

USING MACHINE LEARNING TO IDENTIFY RISK FACTORS FOR DEMENTIA FROM THE 24-HOUR SLEEP-WAKE CYCLE

An analysis of the UK Biobank Study

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OUTLINE



What is machine learning? (10 minutes)

Machine learning using a neural network (10 minutes)

The 24-hour rest-activity cycle and cognitive health (10 minutes)

The UK Biobank study (5 minutes)

My current research project (5 minutes)



Artificial intelligence is the new electricity. Electricity once transformed countless industries: transportation, manufacturing, healthcare, communications, and more. AI will now bring about an equally big transformation.

-Andrew Ng



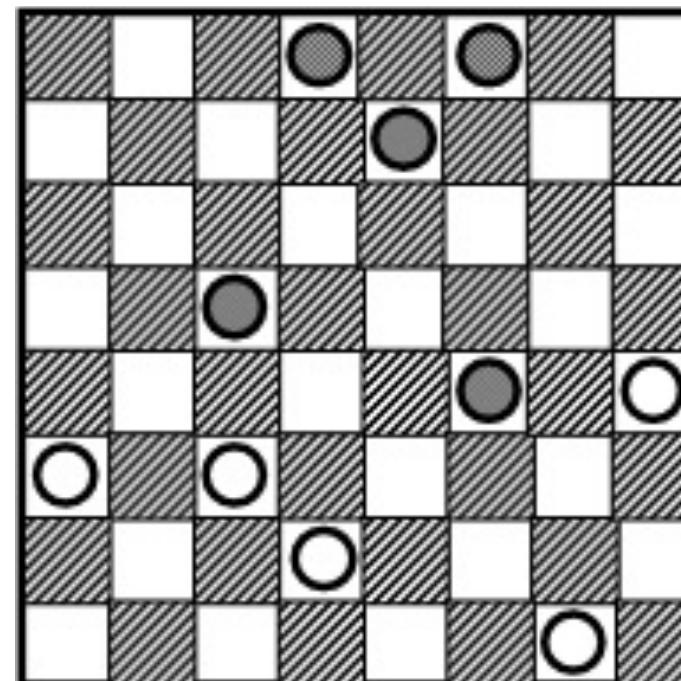
WHAT IS MACHINE LEARNING?

WHAT IS MACHINE LEARNING?



A field of study that gives computers the ability to learn without being explicitly programmed

-Arthur Samuel (1959)



WHAT IS MACHINE LEARNING?



A well-posed machine learning problem is said to be one in which a computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.

-Tom Mitchell (1998)

WHAT IS MACHINE LEARNING?



Email program watches which emails a person does/does not mark as spam.

Experience = the program watches a person label emails a spam or not spam

Task = classifying emails as spam or not

Performance = the number of emails correctly classified as spam/not spam

WHAT IS MACHINE LEARNING?



Broadly, there are two main types of machine learning algorithms:

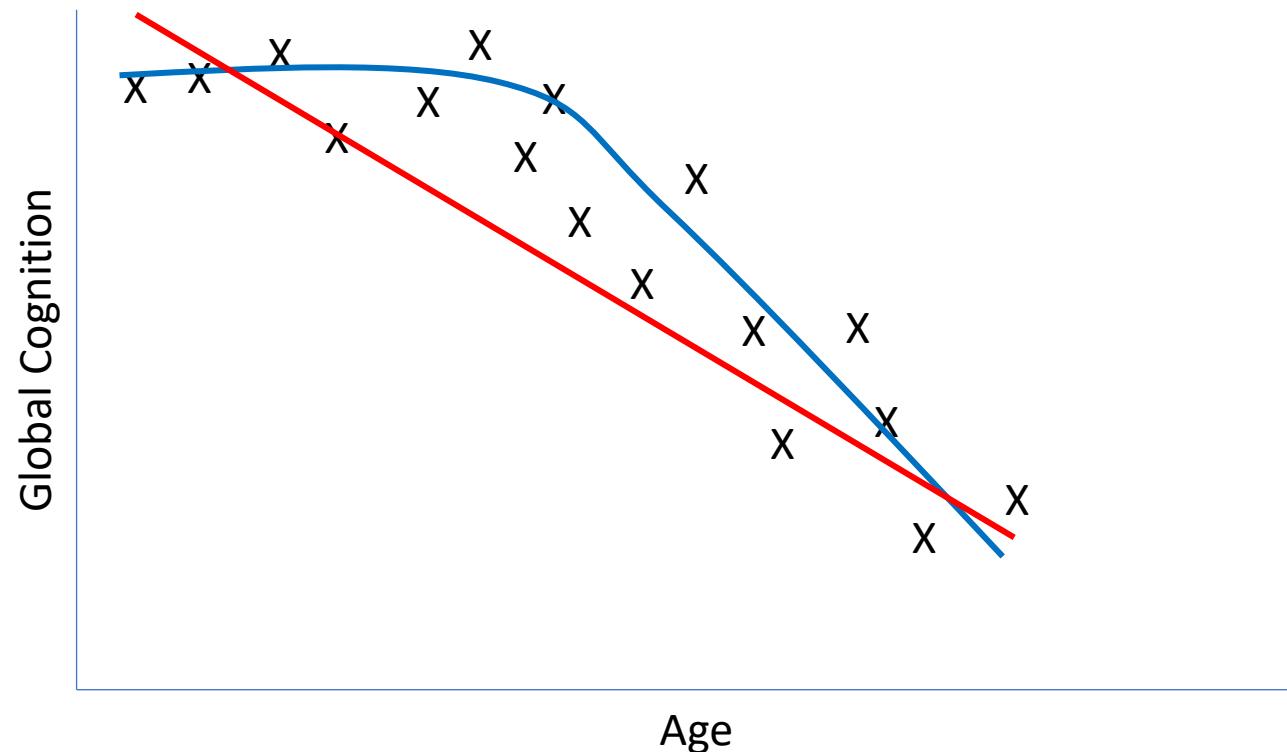
- Supervised learning
- Unsupervised learning

WHAT IS MACHINE LEARNING?



Supervised Learning

- The “right answers” are given

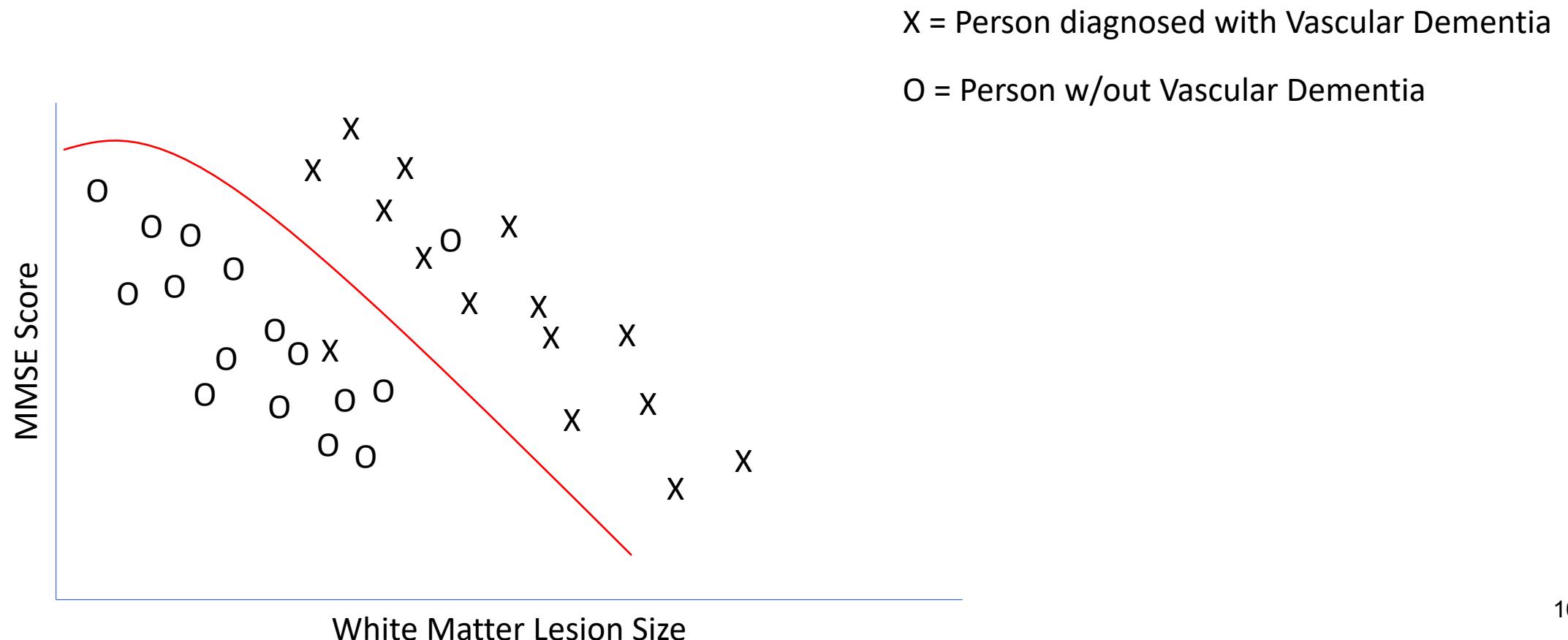


WHAT IS MACHINE LEARNING?



Supervised Learning

-The “right answers” are given



WHAT IS MACHINE LEARNING?



Unsupervised Learning

-Data are left unlabeled

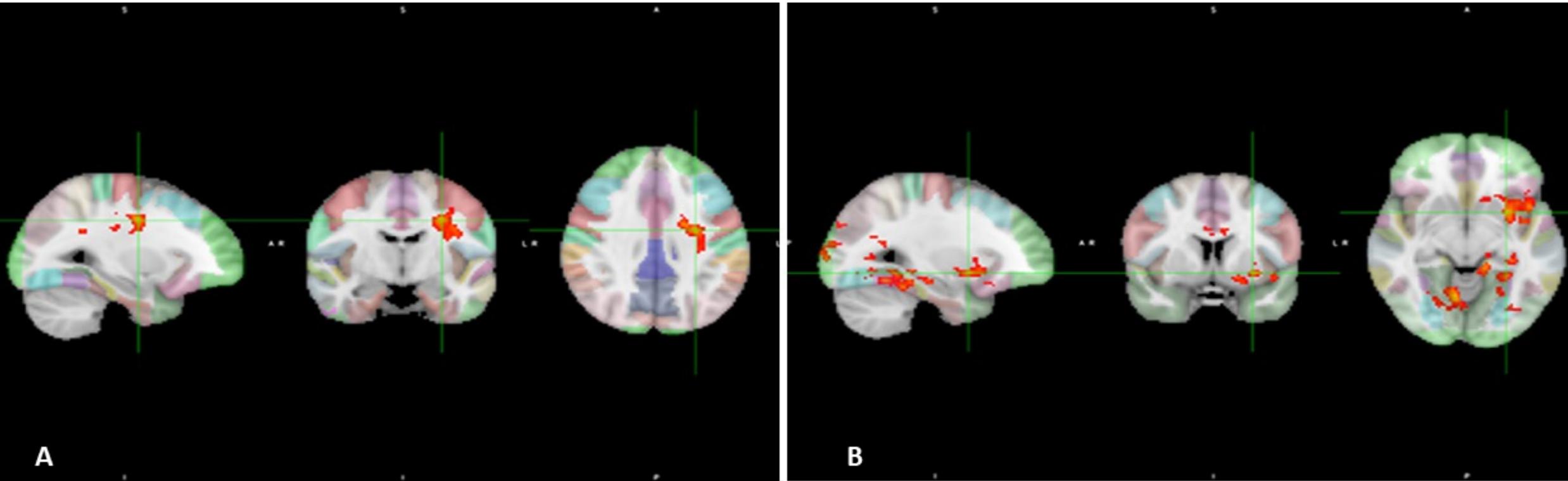


WHAT IS MACHINE LEARNING?



Unsupervised learning

- Data are left unlabeled





MACHINE LEARNING USING NEURAL NETWORKS

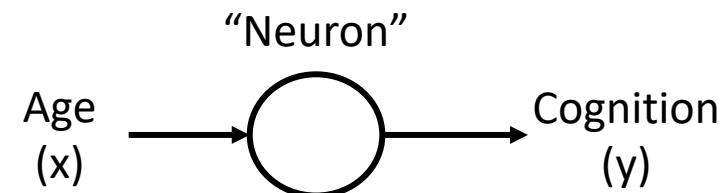
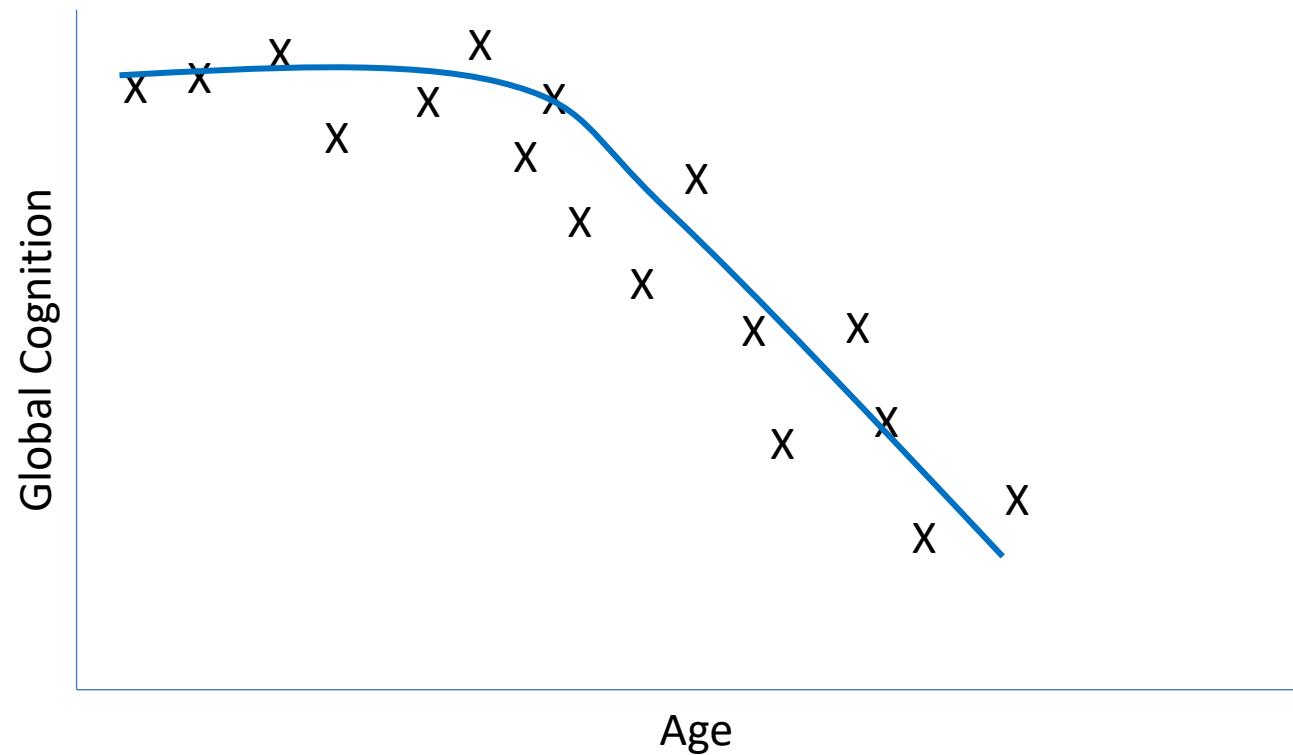
NEURAL NETWORKS



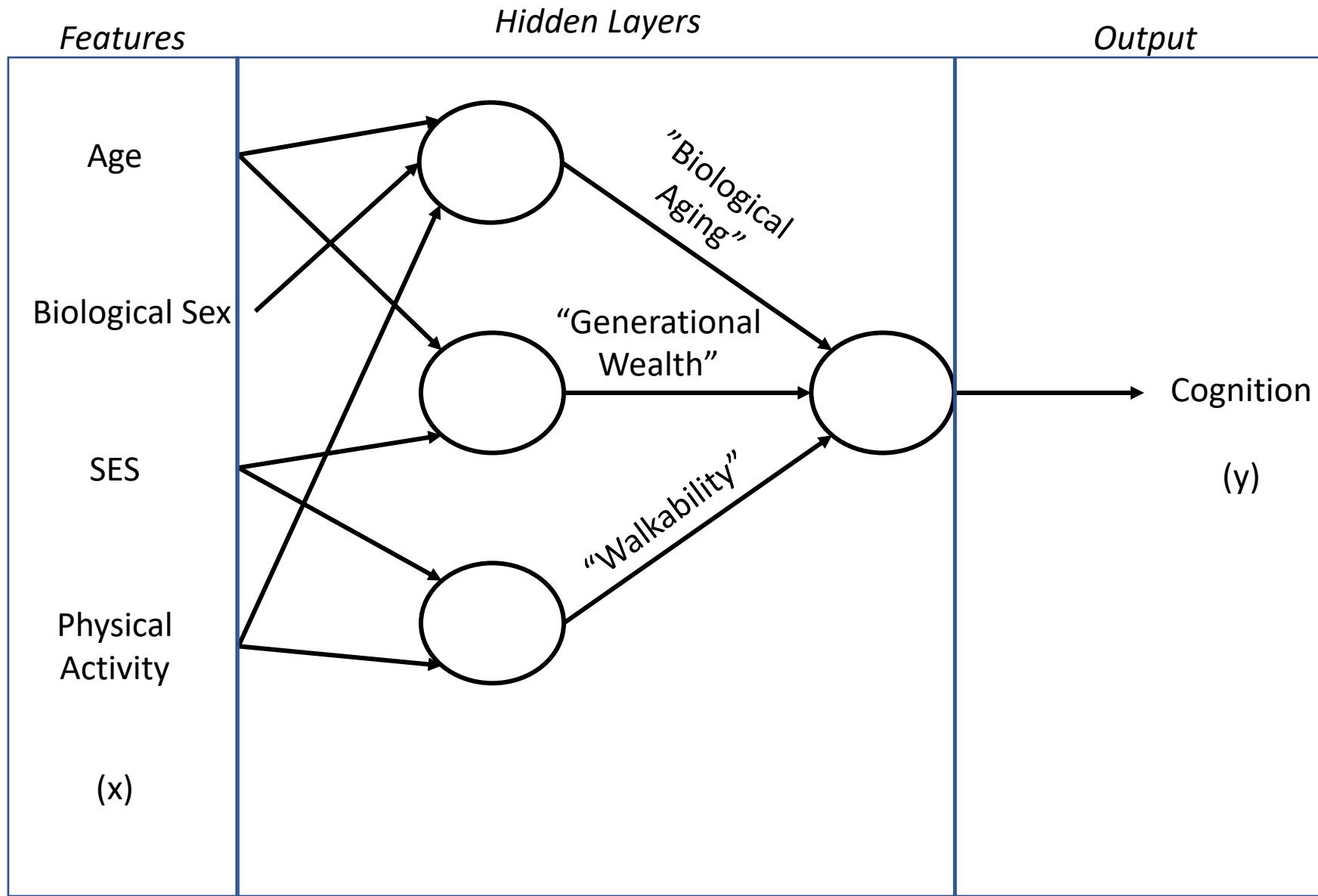
Numerous uses, including:

- Photo tagging
- Online advertising
- Natural language processing (e.g., autocorrect)
- Autonomous driving

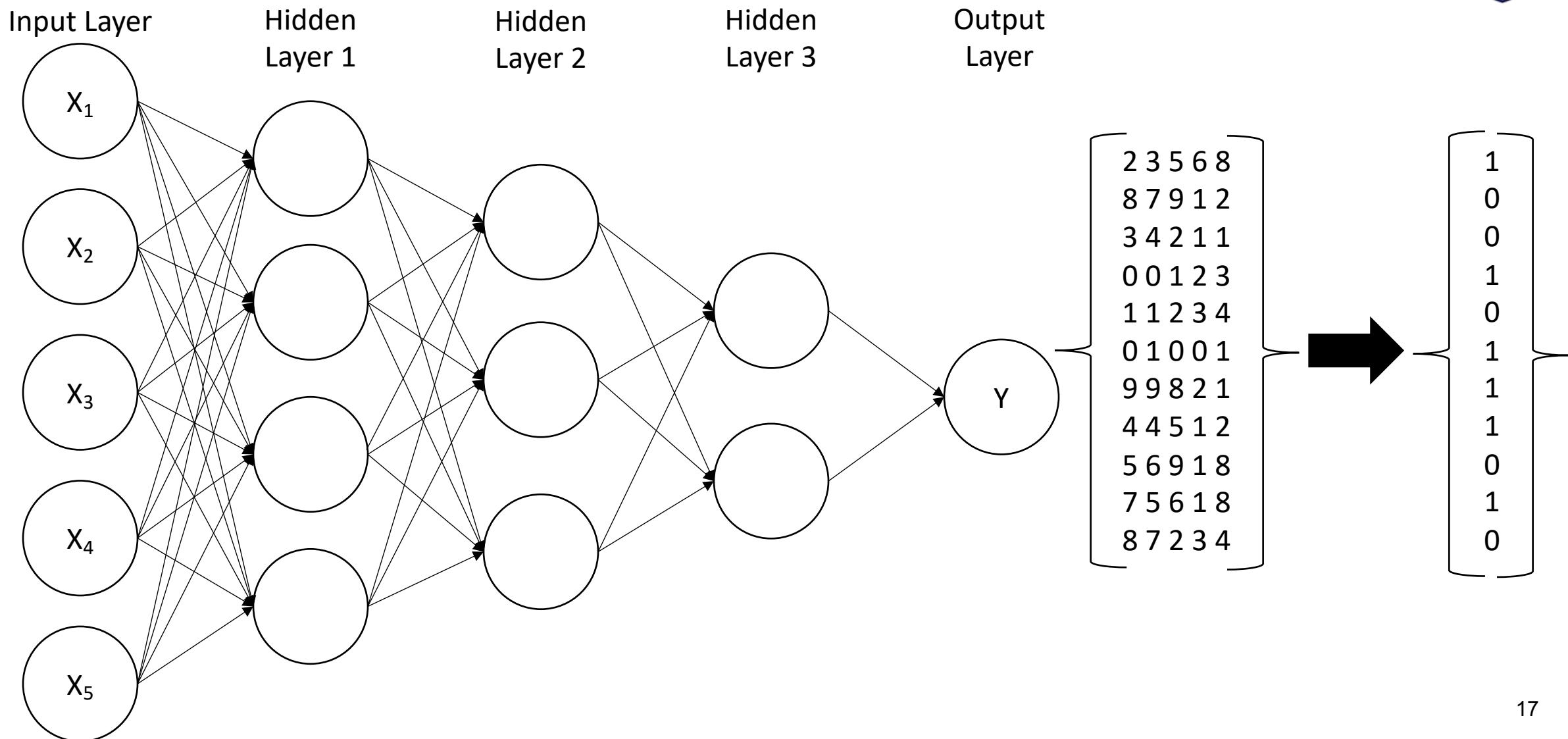
NEURAL NETWORKS



NEURAL NETWORKS



NEURAL NETWORKS



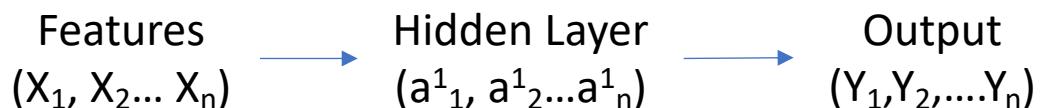
NEURAL NETWORKS



How to create a neural network

Step 1 – Training the network

One hidden layer neural network



Lots of photos of Buddy (Y= 1)



Lots of photos of other dogs (Y= 0)



NEURAL NETWORKS



How to create a neural network

Step 1 – Training the network

Step 2 – Hyperparameter tuning

Hyperparameters we can tune include:

- # Features
- # Hidden Layers
- # Hidden Units
- Learning rate

NEURAL NETWORKS

How to create a neural network

Step 1 – Training the network

Step 2 – Hyperparameter tuning

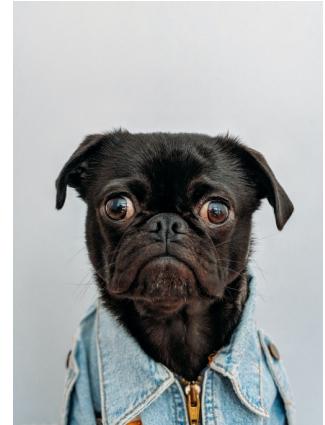
Step 3 – Test network accuracy



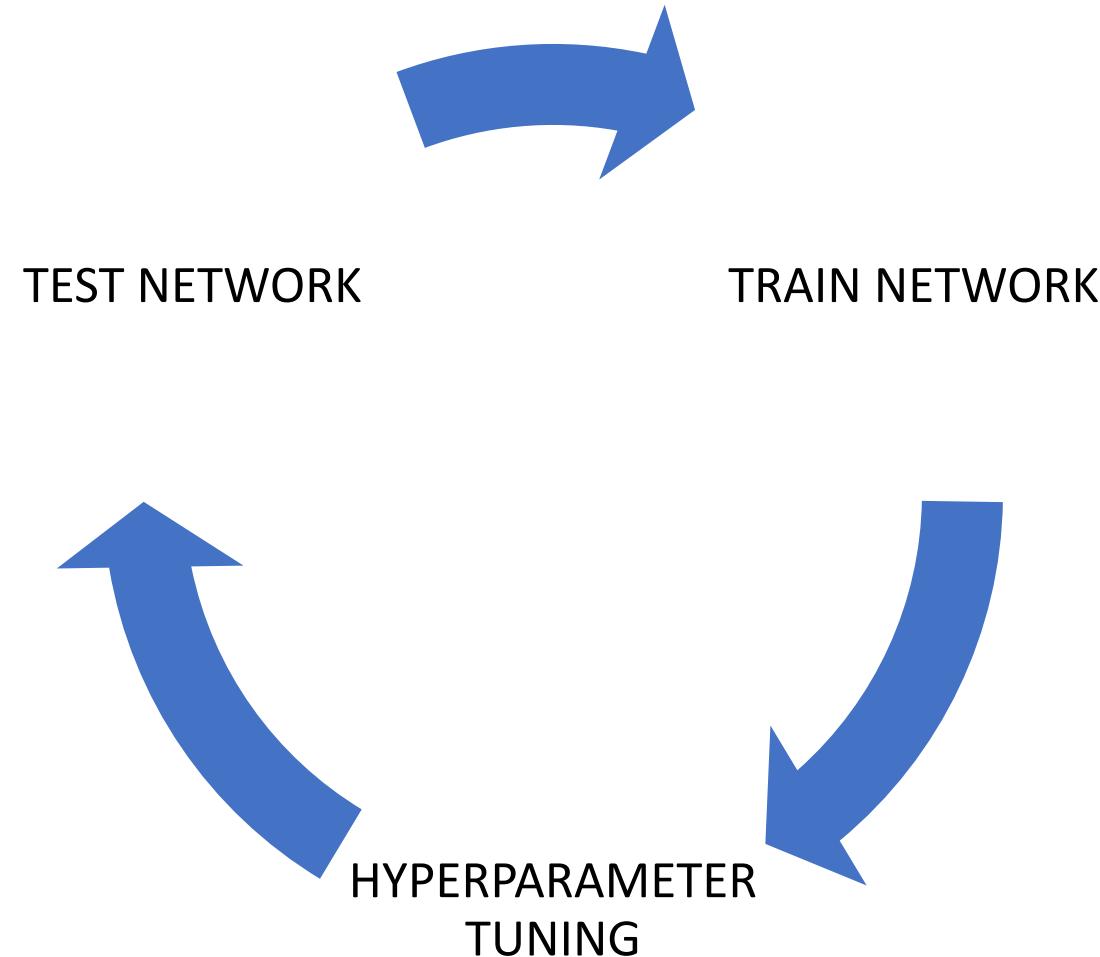
New photos of Buddy (Y= 1)



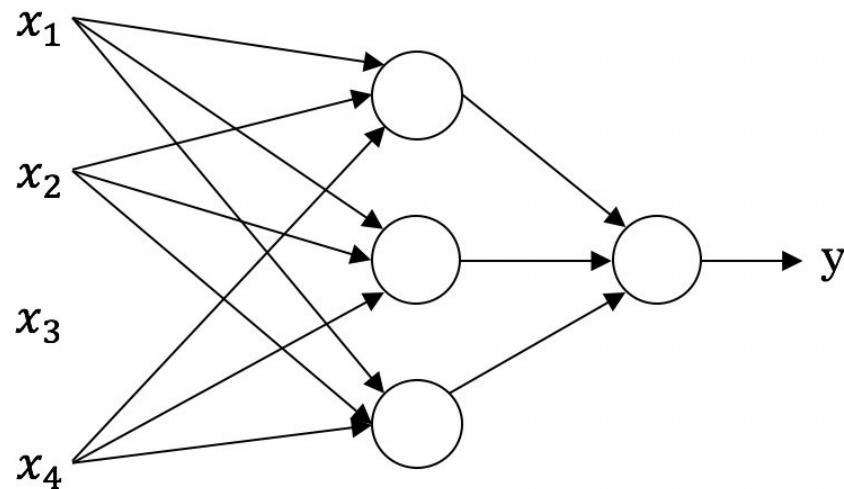
New photos not of Buddy (Y= 0)



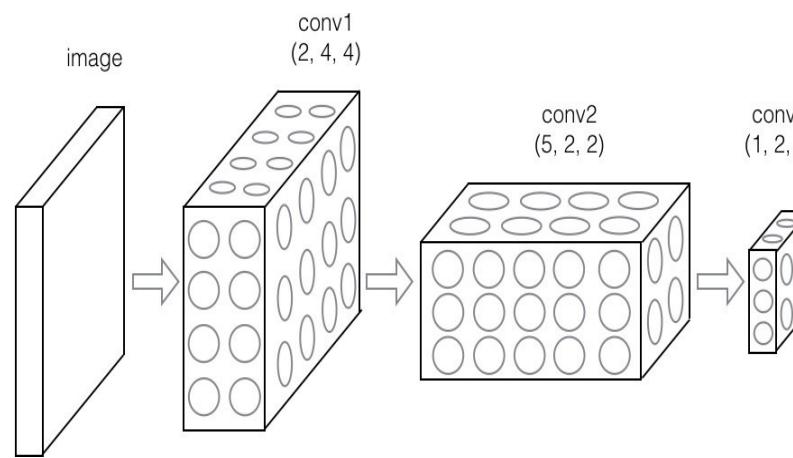
NEURAL NETWORKS



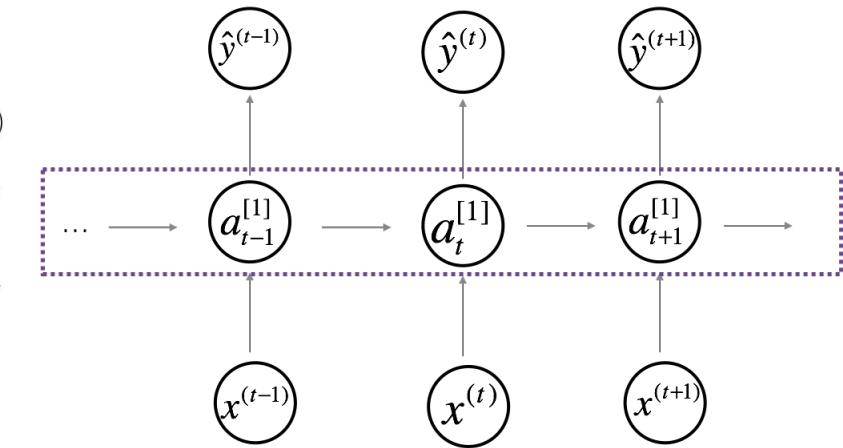
NEURAL NETWORKS



Standard Neural Network

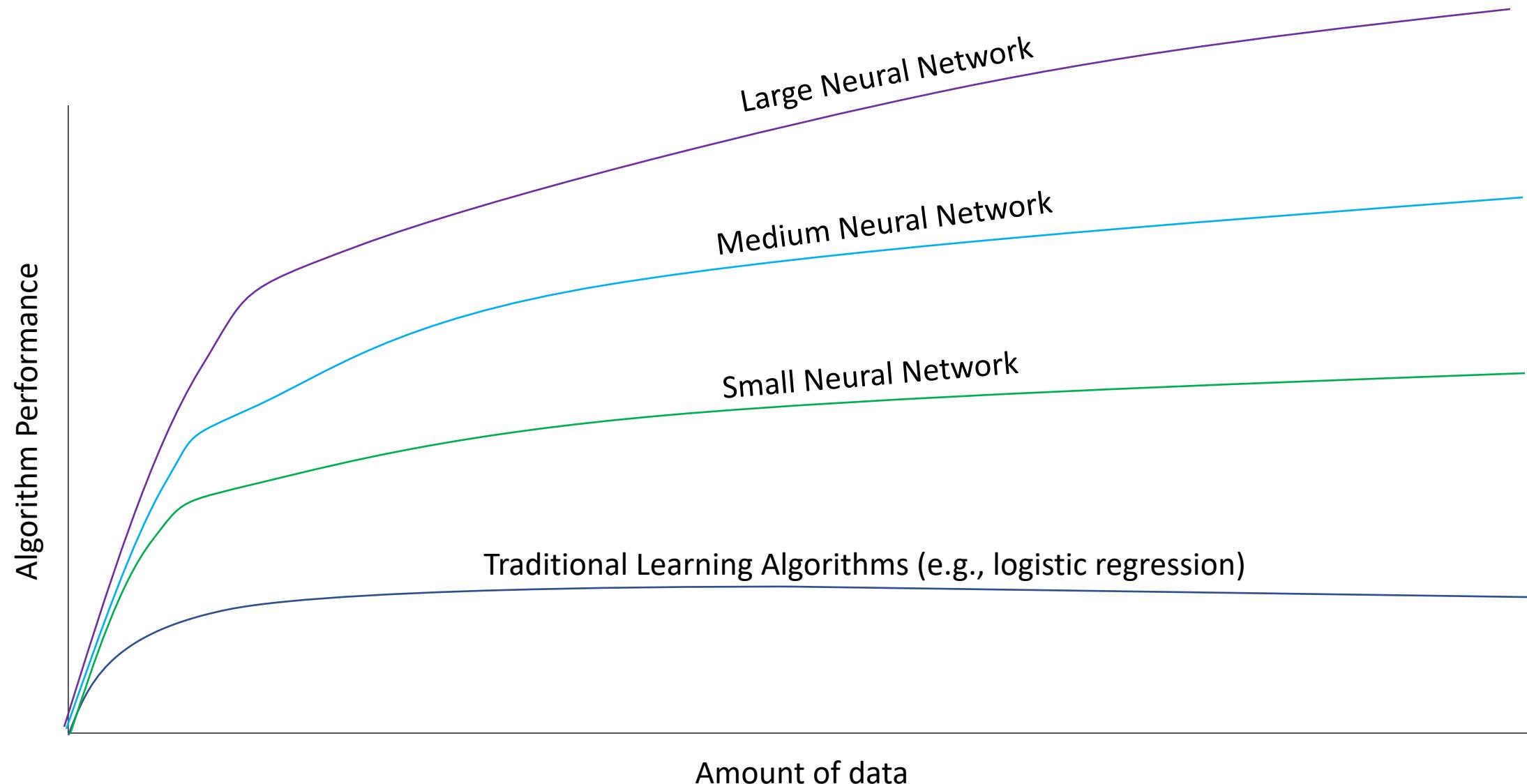


Convolutional Neural Network



Recurrent Neural Network

NEURAL NETWORKS

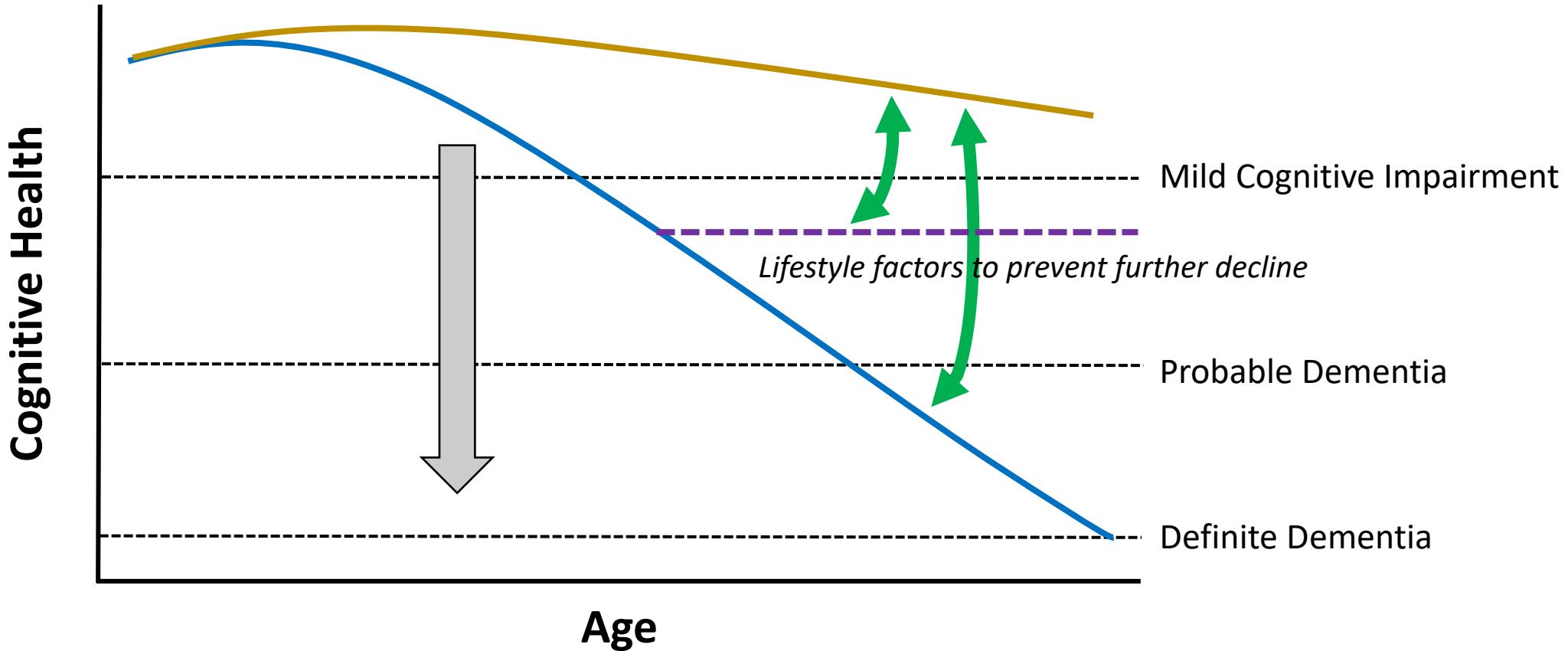




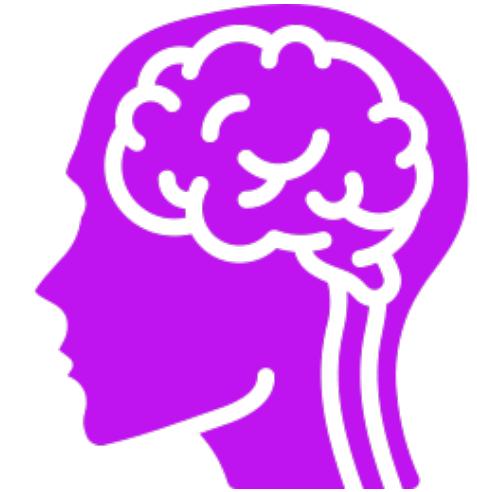
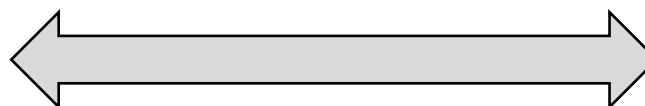
THE 24-HOUR REST-ACTIVITY CYCLE AND COGNITIVE HEALTH

AGE-RELATED COGNITIVE CHANGES

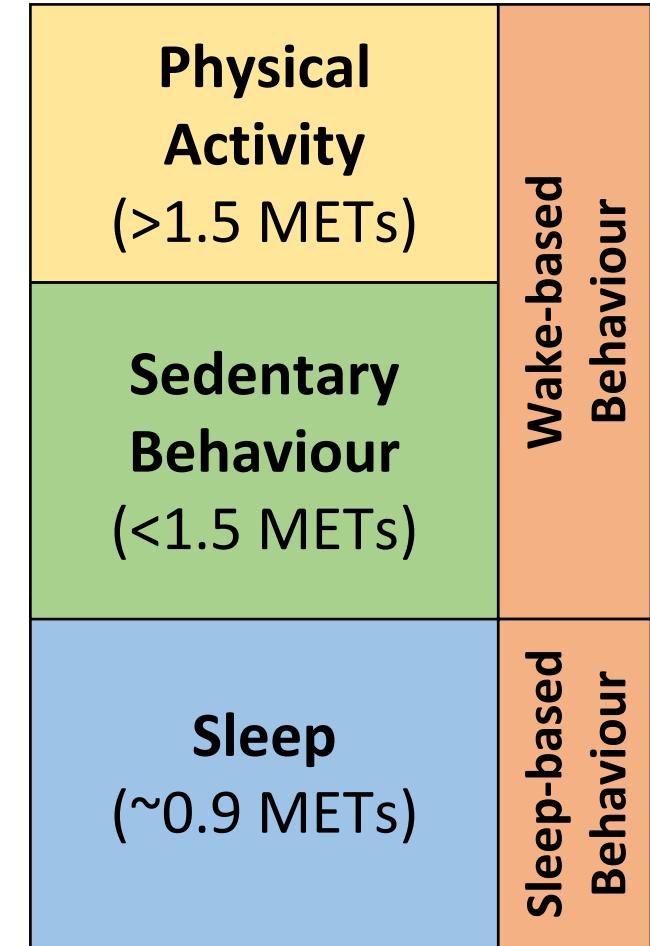
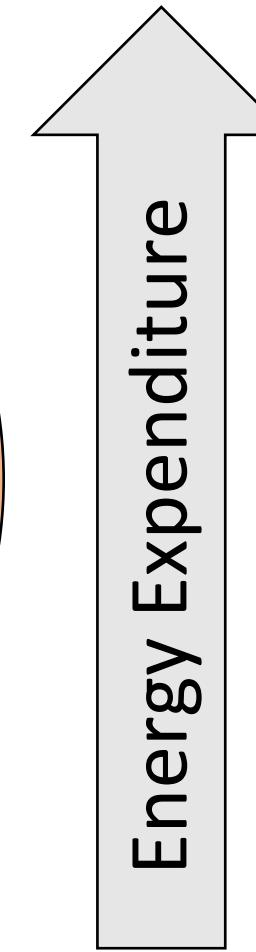
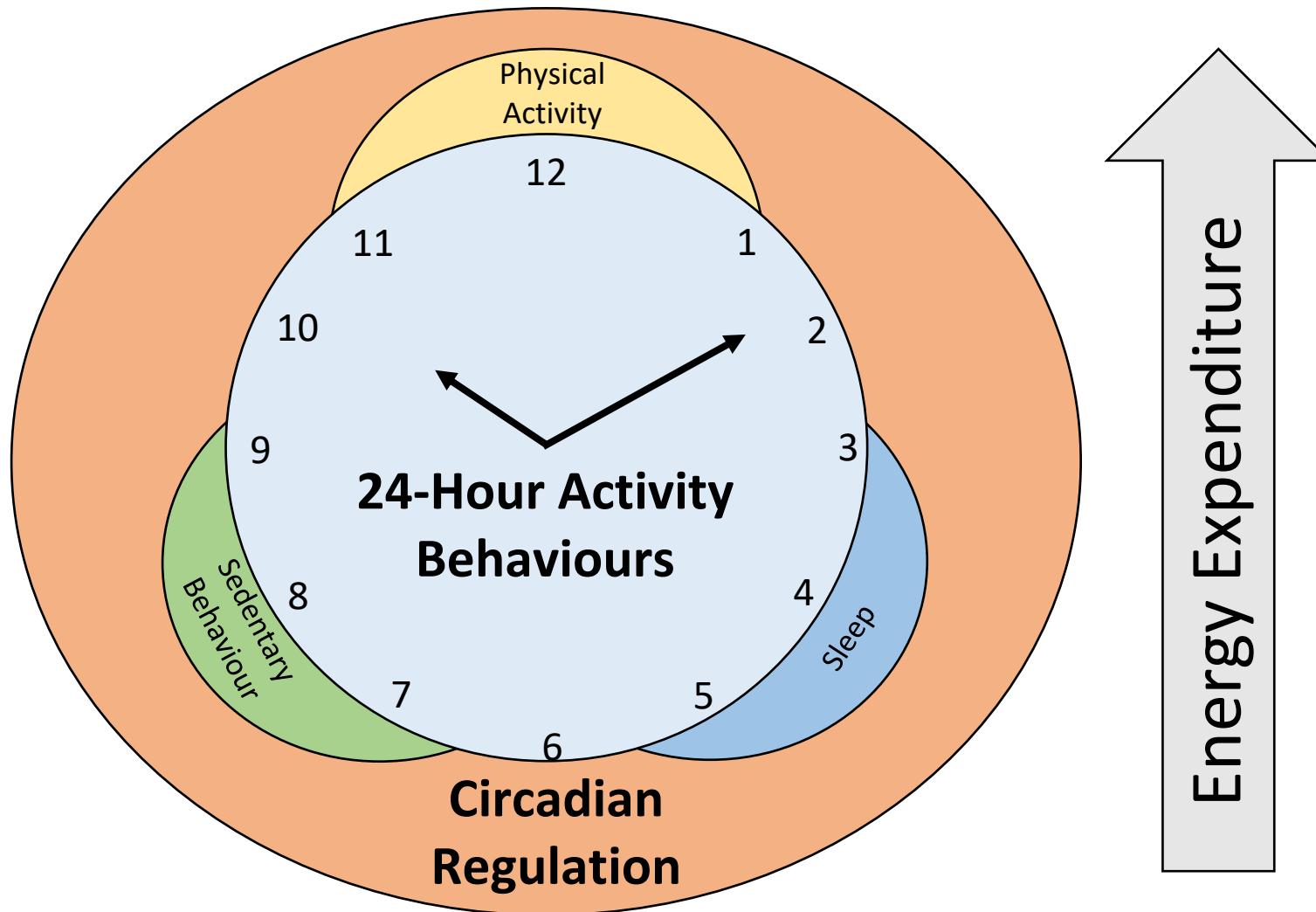
Individual Variability in Cognitive Trajectory



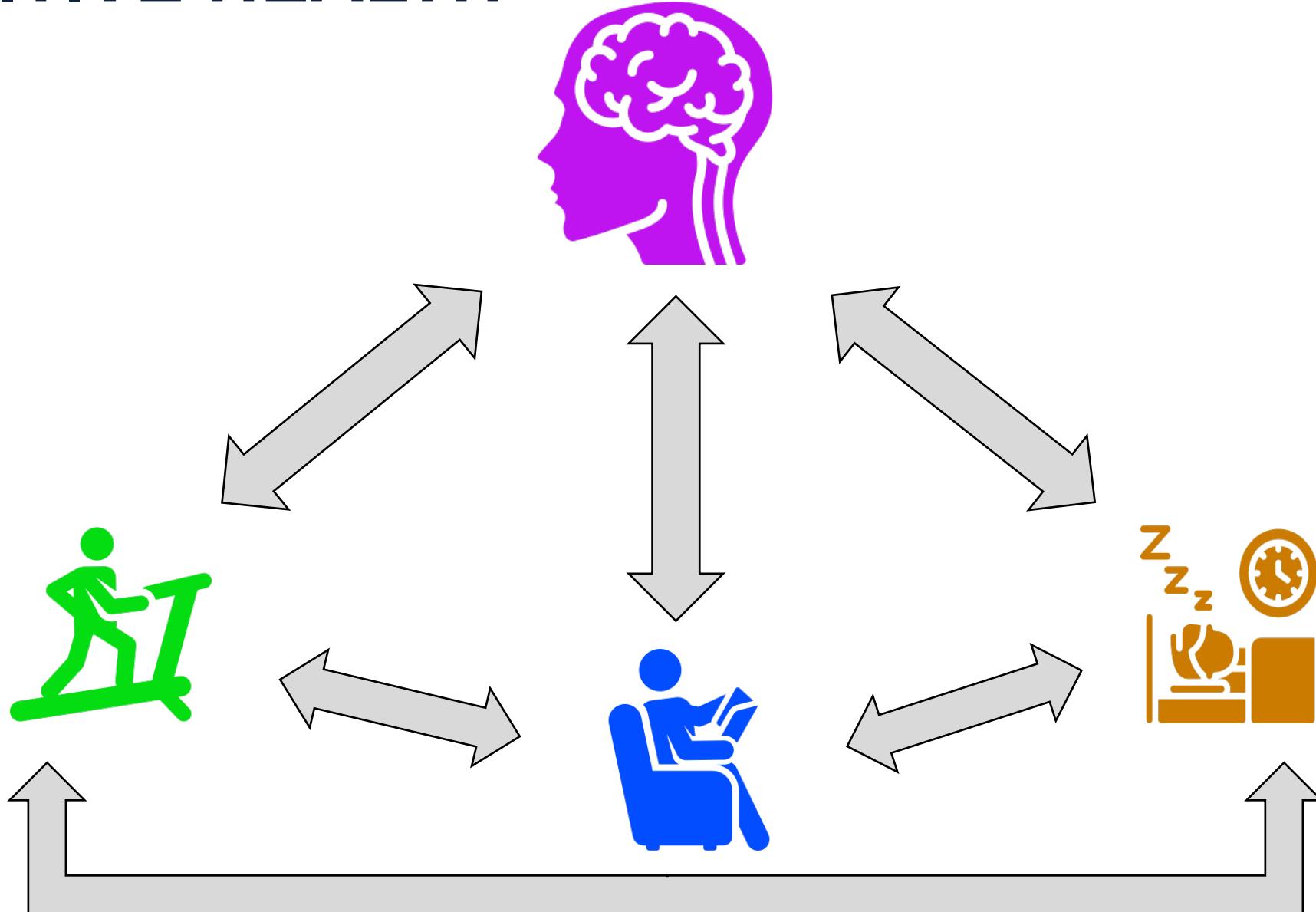
THE 24-HOUR ACTIVITY CYCLE AND COGNITIVE HEALTH



WHAT IS THE 24-HOUR ACTIVITY CYCLE?



THE 24-HOUR ACTIVITY CYCLE AND COGNITIVE HEALTH

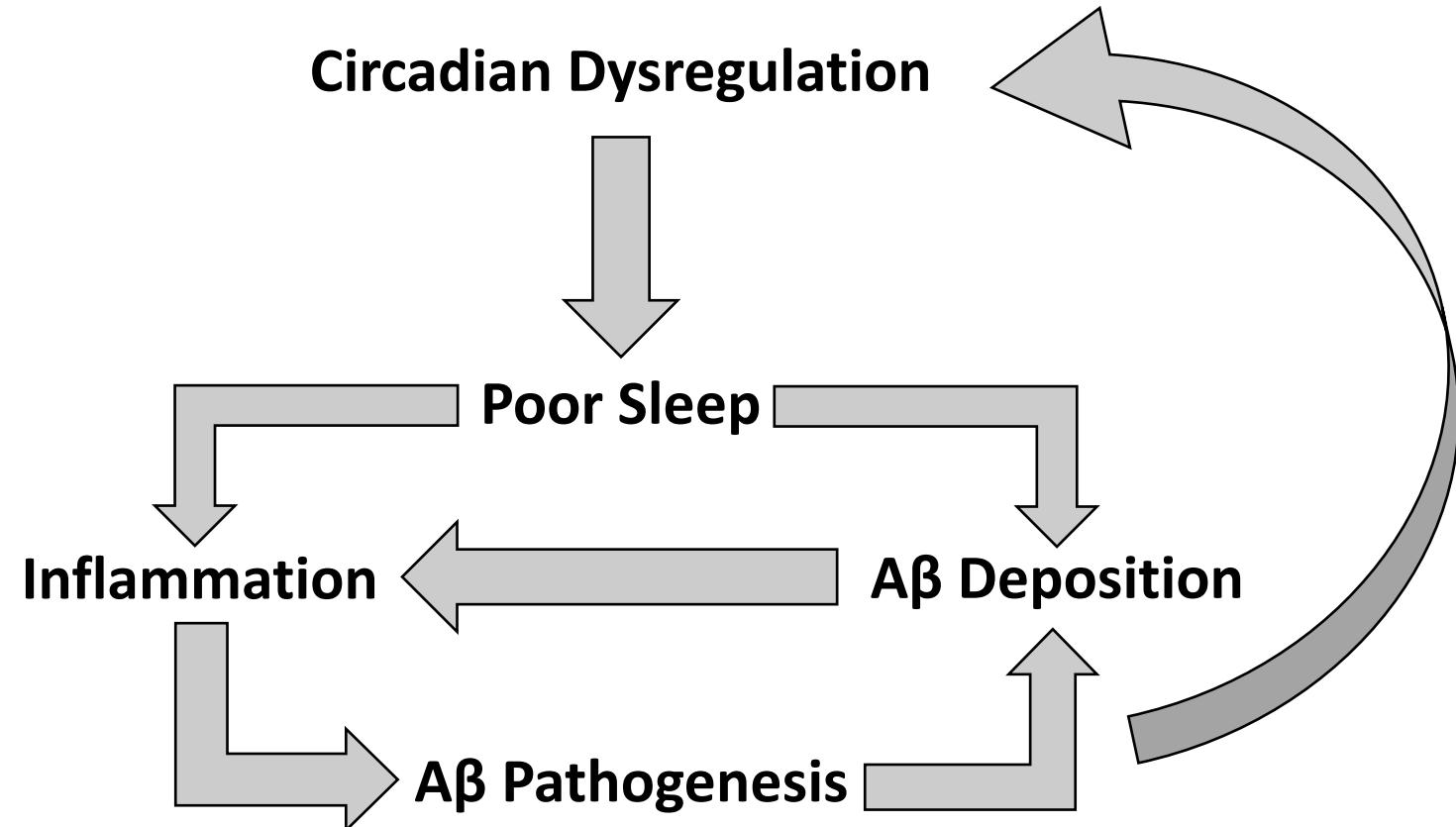


SLEEP, CIRCADIAN RHYTHMS AND COGNITIVE HEALTH

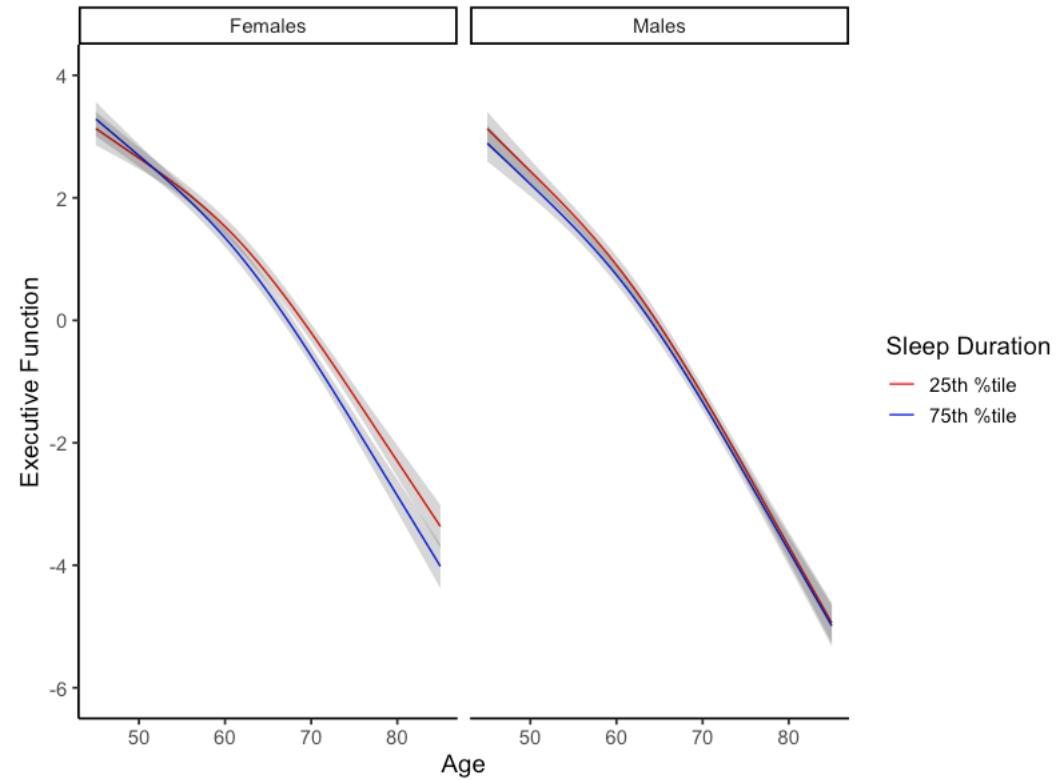
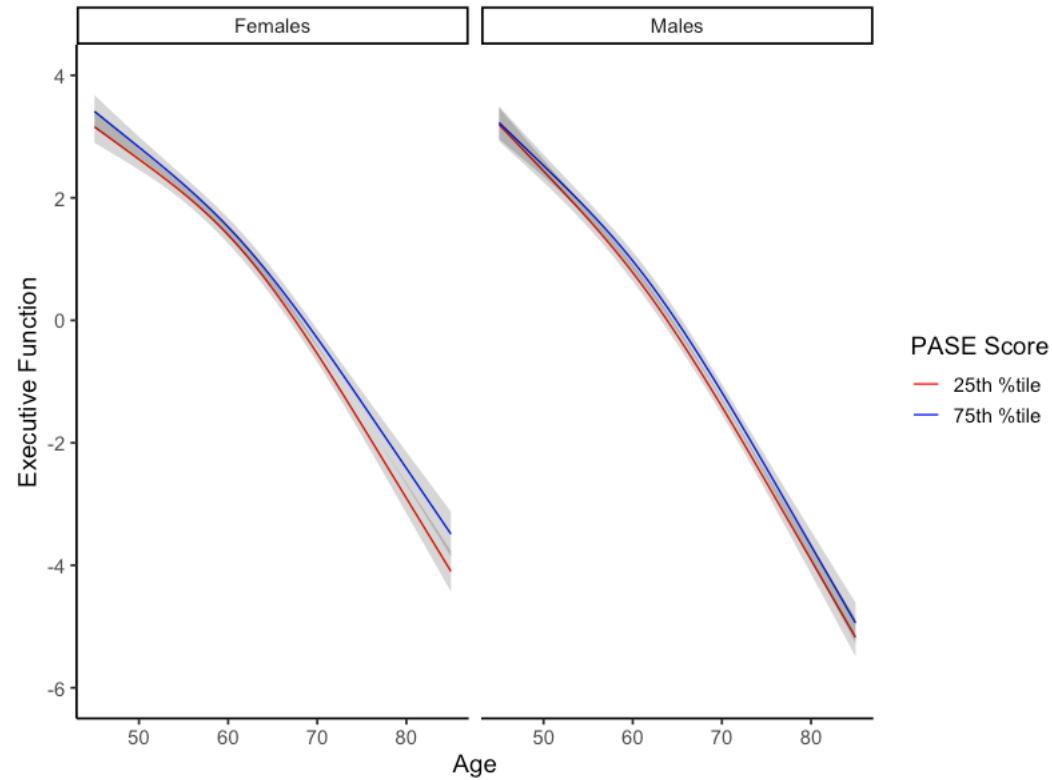
Older adults with poor sleep have ↑risk of MCI and dementia
(da Silva and Chaves, 2015)

Older adults with MCI have ↑risk of sleep disturbances
(Naismith et al., 2014)

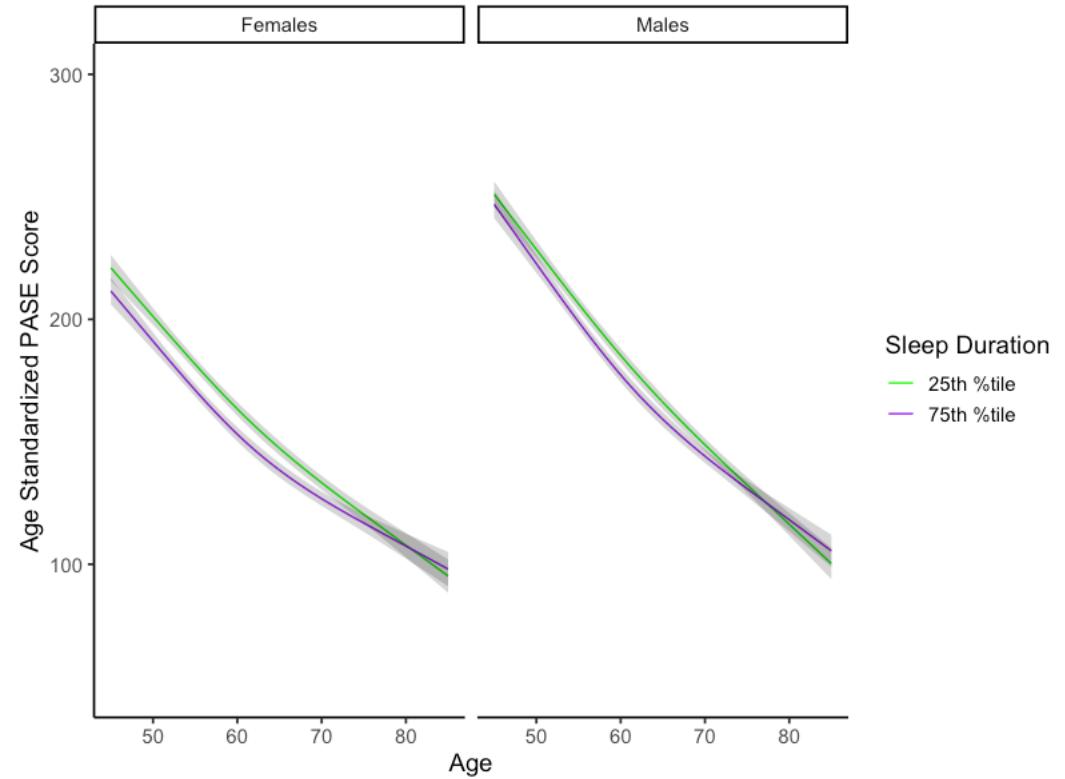
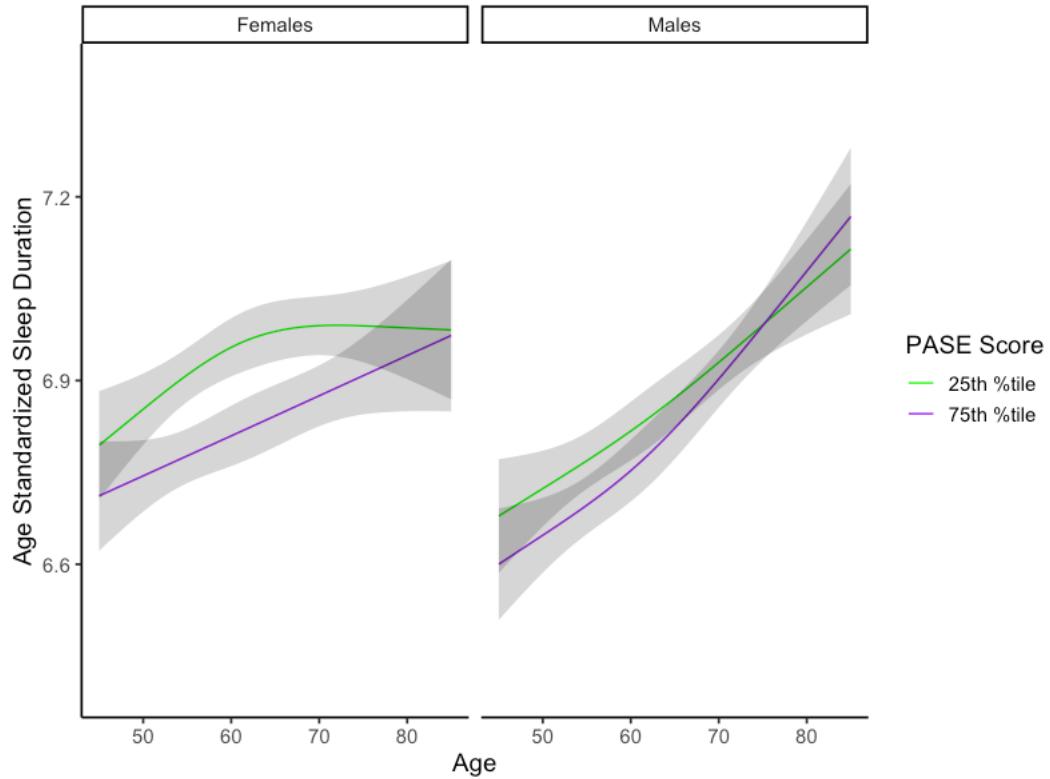
Poor sleep and sleep-wake disturbances associated with ↑risk of converting MCI → dementia
(Tranah et al., 2011)



AGE AND SEX DIFFERENCES IN THE ASSOCIATIONS OF PHYSICAL ACTIVITY AND SLEEP WITH COGNITION



AGE AND SEX DIFFERENCES IN THE ASSOCIATIONS OF PHYSICAL ACTIVITY AND SLEEP

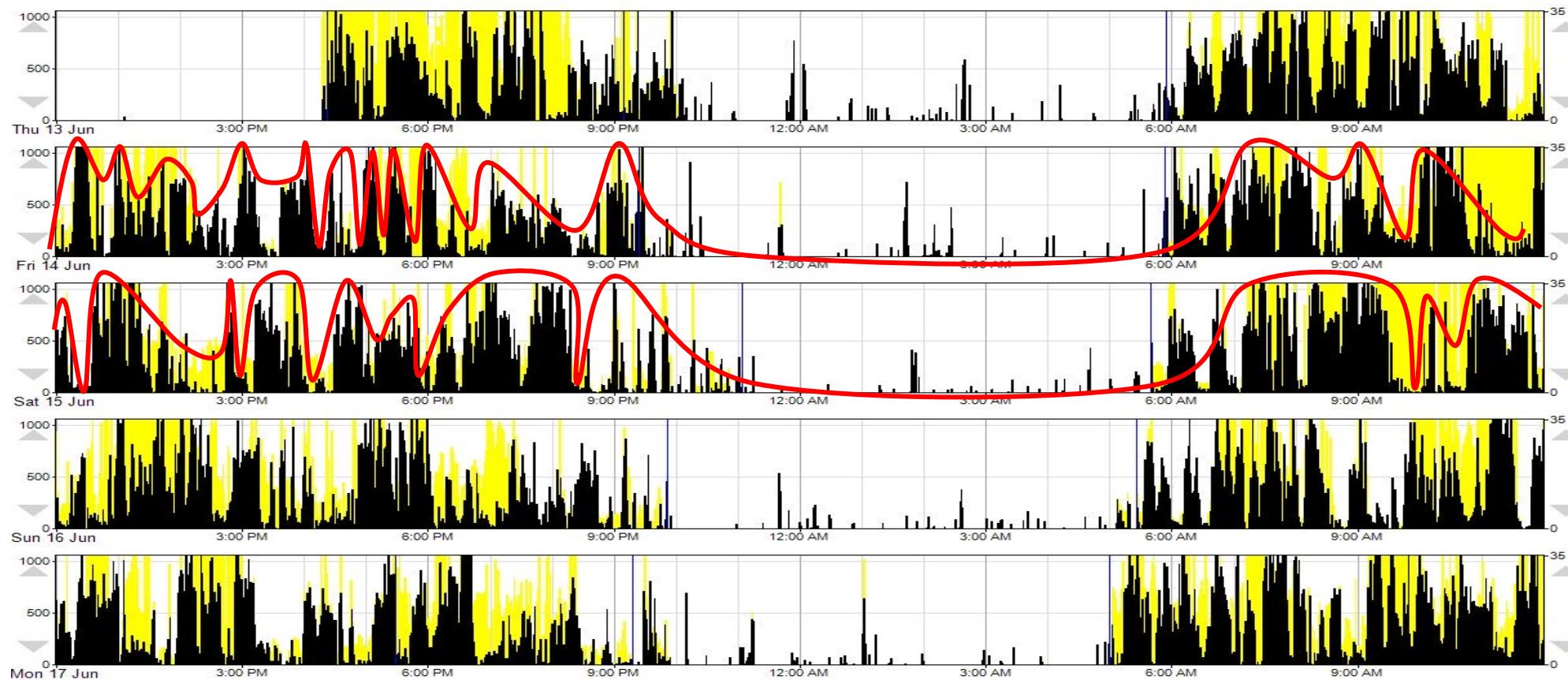


MEASURING THE 24-HOUR CYCLE



**Can also estimate sedentary behaviour*

MEASURING THE 24-HOUR ACTIVITY CYCLE





THE UK BIOBANK STUDY

The logo for the UK Biobank study. The word "biobank" is written in a large, bold, blue sans-serif font. The letter "i" has a small silhouette of a person standing next to it. The letter "b" has a small silhouette of a person sitting next to it. The letter "a" has a small silhouette of a person walking next to it. The letter "n" has a small silhouette of a person running next to it. The letter "k" has a small silhouette of a person jumping next to it. To the right of "biobank" is the suffix ".uk" in a smaller, regular blue font.

THE UK BIOBANK STUDY



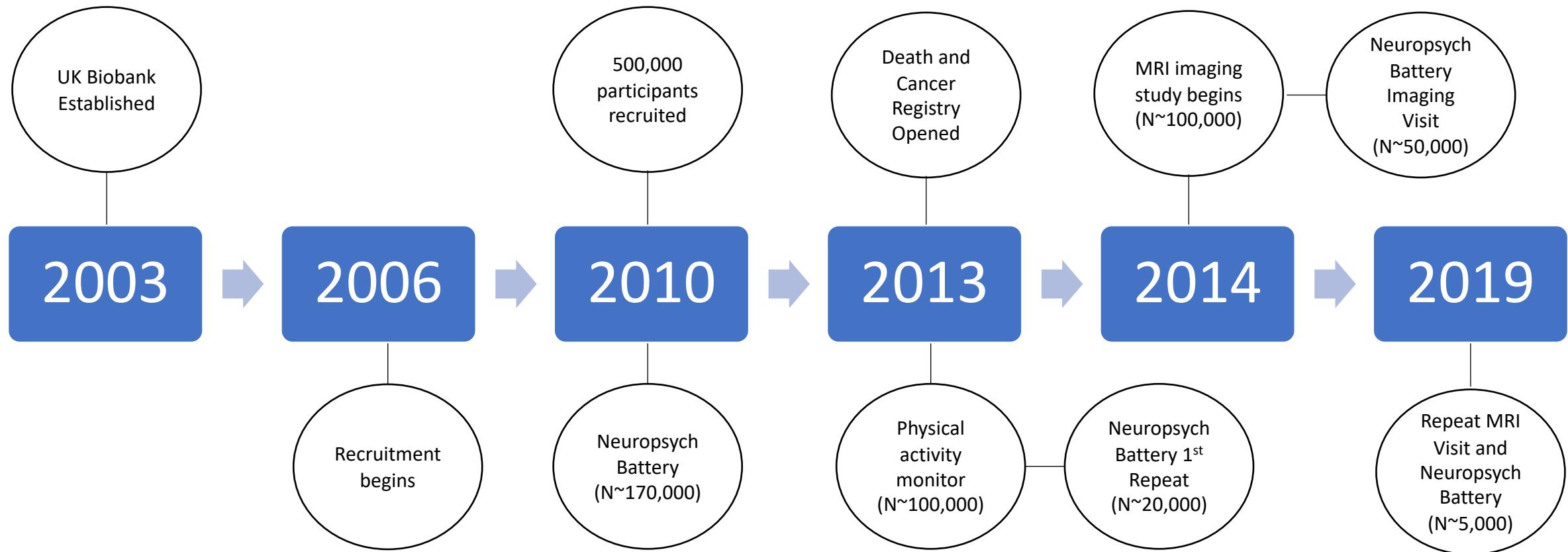
500,000 UK men and women aged 40-69 years when recruited

- Baseline assessment occurred 2006-2010

Follow-up of health outcomes through linkage to electronic medical record (EMR)
and direct contact with participants

Follow-up assessments have occurred throughout the study

THE UK BIOBANK STUDY



THE UK BIOBANK STUDY



Actigraphy data

- Collected between 2013-2015
- ~96,000 participants with valid data
- Data are available as acceleration averages from each hour of the 24-hour day, or as raw files of 5 second epochs

Electronic medical record

- To date, there have been ~2,000 total cases of all-cause dementia identified from the EMR

THE UK BIOBANK STUDY



Neuropsychological testing

- Neuropsych testing was completed at:
 - Baseline ($N \sim 170,000$)
 - 1st repeat in 2013 ($N \sim 20,000$)
 - During the neuroimaging study ($N \sim 50,000$), and
 - 1st repeat of the neuroimaging study in 2019 ($N \sim 5,000$)
- Tests used:
 - Pairs matching
 - Prospective memory
 - Reaction Time
 - Fluid intelligence

THE UK BIOBANK STUDY



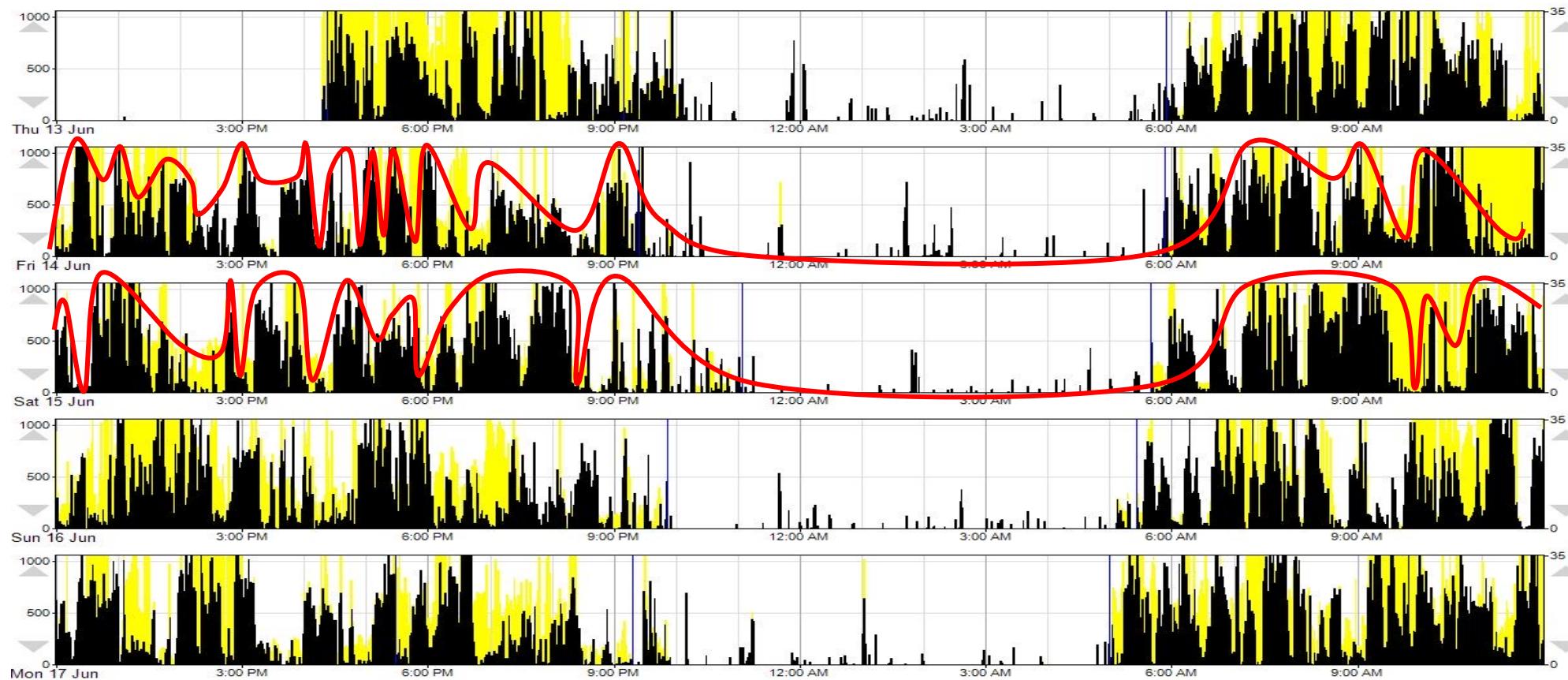
Neuroimaging study

- MRI was conducted in 2016 with a goal of N= 100,000
 - ~50,000 participants completed the MRI in 2016
 - A repeat assessment was conducted in 2019 on ~5,000 participants
- Tests included:
 - Structural T1
 - T2 Flair
 - rs-fMRI
 - task-based fMRI (emotion/facial recognition task?)
 - Diffusion Tensor Imaging

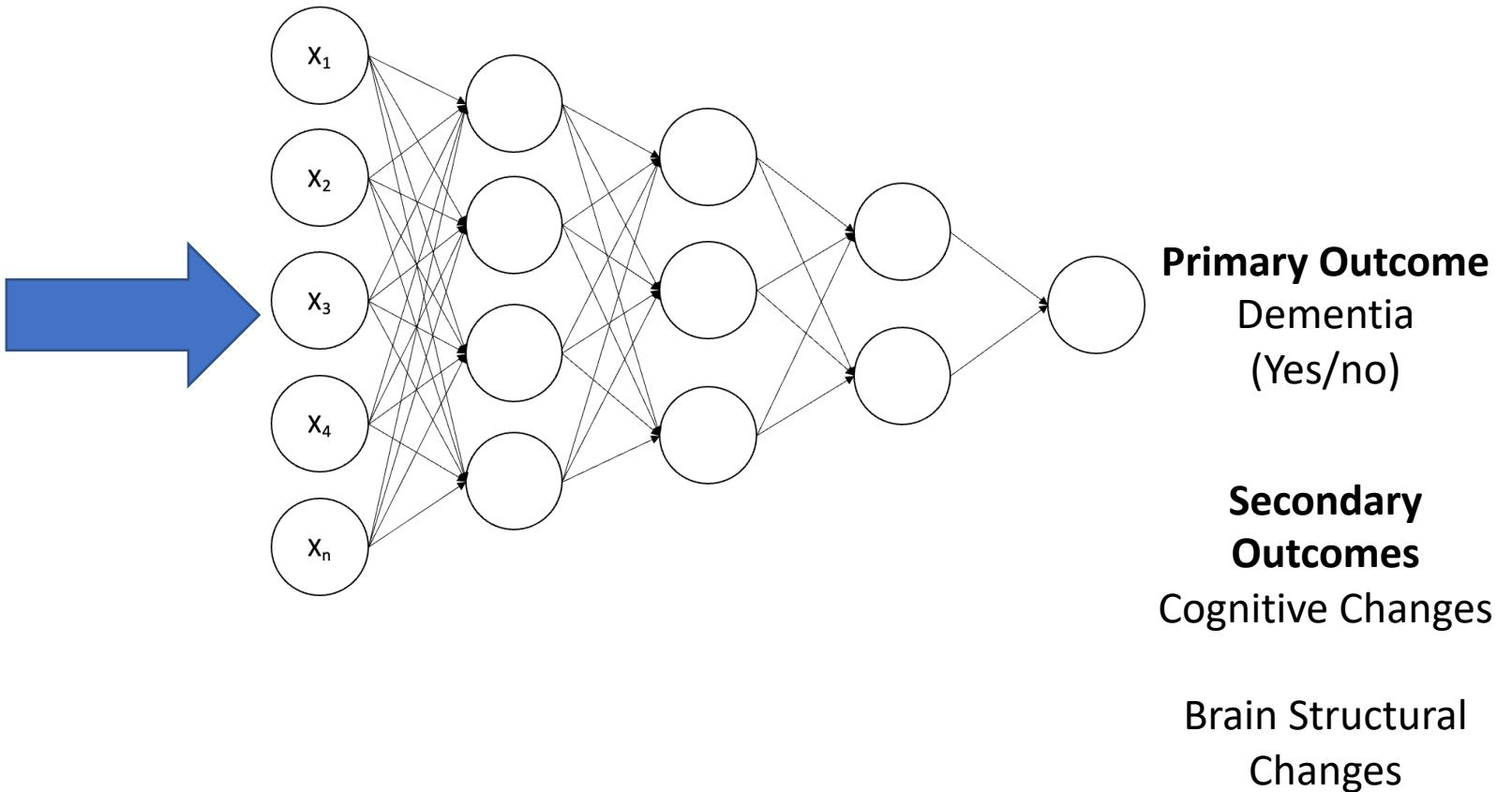
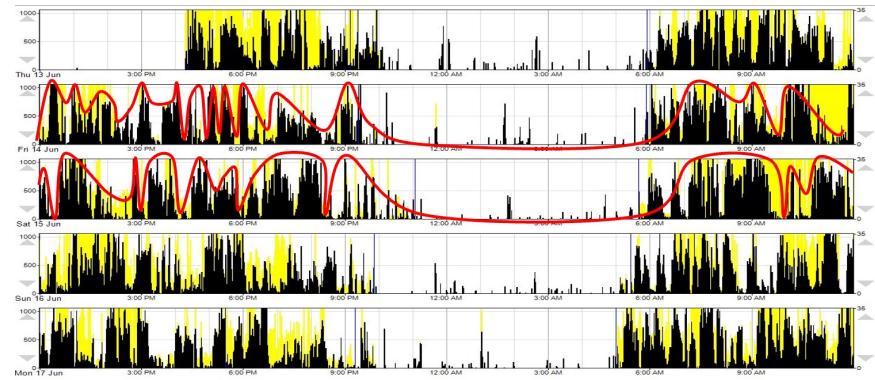


MY CURRENT RESEARCH PROJECT

MY CURRENT RESEARCH PROJECT



MY CURRENT RESEARCH PROJECT





CURRENT ISSUES

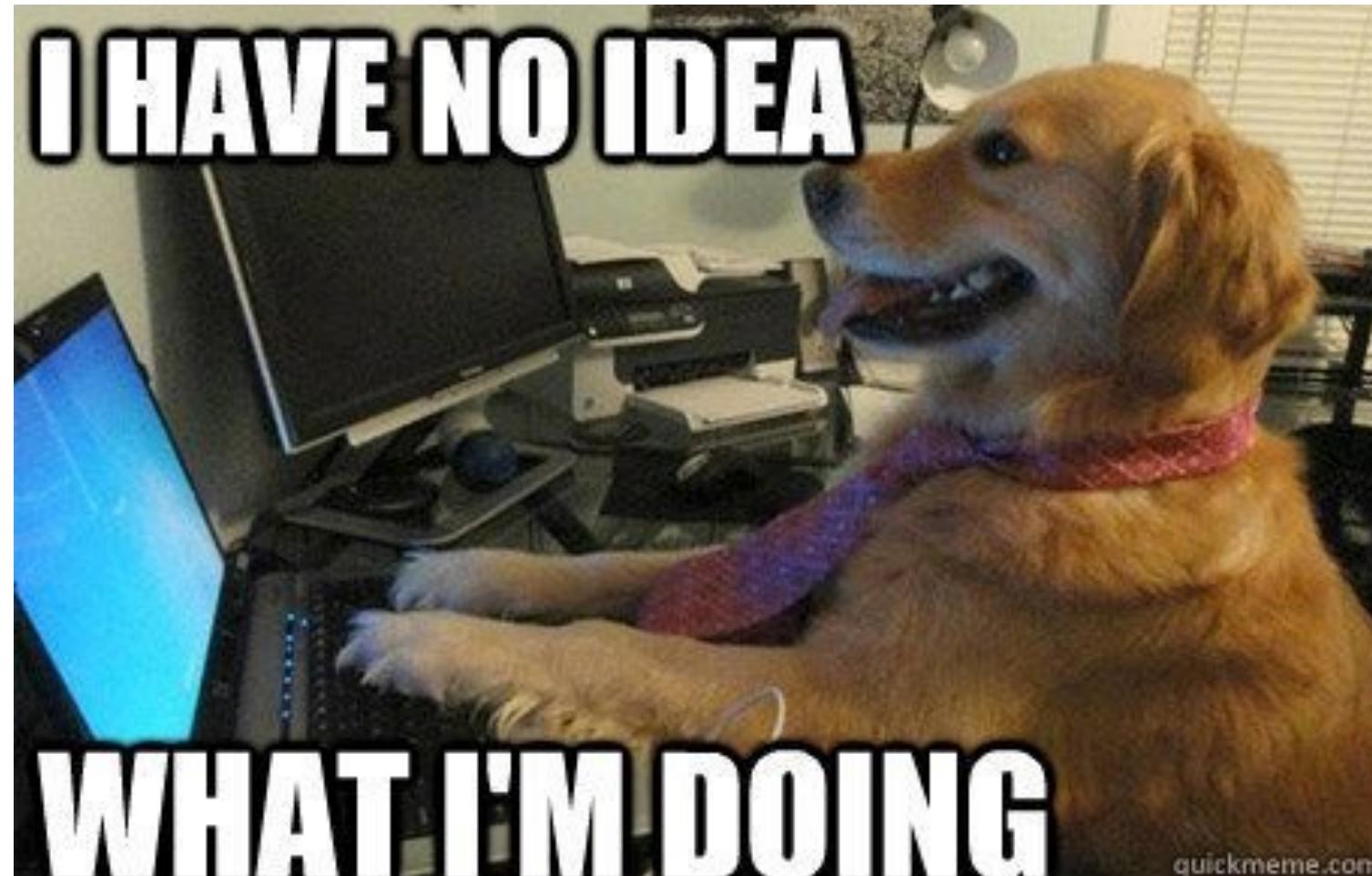
1. Data management
 - a. Data acquisition
 - b. Data availability (bulk files only available through UKB's online platform)
 - c. Data management
 - d. Data storage

2. Feature design
 - a. Maintaining temporality of actigraphy
 - b. Using raw versus filtered data?
 - c. Other features to use

CURRENT ISSUES

3. Model development
 - a. Only a few cases of dementia in actigraphy data (N~125)
 - b. Network design
 - c. Parameter tuning
4. Secondary outcome data
 - a. MRI data is primarily available as pre-processed ROIs
 - b. Follow-up analyses only recruited small sub-set of full sample

CURRENT ISSUES



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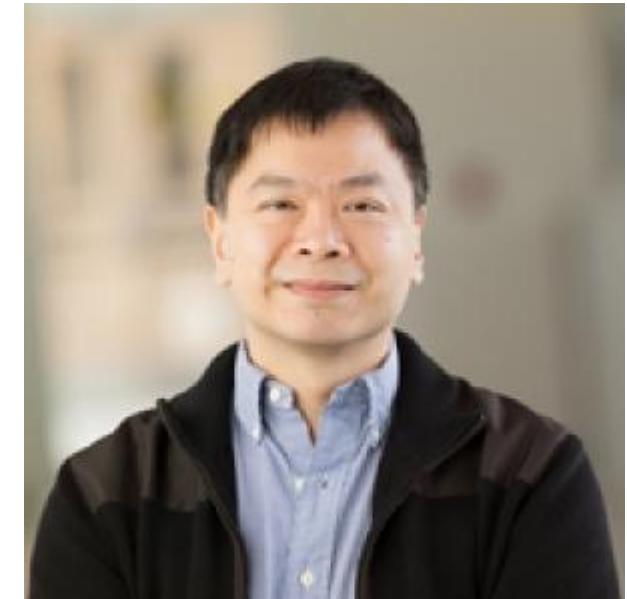
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