

Beyond Atrophy: A Deep-learning Analysis of Consistency and Complementarity Between FDG-PET and sMRI in AD Progression

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We derived an FDG-PET-based metabolic P-score and compared it with an sMRI-derived structural P-score to characterize AD-related neurodegenerative patterns. This multimodal imaging analysis helps quantify AD progression, distinguish cognitive decline, and reveal consistency and complementarity between structural atrophy and glucose hypometabolism.

P2-07



INTRODUCTION

Recent advances show that interpretable deep learning (DL) can extract meaningful neurodegeneration biomarkers of Alzheimer's disease (AD) from sMRI. This study extends these capabilities to functional metabolic imaging.

Objectives:

- ✓ Apply an enhanced Spatial 3DCNN model to FDG-PET scans for the derivation of metabolic biomarkers.
- ✓ Evaluate whether sMRI-derived neurodegenerative patterns are reflected in FDG-PET to assess cross-modal consistency.
- ✓ Characterize FDG-specific progression patterns and explore how metabolic alterations may complement established anatomical and disease-progression frameworks.

METHODS

An interpretable DL technique (Spatial 3DCNN)

- ✓ Ensemble Training: Train attention-enhanced base models on 3D cubes for AD.
- ✓ Cube P-score: Derive metabolic biomarkers from model scores and weights.
- ✓ Atlas Aggregation: Map P-scores to Brainnetome Atlas subdivisions.

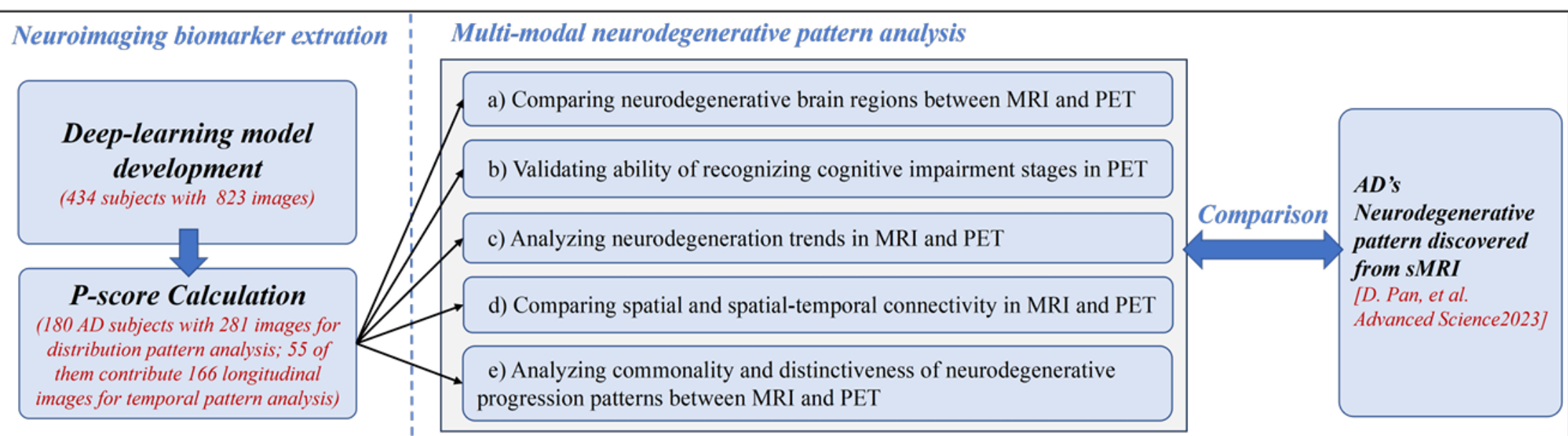


Figure 1. The main work of this study.

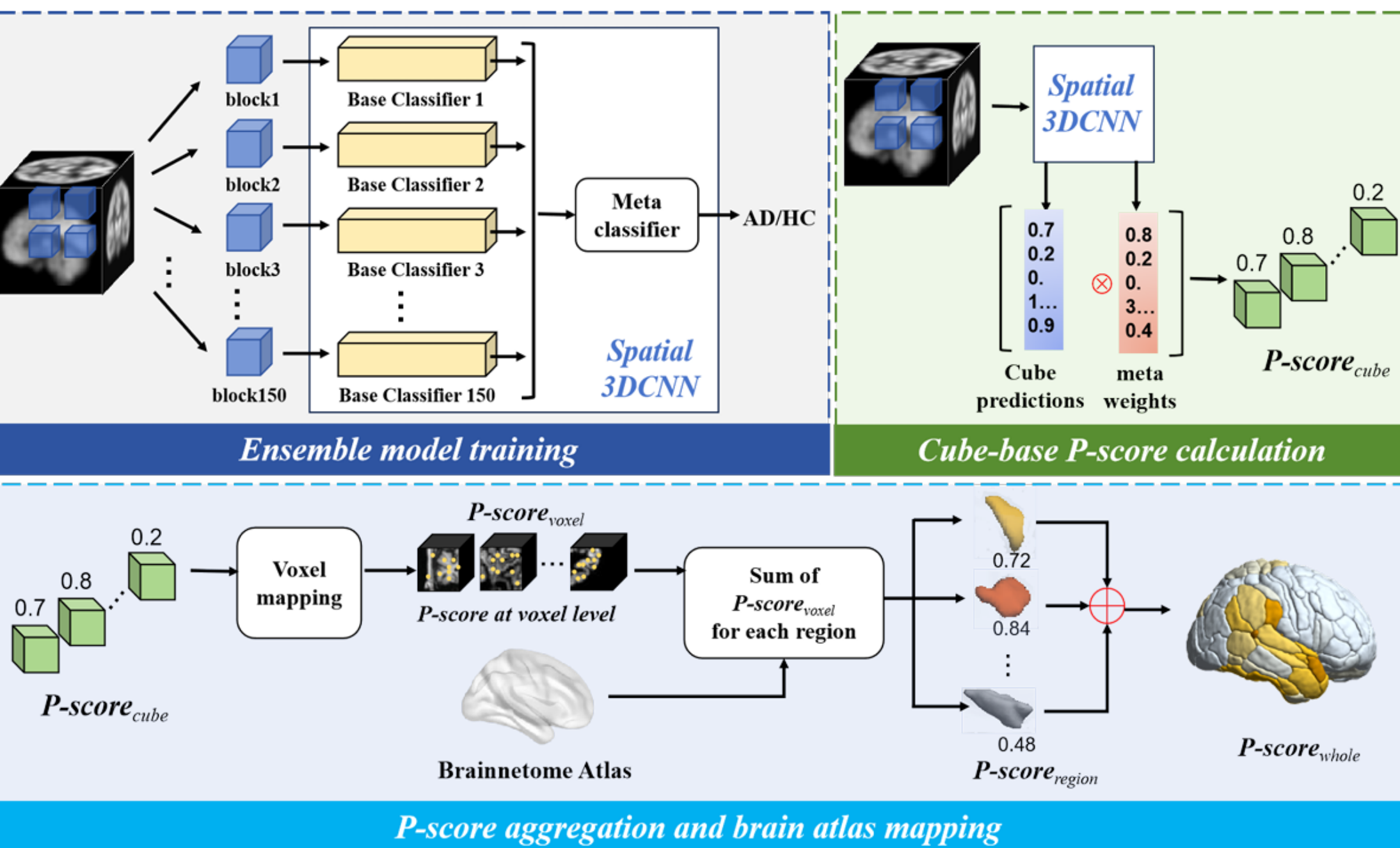


Figure 2. Generic framework for neuroimaging biomarker extraction from multimodal images.

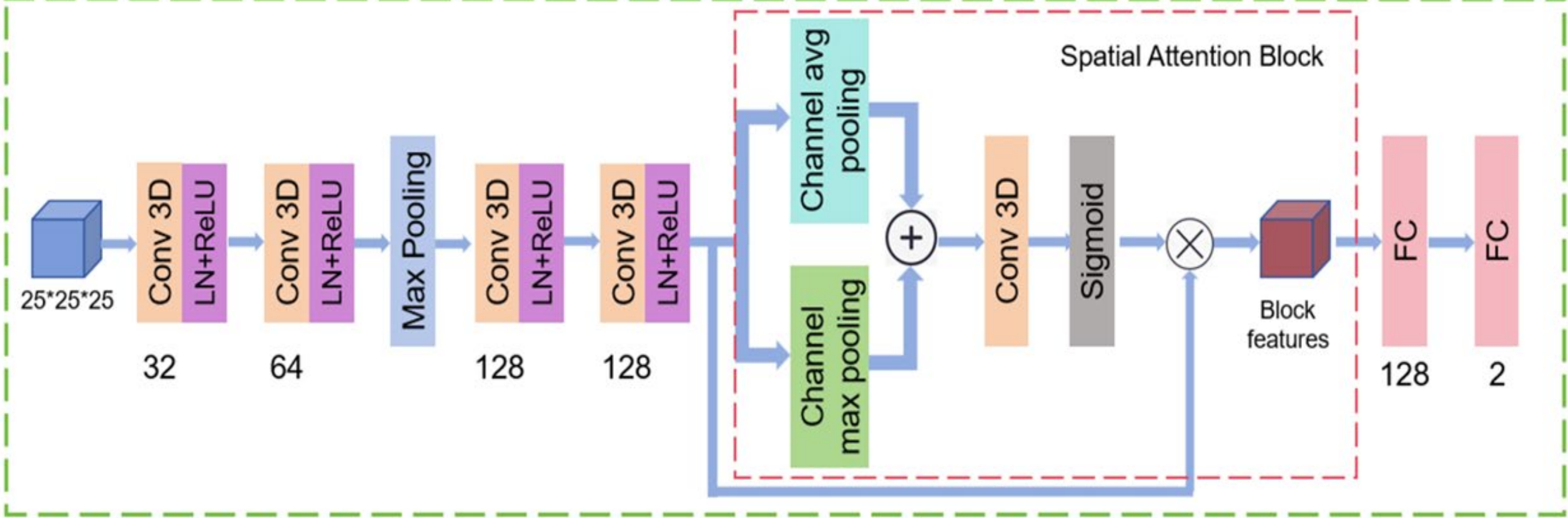


Figure 3. The architecture of the base model used in this paper.

Table 1. Demographic and health-related information of the subjects included in the studied datasets.

Modality	Dataset	Category	Number of subjects (Male/Female)	Age (years)	Weight (kg)	MMSE	CDR	GDS
PET	Training	AD	74 / 51	75.0 ± 8.4	74.5 ± 16.0	23.2 ± 2.3	0.82 ± 0.29	1.61 ± 1.42
		HC	50 / 61	74.1 ± 5.8	73.1 ± 14.1	29.1 ± 1.0	0.00 ± 0.00	0.71 ± 1.07
	Validation	AD	26 / 15	74.4 ± 8.0	75.3 ± 10.9	22.7 ± 2.1	0.83 ± 0.24	2.05 ± 1.50
		HC	43 / 44	74.8 ± 5.3	75.4 ± 20.8	29.1 ± 1.2	0.00 ± 0.00	0.93 ± 1.33
	Test	AD	21 / 11	75.4 ± 7.0	74.6 ± 18.1	22.8 ± 2.5	0.69 ± 0.25	1.88 ± 1.60
		HC	20 / 18	75.1 ± 6.8	73.3 ± 12.0	29.0 ± 1.3	0.00 ± 0.00	0.53 ± 0.73

RESULTS

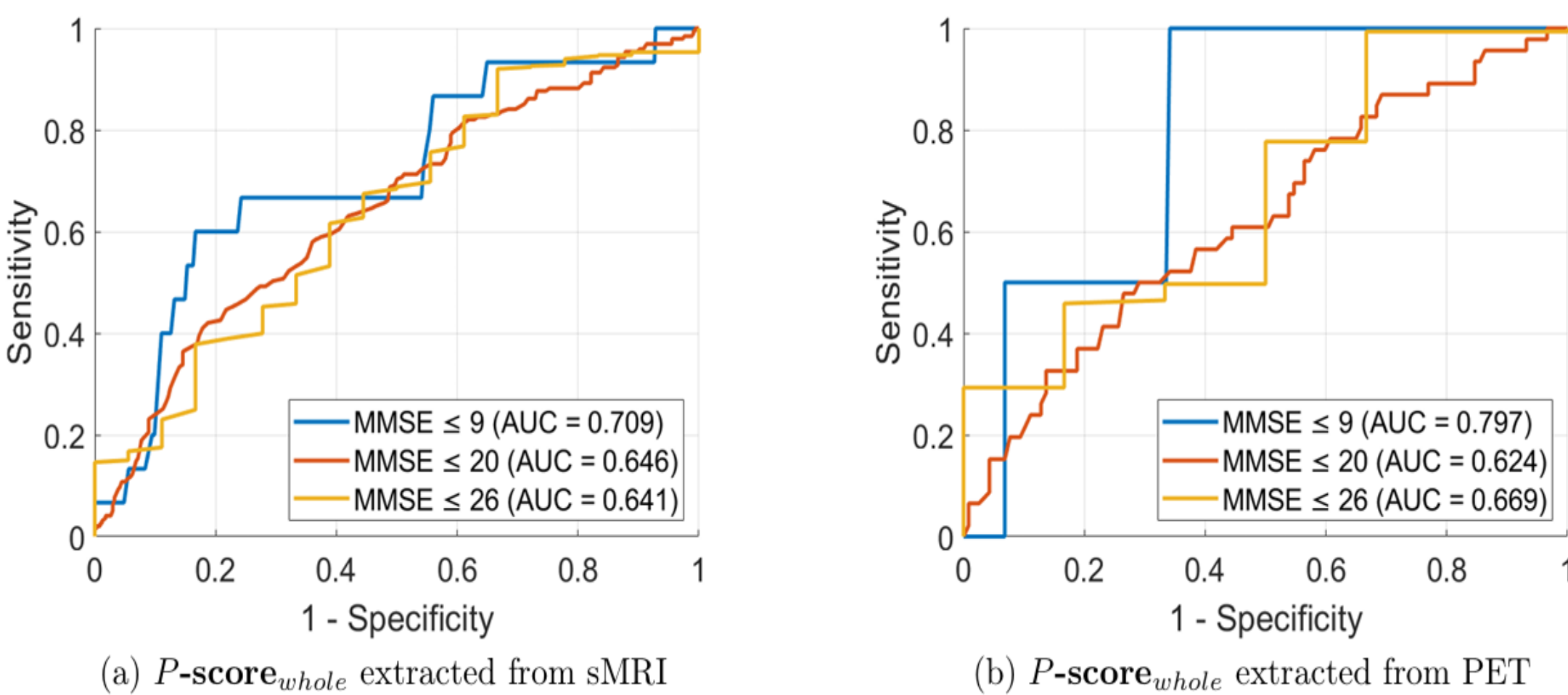


Figure 4. ROC curves in the three binary classification tasks on the recognition of different cognitive impairment levels indicated by MMSE using P-score (whole) extracted from sMRI and FDG-PET, respectively.

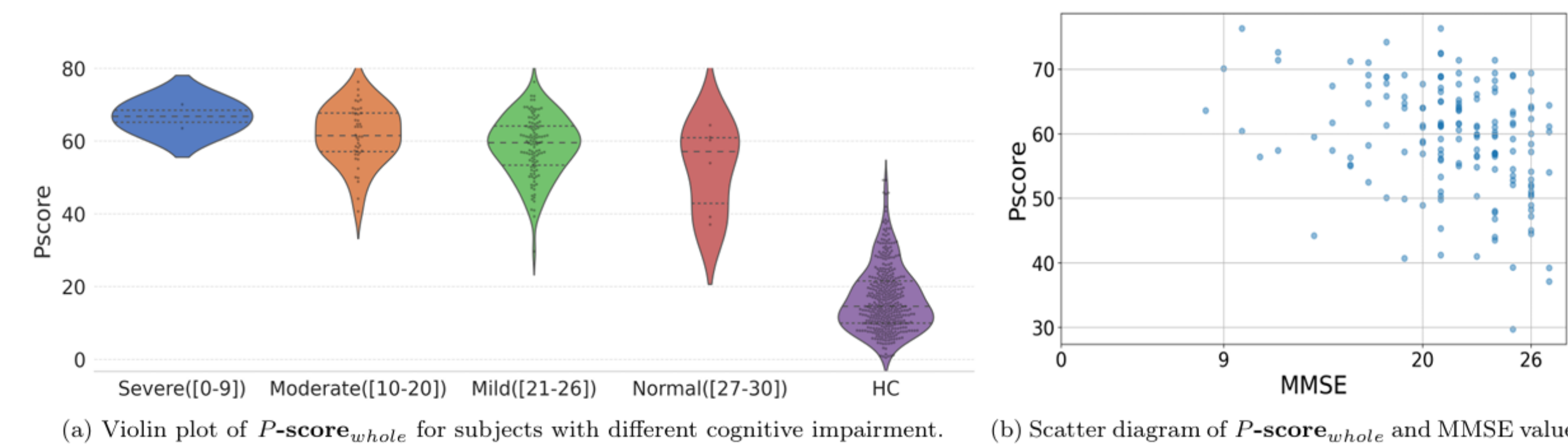


Figure 5. Correlation between whole-brain FDG-PET P-score and cognitive impairment.

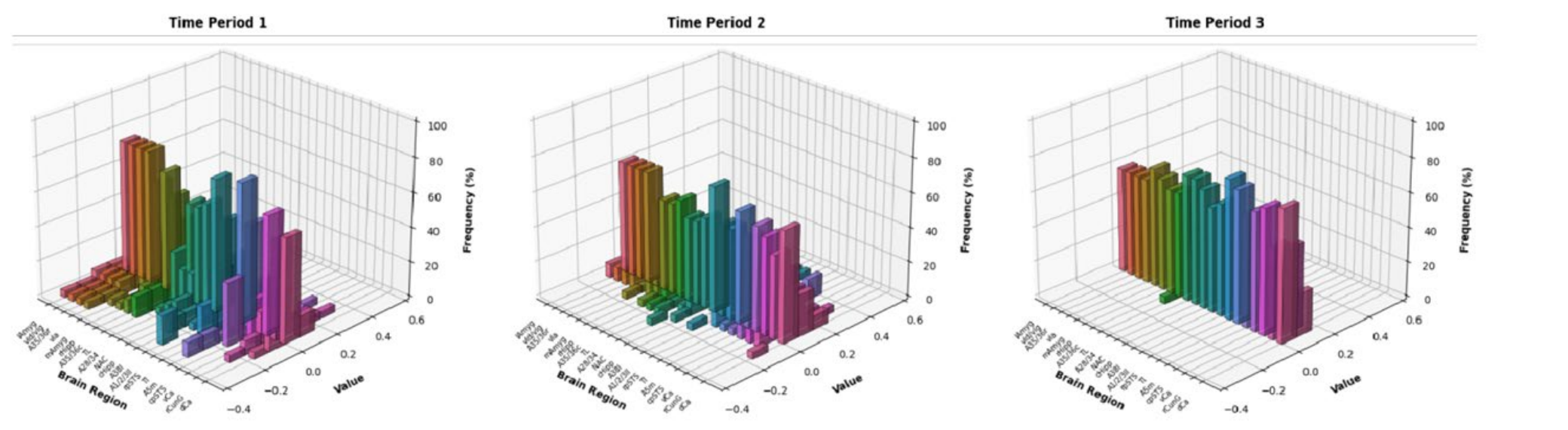


Figure 6. Voxel-level P-score distribution across the top 20 FDG-PET regions.

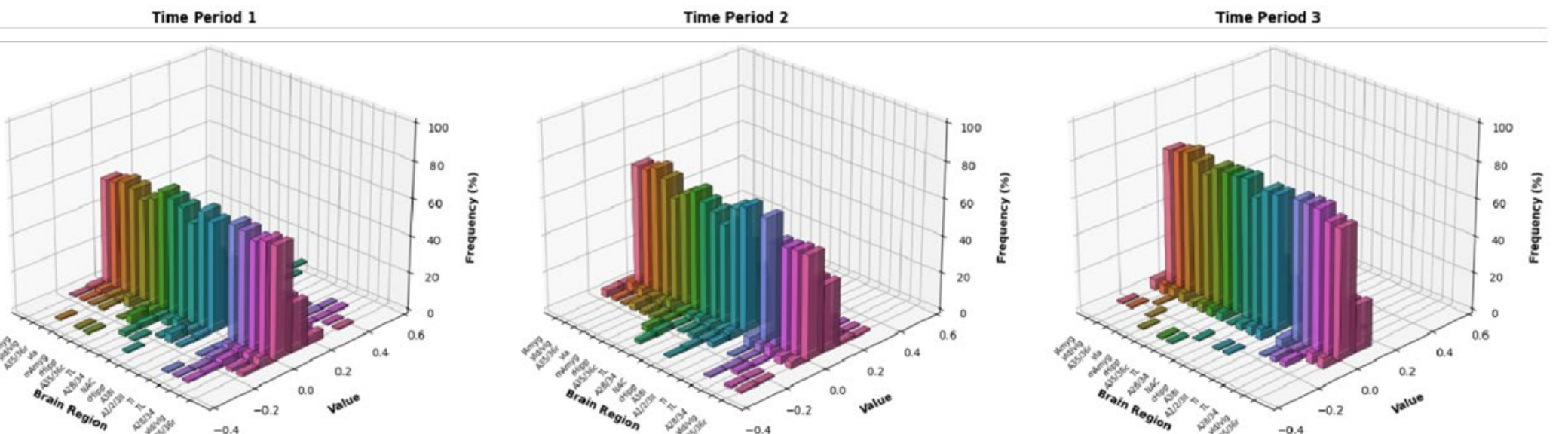


Figure 7. Voxel-level P-score distribution across the top 20 sMRI regions.

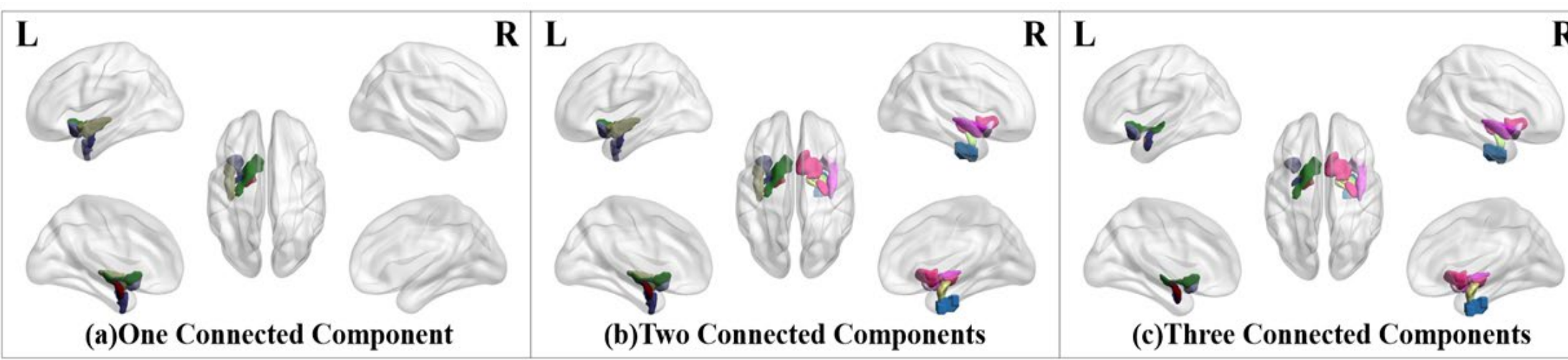


Figure 8. Spatially connected components detected in FDG-PET images of AD subjects.

CONCLUSIONS

- ✓ The study combines non-invasive sMRI & FDG-PET with interpretable DL to characterize consistent and complementary neurodegenerative patterns in AD.
- ✓ It offers new insights into the non-invasive tracking of AD progression using whole-brain multimodal imaging.
- ✓ FDG-PET metabolic P-scores complement sMRI structural P-scores in quantifying AD neurodegenerative changes.

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