

Understanding the brain with explainable artificial intelligence

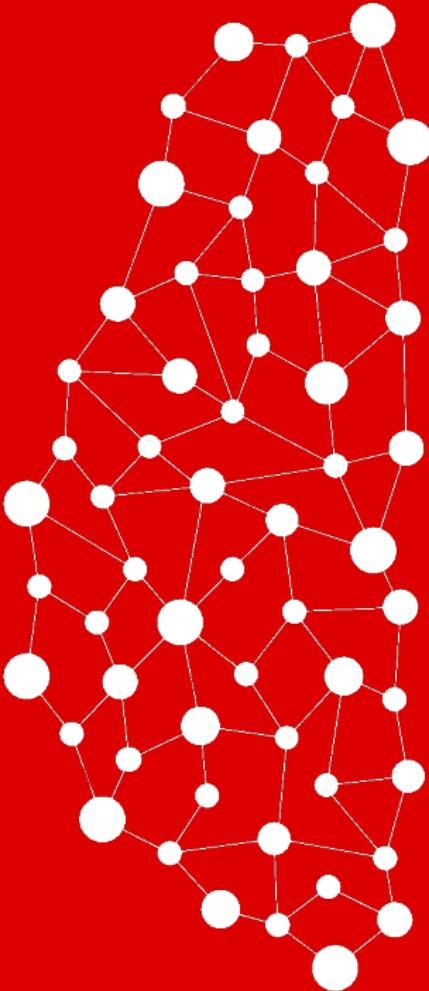
Detecting patterns of abnormal brain aging in patients with neuropsychiatric disorders



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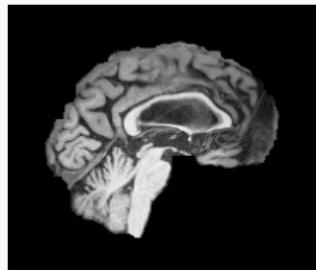
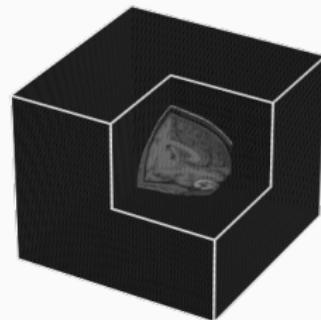
Brain age: Motivation

Cognitive neuroscience

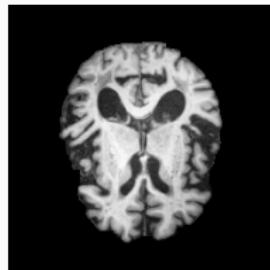


Brain age: Motivation

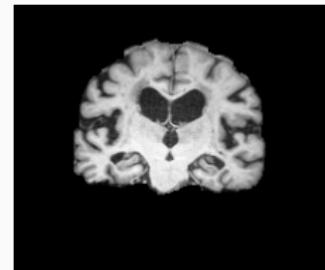
Structural Magnetic
Resonance Imaging (MRI) scans



Side



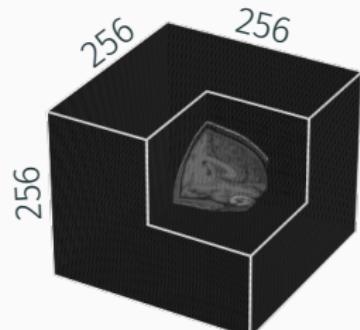
Above



Front



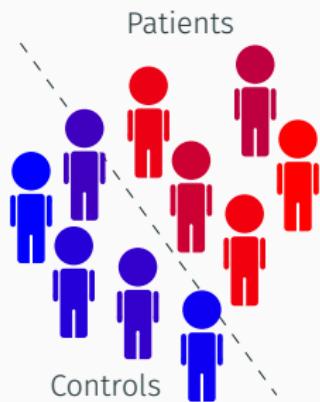
Brain age: Motivation



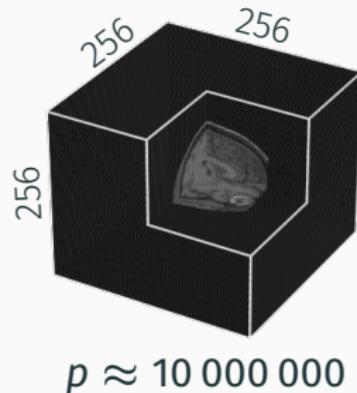
$p \approx 10\,000\,000$



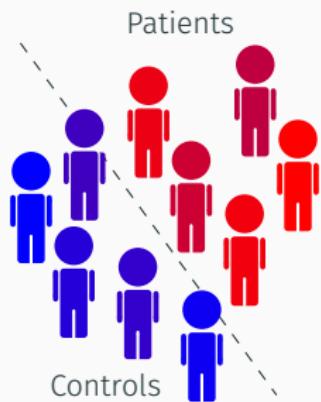
Brain age: Motivation



Clinical datasets
($n \approx 100$)



Brain age: Motivation



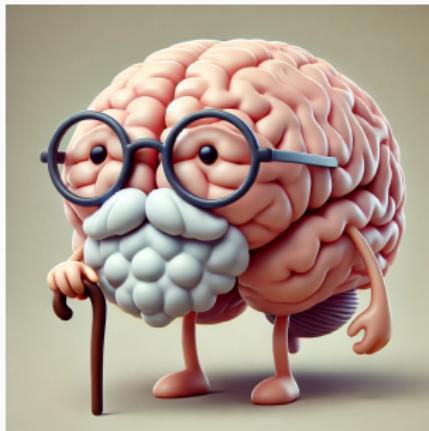
Clinical datasets
 $(n \approx 100)$



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



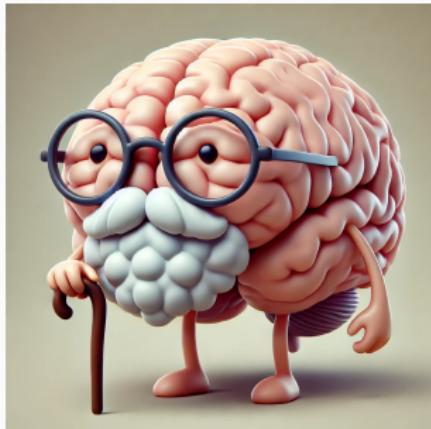
Brain age: Motivation



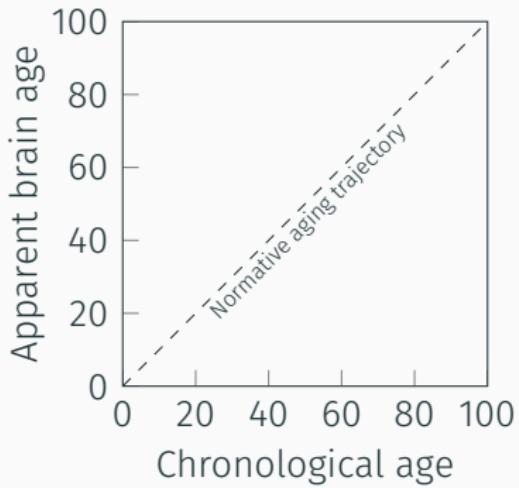
Generated by Dall-E 3



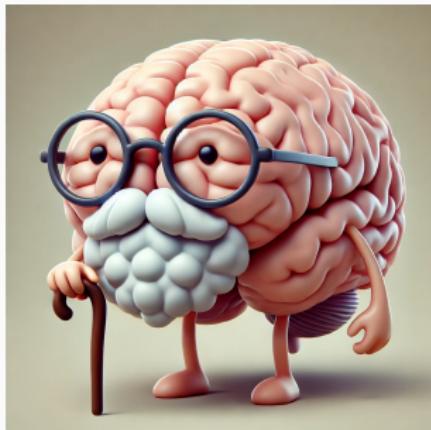
Brain age: Motivation



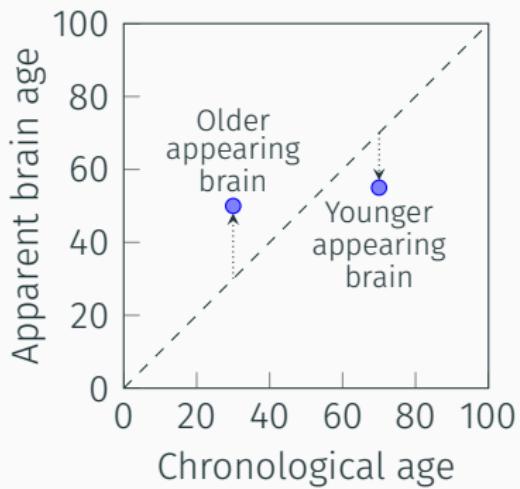
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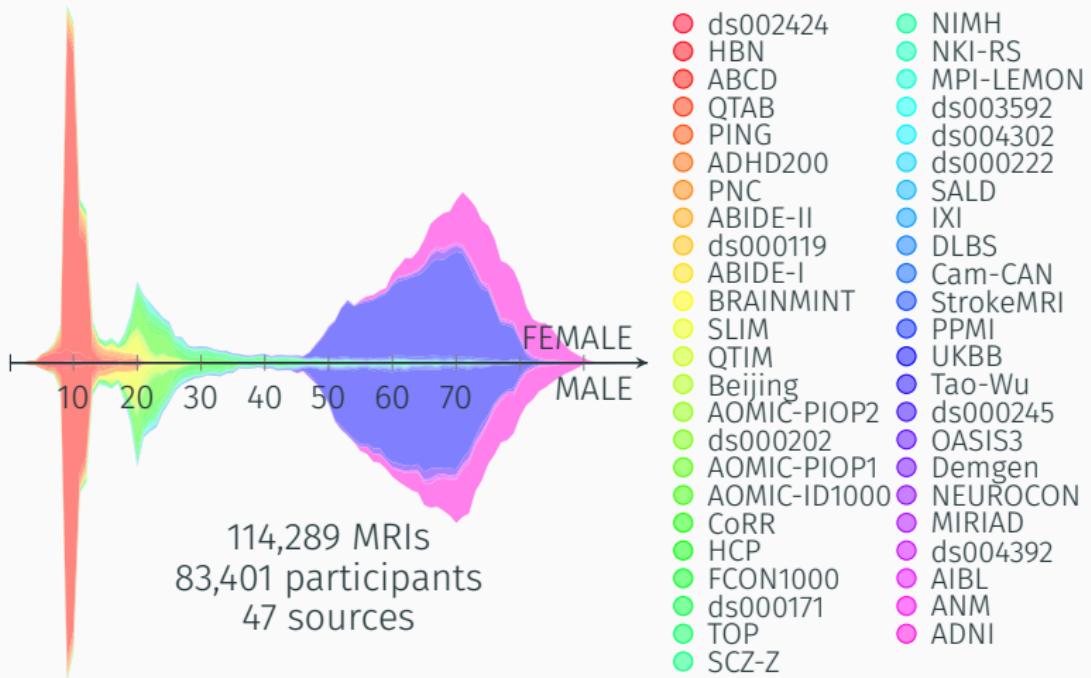
Brain age: Motivation



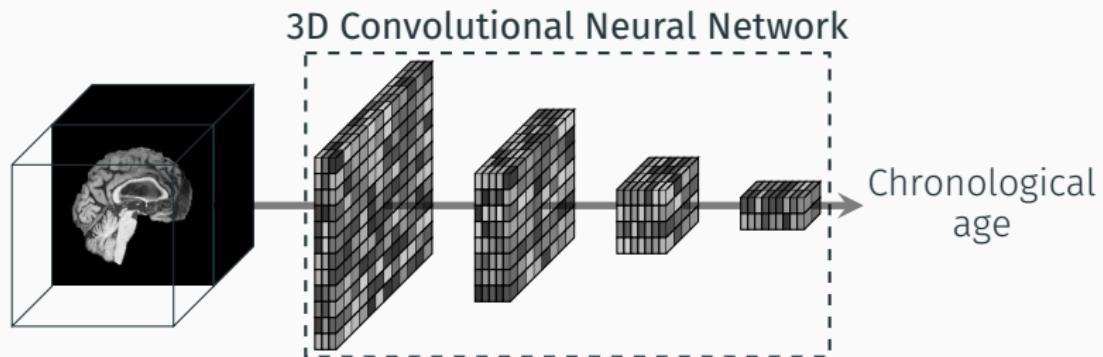
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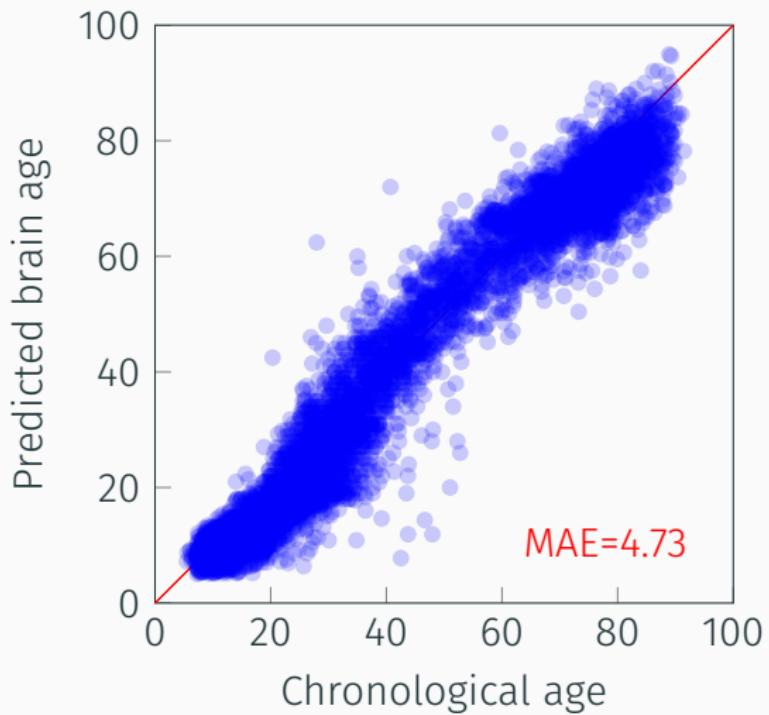
Brain age modelling: Methods



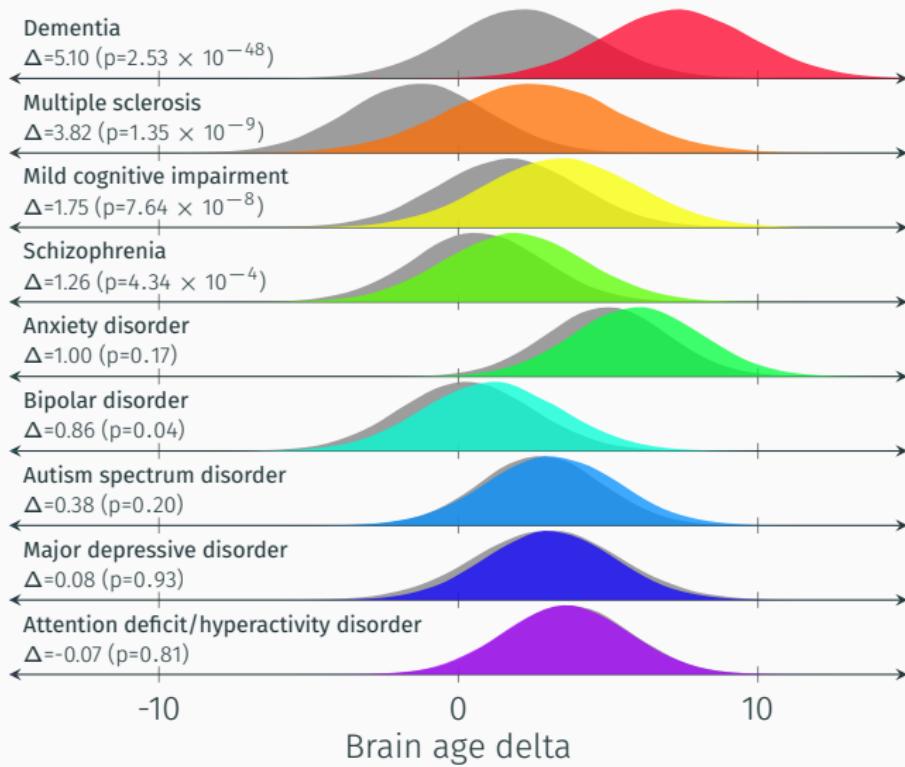
Brain age modelling: Methods



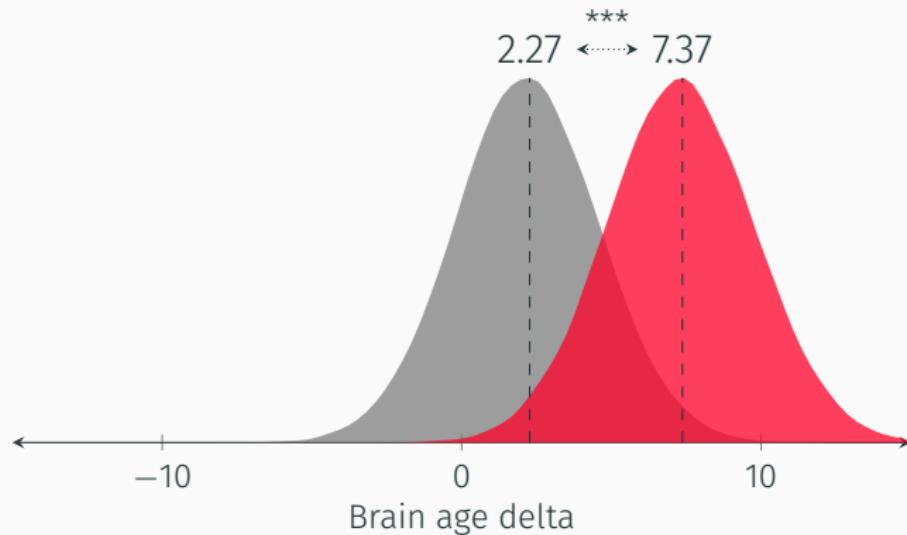
Brain age modelling: Results



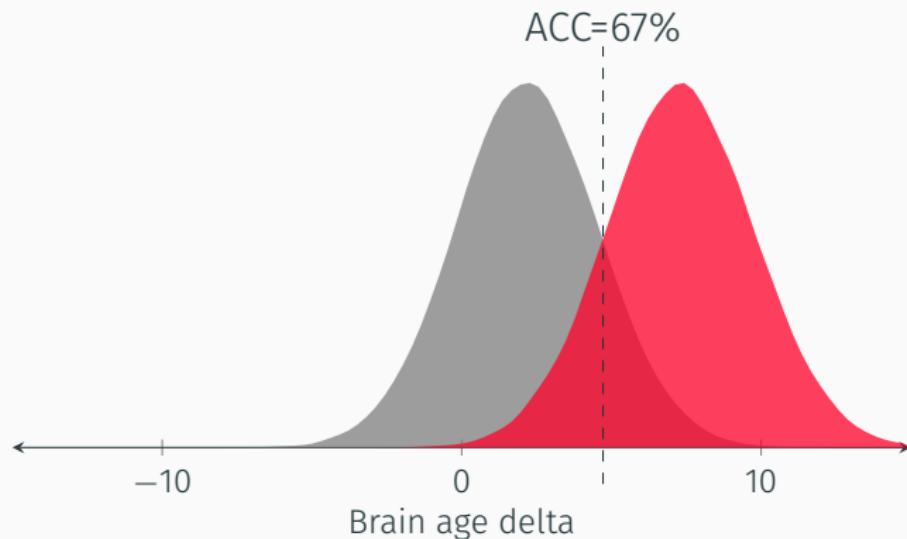
Brain age modelling: Results



Brain age modelling: Results



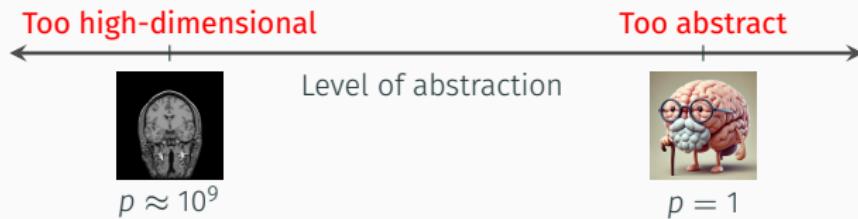
Brain age modelling: Results



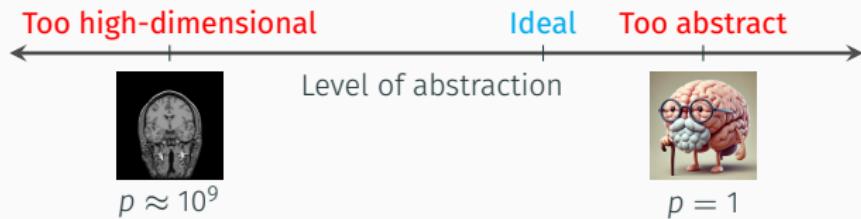
Explainable artificial intelligence: Background



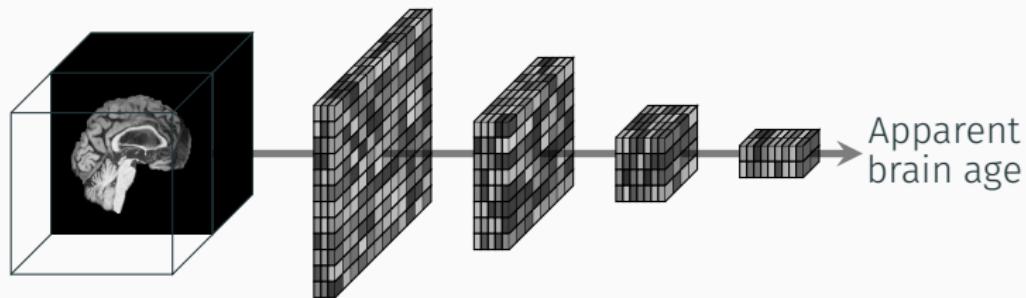
Explainable artificial intelligence: Background



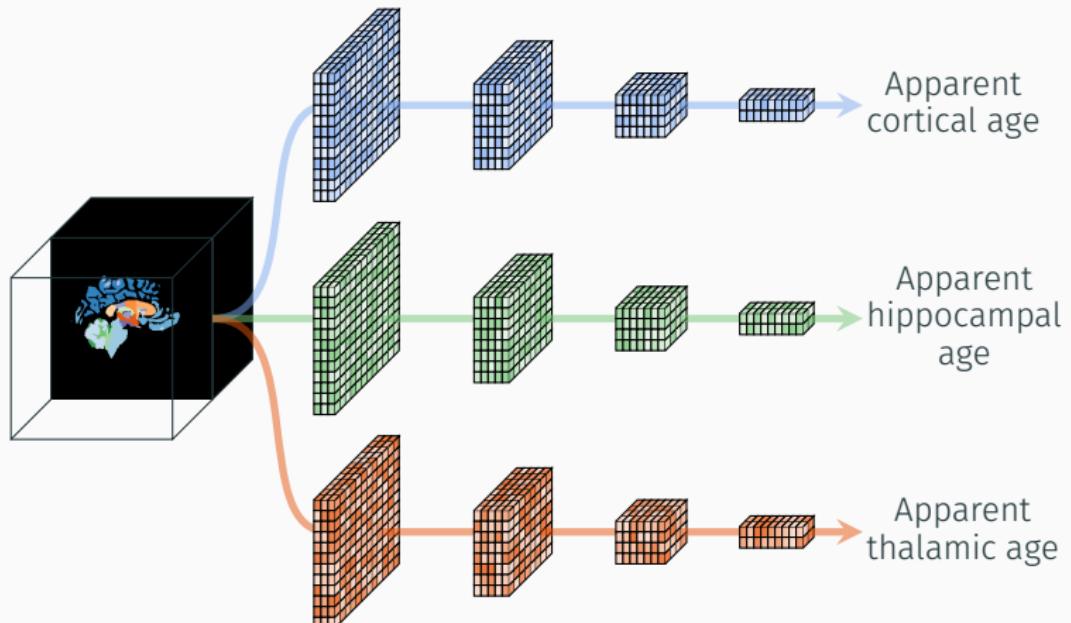
Explainable artificial intelligence: Background



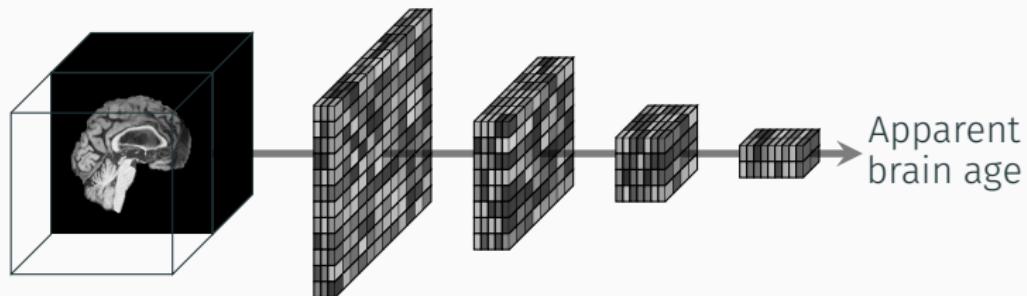
Explainable artificial intelligence: Methods



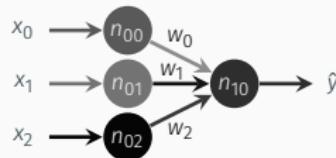
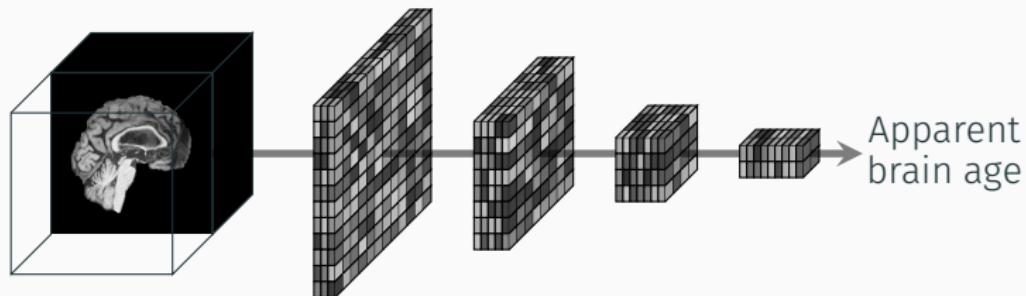
Explainable artificial intelligence: Methods



Explainable artificial intelligence: Methods



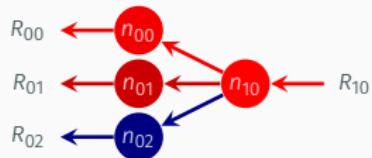
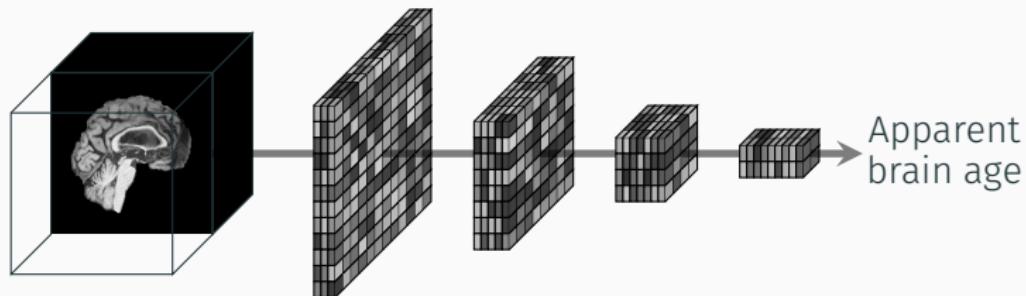
Explainable artificial intelligence: Methods



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



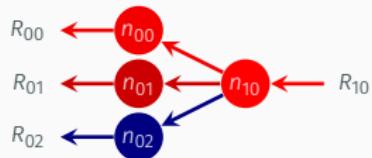
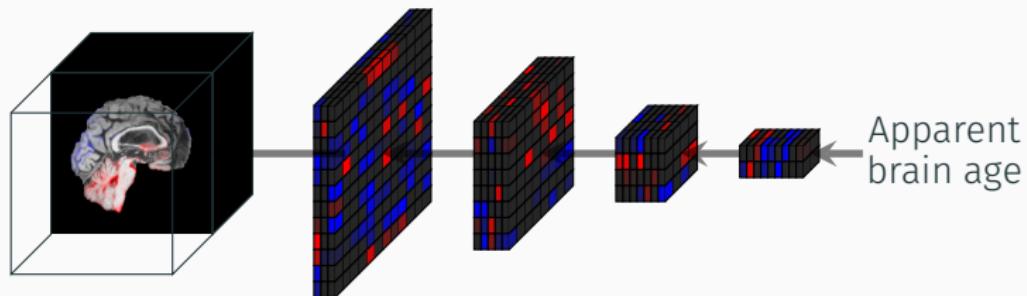
Explainable artificial intelligence: Methods



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



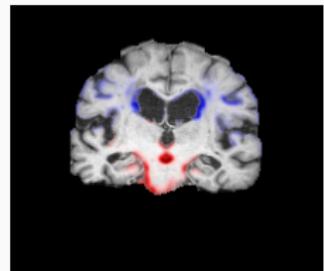
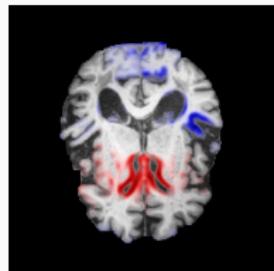
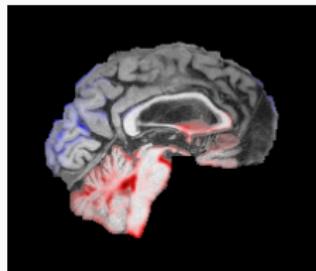
Explainable artificial intelligence: Methods



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



Explainable artificial intelligence: Methods

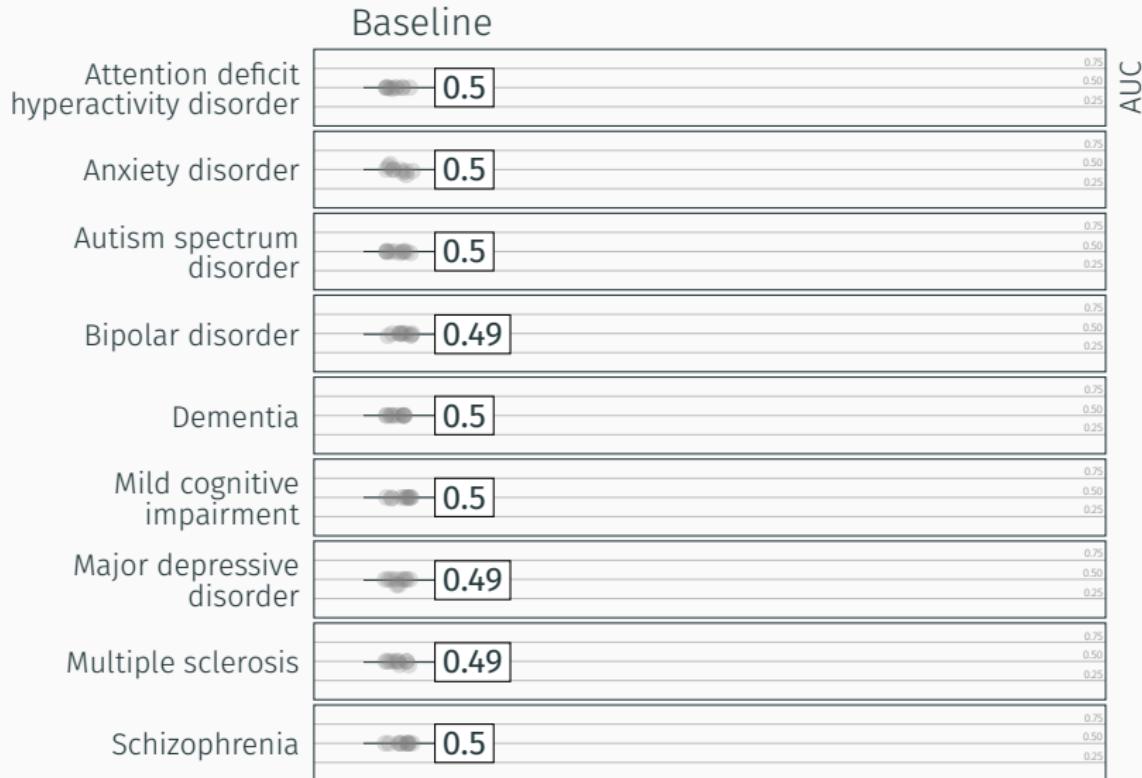


Younger
appearing

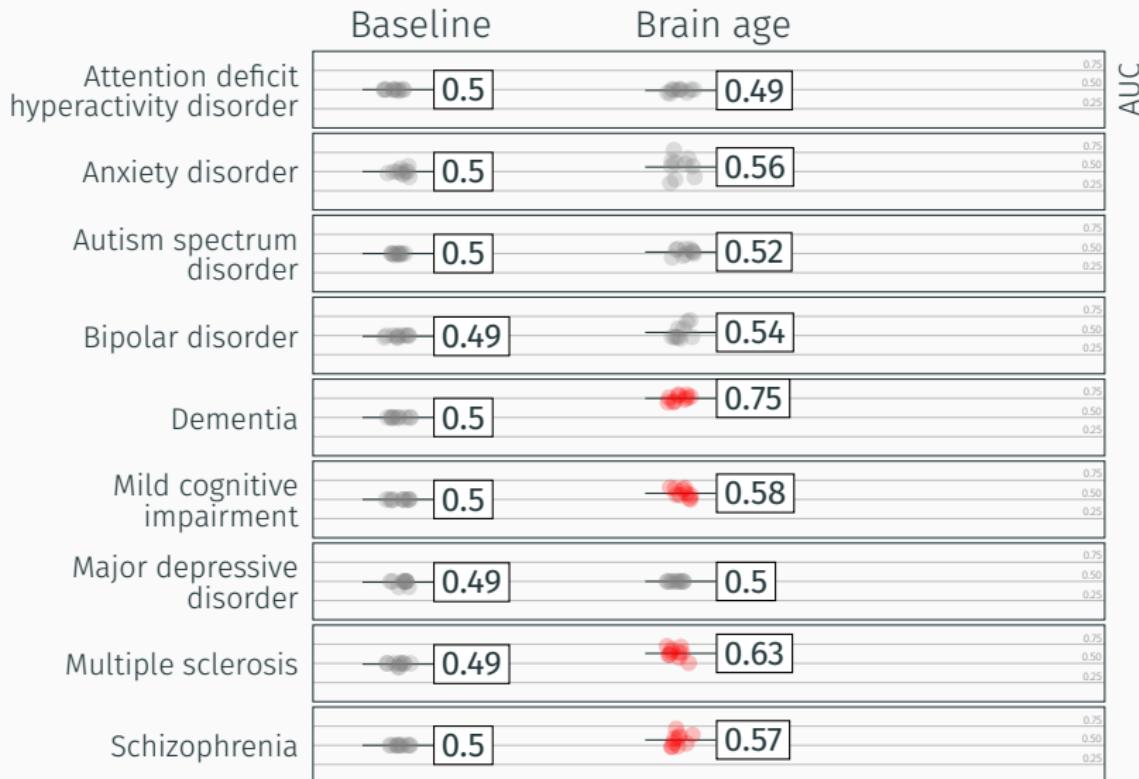
Older
appearing



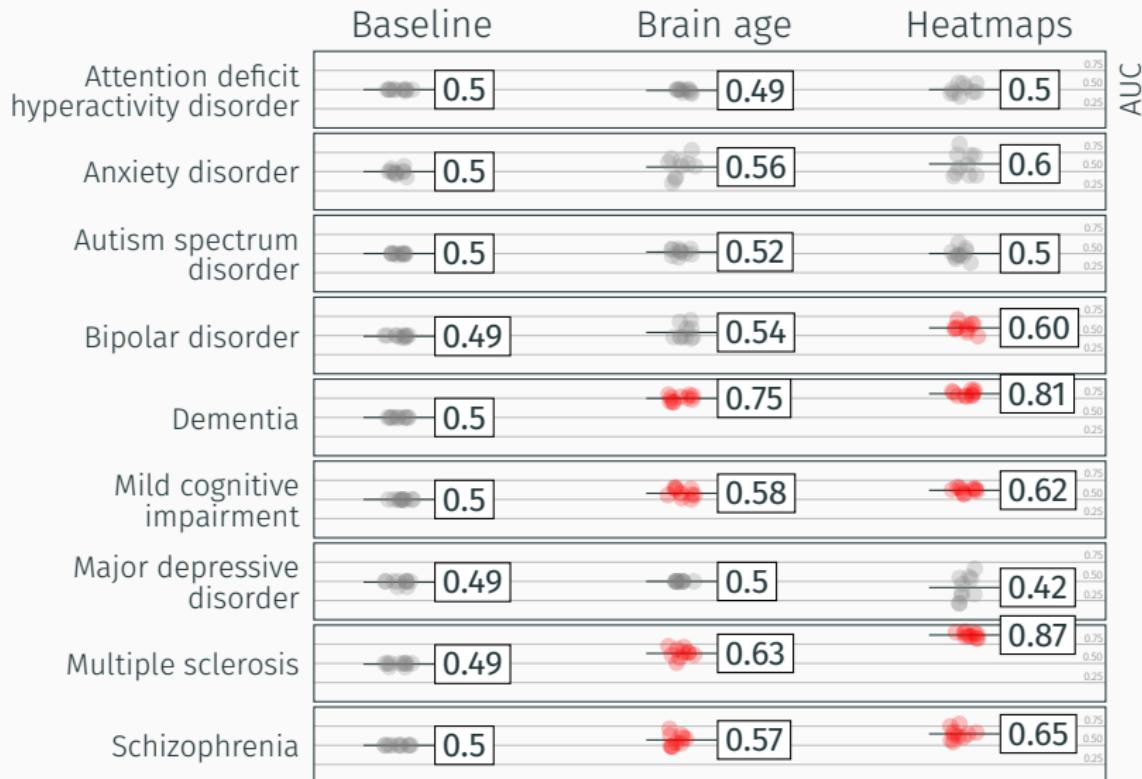
Explainable artificial intelligence: Results



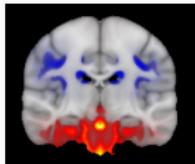
Explainable artificial intelligence: Results



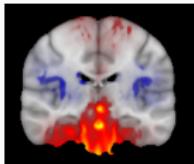
Explainable artificial intelligence: Results



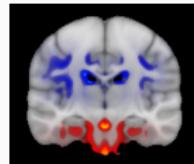
Explainable artificial intelligence: Results



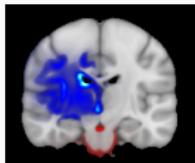
Attention deficit
hyperactivity disorder



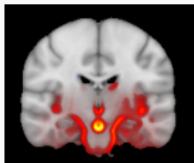
Anxiety
disorder



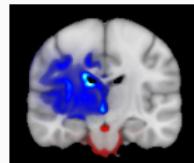
Autism spectrum
disorder



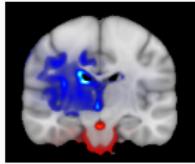
Bipolar
disorder



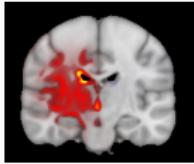
Dementia



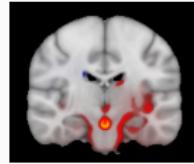
Schizophrenia



Major depressive
disorder



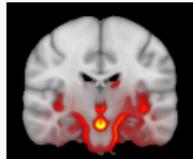
Multiple
sclerosis



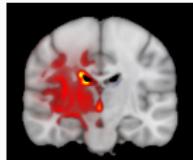
Mild cognitive
impairment



Explainable artificial intelligence: Results



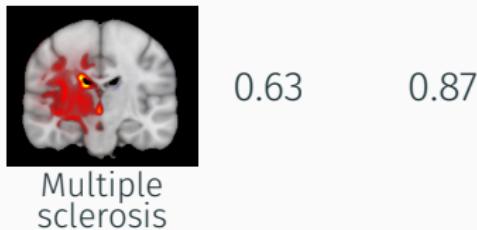
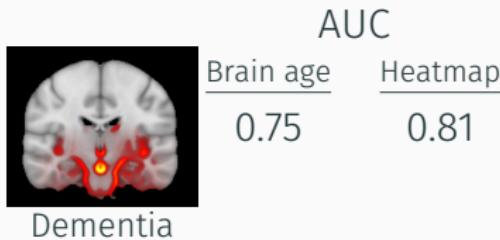
Dementia



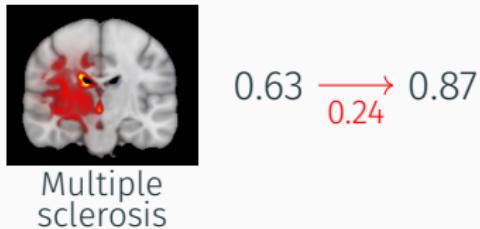
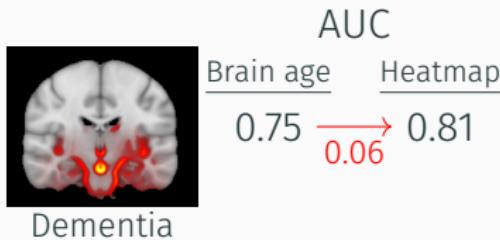
Multiple
sclerosis



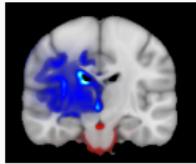
Explainable artificial intelligence: Results



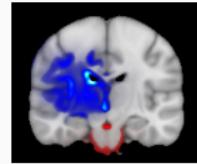
Explainable artificial intelligence: Results



Explainable artificial intelligence: Results



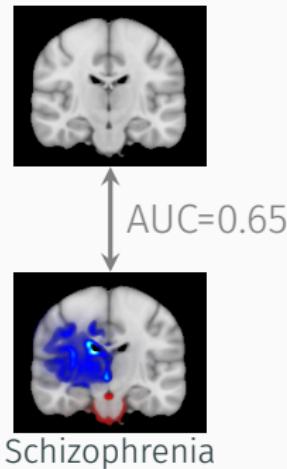
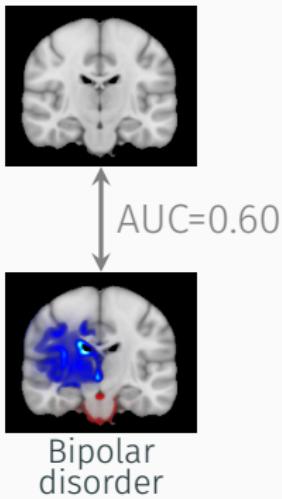
Bipolar
disorder



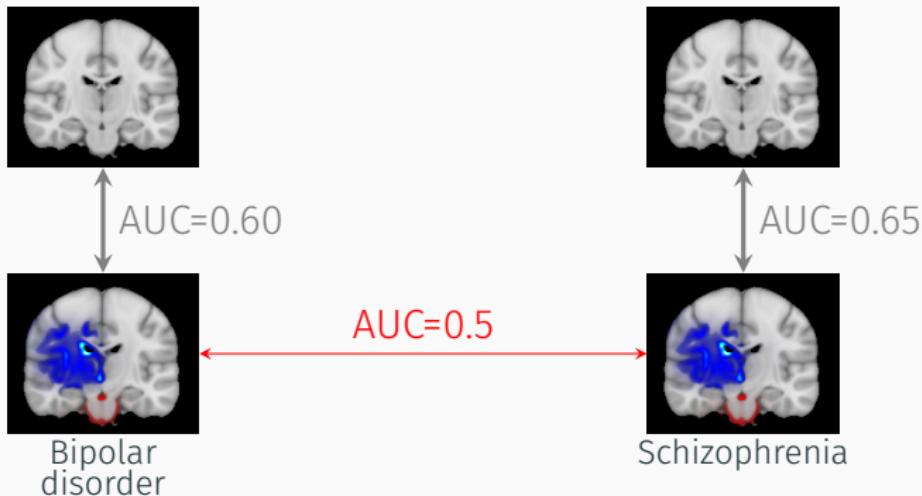
Schizophrenia



Explainable artificial intelligence: Results



Explainable artificial intelligence: Results



Summary

- The innate complexity of neuroimaging data combined with clinical datasets of limited size makes it challenging to find the visual patterns characteristic of complex neuropsychiatric disorders.
- The brain age paradigm is a promising approach to learn a clinically useful abstraction of the brain from population data.
 - Lacks the specificity needed to reach clinical utility.
- Explainable artificial allows us to procure 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

