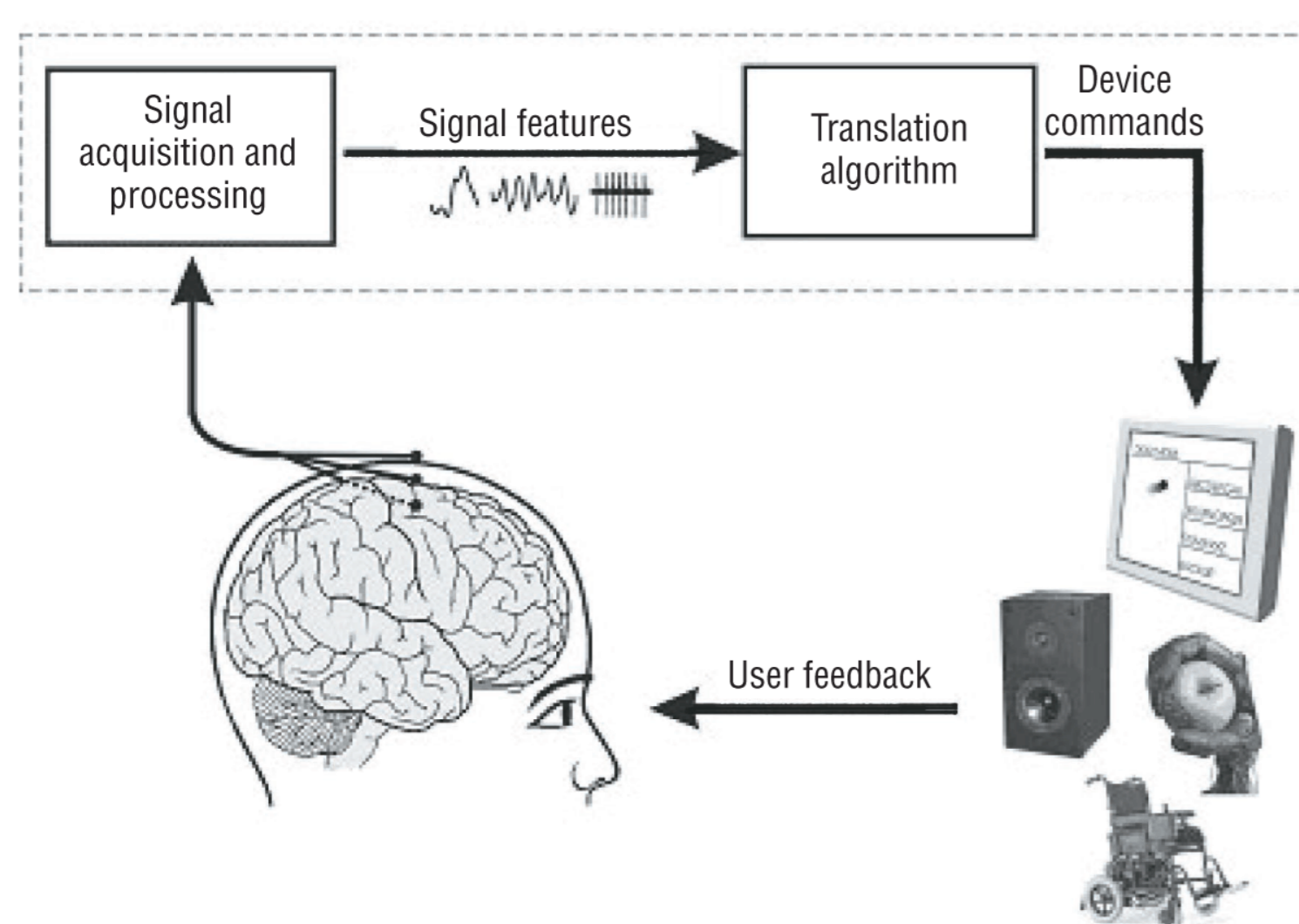


BCI For ALS

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Introduction

- BCI (Brain Computer Interface) is a direct communication channel between the brain and an outer device.
- This interface can assist ALS patients.
- A classifier's performance deteriorates after a long-term use, namely "intersession variability".
- "Intersession Variability" is the change of the EEG signals from a subject's brain due to non-stationarity in time of the brain waves.



BCI Operation of Robotic and Prosthetic Devices

Goal

- To demonstrate an Electroencephalogram (EEG) experiment that can handle the problem of "intersession variability".

Ways of Action

- Algorithms based on Riemannian Geometry.
- We used the "Parallel Transport" (PT) algorithm.

Riemannian Geometry & Covariance Matrices

Advantages

- The estimation of covariance matrices is simple.
- Reduces noise and number of dimensions.
- Provides a mathematical framework for dealing with a non-Euclidean elements.

Disadvantages

- Temporal resolution is compromised in the process.
- Covariance matrices express only linear relations between electrodes.
- Desynchronization of electrodes due to hardware design can decrease the accuracy of the covariance matrices estimation.

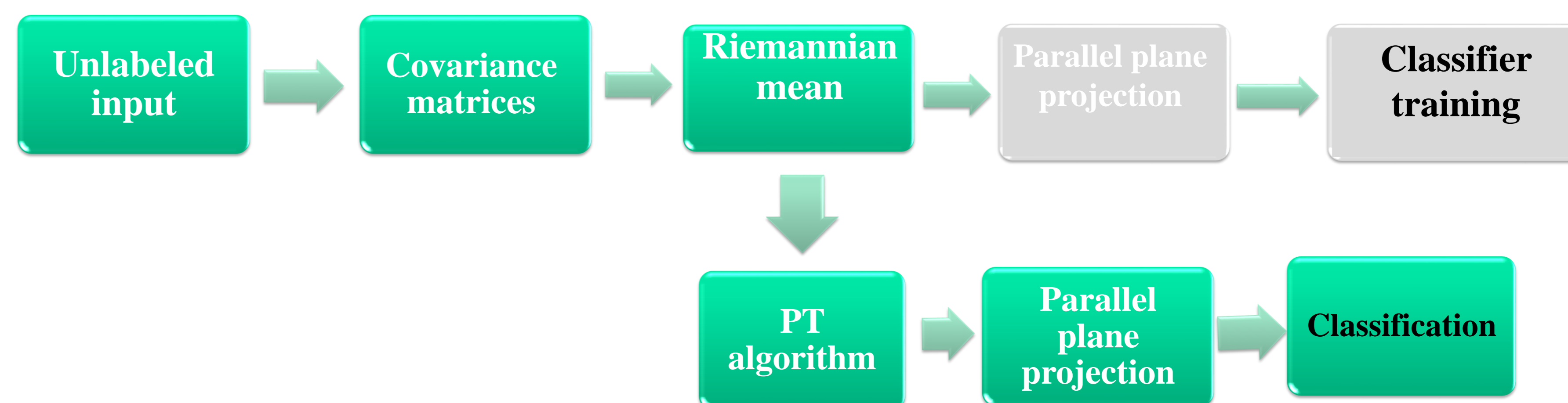
Parallel Transport

Main idea: classification in the parallel plane at the Riemannian mean while executing domain adaptation using a "Parallel Transport" (PT) algorithm which transforms covariance matrices between different domains and enables to improve classification results.

Block Diagram – classifier training

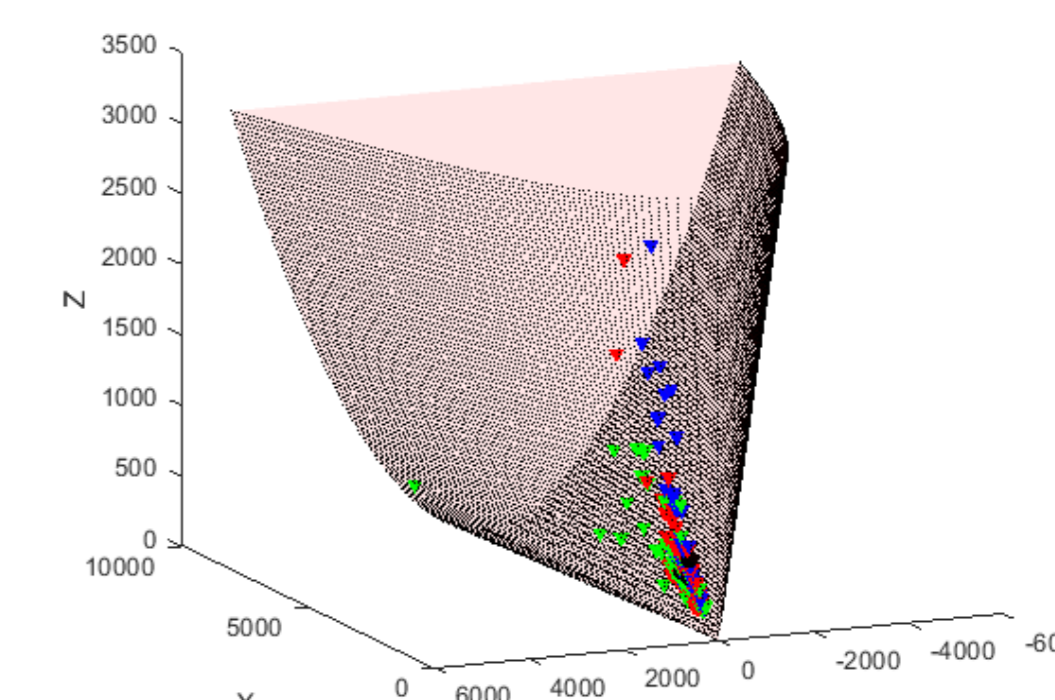


Block Diagram – classification



Signs & Definitions

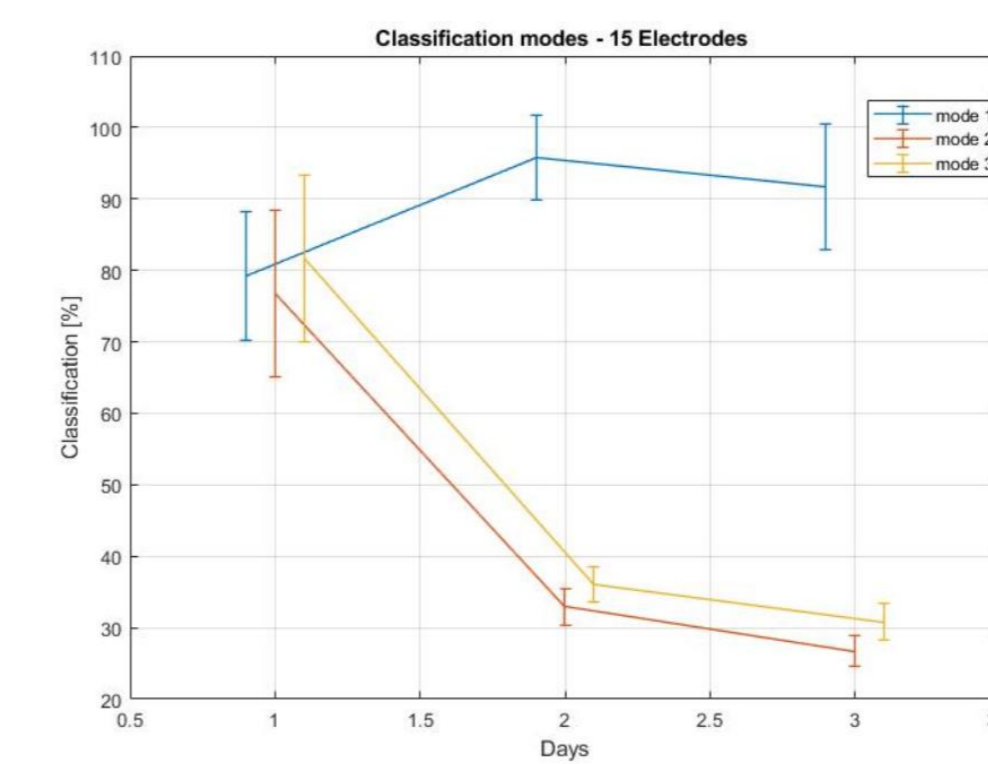
- Riemannian Manifold / Cone Manifold – A non-Euclidean space in the shape of a cone which contains all the SPD (Symmetric Positive Definite) matrices.
- Domain – space. In the context of this project measurements of different subjects are referred to as different domains.
- Domain Adaptation - the adaptation of measurements from different subjects, i.e., different areas on the Riemannian manifold to each other.



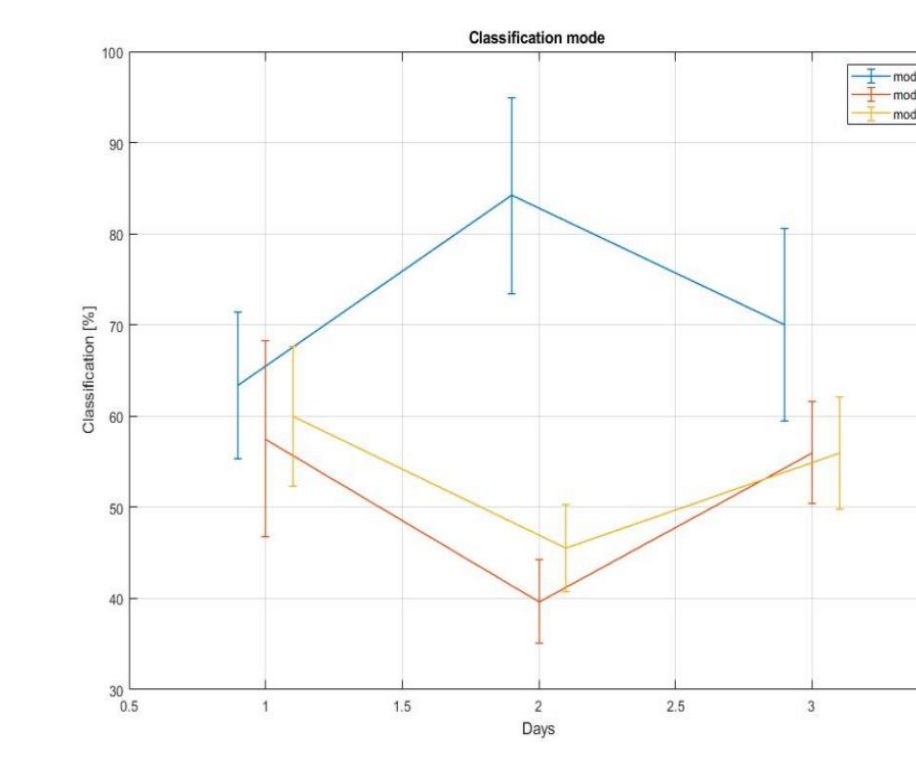
Riemannian manifold with covariance matrices from different trial days

Results

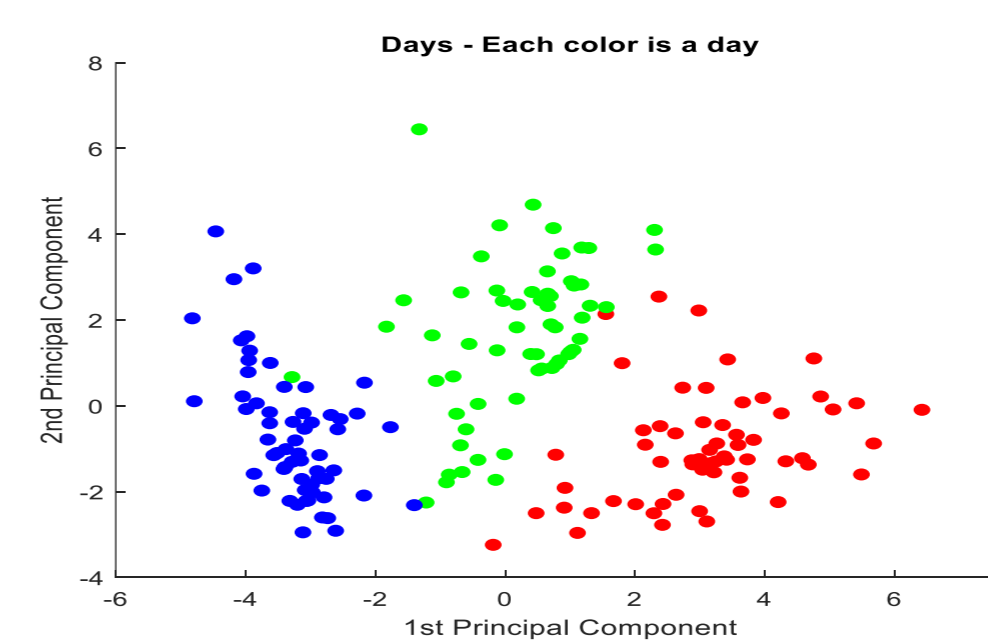
- Measurements from a Motor Imagery (MI) experiment with 3 different classes taken from 3 different days (60 trials per day).
- Classification of 3 different modes:
 - New calibration in each day (Mode 1)
 - Calibration in first day only (Mode 2)
 - Calibration in first day only + Parallel Transport (Mode 3)
- PT is distinguishable using PCA.



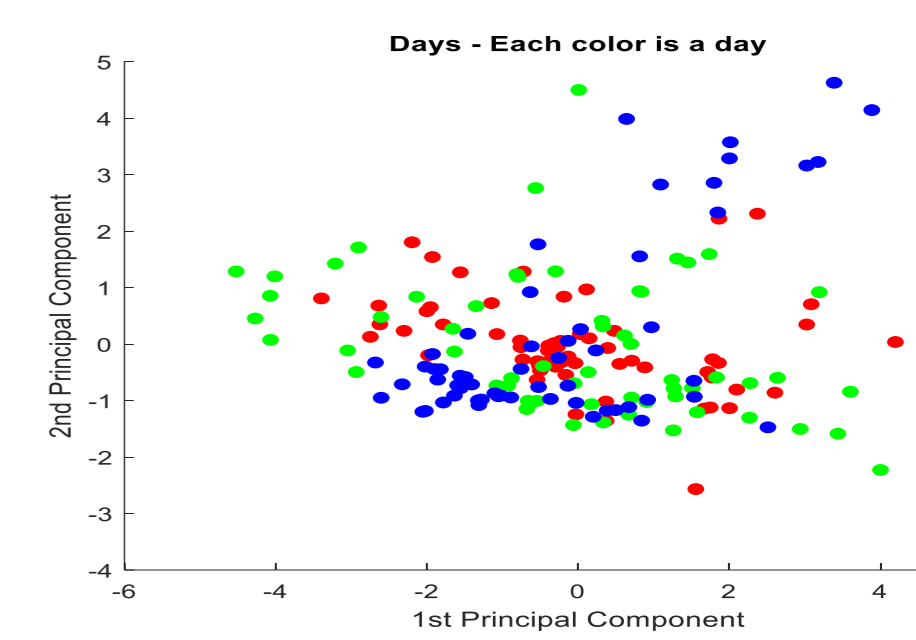
Classification using 15 electrodes



Classification using 2 electrodes



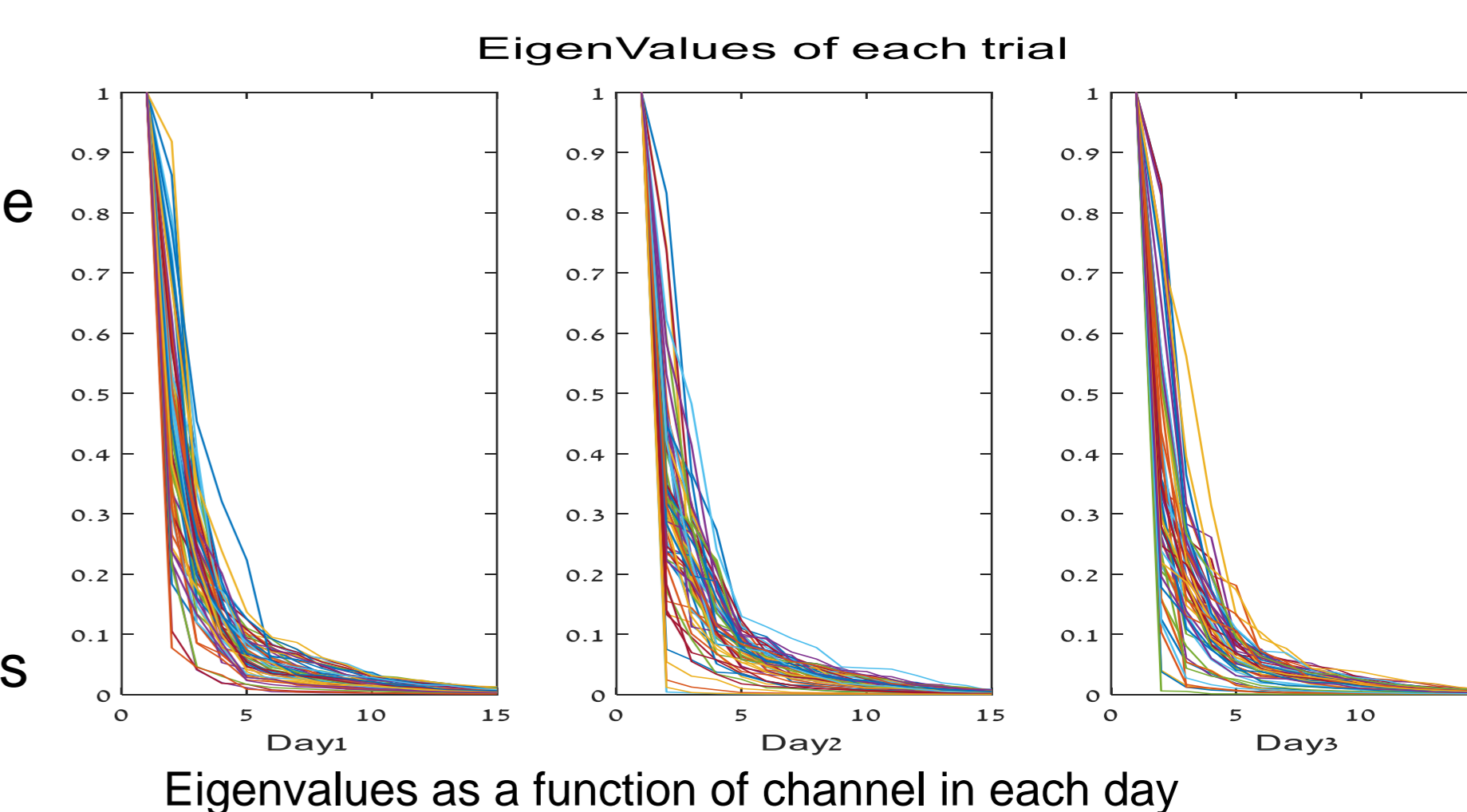
PCA using 15 electrodes without PT (Mode 2)



PCA using 15 electrodes with PT (Mode 3)

Conclusions

- Using PT algorithm gave negligible improvement of the classification results.
- Using 2 electrodes rather than 15 gave better classification results of modes 2,3 in days 2,3. We assume that the reason is that the covariance matrix is not full-rank.



Eigenvalues as a function of channel in each day