

Detecting individual-level deviations in brain morphology among MCI patients with explainable AI

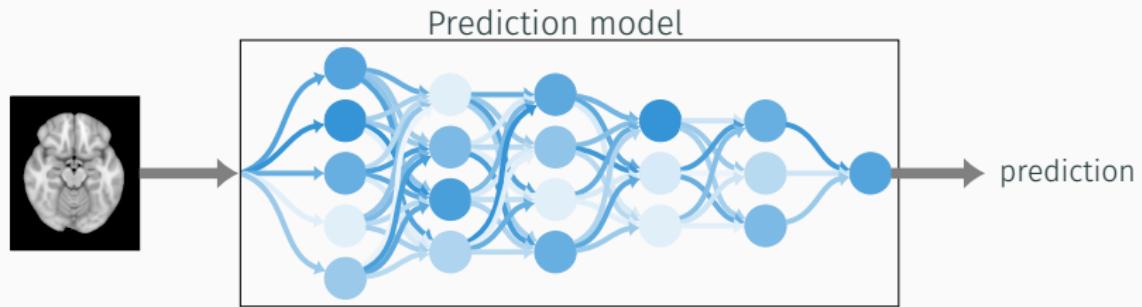
Esten Høyland Leonardsen

20.10.22

UiO:Life Science, University of Oslo

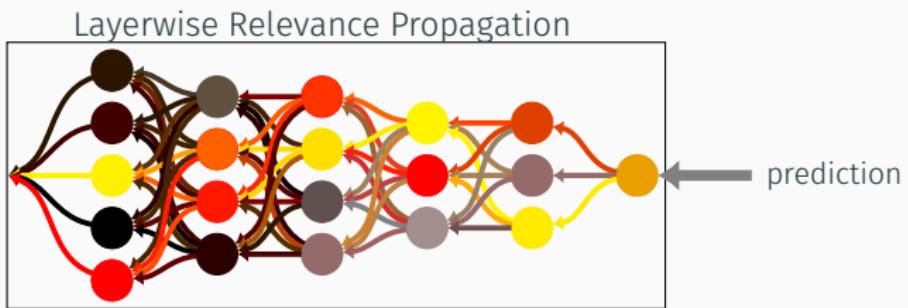


Layerwise Relevance Propagation



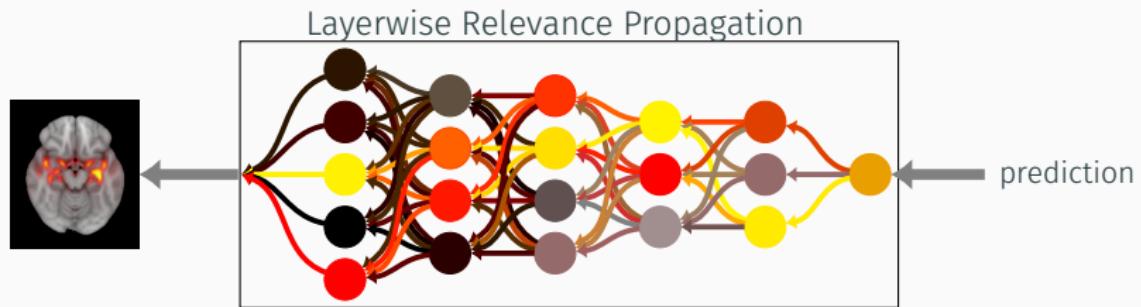
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j}$$

Layerwise Relevance Propagation



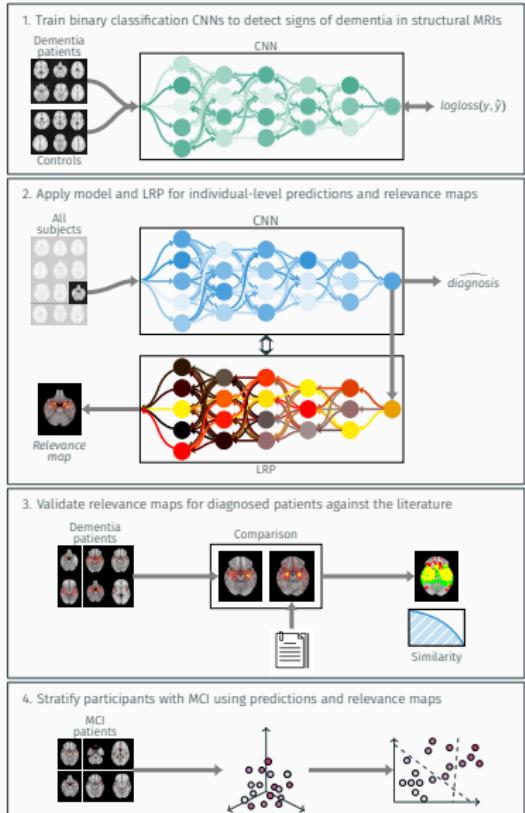
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

Layerwise Relevance Propagation



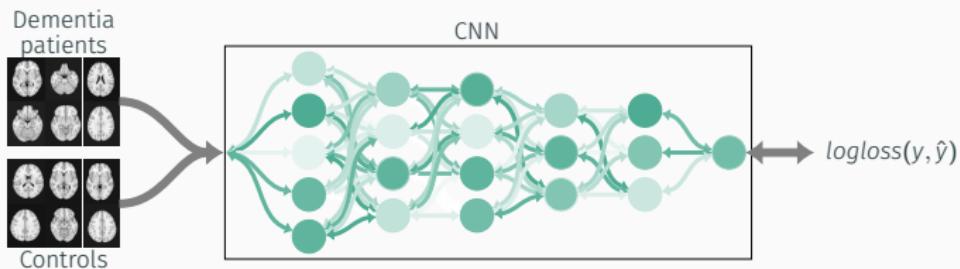
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

Overview

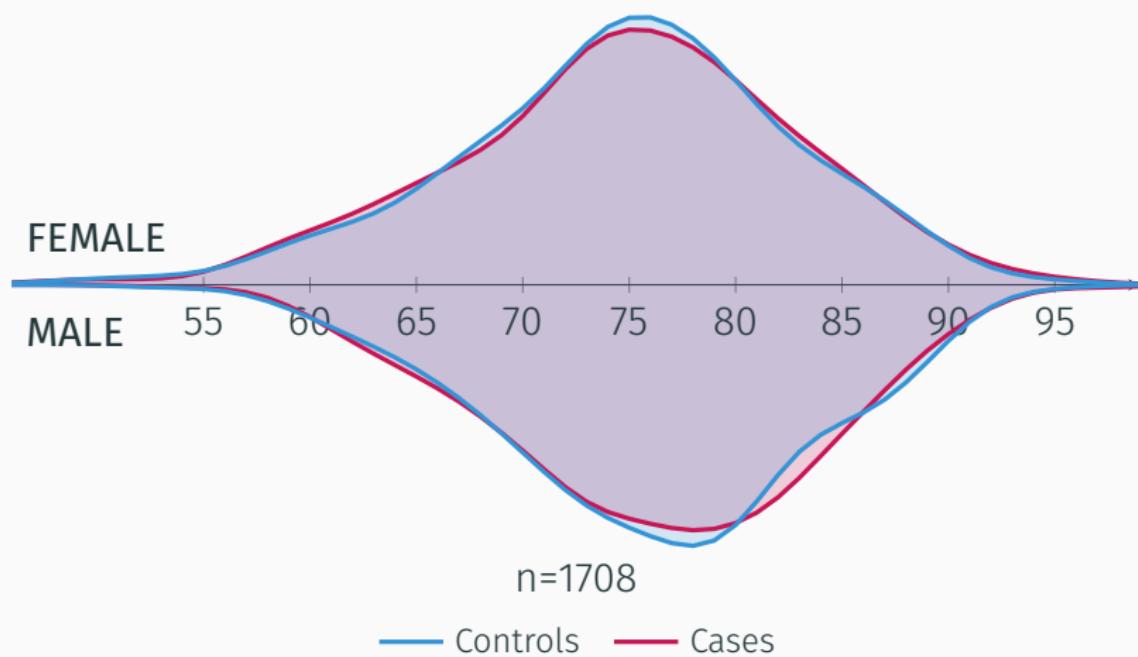


Case-control predictions

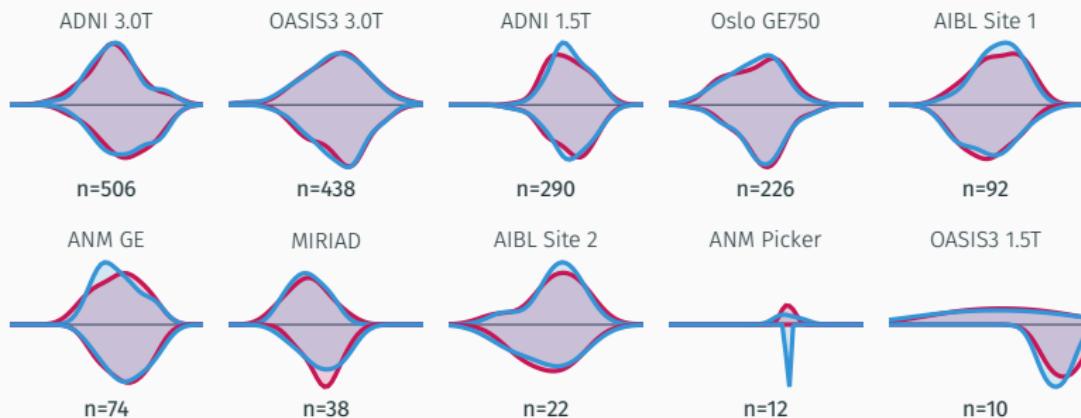
1. Train binary classification CNNs to detect signs of dementia in structural MRIs



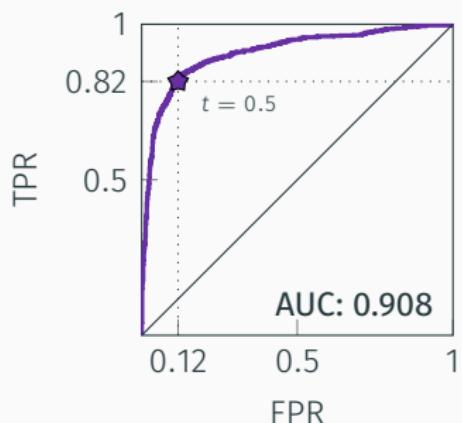
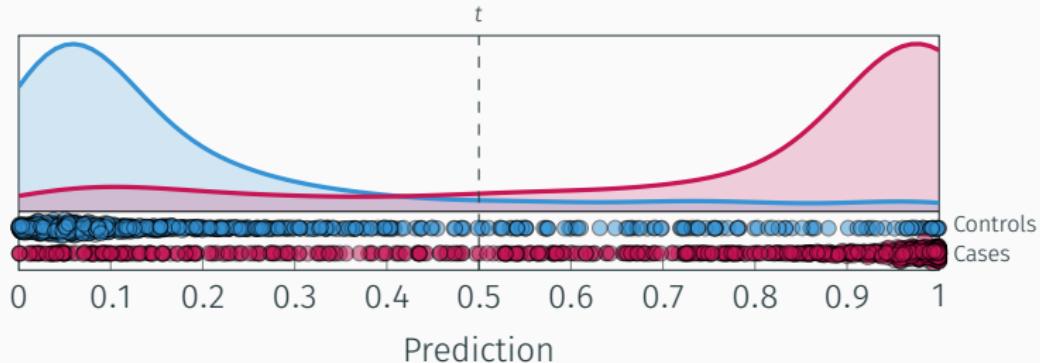
Case-control predictions



Case-control predictions



Case-control predictions

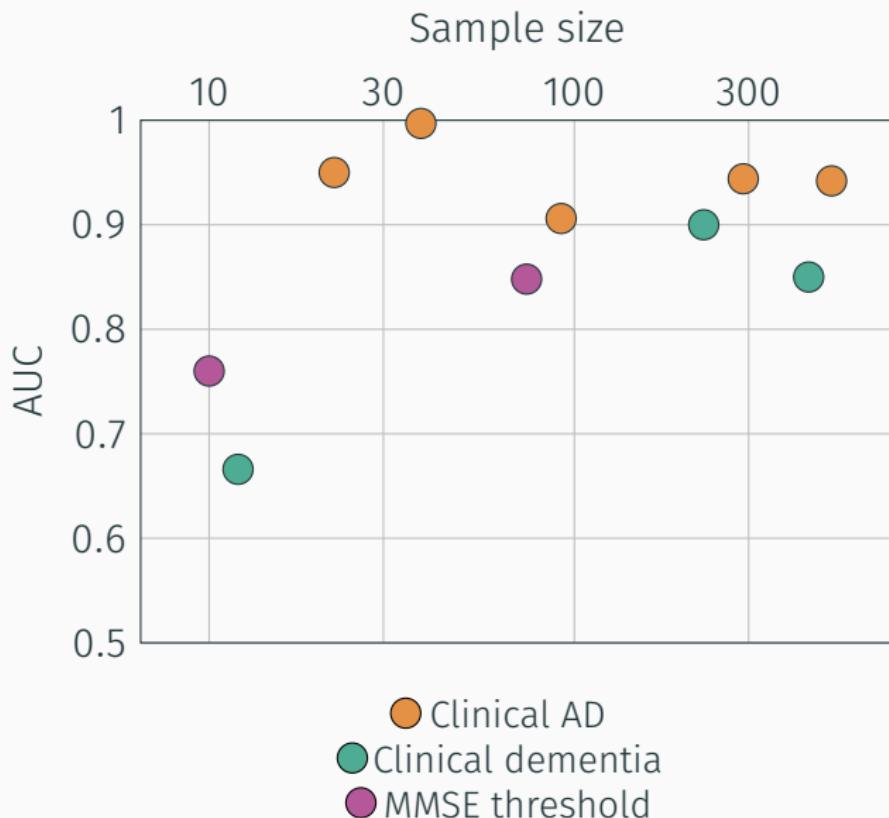


Predicted

Observed	0	1
0	754	100
1	157	697

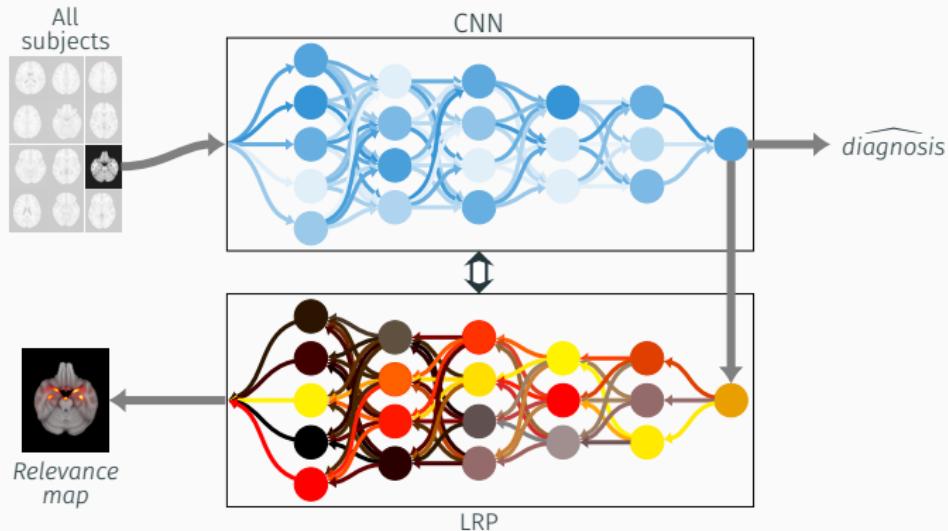
Accuracy: 84.95%

Case-control predictions

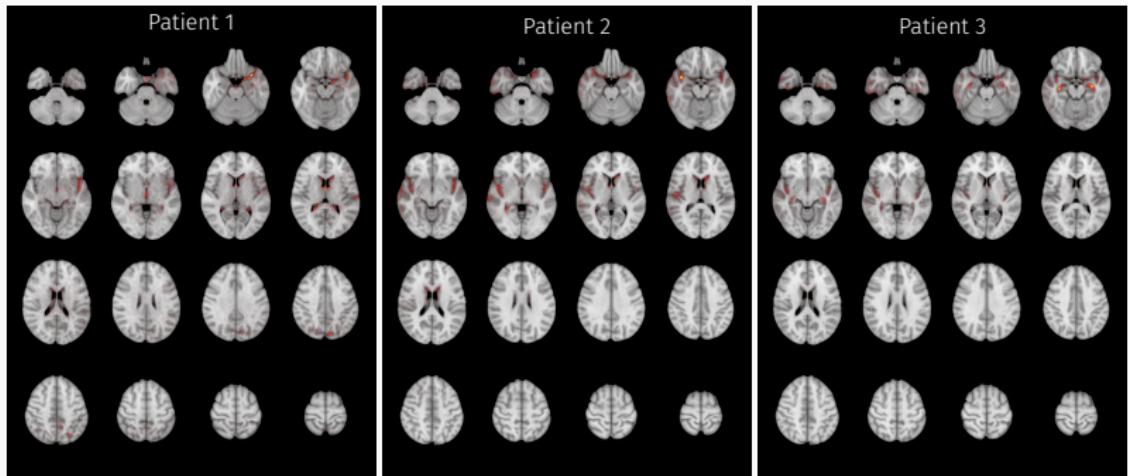


Generating relevance maps

2. Apply model and LRP for individual-level predictions and relevance maps

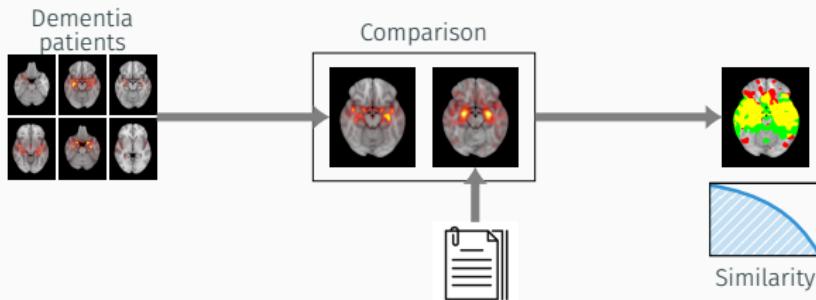


Generating relevance maps



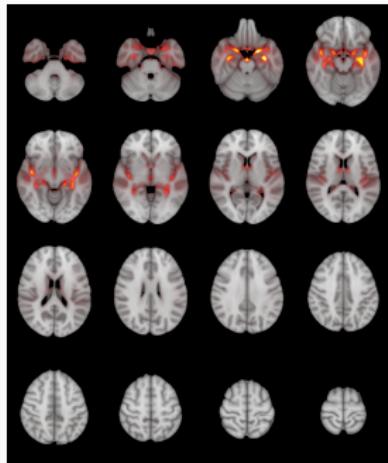
Validating relevance maps in dementia patients

3. Validate relevance maps for diagnosed patients against the literature



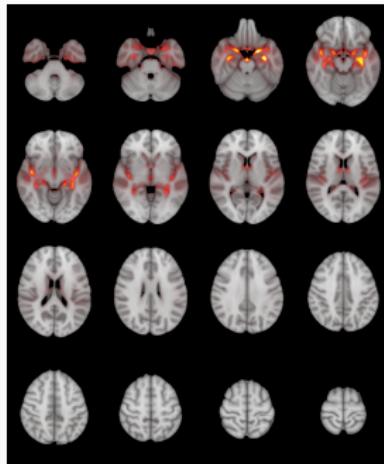
Validating relevance maps in dementia patients

Average dementia patient

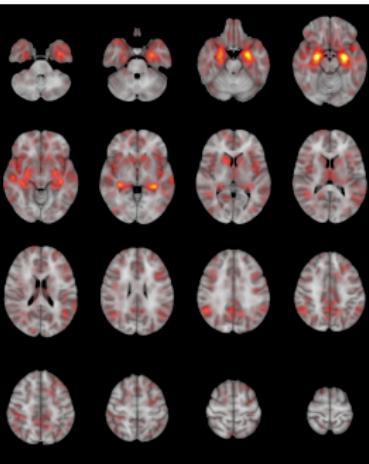


Validating relevance maps in dementia patients

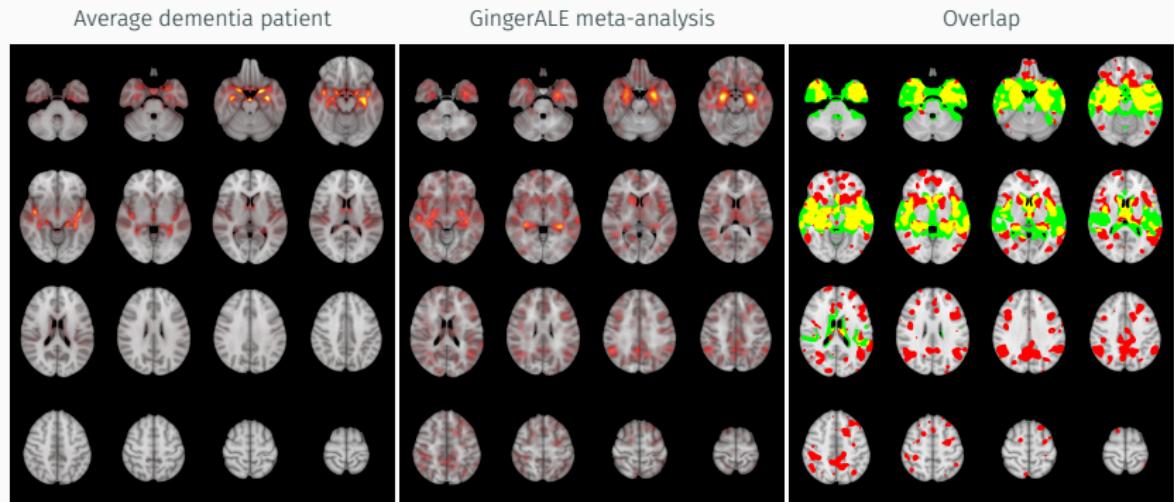
Average dementia patient



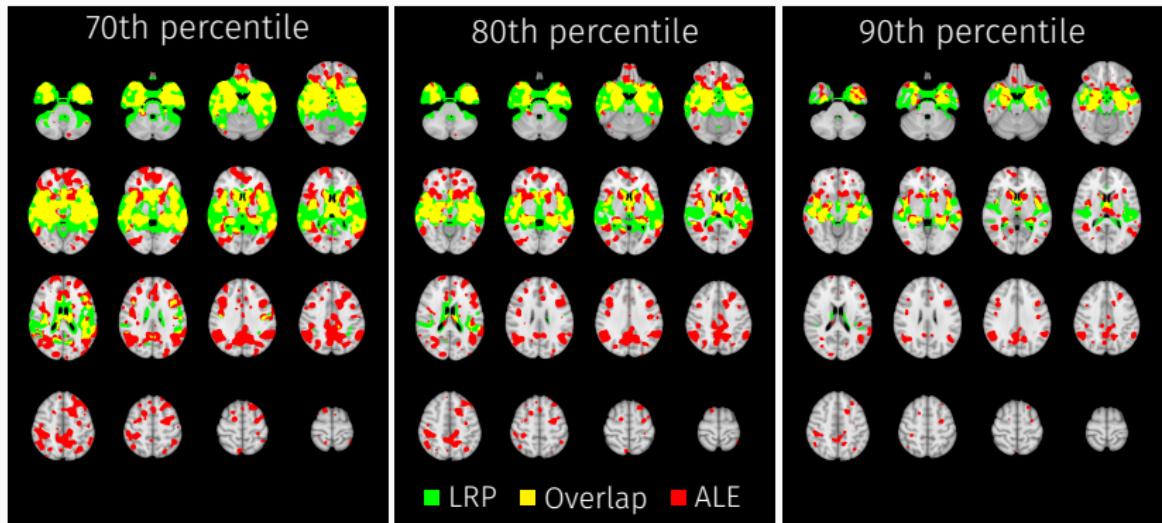
GingerALE meta-analysis



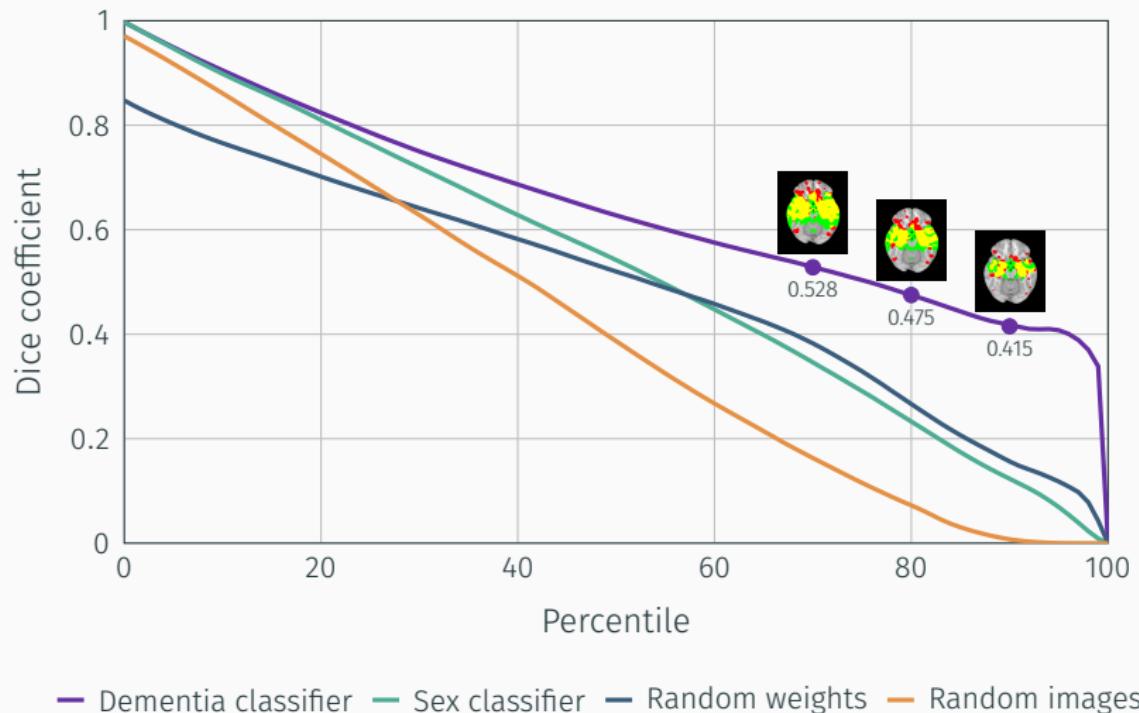
Validating relevance maps in dementia patients



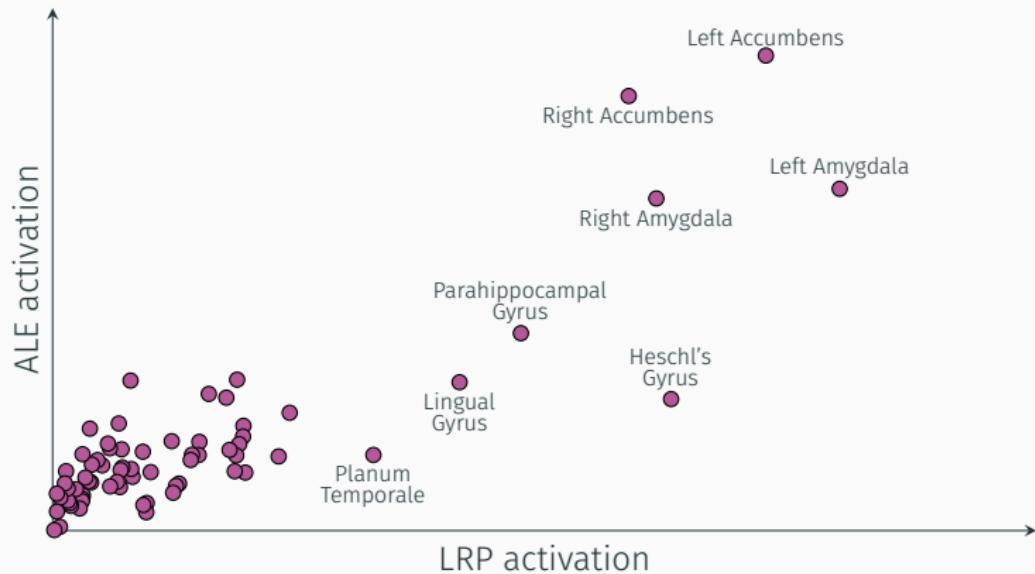
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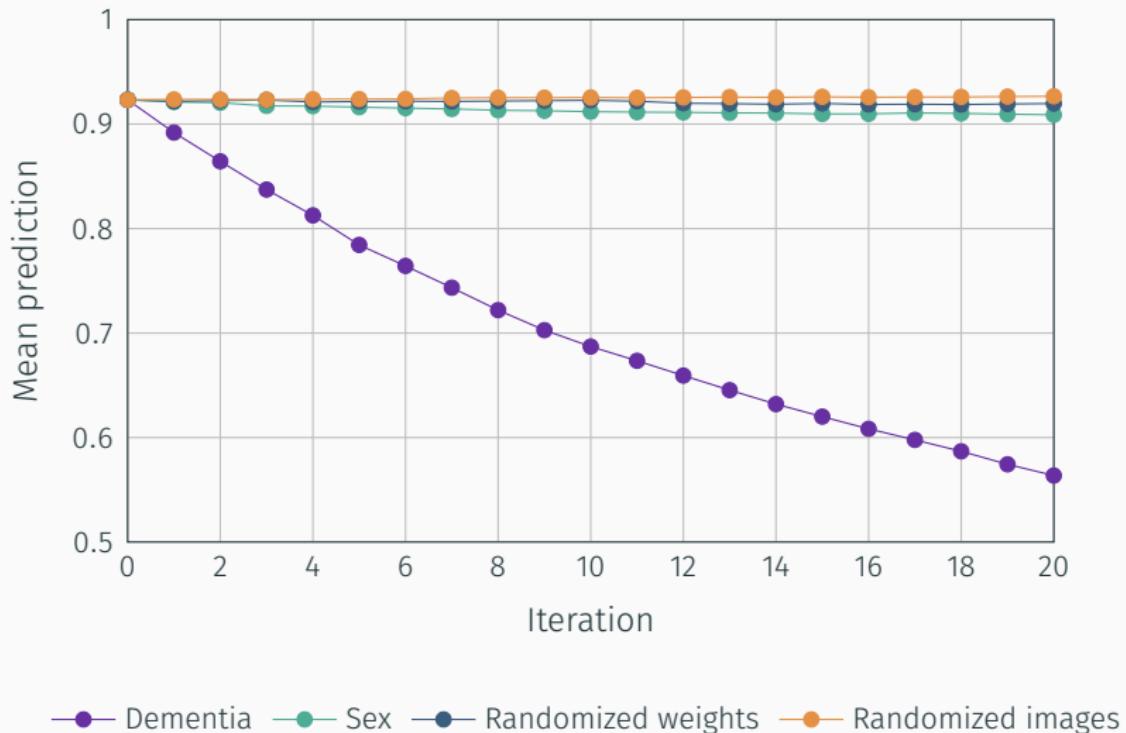
Validating relevance maps in dementia patients



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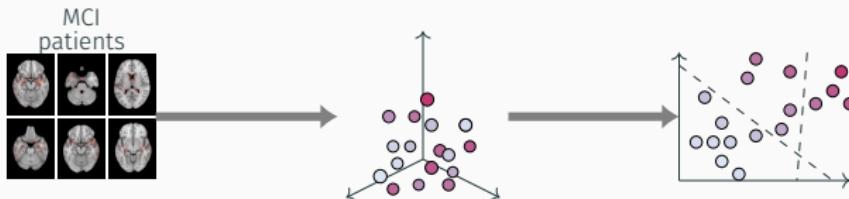


Validating relevance maps in dementia patients

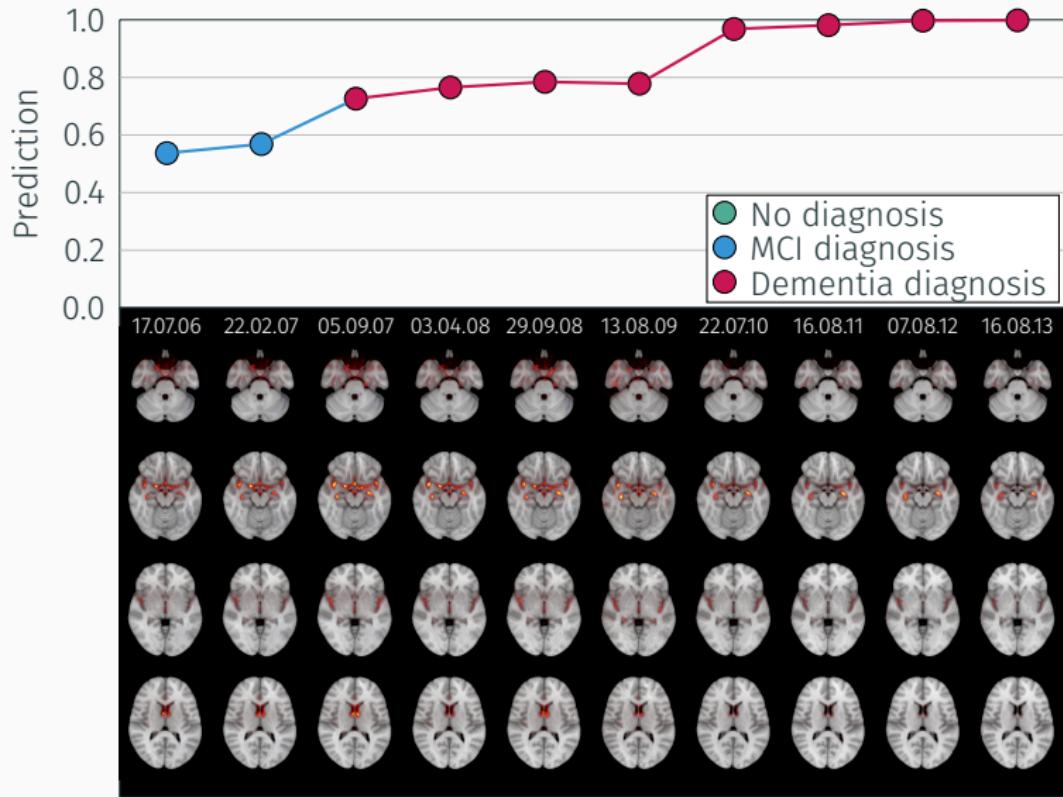


Exploring relevance maps in MCI patients

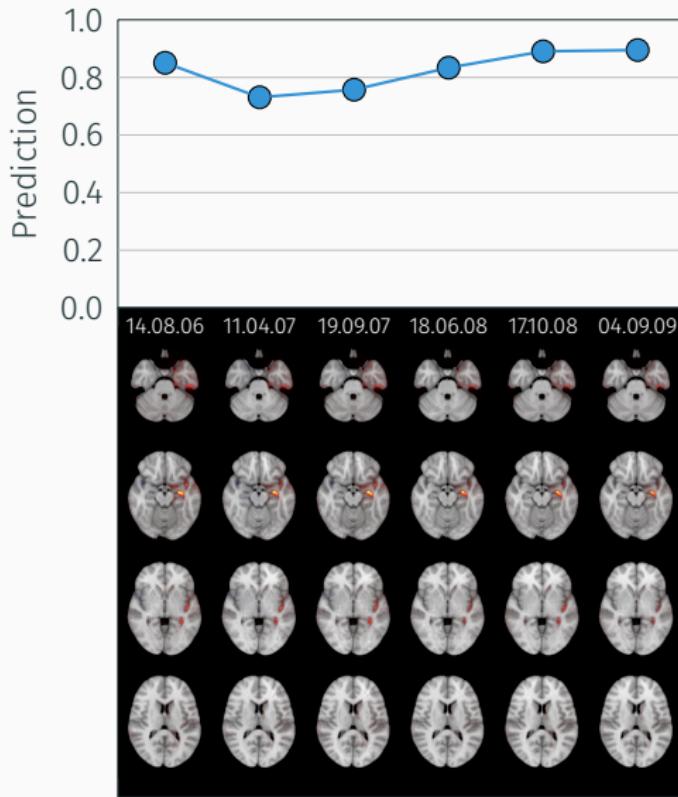
4. Stratify participants with MCI using predictions and relevance maps



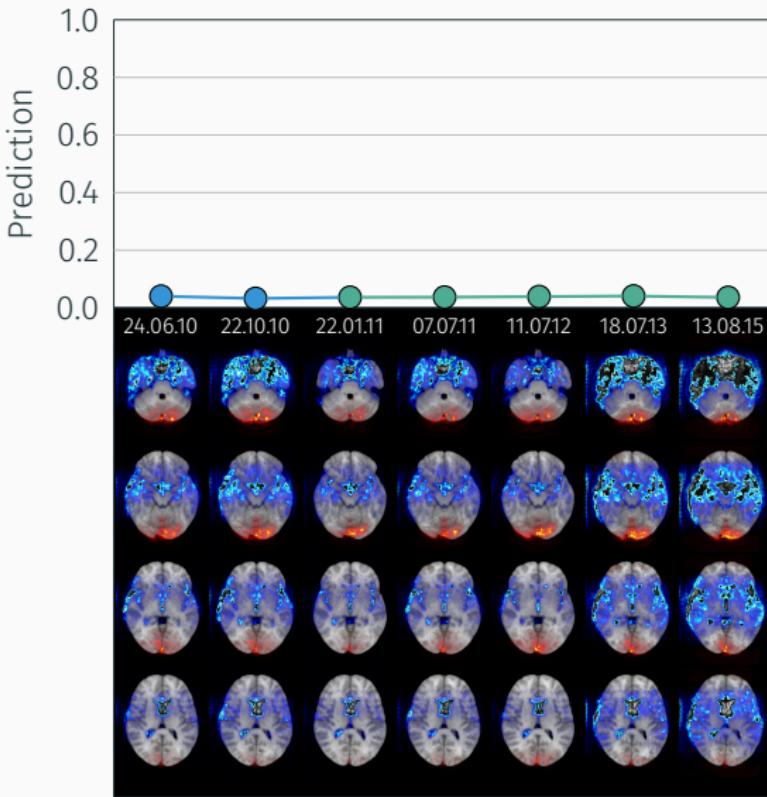
Exploring relevance maps in MCI patients



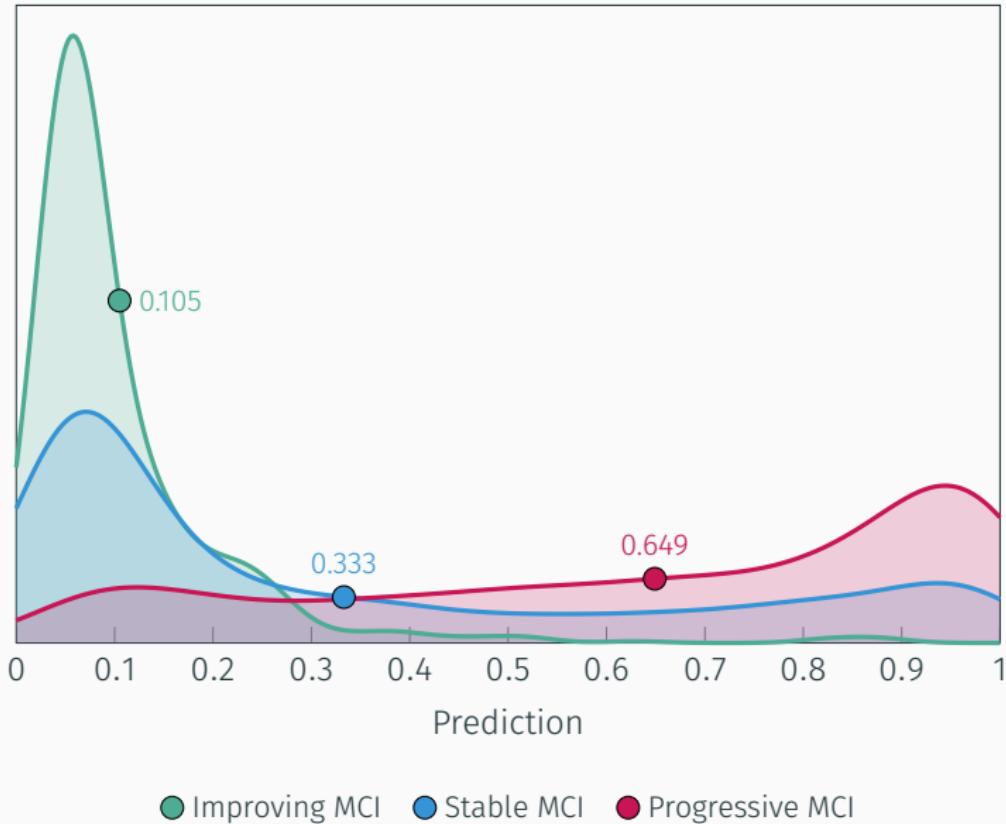
Exploring relevance maps in MCI patients



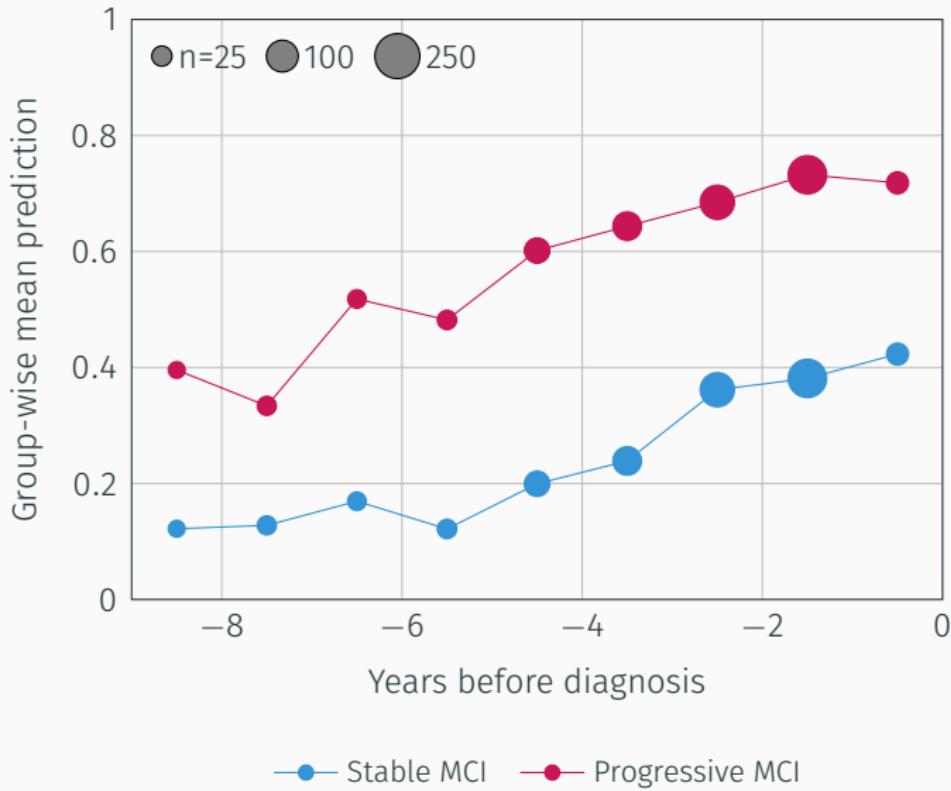
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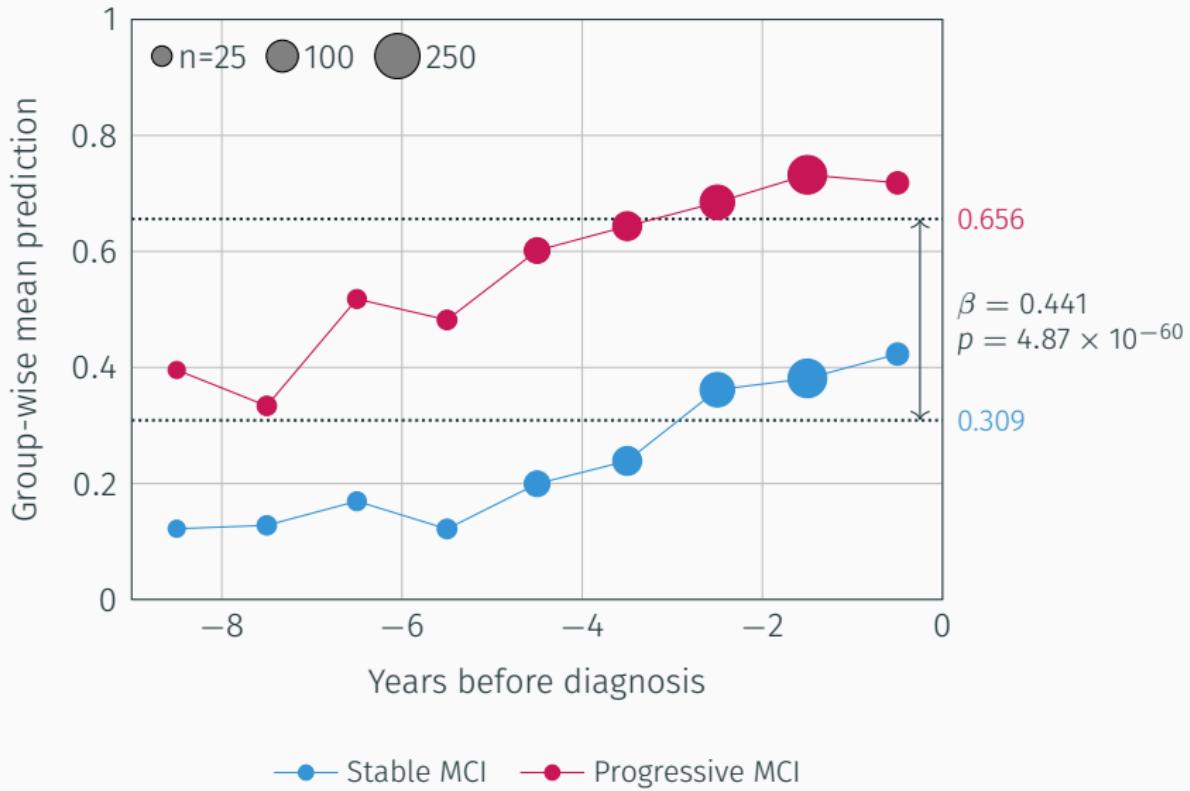
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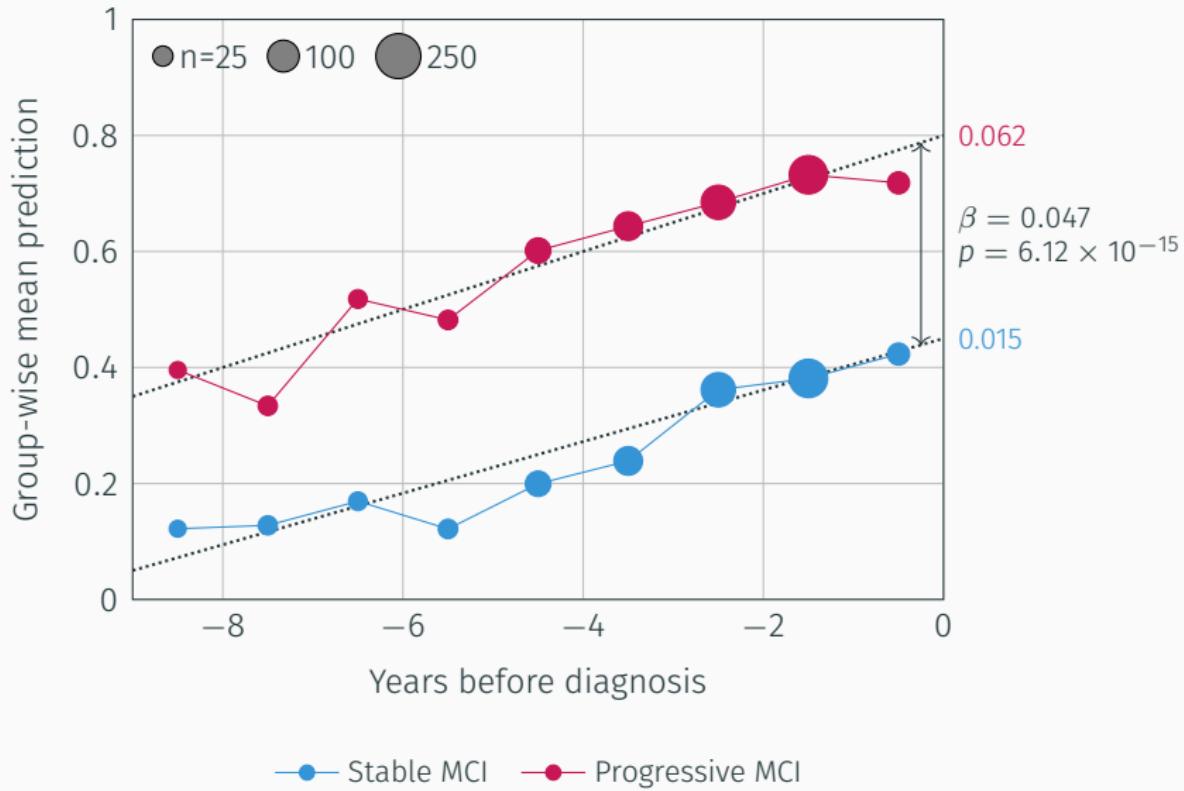
Exploring relevance maps in MCI patients



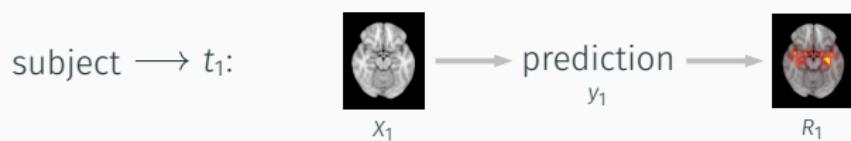
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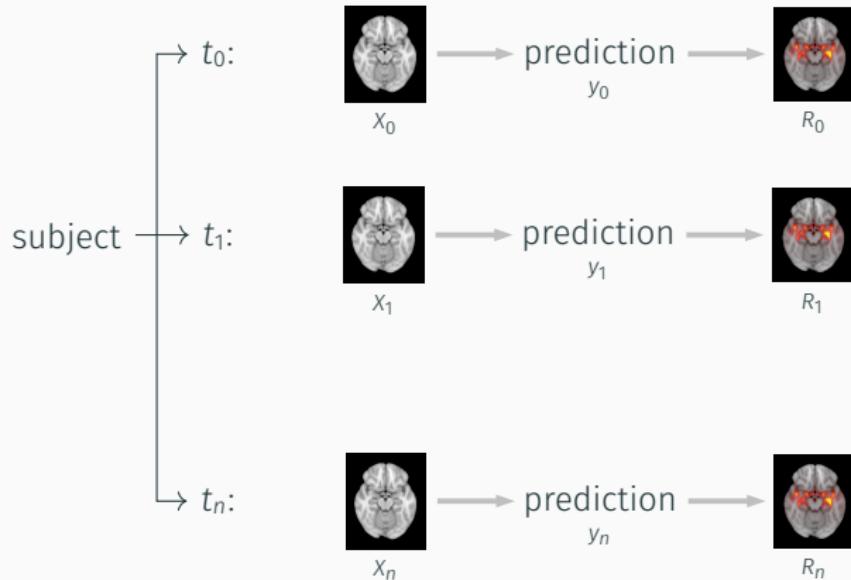
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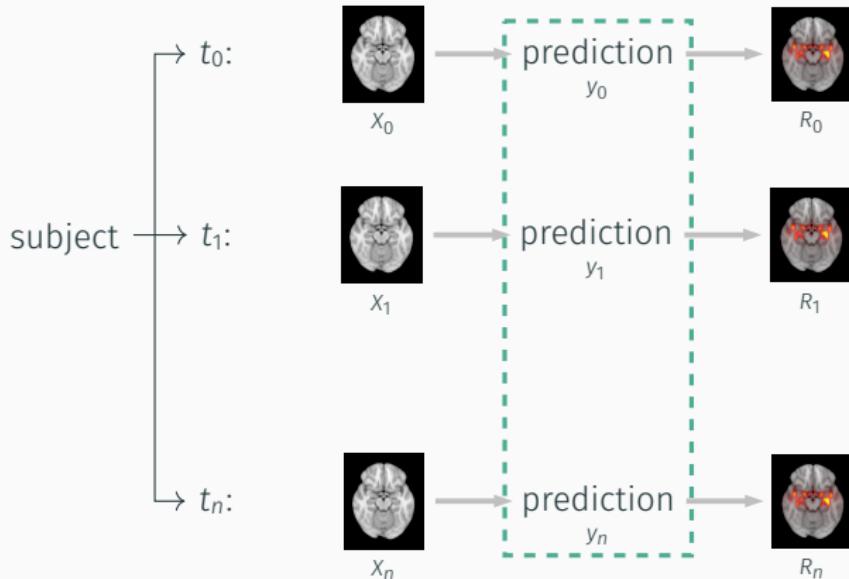
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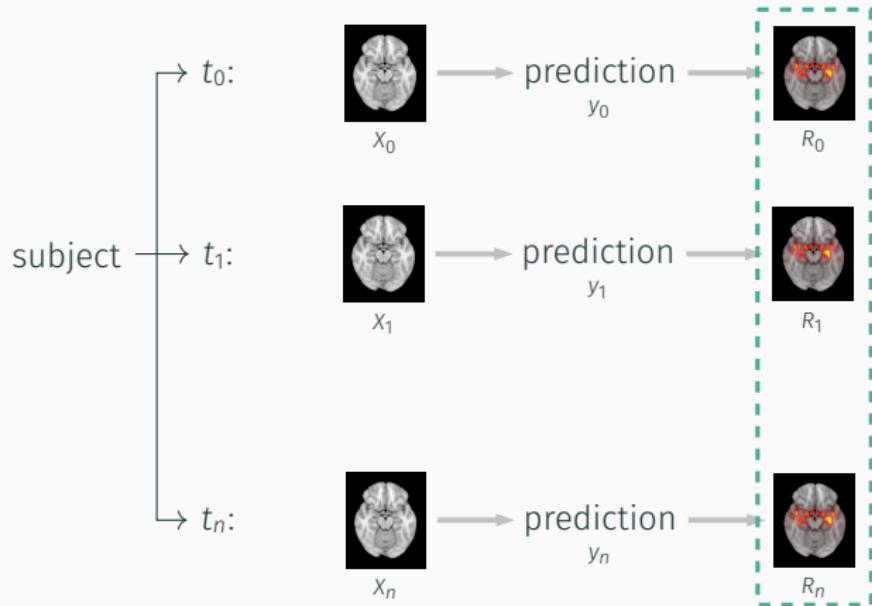
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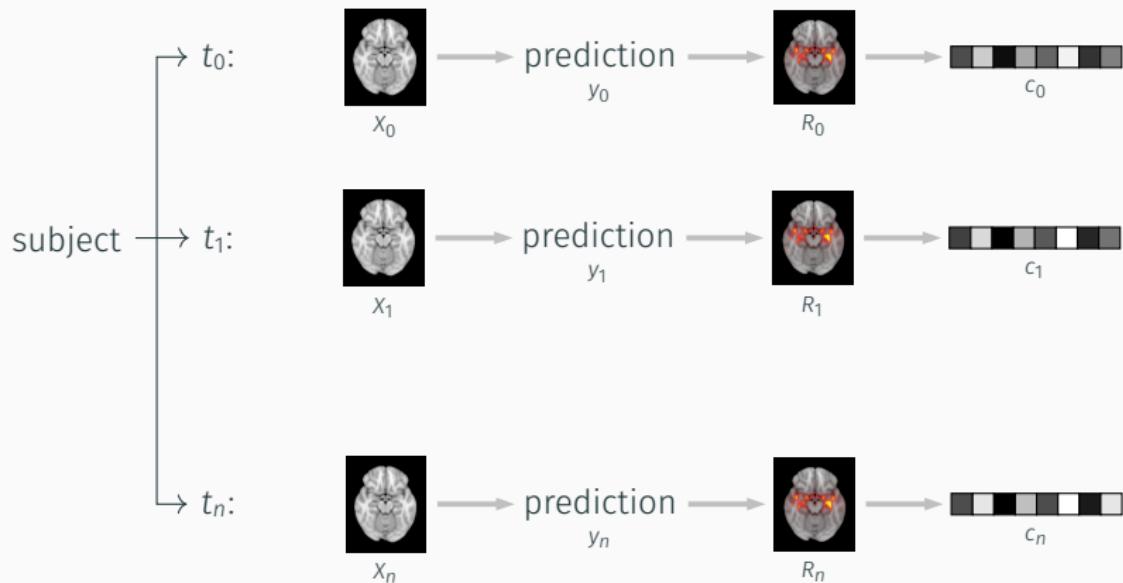
Exploring relevance maps in MCI patients



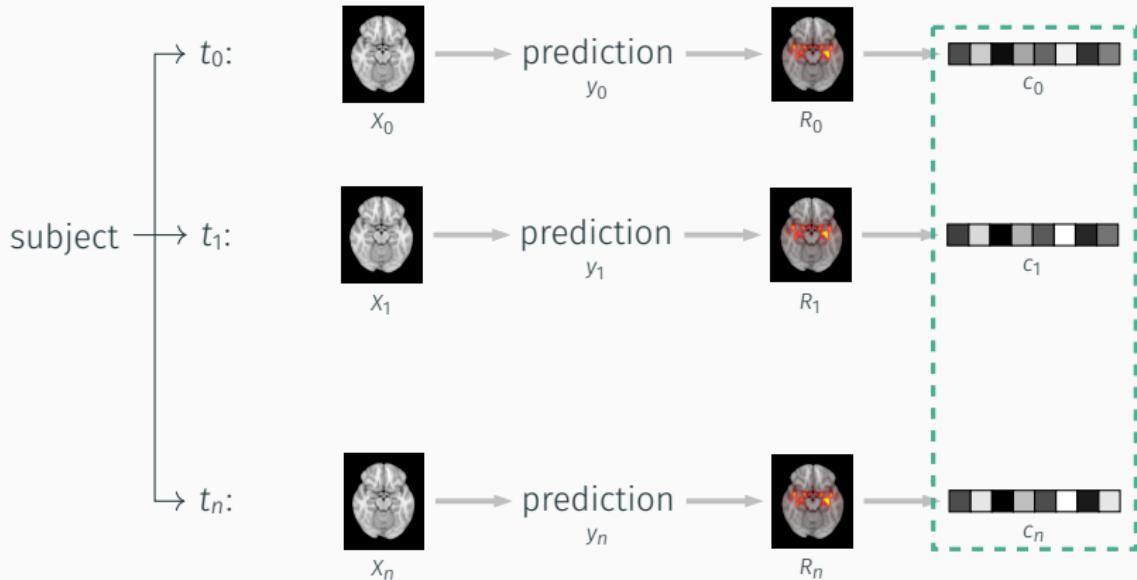
Exploring relevance maps in MCI patients



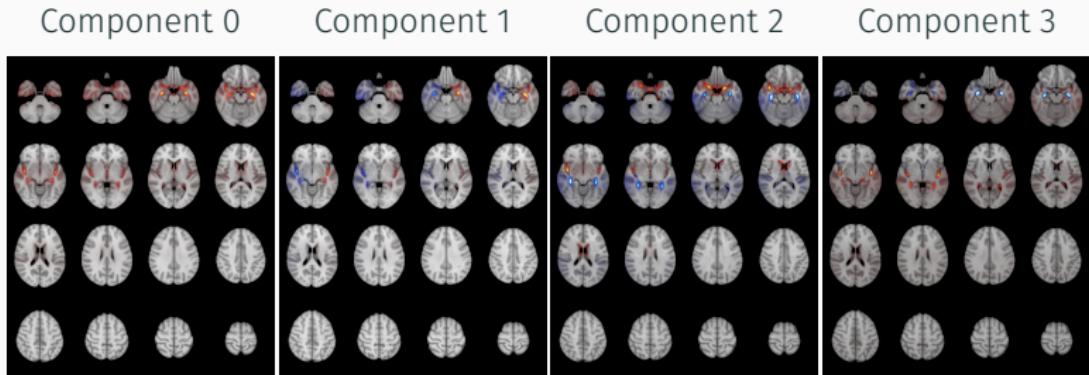
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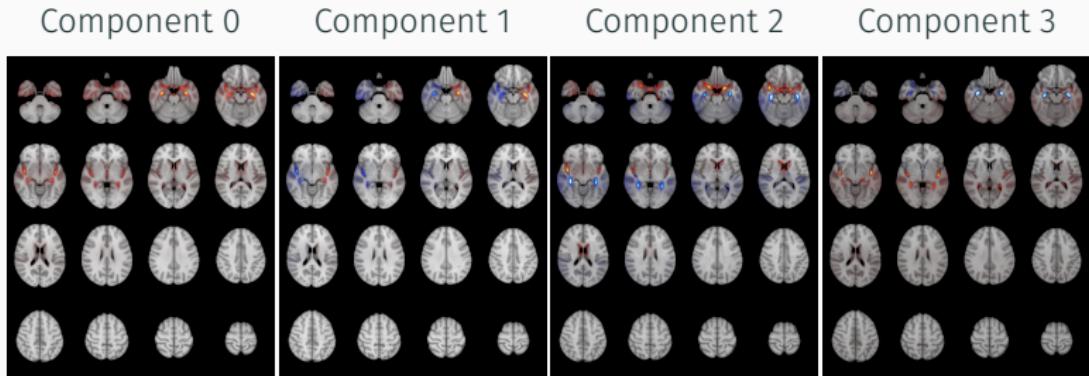
Exploring relevance maps in MCI patients



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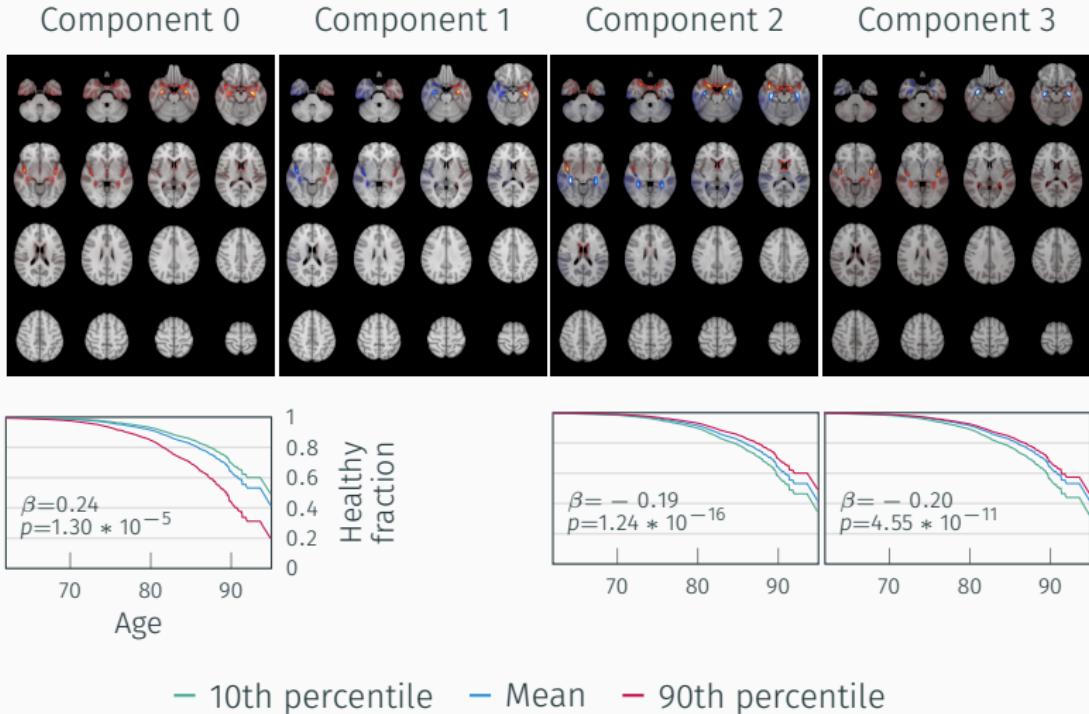


$$p=1.19 * 10^{-15}$$

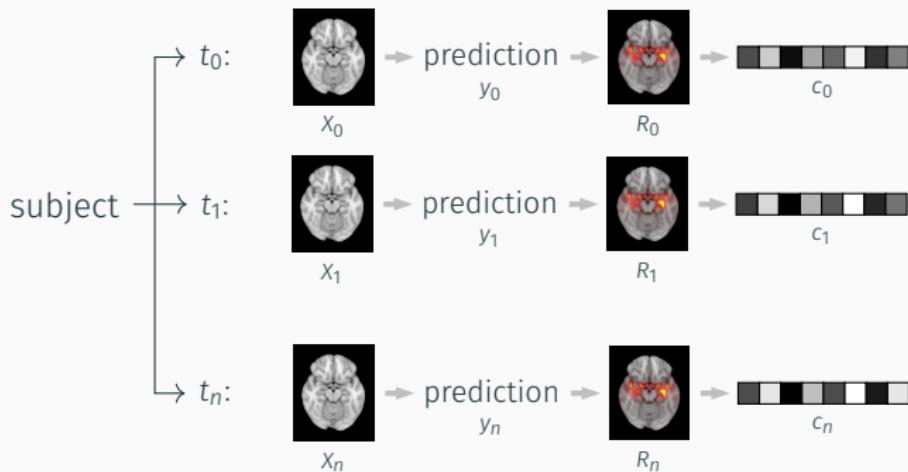
$$p=6.62 * 10^{-4}$$

$$p=1.06 * 10^{-5}$$

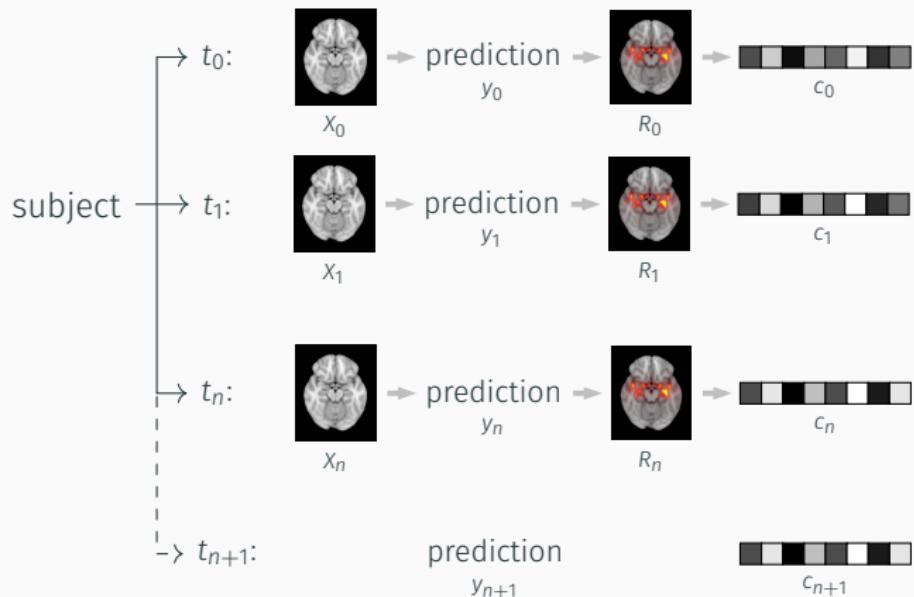
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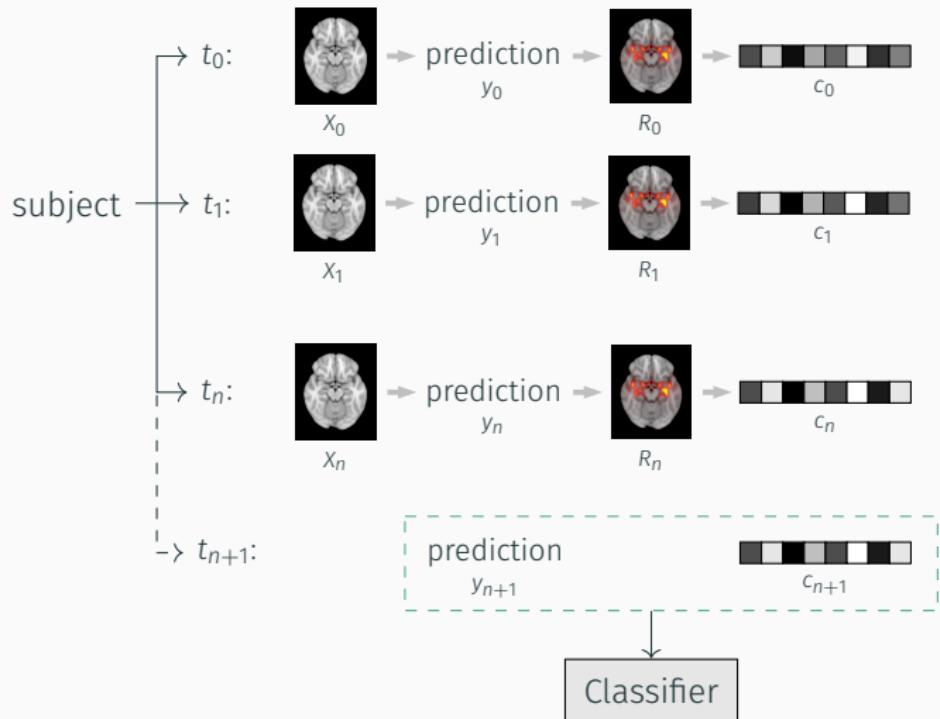
Exploring relevance maps in MCI patients



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Exploring relevance maps in MCI patients

Predictors	AUC	Accuracy	PPV	Sensitivity	Specificity
age + sex	0.538 ± 0.072	53.81 ± 7.25	0.53 ± 0.06	0.62 ± 0.09	0.42 ± 0.13
age + sex + \hat{y}_n	0.808 ± 0.035	76.41 ± 3.79	0.76 ± 0.03	0.75 ± 0.07	0.77 ± 0.04
age + sex + \hat{y}_{n+1}^*	0.806 ± 0.03	75.15 ± 3.34	0.74 ± 0.02	0.76 ± 0.07	0.74 ± 0.04
age + sex + $\hat{y}_n + c_n$	0.810 ± 0.035	75.78 ± 3.45	0.72 ± 0.03	0.78 ± 0.07	0.78 ± 0.03
age + sex + $\hat{y}_{n+1}^* + c_{n+1}^*$	0.831 ± 0.037	74.52 ± 3.08	0.72 ± 0.03	0.78 ± 0.07	0.70 ± 0.05

Prediction of progression at t_{n+1}

Exploring relevance maps in MCI patients

"There is an X% chance the patient will progress into dementia by date XX.YY.ZZZZ based on existing pathology in brain regions A, B and C, and an expected increase/decrease of pathology in regions D and E."

Thank you!



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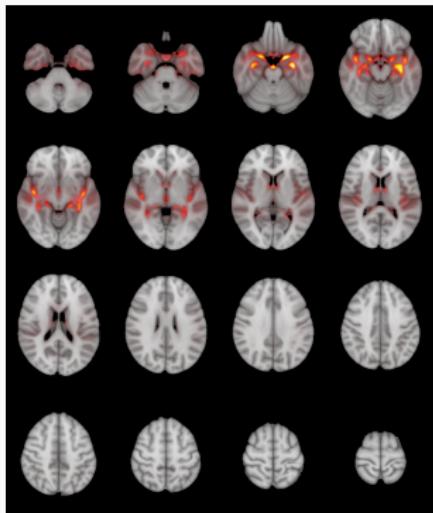


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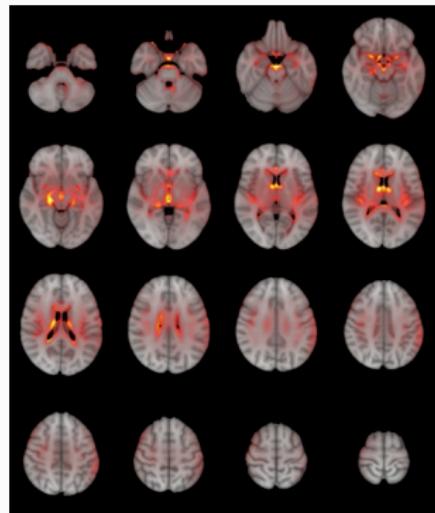


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Appendix 1



Dementia



Multiple Sclerosis