

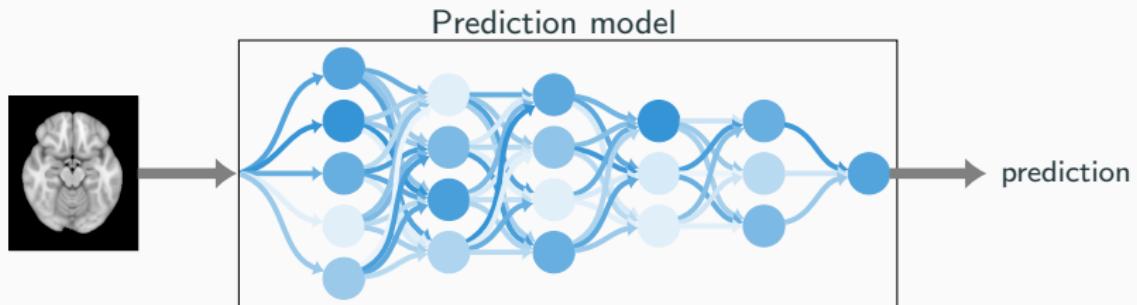
Detecting individual-level deviations in brain morphology in MCI with explainable AI

Esten Høyland Leonardsen

18.10.22

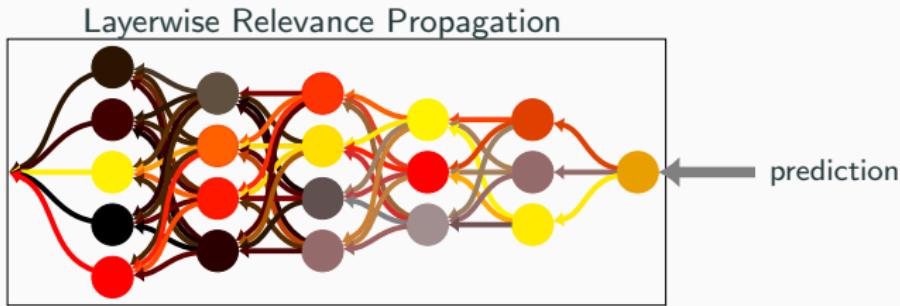
UiO:Life Science, University of Oslo

Layerwise Relevance Propagation



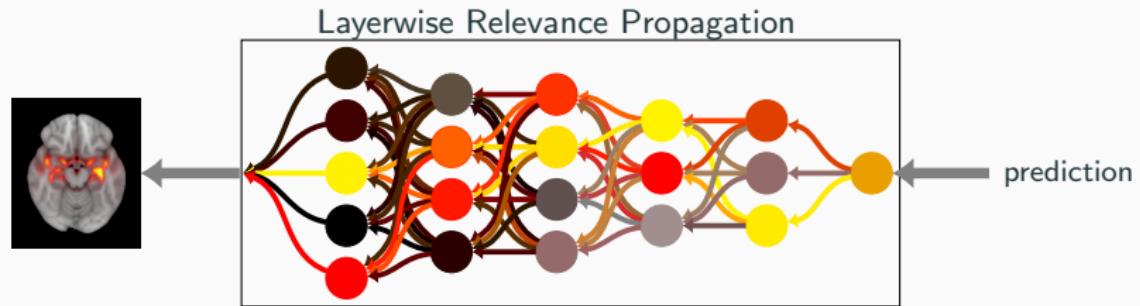
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j}$$

Layerwise Relevance Propagation



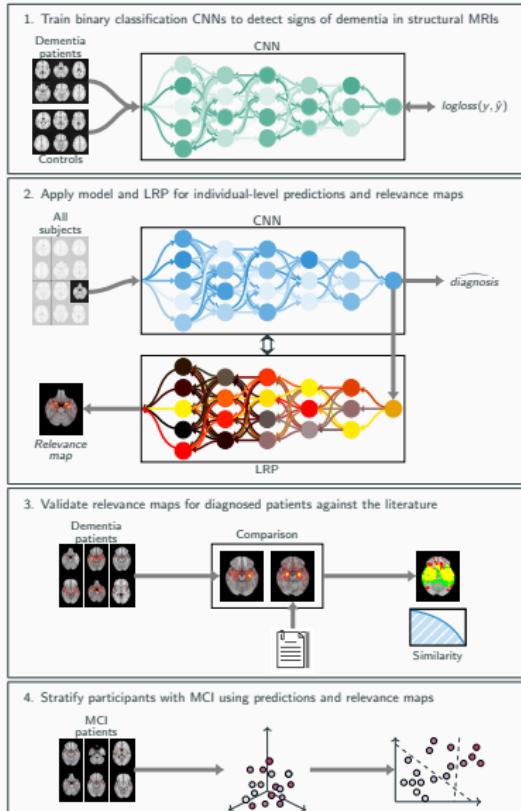
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

Layerwise Relevance Propagation



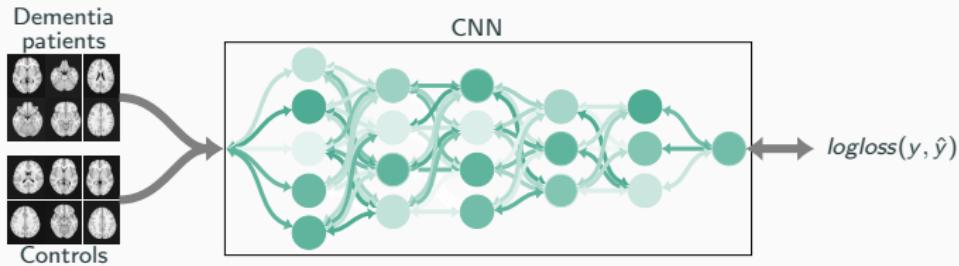
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Overview

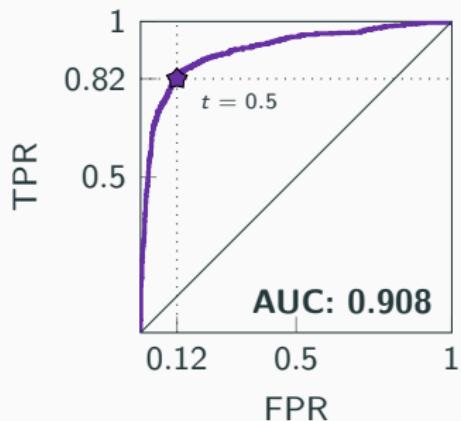
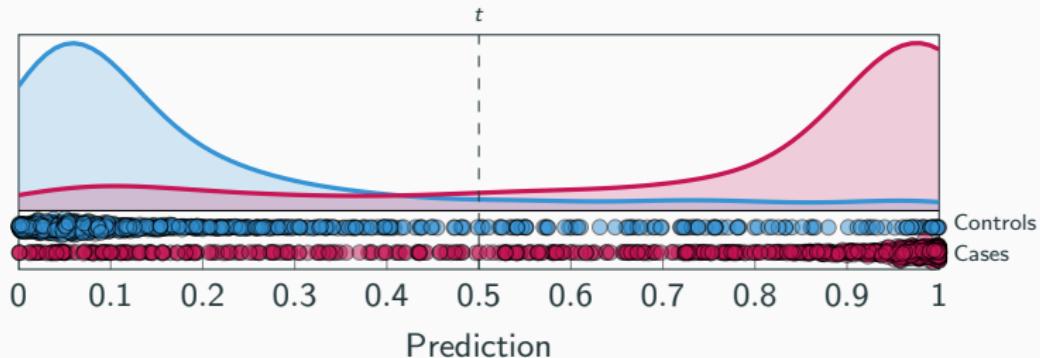


Case-control predictions

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



Case-control predictions



Predicted

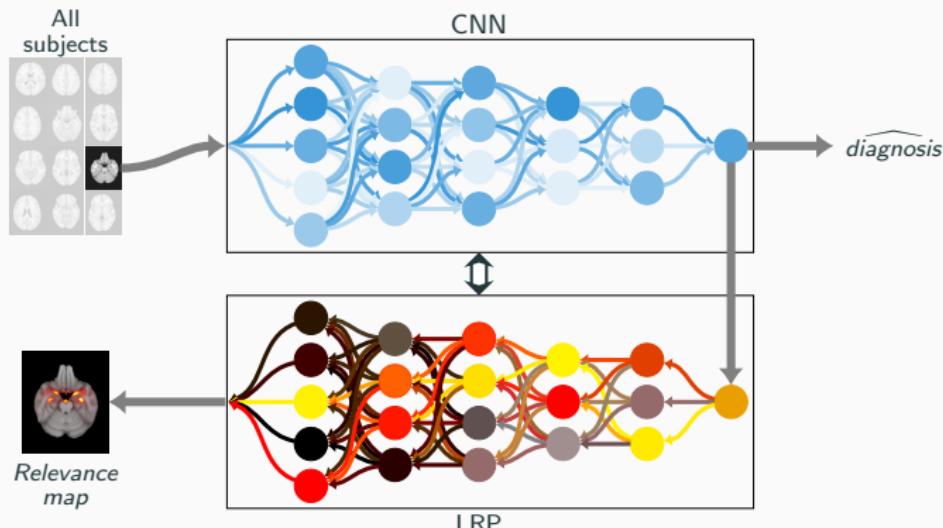
	0	1
0	754	100
1	157	697

Observed

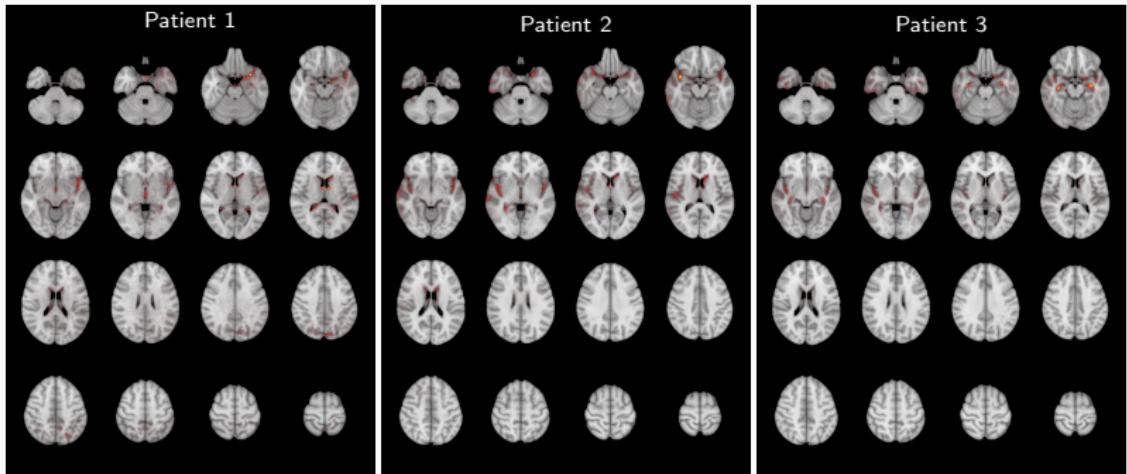
Accuracy: 84.95%

Generating relevance maps

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



Generating relevance maps



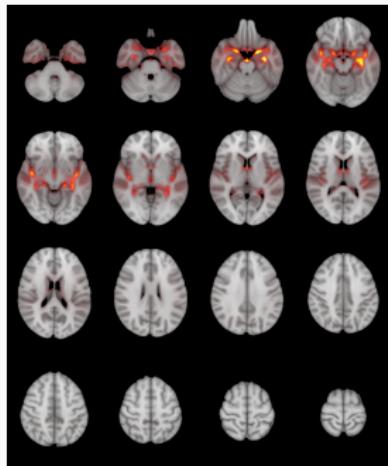
Validating relevance maps in dementia patients

3. Validate relevance maps for diagnosed patients against the literature

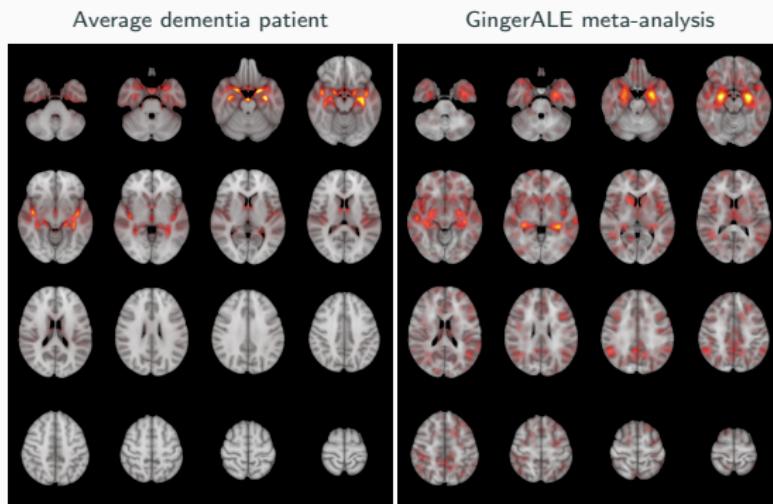


Validating relevance maps in dementia patients

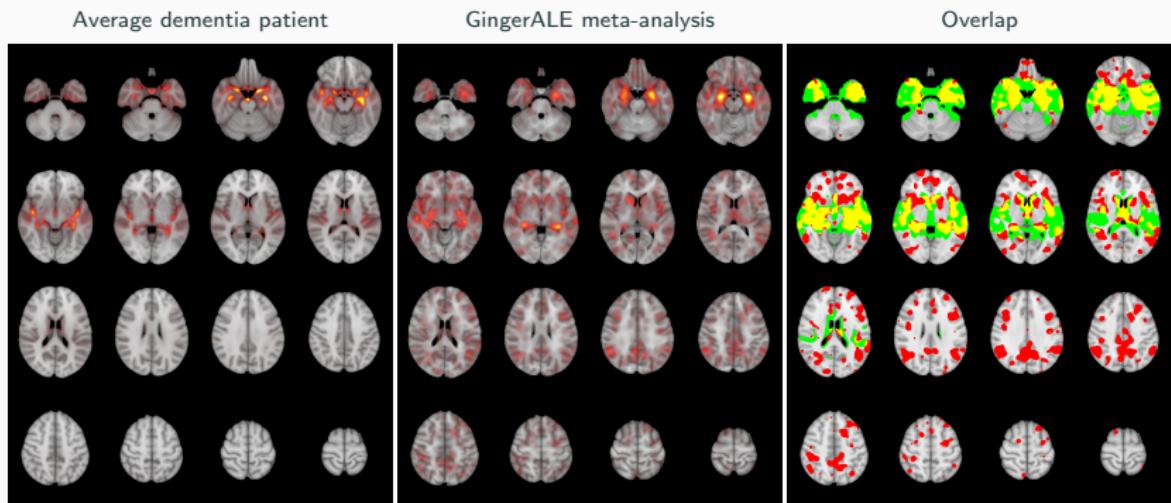
Average dementia patient



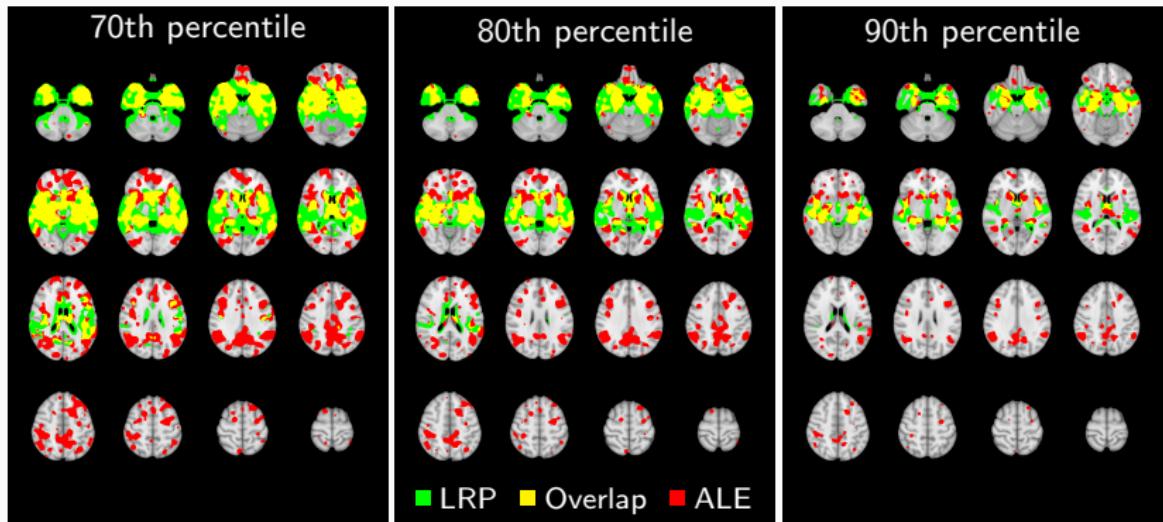
Validating relevance maps in dementia patients



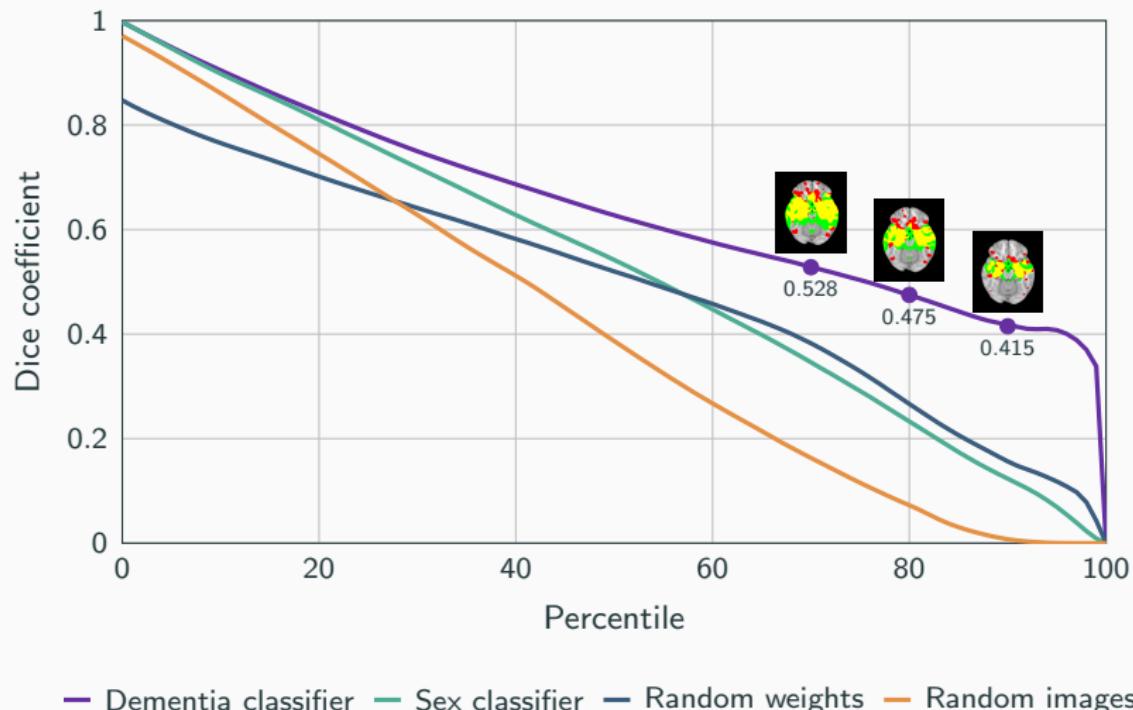
Validating relevance maps in dementia patients



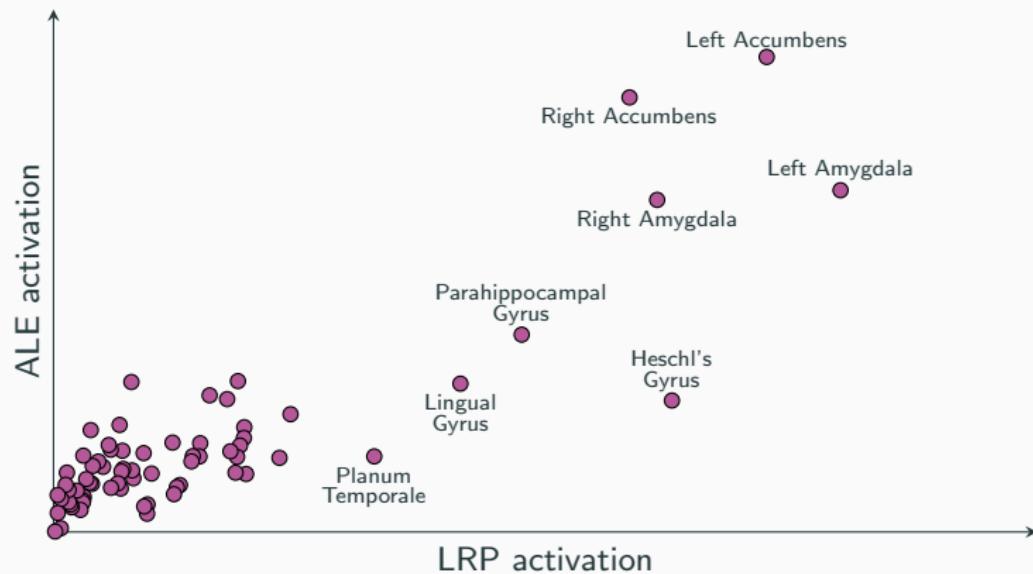
Validating relevance maps in dementia patients



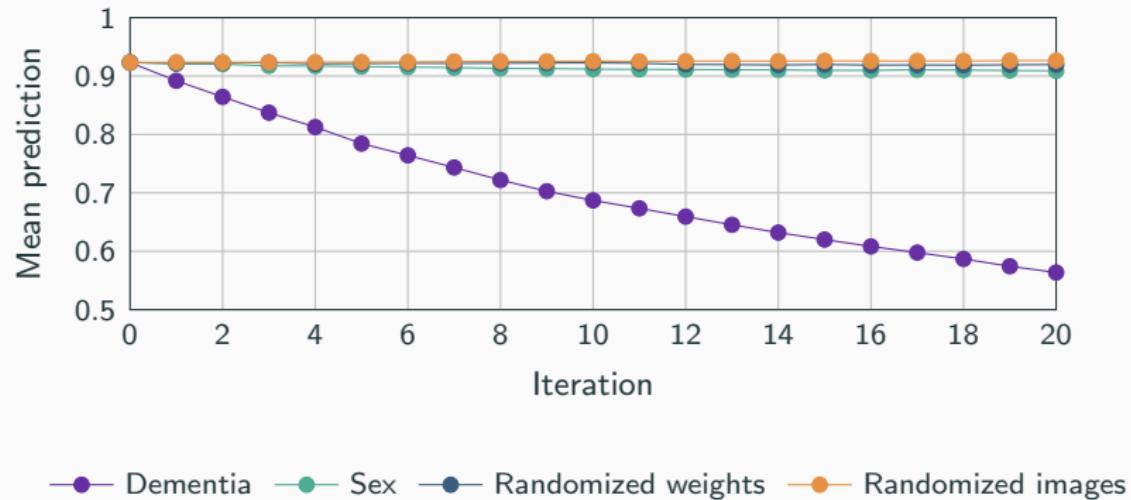
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Validating relevance maps in dementia patients

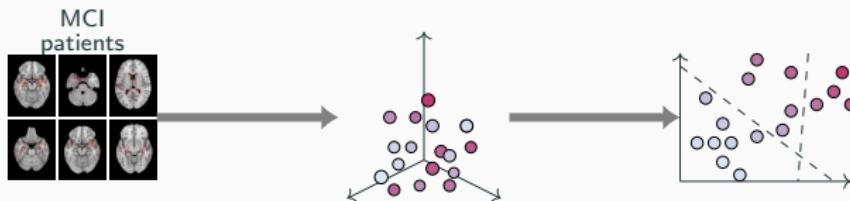


Validating relevance maps in dementia patients

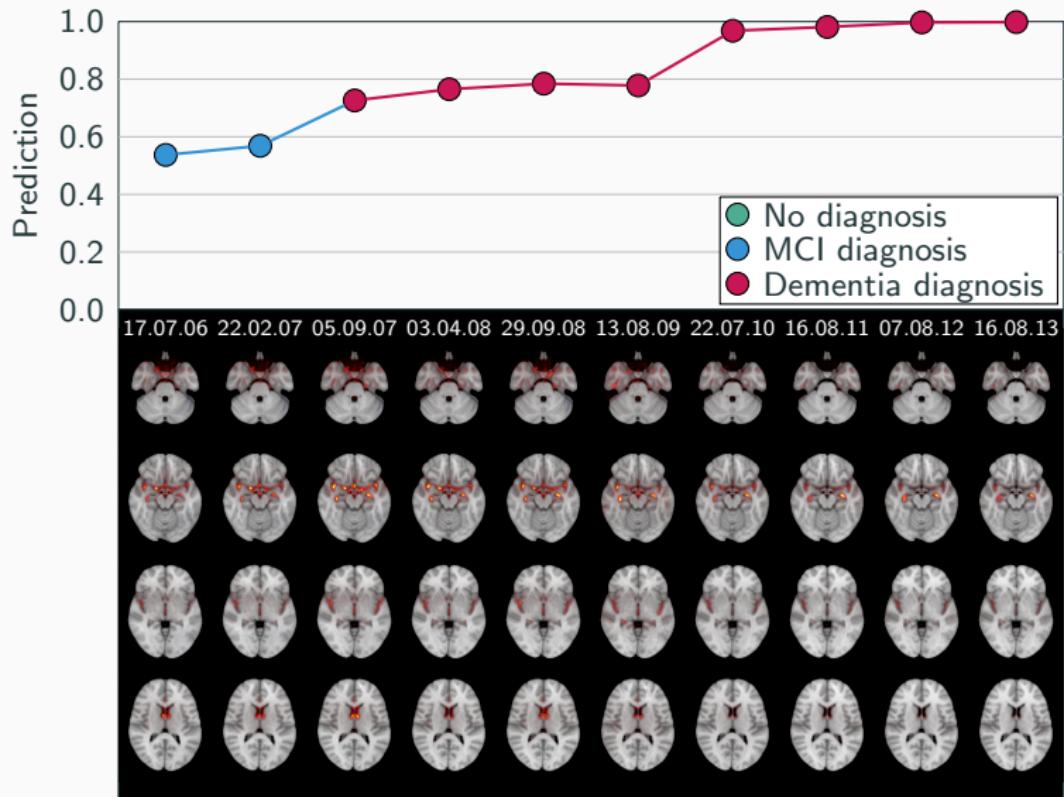


Exploring relevance maps in MCI patients

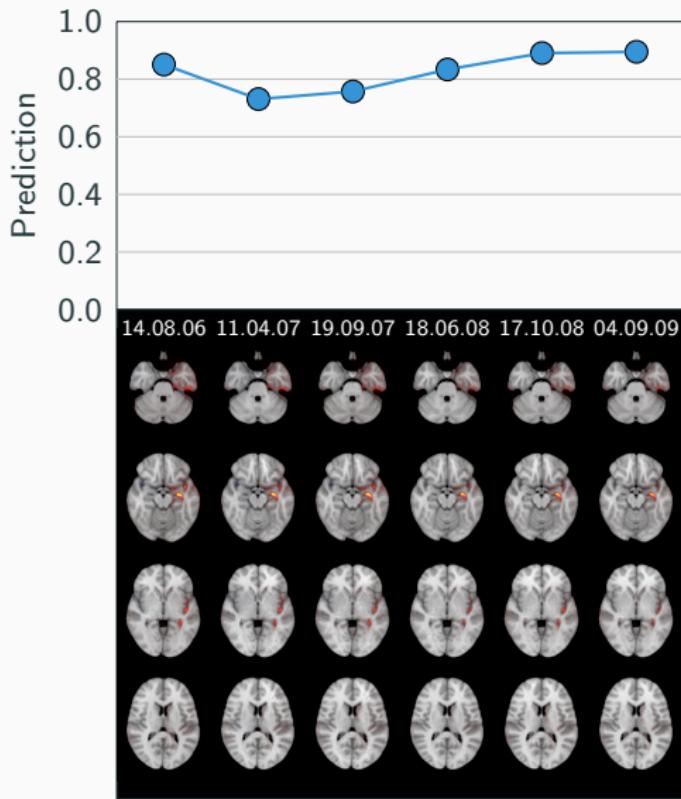
4. Stratify participants with MCI using predictions and relevance maps



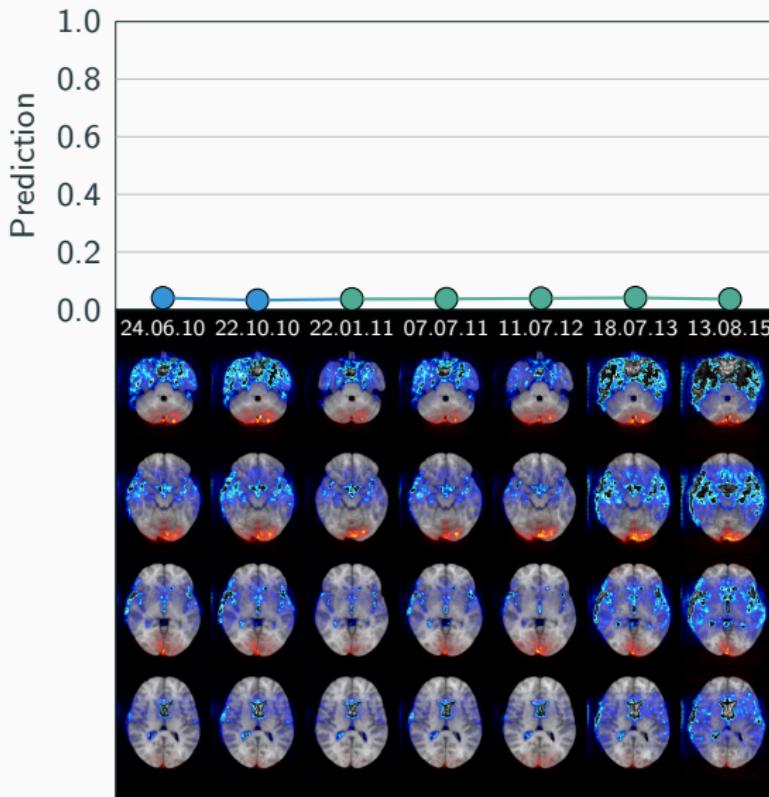
Exploring relevance maps in MCI patients



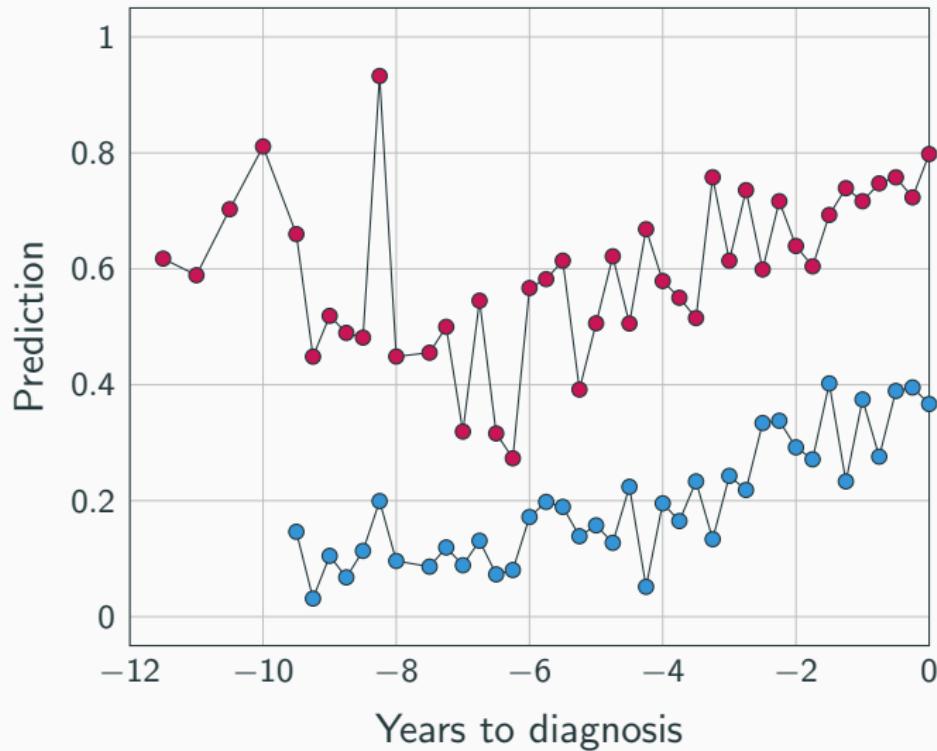
Exploring relevance maps in MCI patients



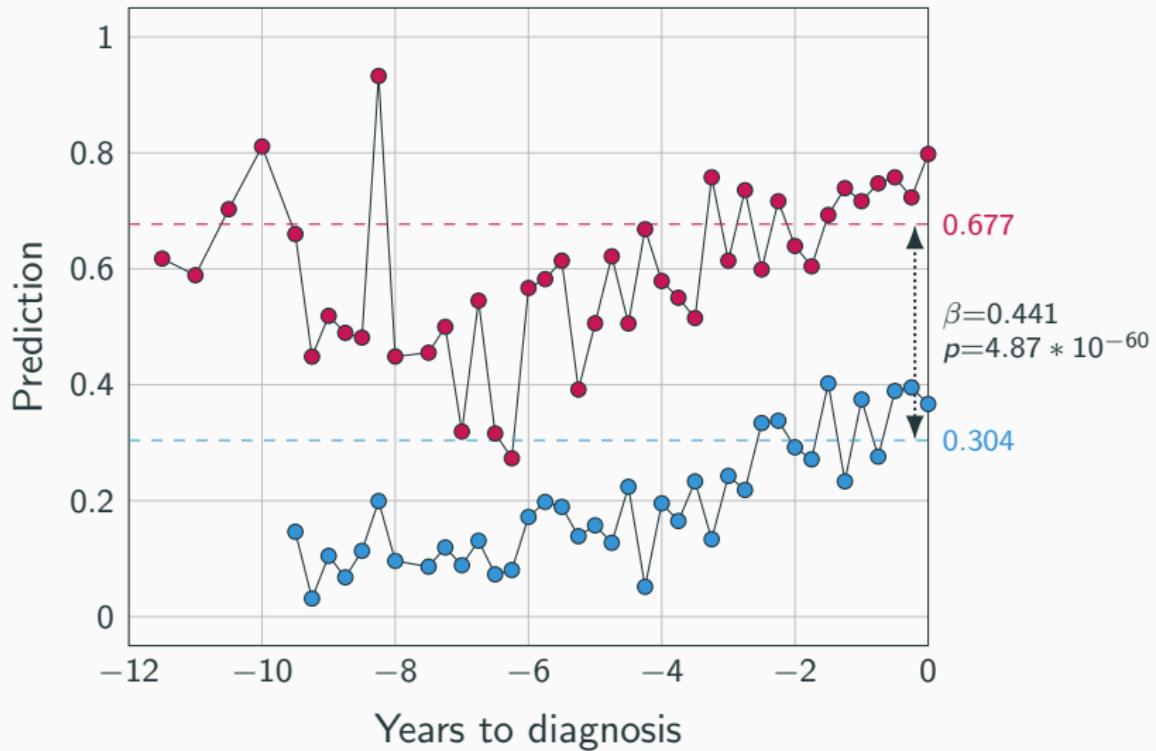
Exploring relevance maps in MCI patients



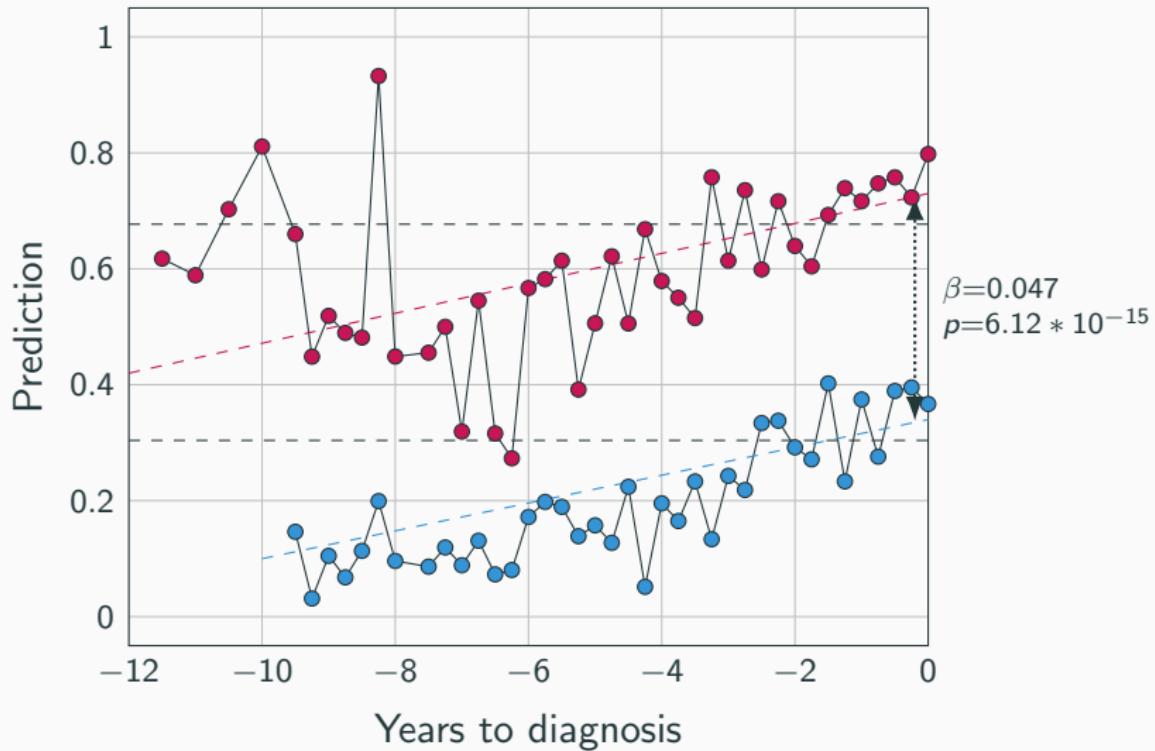
Exploring relevance maps in MCI patients



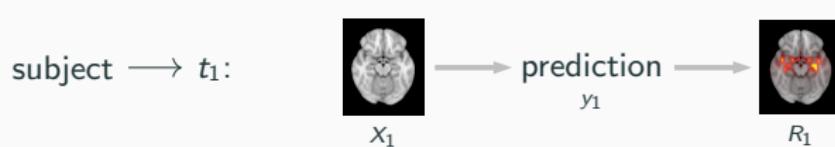
Exploring relevance maps in MCI patients



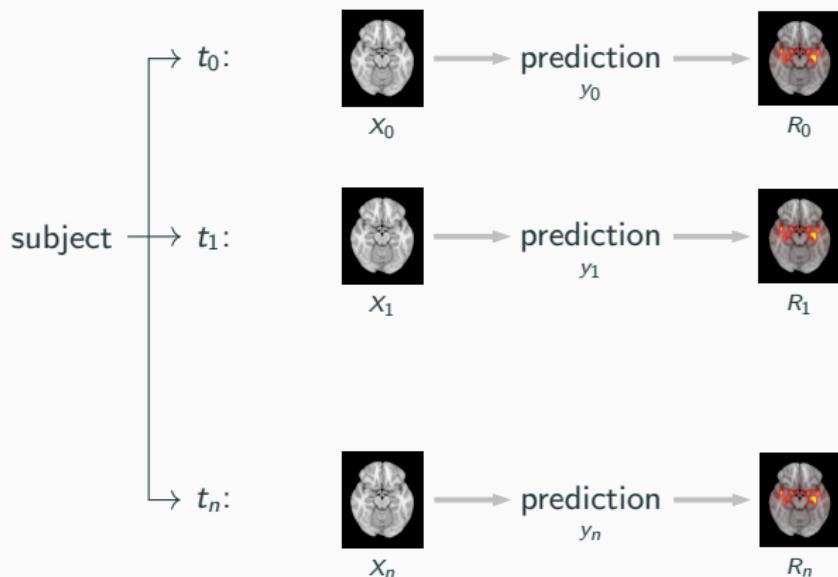
Exploring relevance maps in MCI patients



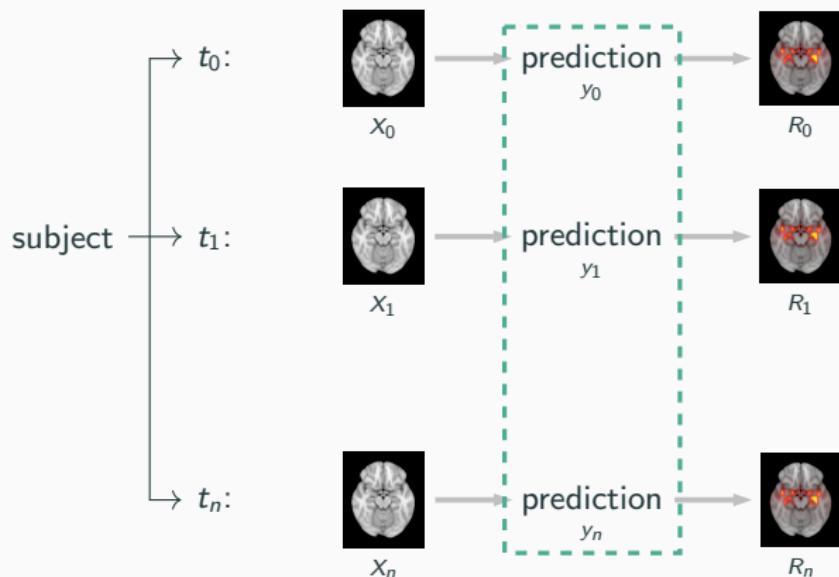
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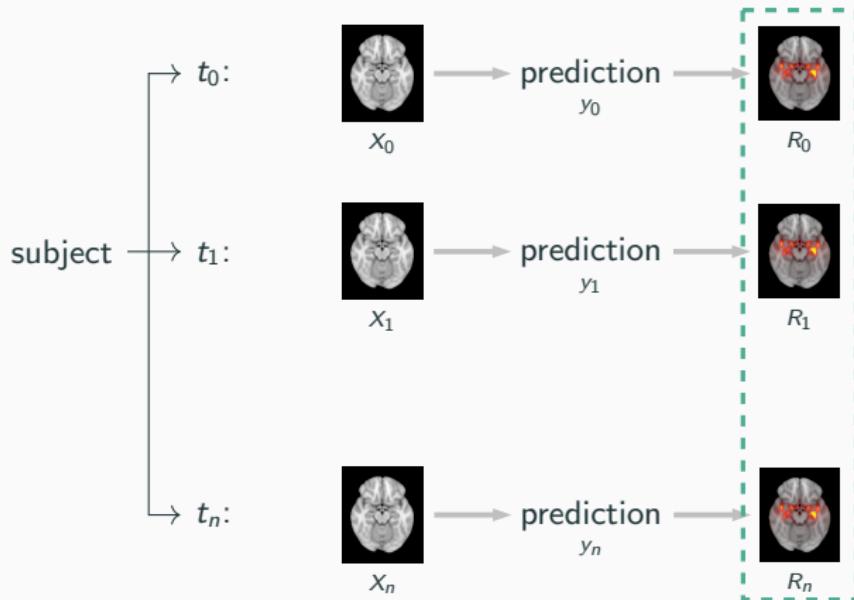
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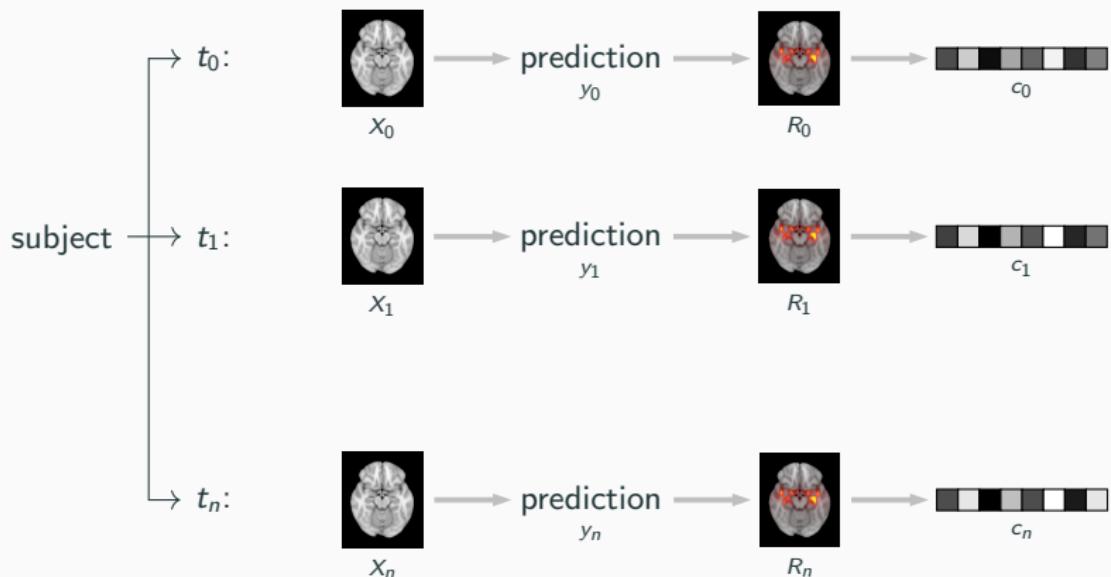
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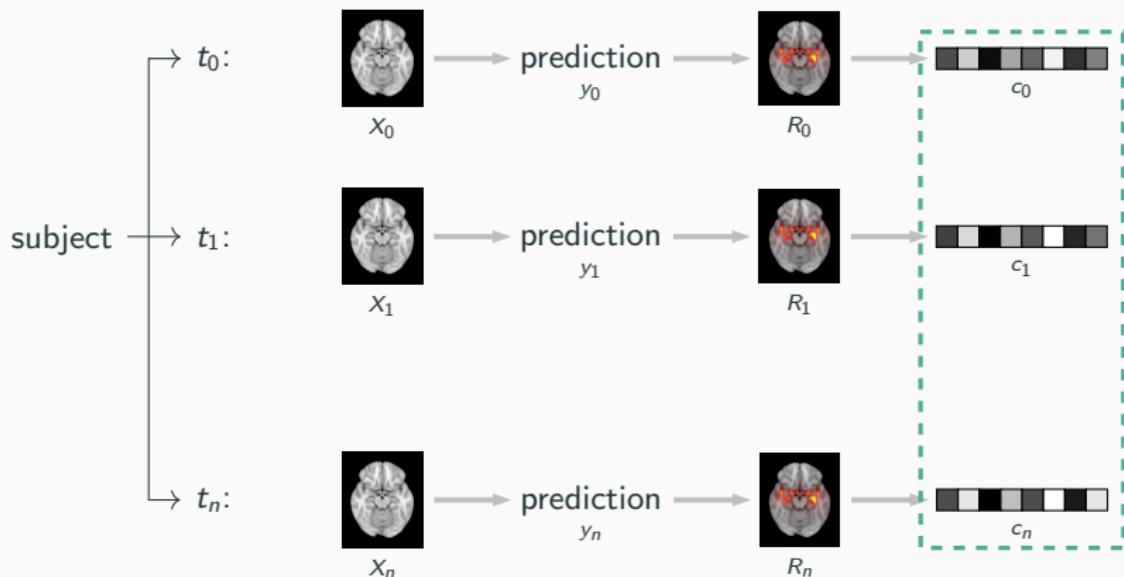
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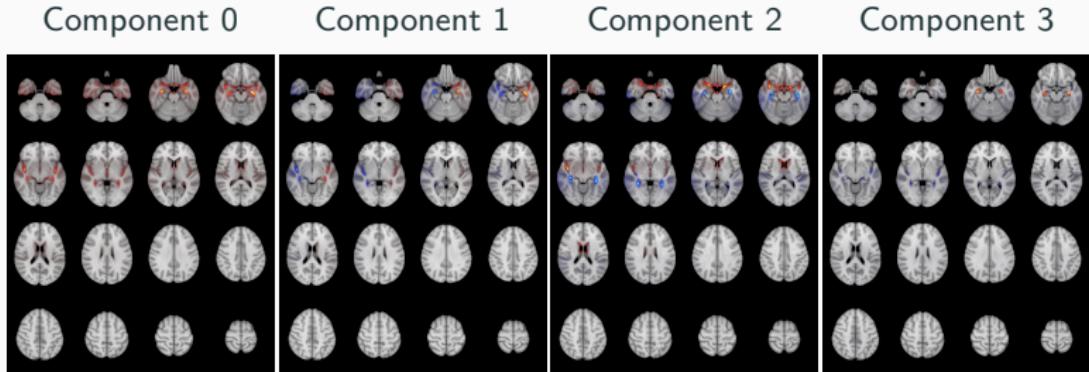
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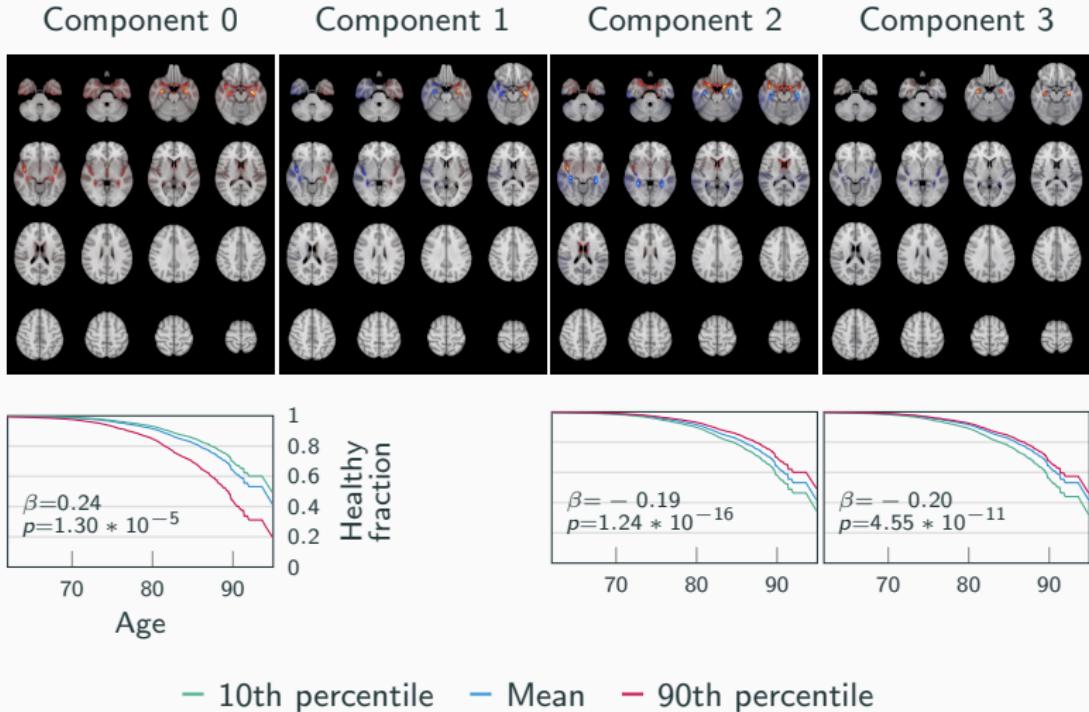
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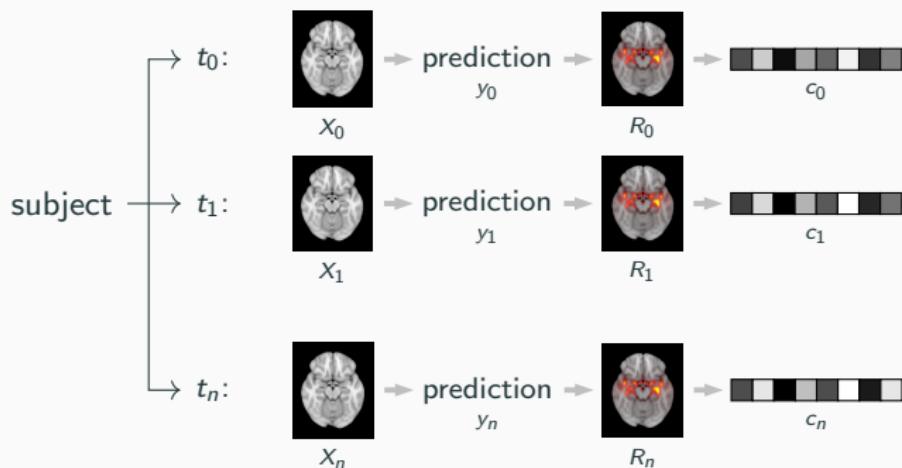
Exploring relevance maps in MCI patients



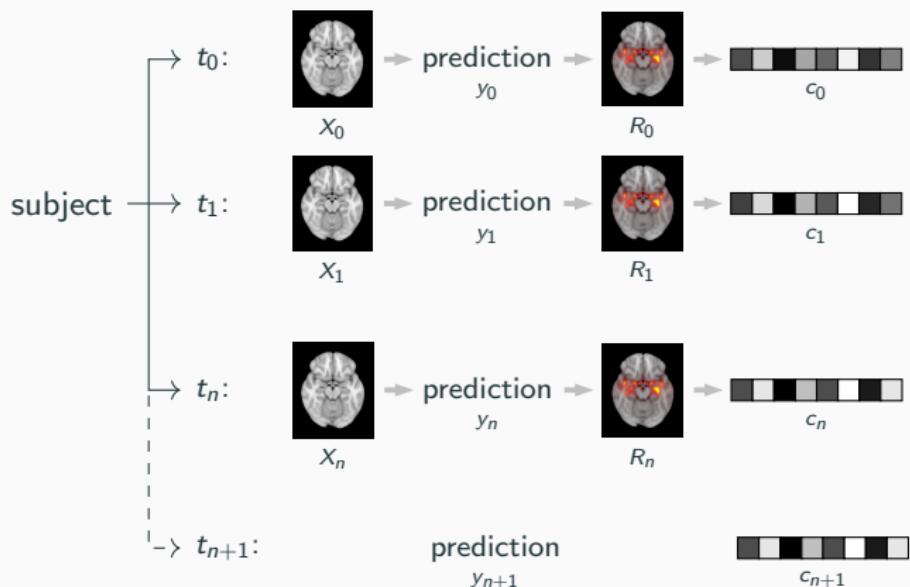
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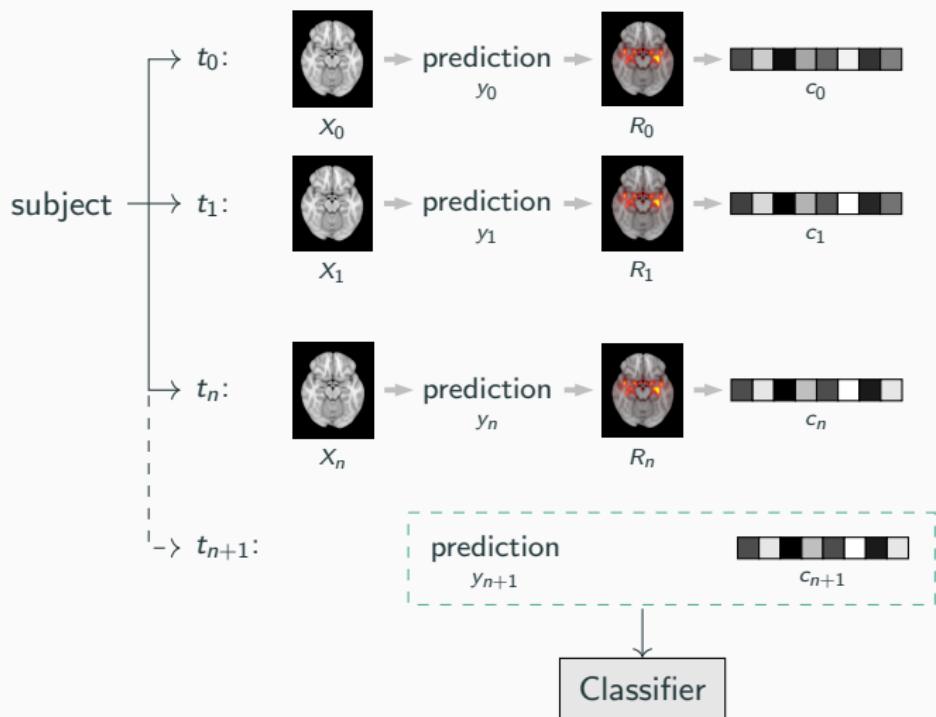
Exploring relevance maps in MCI patients



Exploring relevance maps in MCI patients



Exploring relevance maps in MCI patients



Exploring relevance maps in MCI patients

Covariates	AUC	Accuracy	PPV	Sensitivity	Specificity
$\text{progression}_{n+1} \sim \text{age} + \text{sex}$	0.521 ± 0.029	51.57 ± 3.56	0.61 ± 0.03	0.66 ± 0.03	0.37 ± 0.04
$\text{progression}_{n+1} \sim \text{age} + \text{sex} + \hat{y}_n$	0.833 ± 0.077	75.23 ± 7.03	0.82 ± 0.10	0.72 ± 0.11	0.79 ± 0.09
$\text{progression}_{n+1} \sim \text{age} + \text{sex} + \hat{y}_n * c_n + c_{n+1}$	0.848 ± 0.076	78.08 ± 8.92	0.84 ± 0.09	0.76 ± 0.13	0.80 ± 0.08
$\text{progression}_{n+1} \sim \text{age} + \text{sex} + \hat{y}_{n+1} + c_{n+1}$	0.849 ± 0.074	76.97 ± 9.46	0.82 ± 0.10	0.78 ± 0.15	0.76 ± 0.08

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."