



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

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UNIVERSITY OF
CAMBRIDGE



THE ROYAL
SOCIETY

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

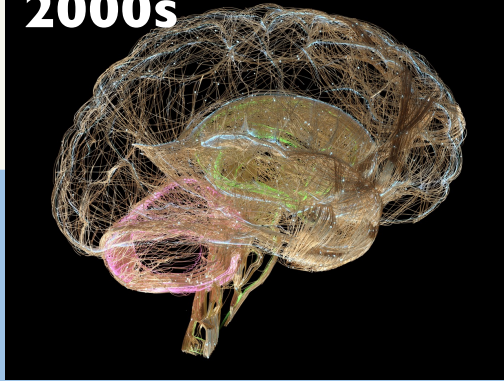


*Oleson & Leonardi, 2003
Office for National Statistics, 2021*

Two decades of scientific transformation

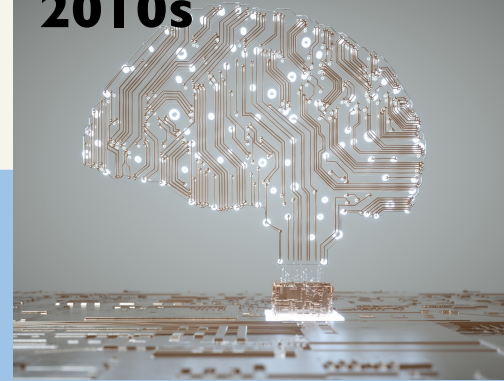
Scientific insight has been transformed over the past twenty years:

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

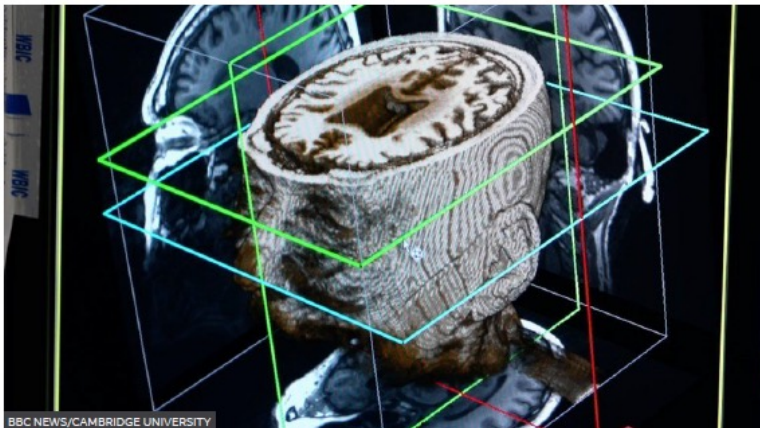
How do we harness these revolutions to improve brain health?

Leveraging AI for early prediction of brain and mental health disorders

Artificial Intelligence may diagnose dementia in a day

By Pallab Ghosh
Science correspondent

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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

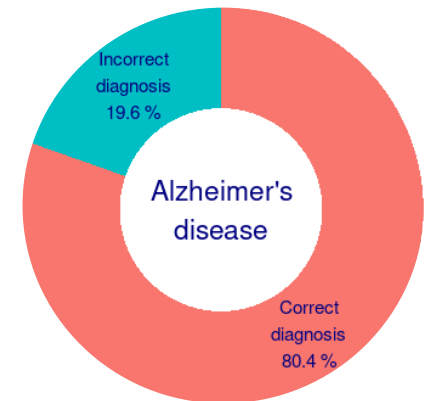
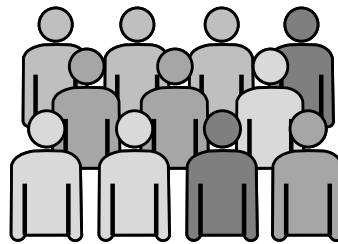


55 million

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

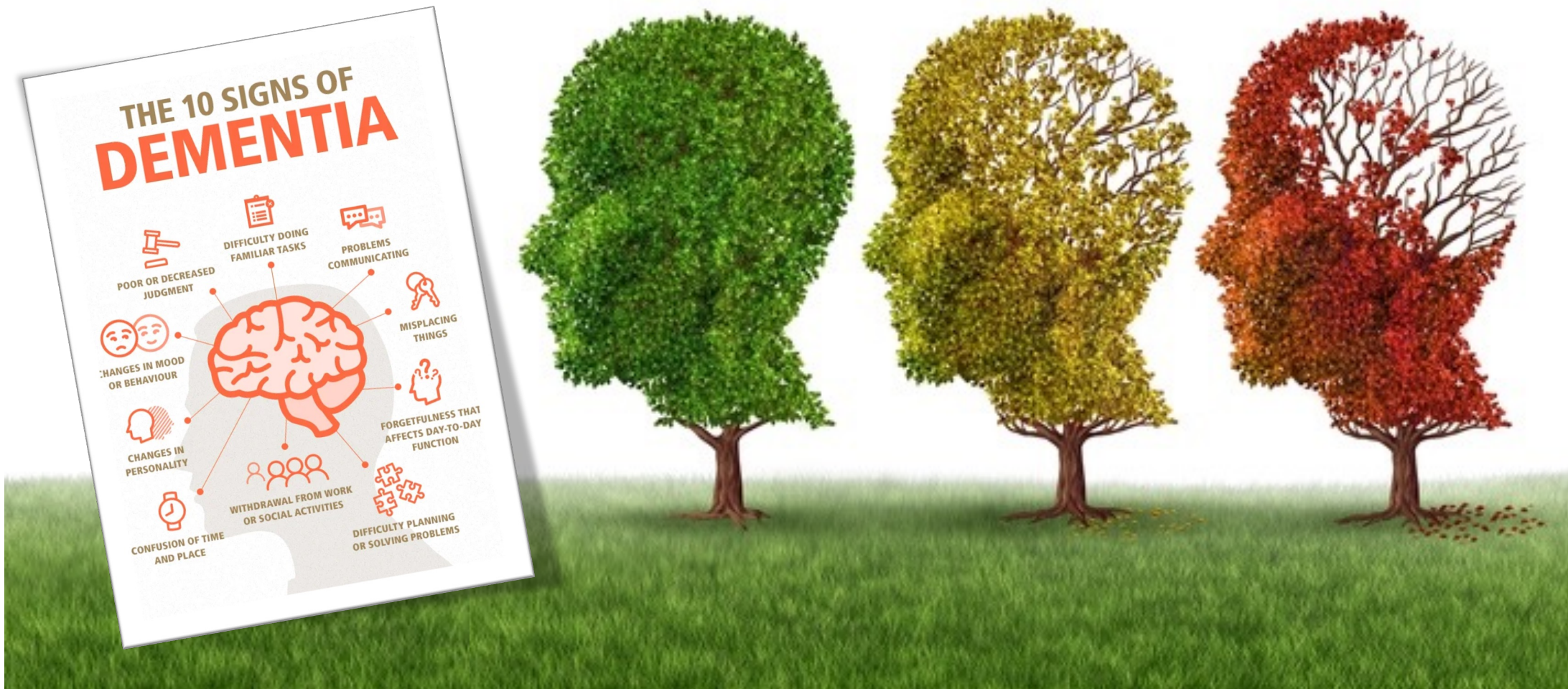
\$8000
per month

Cost of new
immunotherapies

After 30 years: new disease modifying treatments!

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

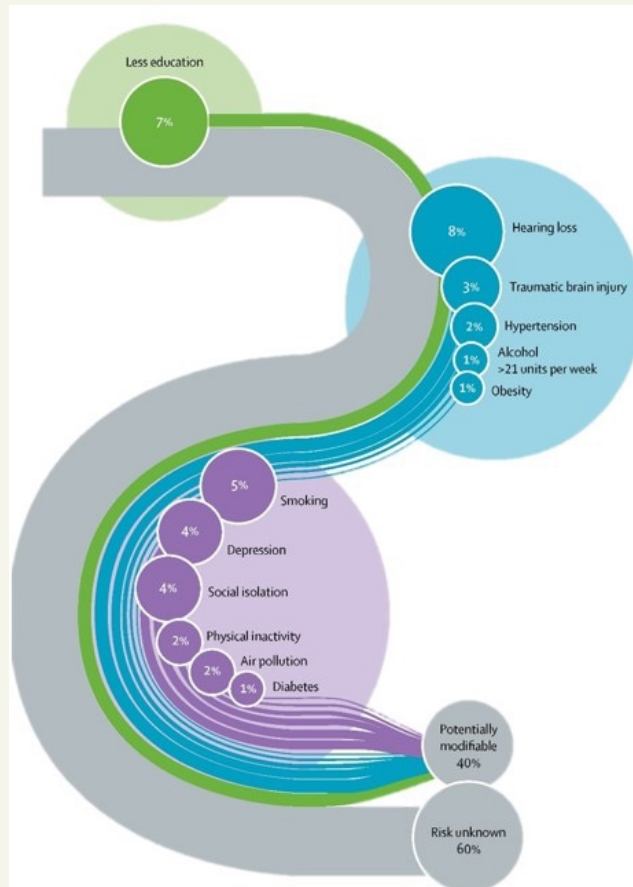
Challenge: Using AI to predict dementia before symptoms appear



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

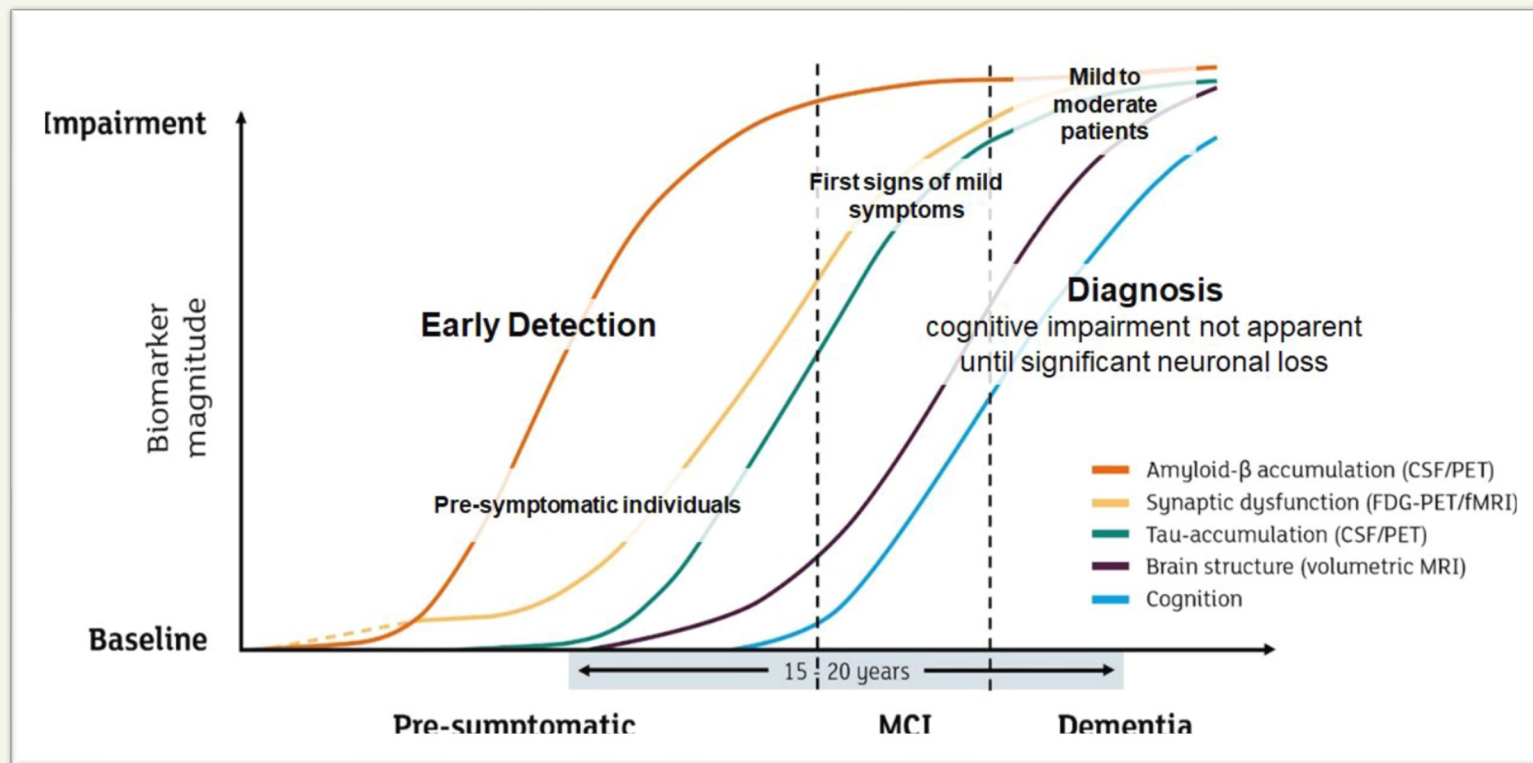
Make best use of treatments

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

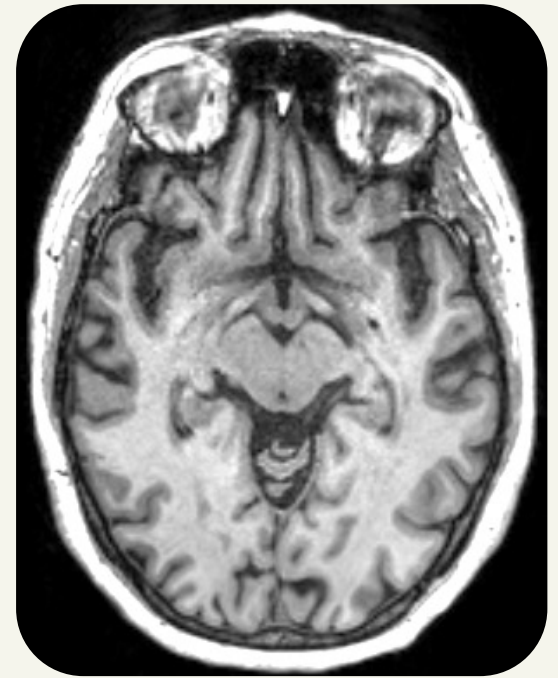
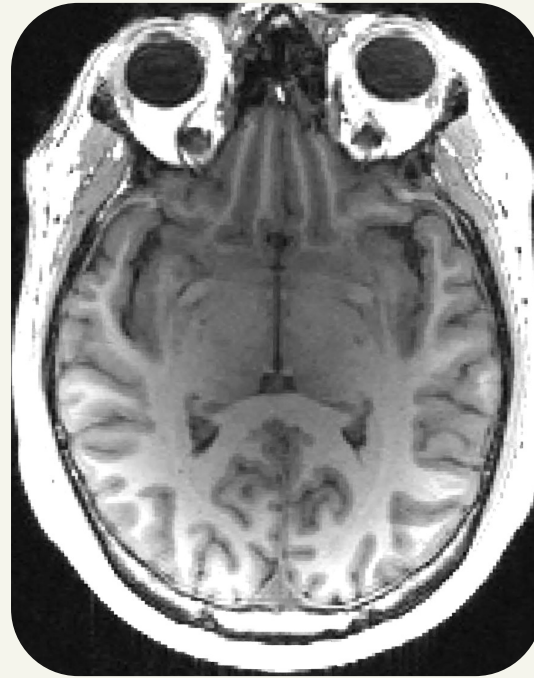


Jack CR Jr, et al., *Brain*. 2010
Petersen RC, et al. *Arch Neurol*, 1999

Predicting at early dementia stages

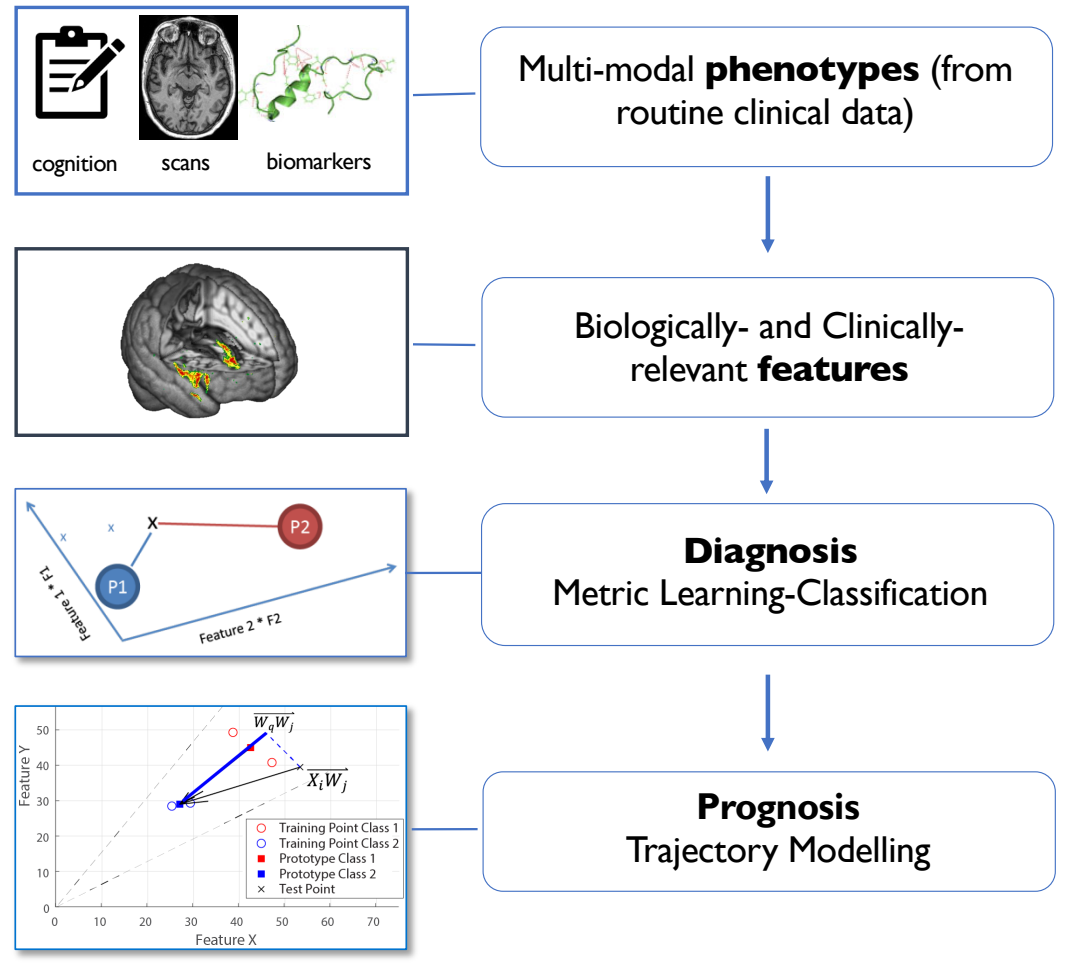
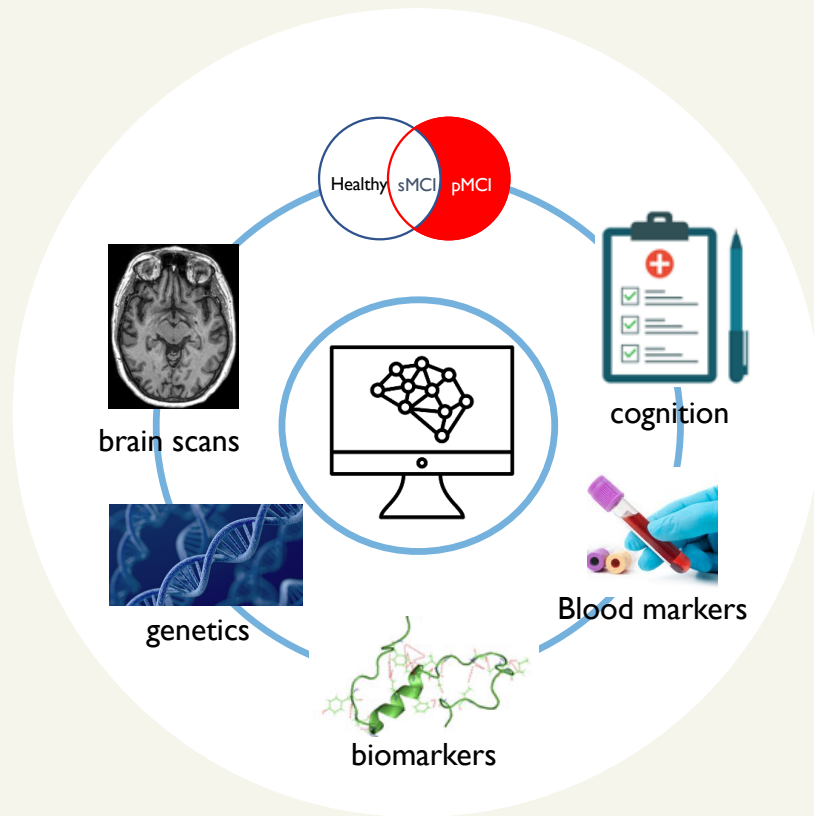


Alzheimer's



*Healthy?
or
Mild Cognitive Impairment?*

PPM: Predictive Prognostic Multimodal Modelling

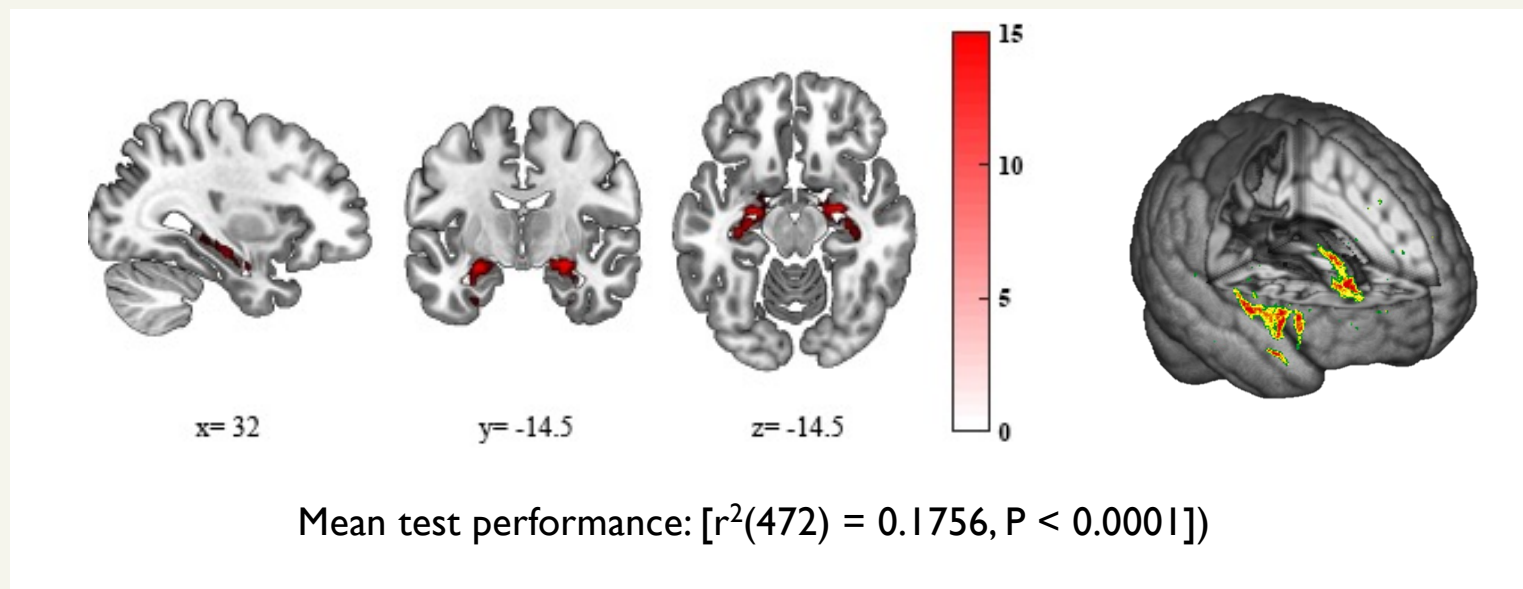


Giorgio.. Kourtzi, *NeuroImage Clinical*, 2020

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

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

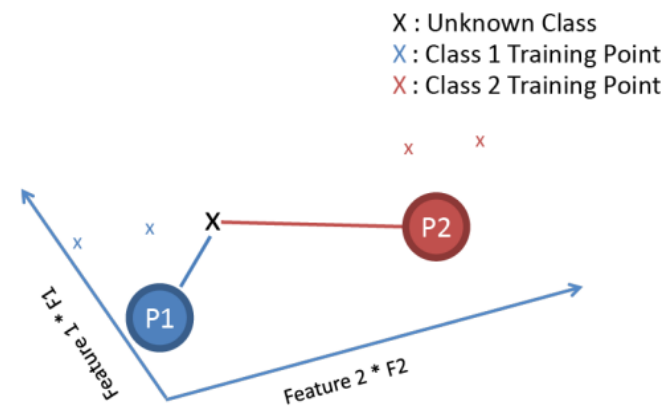
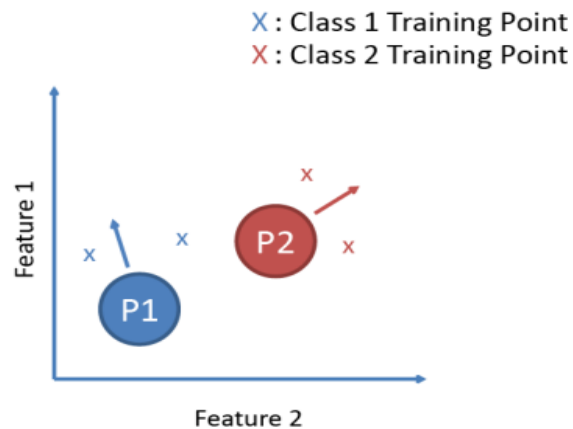
Extracting biologically relevant features



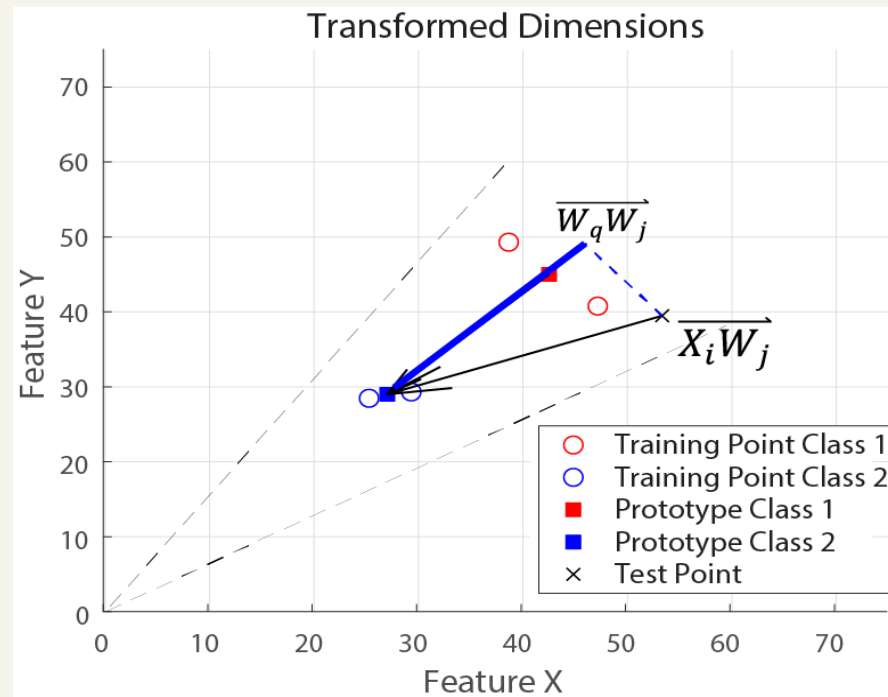
PLS-derived Grey Matter Score predicts cognitive decline (variance in ADNI-Mem scores)

Multimodal Machine Learning for patient classification

Generalised Metric Learning Vector Quantisation: GMLVQ

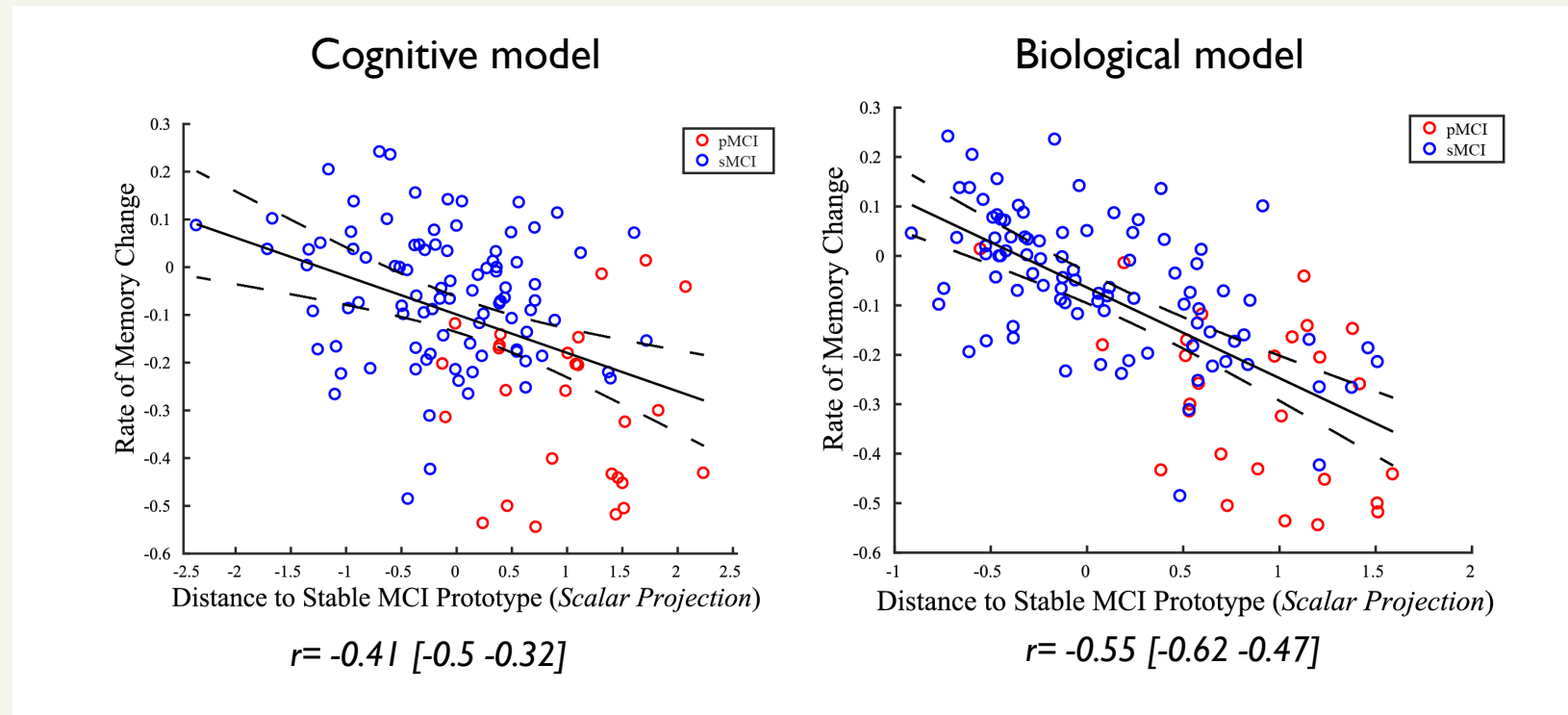


Trajectory modelling: deriving a multimodal prognostic index

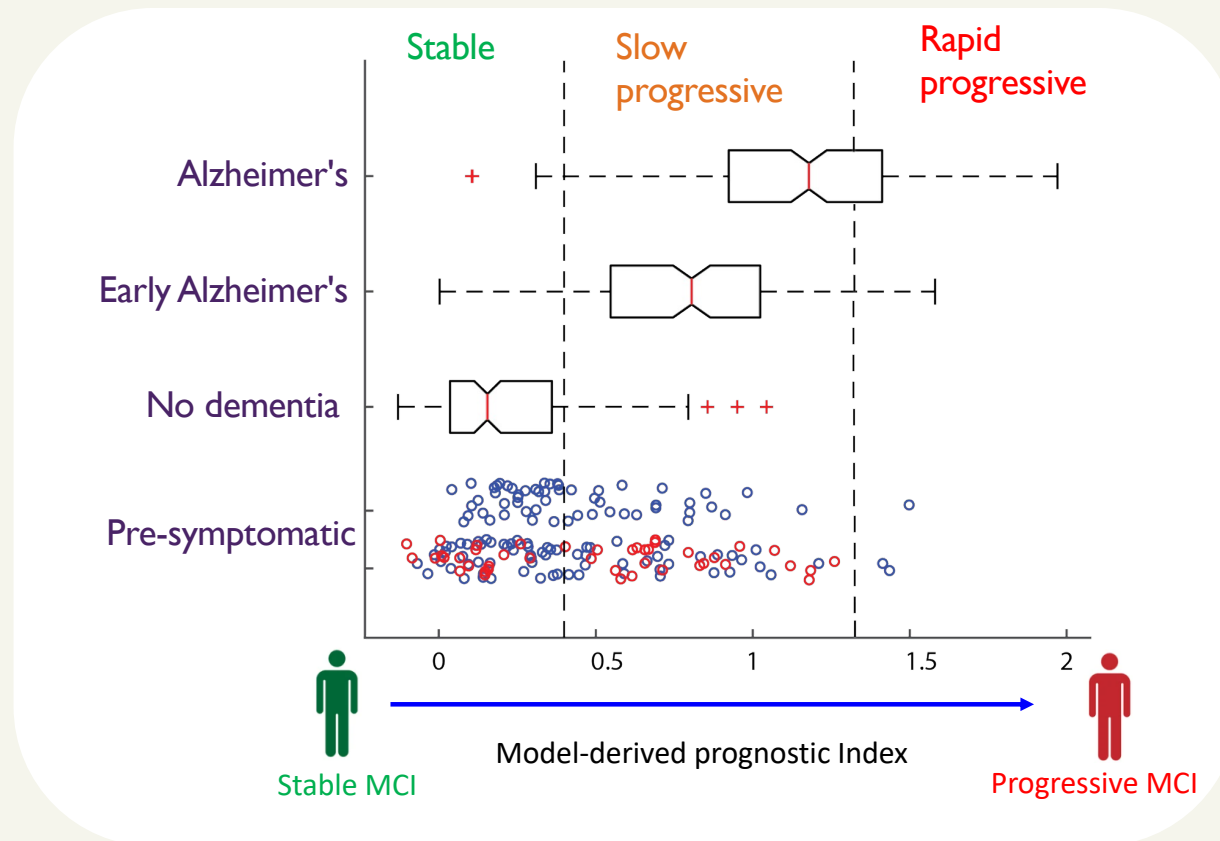


Scalar Projection determines distance from stable MCI prototype

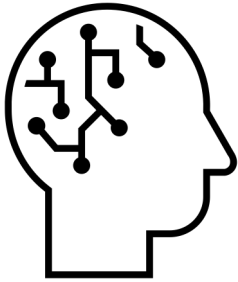
Multimodal prognostic index predicts rate of cognitive decline



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



Accountability

Inclusivity,
fairness and
equity



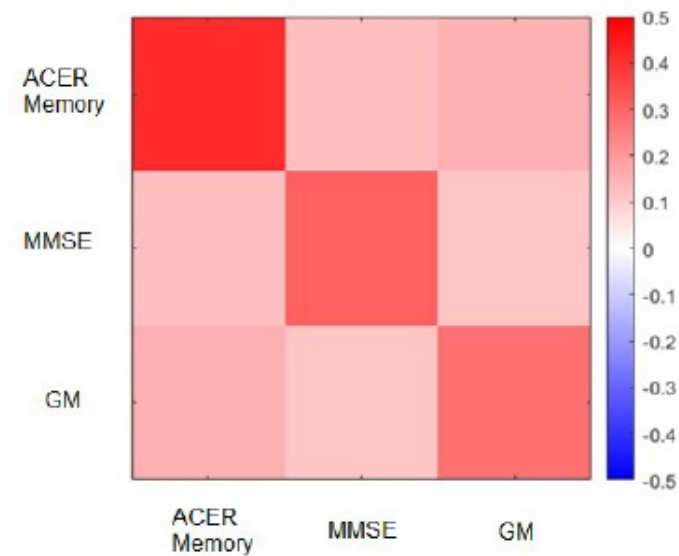
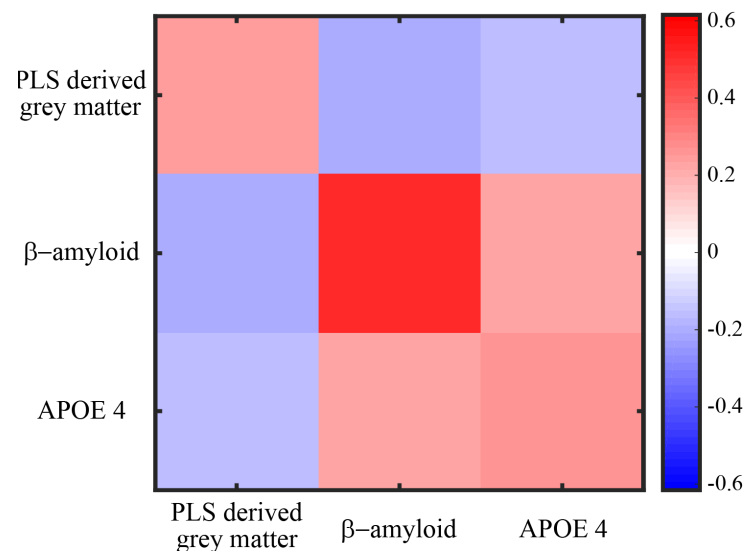
The challenges of *responsible* clinical AI



Transparency

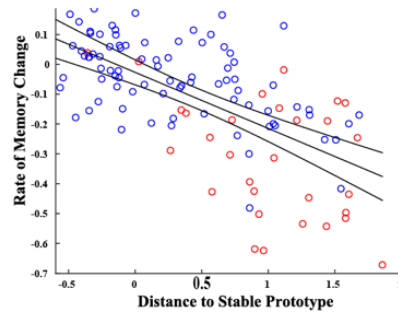
Making AI predictions interpretable

Interpretable model-based stratification: stable vs. progressive MCI

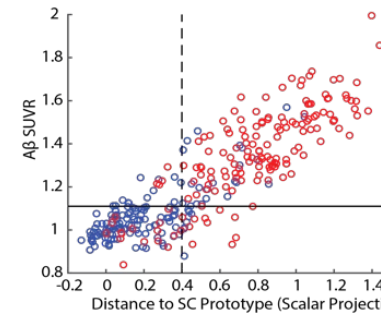


Ensuring the clinical validity of AI predictions

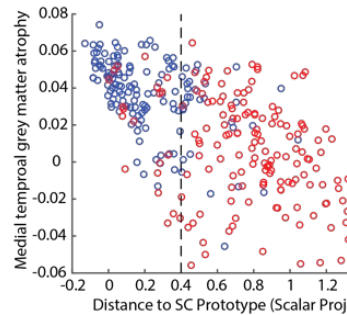
Building AI-guided markers with clinical utility



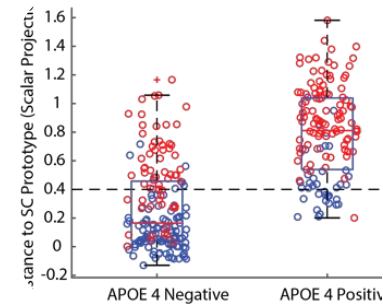
Prognostic index vs. cognitive decline
 $r(116) = -0.65, P < 0.0001$



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



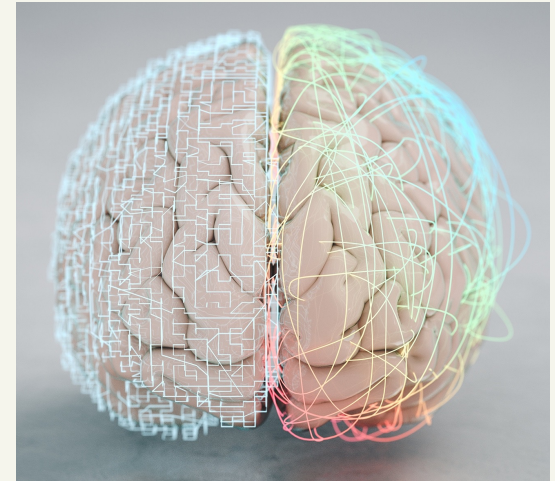
Prognostic index vs. MTL atrophy
 $R^2=37\% p<0.0001$



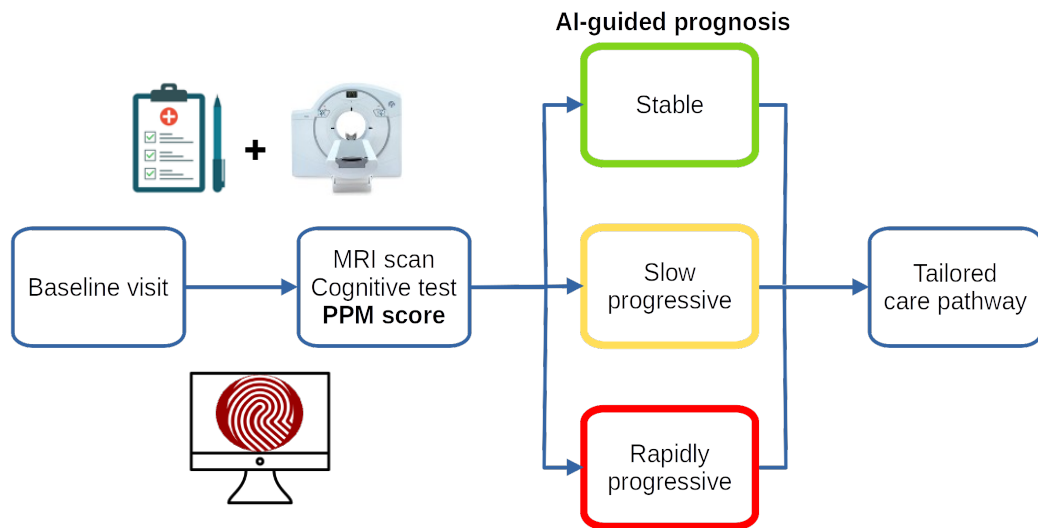
Prognostic index vs. APOE 4
 $t(305)=15 p<0.0001$

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



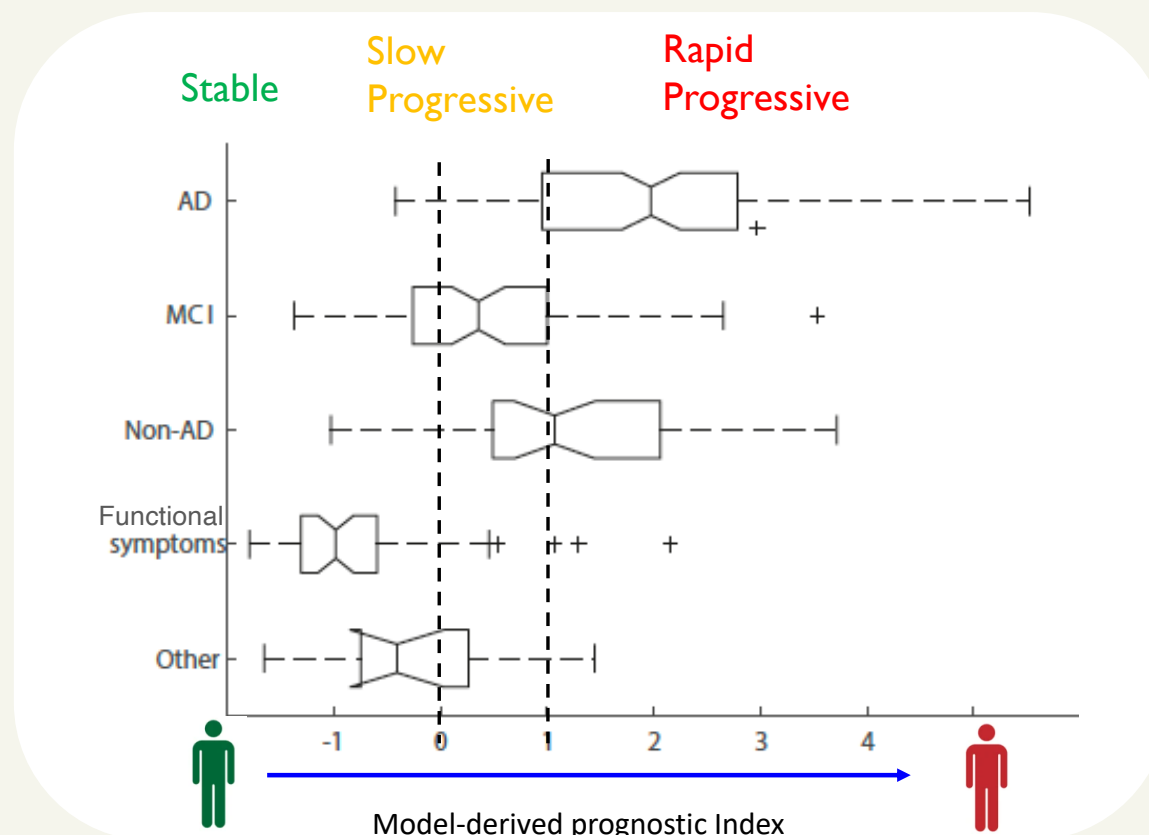
Digital NeuroDetection tool: Translating AI to clinical pathways



The screenshot shows a web application titled 'Dementia Score Calculations' with the University of Cambridge and NHS logos. It features an 'Admin' tab and a table of calculation results. Each row in the table includes a Request ID, Patient ID, Name, Request Date, and Result. To the right of the result is a vertical bar with colored segments (green, yellow, red) indicating the severity of the dementia. Below the table is a 'New calculation' button.

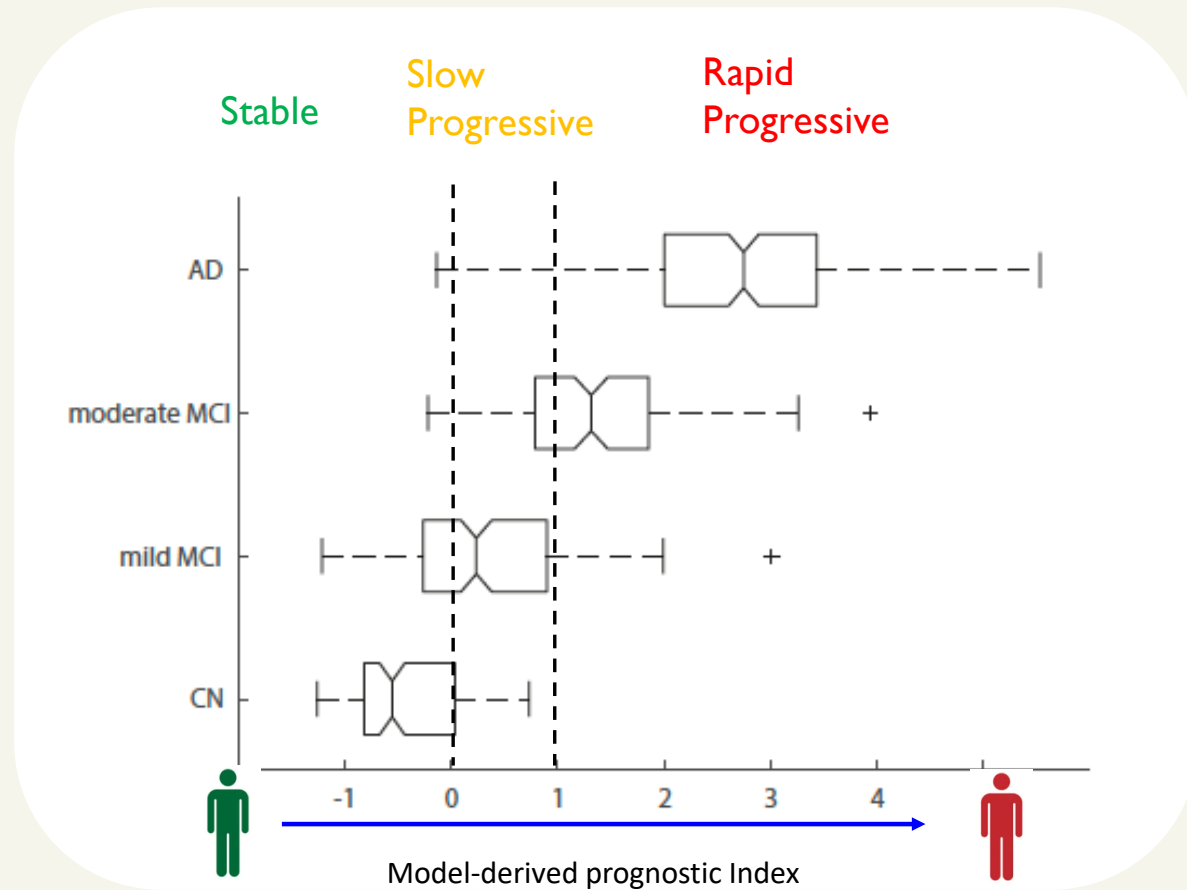
Request ID	Patient ID	Name	Request Date	Result
1	20169	Smith, John	2022-06-14 14:07:30	34.9
2	25568	Caecilius, Lucius	2022-06-14 14:12:26	63.2
3	25569	Green, G	2022-06-15 17:25:20	85.3

Translating clinical AI from the lab to the clinic



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

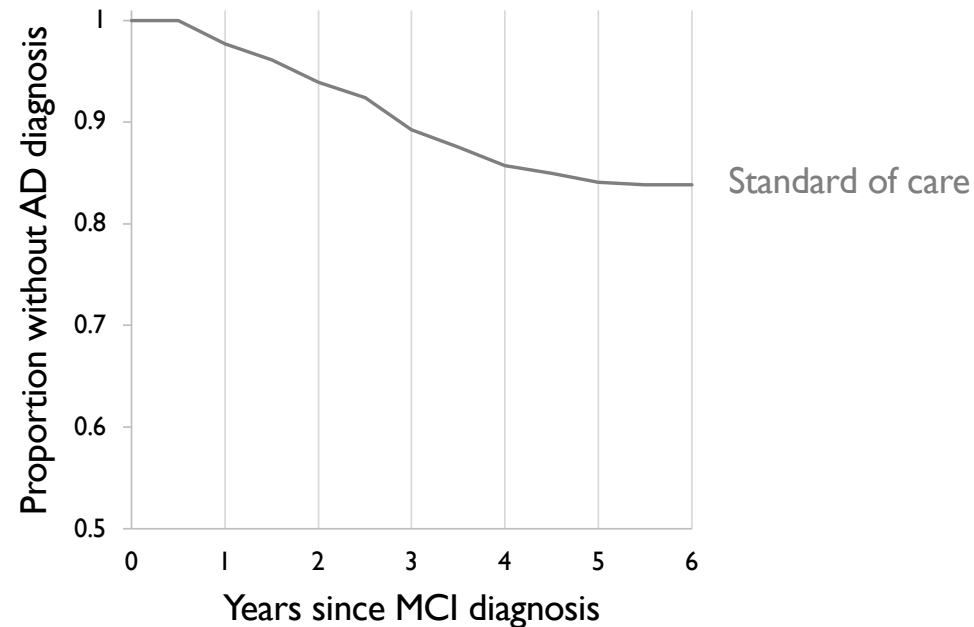
Generalising clinical AI tools across sites and countries



Real-world memory clinic data: MACC, Singapore

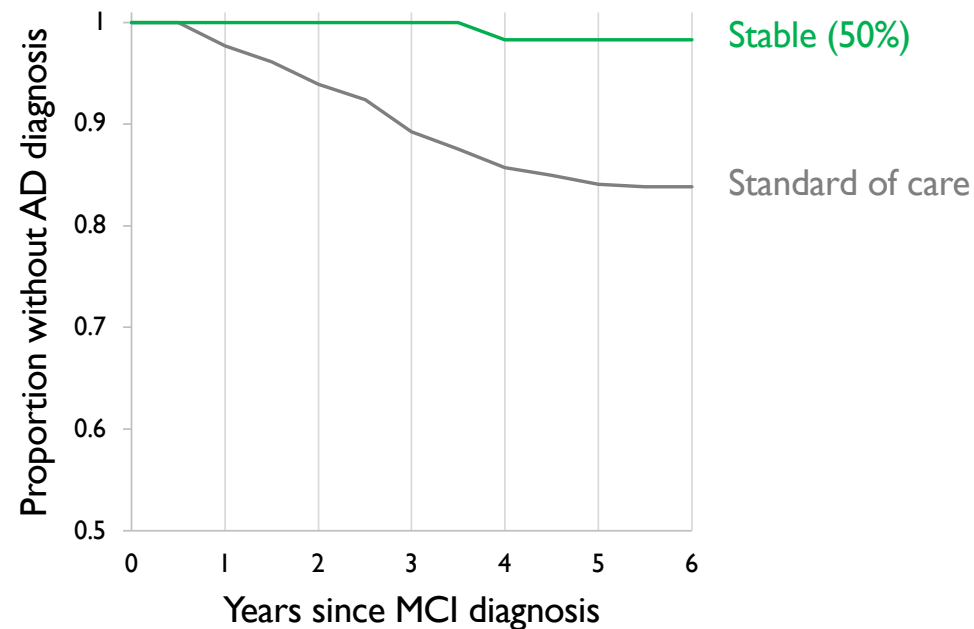
Validating AI predictions with real-world, longitudinal clinical data

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



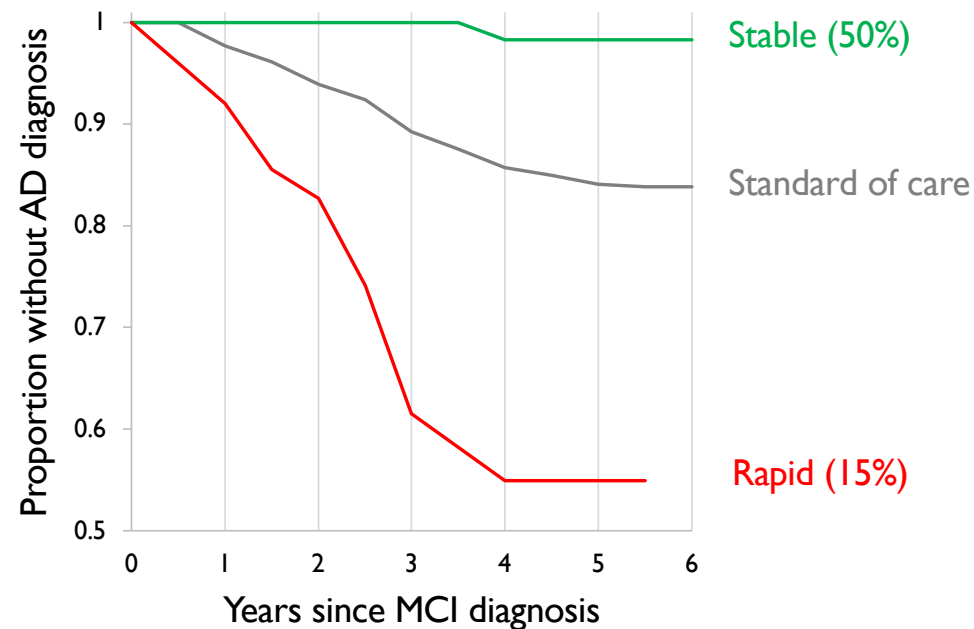
Validating AI predictions with real-world, longitudinal clinical data

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



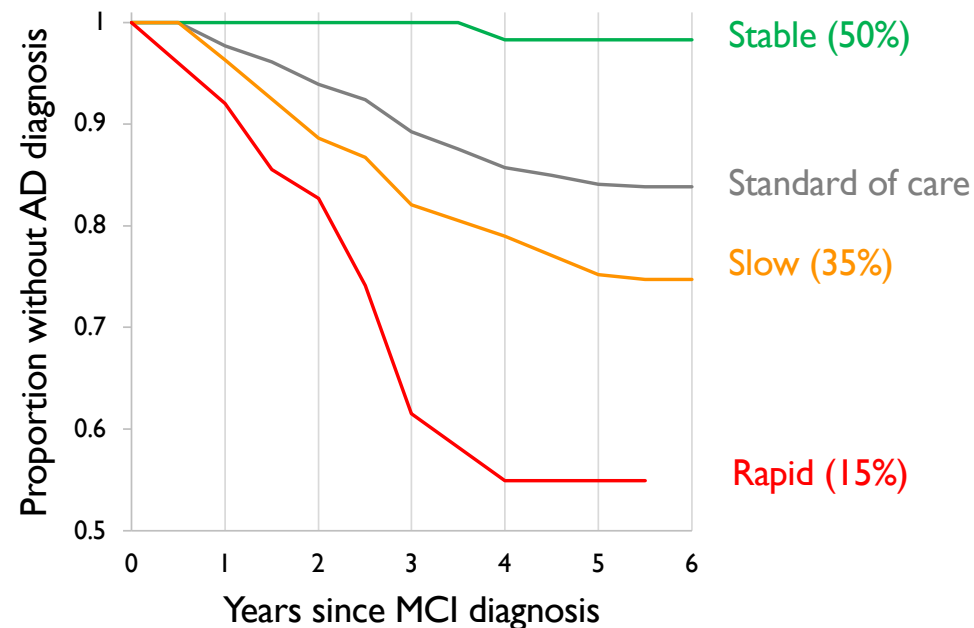
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Validating AI predictions with real-world, longitudinal clinical data

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



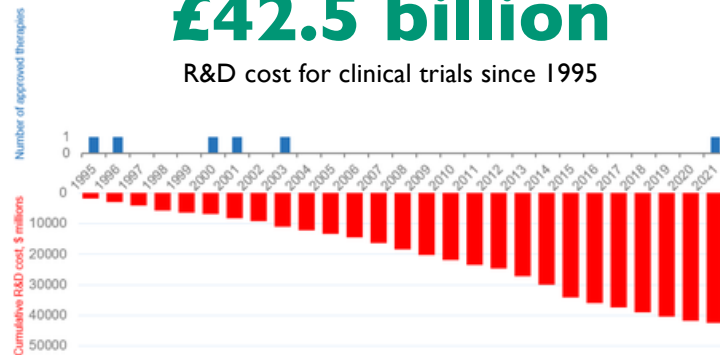
Stratified at baseline – predictive value over 5+ years for mild MCI patients

Lee.. Kourtzi, eClinical Medicine, 2024

Clinical AI for efficient and effective clinical trials

£42.5 billion

R&D cost for clinical trials since 1995



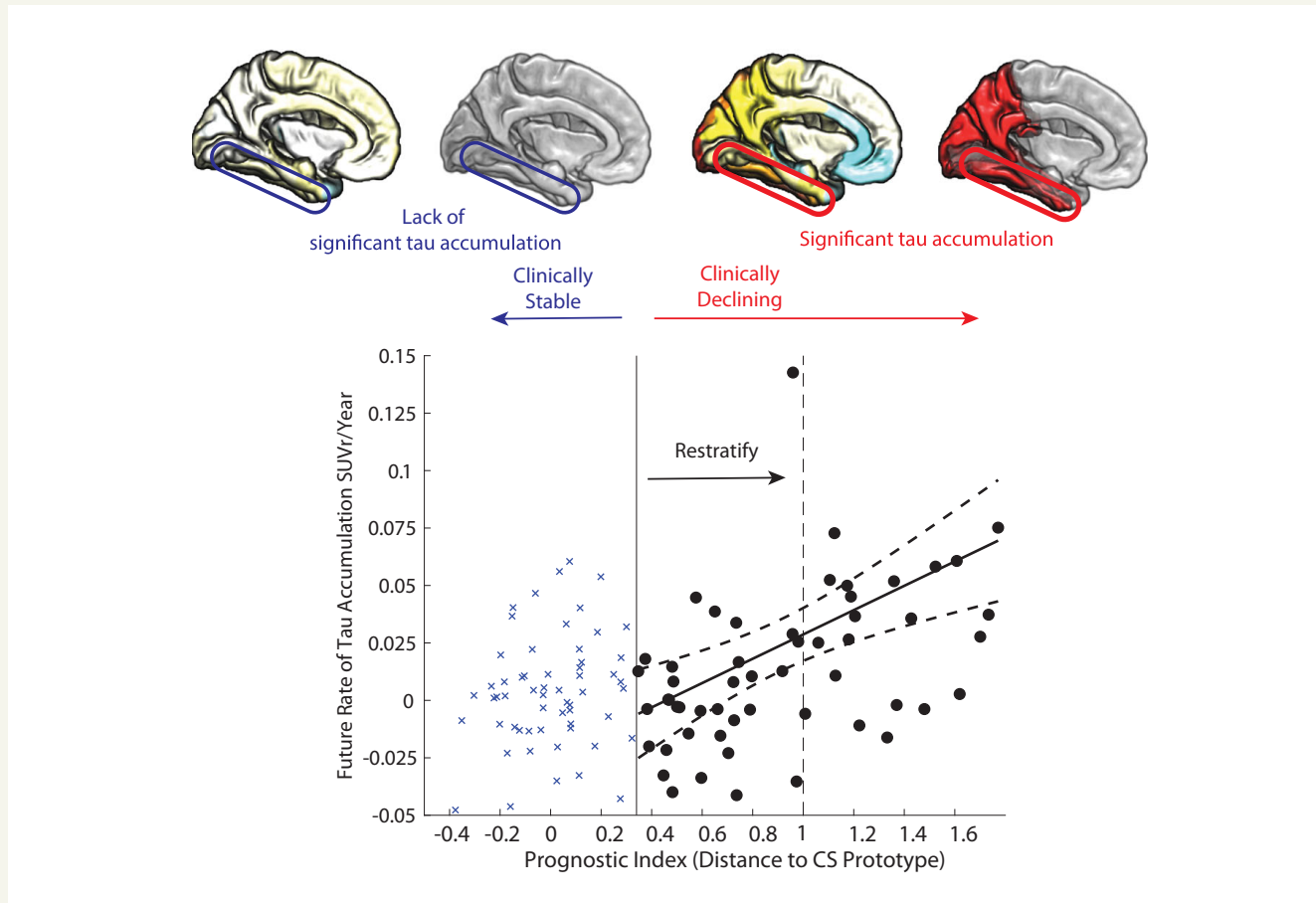
**\$8000
per month**

Cost of new
immunotherapies

After 30 years we have
the first disease
modifying drugs!



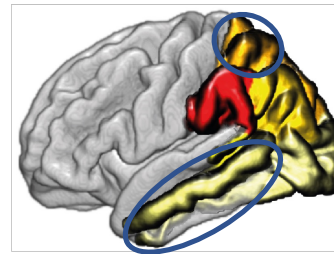
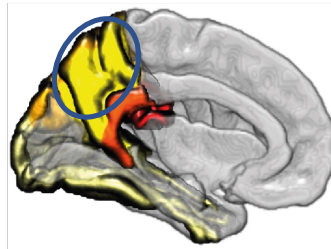
AI-guided patient stratification for clinical trials



Clinical AI marker enhances efficiency of clinical trials

Precuneus 26% reduction:

- Scalar Projection: n=937
- β -amyloid: n=1274

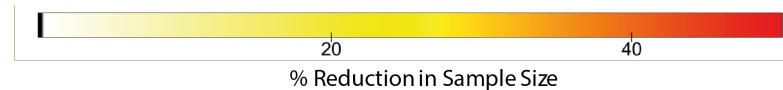


Superior Parietal 33% reduction:

- Scalar Projection: n=659
- β -amyloid: n=990

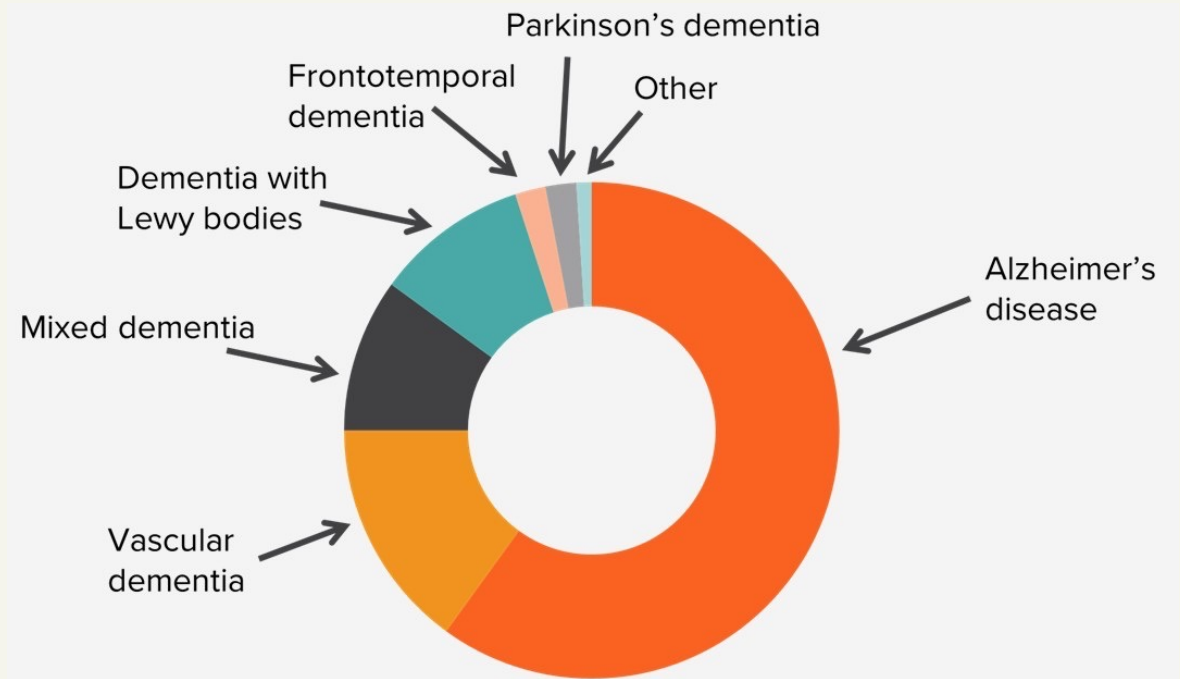
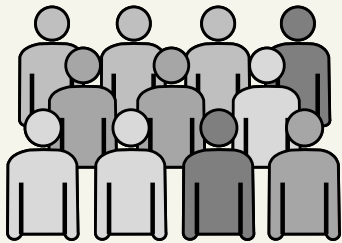
Middle Temporal 14% reduction:

- Scalar Projection: n=613
- β -amyloid: n=713



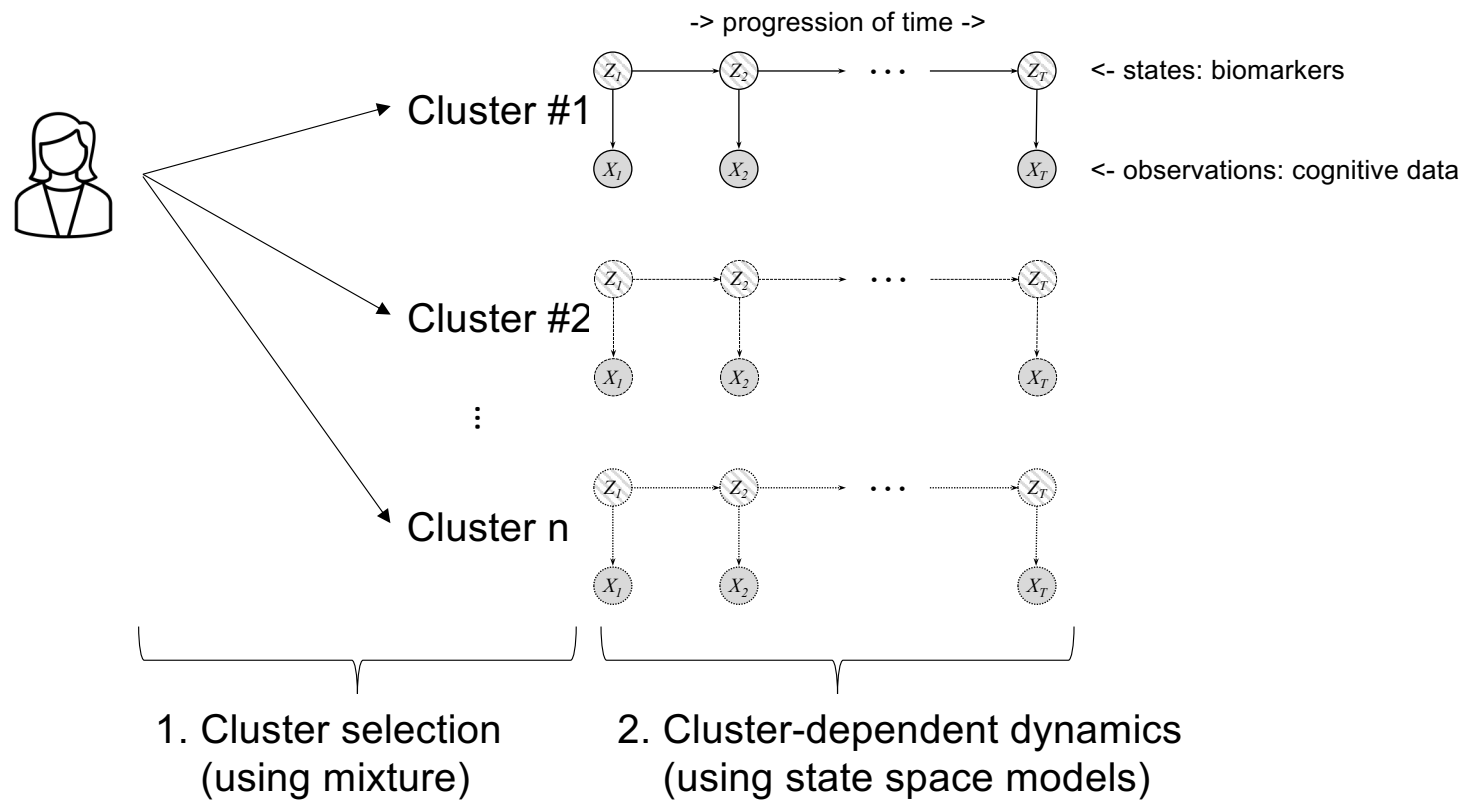
Mean 30% reduction in sample size to measure change in tau (25% decrease) when stratifying based on predictive prognostic index vs. β amyloid

Can we use AI to track brain health trajectories?

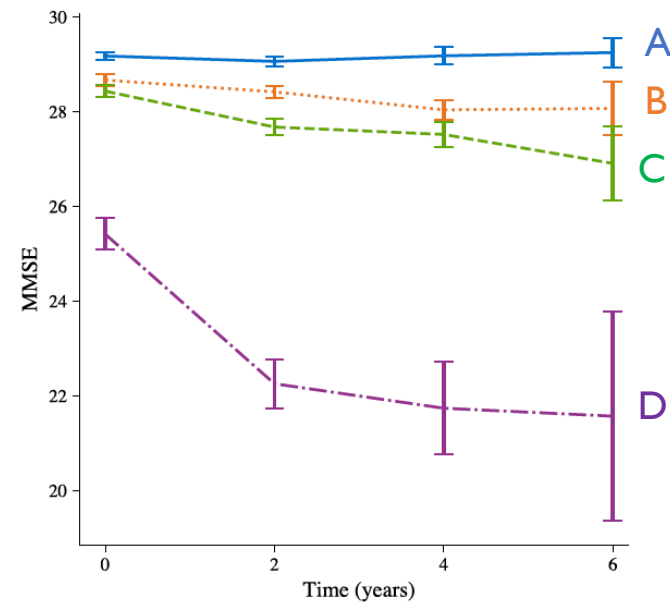
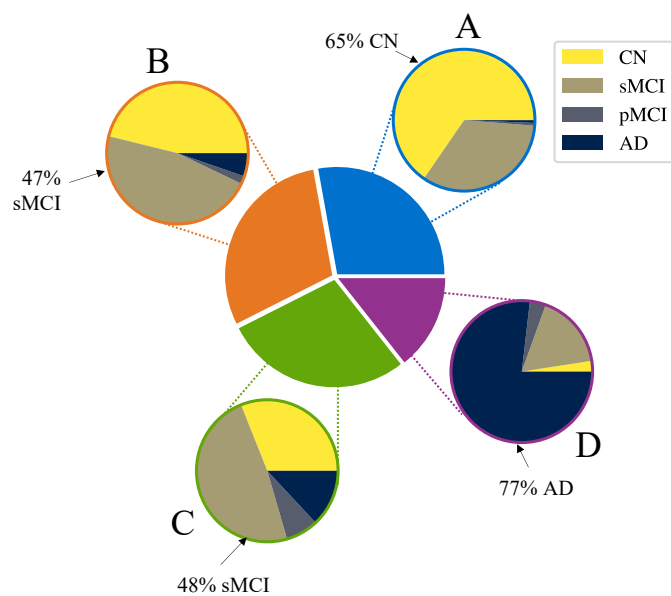


Towards brain health checks: Predicting before symptoms occur

Unsupervised trajectory modeling based on mixture of state space models



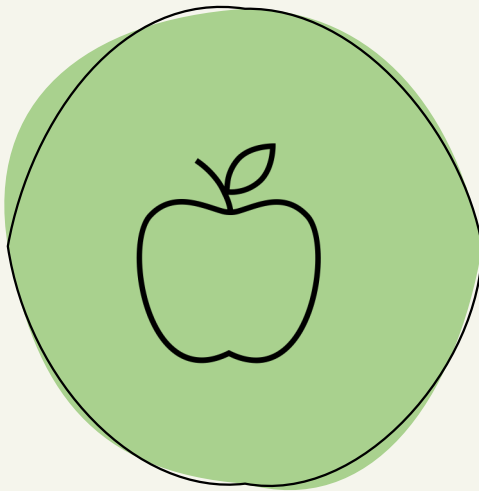
Predicting cognitive health trajectories



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



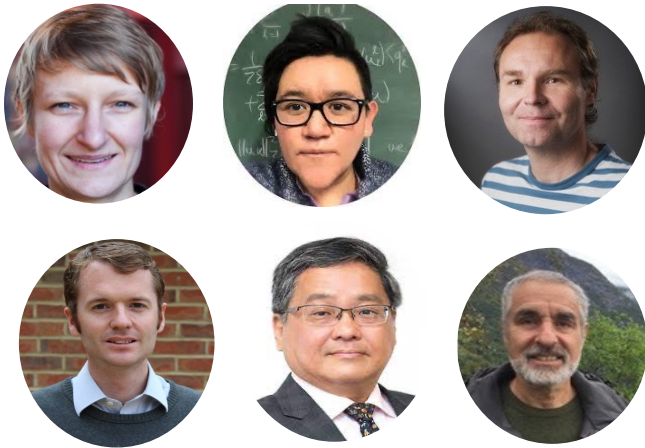
- Optimize trial design and maximize chance of success
- Learn from dementia subtypes to identify new targets

Clinical decision support



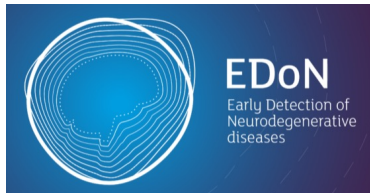
- Reduce invasive testing
- Optimize healthcare resources
- Match patients to treatments
- Better clinical outcomes

With thanks to:



Adaptive Brain Lab

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RESEARCH UK** **FOR A
CURE**



DOWNING COLLEGE CAMBRIDGE

**The
Alan Turing
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