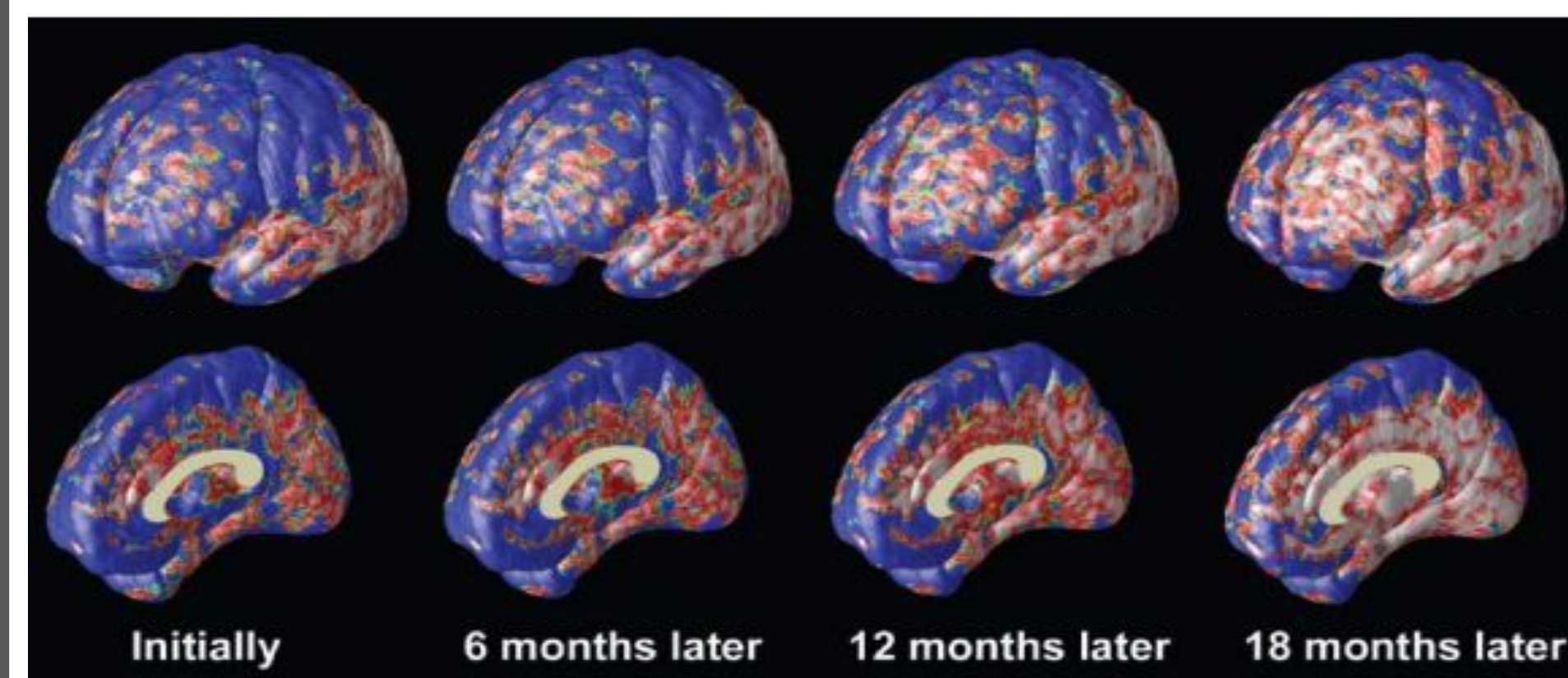


Problem Statement

We aim to create a feature that can quantify how **shriveled the cortex** is to improve Alzheimer's Disease forecasting performance in recurrent deep learning models.



On the left, we can see a healthy brain. The cortex, the outermost layer, is more smooth.



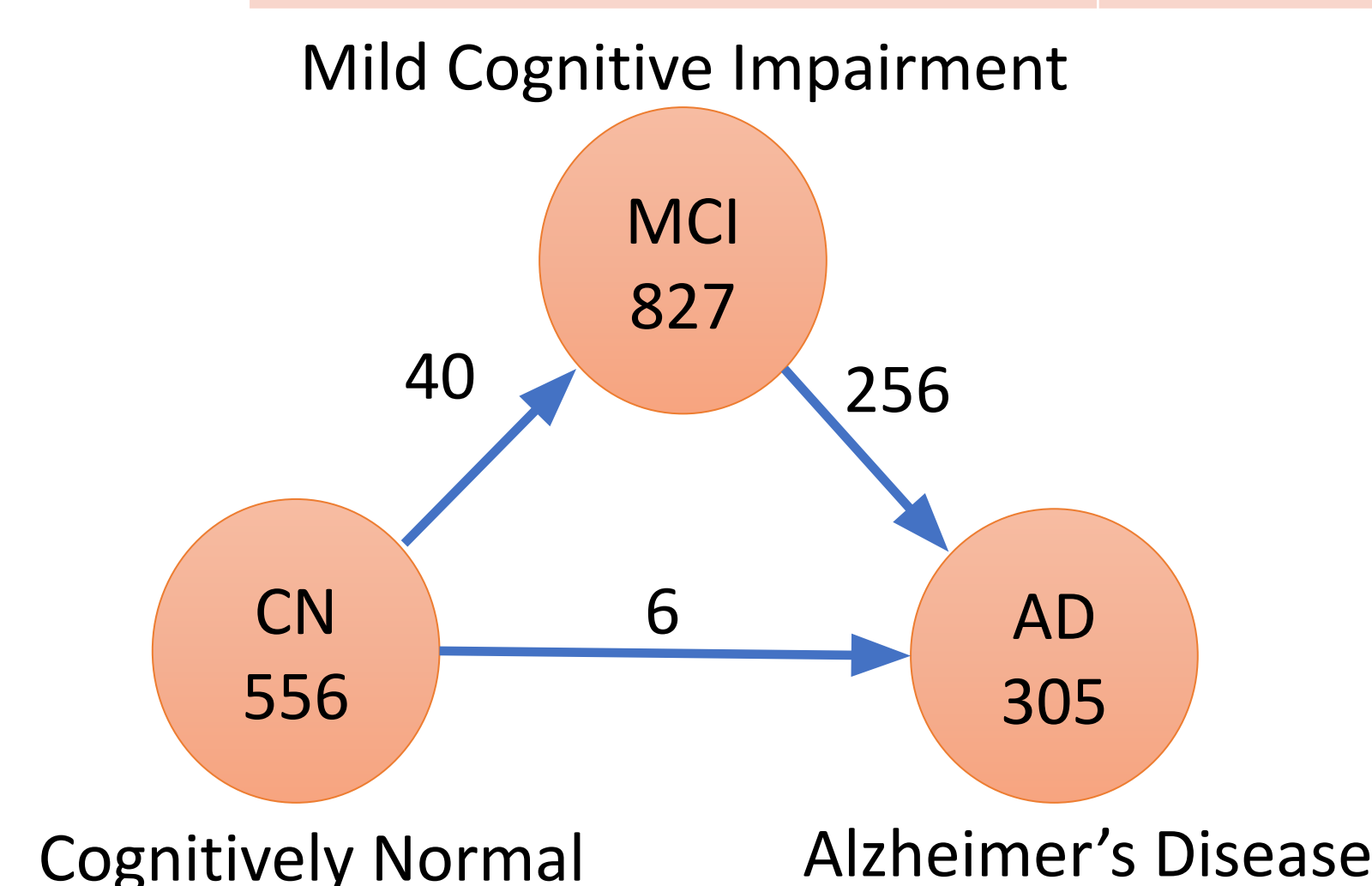
On the right, we can see a brain with Alzheimer's Disease. The cortex is shriveled and rough.

Dataset

ADNI provides the following data for 1688 patients

- Cognitive Test Scores
- Demographic information
- MRI scan
- Severity Level
 - Cognitively Normal
 - Mild Cognitive Impairment
 - Alzheimer's Disease

Disease Label	Frequency
Cognitively Normal	2538
Mild Cognitive Impairment	3770
Alzheimer's Disease	2004



Patients visit at most once every 6 months

Inspiration

Our solution to the problem is inspired by the problem of finding the fractal dimension of United Kingdom's coastline. Using smaller rulers, we capture more details of the UK's coastline. By comparing the perimeters generated from different rulers, we can reveal how rough the coastline is.



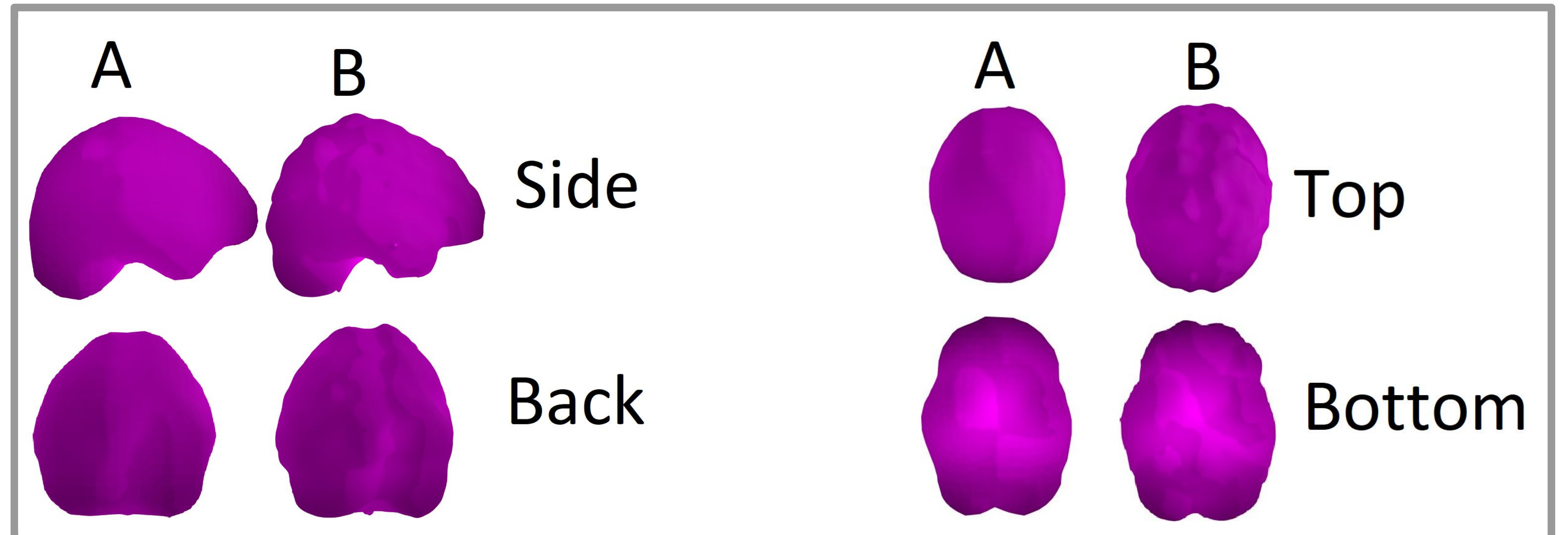
This visualization is from:
<https://commons.wikimedia.org/>

Acknowledgements

This research is supported by the Manning/IALS research award.

Method

We generate two scans of the brain: A is smoother and B retains more details and is therefore rougher

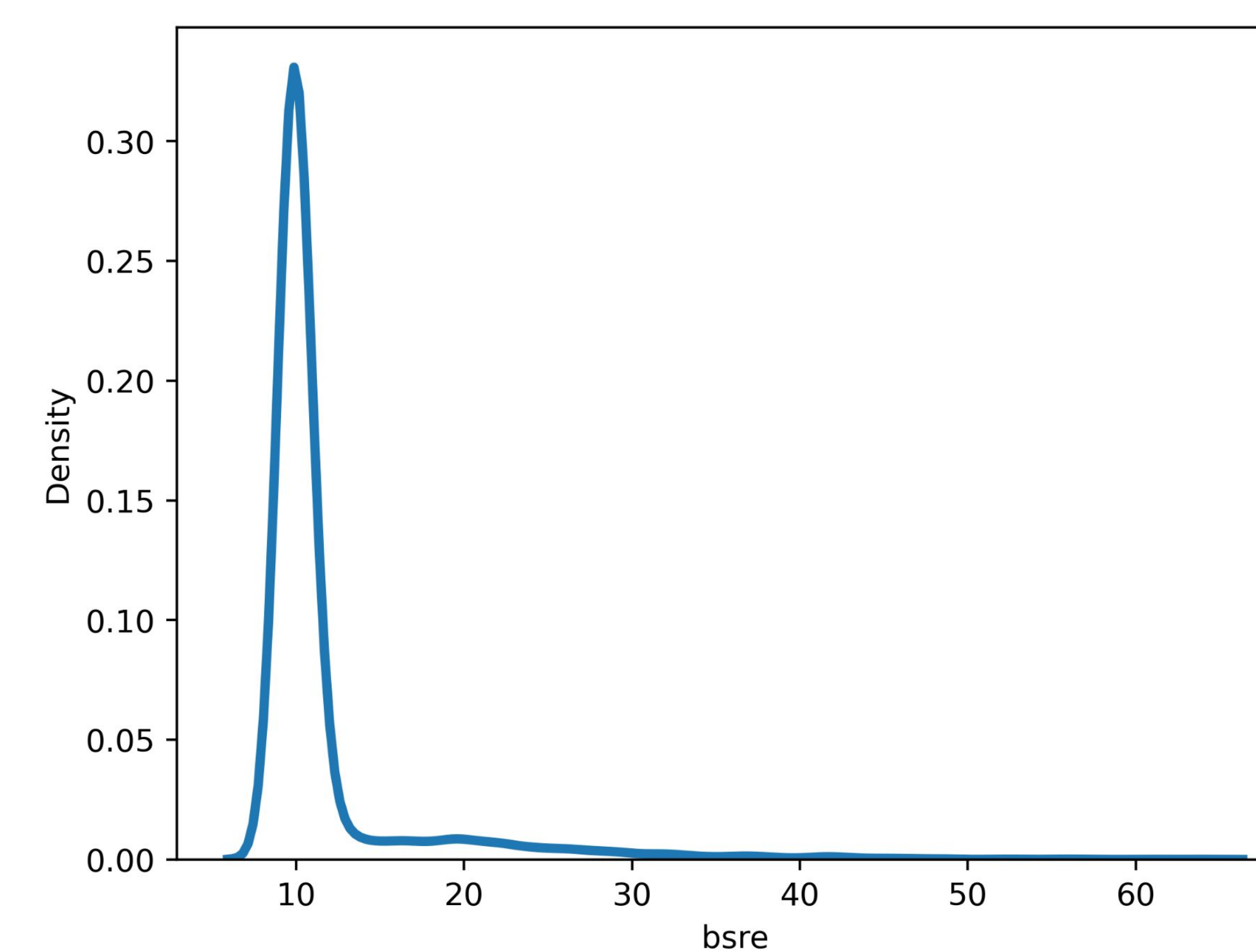


- To compare the two, we can divide the surface area of B by the surface area of A.
- The division of surface areas rarely deviate much from one.
- To make it easier for deep learning models to interpret, we instead compute:

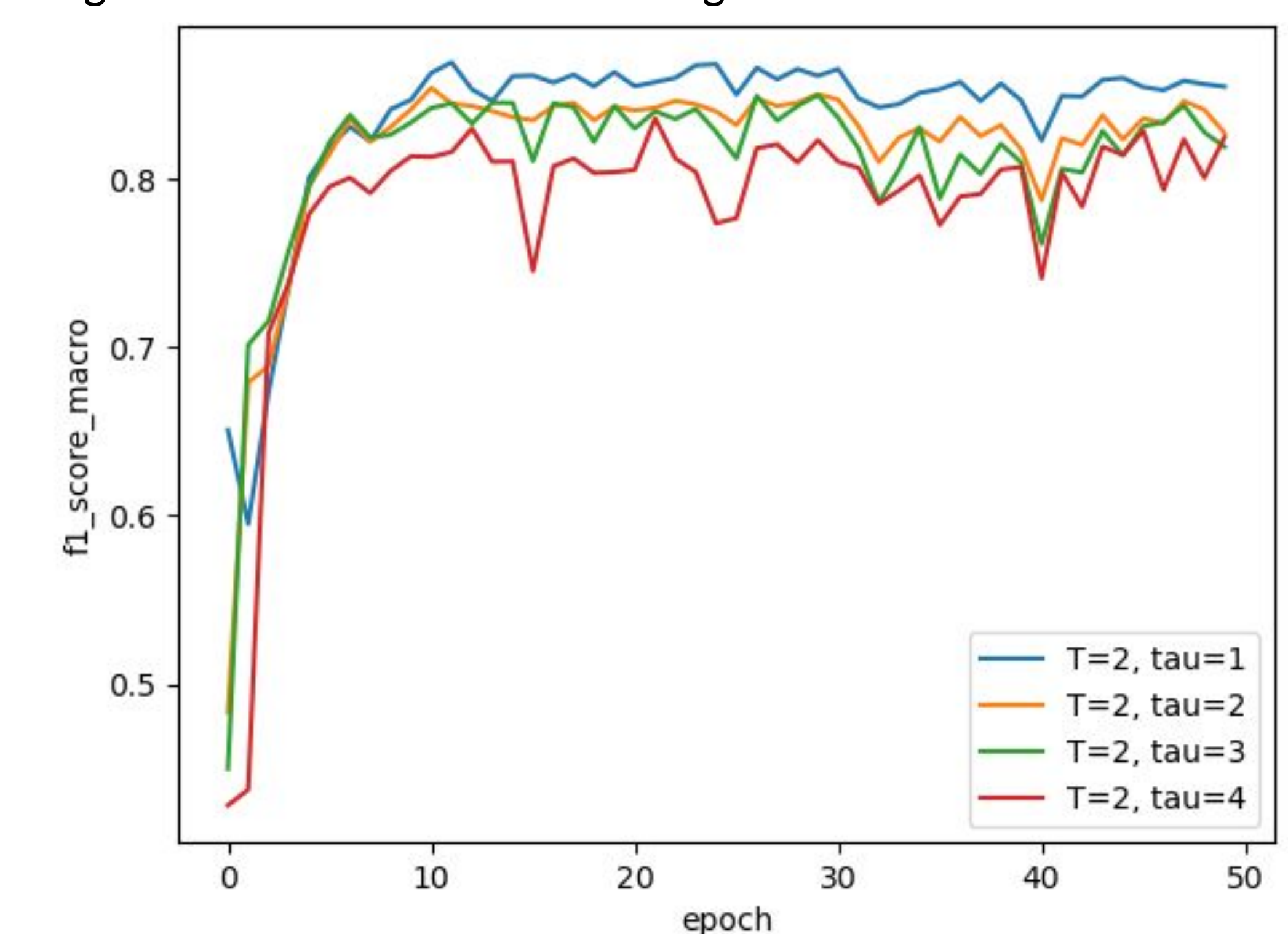
$$e^{2 \frac{\text{Surface area of B}}{\text{Surface area of A}}}$$

Discussion & Results

Distribution of the feature (BSRE) over all of the data from ADNI



Running FLARe with Brain Surface Roughness Estimation: F1 score vs epochs



	12 month forecast F1 ± Standard Deviation	18 month forecast F1 ± Standard Deviation	24 month forecast F1 ± Standard Deviation
Cognitive Test Scores & Demographics	0.83594 ± 0.00627	0.83895 ± 0.00587	0.77551 ± 0.04864
Hippocampus Volume	0.81708 ± 0.01308	0.82211 ± 0.01325	0.79890 ± 0.01417
Brain Surface Roughness Estimation	0.83507 ± 0.01541	0.83985 ± 0.01884	0.81240 ± 0.02352
Hippocampus Volume & Brain Surface Roughness Estimation	0.81730 ± 0.01041	0.81311 ± 0.02180	0.79187 ± 0.01660

Brain Surface Roughness Estimation has outperformed other indicators of Alzheimer's Disease when forecasting 18 months and two years in advance.