

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.

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

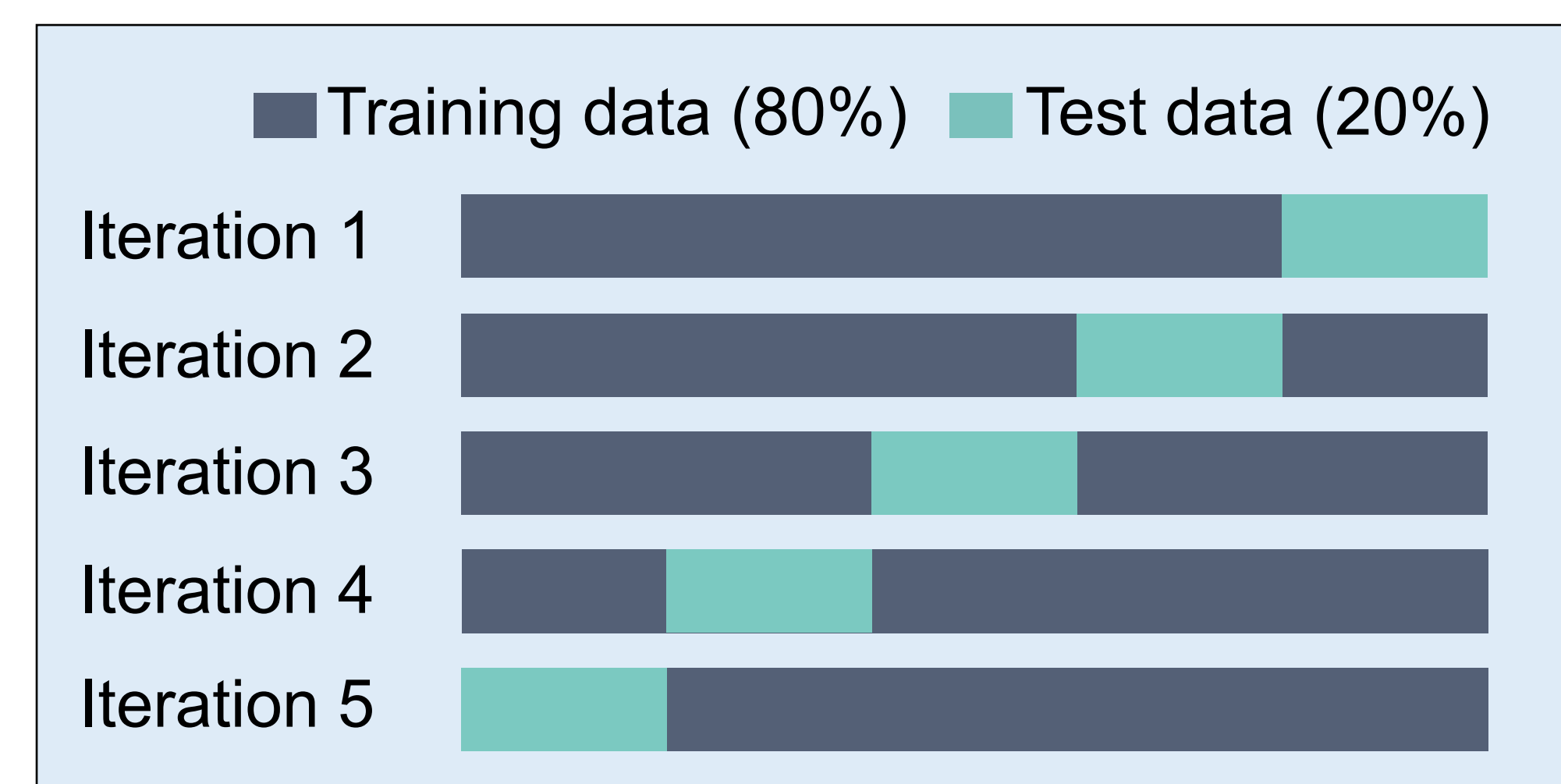
Siemens Trio 3T; 32-ch coil; T1 ME-MPRAGE; 1mm³ voxels

Data preprocessing

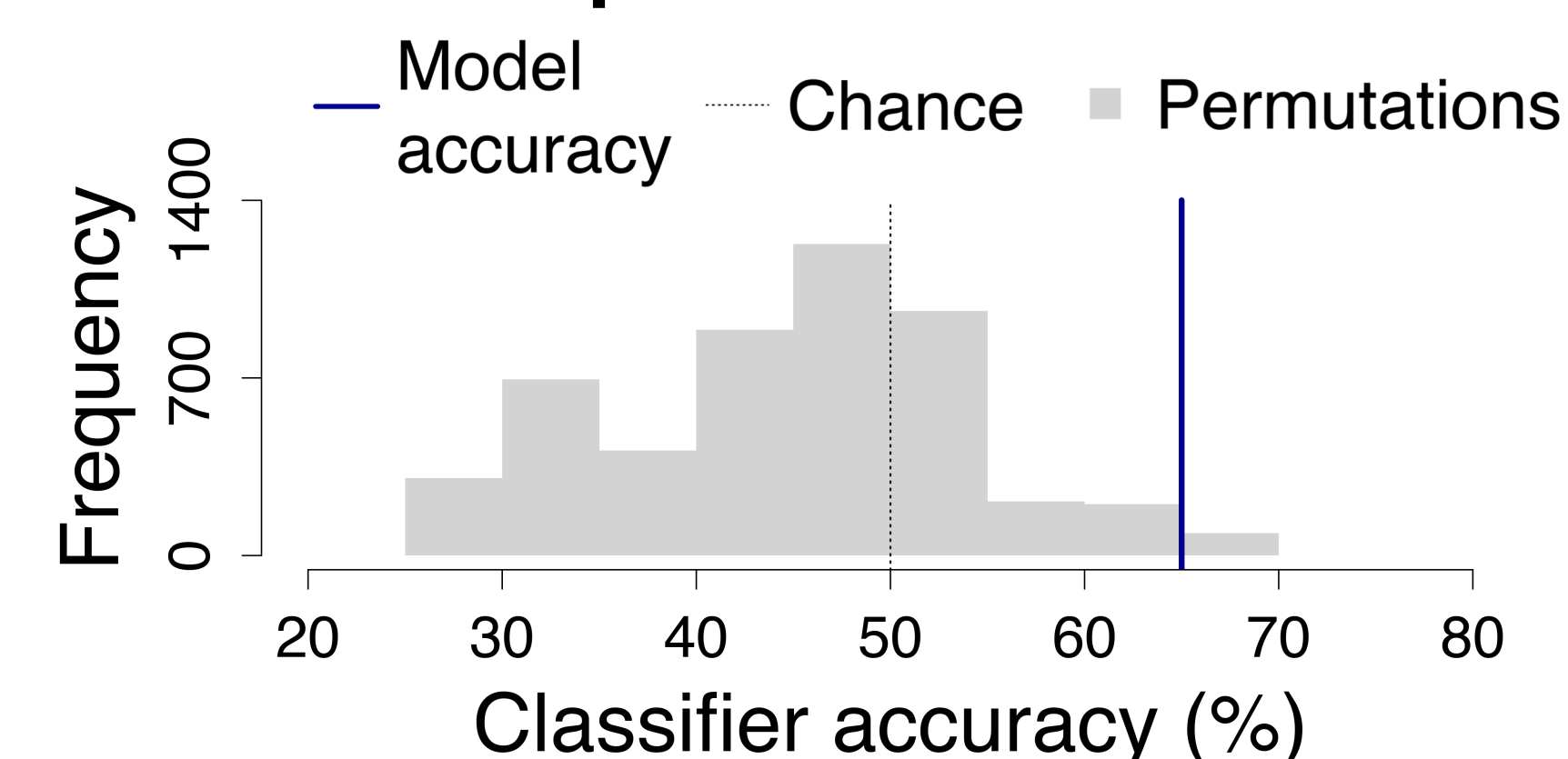
- Each subject's T1 image was segmented into gray matter, white matter and CSF; then the GMD and WMD were calculated, all using Atropis in ANTs.
- Each subject's GMD and WMD maps parcellated using Freesurfer.
- Mean GMD and WMD within each parcel was calculated.
- Parcellated GMD and WMD maps were normalized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

Model 1

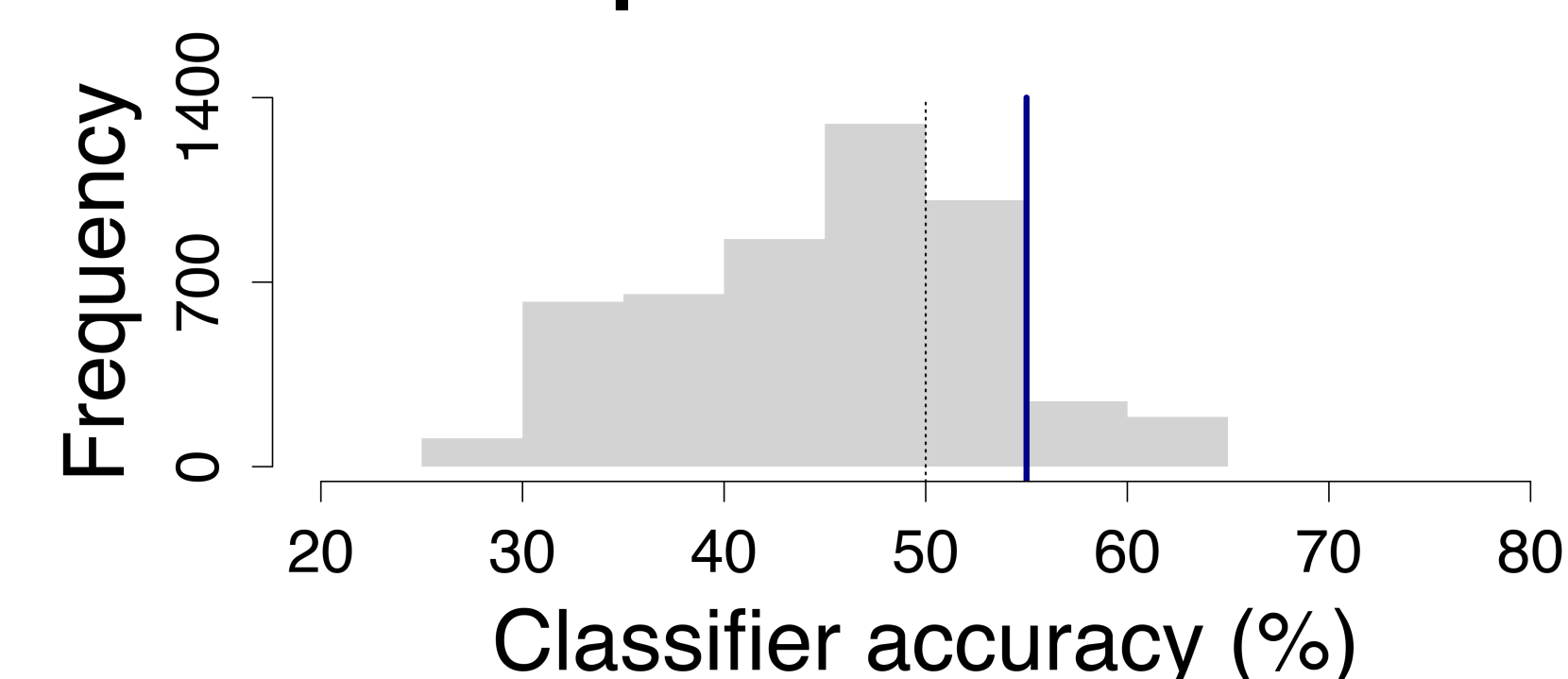
- 5-fold cross-validation with SVM classifier
- GMD was classified with accuracy of 65.5%; Classification accuracy for WMD was at 55.2%



Classifier performance: GMD

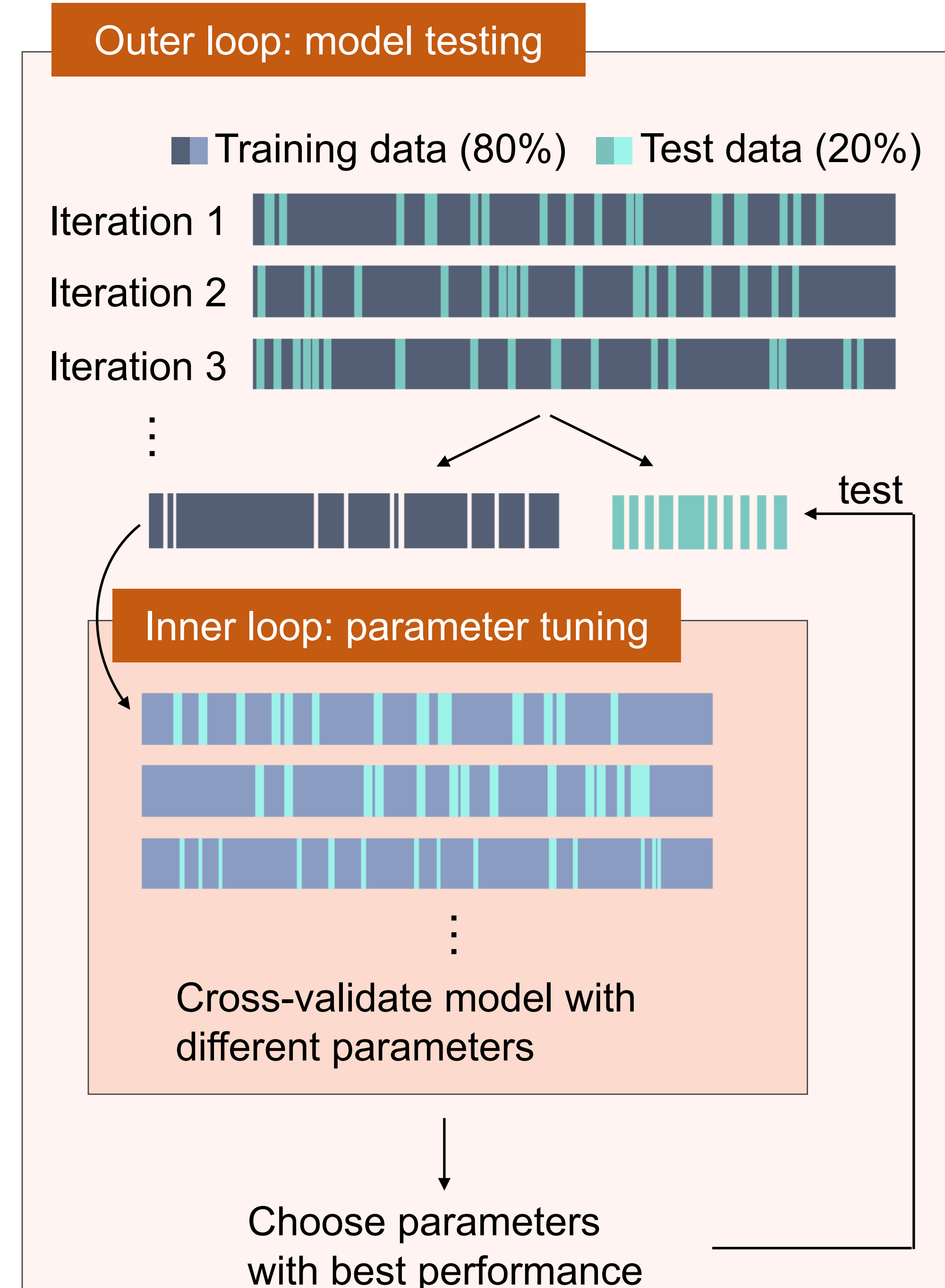


Classifier performance: WMD

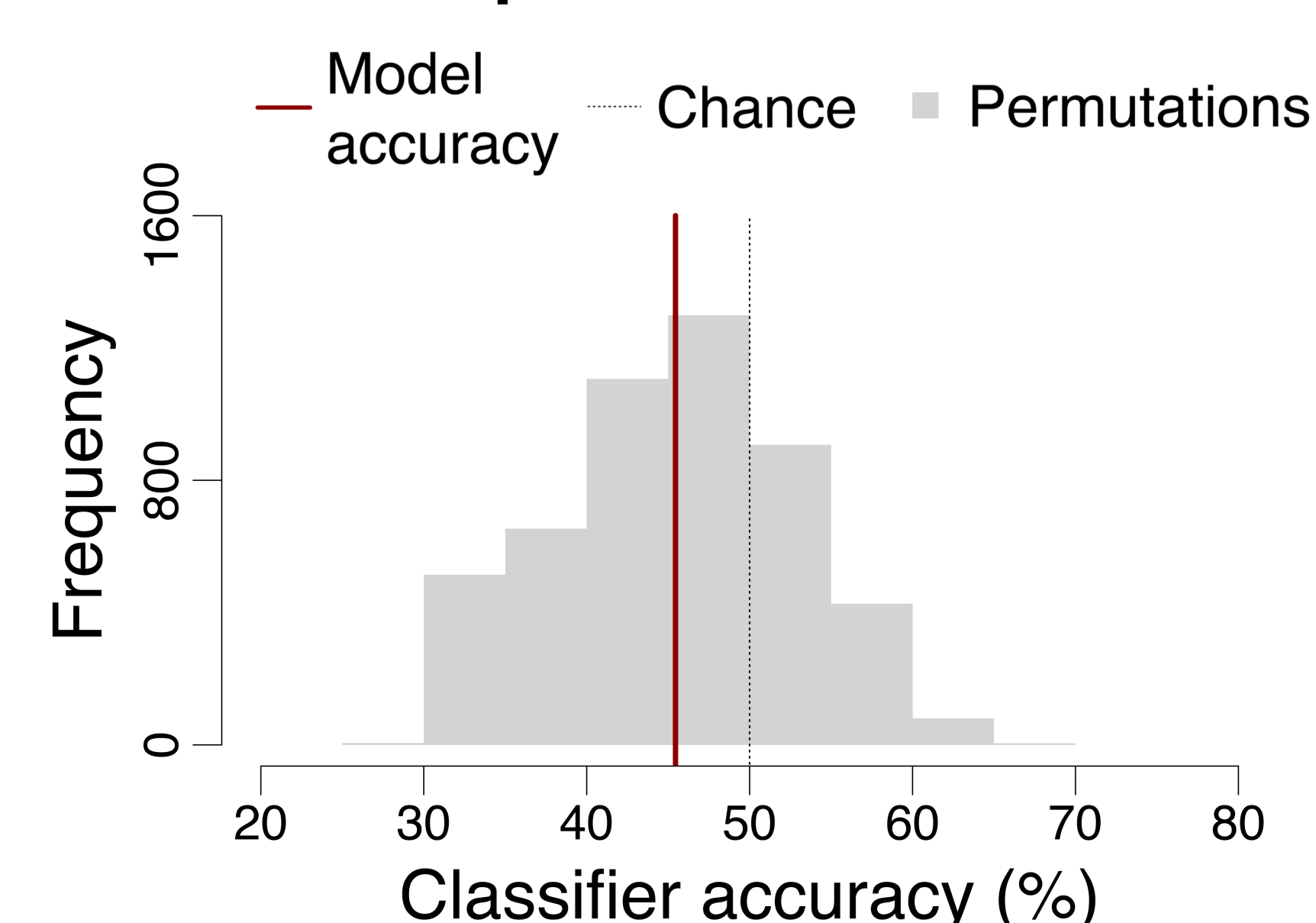


Model 2

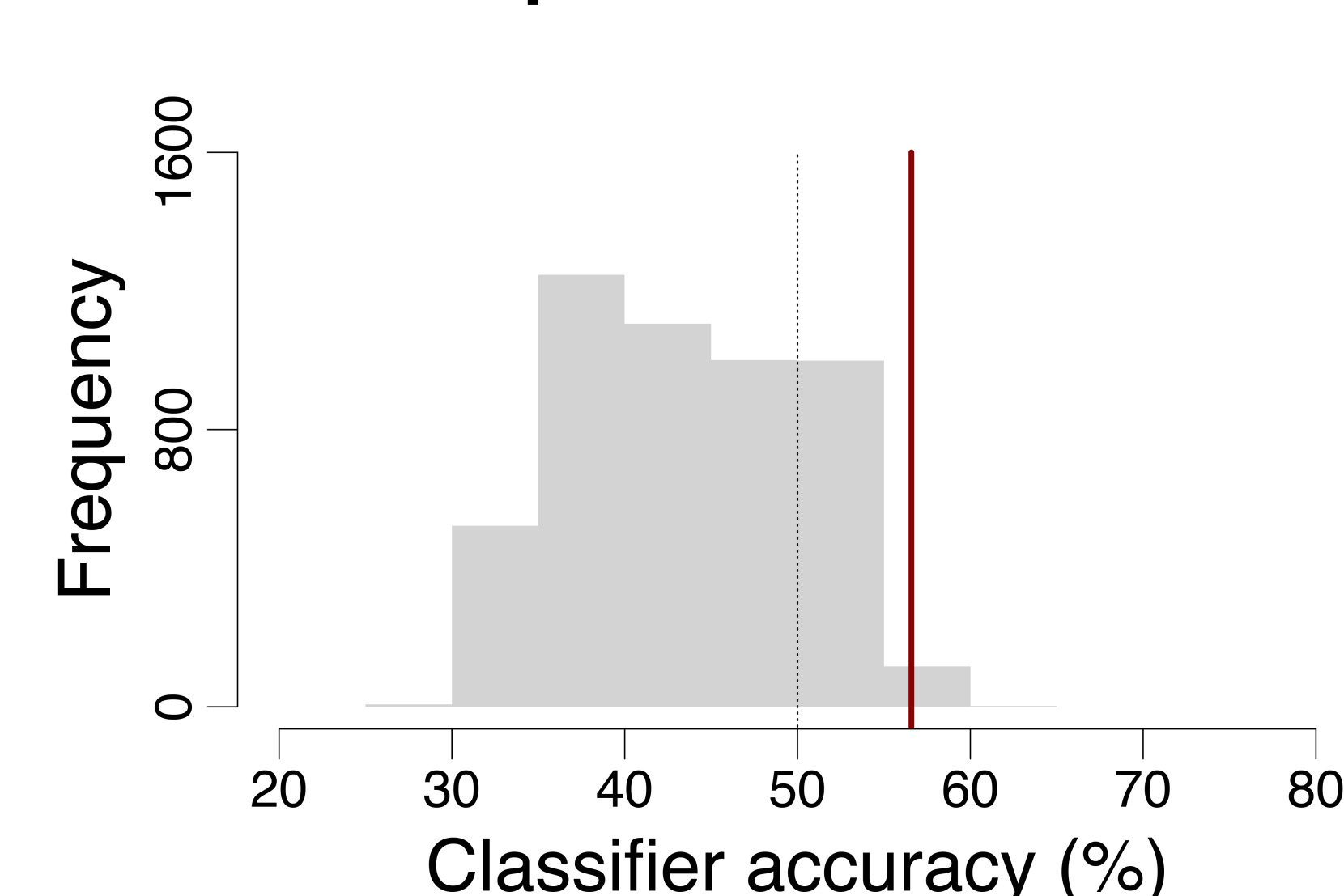
- Nested cross-validation procedure for parameter optimization with Extra trees classifier and shuffle-split cross validation
- Classification accuracy for GMD was at 45.5%, not significantly better than bootstrapping.
- Classification accuracy for WMD was at 56.6%.



Classifier performance: GMD

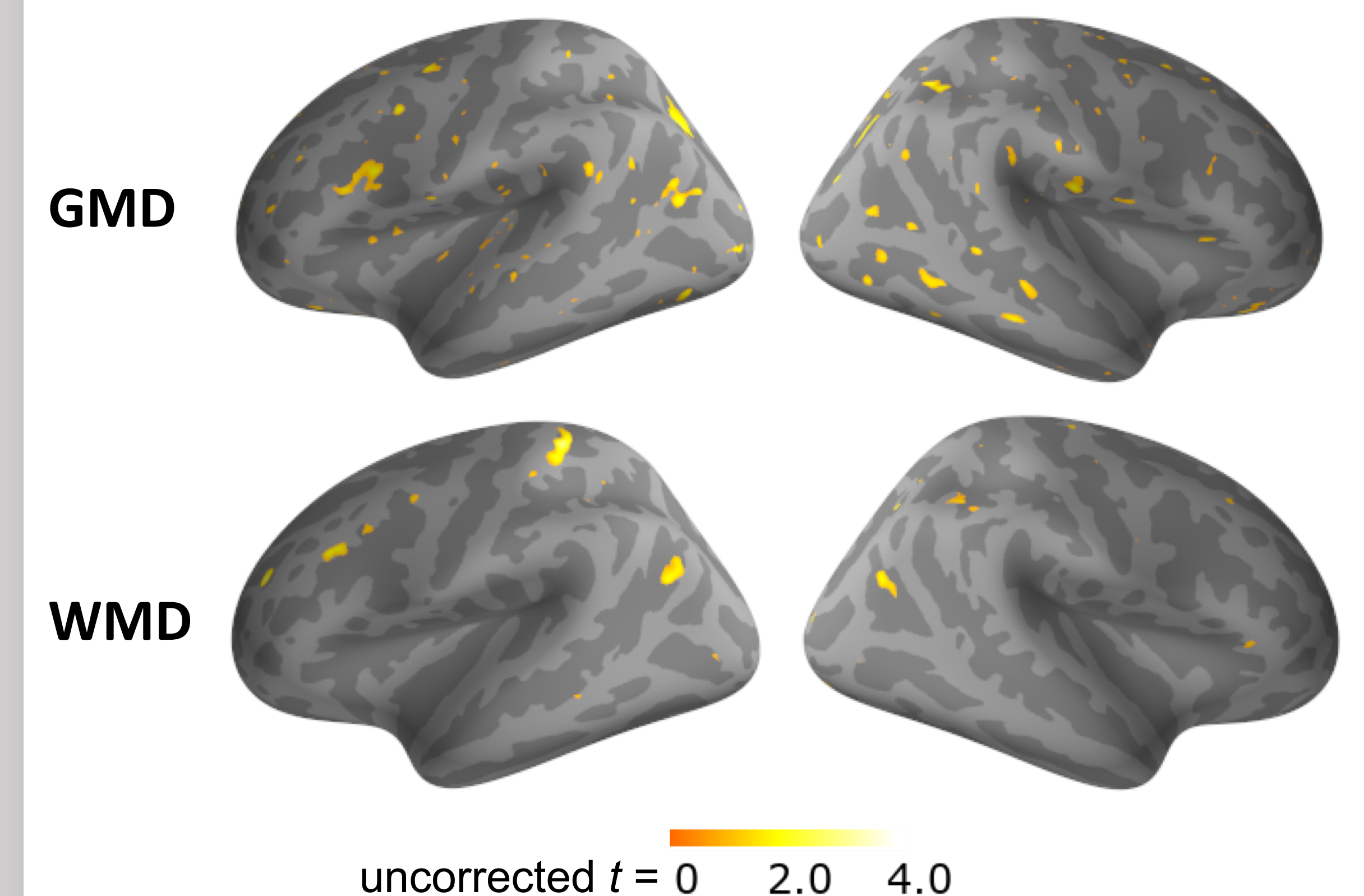


Classifier performance: WMD



VBM

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



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

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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.