Please mute your mic upon entering the room

July 23, 2022 (Saturday) 10:00 am – 1:00 pm

by Dr Guang Ouyang, Assistant Professor, Faculty of Education, The University of Hong Kong

EEG + AI

Workshop & Competition

July 23, 2022 (Saturday) 10:00 am – 1:00 pm

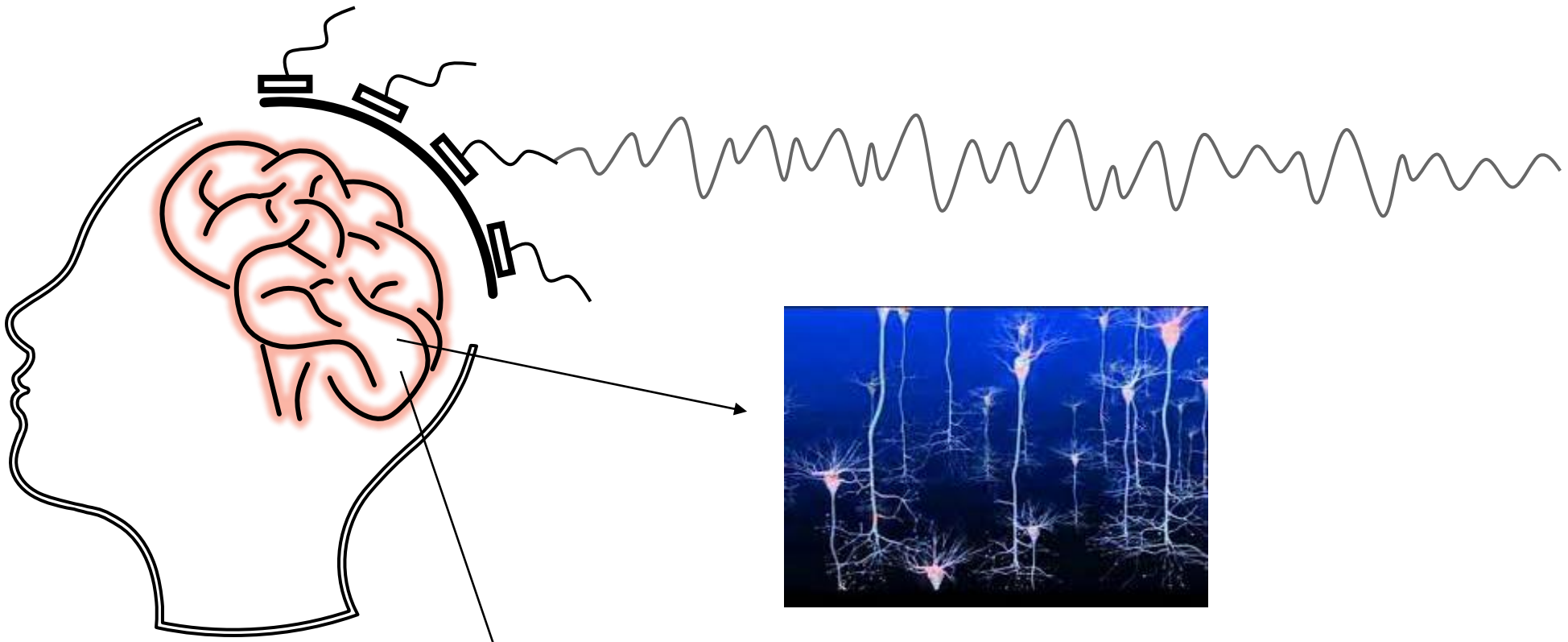
by Dr Guang Ouyang, Assistant Professor, Faculty of Education, The University of Hong Kong

Outline

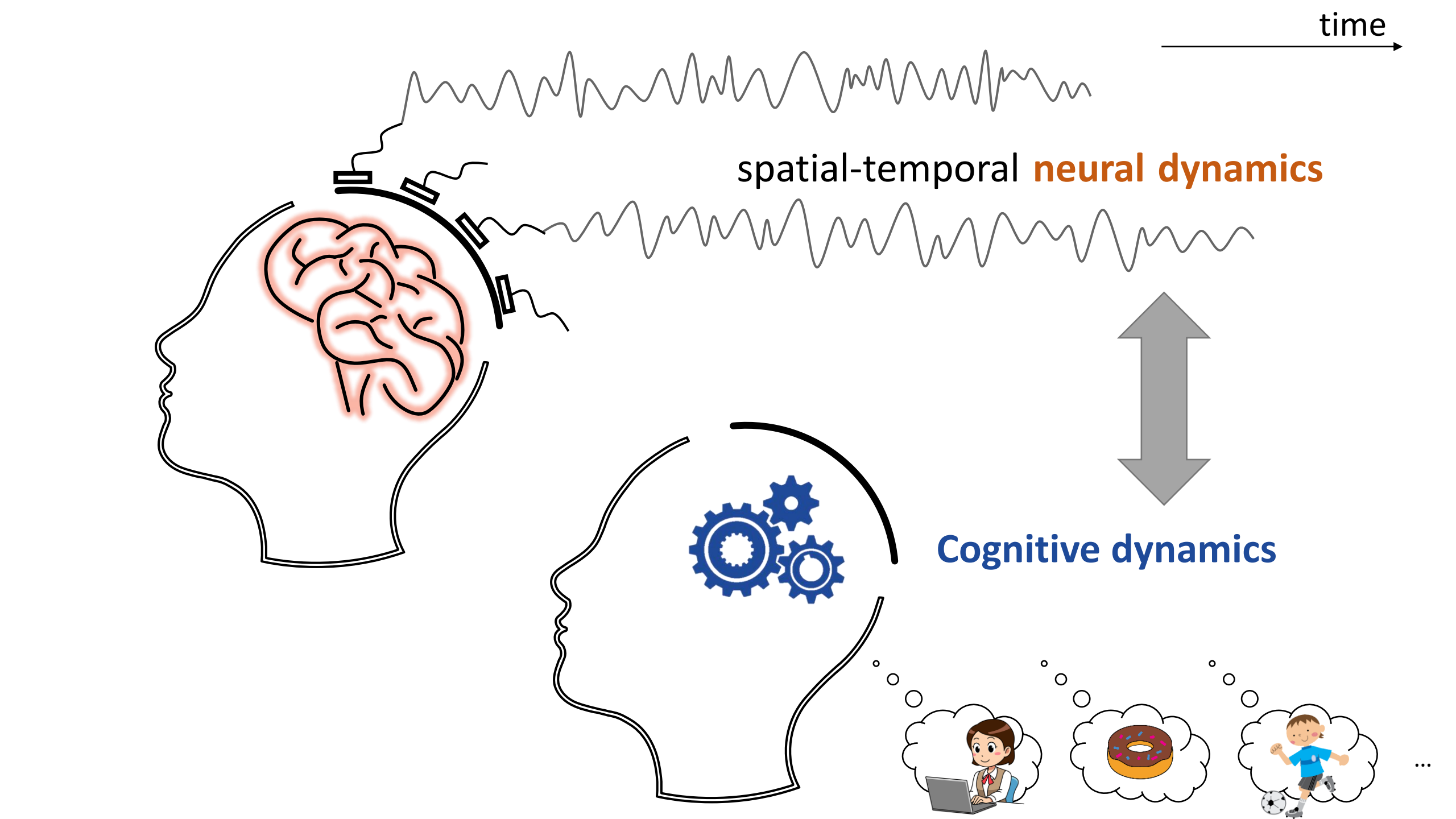
- EEG Basics (1.5 hours)
- Basic concepts of AI and its application on EEG (0.5 hours)
- Details and tips about the competition event (0.5 hours)
- Q&A (0.5 hours)

Previous EEG workshop (4 hours)
https://www.youtube.com/watch?v=OYNw87lGcZM

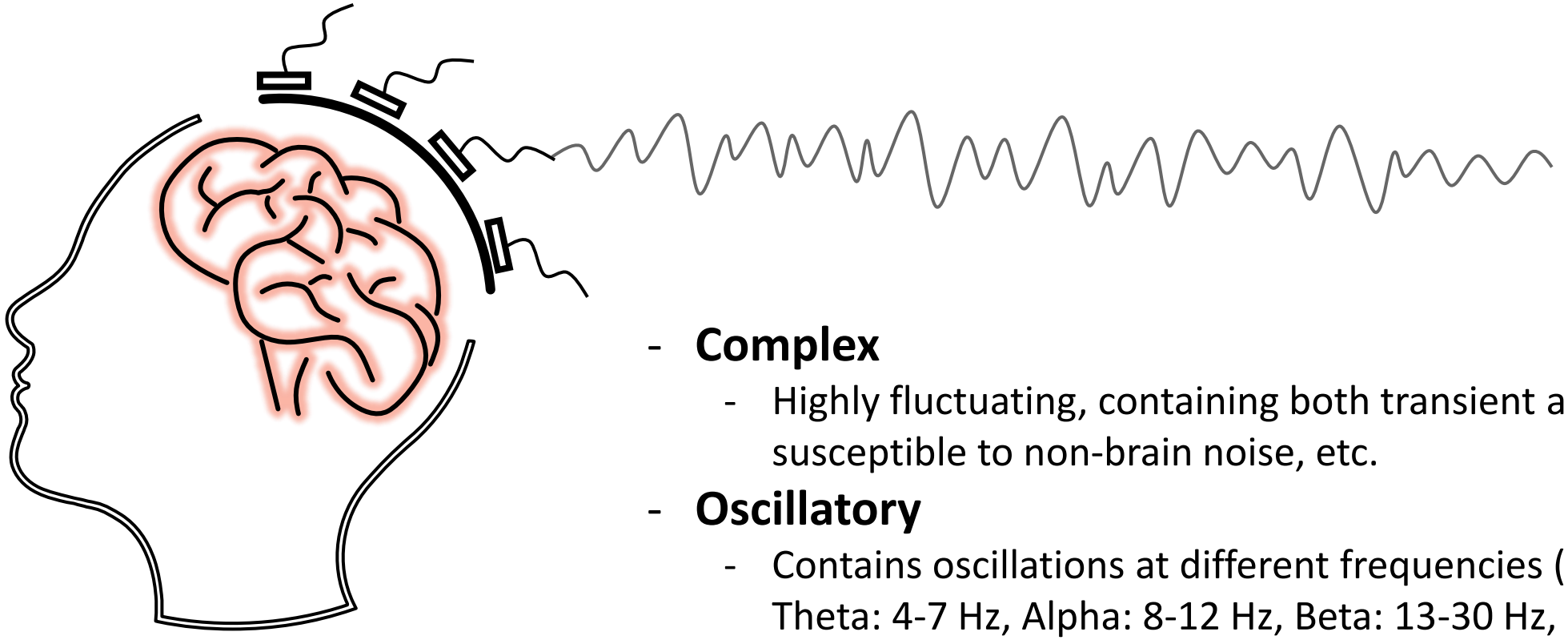
EEG (Electroencephalography)



fMRI (neurovascular activity, or hemodynamics)

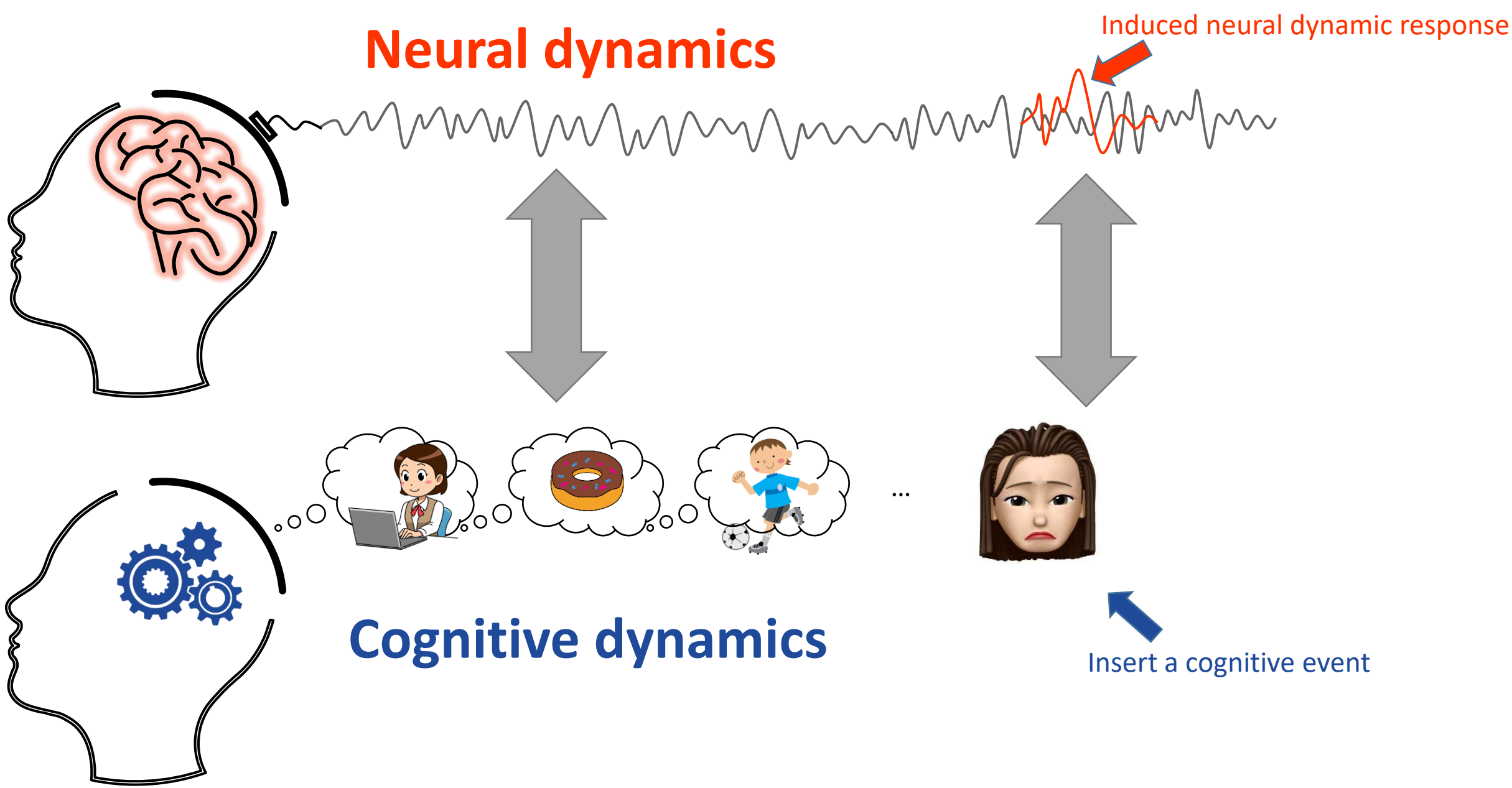

time
spatial-temporal neural dynamics
Cognitive dynamics
...

Features of EEG data on a coarse level

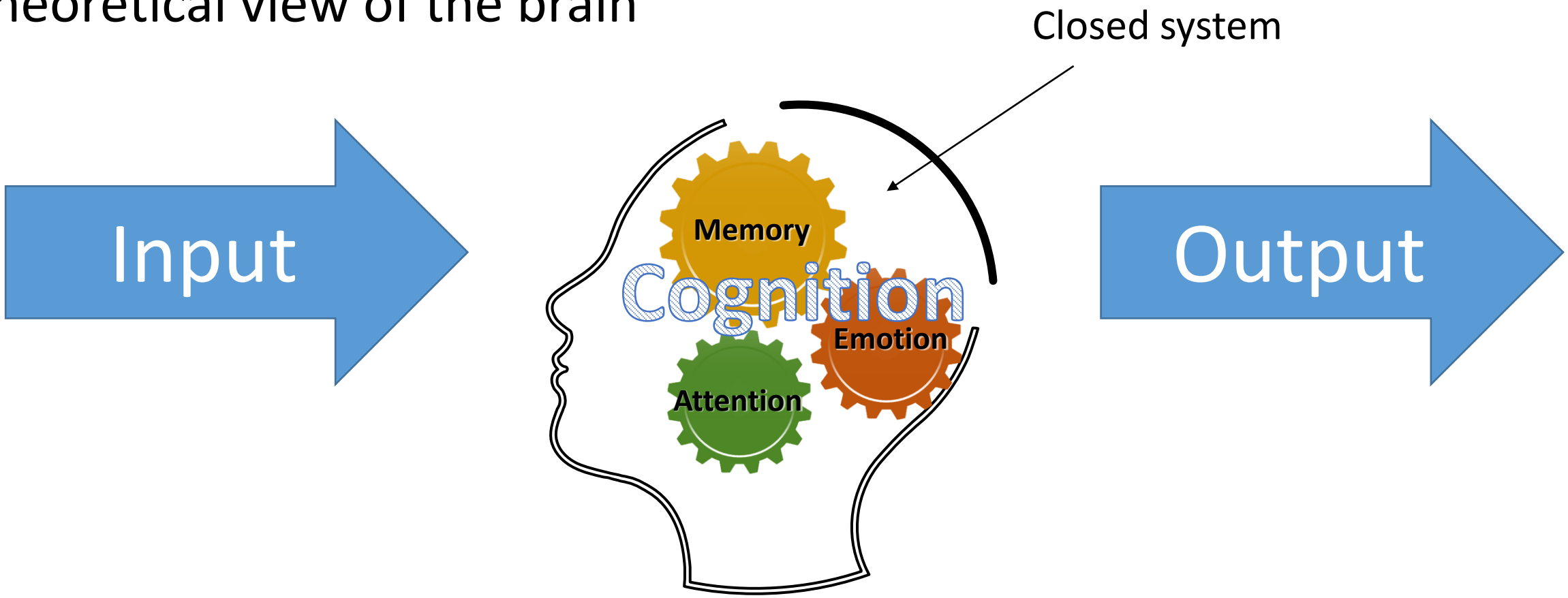


- **Complex**
  - Highly fluctuating, containing both transient and stationary signals, susceptible to non-brain noise, etc.
- **Oscillatory**
  - Contains oscillations at different frequencies (Delta: below 3 Hz, Theta: 4-7 Hz, Alpha: 8-12 Hz, Beta: 13-30 Hz, Gamma: above 30 Hz)

How to extract information related to cognitive activity?


Neural dynamics
Induced neural dynamic response
...
Cognitive dynamics
Insert a cognitive event

Theoretical view of the brain



Other (newer) views: embodied cognition, grounded cognition, sensorimotor contingency, etc

Perturb and observe method

pendulum

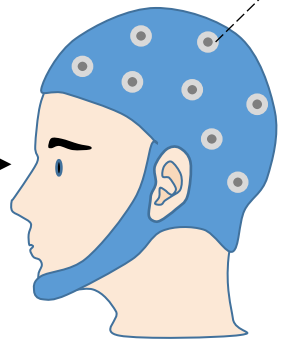
hit

x

time

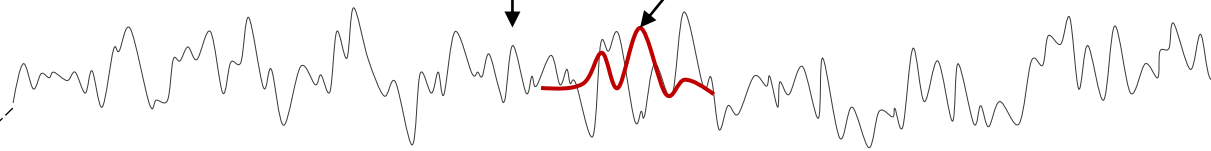
Response pattern

hit

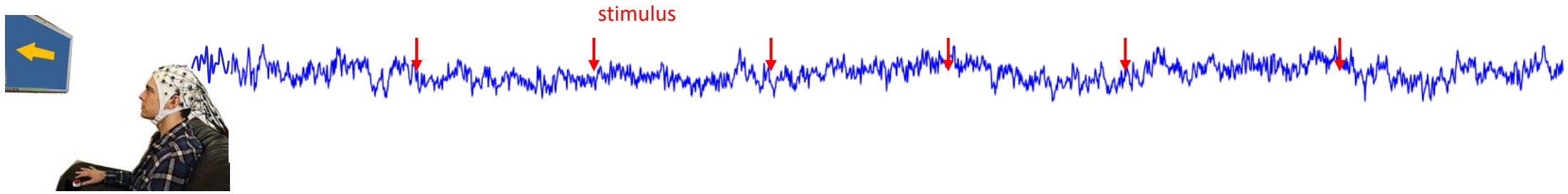


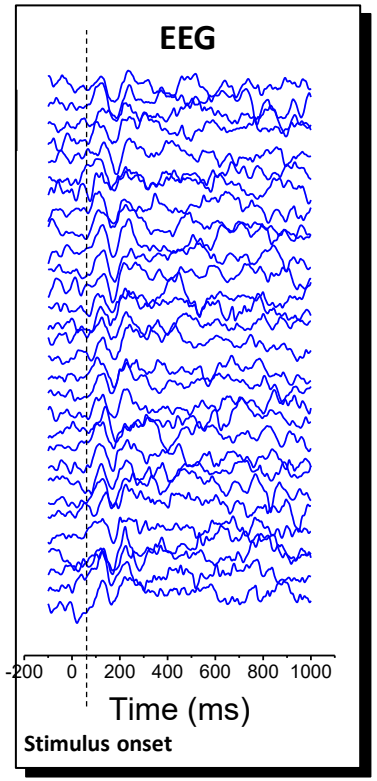
stimulus

Evoked response activity

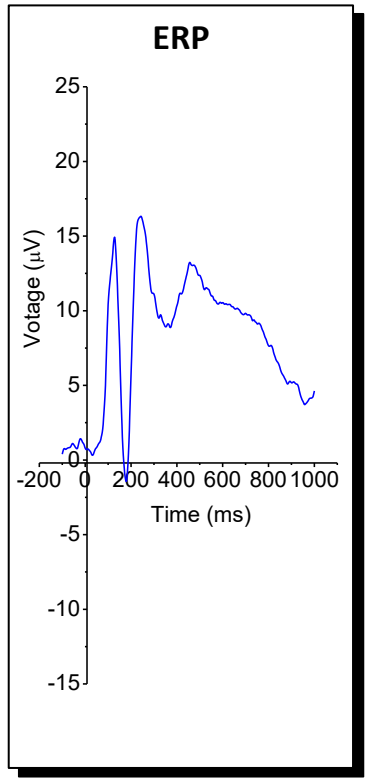


Perturb-and-observe method (ERP method)



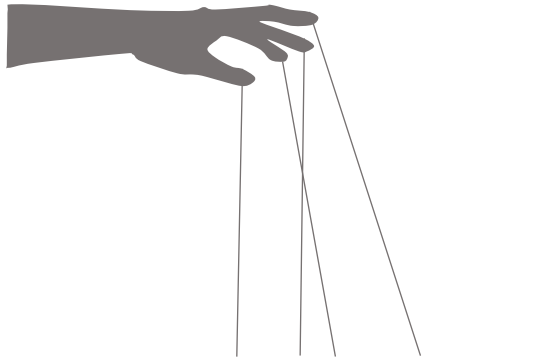


average

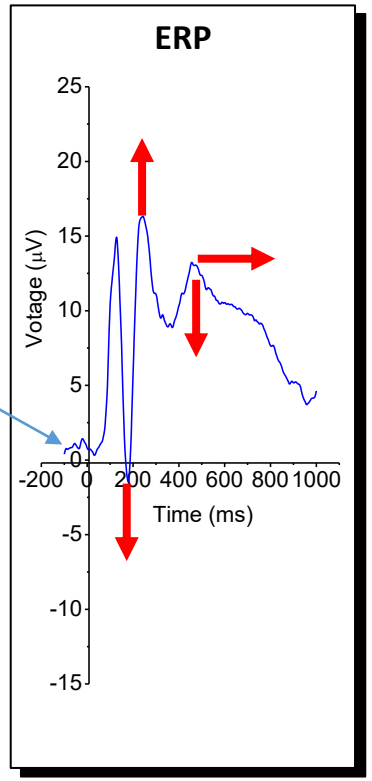


ERP (Event-related Potential)

Perturb-and-observe method (ERP method)



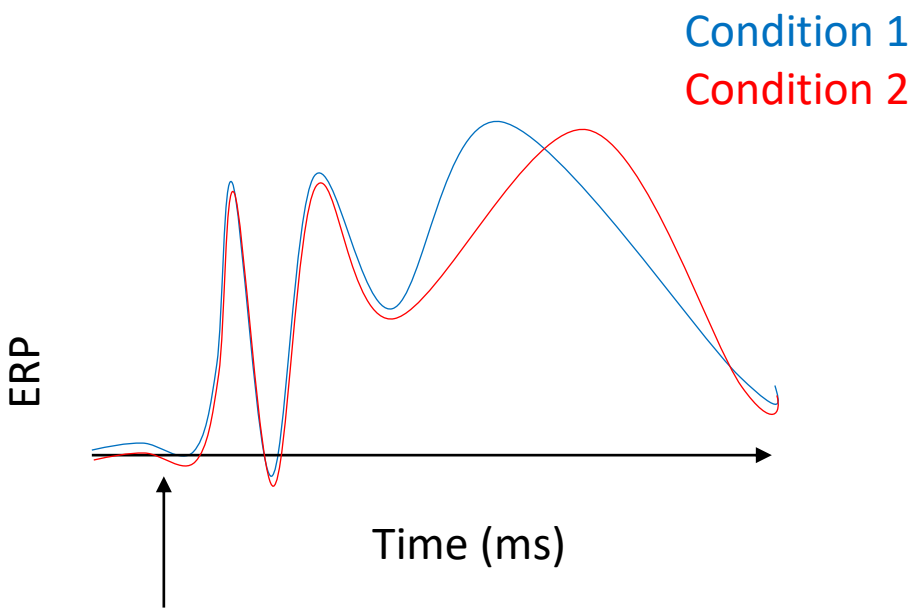
Stimulus



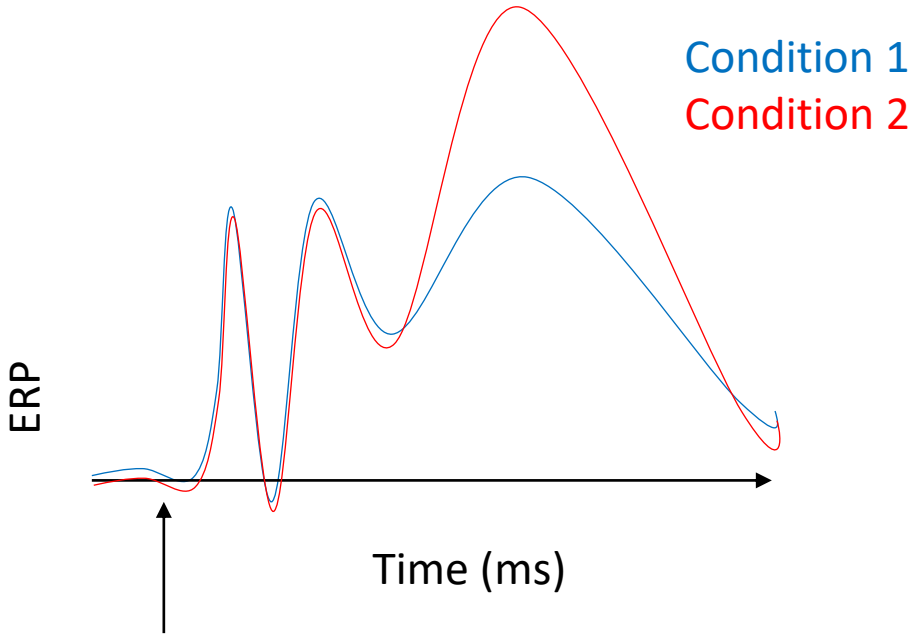
ERP (Event-related Potential)

Perturb-and-observe method (ERP method)

Change in timing
(reflects cognitive processing speed)

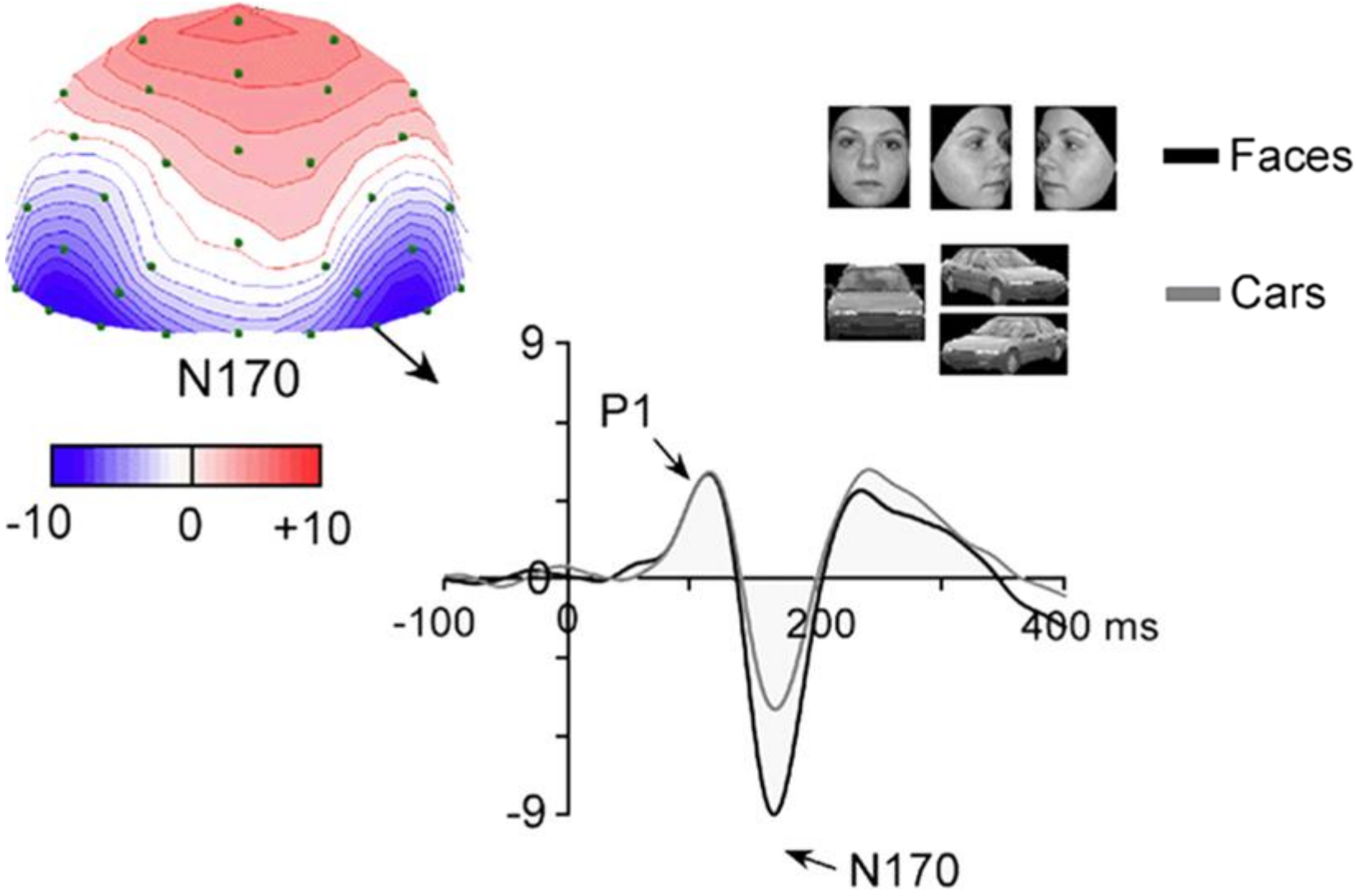


Change in amplitude
(reflects cognitive effort)



Using ERP method to link mind and brain

Example: The brain responds differently to faces and cars



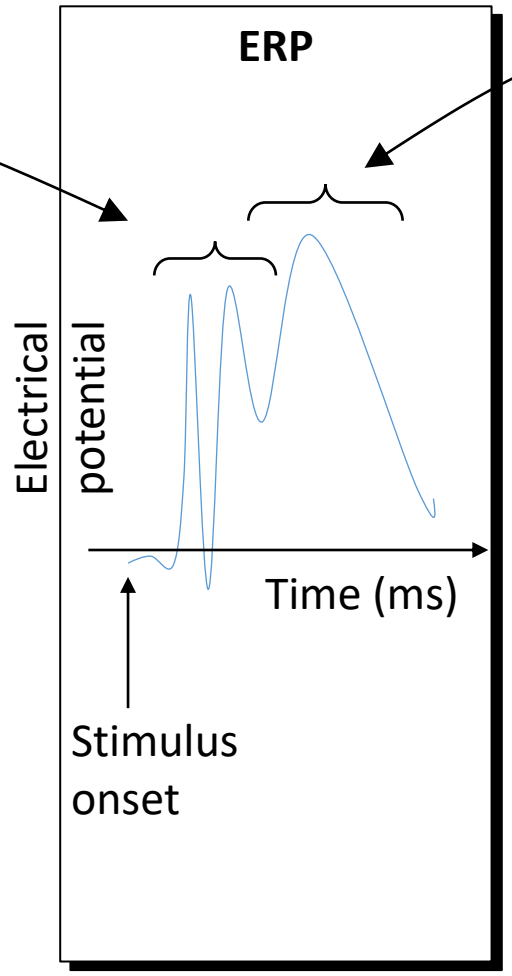
Rossion, B., & Jacques, C. (2008).

Perturb-and-observe method (ERP method)

How ERP components reflect cognitive activity?

Early components

- Low level processing, e.g., size, luminance, sound intensity, etc
- Sometimes by top-down modulation, e.g., emotion, attention, etc.

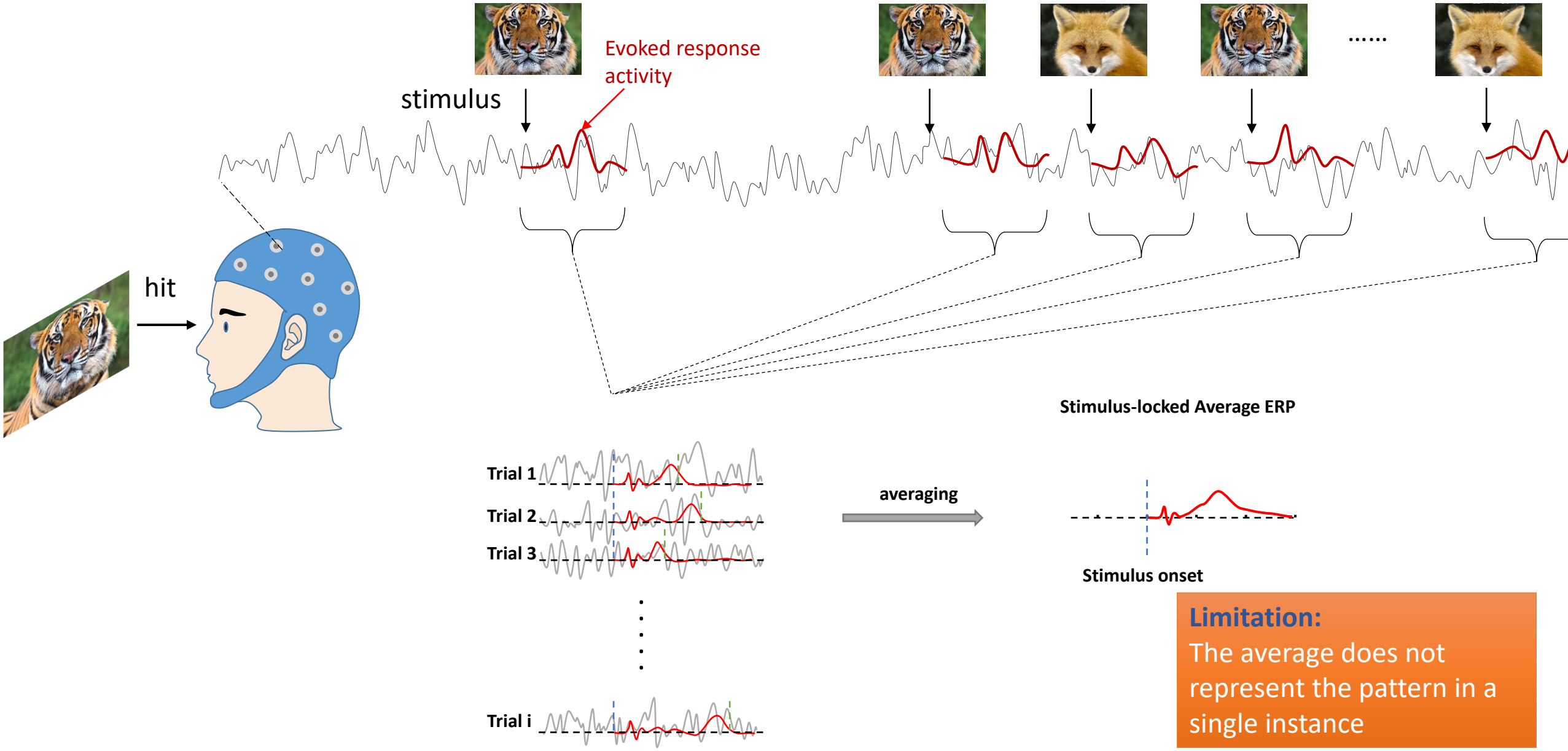


Late components

- Medium-to-high level processing, e.g., conflict processing, surprises, emotion, memory recollection, etc.

ERP (Event-related Potential)

Limitation of ERP method



Limitation:
The average does not represent the pattern in a single instance

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What is AI?

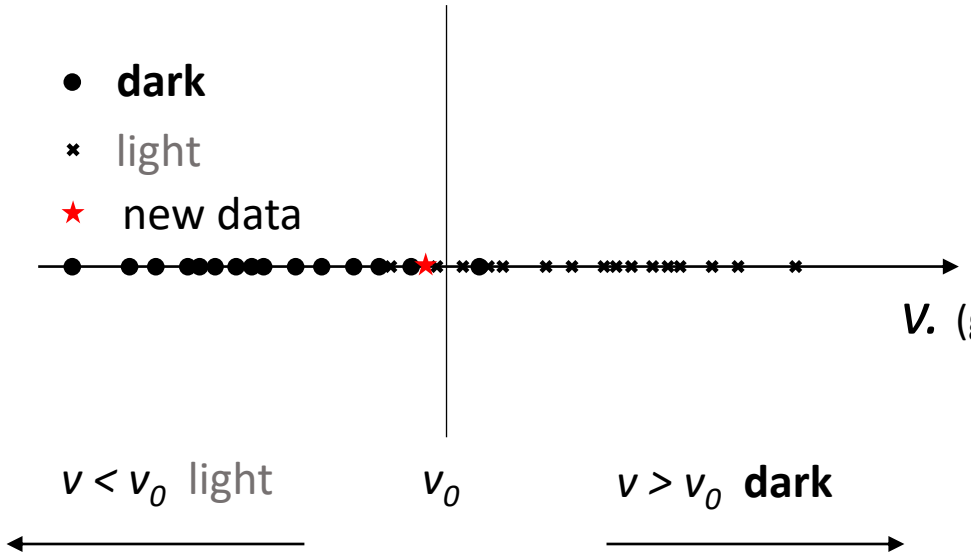
Artificial intelligence

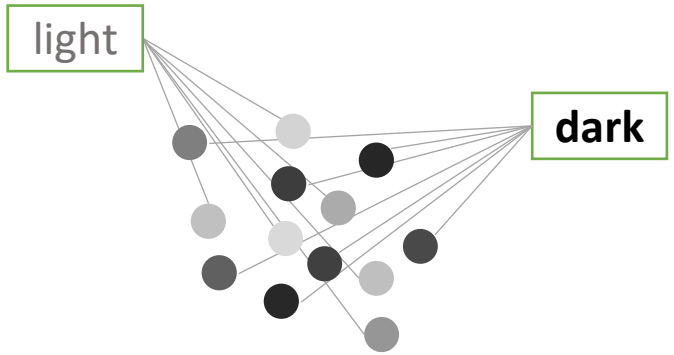
- **have learning ability**
- constantly evolving and improving
- often not fully understood (even by the developer)
- often not fully predictable

algorithms

Learning and recognition

One-dimensional data:

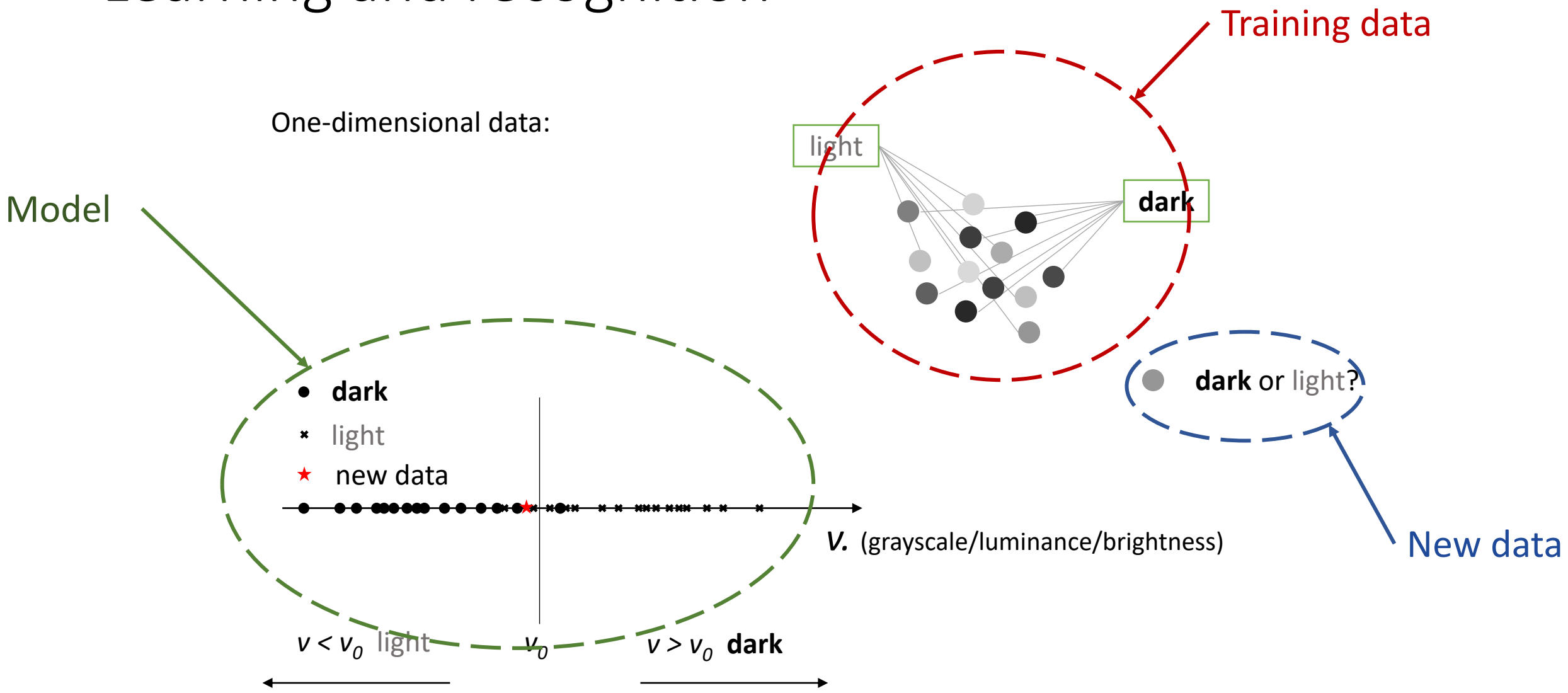




dark or light?

V. (grayscale/luminance/brightness)

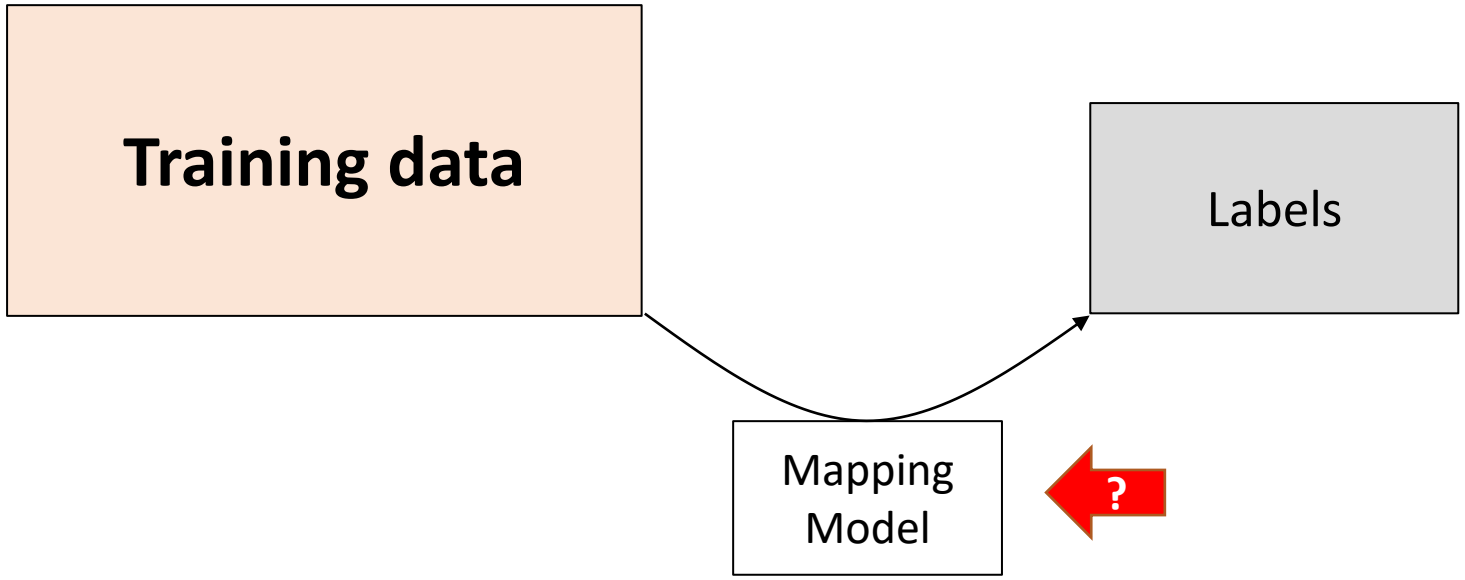
Learning and recognition



Machine learning

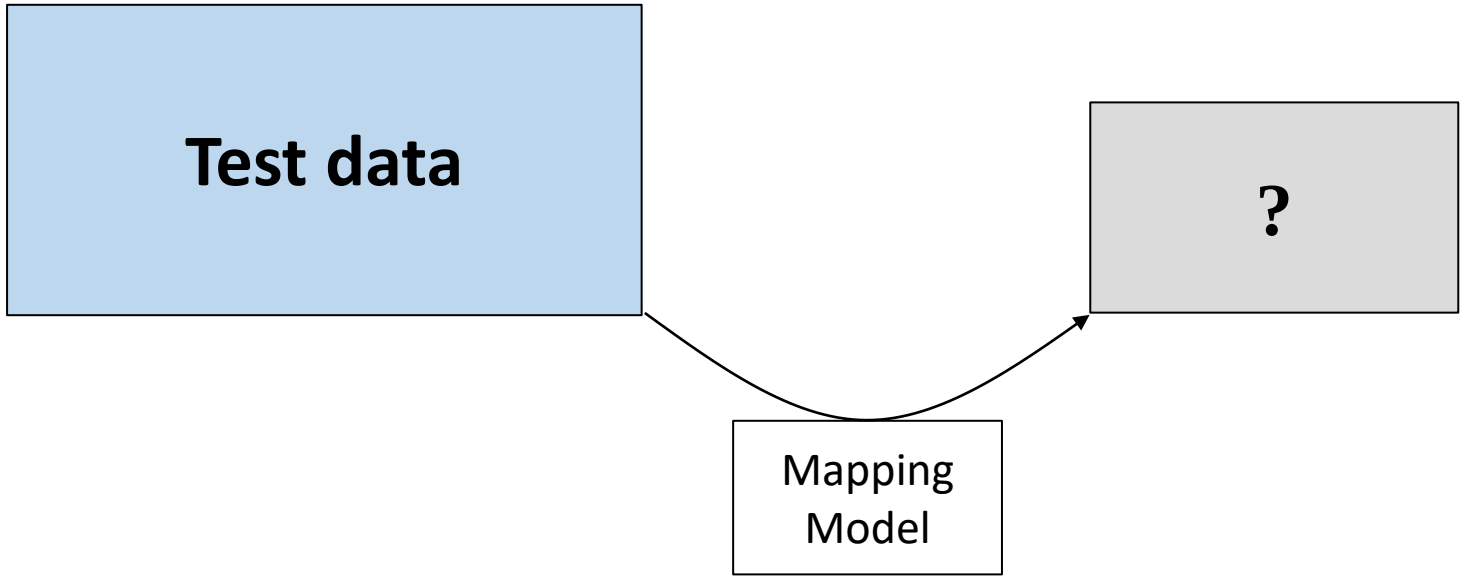
Learning

Training



Recognition

Prediction, classification, Etc



Machine learning

Raw data
photos, videos, sound, …

Mapping model
prediction,
recognition,
classification,
information
refinement/compression,
generation

Labels
semantic information
categorical information

tiger

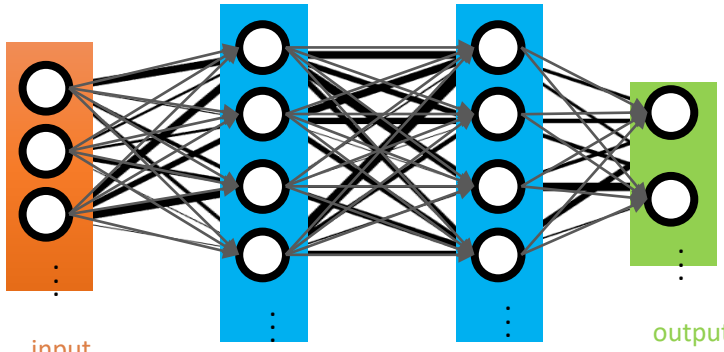
apple

A cute corgi lives in a house made out of sushi.

cat dog dog cat dog dog cat dog dog dog cat dog ....

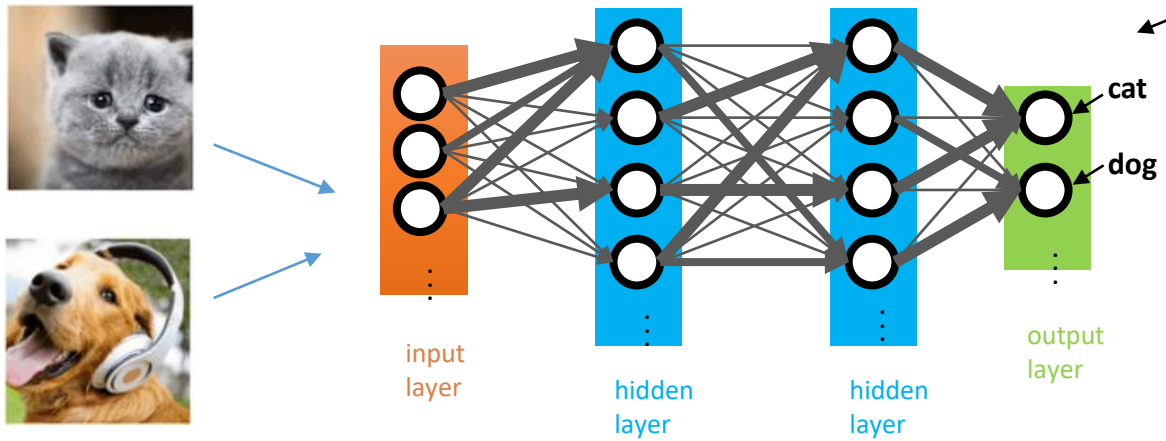
.....

feed for training



Can have many hidden layers

after training



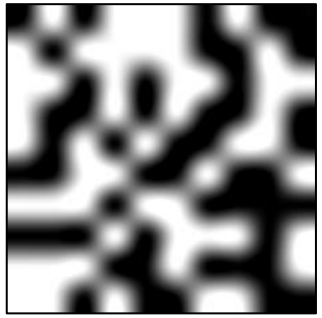
P(cat) = 0.954
P(dog) = 0.006

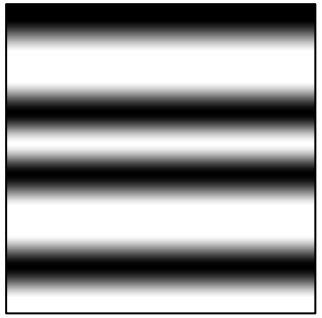
P(cat) = 0.079
P(dog) = 0.921

Can have many hidden layers

Demonstration

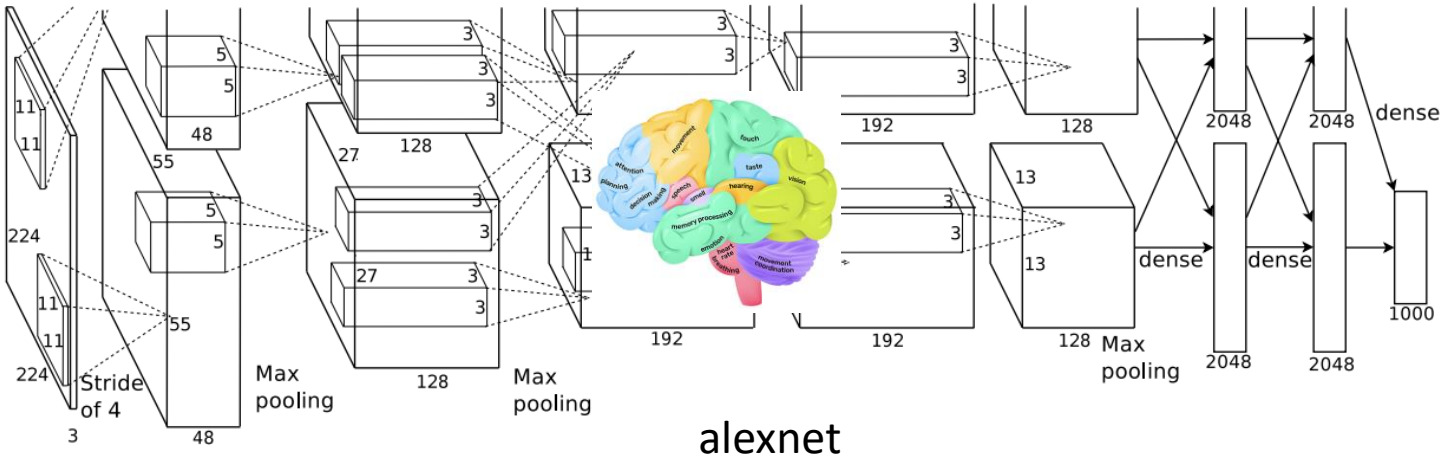
→ Take hours to train





→ Take minutes to train

input



alexnet

output

Code available:
https://github.com/guangouyang/data_handling_workshop/tree/main/task6

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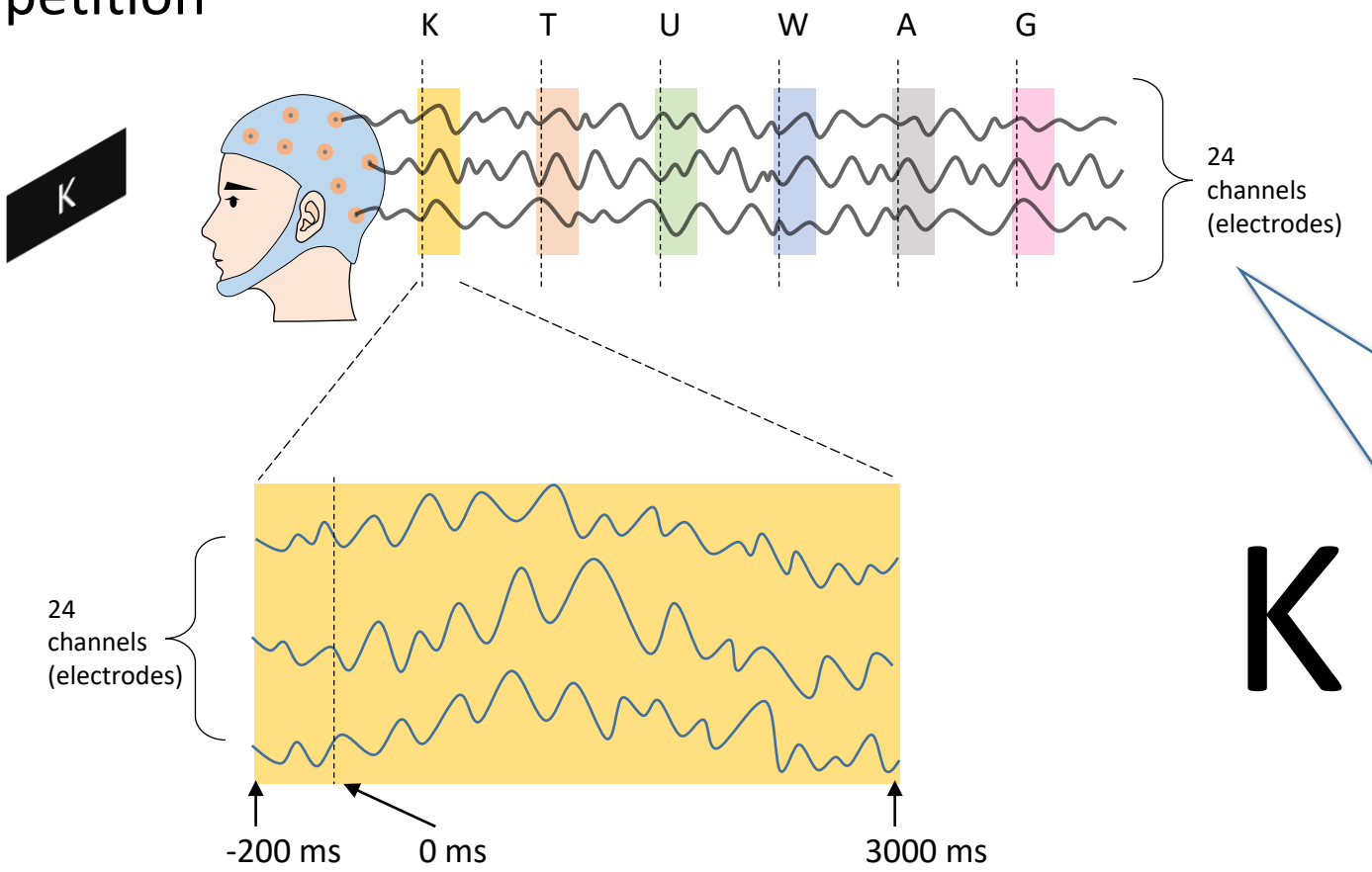
Dataset for the competition



collected by

mbt

https://mbraintrain.com

K

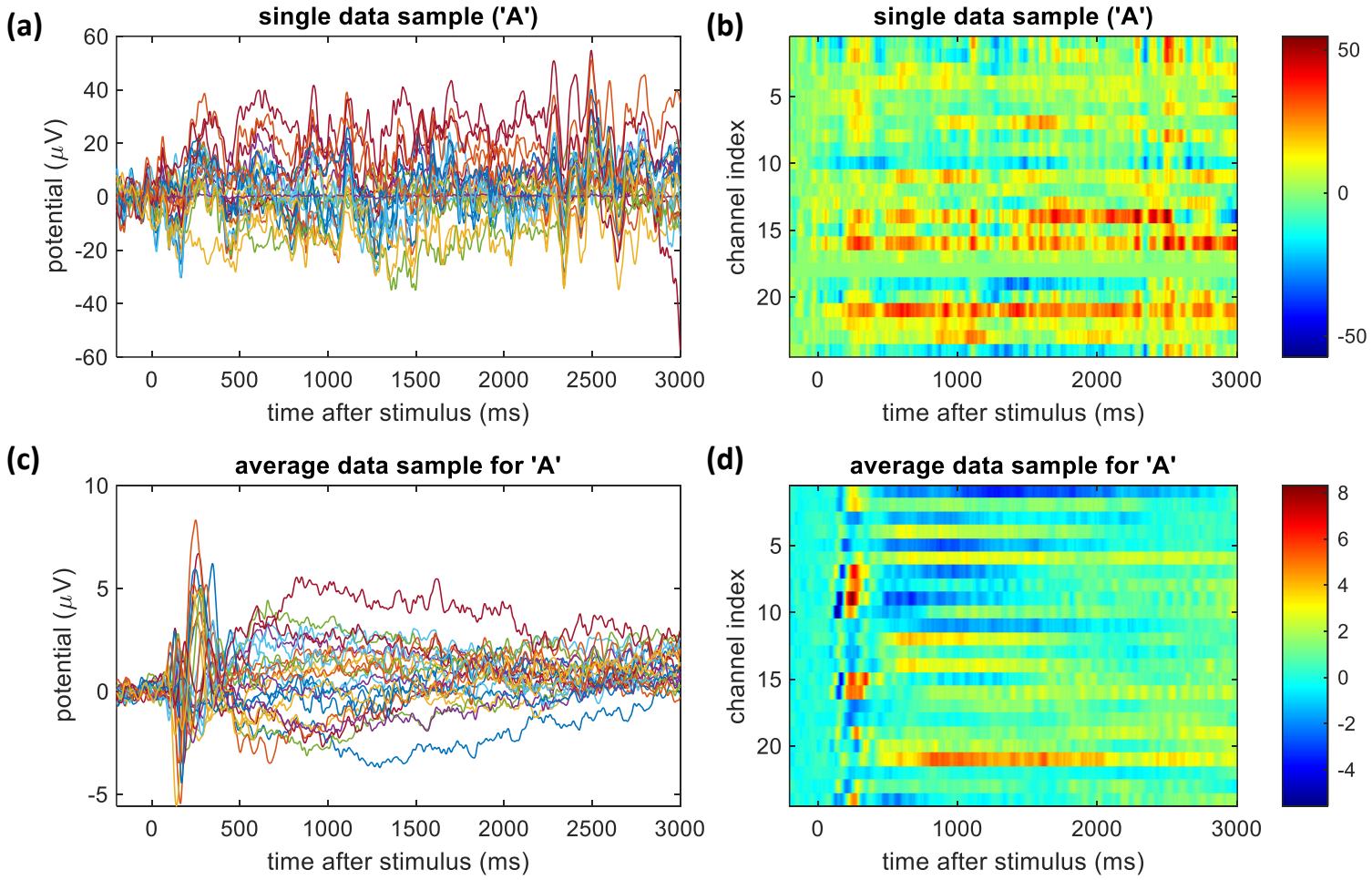
data

- 3d array (24*801*7800, electrodes*time points*samples)
- Each sample is a 2d matrix (24*801, electrodes*time points)
- 7800 data sample (300*26)
- Each alphabet has 300 samples

label

- 1d vector (7800*1)
- Value: 1-26, representing the index of alphabets

Dataset for the competition



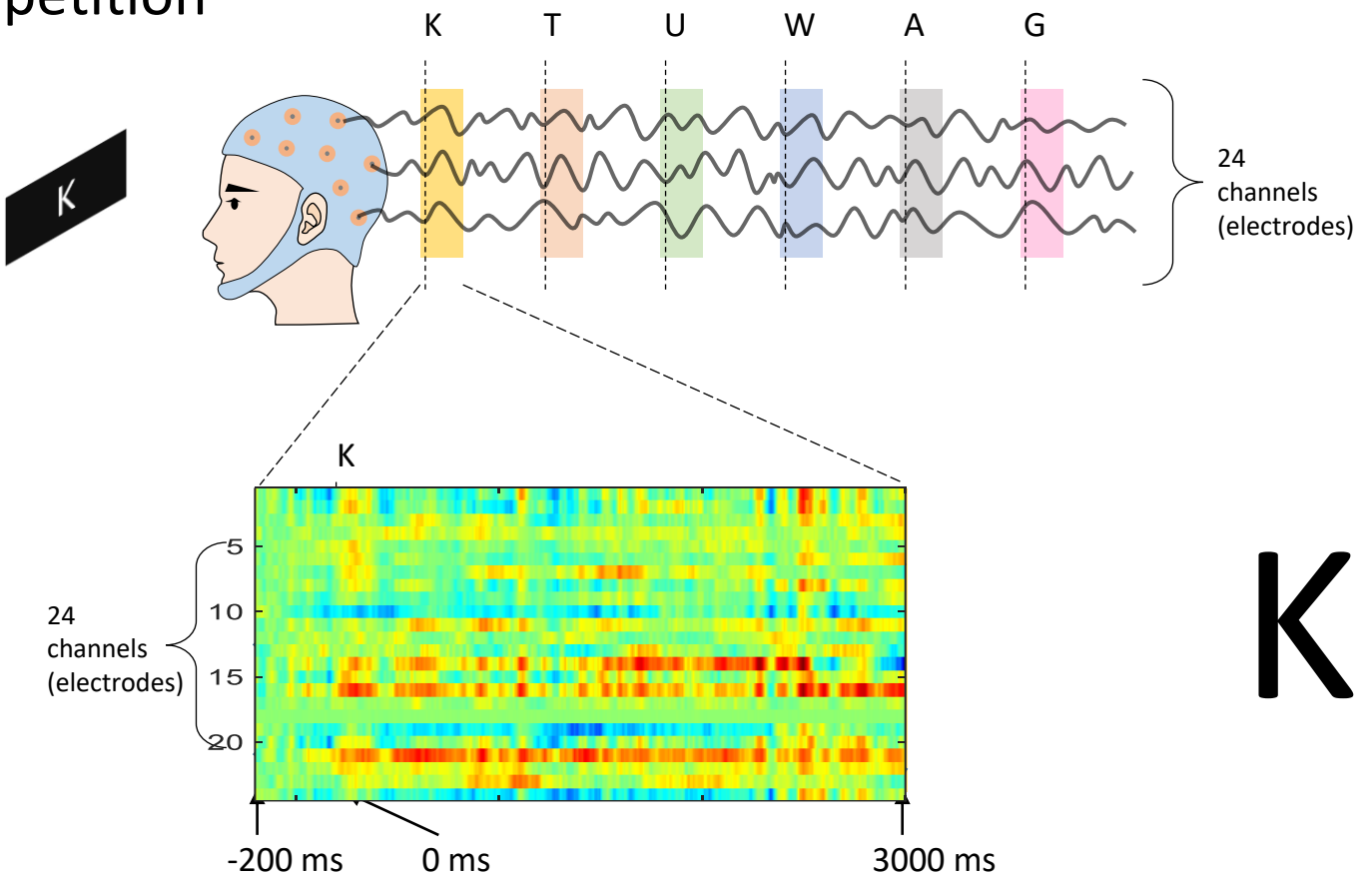

```
figure;
plot(time_points,data(:,:,1)');
xlabel('time after stimulus (ms)');
ylabel('potential (\muV)');
title('single data sample (''A'')');

figure;
imagesc(time_points,1:24,data(:,:,1));
colormap(jet);colorbar;
xlabel('time after stimulus (ms)');
ylabel('channel index)');
title('single data sample (''A'')');

figure;
plot(time_points,mean(data(:,:,label==1),3)');
xlabel('time after stimulus (ms)');
ylabel('potential (\muV)');
title('average data sample for ''A''');

figure;
imagesc(time_points,1:24,mean(data(:,:,label==1),3));
colormap(jet);colorbar;
xlabel('time after stimulus (ms)');
ylabel('channel index)');
title('average data sample for ''A''');
```

Dataset for the competition



K

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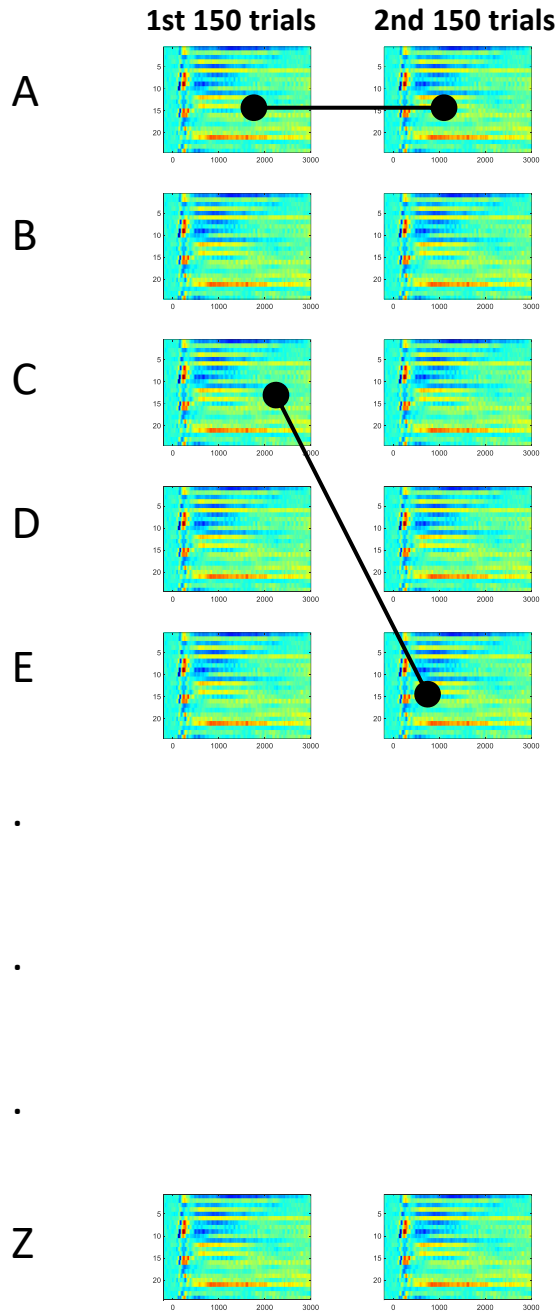
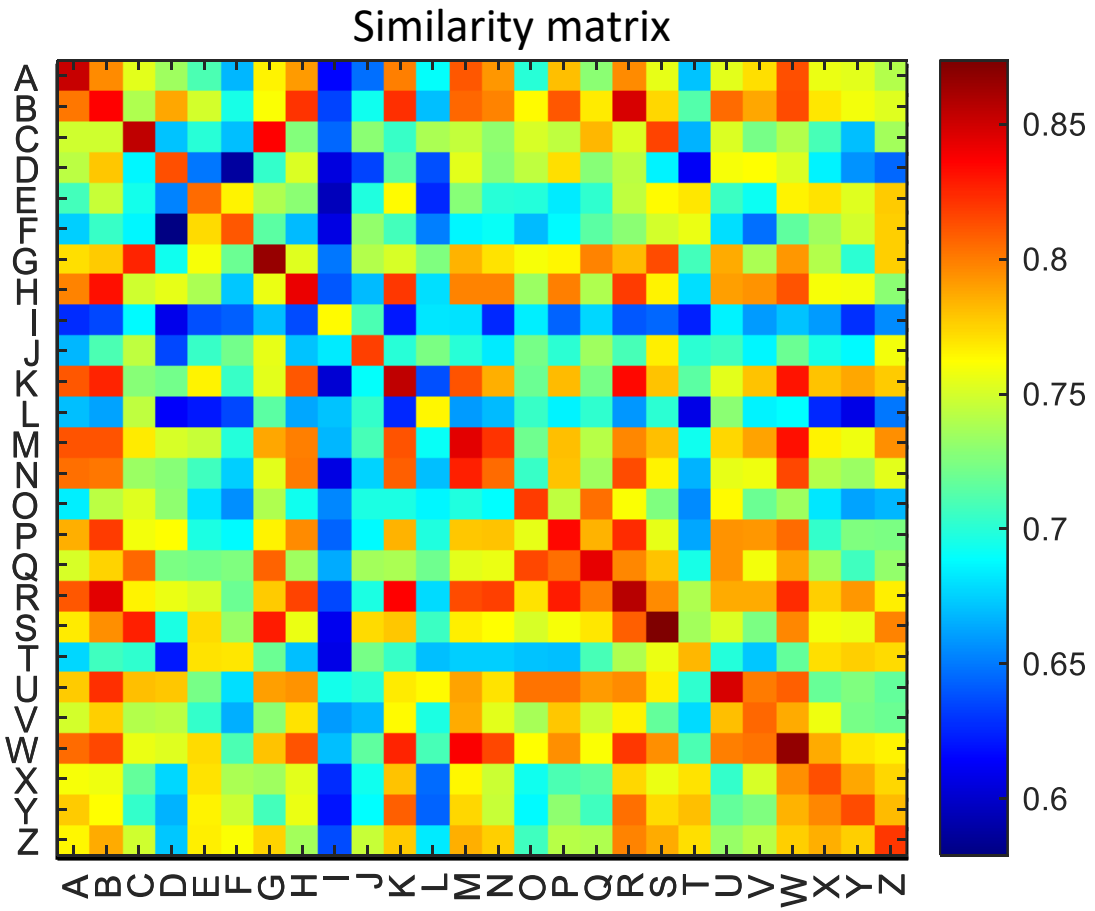


Alphabet-specificity of brain response patterns (ERP)



Tips and requirement

- Self-customized convolutional neural network (no necessarily use the alexnet)
- Self-customized recurrent neural network
- Established nets (e.g., Alexnet); image size mis-match issue
- **Lowest chance 3.8%** (Don't hesitate to submit your application when you achieve a slightly better accuracy, e.g., 8%, 10%, 15%, 30%; you may still get the awards; you never know)
- Try to extract information in different frequency bands (1-50 Hz), e.g., using wavelet transformation
- You may try to extract complex (high-order features), e.g., entropy, etc.
- The accuracy must be on test data (minimum percentage: 10%)

More details about the competition, data, and tips:
https://github.com/guangouyang/EEG_AI_competition/blob/main/competition.pdf

Gold HKD 5000 + a certificate

Silver HKD 2000 + a certificate

Bronze HKD 1000 + a certificate

- **Based on the accuracy your classifier achieves (on test data,** minimum percentage: 10%**)**
- **Submit your demo before September 30, 2022 (Friday)**

(original code and full instruction for implementing the code; if the instruction is not clear, we may require an interview)

- **Must be undergraduate students from universities in Hong Kong**
- **Participate individually or team up with others (max. 3)**

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