RacLab

Decoding and representational dynamics in EEG

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Introduction

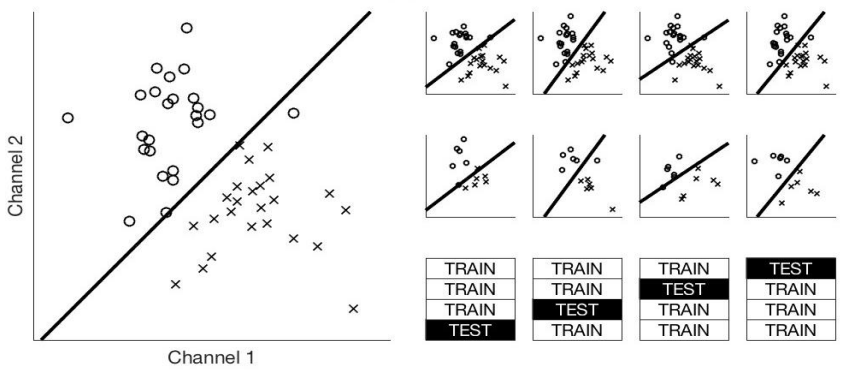
take into account the relationships between multiple variables

{ voxels in fMRI

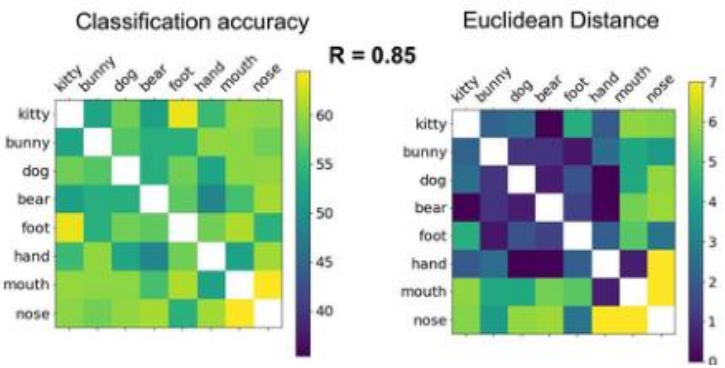
channels in MEG/EEG

- MVPA: Multivariate pattern analysis(多变量模式分析)
  - Decoding: predicting the condition from the data

machine learning classifier

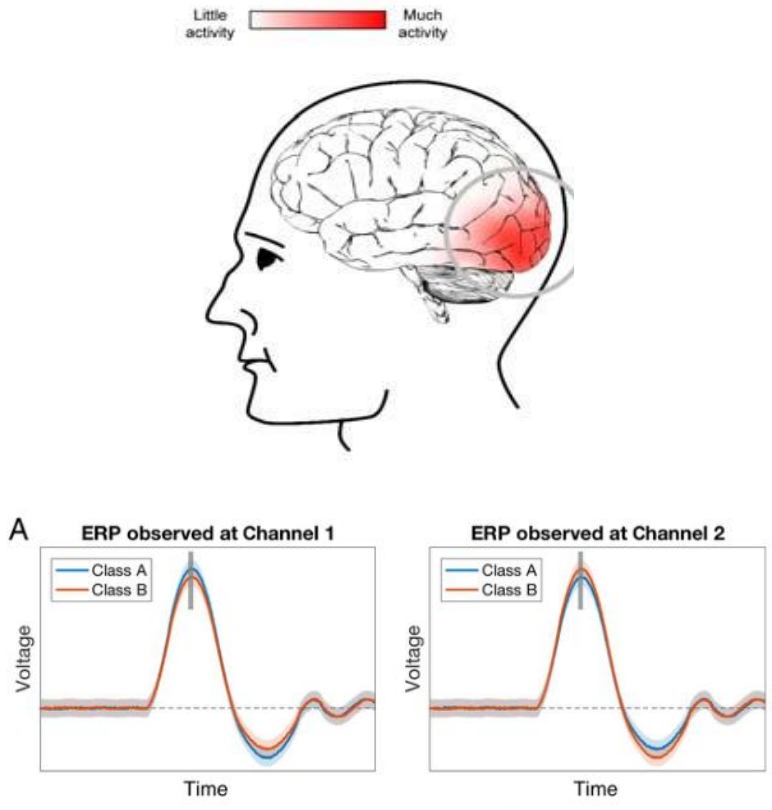


representational similarity analysis



Why MVPA?

- MVPA: Multivariate pattern analysis

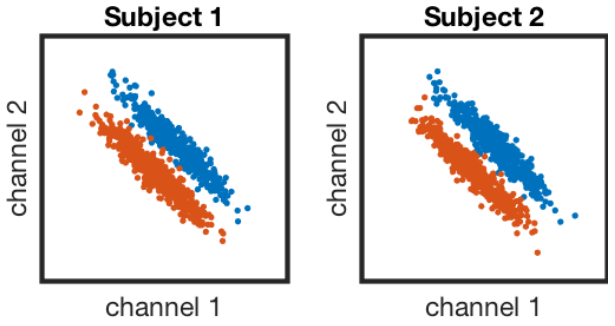


averaged signals

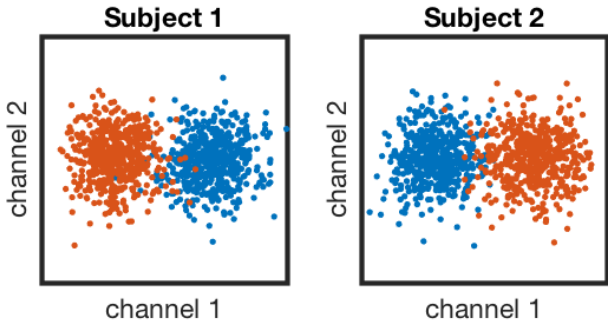
单变量方法依赖于一个或多个通道的平均值，忽略了这些簇中包含的模式中可能表示的信息

Classifiers used in decoding approaches can use information that would not be detected when comparing the averaged signals

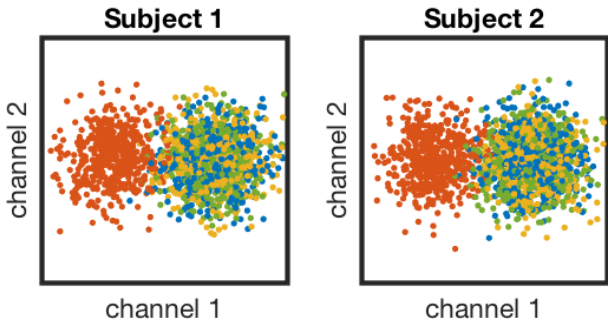
Why MVPA?



- Single variable vs multiple variables
  - No difference between **A** & **B** in either channel
  - Information in the channels about **A** & **B**



- Directional vs non-directional
  - Directional: **A** > **B**
  - Non-directional: **A** ≠ **B**

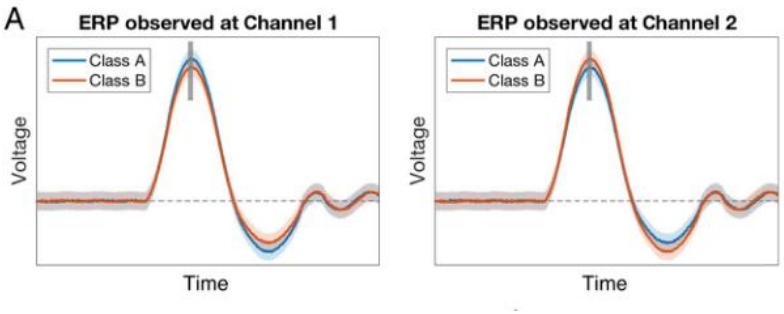


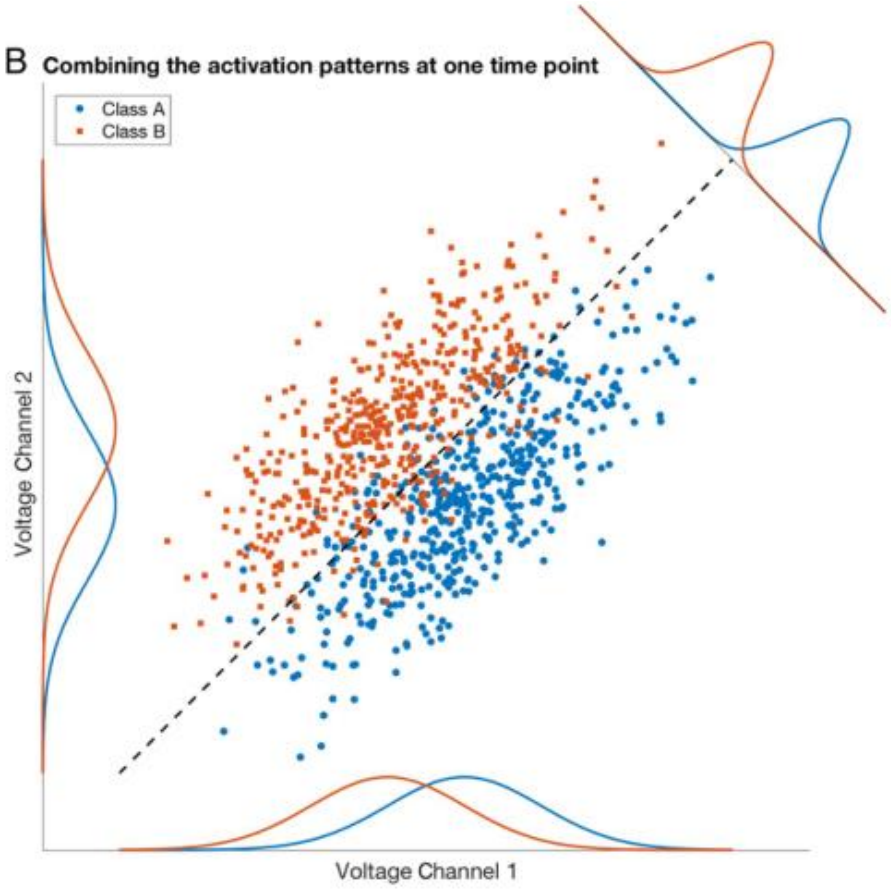
- Activation vs inforAmation
  - Activation: increased response for **B**, **C**, **D**
    - Response reflects **B**, **C**, **D**
  - Information: **A** is different from **B**, **C**, **D**
    - Response encodes information about **A**

cf. Hebart & Baker, 2018, NeuroImage

Introduction

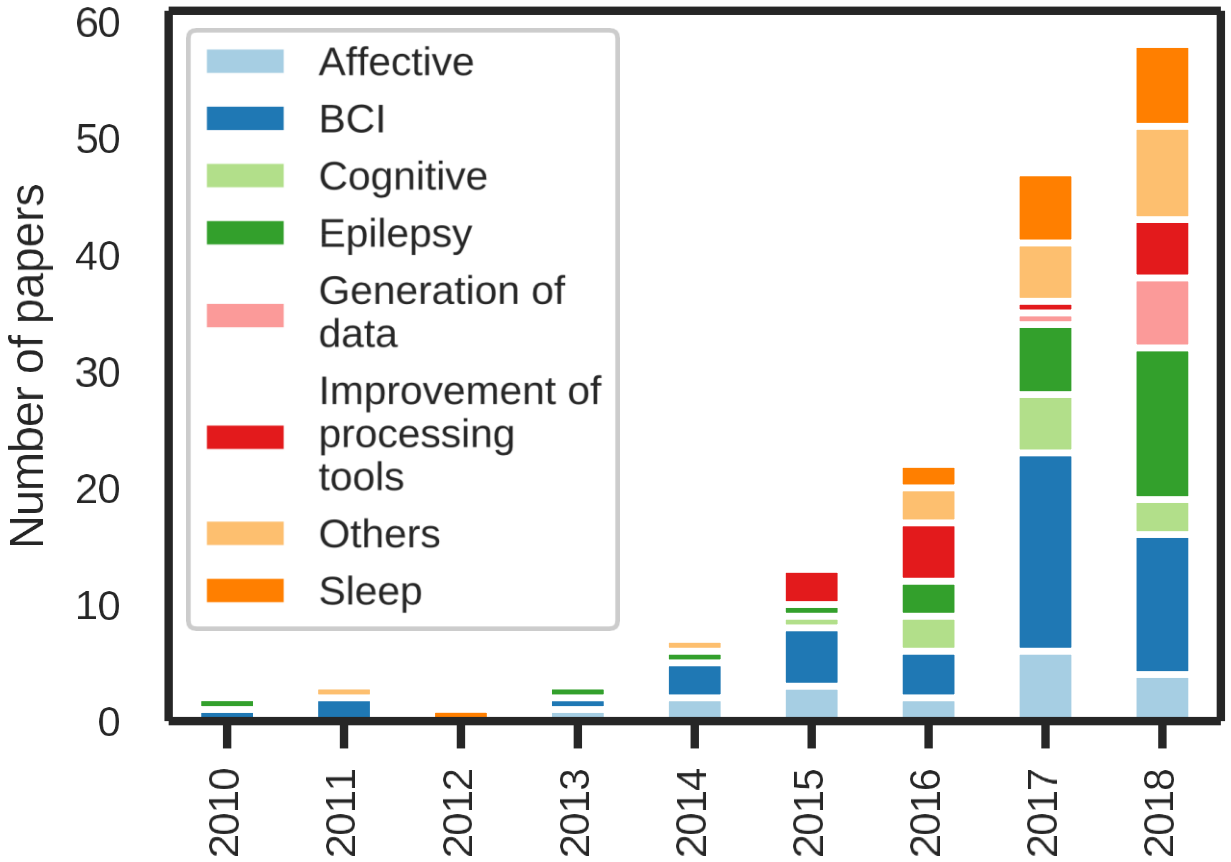
- MVPA: Multivariate pattern analysis





Introduction

- MVPA/decoding well established for fMRI
- Relatively new in MEG/EEG
  - Univariate methods well established
  - Can lead to confusion (cf. Hebart & Baker 2018)



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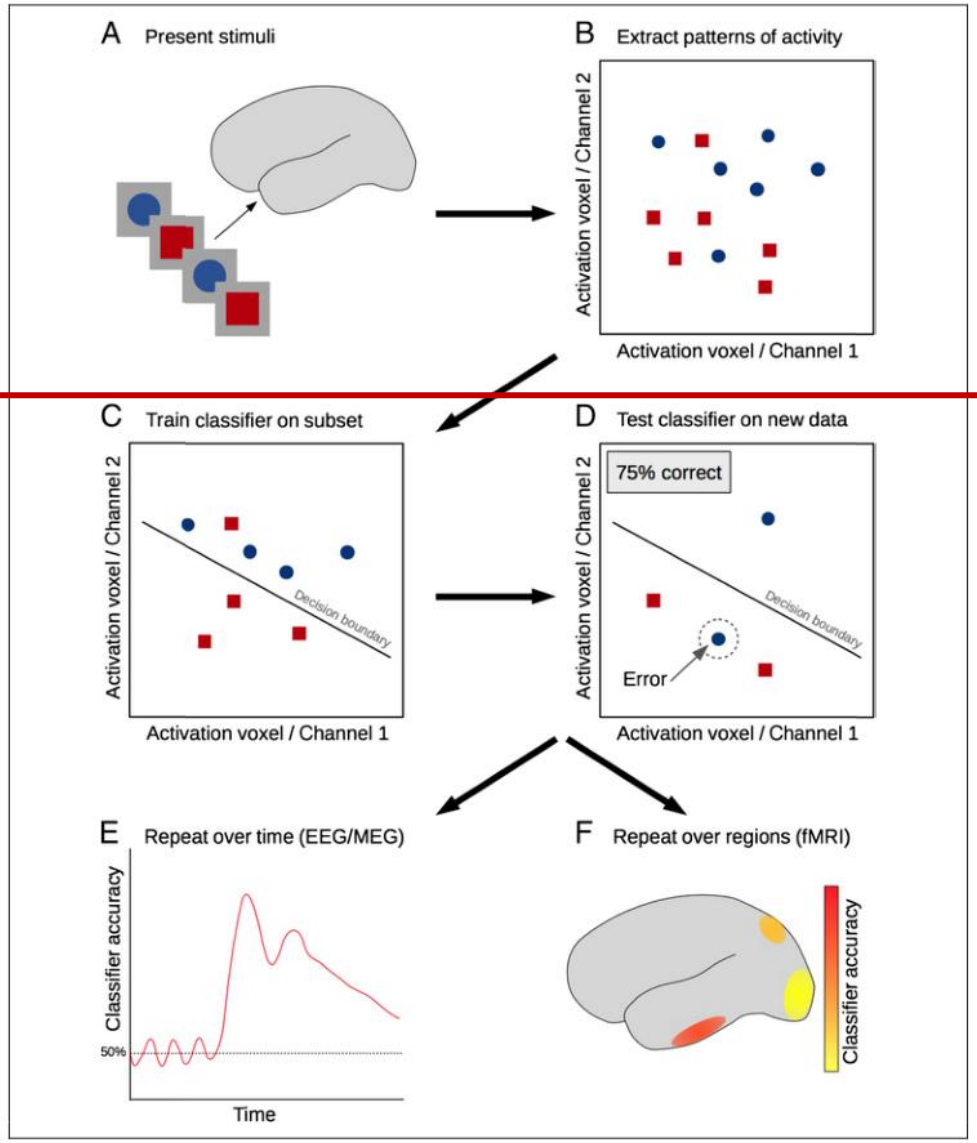

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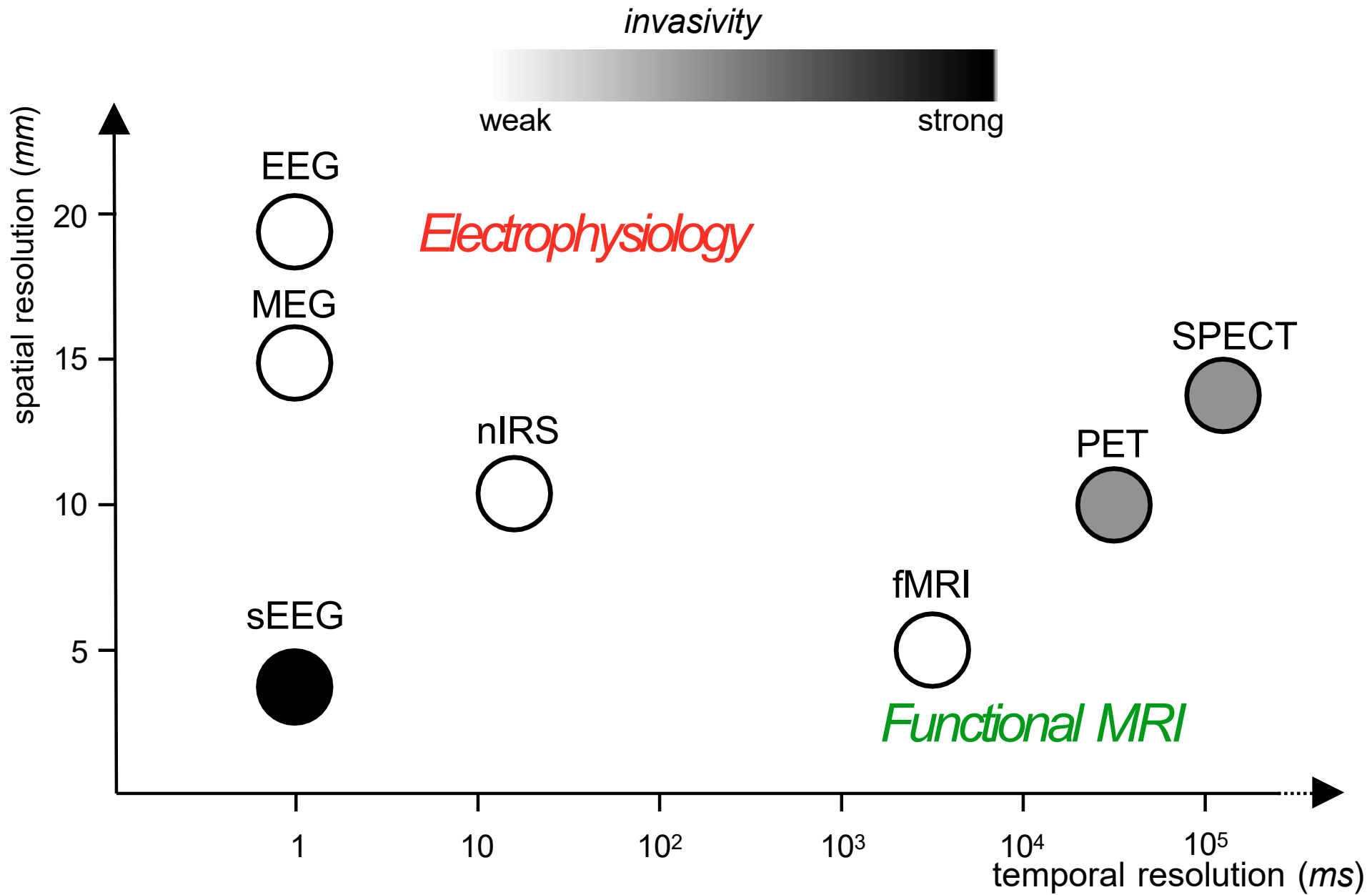

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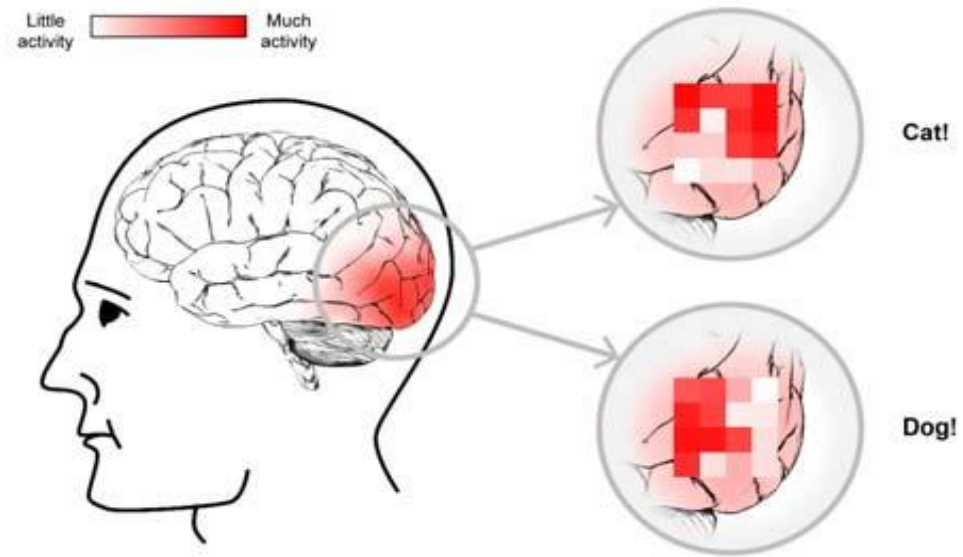

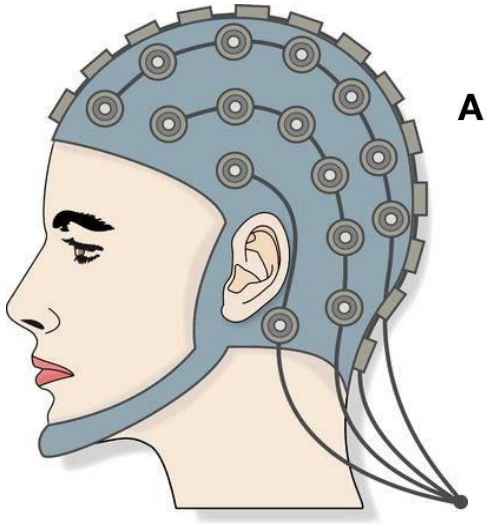

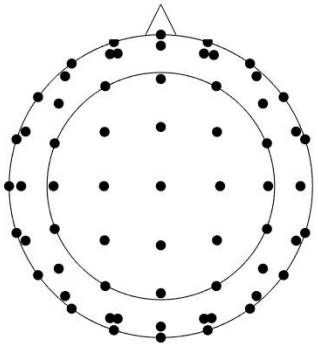

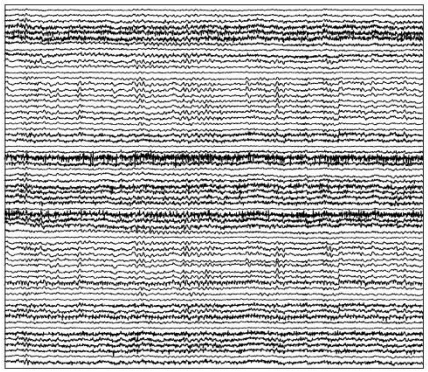

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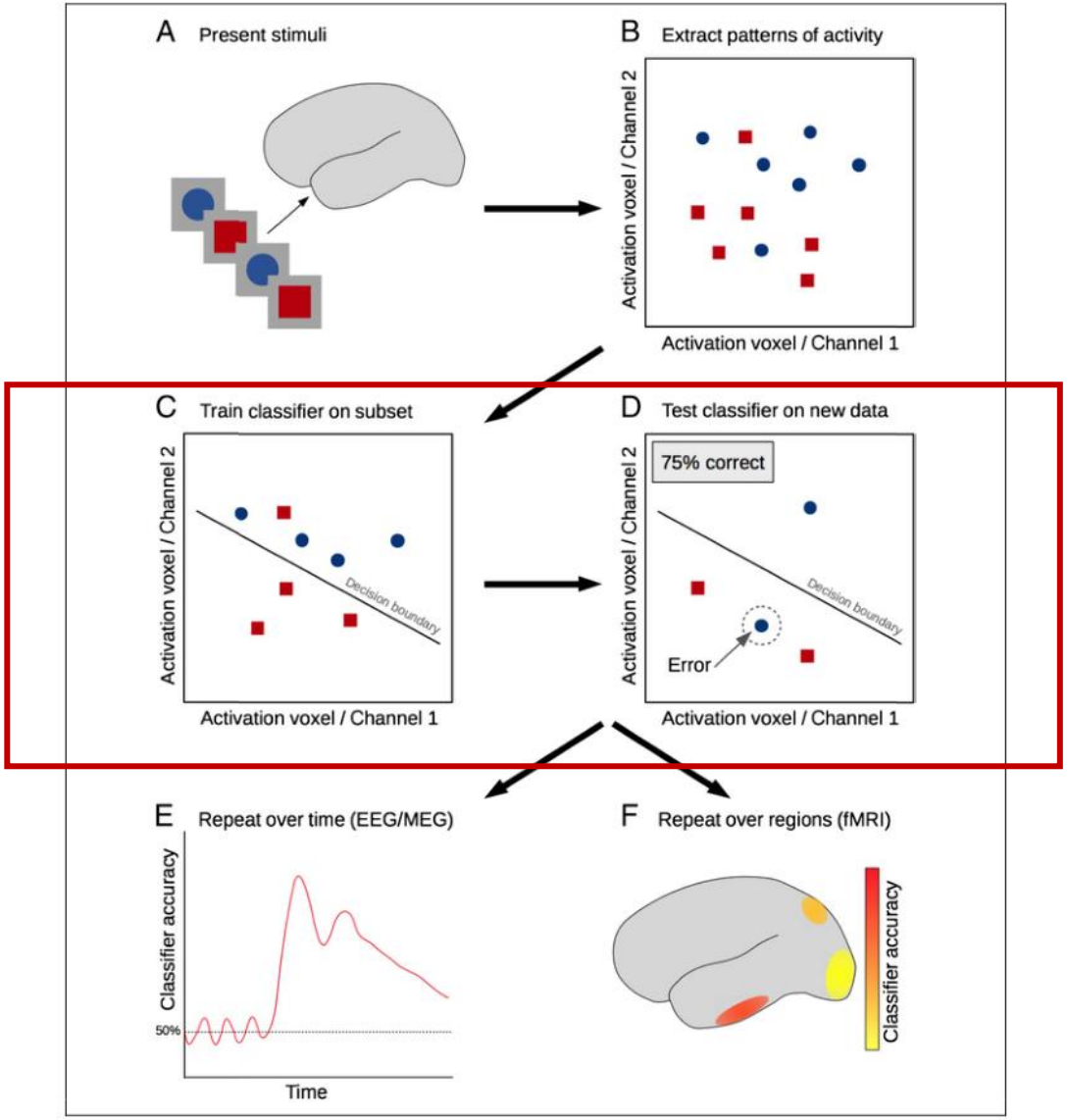
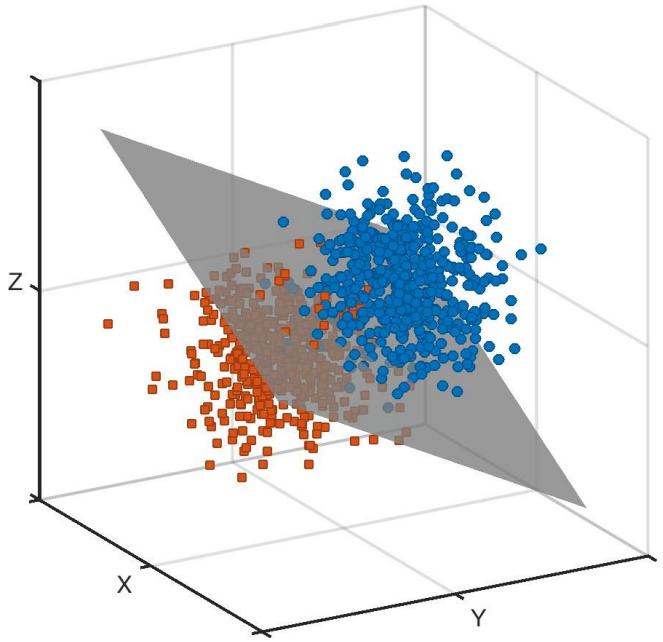
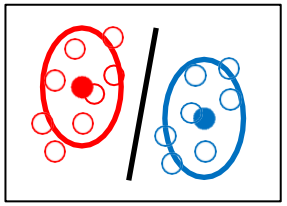


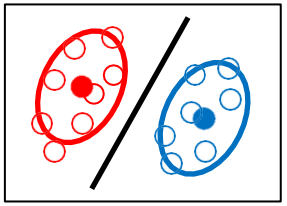
Introduction

- Train classifier on brain activation (channel, voxel, electrode)
- One point is one observation (e.g., trial, stimulus)

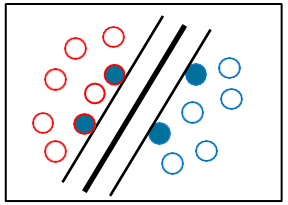




Gaussian Naïve Bayes (GNB)



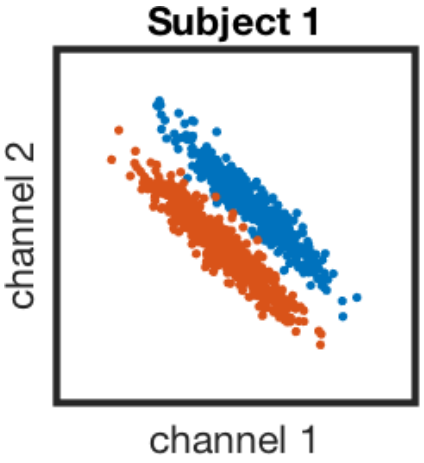
Linear Discriminant Analysis (LDA)



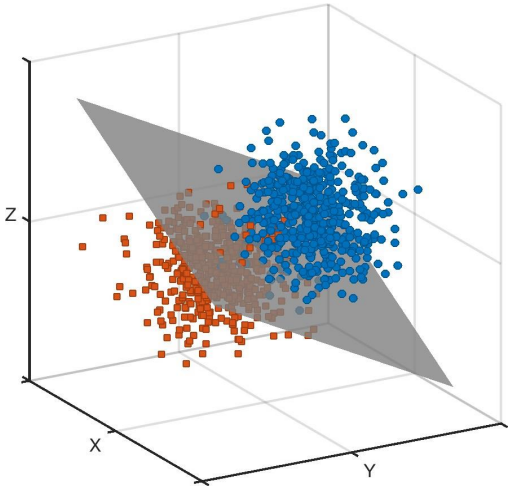
Support Vector Machine (SVM)

Introduction

Support Vector Machine (SVM)

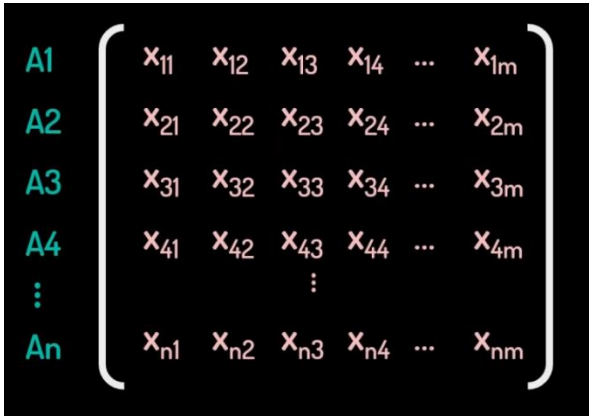


channel, voxel, electrode



从一个n样本 x m维度 的数据中

找到一个m-1维度的超平面区分两组数据



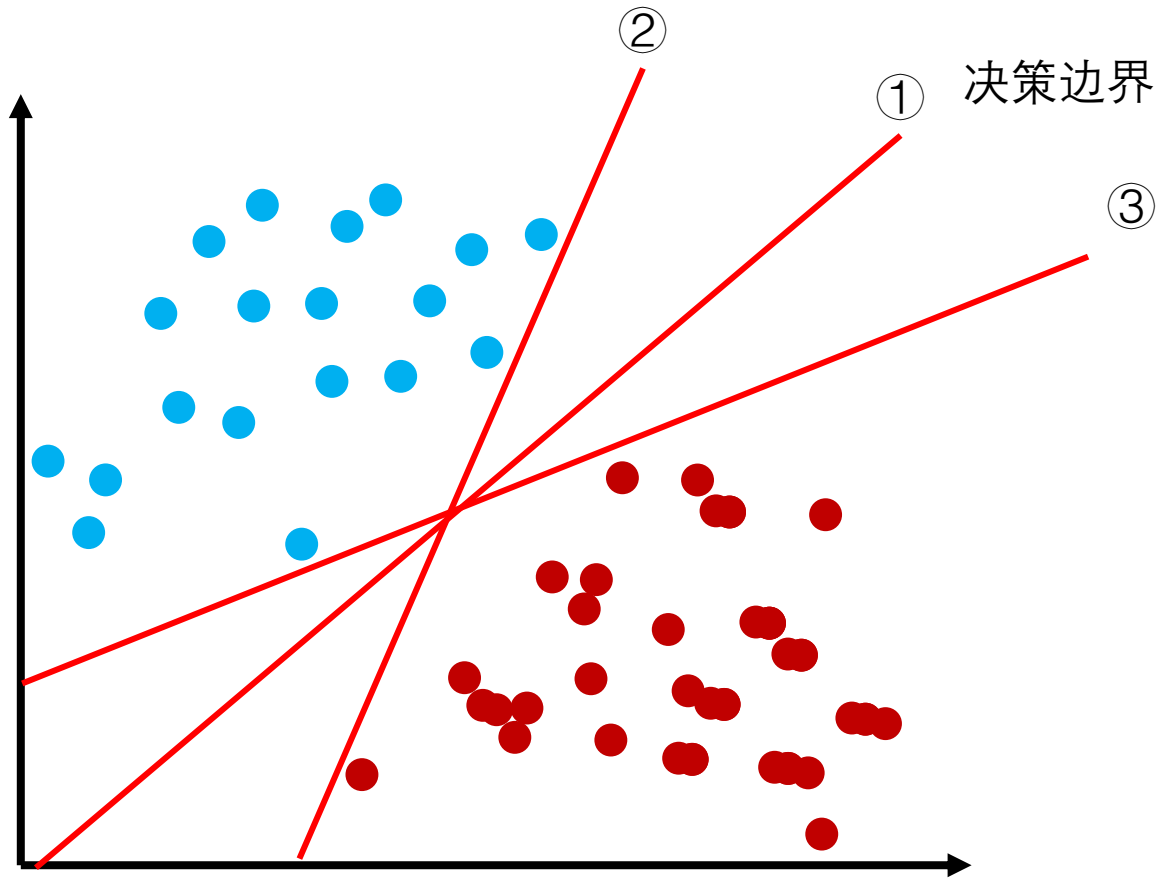
$$W_1X_1+W_2X_2+\ldots+W_mX_m+B=0$$

权重　　维度数

决策超平面

Introduction

Support Vector Machine (SVM)



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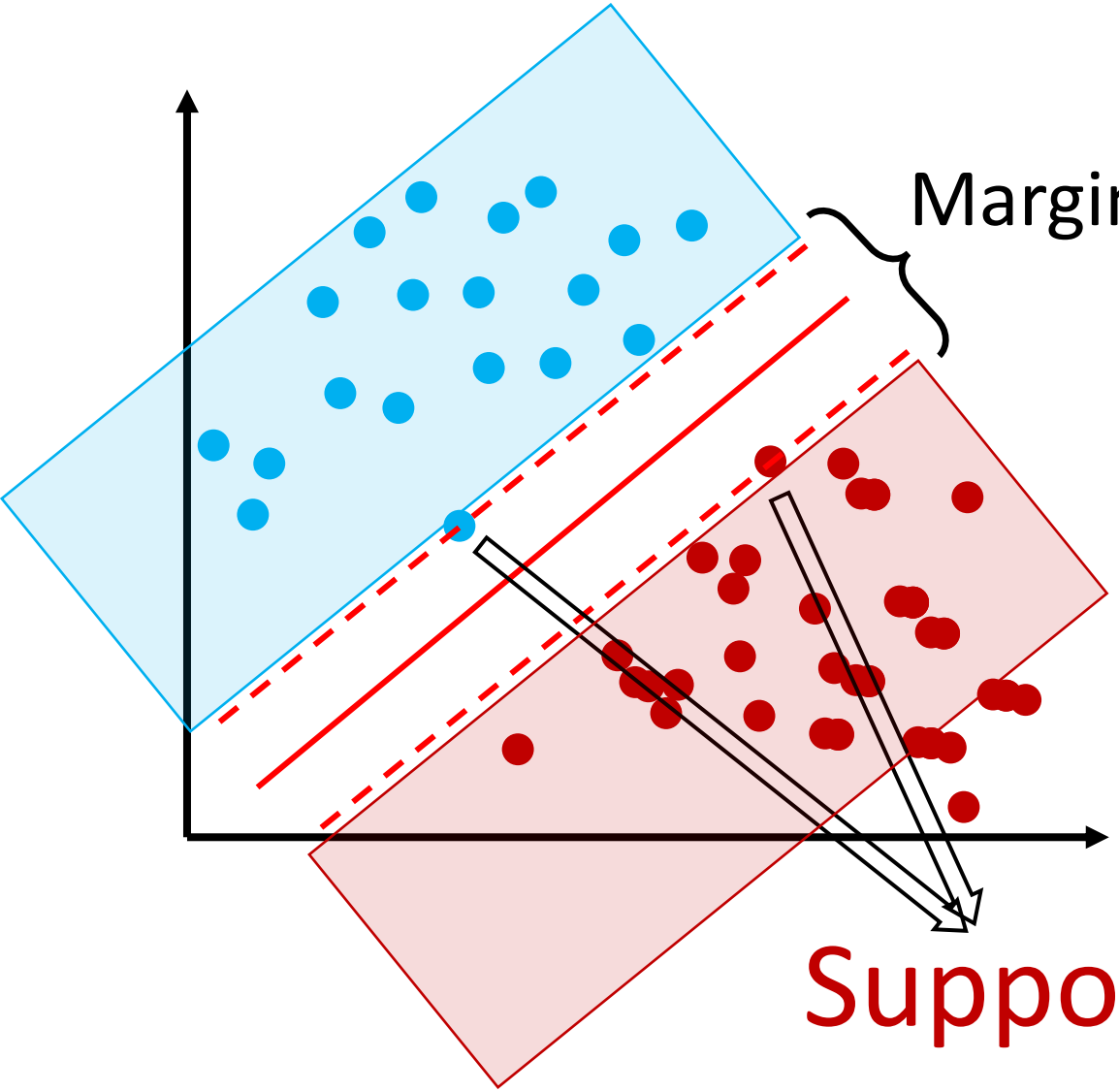

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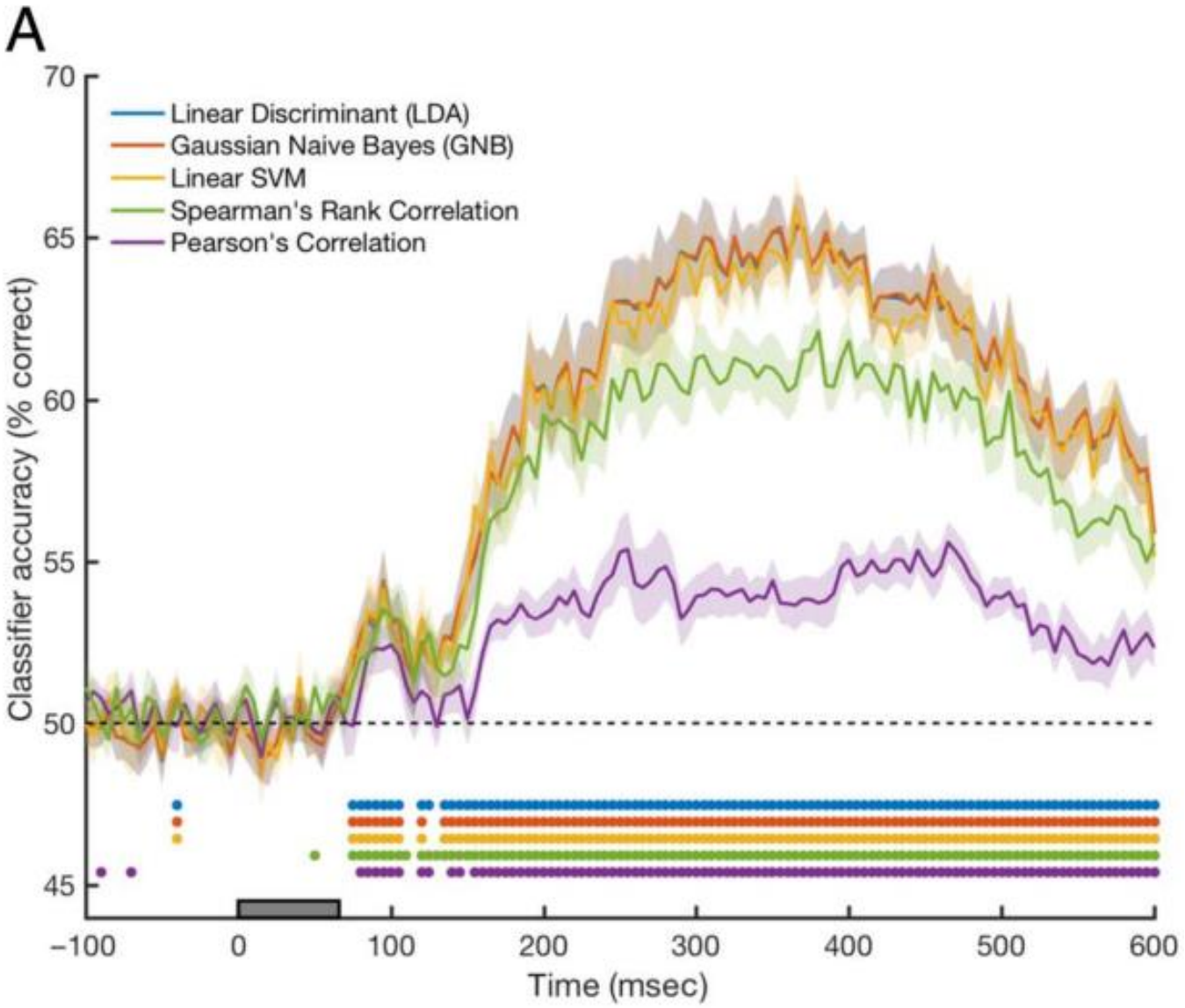
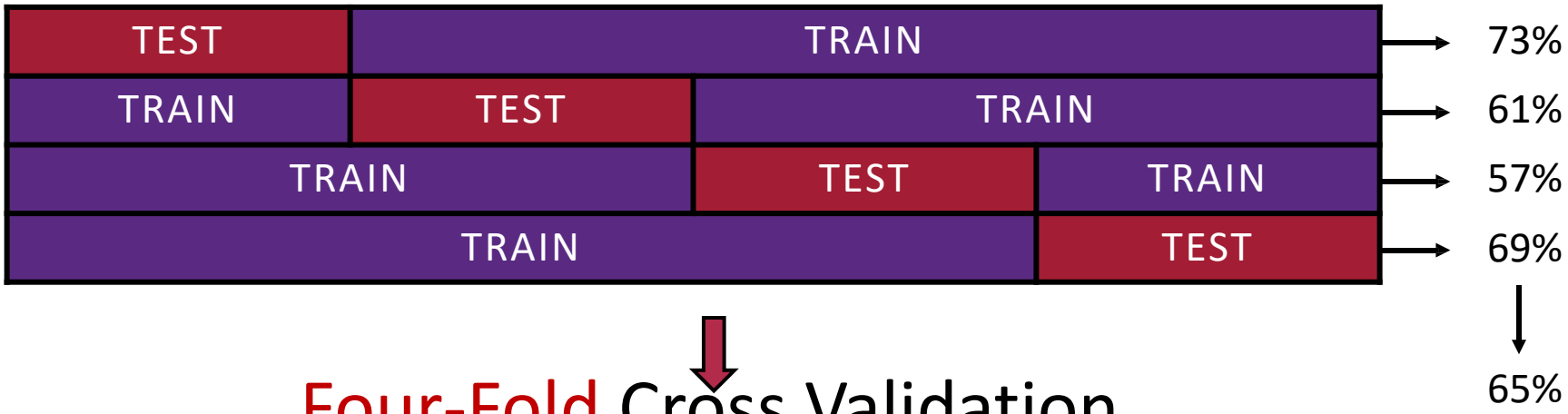
Support Vector Machine (SVM)



Introduction cross-validation

- Train classifier on brain activation (channel, voxel, electrode)
- Test predictions on unseen (held-out) data
- Repeat training & testing on different splits (folds)
- Mean cross-validated classification accuracy



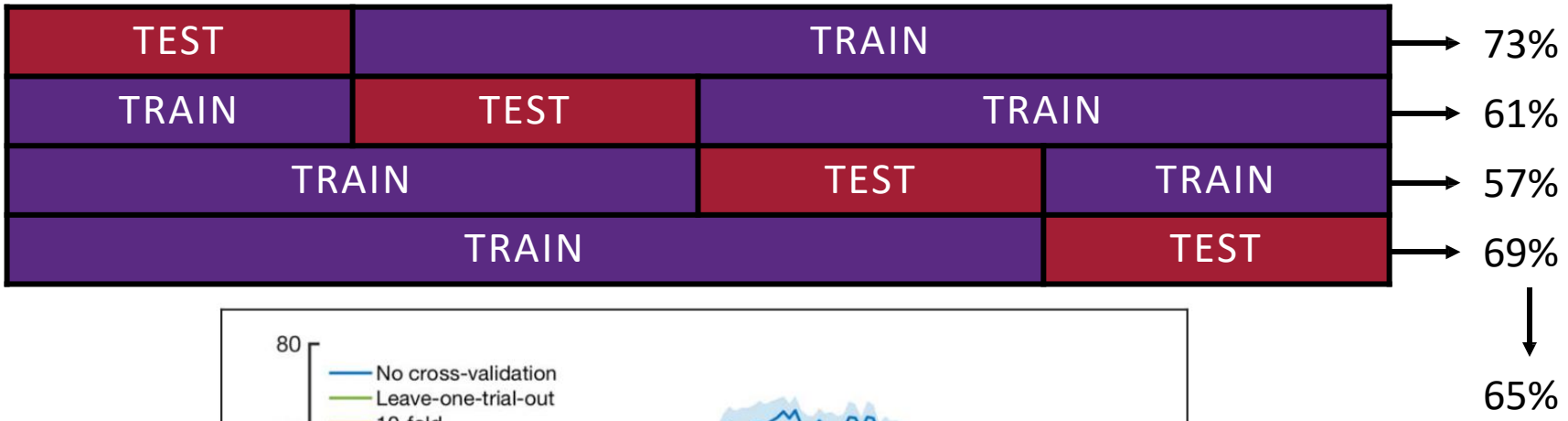
Four-Fold Cross Validation

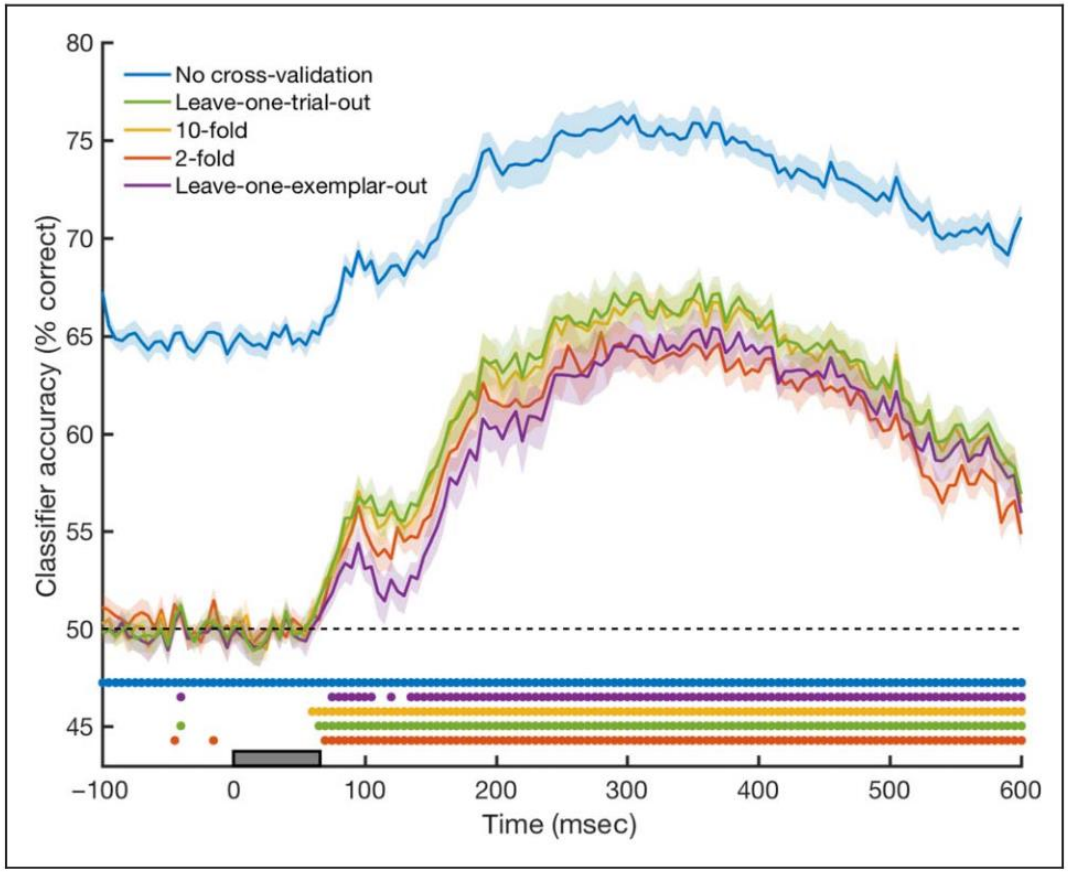
X-Fold Cross Validation

Leave One Out Cross Validation

Introduction

cross-validation





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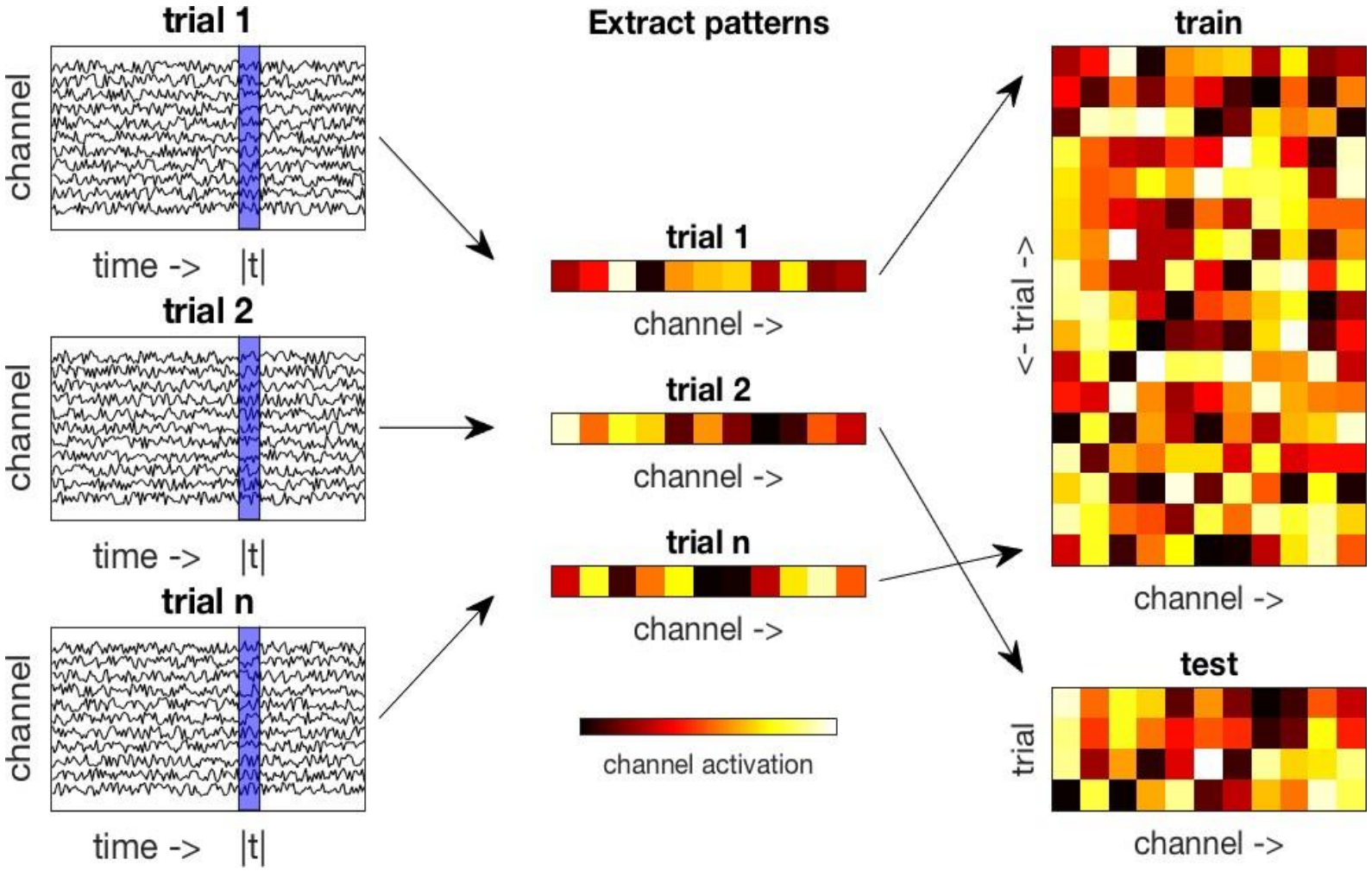

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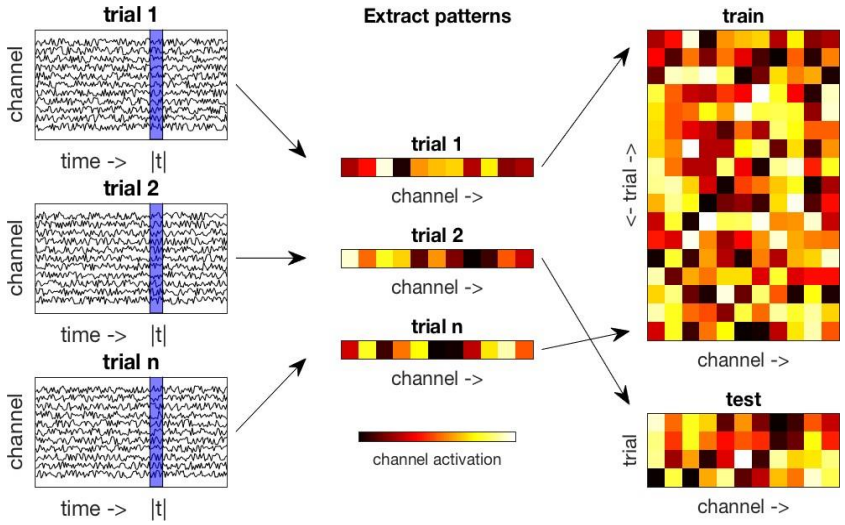

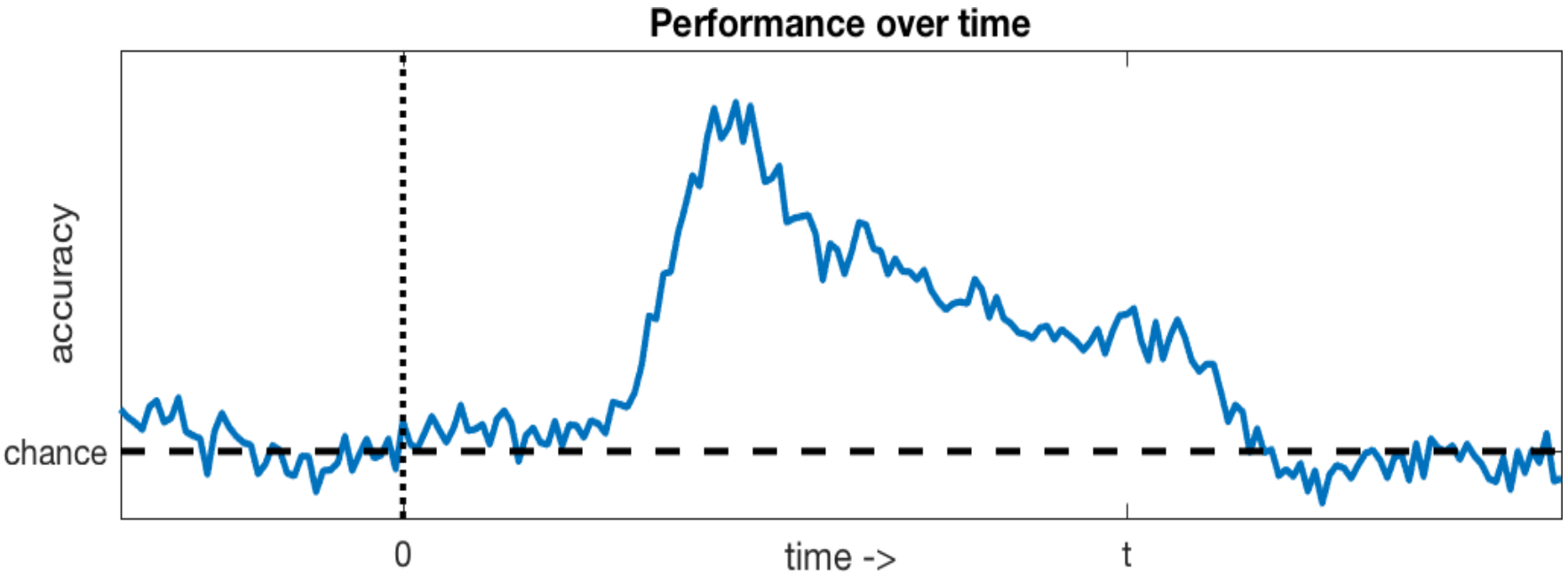

Introduction

Group level inference

- Repeat process over subjects
- Test group-mean accuracy > chance at each time point
  - t-test (popular)
  - Sign-rank test (fewer assumptions)
  - Permutation test (data driven)
  - …
- Correct for multiple comparisons across time
  - Bonferroni
  - False Discovery Rate (FDR)
  - Cluster-based methods

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