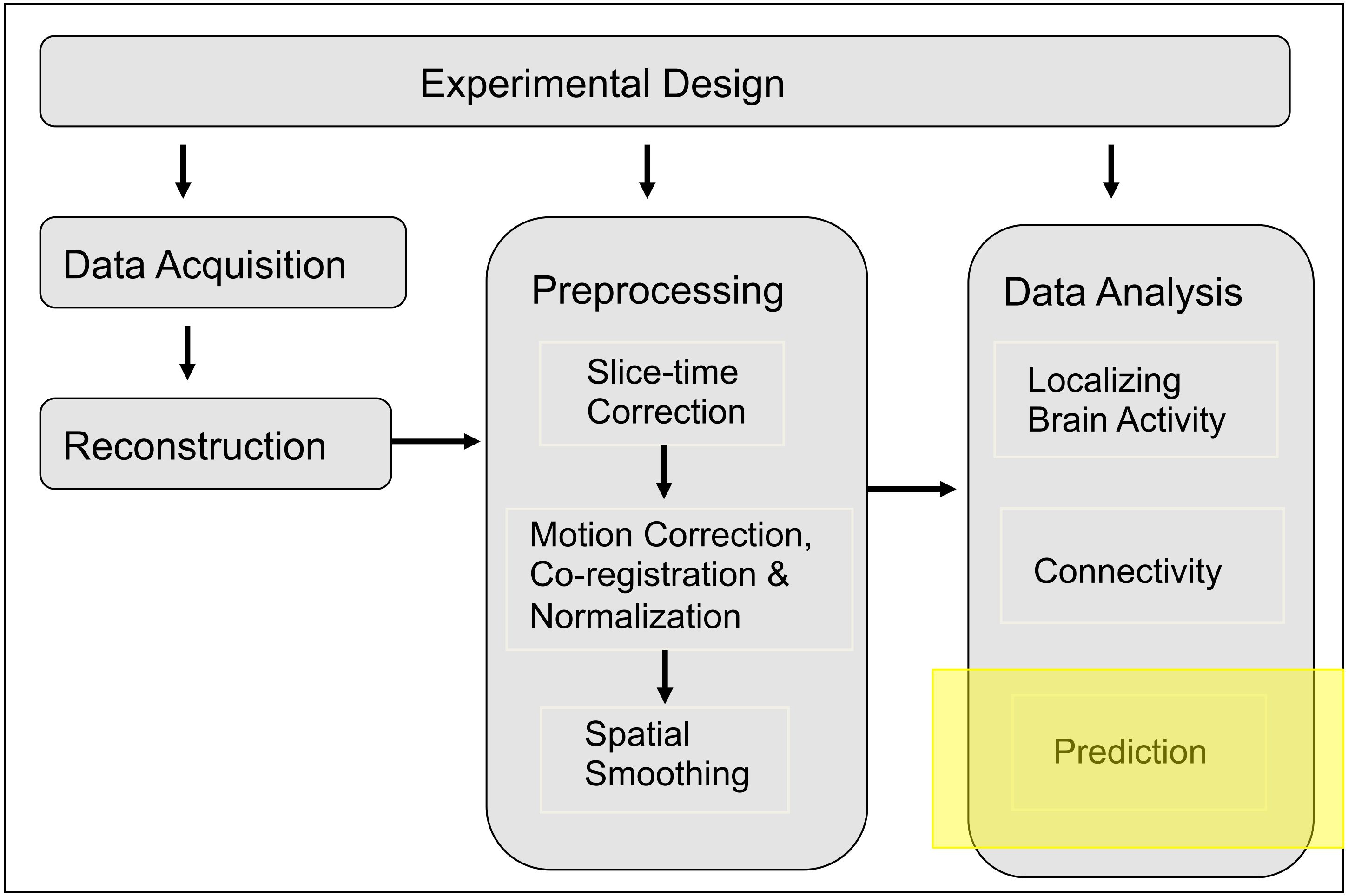
Module 27:
Multi-voxel Pattern Analysis

Data Processing Pipeline



Classification and Prediction

- There is a growing interest in using fMRI data for classification of mental disorders and predicting the early onset of disease.

- In addition, there is interest in developing methods for predicting stimuli directly from functional data.

- This opens the possibility of inferring information about subjective human experience directly from brain activation patterns.

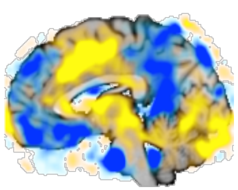
Machine Learning

- Predicting brain states is challenging and requires the application of novel statistical and machine learning techniques.

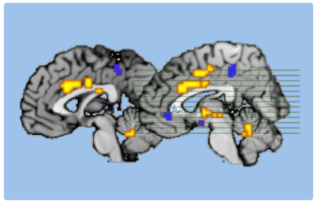
- Various techniques have successfully been applied to fMRI data in which a classifier is trained to discriminate between different brain states and then used to predict the brain states in a new set of fMRI data.

Machine Learning

- When applied to fMRI data the result is often a pattern of weights across brain regions that can be applied prospectively to new brain activation maps to quantify the degree to which the pattern responds to a particular type of event.



$\underline{x} = (x_1, \ldots. x_V)$



$\underline{w} = (w_1, \ldots. w_V)$

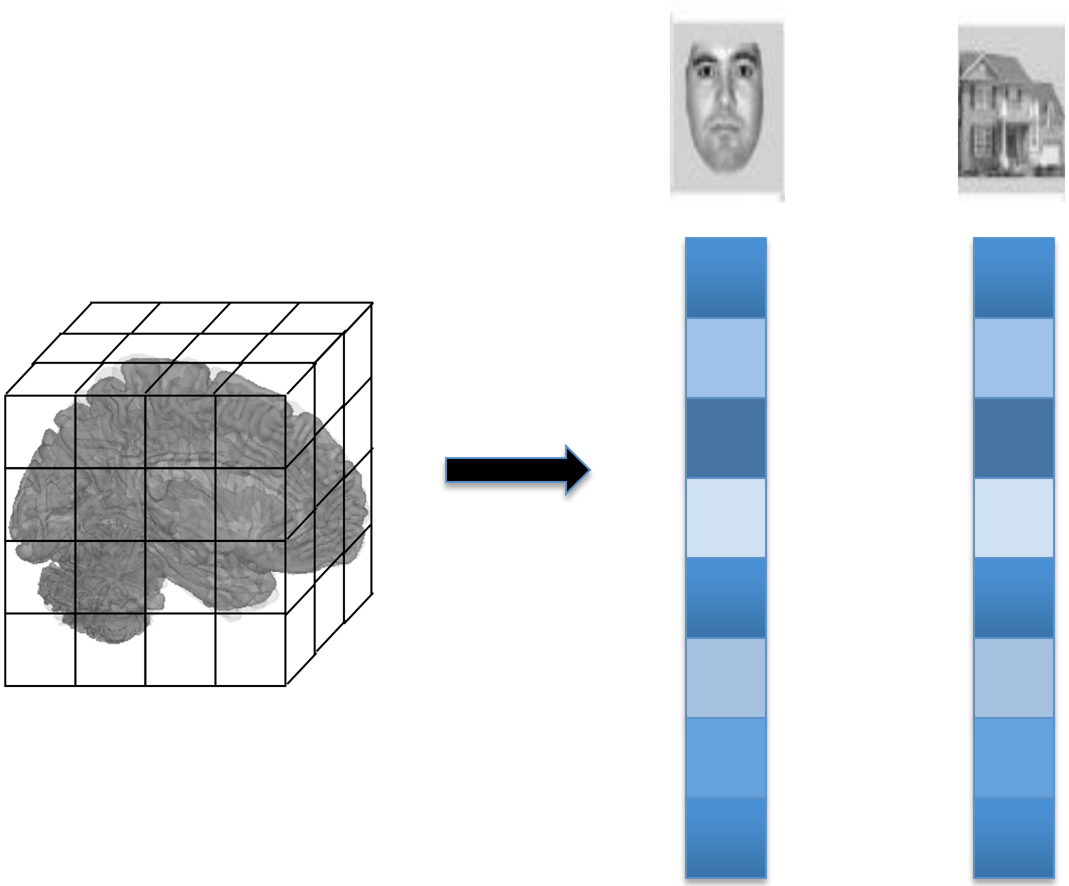
$\underline{w}^T \underline{x} > 0$ Group A

$\underline{w}^T \underline{x} < 0$ Group B

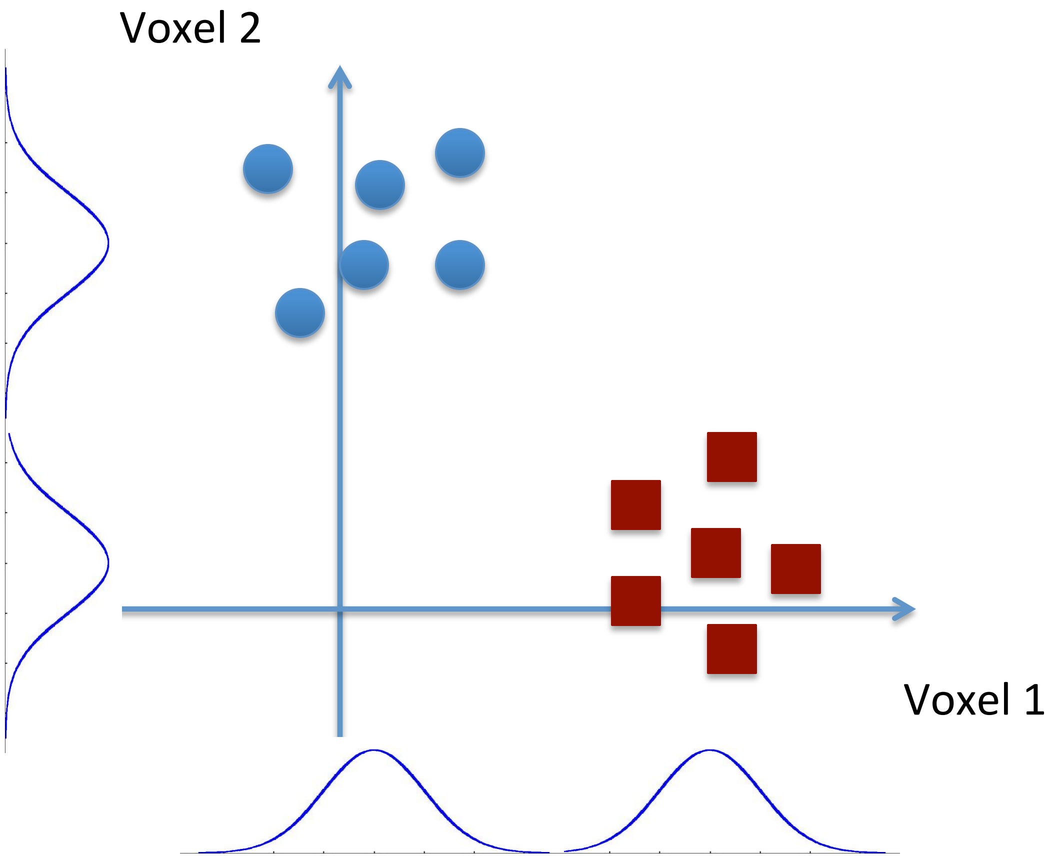
MVPA

- The application of machine learning methods to fMRI data is often referred to as multi-voxel pattern analysis (MVPA)
- Instead of focusing on single voxels, MVPA uses pattern-classification algorithms applied to multiple voxels to decode the patterns of activity.

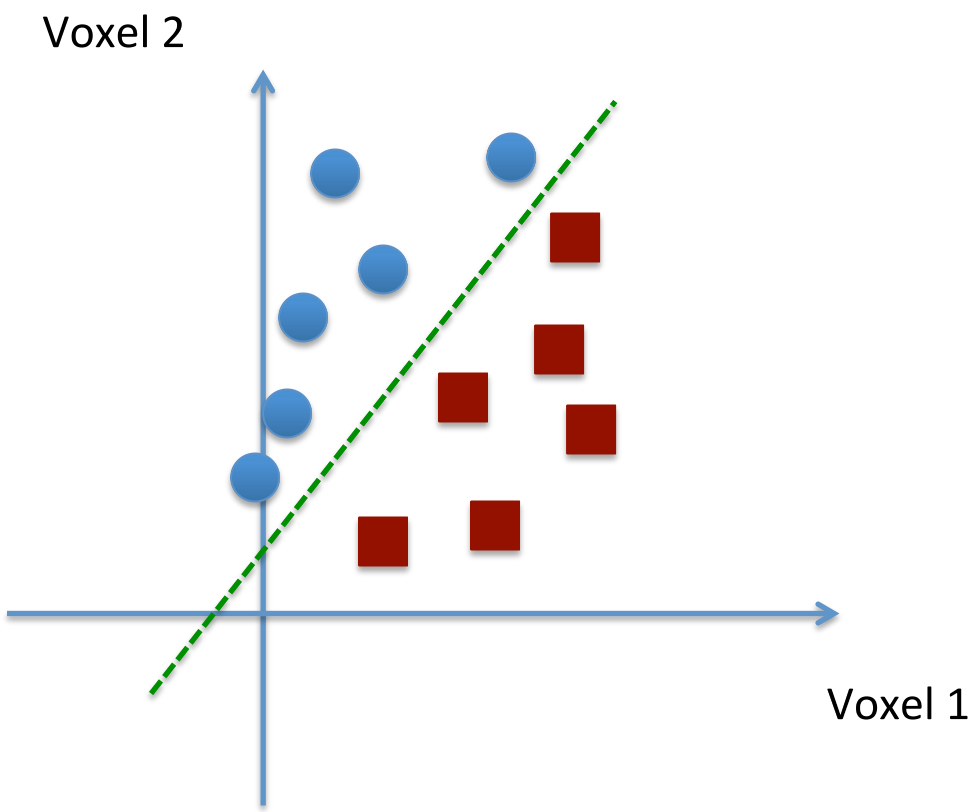
Multivariate Analysis



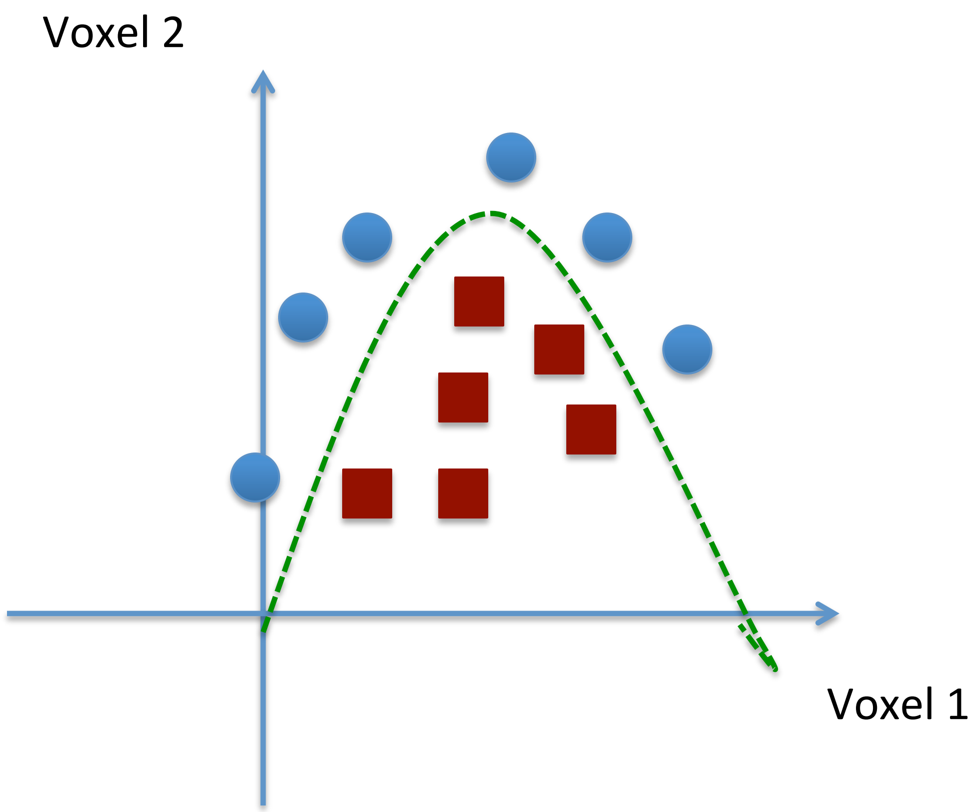
Multivariate Analysis



Multivariate Analysis



Multivariate Analysis



MVPA vs GLM

- In MVPA the goal is to determine the model parameters that allow for the most accurate prediction of new observations.
  - Seek to create rules that can be used to categorize new observations.

- In contrast, the GLM seeks to determine the model parameters that best fit the data at hand.

Classifiers

- A classifier is a function f(.) that takes the values of observed features (e.g., voxels) and predicts to which class the observation belongs (e.g., disease state).

- Let us denote the set of features $\underline{x}=(x_1,\ldots x_V)$ and the class label y.

- Predicted class: $\hat{y} = f(\underline{x})$

Training Data

- A classifier has a number of parameters <u>w</u> that needed to be estimated, or learned.

- The learning is typically performed on a subset of the observations called the training data.

- The learned classifier models the relationship between the features and class labels in the training data set.

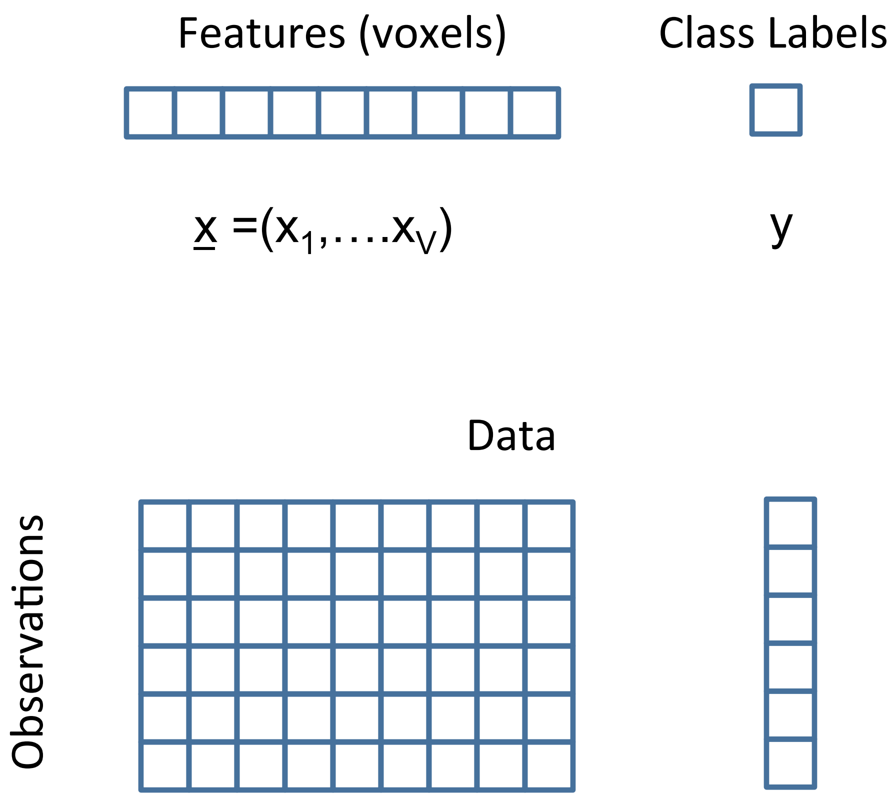
Test Data

- Once trained, the classifier is evaluated using an independent set of observations called the test data.

- If the classifier truly captures the relationship between features and classes, it should be able to predict the class label for data it hasn't seen before.

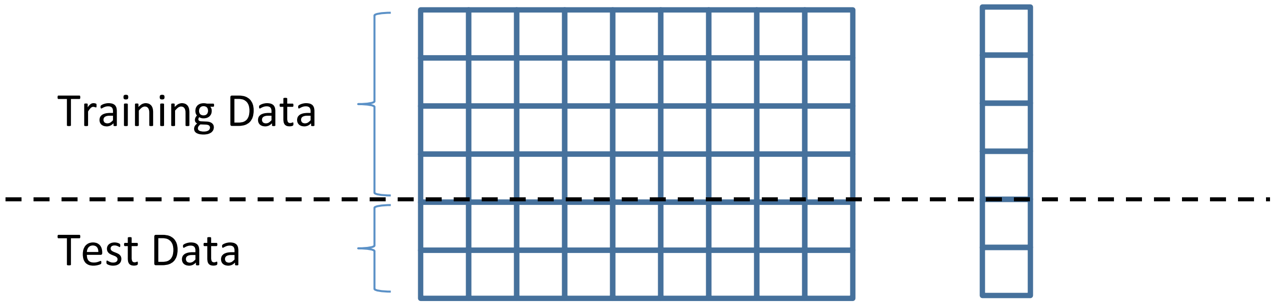
- The accuracy of the classifier measures the fraction of observations in the test data for which the correct label was predicted.

Illustration

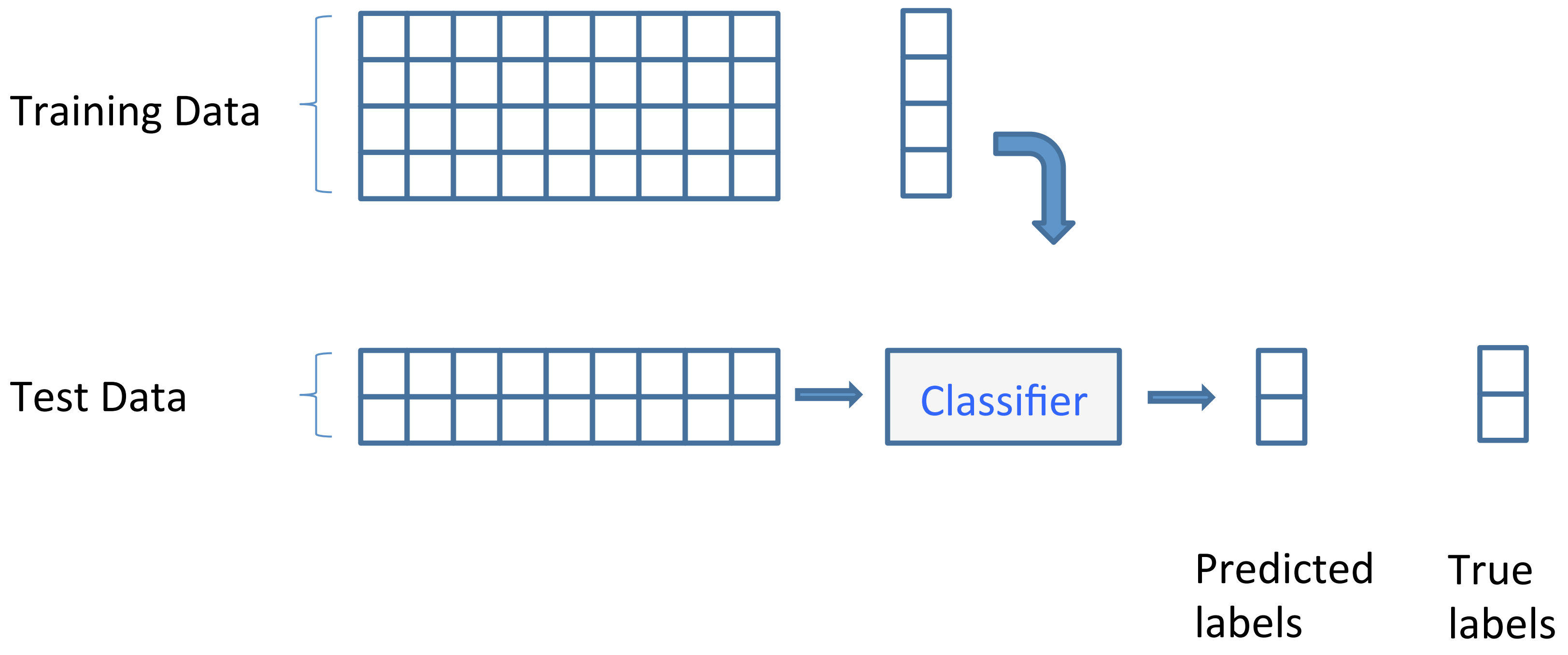


Illustration

The full data set is split into two parts: training and test data



Illustration



End of Module

@fMRIstats