

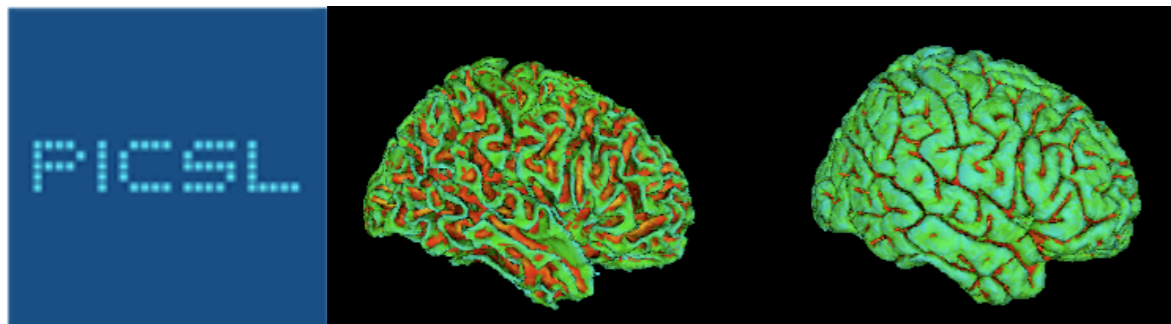
# Specializing ANTS for Scanner-to-Study Neuroimage Processing

**Brian Avants, N. Tustison, G. Song, P. Cook, J. Pluta,  
J. T. Duda, S. Das, H. Zhang, J. Perry, James C. Gee**

Penn Image Computing & Science Laboratory

Center for Functional Neuroimaging

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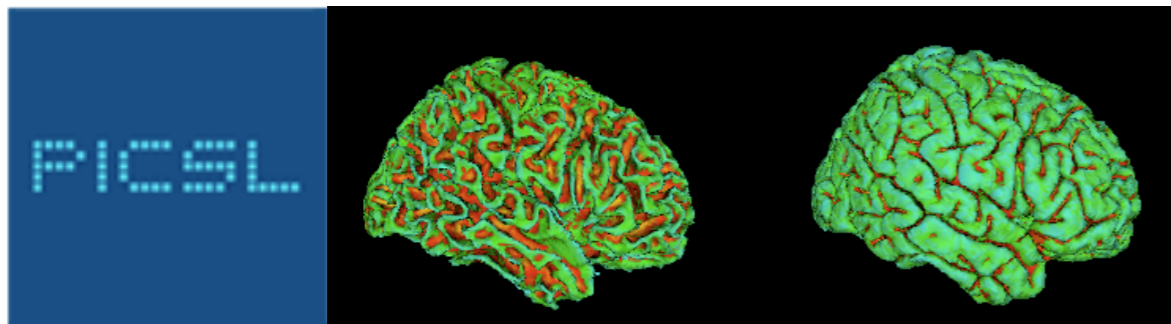
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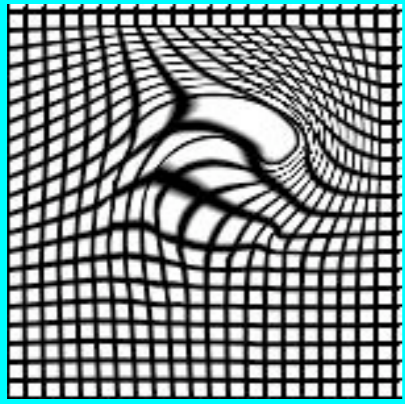
**contact:**

**google** : [picsl ANTS](#)

[picsl.upenn.edu/ANTS/](http://picsl.upenn.edu/ANTS/)

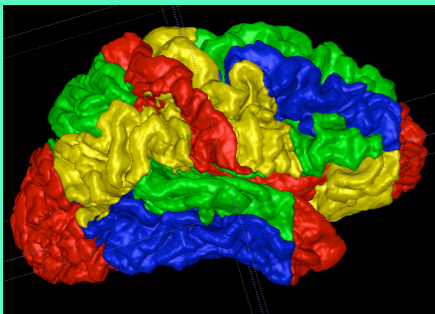


# Overview of Additions



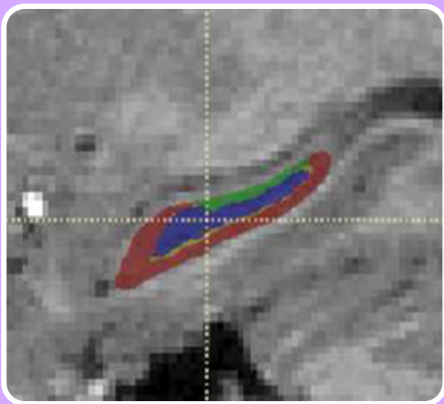
## Software Specific to Brain Mapping

Updates to ANTS, PipeDream



## New Biomarkers

Thickness, Diffusion Tensors



## Scripted Applications

Cross-sectional and Longitudinal MultiVar. Studies

# Advanced Normalization Tools

NITRC

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NITRC

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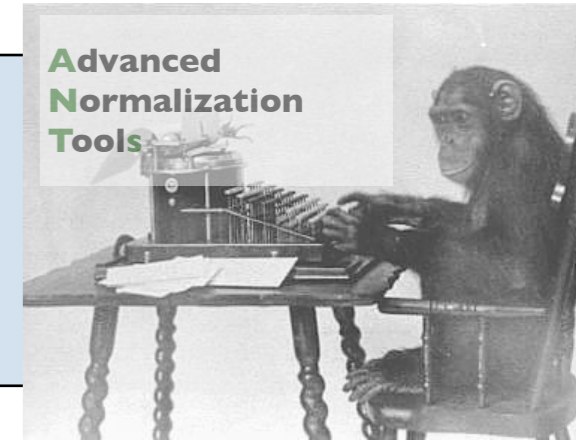
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CDash - ANTS

http://www.picsl.upenn.edu/cdash/index.php?project=ANTS

Google

Login | Dashboards

Tuesday, May 19 2009 12:11:01 EDT



# ANTs Dashboard

## NITRC

DASHBOARD CALENDAR PREVIOUS CURRENT PROJECT

No update data as of 2009-05-19T01:00:00 EDT [Help](#)

[Show Filters](#)

### Nightly



Site	Build Name	Update		Configure			Build			Test				Build Time	Labels
		Files	Min	Error	Warn	Min	Error	Warn	Min	NotRun	Fail	Pass	Min		
<a href="#">bigmac.uphs.upenn.edu</a>	<a href="#">Linux-c++</a>	0	3.2	0	0	0.1	0	14	15.2	0	5	115 <sub>+1</sub>	66.7	2009-05-19T02:33:28 EDT	(none)
<a href="#">mingus.uphs.upenn.edu</a>	<a href="#">Linux-c++</a>	0	3.2	0	0	0.1	0	0	0	0	6	114	70.8	2009-05-19T03:33:18 EDT	(none)
Totals	2 Builds	0	6.4	0	0	0.2	0	14	15.2	0	11	229	137.5		

No Continuous Builds

No Experimental Builds

No Coverage

No Dynamic Analysis

CDash 1.4.1 © 2009 [Kitware Inc.](#)  
[\[report problems\]](#)

Joint work with Tustison, Song, Das, Cook, Duda

# ANTS Transformation Models

Category	Transformation, $\phi$	Similarity Measures	Brief Description
<b>Linear</b>	Rigid <sup>†</sup>	MI, MSQ	Rigid registration.
	Affine <sup>†</sup>	MI, MSQ	Affine registration.
<b>Elastic</b>	Deformable	CC, PR, MI, MSQ, PSE	Demons-like algorithm.
	DMFFD	CC, PR, MI, MSQ, PSE	FFD variant.
<b>Diffeo.</b>	Exponential <sup>†</sup>	CC, PR, MI, MSQ, PSE	$\min \mathbf{v}(\mathbf{x})$
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Affine

Elastic

Diffeomorphic

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## Scripting

call “sh ants.sh” to get usage  
encodes current “best practice” parameters



Affine



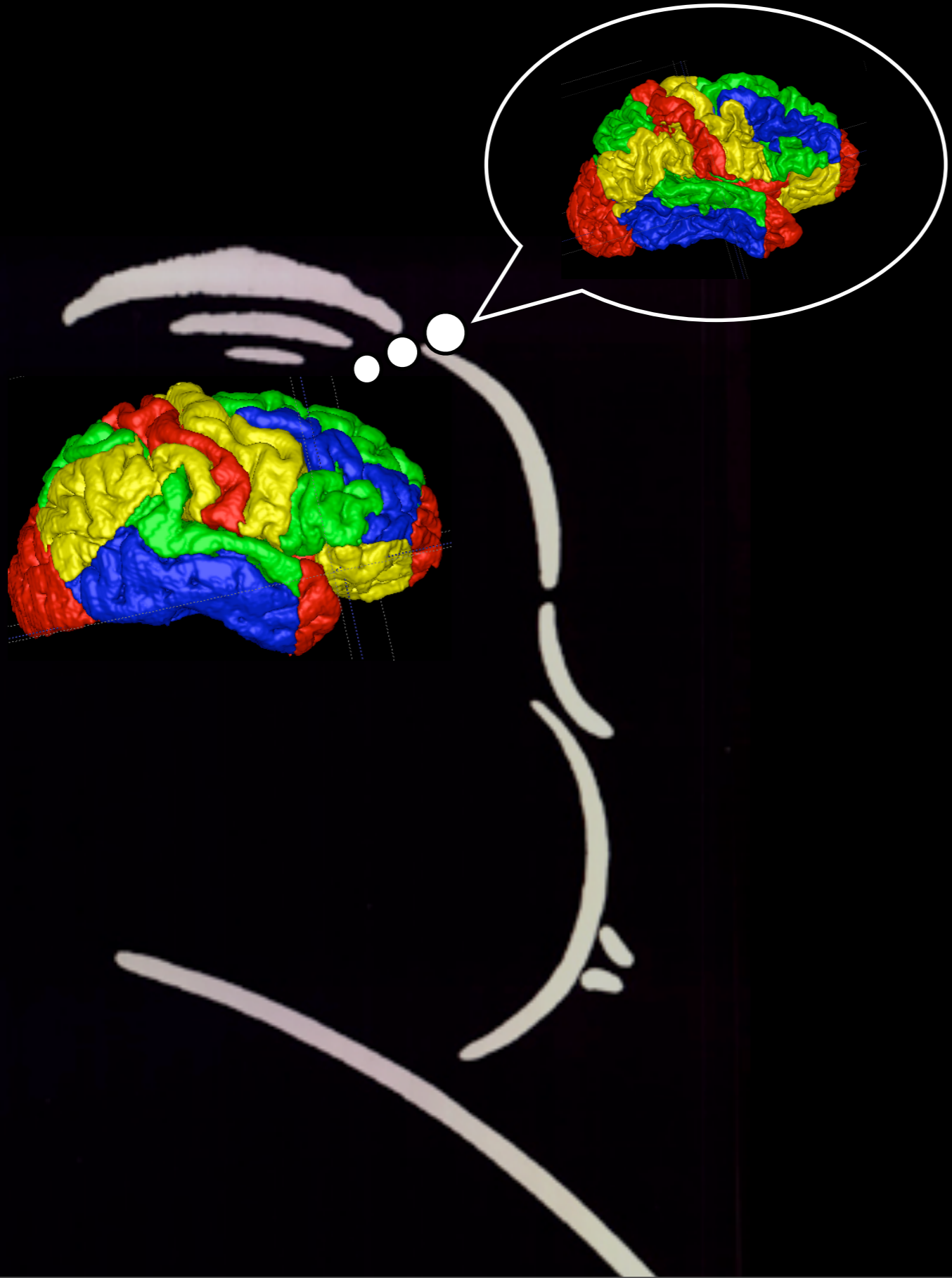
Elastic



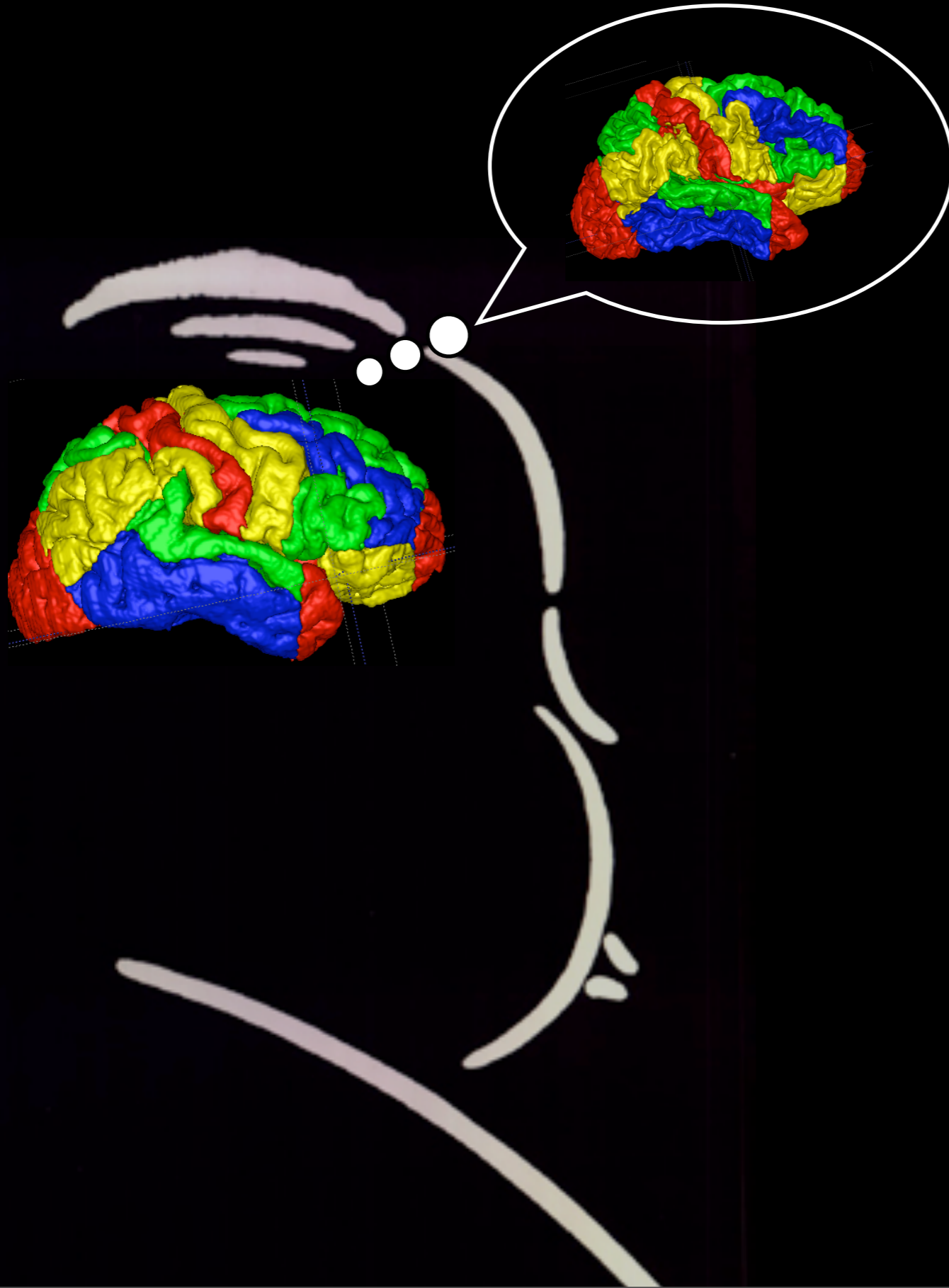
Diffeomorphic



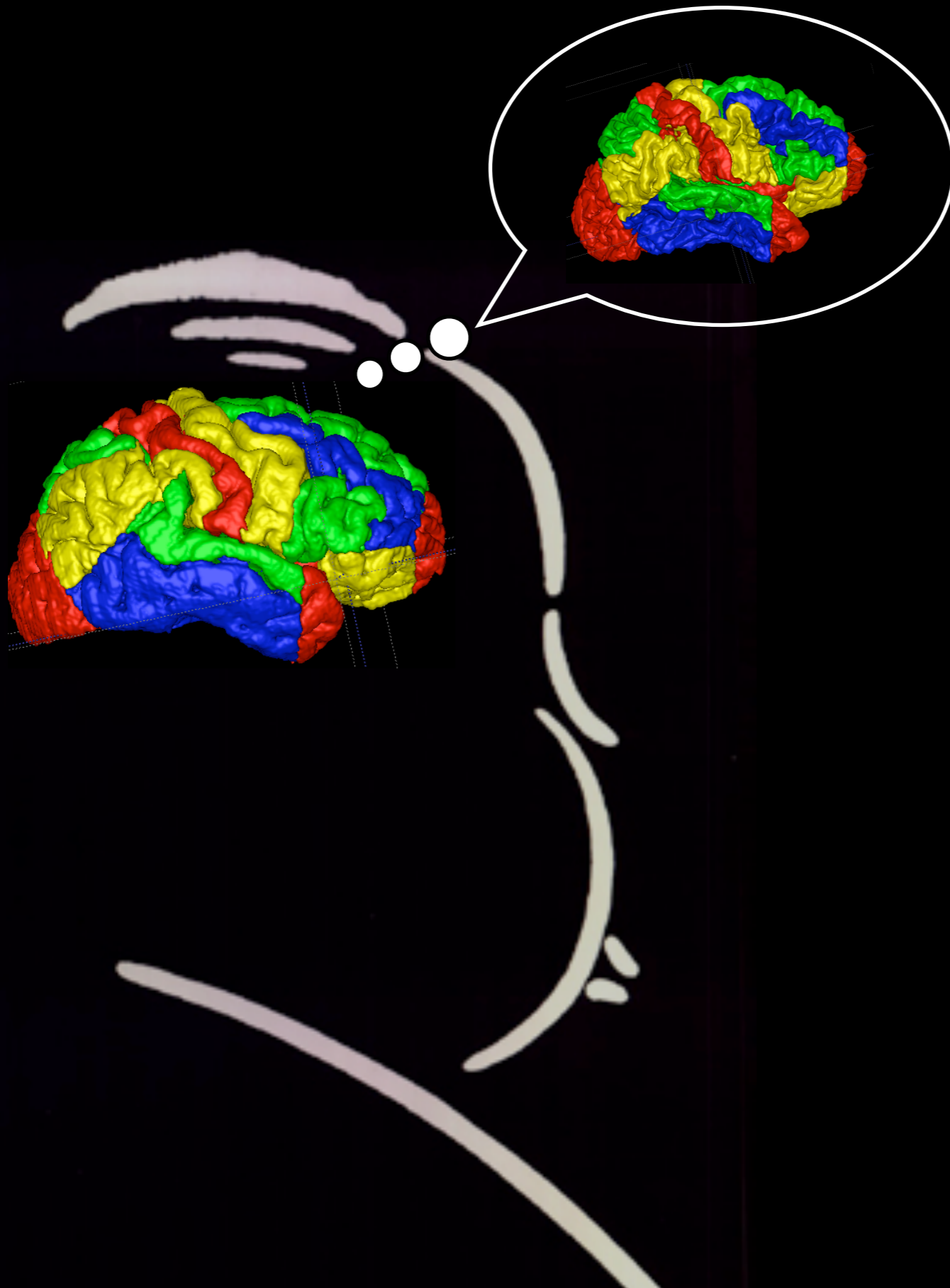
# Pipe Dream



# Pipe Dream : pipelined brain mapping



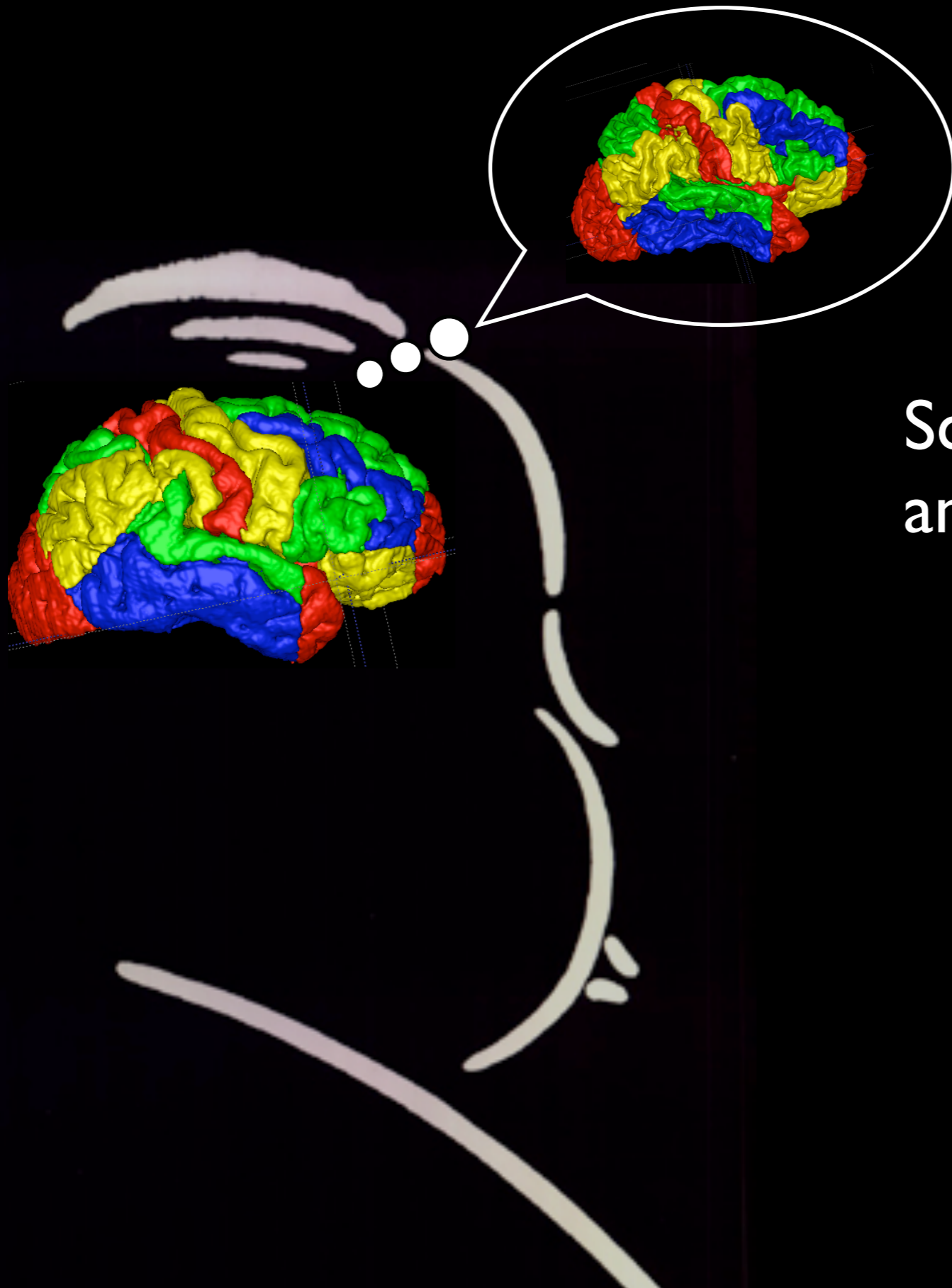
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We embed our population analysis tools in a portable set of shell scripts.



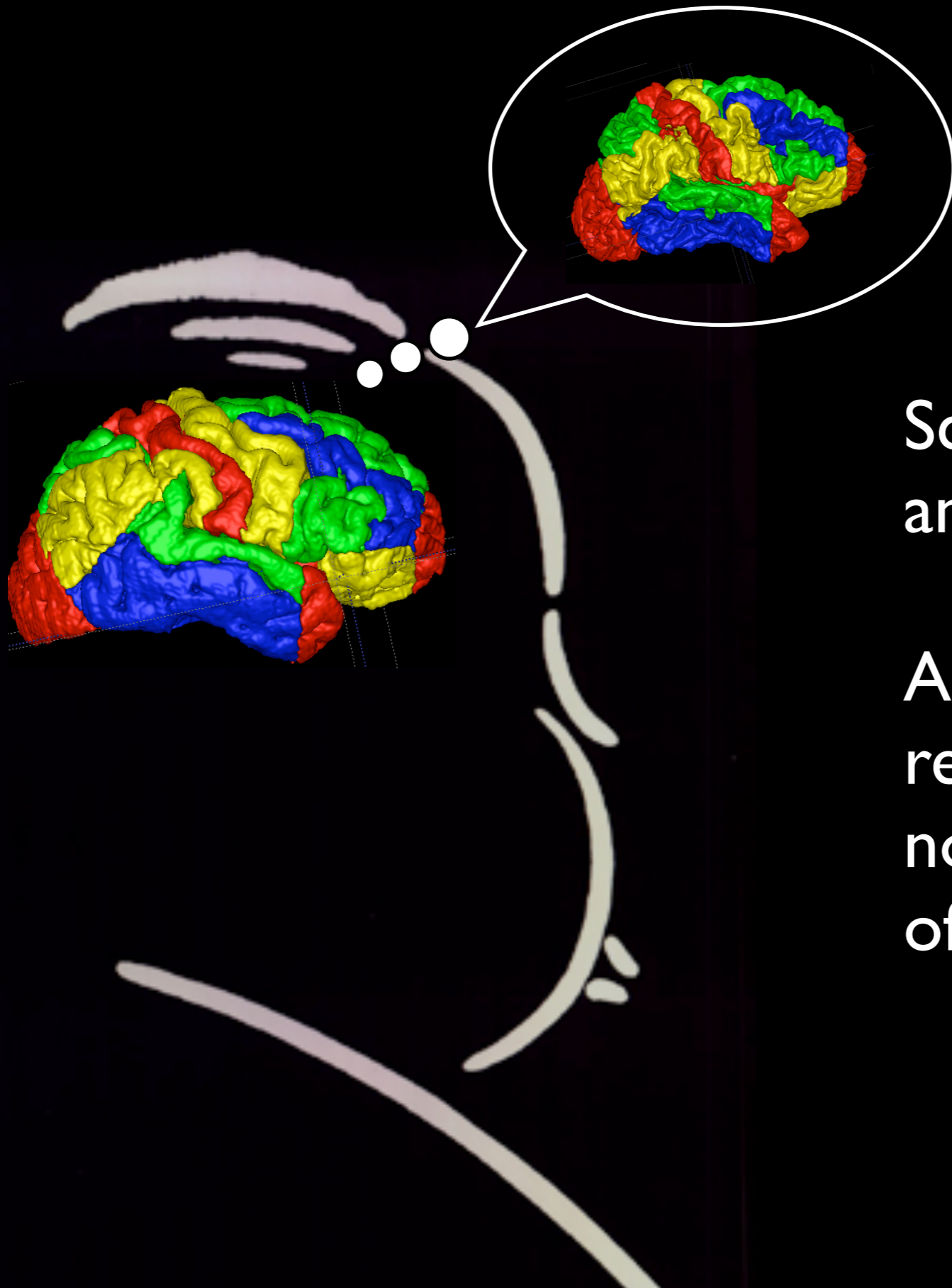
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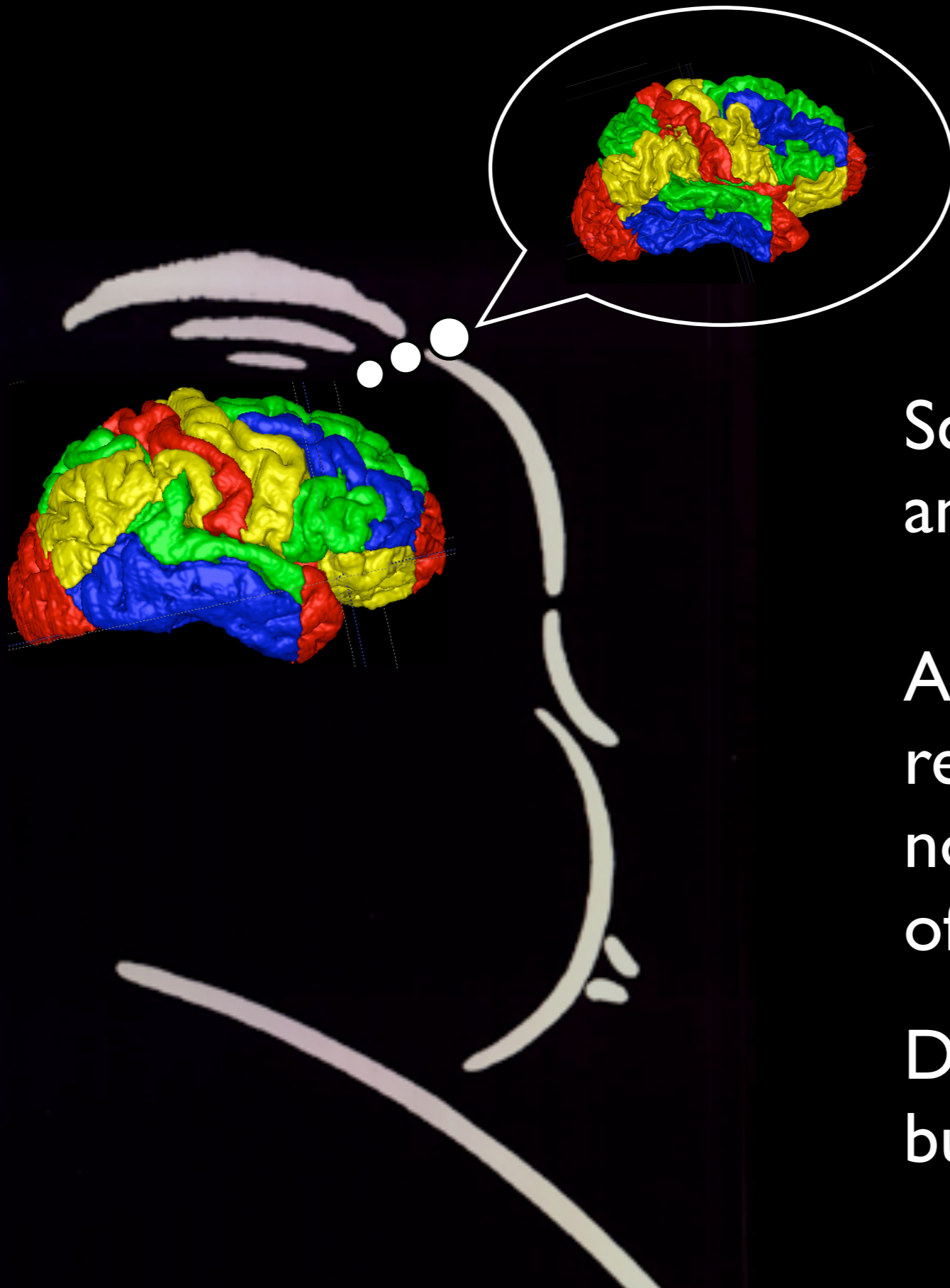


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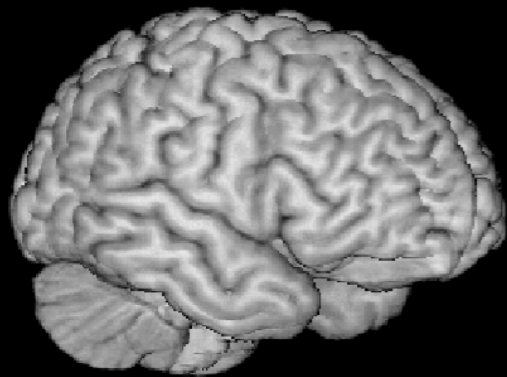
Automate image reconstruction, population normalization and encoding of anatomical statistics.

Designed for naive users, but extensible.

# ANTS+PipeDream Processing

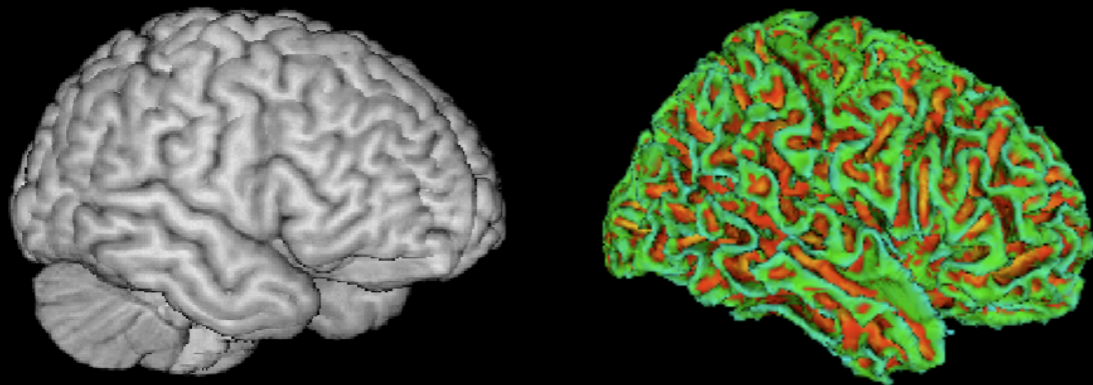
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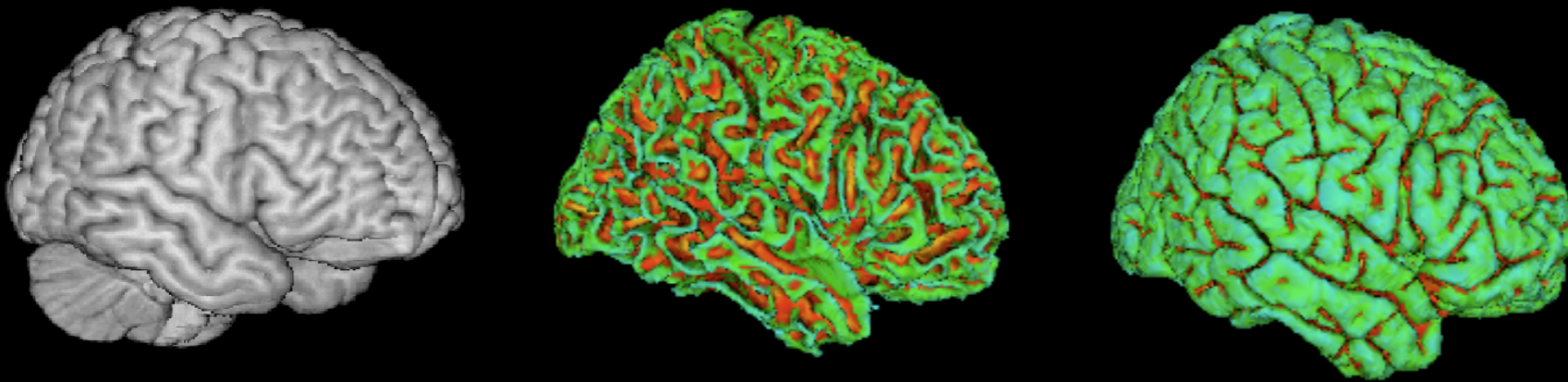
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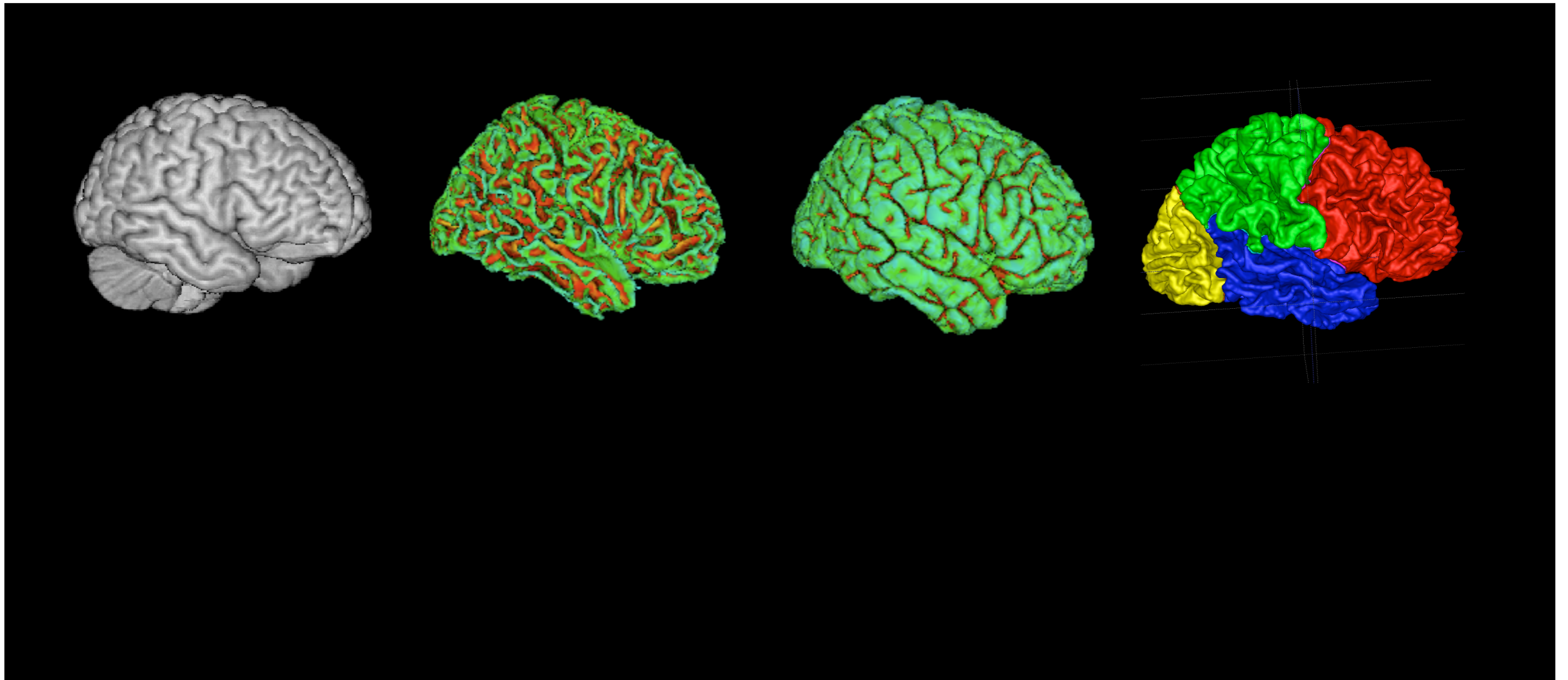
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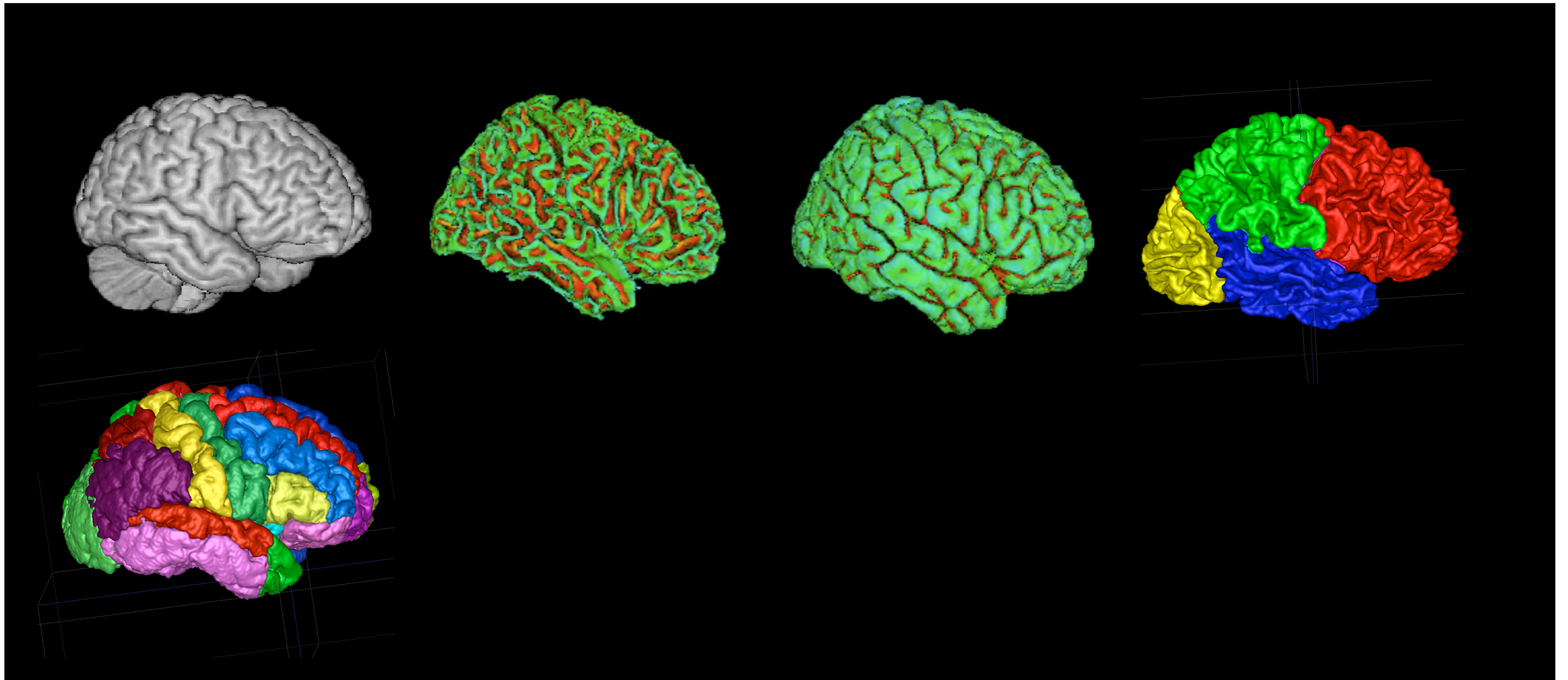


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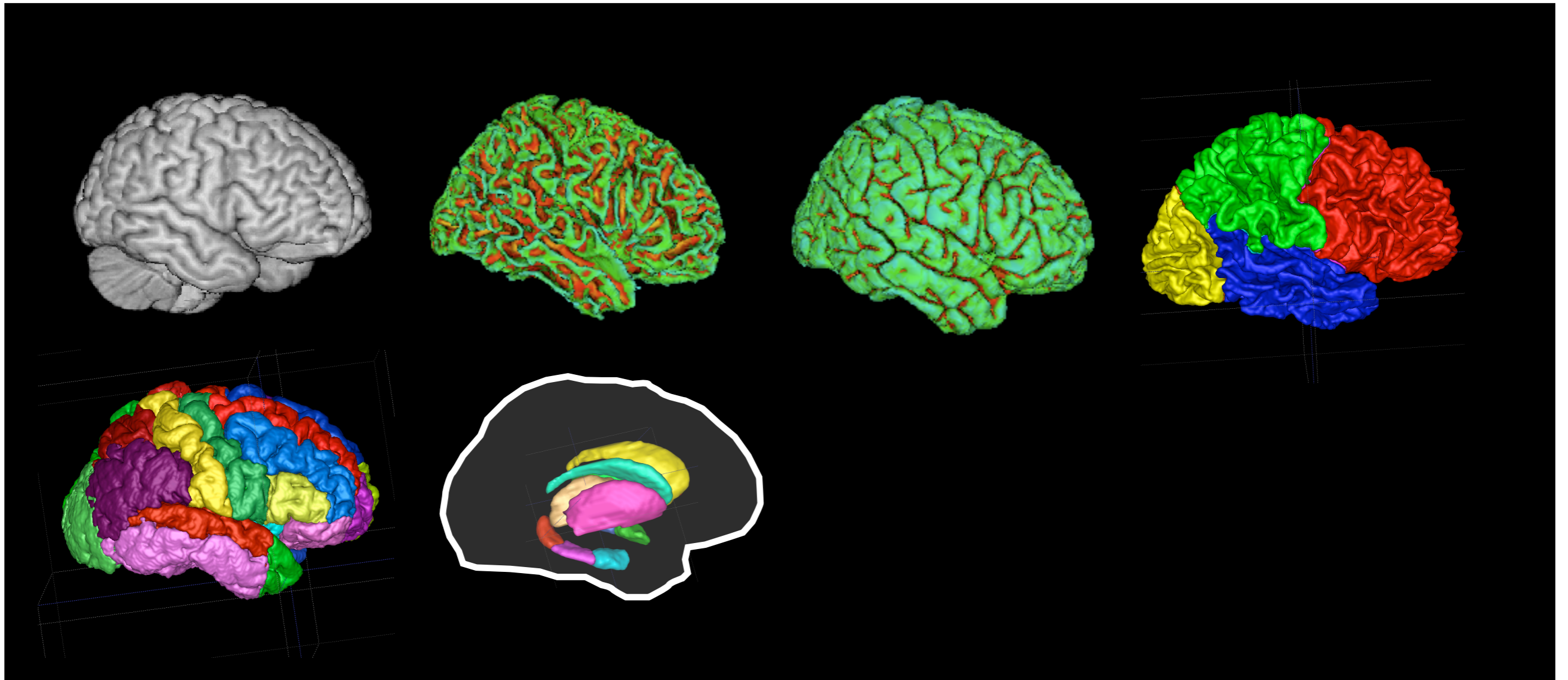
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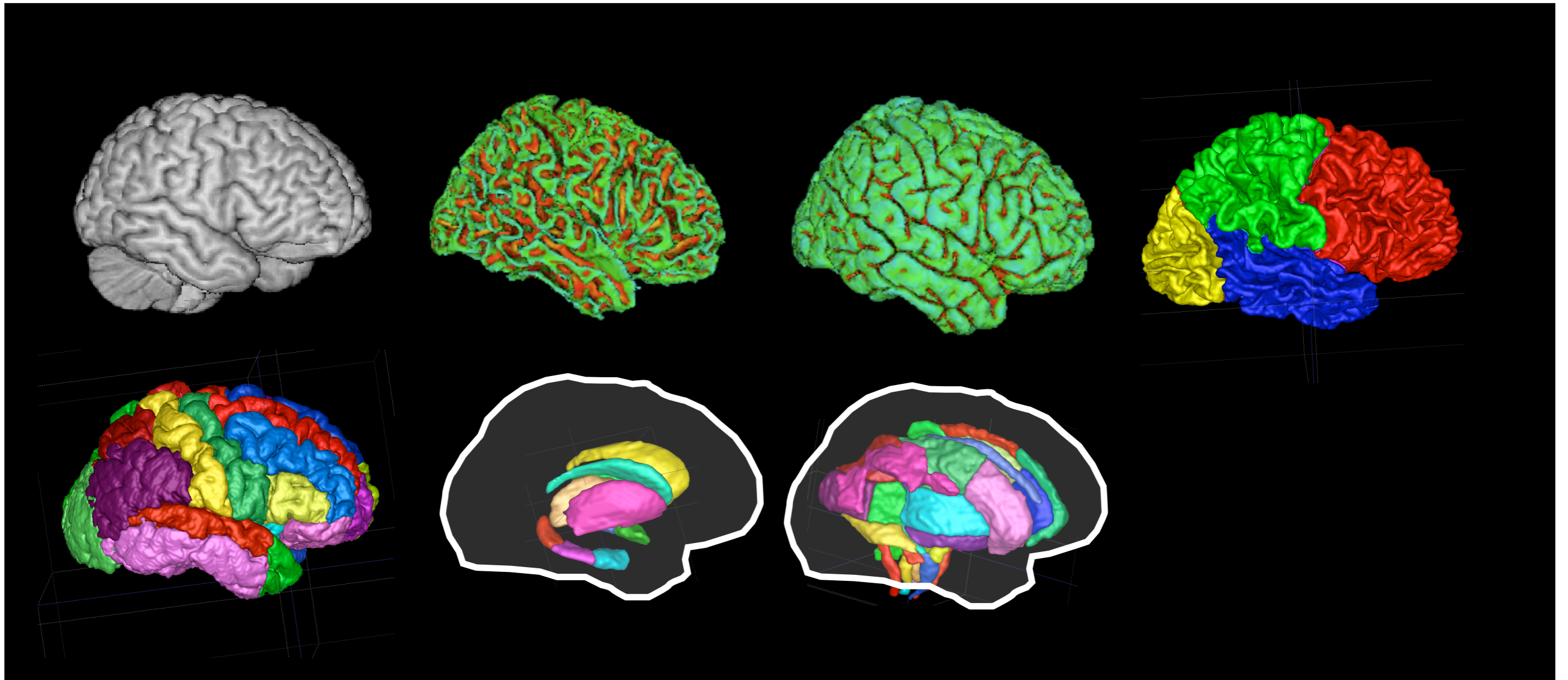
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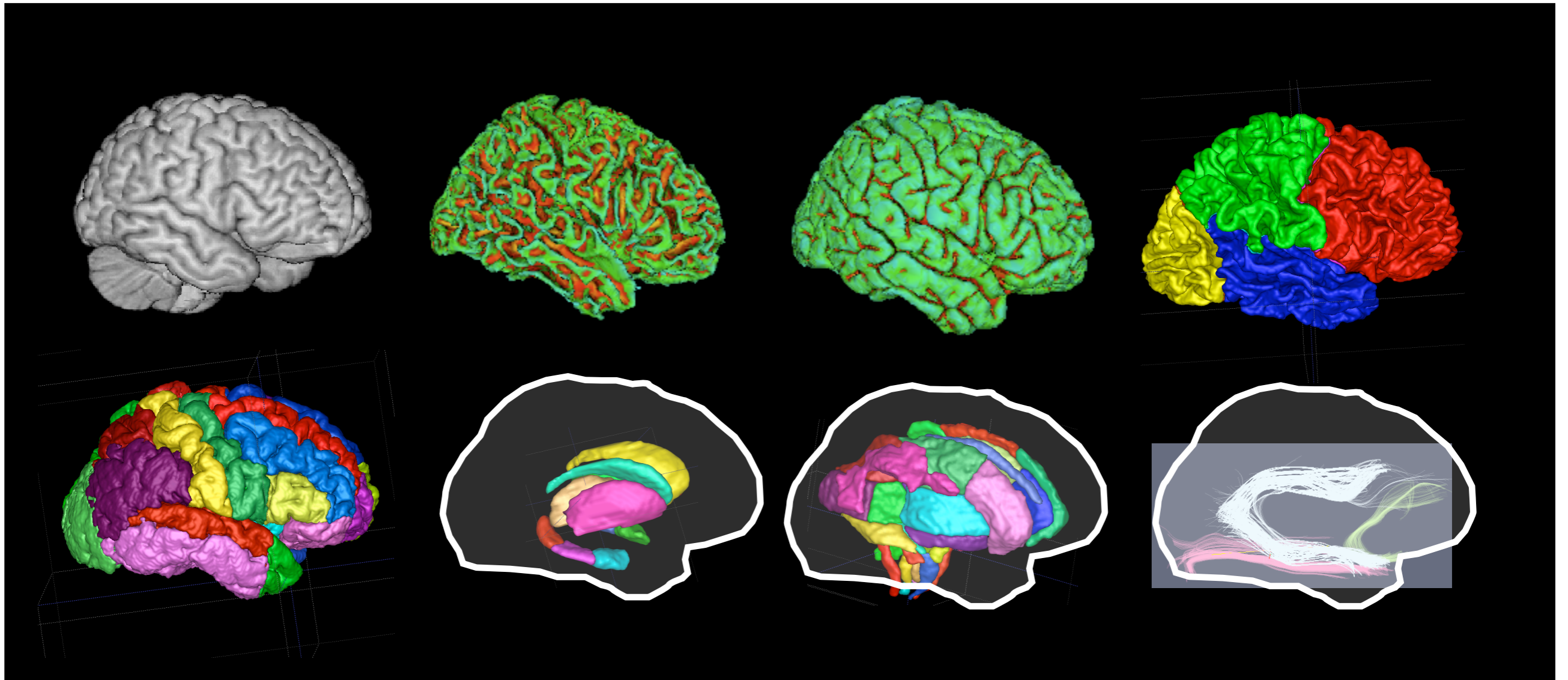


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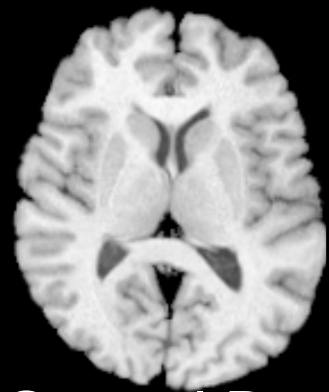
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# ANTs Segmentation Tools



Original Data



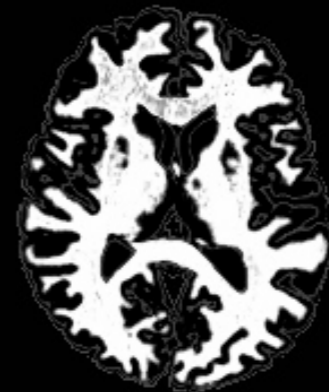
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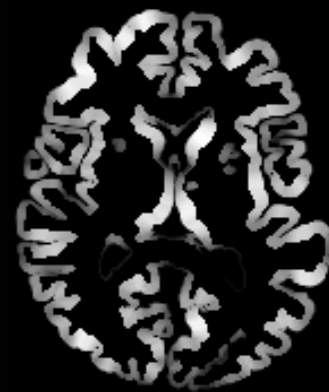
Probability CSF



Probability GM



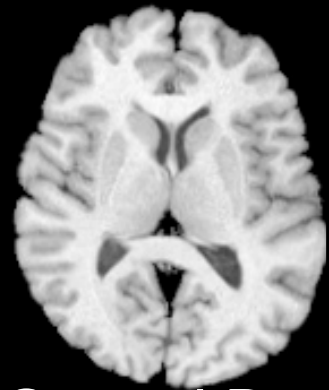
Probability WM



Thickness



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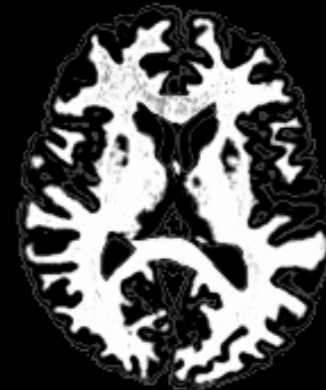
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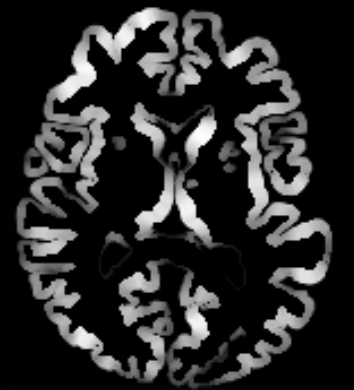
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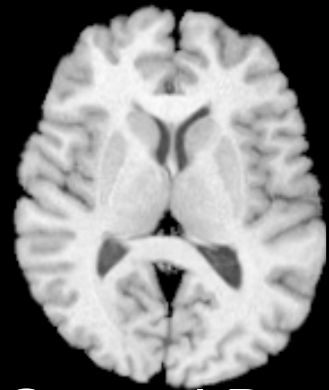
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Prior Based Segmentation

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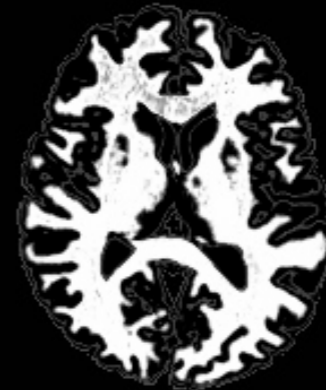
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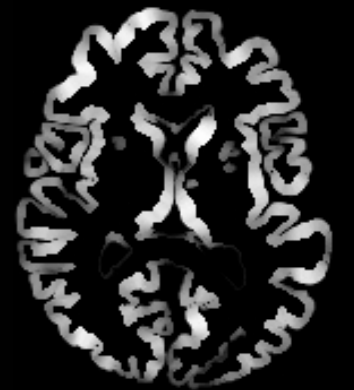
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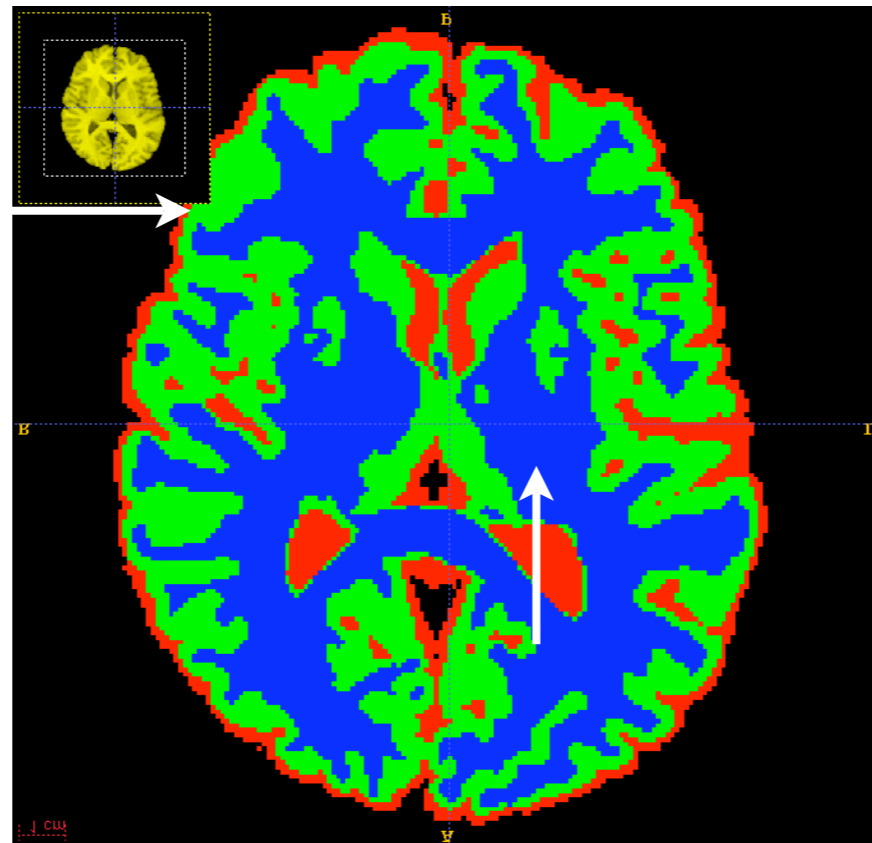
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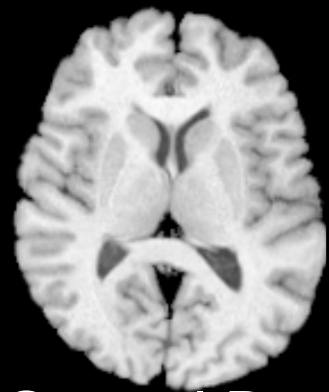


Thickness



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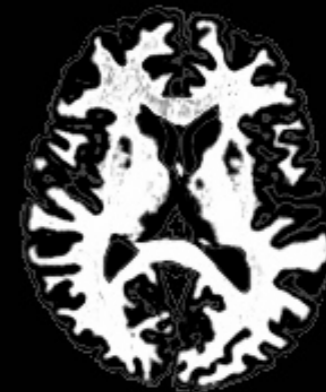
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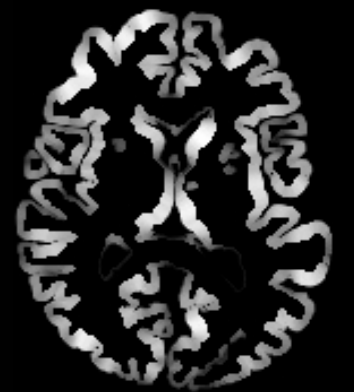
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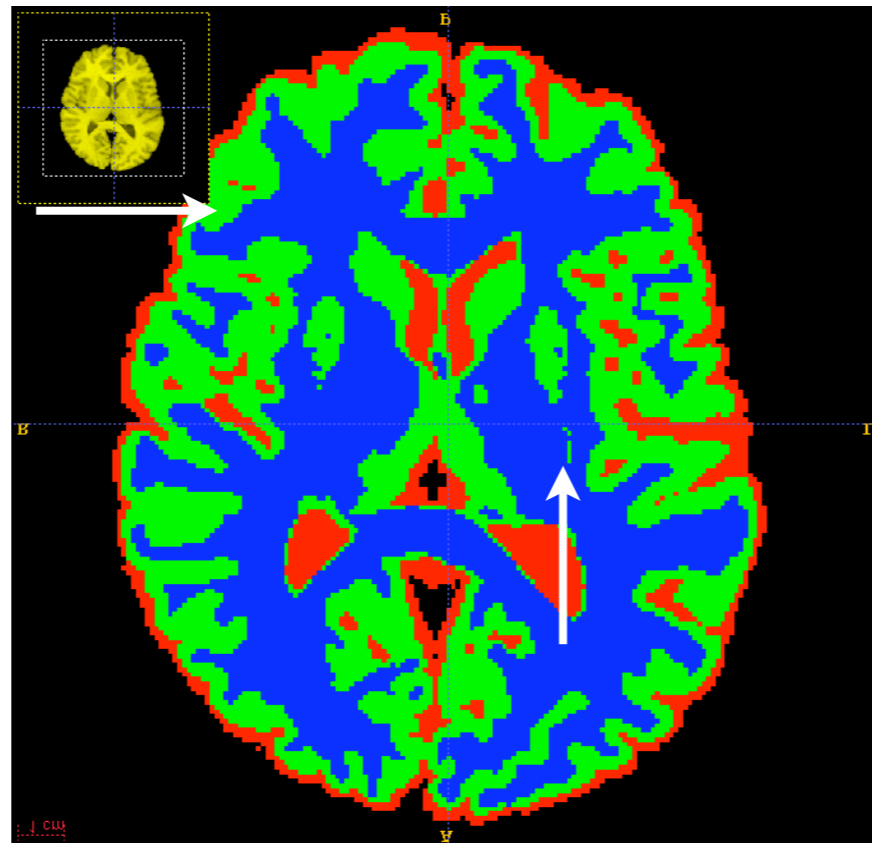
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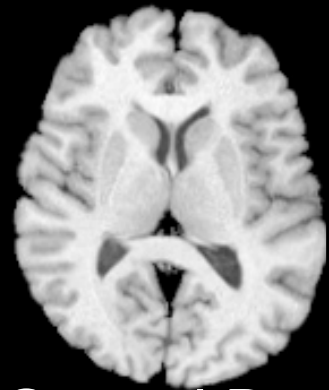


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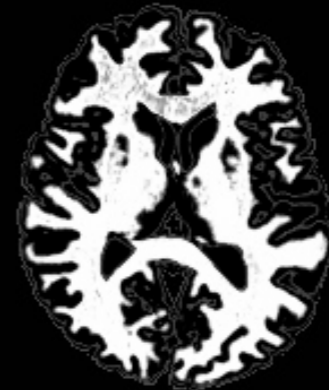
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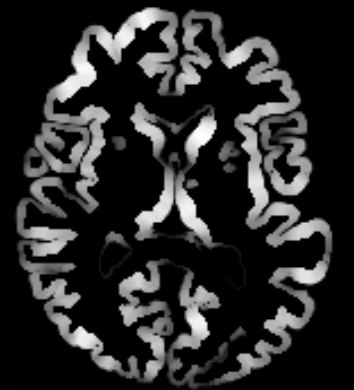
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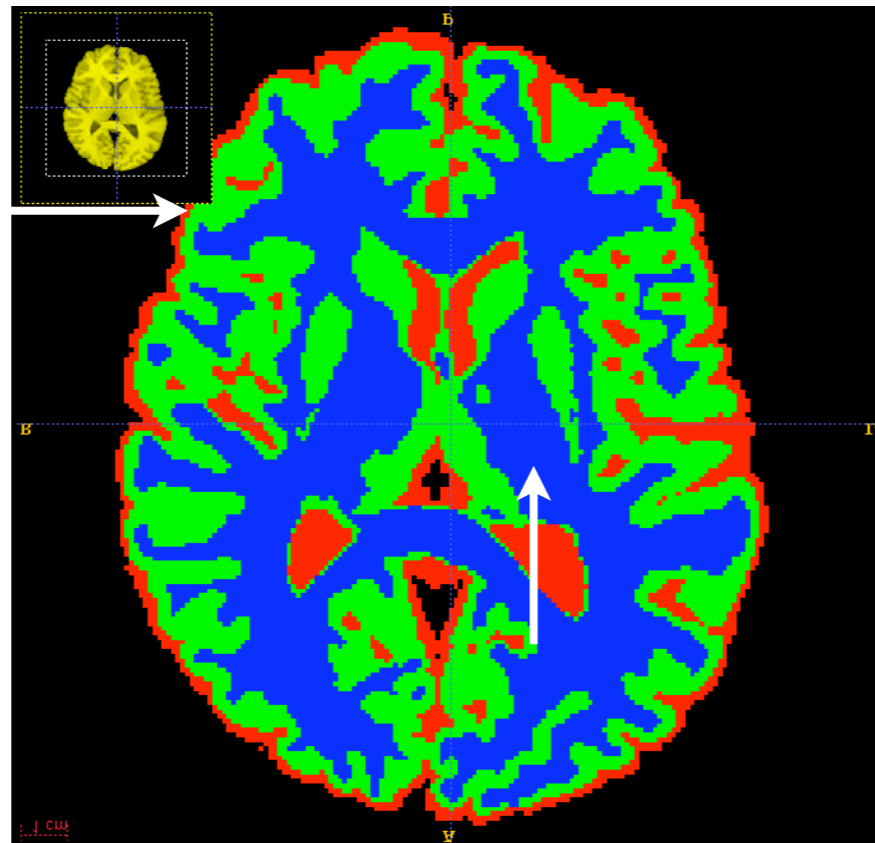
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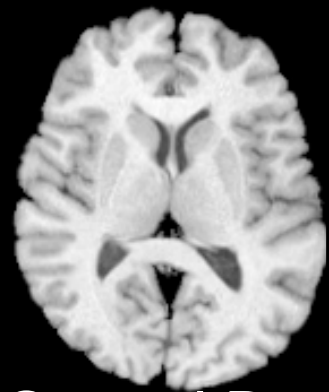


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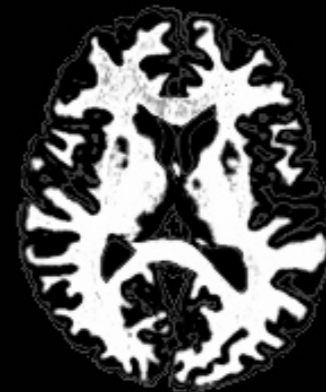
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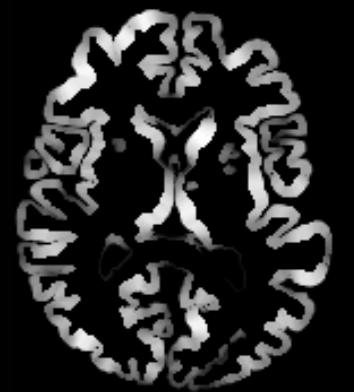
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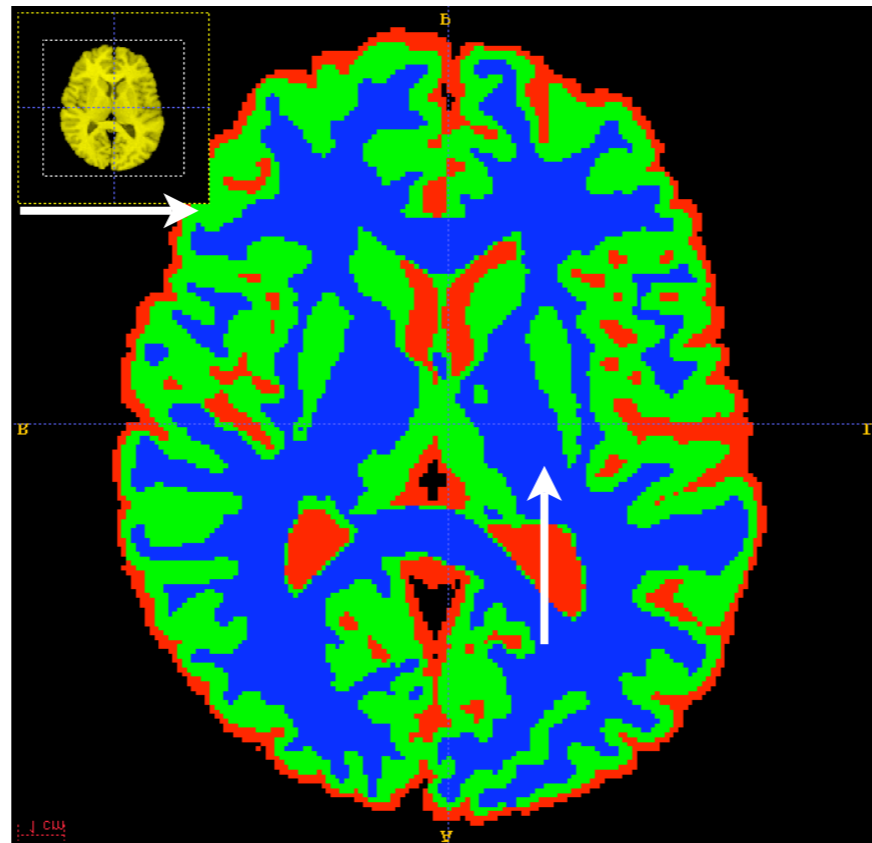
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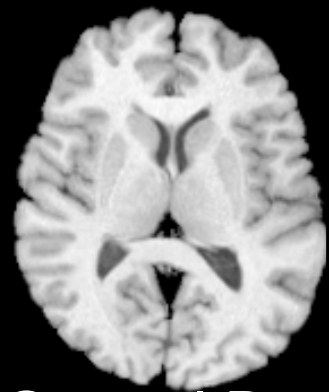
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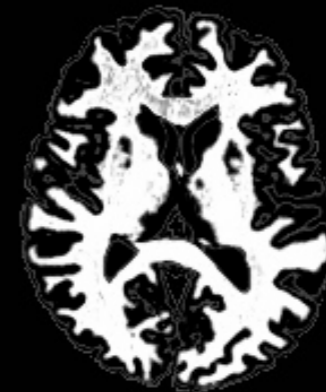
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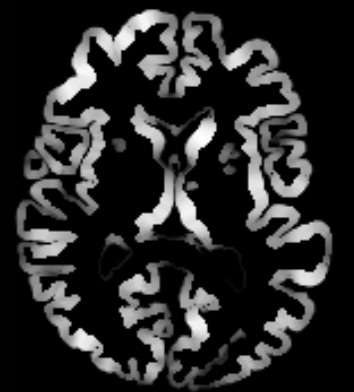
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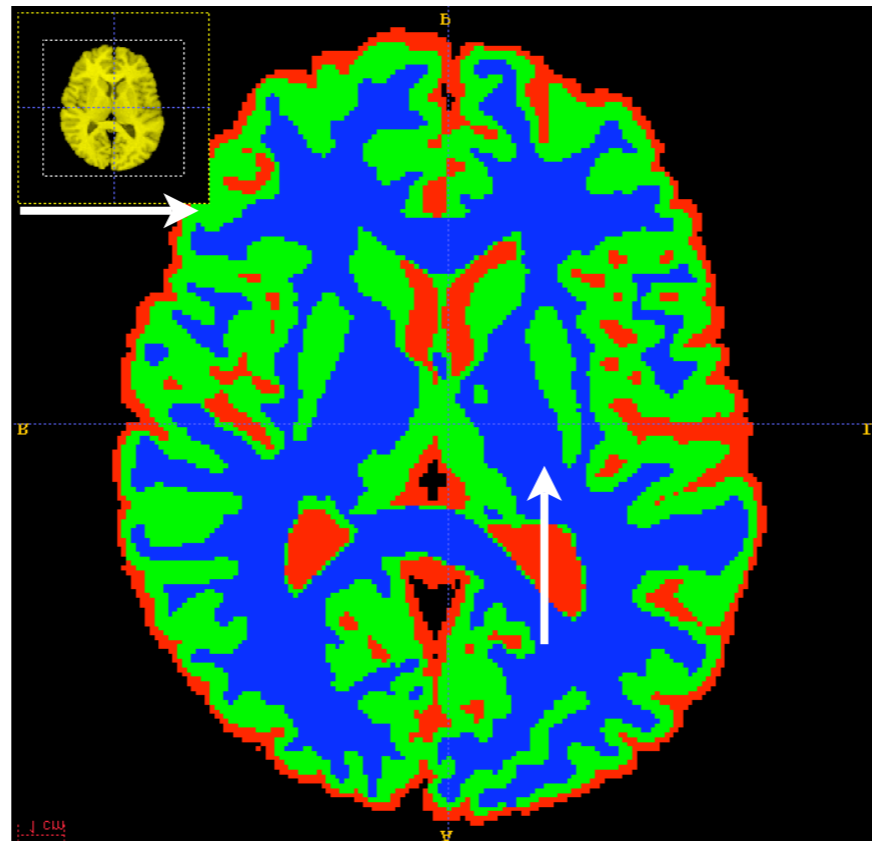
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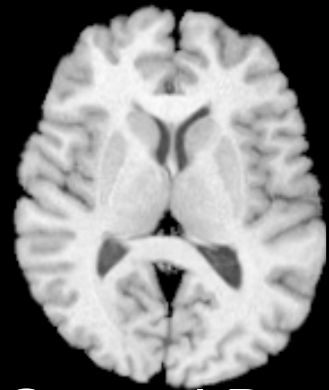


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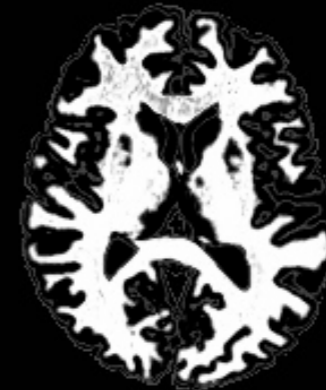
Segmentation



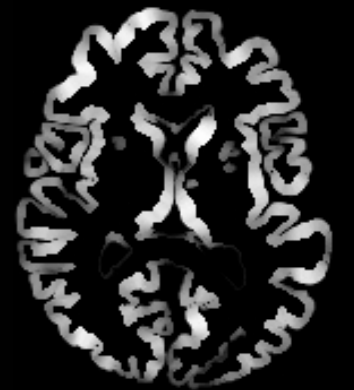
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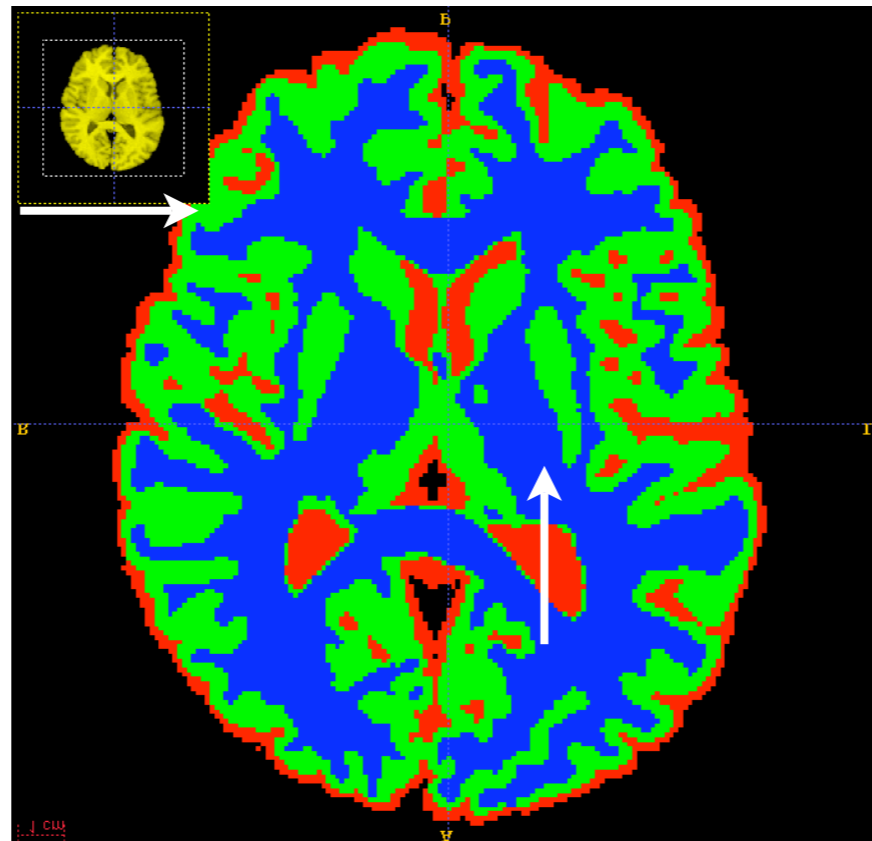


Probability WM



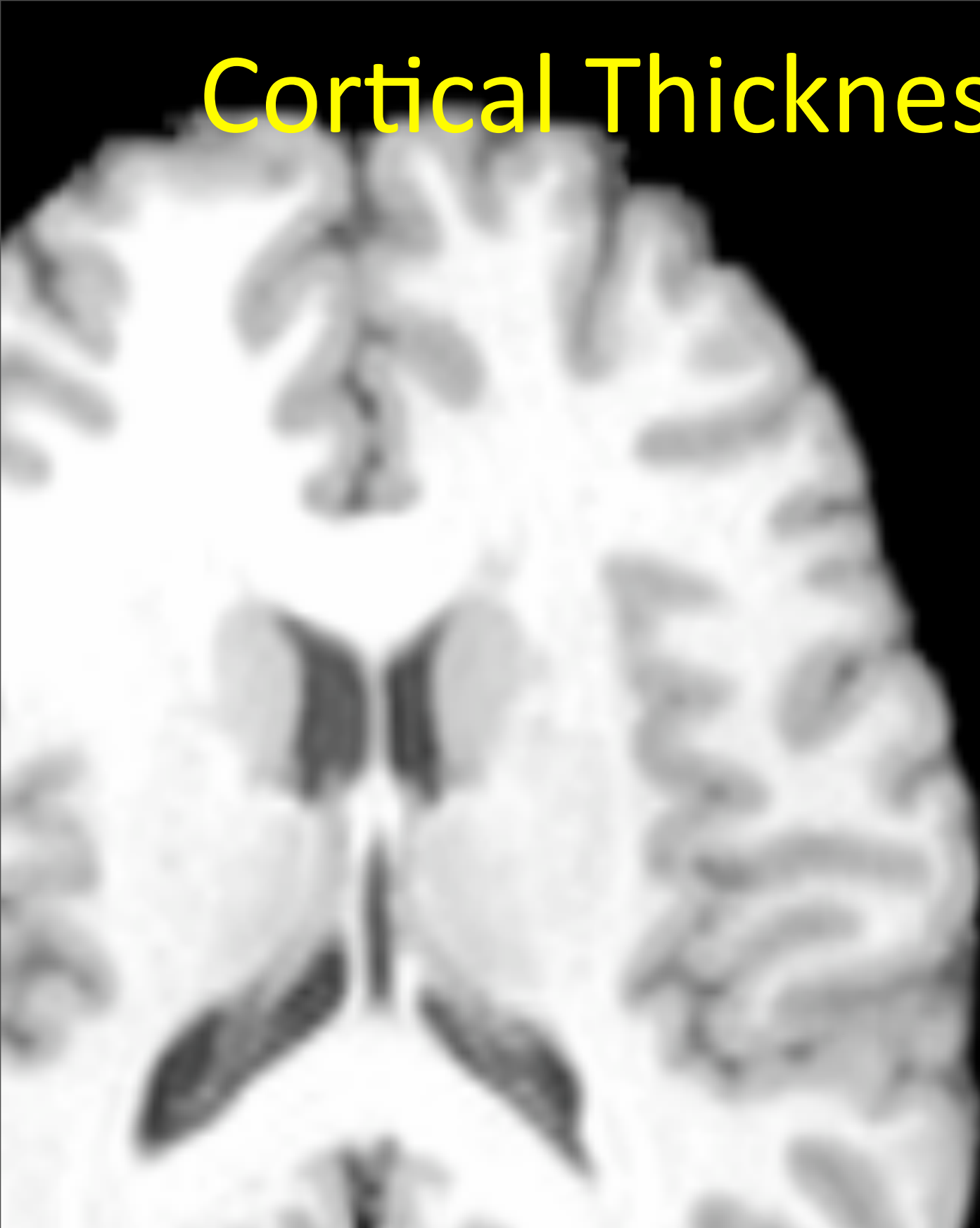
Thickness

Needs  
Evaluation



Prior Based Segmentation

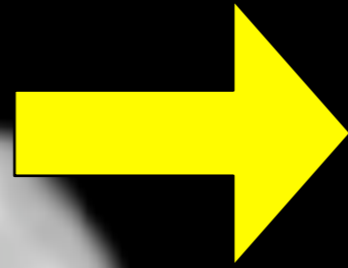
# Cortical Thickness Measurement



Thickness of the cortex  
correlates with IQ, reading  
skill, disease, etc. :  
Valuable biomarker.

Das, et al., *Diffeomorphic Registration Based Cortical Thickness*,  
*Neuroimage* 2009.

# Cortical Thickness Measurement

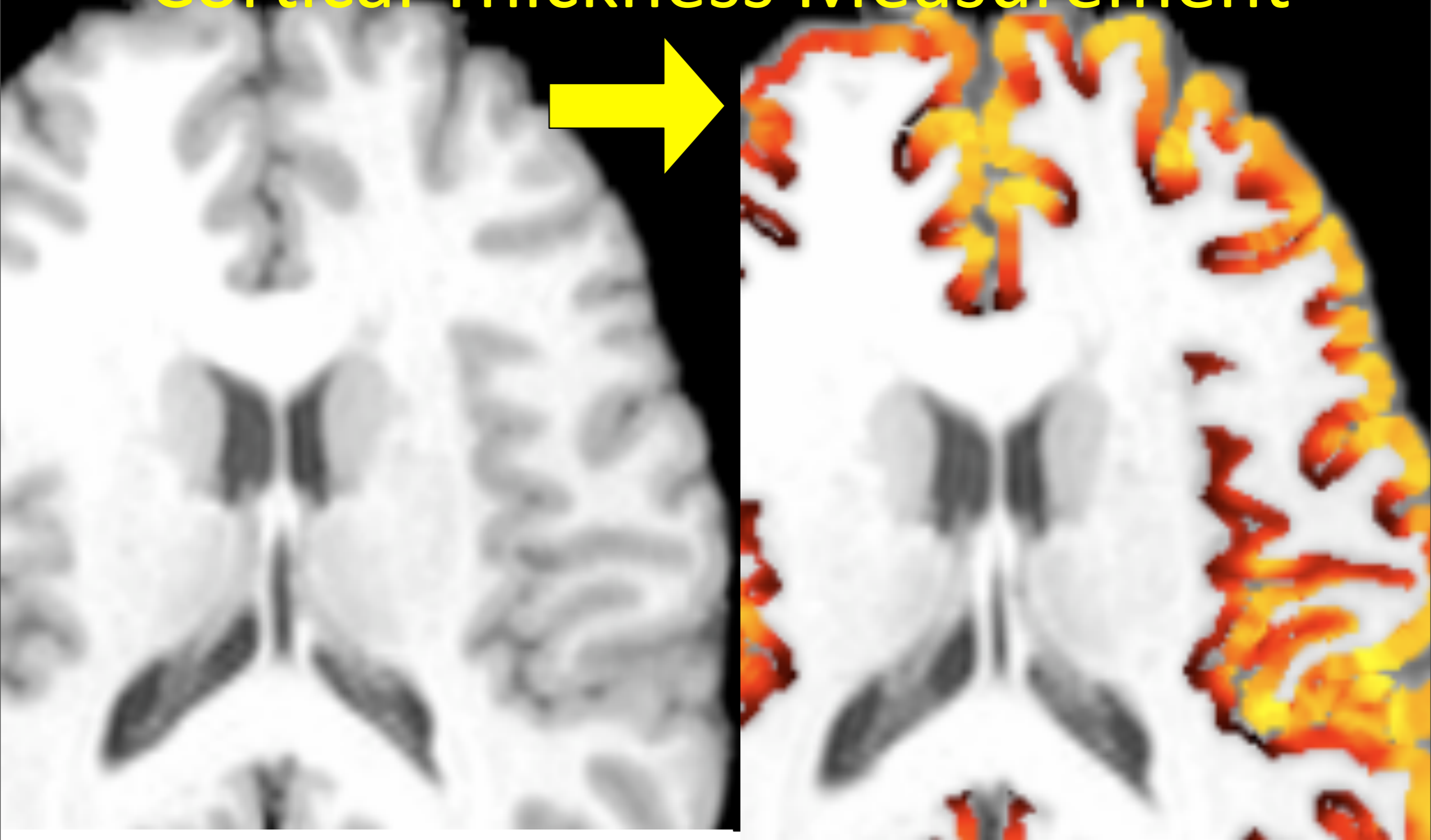


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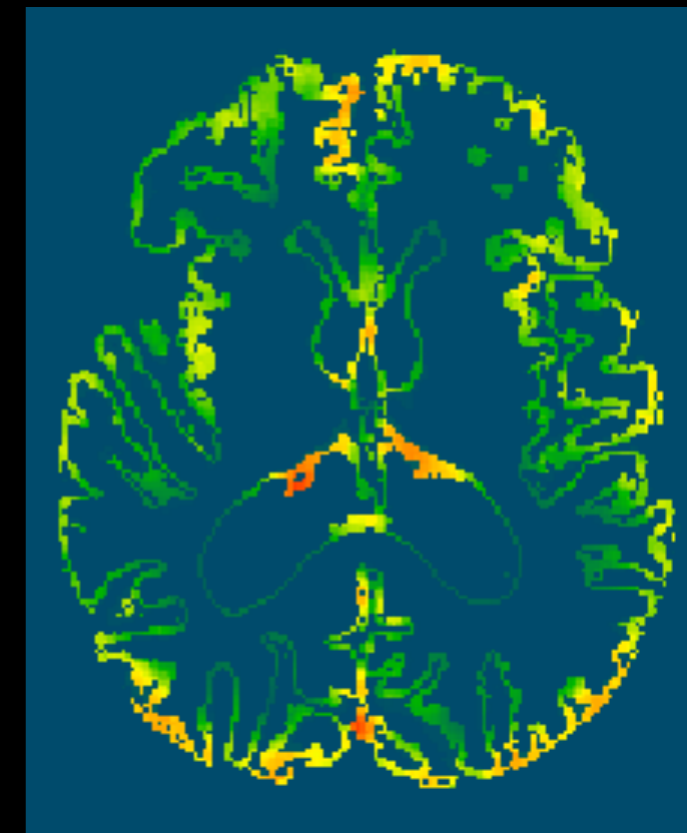
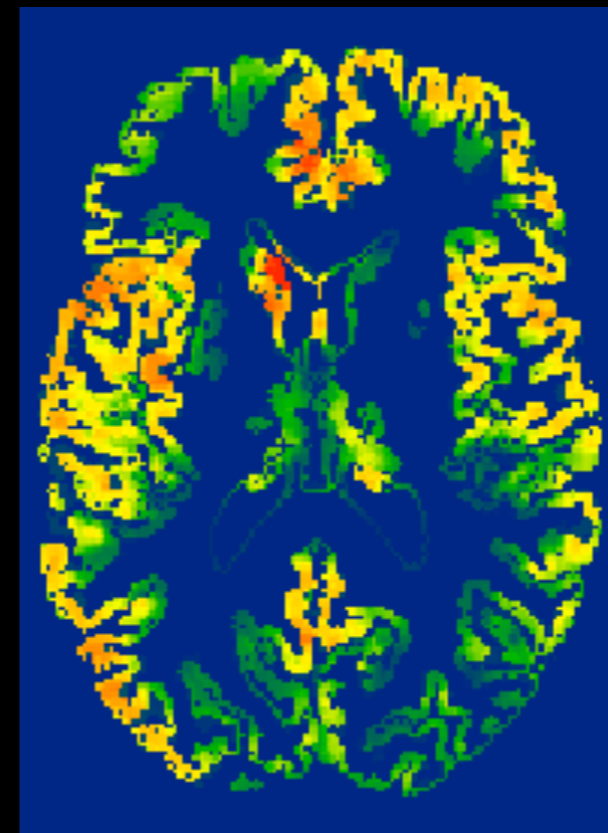
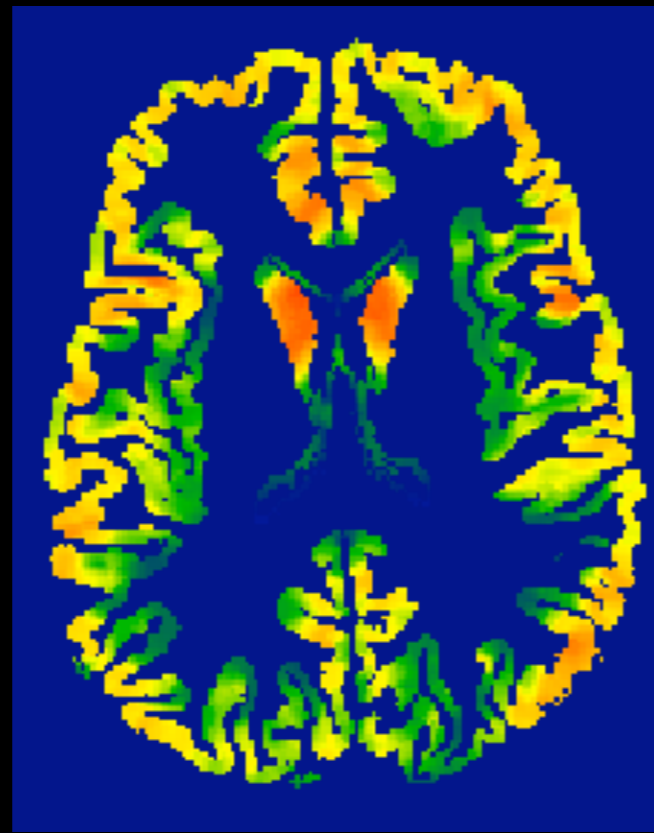
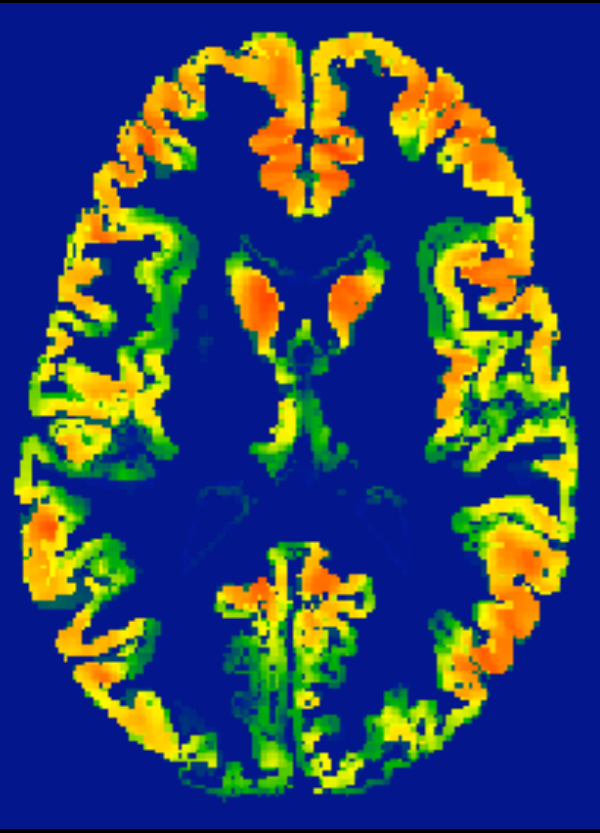
# Cortical Thickness Across the Lifespan

Adolescent

Young

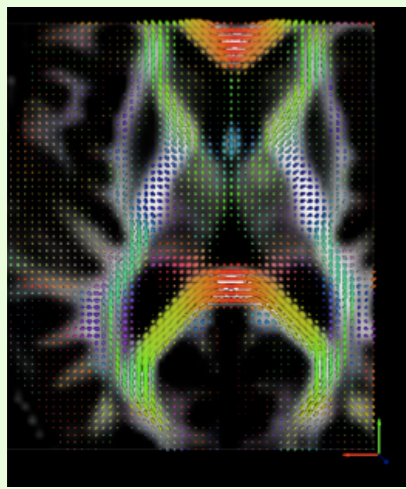
Elderly

Neurodegenerative



ANTS/Laplacian Thickness

# PipeDream T1+DTI Normalization Strategy



Diffusion



Anatomical

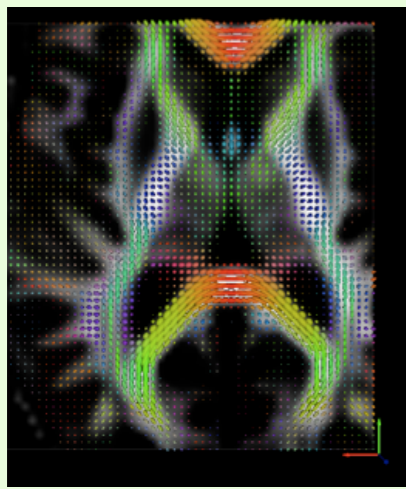


GM Prior

Template Space

Individual Space

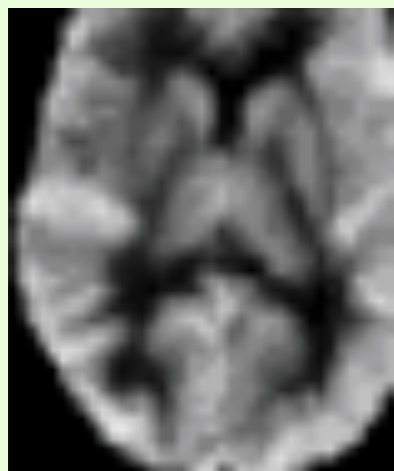
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Diffusion

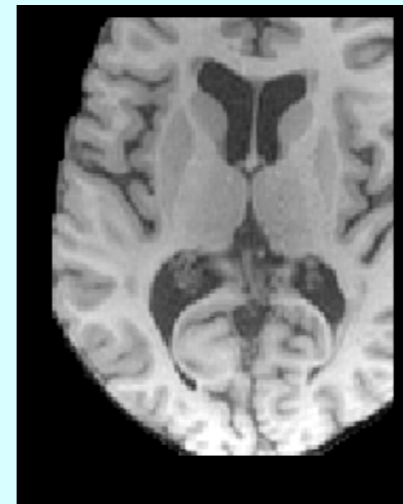


Anatomical

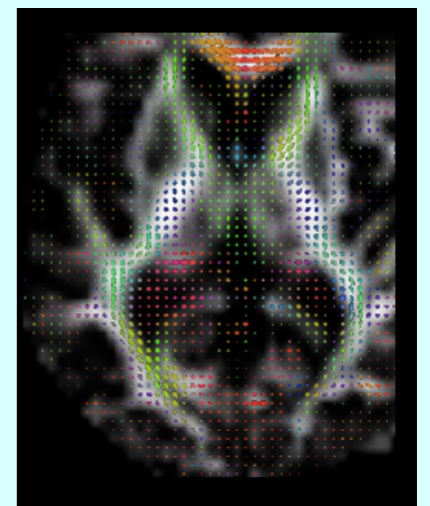


GM Prior

Template Space



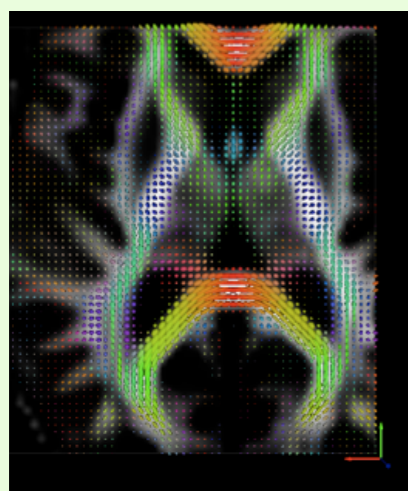
Anatomical



Diffusion

Individual Space

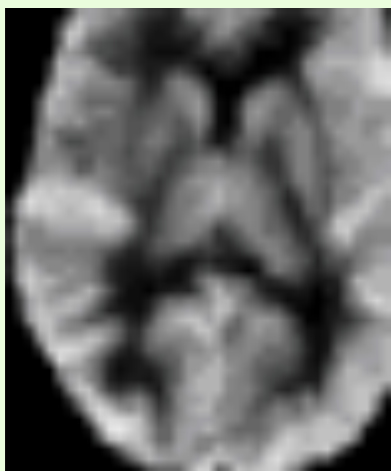
# PipeDream T1+DTI Normalization Strategy



Diffusion



Anatomical

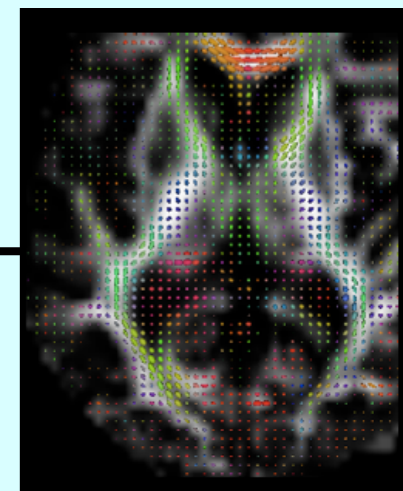


GM Prior

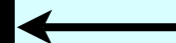
Template Space



Anatomical



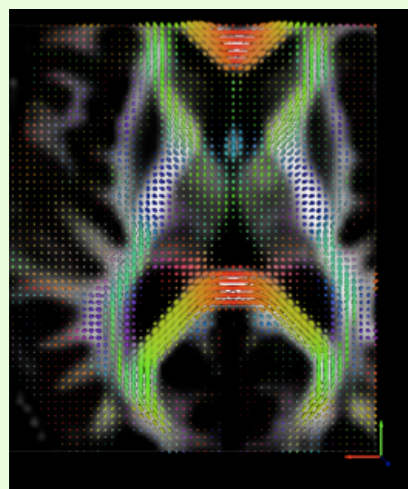
Diffusion



Individual Space



# PipeDream T1+DTI Normalization Strategy



Diffusion

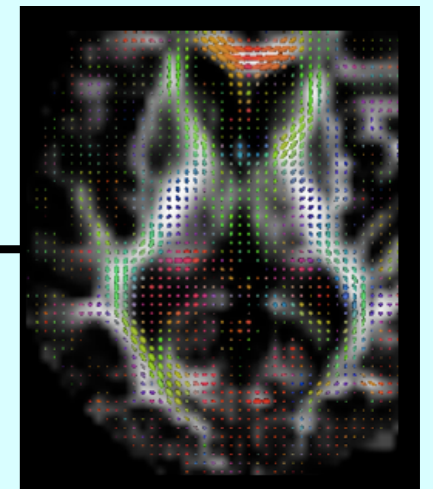


Anatomical

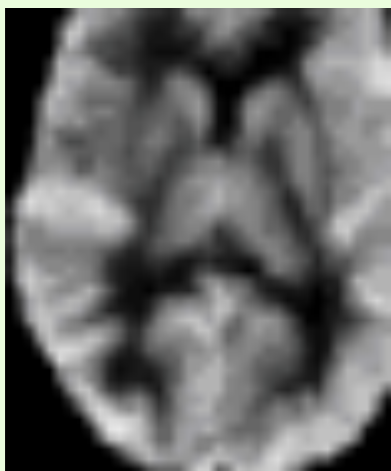
Diffeomorphic Mapping via ANTS



Anatomical



Diffusion



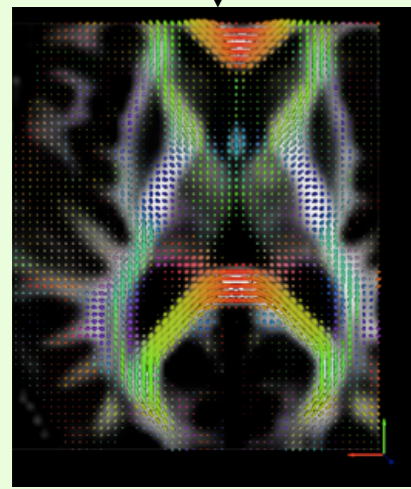
GM Prior

Template Space

Individual Space



# PipeDream T1+DTI Normalization Strategy



Diffusion



Anatomical

Diffeomorphic Mapping via ANTS

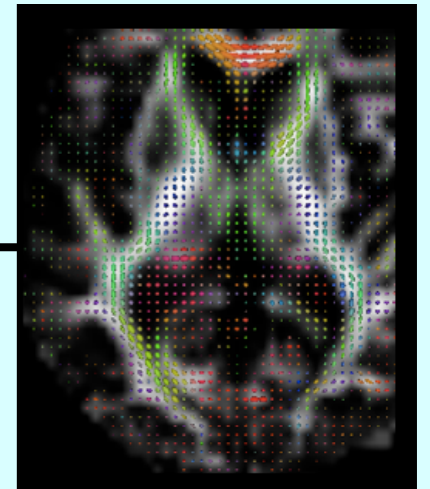


GM Prior

Template Space



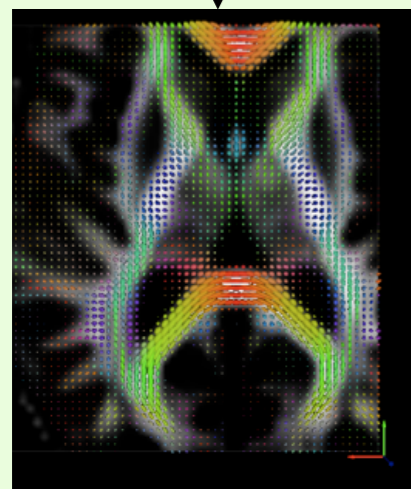
Anatomical



Diffusion

Individual Space

# PipeDream T1+DTI Normalization Strategy



Diffusion



Anatomical



GM Prior

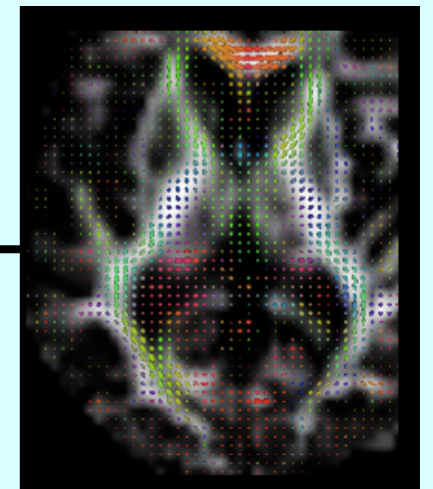
Template Space

Diffeomorphic Mapping via ANTS

Information is transferred bidirectionally and mapping is unbiased with respect to time points



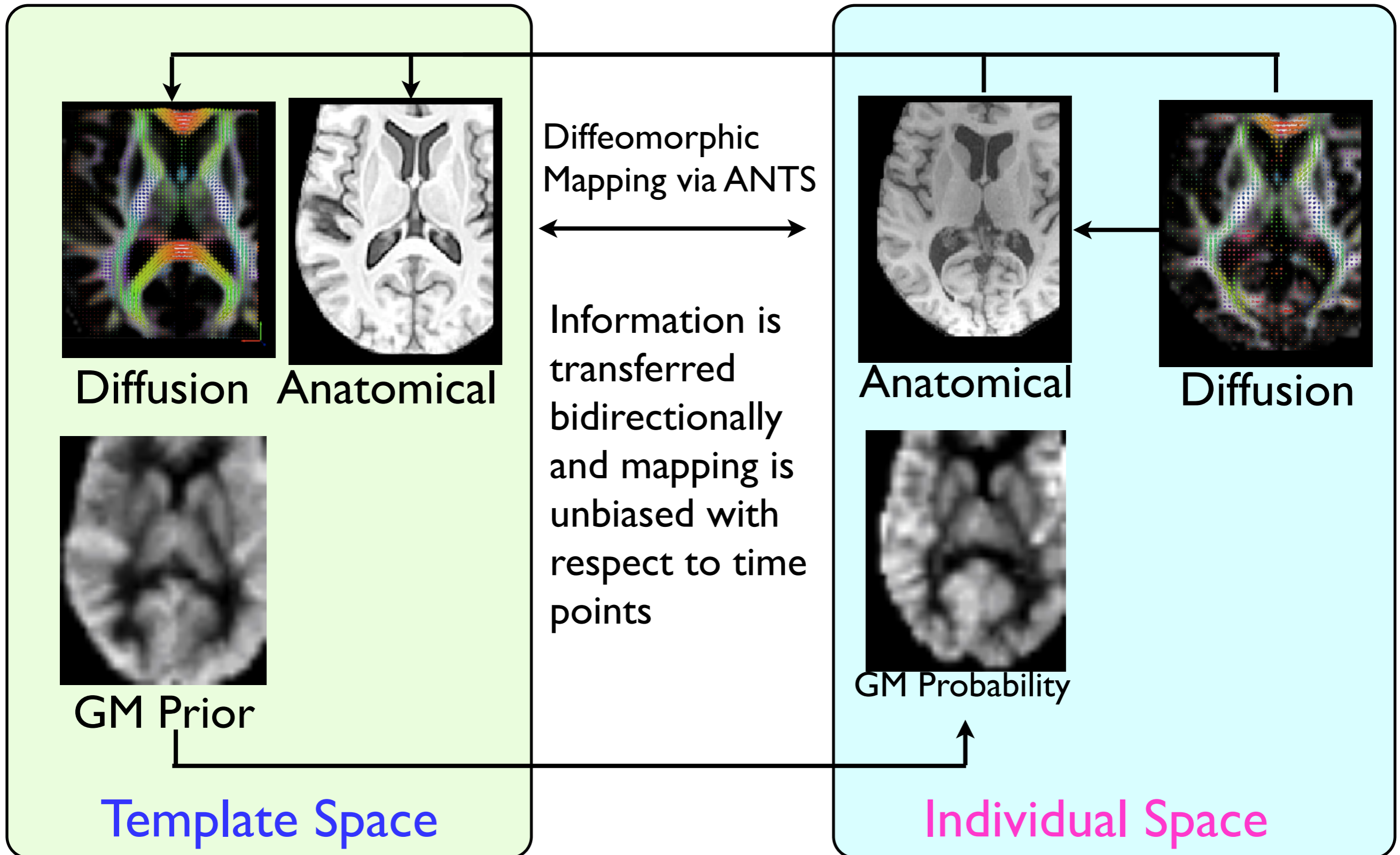
Anatomical



Diffusion

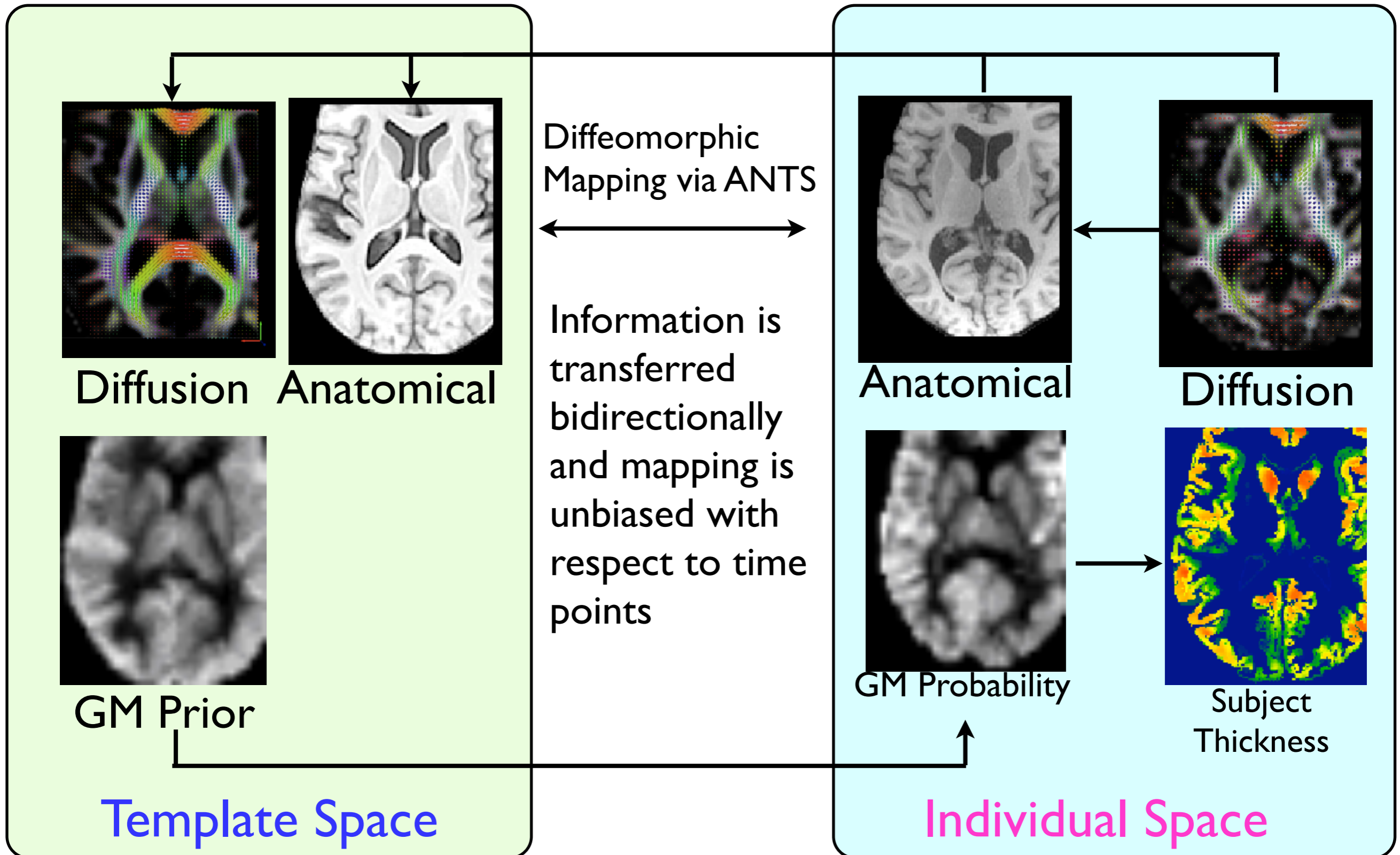
Individual Space

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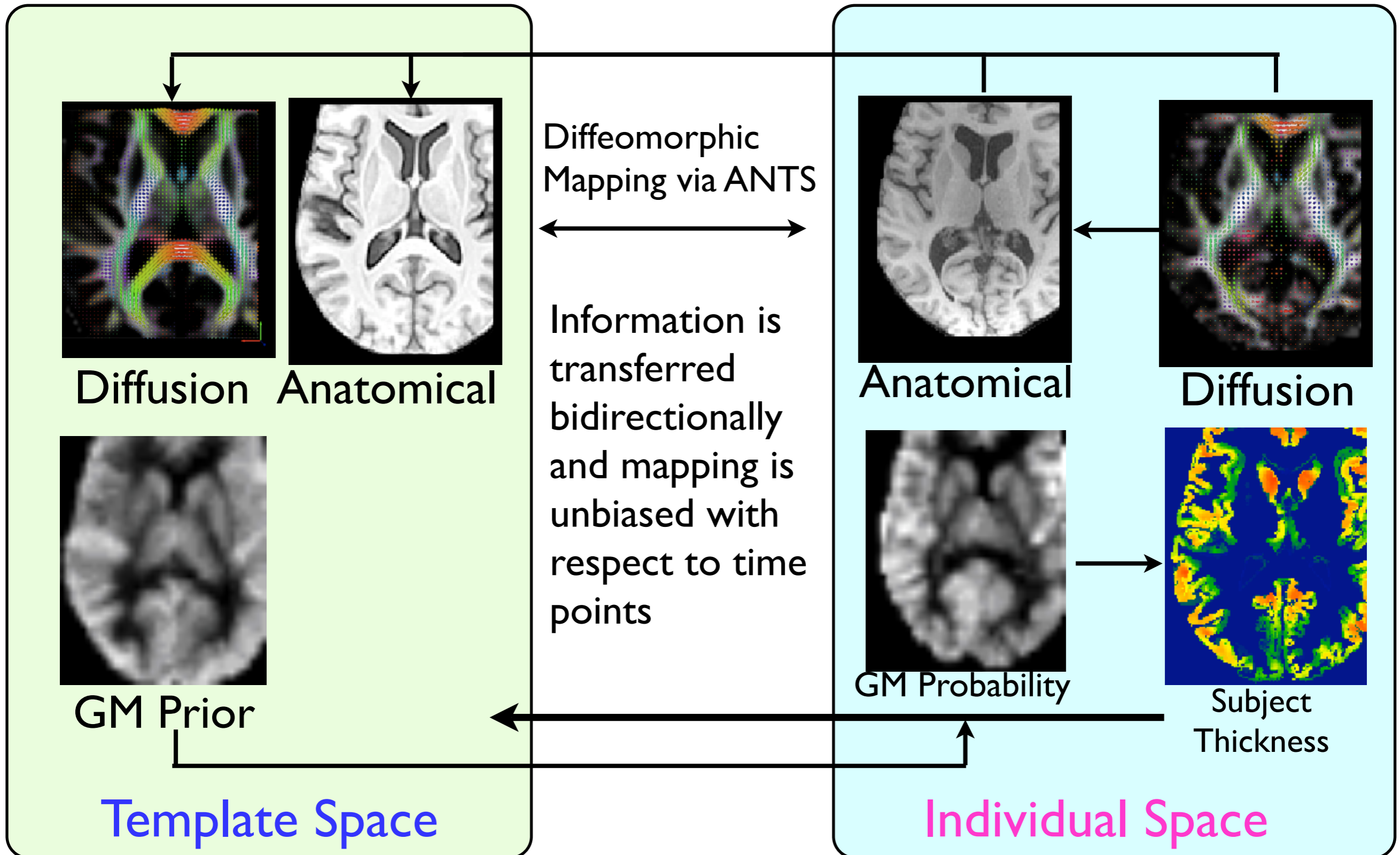




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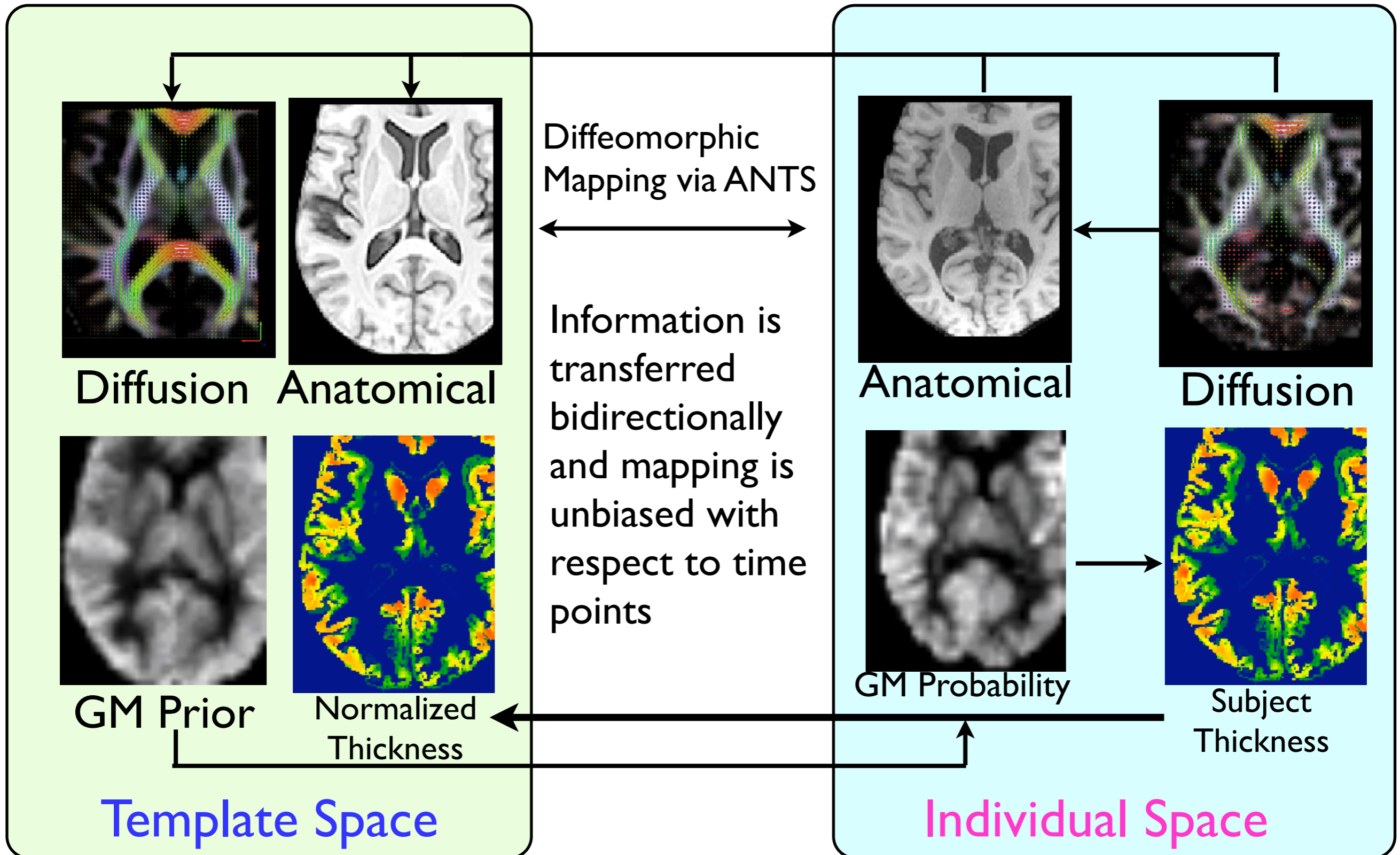


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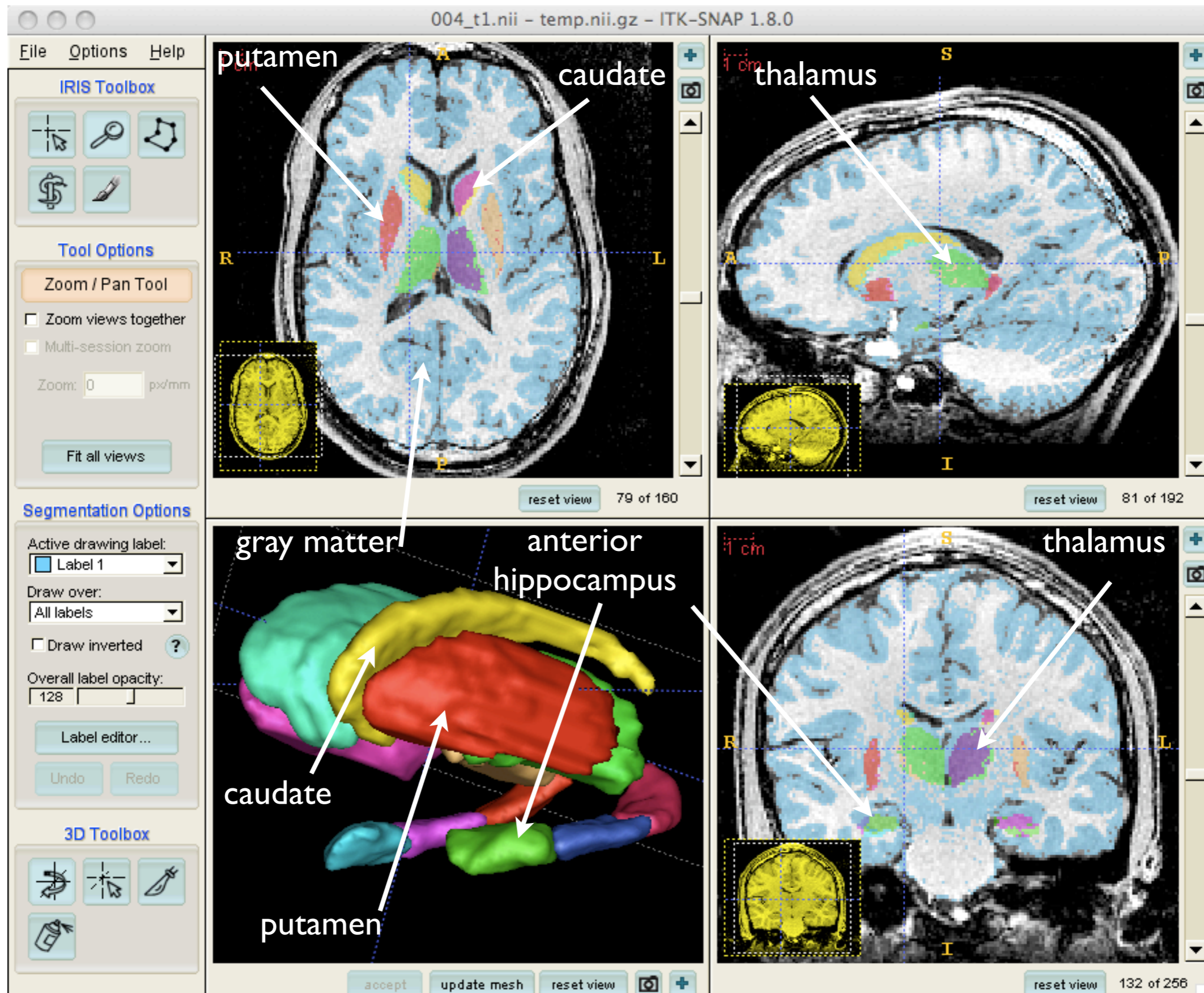




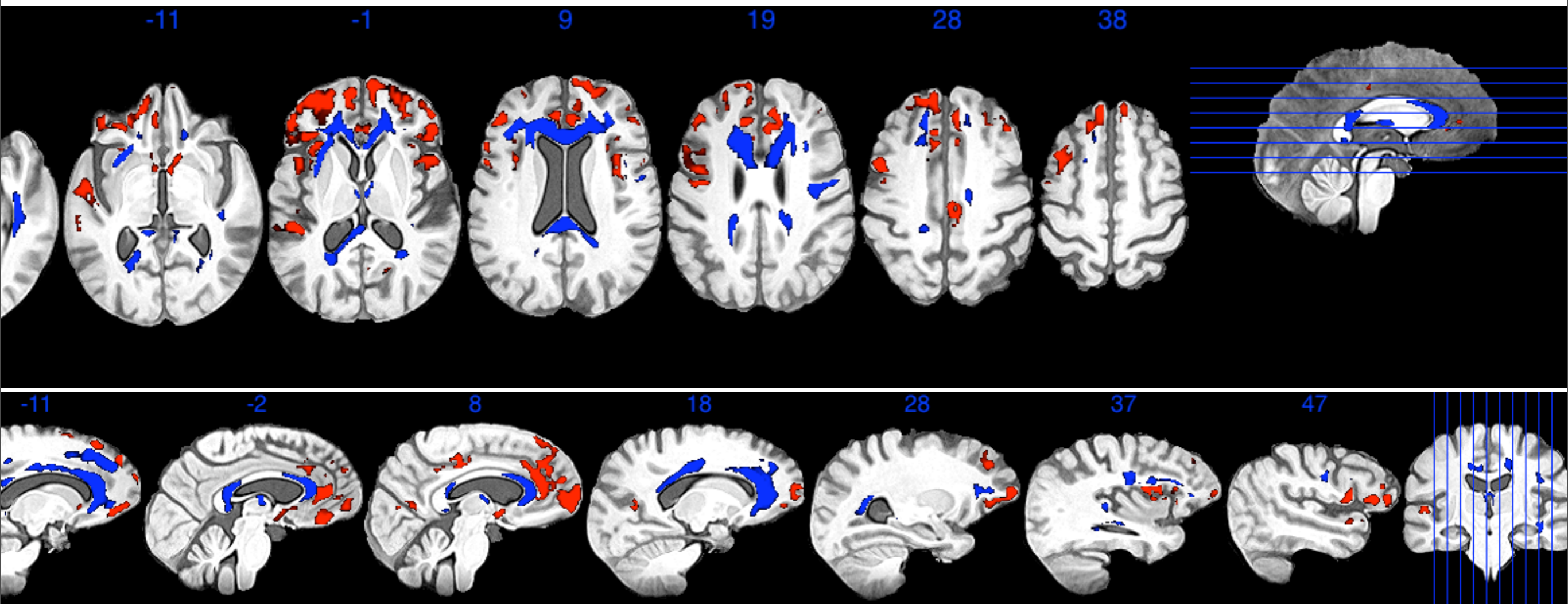
# Application to Human Brain Mapping



# ANTS + ITK-SNAP



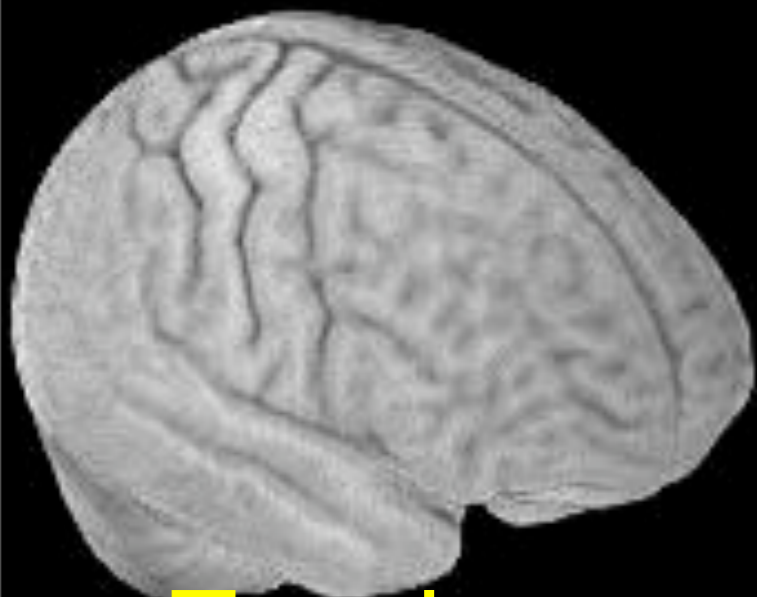
# Cross-Sectional Results in FTD: Cortex and White Matter Integrity



In preparation

# Brain Development in Adolescents: Cortex and White Matter Integrity

Longitudinal MV Changes in Neurodevelopment: Age 14 to 18



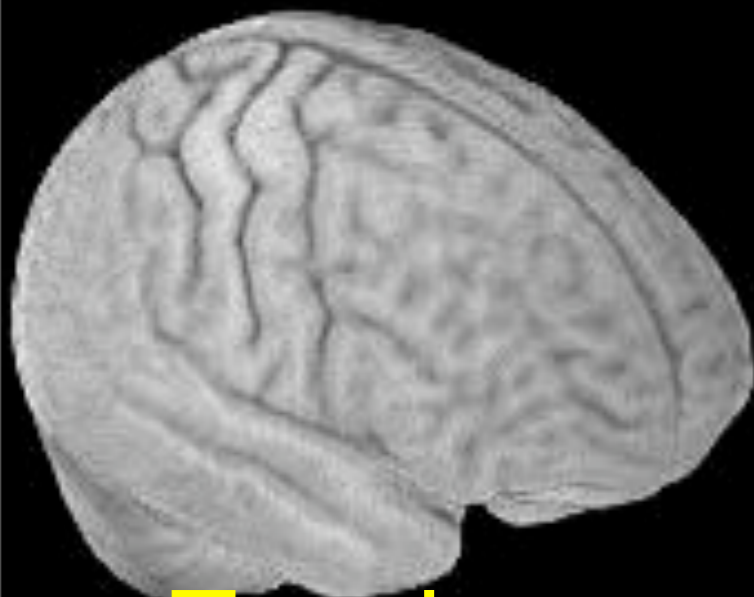
Template

*Avants, et al. HBM 2009*

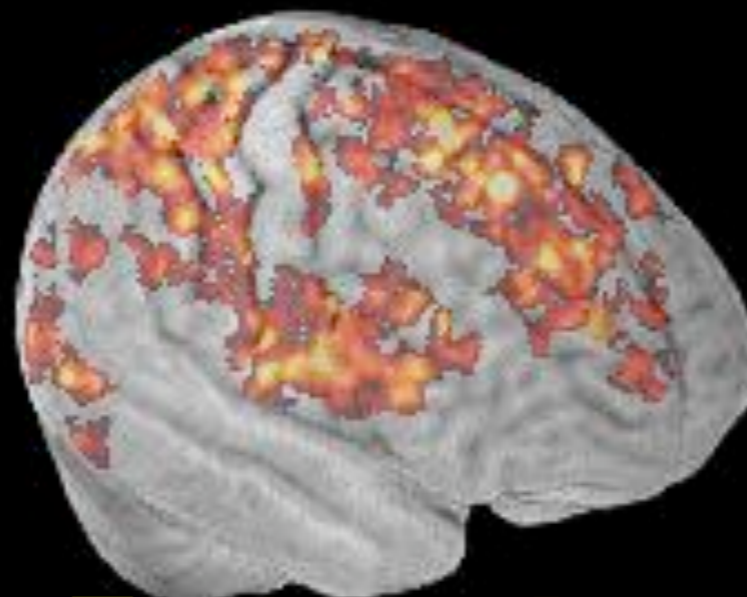


# Brain Development in Adolescents: Cortex and White Matter Integrity

Longitudinal MV Changes in Neurodevelopment: Age 14 to 18



Template

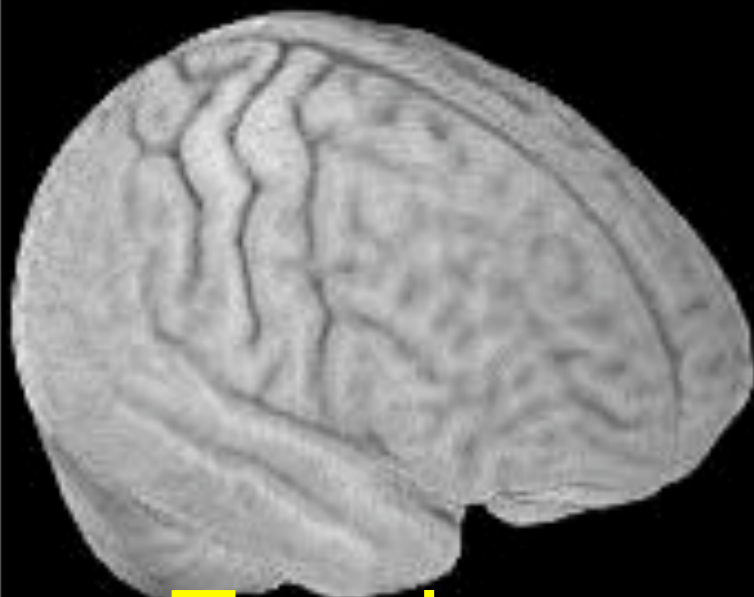


Thickness Decrease

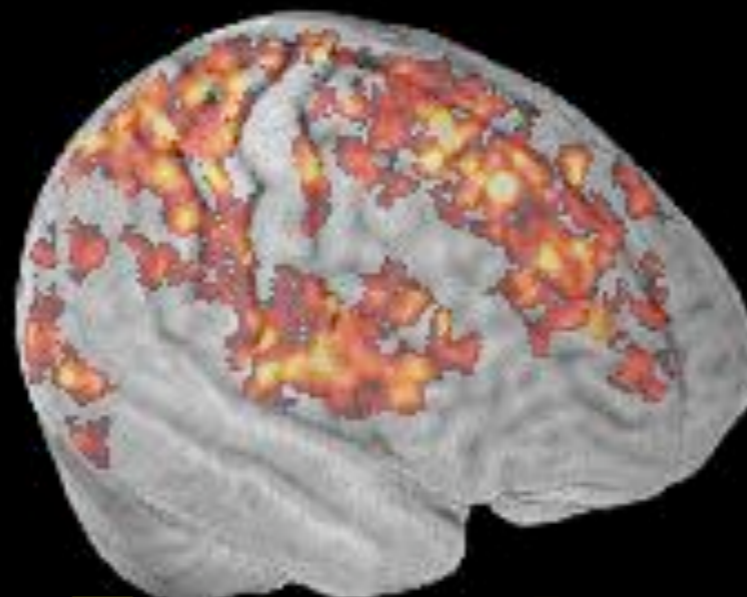
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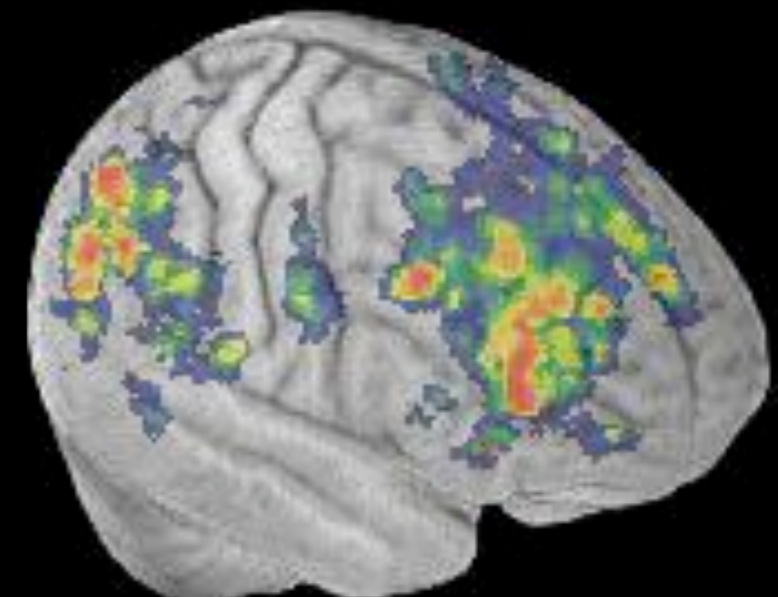
Longitudinal MV Changes in Neurodevelopment: Age 14 to 18



Template



Thickness Decrease

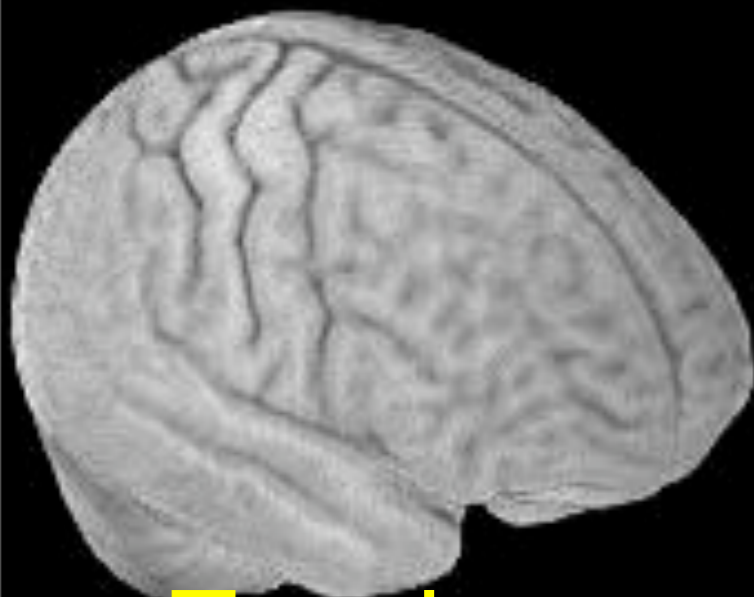


FA Increase

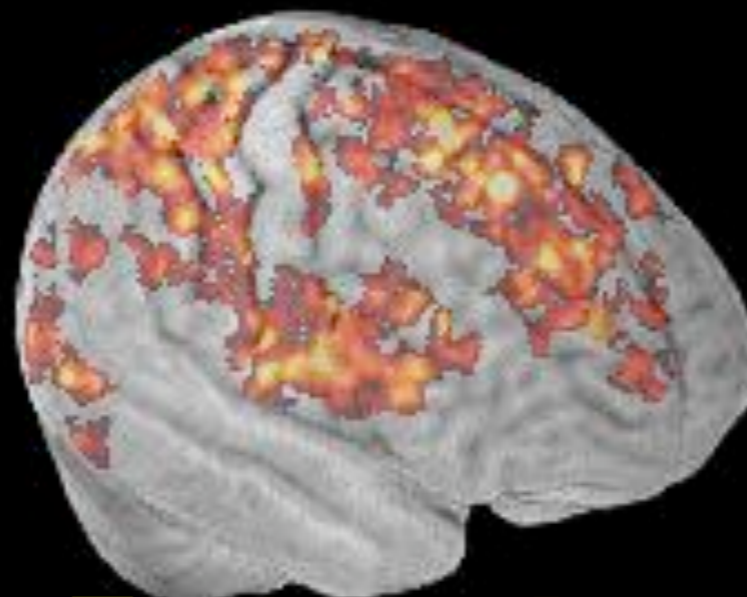
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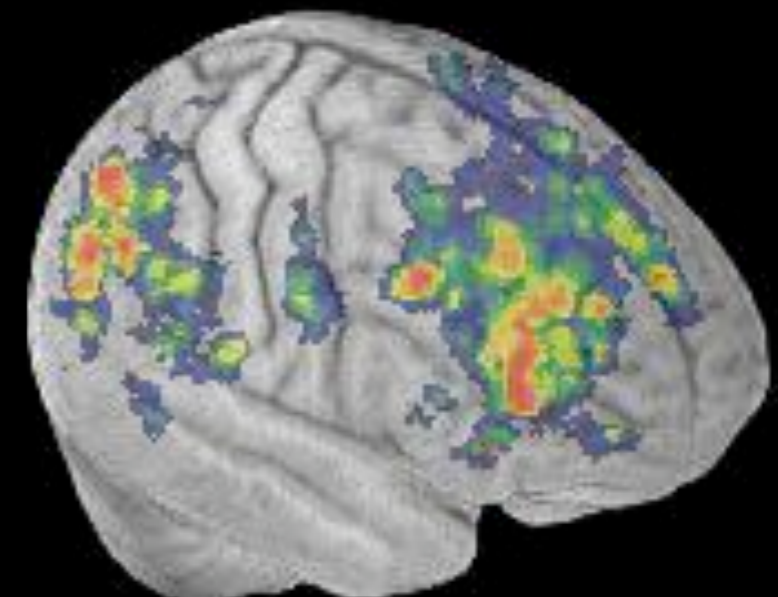
Longitudinal MV Changes in Neurodevelopment: Age 14 to 18



Template



Thickness Decrease



FA Increase

Paired design, all results are FDR-corrected with  $p < 0.05$

*Avants, et al. HBM 2009*

# The PipeDream Interface

Requires: ANTS, dcm2nii, image-magick

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HAL-2009> sh dicom2dt.sh <raw_data_dir> <protocol_name>  
<output_dir> <output_file_root>
```

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```

```
HAL-2009> sh dicom2dt.sh <raw_data_dir> <protocol_name>  
<output_dir> <output_file_root>
```

```
HAL-2009> sh pipedreamMapT1.sh PipeDreamT1Params.txt
```

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<output_dir> <output_file_root>
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<output_dir> <output_file_root>
```

```
HAL-2009> sh pipedreamMapT1.sh PipeDreamT1Params.txt
```

Output: Quality assurance metrics + cortical and deep gray matter labels, DT and T1 normalization, Jacobian, thickness ...

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Thanks to NIH and NITRC for supporting this work.