

# Understanding the brain with explainable artificial intelligence

Detecting patterns of abnormal brain aging in patients with neuropsychiatric disorders

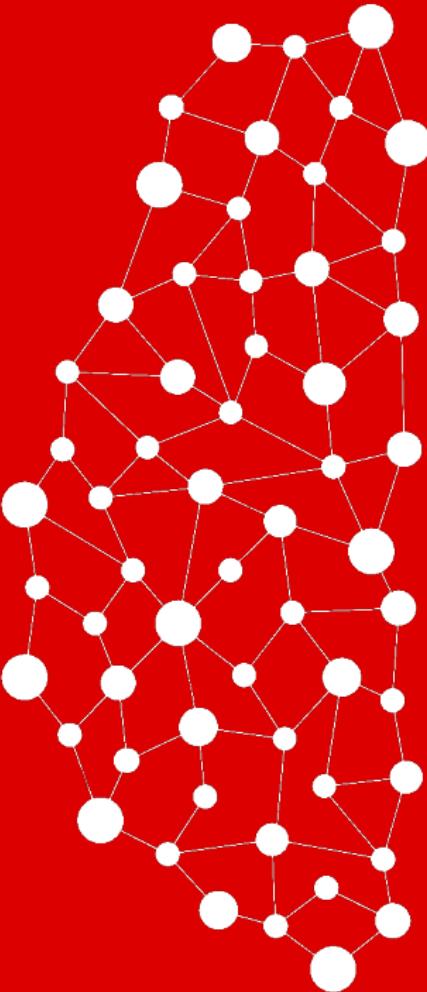


Esten H. Leonardsen

Post-doc at the Multimodal Imaging group,  
Department of Psychology, University of Oslo  
Chief Scientific Officer, baba.vision



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# Brain age: Motivation

Cognitive neuroscience



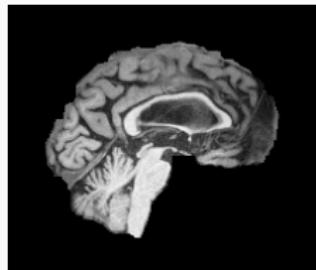
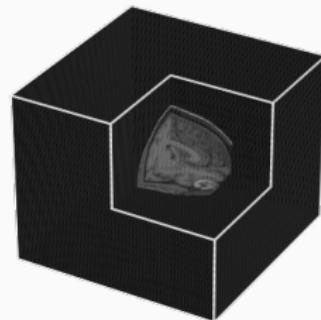
# Brain age: Motivation

Brain complexity

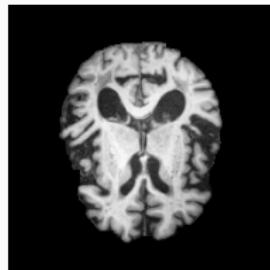


# Brain age: Motivation

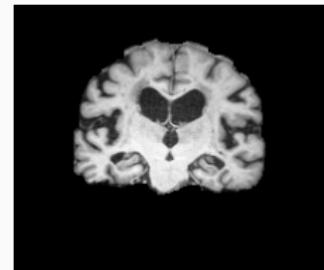
Structural Magnetic  
Resonance Imaging (MRI) scans



Side



Above



Front

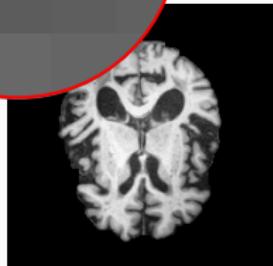


# Brain age: Motivation

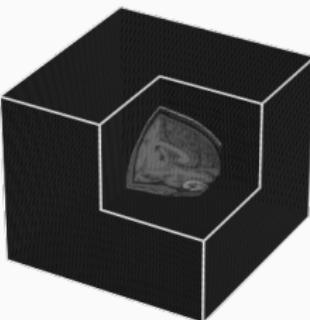
Structural Magnetic Resonance Imaging (MRI) scans



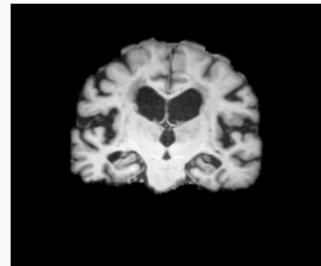
Side



Above

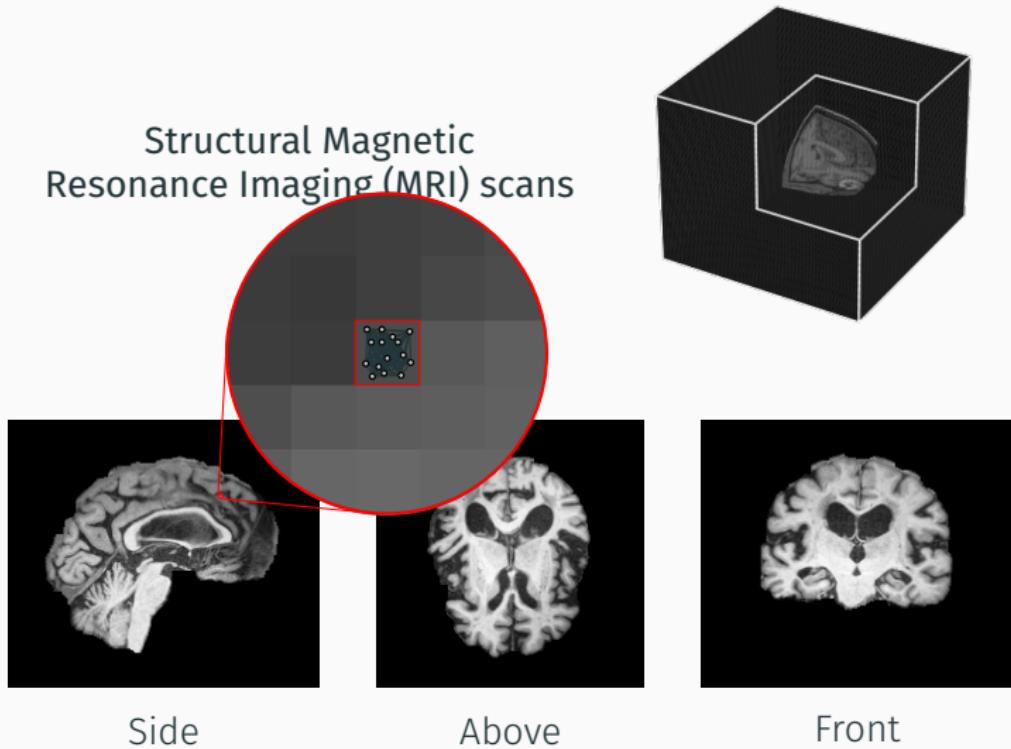


Front

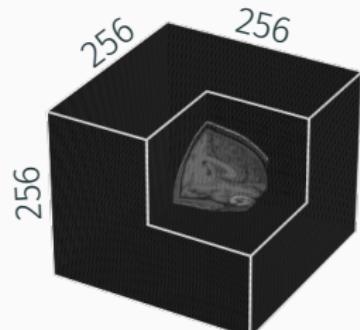


# Brain age: Motivation

Structural Magnetic Resonance Imaging (MRI) scans



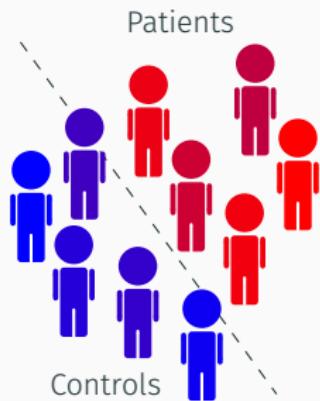
# Brain age: Motivation



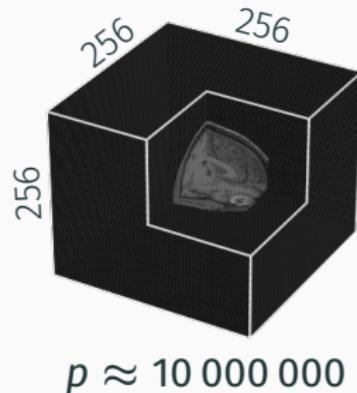
$p \approx 10\,000\,000$



# Brain age: Motivation



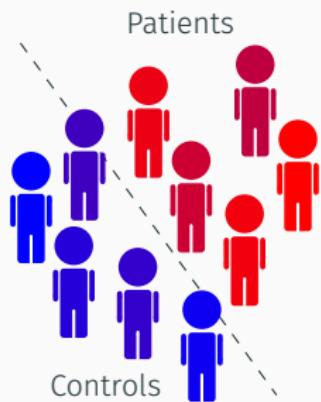
Clinical datasets  
( $n \approx 100$ )



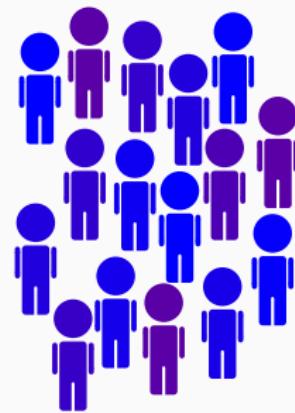
$p \approx 10\,000\,000$



# Brain age: Motivation



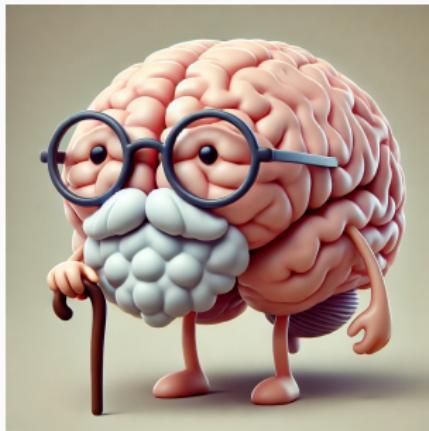
Clinical datasets  
 $(n \approx 100)$



Population datasets  
 $(n \approx 10\,000)$



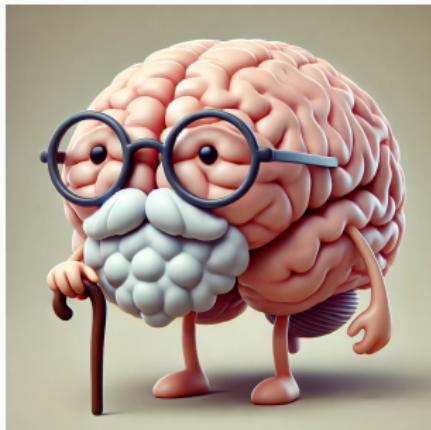
# Brain age: Motivation



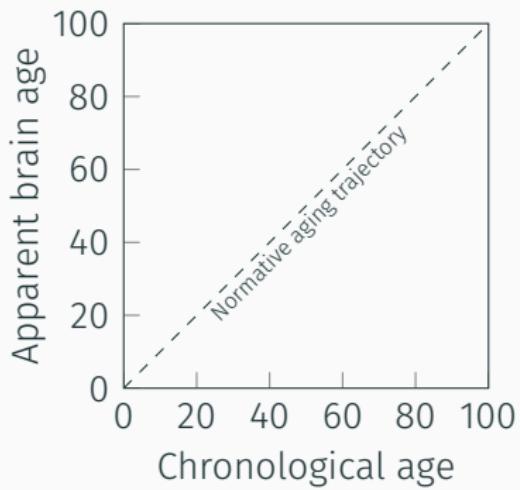
Generated by Dall-E 3



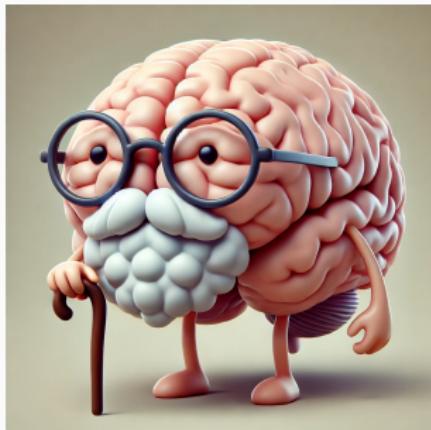
# Brain age: Motivation



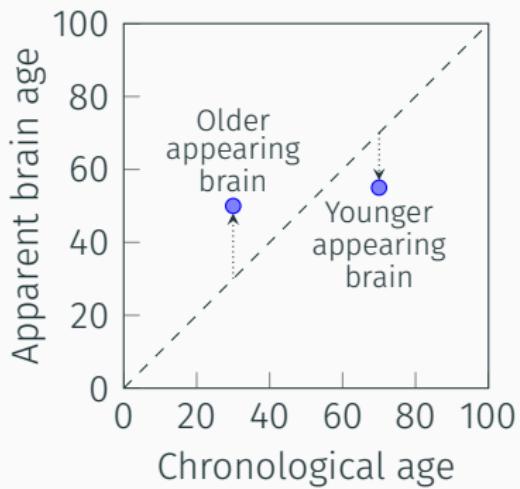
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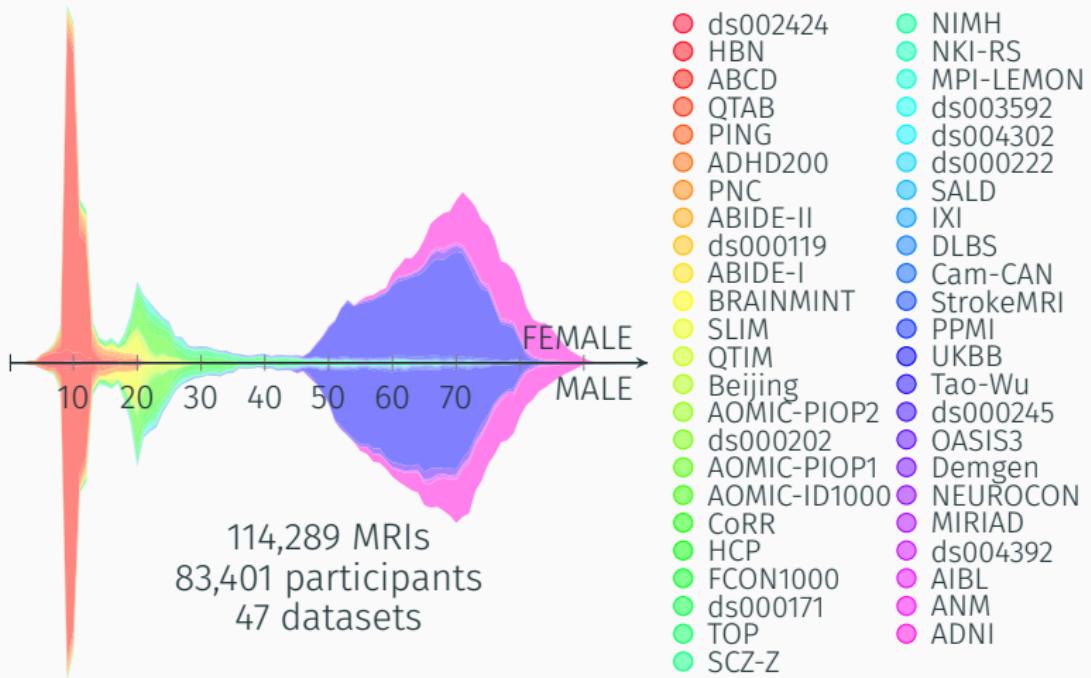
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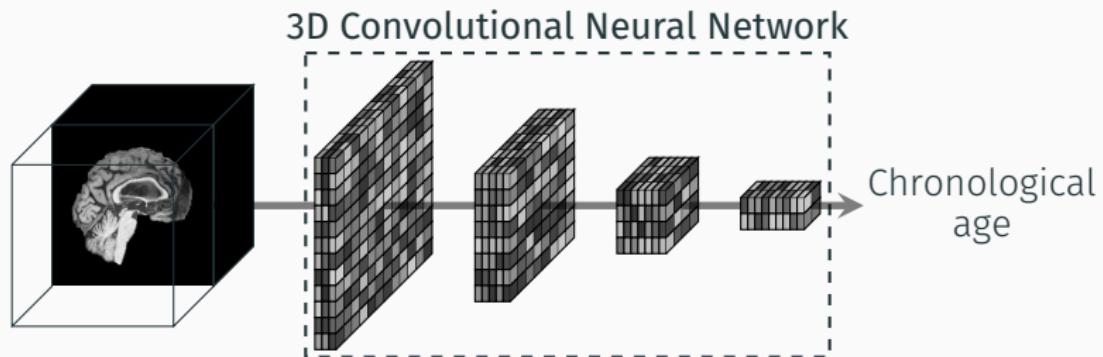
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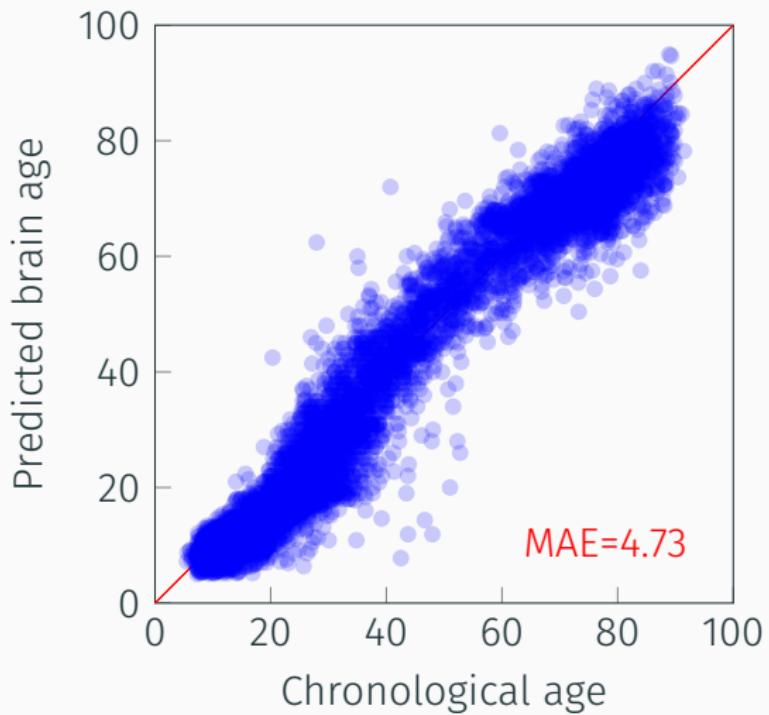
# Brain age modelling: Methods



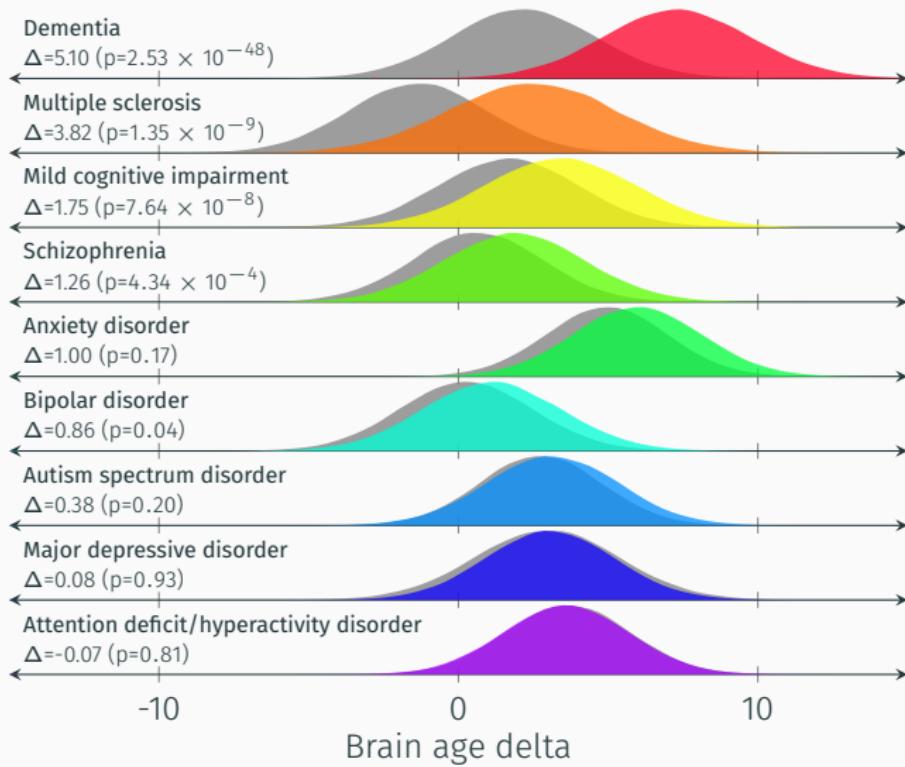
# Brain age modelling: Methods



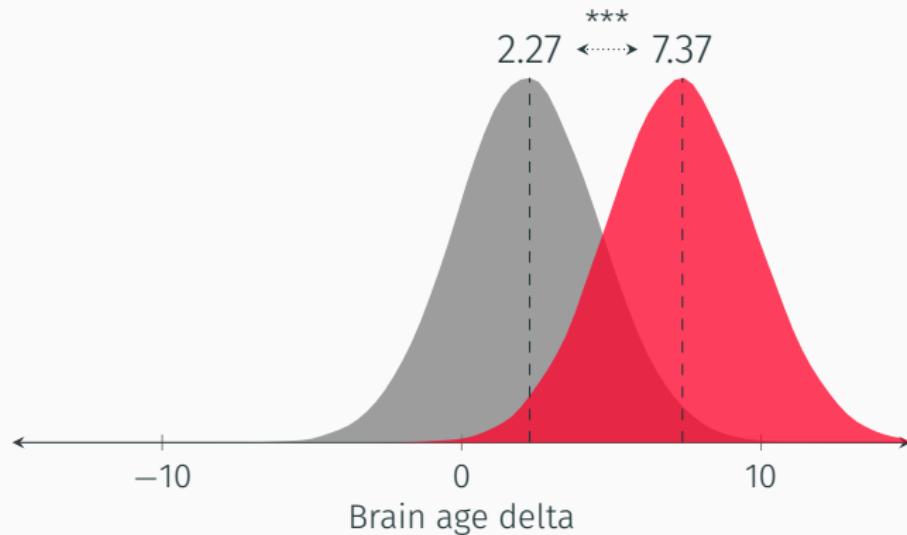
# Brain age modelling: Results



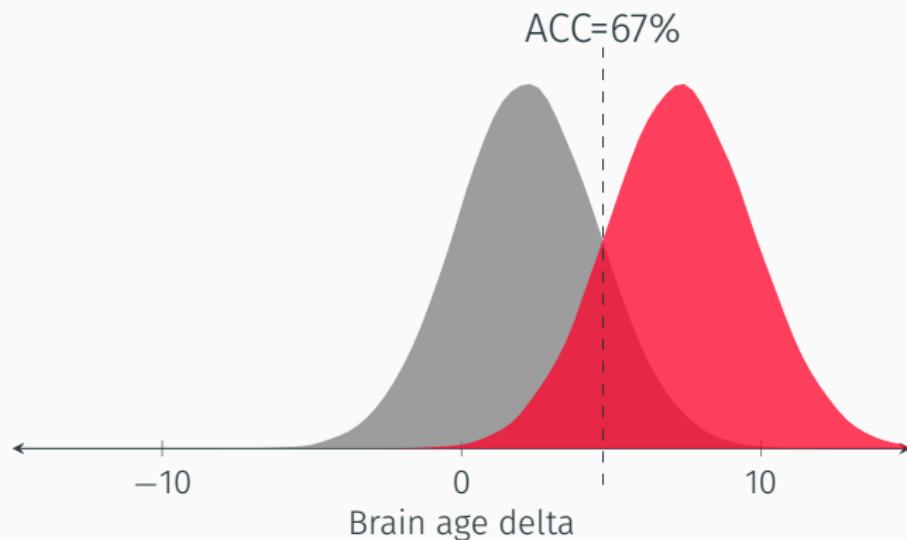
# Brain age modelling: Results



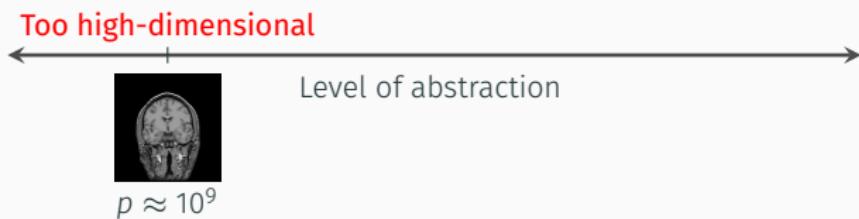
# Brain age modelling: Results



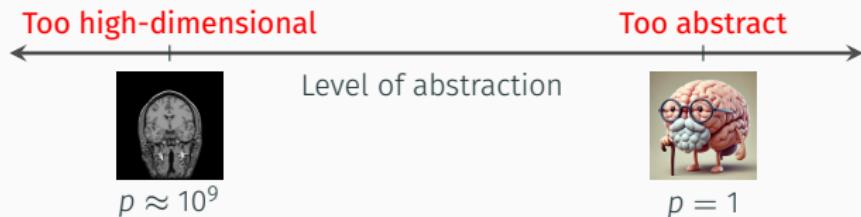
# Brain age modelling: Results



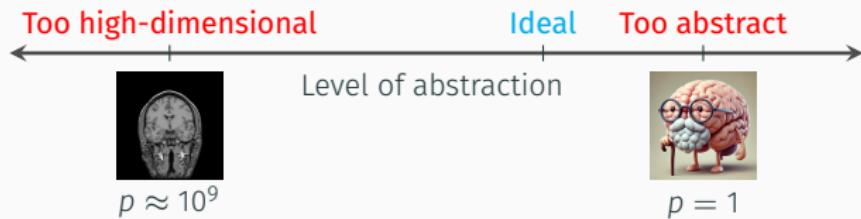
# Explainable artificial intelligence: Background



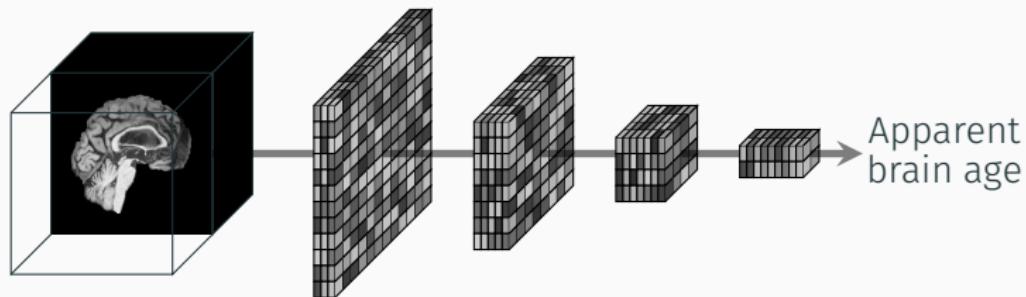
# Explainable artificial intelligence: Background



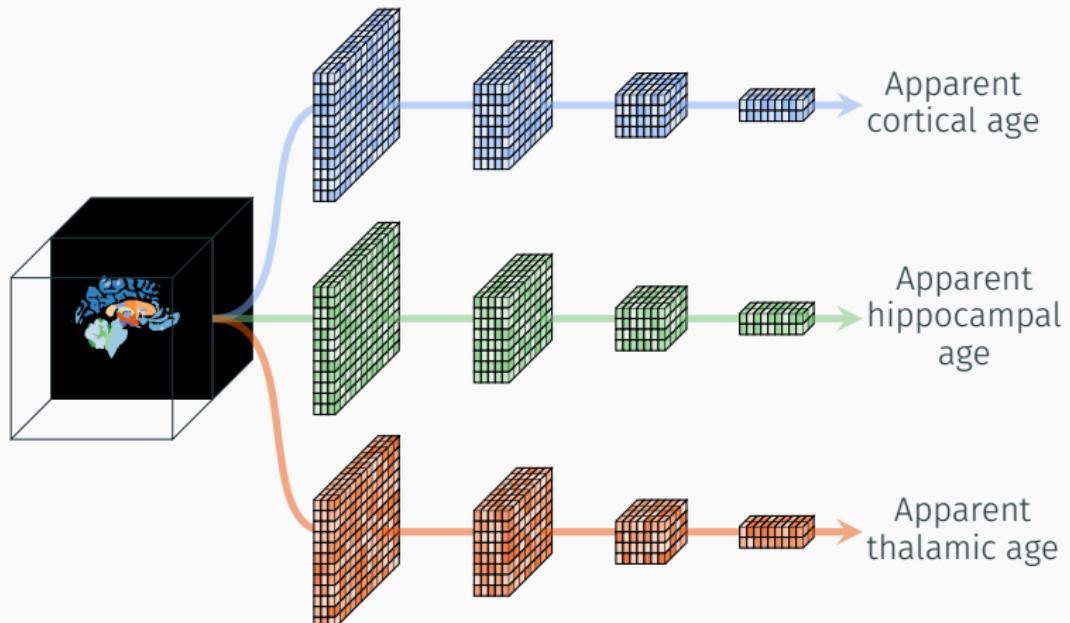
# Explainable artificial intelligence: Background



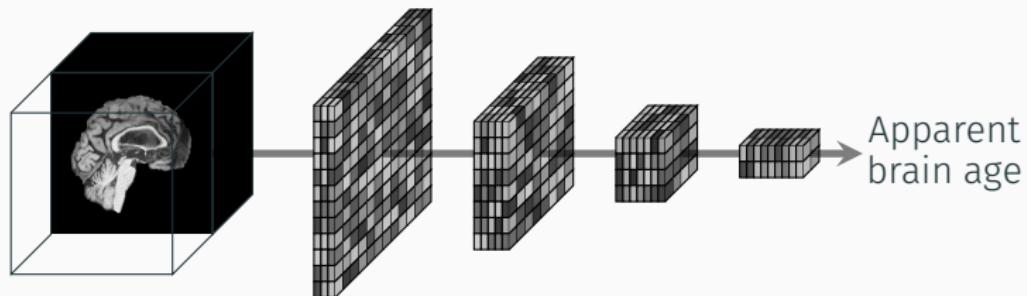
# Explainable artificial intelligence: Methods



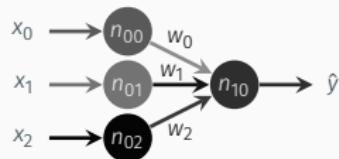
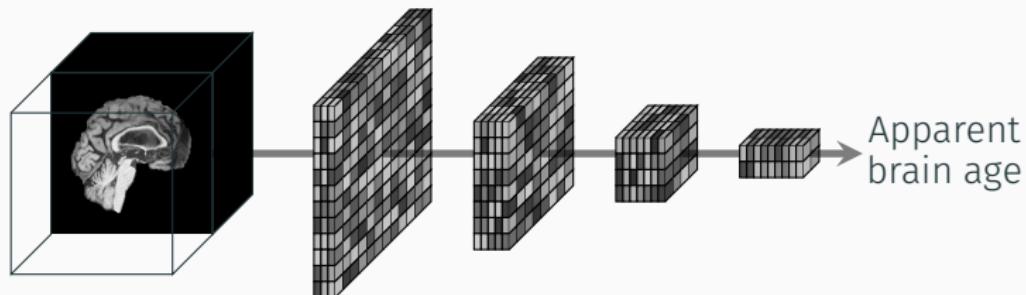
# Explainable artificial intelligence: Methods



# Explainable artificial intelligence: Methods



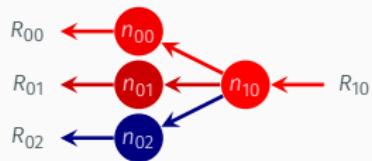
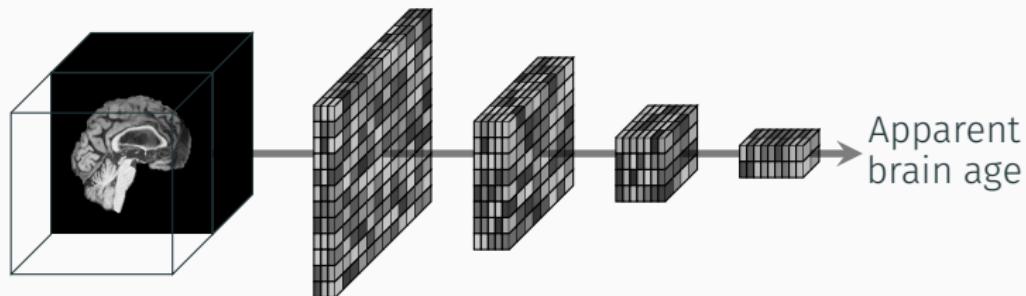
# Explainable artificial intelligence: Methods



$$\hat{y} = f \left( \sum_i^N w_i \cdot n_{0i} \right)$$



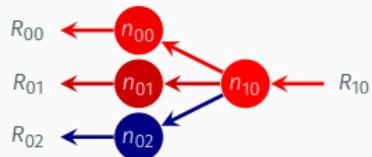
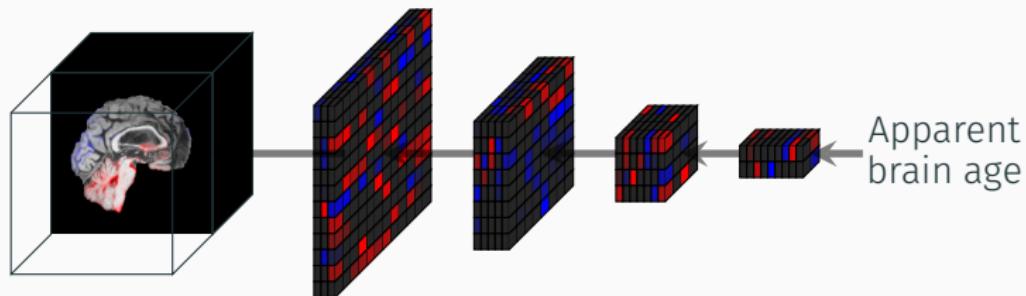
# Explainable artificial intelligence: Methods



$$R_{0i} = \sum_j \frac{n_{0i} w_i}{\sum_k n_{0k} w_k} R_{1j}$$



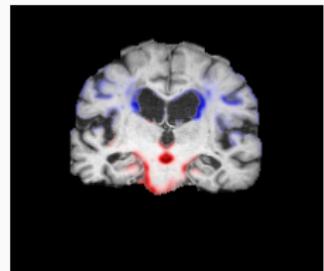
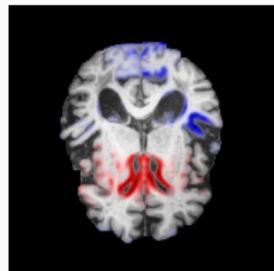
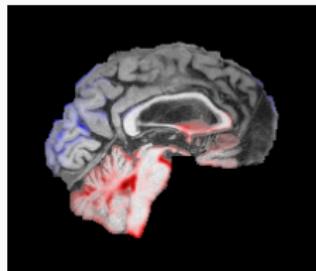
# Explainable artificial intelligence: Methods



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# Explainable artificial intelligence: Methods

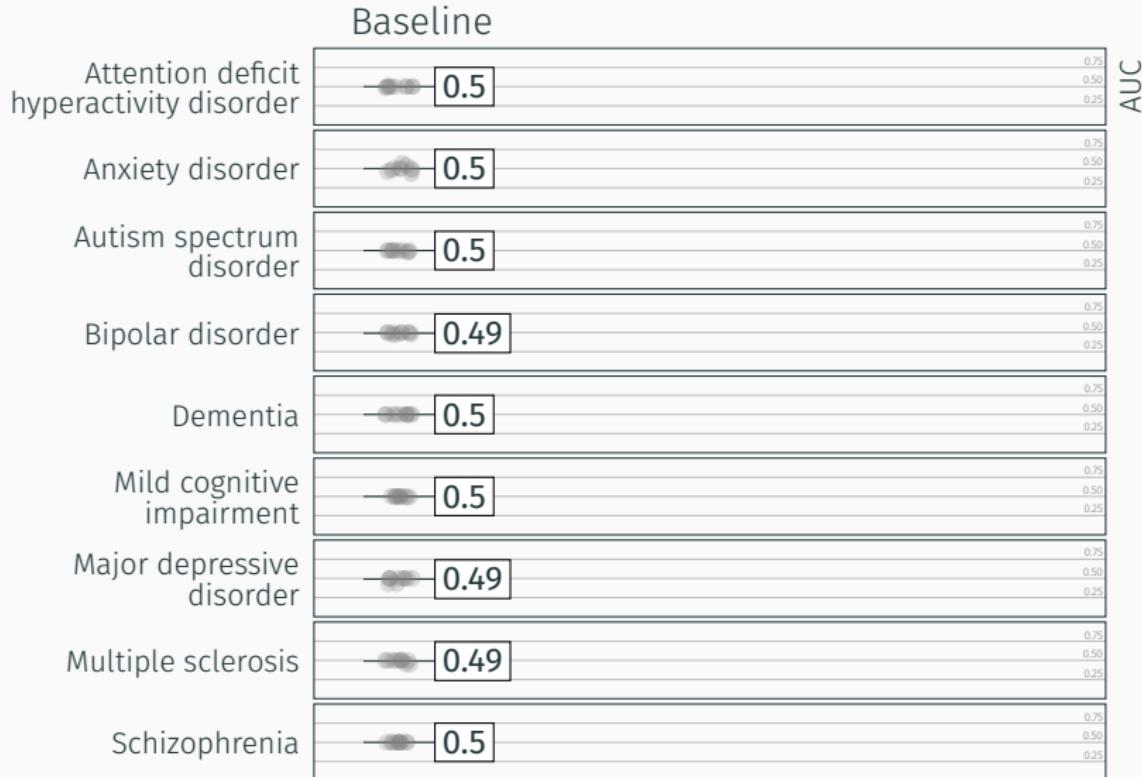


Younger  
appearing

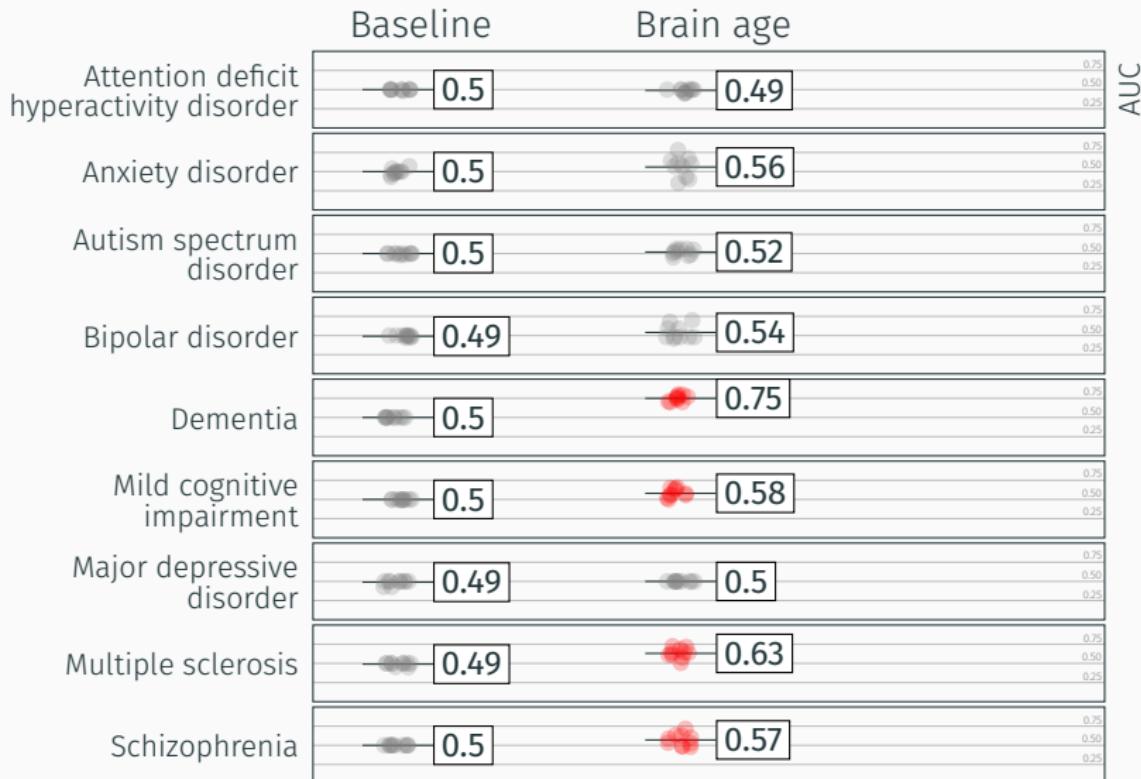
Older  
appearing



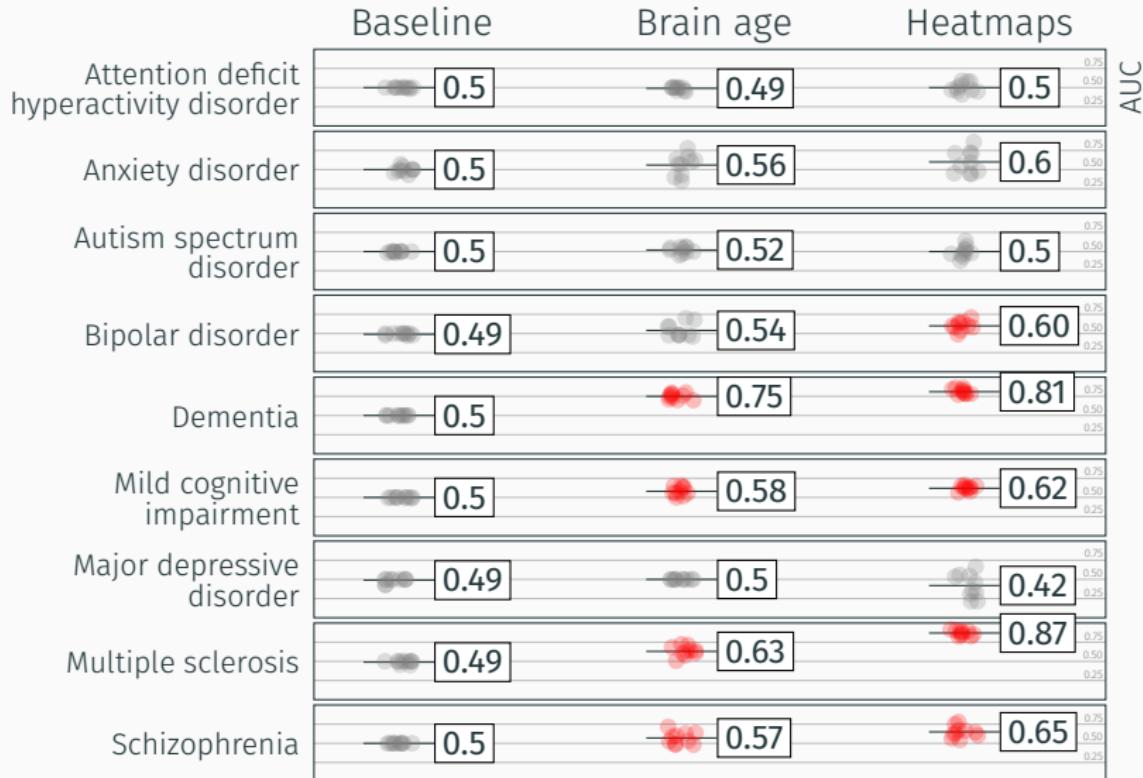
# Explainable artificial intelligence: Results



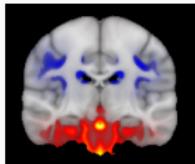
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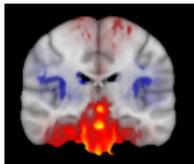
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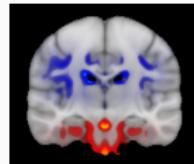
# Explainable artificial intelligence: Results



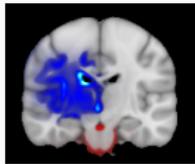
Attention deficit  
hyperactivity disorder



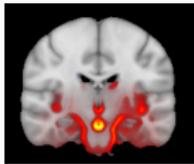
Anxiety  
disorder



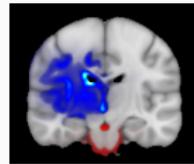
Autism spectrum  
disorder



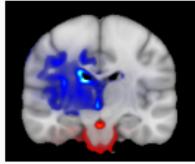
Bipolar  
disorder



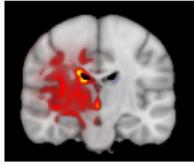
Dementia



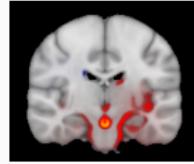
Schizophrenia



Major depressive  
disorder



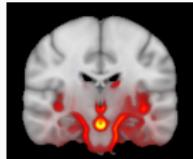
Multiple  
sclerosis



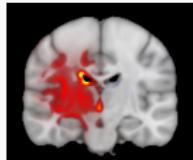
Mild cognitive  
impairment



# Explainable artificial intelligence: Results



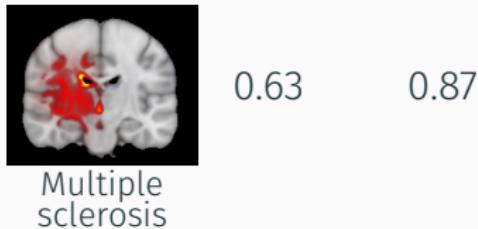
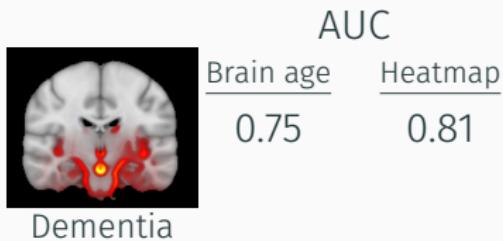
Dementia



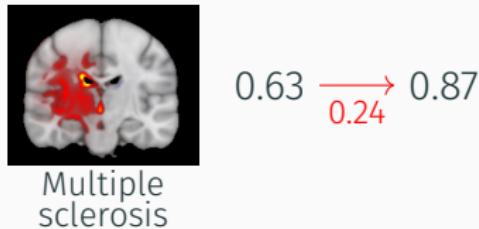
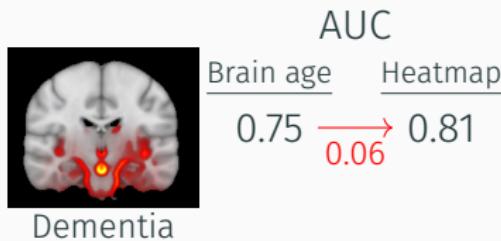
Multiple  
sclerosis



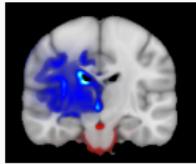
# Explainable artificial intelligence: Results



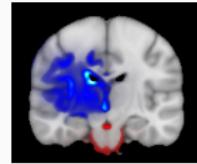
# Explainable artificial intelligence: Results



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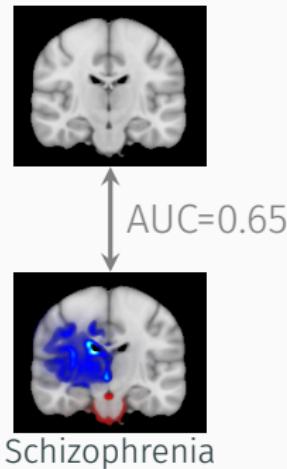
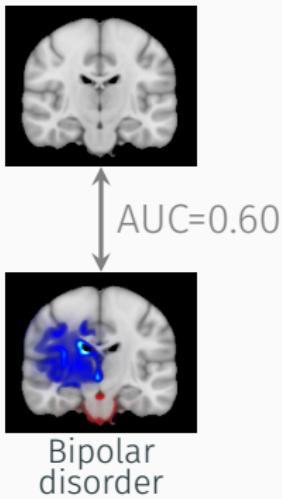
Bipolar  
disorder



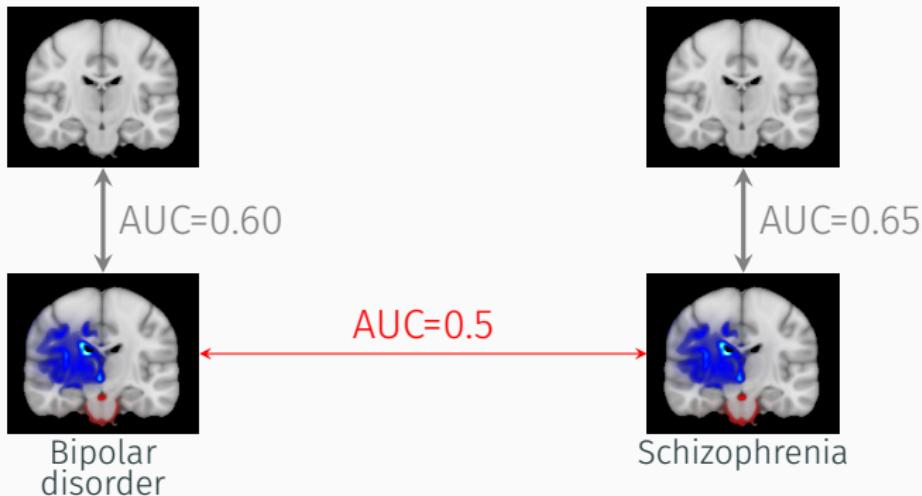
Schizophrenia



# Explainable artificial intelligence: Results



# Explainable artificial intelligence: Results



# Summary

- The innate complexity of neuroimaging data and clinical datasets of limited size makes it challenging to identify the visual patterns characteristic of complex disorders.
- Brain age modelling is a promising approach to learn a clinically useful abstraction of the brain from population data.
  - Lacks the specificity needed for clinical applications.
- Explainable AI allows us to construct a new data modality, that extends upon the brain age paradigm by *localizing* patterns of abnormal aging.
  - Yields higher discrimination for case-control predictions.
  - Allows for biological interpretations
- Future work should investigate the efficacy of the approach for more clinically relevant questions, such as prognostication and differential diagnosis.

