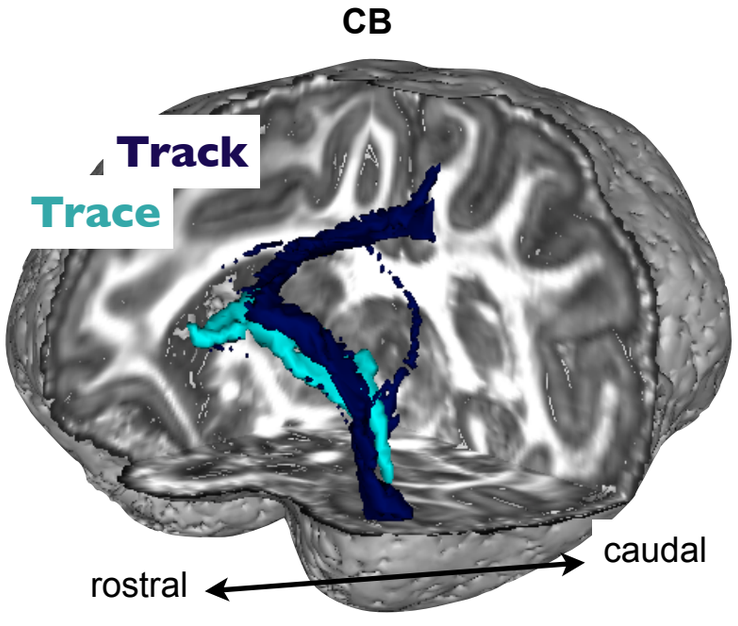
Maier-Hein et al. (Nat. Comm., 2017)

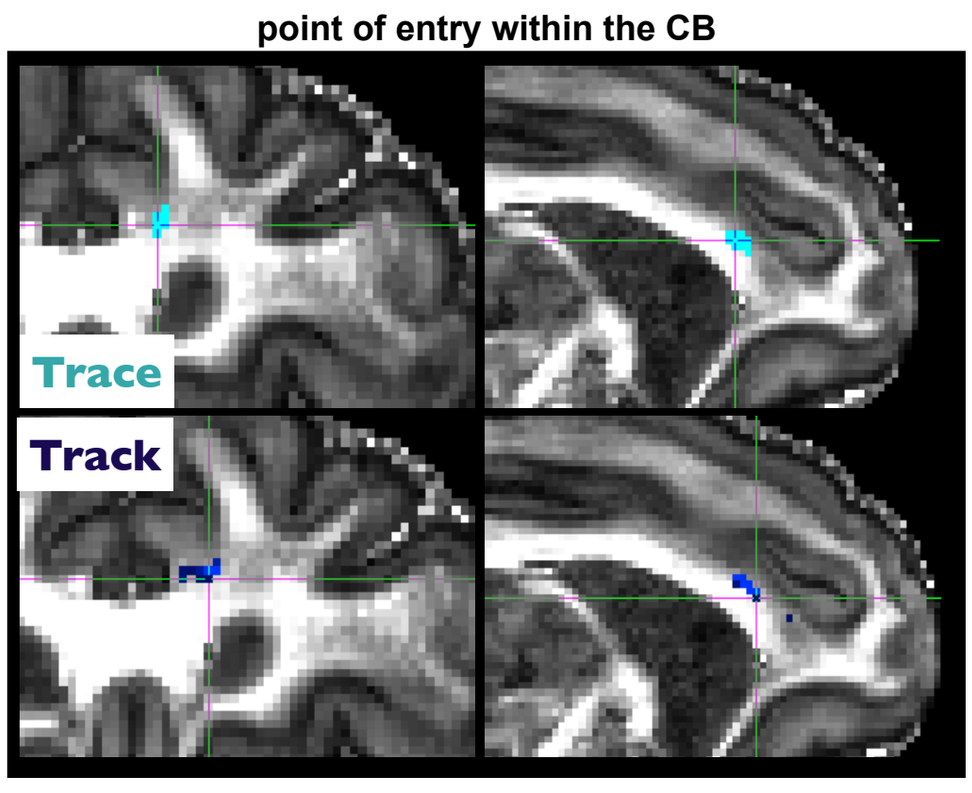
Validation: comparison with classical chemical tracing





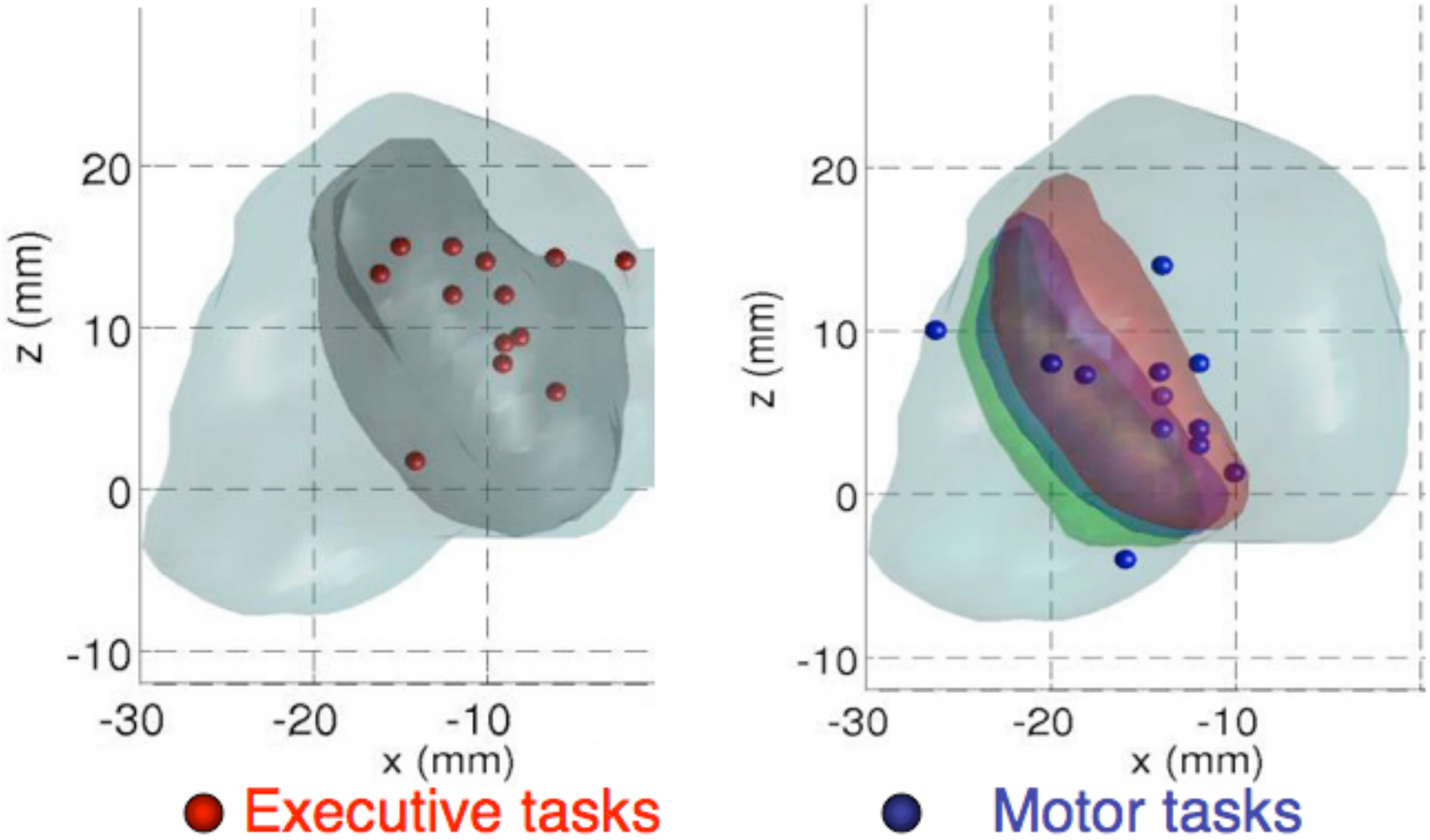






Jbabdi et al, Journal of Neuroscience, 2013

Functional validation: meta-analysis of FMRI activations within thalamus

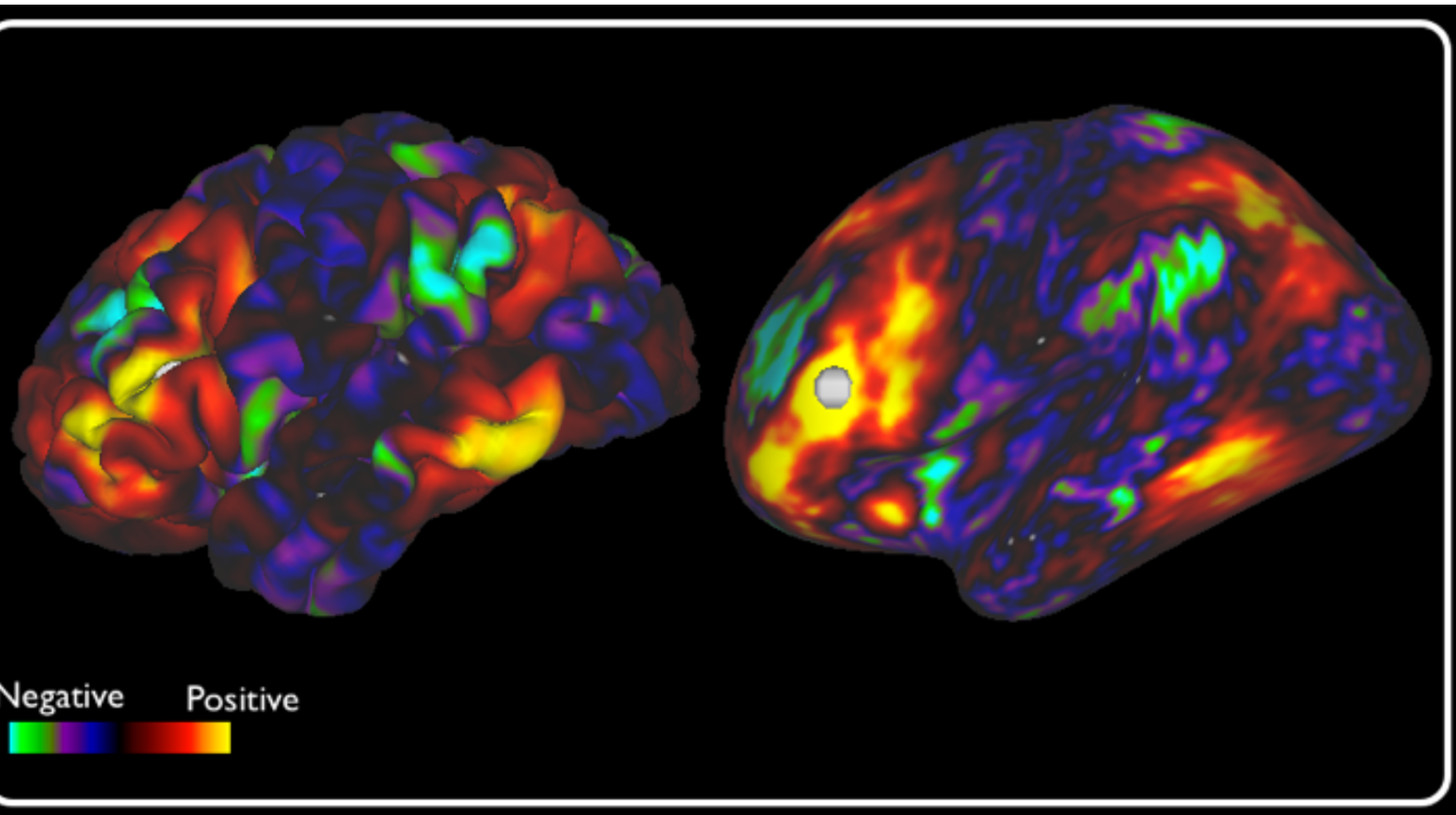


Johansen-Berg et al, Cerebral Cortex, 2005

The Human Connectome Project

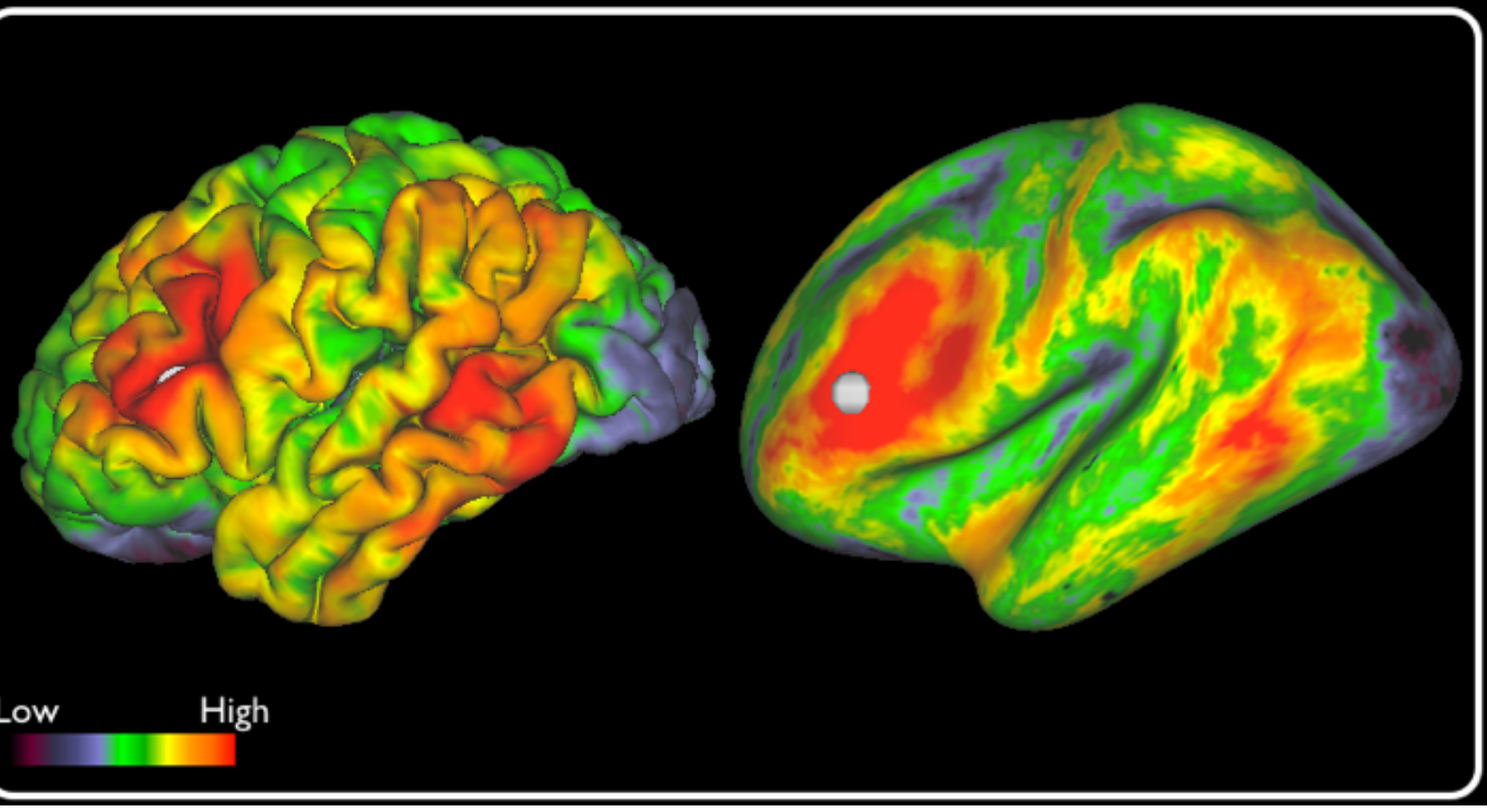
www.humanconnectome.org

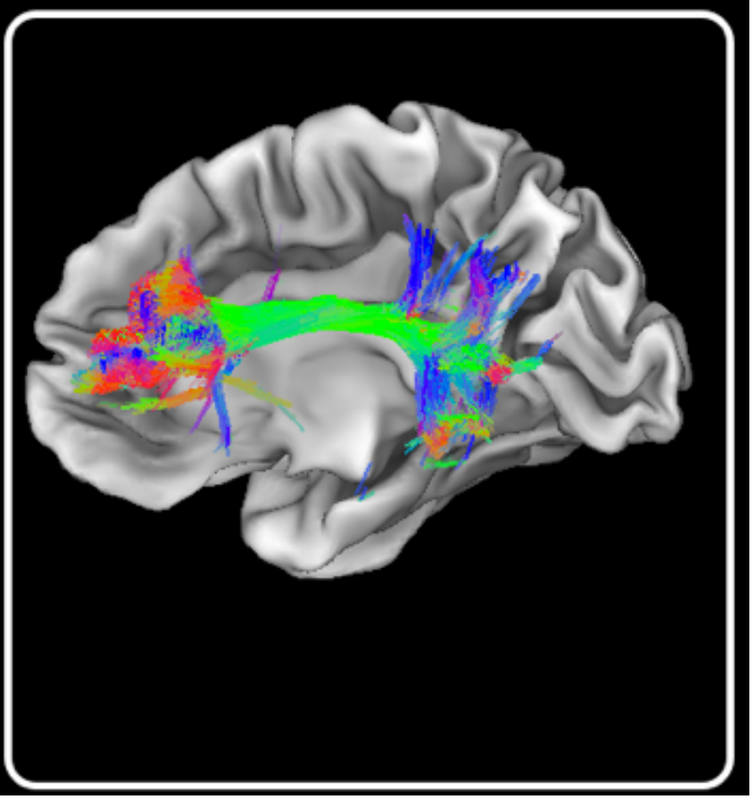
Functional Connectivity



Predominant Structural Connections from a Certain Point (dot)

Structural Connectivity





That's all folks