

Introduction:

- The behavioral variant of frontotemporal dementia (bvFTD) is an early-onset dementia subtype associated with behavioral changes caused by neurodegeneration in the frontal temporal lobes¹.
- bvFTD classification remains challenging due to limited feature representation, underuse of 3D MRI information, and class imbalance².
- Multi-view frameworks combining Convolutional Neural Network (CNN) and Multi-layer Perceptron (MLP) models was developed for classifying bvFTD, Alzheimer Disease (AD), and Healthy Control (HC).
- Data augmentation and late fusion strategies were applied to address class imbalance and improve classification robustness.

Discussion & Conclusion:

- Multi-view fusion provides a more comprehensive characterization of bvFTD pathology and consistently improves diagnostic performance compared to single-modality approaches.
- Data augmentation improves classification of the minority bvFTD class but must be applied carefully, as it may reduce performance in closely related diagnostic categories.
- Ensemble fusion strategy is more stable across tasks, while fully connected fusion better improves sensitivity to bvFTD.
- Combining heterogeneous feature types enables more reliable modeling of neurodegenerative patterns in MRI data.

Materials & Methods:

- Whole-brain MRI data from 5,928 participants were collected from 10 datasets (3,415 HC, 2,276 AD, 237 bvFTD).
- bvFTD represented only ~4% of the dataset. Data augmentation was applied to 60% of bvFTD samples using elastic deformation, gamma transformation, and bias field distortion.
- A 3D DenseNet was developed for T1-weighted MRI classification to capture whole-brain spatial patterns and improve feature learning efficiency and enhance parameter efficiency³.
- MRI scans were processed using FastSurfer⁴ for automated cortical and subcortical segmentation.

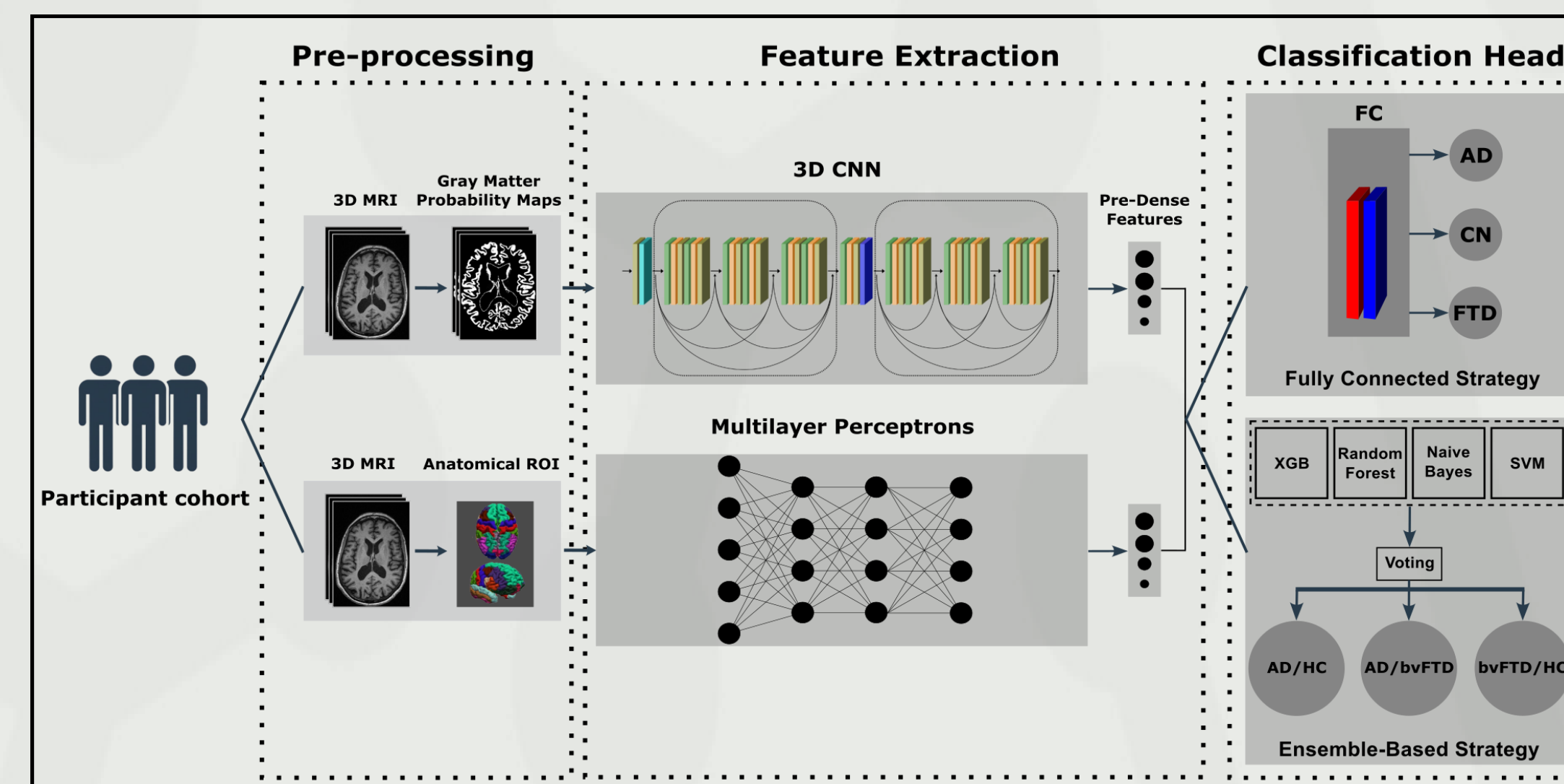


Figure 1. Overview of the proposed multimodal fusion frameworks for dementia classification.

- Fully Connected Fusion Strategy:** Combined features were processed through a fully connected neural network for three-class classification.
- Ensemble-Based Fusion Strategy:** A weighted soft-voting ensemble model that integrates multiple classifiers to leverage their complementary strengths.
- Twelve CNN models with varying hyperparameter configurations were trained using stratified data splits (70% training, 15% validation, 15% testing) to ensure balanced and consistent evaluation across experiments.

Results:

Fully Connected Fusion Strategy:

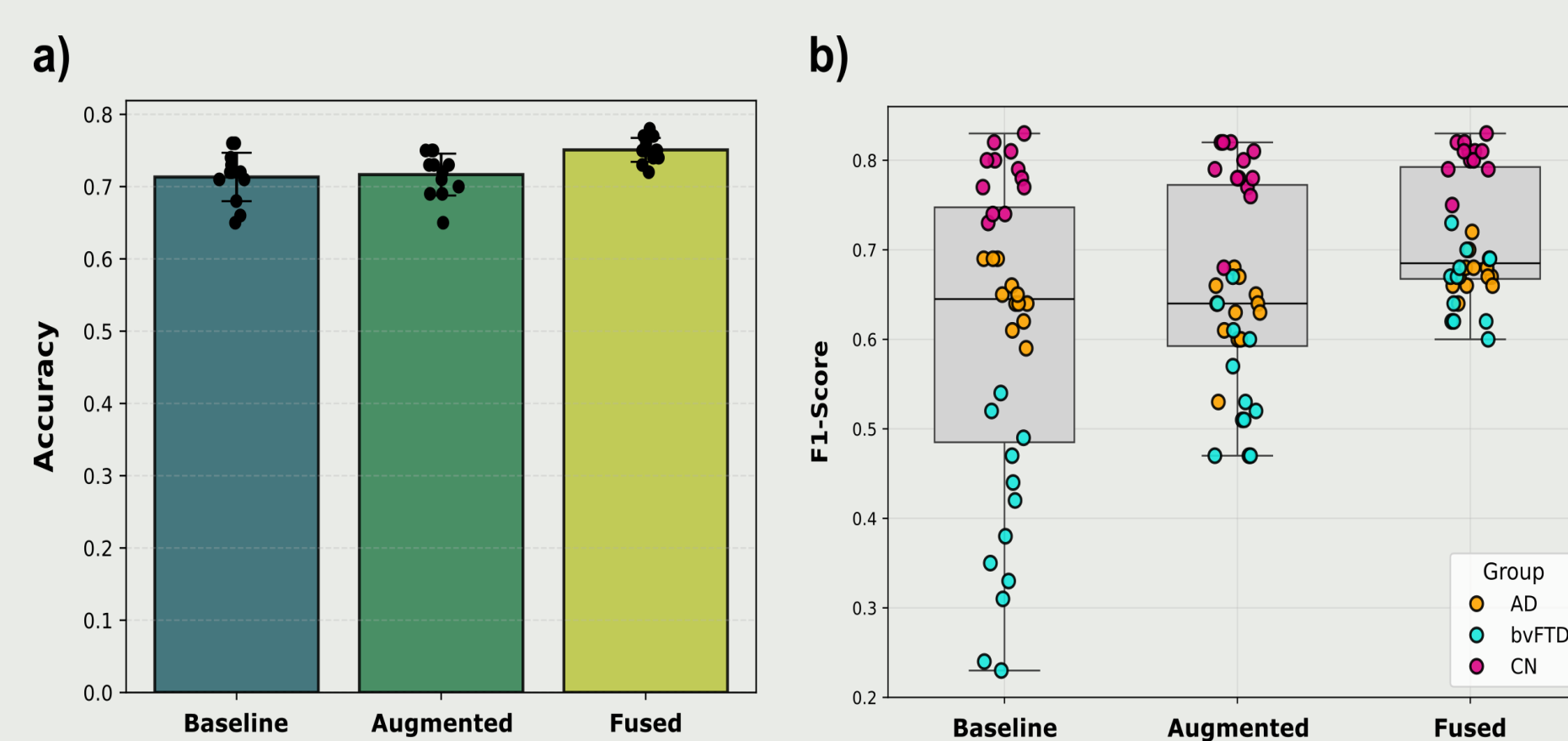


Figure 2. Comparison of model performance across FC settings: Baseline, Augmented, and Fused.

Ensemble-Based Fusion Strategy:

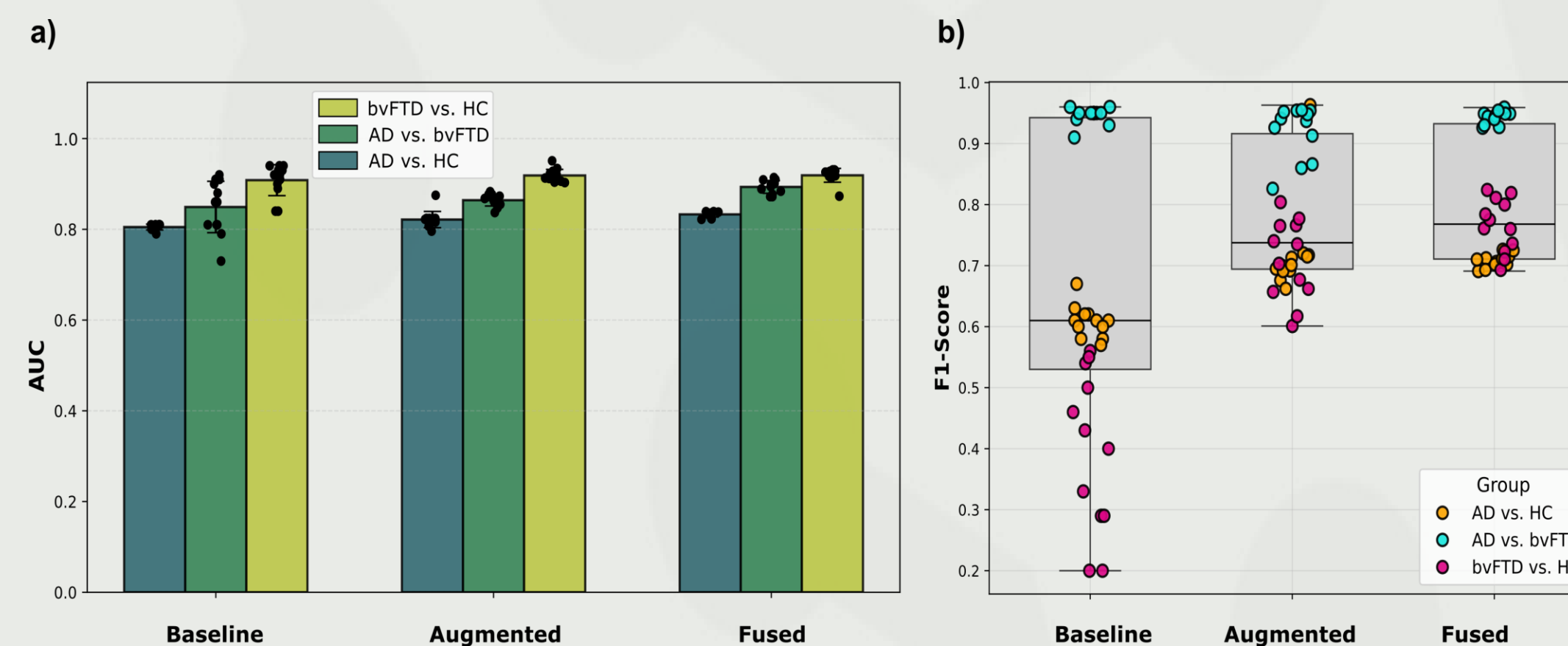


Figure 3. Comparison of model performance across EB settings: Baseline, Augmented, and Fused.

- LRP-based relevance maps revealed distinct disease-specific spatial patterns.
- Across all groups, the relevance maps demonstrated that the model relies on anatomically meaningful brain regions for disease classification.

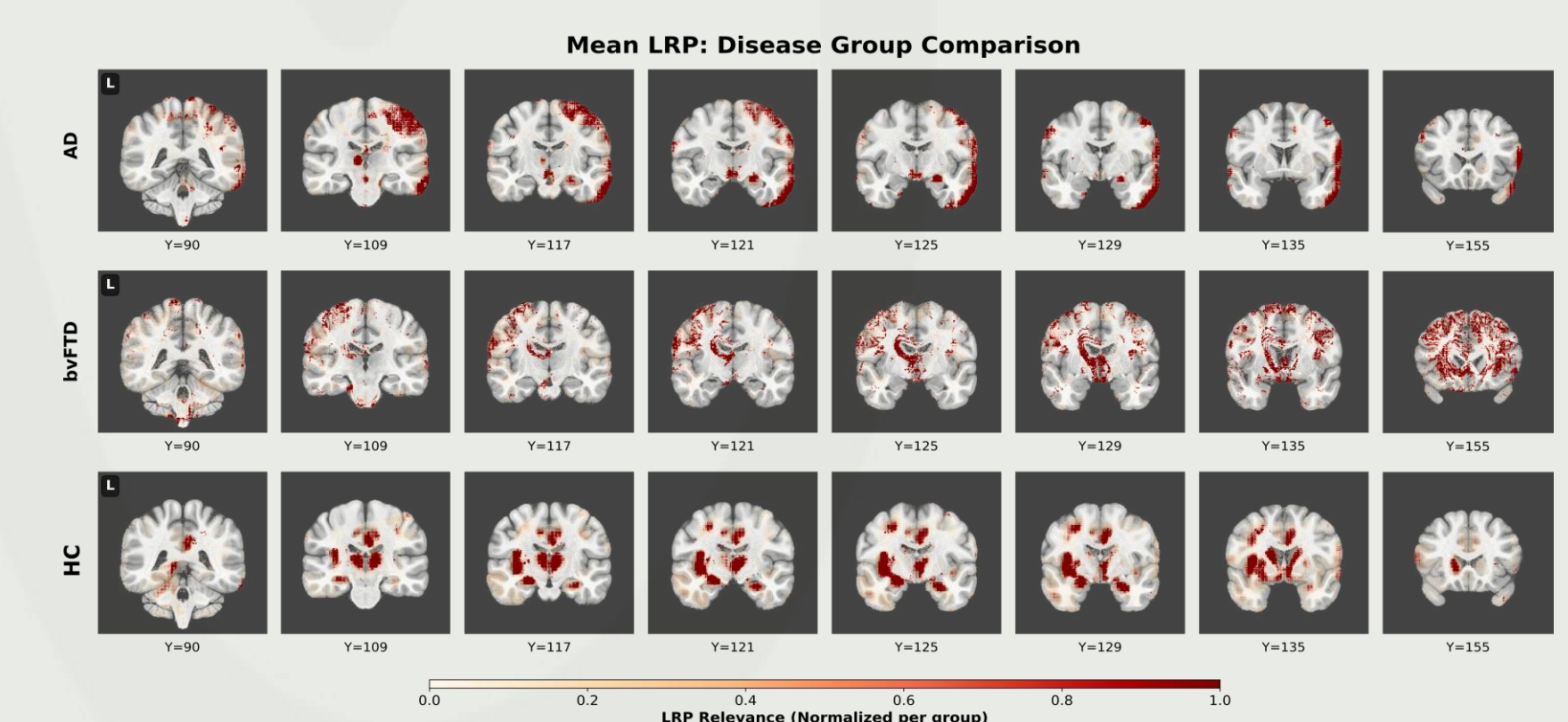
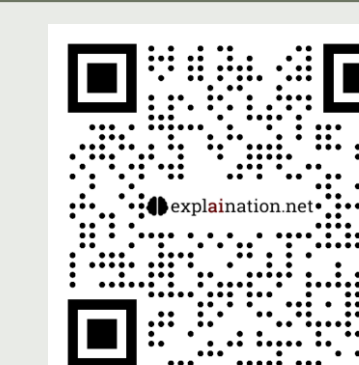


Figure 4. Group-averaged LRP heatmaps across brain slice

References:

- [1] A. Antonioni, et al., Frontotemporal dementia, where do we stand? a narrative review, Int. J. Mol. Sci., 2023.
- [2] S. Ducharme, et al., Recommendations to distinguish behavioural variant frontotemporal dementia from psychiatric disorders, Brain. 2020.
- [3] D. Singh, et al., A computational ontology framework for the synthesis of multi-level pathology reports from brain MRI scans, J Alzheimers Dis. 2025.
- [4] L. Henschel, et al., FastSurfer - A fast and accurate deep learning based neuroimaging pipeline, NeuroImage. 2020.



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