

Multivoxel pattern analyses of brain structure to classify dyslexia

Ja Young Choi^{1,2}, Gabrielle-Ann Torre², Yaminah Carter², Terri Scott², Satrajit Ghosh¹, Tyler Perrachione²

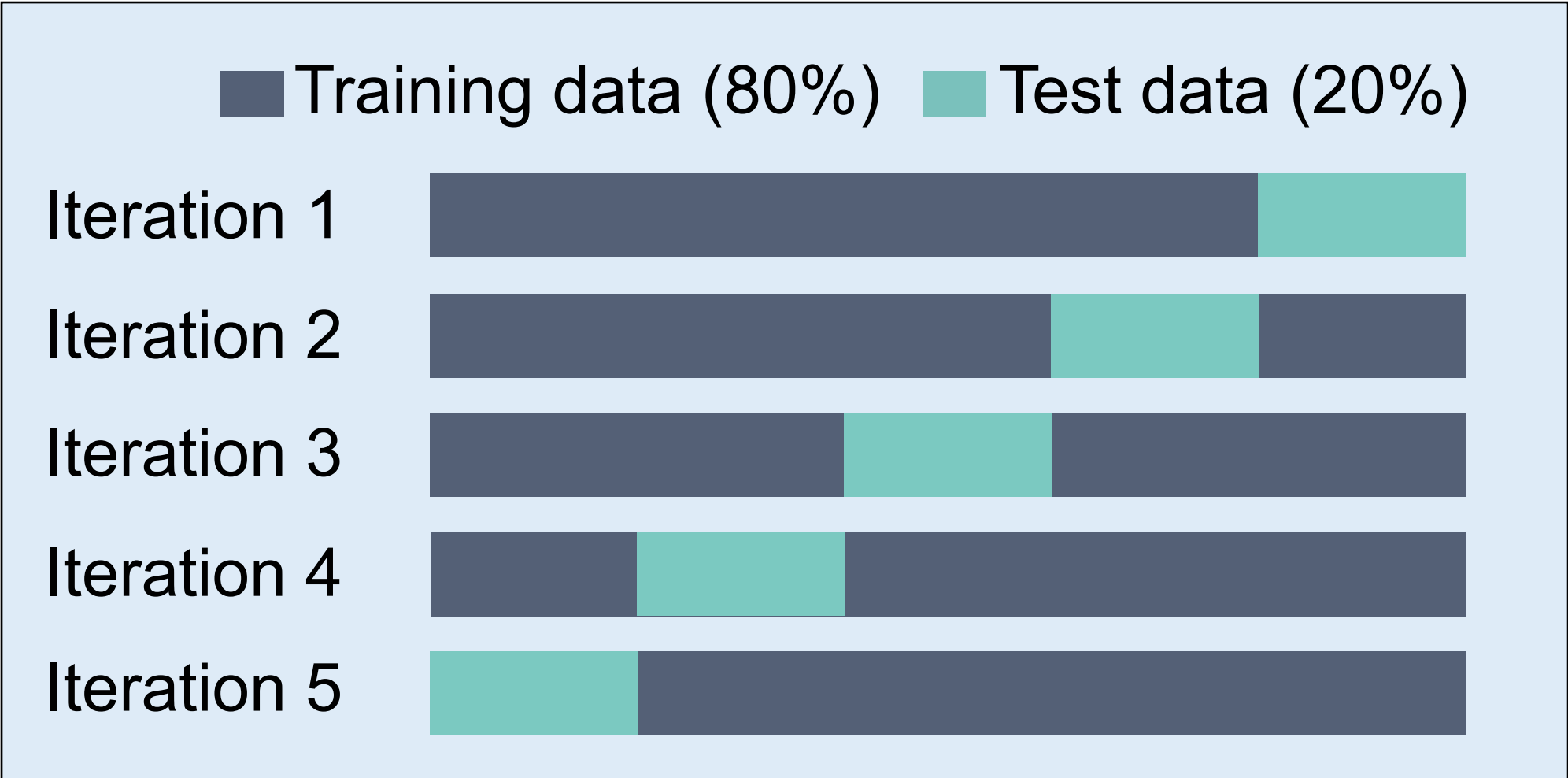
¹Program in Speech and Hearing Bioscience and Technology, Harvard University
²Department of Speech, Language & Hearing Sciences, Boston University

Summary

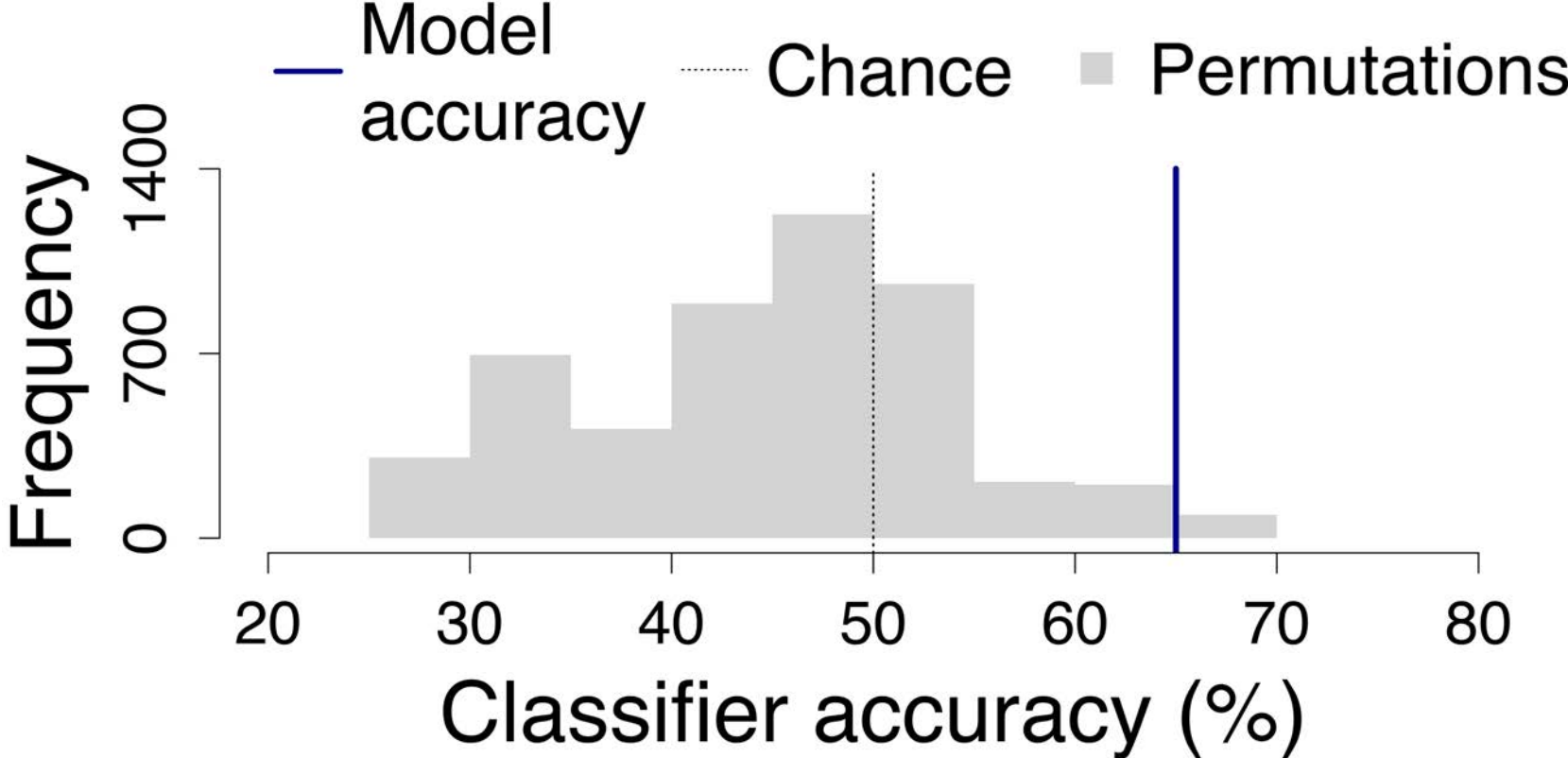
- Previous research has shown inconsistent results on neuroanatomical differences between control and dyslexic groups.
 - Studies have used various morphometric measures and small sample sizes.
- Research question:**
Do local differences in gray matter density (GMD) or white matter density (WMD) across the whole brain characterize dyslexia?
- Using univariate voxel-based morphometry analyses, we found no significant difference in GMD or WMD between control and dyslexia.
 - We used two machine learning models to classify WMD and GMD maps into two groups.

Model 1

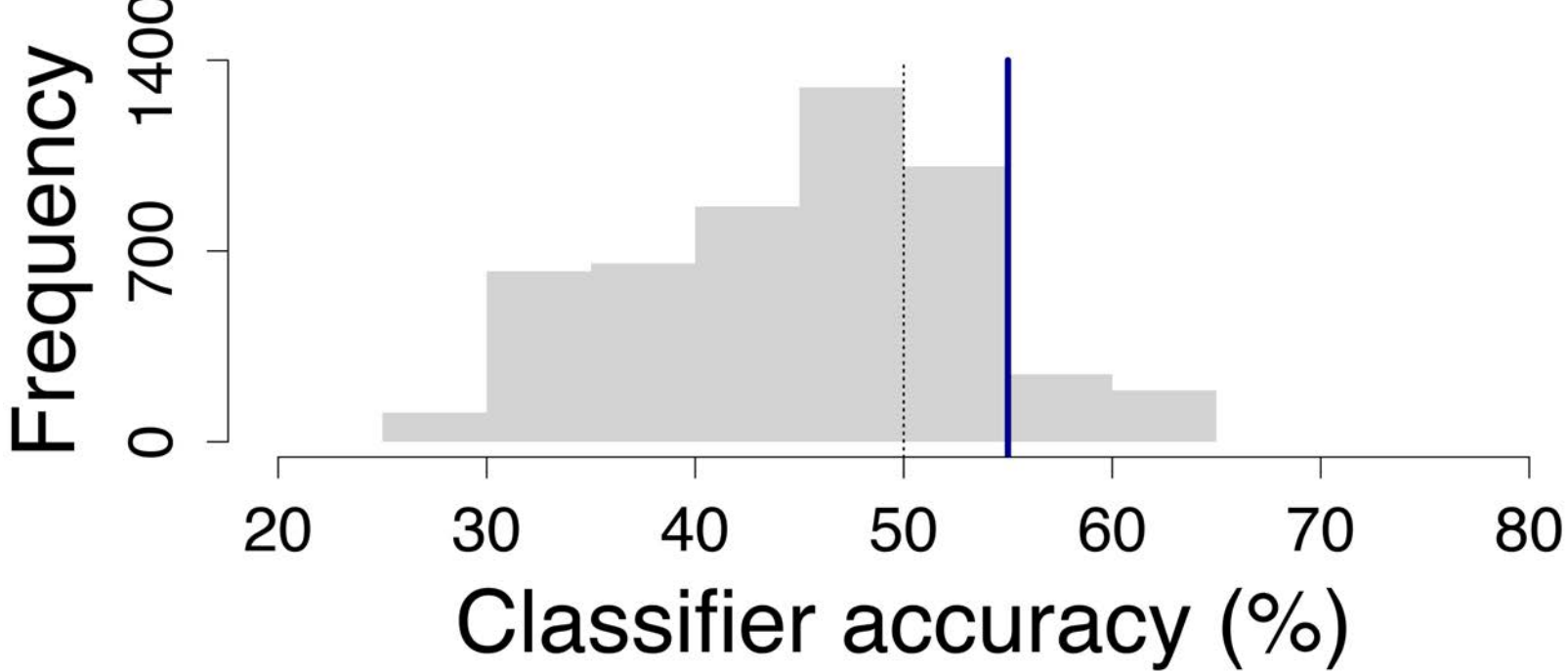
- 5-fold cross-validation with SVM classifier
- GMD was classified with accuracy of 65.5%; Classification accuracy for WMD was at 55.2%



Classifier performance: GMD

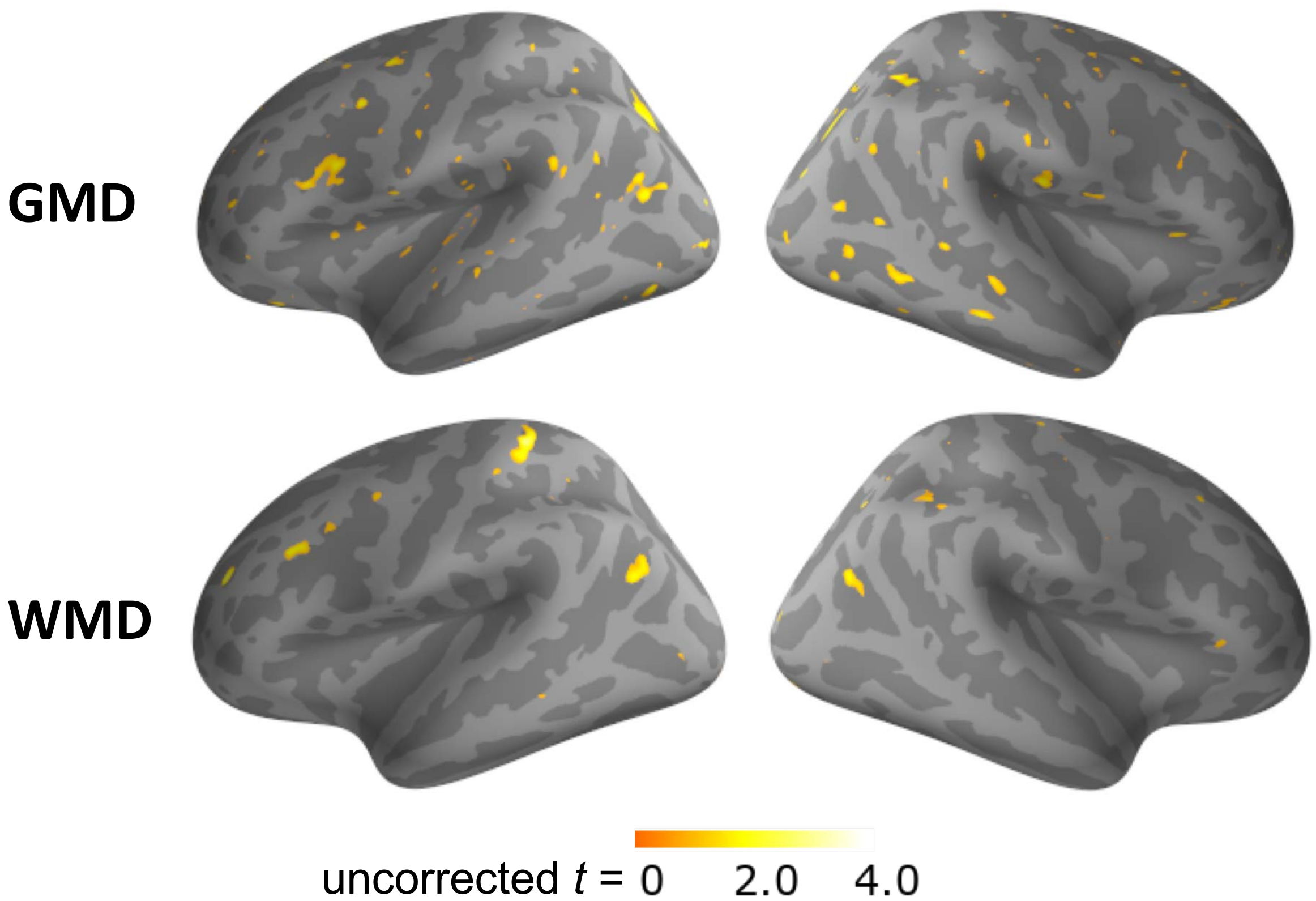


Classifier performance: WMD



VBM

- There was **no significant difference** in GMD or WMD between control and dyslexic groups.



Subjects

	Control (n=56)	Dyslexia (n=52)
Mean age (range)	22.83 (18-32)	23.84 (18-38)
Sex	F 31 / M 25	F 38 / M 14
Non-verbal IQ (WASI)	116 ± 9.5	111 ± 12.4
WRMT ID	105 ± 13.4	96 ± 11.5
WRMT WA	103 ± 14.9	89 ± 13.0
TOWRE SWE	101 ± 16.0	87 ± 16.2
TOWRE Decoding	100 ± 16.5	85 ± 13.6

Data acquisition

Siemens Trio 3T; 32-ch coil;
T1 ME-MPRAGE; 1mm³ voxels

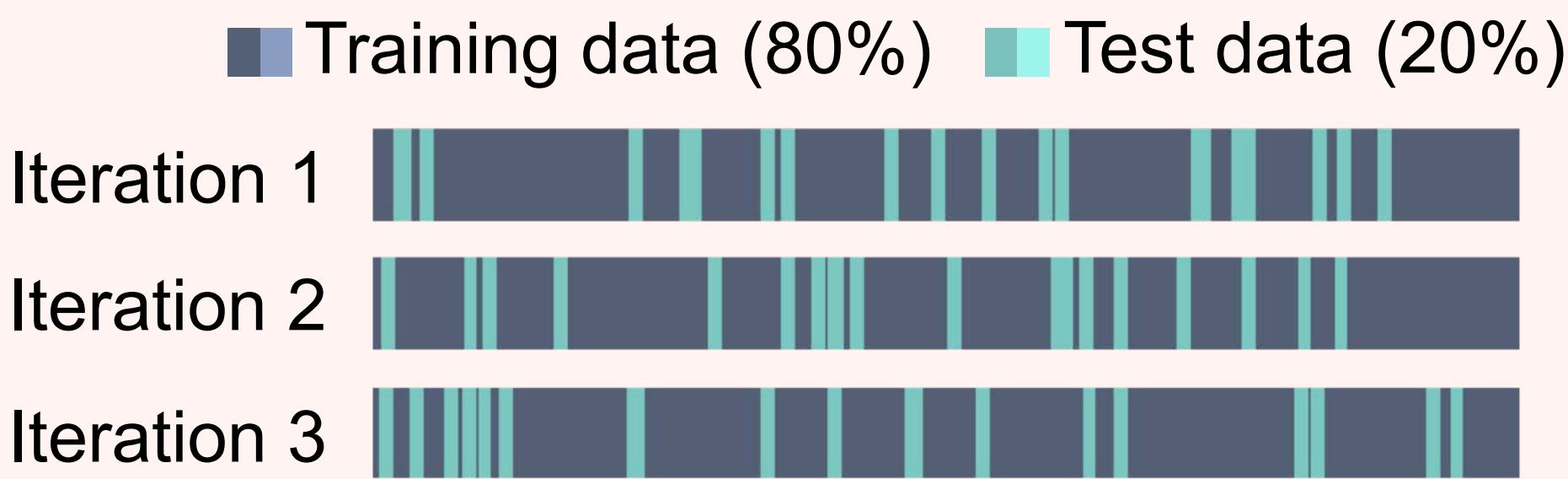
Data preprocessing

- Each subject's T1 image was segmented into gray matter, white matter and CSF; then the GMD and WMD were calculated, all using Atropos in ANTs.
- Each subject's GMD and WMD maps parcellated using Freesurfer.
- Mean GMD and WMD within each parcel was calculated.
- Parcellated GMD and WMD maps were normalized to MNI template.

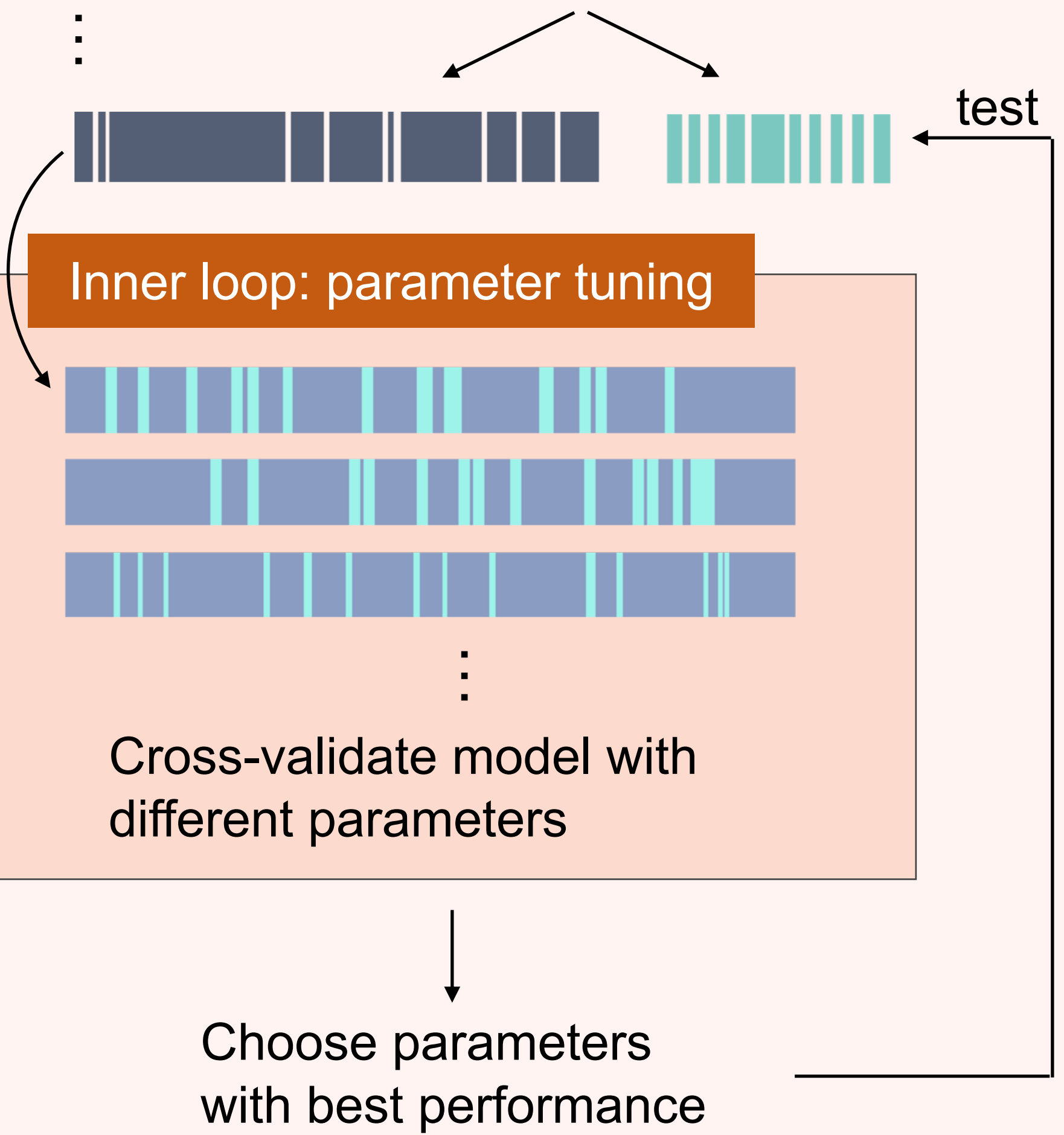
Model 2

- Nested cross-validation procedure for parameter optimization with Extra trees classifier and shuffle-split cross validation
- Classification accuracy for GMD was at 45.5%, not significantly better than bootstrapping.
- Classification accuracy for WMD was at 56.6%.

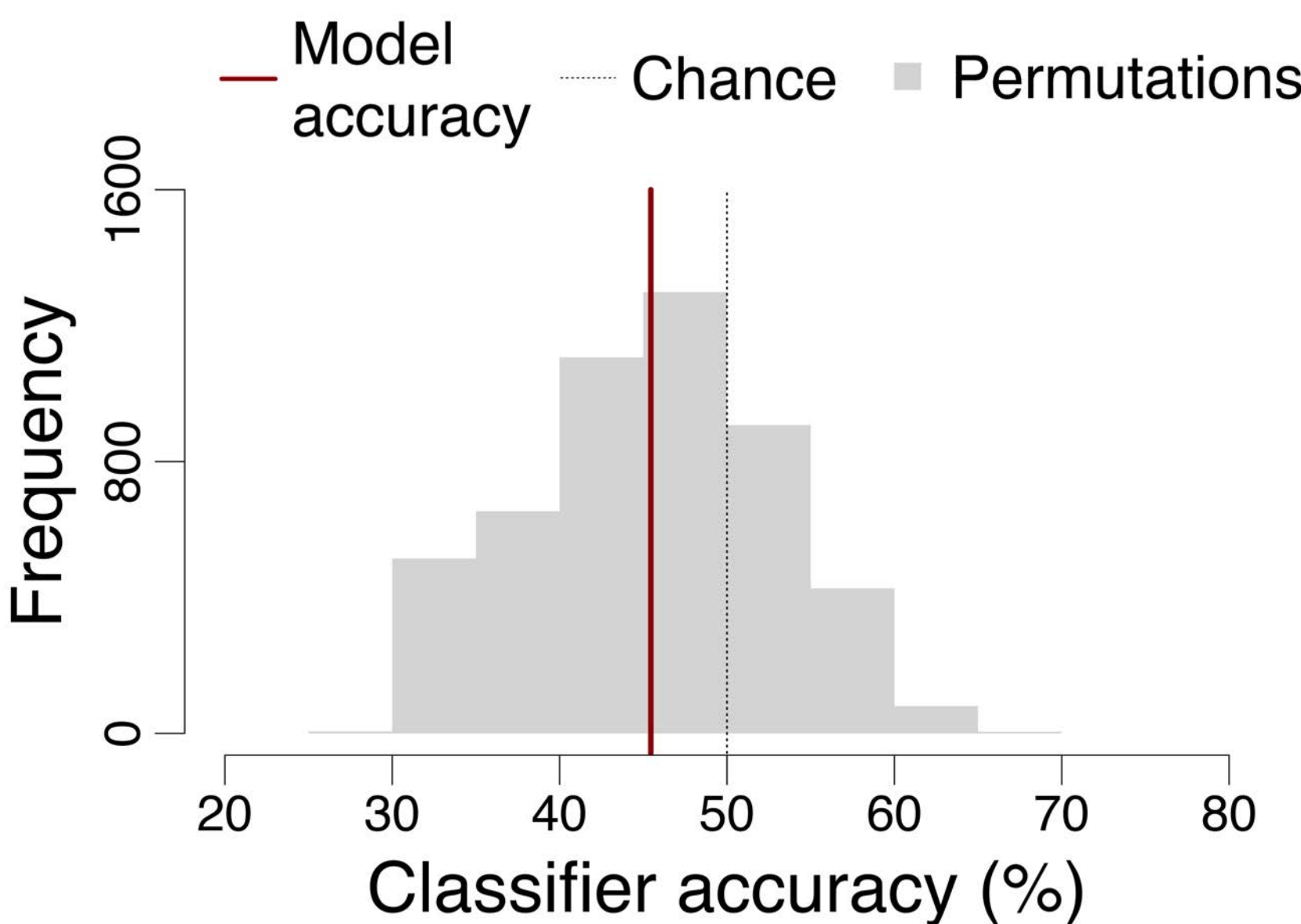
Outer loop: model testing



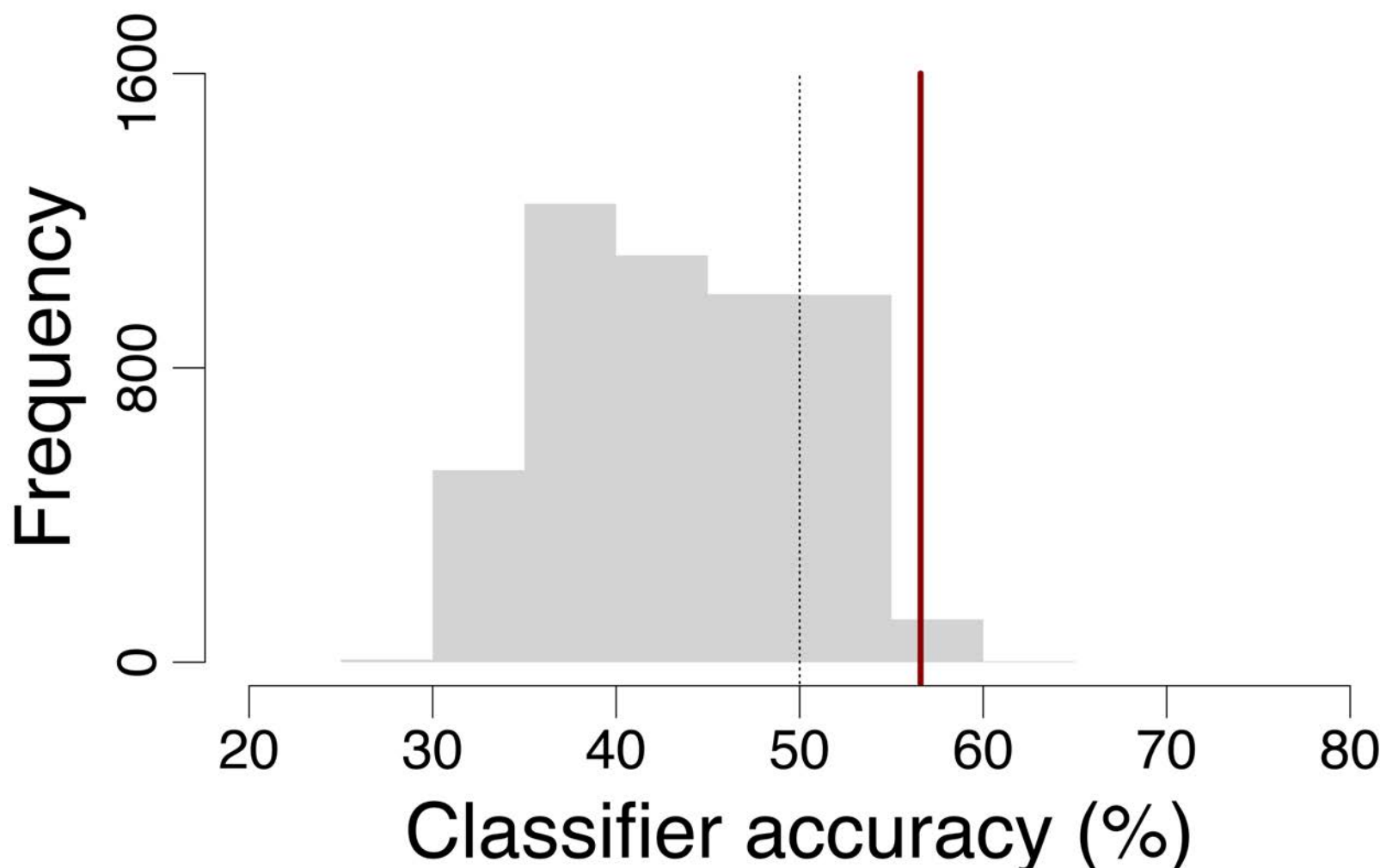
Inner loop: parameter tuning



Classifier performance: GMD



Classifier performance: WMD



Discussion

- No significant difference was found in GMD or WMD between control and dyslexia groups.
- A large number of subjects and multiple different approaches are necessary to explore neuroanatomical difference between control and dyslexia groups.
- The results suggest no evidence that dyslexia is characterized by macro-morphological features of the whole brain.
- This is a preliminary study of a larger future study involving more than 1000 brains.

Acknowledgments

This research is supported by the NICHD of the National Institutes of Health under award number R03HD096098 to TP.

References

Ramus, F., Altarelli, I., Jednoróg, K., Zhao, J., & Di Covella, L. S. (2018). Neuroanatomy of developmental dyslexia: Pitfalls and promise. *Neuroscience & Biobehavioral Reviews*, 84, 434-452.

Richlan, F., Kronbichler, M., & Wimmer, H. (2013). Structural abnormalities in the dyslexic brain: A meta-analysis of voxel-based morphometry studies. *Human brain mapping*, 34(11), 3055-3065.

Moreau, D., Wiebels, K., Wilson, A. J., & Waldie, K. E. (2019). Volumetric and surface characteristics of gray matter in adult dyslexia and dyscalculia. *Neuropsychologia*, 127, 204-210.