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Improving Brain Decoding Methods and Evaluation

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Yiming Cai, Oliver Richter, Roger Wattenhofer

Distributed Computing Laboratory

ETH zürich

What is Brain Decoding?

Stimuli

What is Brain Decoding?

Stimuli

fMRI

Word

“ability”

What is Brain Decoding?

Stimuli

fMRI

Decoder

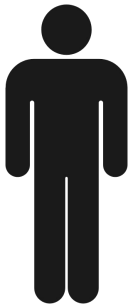
Word

“ability”

Dataset[1]

[1] F. Pereira et al. Toward a universal decoder of linguistic meaning from brain activation. *Nature communications*, 9(1):1–13, 2018.

Dataset[1]



x 15

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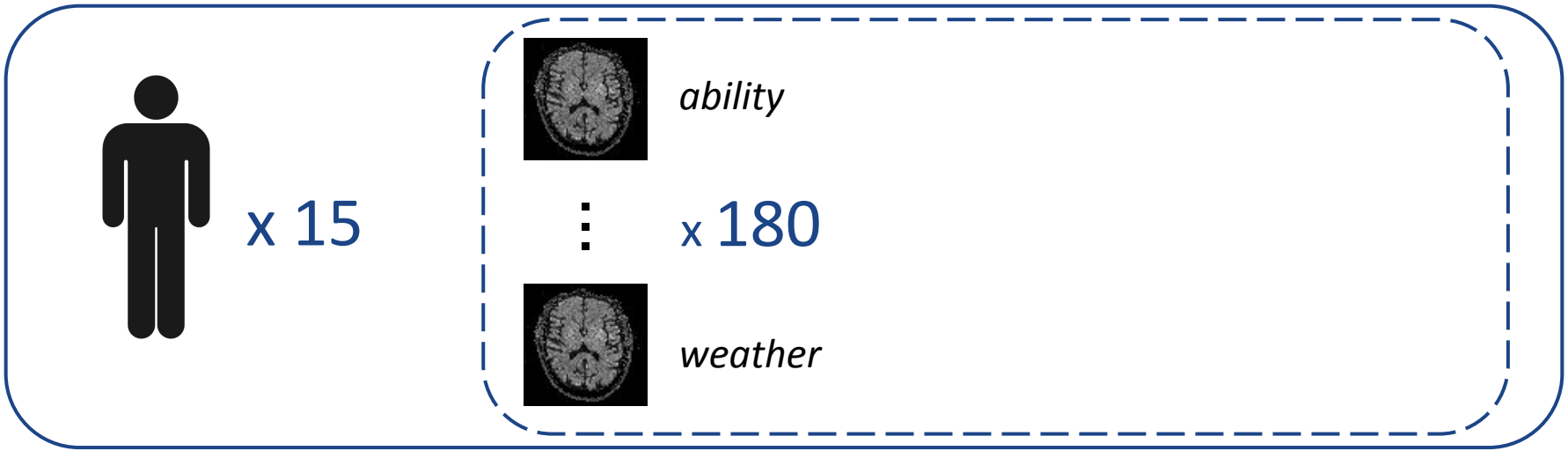

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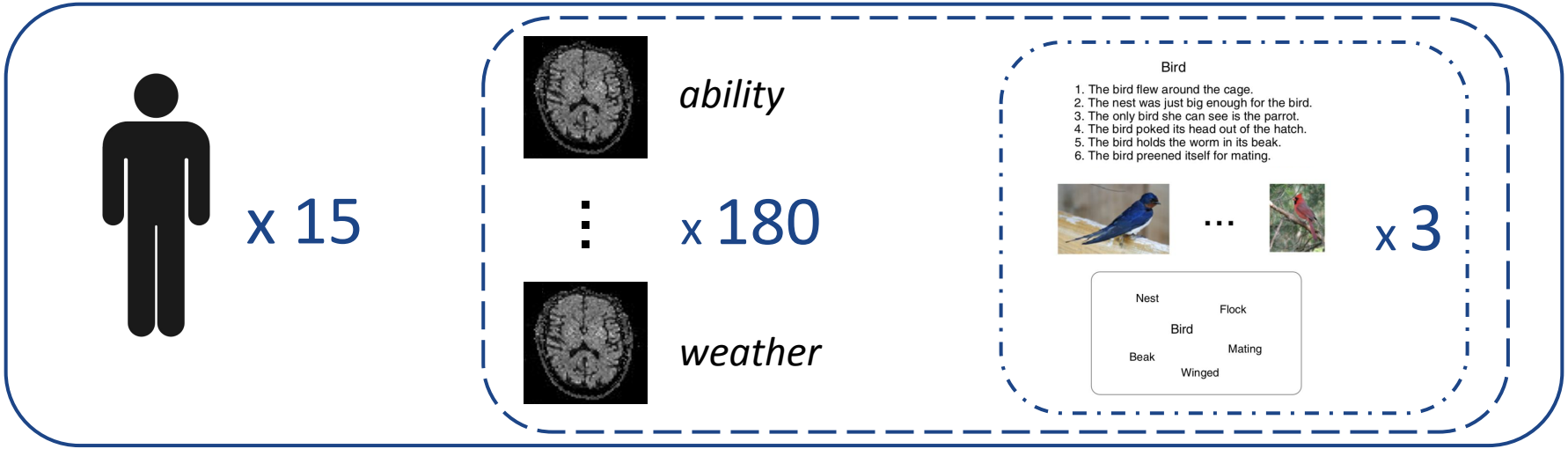

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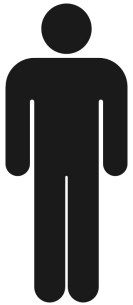

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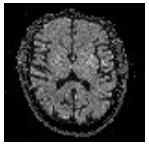
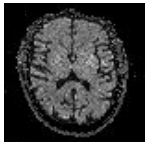


ability

⋮

x 180



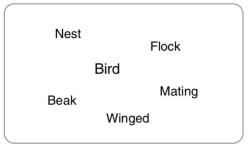
weather

Bird

1. The bird flew around the cage.
2. The nest was just big enough for the bird.
3. The only bird she can see is the parrot.
4. The bird poked its head out of the hatch.
5. The bird holds the worm in its beak.
6. The bird preened itself for mating.

...

x 3



Sentence

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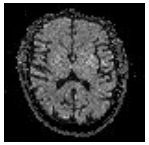

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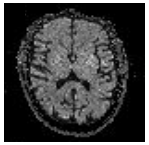

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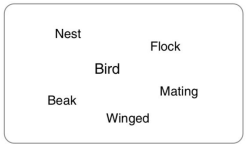

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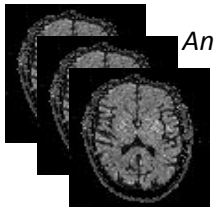

An apartment is a self-contained home that is part of a building.

⋱

Arson is the criminal act of burning a building or wildland.

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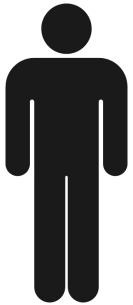

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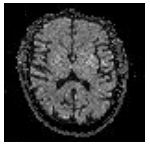

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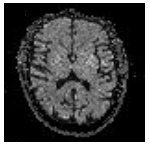

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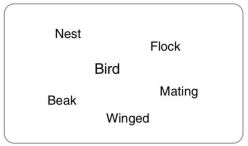

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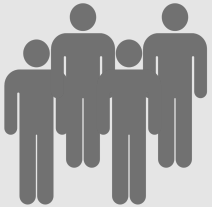

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Outline

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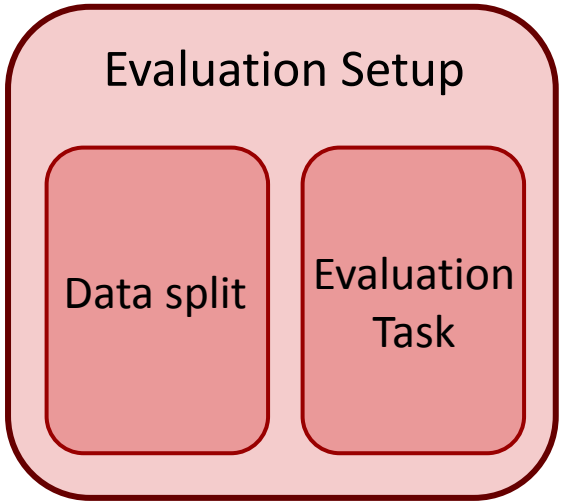


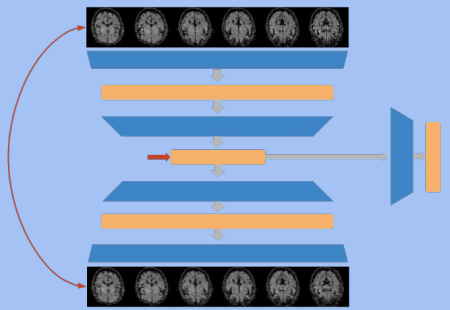
Outline

Evaluation Setup

Data split

Evaluation Task

Decoder



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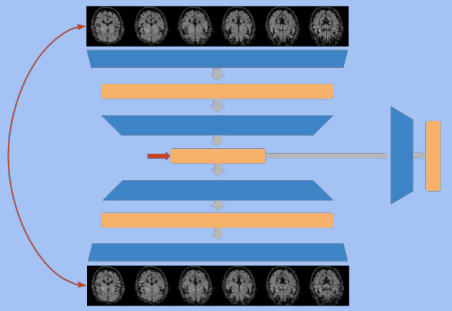
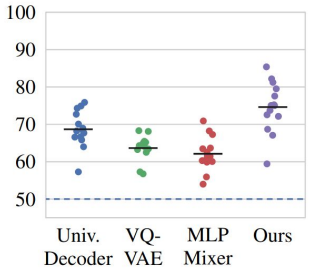


Results



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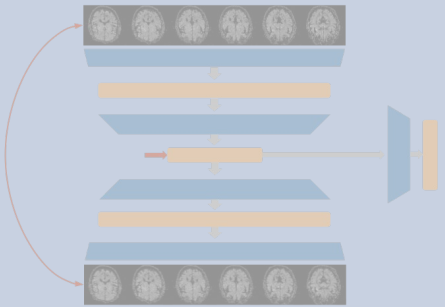

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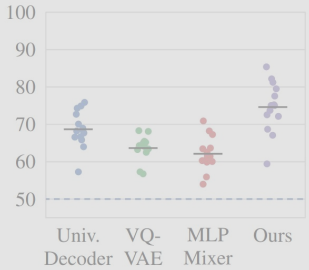
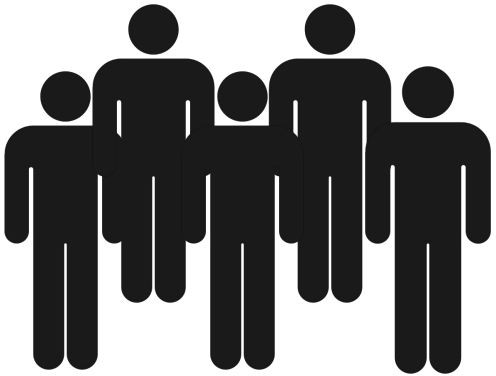


Intra-subject split



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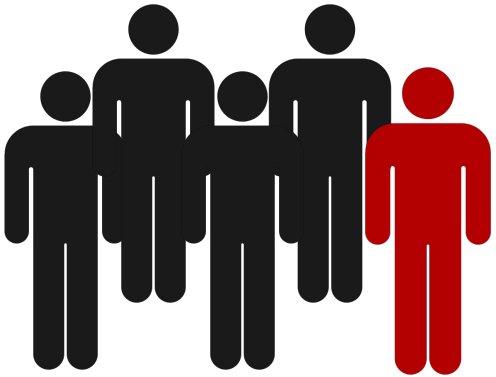

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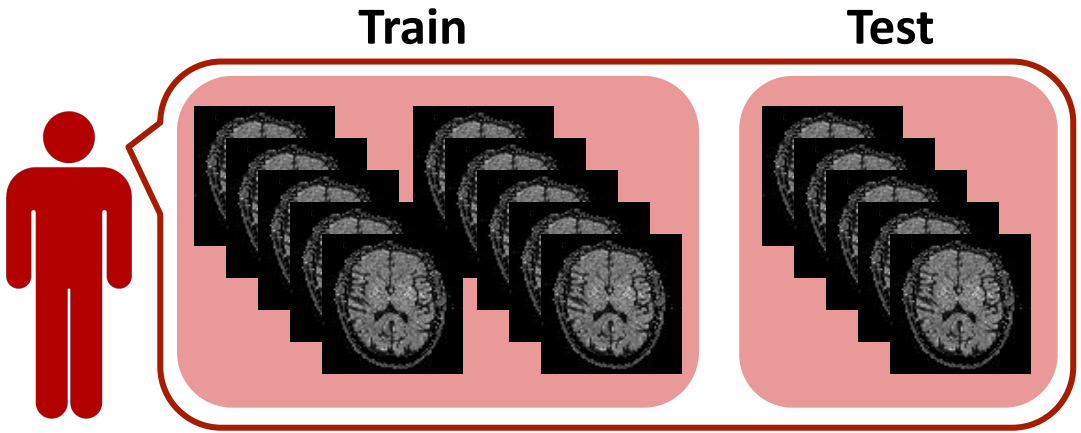

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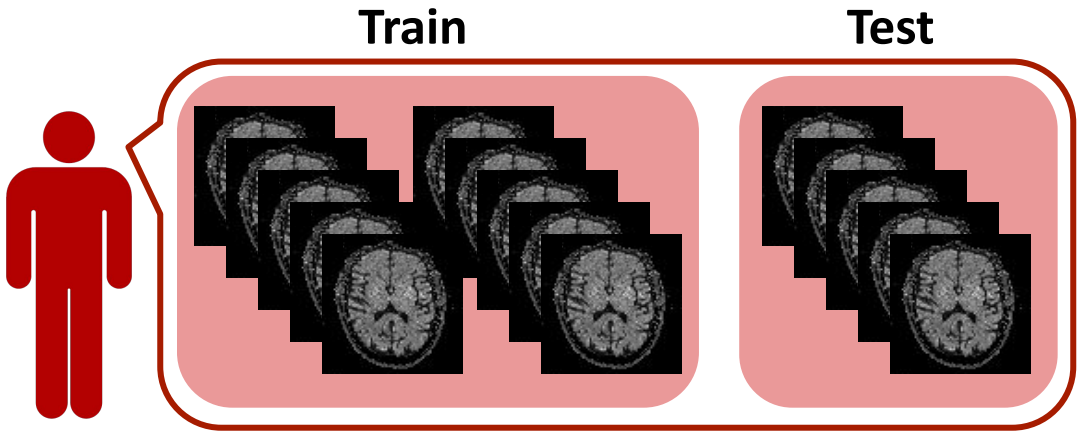
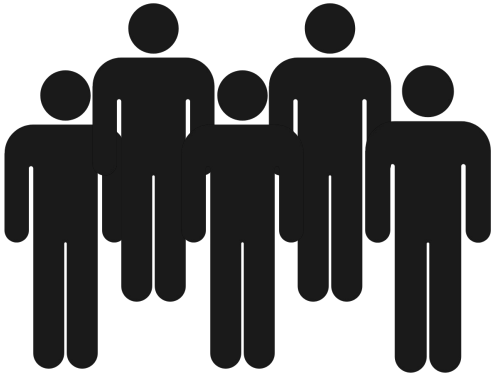
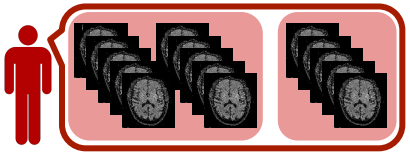


New subject: Record new data

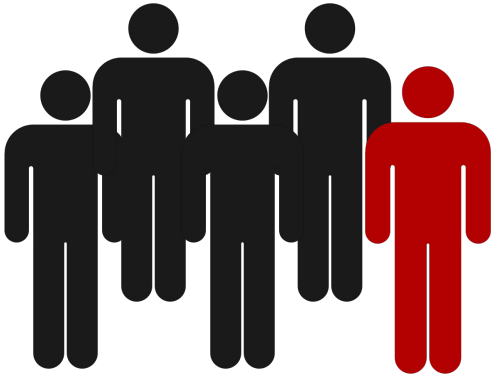
Leave-one-out



Intra-subject



Leave-one-out



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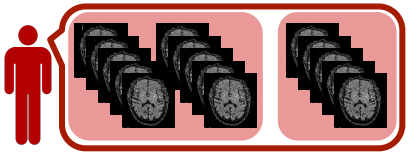

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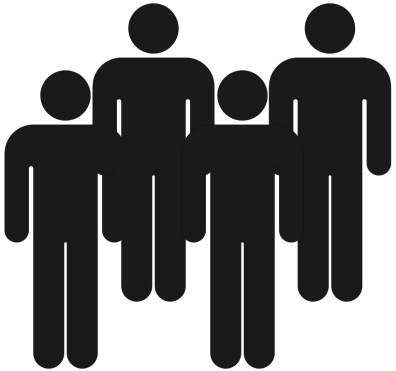

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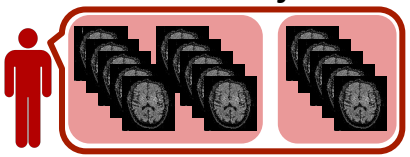

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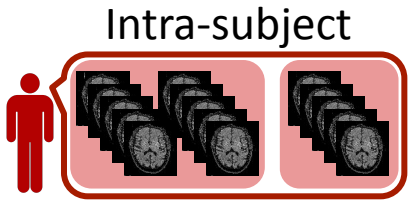

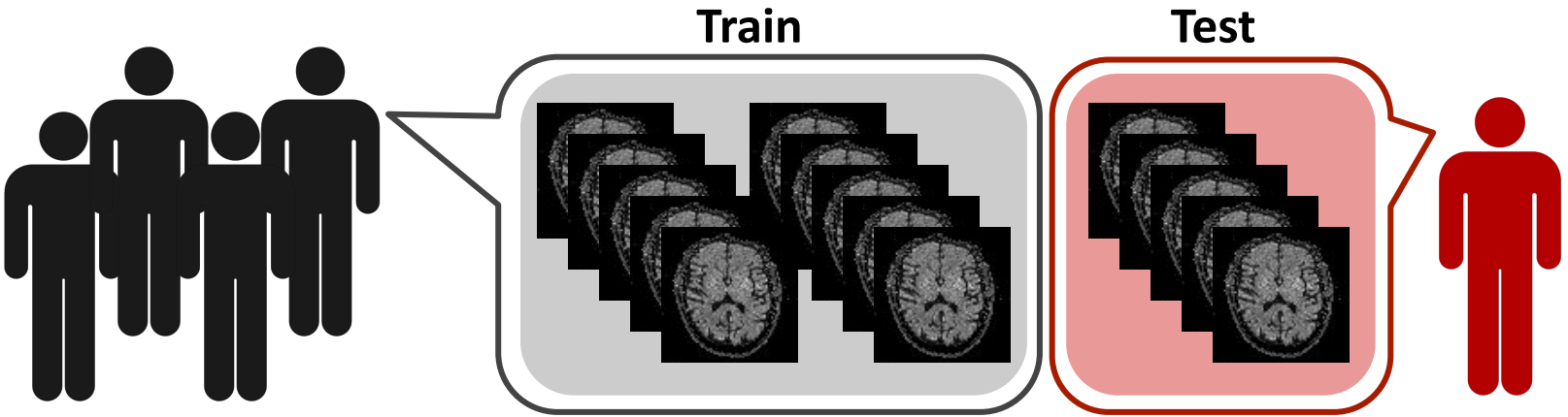

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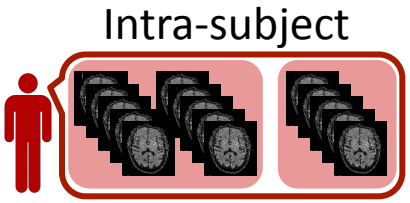
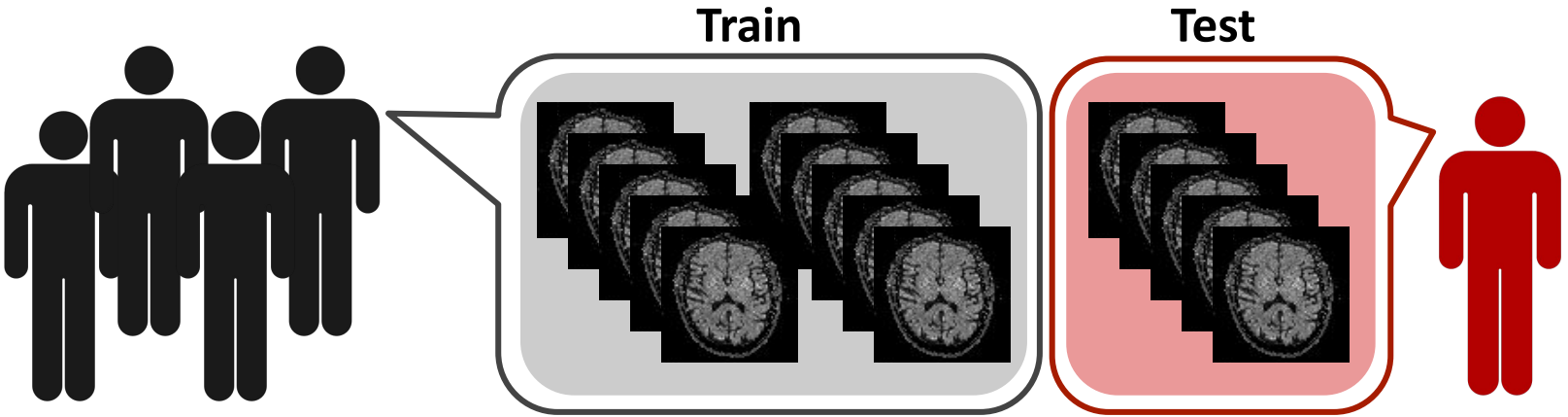
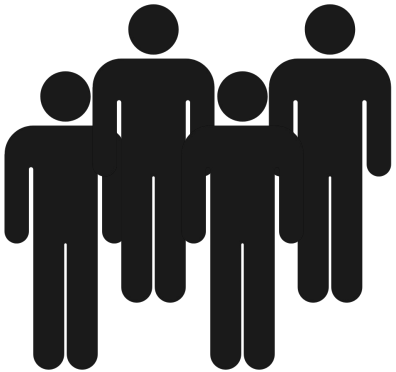




Harder: Subject variability

More data available

Fine-tuning



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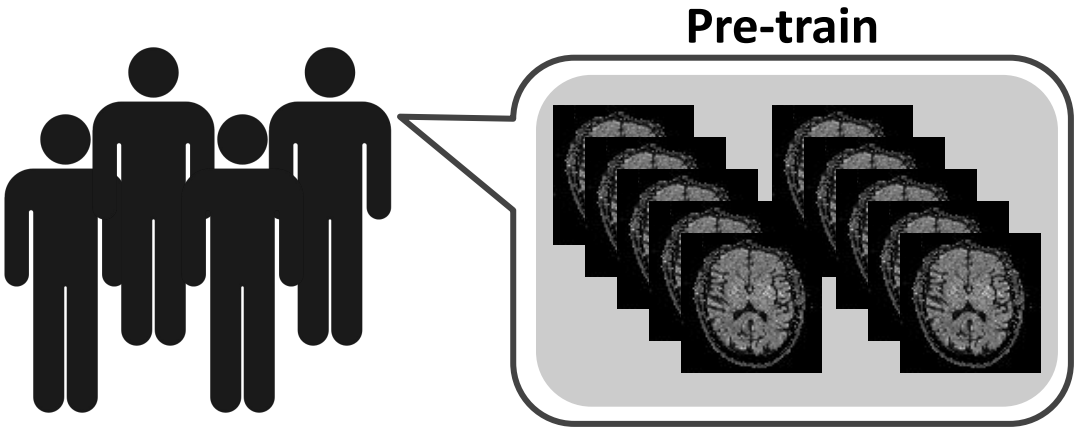

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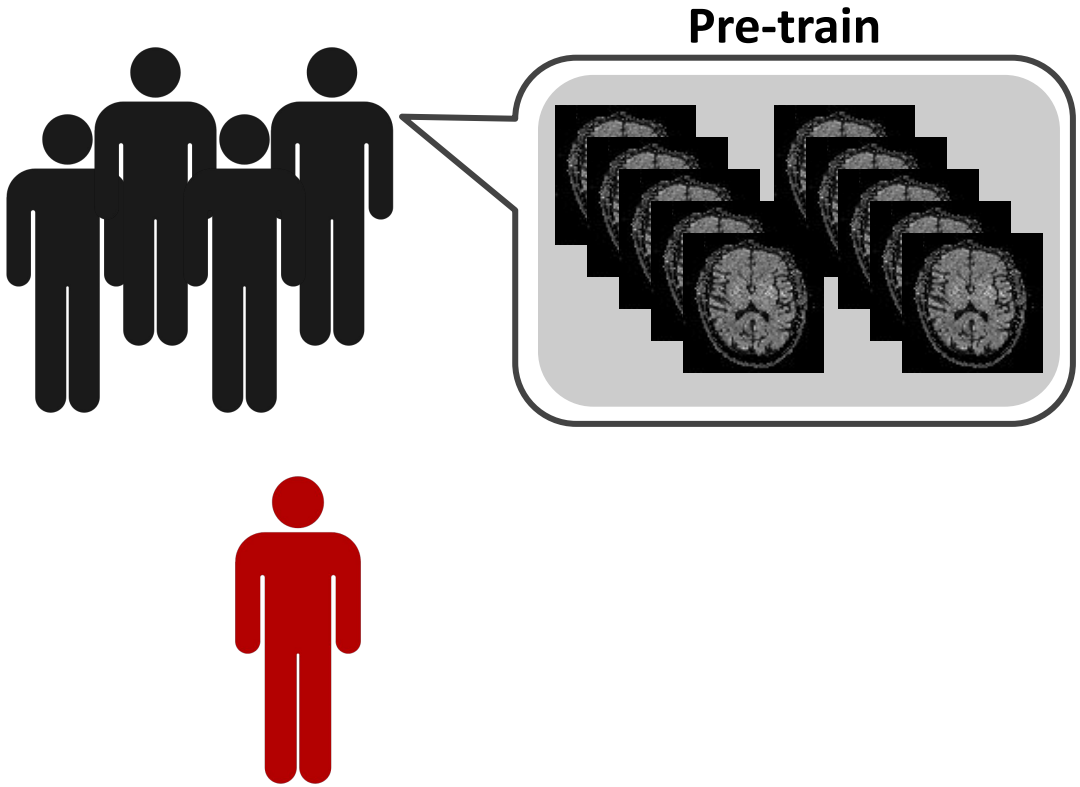

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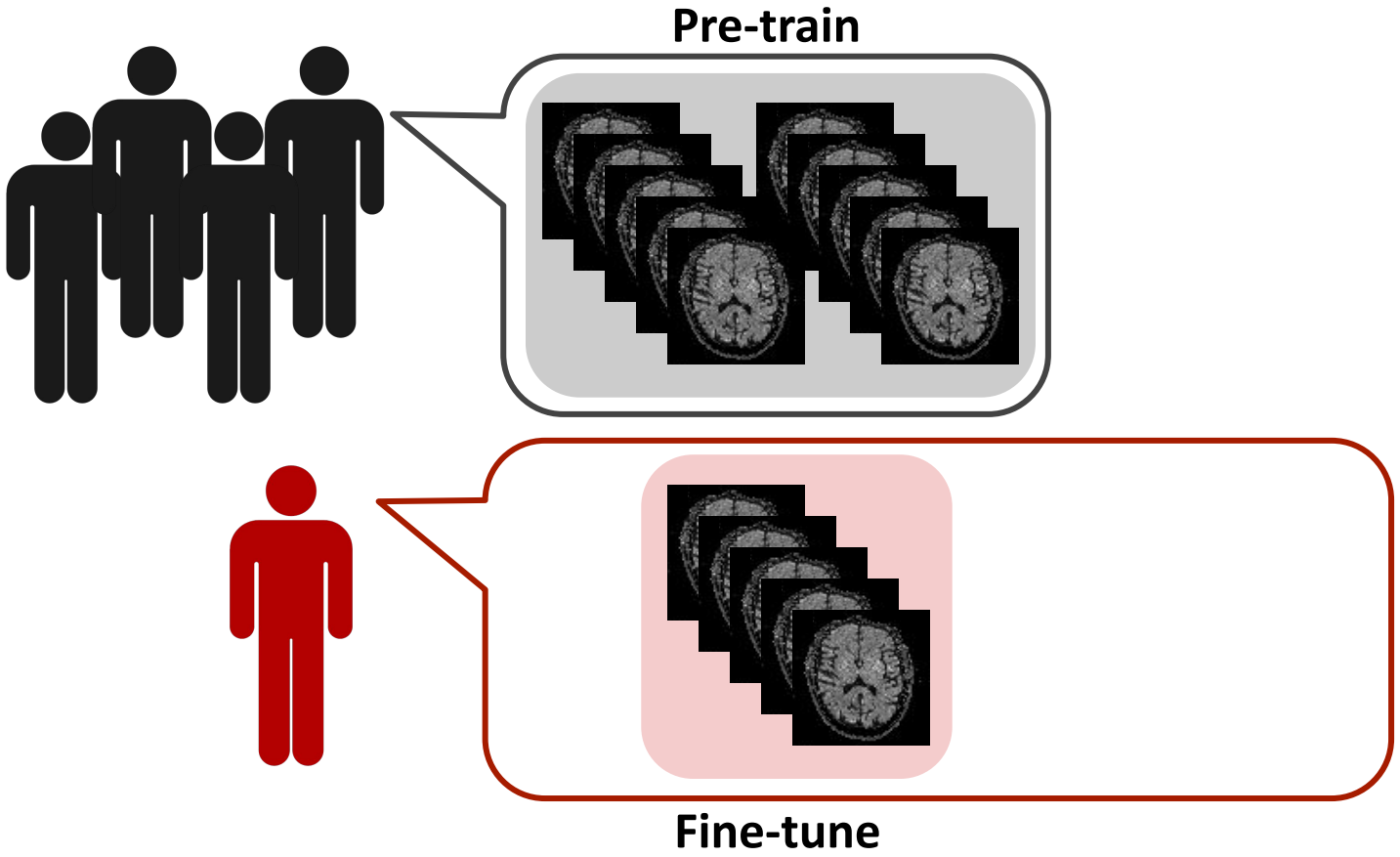

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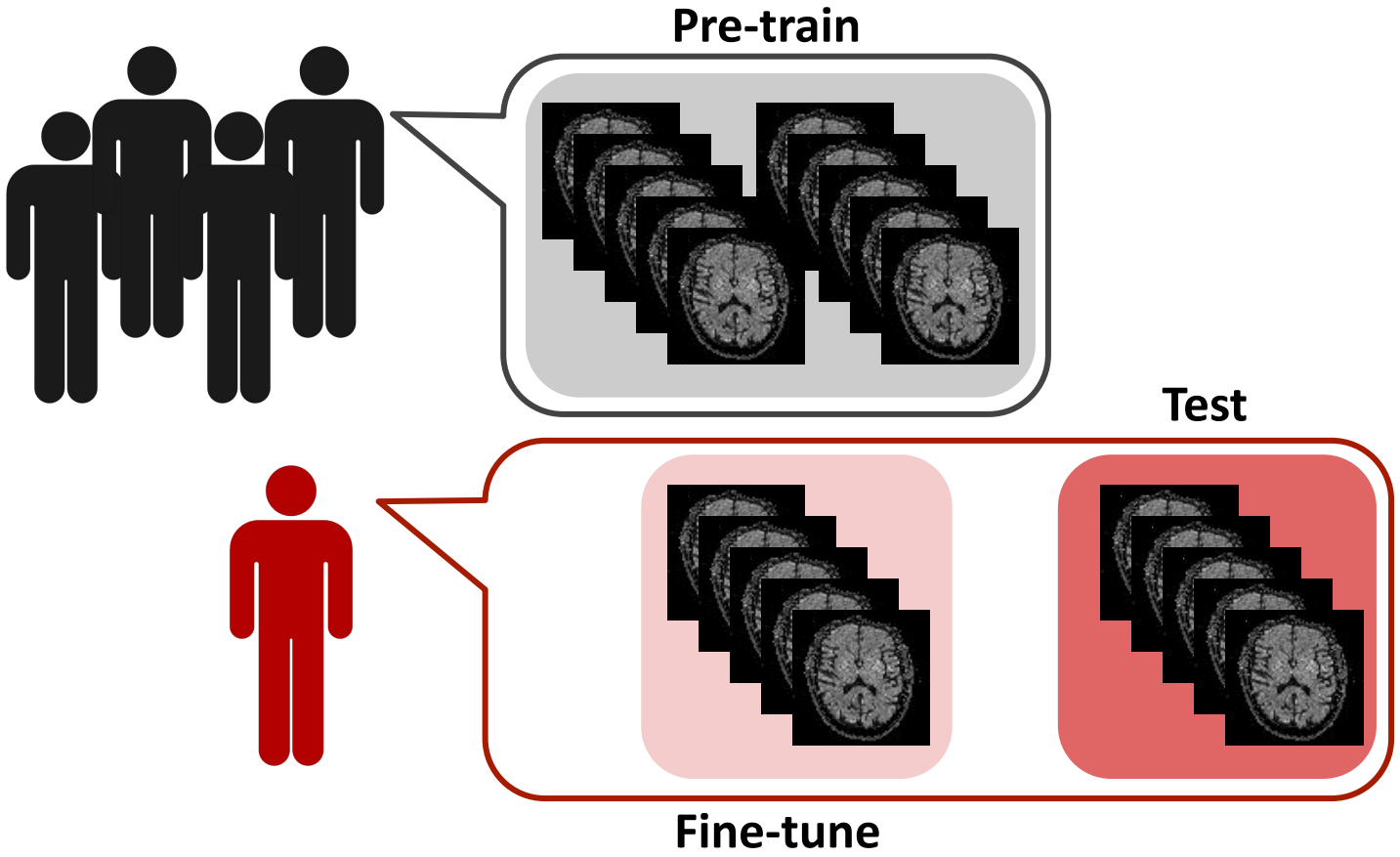

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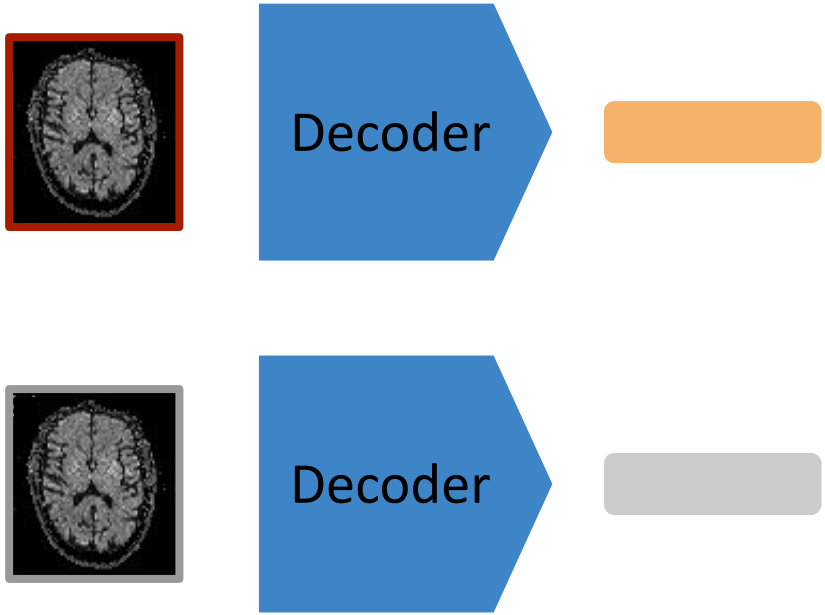

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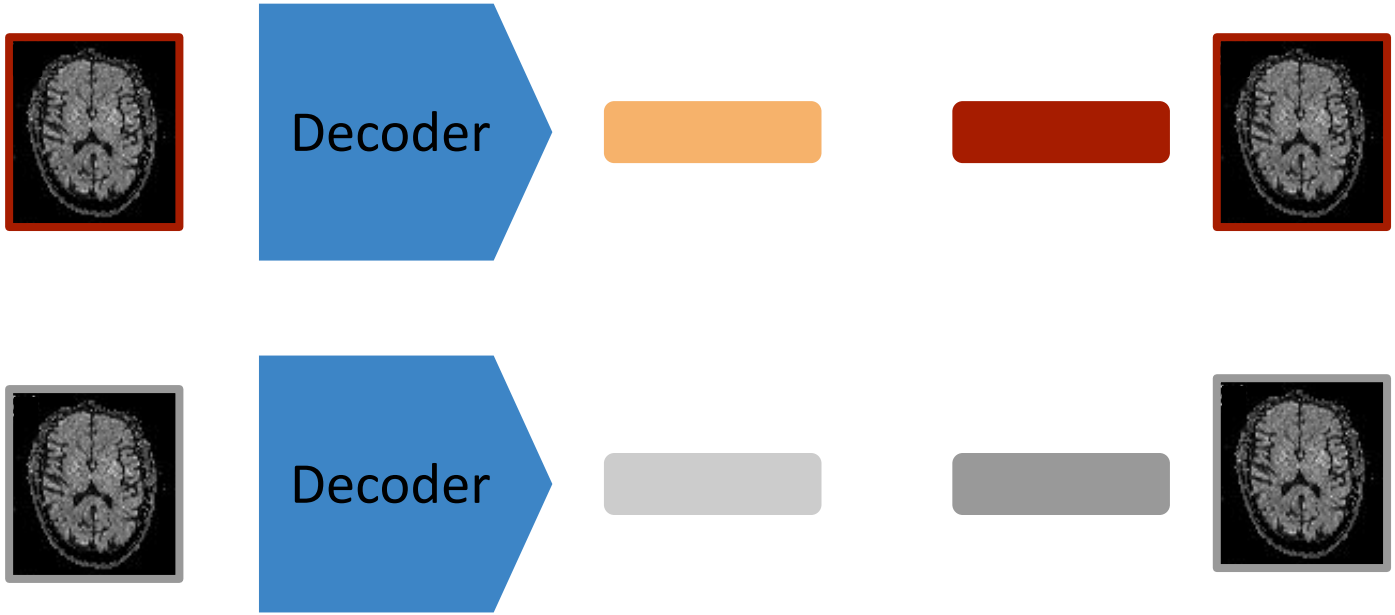

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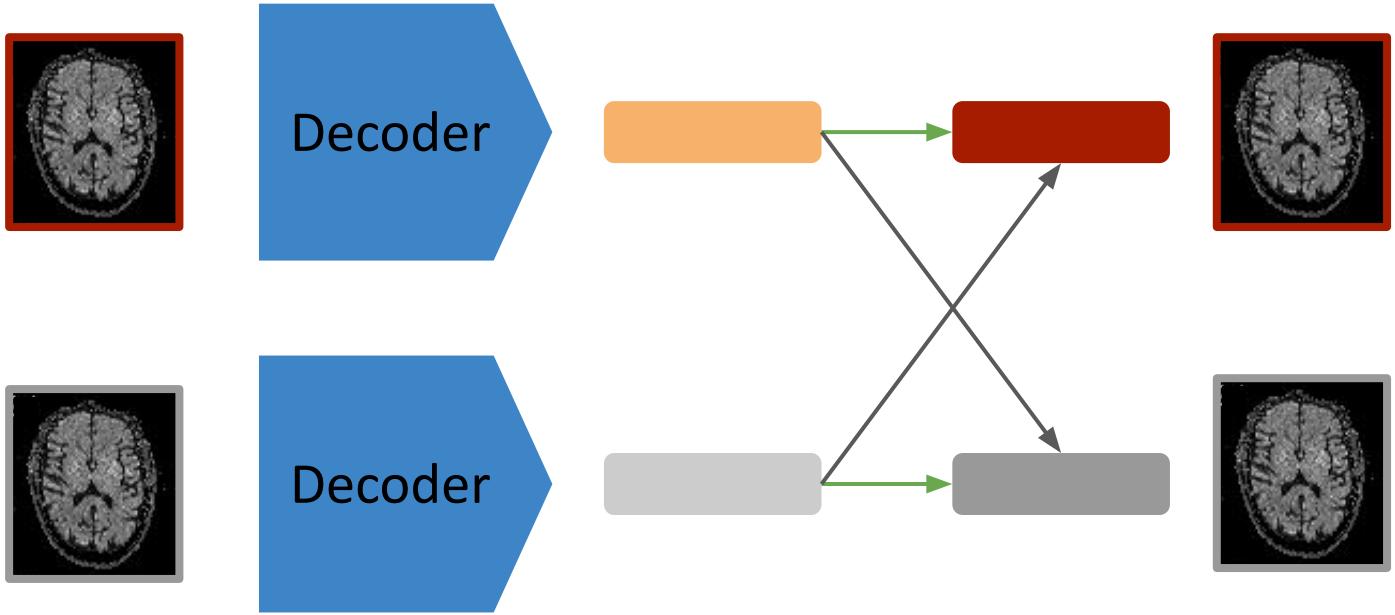

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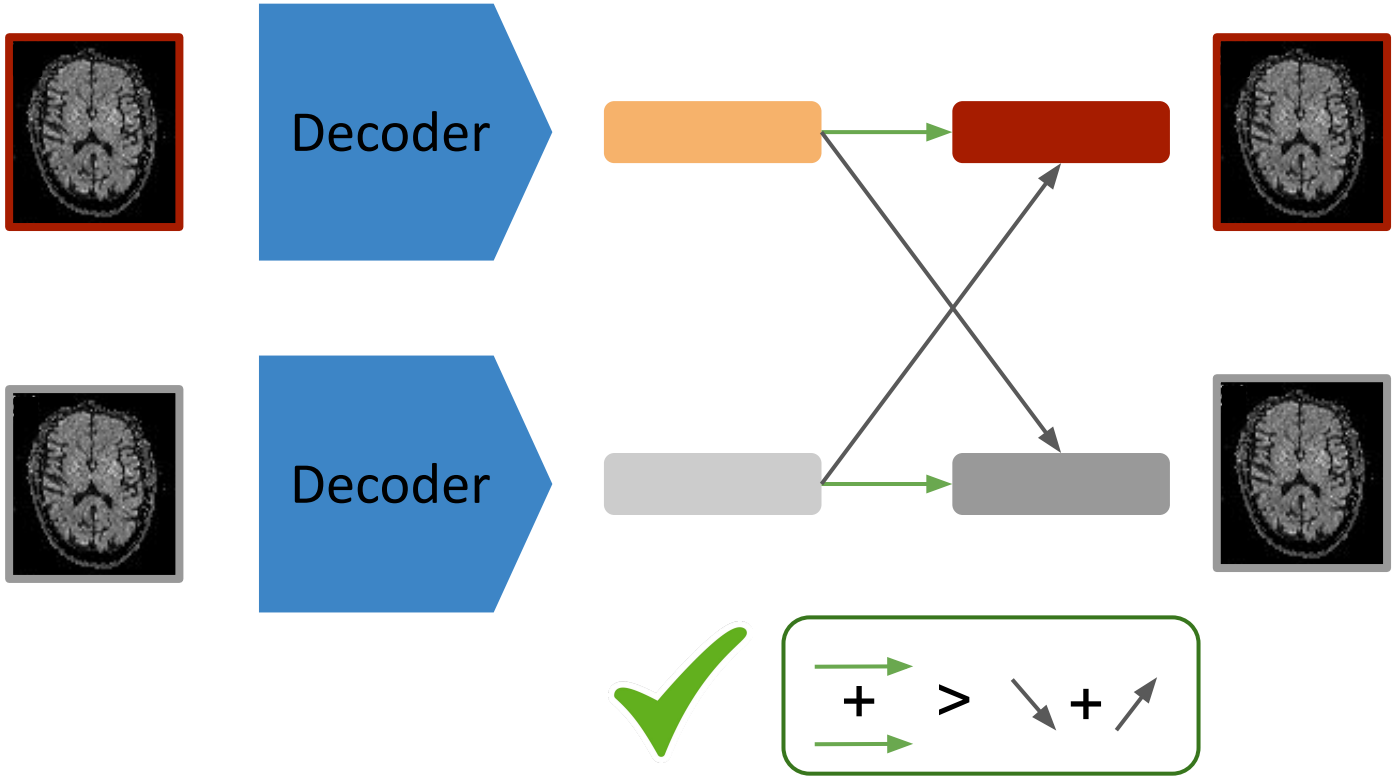

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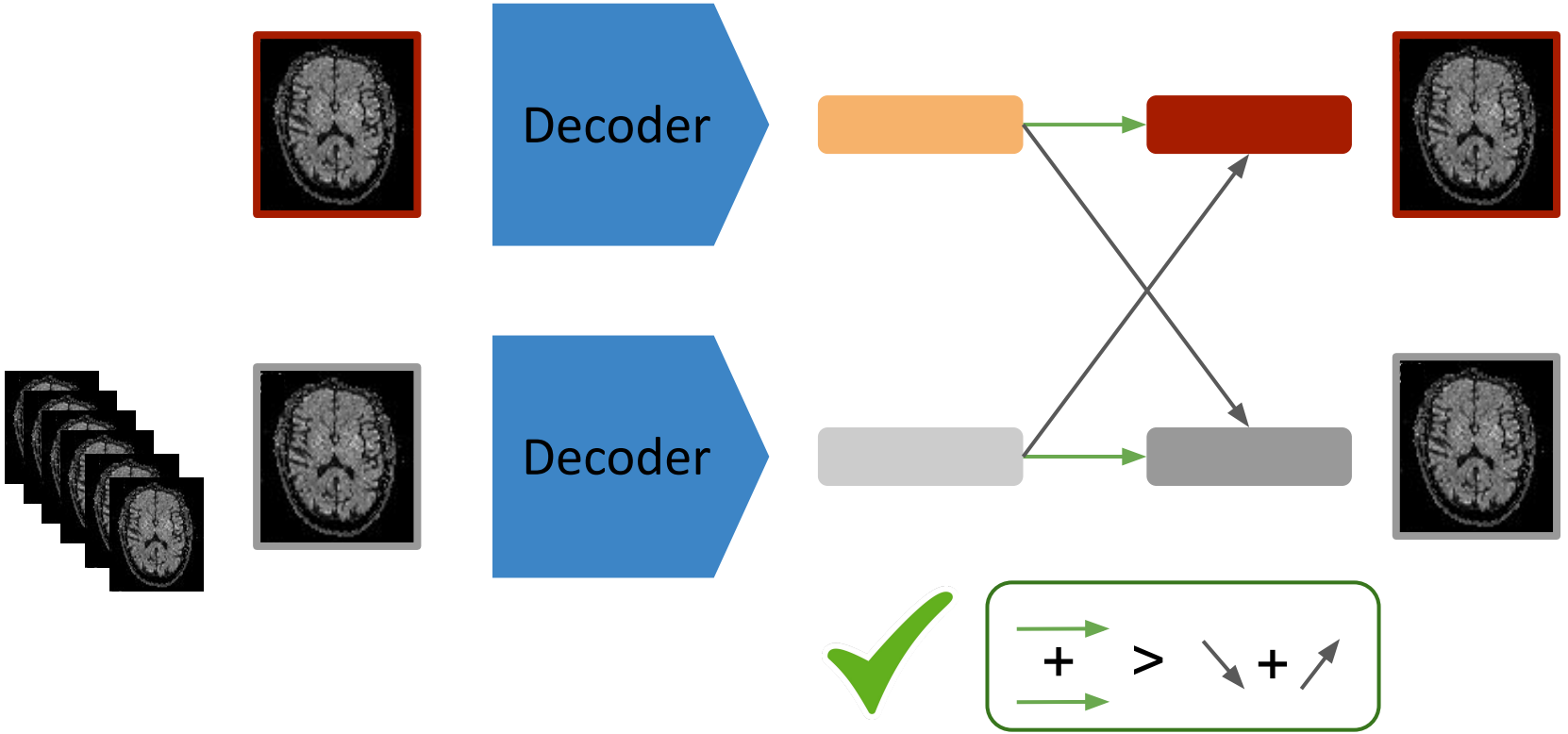

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Shortcomings of Pairwise Classification

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Decoder

Textual representation
e.g. *GloVE*

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Non-semantic information not in fMRI![2]

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2) Random baseline: 50%

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2) Random baseline: 50% → **Hard to assess progress**

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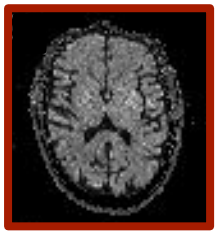
Direct Classification

Direct Classification



word

Decoder

$\boldsymbol{p}$

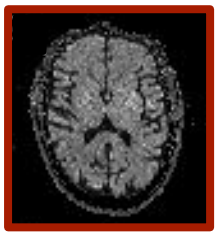
p_1

p_i

p_n

Vocabulary

Direct Classification



word

Decoder

$\boldsymbol{p}$

p_1

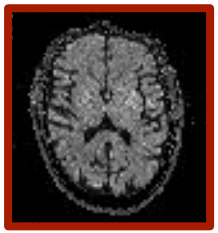
p_i

p_n

Vocabulary

argmax $\boldsymbol{p}$ = **word**

Direct Classification



word

Decoder

$\boldsymbol{p}$

p_1

p_i

p_n

Vocabulary

argmax $\boldsymbol{p}$ = **word**

Baseline: 1/Vocabulary

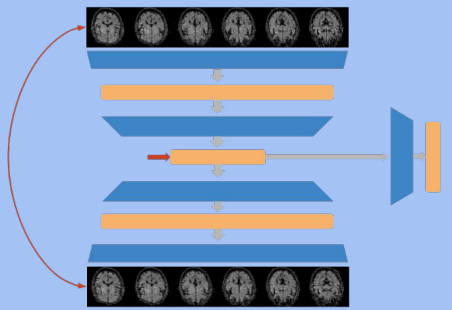
Outline

Evaluation Setup

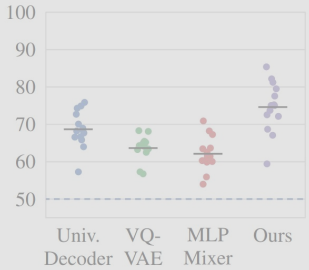
Data split

Evaluation Task

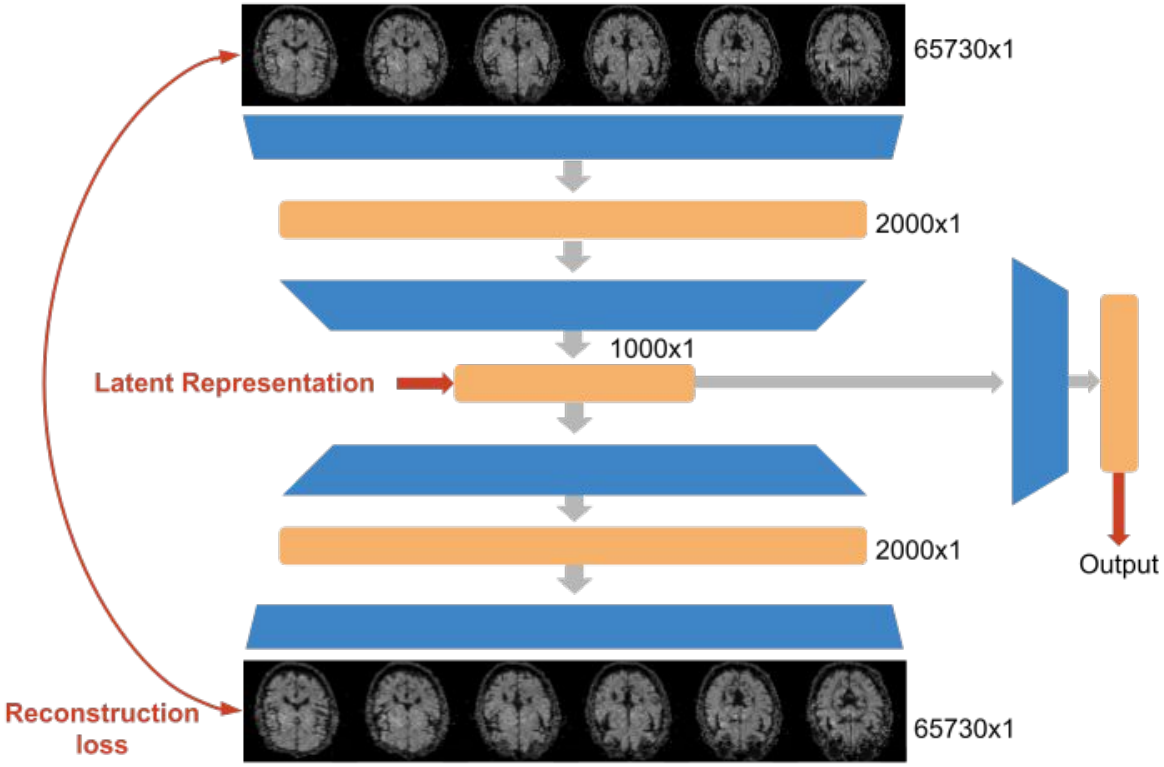
Decoder



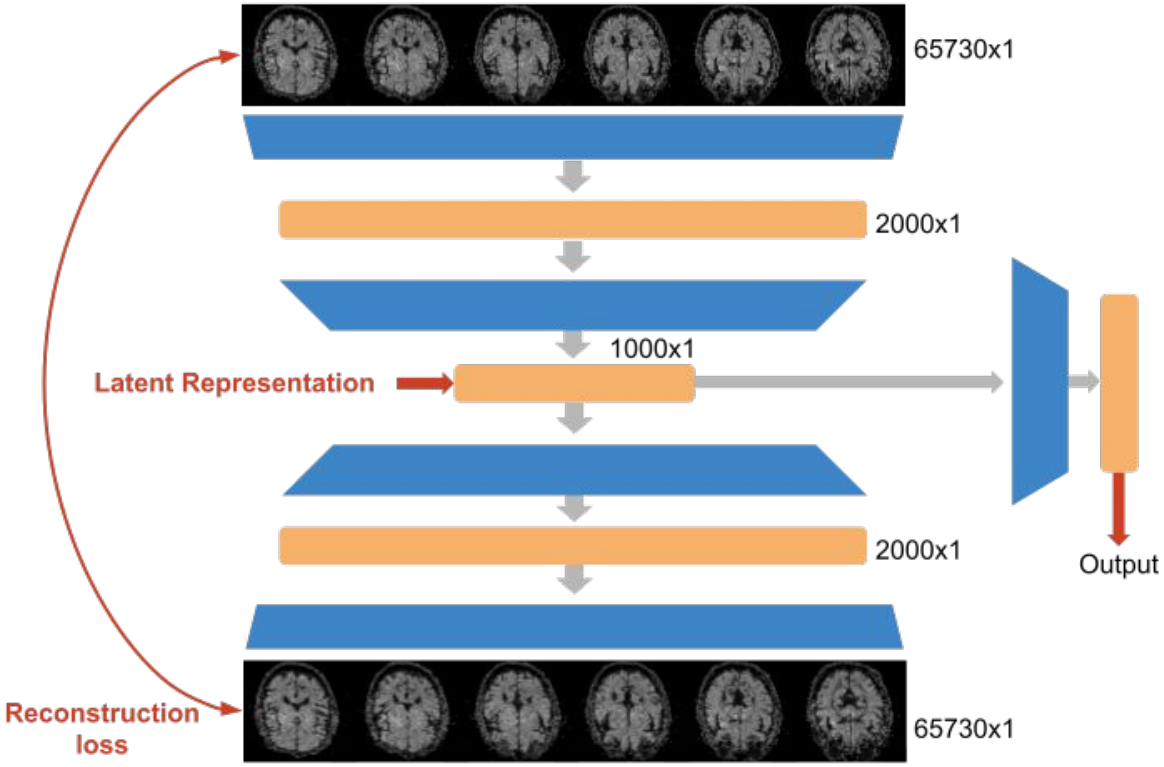
Results



Model


65730x1
2000x1
1000x1
Latent Representation
2000x1
Output
Reconstruction loss
65730x1

Model



Output

Pairwise: 300-dim GloVe

Classification: 180 classes

Outline

Evaluation Setup

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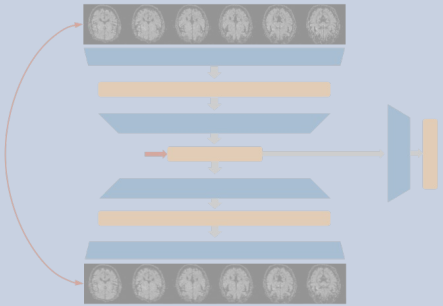
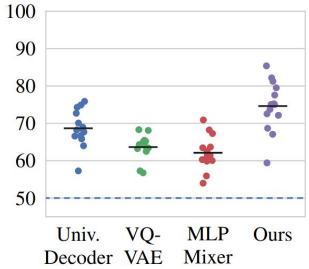
Decoder



Results



Evaluation

Universal Decoder[1]
(Ridge regression)

PCA + XGBoost

VQ-VAE[4]

MLP-Mixer[5]

Ours

[1] F. Pereira et al. Toward a universal decoder of linguistic meaning from brain activation. Nature communications, 9(1):1–13, 2018.
[4] A. Van Den Oord, et al. Neural discrete representation learning. In *Advances in Neural Information Processing Systems*, 2017
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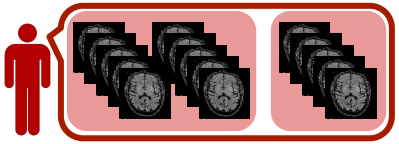

PCA + XGBoost

VQ-VAE[4]

MLP-Mixer[5]

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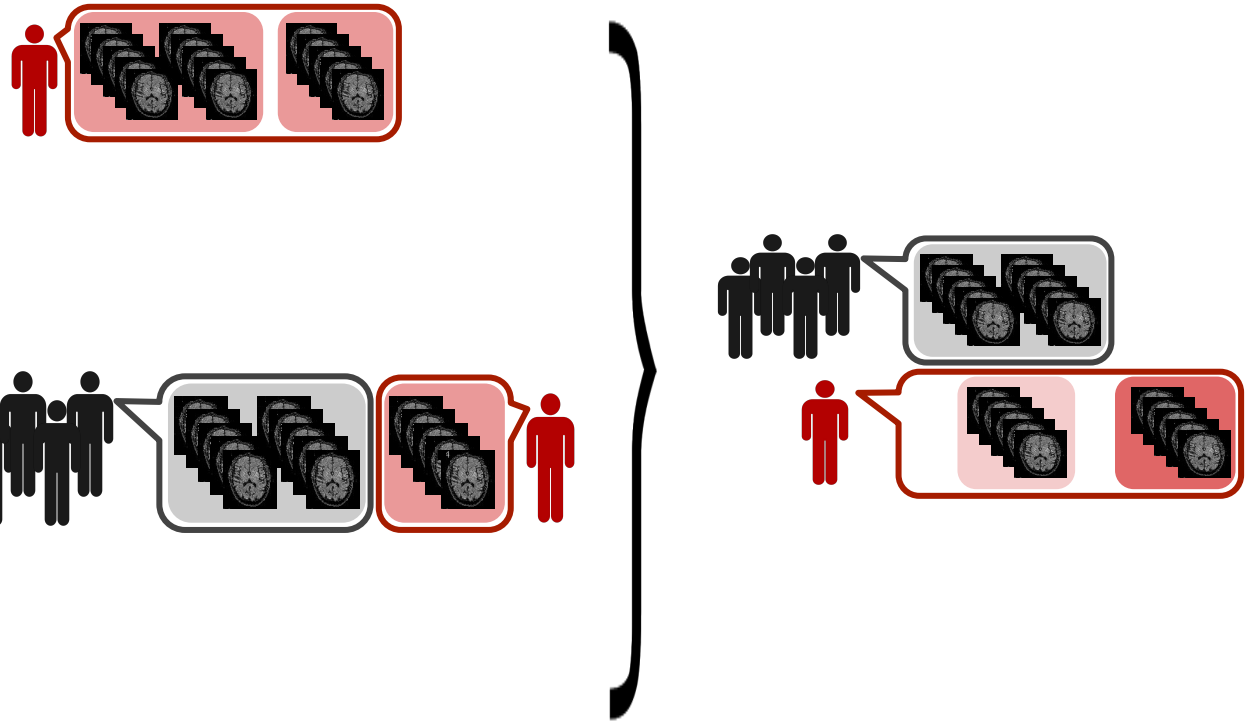

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Evaluation

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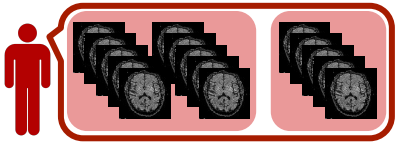


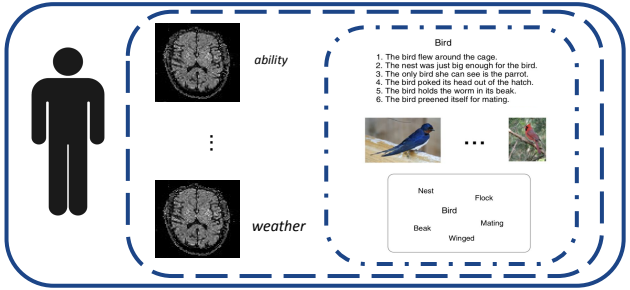
MLP-Mixer

VQ-VAE[4]

Ours

Dataset

Word

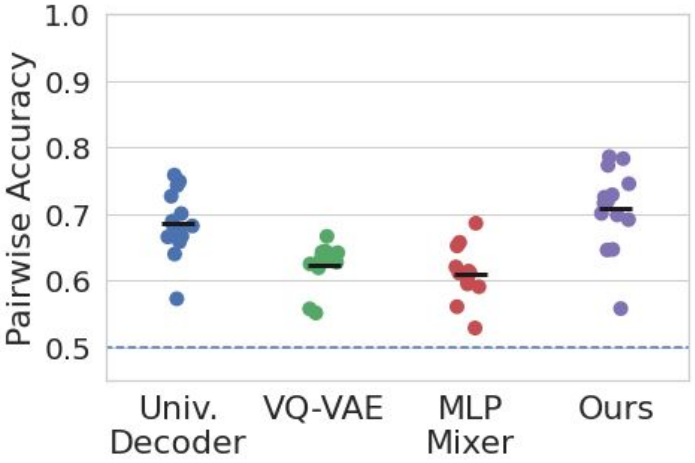


14 subjects

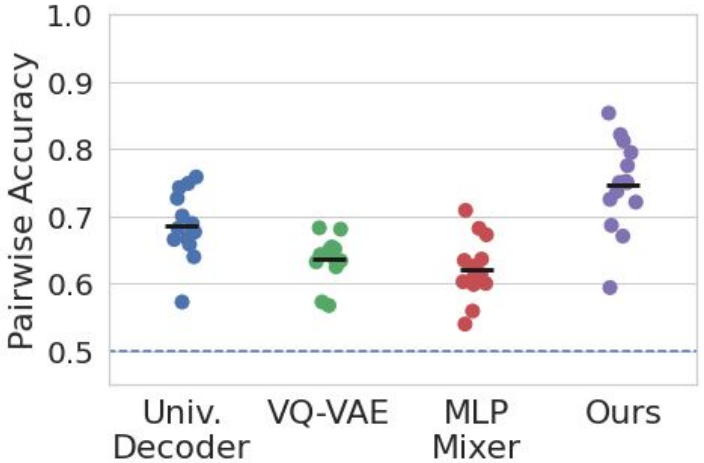
[1] F. Pereira et al. Toward a universal decoder of linguistic meaning from brain activation. Nature communications, 9(1):1–13, 2018.
[4] A. Van Den Oord, et al. Neural discrete representation learning. In *Advances in Neural Information Processing Systems*, pages 6306–6315, 2017

Pairwise accuracy

Leave-one-out

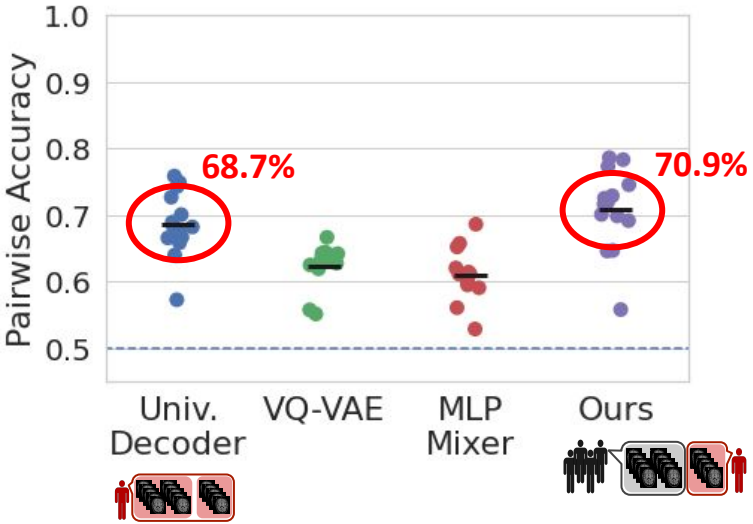


Fine-tuning



Pairwise accuracy

Leave-one-out



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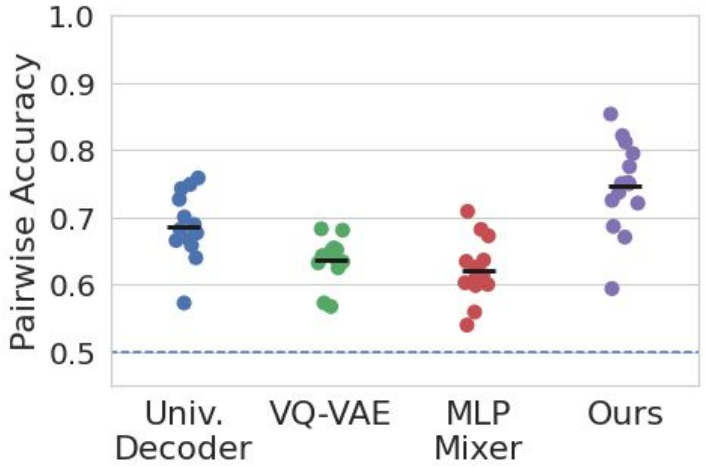
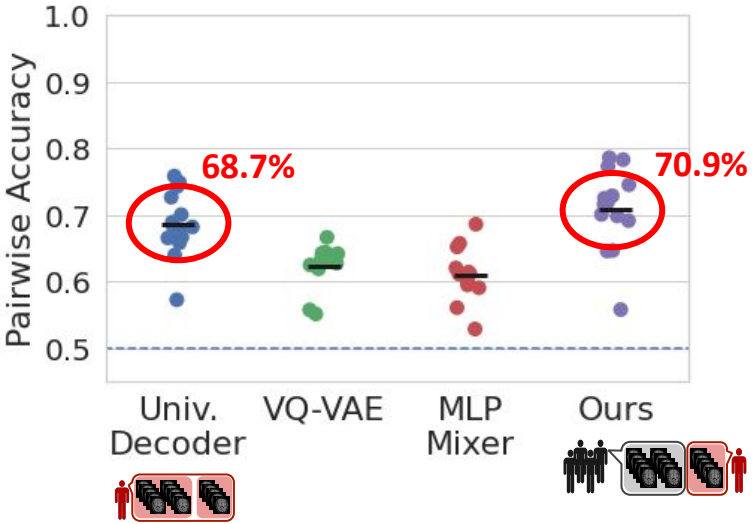


Pairwise accuracy

Leave-one-out



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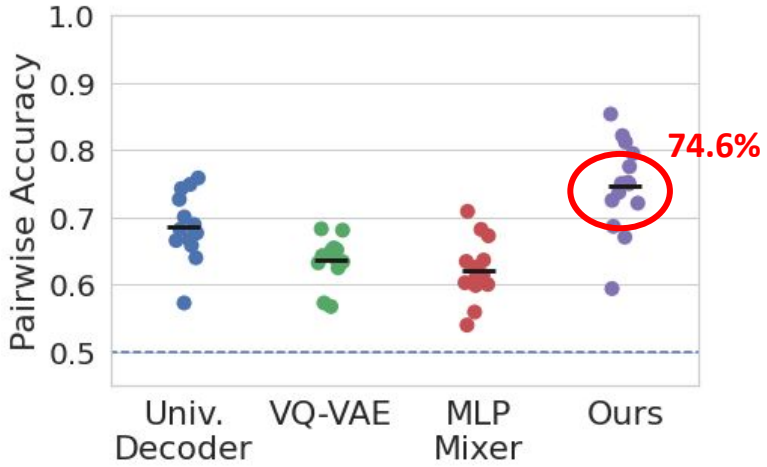
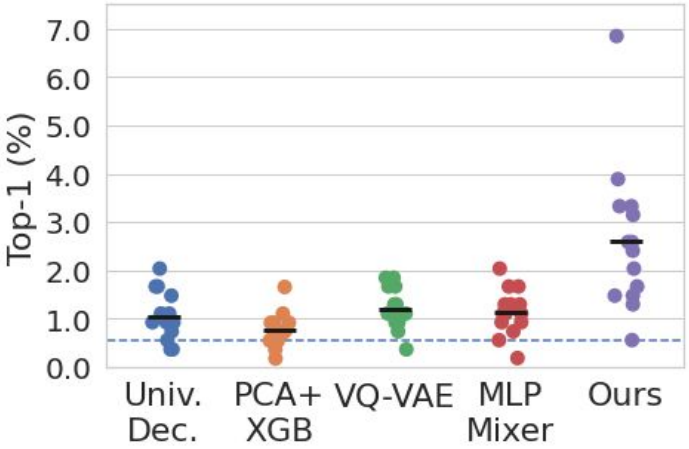


Direct Classification

Leave-one-out



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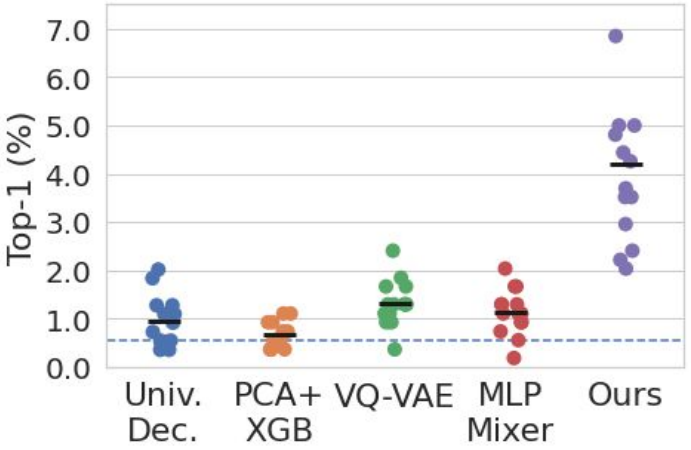

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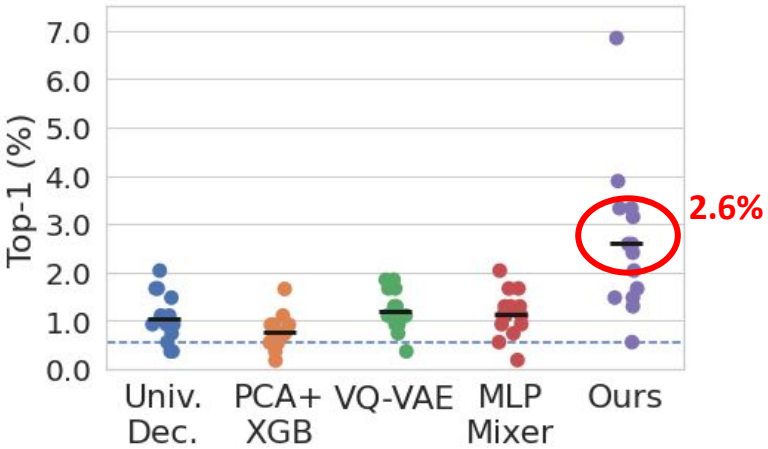

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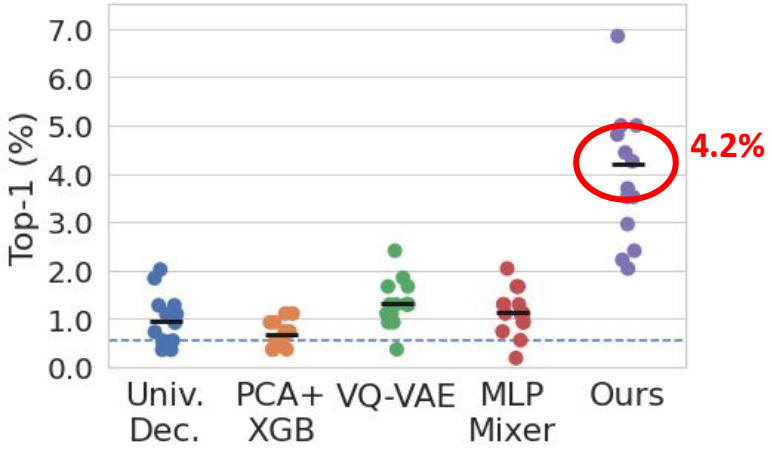

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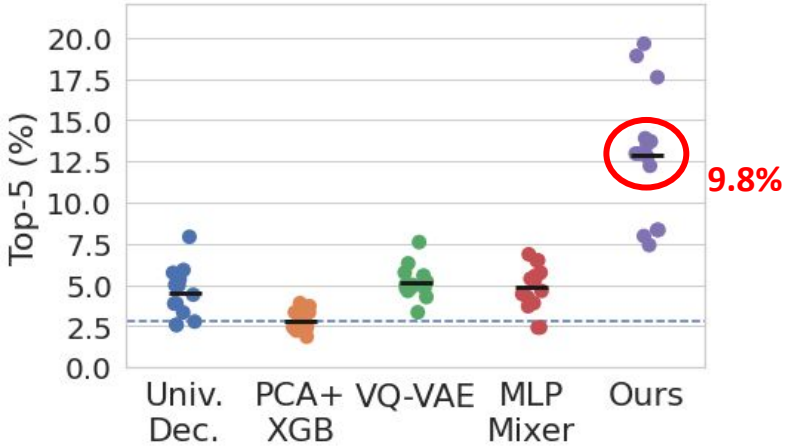

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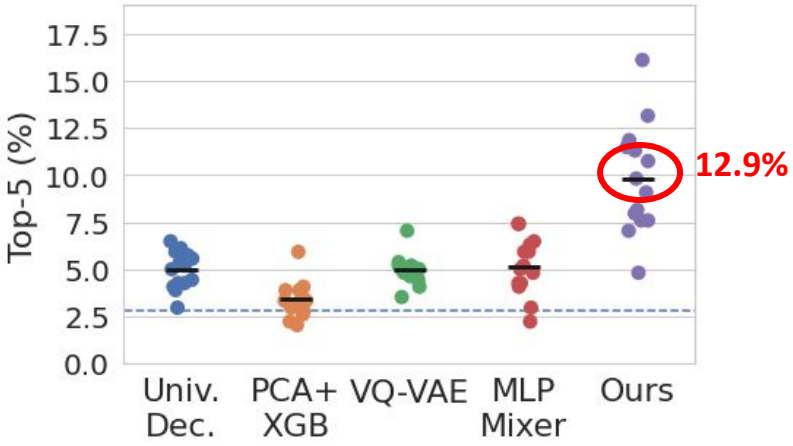

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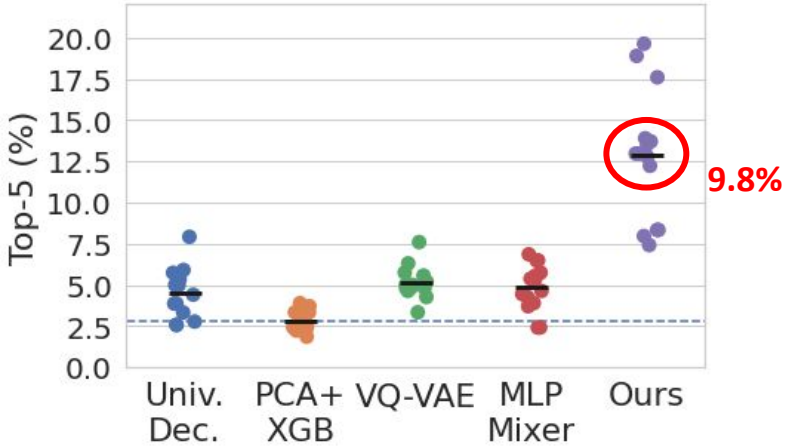

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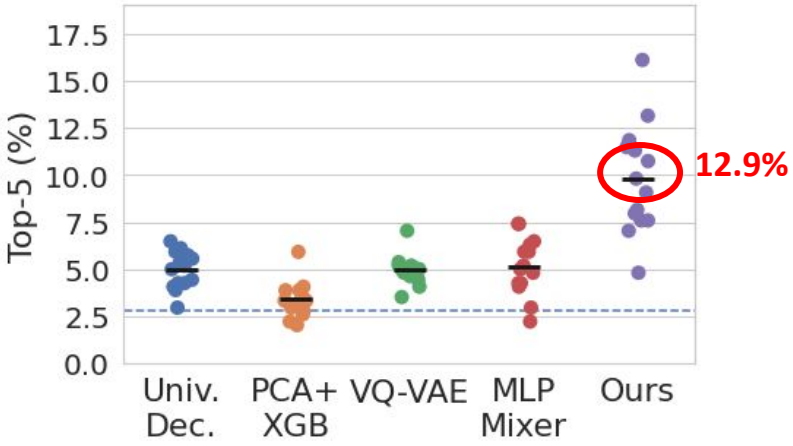
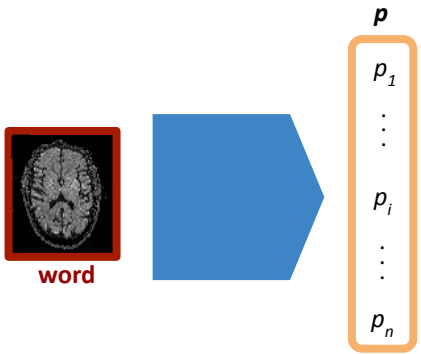


Conclusion

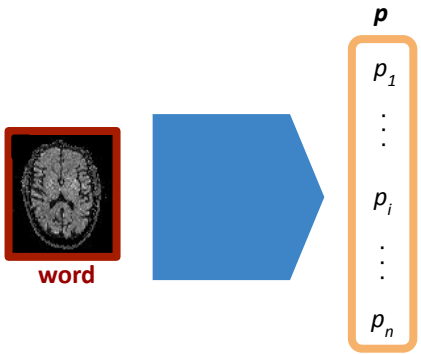
Conclusion

Evaluation

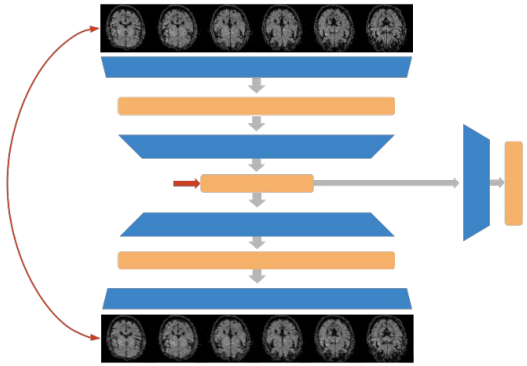


Conclusion

Evaluation



Model



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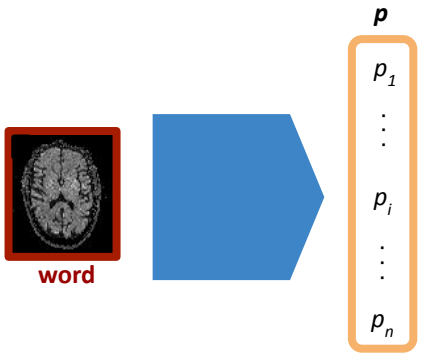
Evaluation



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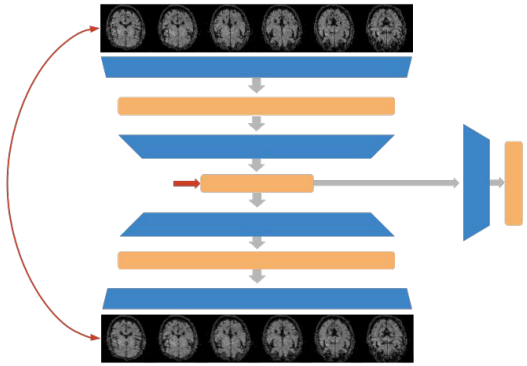

Results

Leave-one-out

2.6% Top 1

9.8 % Top 5