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

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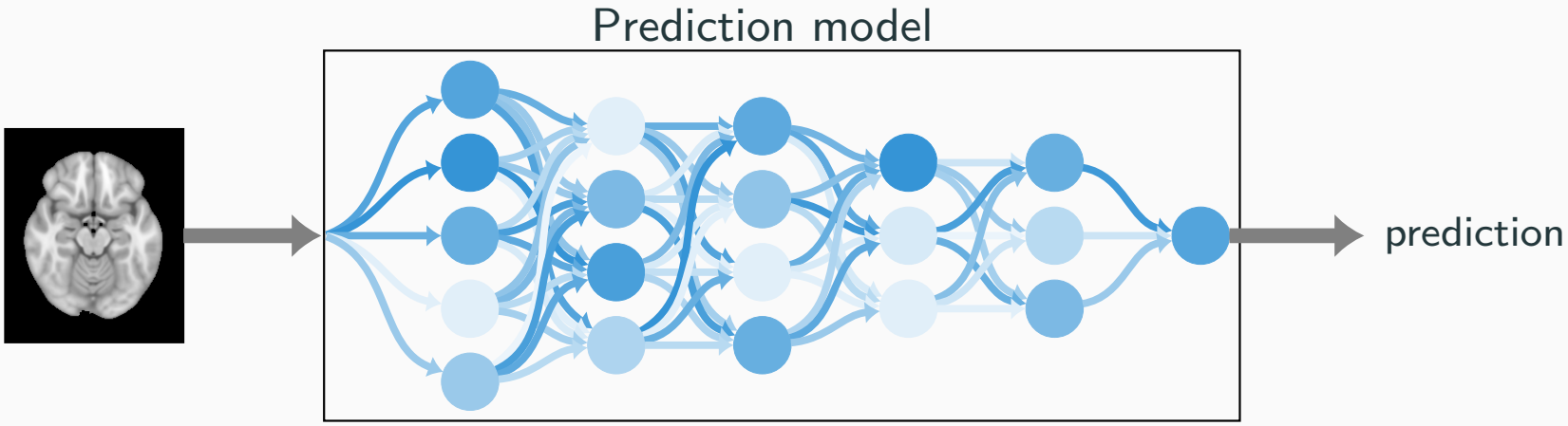
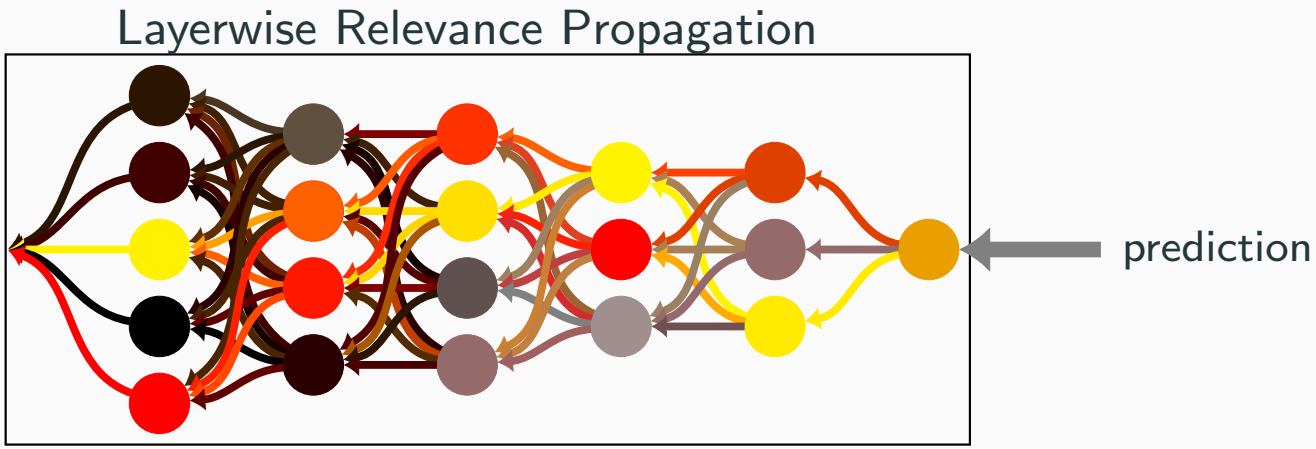
Layerwise Relevance Propagation



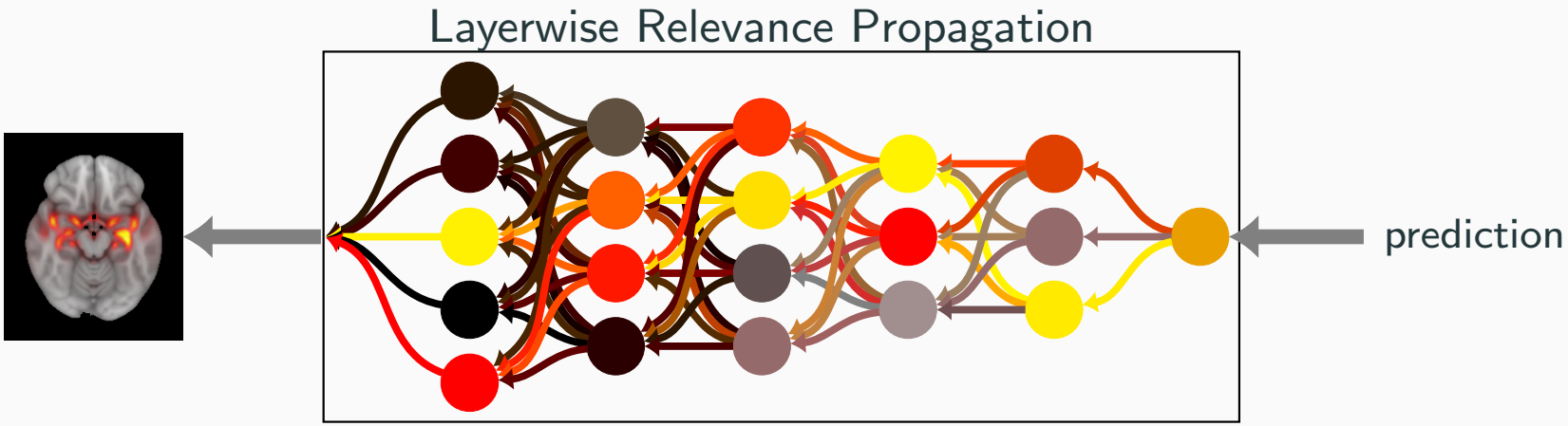
$$n_{i,j} = \sum_k n_{i-1,k} w_{k,j}$$

Layerwise Relevance Propagation



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

Layerwise Relevance Propagation



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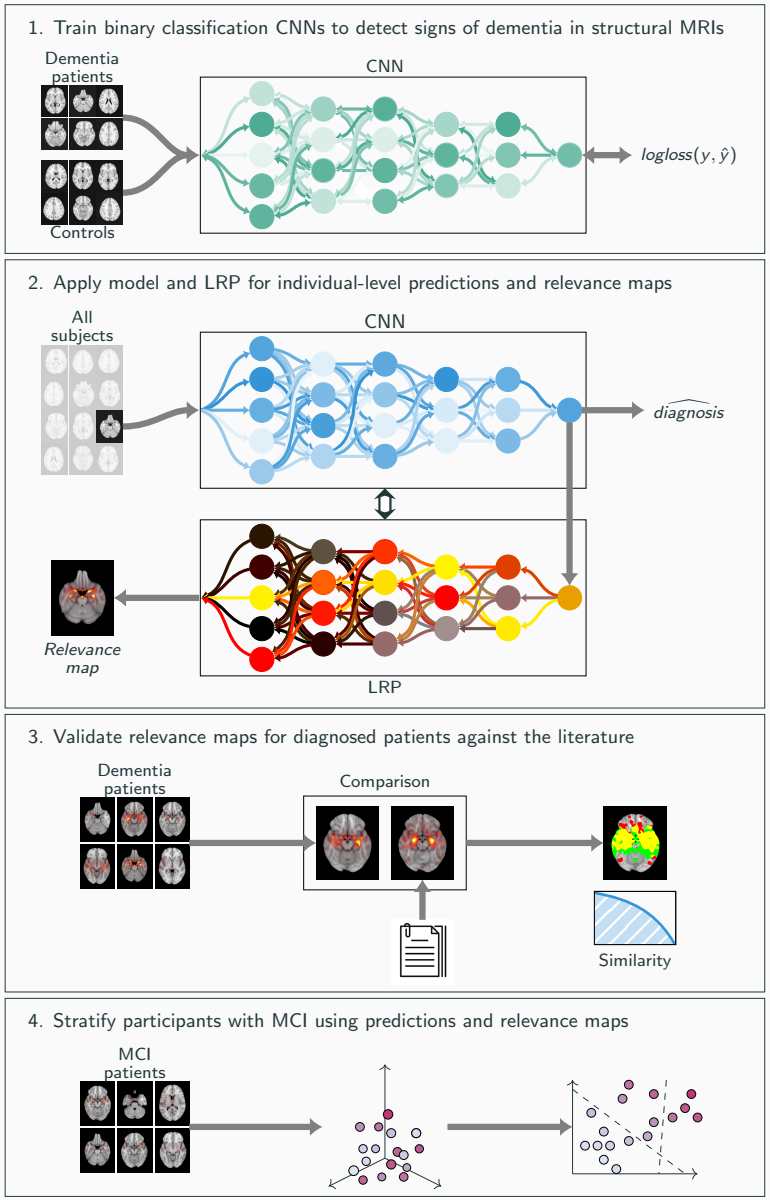
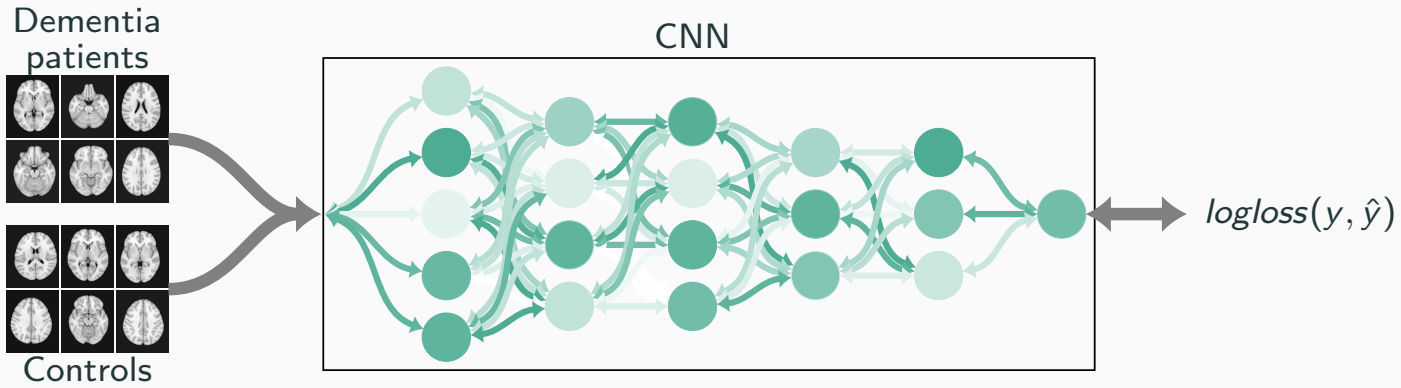
Overview

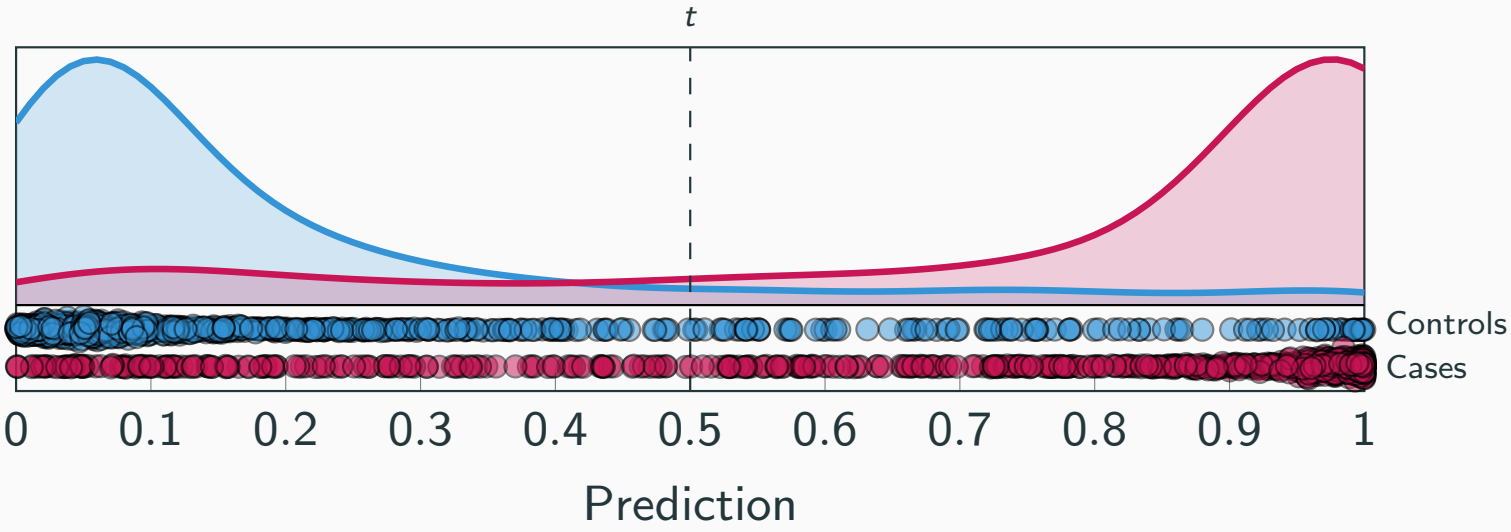

1. Train binary classification CNNs to detect signs of dementia in structural MRIs
Dementia patients
Controls
CNN
$logloss(y, \hat{y})$
2. Apply model and LRP for individual-level predictions and relevance maps
All subjects
CNN
$\widehat{diagnosis}$
Relevance map
LRP
3. Validate relevance maps for diagnosed patients against the literature
Dementia patients
Comparison
Similarity
4. Stratify participants with MCI using predictions and relevance maps
MCI patients

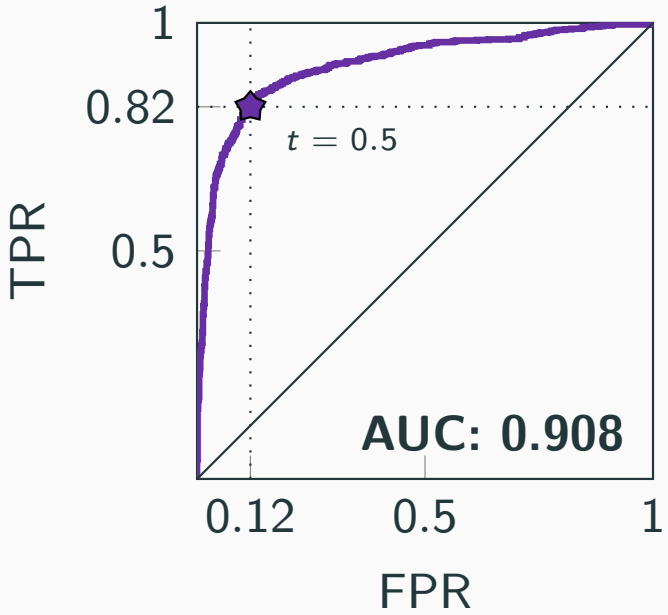
Case-control predictions

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



Case-control predictions

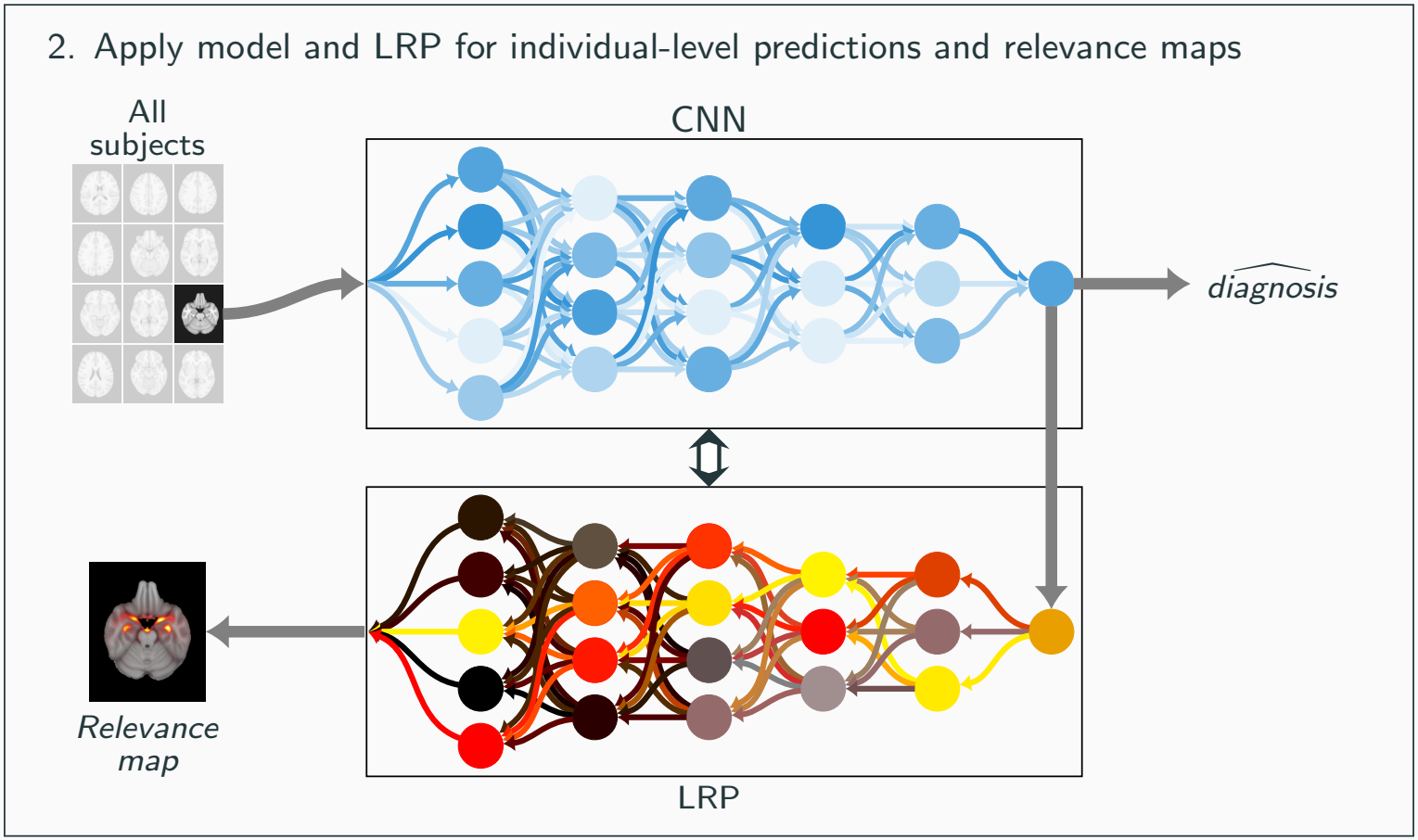




		Predicted	
		0	**1**
Observed	**0**	754	100
	1	157	697

Accuracy: 84.95%

Generating relevance maps



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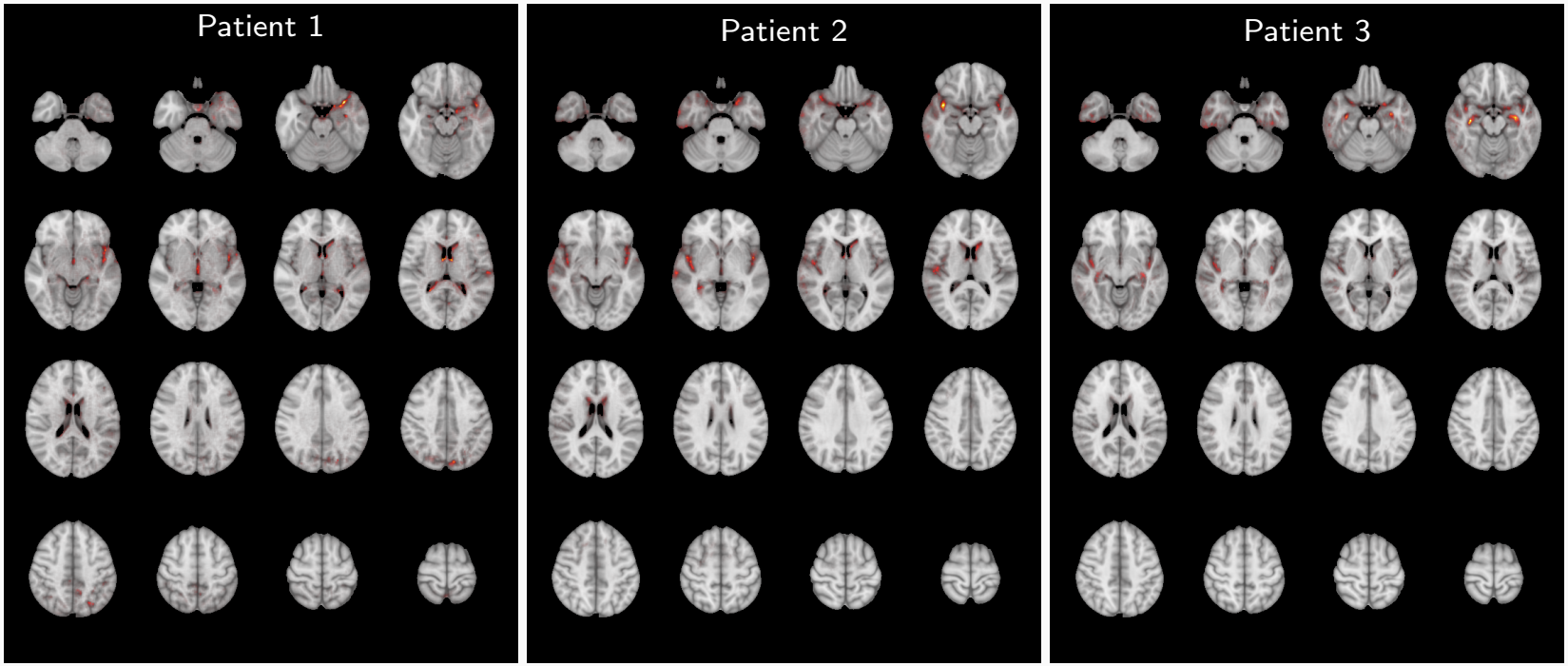
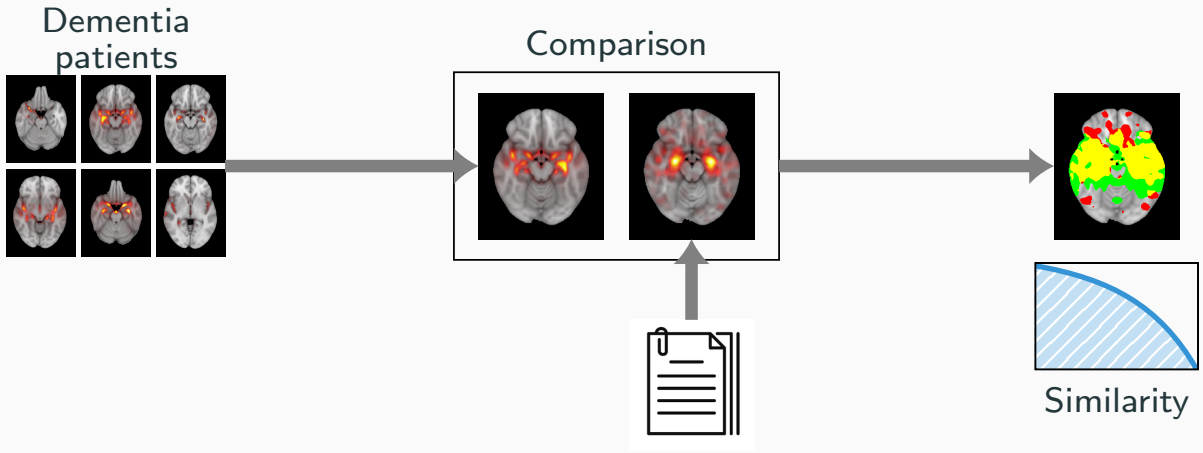


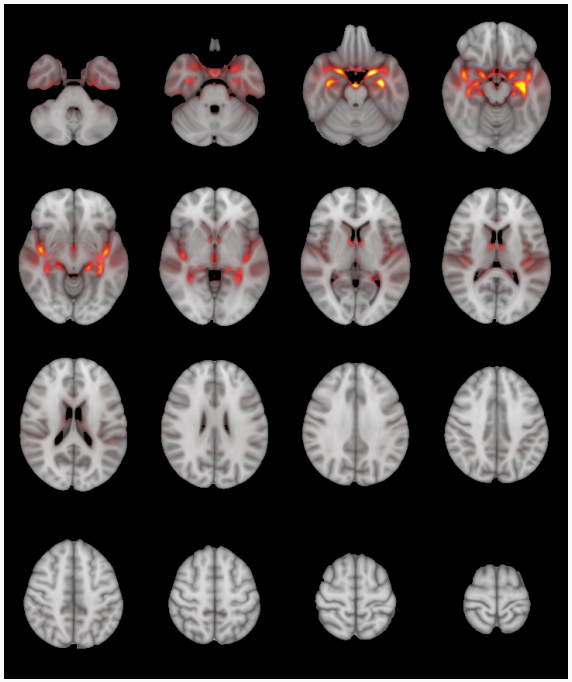
Validating relevance maps in dementia patients

3. Validate relevance maps for diagnosed patients against the literature



Validating relevance maps in dementia patients

Average dementia patient



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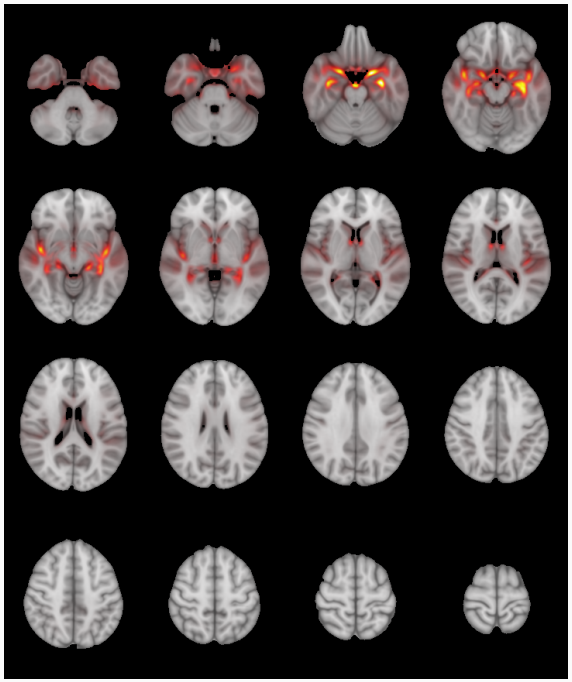
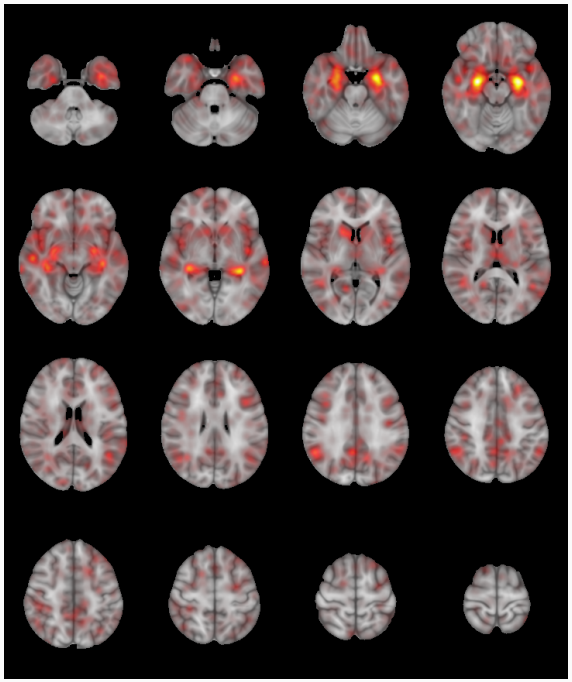


GingerALE meta-analysis



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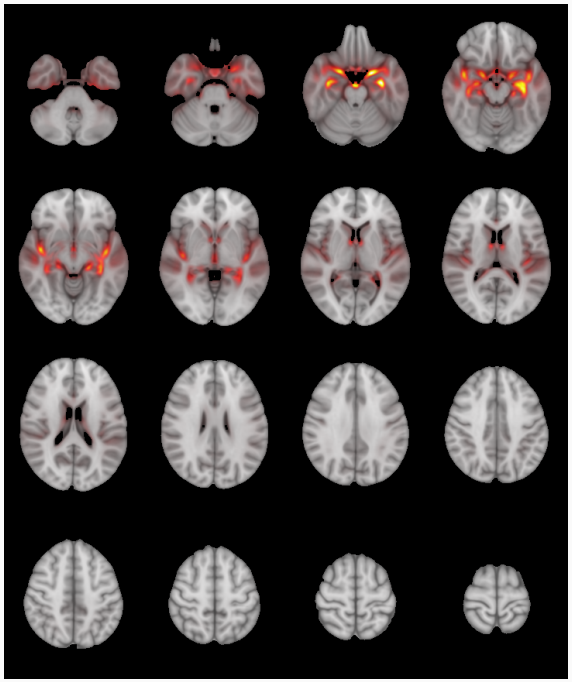
Average dementia patient



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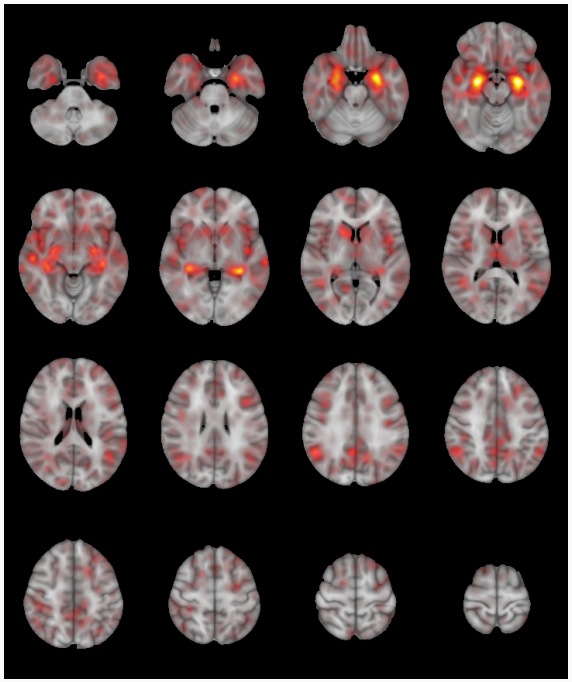
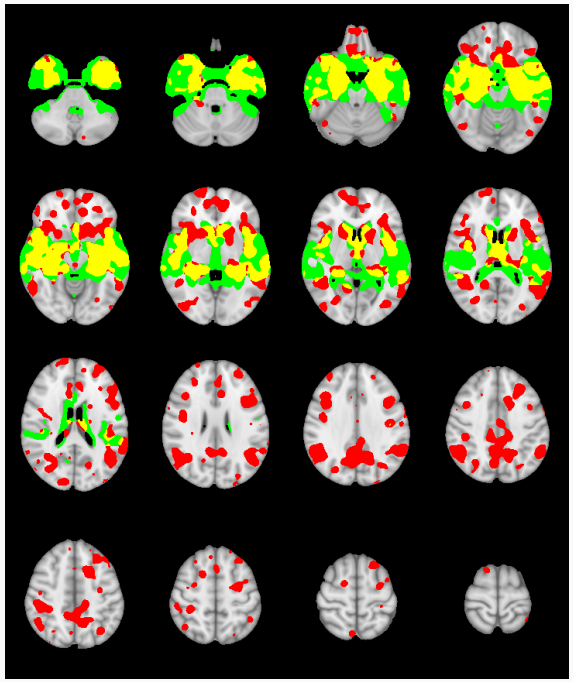


Overlap



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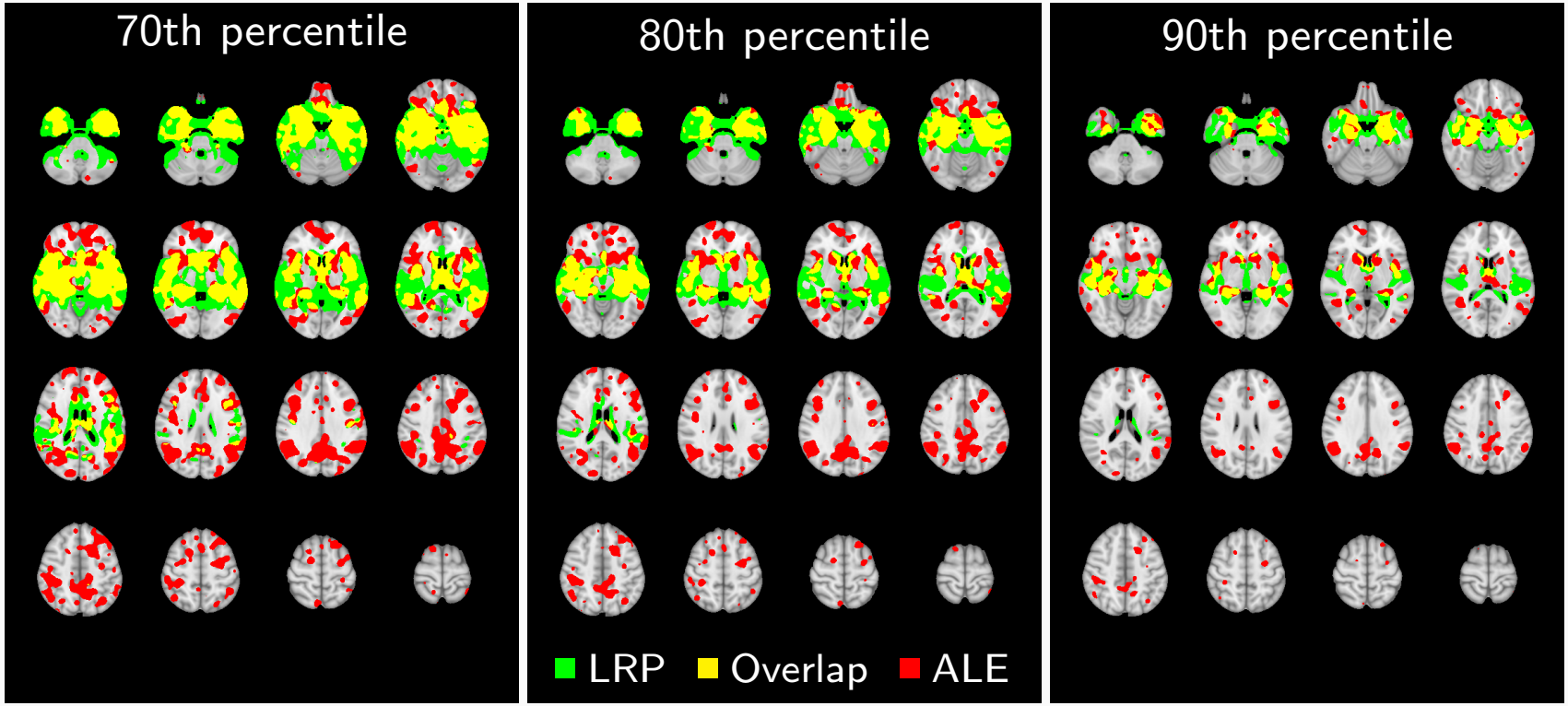

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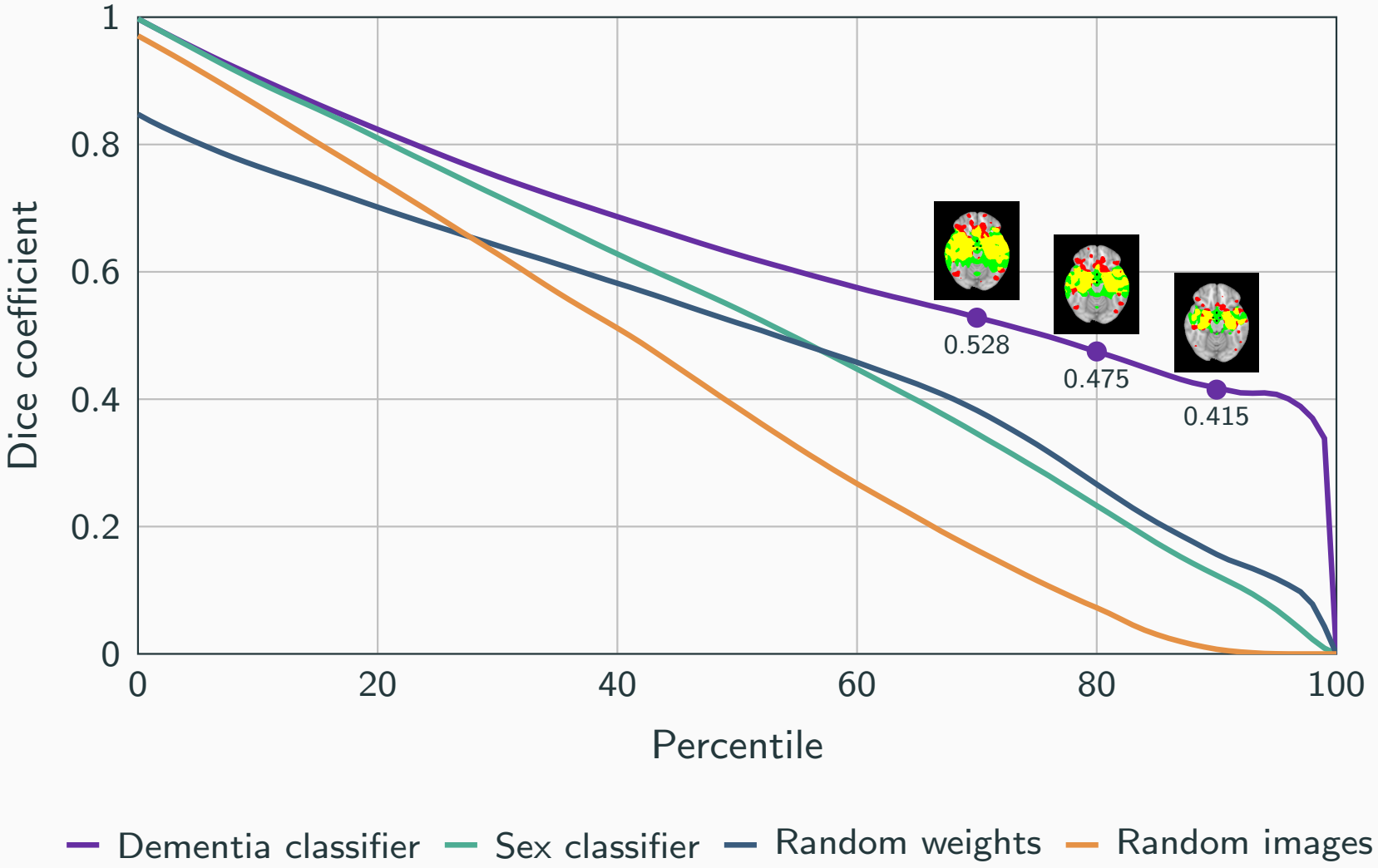

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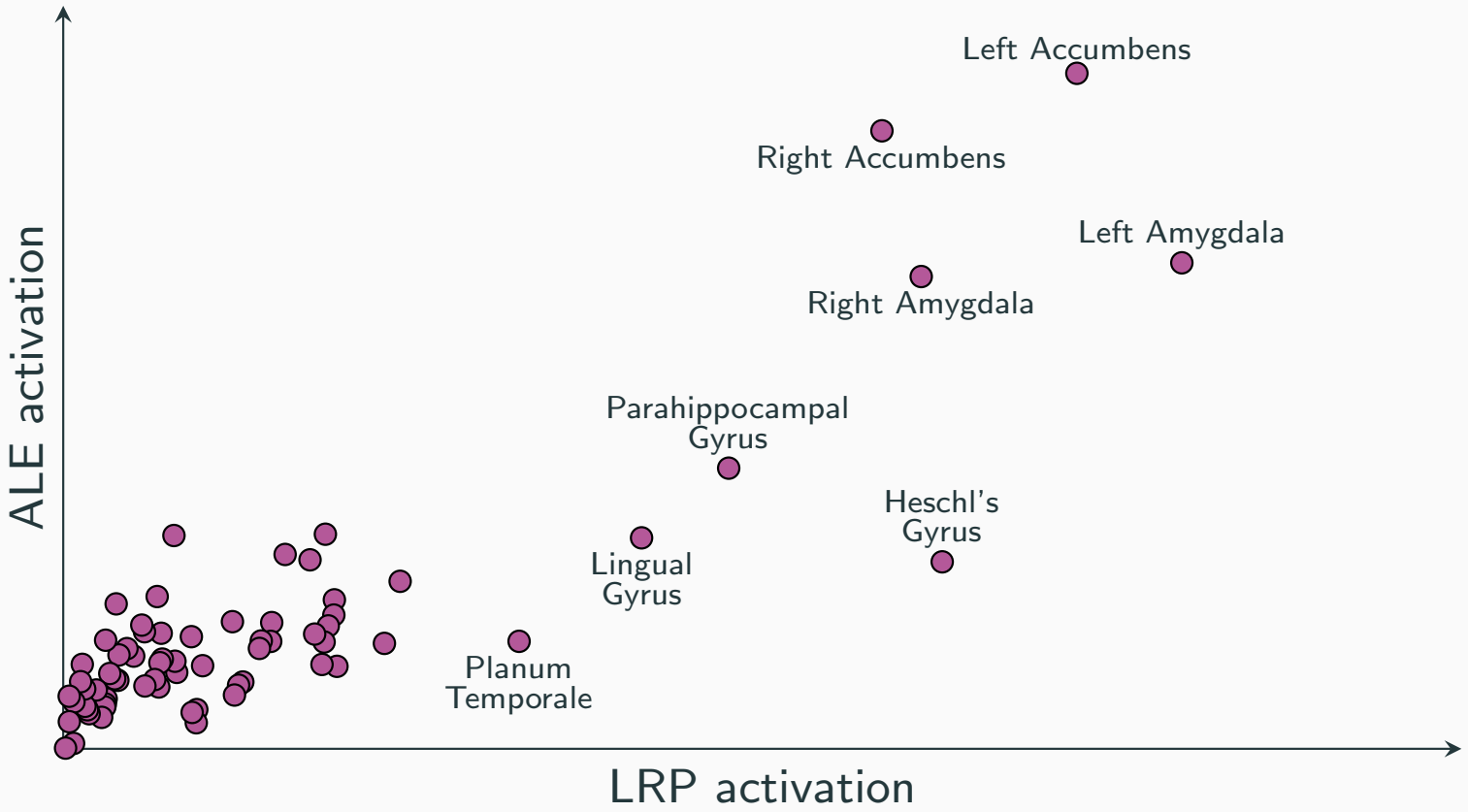
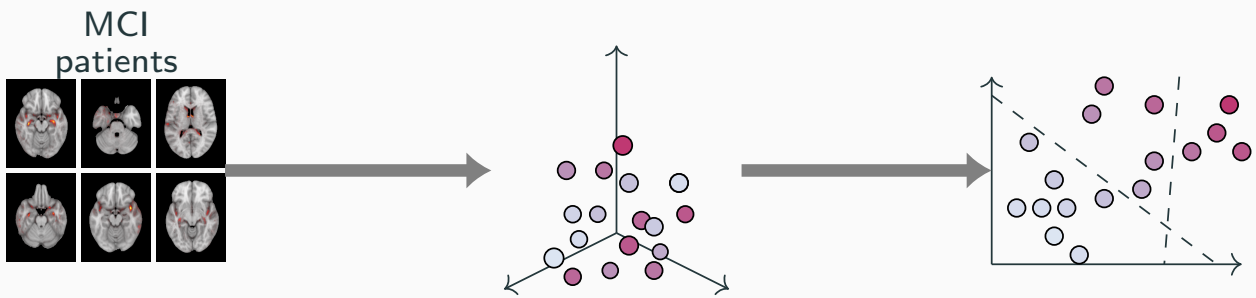


Exploring relevance maps in MCI patients

4. Stratify participants with MCI using predictions and relevance maps



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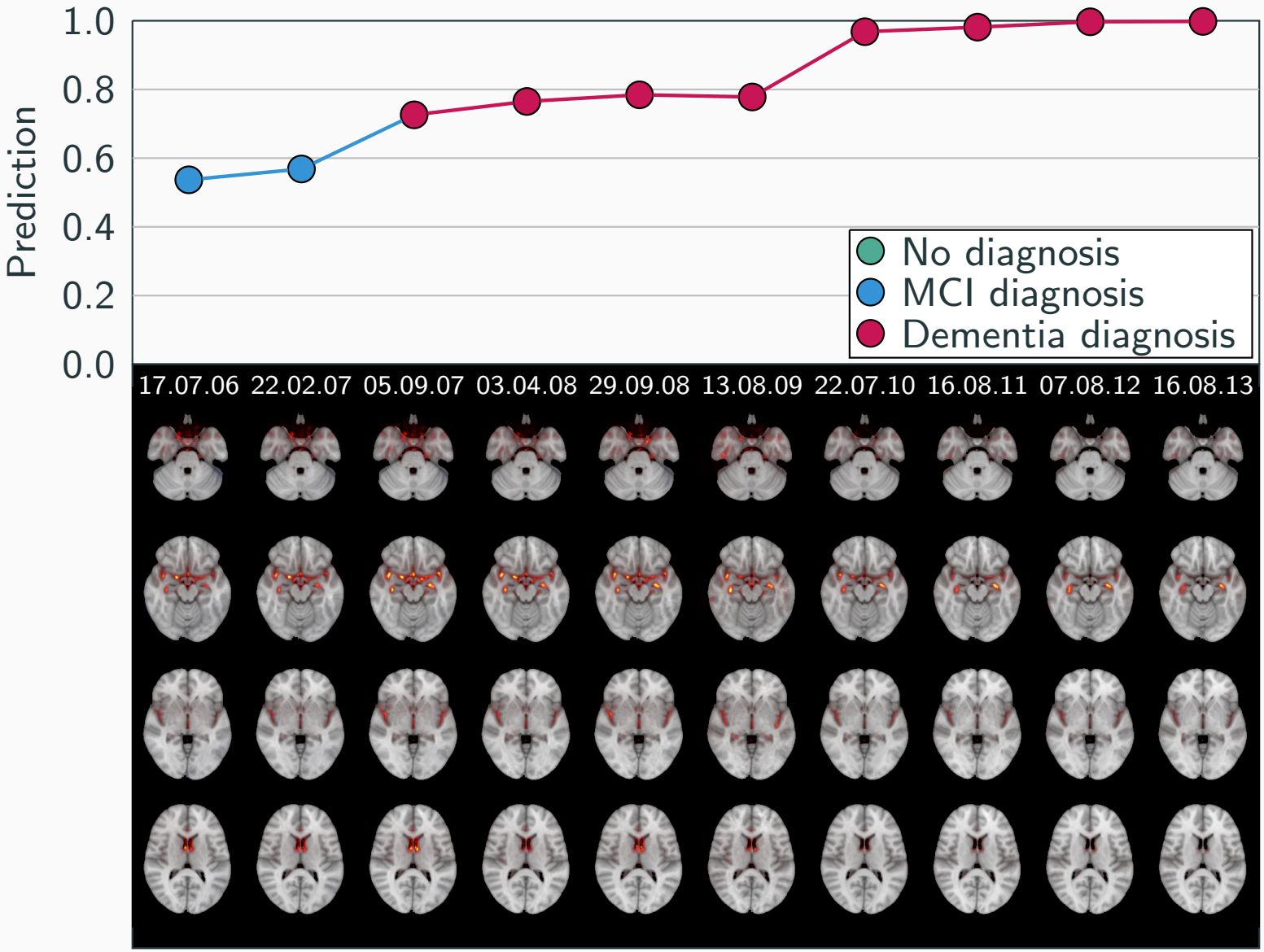

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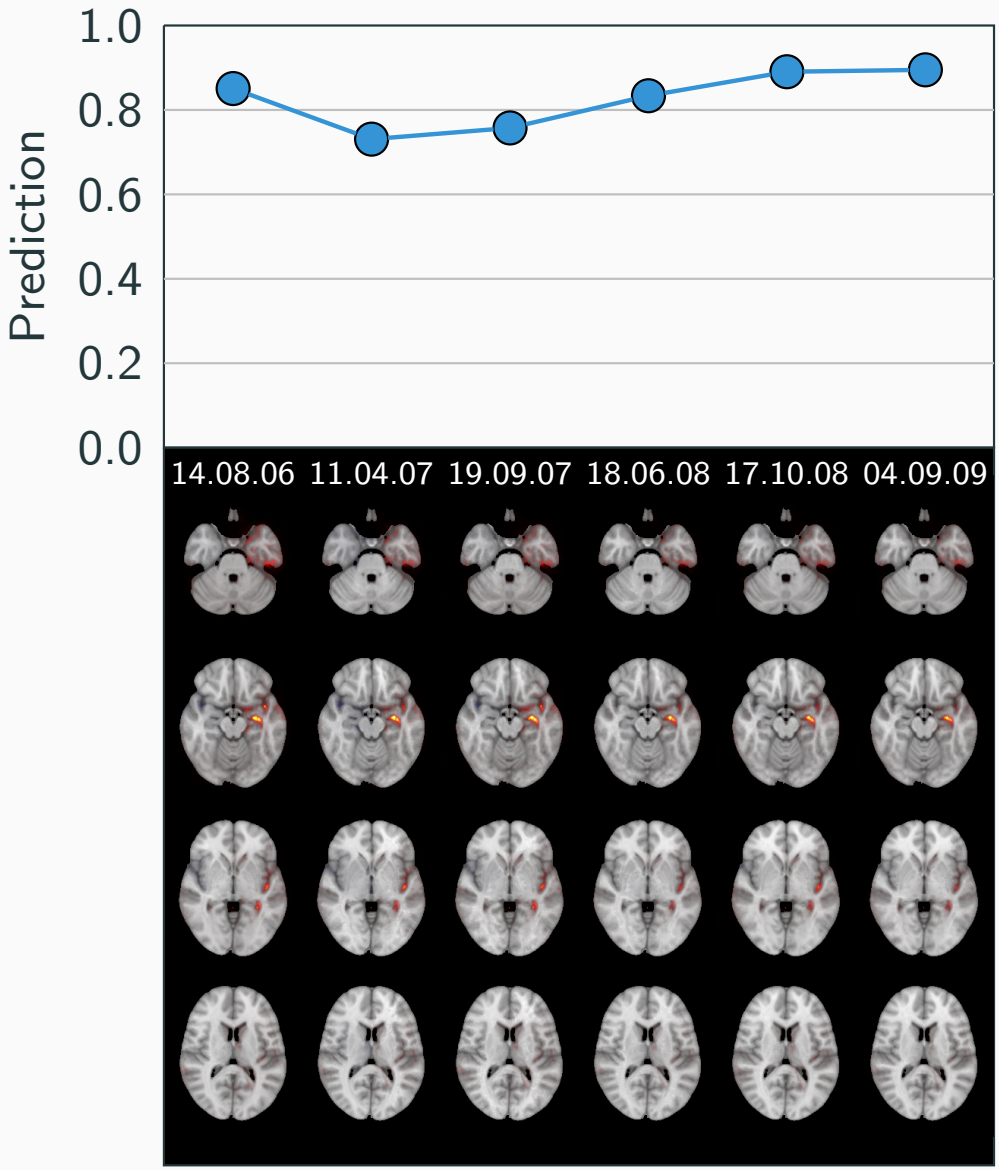

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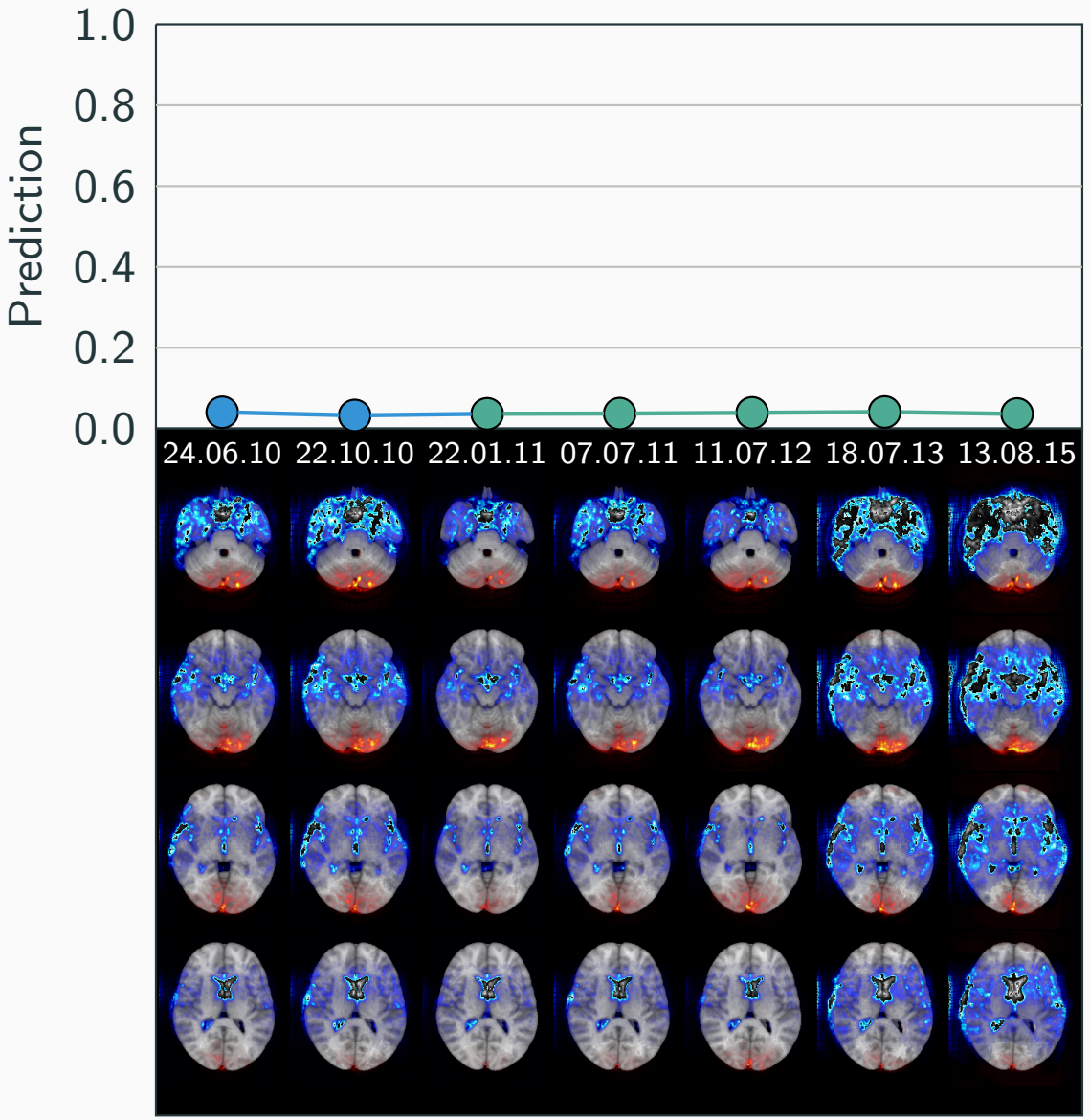

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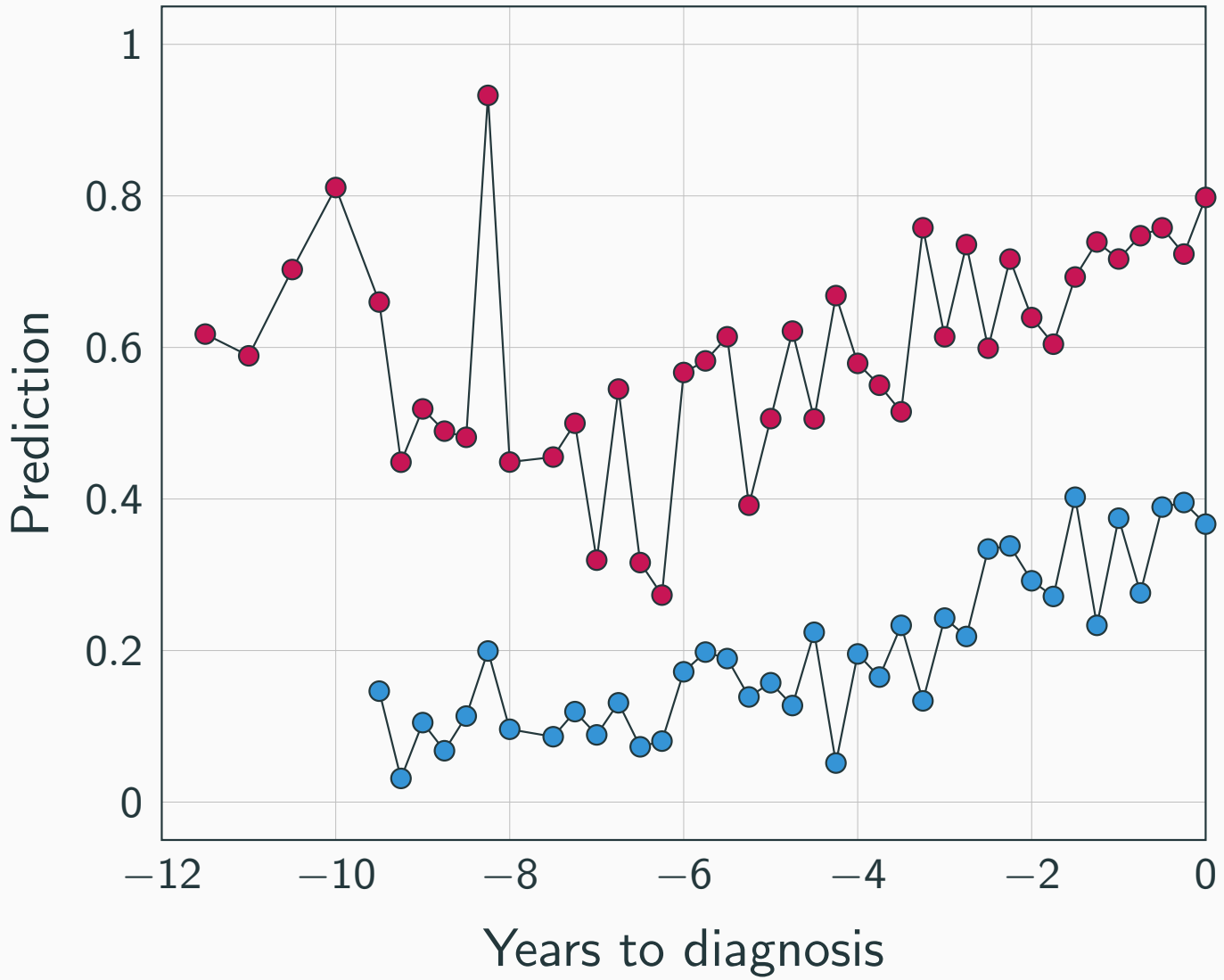

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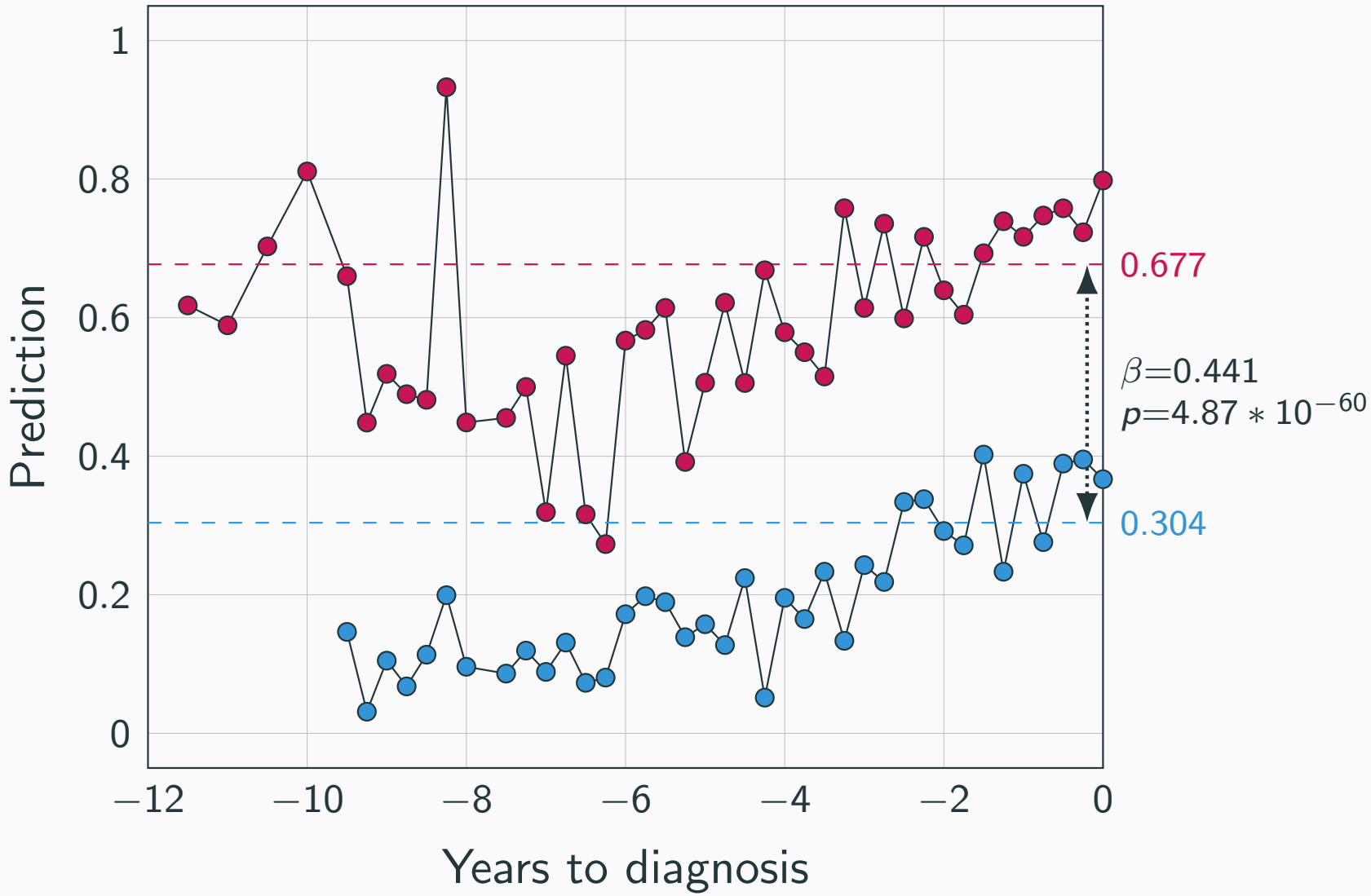

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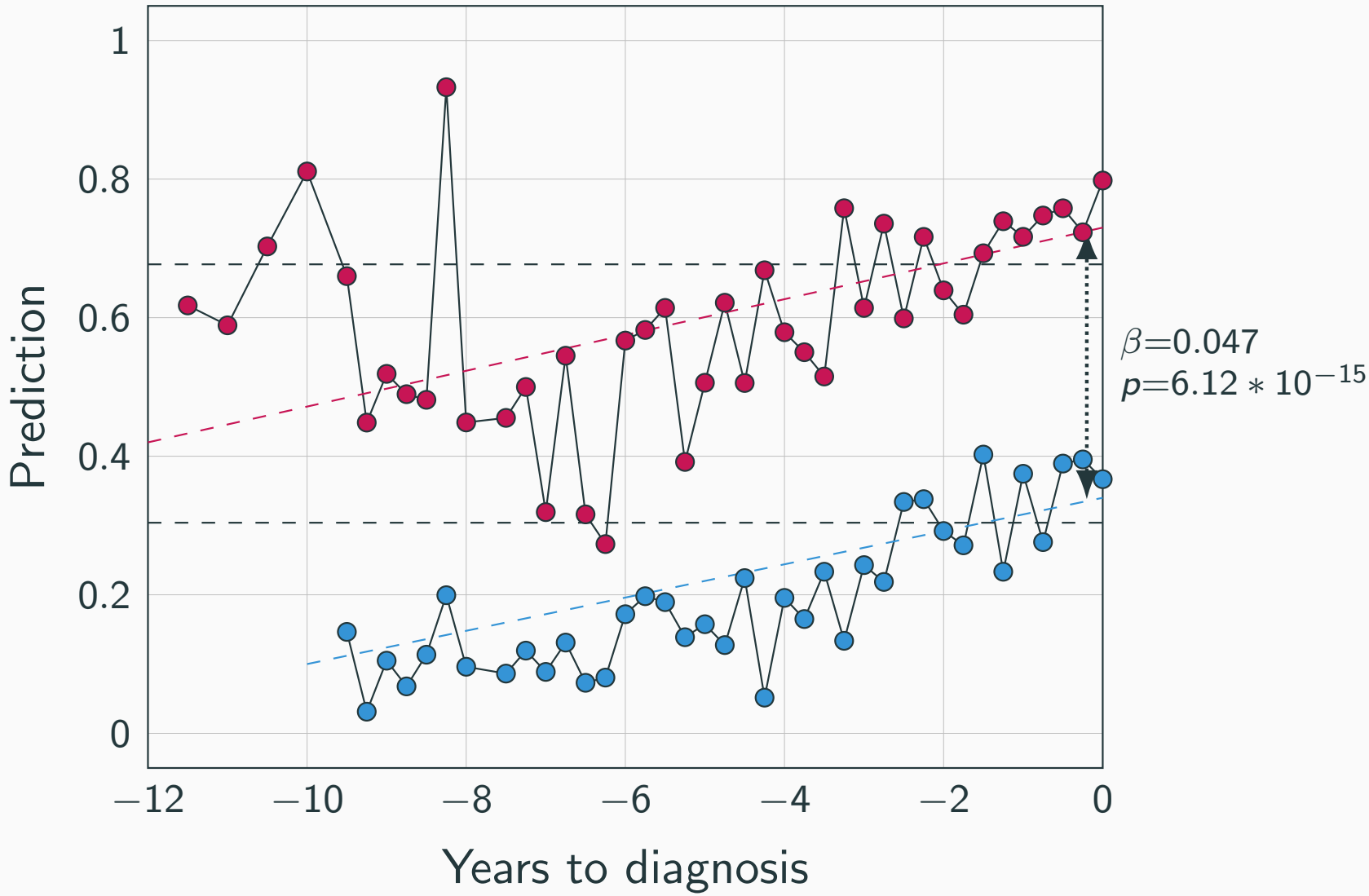
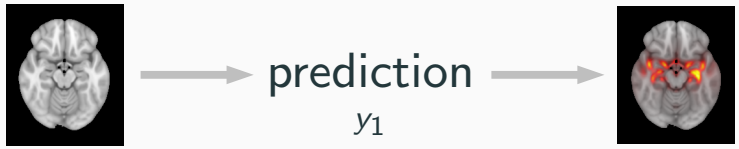


Exploring relevance maps in MCI patients

subject $\longrightarrow$ t_1:



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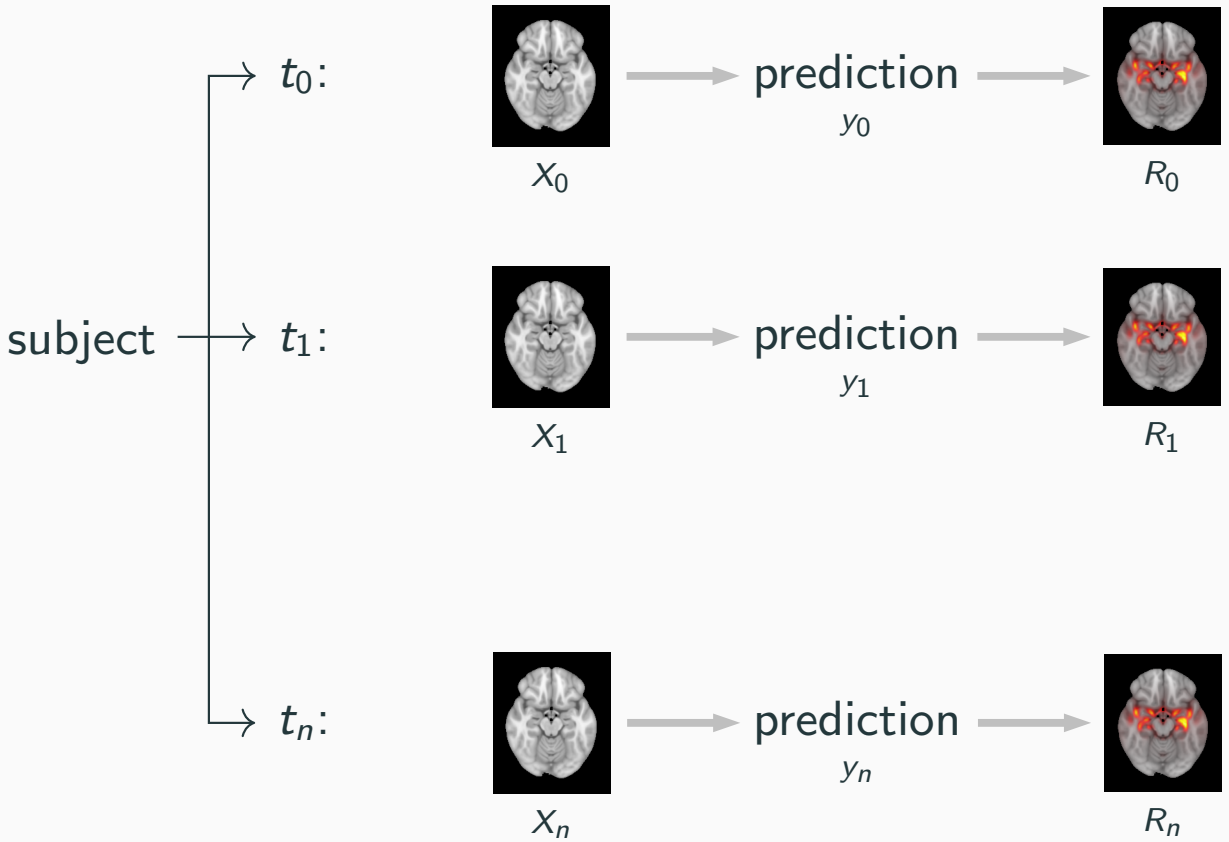

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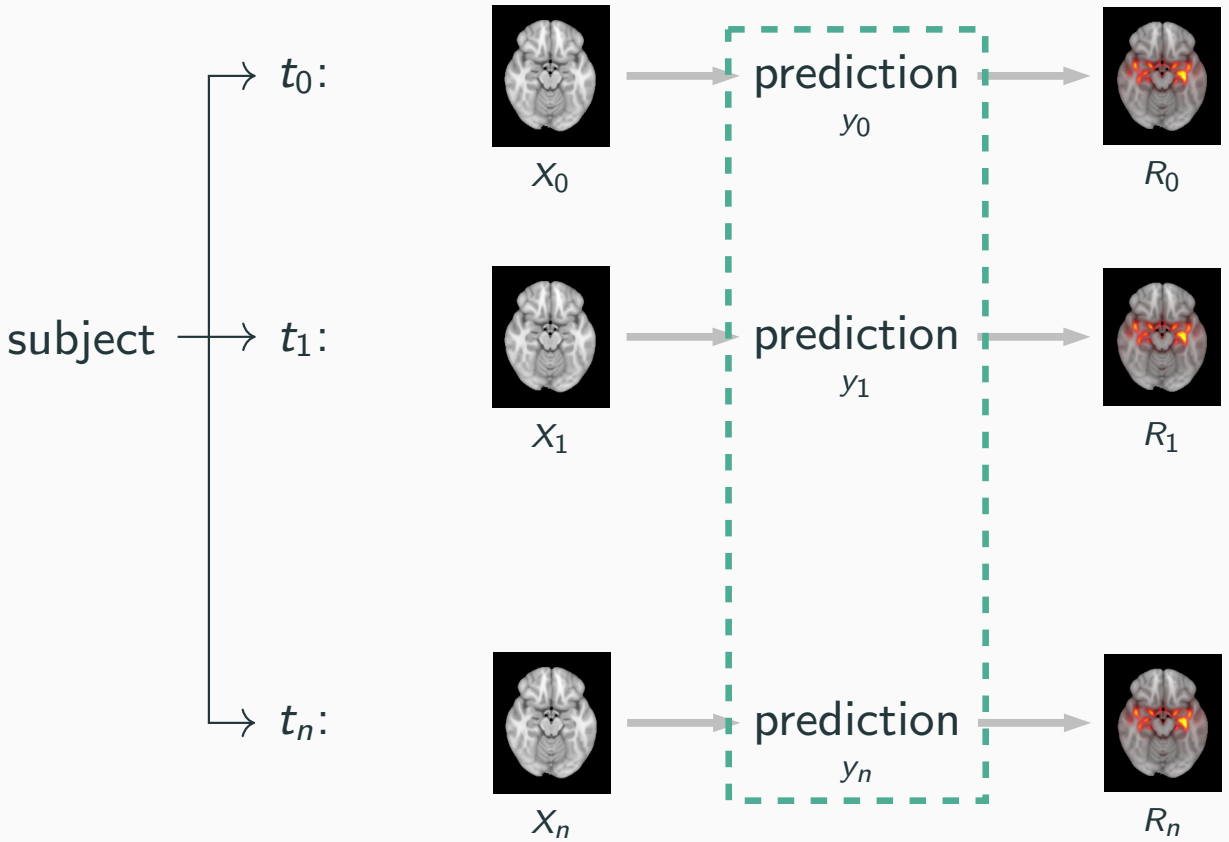

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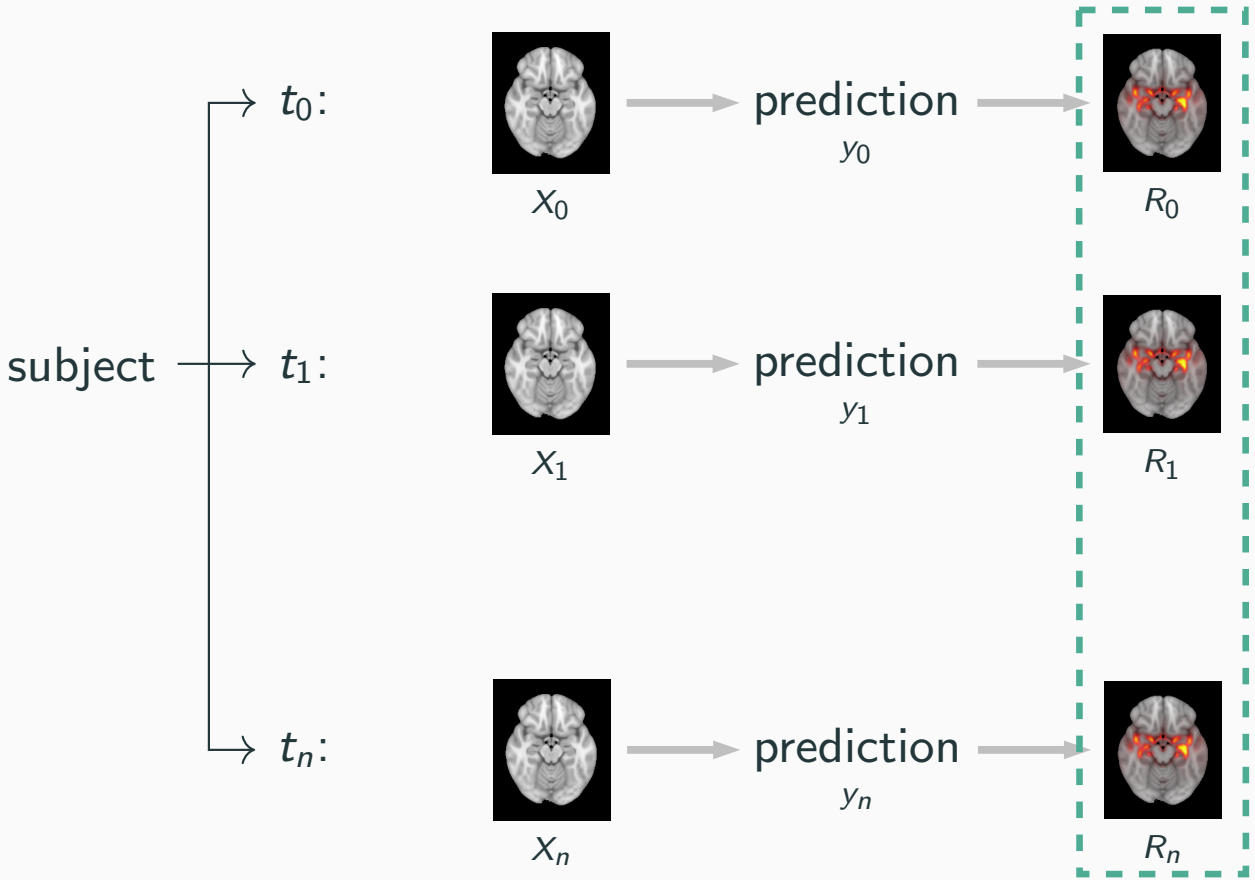

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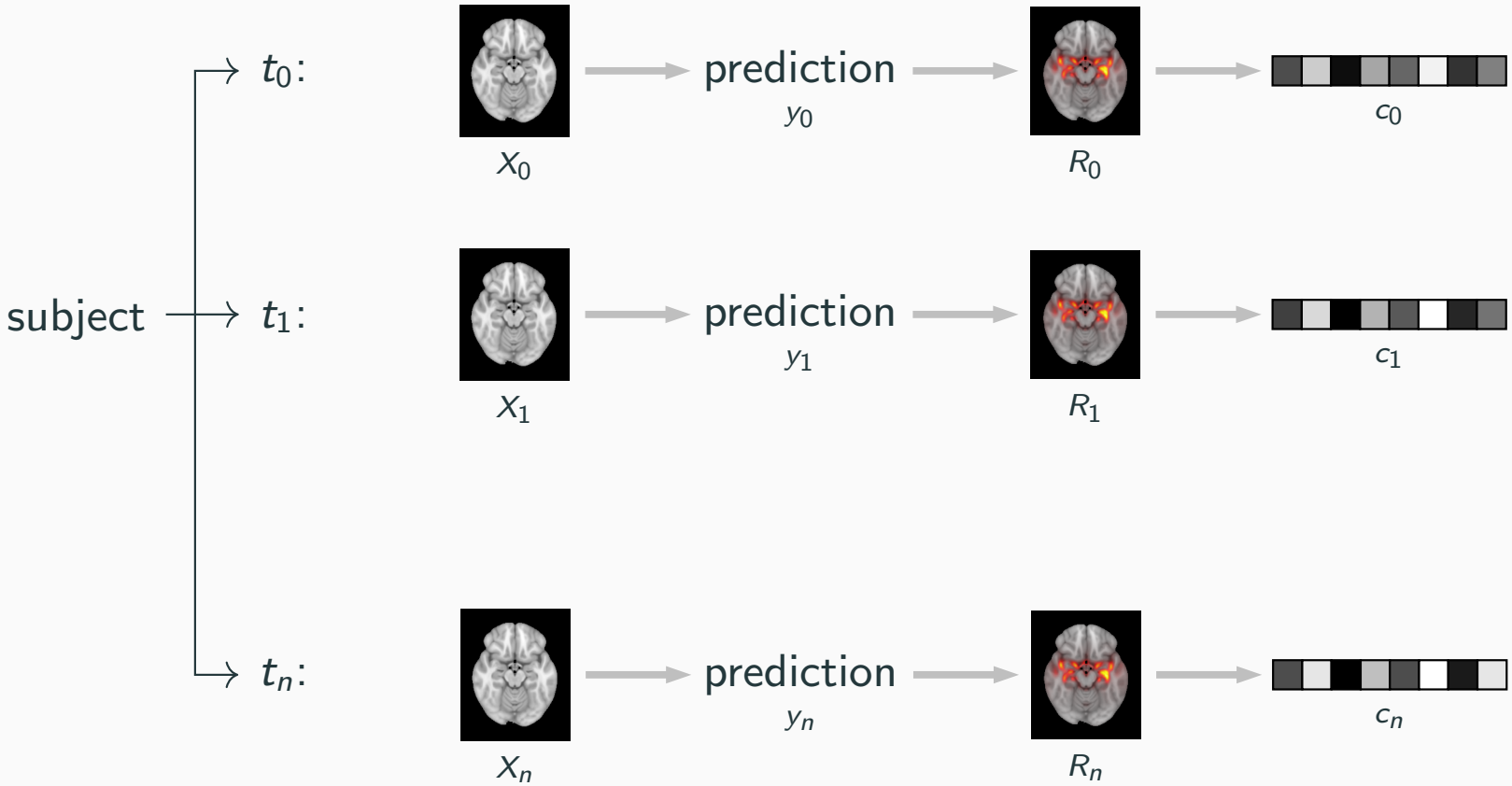

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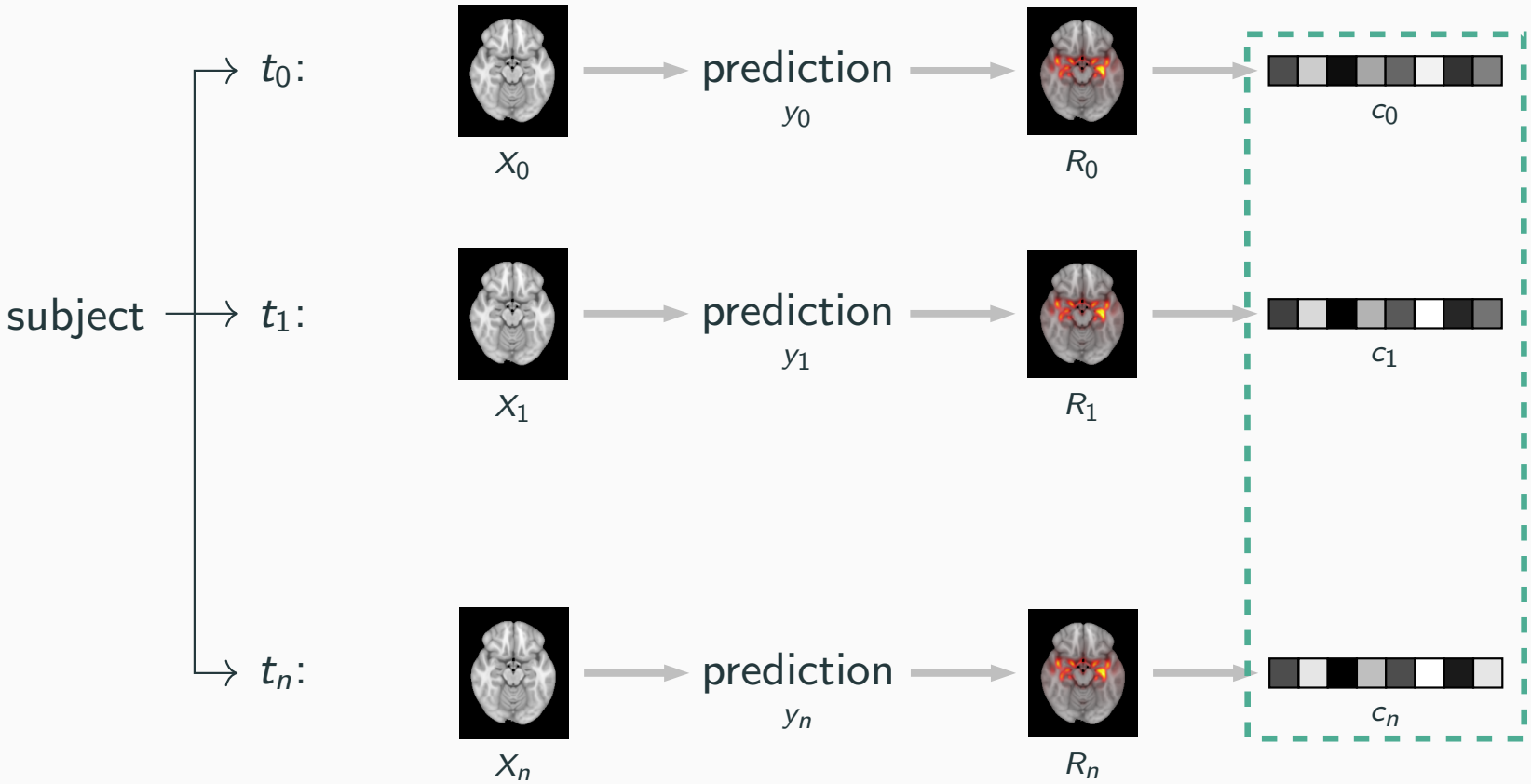
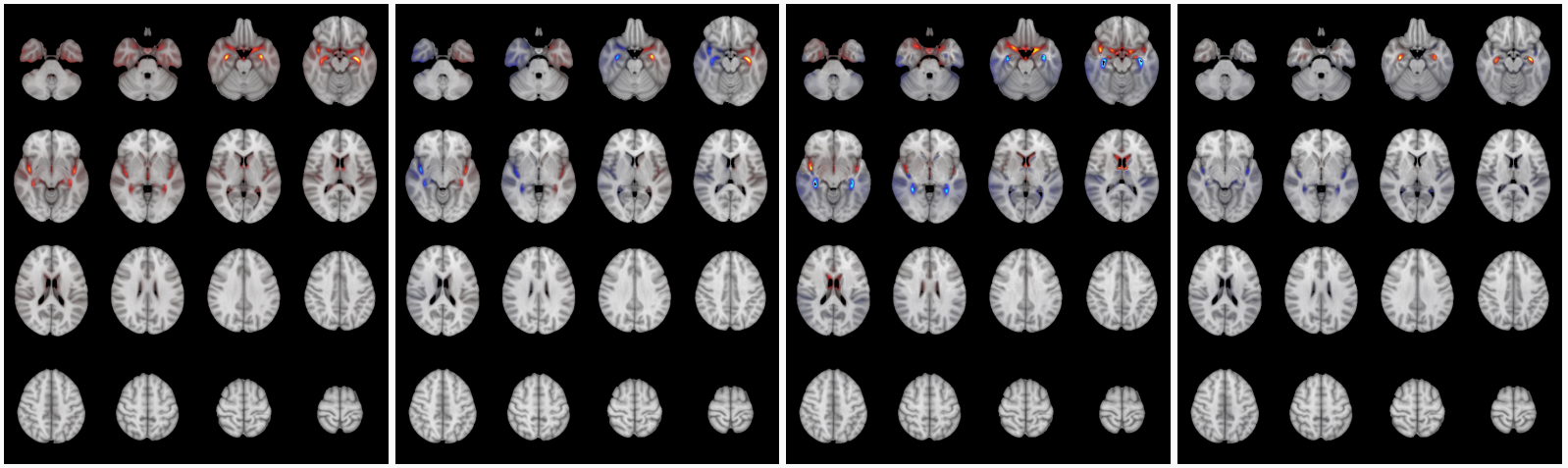


Exploring relevance maps in MCI patients

Component 0 Component 1 Component 2 Component 3



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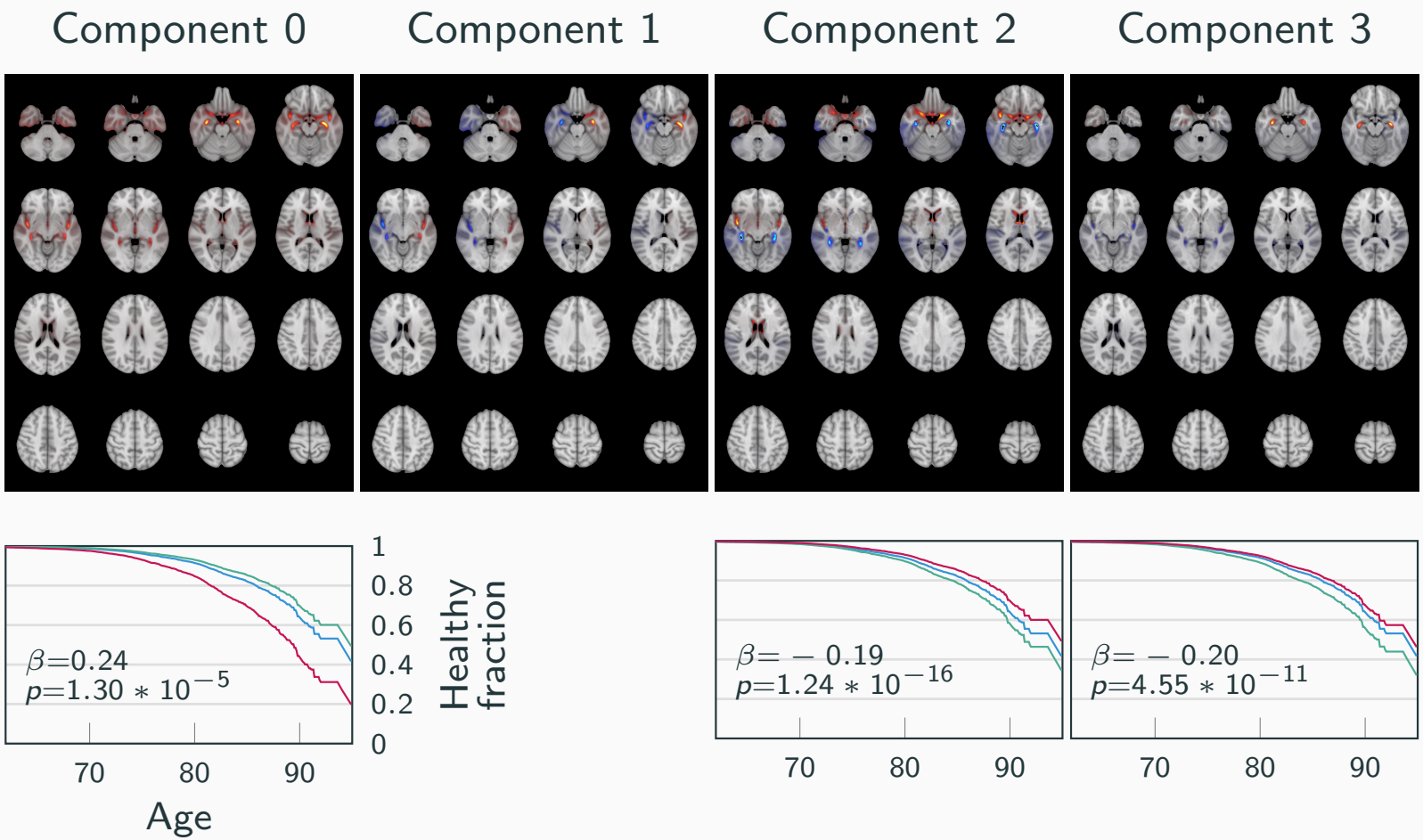

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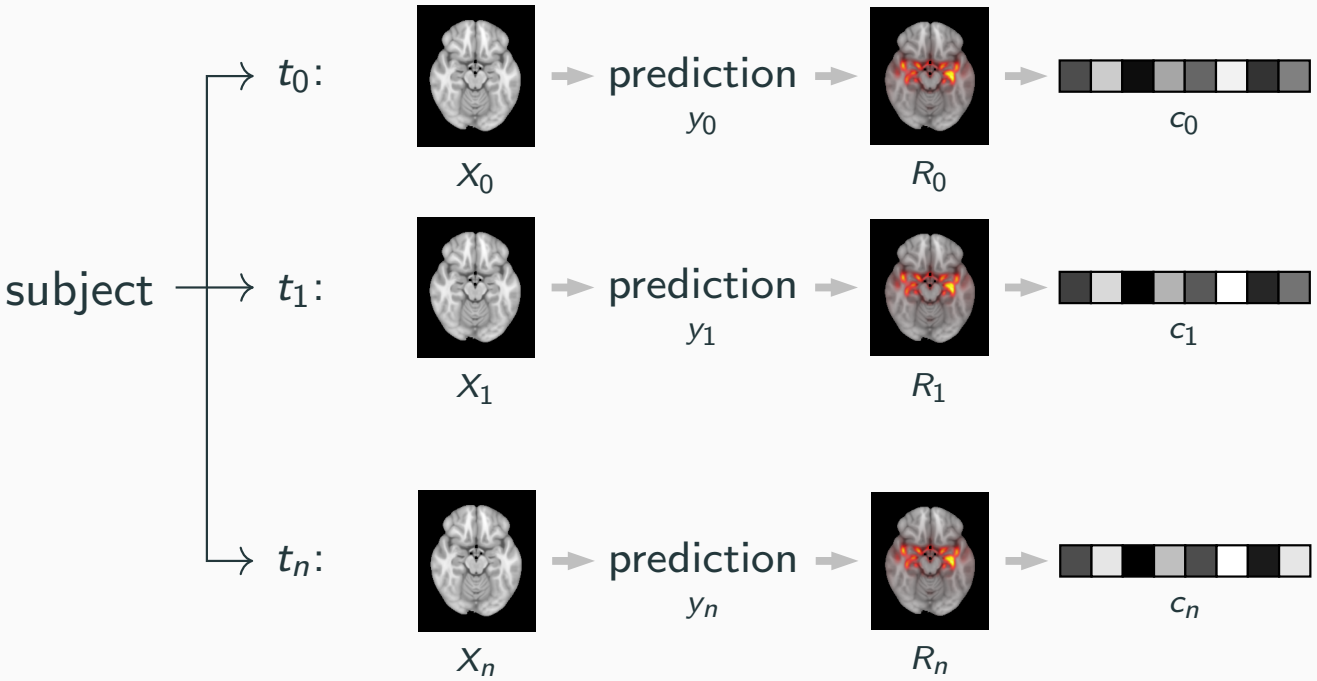

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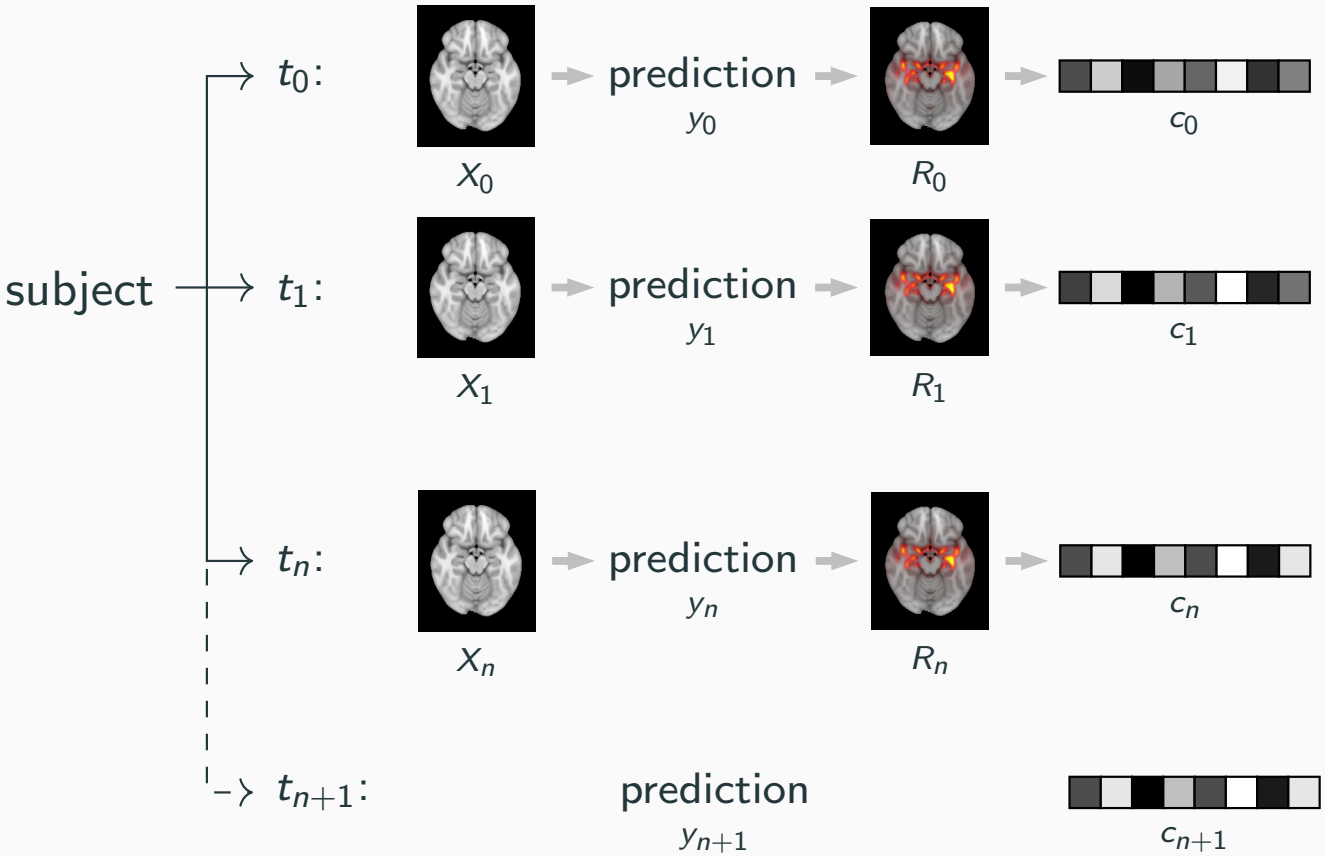

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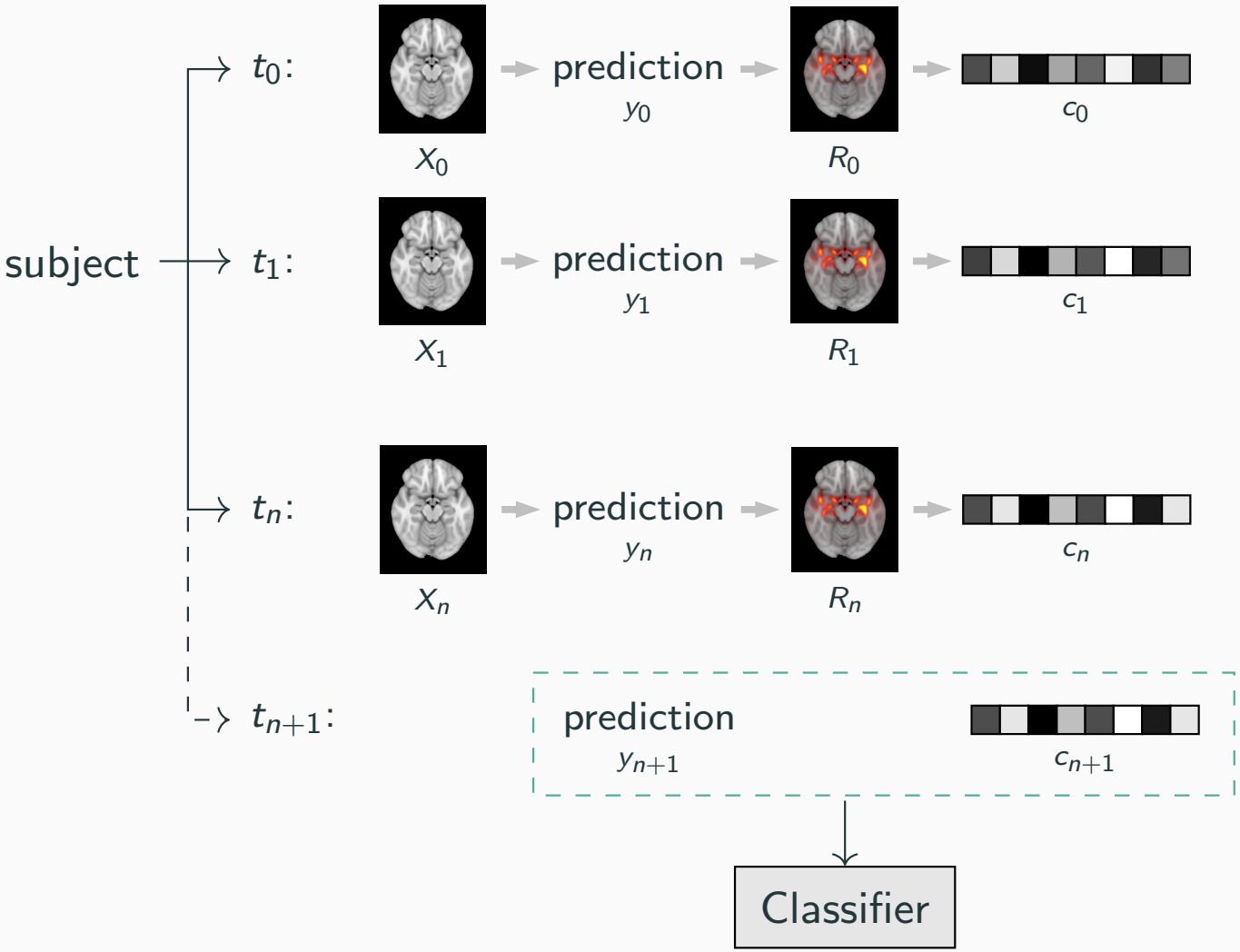

Exploring relevance maps in MCI patients

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."