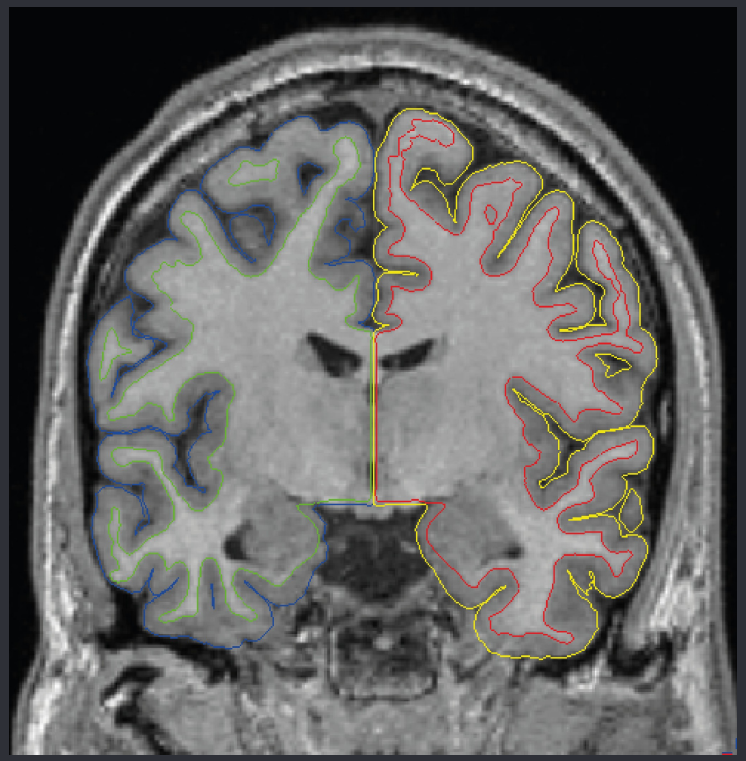
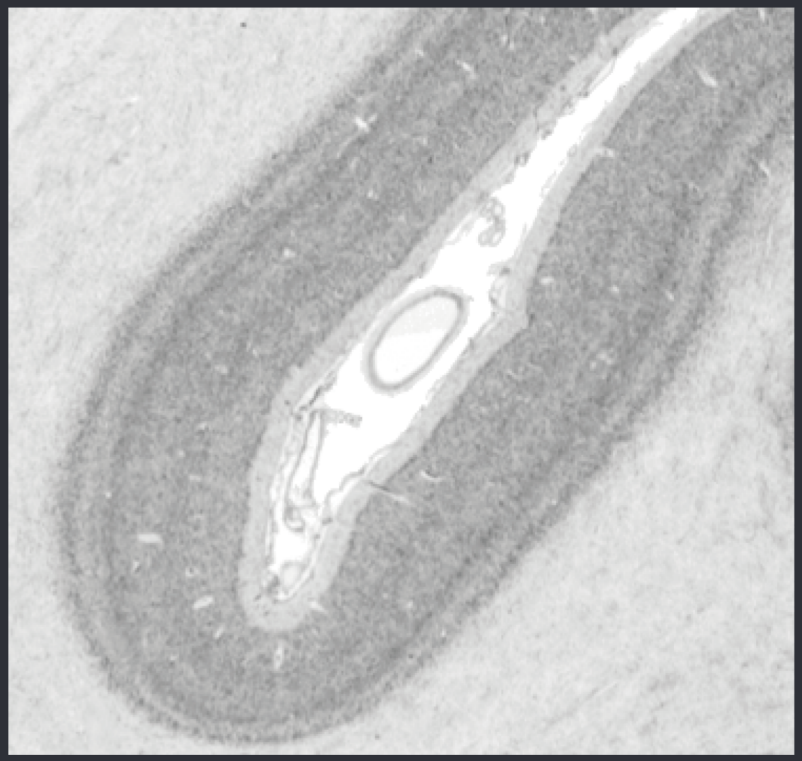
BigBrain atlas of cortical layers: Linking cortical microstructure to *in vivo* measures of cortical structure.

Konrad Wagstyl MBPhD

@KonradWagstyl

Bridging MRI and histology



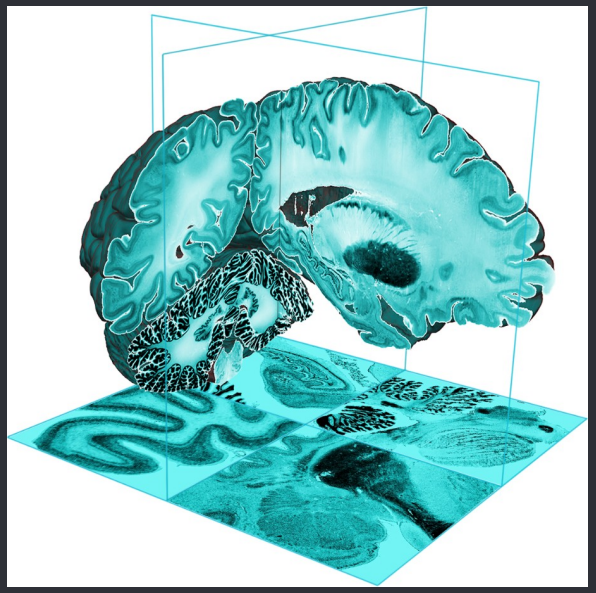


- *in vivo* and large N.
- Low resolution, ambiguous signal.

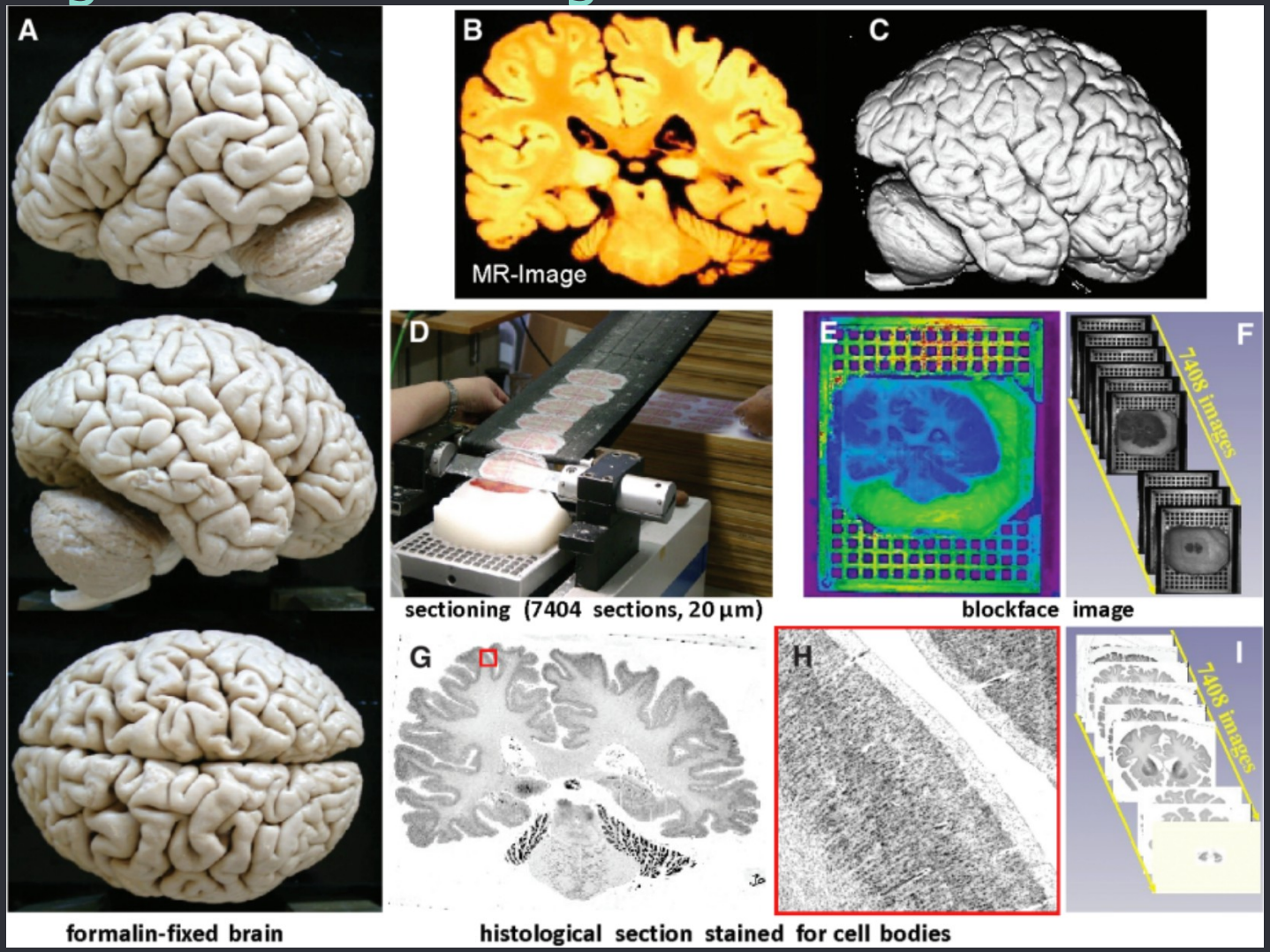
- High resolution, staining/labelling
- 2D, small N, limited samples, manual

OUTLINE

- Cortical intensity profiles of laminar structure
- Automated segmentation of cortical layers
- Atlas of cortical layers



BigBrain: An Ultrahigh-Resolution 3D Human Brain

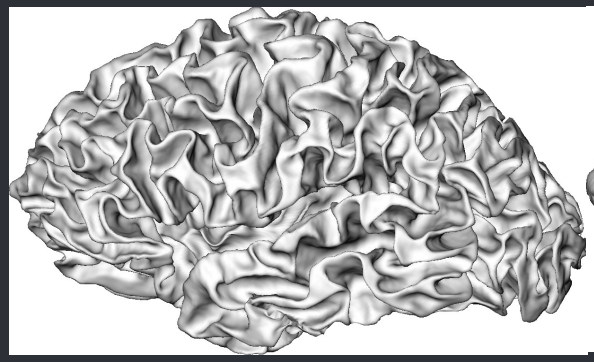


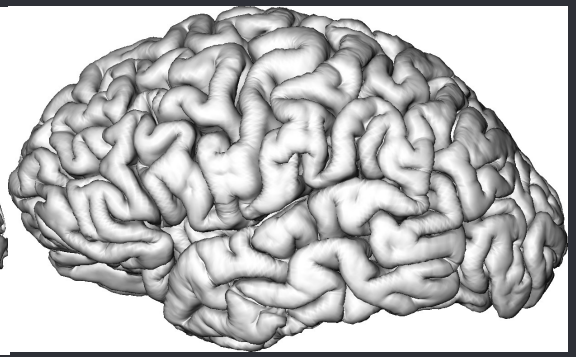
Amunts et al., 2013

Cortical Surface Extraction

Modified from CIVET:

- Tissue classification
- Extract white matter surface using marching-cubes algorithm
- Expand white surface to pial boundary using CLASP （CIVET）

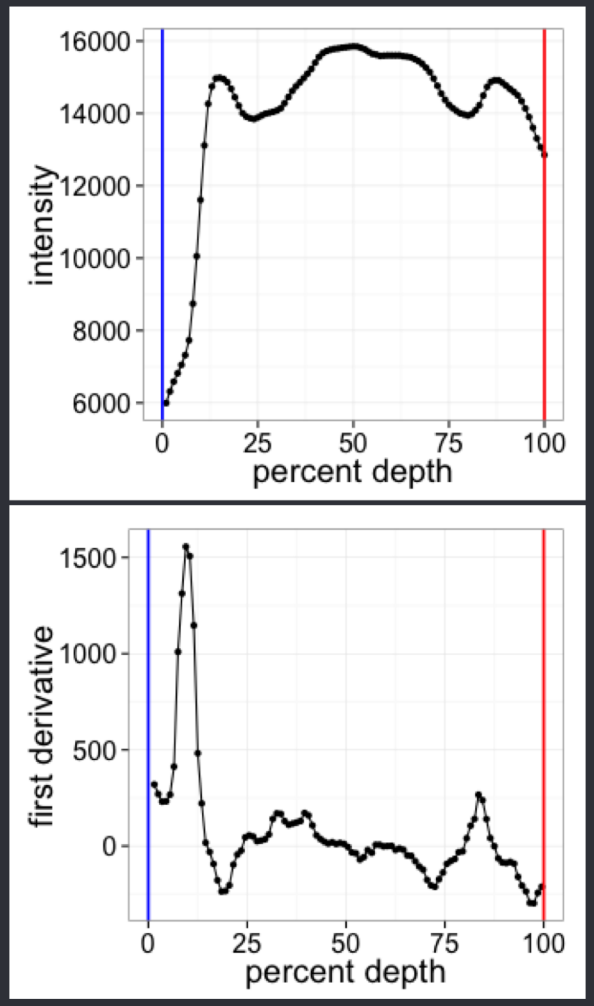




Intensity profiles

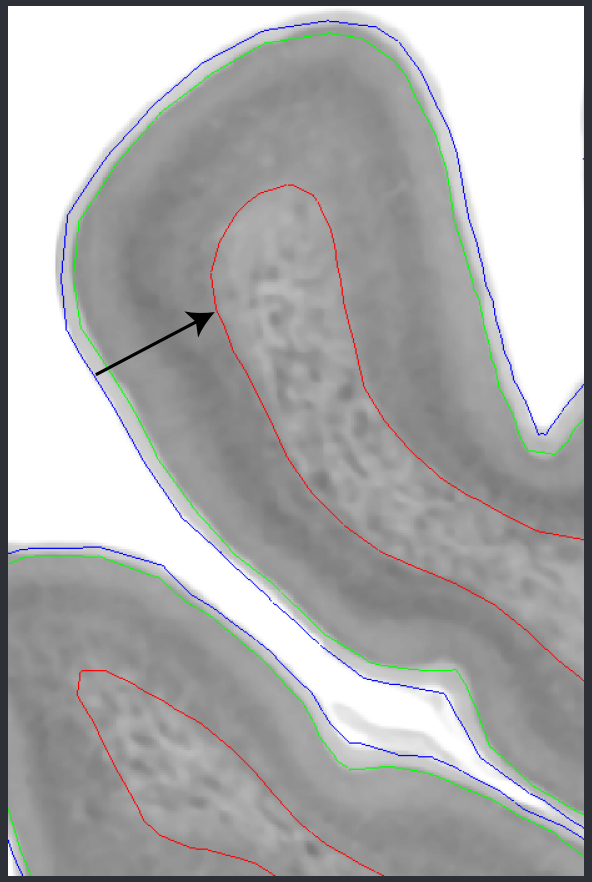
- Intensity samples at 100 points between pial and white matter surfaces
- Create intensity profile for each vertex on the surface

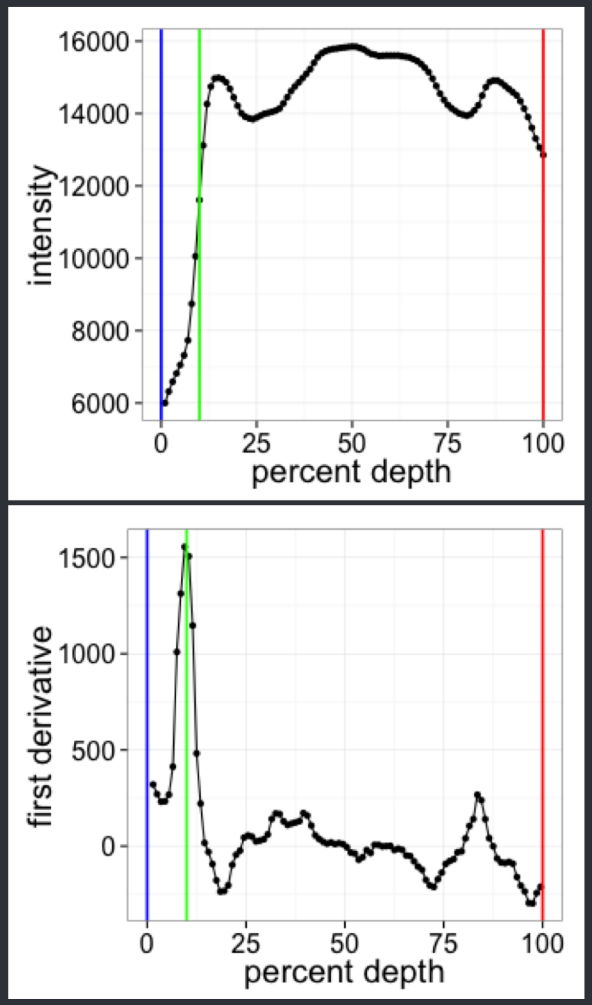
Finding layers



Pial - blue, White matter - red

Finding layers from profiles





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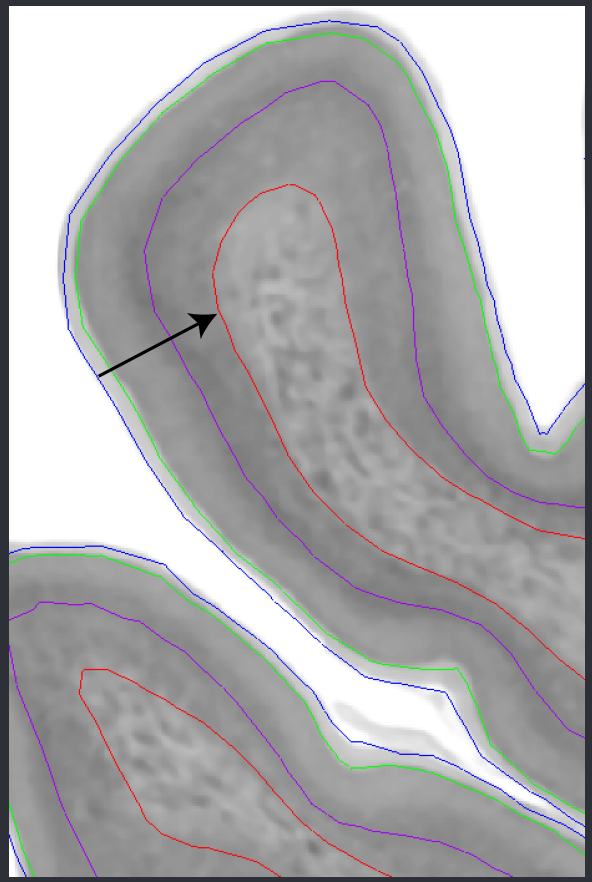
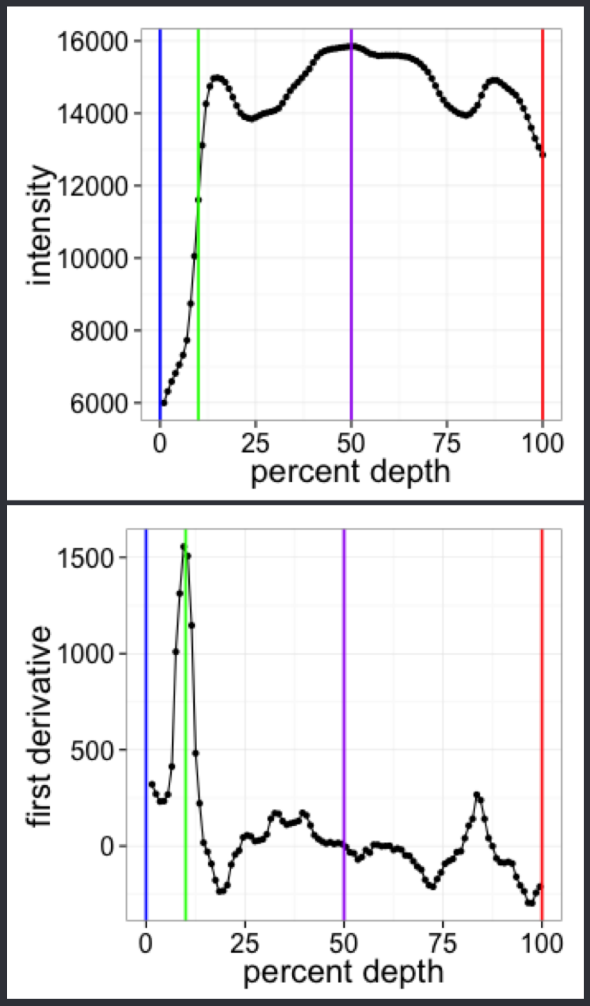
Finding layers from profiles





Pial - blue, White matter - red

Cortical layers in 3D

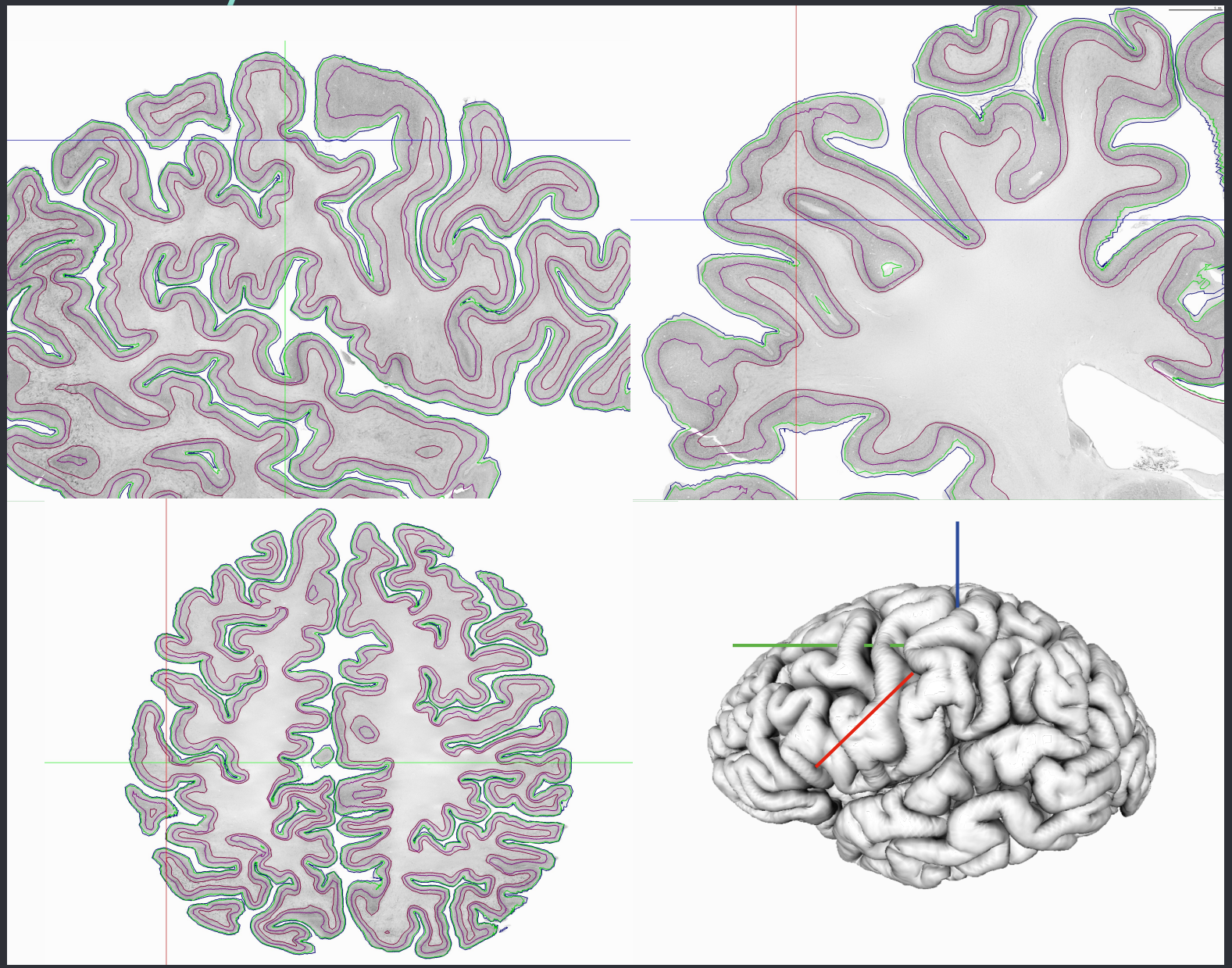


Figure: Wagstyl et al., Cerebral Cortex, 2018

Layer depths predicted by curvature

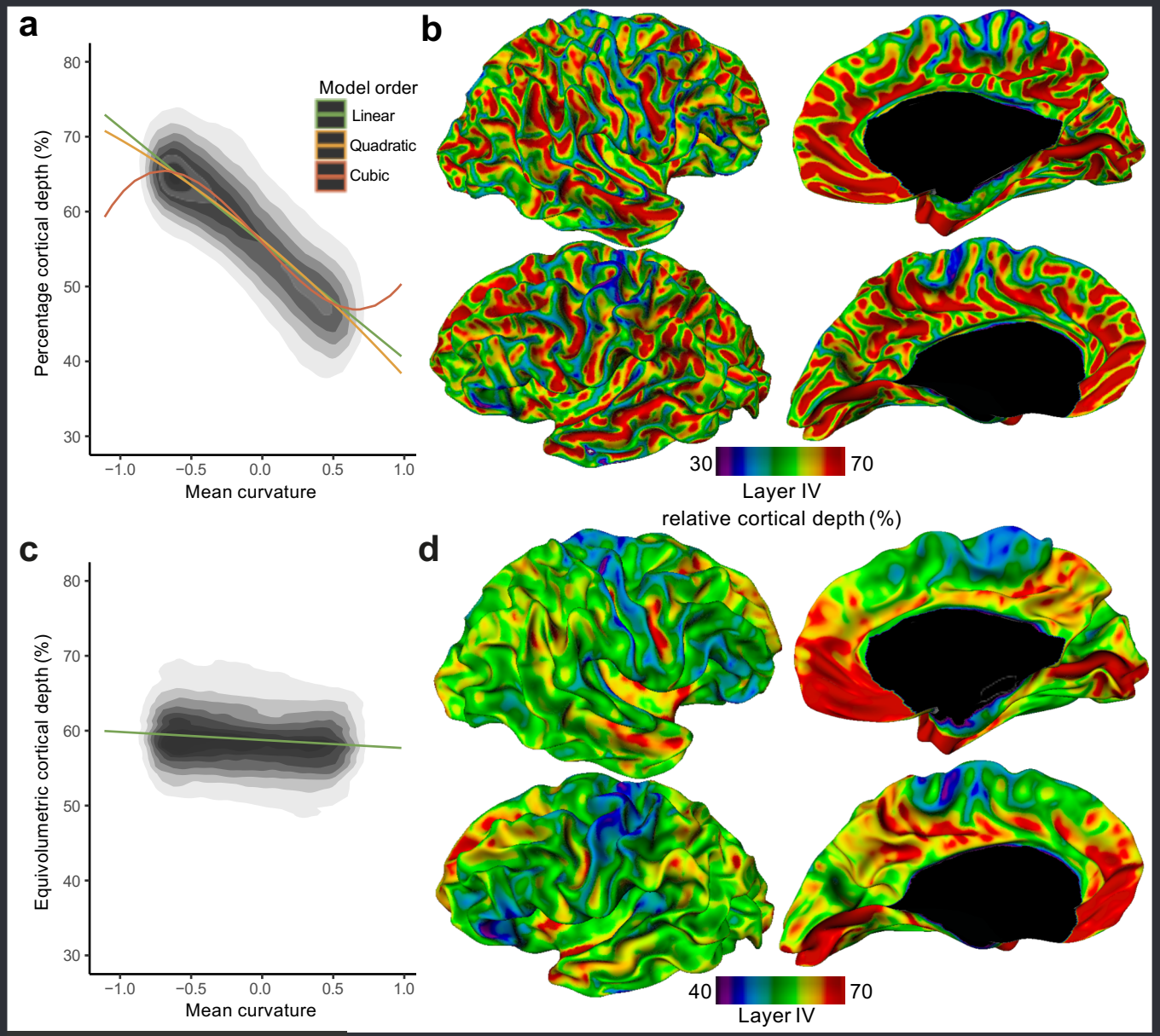
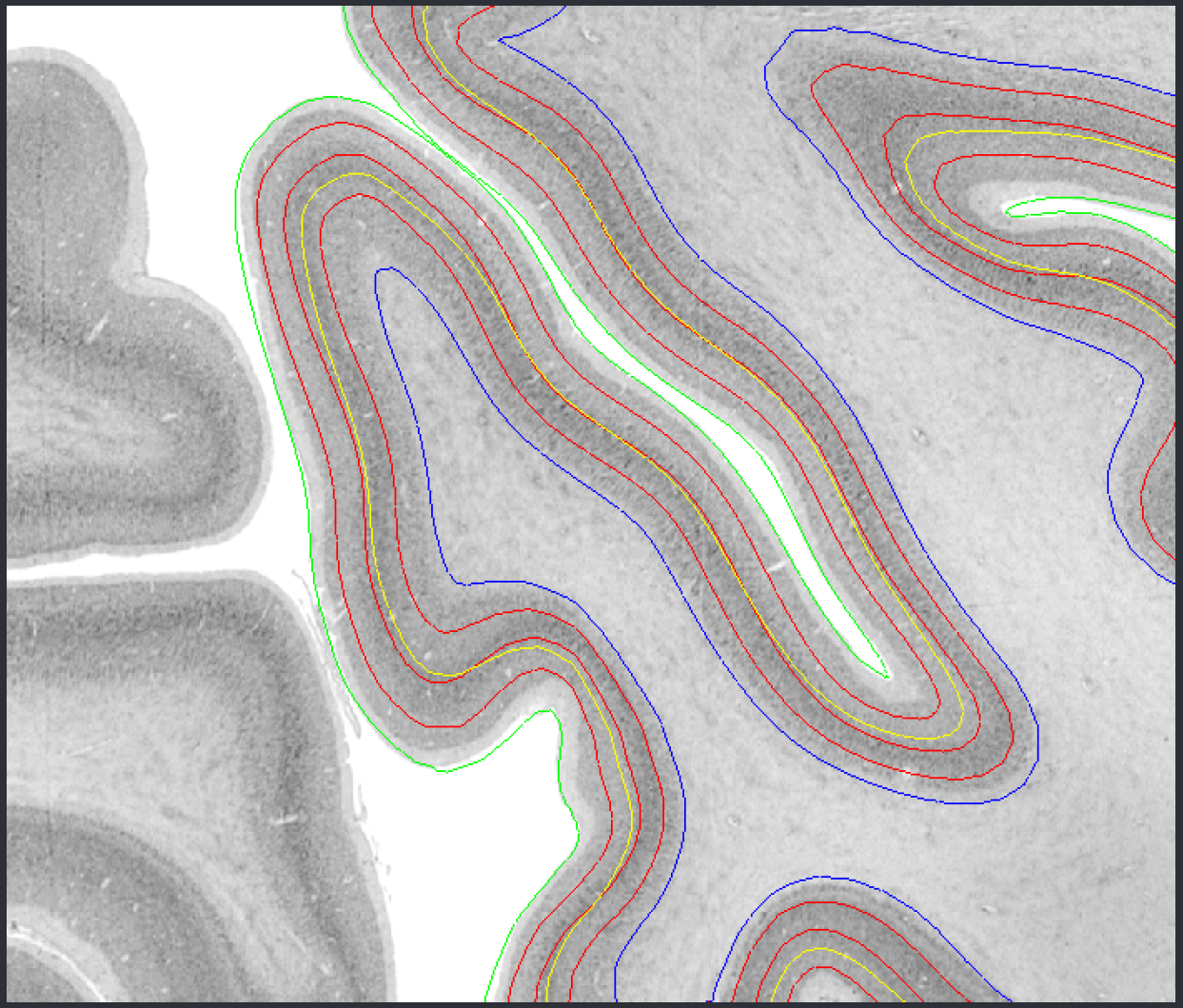


Figure: Wagstyl et al., Cerebral Cortex, 2018

Equivolumetric surfaces

- Surface-based equivolume implementation of Waehnert et al., 2014
- Compatible with Freesurfer & CIVET.
- https://github.com/kwagstyl/surface_tools



OUTLINE

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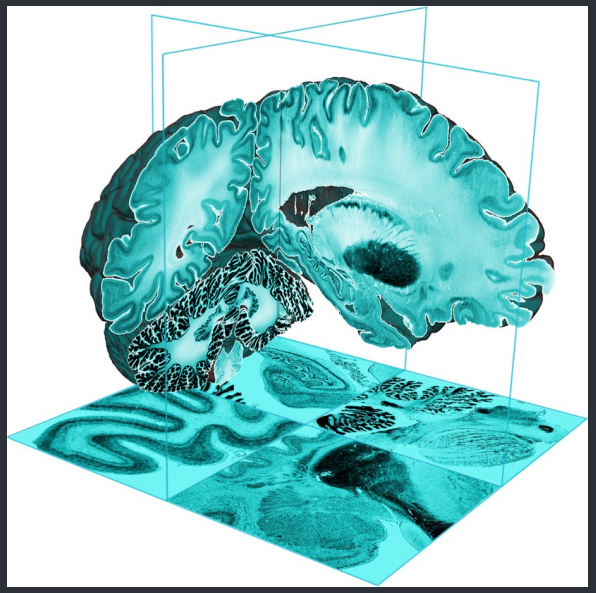
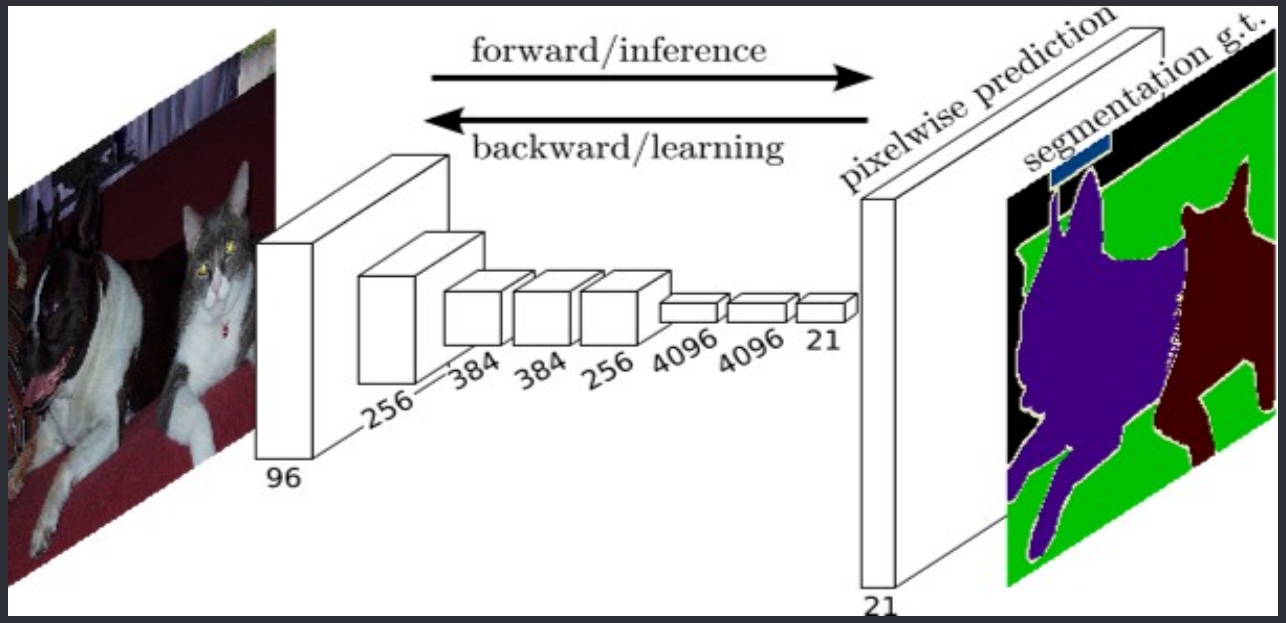
- Automated segmentation of cortical layers
- Atlas of cortical layers



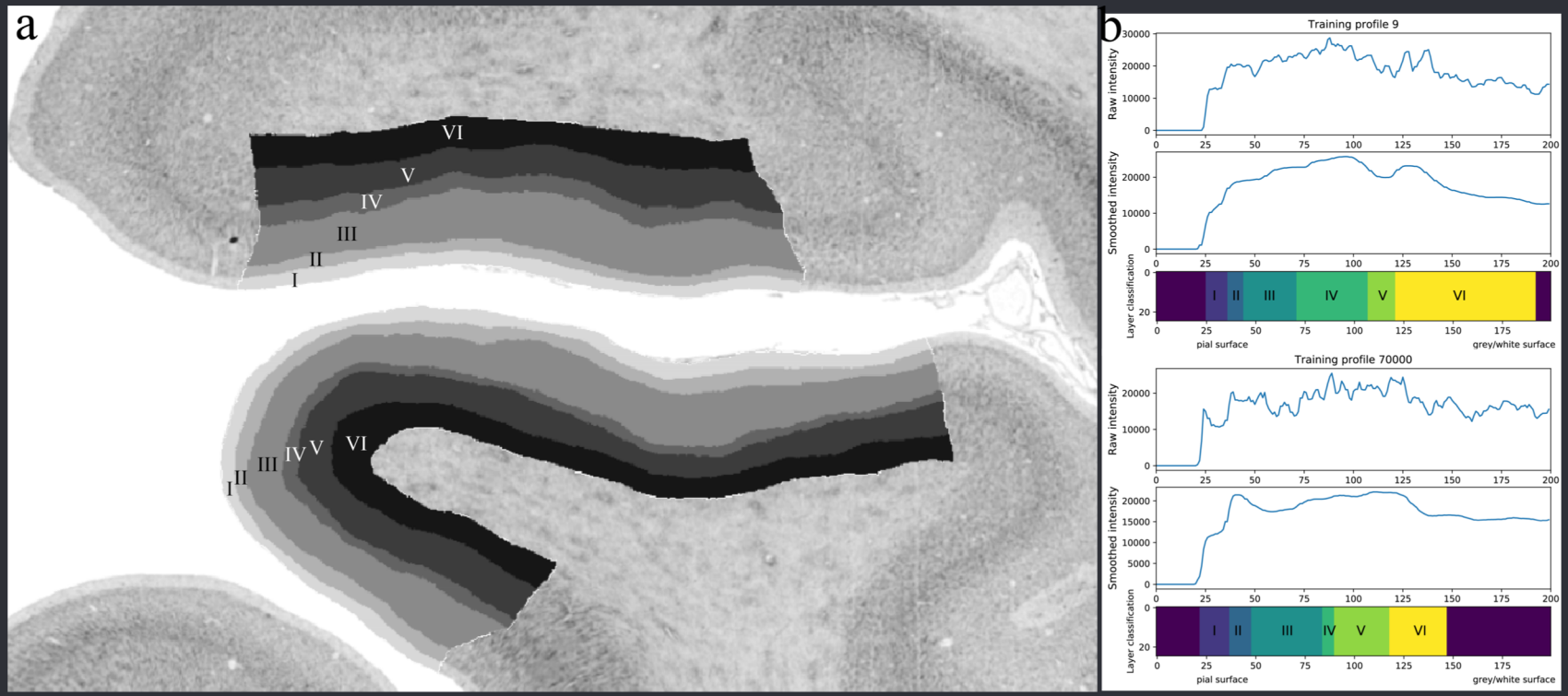
Deep learning - convolutional networks

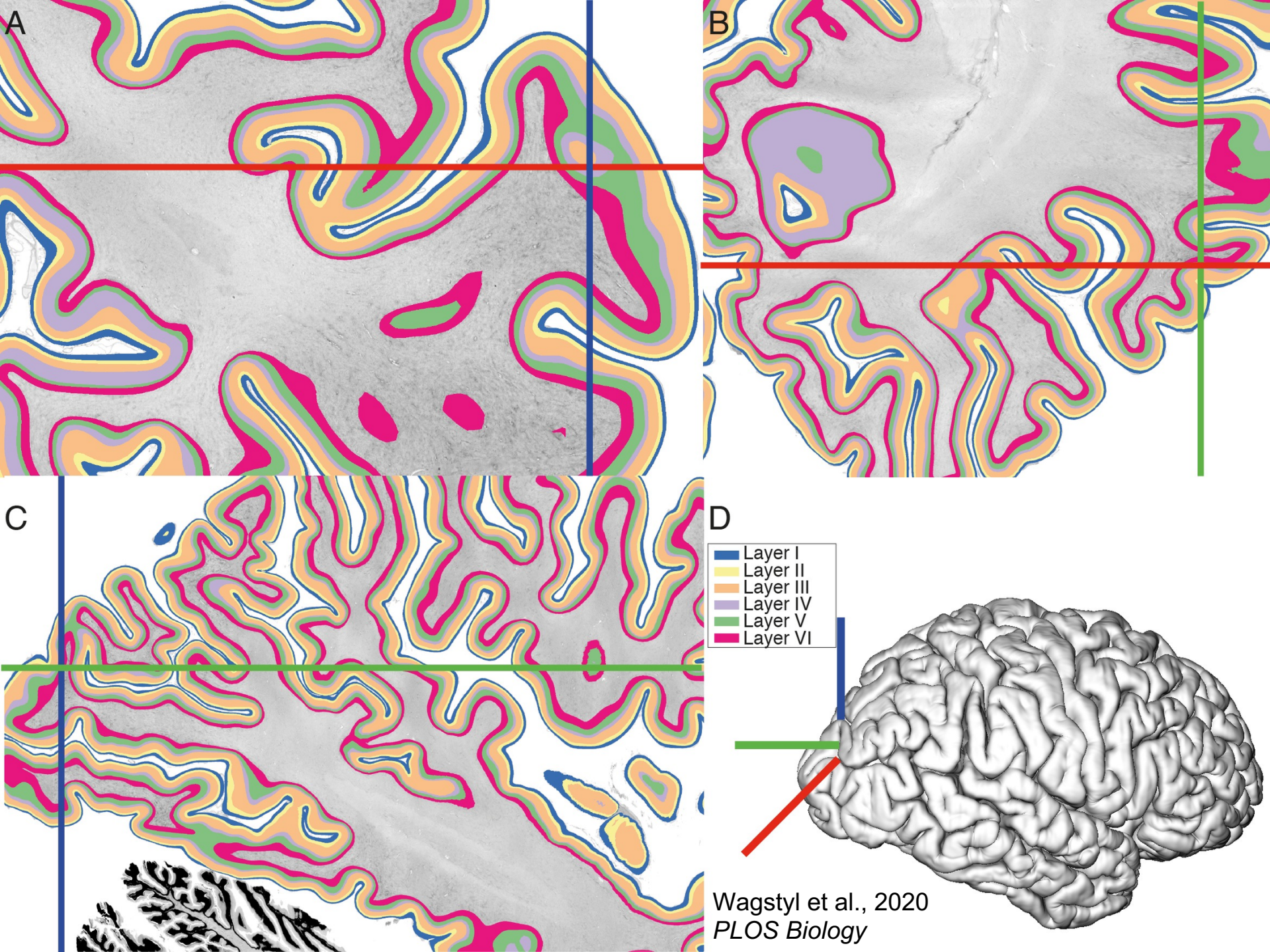
- Variable cytoarchitecture and laminar features
- Deep learning:
- Learn filters for useful features
- BUT
- Requires large training dataset -> 1D profile-based approach



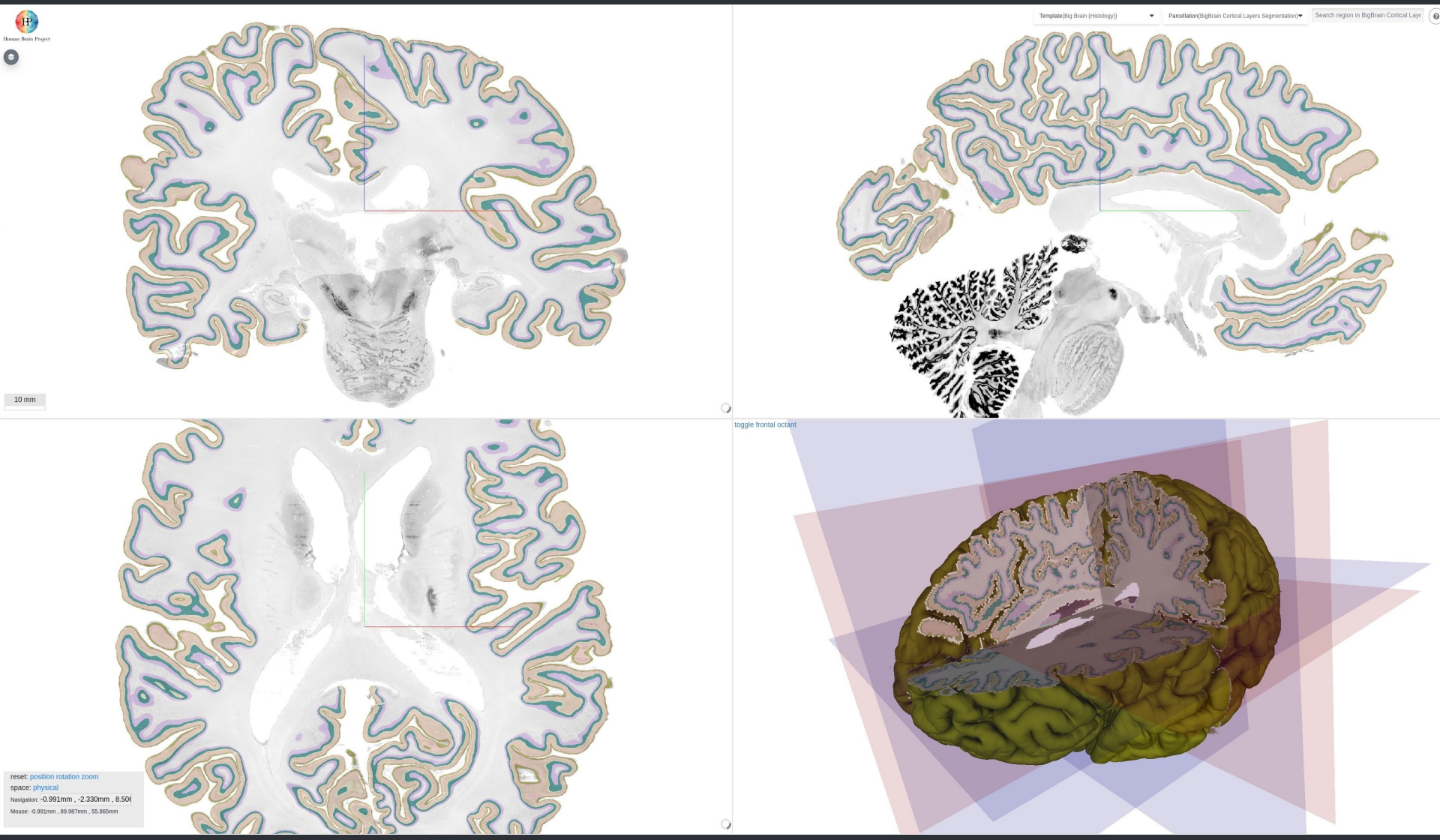
Manual segmentation of training data

- 60 training regions at manually labelled 5μm resolution.
- Over 500k labelled training profiles.

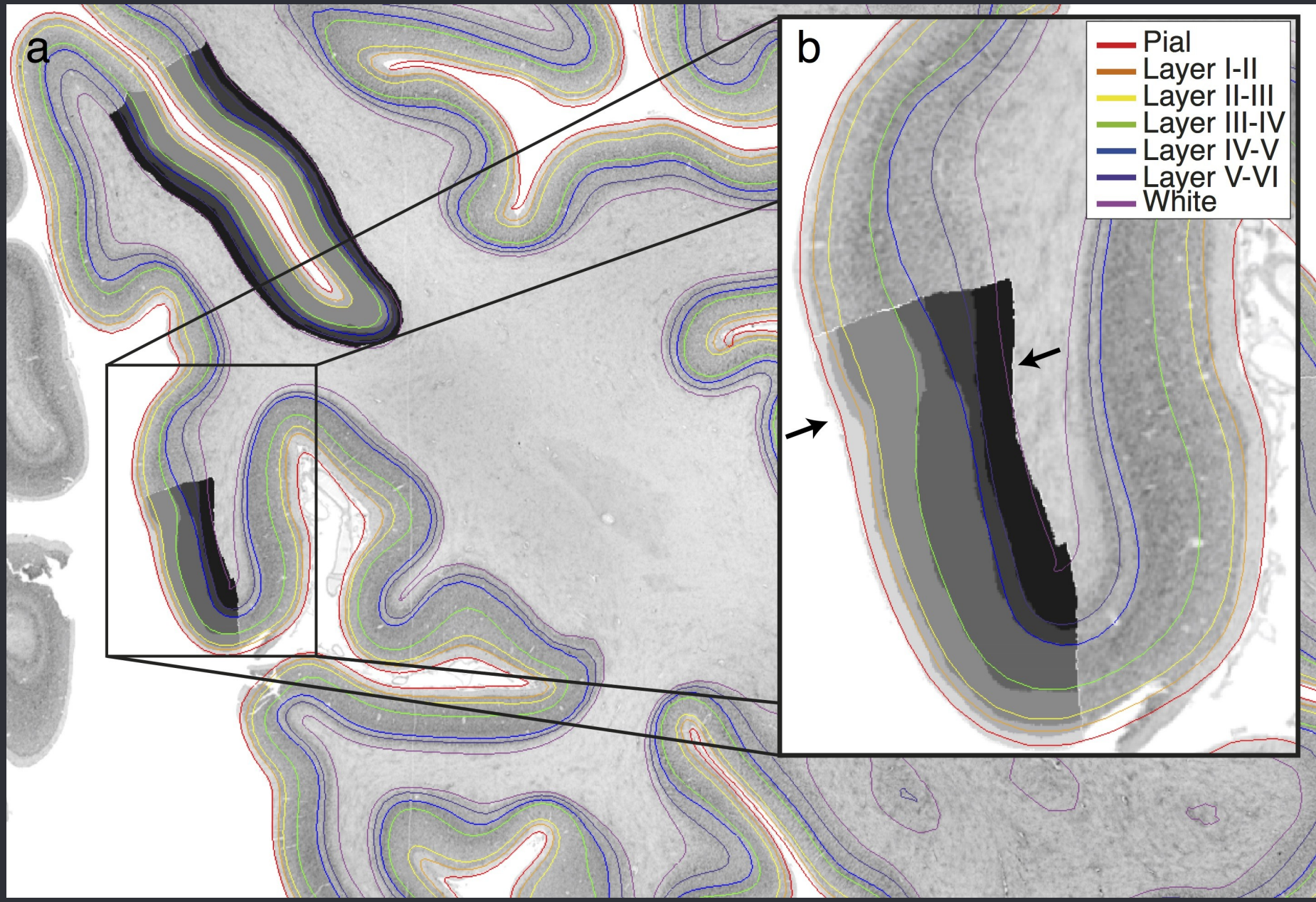



A
B
C
D
Layer I
Layer II
Layer III
Layer IV
Layer V
Layer VI
Wagstyl et al., 2020
PLOS Biology

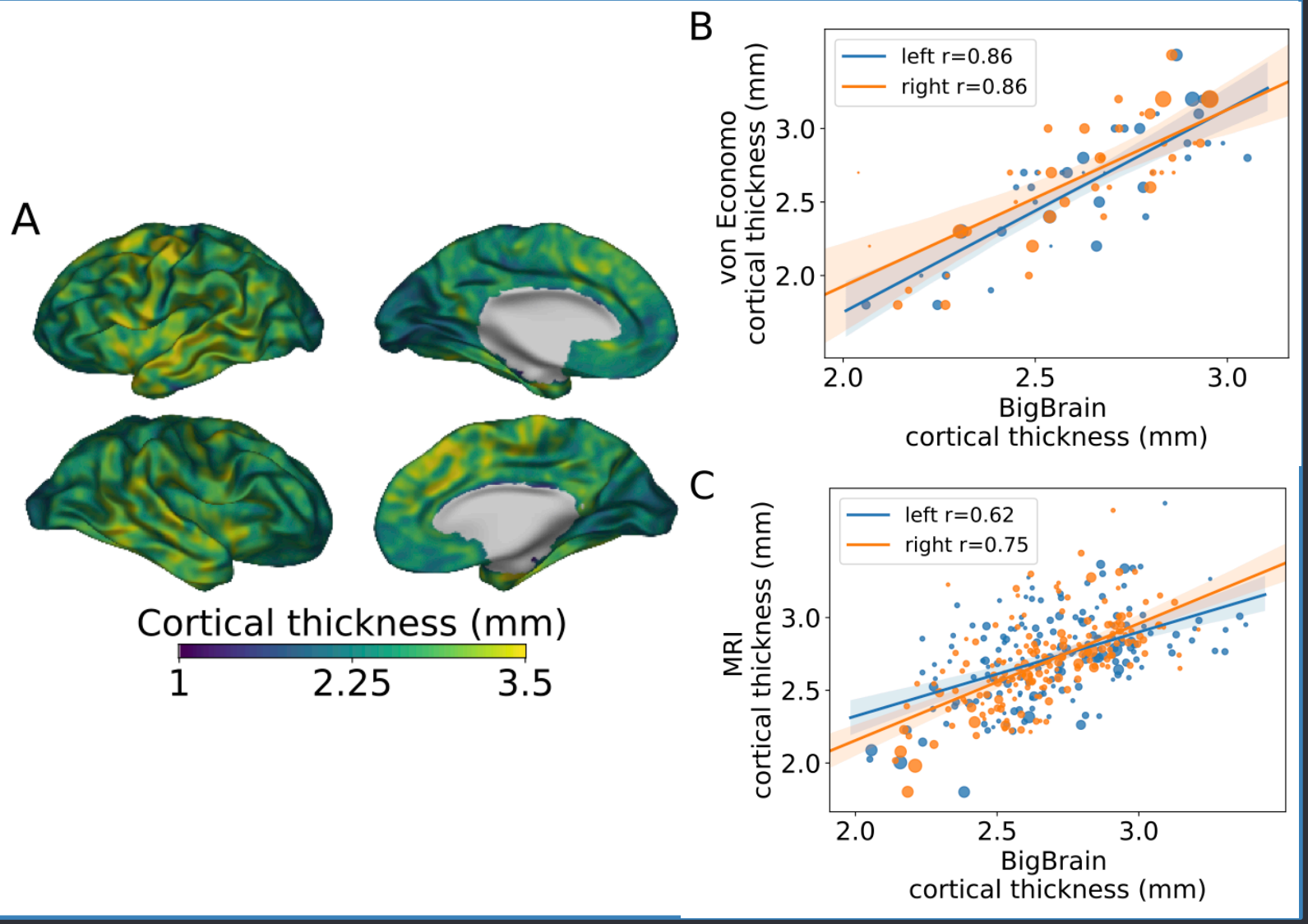
Human Brain Project Atlas



V1 V2 layer thickness differences

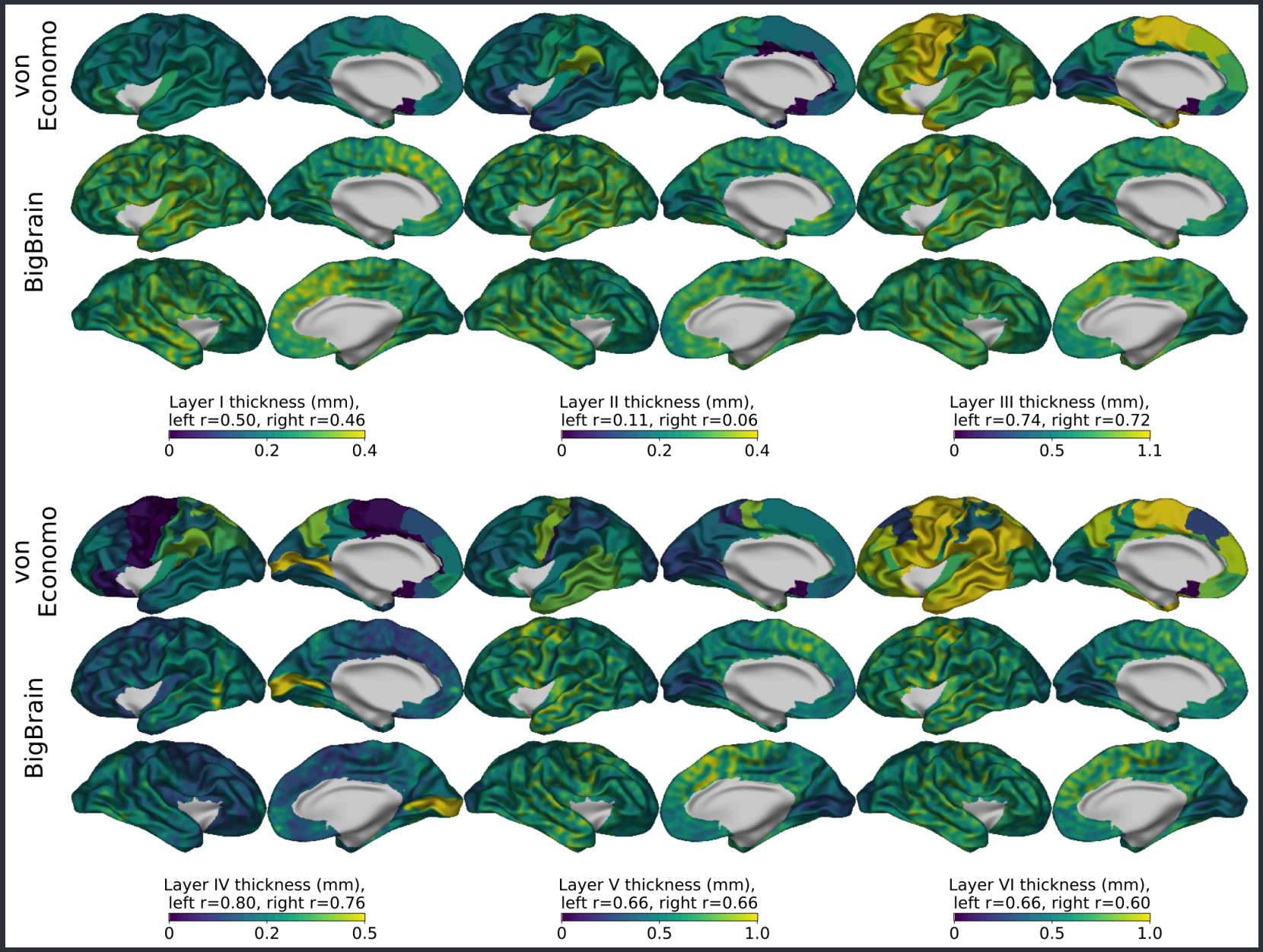


Total cortical thickness



Comparison of BigBrain thickness with von Economo (B) and HCP (C)

Laminar thicknesses

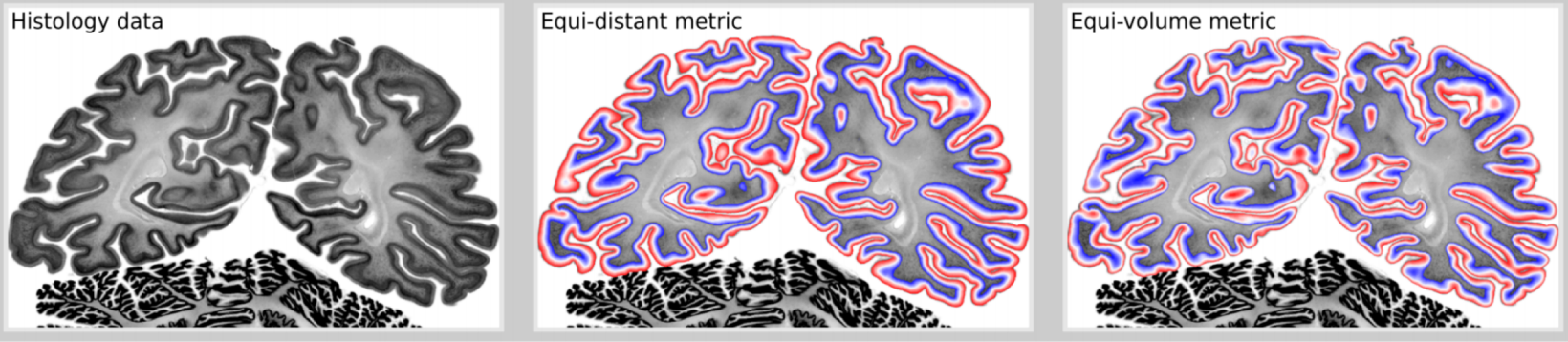


Summary

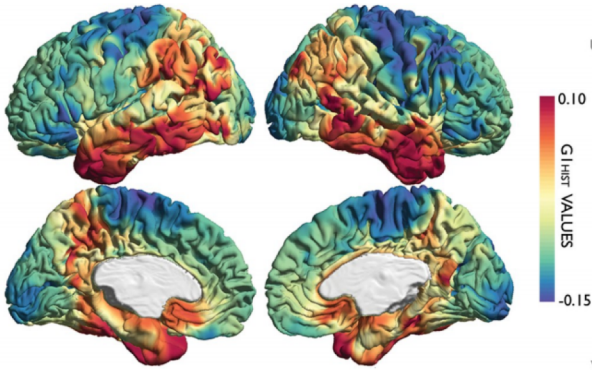
- BigBrain 3D atlas of cortical layers
- Intensity profiles describe laminar structure
- Surface atlas of cortical and laminar thickness
- Links micro-, meso- and *in vivo* neuroimaging

Whole brain from BigBrain

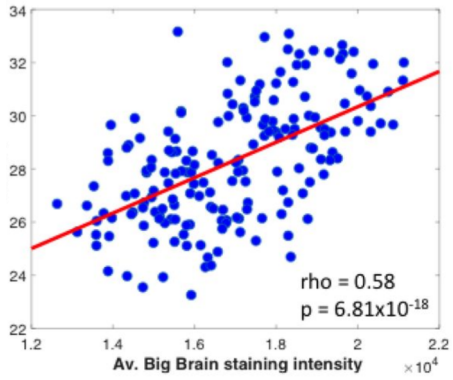
Huber et al., *BioRxiv* 2020



Paquola et al., *PLOS Biology* 2020



McColgan et al., *BioRxiv* 2020



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