

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

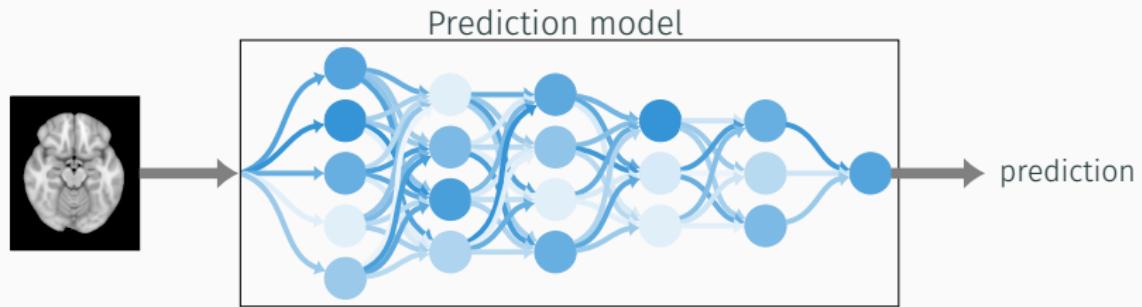
Esten Høyland Leonardsen

24.10.22

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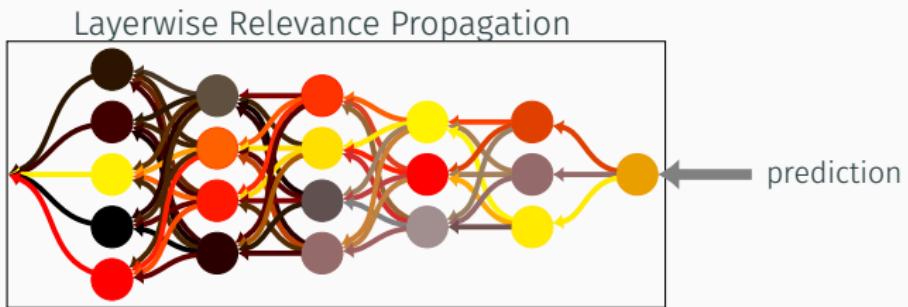


Layerwise Relevance Propagation



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

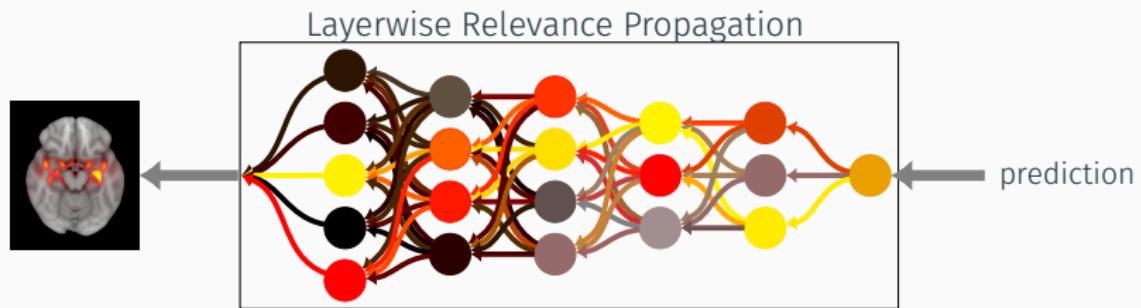
Layerwise Relevance Propagation



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

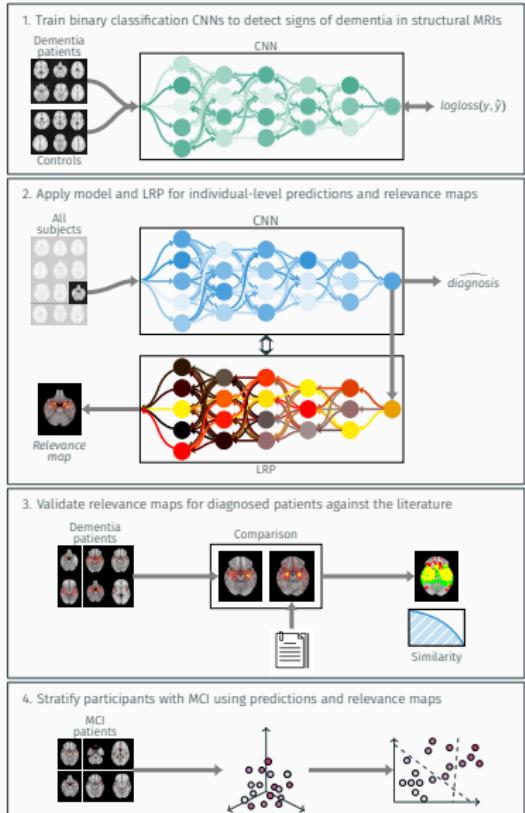
$$R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

Layerwise Relevance Propagation



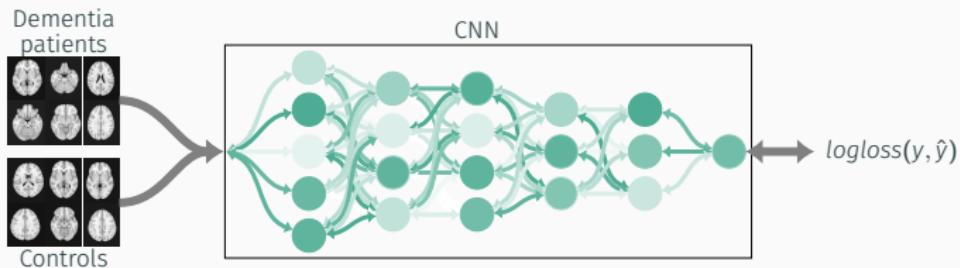
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

Overview

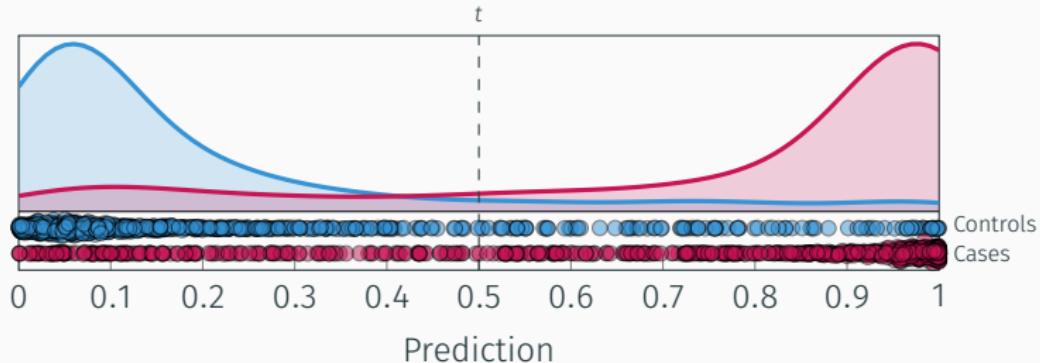


Case-control predictions

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



Case-control predictions

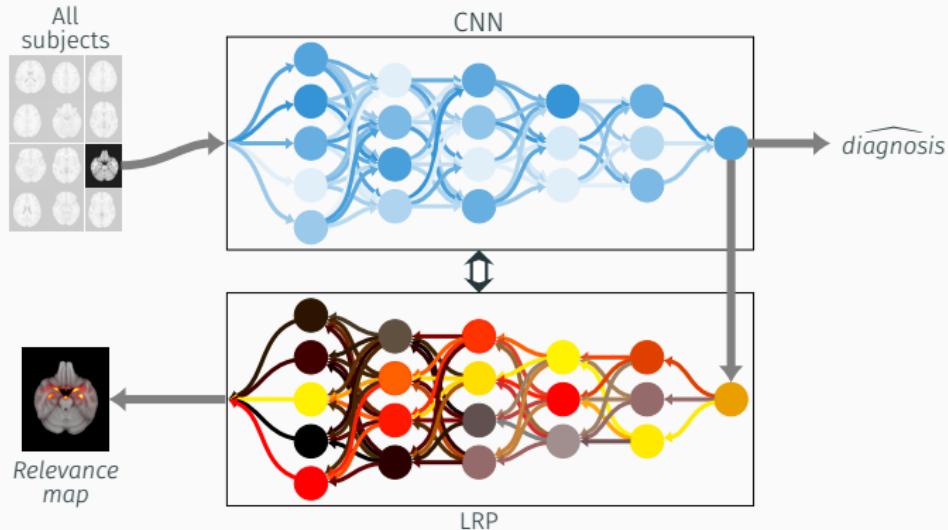


		Predicted	
		0	1
Observed	0	754	100
	1	157	697

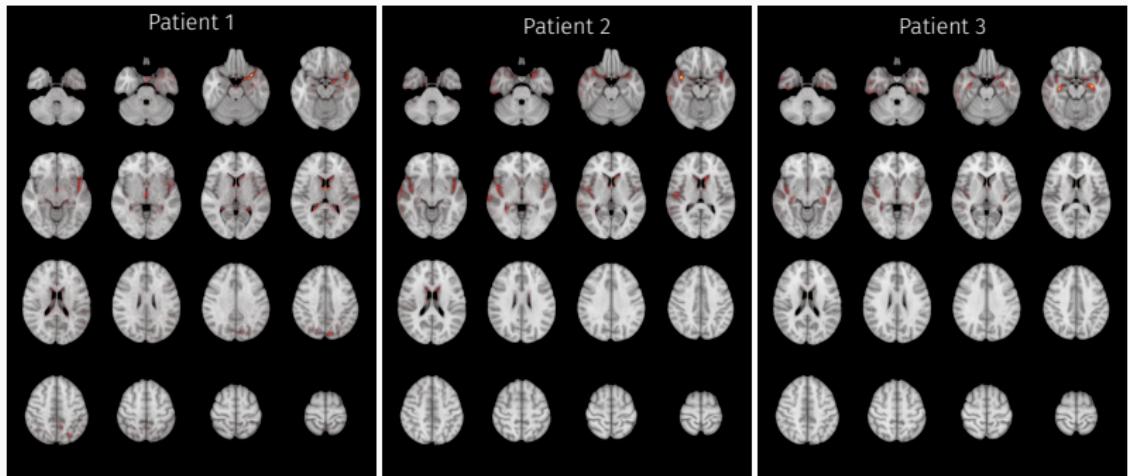
Accuracy: 84.95%

Generating relevance maps

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

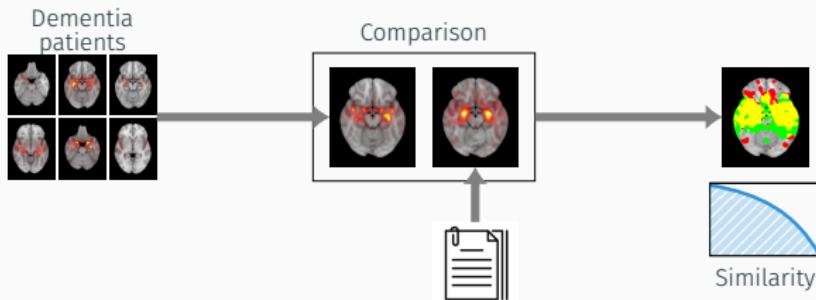


Generating relevance maps



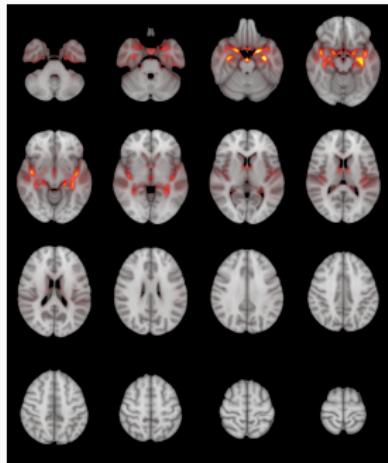
Validating relevance maps in dementia patients

3. Validate relevance maps for diagnosed patients against the literature



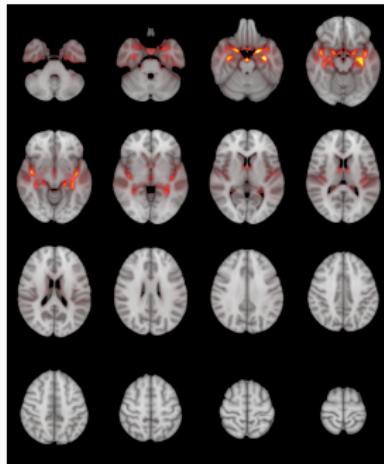
Validating relevance maps in dementia patients

Average dementia patient

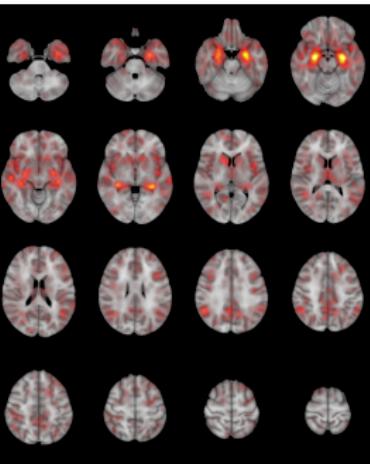


Validating relevance maps in dementia patients

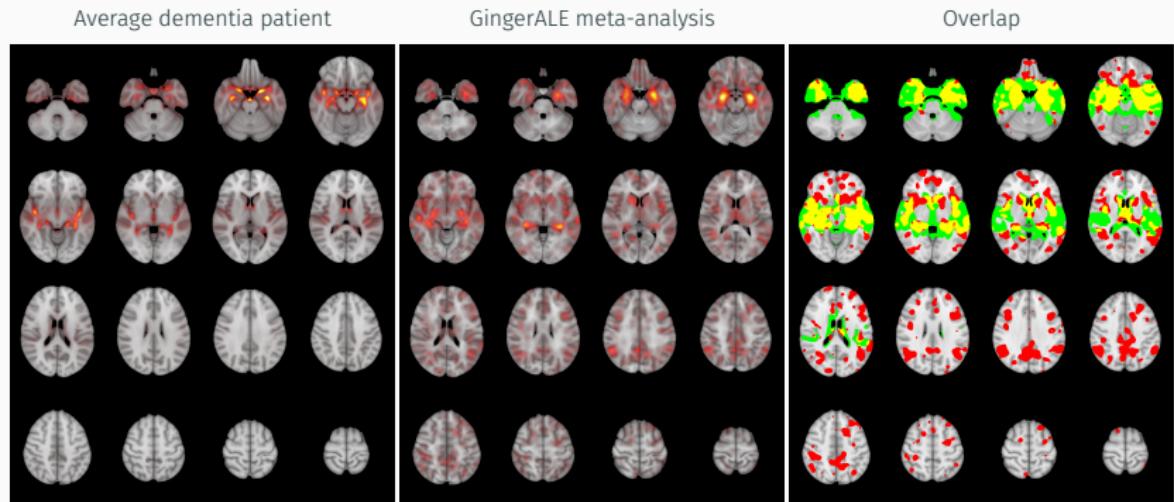
Average dementia patient



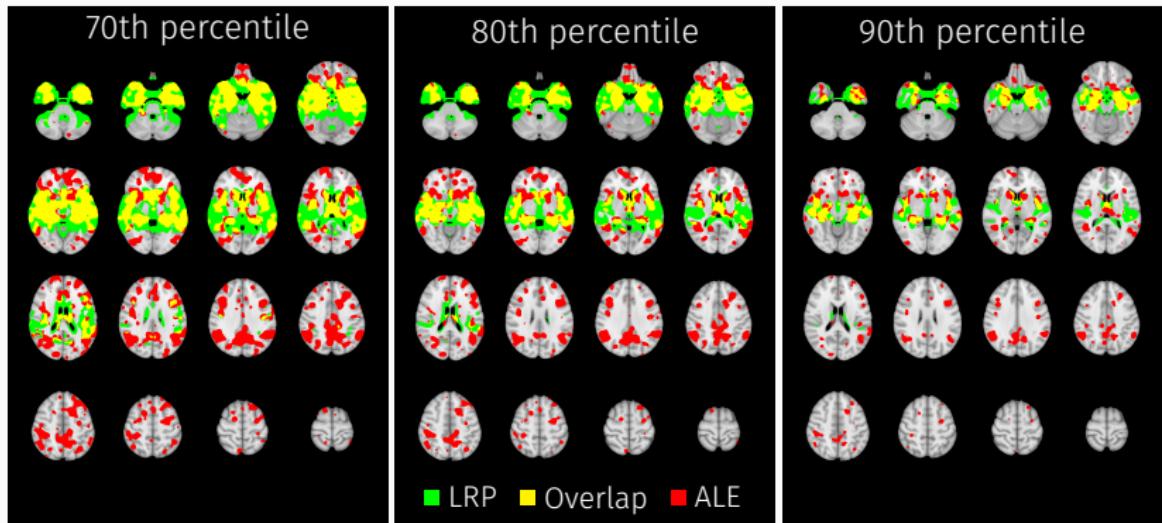
GingerALE meta-analysis



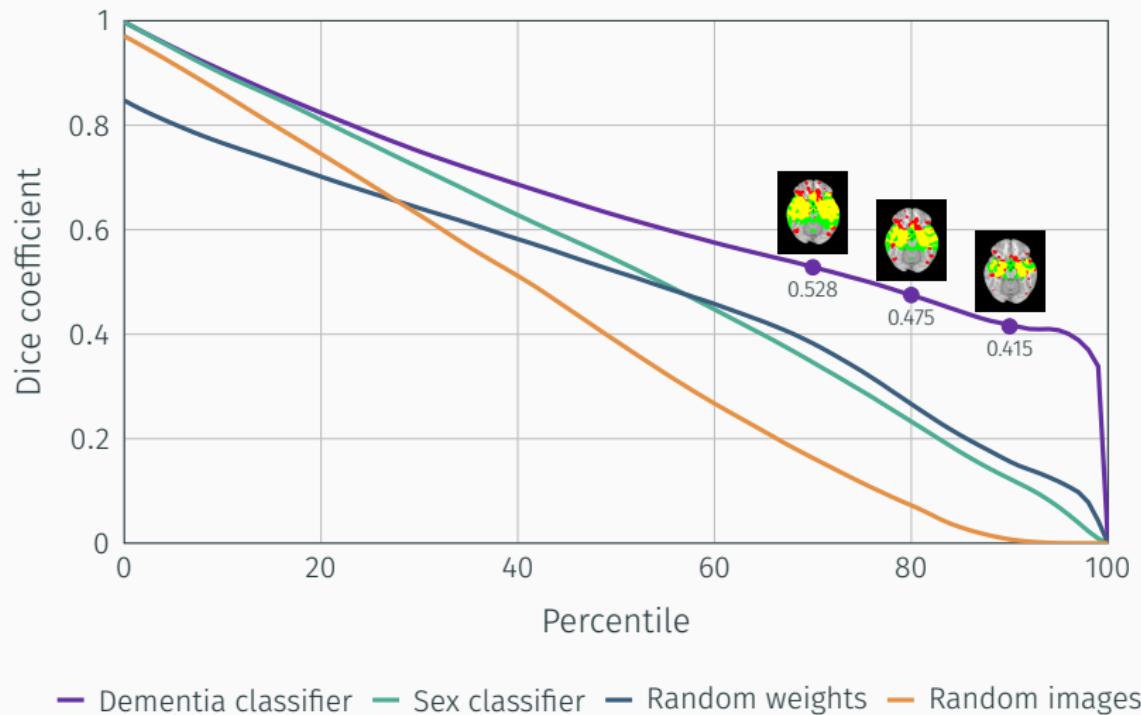
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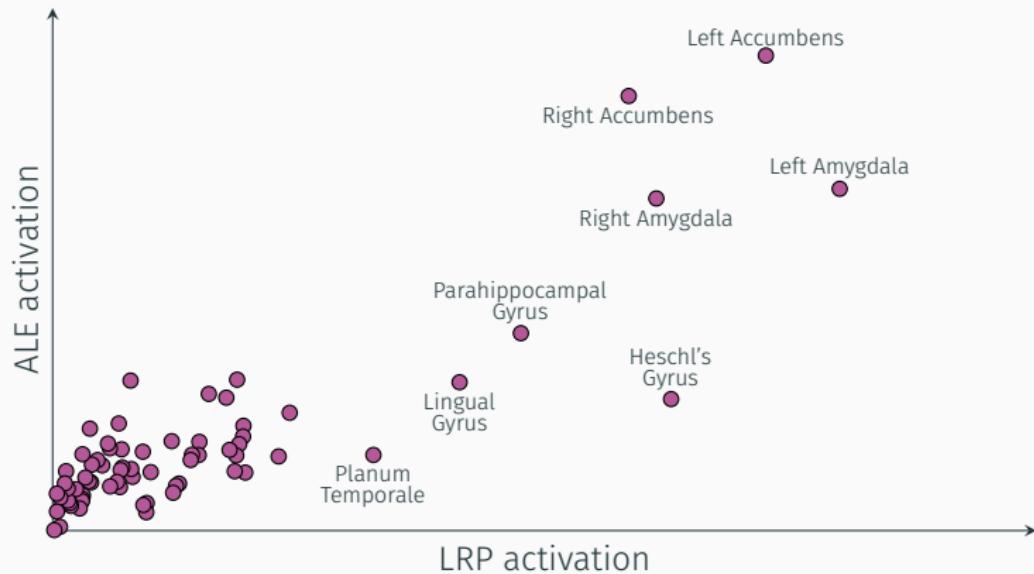
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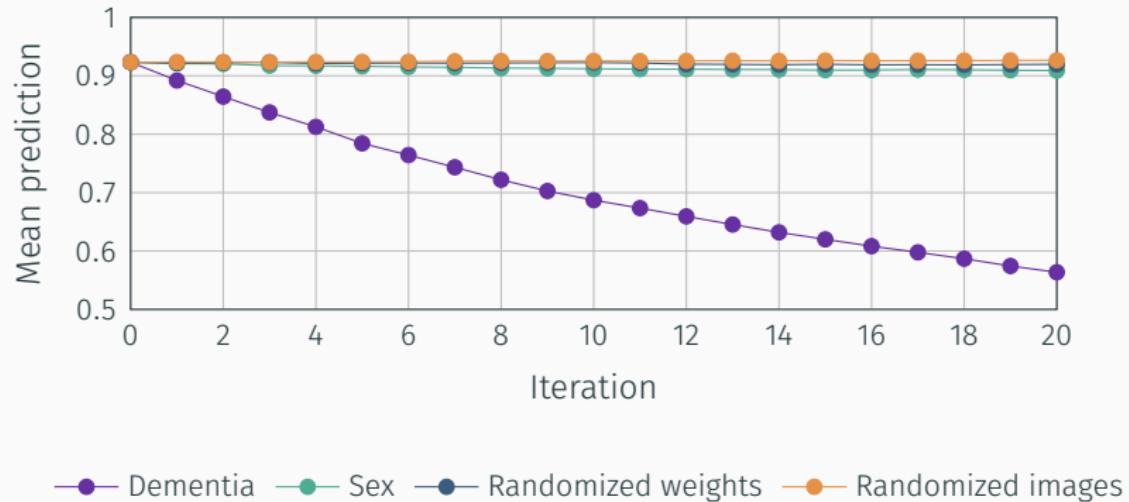
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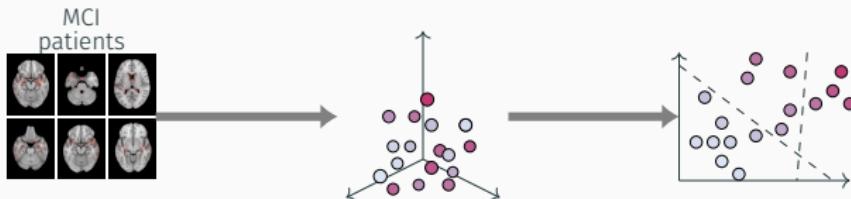


Validating relevance maps in dementia patients

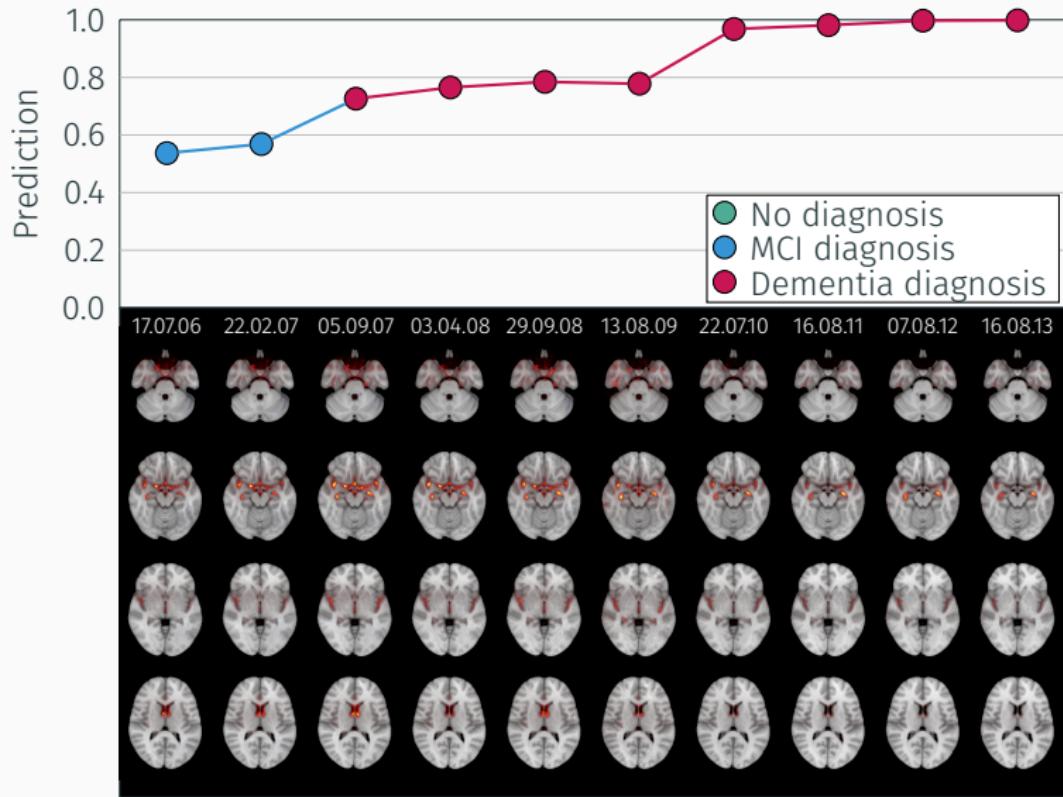


Exploring relevance maps in MCI patients

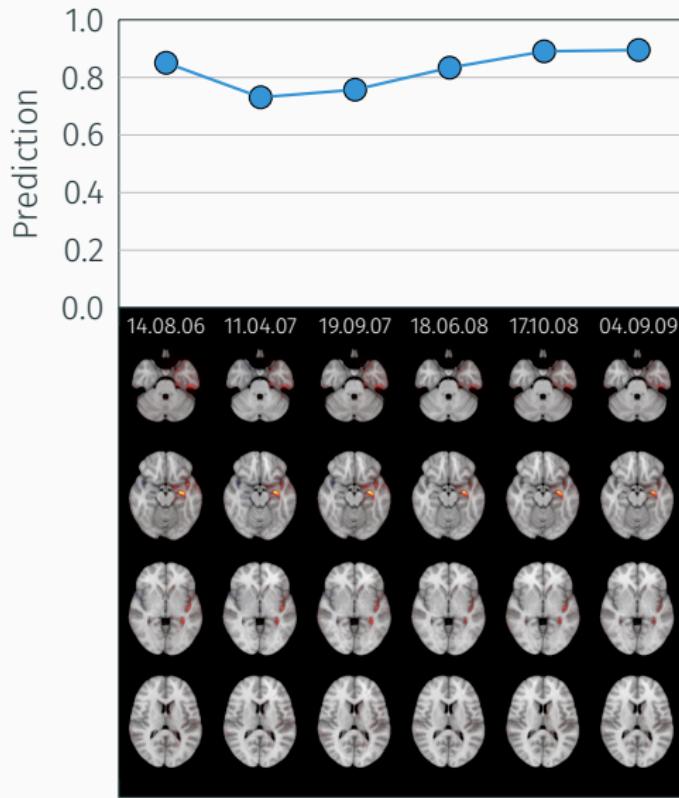
4. Stratify participants with MCI using predictions and relevance maps



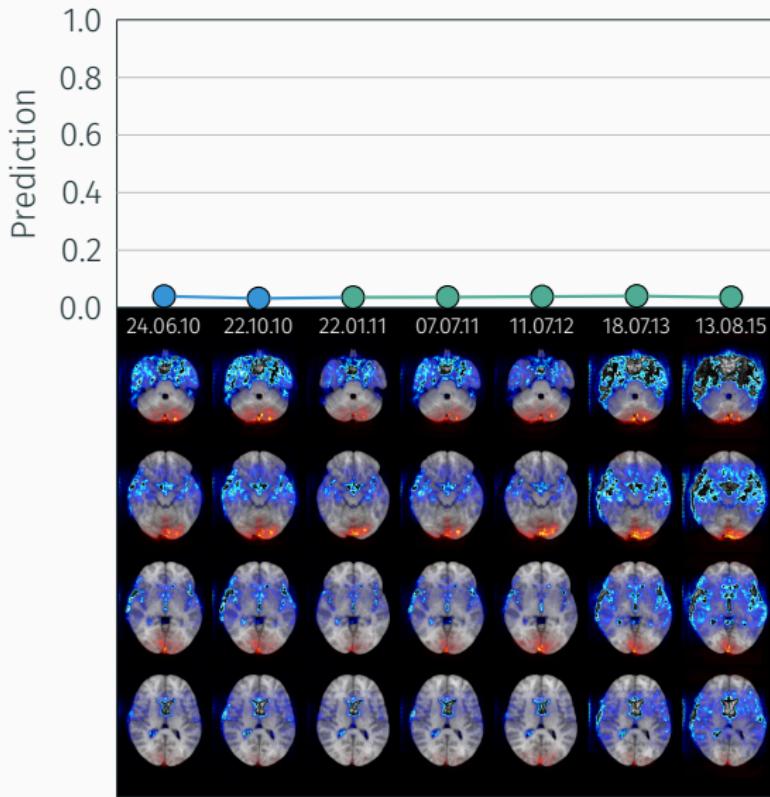
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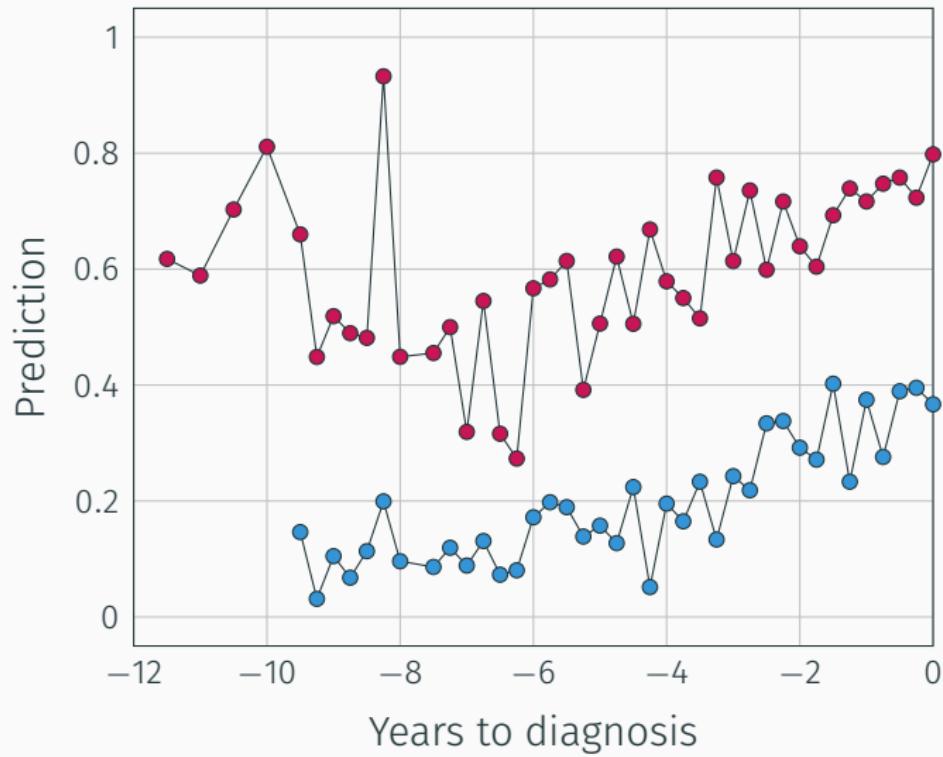
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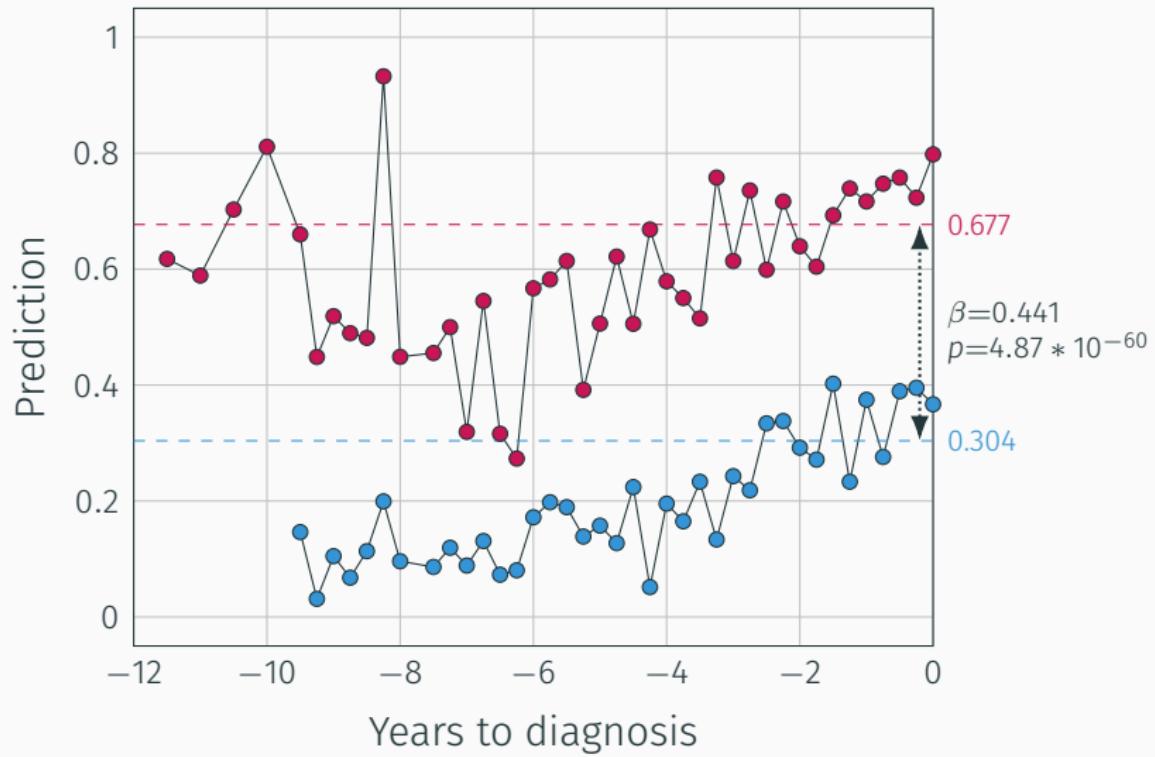
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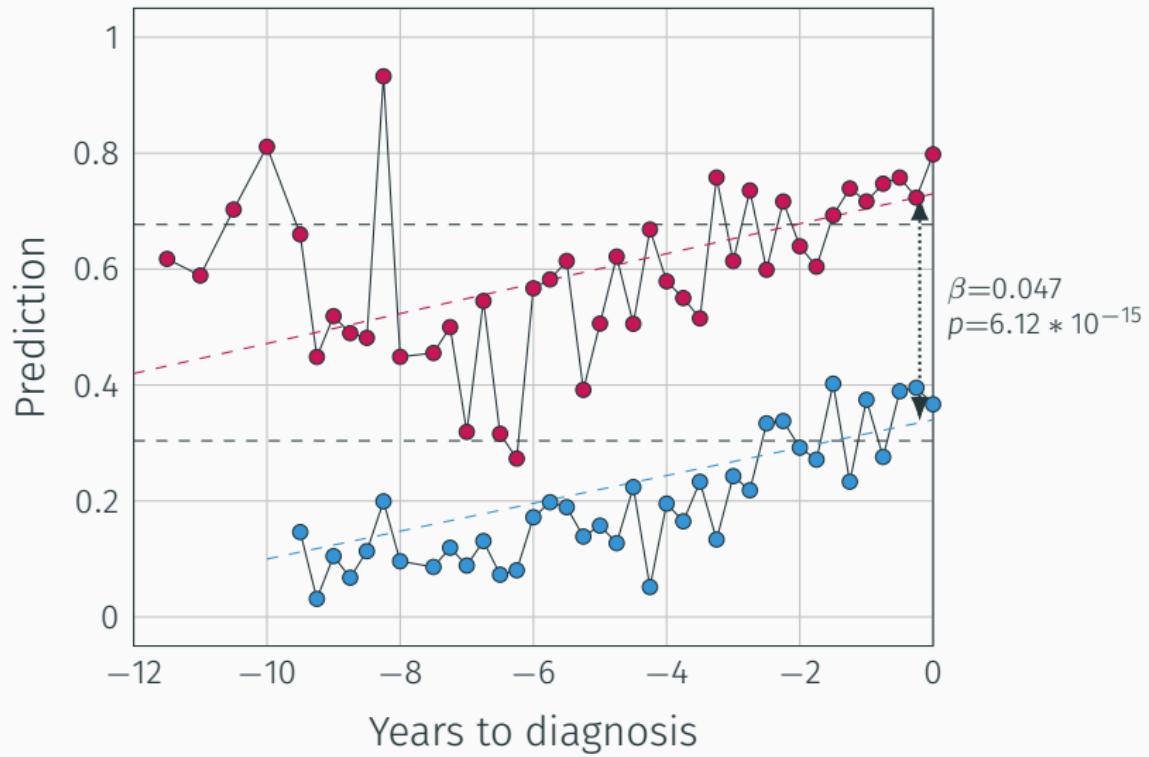
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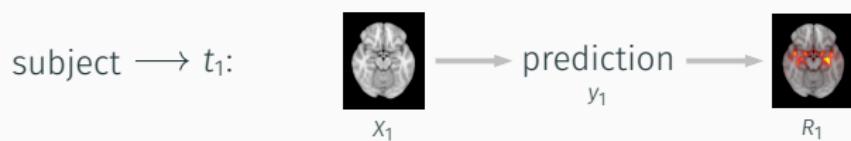
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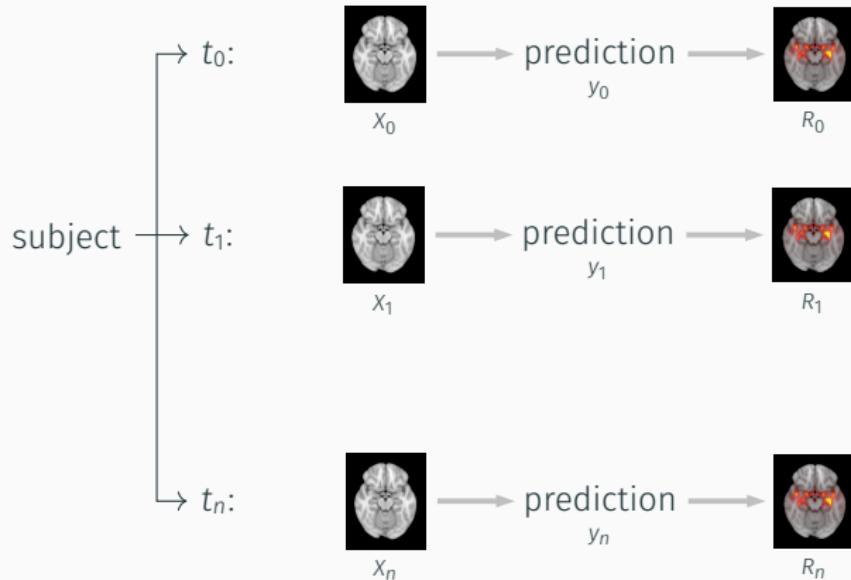
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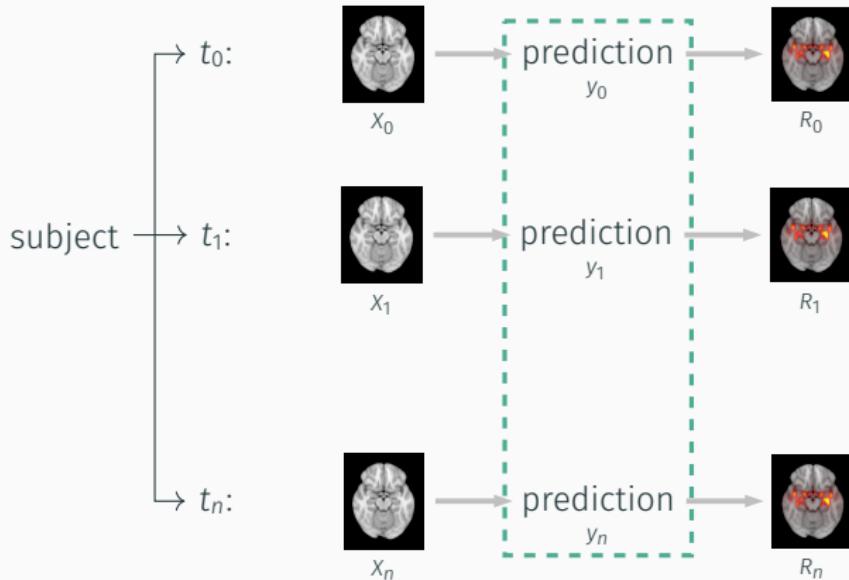
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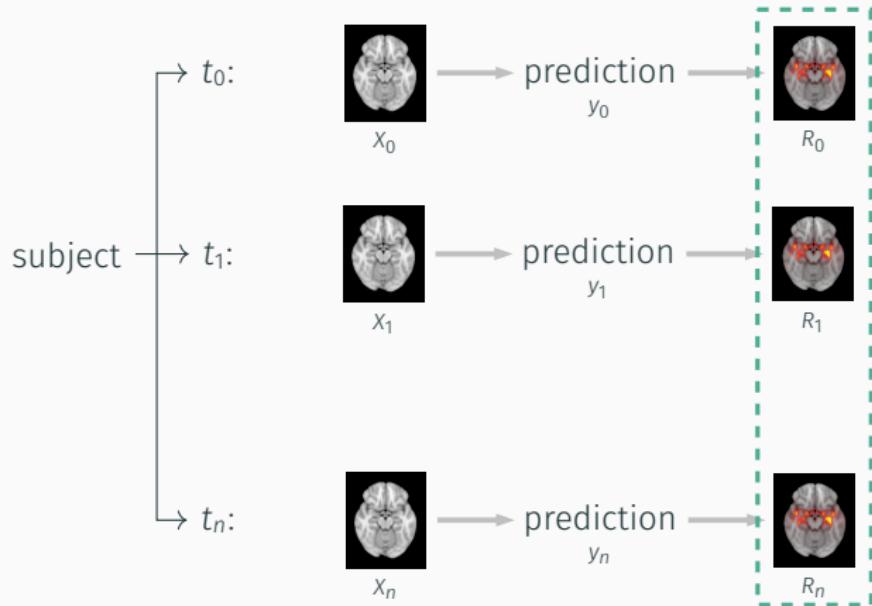
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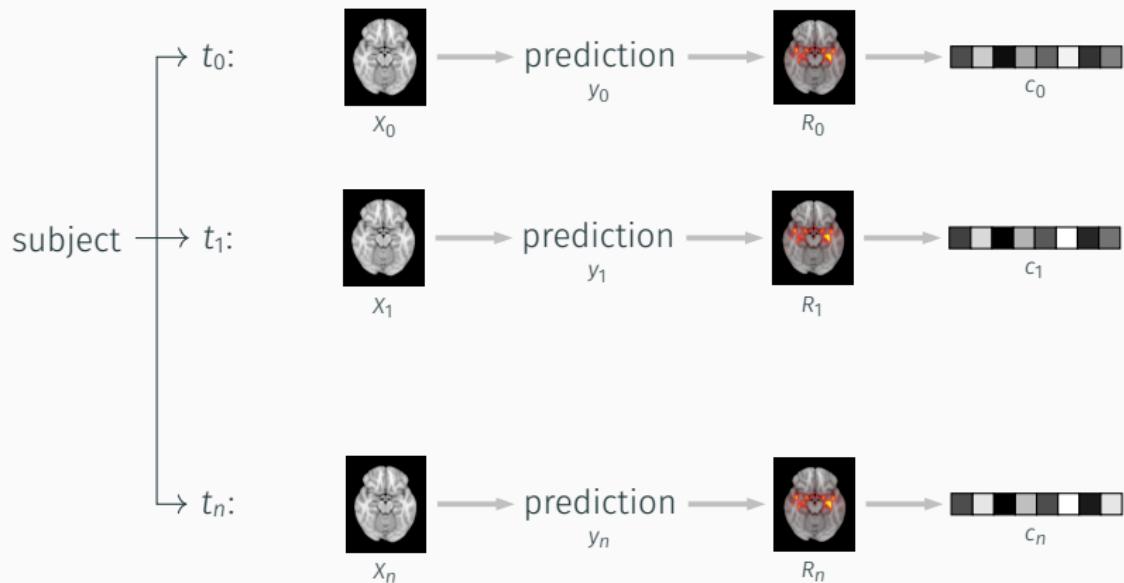
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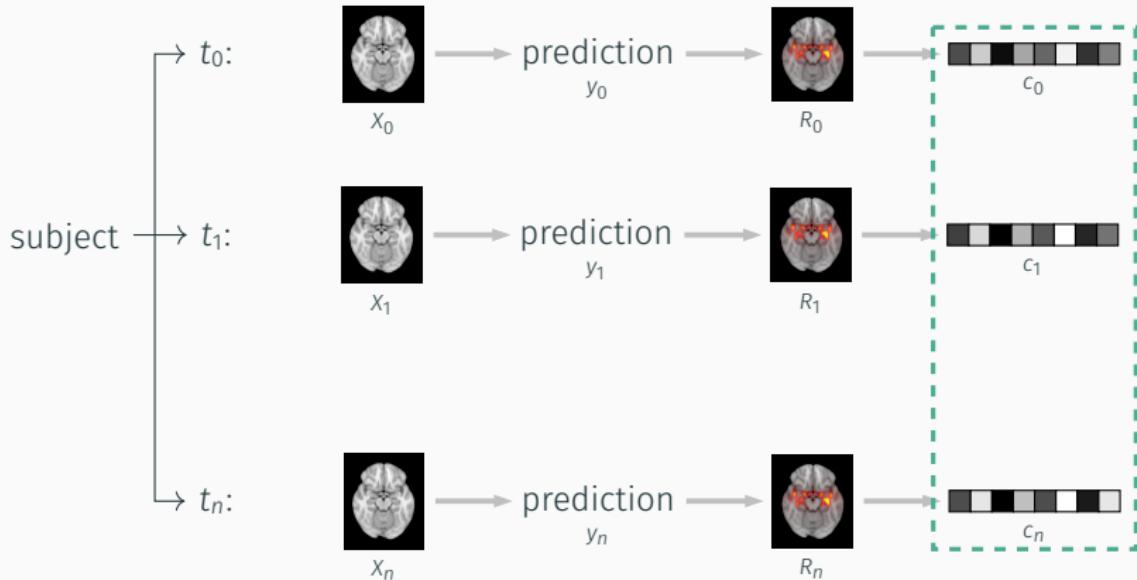
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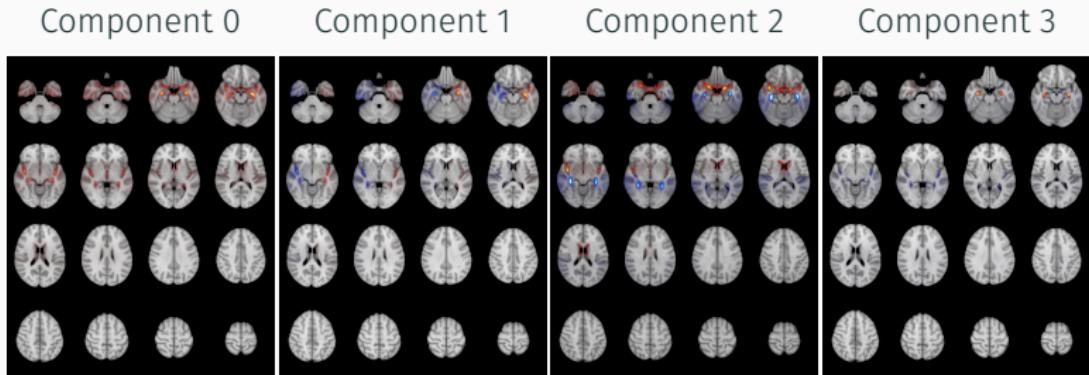
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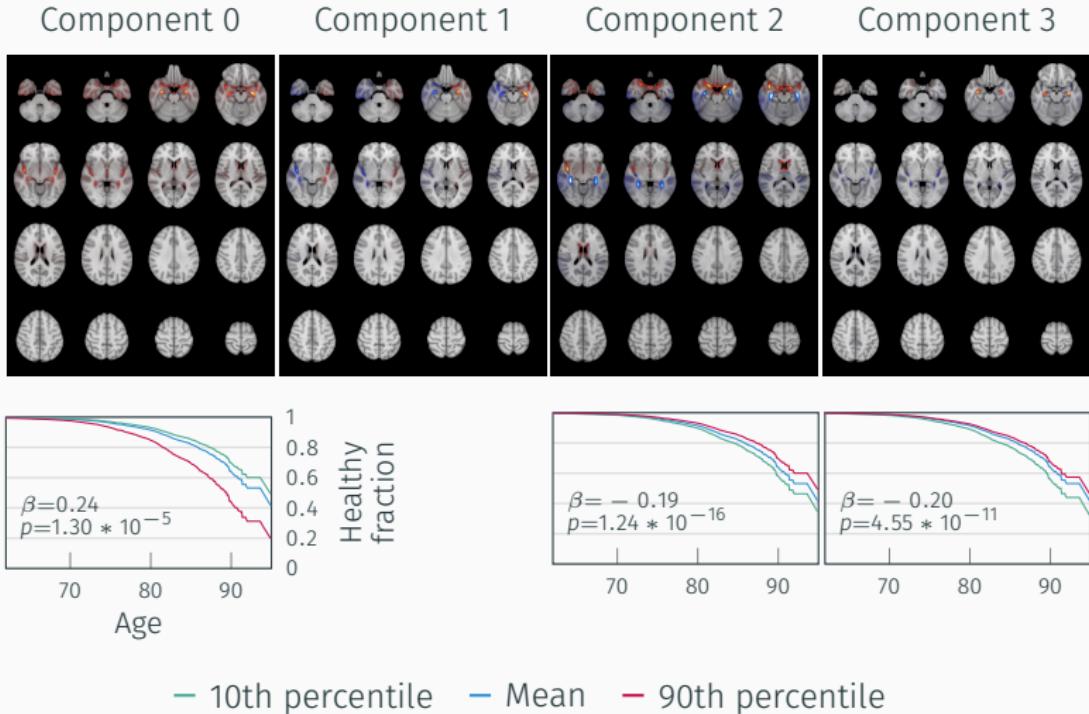
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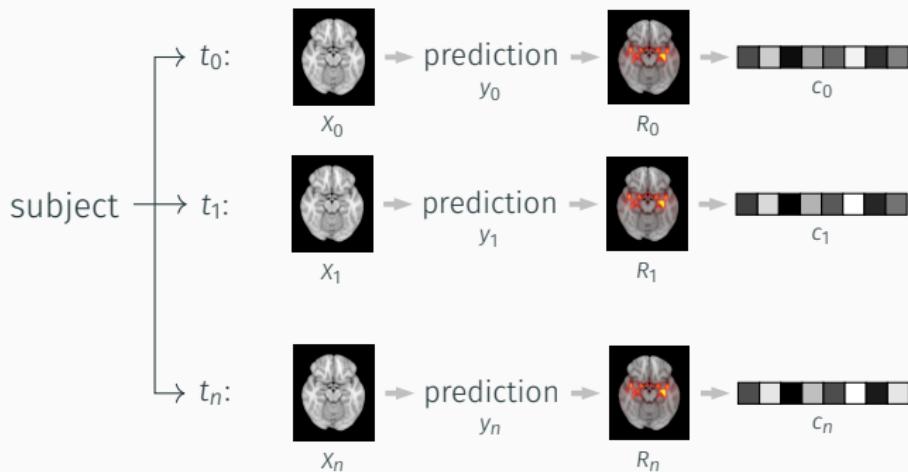
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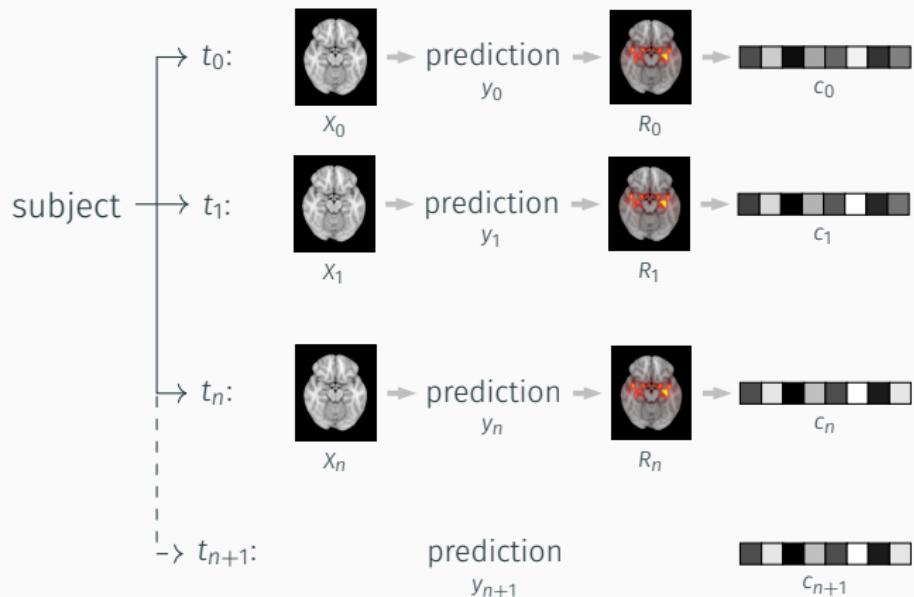
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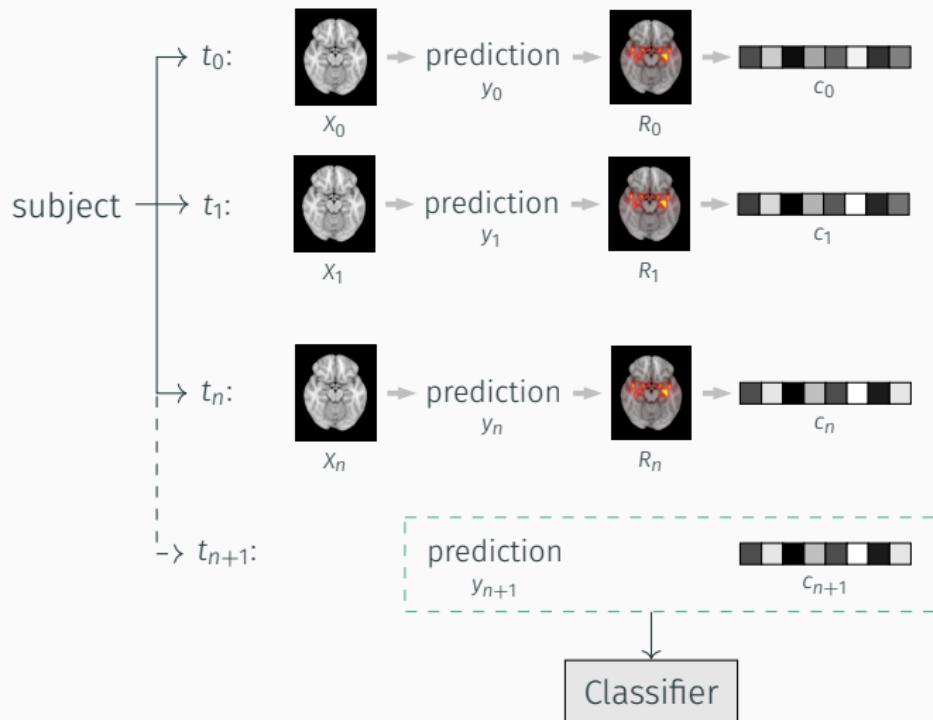
Exploring relevance maps in MCI patients



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Exploring relevance maps in MCI patients

Predictors	AUC	Accuracy	PPV	Sensitivity	Specificity
age + sex	0.476 ± 0.0711	47.80 ± 7.18	0.58 ± 0.08	0.66 ± 0.11	0.29 ± 0.15
age + sex + \hat{y}_n	0.810 ± 0.125	74.94 ± 11.23	0.82 ± 0.12	0.72 ± 0.13	0.77 ± 0.14
age + sex + $\hat{y}_n + c_n$	0.815 ± 0.117	68.02 ± 7.52	0.87 ± 0.12	0.44 ± 0.09	0.91 ± 0.07
age + sex + $\hat{y}_n^* + c_n^*$	0.825 ± 0.122	75.98 ± 12.57	0.83 ± 0.11	0.72 ± 0.13	0.79 ± 0.13
age + sex + $\hat{y}_{n+1}^* + c_{n+1}^*$	0.831 ± 0.129	78.18 ± 12.09	0.84 ± 0.10	0.78 ± 0.13	0.78 ± 0.15

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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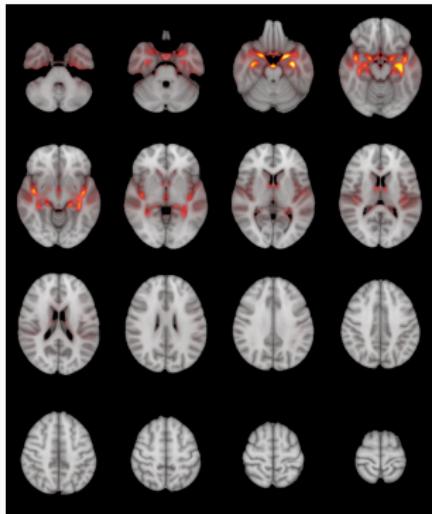


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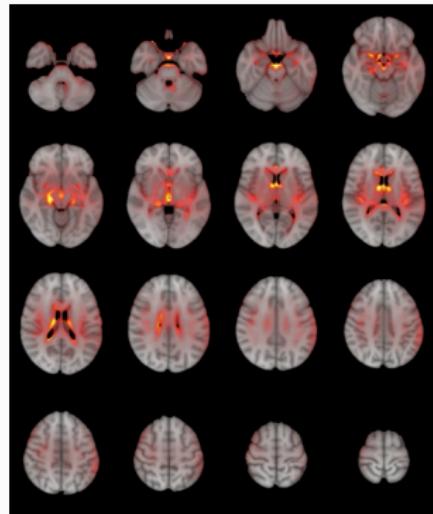


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But wait



Dementia



Multiple Sclerosis