

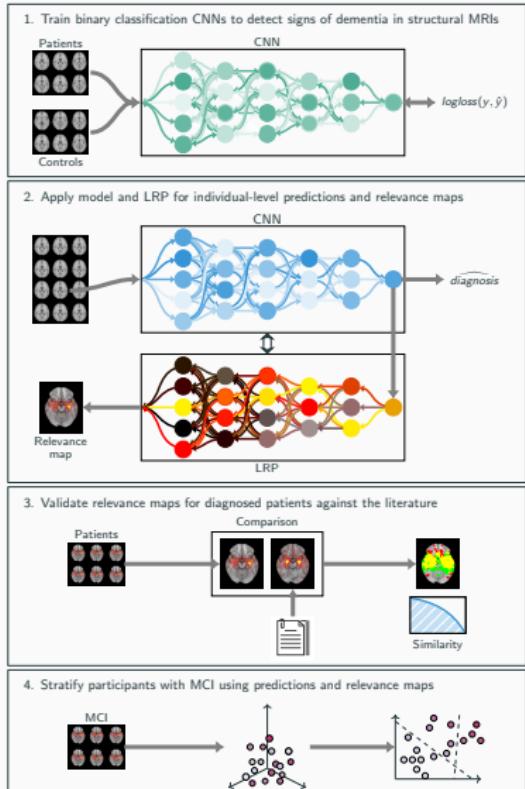
Detecting individual-level deviations in brain morphology in MCI with explainable AI

Esten Høyland Leonardsen

27.09.22

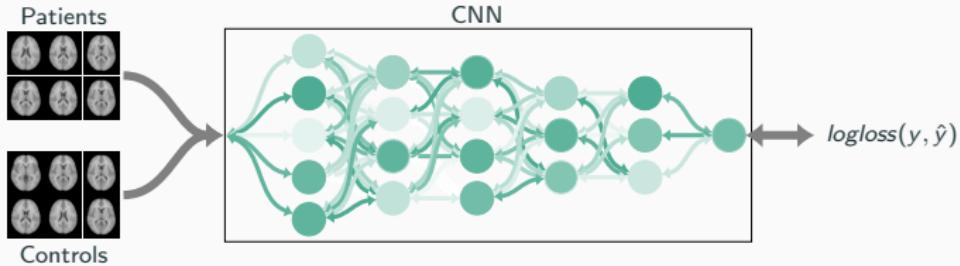
UiO:Life Science, University of Oslo

Overview

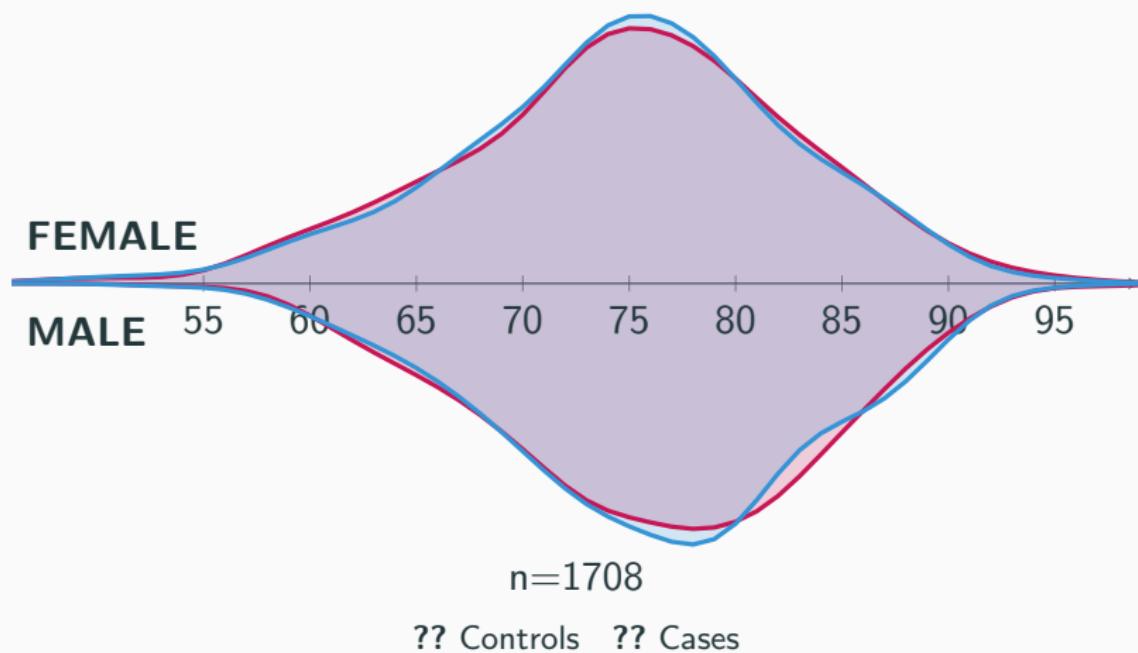


Case-control predictions

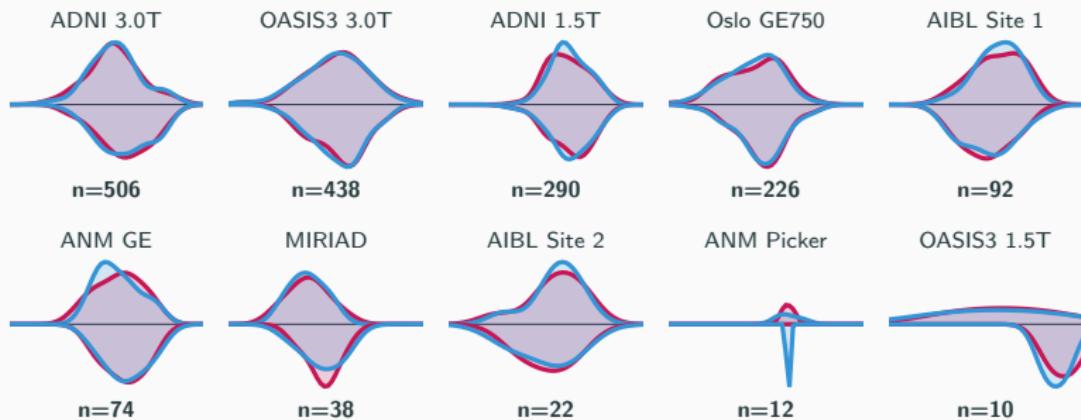
1. Train binary classification CNNs to detect signs of dementia in structural MRIs



Case-control predictions



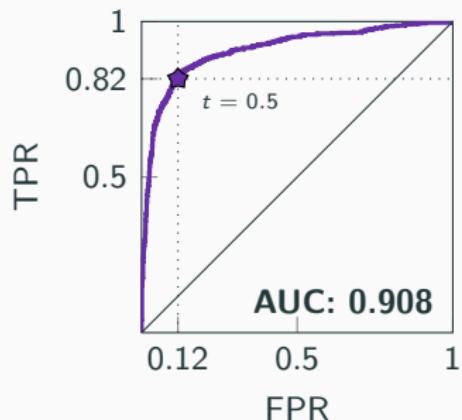
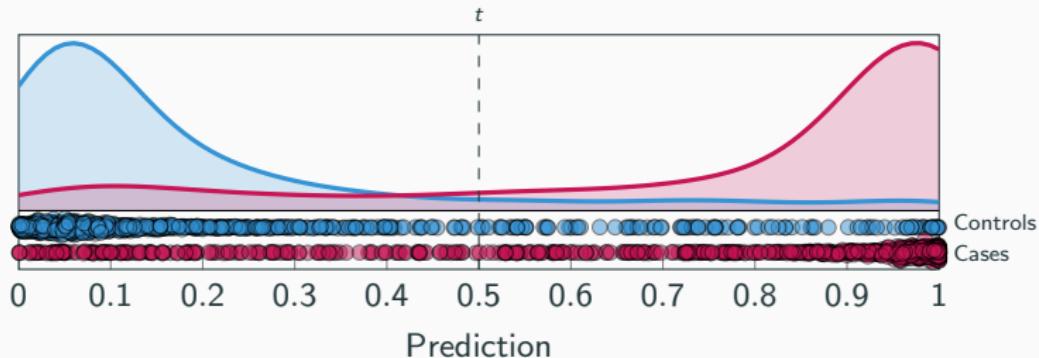
Case-control predictions



Case-control predictions

Dataset	Controls	Patients
AddNeuroMed	$\text{MMSE} \geq 24$	$\text{MMSE} < 19$
ADNI	Group = CN	Group = AD
AIBL	Group = DXNORM	$\text{Group} \in \{\text{DXAD}, \text{DXOTHDEM}\}$
Demgen	-	$\text{DX} \in \{\text{AD}, \text{OtherDem}, \text{UnspecDem}, \text{VaD}\}$
MIRIAD	Group = Control	Group = AD
OASIS3	$\text{NORMCOG} = 1$	$\text{NORMCOG} = 0 \ \& \ \text{DEMENTED} = 1$
StrokeMRI	Group = Control	-
TOP	diagnosis = CTRL	-

Case-control predictions



Predicted

	0	1
0	754	100
1	157	697

Observed

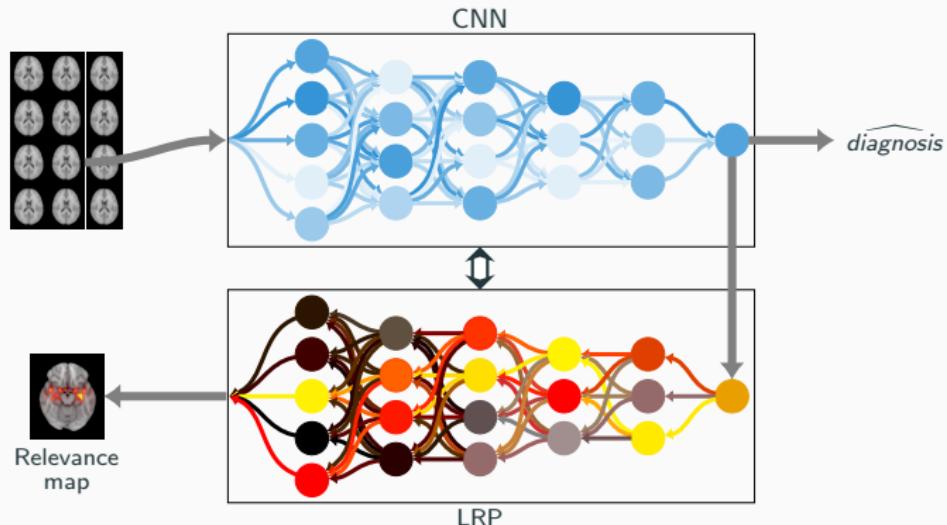
Accuracy: 84.95%

Case-control predictions

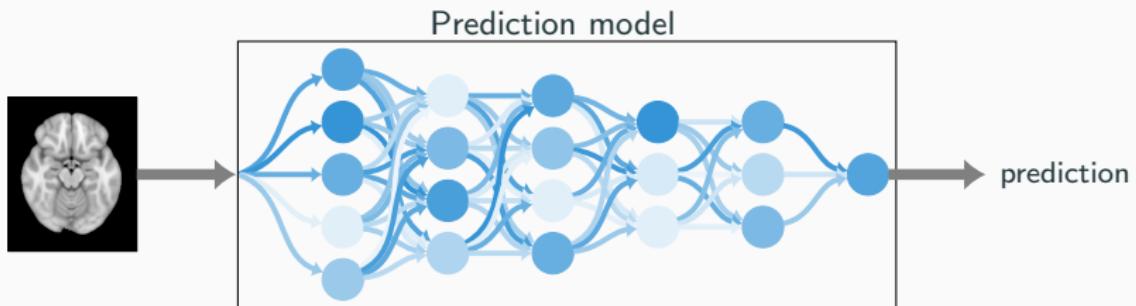
Sites	Size	AUC	Accuracy	Confusion Matrix	
ADNI 3.0T	506	0.942	90.11	237	16
				34	219
OASIS 3.0T	438	0.850	79.45	185	34
				56	163
ADNI 1.5T	290	0.944	87.93	125	20
				15	130
Oslo GE750	226	0.900	84.07	102	11
				25	88
AIBL Site 1	92	0.906	84.78	43	3
				11	35
ANM GE	74	0.848	72.97	26	11
				9	28
Miriad 1.5T	38	0.997	97.36	19	0
				1	18
AIBL Site 2	22	0.950	86.36	11	0
				3	8
OASIS 1.5T	12	0.666	58.33	3	3
				2	4
ANM Picker	10	0.76	70.00	3	2
				1	4

Generating relevance maps

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

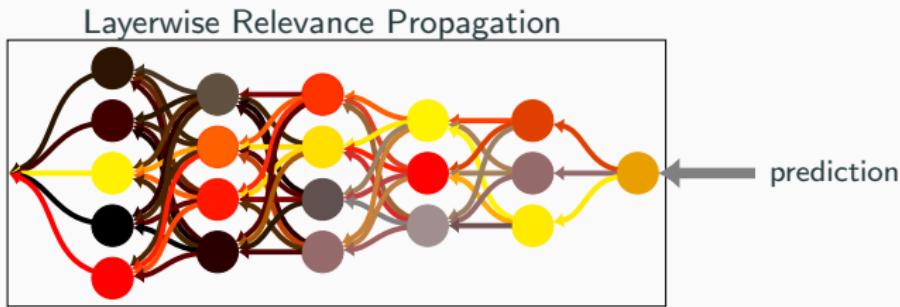


Generating relevance maps



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

Generating relevance maps



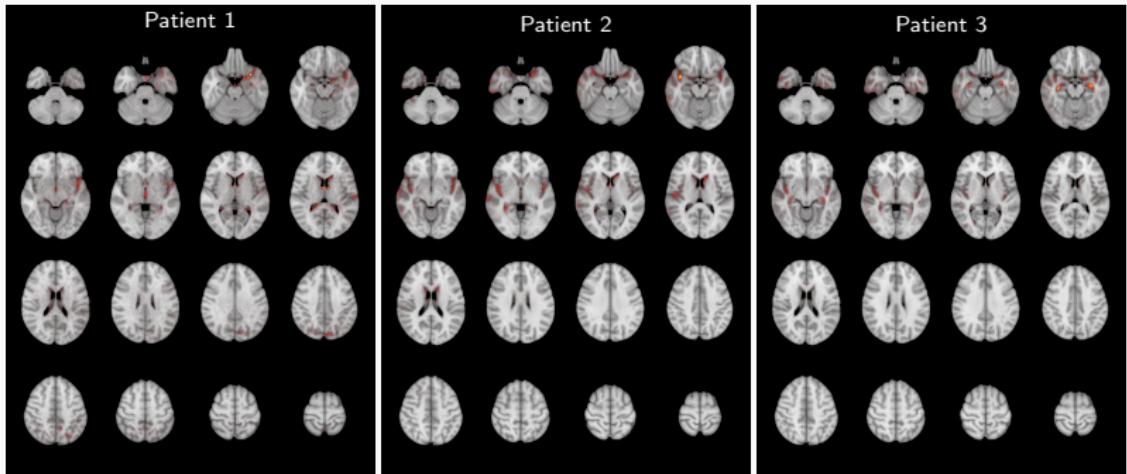
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

Generating relevance maps



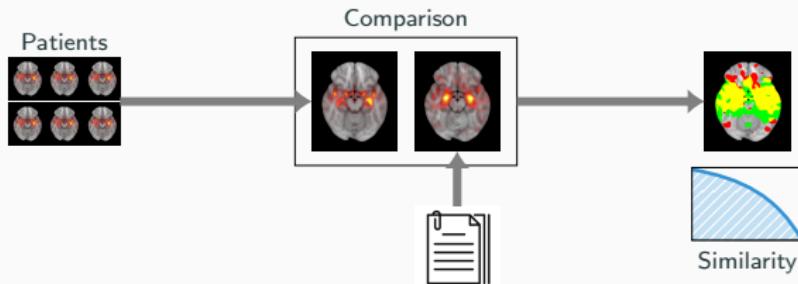
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Generating relevance maps



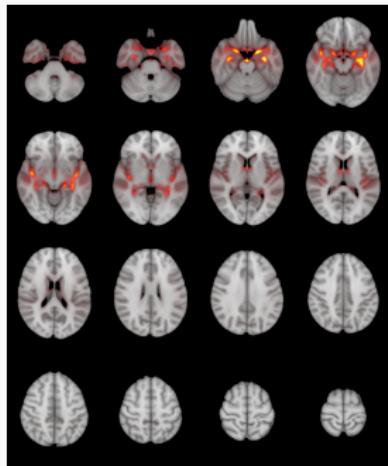
Validating relevance maps in dementia patients

3. Validate relevance maps for diagnosed patients against the literature

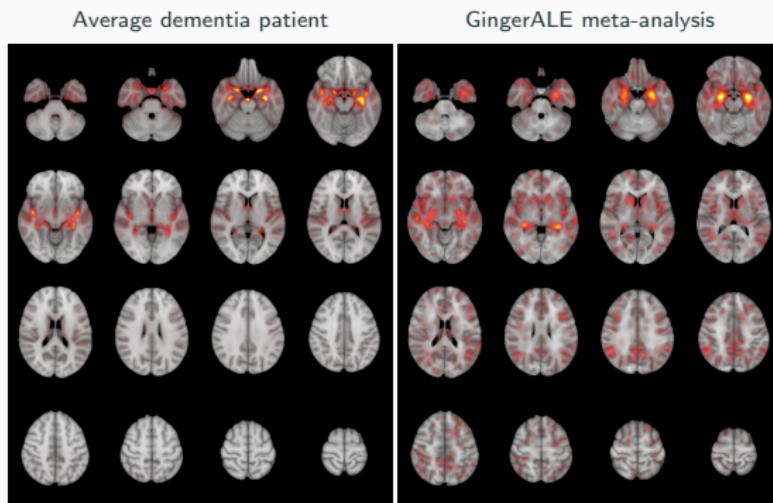


Validating relevance maps in dementia patients

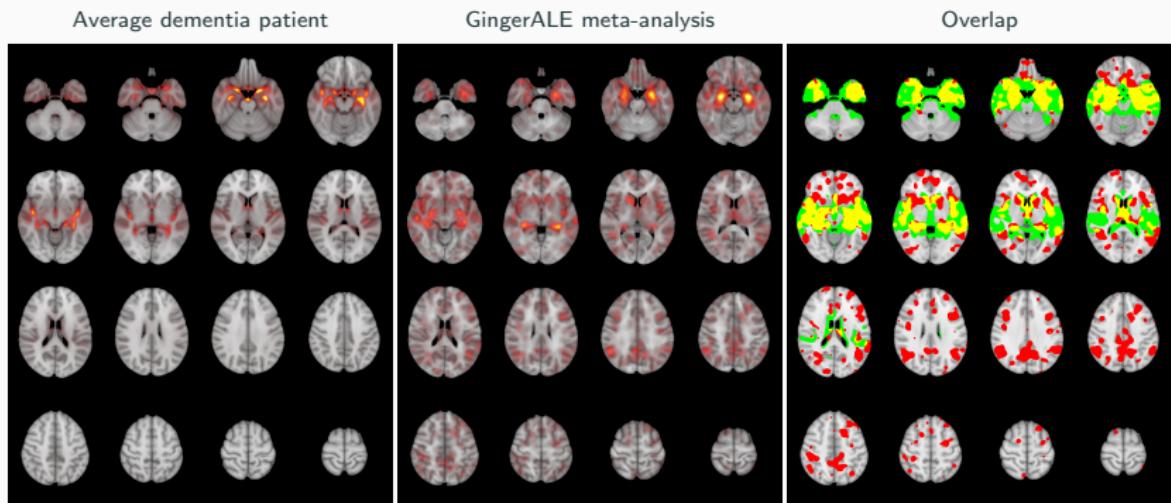
Average dementia patient



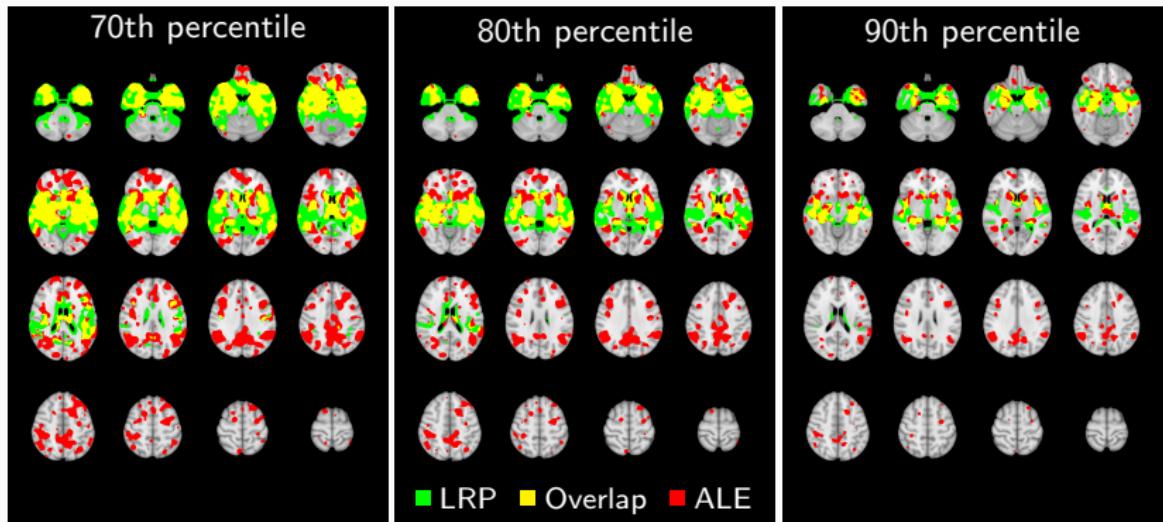
Validating relevance maps in dementia patients



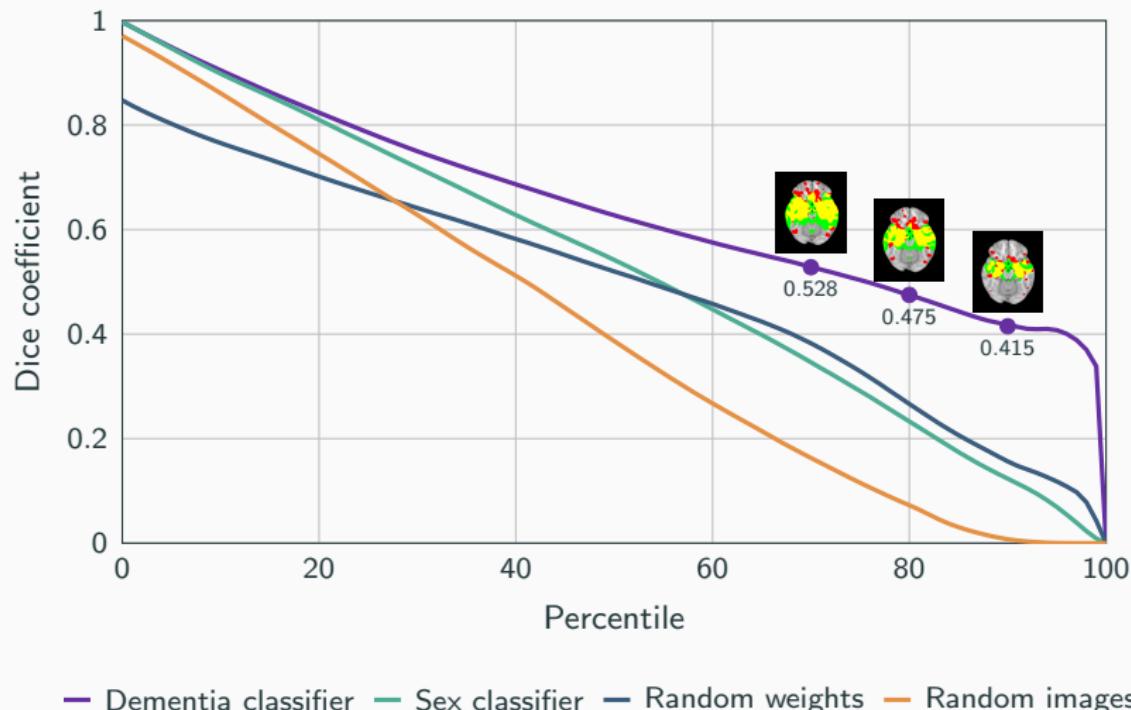
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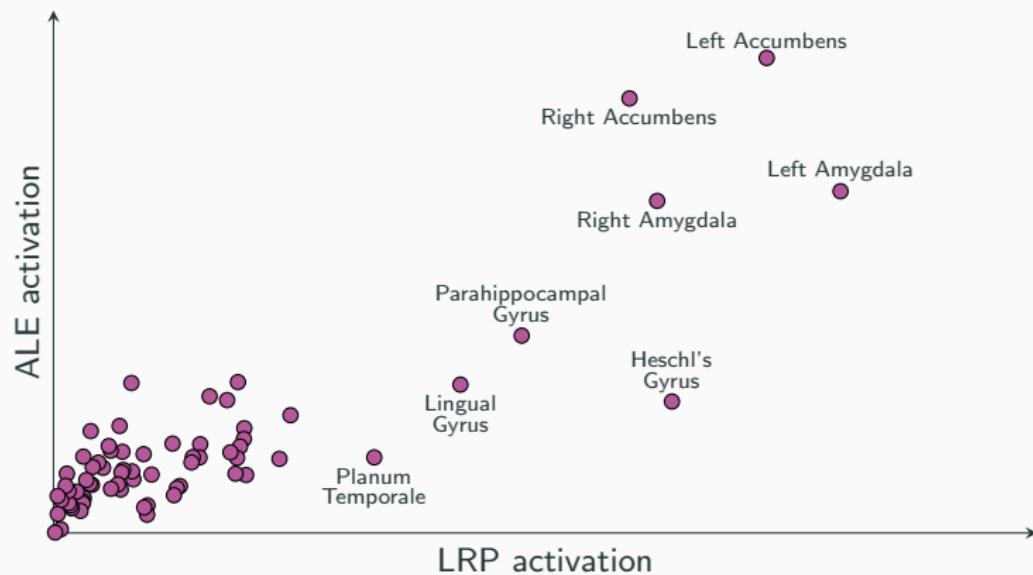
Validating relevance maps in dementia patients



Validating relevance maps in dementia patients

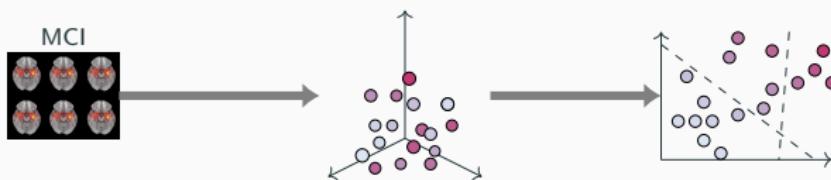


Validating relevance maps in dementia patients

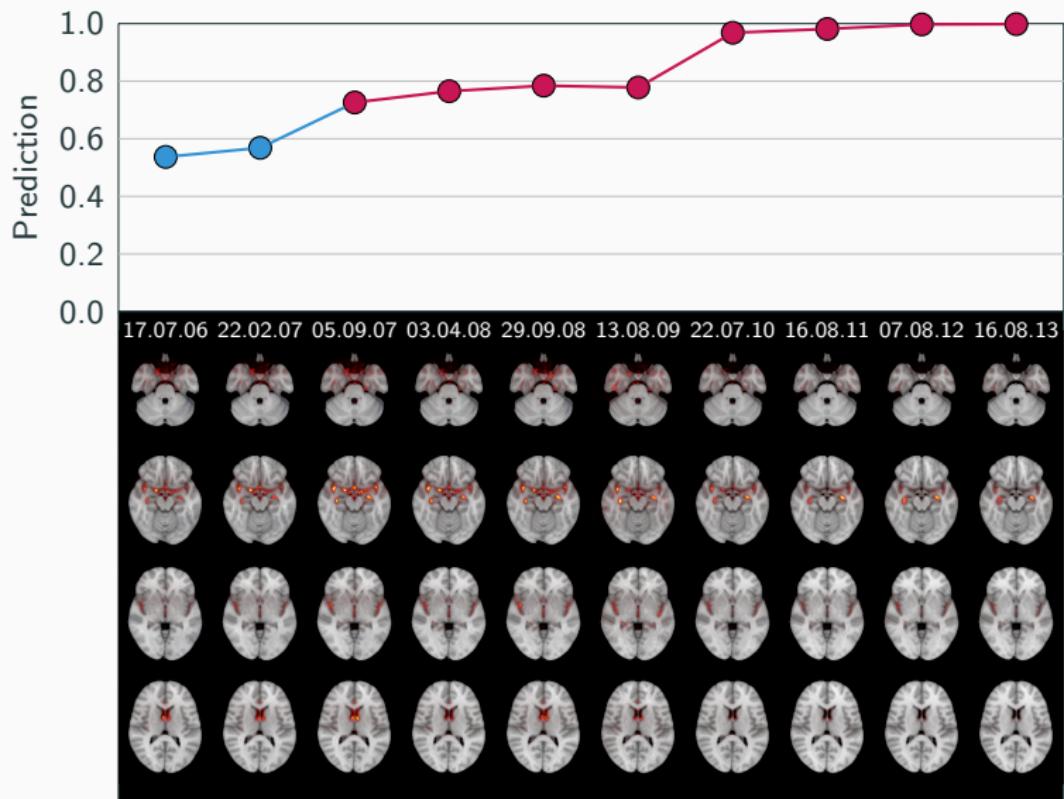


Exploring relevance maps in MCI patients

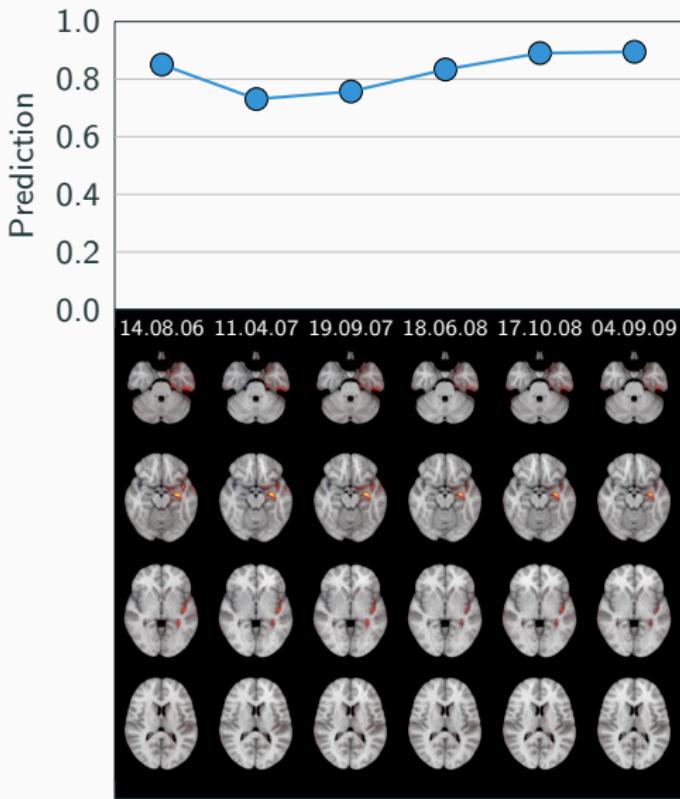
4. Stratify participants with MCI using predictions and relevance maps



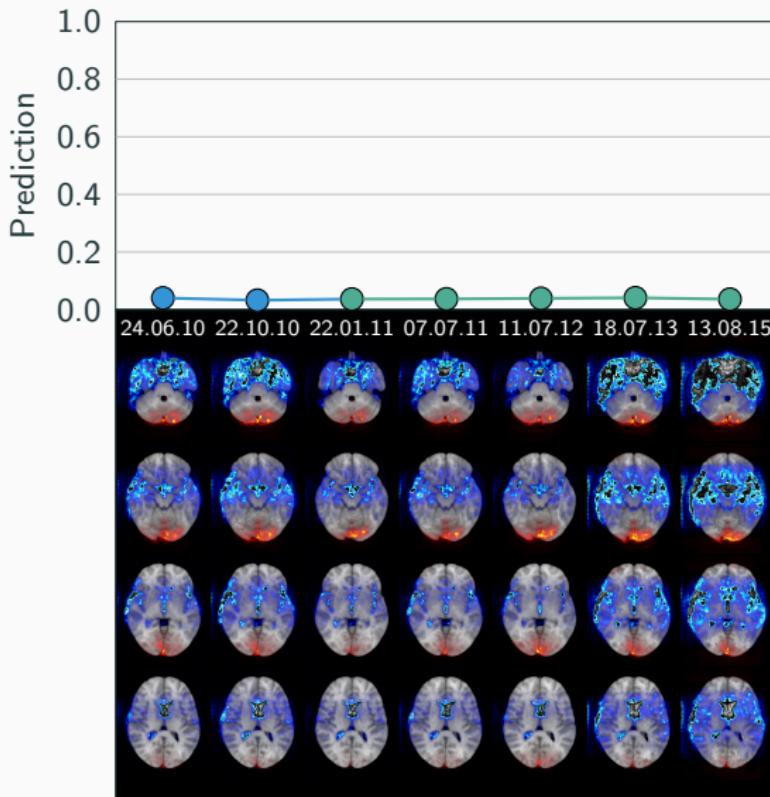
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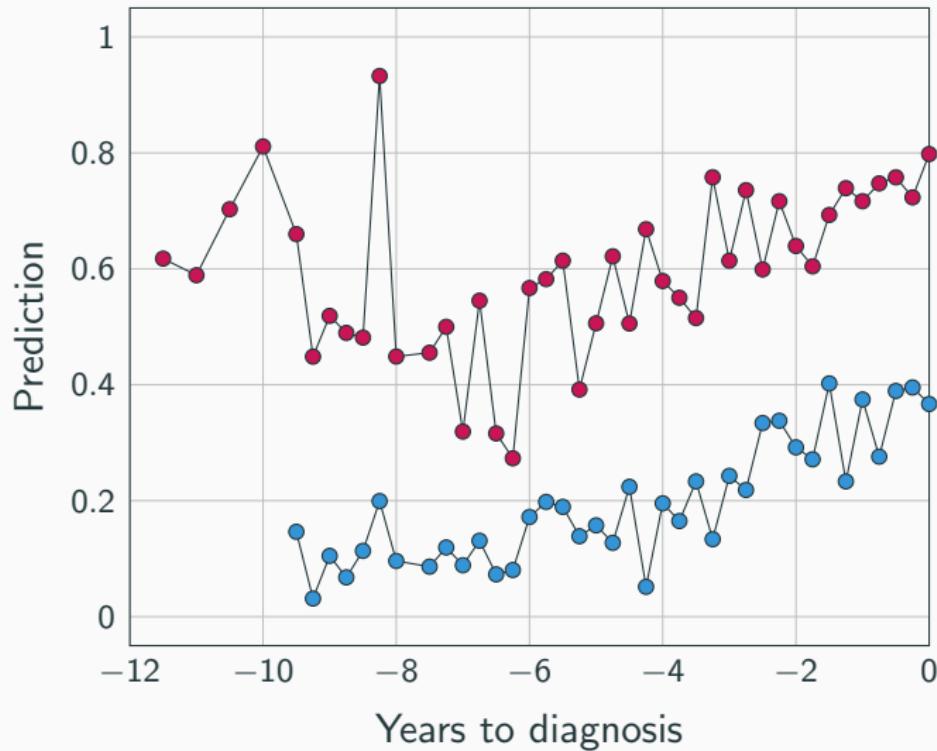
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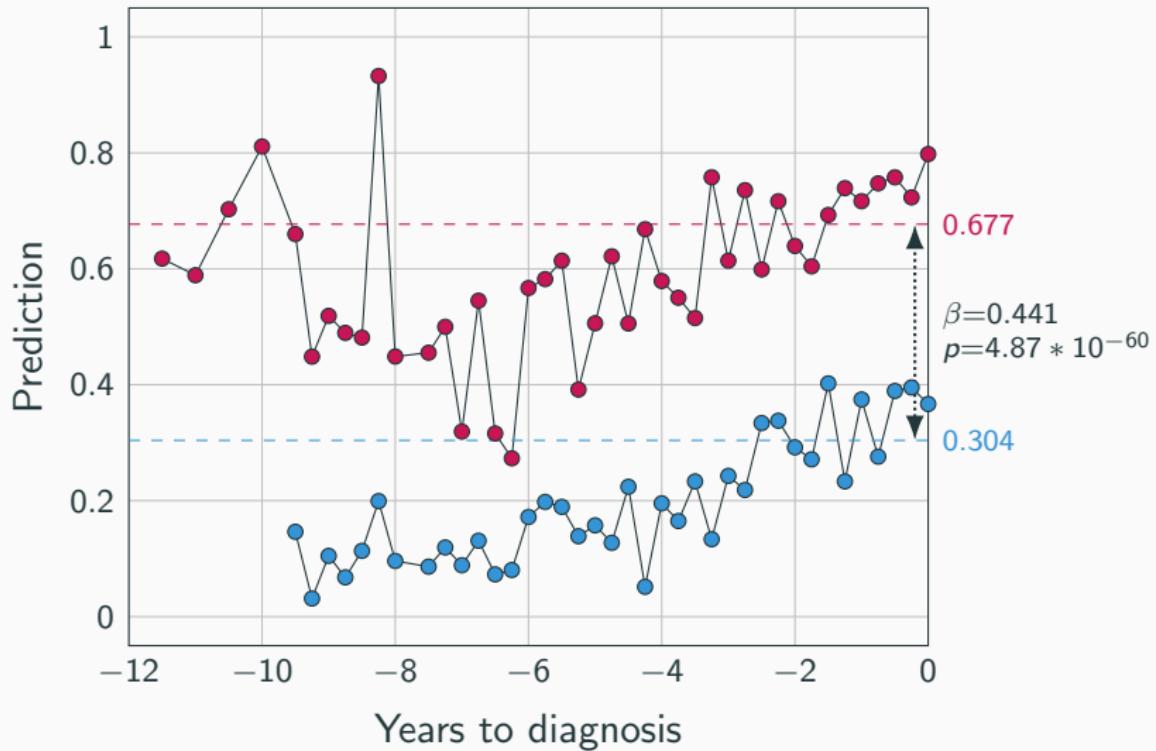
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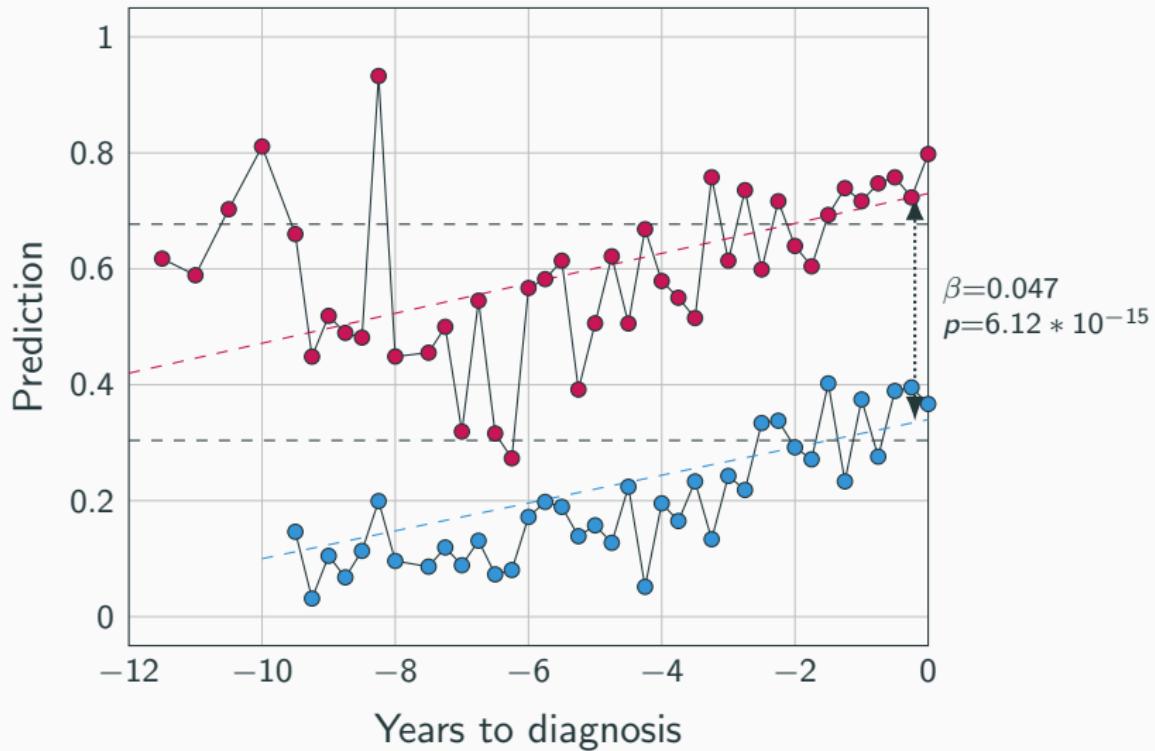
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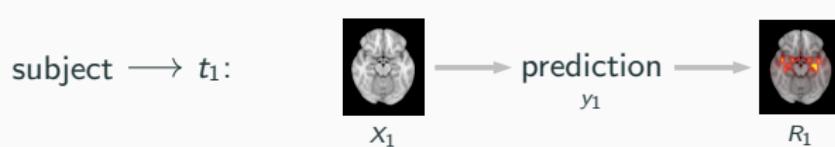
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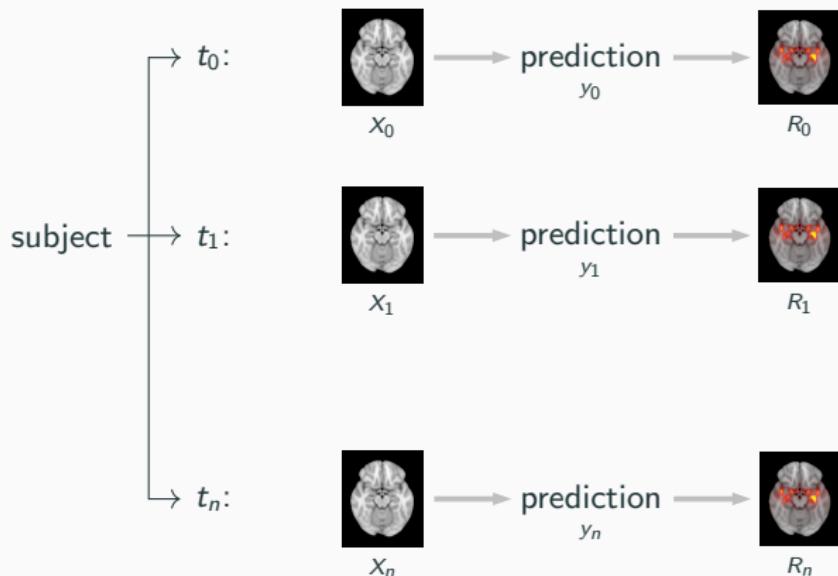
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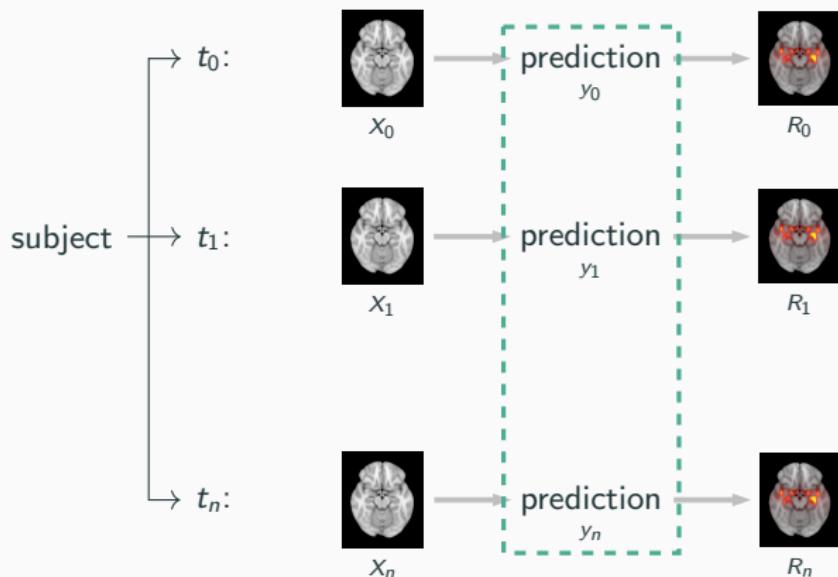
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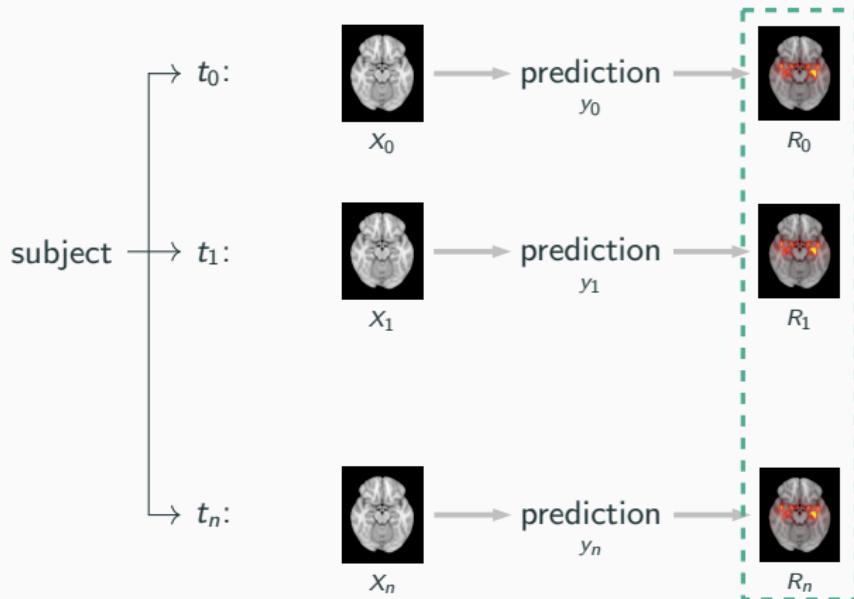
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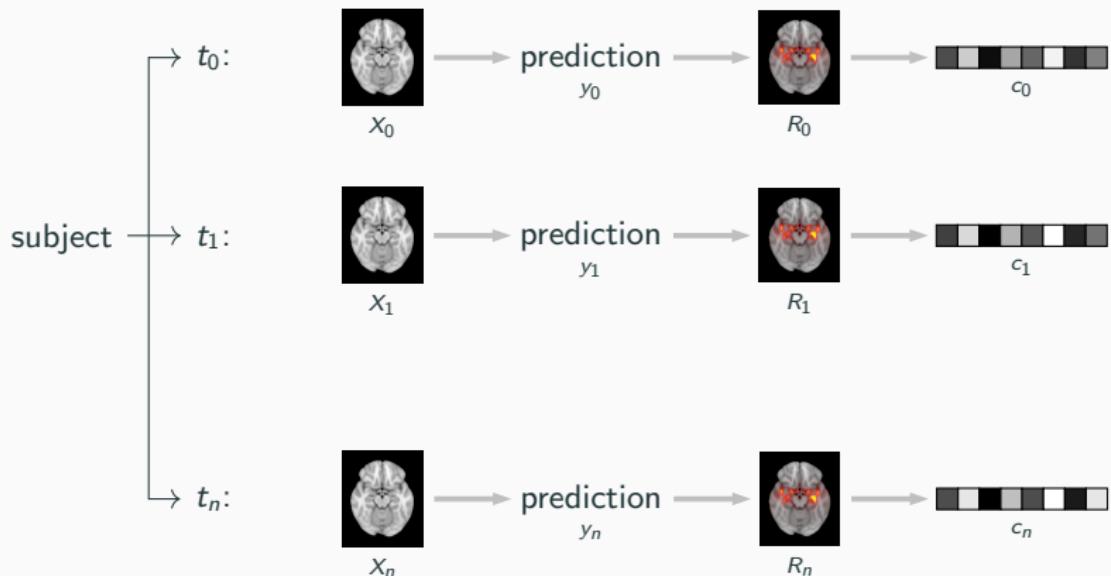
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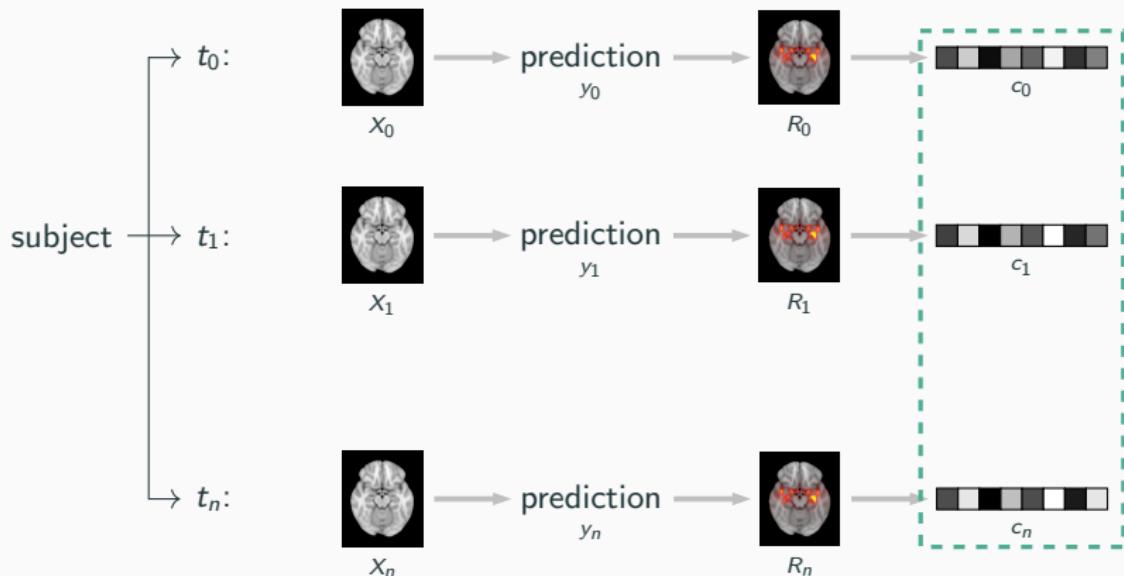
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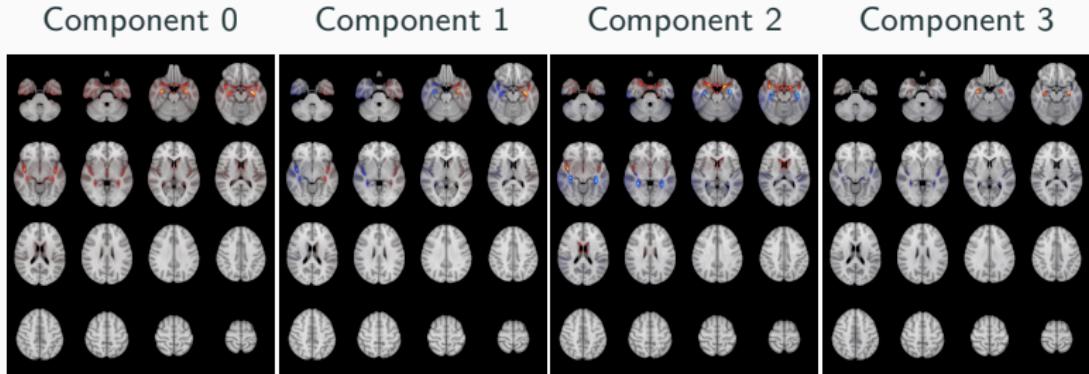
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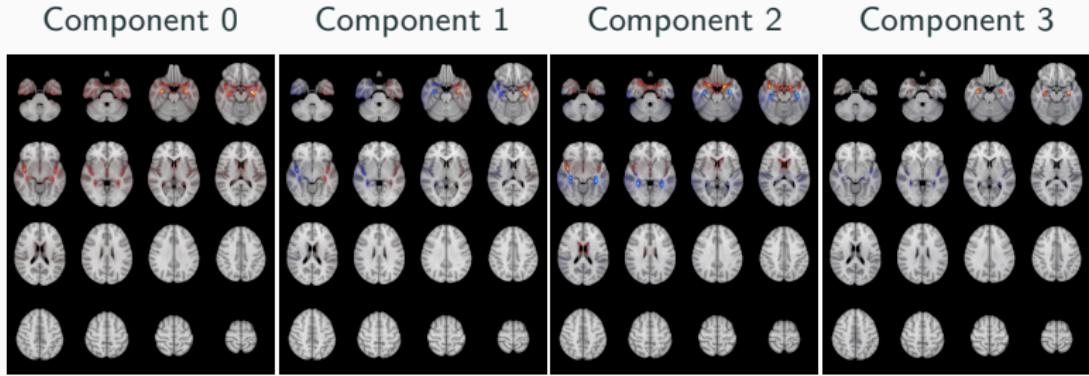
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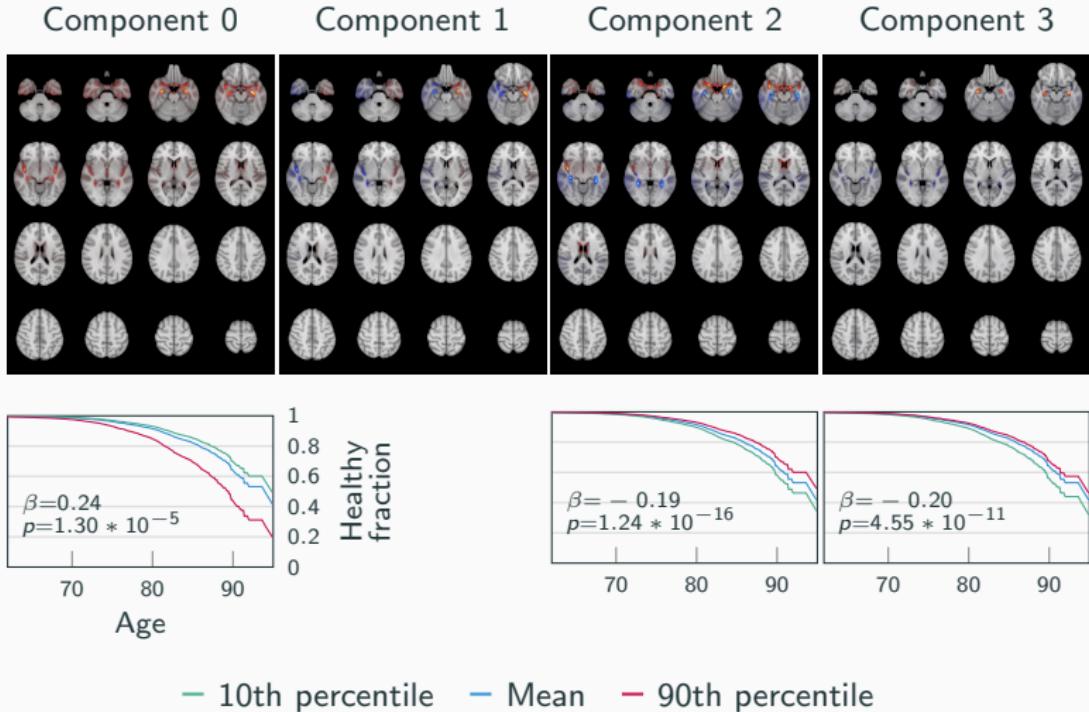


$$p=1.19 * 10^{-15}$$

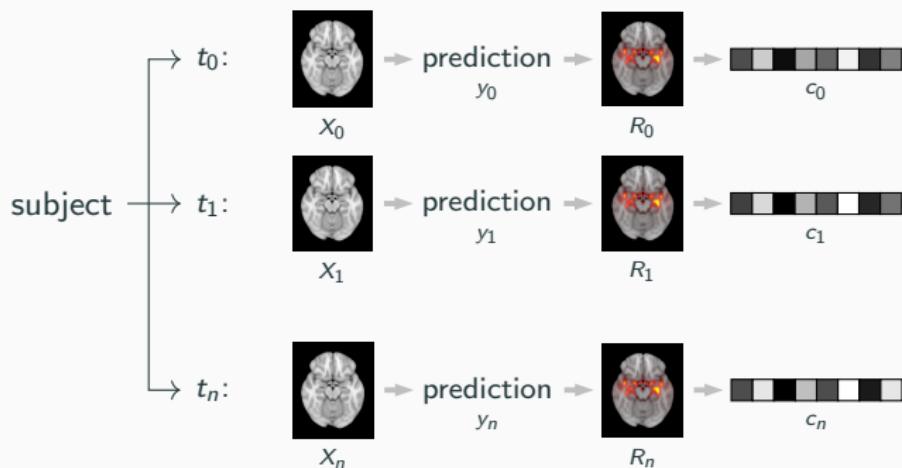
$$p=6.62 * 10^{-4}$$

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

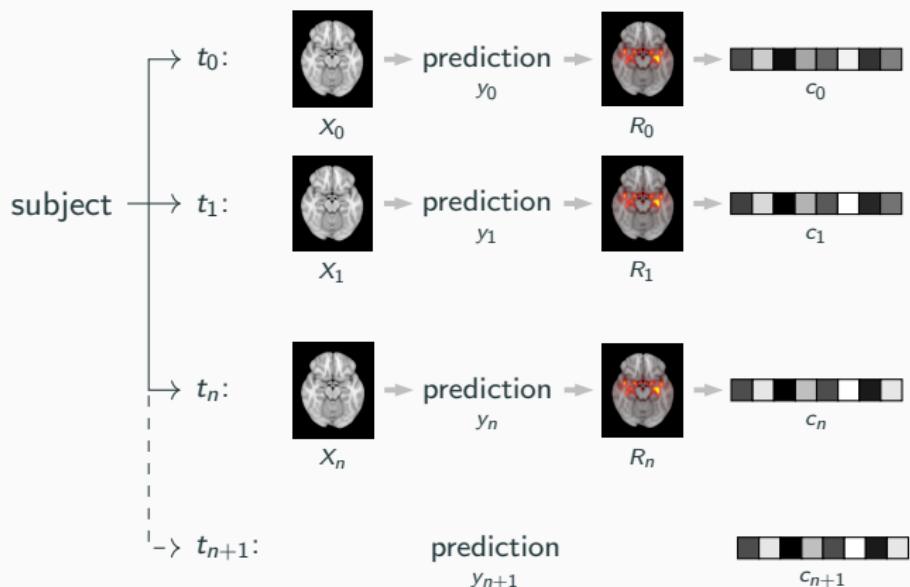
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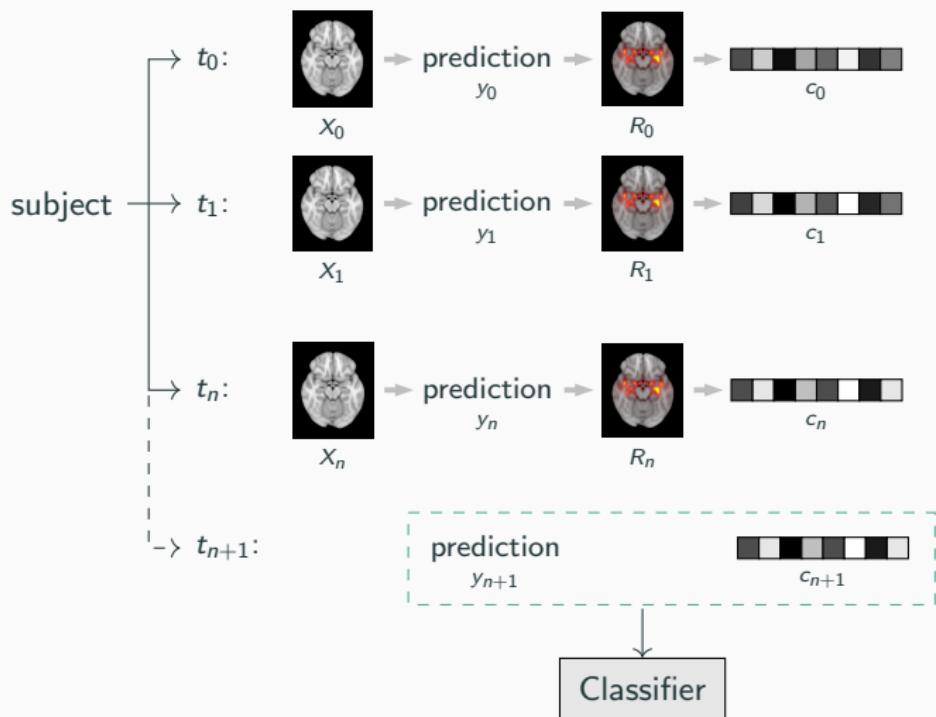
Exploring relevance maps in MCI patients



Exploring relevance maps in MCI patients



Exploring relevance maps in MCI patients



Exploring relevance maps in MCI patients

Covariates	AUC	Balanced accuracy
age+sex+age:sex	0.515	50.40%
age+sex+age:sex+ y_n	0.719	59.12%
age+sex+age:sex+ $\hat{y}_{n+1} + \hat{c}_{n+1}$	0.822	75.06%

Prediction of $diagnosis_{n+1}$

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."