

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

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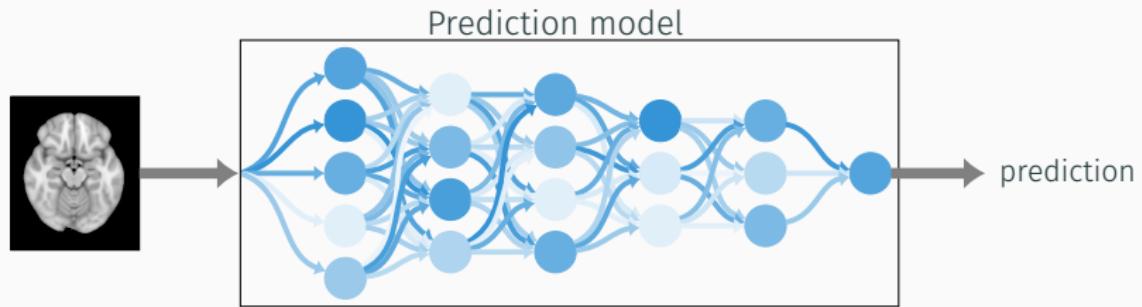
Esten Høyland Leonardsen

24.10.22

UiO:Life Science, University of Oslo

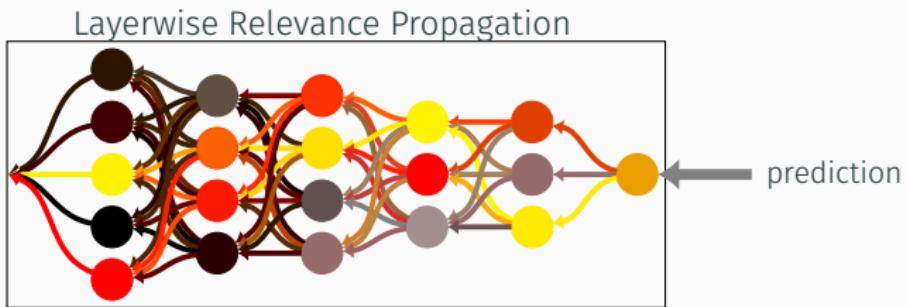


# Layerwise Relevance Propagation



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

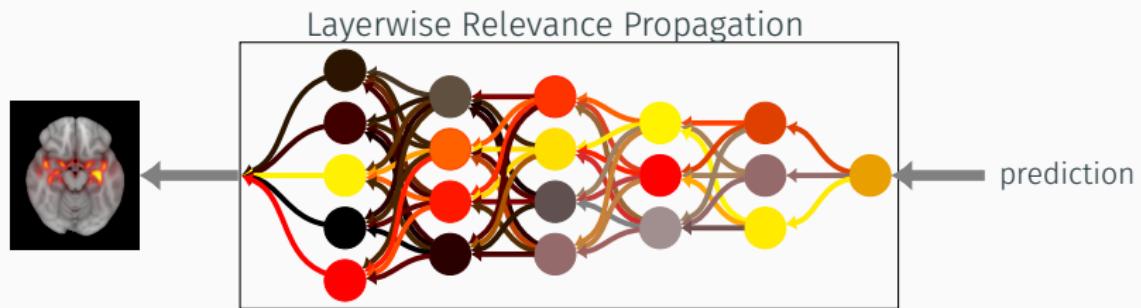
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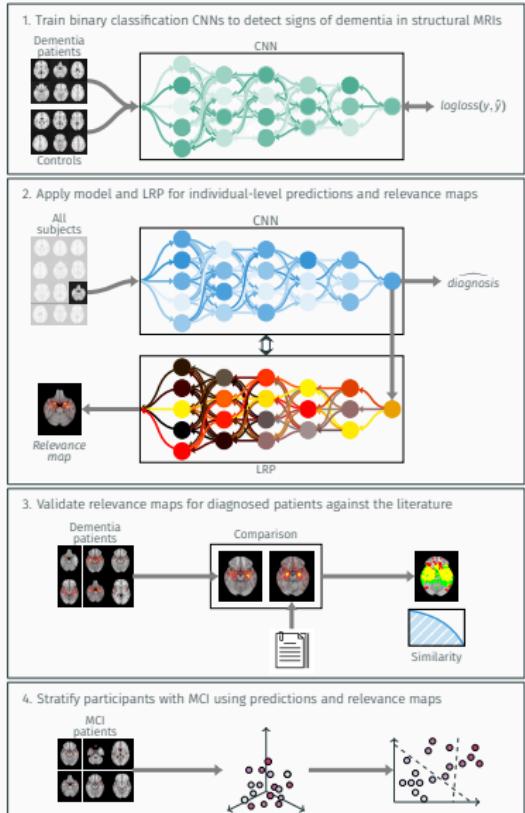
$$R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

# Layerwise Relevance Propagation



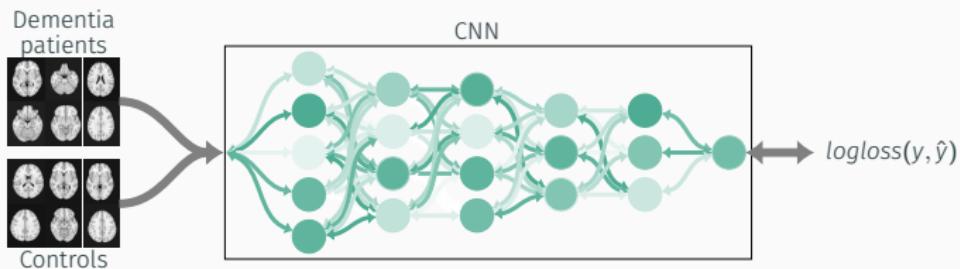
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j} \quad R_{i,j} = \sum_k \frac{a_j w_{j,k}}{\sum_l a_l w_{l,k}} R_{i+1,k}$$

# Overview

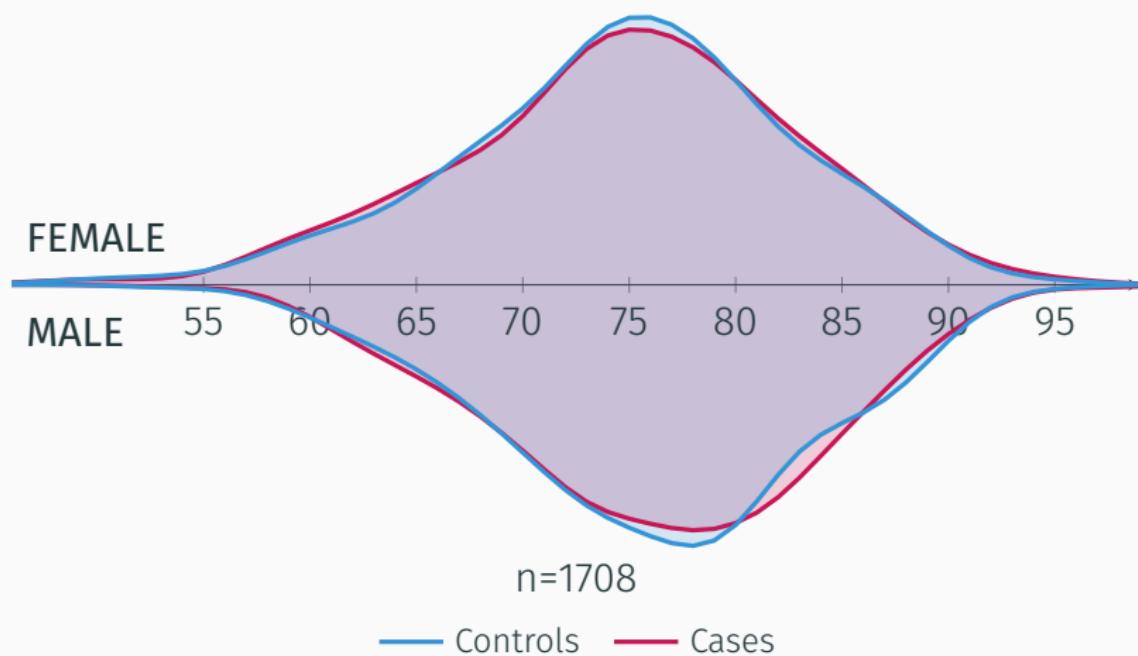


# Case-control predictions

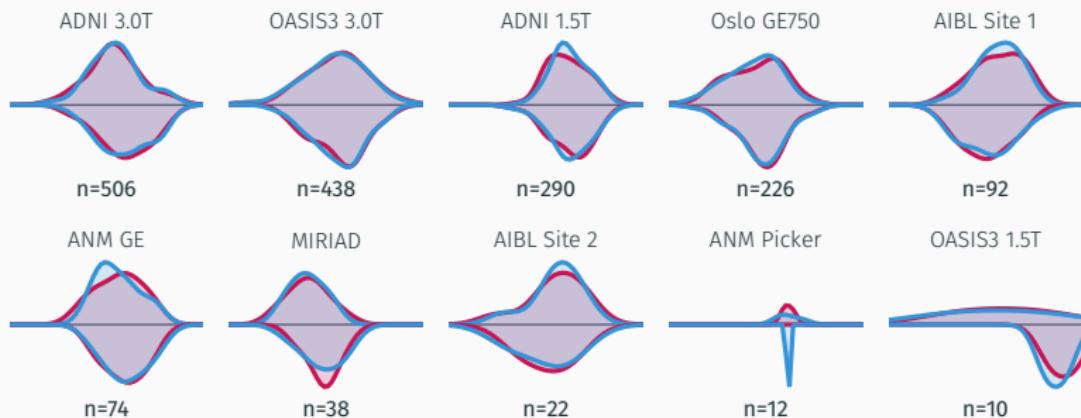
1. Train binary classification CNNs to detect signs of dementia in structural MRIs



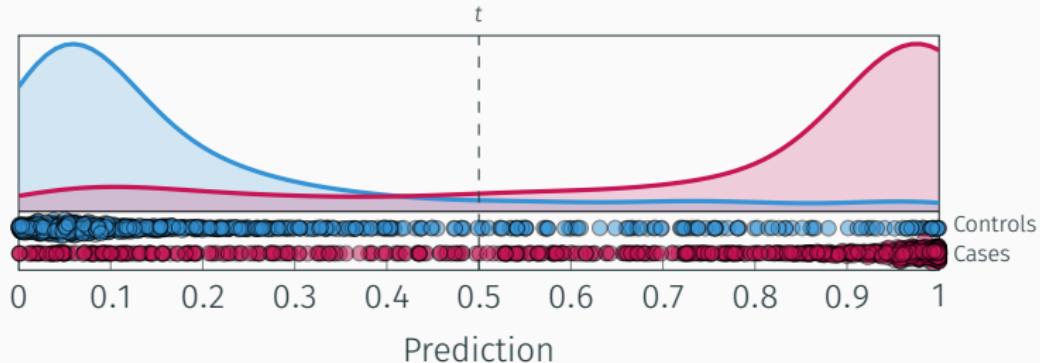
## Case-control predictions



# Case-control predictions



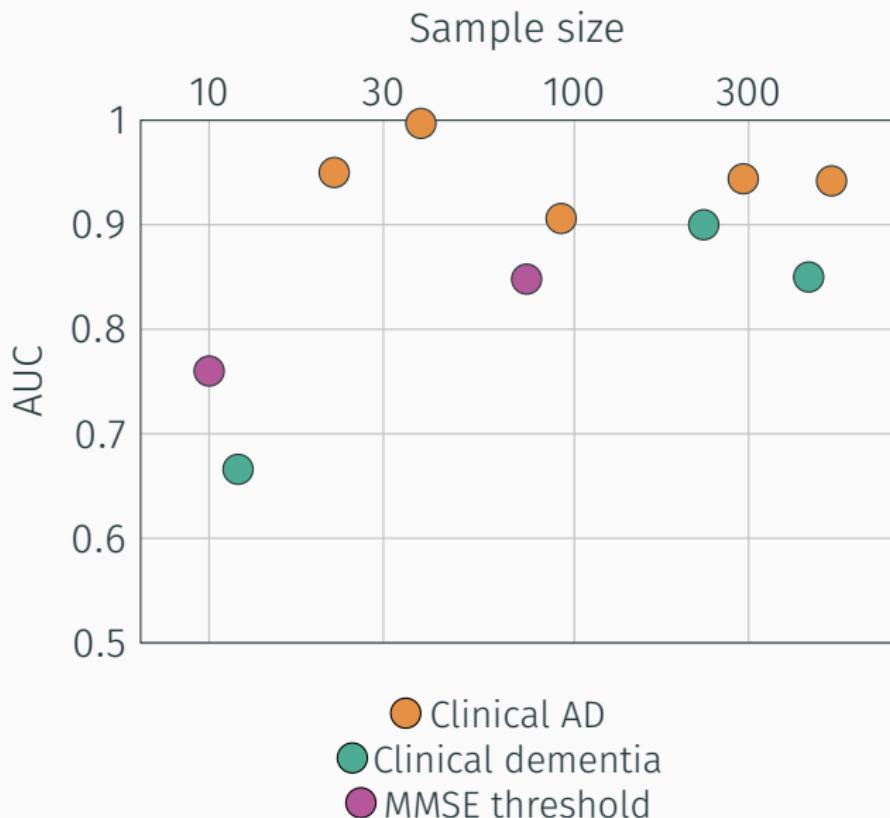
# Case-control predictions



		Predicted	
		0	1
Observed	0	754	100
	1	157	697

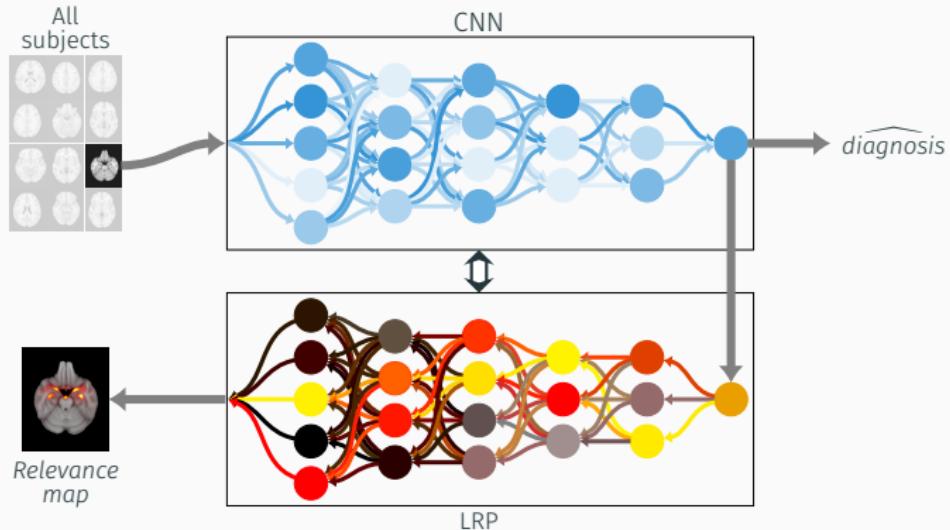
Accuracy: 84.95%

## Case-control predictions

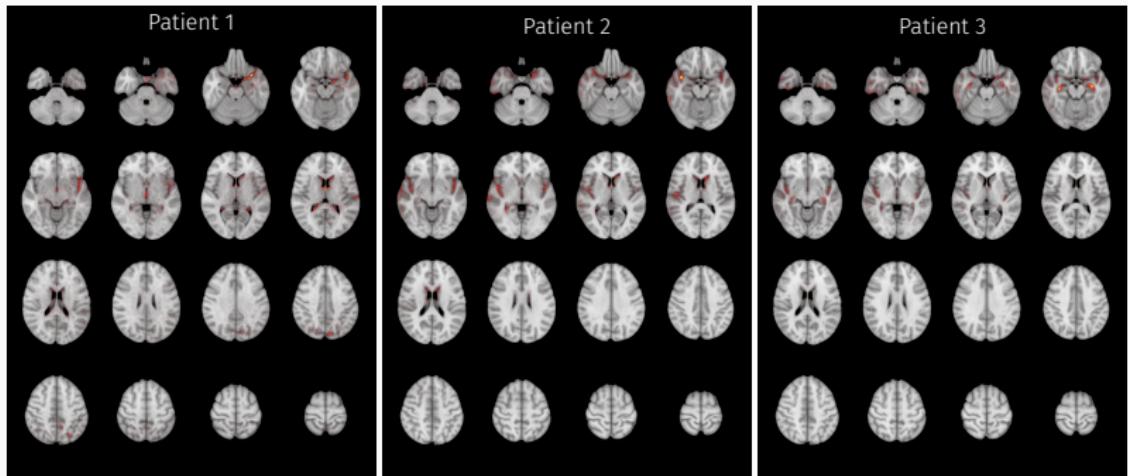


# Generating relevance maps

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

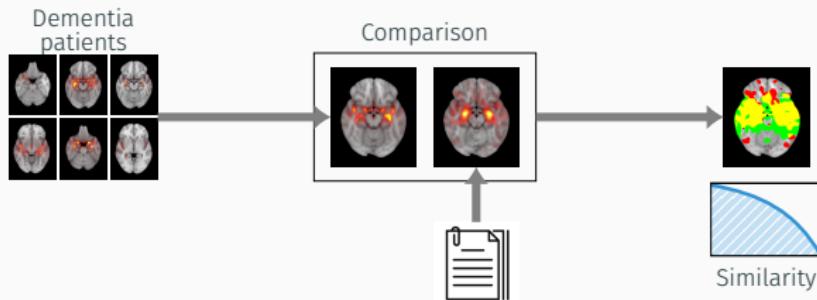


# Generating relevance maps



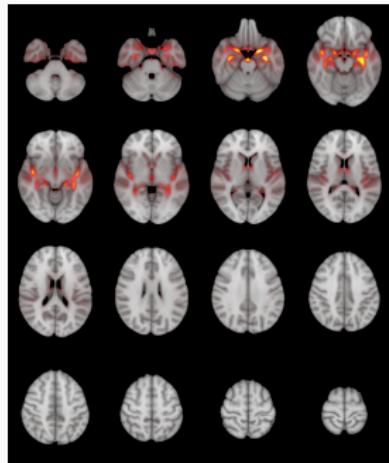
# Validating relevance maps in dementia patients

3. Validate relevance maps for diagnosed patients against the literature



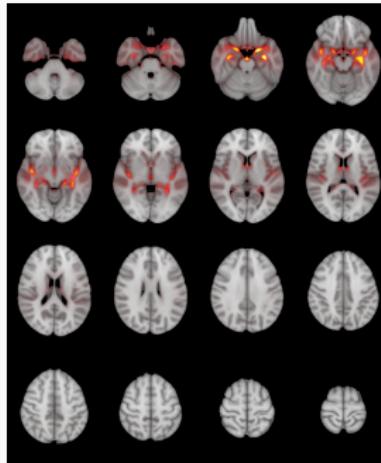
# Validating relevance maps in dementia patients

Average dementia patient

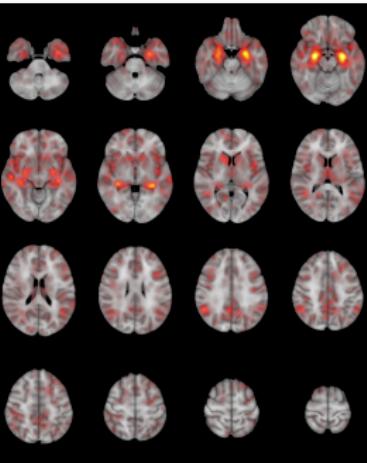


# Validating relevance maps in dementia patients

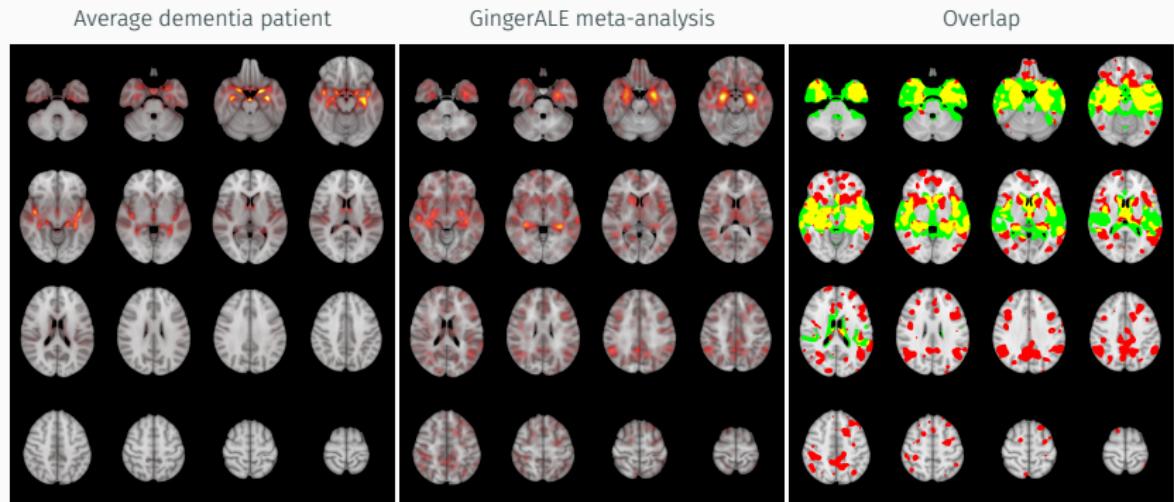
Average dementia patient



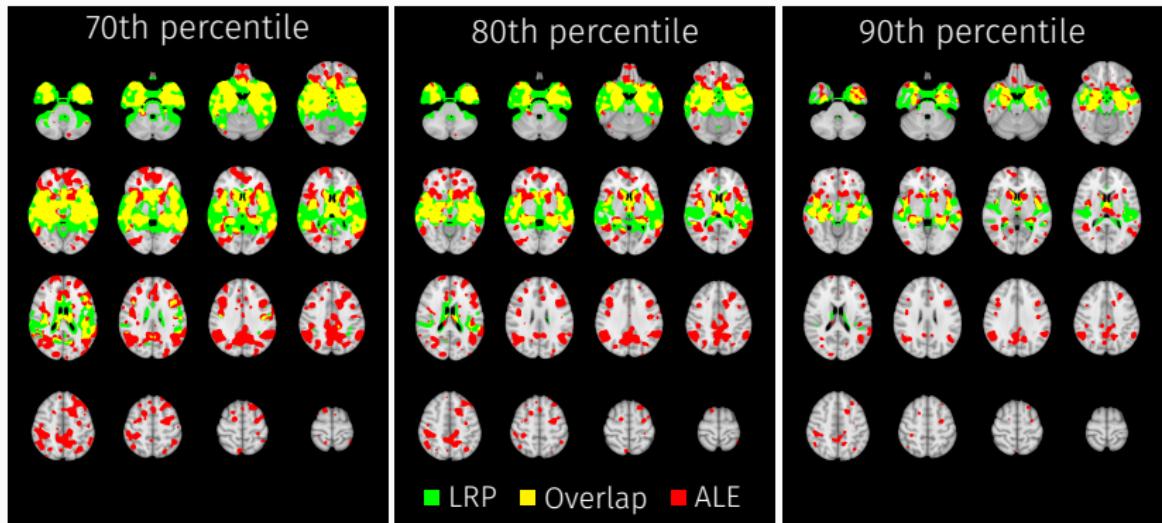
GingerALE meta-analysis



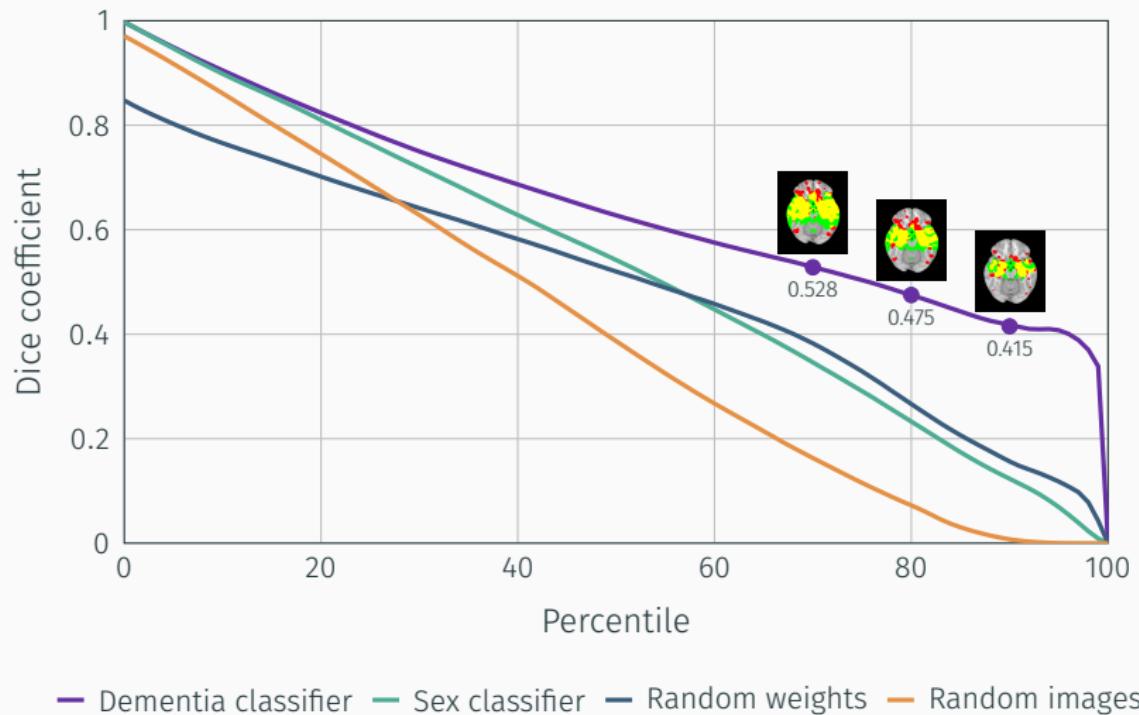
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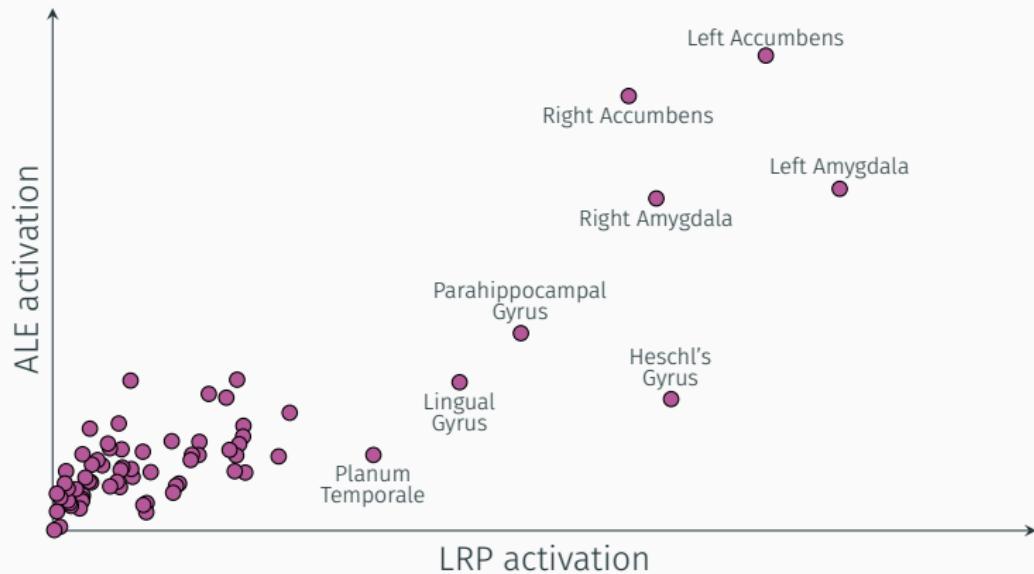
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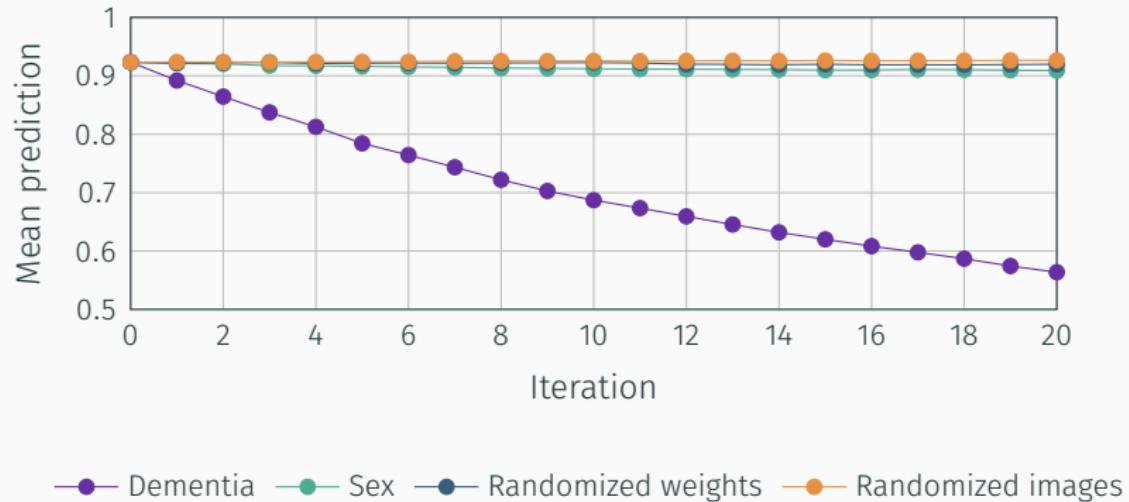
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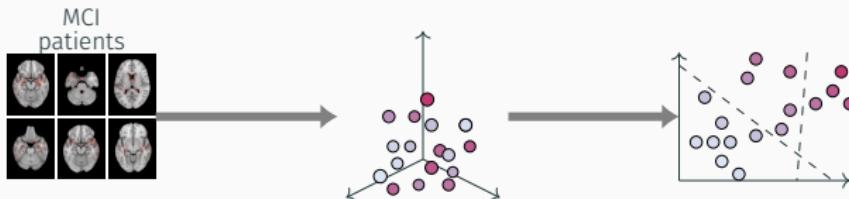


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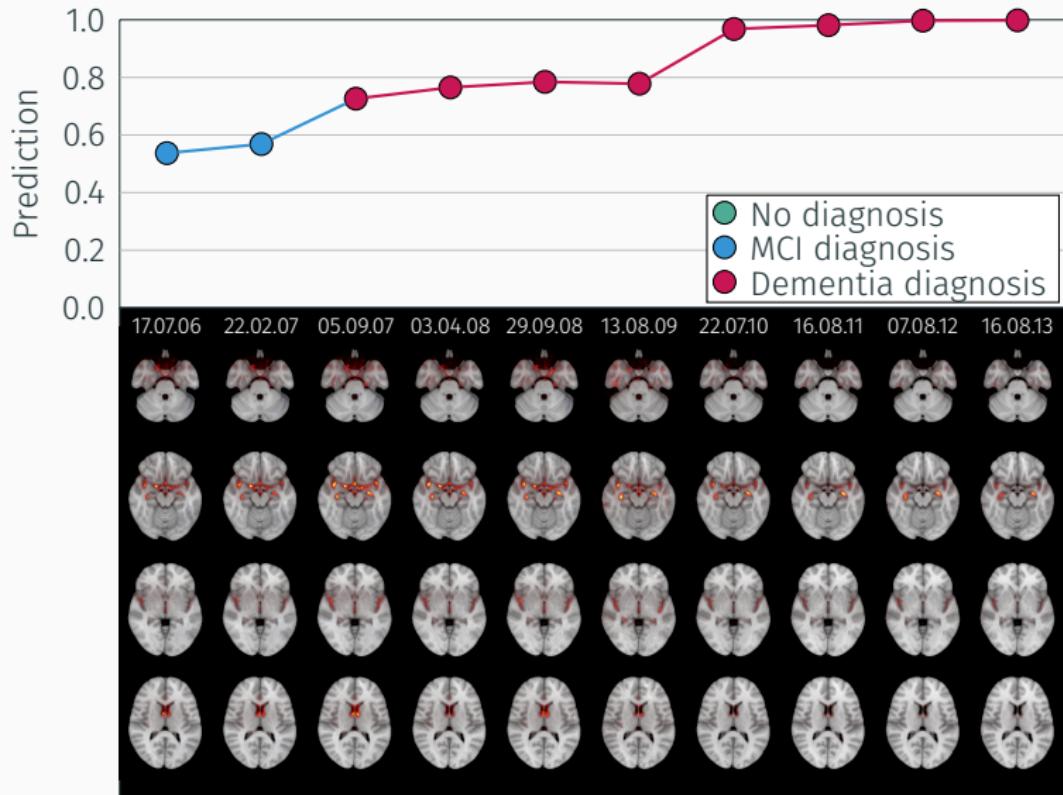


# Exploring relevance maps in MCI patients

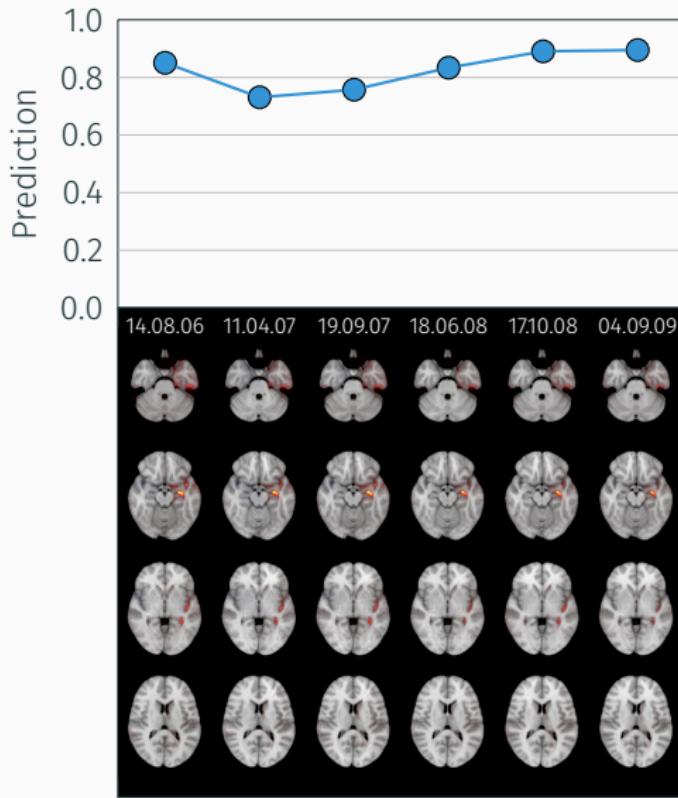
## 4. Stratify participants with MCI using predictions and relevance maps



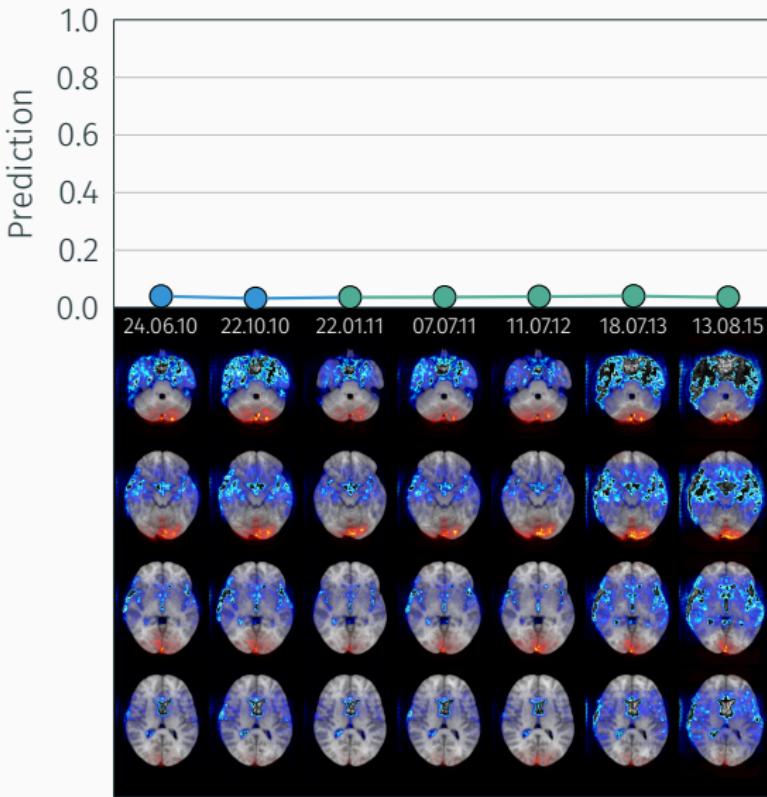
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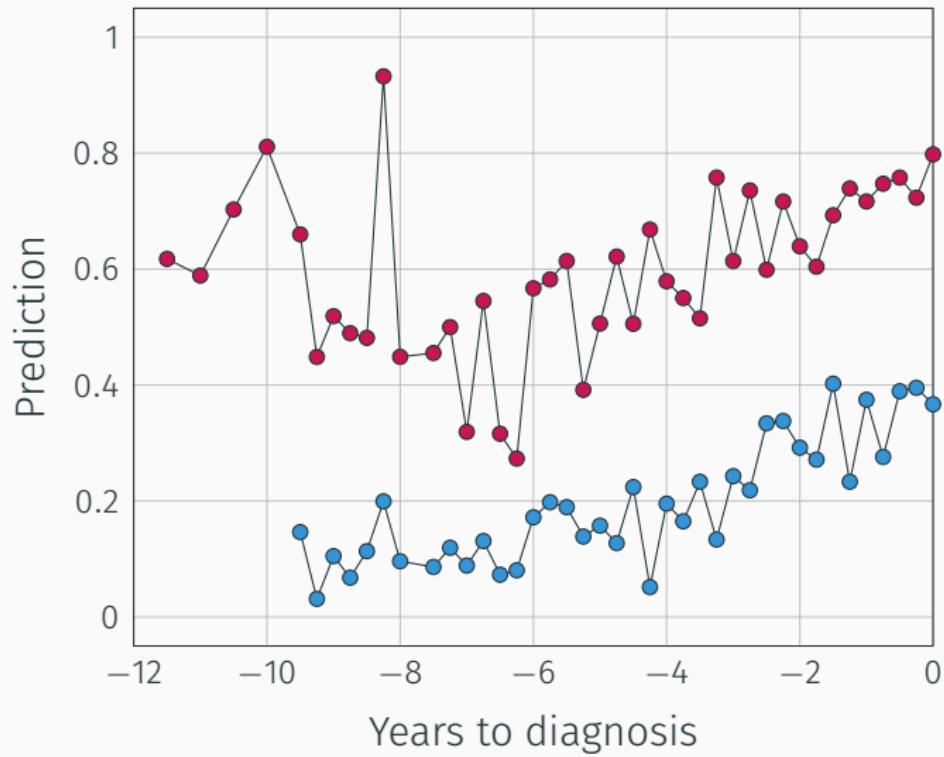
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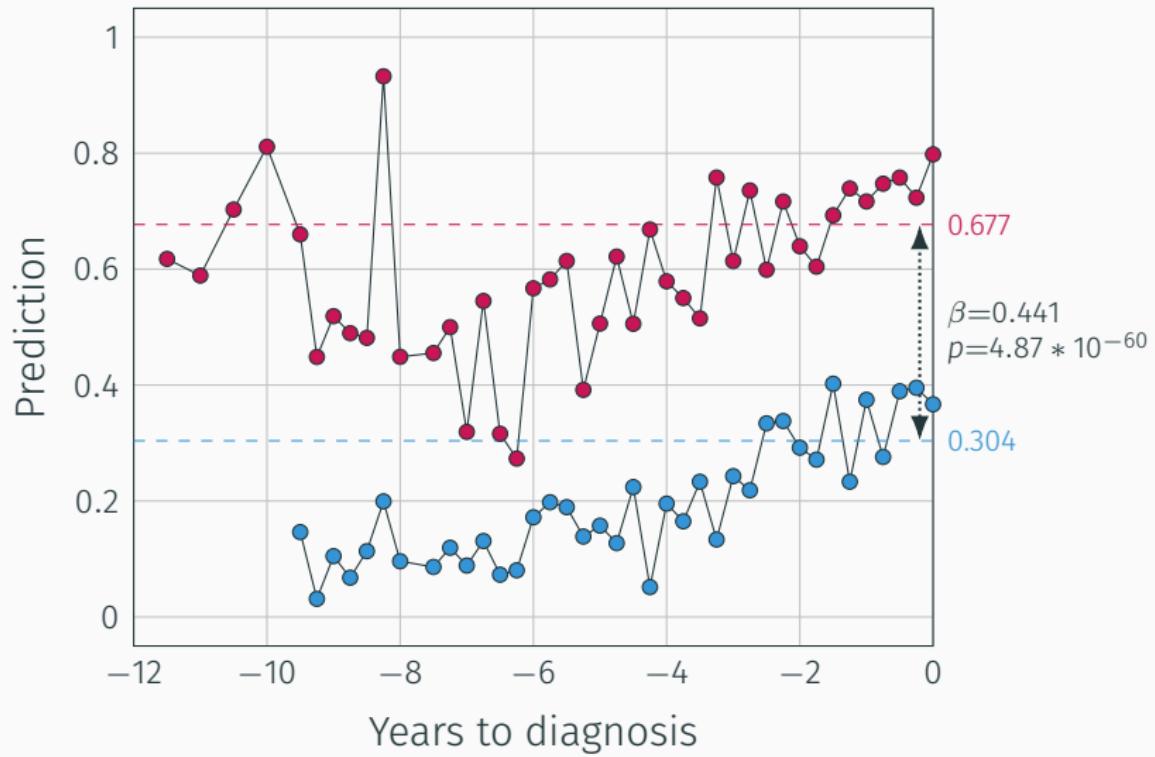
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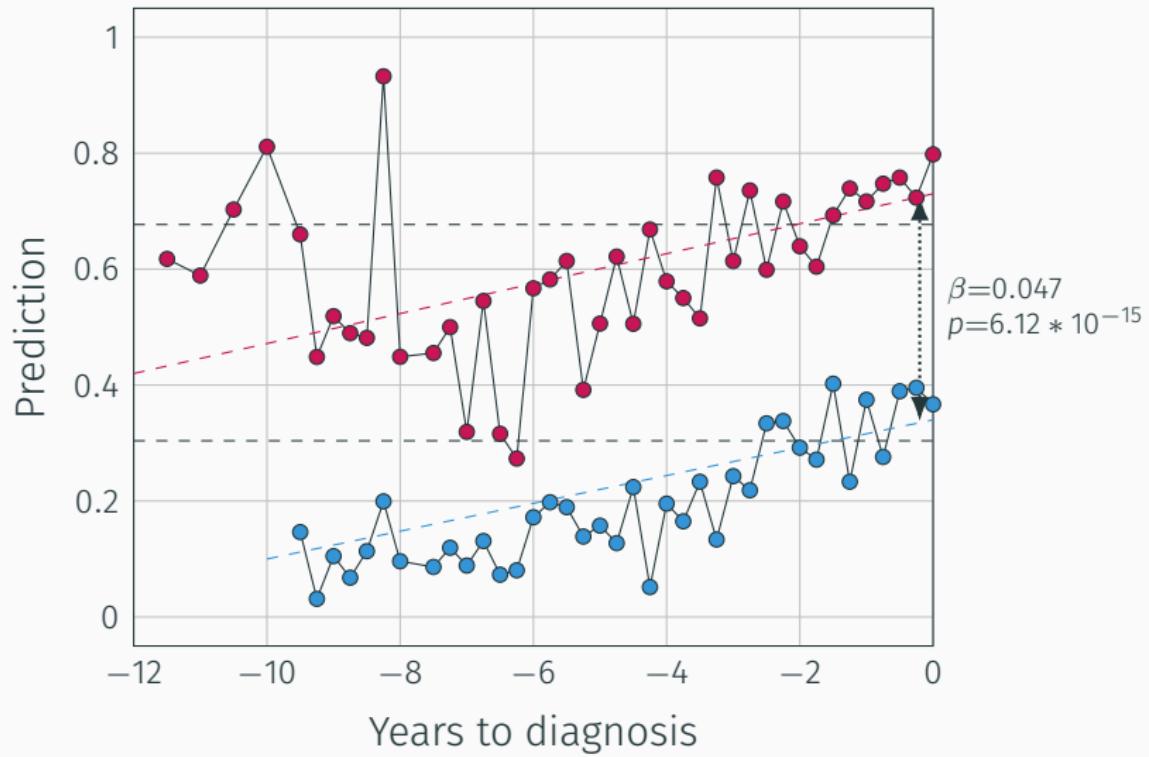
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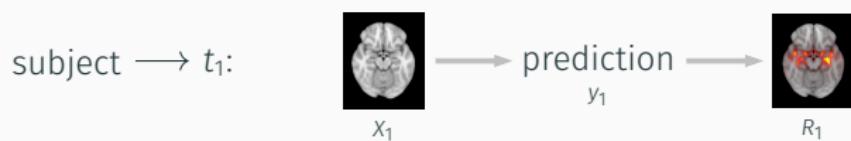
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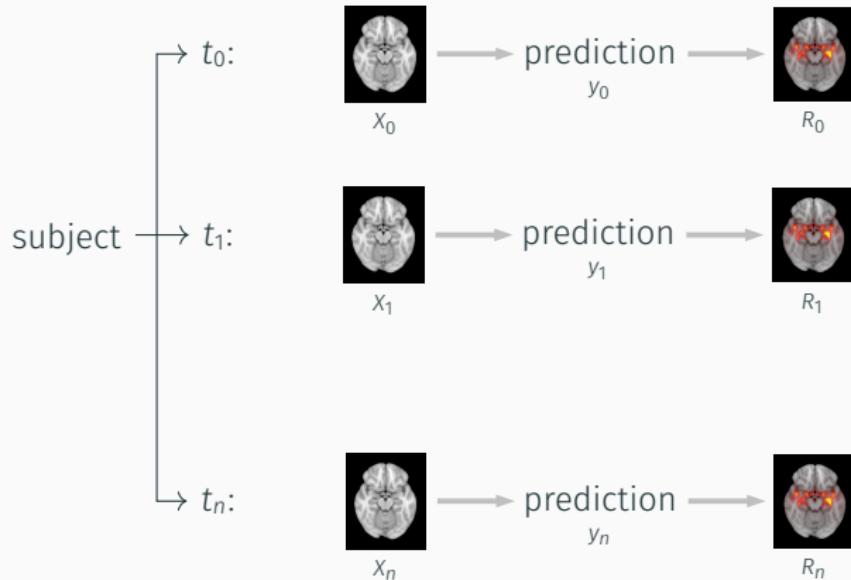
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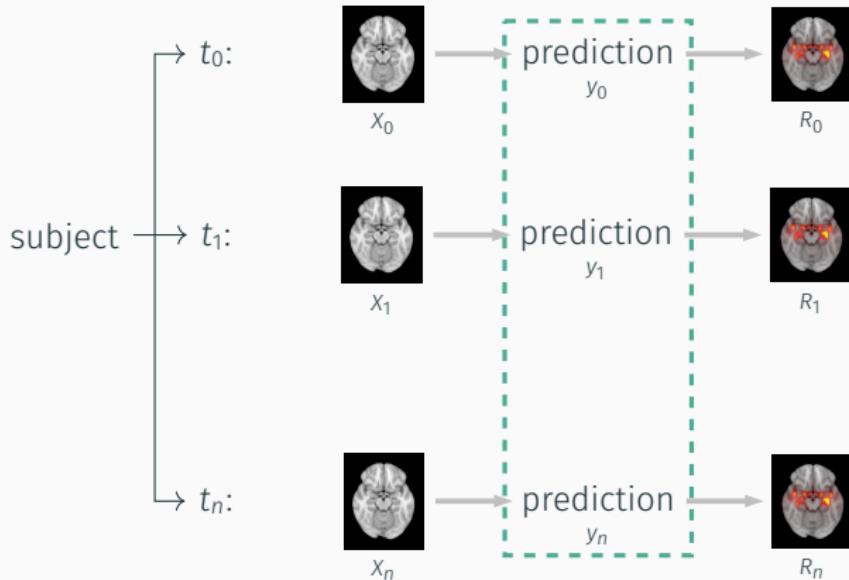
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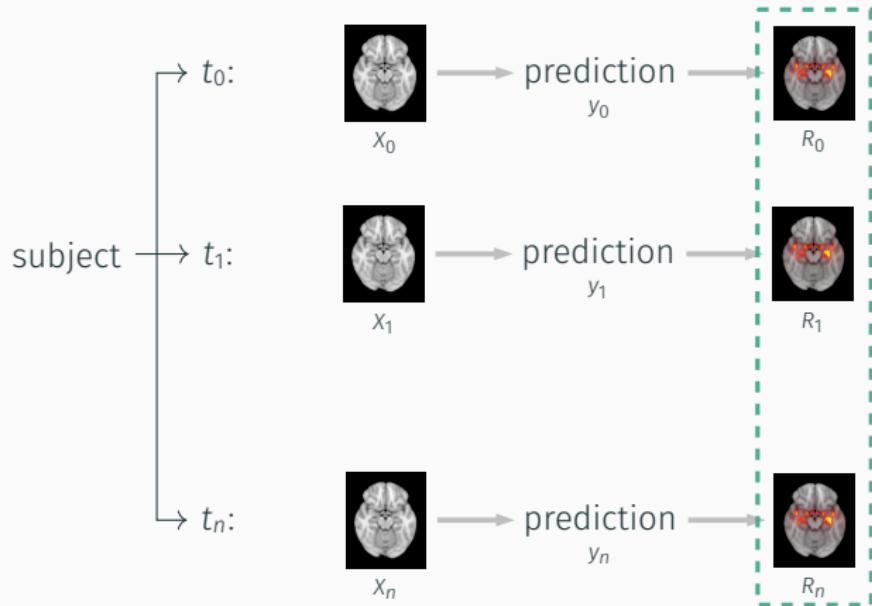
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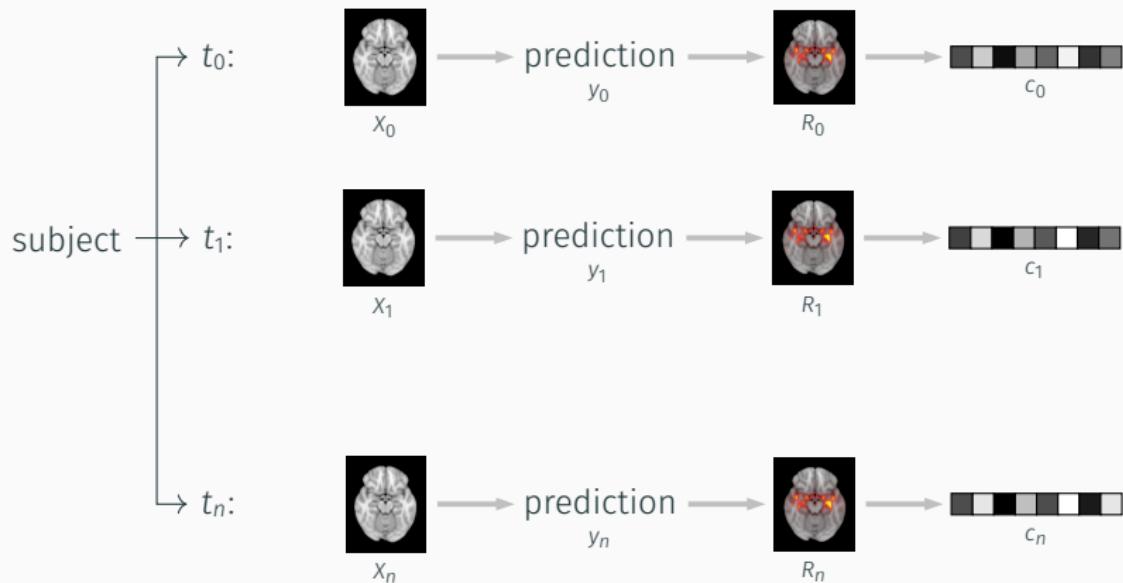
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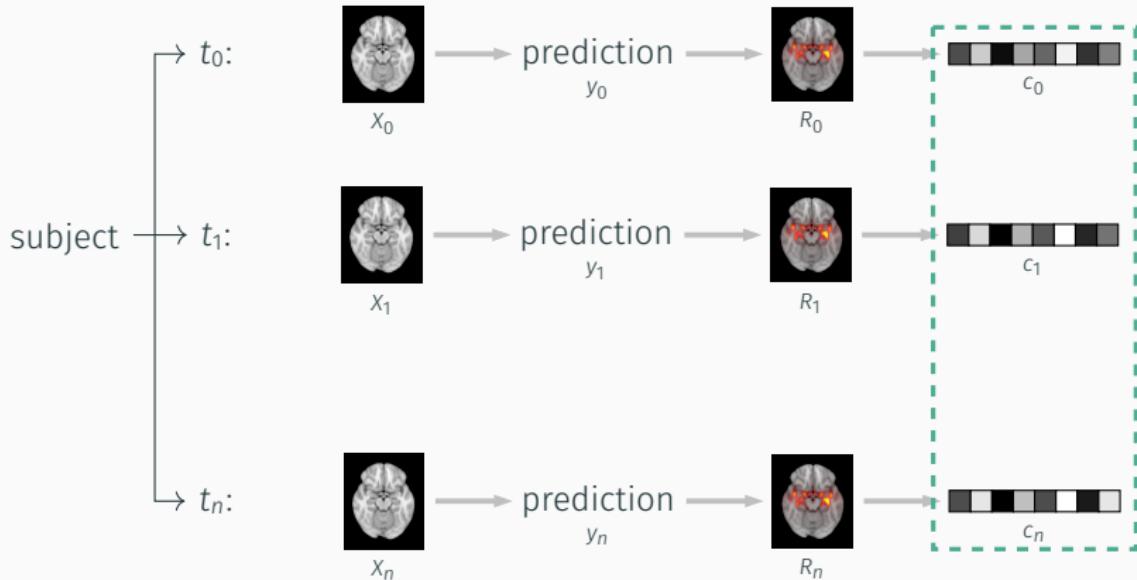
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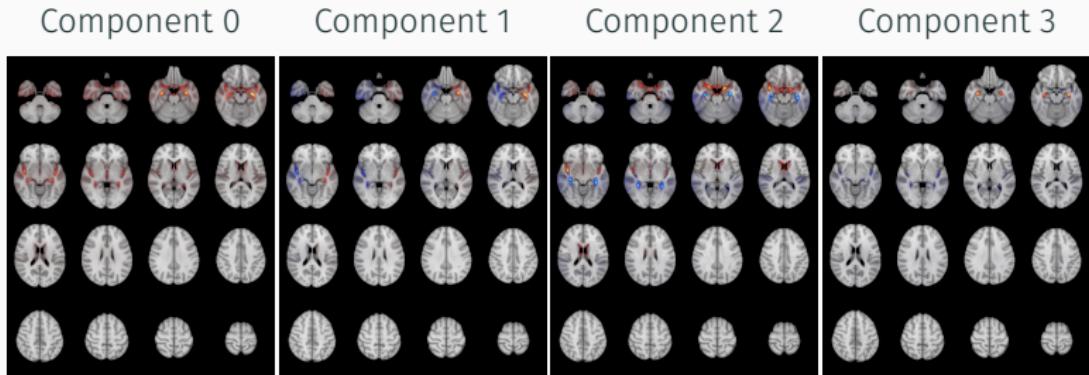
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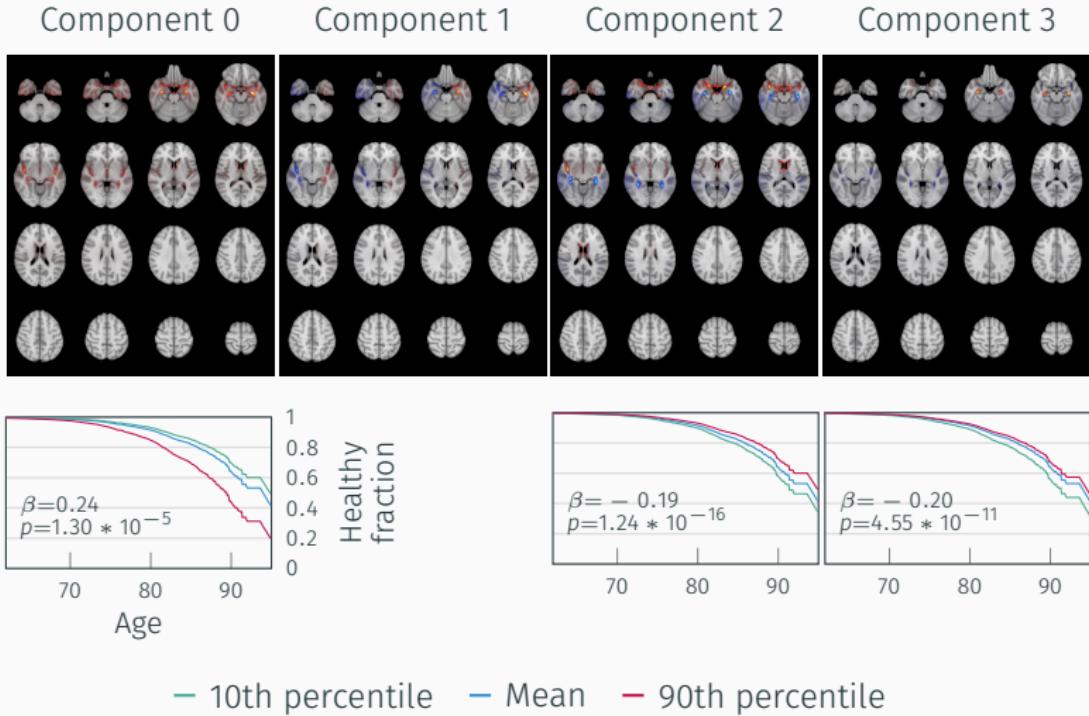
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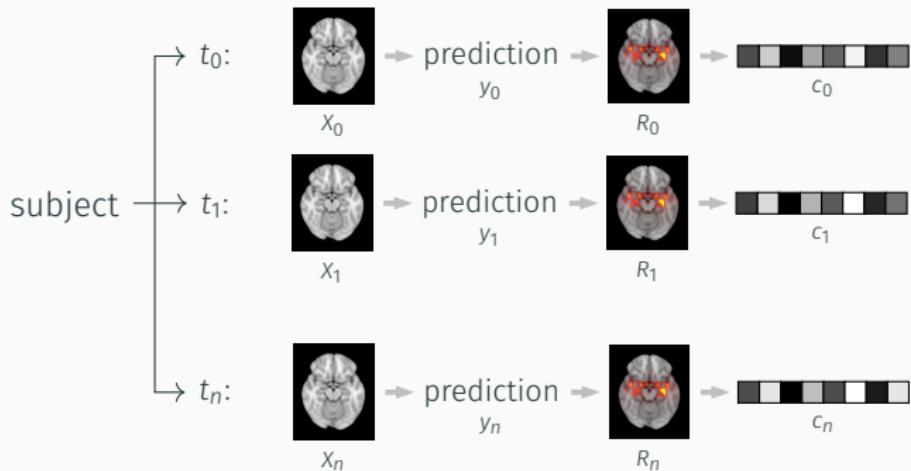
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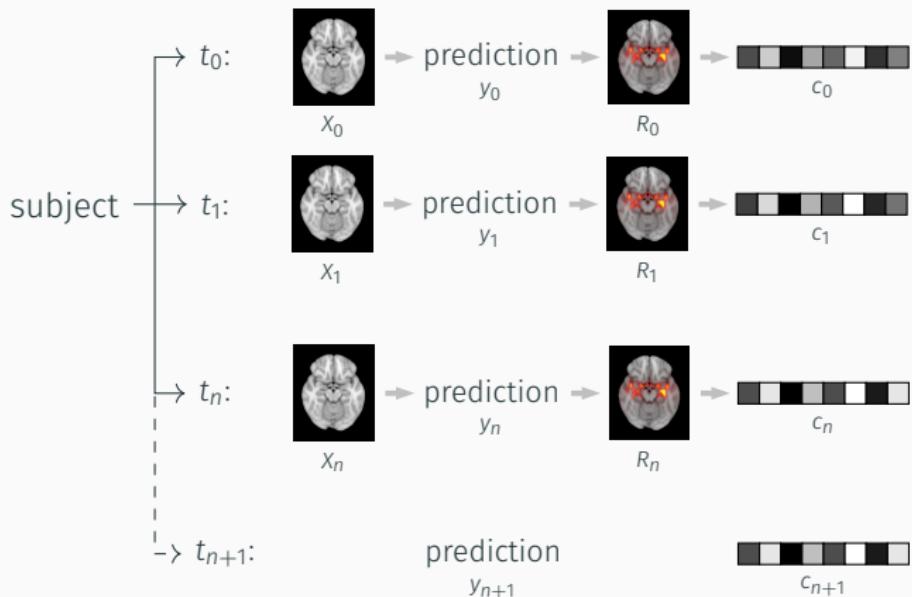
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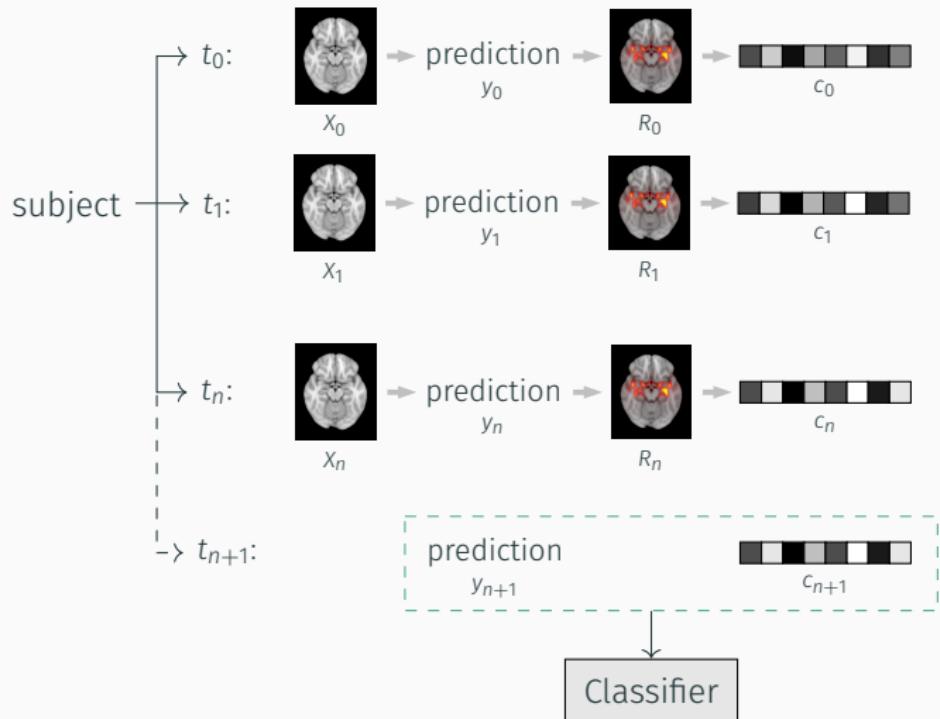
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# Exploring relevance maps in MCI patients

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

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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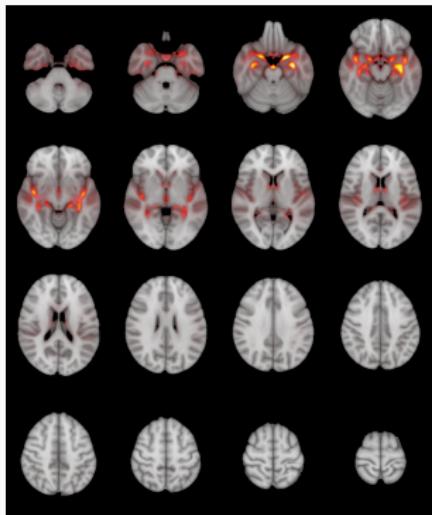


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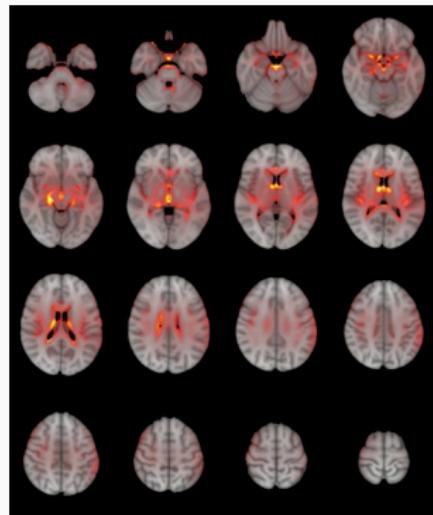


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But wait



Dementia



Multiple Sclerosis