Analyzing a large neuroimaging dataset with cloud-based tools

by Josiah Leong
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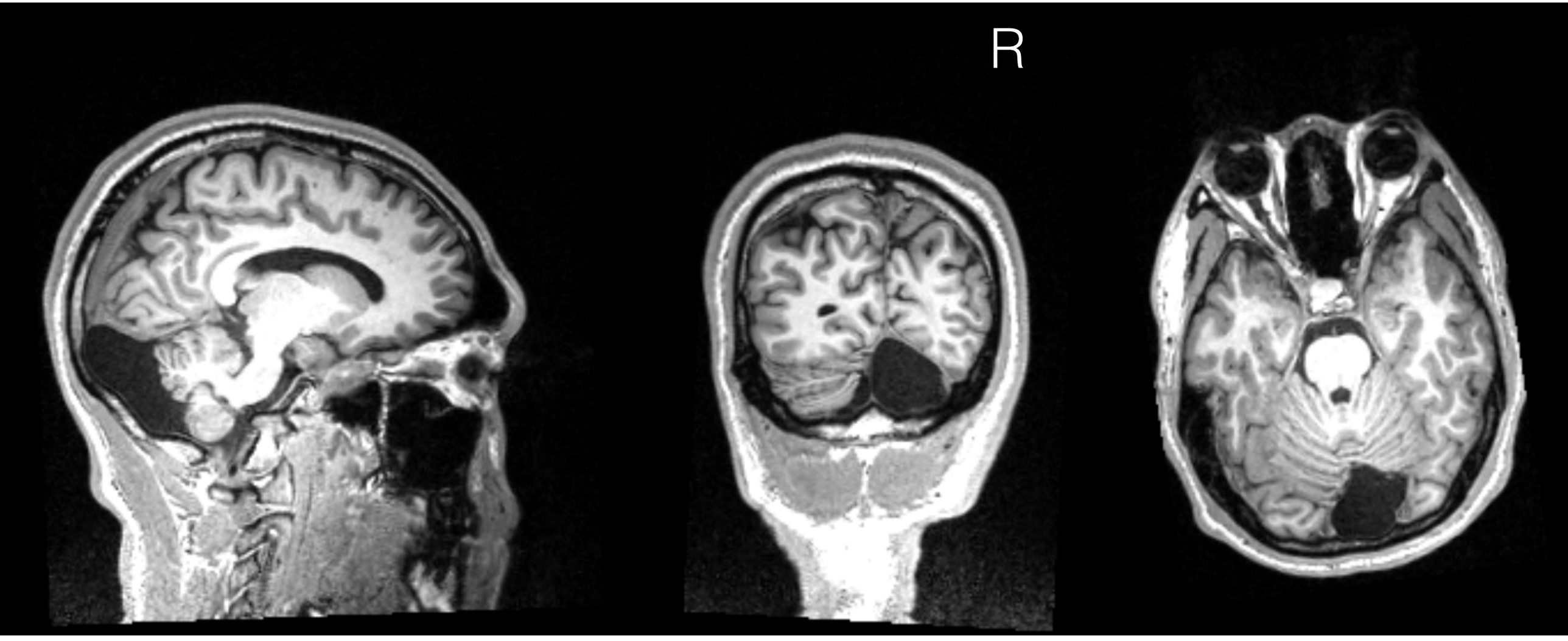
My brain

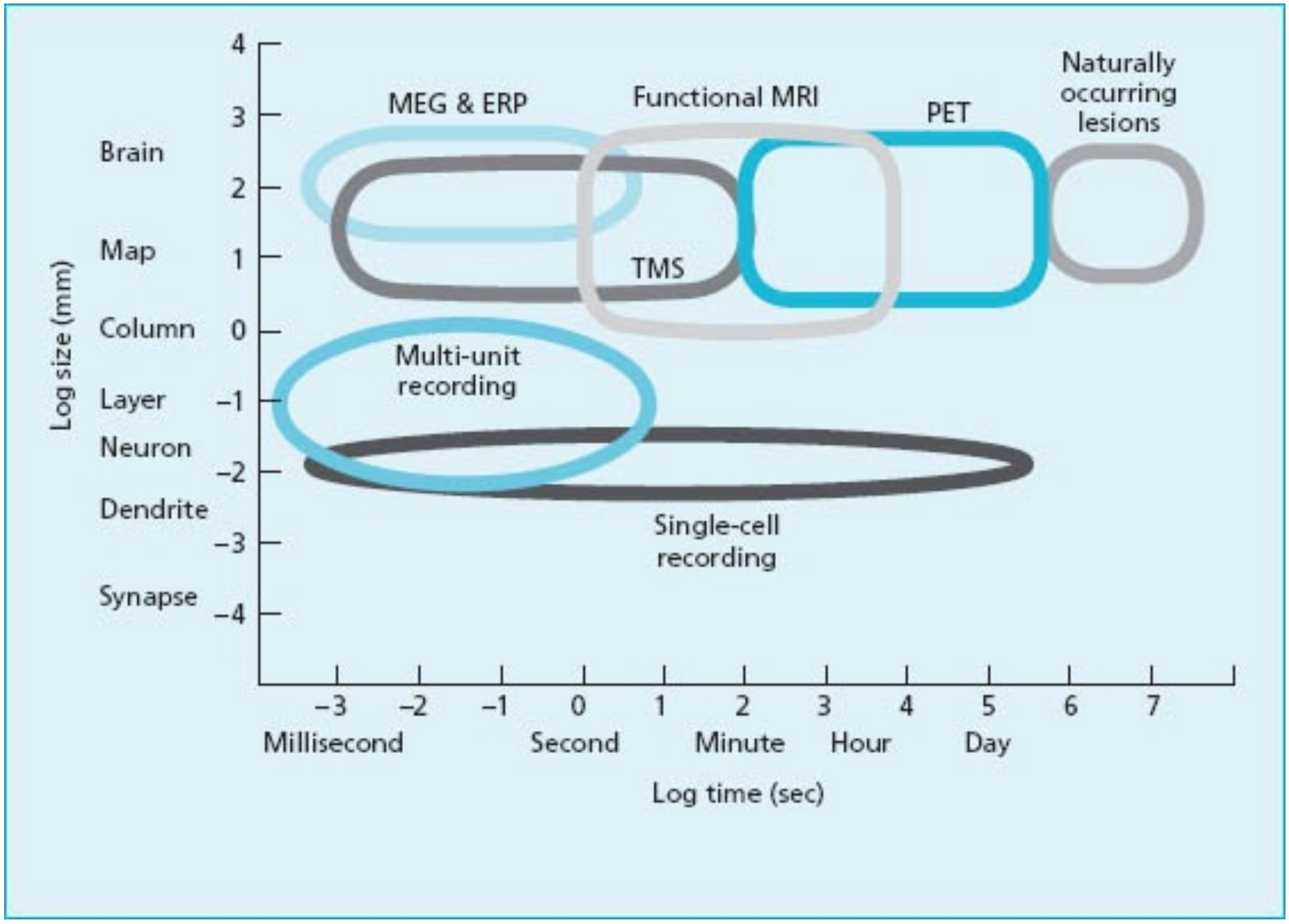


Raw brain

Why study the brain?

Data		

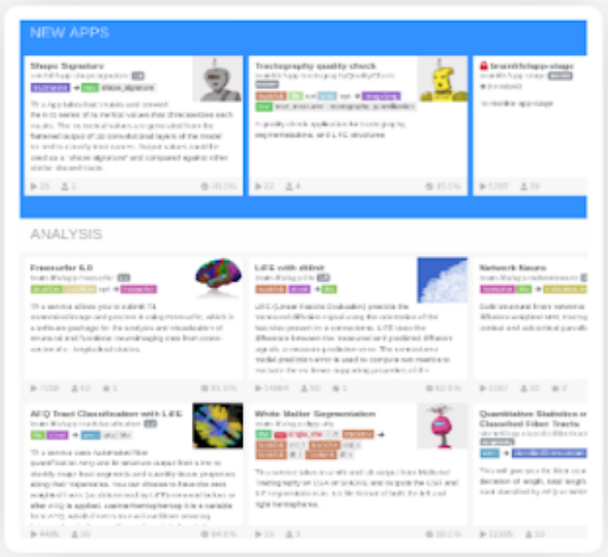
How to measure the brain?



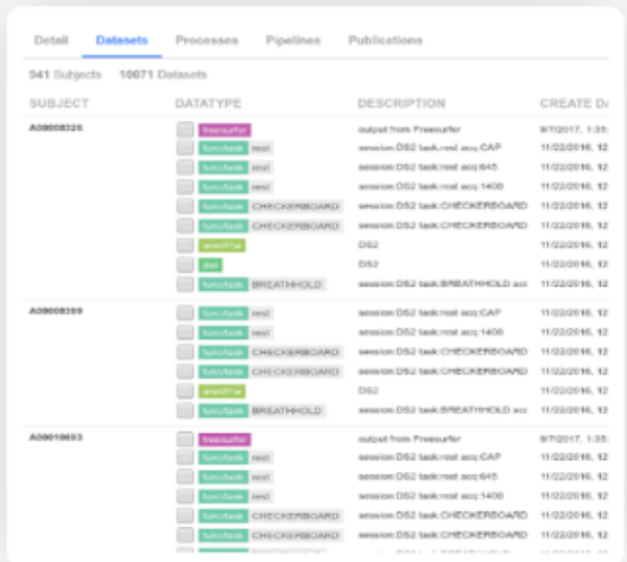
Data		

Processing brain data

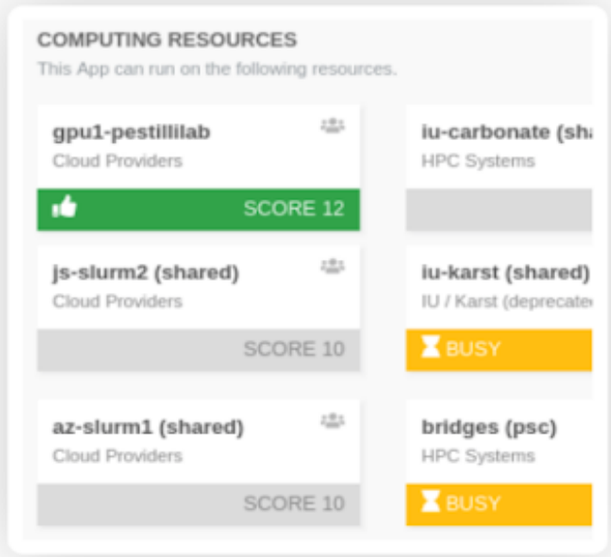
Code



Data



Computing



Data		

Brainlife

brainlife.io warehouse

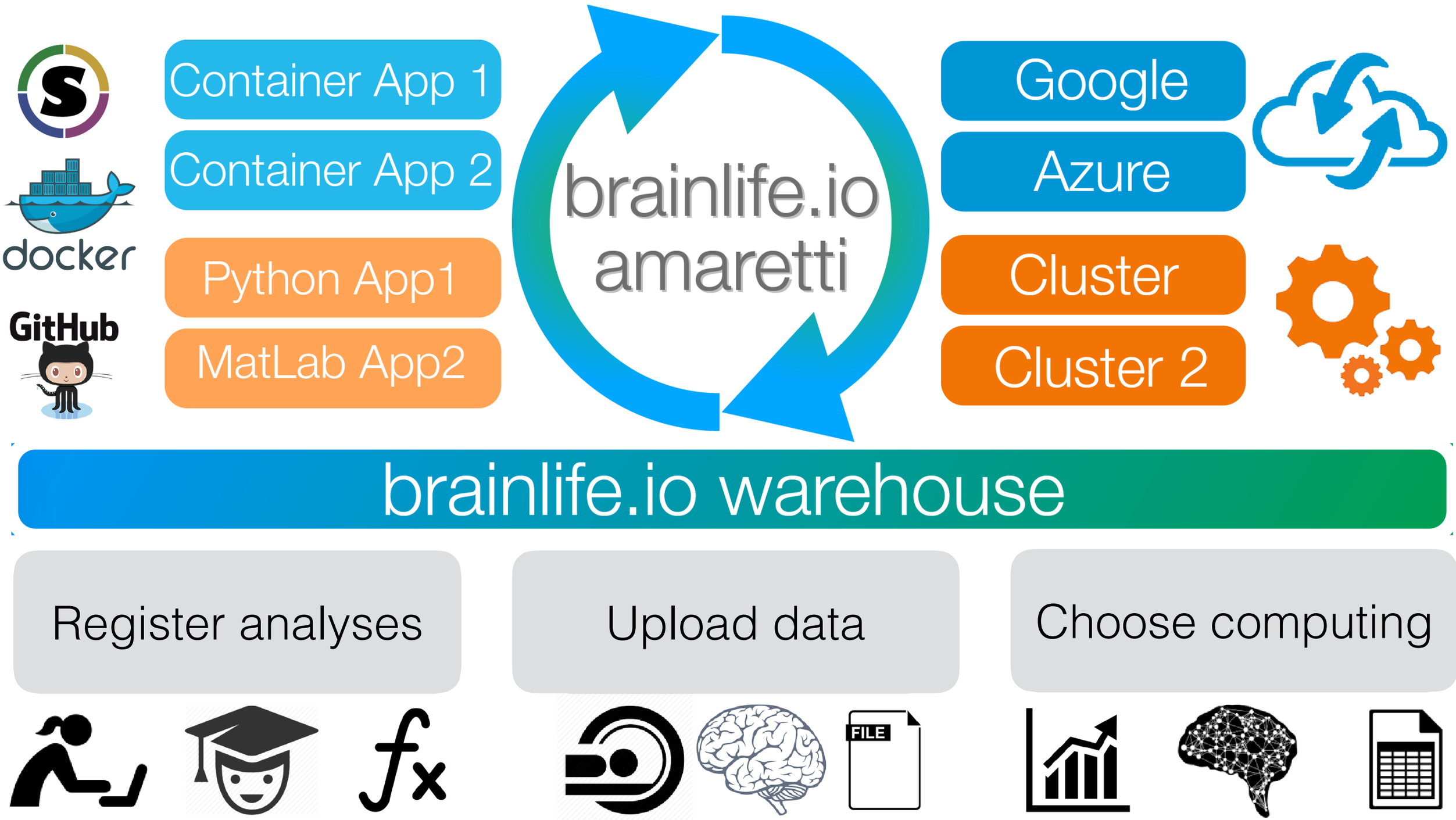
Register analyses

Upload data

Choose computing

Data		

Brainlife



	Science	

“Incentivized inhibition"

“Incentivized inhibition”

- **Incentive** anticipation
  - brain activity when anticipating incentive
  - activity can predict financial decisions (purchases, gambles)

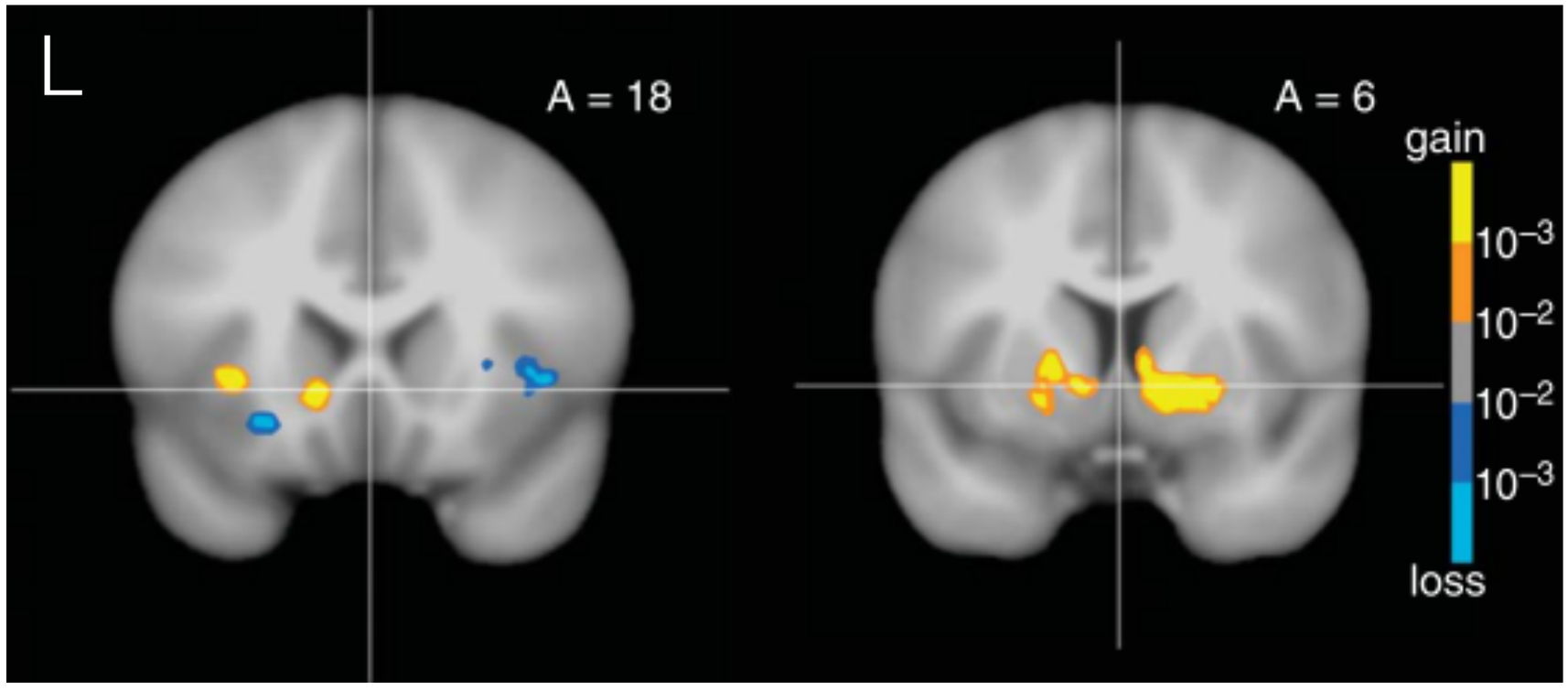
- Response **inhibition**
  - brain activity when stopping motor actions

- Importance
  - individual differences of ability to inhibit for incentives may be important in short and long terms (survival, health, wealth)

Knutson & Greer (2008); Aron, Robbins, & Poldrack (2004 & 2014), TICS

	Science	

Incentive anticipation

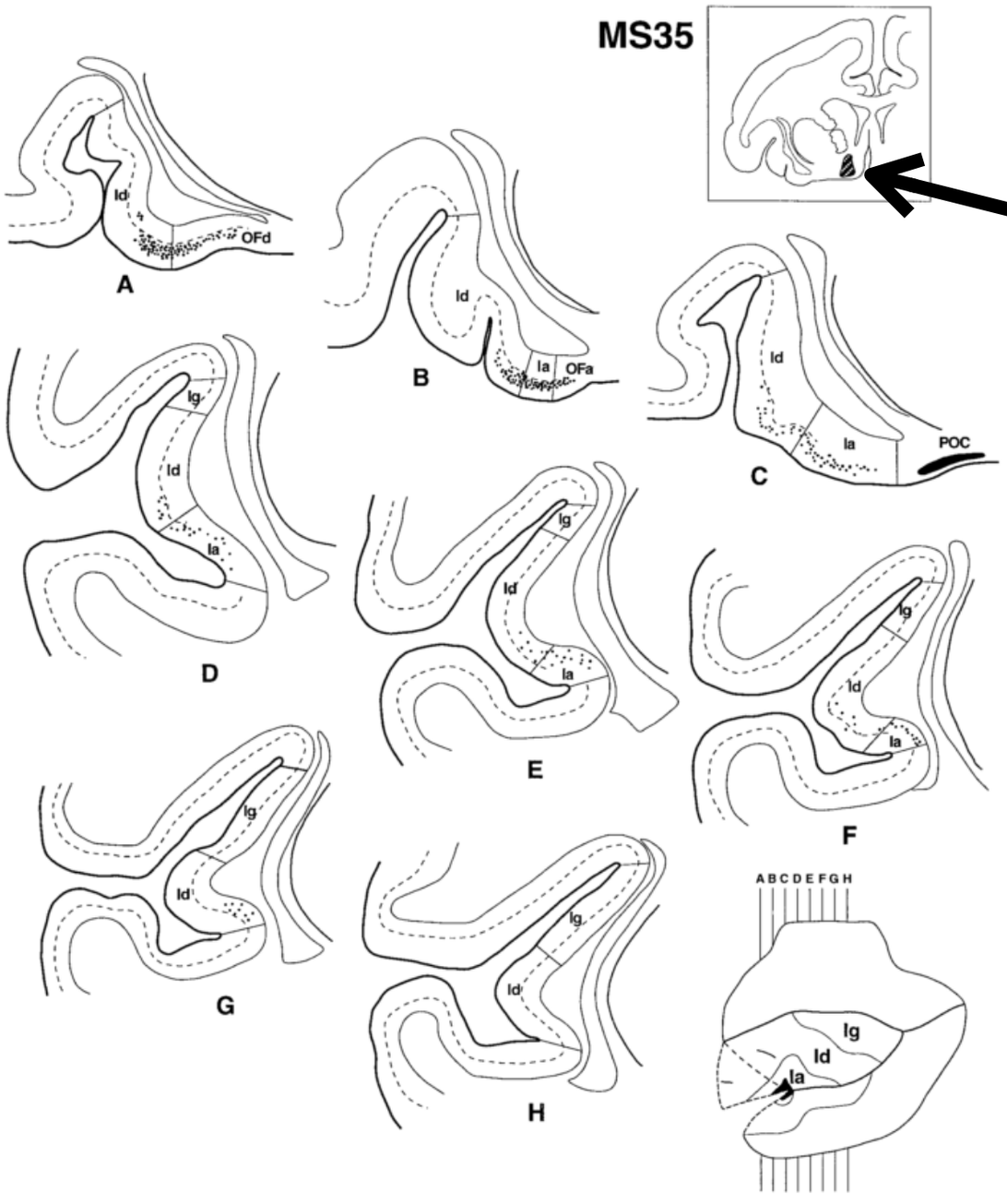


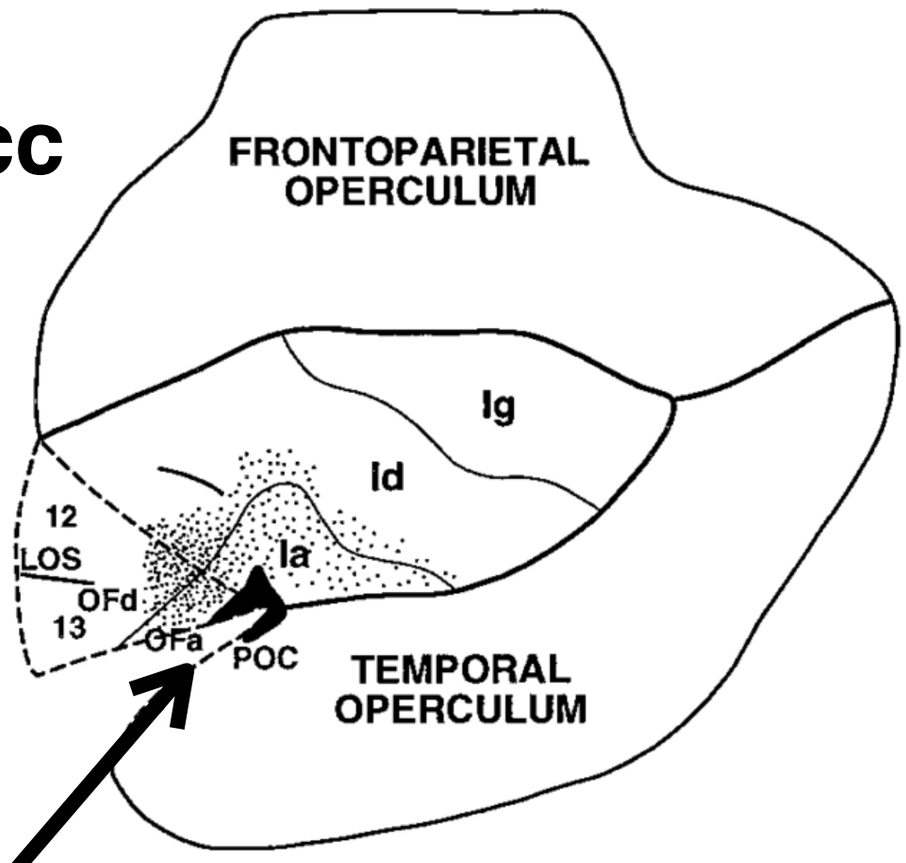
Anterior Insula
(**AIns**)

Nucleus accumbens
(**NAcc**)

Knutson & Greer (2008), Proc R Soc B

AIns—NAcc connection in monkeys



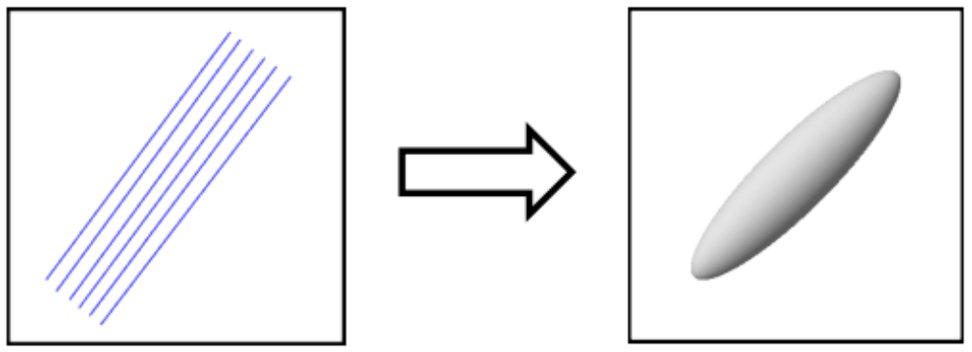


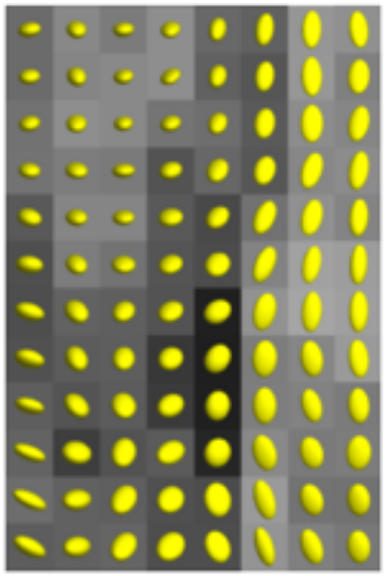
AIns

Chikama et al (1997); Reynolds & Zahm (2005), J Neuro

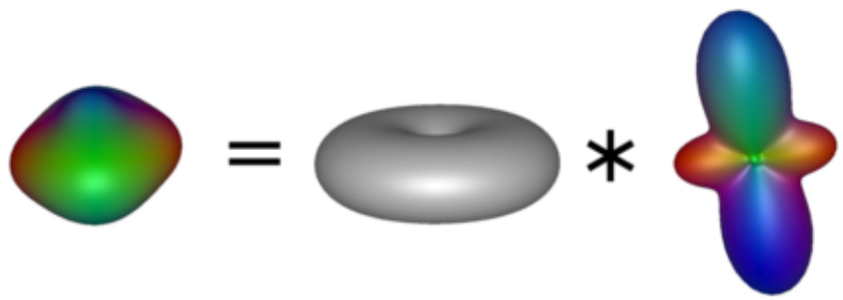
Diffusion MRI models

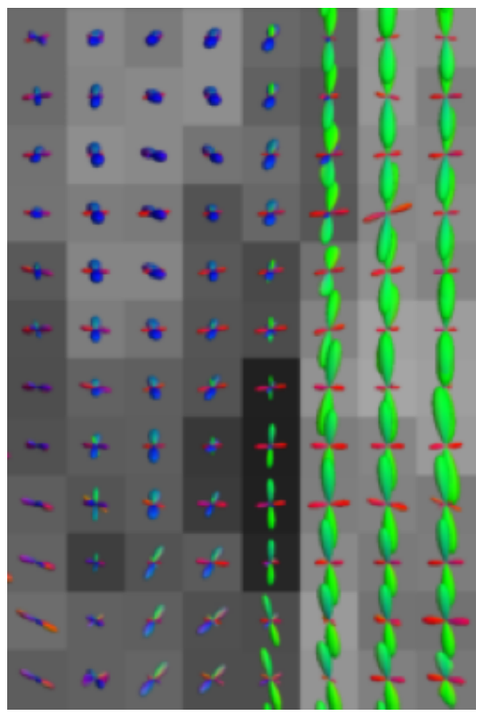
Tensor model





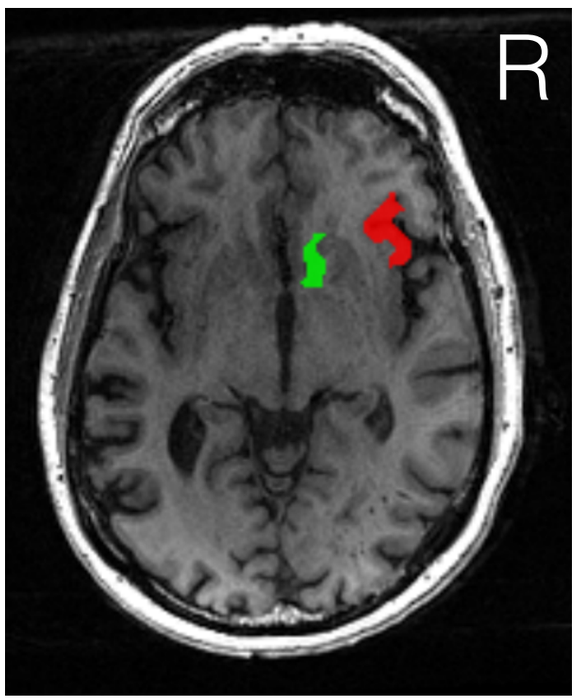
Constrained spherical deconvolution

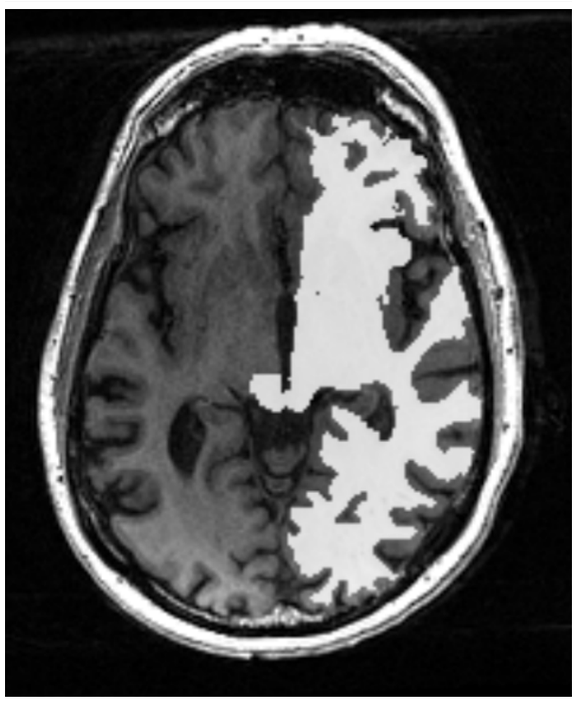




Tournier et al (2007), NeuroImage

Diffusion MRI data processing





Seed FreeSurfer volumes

- NAcc
- Anterior insula
- white matter mask

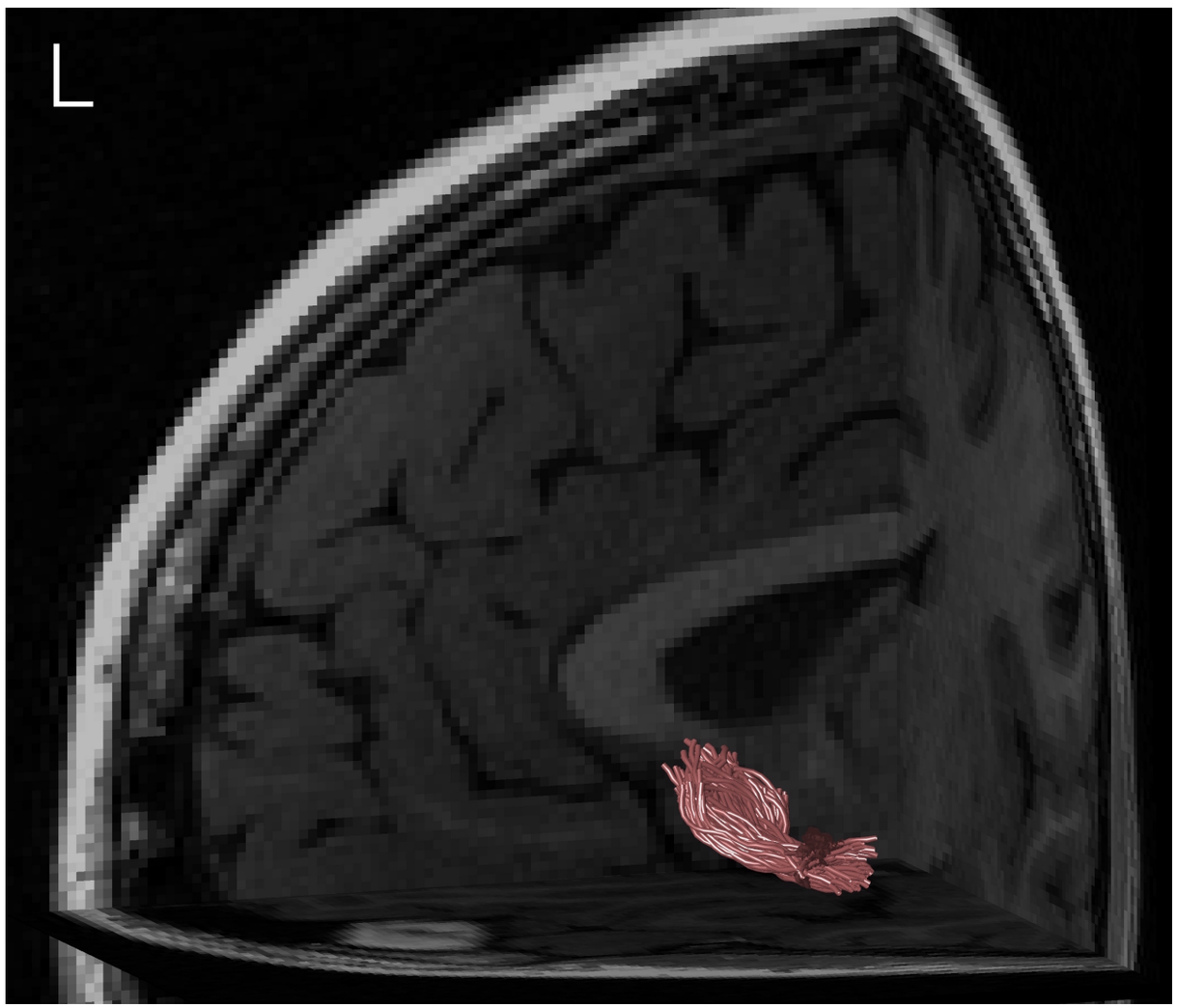
MRtrix probabilistic tractography

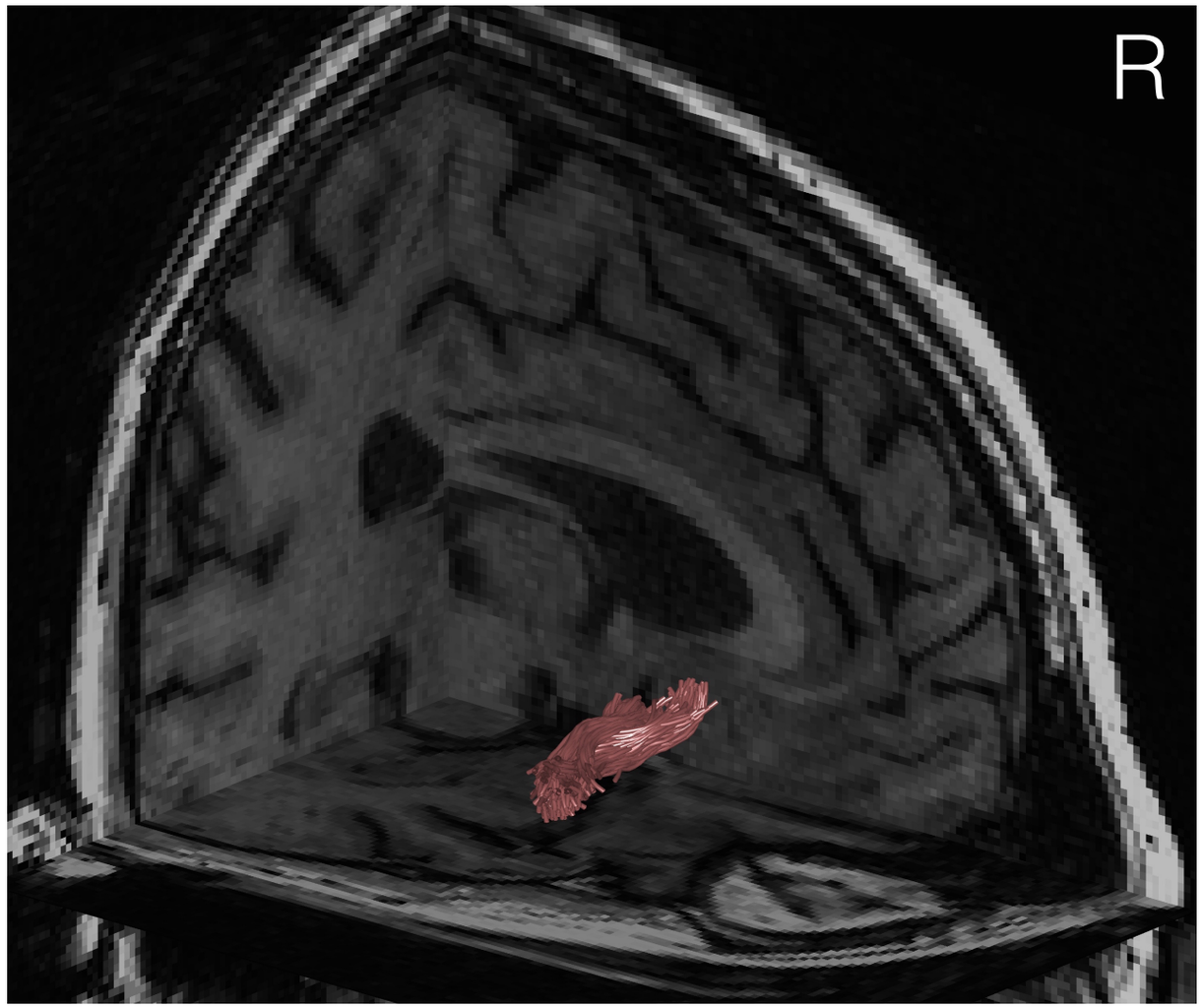
- CSD L_{max} = 10
- 0.05 FA cutoff
- 60° curvature
- 5,000 fibers
- 500,000 max

Desikan et al (2006); Destrieux et al (2009); Tournier et al (2007), NeuroImage

	Science	

AIns—NAcc connection in humans

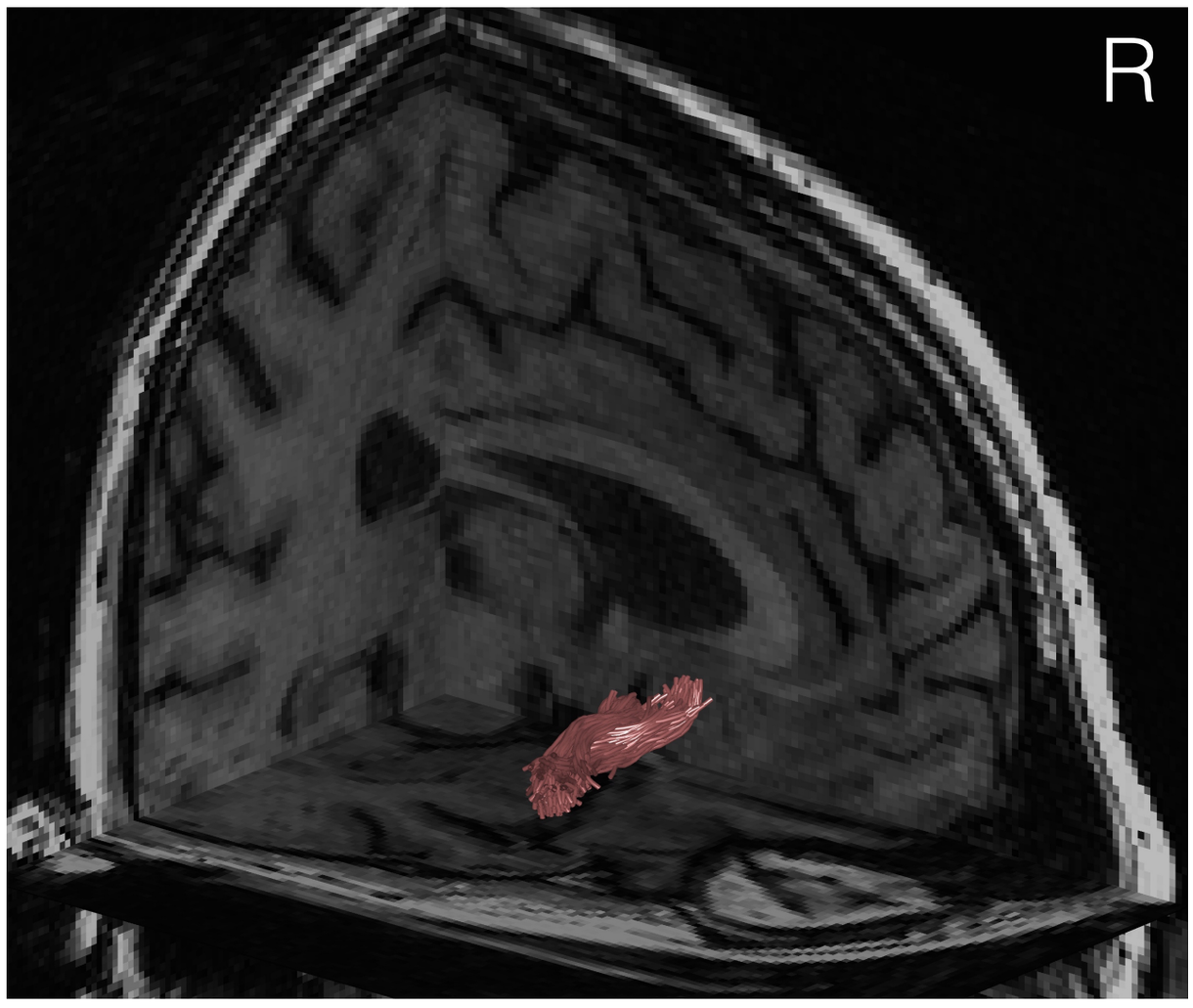


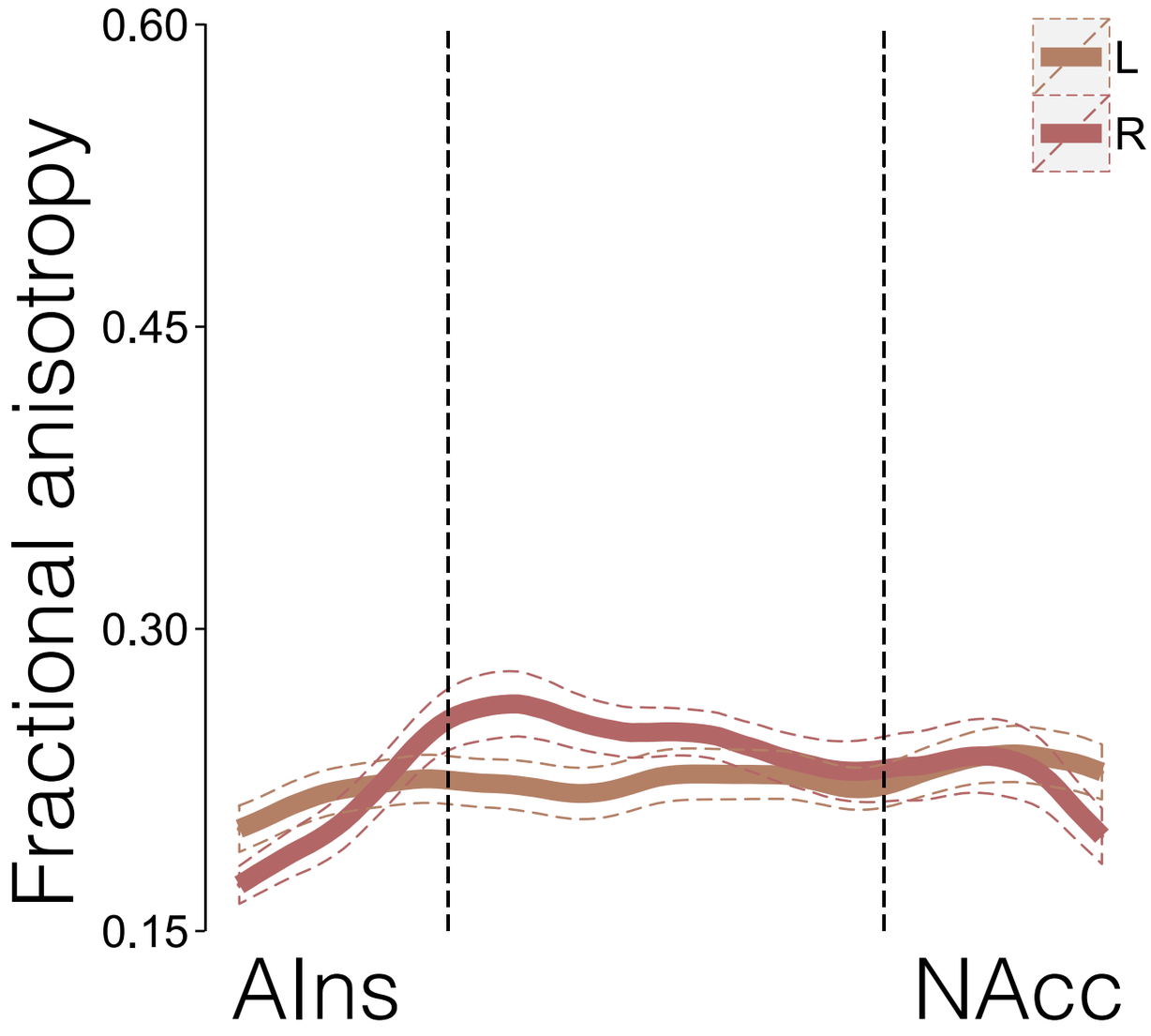


Leong, Pestilli, Wu, Samanez-Larkin, & Knutson (2016), Neuron
Leong, MacNiven, Samanez-Larkin, & Knutson (2018), NeuroImage

	Science	

Connection strength

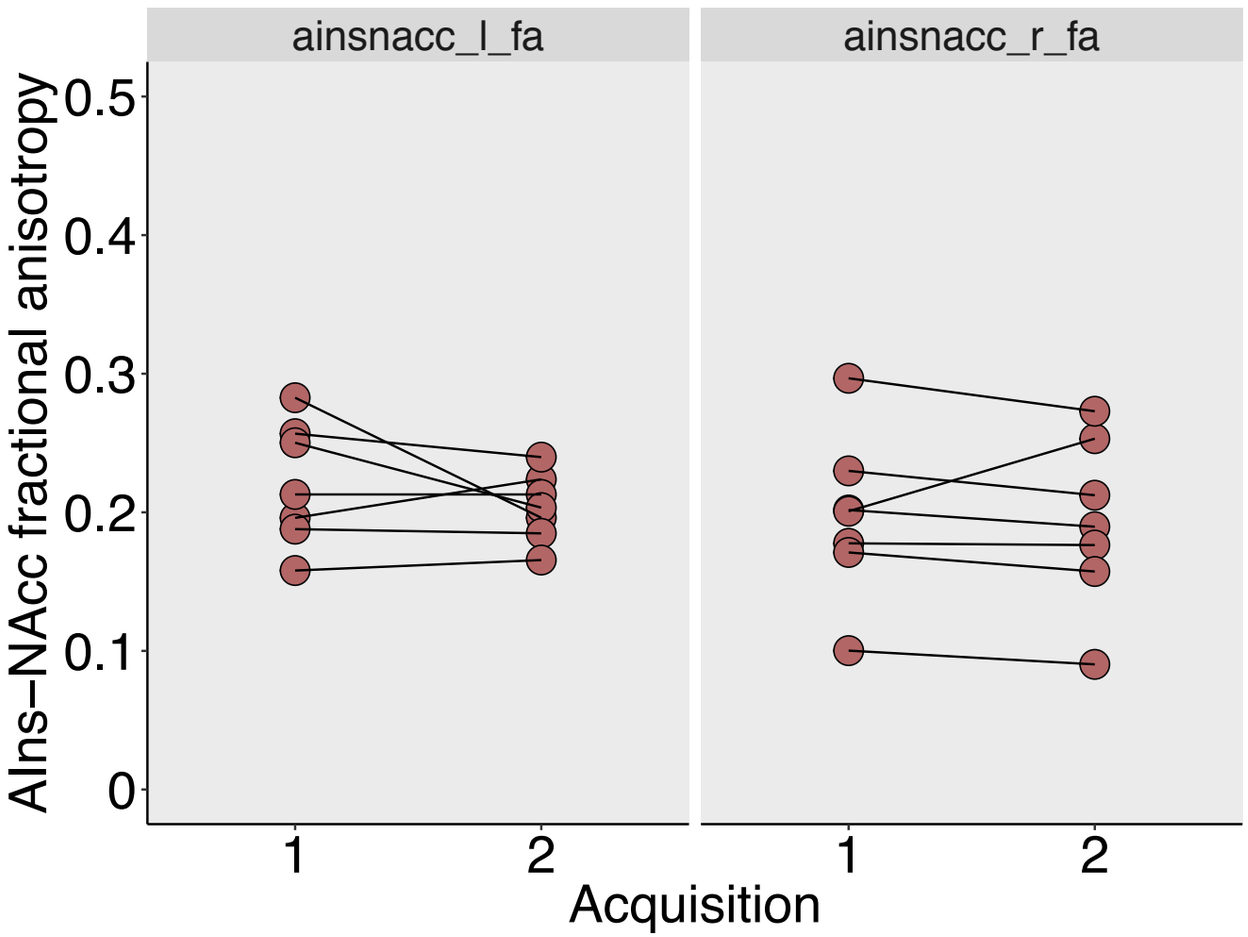


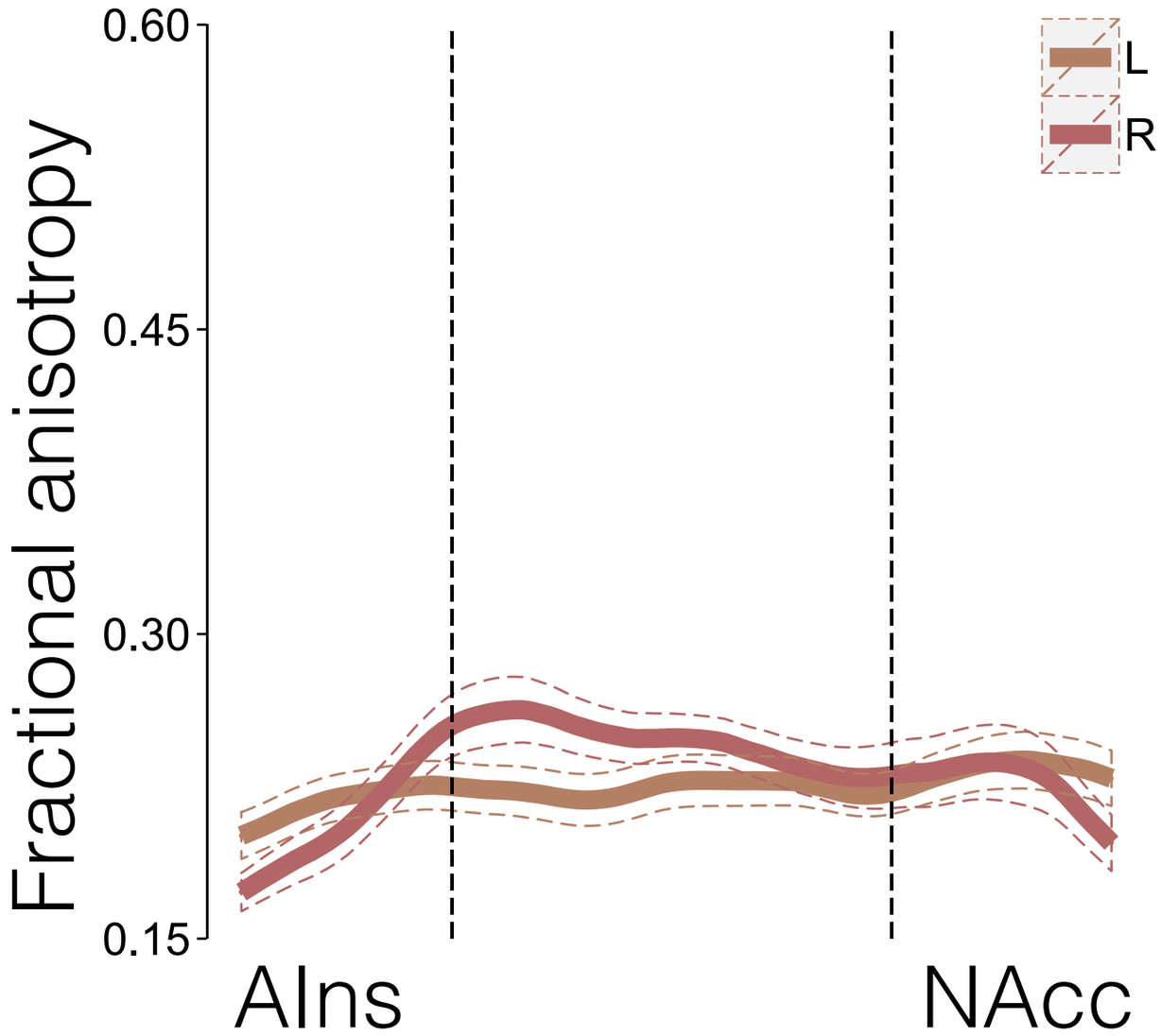


Leong, Pestilli, Wu, Samanez-Larkin, & Knutson (2016), Neuron
Leong, MacNiven, Samanez-Larkin, & Knutson (2018), NeuroImage

	Science	

Measurement reliability





ICC2k = 0.96, p < 0.001

Leong, Pestilli, Wu, Samanez-Larkin, & Knutson (2016), Neuron
Leong, MacNiven, Samanez-Larkin, & Knutson (2018), NeuroImage

Adolescent brain development

How neuroimaging measures might be useful?

- Link structure and function of incentive and inhibition circuits in adolescents
- Characterize longitudinal development of brain circuits
- Predict future life outcomes

Adolescent Brain Cognitive Development (ABCD) study

Data

- 11,000 subjects, 9-11 years old
- collect data every 2 years for 10 years
  - structural and functional MRI
  - real-life and laboratory behaviors
  - genetics

Software

- Brainlife

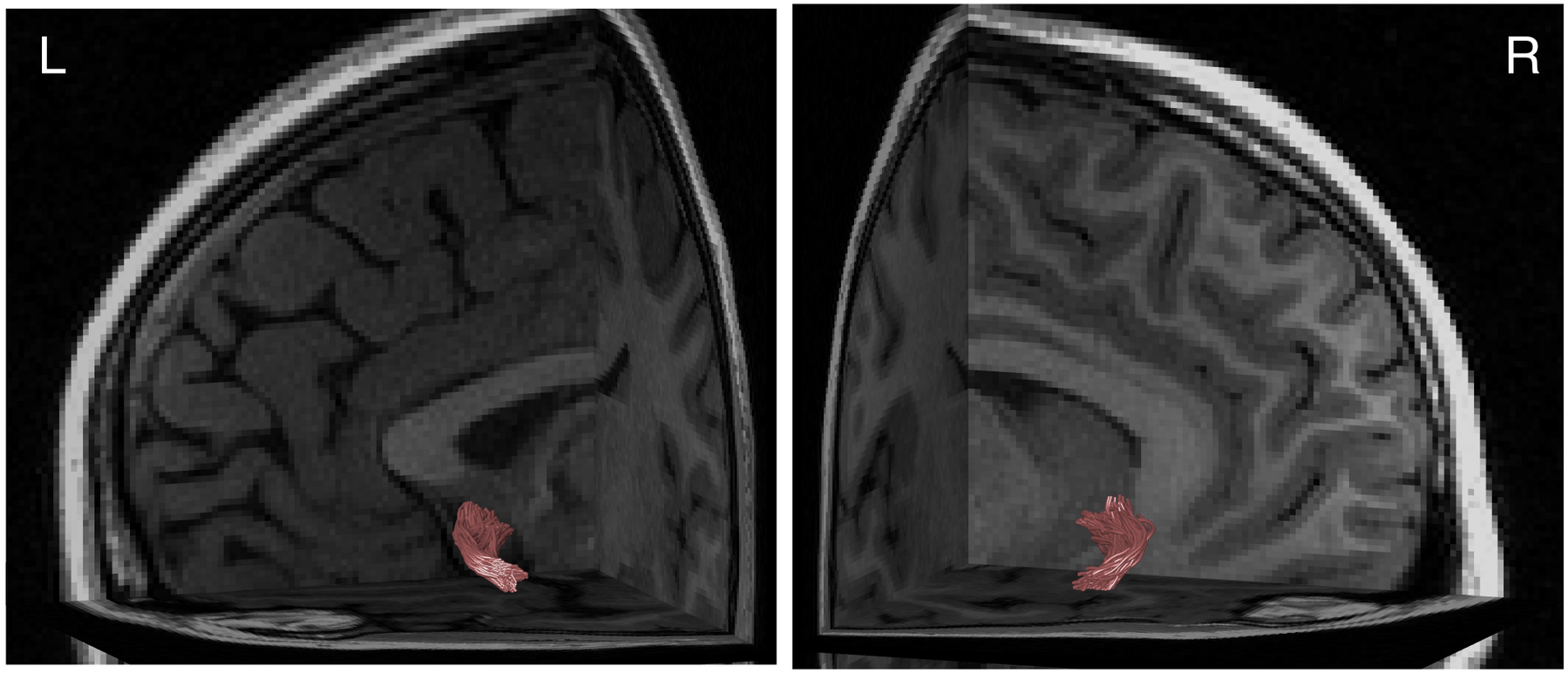
Hardware

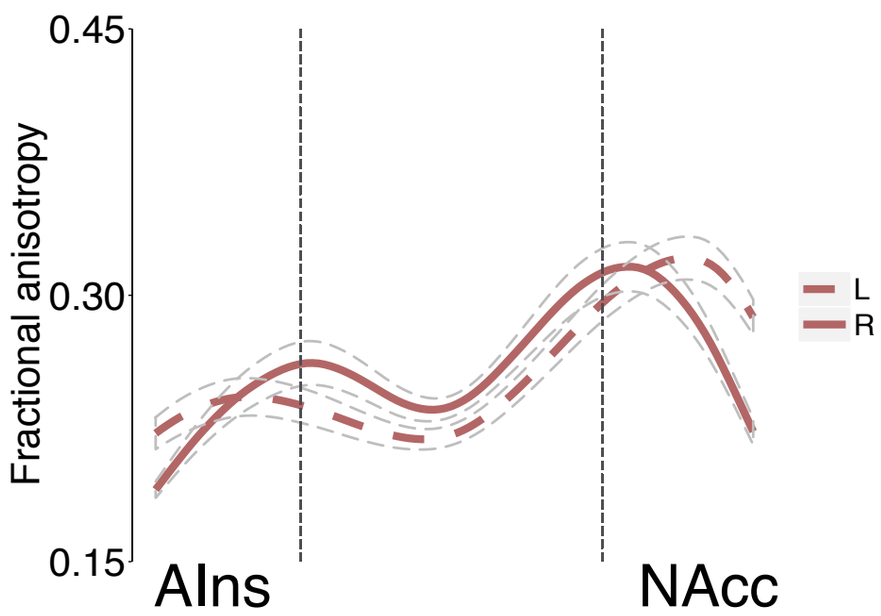
- Microsoft Azure (4 customized computing nodes)
- Indiana University high-performance computing clusters
- Open Science Grid

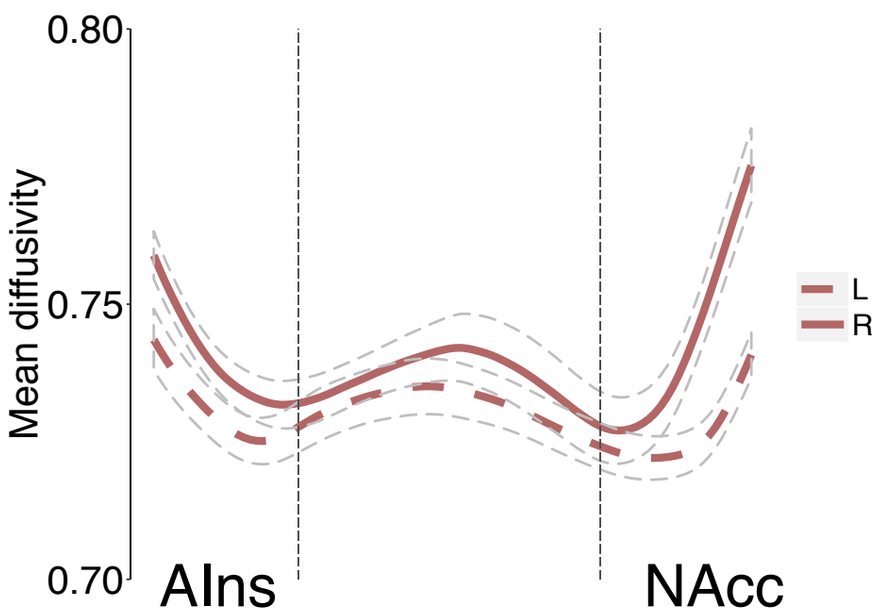
		Application

AIns—NAcc connection in adolescents

Sample
n=91
age mean=11
range = 9-13
59 females

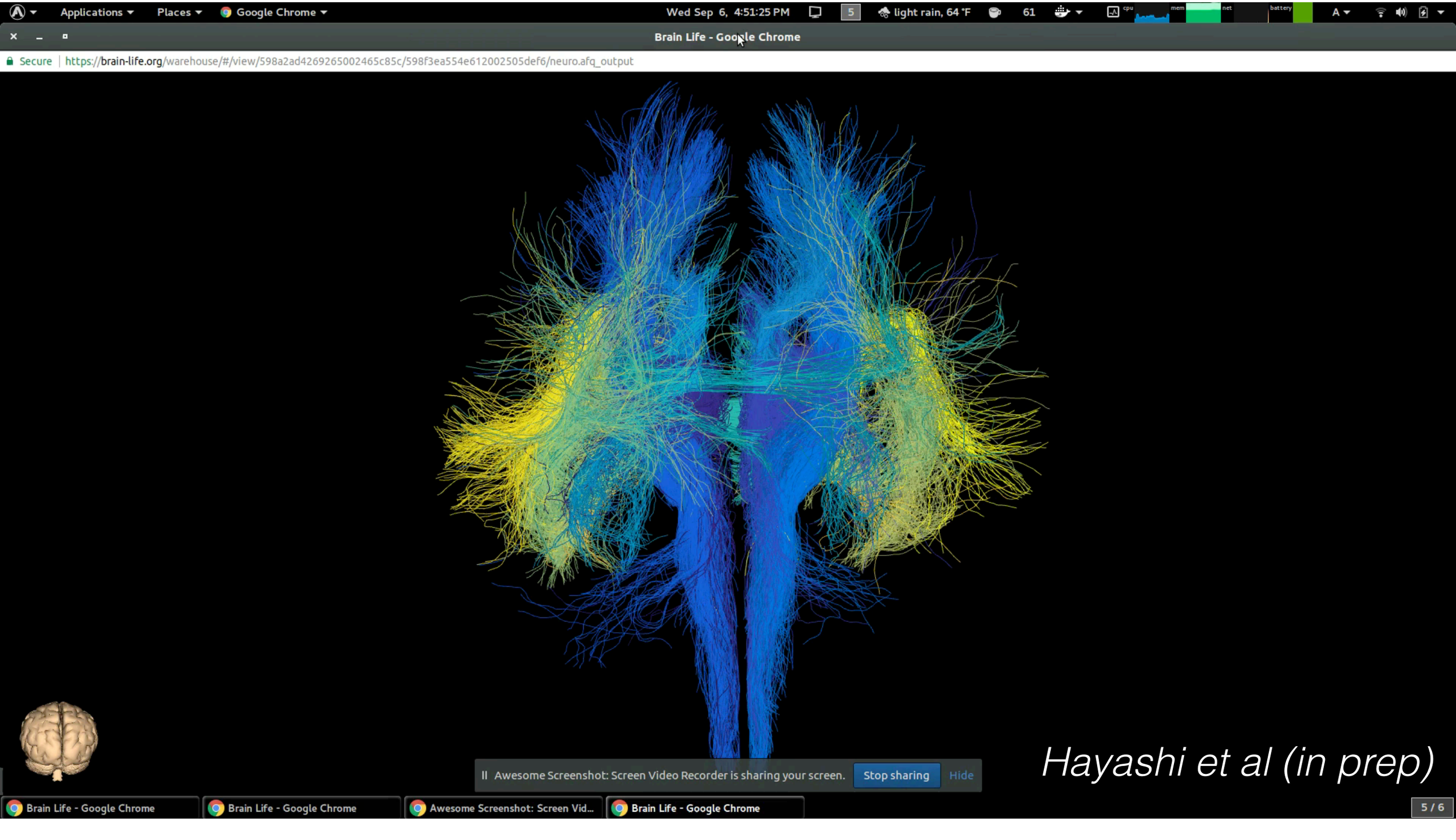






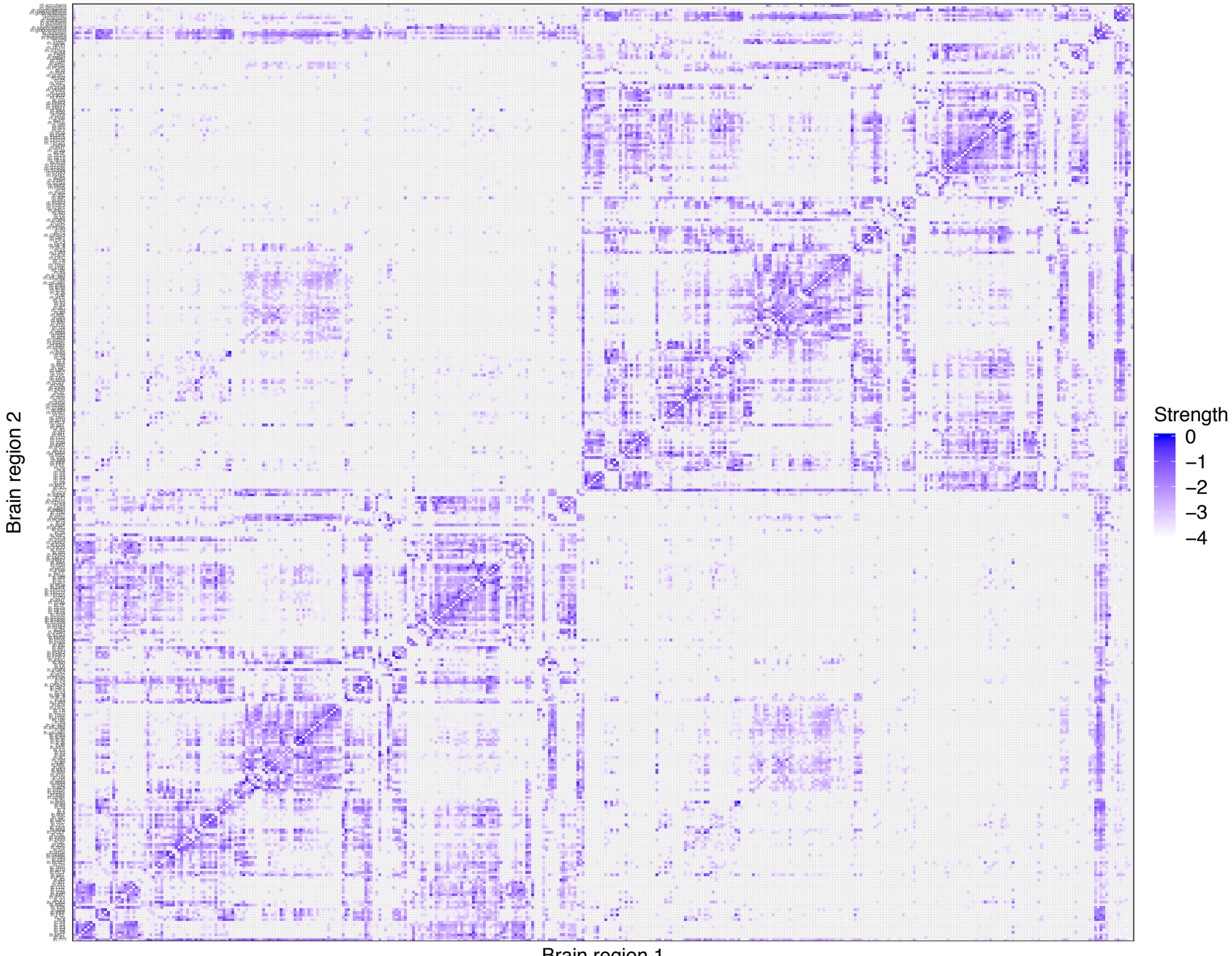
		Application

Whole-brain structural connectivity



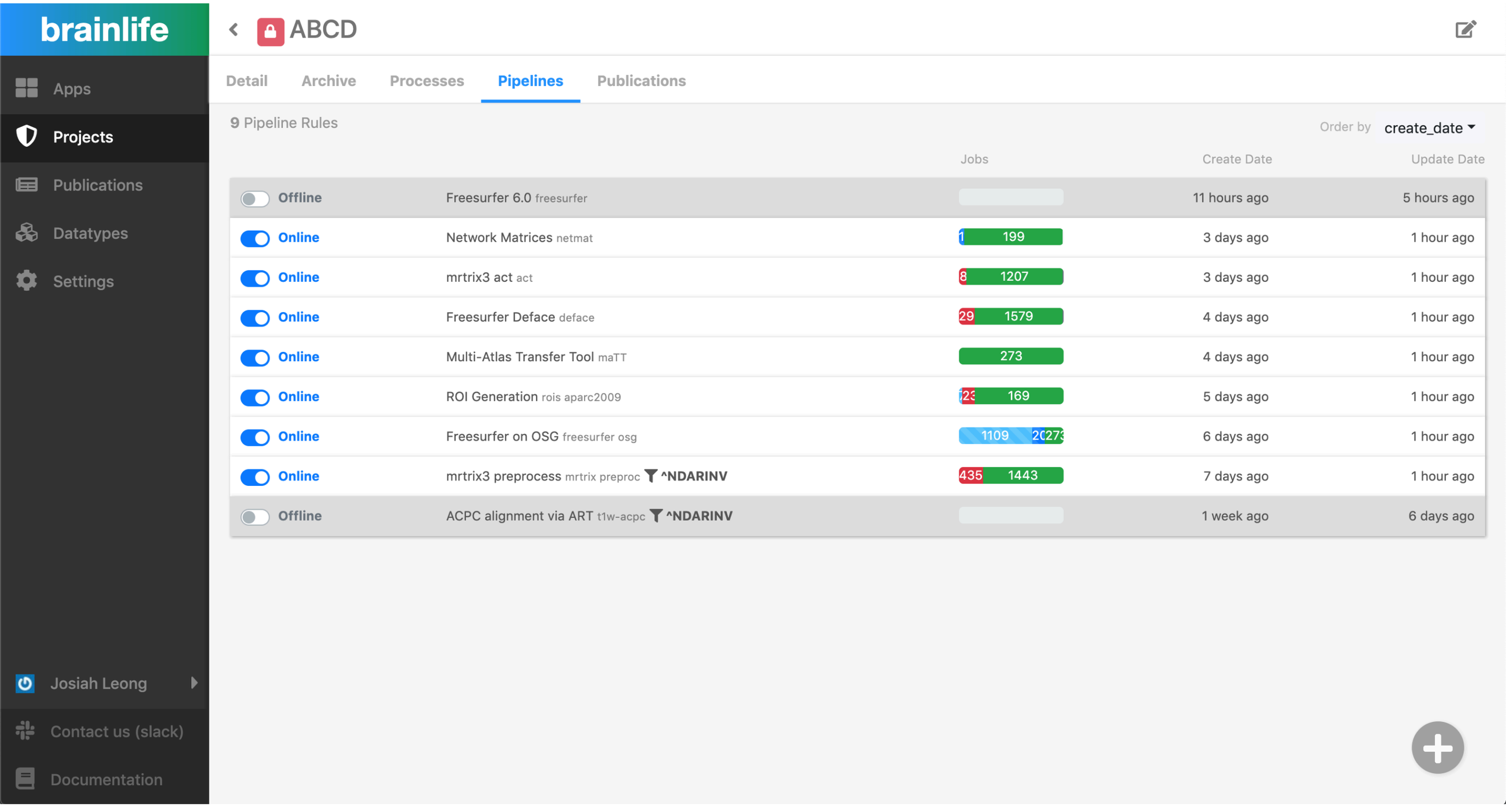
Hayashi et al (in prep)

Whole-brain structural connectivity



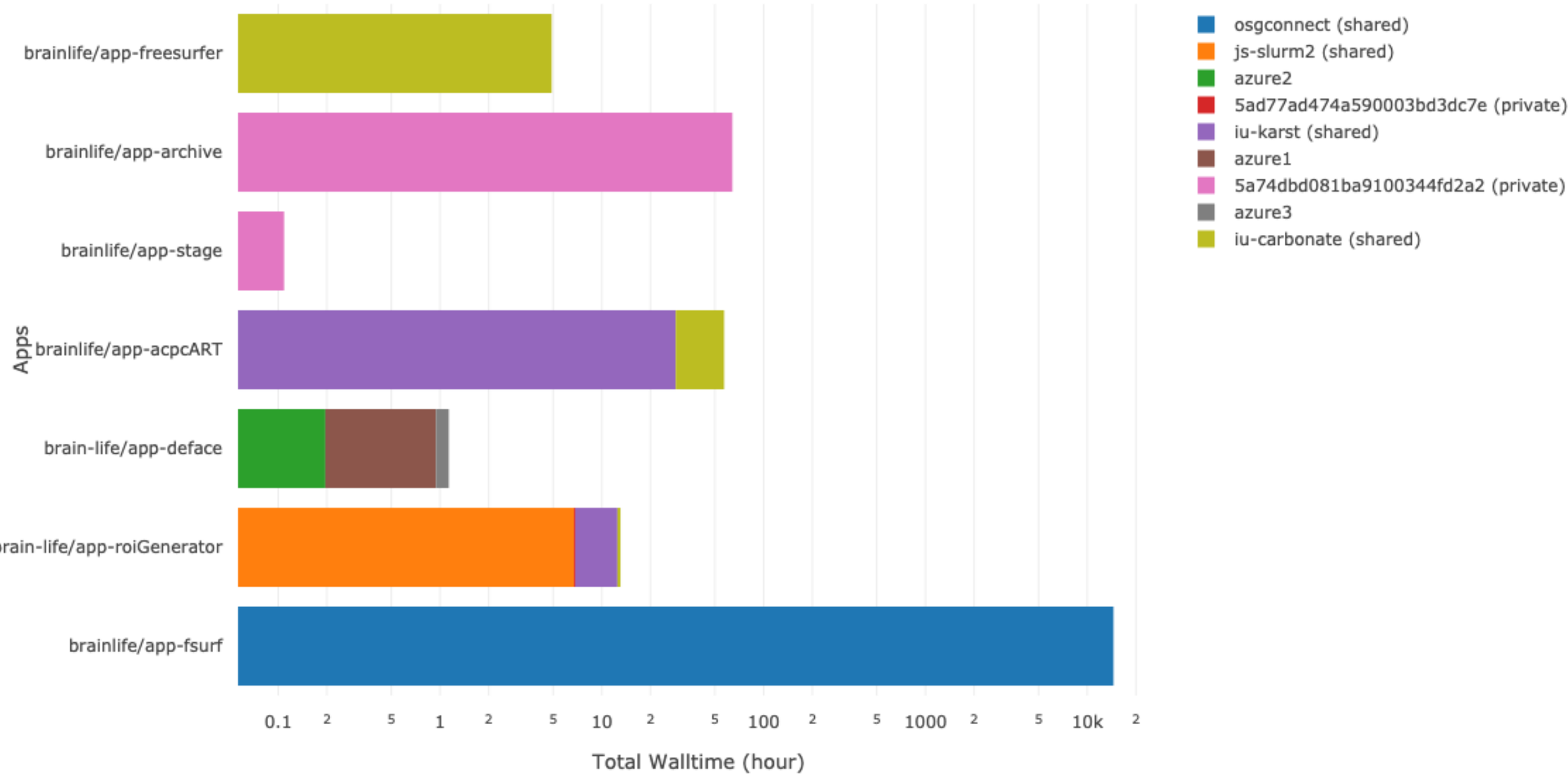
		Application

Processing pipeline



		Application

Hardware usage



Data	Science	Application

Summary

- Brainlife platform allows neuroscientists to process large datasets on any computing resource (e.g., Microsoft Azure)

- Visualized and measured specific white-matter connections and whole-brain structural connectivity

What next?

- Analyze more subjects (n ~10,000)

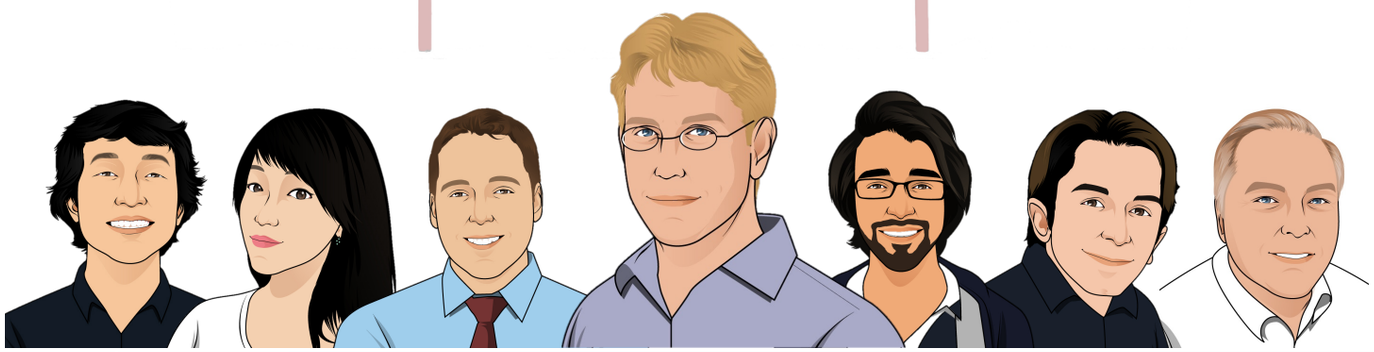
- Link brain to behaviors and genetics

- Predict future behaviors (e.g., problematic drug use, neuropsychiatric disorders)

Thank you! Questions?

spanlab

NEURO-AVENGERS



Funding

Indiana University Pervasive Technology Institute

Stanford NeuroChoice Initiative

NIMH Affective Science Program

NSF

Microsoft Azure

brainlife.io