



AI for better brain and mental health: from cloud to clinic

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The growing global challenge of brain diseases

- 1/3rd of global disease burden comes from neurological and psychiatric conditions, and it is growing
- There is a growing mental health crisis, particularly in young people
- Dementia is hugely costly and the leading cause of death in the UK

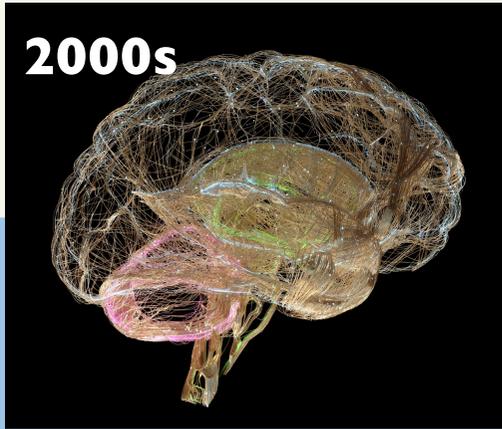


*Oleson & Leonardi, 2003
Office for National Statistics, 2021*

Two decades of scientific transformation

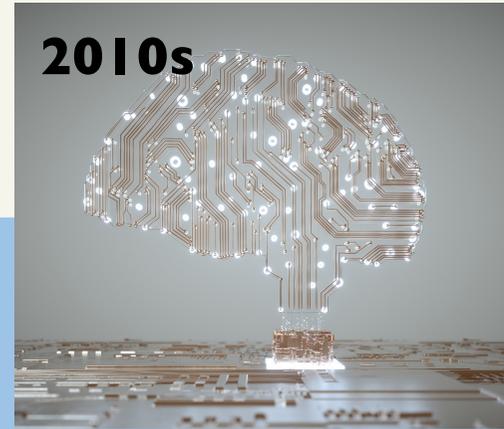
Scientific insight has been transformed over the past twenty years:

2000s



Revolution in brain imaging technology:
opening the 'black box' of the mind and
transforming understanding of brain function

2010s



Revolution in AI and data science:
translation of brain-inspired AI to healthcare

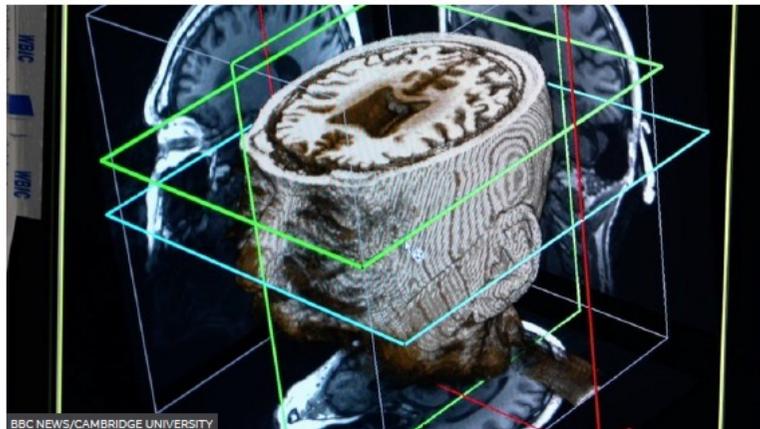
How do we harness these revolutions to improve brain health?

Leveraging AI for early prediction of brain and mental health disorders

Artificial Intelligence may diagnose dementia in a day

By Pallab Ghosh
Science correspondent

© 10 August 2021 | [Comments](#)



BBC NEWS/CAMBRIDGE UNIVERSITY

BBC Sign in

NEWS

AI could diagnose dementia before symptoms show



THE TIMES

Clinical Need:

Assign the right patient to the right treatment at the right time

Every 3 seconds
someone is diagnosed
with dementia

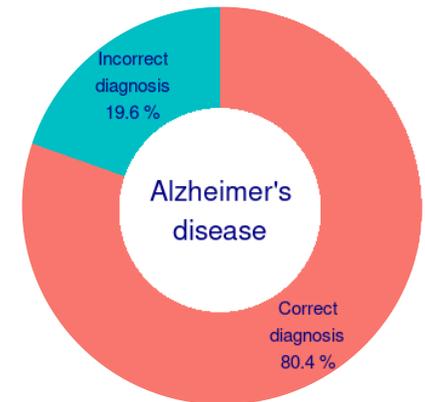
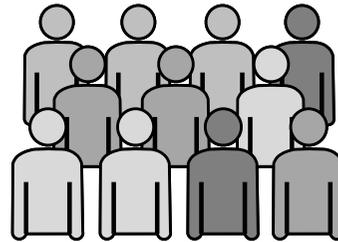


55 million

People living with dementia worldwide

£42 billion

Cost of dementia in the UK in 2024



50% of individuals with dementia are undiagnosed and 20–30% are misdiagnosed

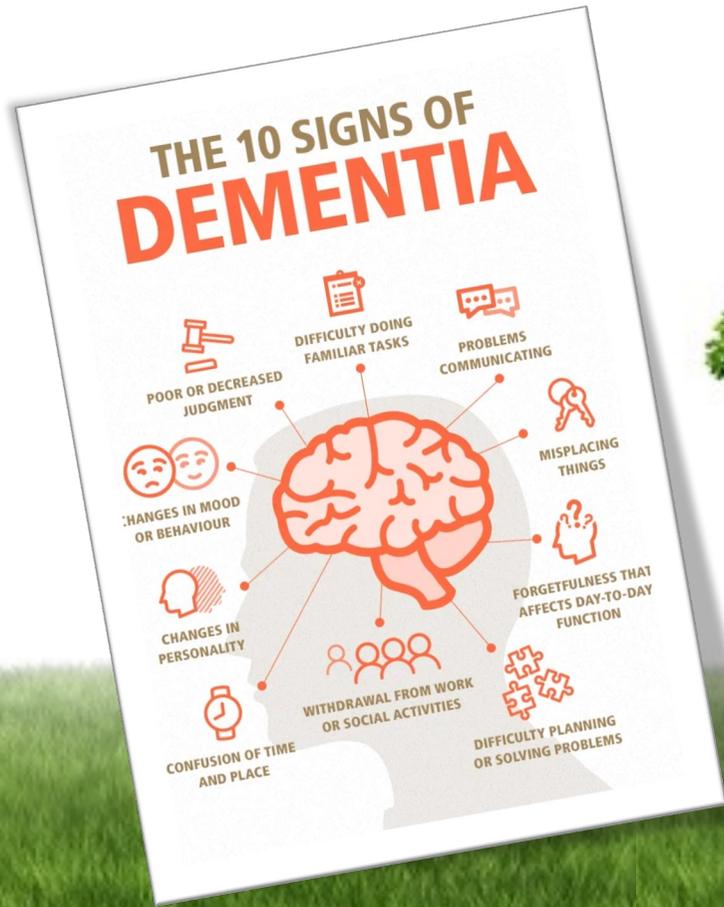
\$8000
per month

Cost of new
immunotherapies

After 30 years: new disease modifying treatments!

- they are expensive
- may work best when given early.

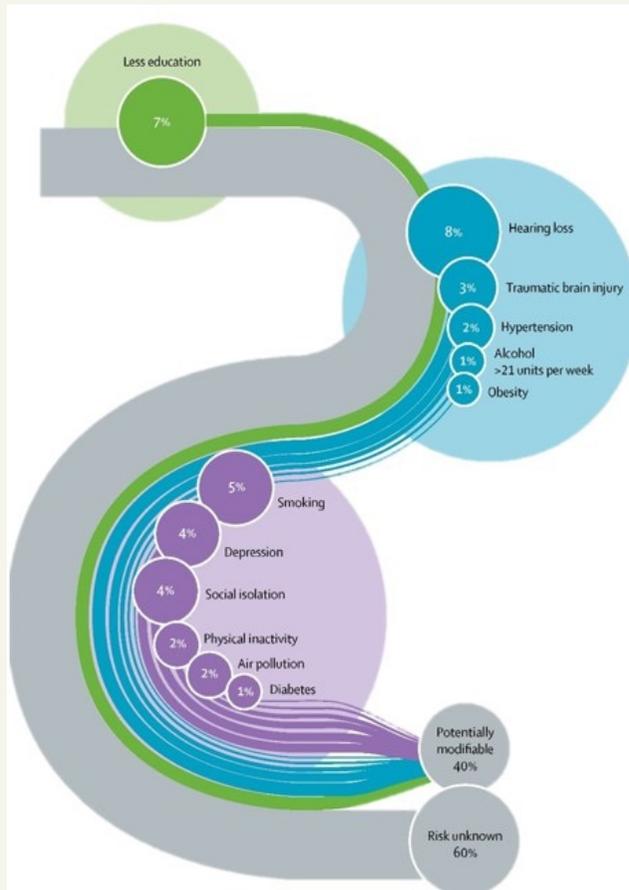
Challenge: Using AI to predict dementia before symptoms appear



Why early prediction?

Dementia starts in the brain 10-15 years before symptoms appear

Start sooner, treat smarter, scale-up



Prevention

Up to 40% of dementia cases could be prevented or delayed by lifestyle changes

Reduce burden

Improve patient wellbeing by reducing invasive and costly diagnostic testing

Improve wellbeing

Patients face an uncertain future – increases stress and blocks meaningful planning

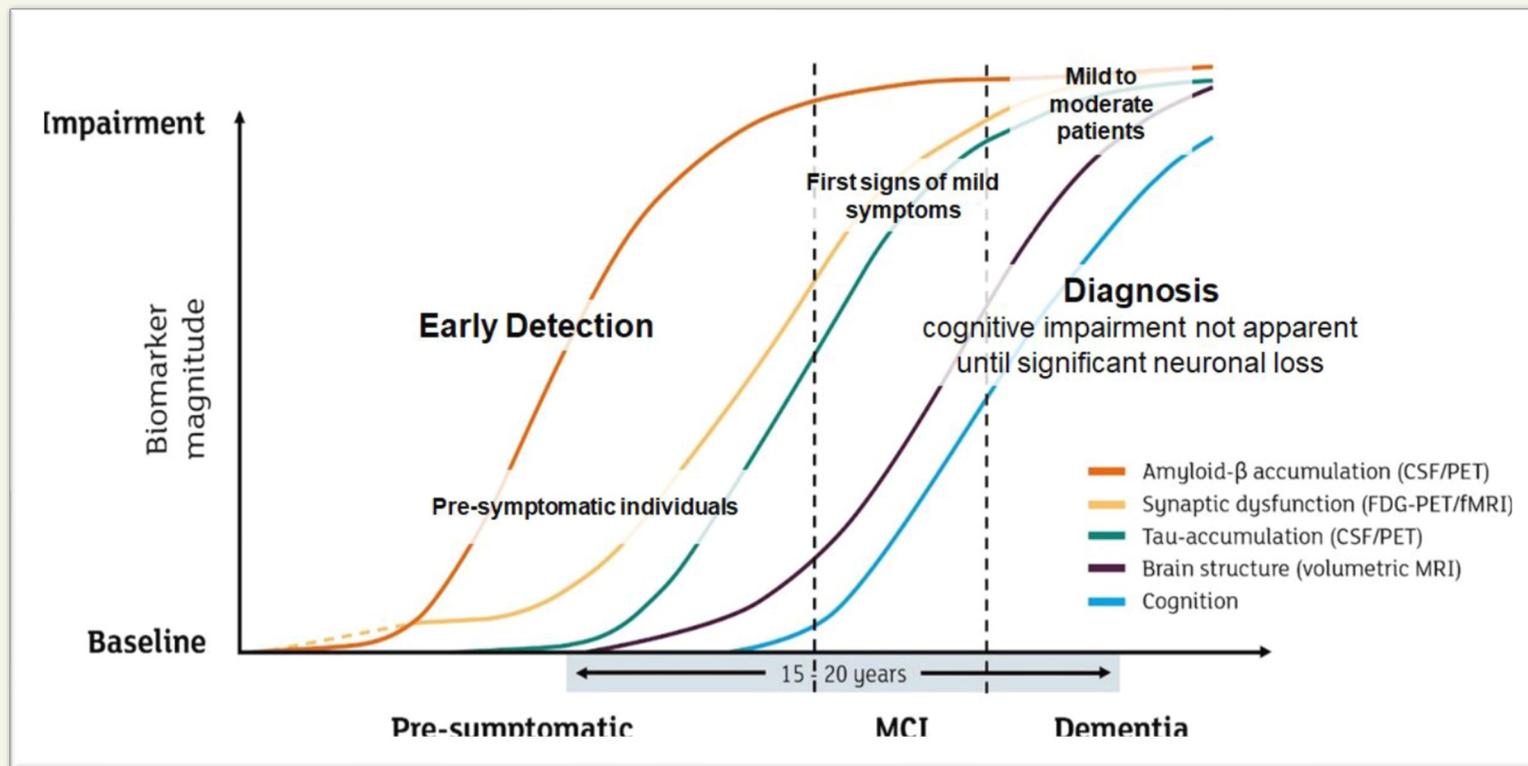
Make best use of treatments

New treatments need to be given early in disease – and do not work for everyone

Optimize spend

Target resources to patients who need them the most

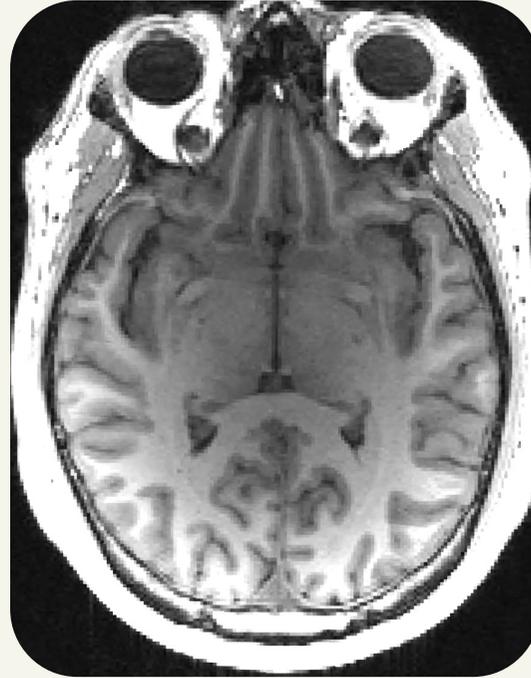
Predicting early from non-invasive data



Predicting at early dementia stages

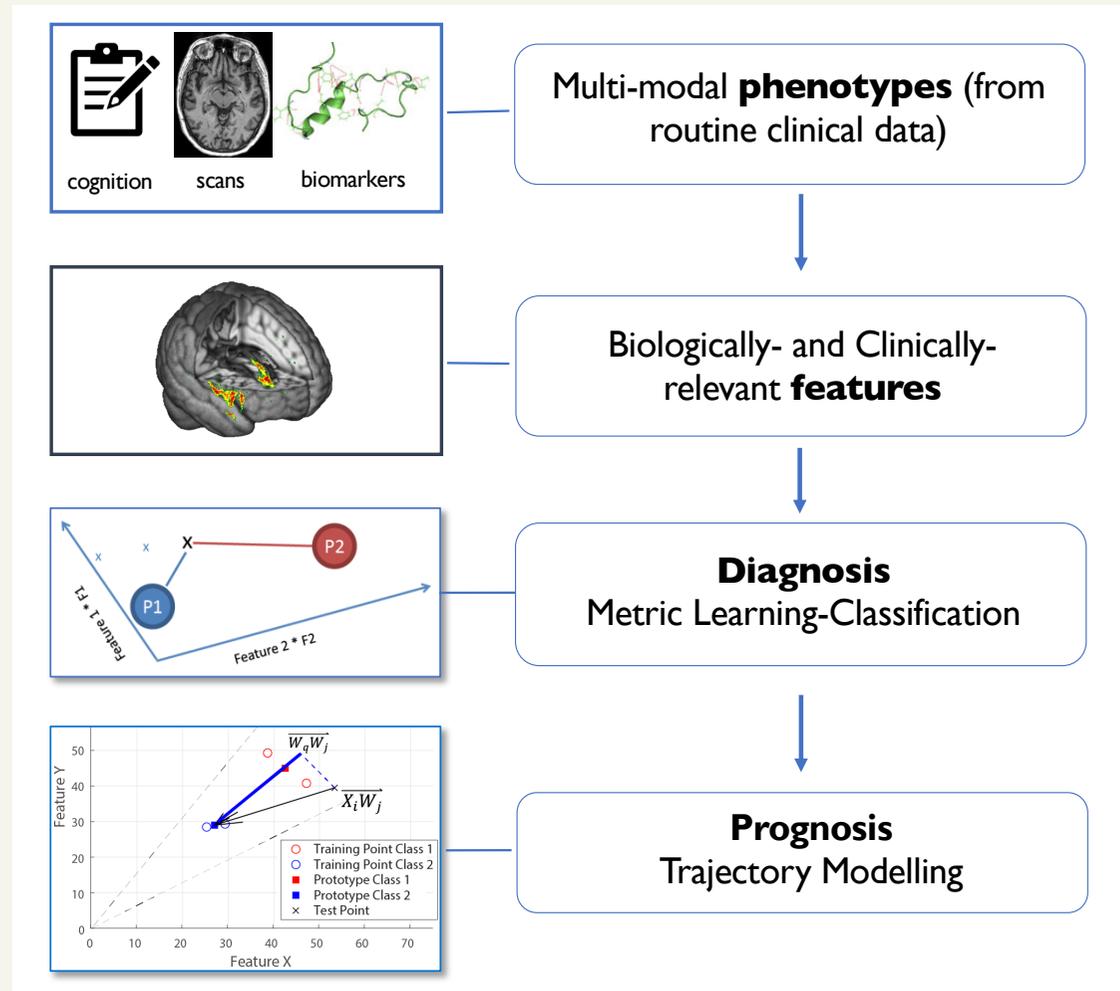
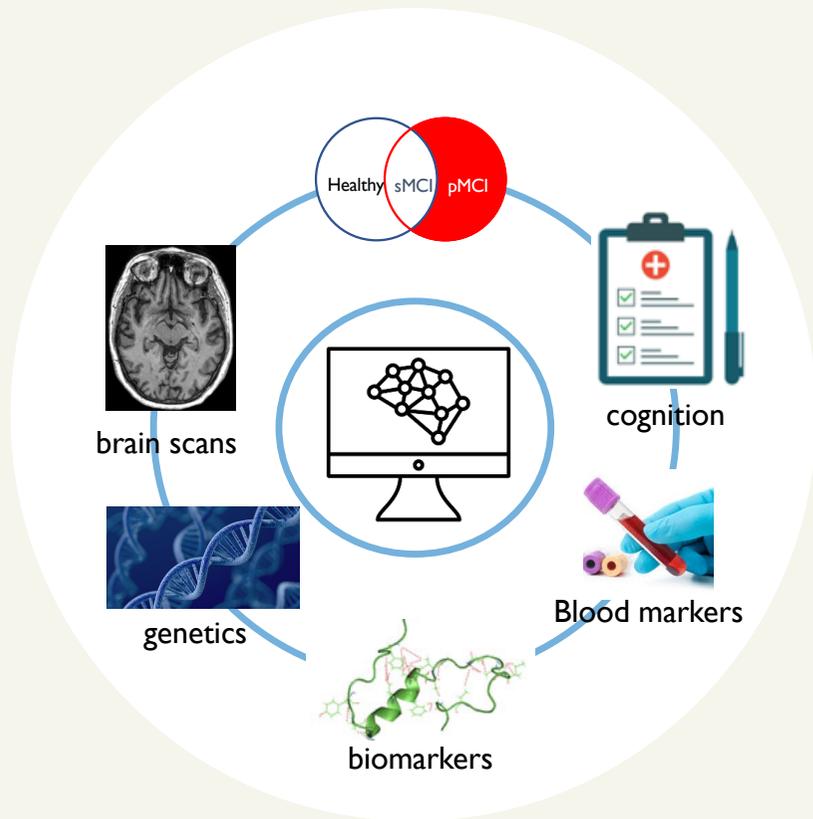


Alzheimer's



*Healthy?
or
Mild Cognitive Impairment?*

PPM: Predictive Prognostic Multimodal Modelling

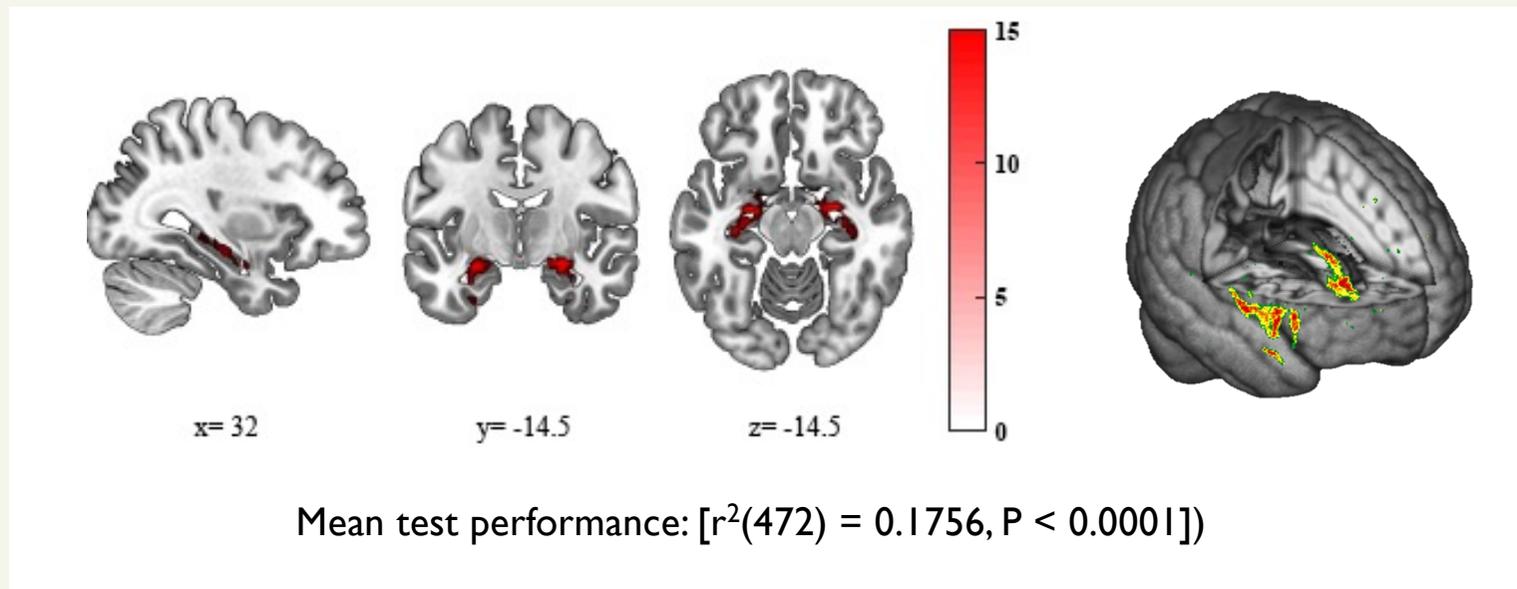


Giorgio.. Kourtzi, *NeuroImage Clinical*, 2020

Giorgio.. Kourtzi,, *Nature Comms*, 2022

Lee... Kourtzi, *eClinical Medicine*, 2024

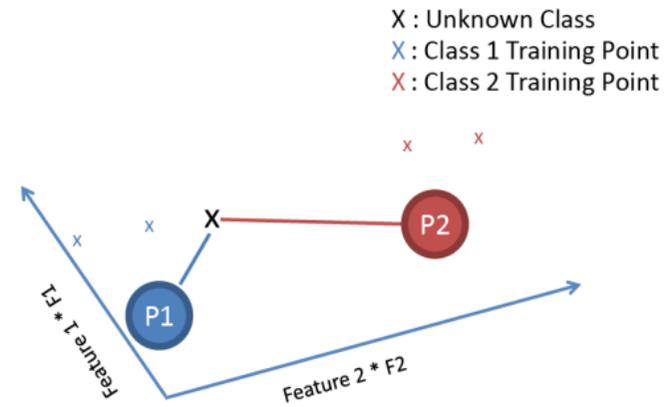
Extracting biologically relevant features



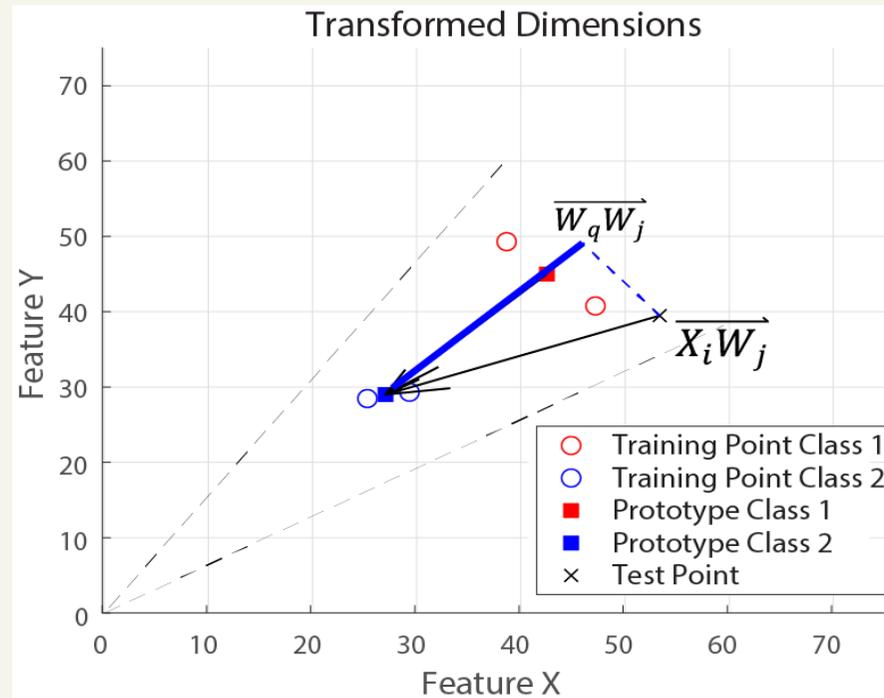
PLS-derived Grey Matter Score predicts cognitive decline (variance in ADNI-Mem scores)

Multimodal Machine Learning for patient classification

Generalised Metric Learning Vector Quantisation: GMLVQ

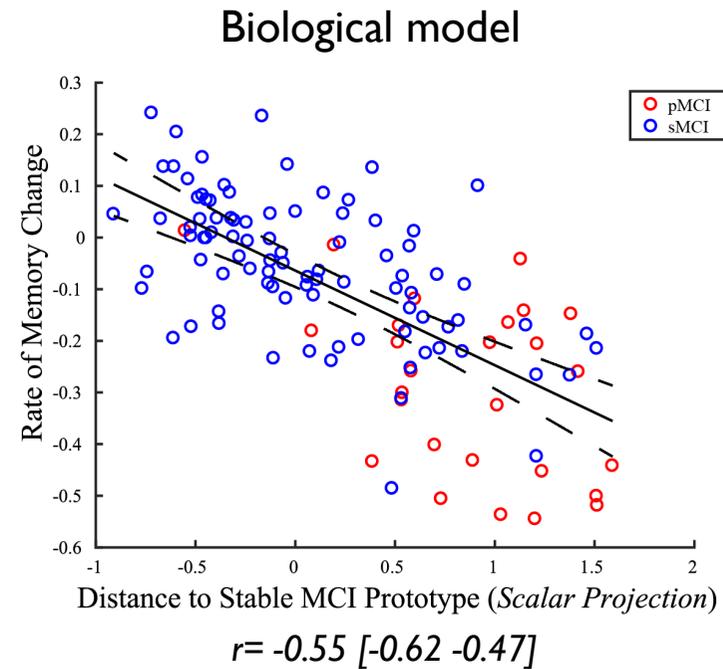
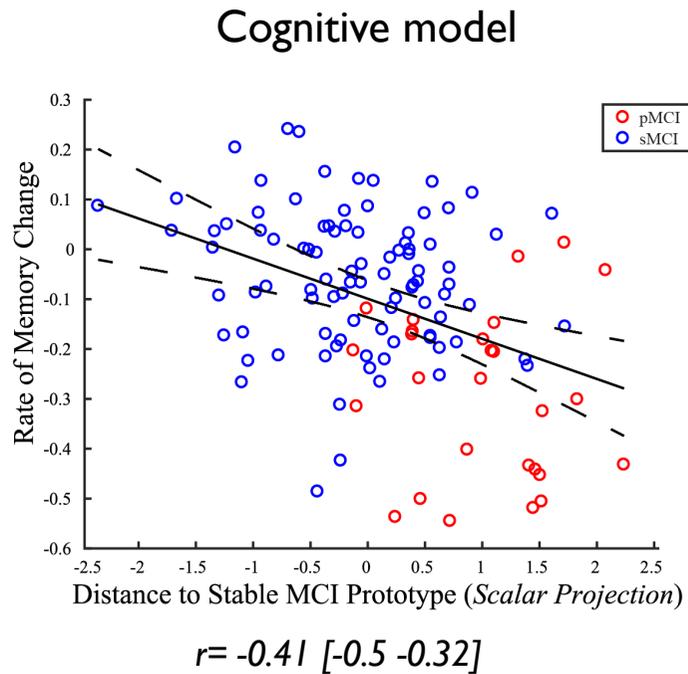


Trajectory modelling: deriving a multimodal prognostic index

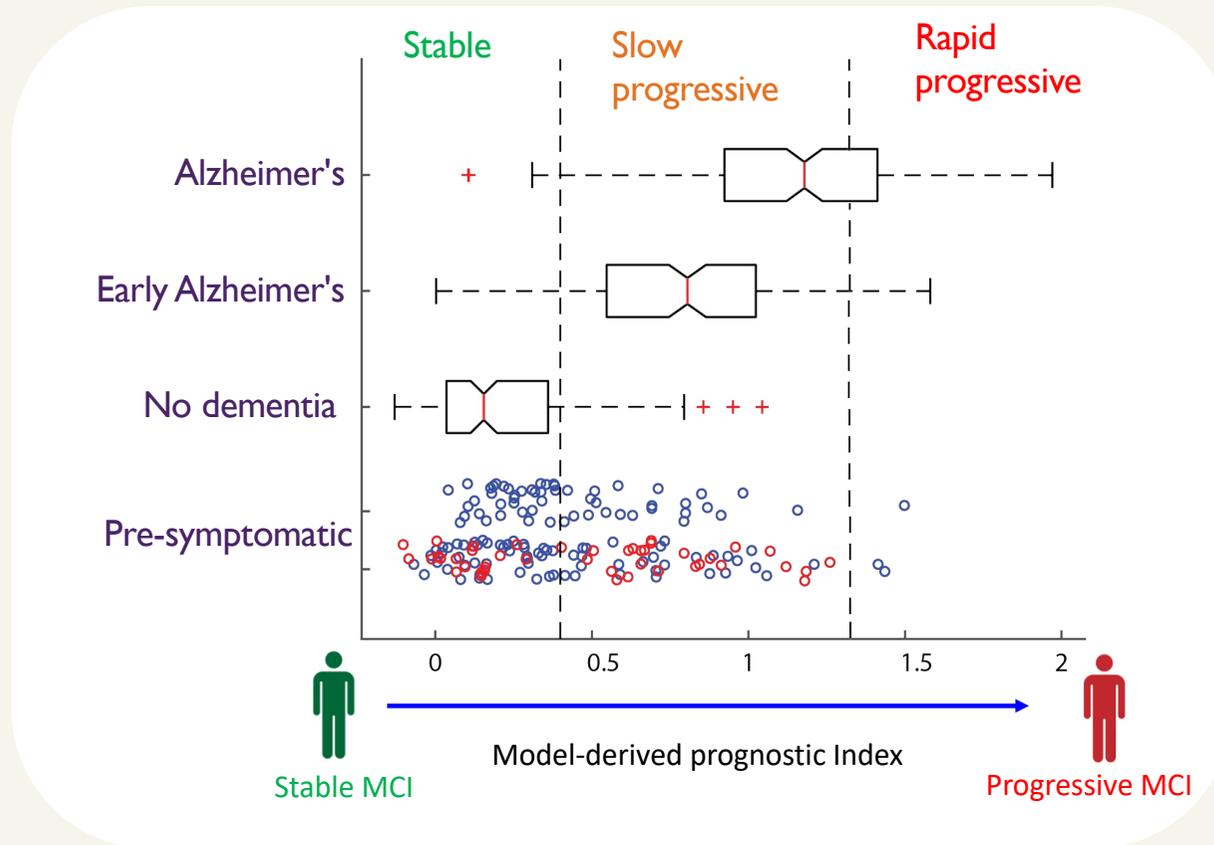


Scalar Projection determines distance from stable MCI prototype

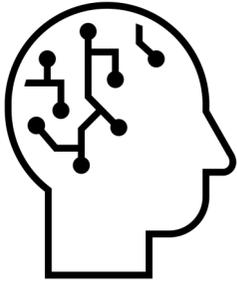
Multimodal prognostic index predicts rate of cognitive decline



Clinical AI marker stratifies at early and pre-symptomatic stages



Clinical AI marker classifies Cognitive Normal vs. MCI at 91% accuracy based on MTL grey matter, β -Amyloid, APOE 4



People
and AI

Safety and
wellbeing



Safety and
security

Inclusivity,
fairness and
equity



Accountability



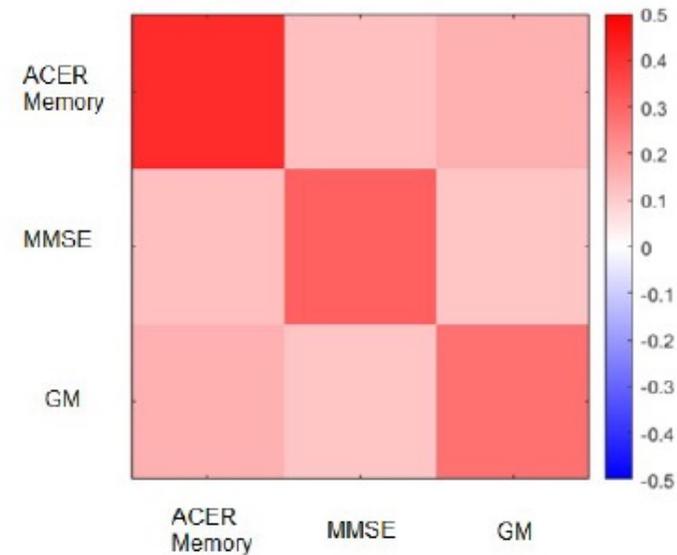
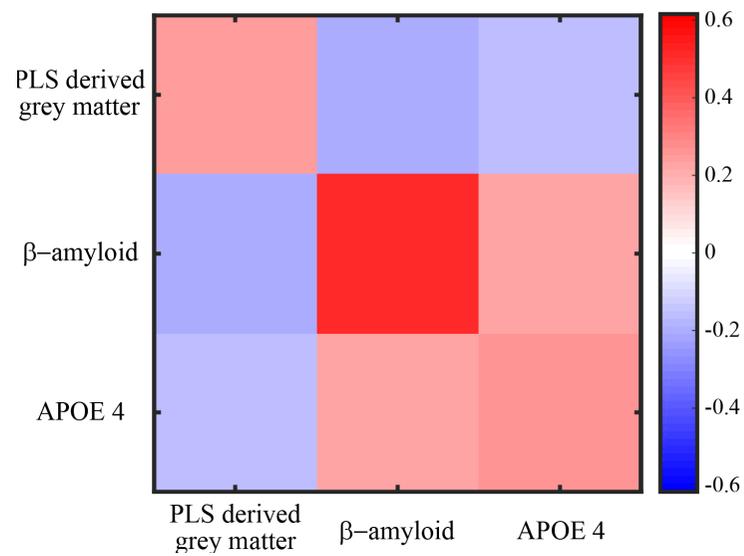
The challenges of *responsible* clinical AI



Transparency

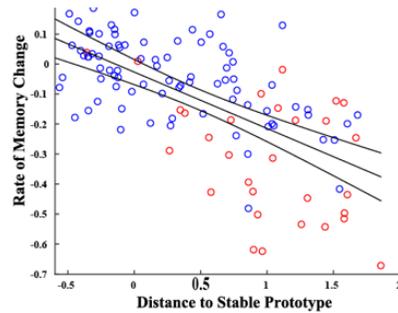
Making AI predictions interpretable

Interpretable model-based stratification: stable vs. progressive MCI

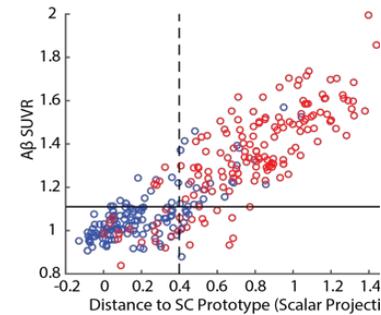


Ensuring the clinical validity of AI predictions

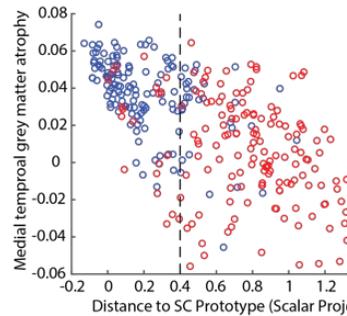
Building AI-guided markers with clinical utility



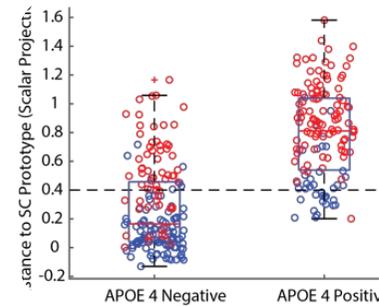
Prognostic index vs. cognitive decline
 $r(116) = -0.65, P < 0.0001$



Prognostic index vs. β -amyloid
 $R^2=77\% p<0.0001$



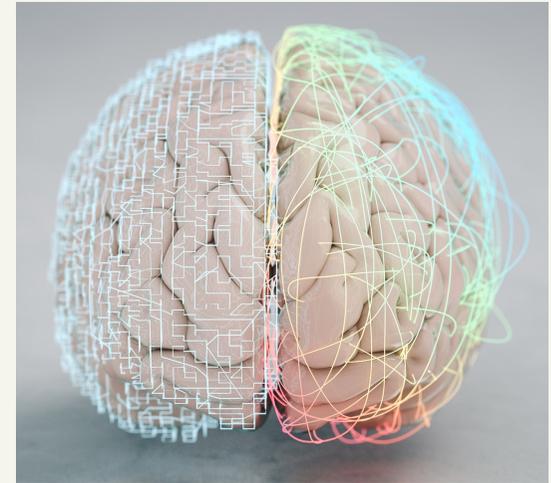
Prognostic index vs. MTL atrophy
 $R^2=37\% p<0.0001$



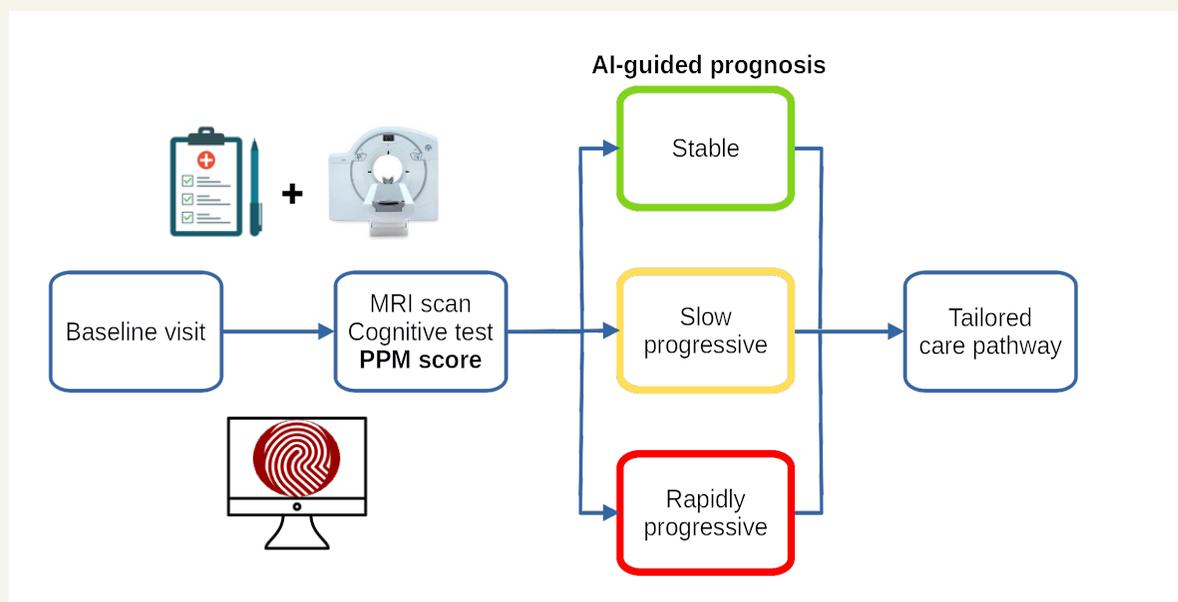
Prognostic index vs. APOE 4
 $t(305)=15 p<0.0001$

Clinical Utility: Translating AI from the cloud to the clinic

1. Changing the clinical pathway
2. Enhancing clinical trial efficiency
3. Towards brain health checks



Digital NeuroDetection tool: Translating AI to clinical pathways

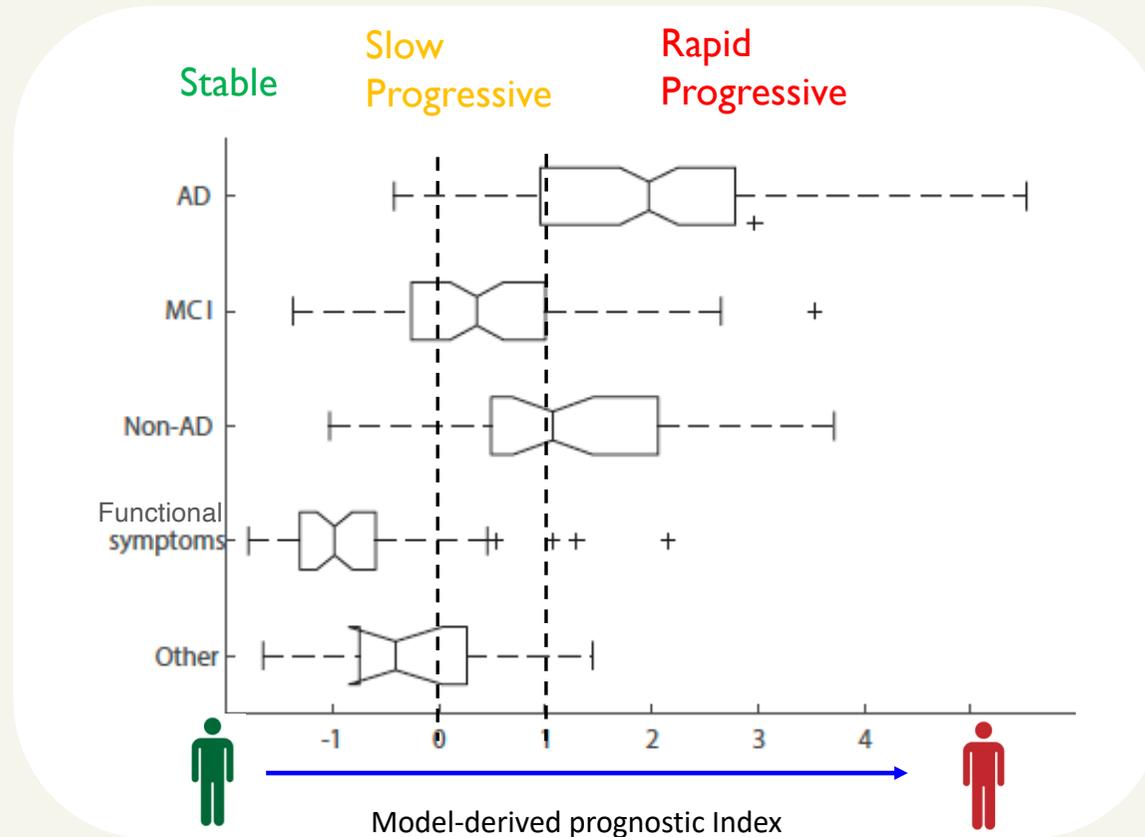


The screenshot shows a web application interface for 'Dementia Score Calculations'. The header includes the University of Cambridge and NHS logos. The main content area displays a table with the following data:

Request ID	Patient ID	Name	Request Date	Result
1	20169	Smith, John	2022-06-14 14:07:30	34.9
2	25568	Caecilius, Lucius	2022-06-14 14:12:26	63.2
3	25569	Green, G	2022-06-15 17:25:20	85.3

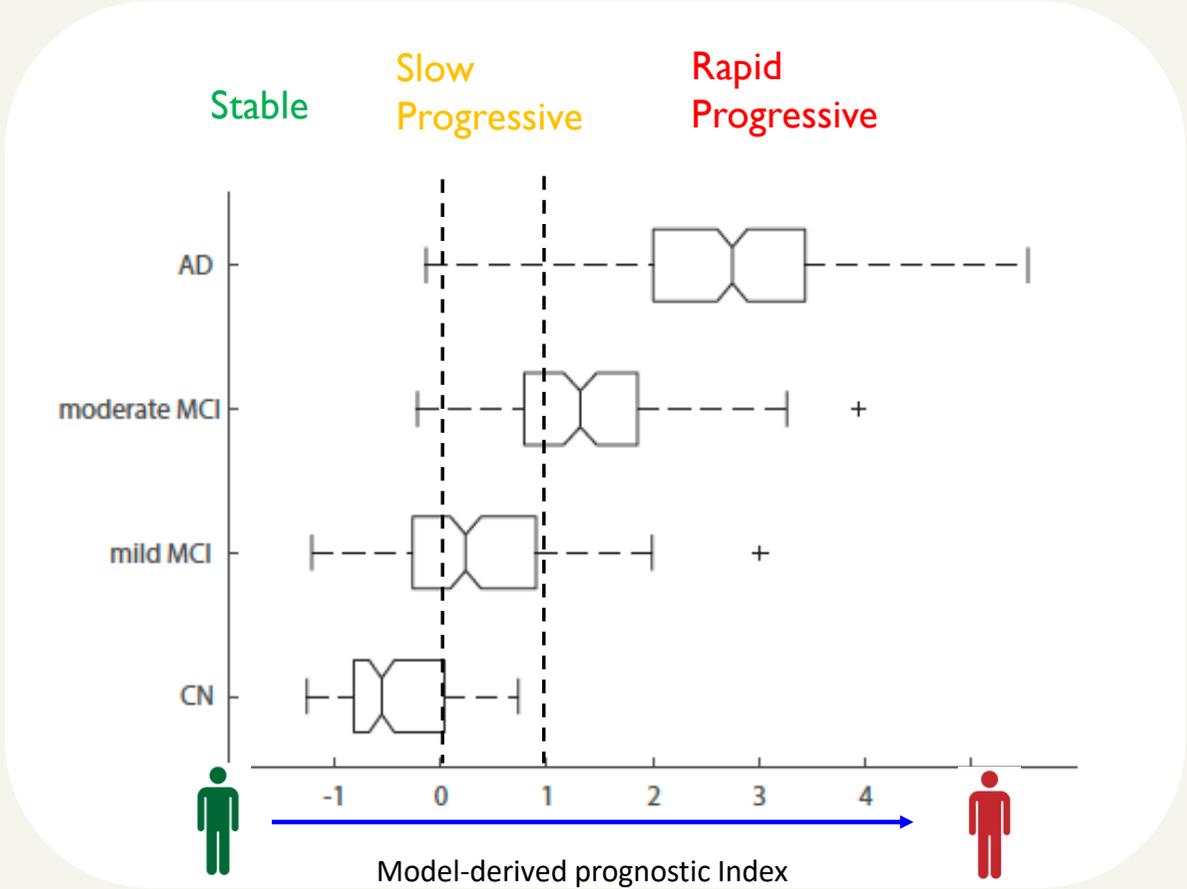
Below the table, there is a 'New calculation' button. The interface also shows a navigation menu with 'Admin' selected.

Translating clinical AI from the lab to the clinic



Real-world memory clinic data: QMIN-MC, UK

Generalising clinical AI tools across sites and countries

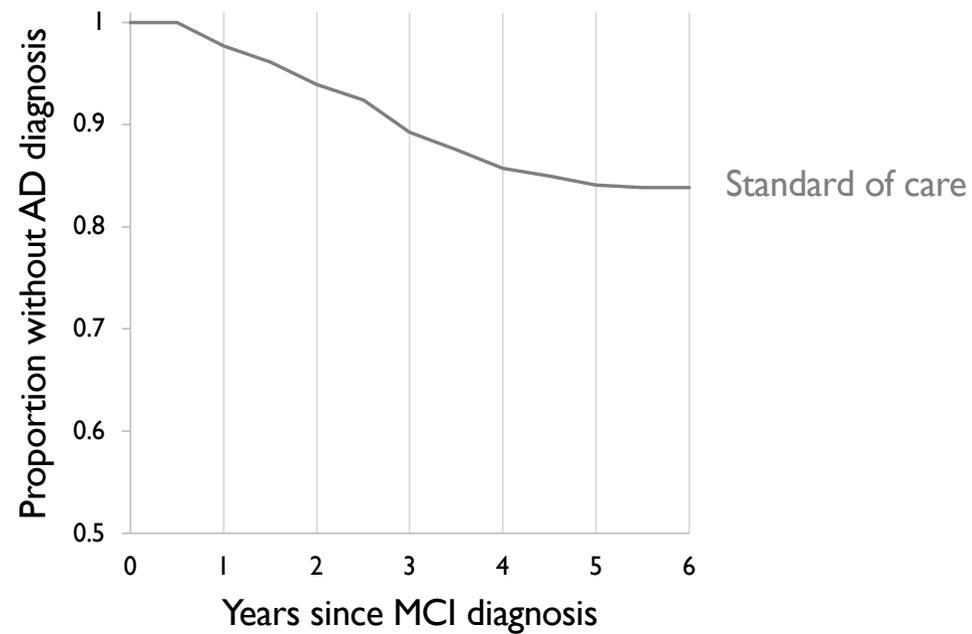


Real-world memory clinic data: MACC, Singapore

Lee.. Kourtzi, eClinical Medicine, 2024

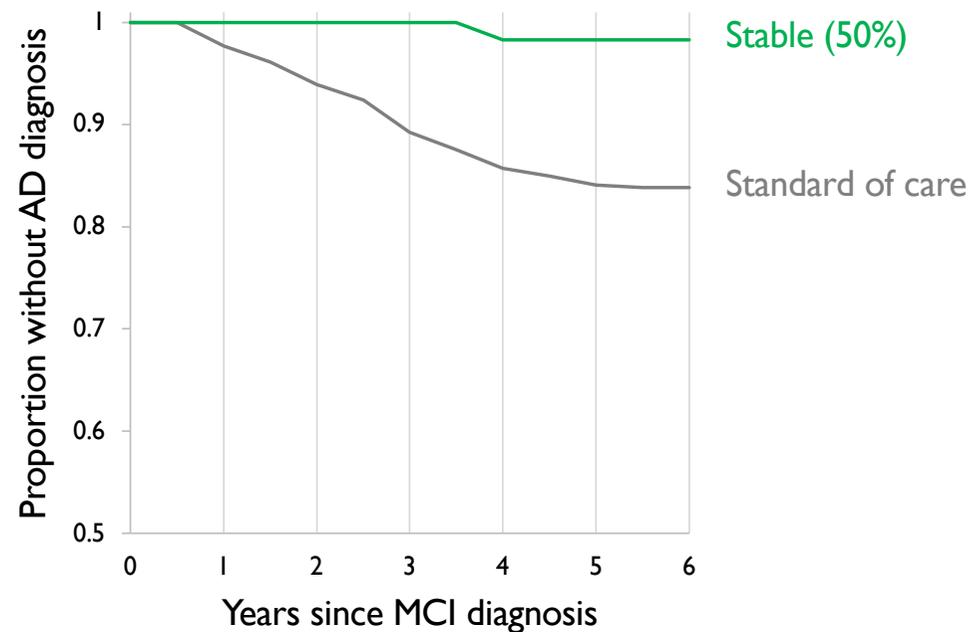
Validating AI predictions with real-world, longitudinal clinical data

Clinical AI marker predicts conversion to AD 3x more precisely than clinical diagnosis



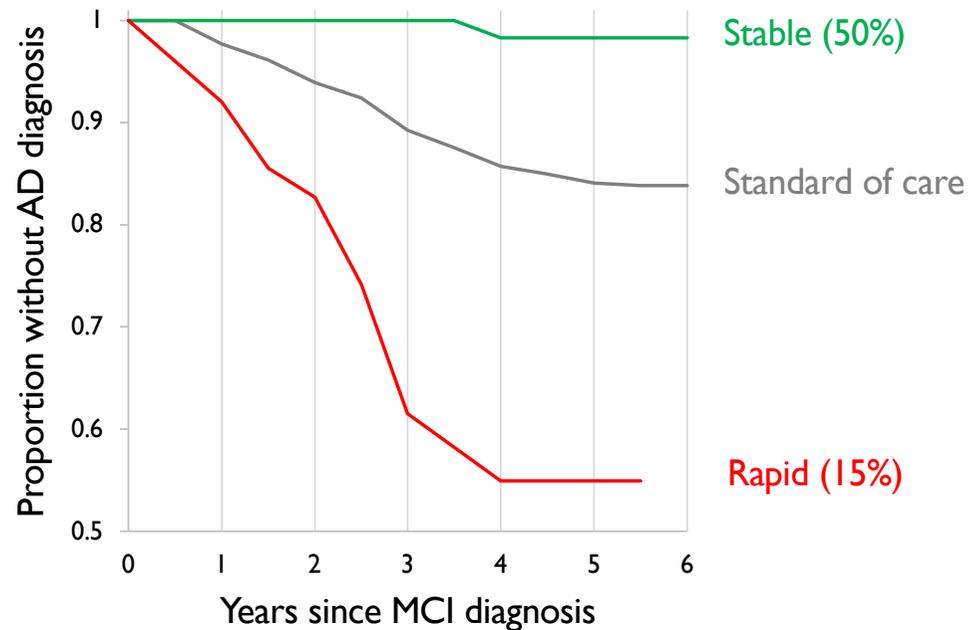
Validating AI predictions with real-world, longitudinal clinical data

Clinical AI marker predicts conversion to AD 3x more precisely than clinical diagnosis



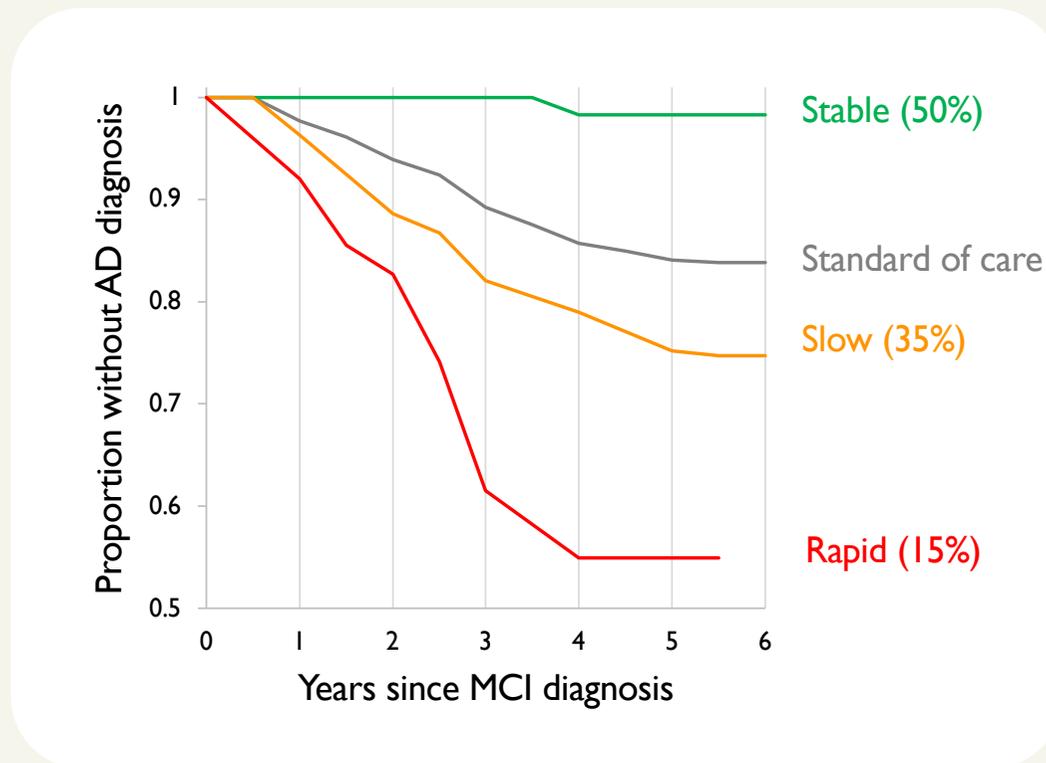
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Validating AI predictions with real-world, longitudinal clinical data

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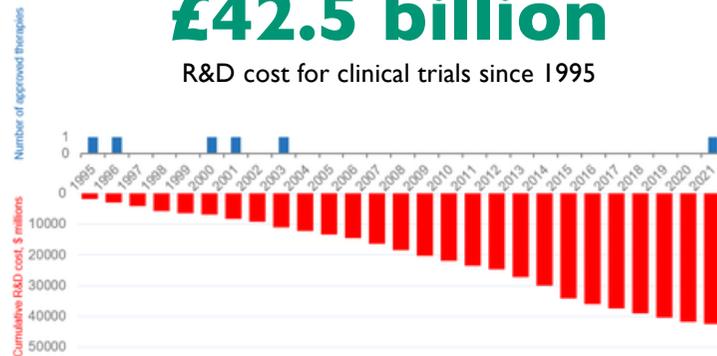


Stratified at baseline – predictive value over 5+ years for mild MCI patients

Clinical AI for efficient and effective clinical trials

£42.5 billion

R&D cost for clinical trials since 1995



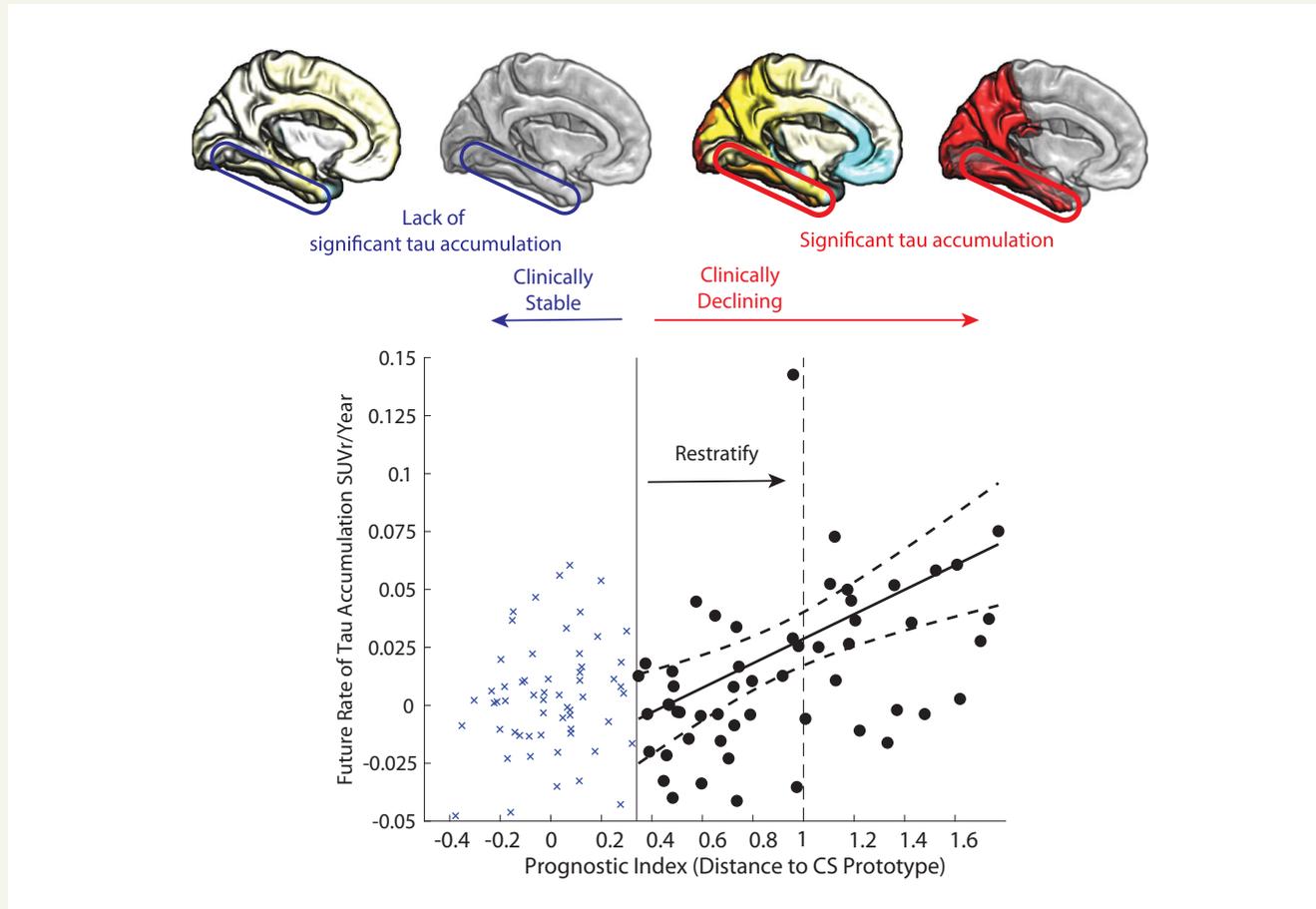
\$8000
per month

Cost of new
immunotherapies

After 30 years we have
the first disease
modifying drugs!

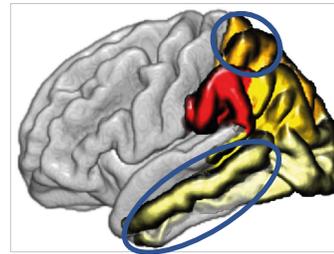
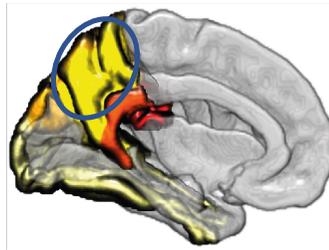


AI-guided patient stratification for clinical trials



Clinical AI marker enhances efficiency of clinical trials

Precuneus 26% reduction:
• Scalar Projection: n=937
• β -amyloid: n=1274



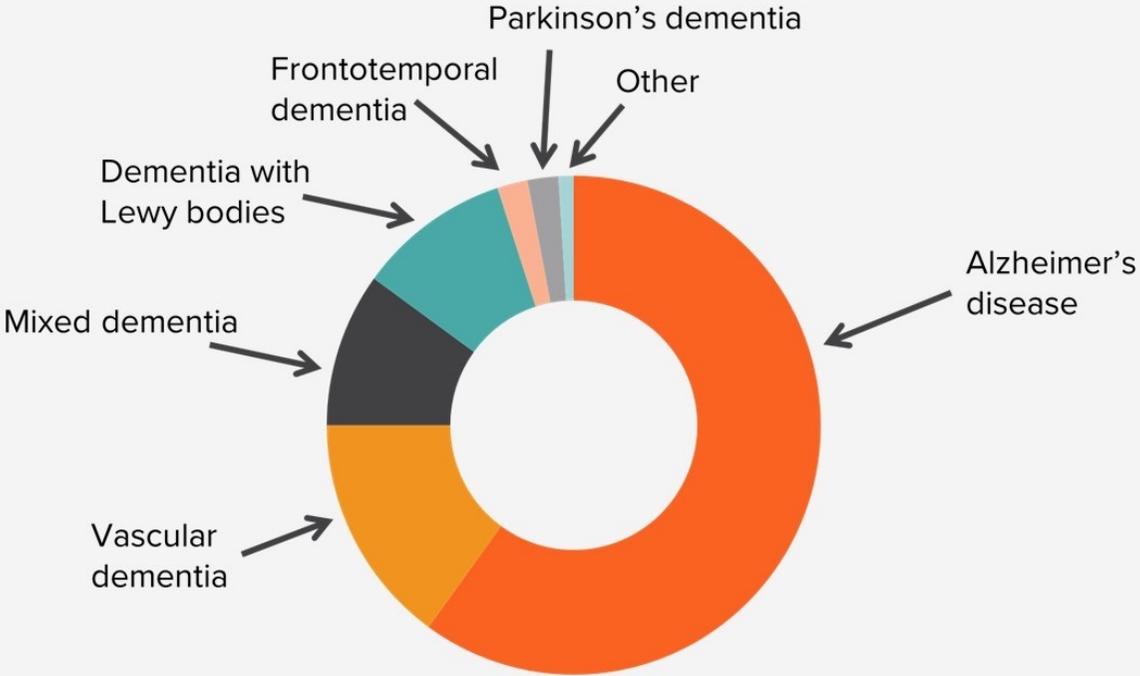
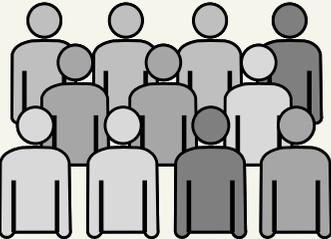
Superior Parietal 33% reduction:
• Scalar Projection: n=659
• β -amyloid: n=990

Middle Temporal 14% reduction:
• Scalar Projection: n=613
• β -amyloid: n=713



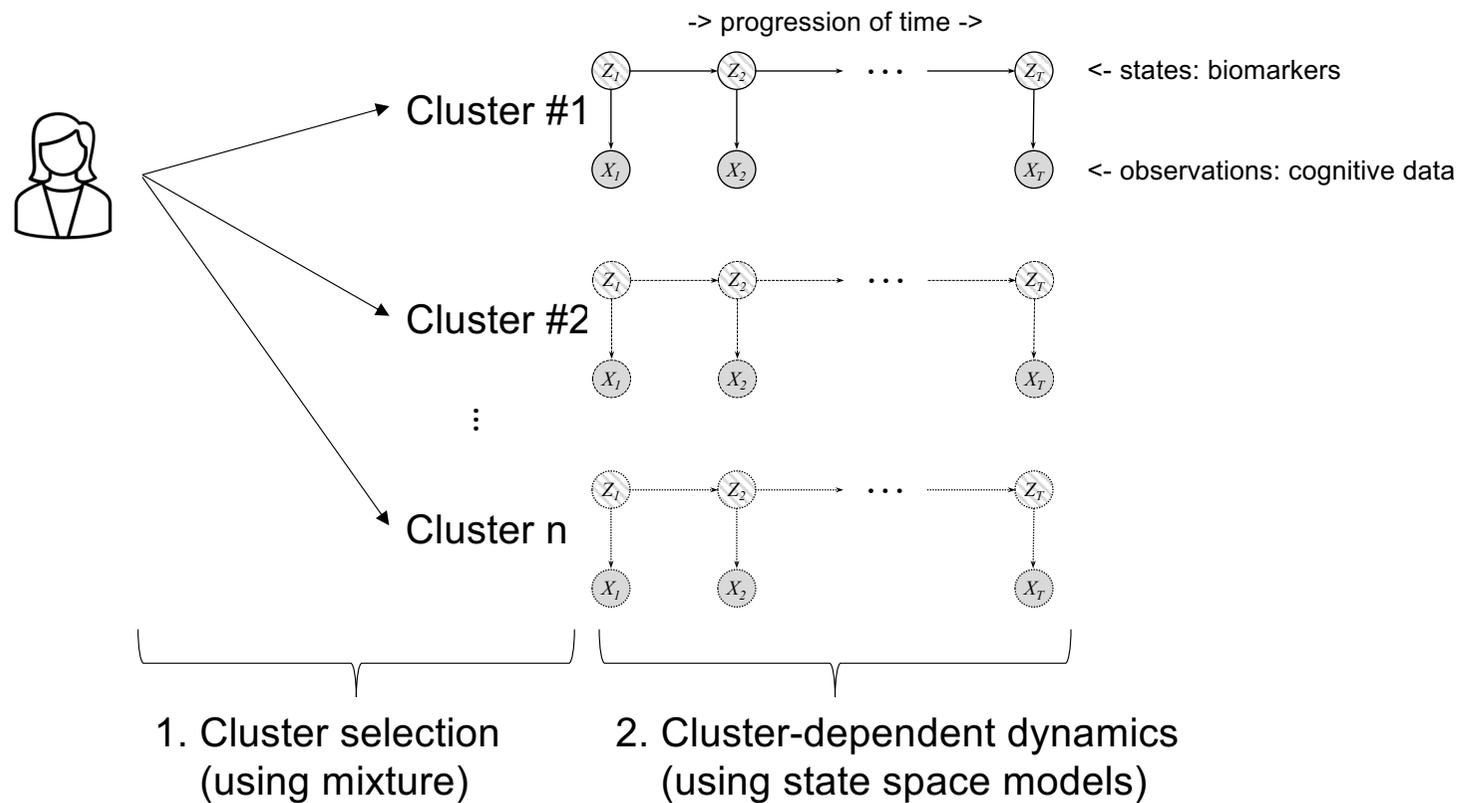
Mean 30% reduction in sample size to measure change in tau (25% decrease) when stratifying based on predictive prognostic index vs. β amyloid

Can we use AI to track brain health trajectories?

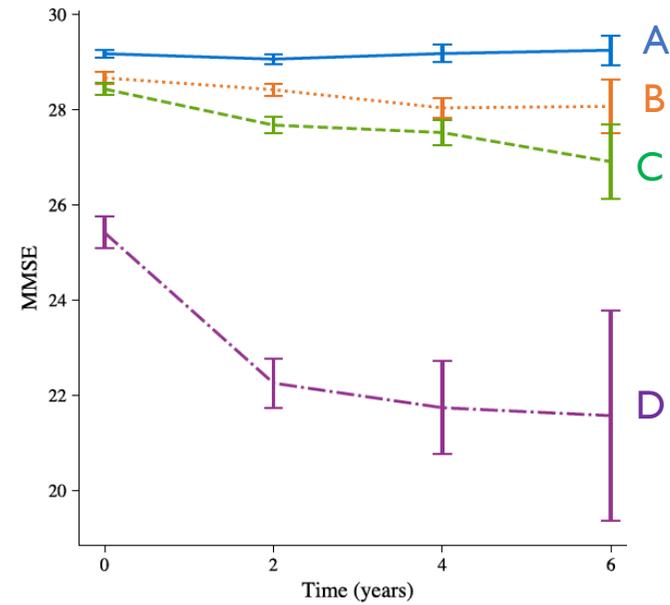
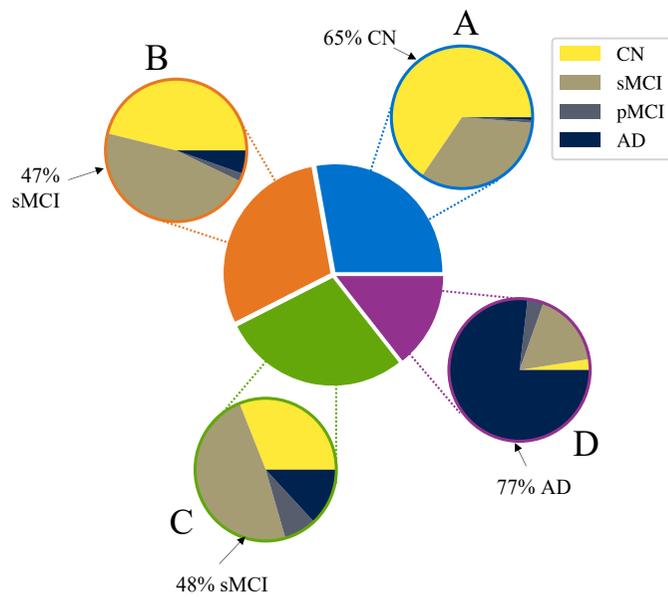


Towards brain health checks: Predicting before symptoms occur

Unsupervised trajectory modeling based on mixture of state space models



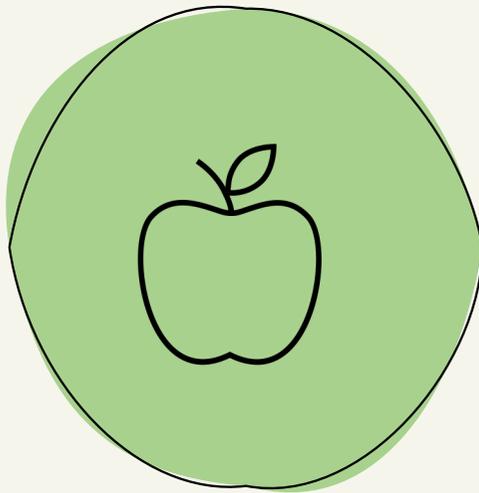
Predicting cognitive health trajectories



Multimodal Trajectory Modeling predicts cognitive health without clinical diagnosis

AI for Better brain health – from cloud to clinic

Prevention



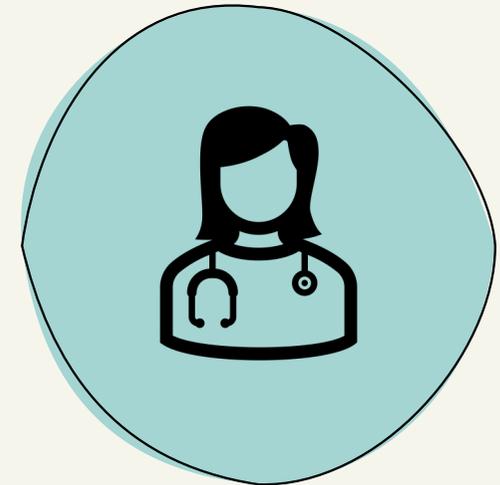
- Early course correction to prevent / lessen dementia
- Low-cost, life-style choices

Drug discovery and clinical development



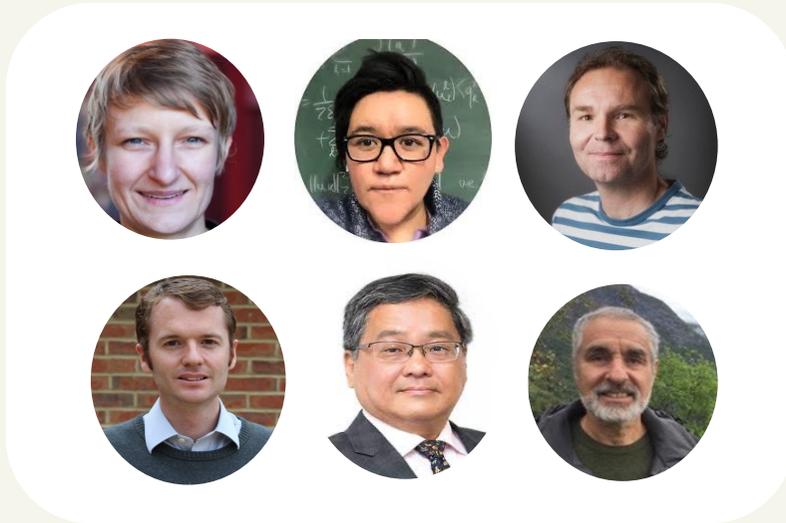
- Optimize trial design and maximize chance of success
- Learn from dementia subtypes to identify new targets

Clinical decision support



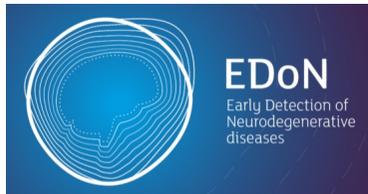
- Reduce invasive testing
- Optimize healthcare resources
- Match patients to treatments
- Better clinical outcomes

With thanks to:



Adaptive Brain Lab

ALZHEIMER'S RESEARCH UK **FOR A CURE**



DOWNING COLLEGE CAMBRIDGE

The Alan Turing Institute



THE ROYAL SOCIETY

