

Analysis of Brain Regional Volumetric Changes in Autism Spectrum Disorder Using Generative Adversarial Networks

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Introduction

- **Autism Spectrum Disorder (ASD)** diagnosis relies on subjective behavioral assessments
- **Longitudinal MRI studies show atypical brain growth neurodevelopment in children with ASD¹**
- Longitudinal neuroimaging data is **limited**, and anatomical changes are very subtle

GOALS:

- Condition a **Generative Adversarial Network (GAN)** on age and diagnosis to simulate subject-specific brain trajectories using only cross-sectional, non-longitudinal data
- **Analyze ASD-related brain changes** in youth to identify developmental biomarkers from limited data

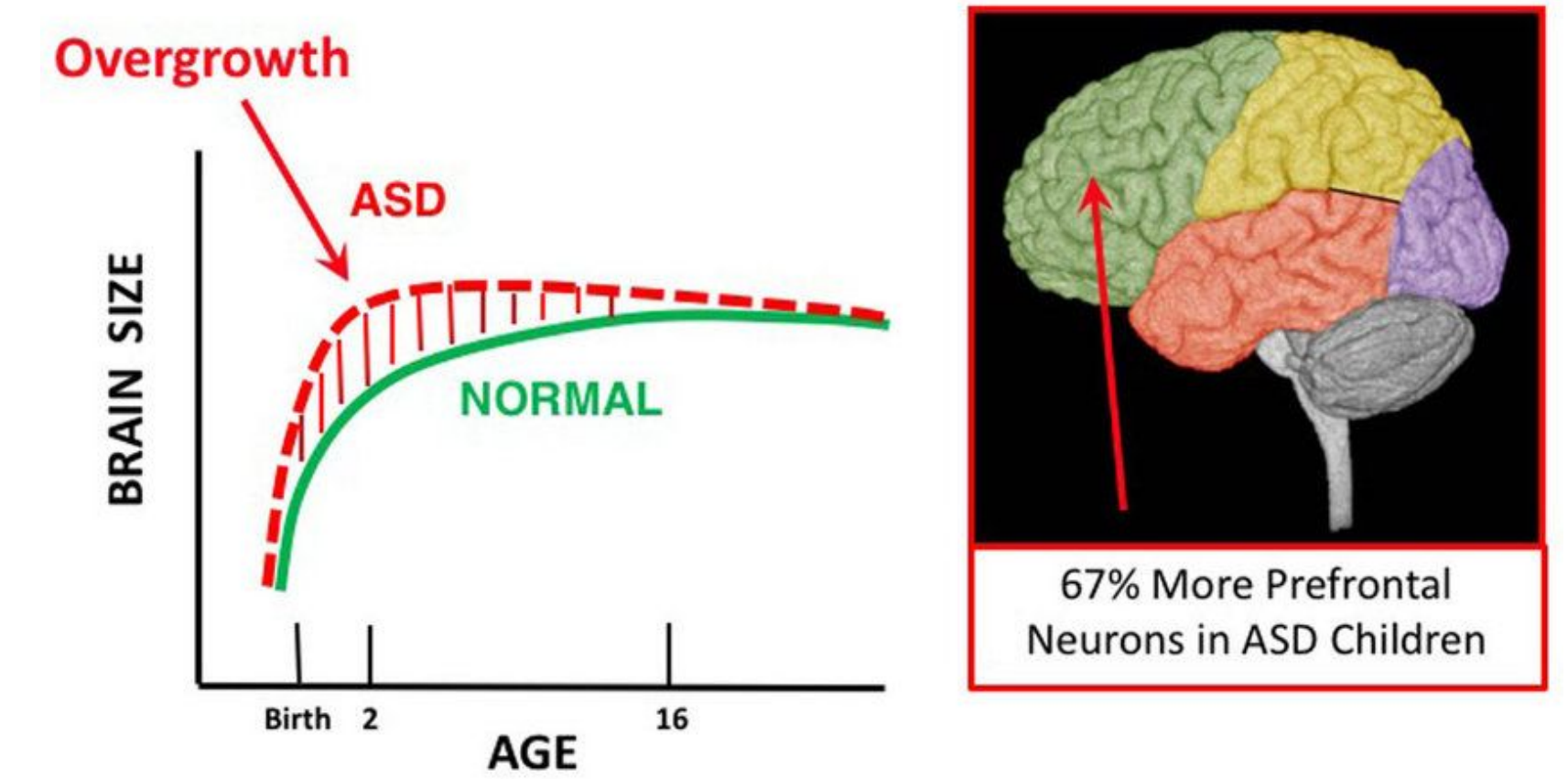
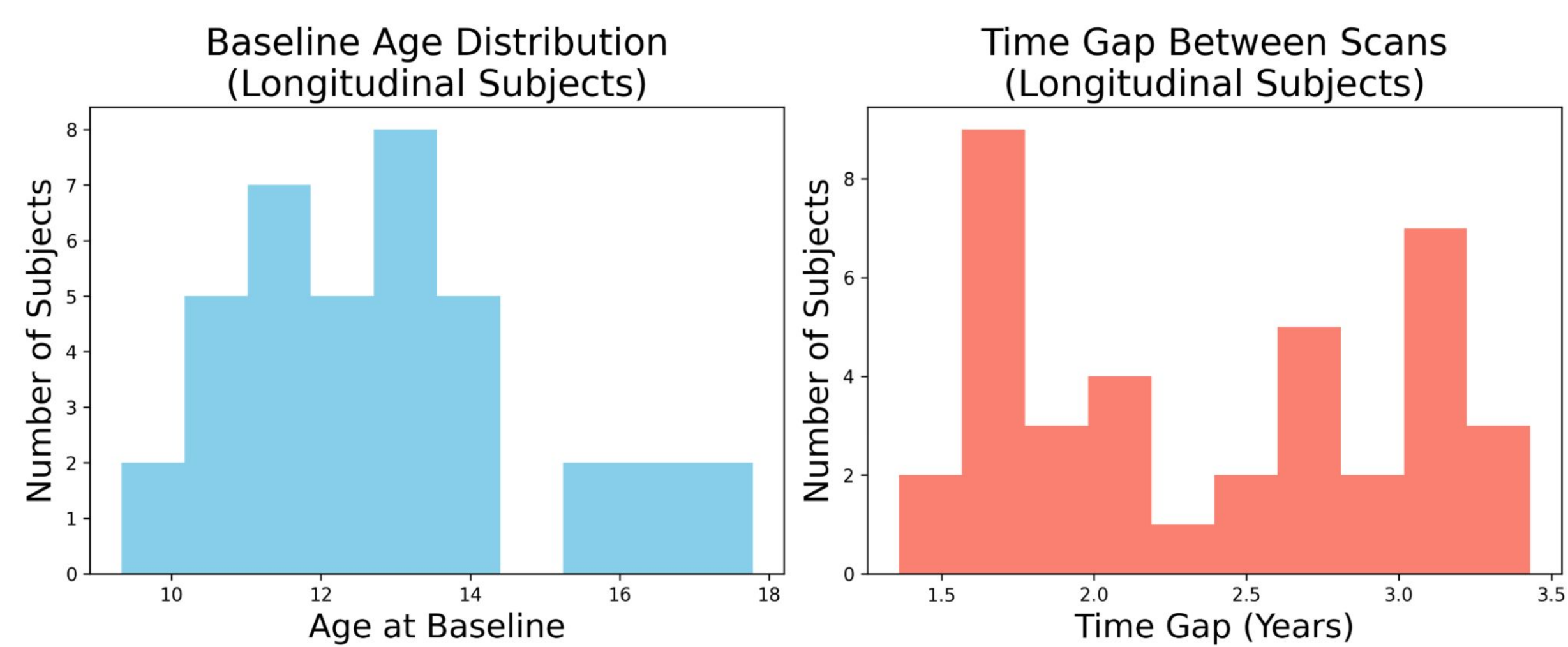


Illustration of early brain growth dysregulation in ASD (ASD Living Biology, ResearchGate, accessed 2025)²

Methods

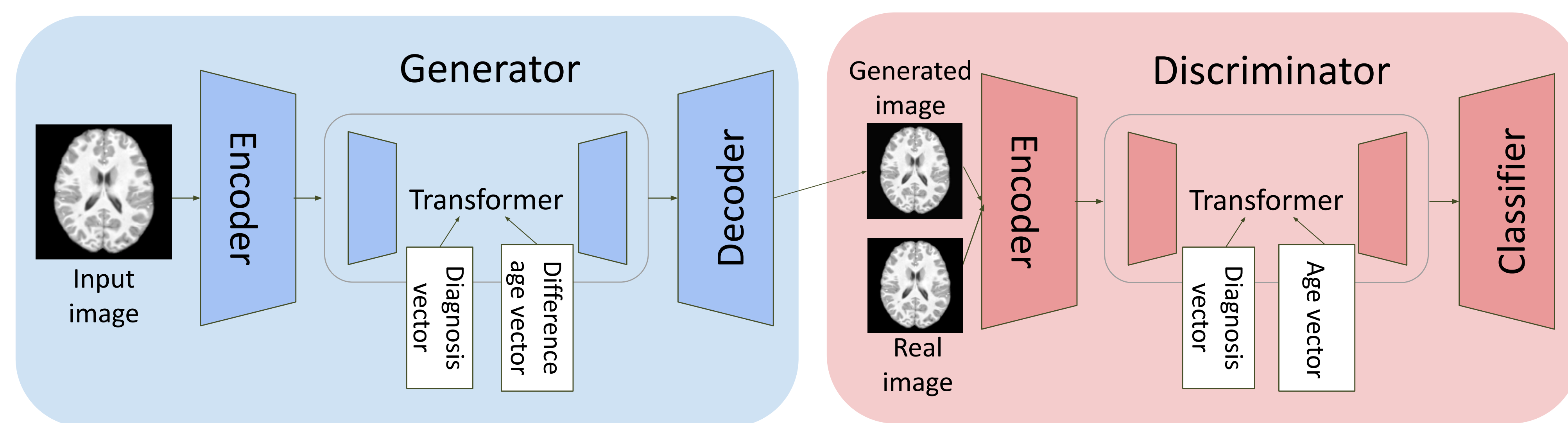
DATA:

- **Autism Brain Imaging Data Exchange (ABIDE) I and II** functional and structural MRI datasets:
 - Took 2D axial MRI slices of subjects under 21
 - Training and validation: 1392 non-longitudinal subjects
 - Testing: 38 real longitudinal subjects



MODEL ARCHITECTURE:

- **Conditional GAN** with **generator** (inputs real MRI image, conditional 20-D age and 1-D diagnosis vectors, outputs synthetic image) and **discriminator** (evaluates real vs. synthetic images)
- Adversarial, content, and perceptual loss to retain subject identity and realistic image generation
- Compute **Jacobian determinant maps** to quantify brain expansion and contraction



Results

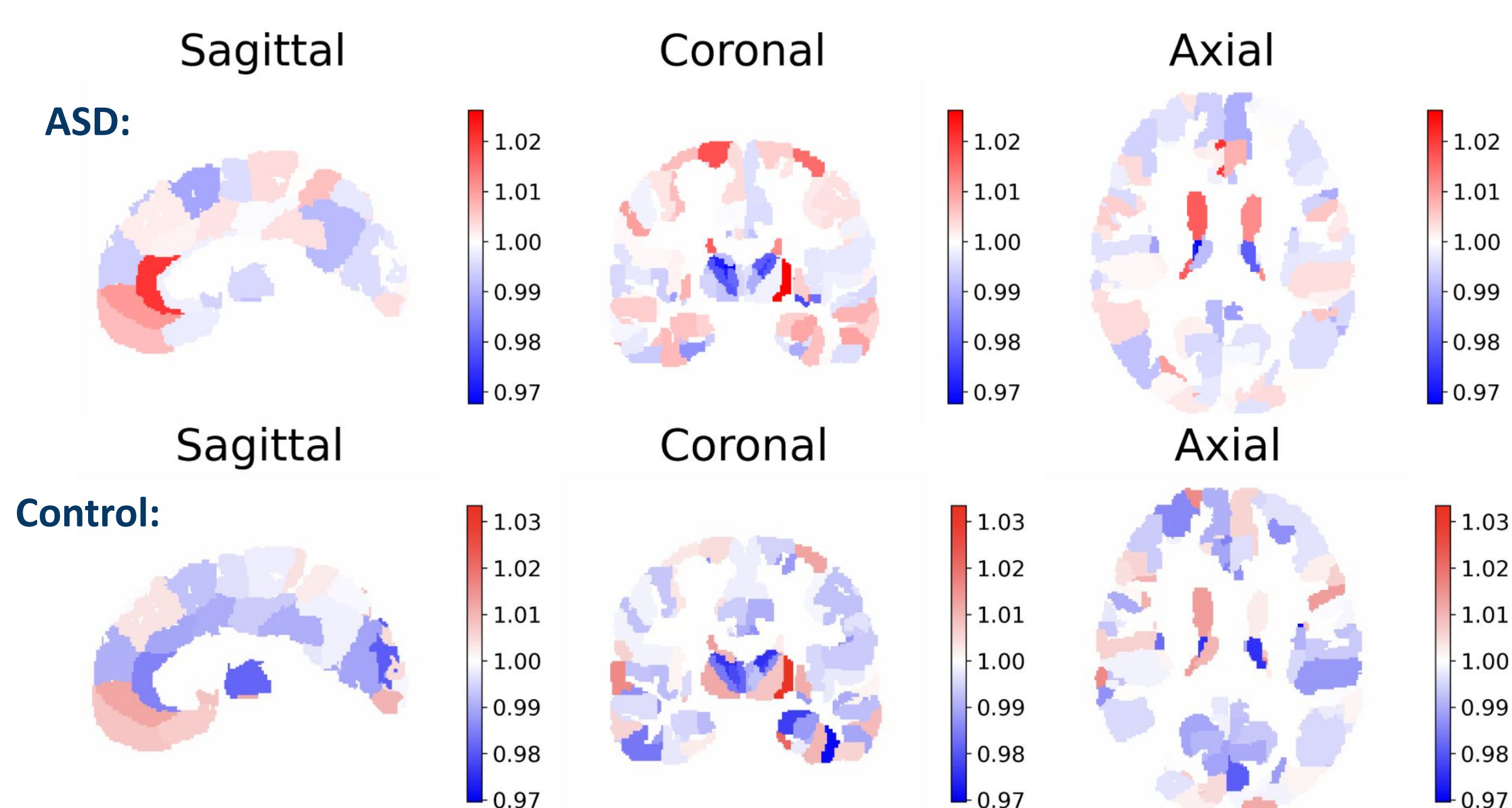


Fig. 1: Average Jacobian determinants in Brainnetome Atlas Regions of Interest (ROIs) in real longitudinal data tend to be greater in ASD vs. Control brains

Table 1: Two-sided t-tests show strong evidence that average Jacobian values in these top ROIs from real longitudinal data differ between ASD vs. Control groups

Top 3 Regions	P-value
3 (left dorsolateral area in frontal lobe)	< 1e-10
13 (left medial area in frontal lobe)	< 1e-10
18 (right inferior frontal junction in frontal lobe)	< 1e-10

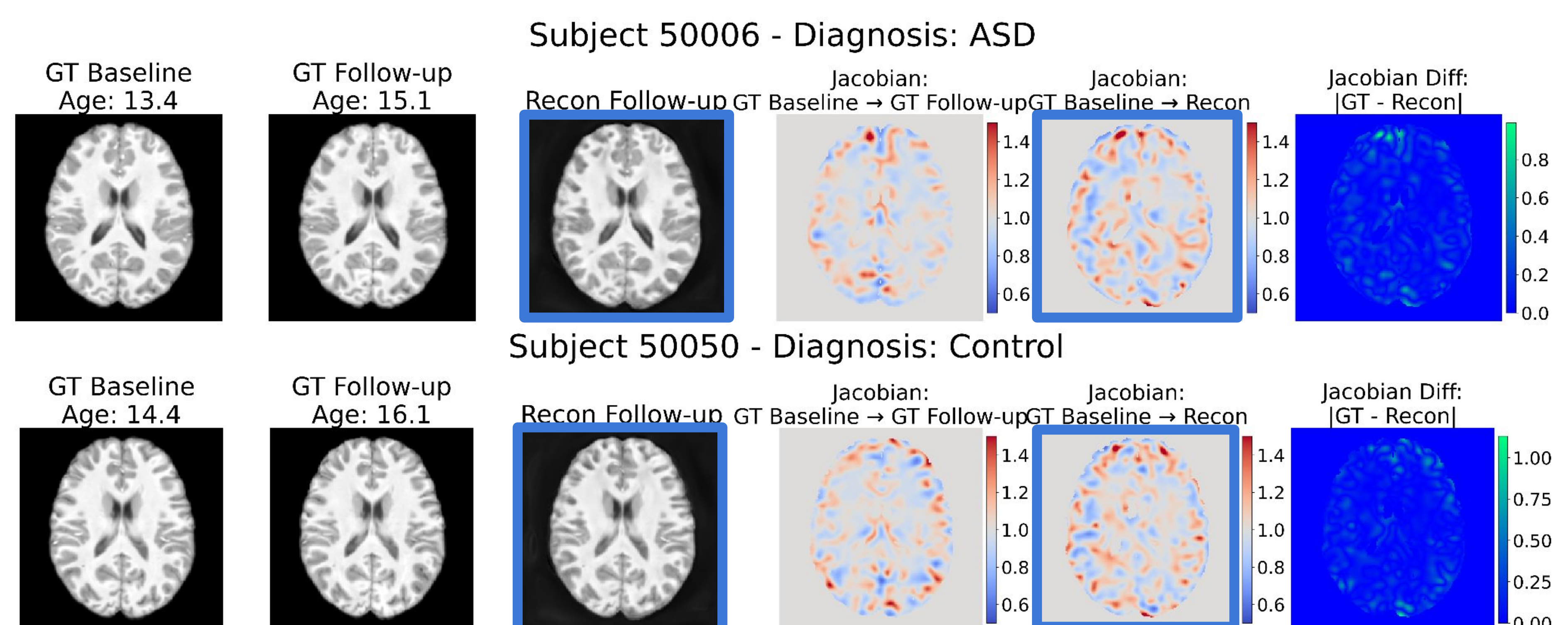


Fig. 2: Example subject-specific ground truth and synthetic scans and Jacobian determinant maps

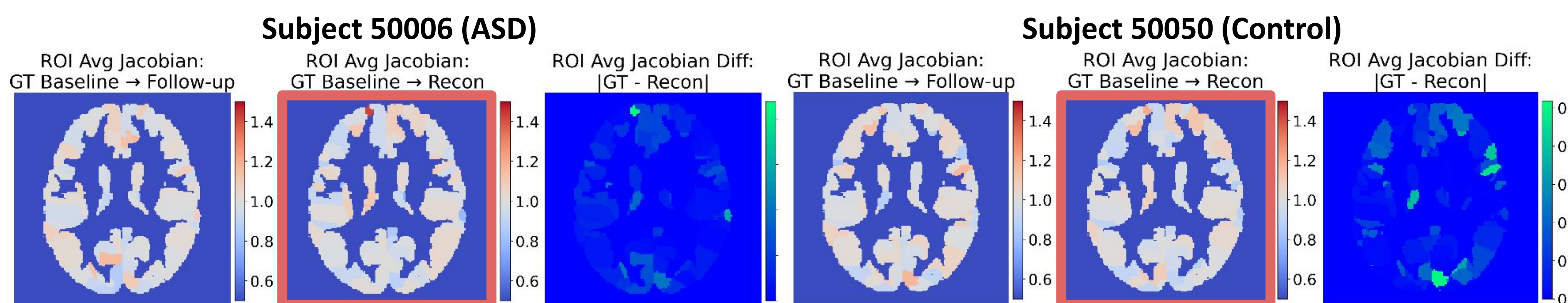


Fig. 3: Example subject-specific ROI average Jacobian determinant maps

Discussion & Conclusion

- Visualizations and statistical tests on real longitudinal data support previous findings of ASD-related brain growth
- Consistent volume change patterns in reconstructions show our GAN can predict subject-specific key regional growth or shrinkage associated with ASD
 - But our current GAN may not fully capture subtle or complex morphological variations within very short timespans, *e.g.* 2 years
- Our work demonstrates AI's potential to predict brain growth in medical imaging as an ASD biomarker

References

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- (2) ASD Living Biology: From Cell Proliferation to Clinical Phenotype. *ResearchGate*. https://www.researchgate.net/figure/Illustration-of-early-brain-growth-dysregulation-in-ASD_fig1_325931467 (accessed Aug 1, 2025).

Acknowledgements

We thank the ABIDE initiative for sharing the MRI data used in this project. Thank you to BU RISE and Professor Archana Venkataraman for this incredible opportunity, and Jueqi Wang for her unmatched mentorship and guidance.