

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

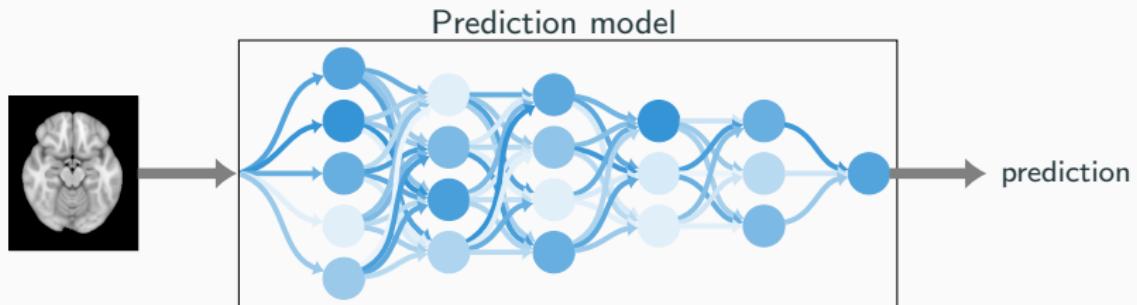
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Esten Høyland Leonardsen

18.10.22

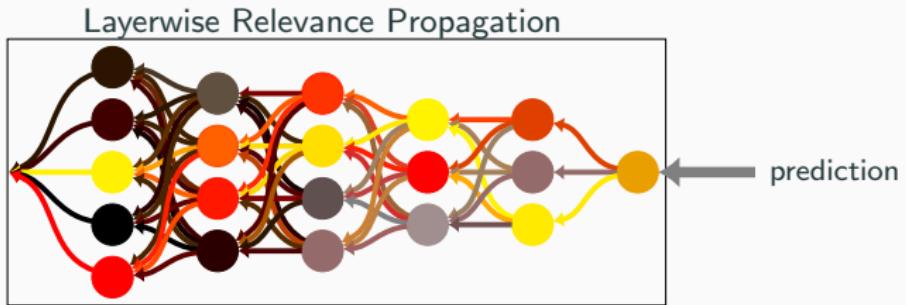
UiO:Life Science, University of Oslo

# Layerwise Relevance Propagation



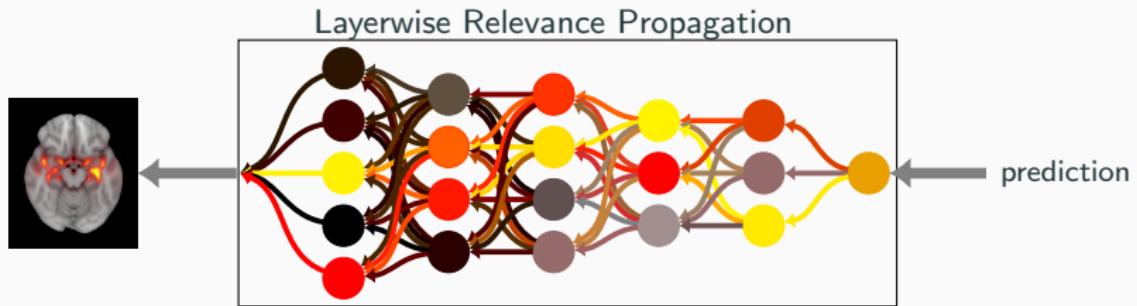
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j}$$

# Layerwise Relevance Propagation



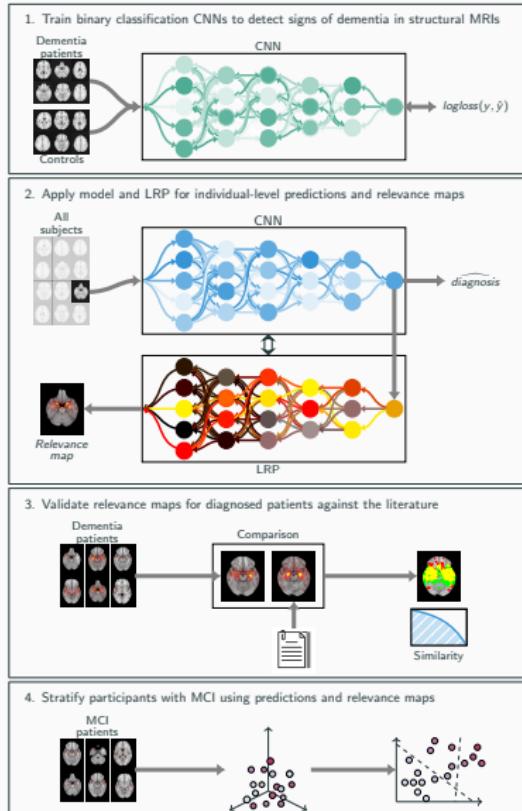
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

# Layerwise Relevance Propagation



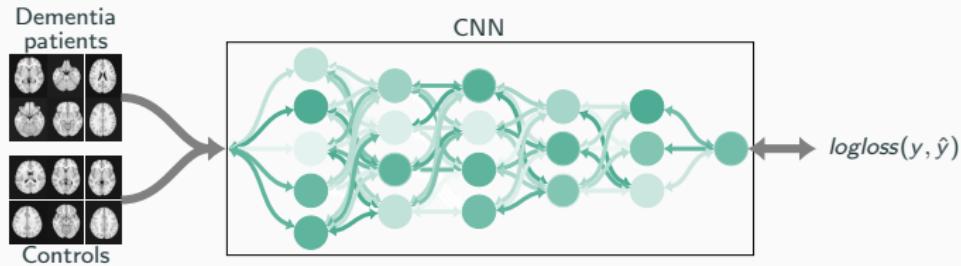
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# Overview

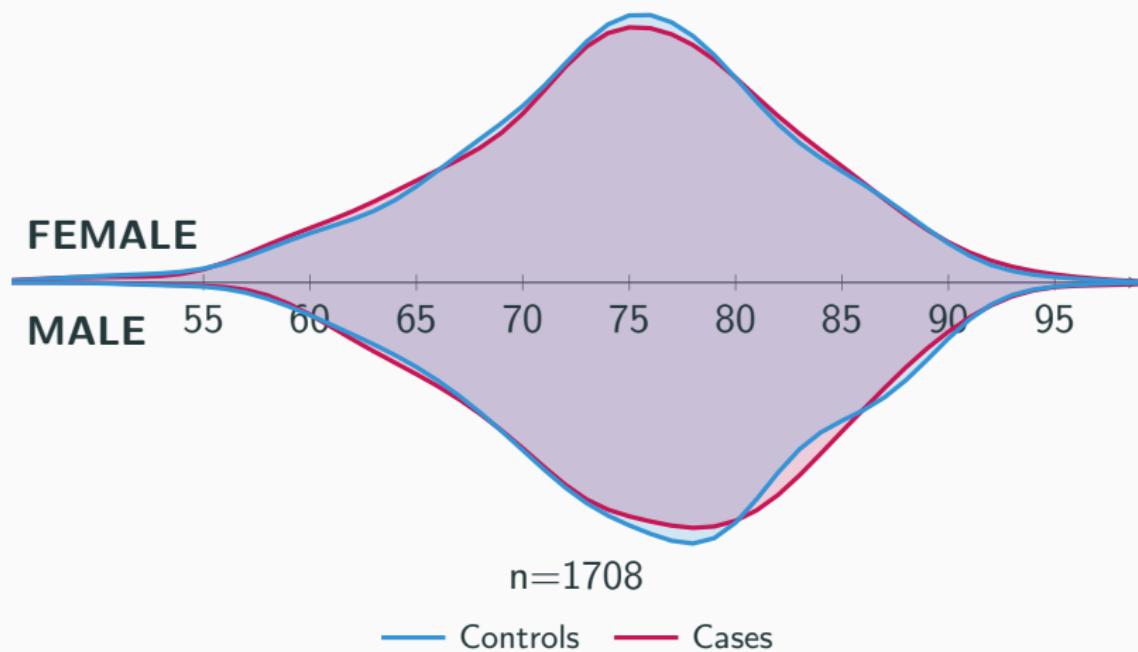


# Case-control predictions

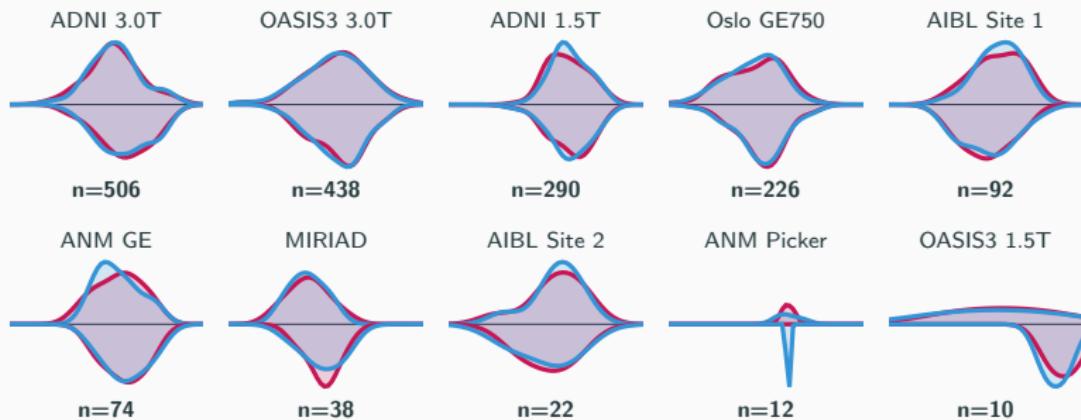
1. Train binary classification CNNs to detect signs of dementia in structural MRIs



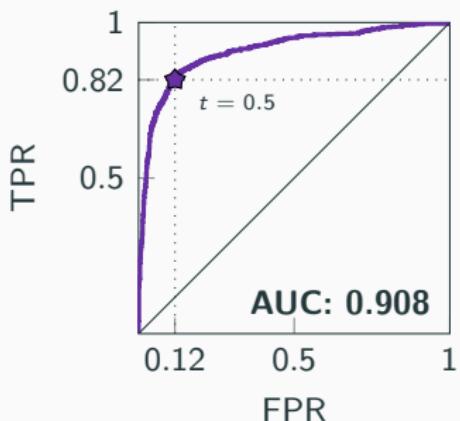
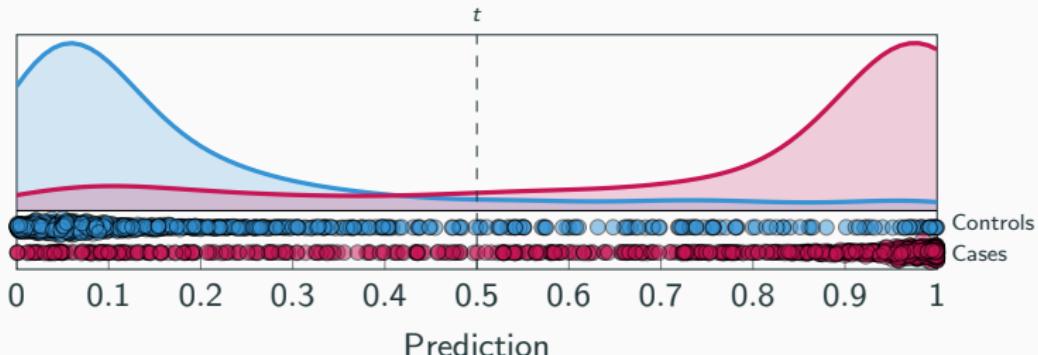
## Case-control predictions



# Case-control predictions



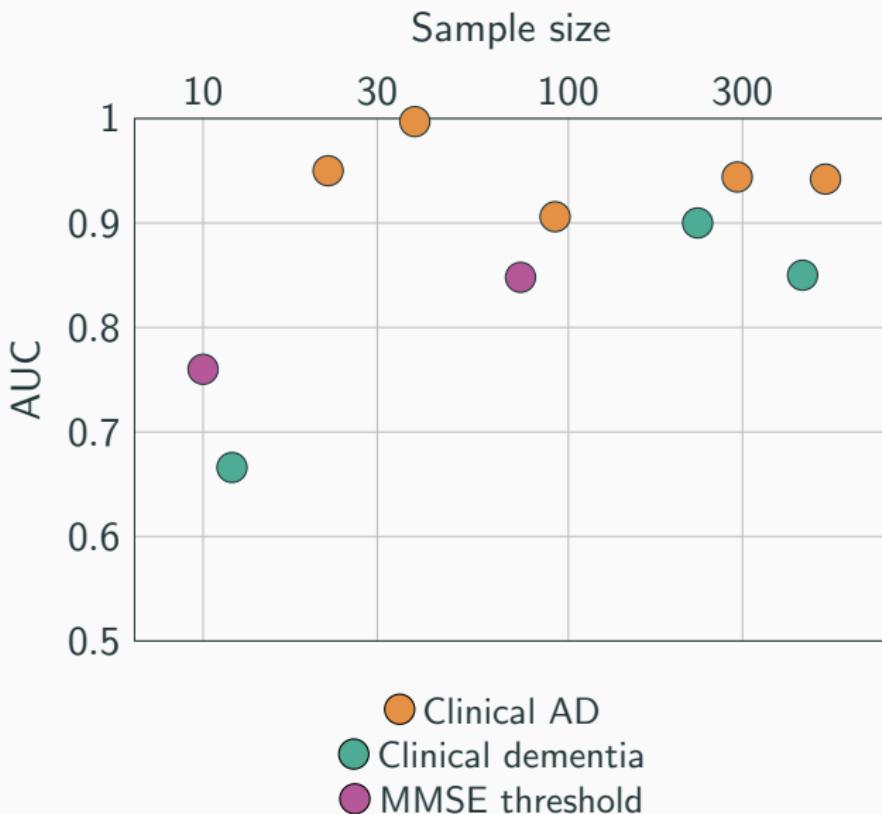
## Case-control predictions



		Predicted	
		0	1
Observed	0	754	100
	1	157	697

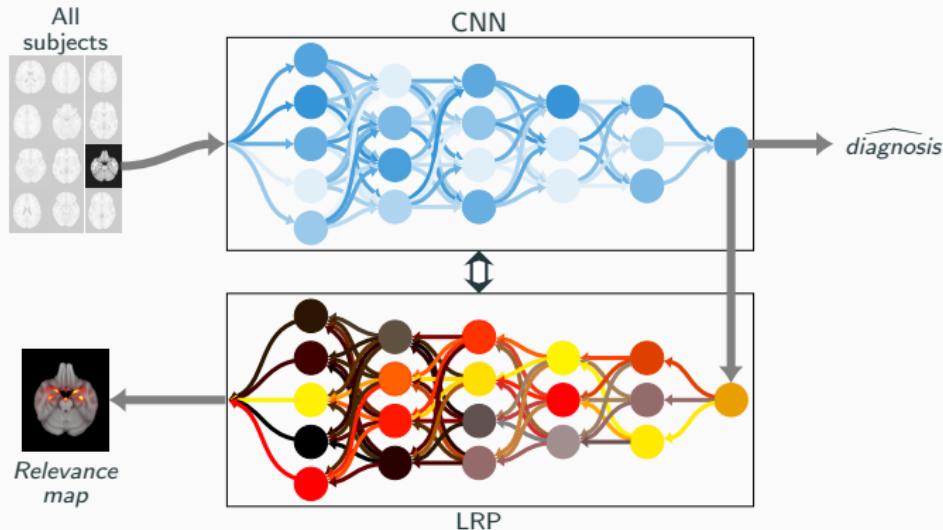
Accuracy: 84.95%

## Case-control predictions

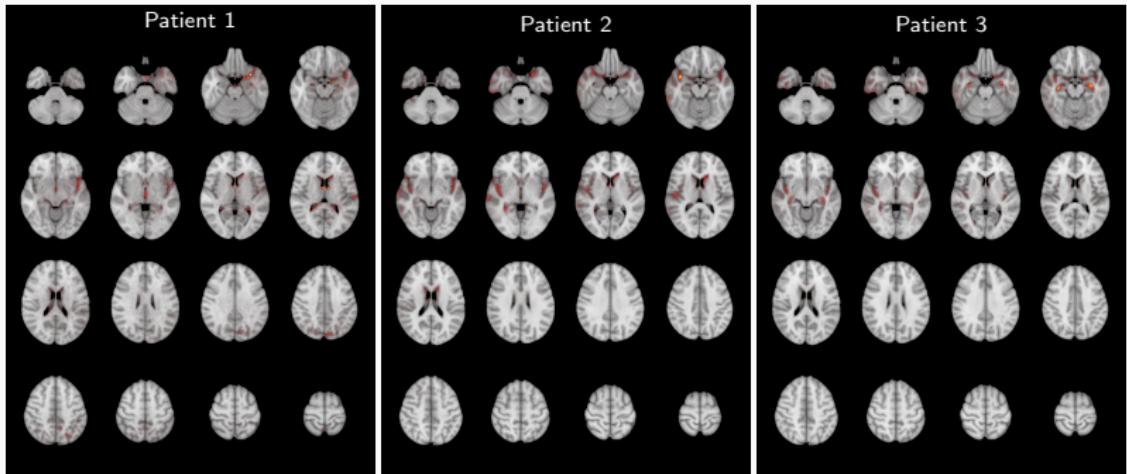


# Generating relevance maps

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

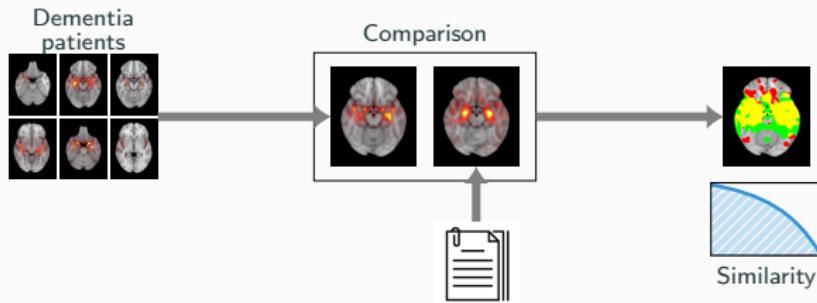


# Generating relevance maps



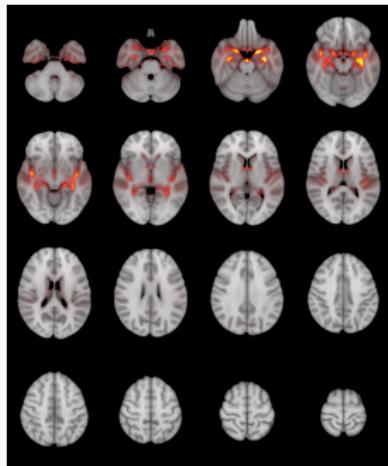
# Validating relevance maps in dementia patients

## 3. Validate relevance maps for diagnosed patients against the literature

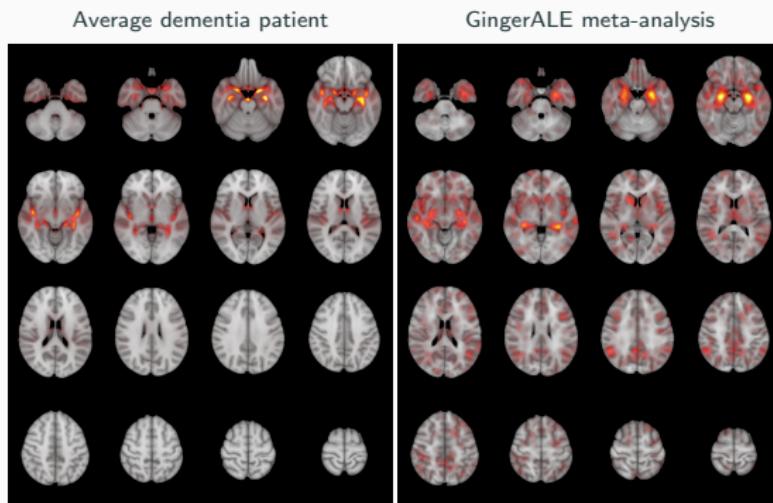


# Validating relevance maps in dementia patients

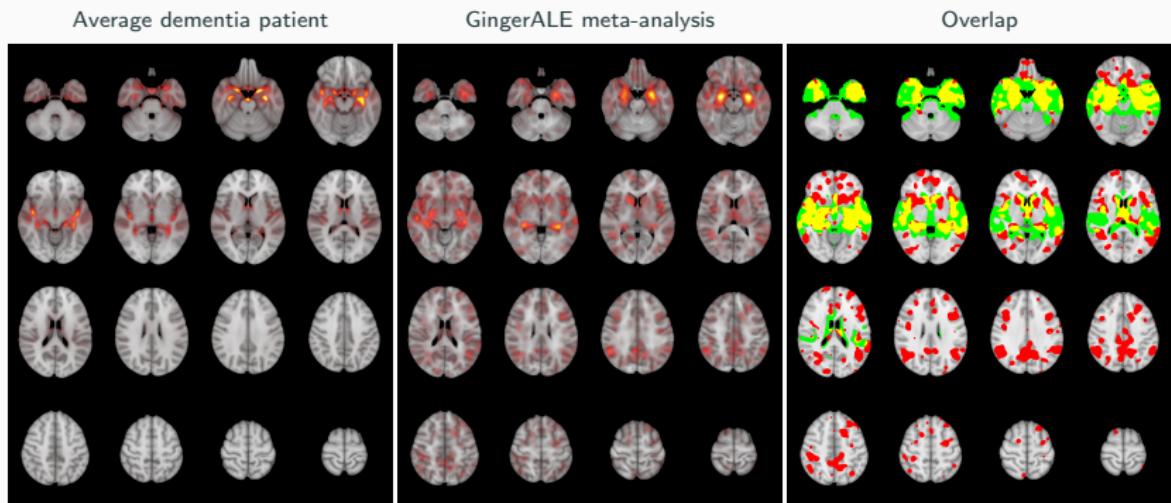
Average dementia patient



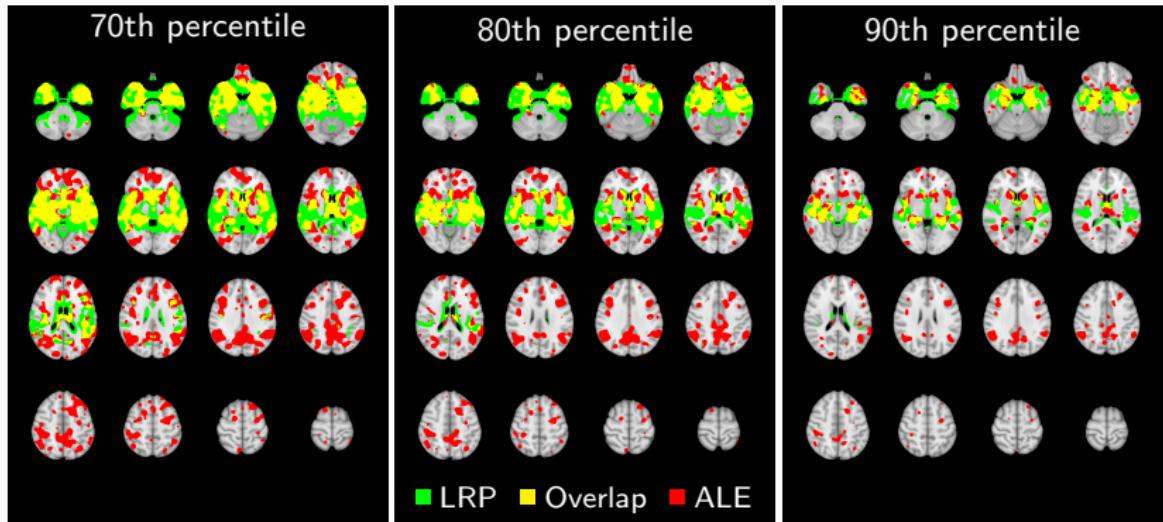
# Validating relevance maps in dementia patients



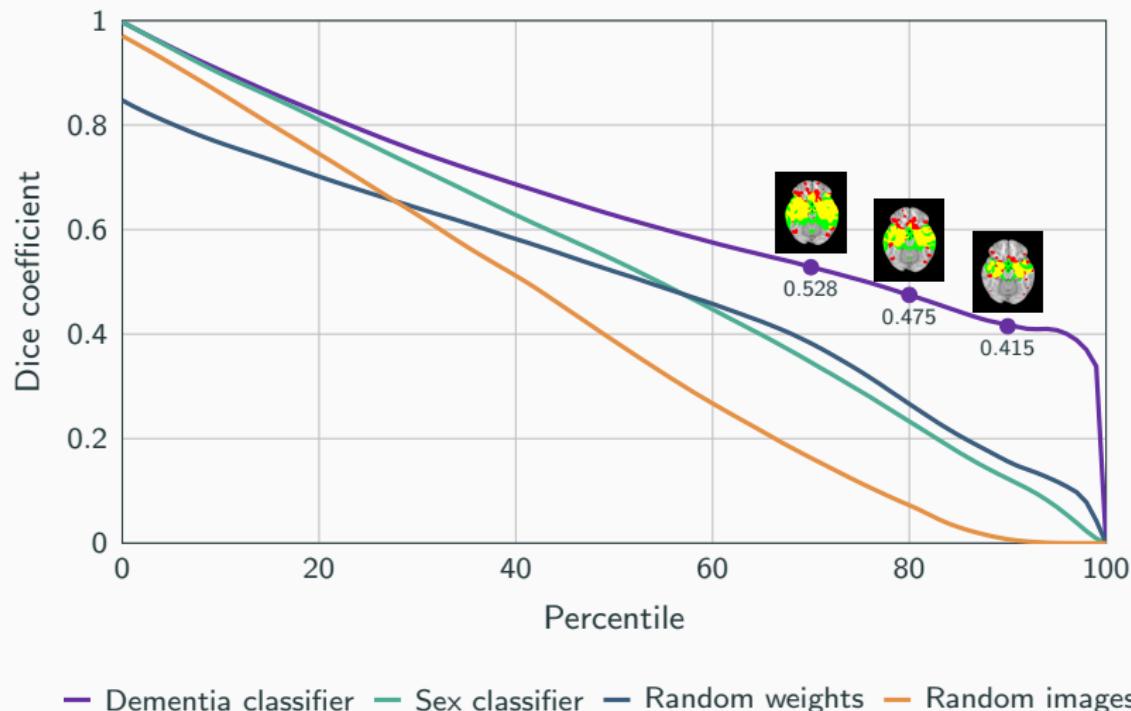
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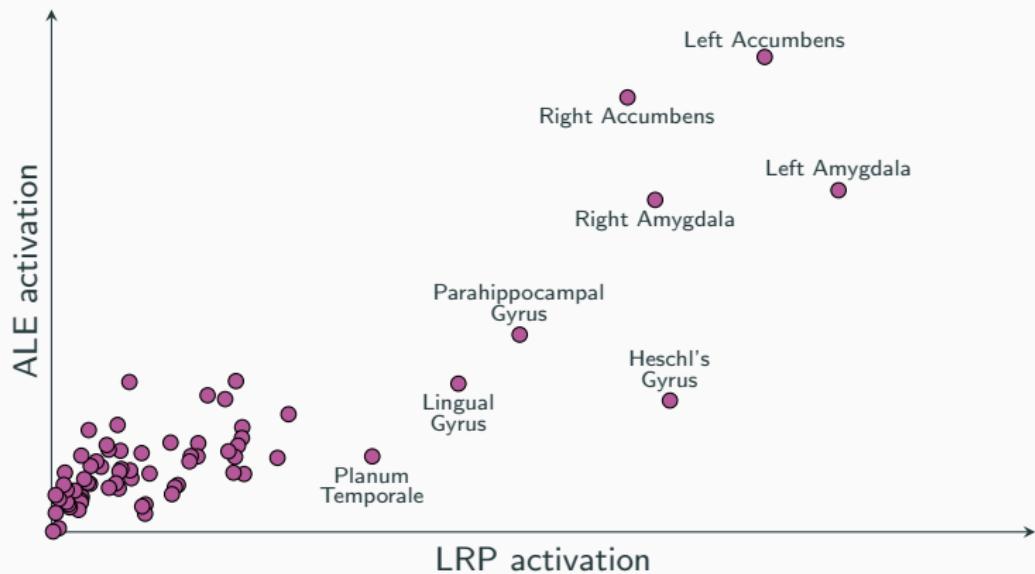
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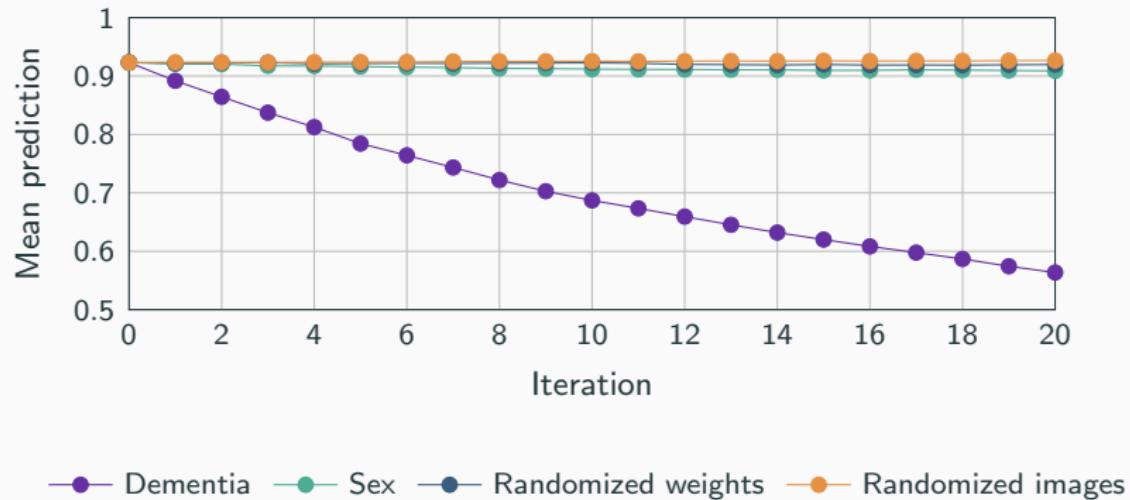
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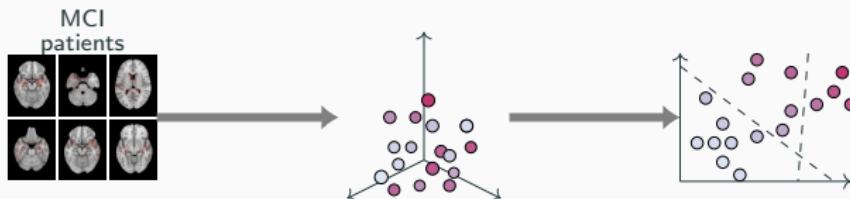


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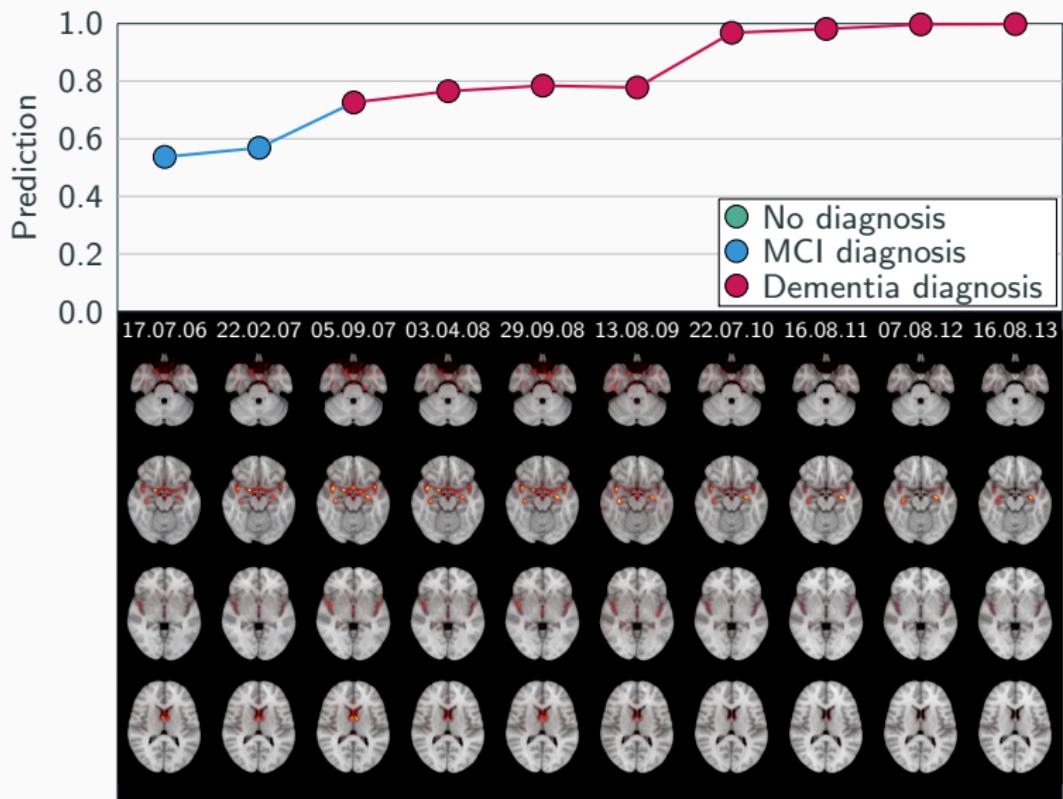


# Exploring relevance maps in MCI patients

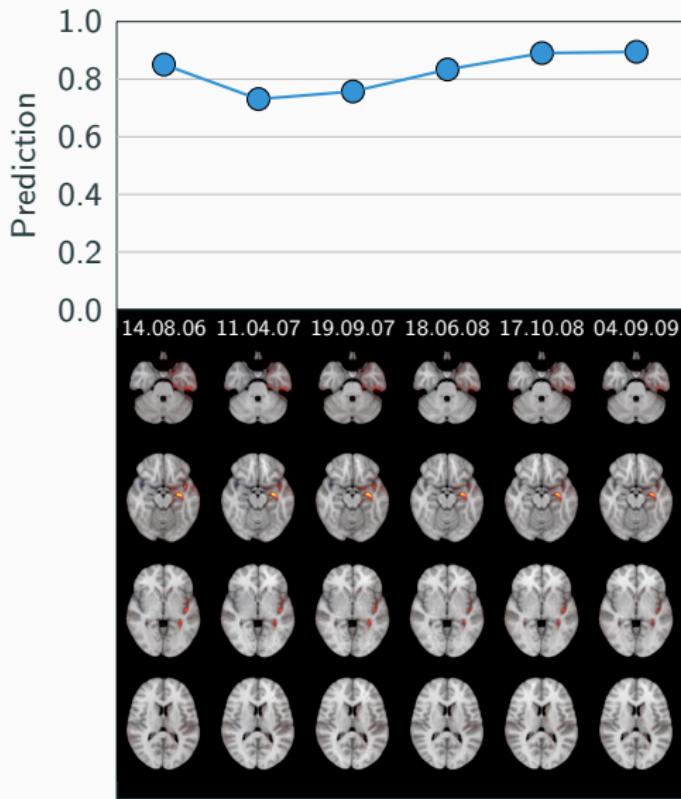
## 4. Stratify participants with MCI using predictions and relevance maps



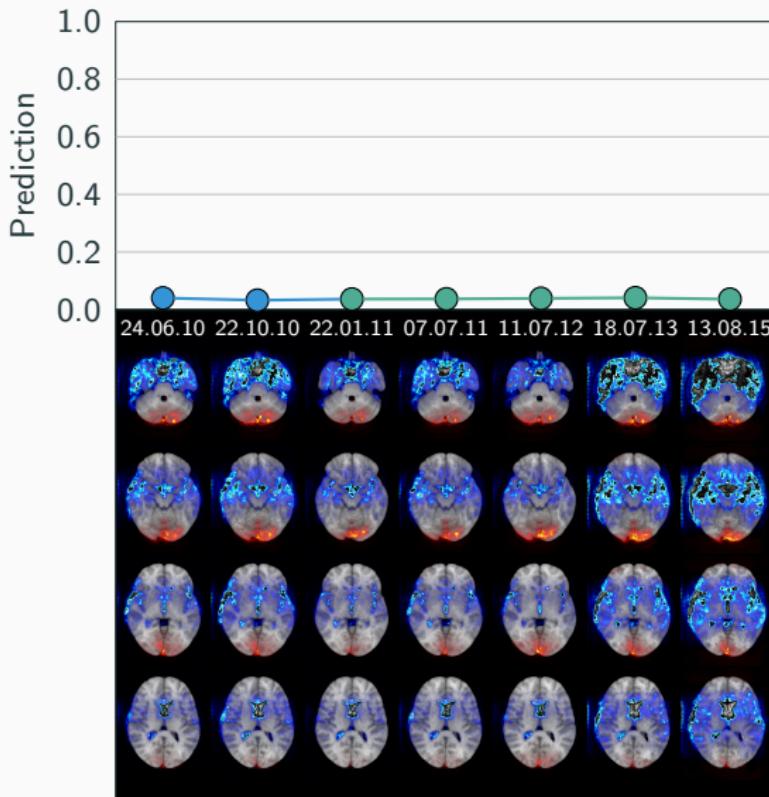
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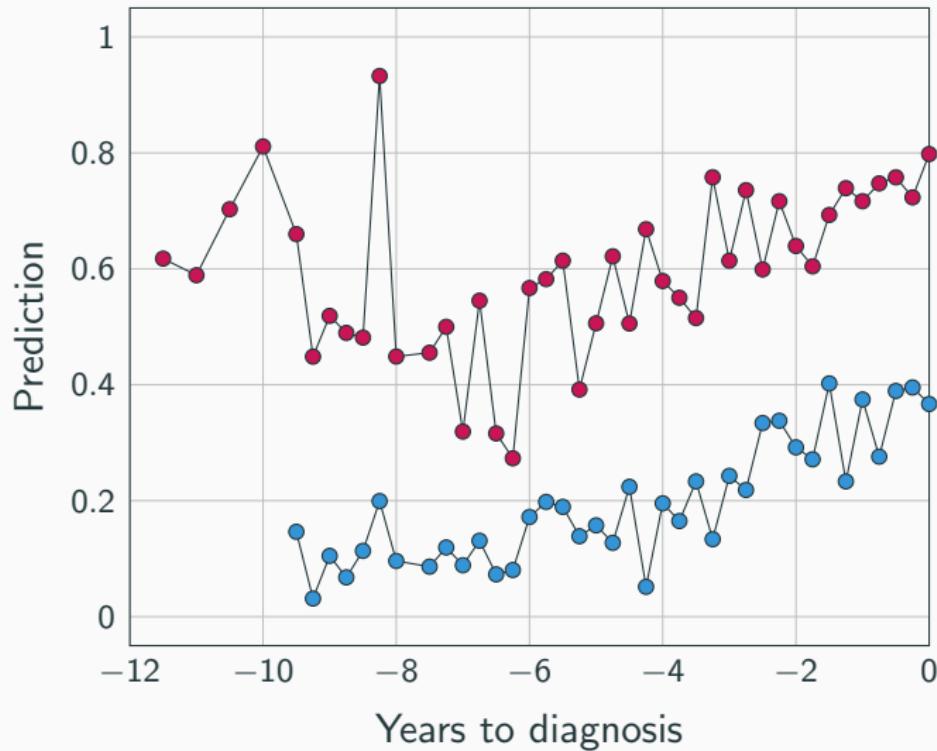
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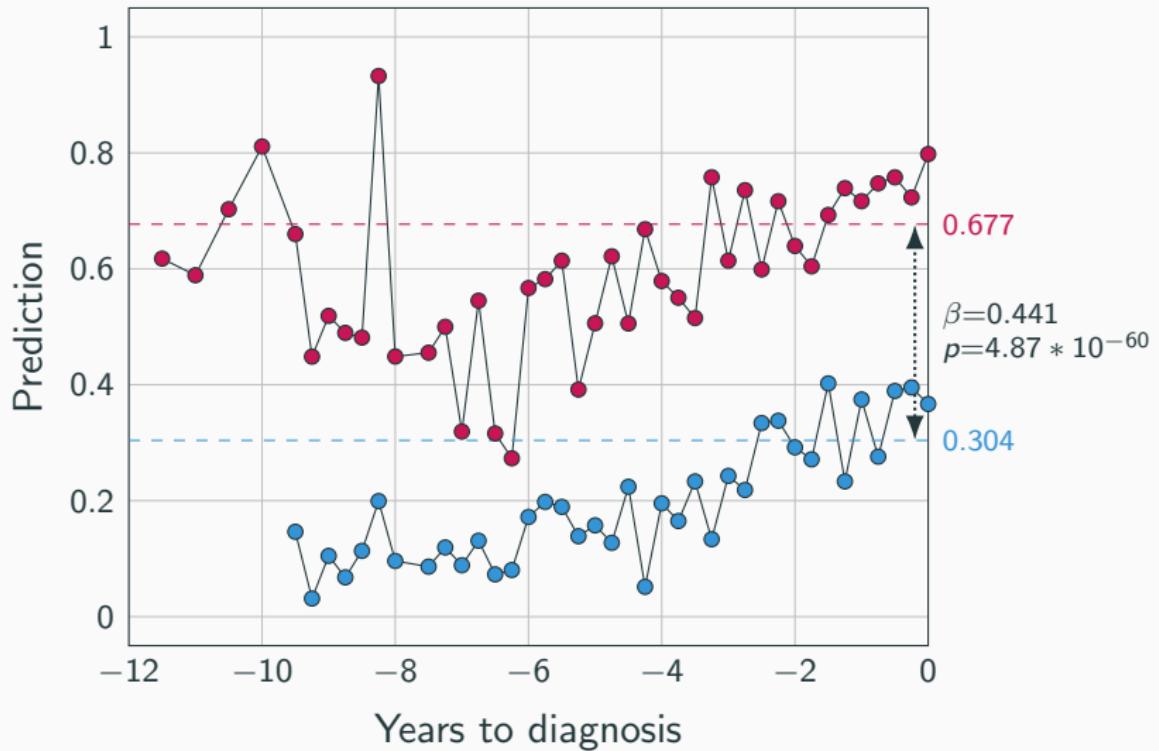
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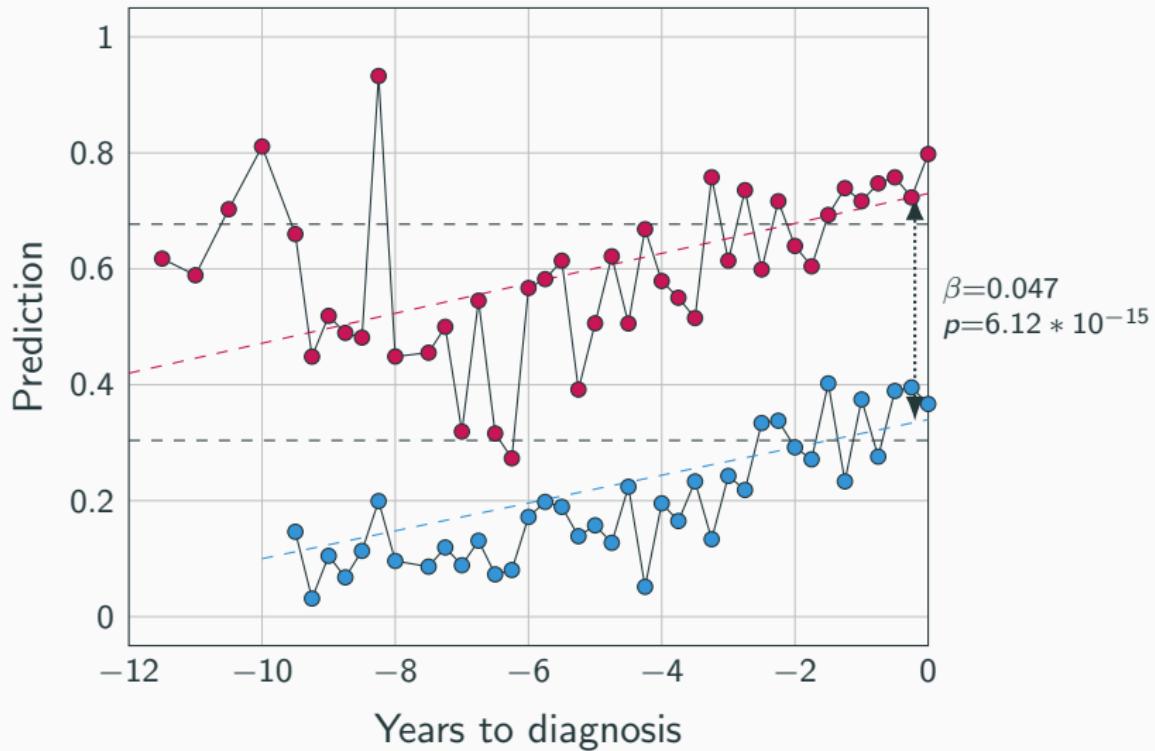
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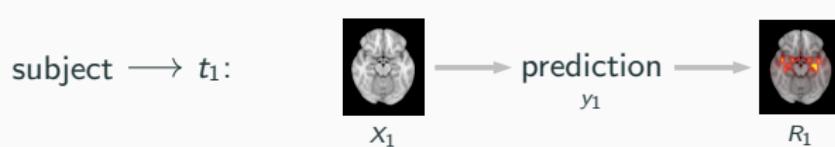
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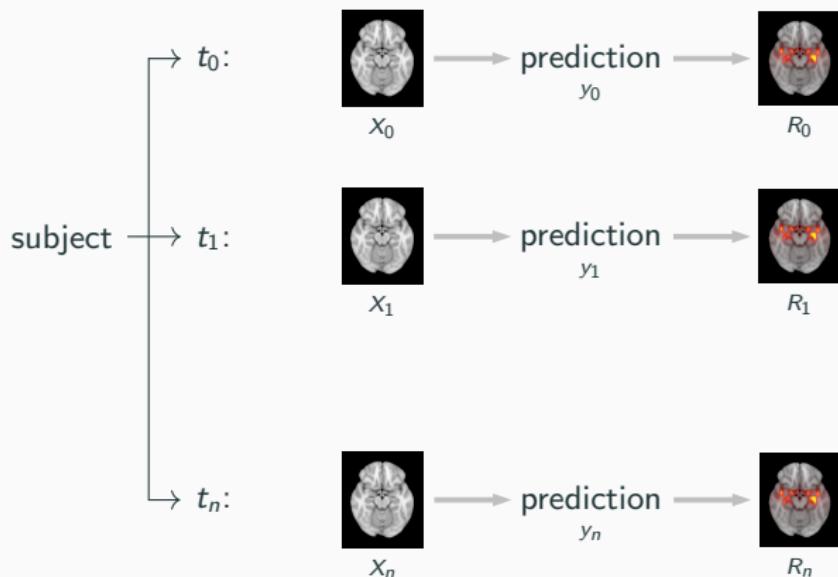
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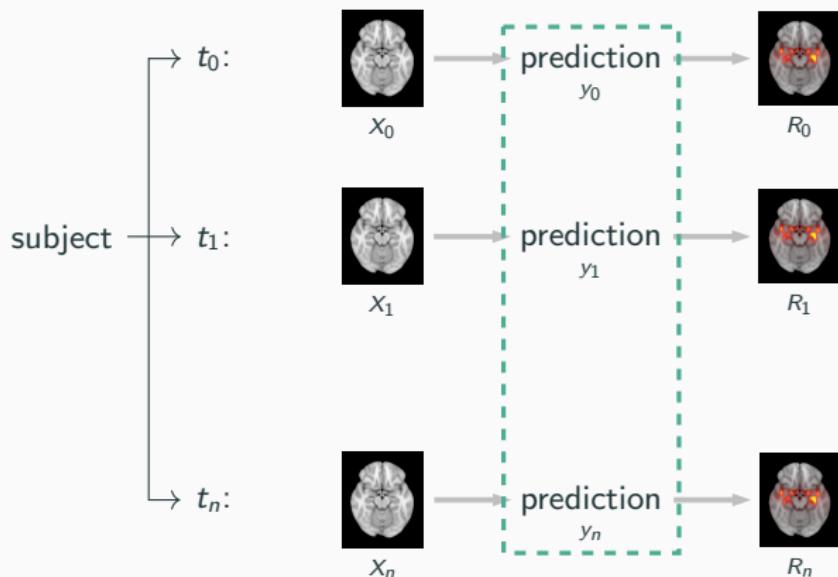
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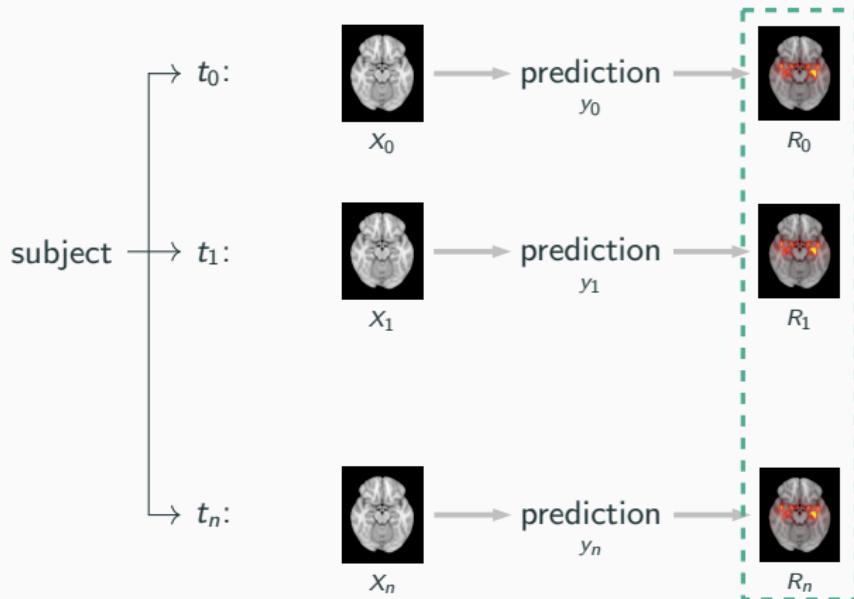
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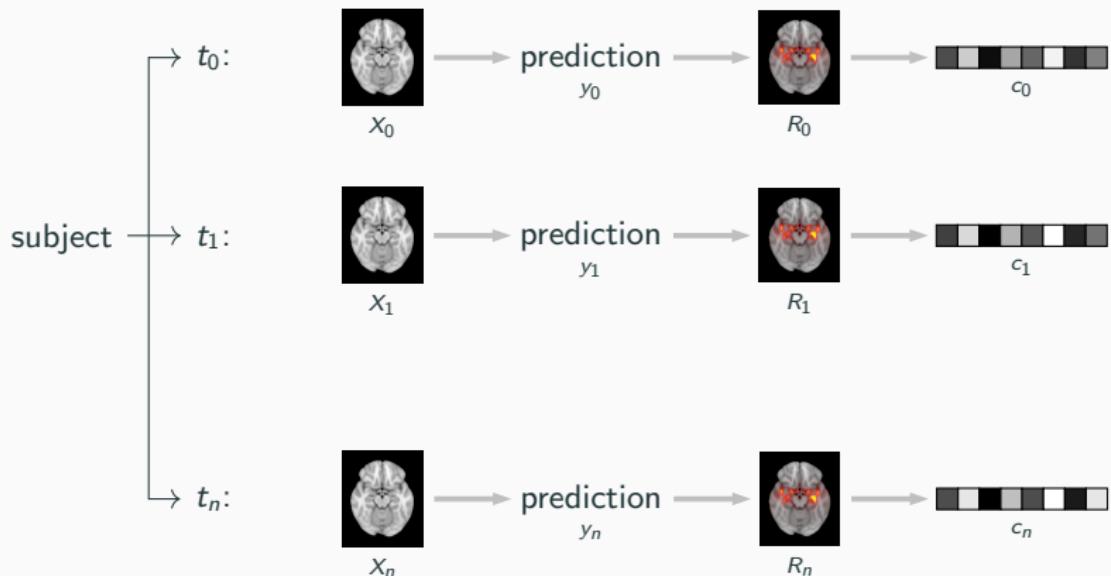
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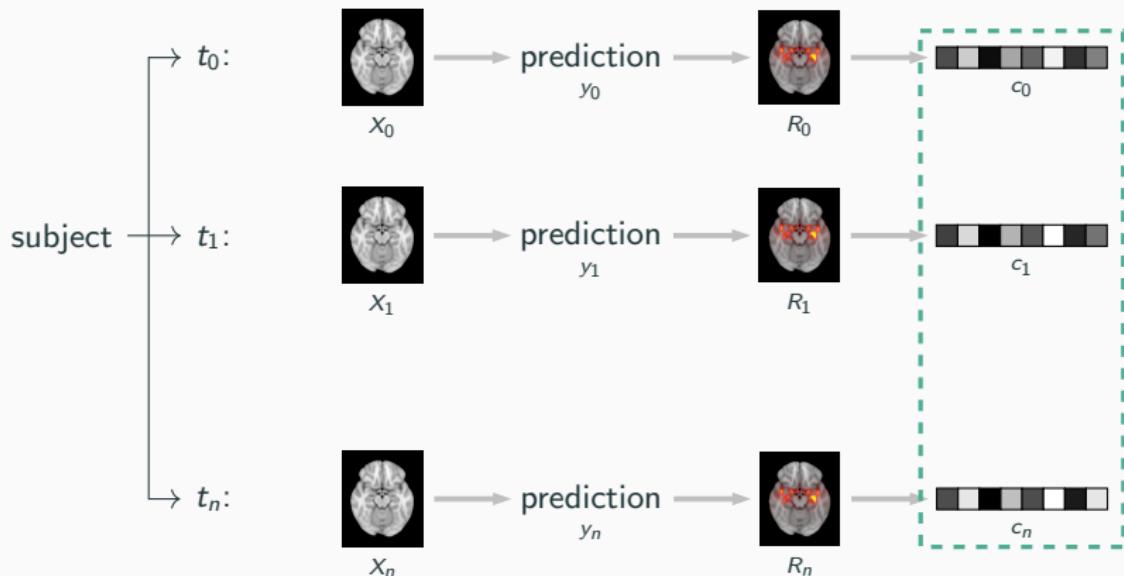
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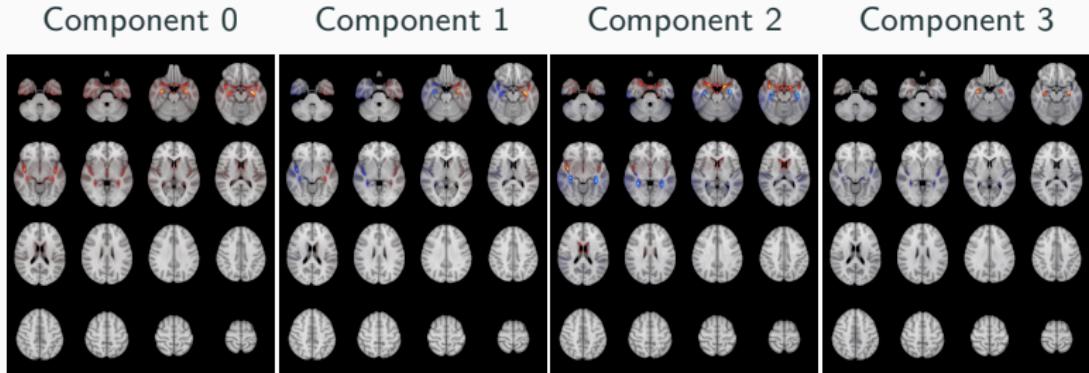
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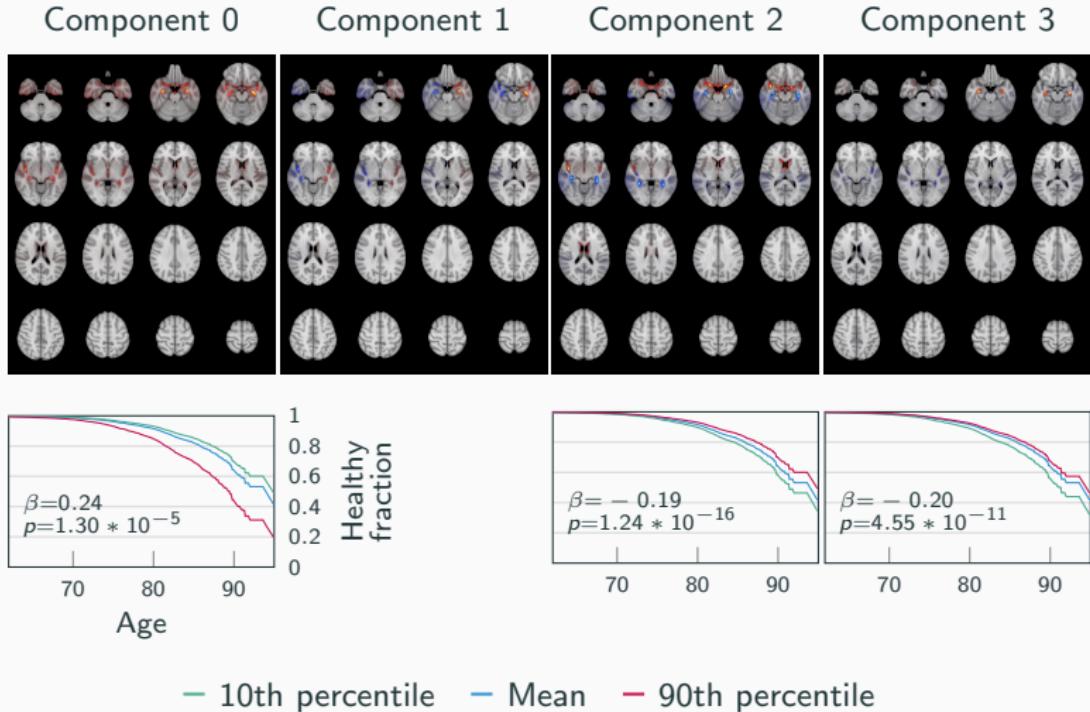
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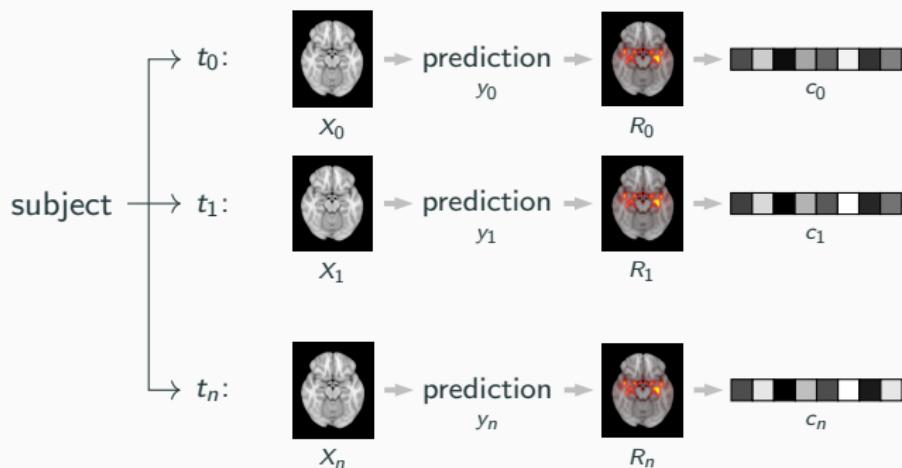
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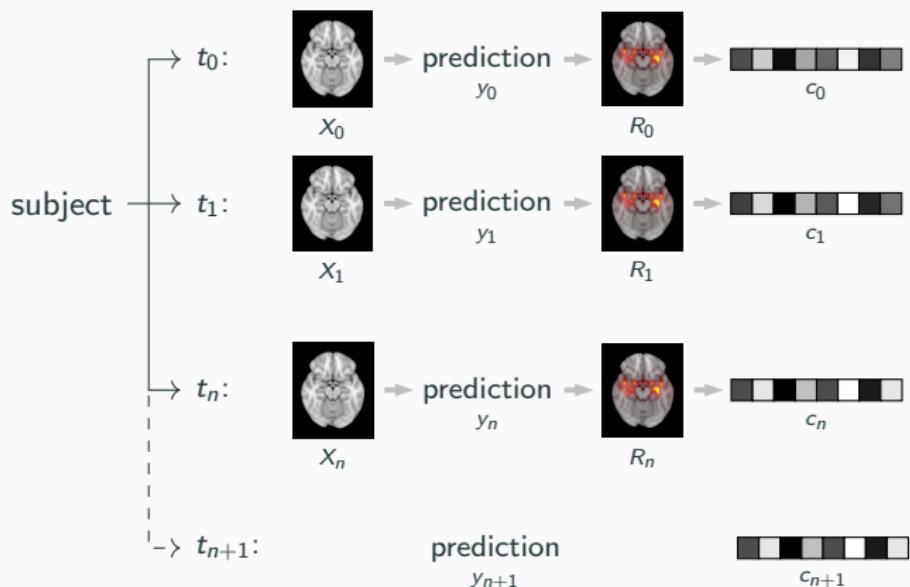
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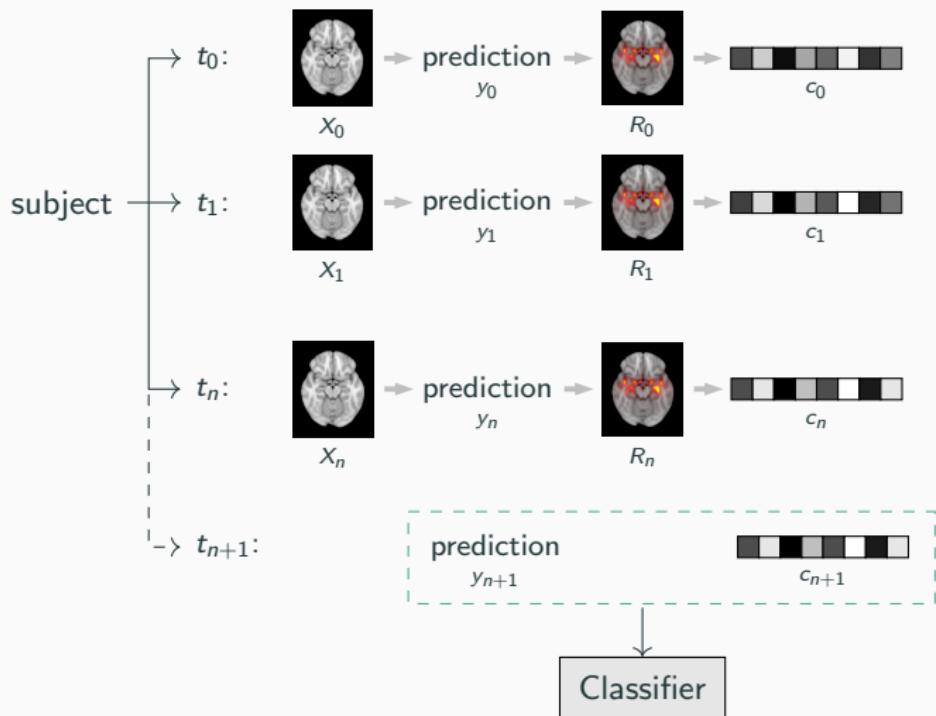
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# Exploring relevance maps in MCI patients

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

## 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."*