

Psychosis Diagnosis Using Multiscale Independent Component Analysis And Classification Techniques



Overview

Preface

- What is the presentation about
- Psychosis Conditions of the mind
- Quantification of human brain activity
- Human Brain Domains and Networks
- Independent Component Analysis

Project

- Motivation for psychosis classification
- Dataset
- Classification predictive modeling
- Feature selection
- Hyperparameter tuning
- Analyzing the results

What next...

Project overview

Psychosis Diagnosis Using Multiscale Independent Component Analysis And Classification Techniques

- Psychotic Disorders – Condition of the mind
- Signal processing strategies – Feature Engineering
- Classification problem
- Supervised learning algorithm

Psychosis Conditions

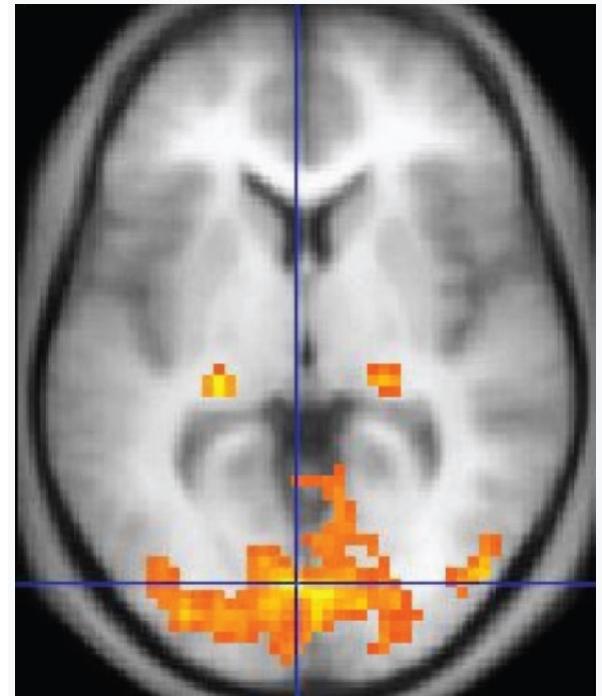
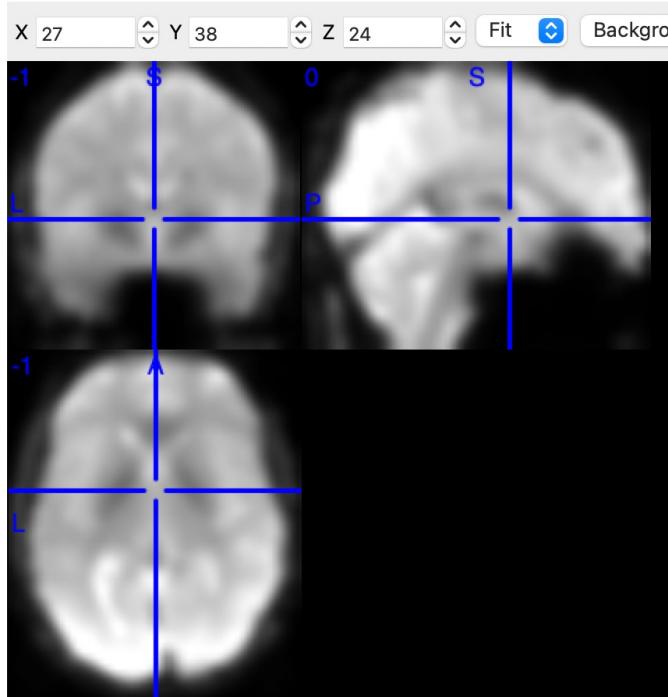
- Psychotic Disorders – Condition of the mind
- Inability to distinguish reality and imagination
- Mental Illness Conditions
- Schizophrenia
- Bipolar Disorder
- Psychotic Depression
- Sensory Deprivation

Quantification of human brain activity

fMRI – Functional magnetic resonance imaging

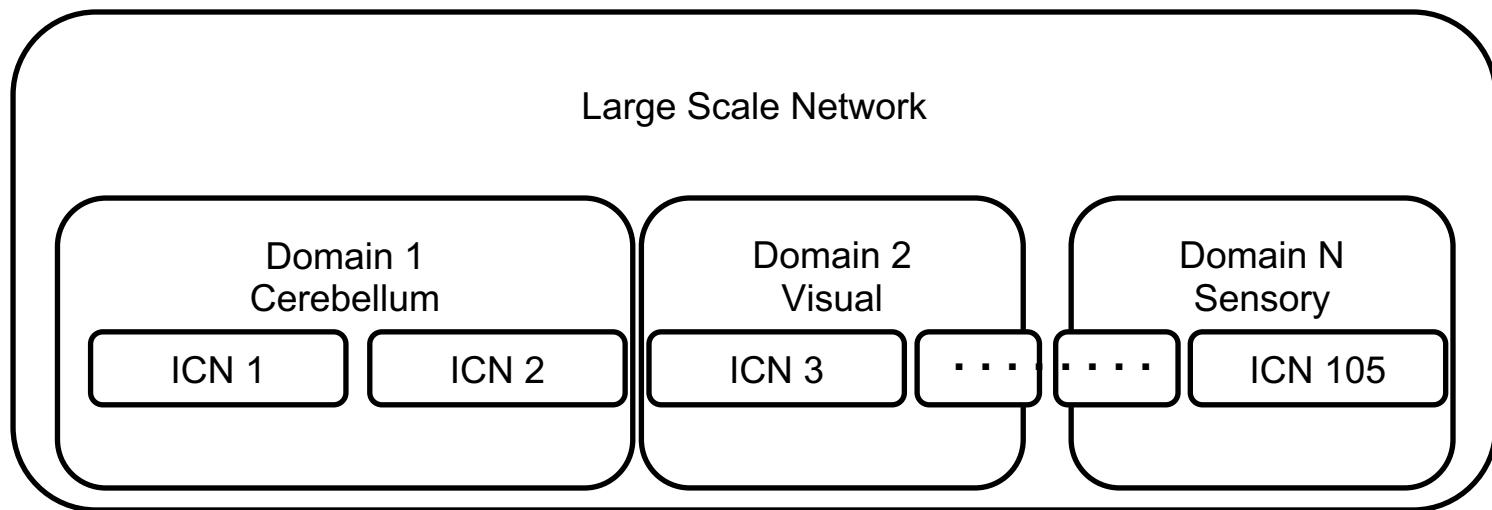
- Measure brain activity over time with imaging technique
- Brain activity is associated with blood flow
- Neuroimaging
- Tumors
- Cancer detection
- Cardiac MRI

3-Dimensional Data * Time



Human brain Domains and Networks

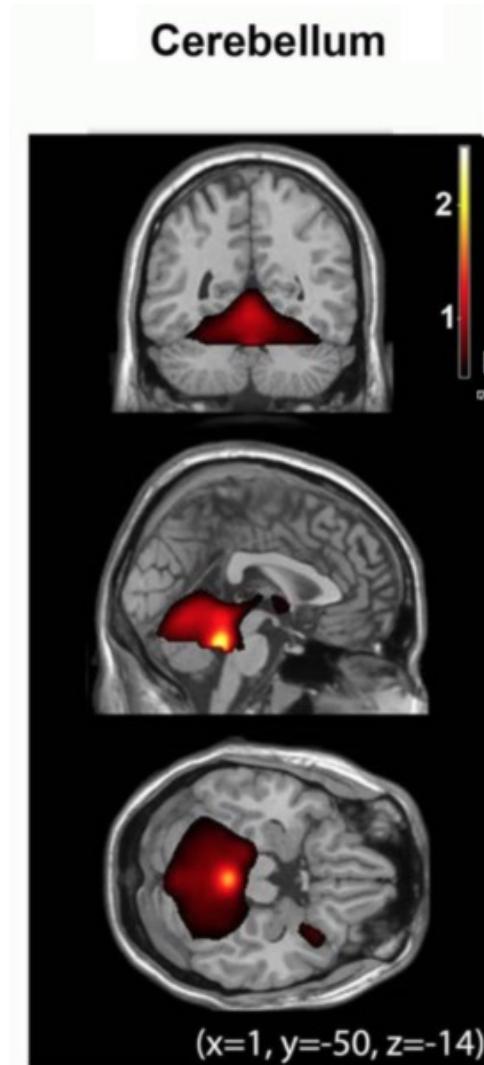
- Brain region – Neural connections forms a large scale brain network
- Large Scale Network – Collection of Domains or Core Networks
- Core networks – Collection of ICNs
- Each domain region is collection of neuronal activity, all together called Intrinsic Connectivity Networks



Human brain Domains and Networks

Core Networks / Domains - Cerebellum

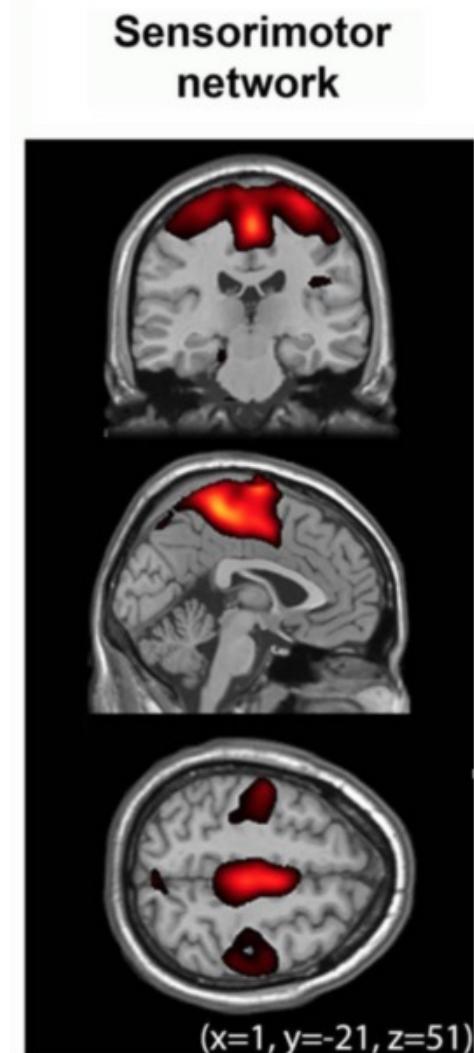
- Cognitive function such as attention
- Language
- Emotion of fear
- Pleasure response



Human brain Domains and Networks

Core Networks / Domains - Sensorimotor

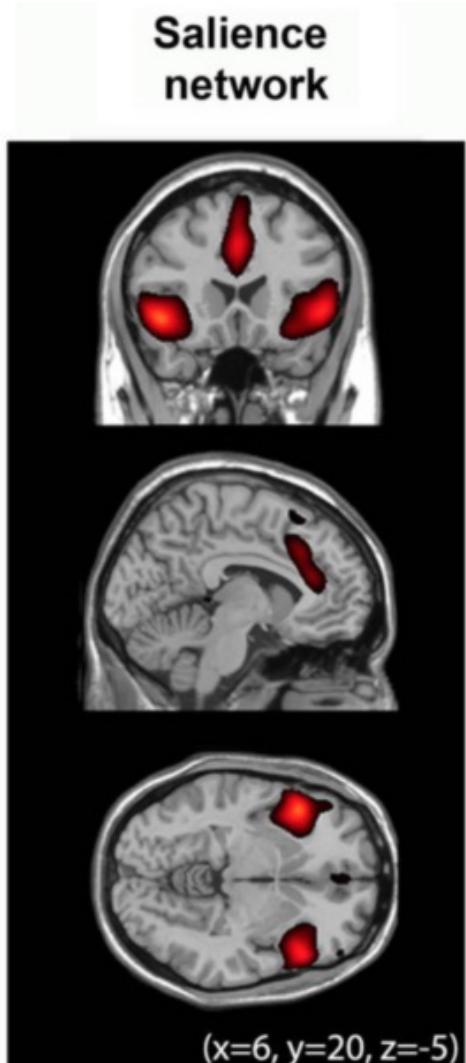
- Coordinates subset of sense
- Touch
- Temperature
- Pain
- Motion



Human brain Domains and Networks

Core Networks / Domains – Salience / Subcortical

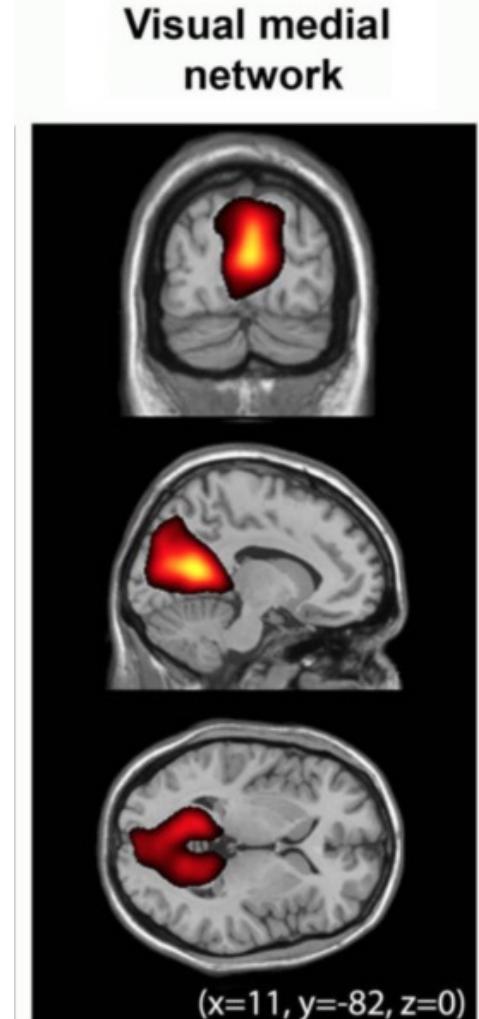
- Communication
- Social behavior
- Self awareness



Human brain Domains and Networks

Core Networks / Domains – Visual / Occipital

- Sensory organ(the eye)
- Pattern recognition
- Motor coordination under visual guidance

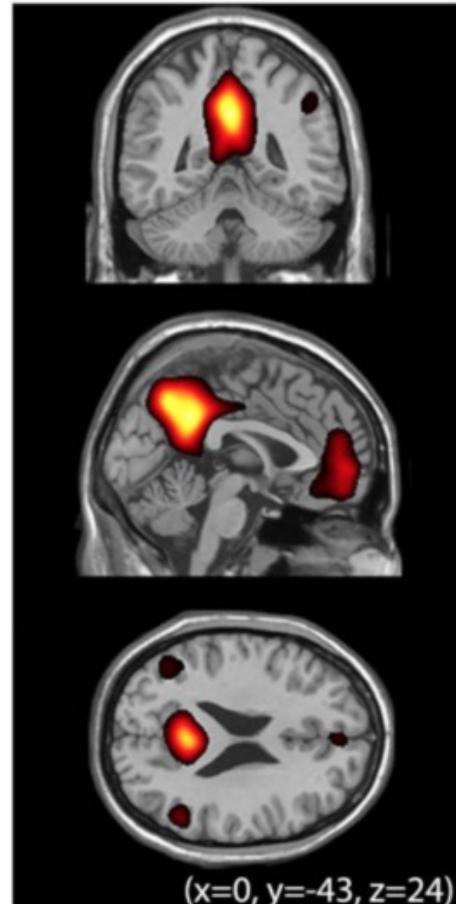


Human brain Domains and Networks

Core Networks / Domains – Higher Order Networks

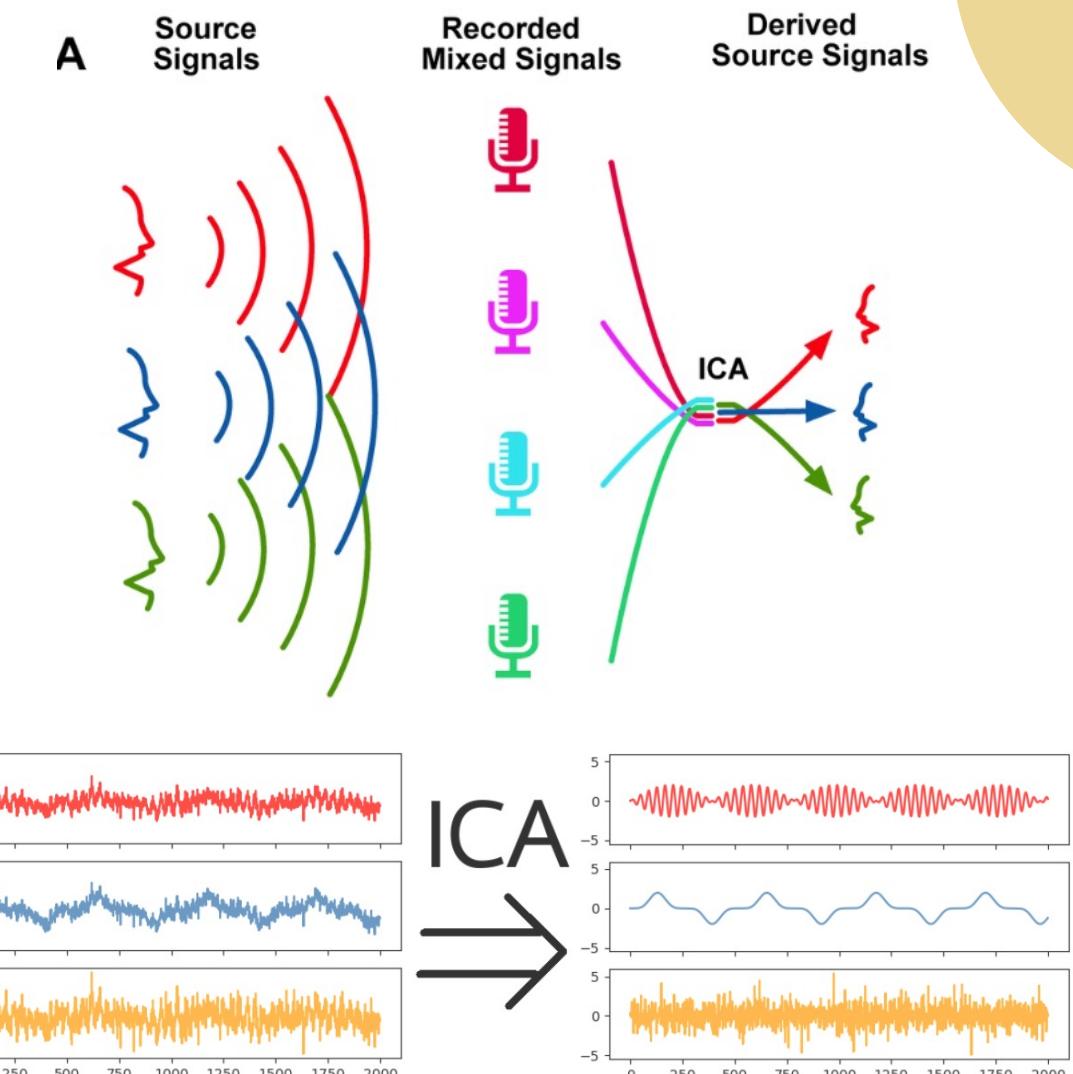
- Higher order cognitive processes / UNK :
- Default mode network
- These are active when awake and rest
- Daydreaming and memories

Default mode
network



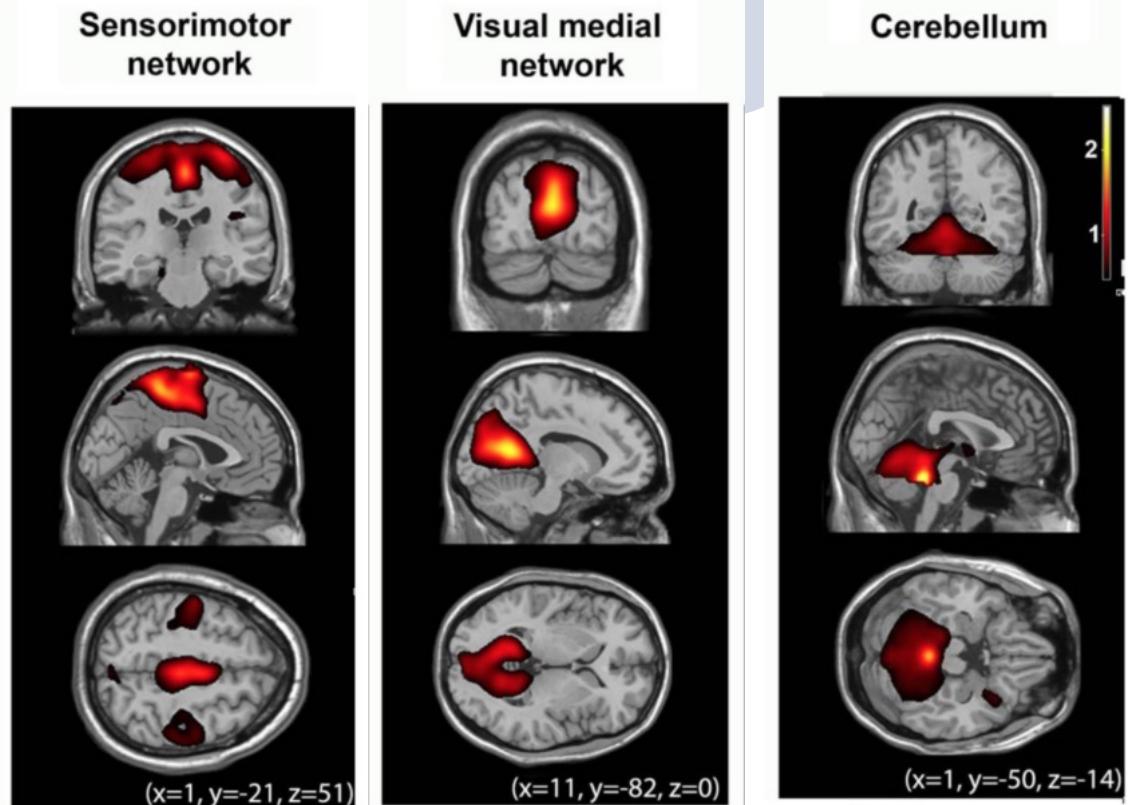
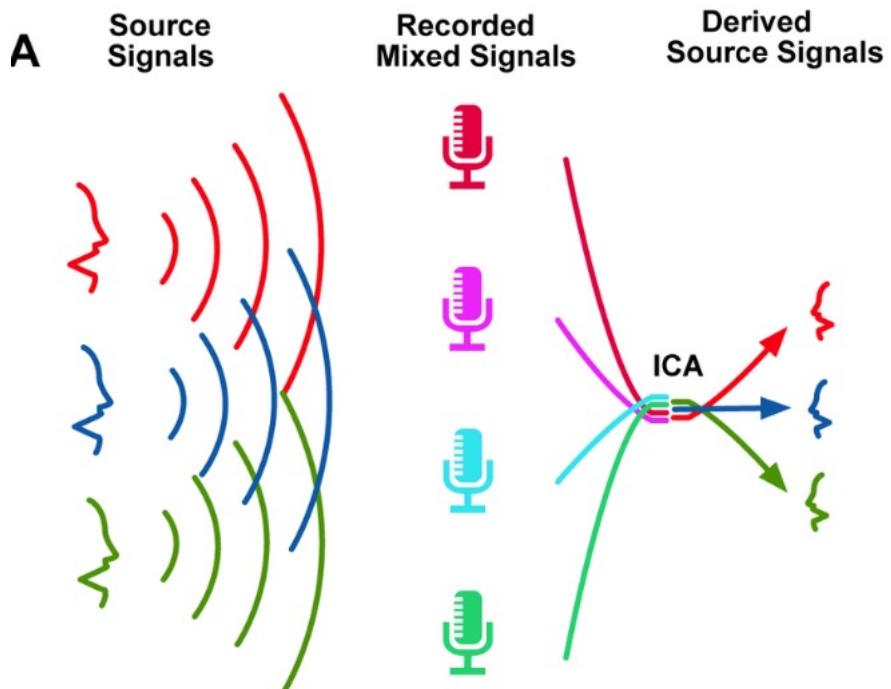
Independent Component Analysis

- Signal Processing computational method
- Multivariate signals to independent signals
- ICA decomposition
- Blind Source Separation
- Cocktail Party Problem



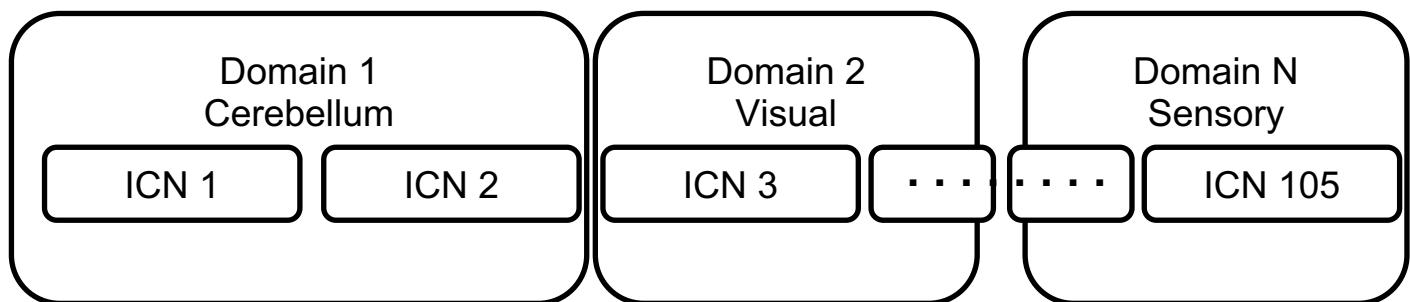
Brain Networks and ICA

- ICA decomposition applied to fMRI 3D * Time series data
- Obtain independent ICN network signals
- Signals are neuronal activity
- Combination of certain signals reflect a domain

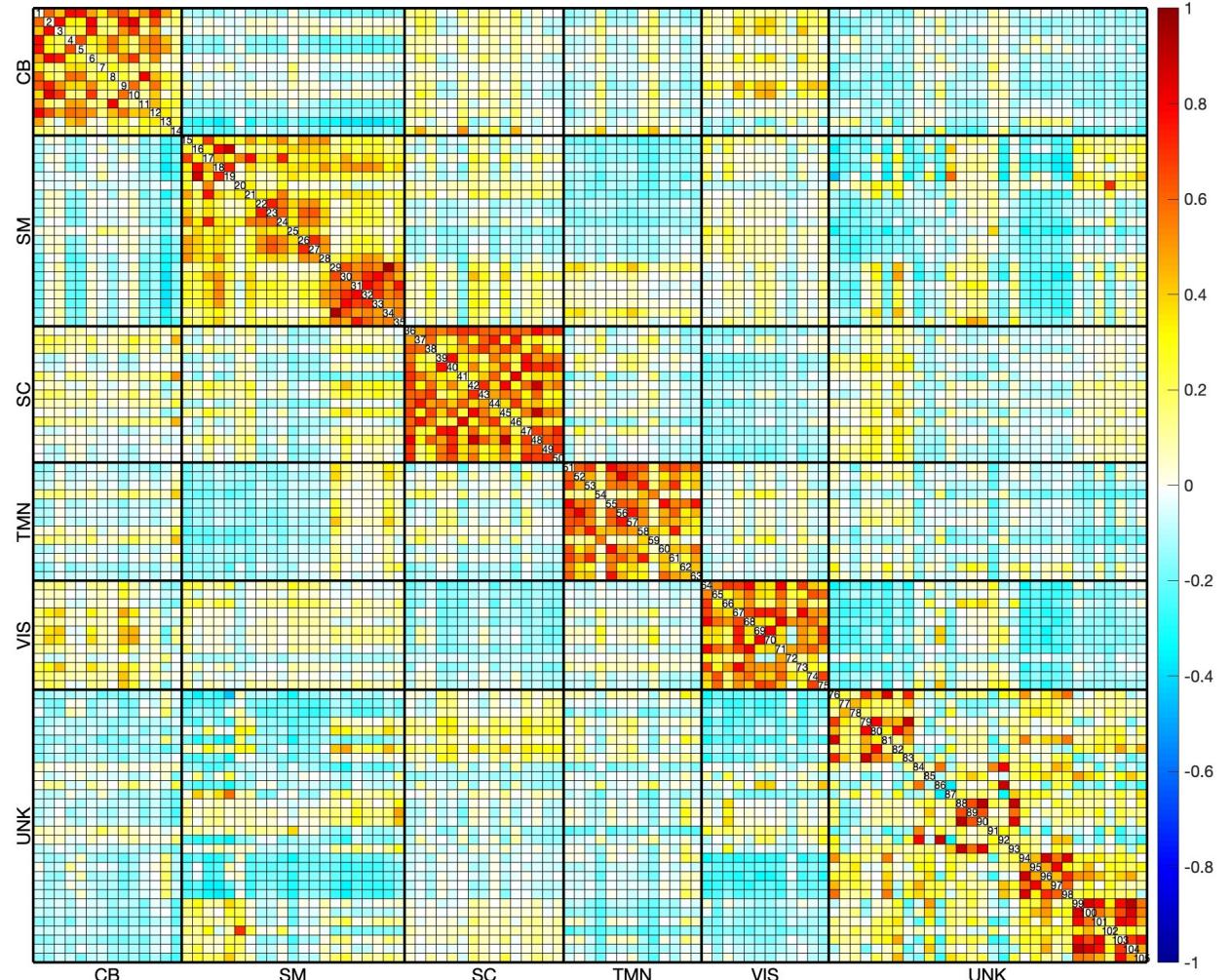


Features for analyzing brain activity

- Independent network signals called ICN (Intrinsic Connectivity Networks)
- Signals are time series data
- Combination of ICN represent Domains
- Pearson Correlation :
- Linear relation of different domains : Intra – Functional group correlations
- Linear relation of independent networks : Inter – ICN correlations



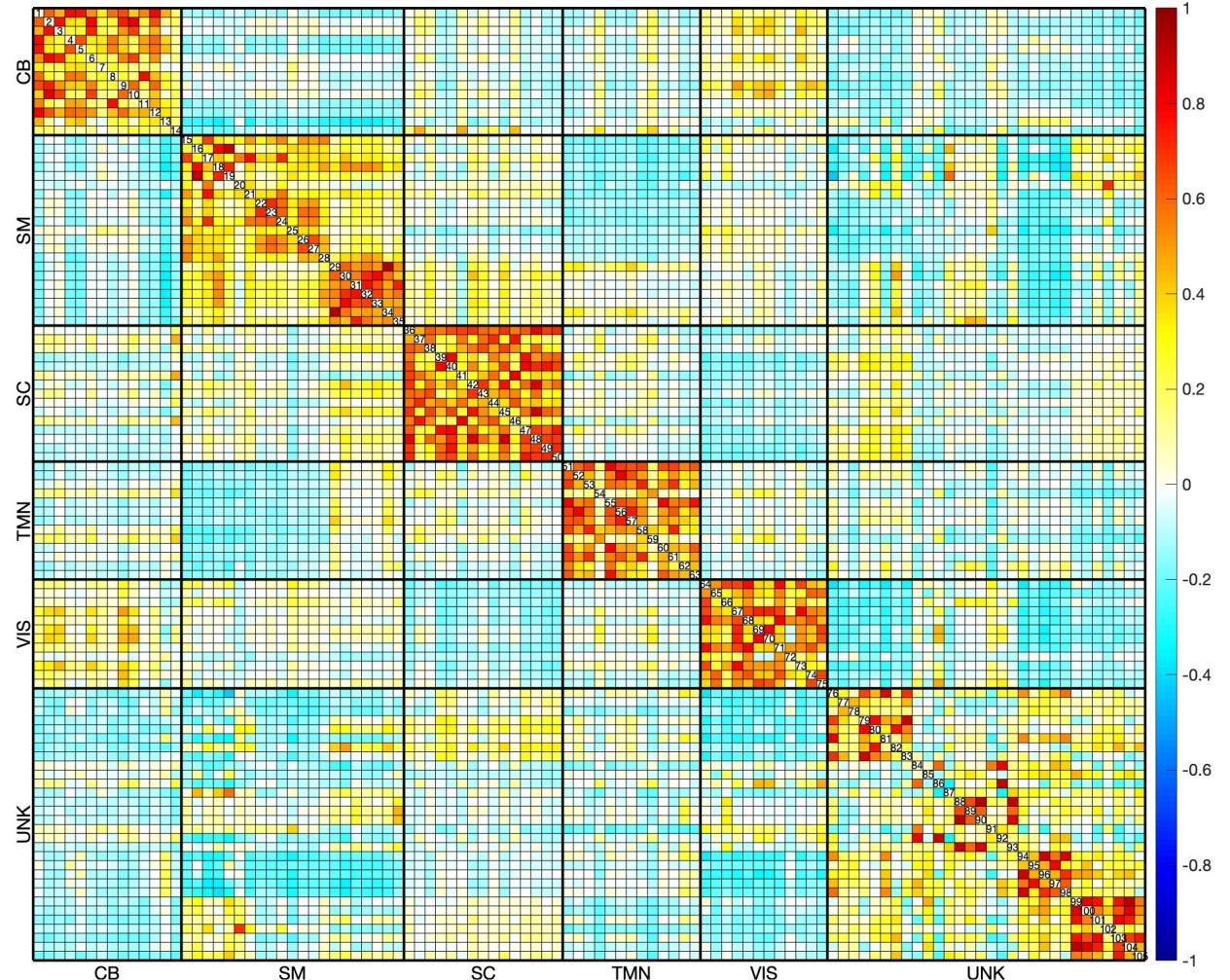
Features for analyzing brain activity



Average Multi spatial scale FNC - CON



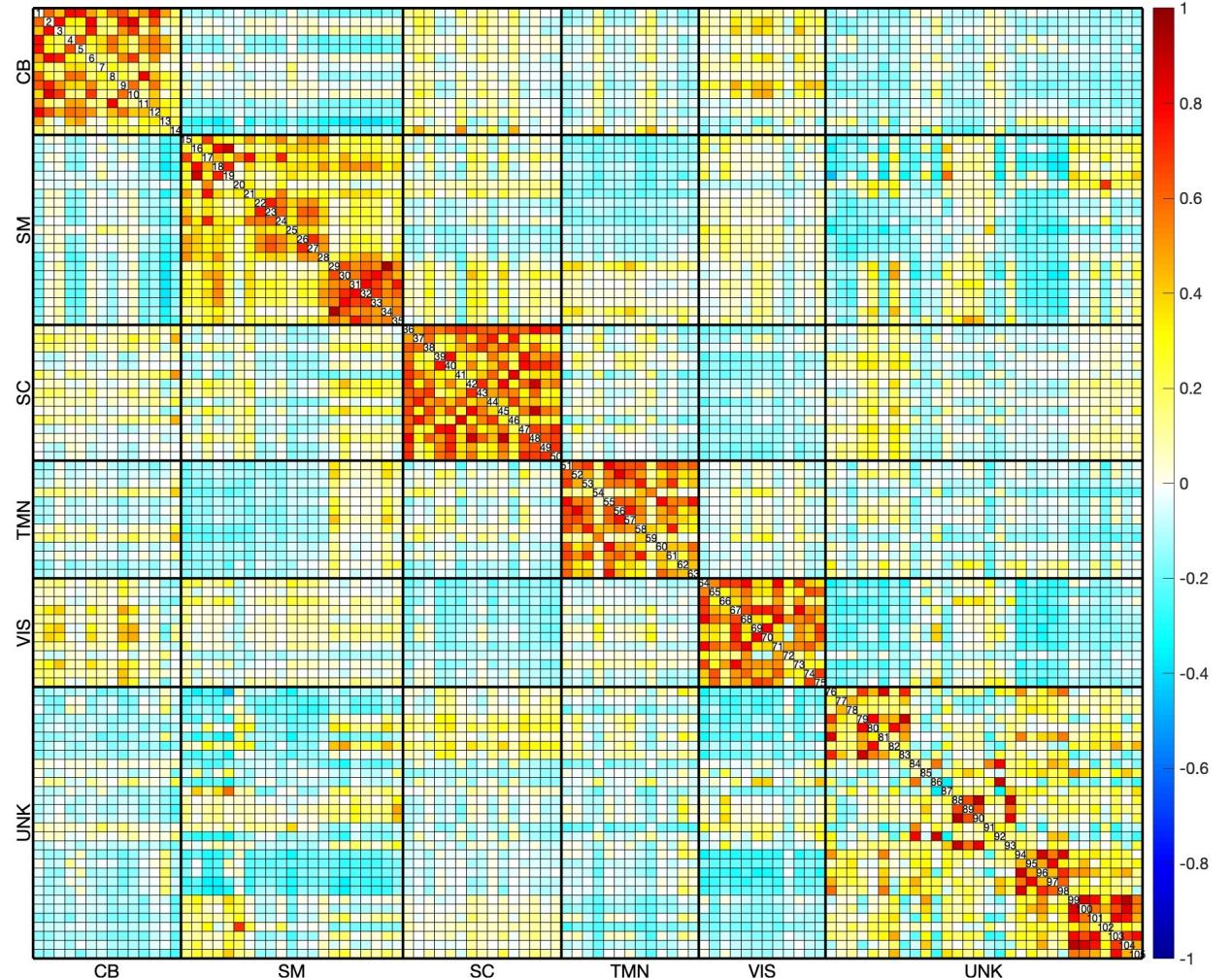
Features for analyzing brain activity



Average Multi spatial scale FNC - SZ



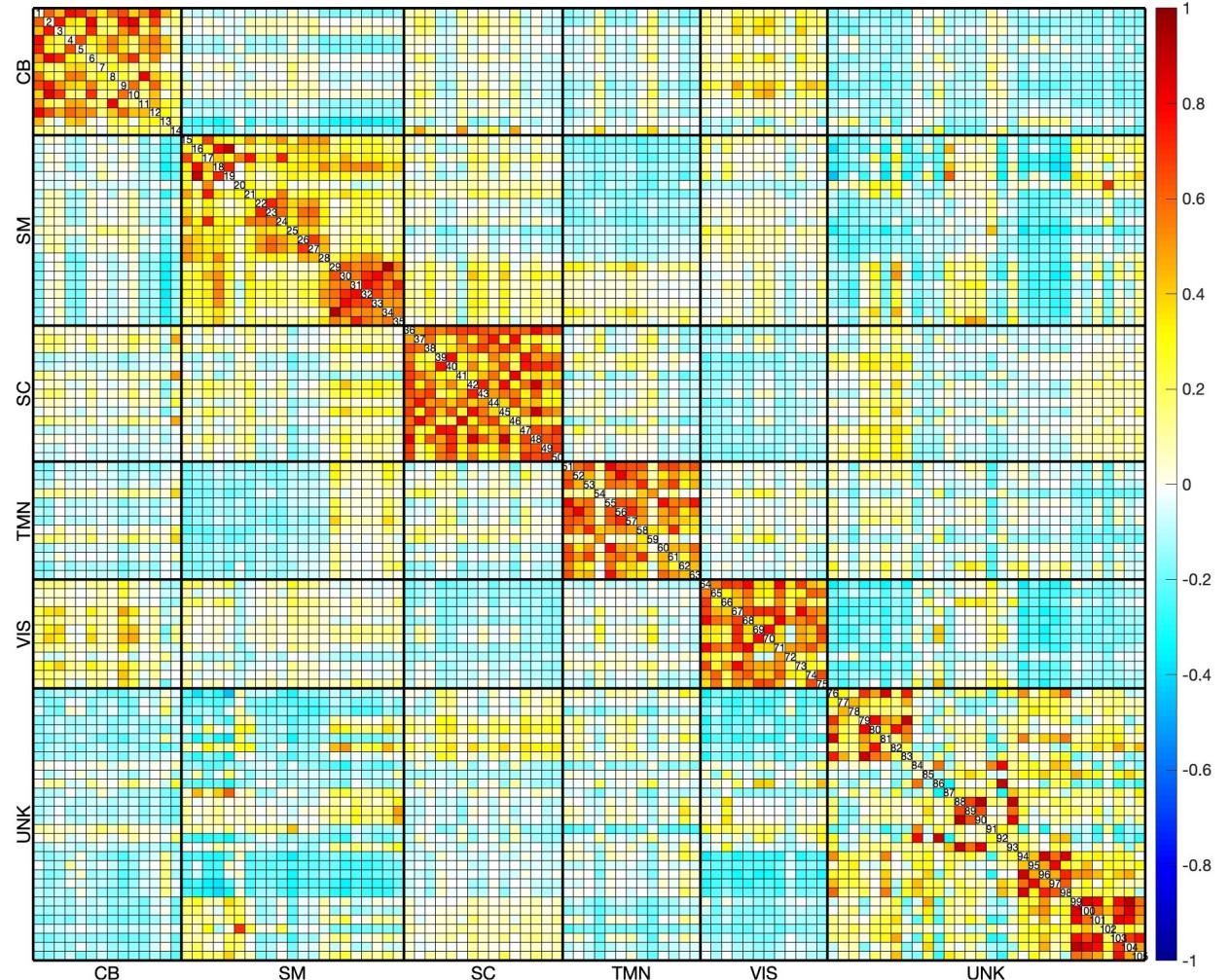
Features for analyzing brain activity



Average Multi spatial scale FNC - CON



Features for analyzing brain activity



Average Multi spatial scale FNC - BP



Motivation for psychosis classification

Reliable ICN templates – comparable functional patterns across fMRI datasets

- Replicable network template
- 100k+ individual subjects
- Accurate and Precise individualized dynamic networks, retaining cross correspondence

A. Iraji et al., "Canonical and Replicable Multi-Scale Intrinsic Connectivity Networks in 100k+ Resting-State fMRI Datasets," *bioRxiv*, p. 2022.09.03.506487, 2022, doi: 10.1101/2022.09.03.506487.

Multi Spatial Scale Functional Network Connectivity And Its Application In Psychosis

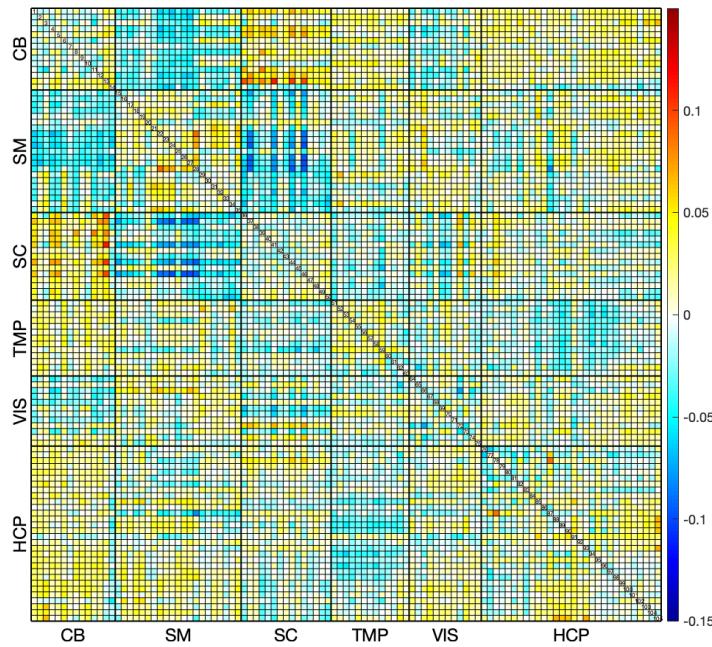
- Using reliable ICN network template
- Compare and study functional patterns across subjects and studies
- Outlines first clinical application of the reliable ICN template

Motivation for psychosis classification

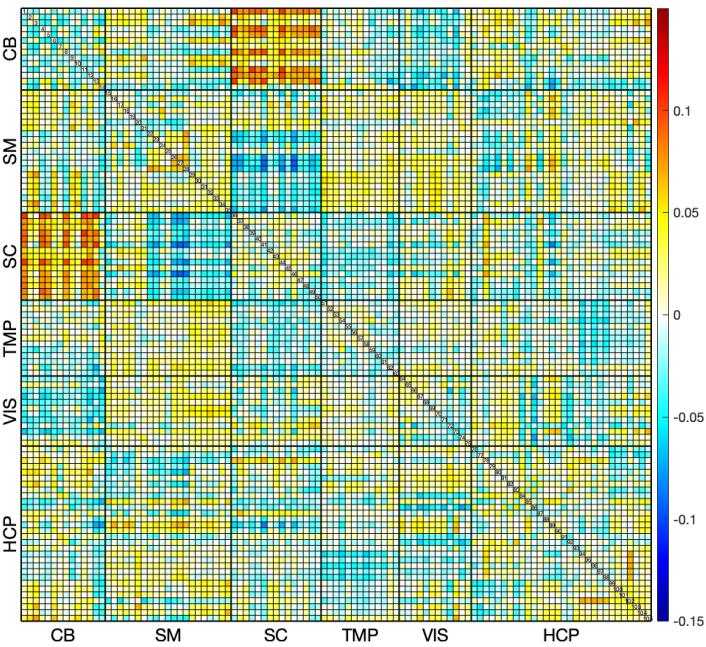
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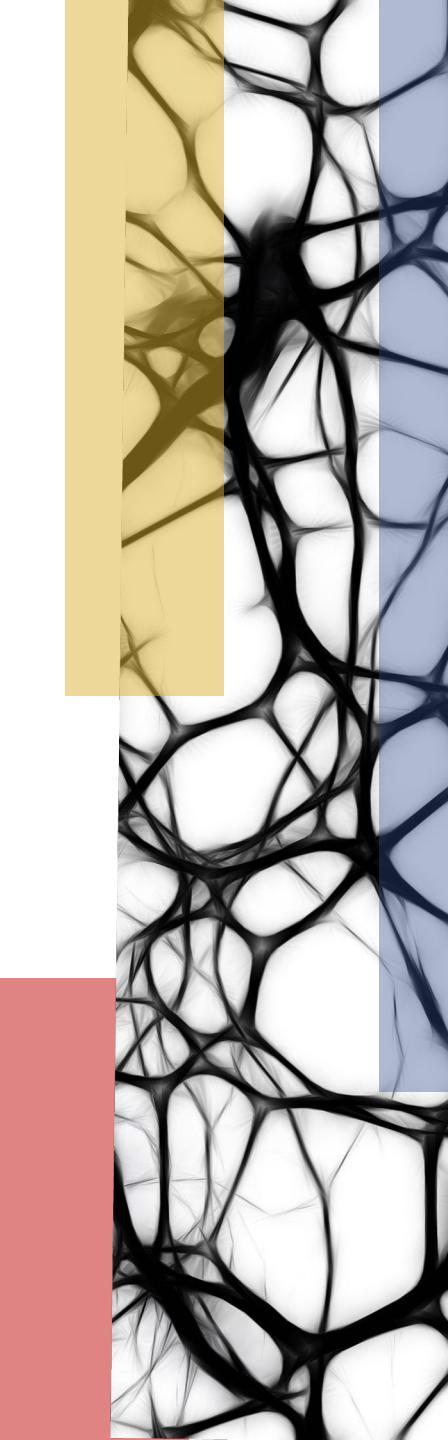
IEEE ISBI 2023 Conference Publication



Group Difference CON – BP



Group Difference CON – SZ



Dataset analysis

BSNIP – 1 and BSNIP – 2

- 1428 resting state fMRI data
- Features include ICN correlations (5460 * 1)
- Demographic Data Features
- { Age, Gender, Race/Ethnicity, Group }
- Categorical and Continuous Data

Healthy / Control (NC) patients 635

Bipolar (BP) patients 309

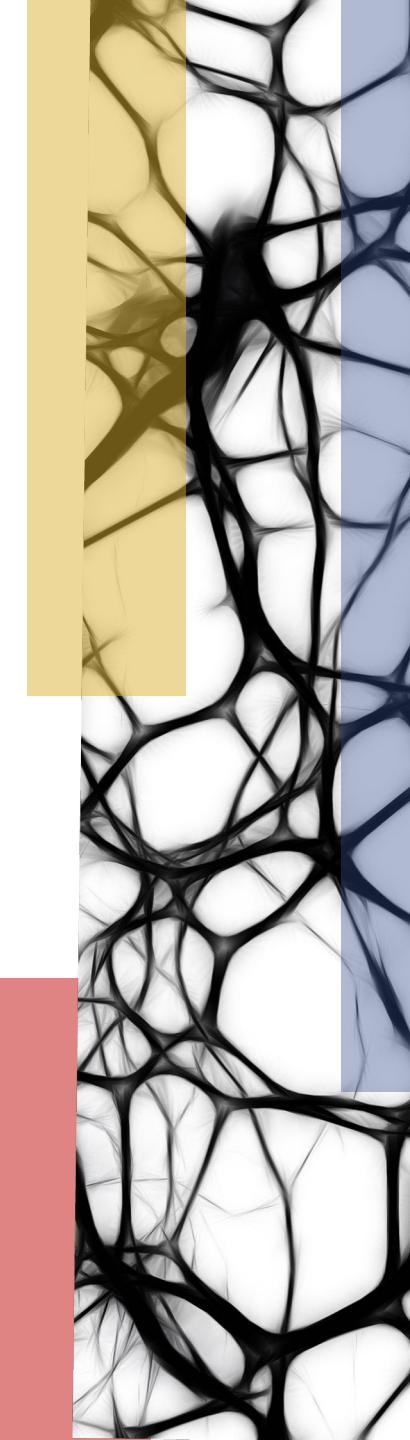
Schizophrenia (SZ) patients 484

Females 635

Males 309

Age Range : 15 – 64

AA African American	498
AE American Indian / Alaskan Native	5
AS Asian	68
CA Central American	758
MR More than one race	56
NH Native Hawaiian / Pacific Islander	2
OT Other	39
UNK Unknown / Not Reported	2



Classification Predictive Modeling

Linear Support Vector Machines – Binary Classification Modeling

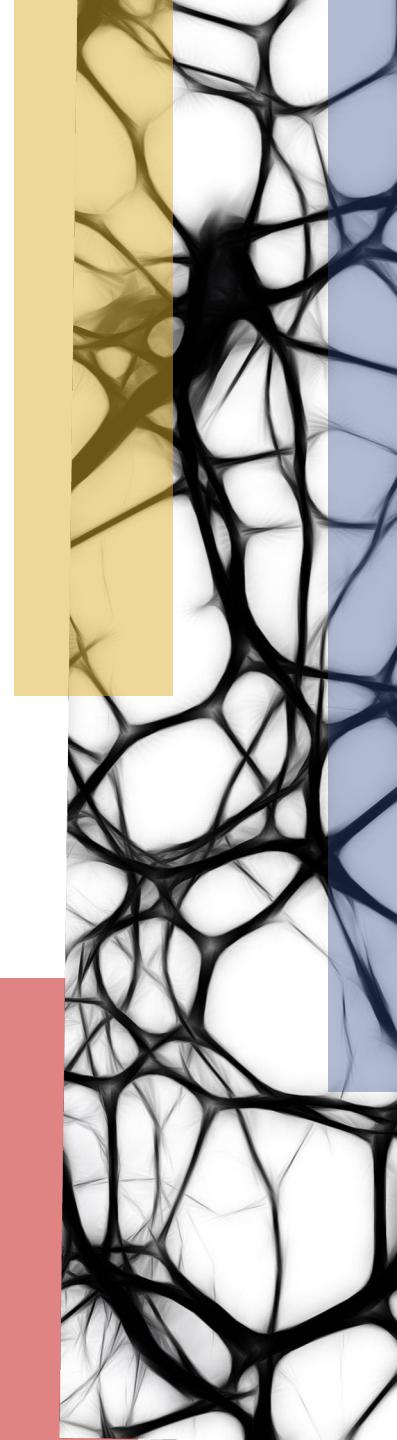
- Control / Healthy VS Psychosis (BP and SZ)
- Holdout Validation (20%)
- 5 – Fold Cross Validation
- Demographic Data and Correlations of ICN's as Features

Feature Selection and Classification

- Two Sample Test
- Chi Squared Test
- Minimum Redundancy Maximum Relevance algorithm

Hyperparameter Tuning

- Kernel Function
- Kernel Scale
- Standardization
- Regularization – Box Constraint & Misclassification Cost



Classification Modeling – Holdout Validation

Linear Support Vector Machines – Binary Classification Modeling

- Control / Healthy VS Psychosis (BP and SZ)
- Holdout Validation (20%)
- Demographic Data and Correlations of ICN's as Features

Result Analysis

- F – Score = 59.29

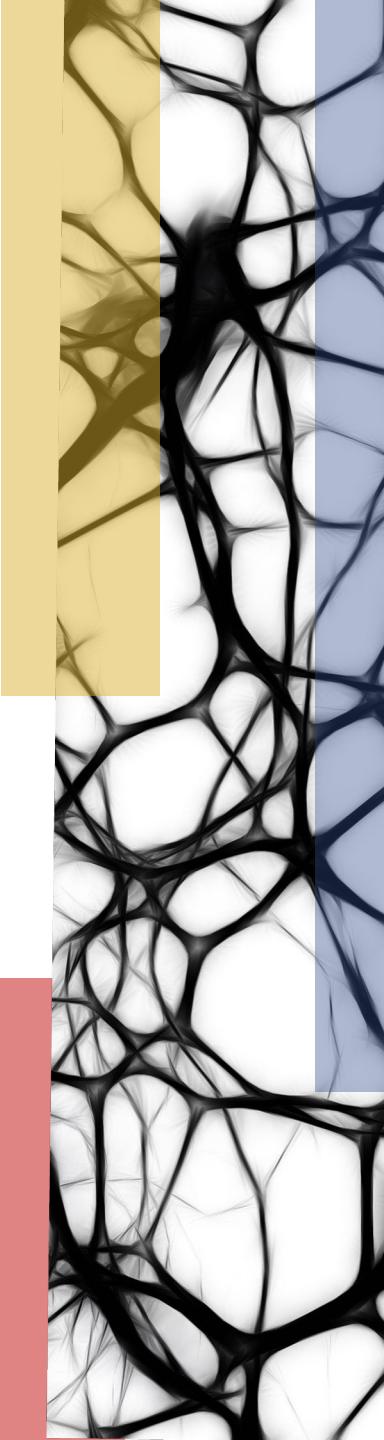
Classification Modeling – K Fold Cross Validation

Linear Support Vector Machines – Binary Classification Modeling

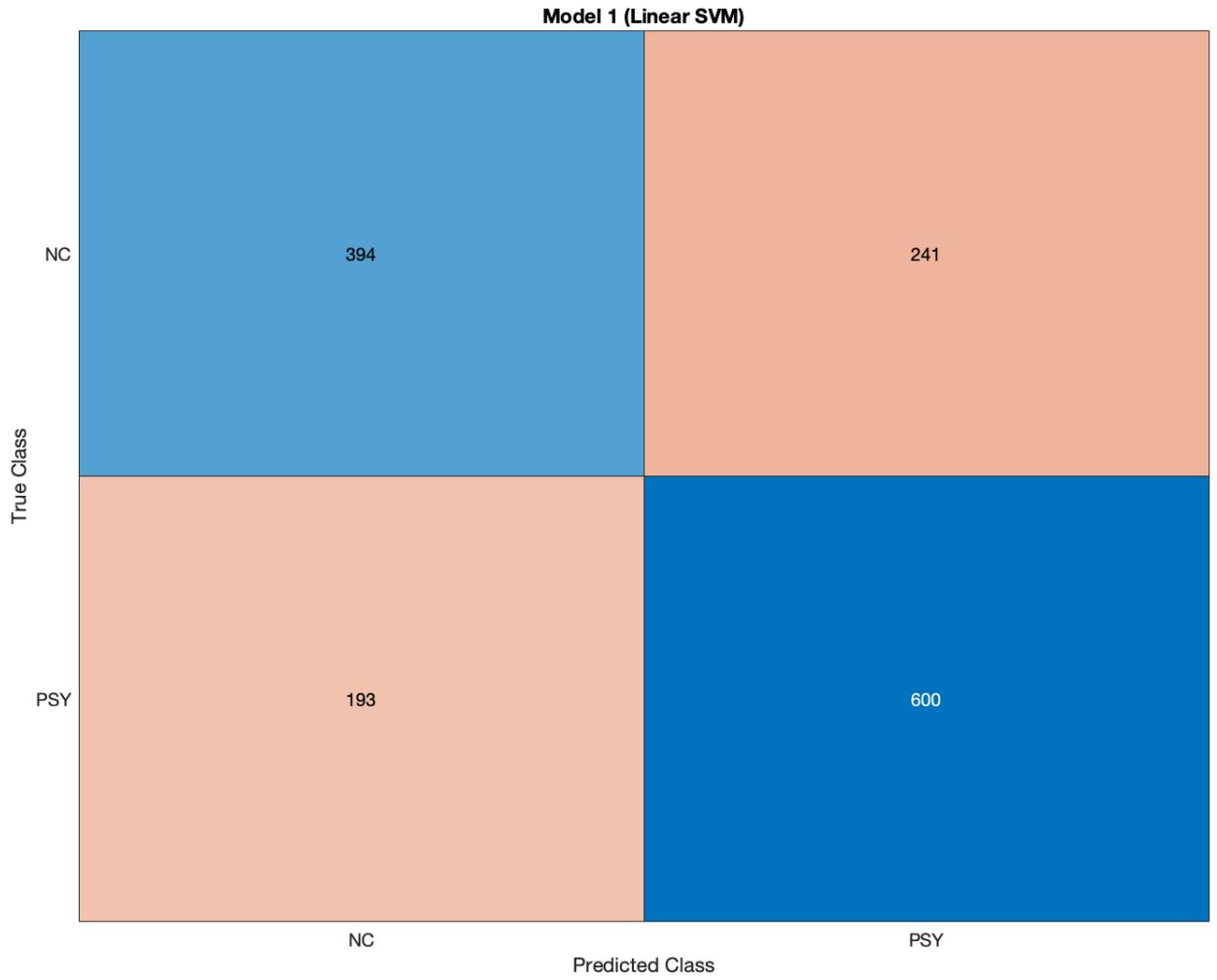
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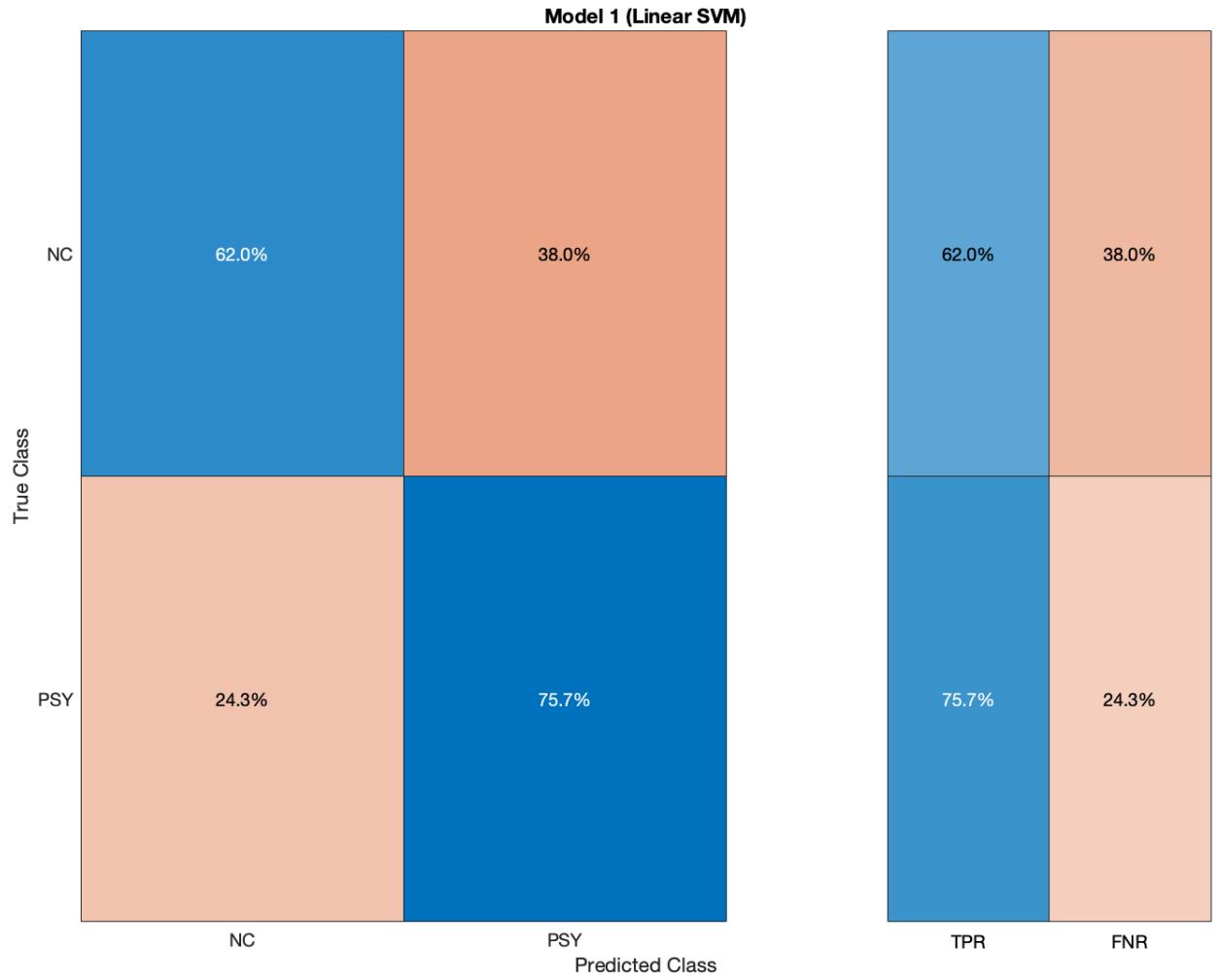
- Confusion Matrix
- **F – Score = 69.6**
- ROC and AUC
- Outlier Rate
- K – Fold Loss



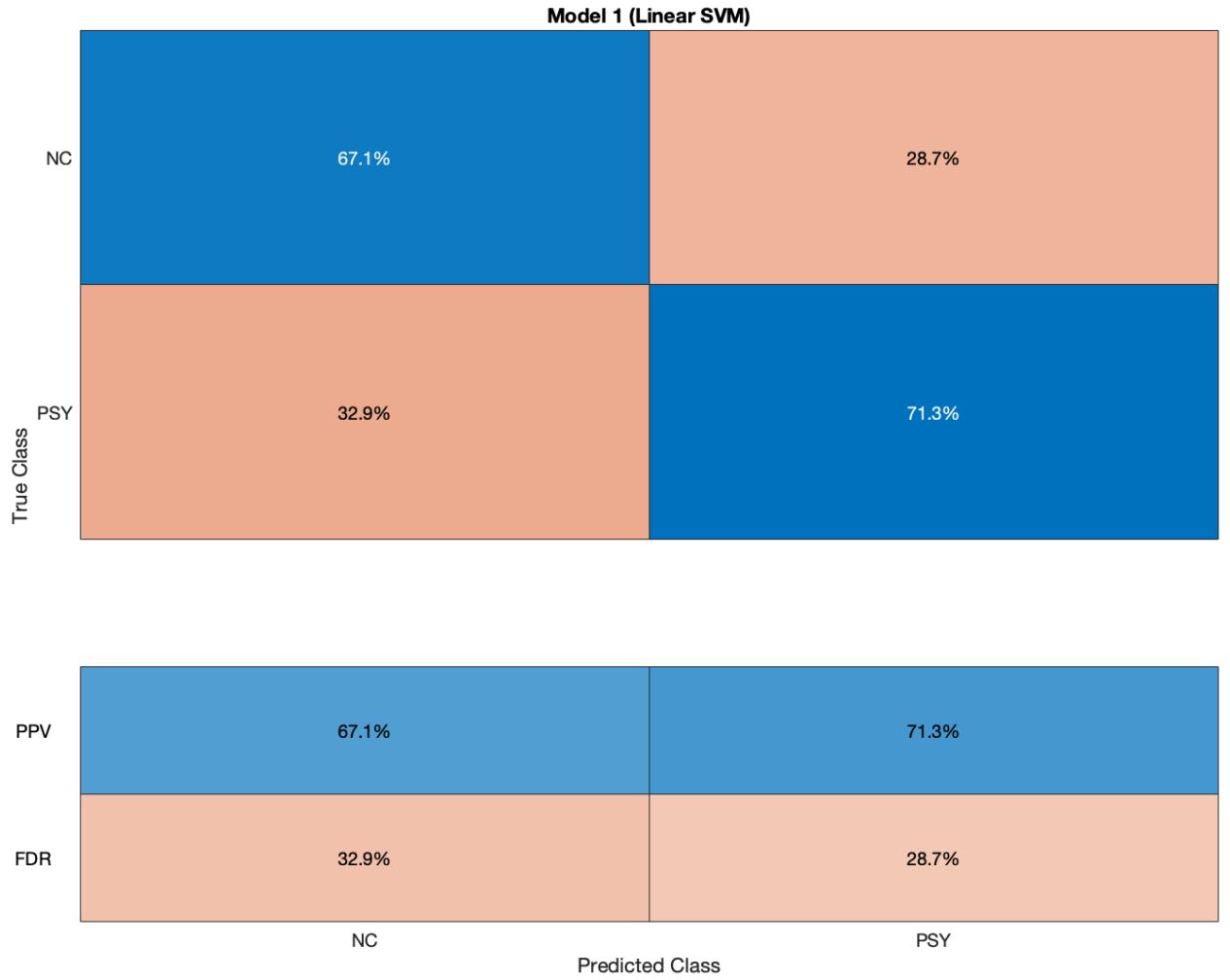
Classification Modeling – K Fold Cross Validation



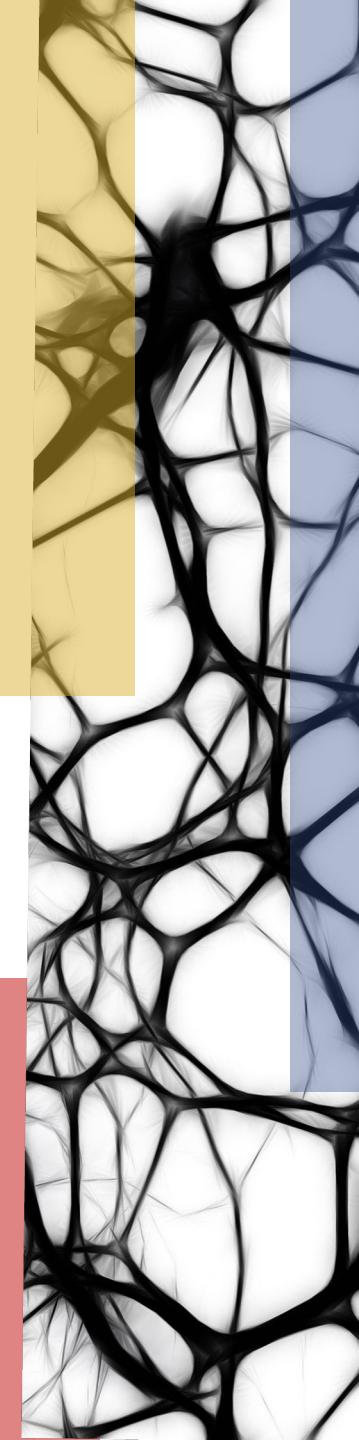
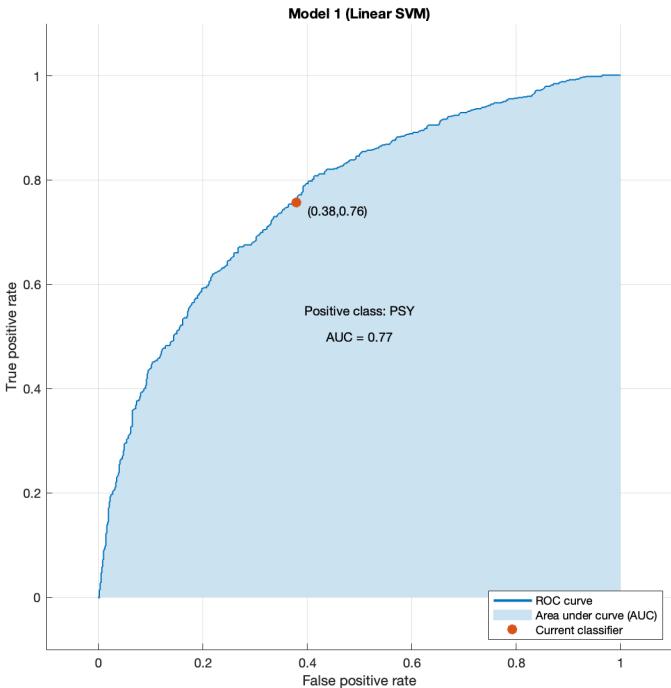
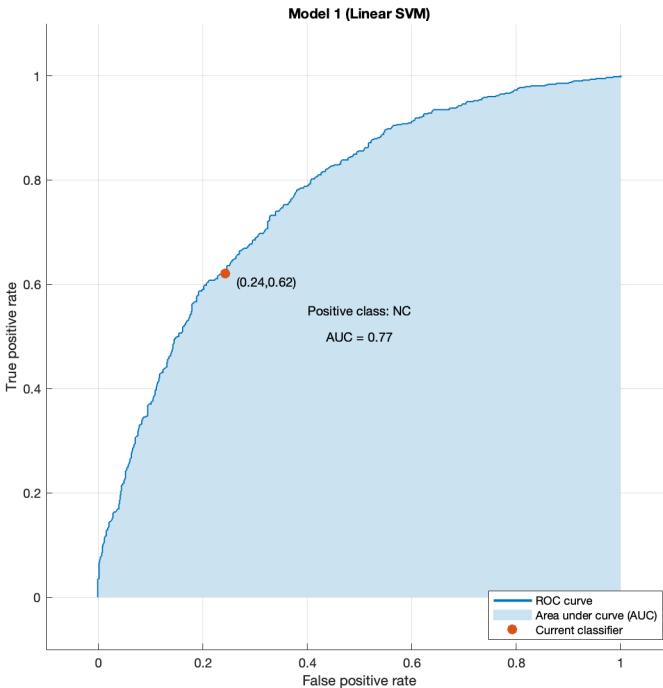
Classification Modeling – K Fold Cross Validation



Classification Modeling – K Fold Cross Validation



Classification Modeling – K Fold Cross Validation



Classification Modeling – Feature Selection

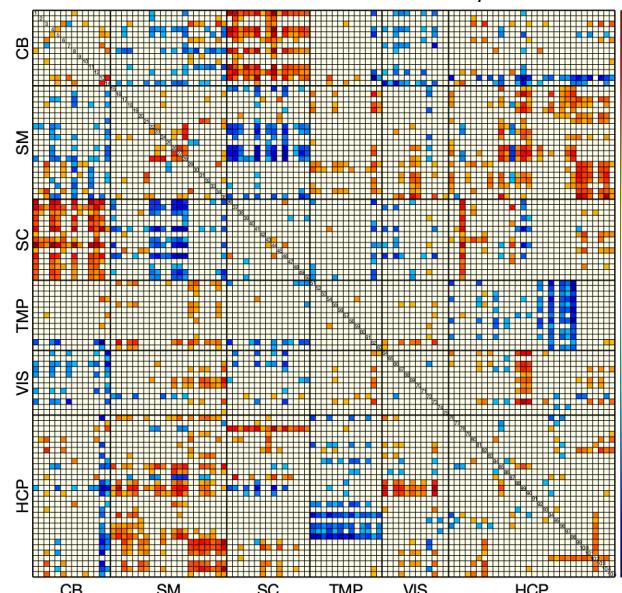
Holdout Validation

Feature Selection and Classification with highest ranking predictors

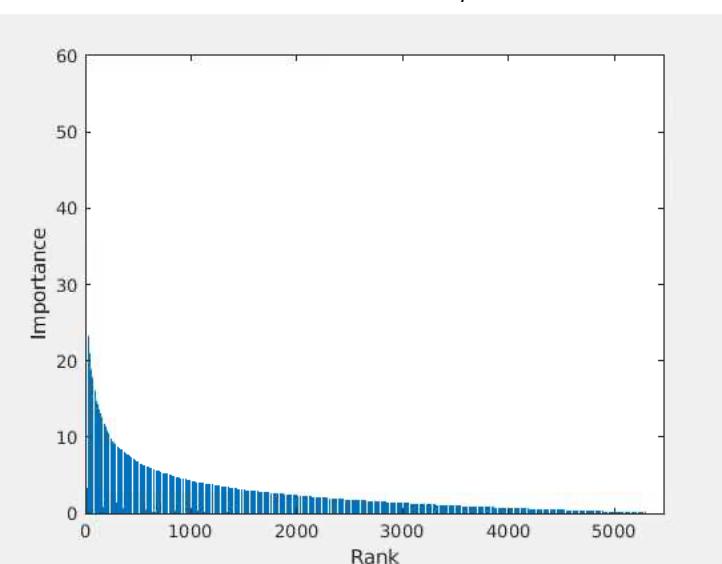
- Two Sample Test
- Chi Squared Test
- Minimum Redundancy Maximum Relevance algorithm

FS Algorithm	T–Test	Chi Squared Test	MRMR
F – Scores	61.75	67.71	68.07

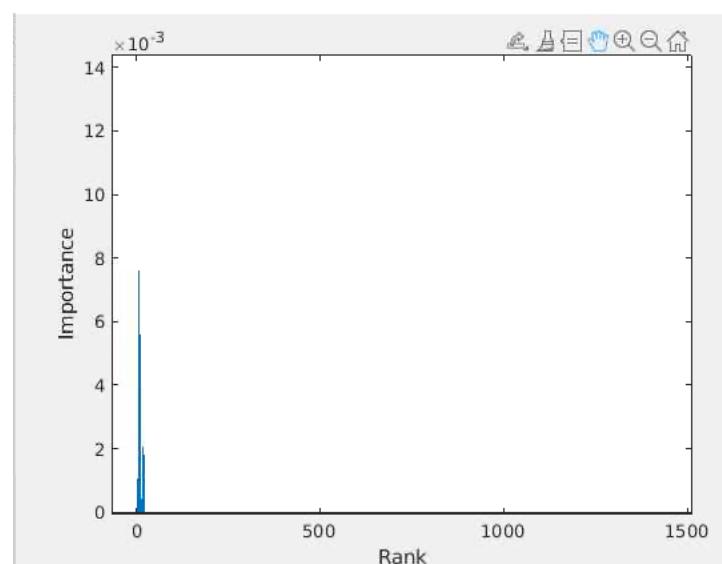
Relevant Features – Two Sample Test



Relevant Features – Chi Squared Test



Relevant Features – MRMR



Classification Modeling – Feature Selection

Holdout Validation

Feature Selection and Classification with highest ranking predictors

- Two Sample Test
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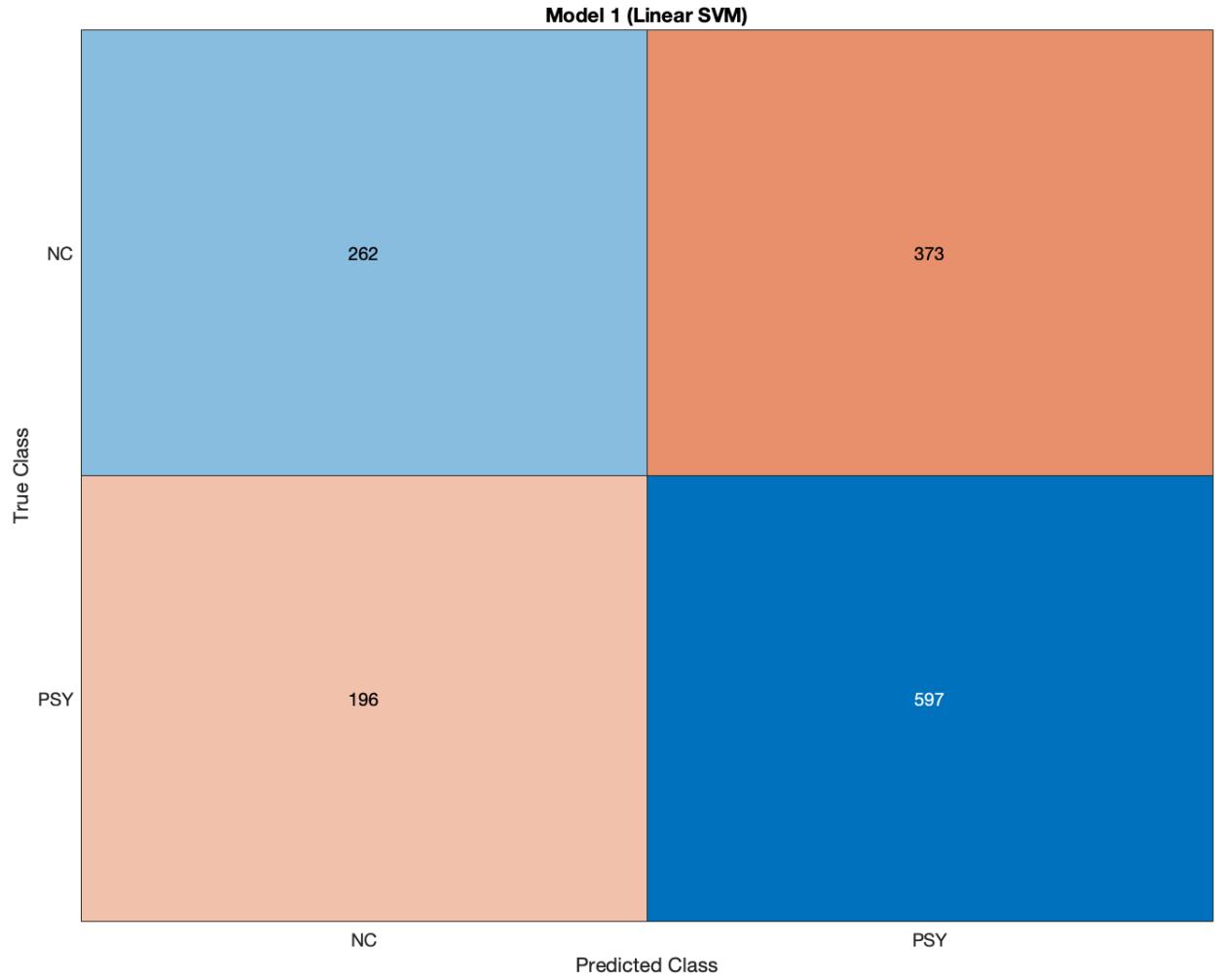
Result Analysis

- Confusion Matrix
- F – Score
- ROC and AUC
- Outlier Rate
- K – Fold Loss

FS Algorithm (K-Fold)	T– Test	Chi Squared Test	MRMR
F – Scores	60.2	71	68.2

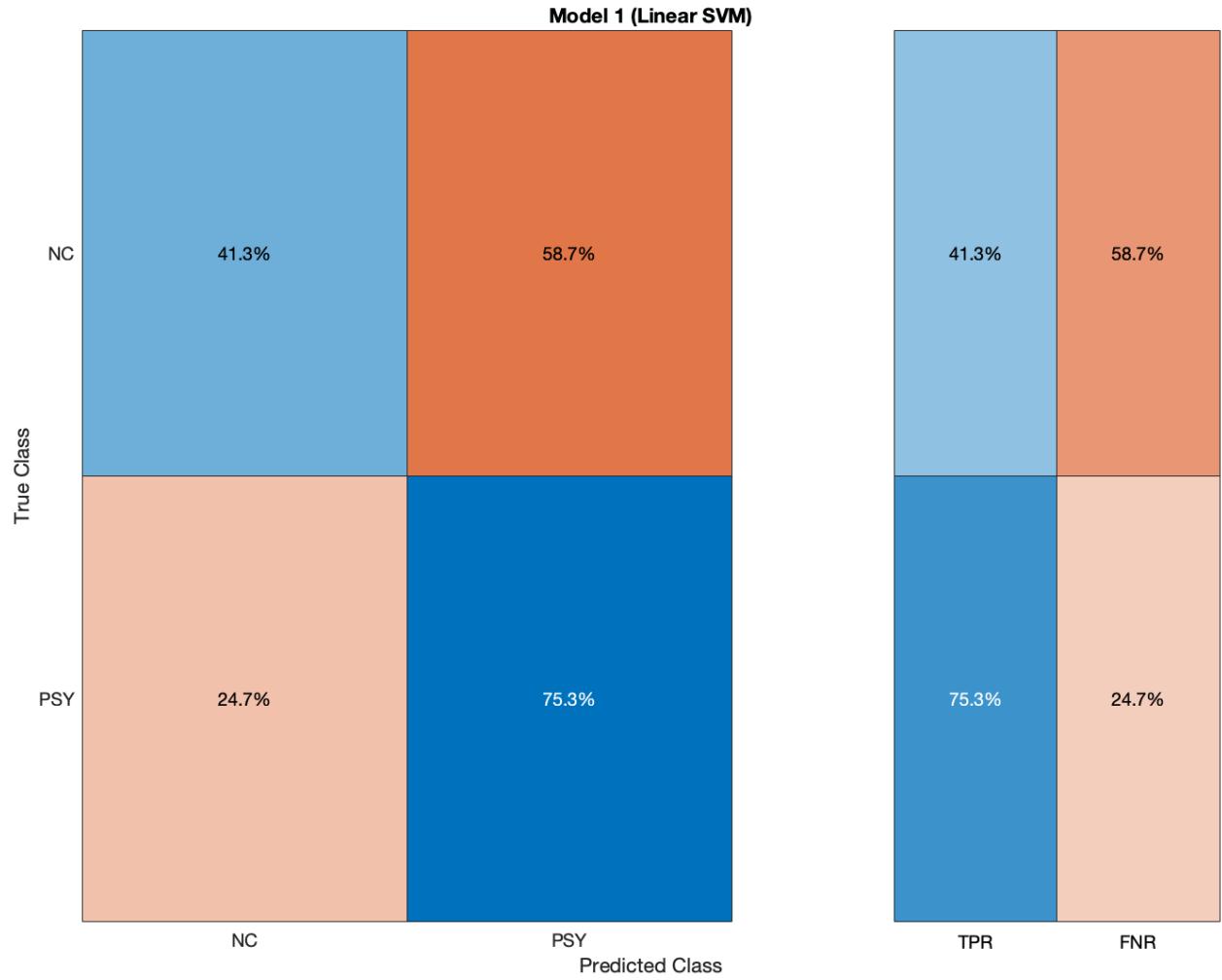
Classification Modeling Feature Selection - TTest

K Fold Cross Validation



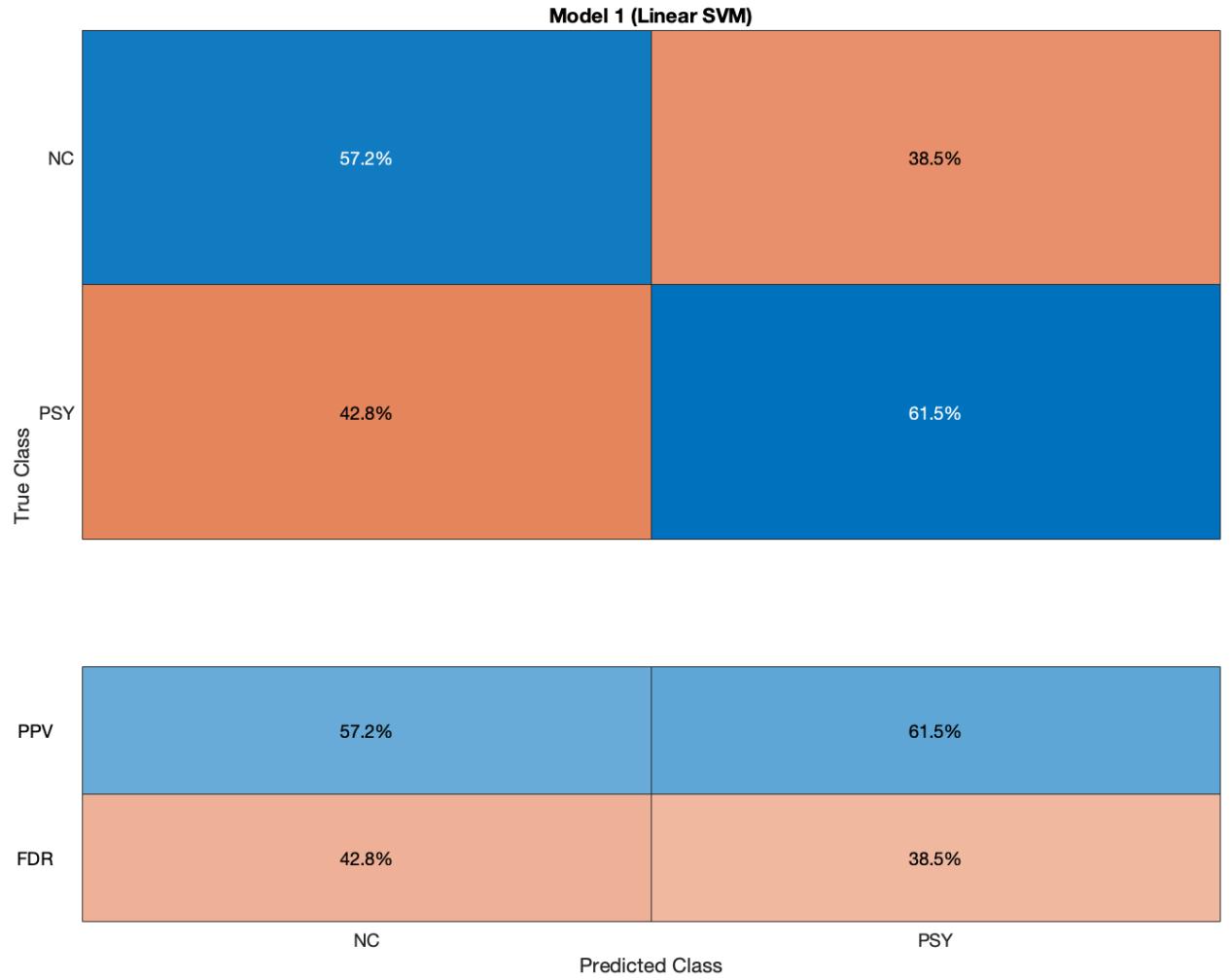
Classification Modeling Feature Selection - TTest

K Fold Cross Validation

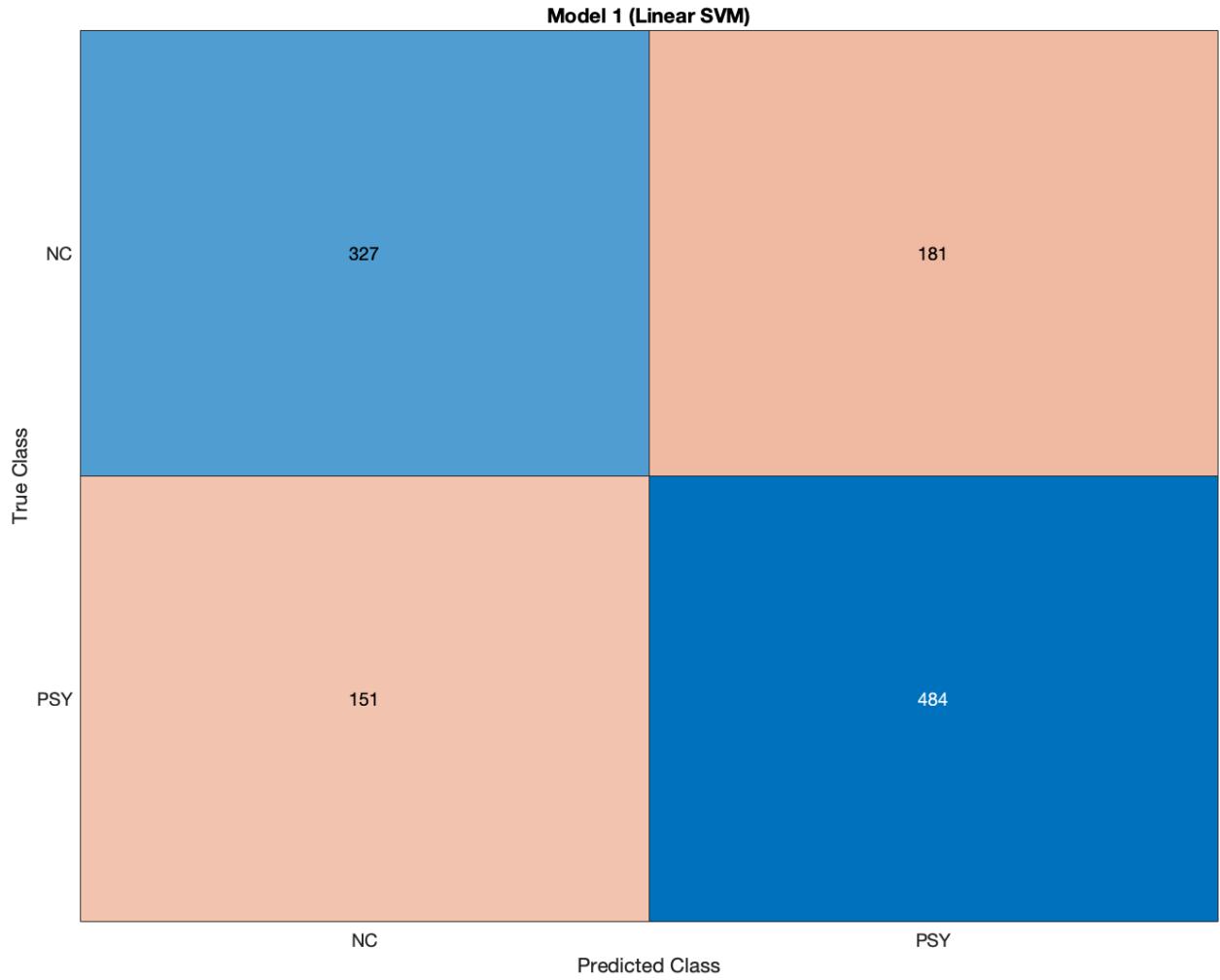


Classification Modeling Feature Selection - TTest

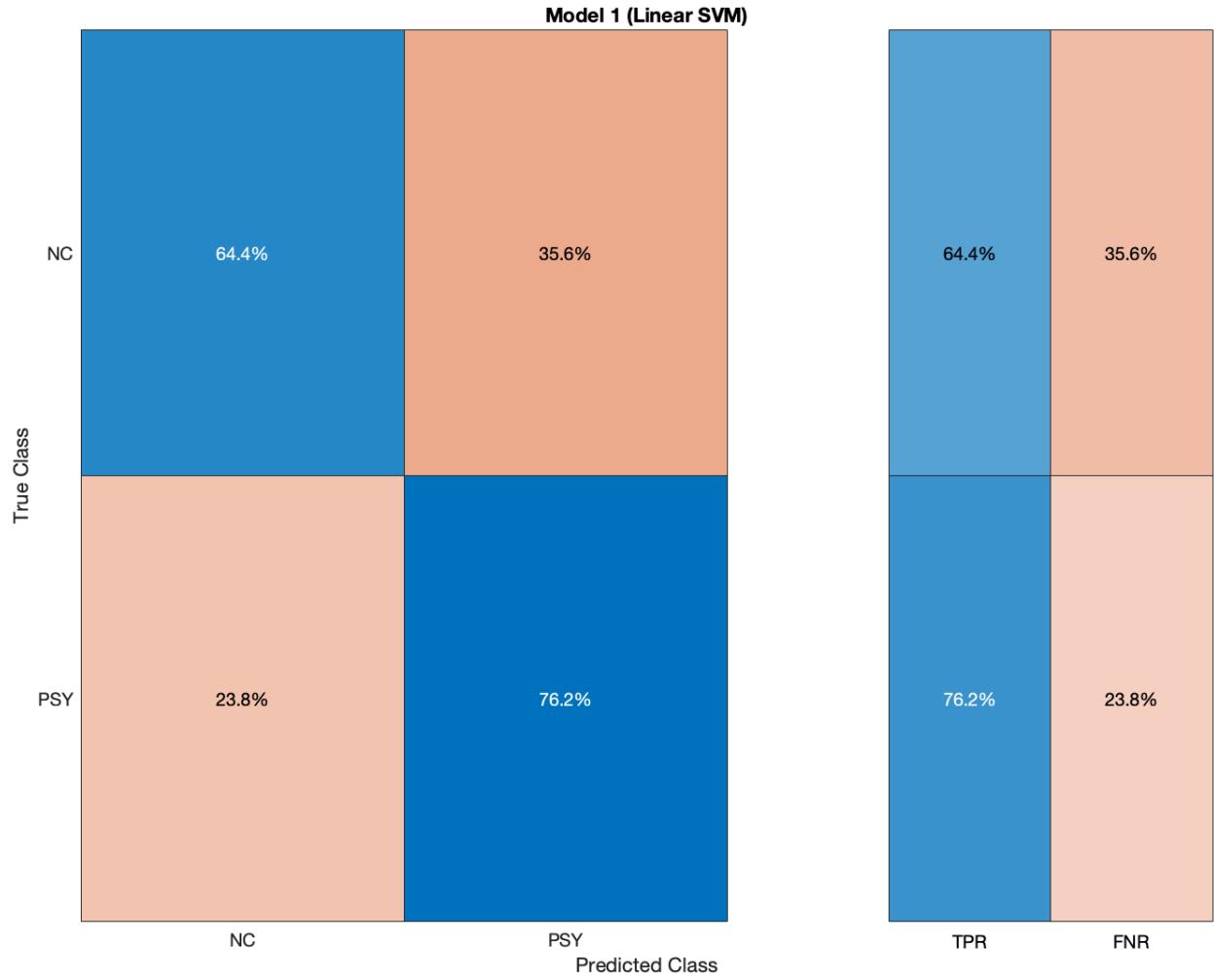
K Fold Cross Validation



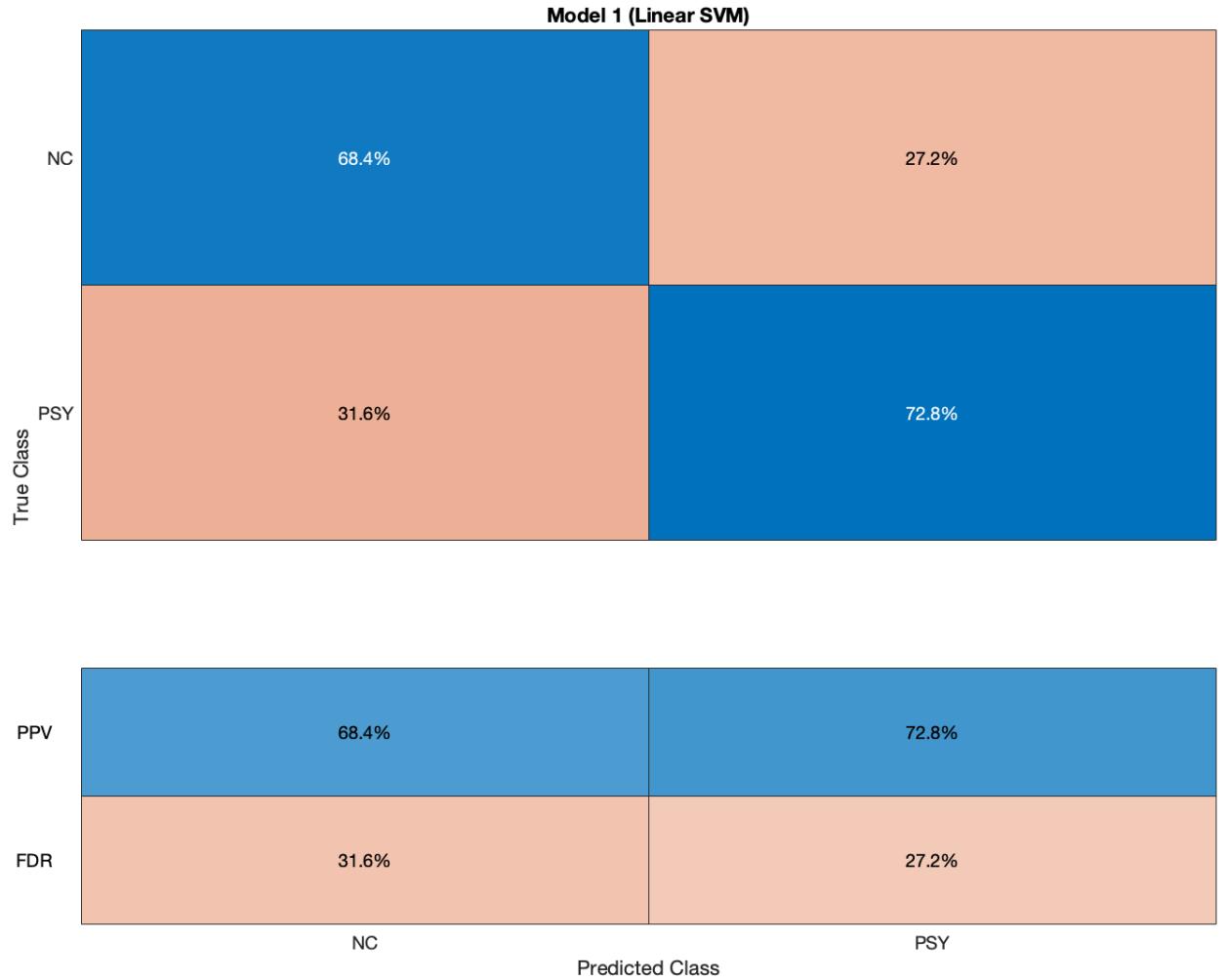
Classification Modeling Feature Selection – Chi Square K Fold Cross Validation



Classification Modeling Feature Selection – Chi Square K Fold Cross Validation

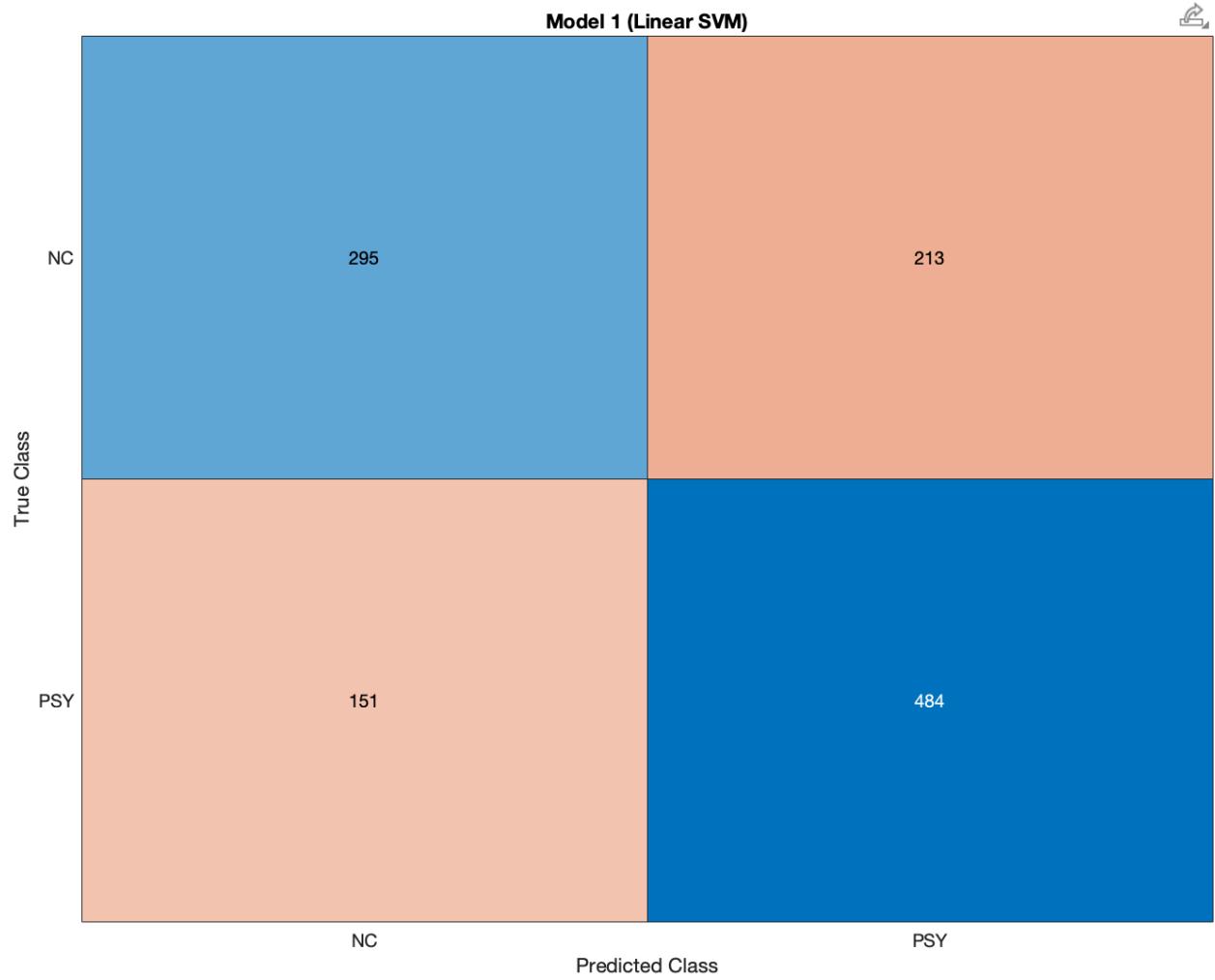


Classification Modeling Feature Selection – Chi Square K Fold Cross Validation



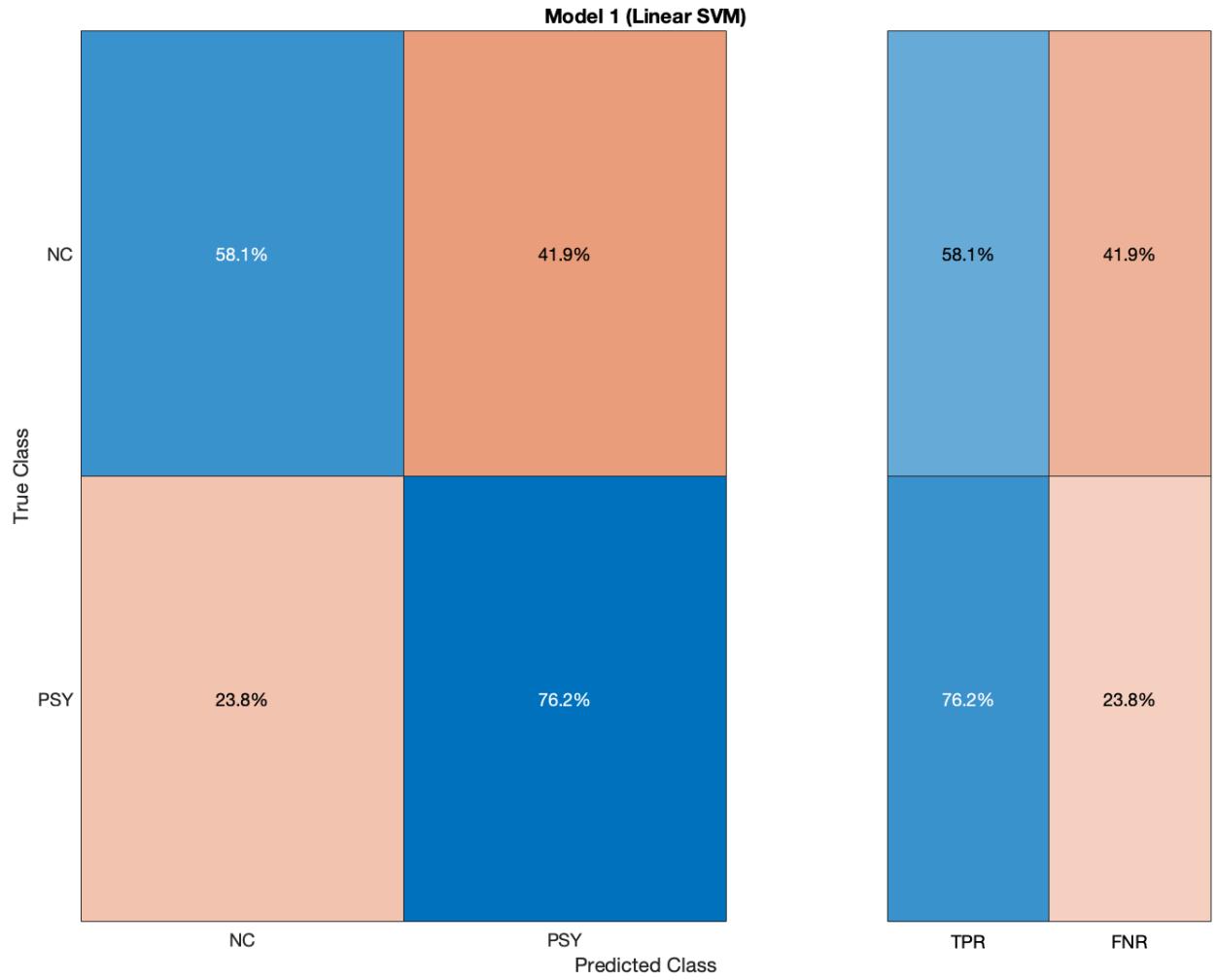
Classification Modeling Feature Selection - MRMR

K Fold Cross Validation



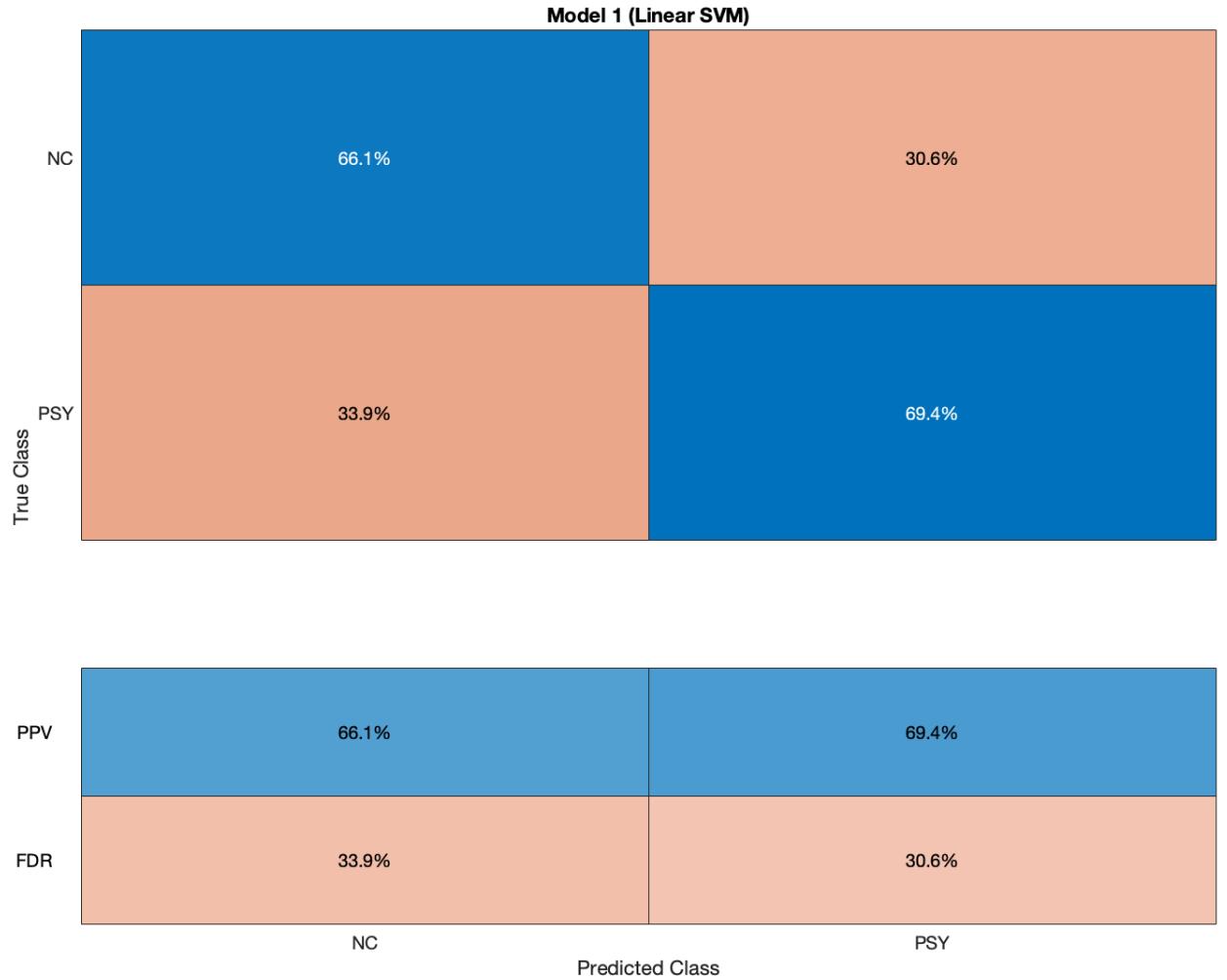
Classification Modeling Feature Selection - MRMR

K Fold Cross Validation



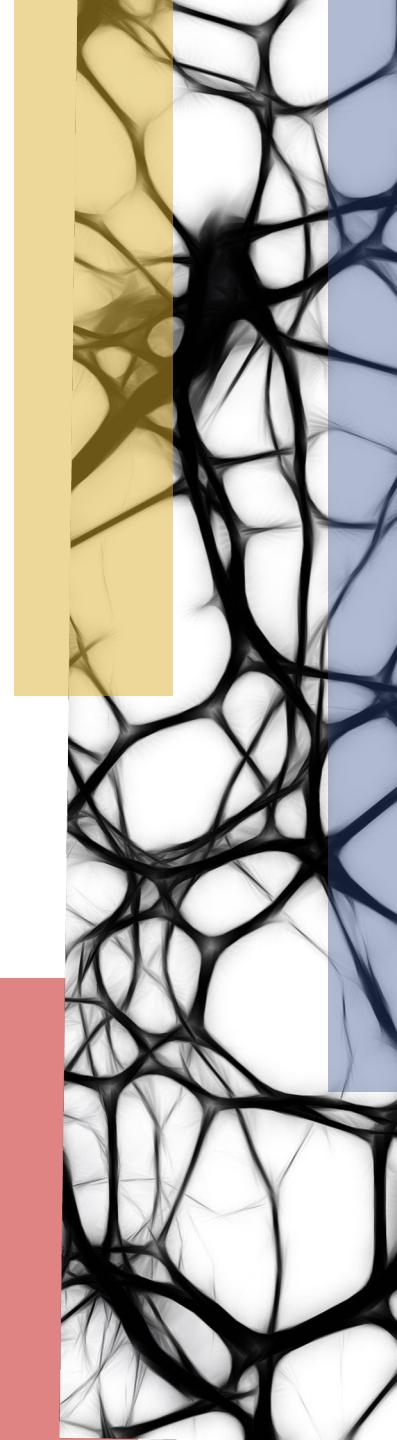
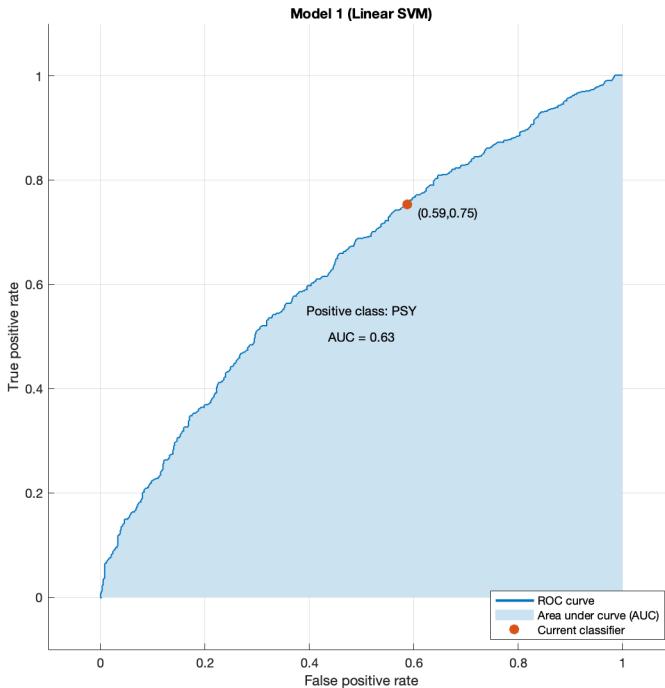
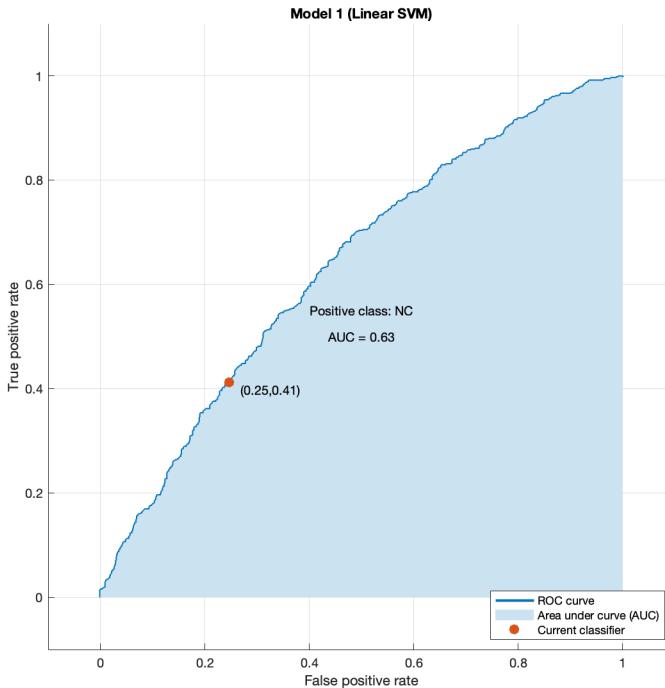
Classification Modeling Feature Selection - MRMR

K Fold Cross Validation

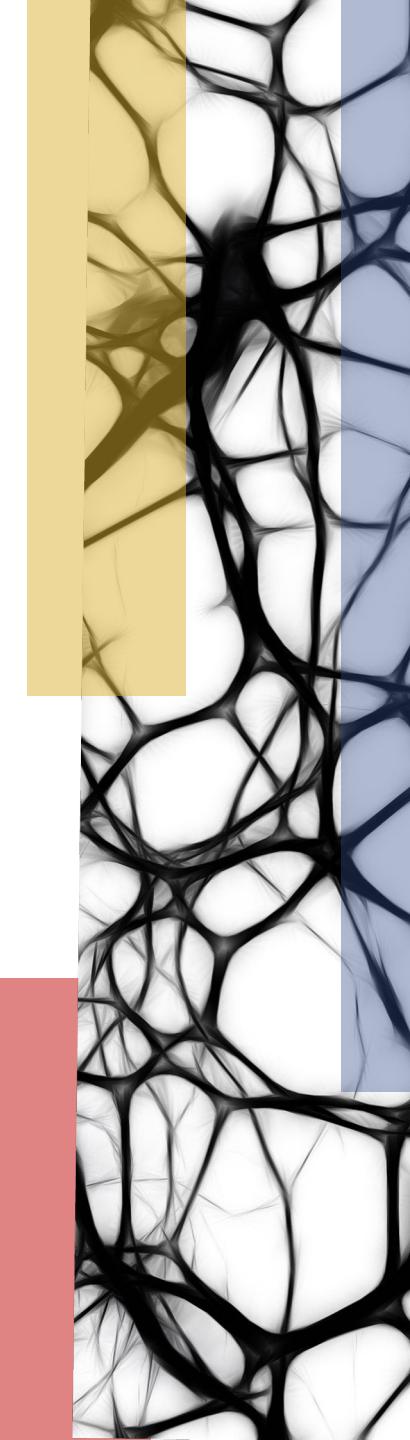
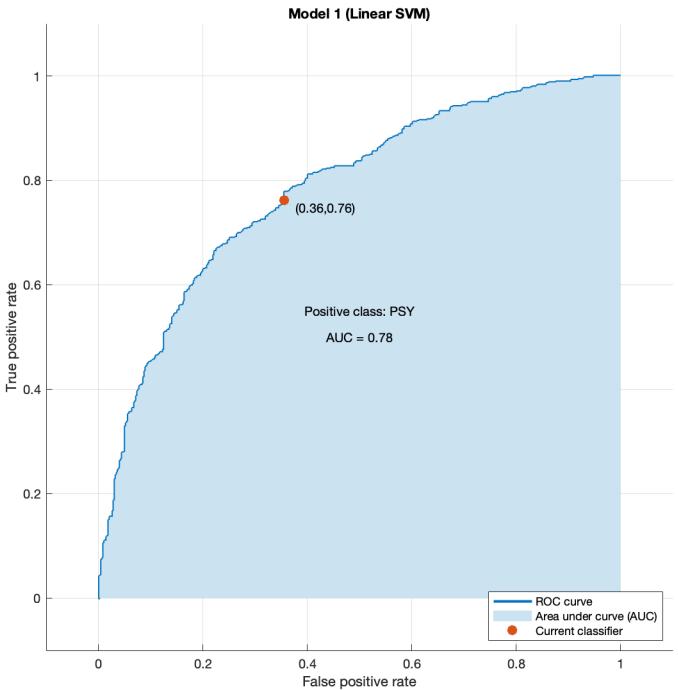
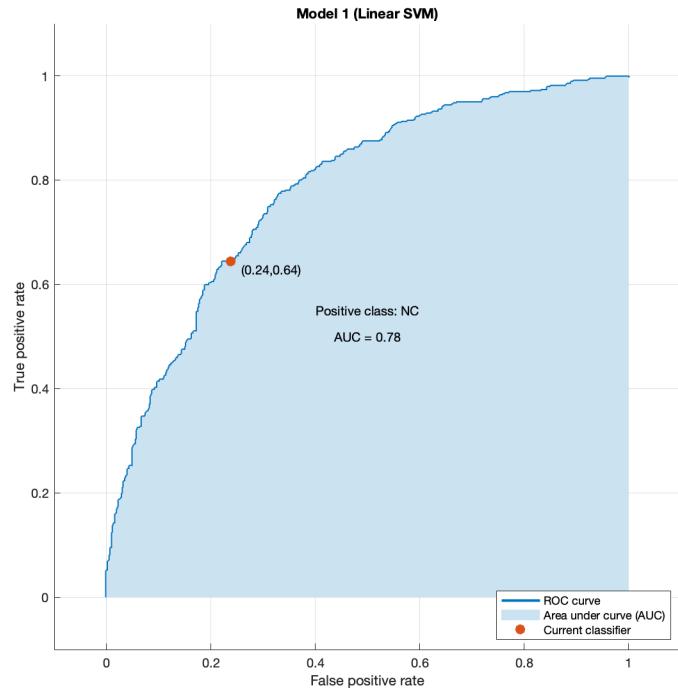


Classification Modeling Feature Selection - TTest

K Fold Cross Validation

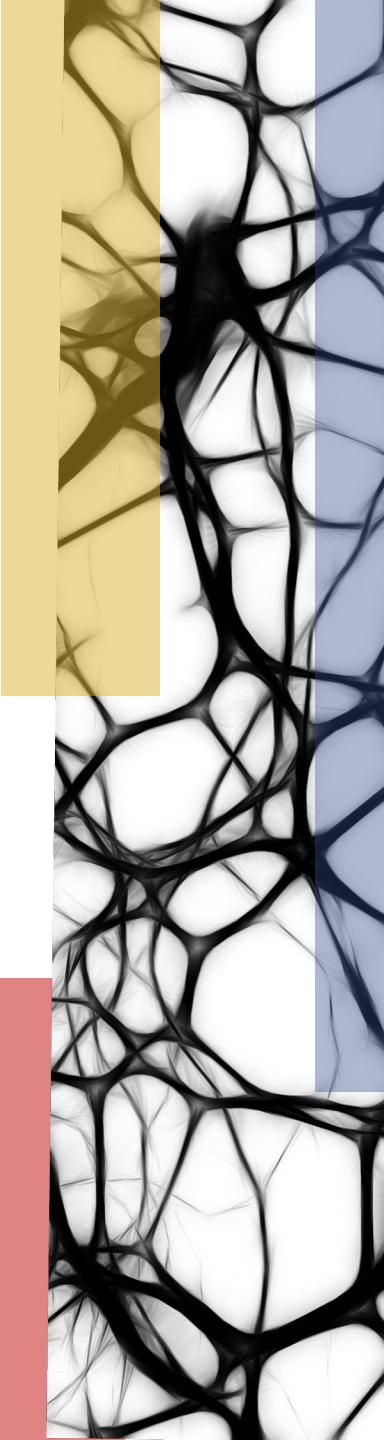
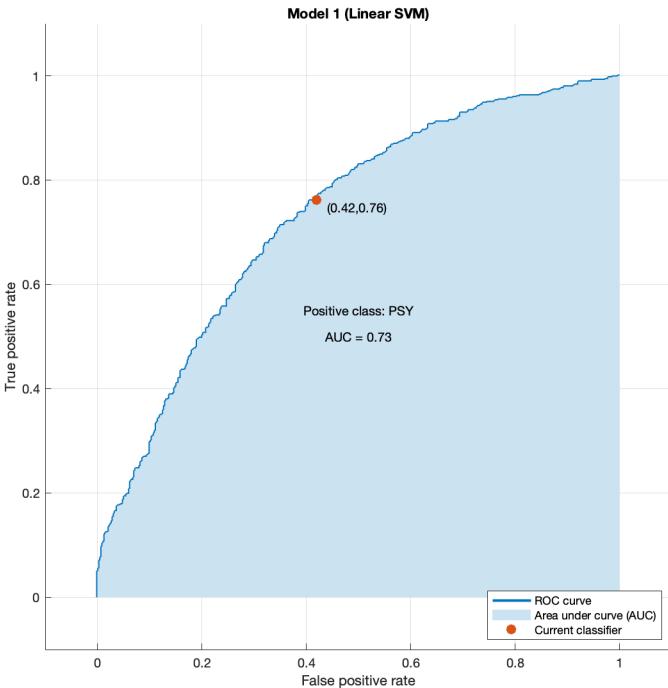
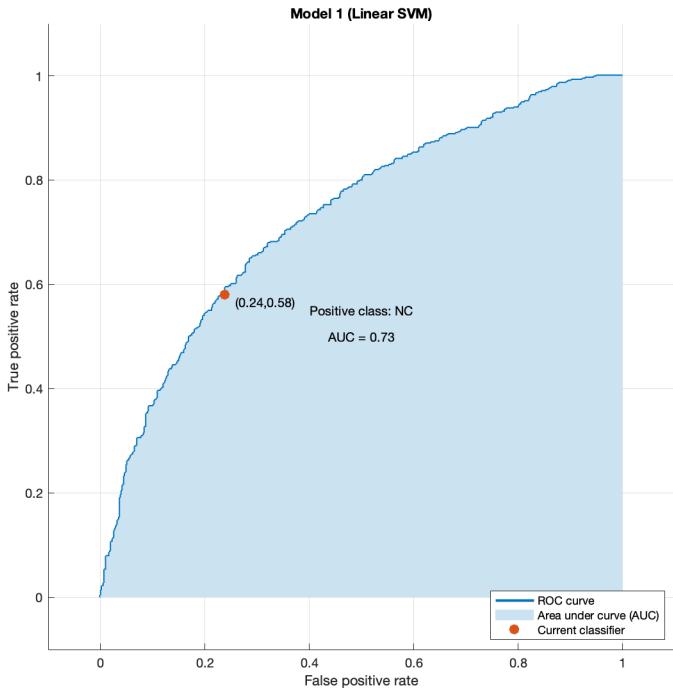


Classification Modeling Feature Selection – Chi Squared K Fold Cross Validation



Classification Modeling Feature Selection - MRMR

K Fold Cross Validation



Classification Modeling – Hyperparameter Tuning

K – Fold Cross Validation

Hyperparameter Tuning

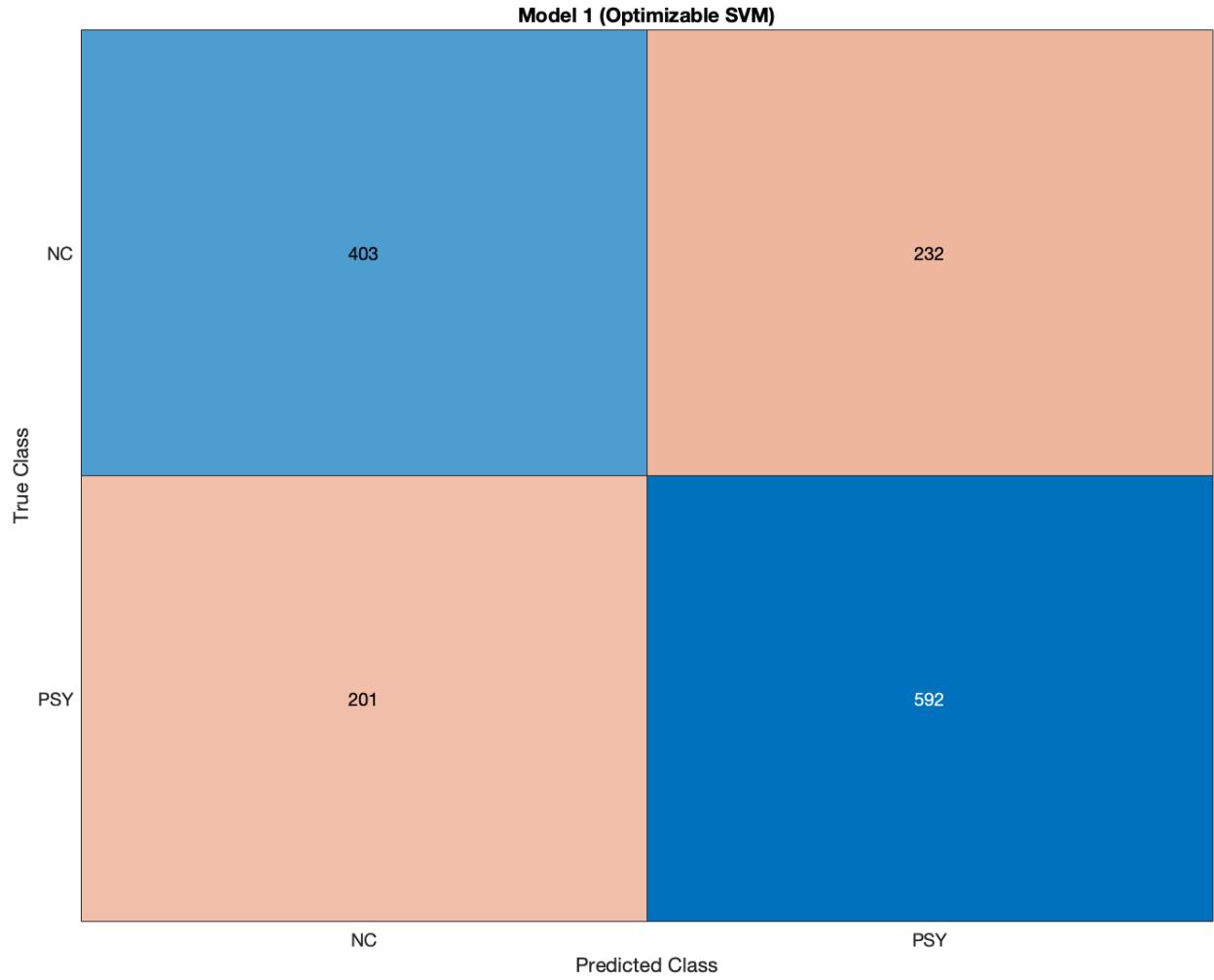
- 30 Iterations
- Kernel Function – [Gaussian, Linear, Quadratic, Cubic]
- Kernel Scale – [0.0001 – 1000]
- Standardization – True / False
- Regularization – Box Constraint & Misclassification Cost : [0.0001 – 1000]

Result Analysis

- Confusion Matrix
- **F – Score = 69.7**
- ROC and AUC
- Outlier Rate
- K – Fold Loss

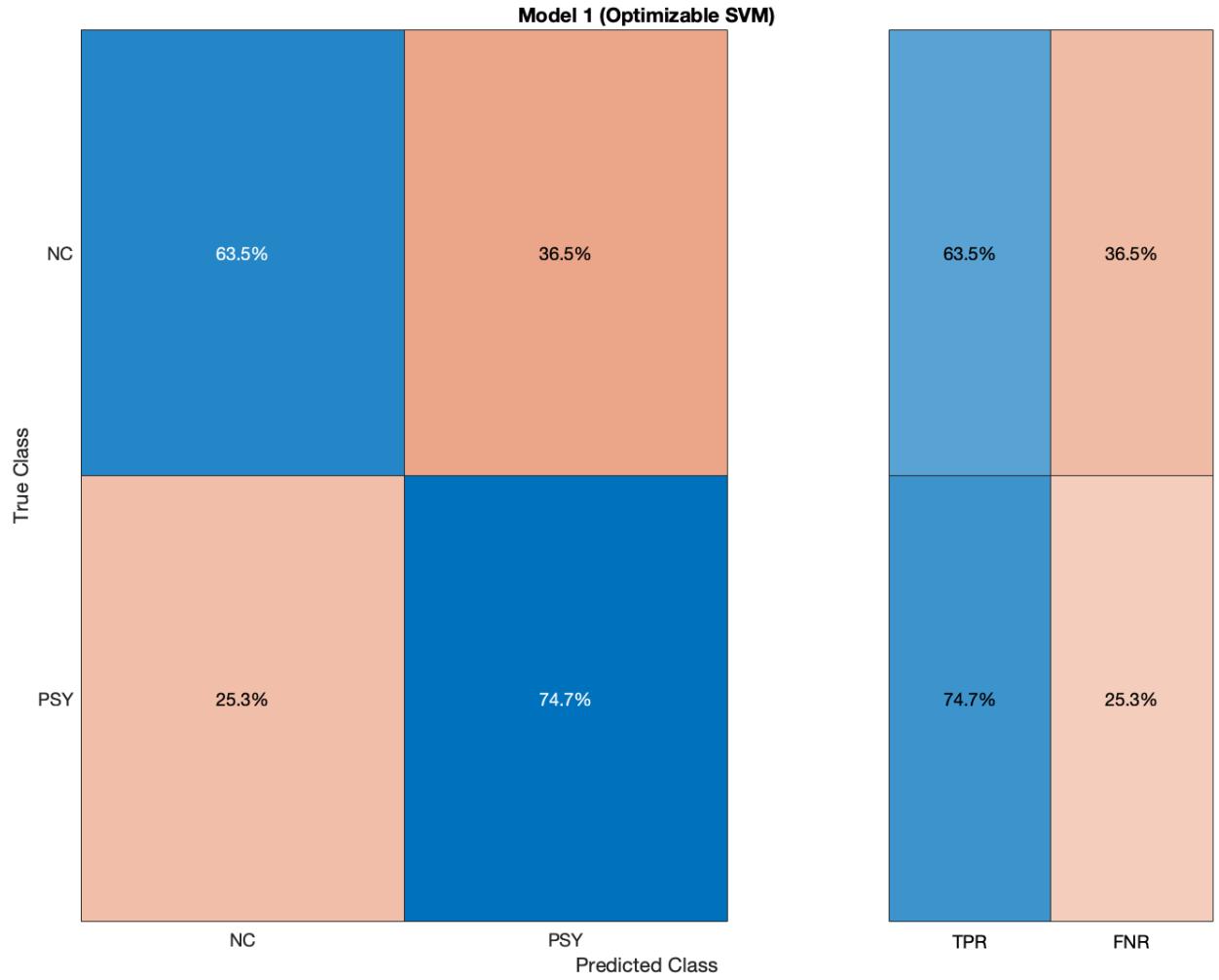
Classification Modeling – Hyperparameter Tuning

K – Fold Cross Validation



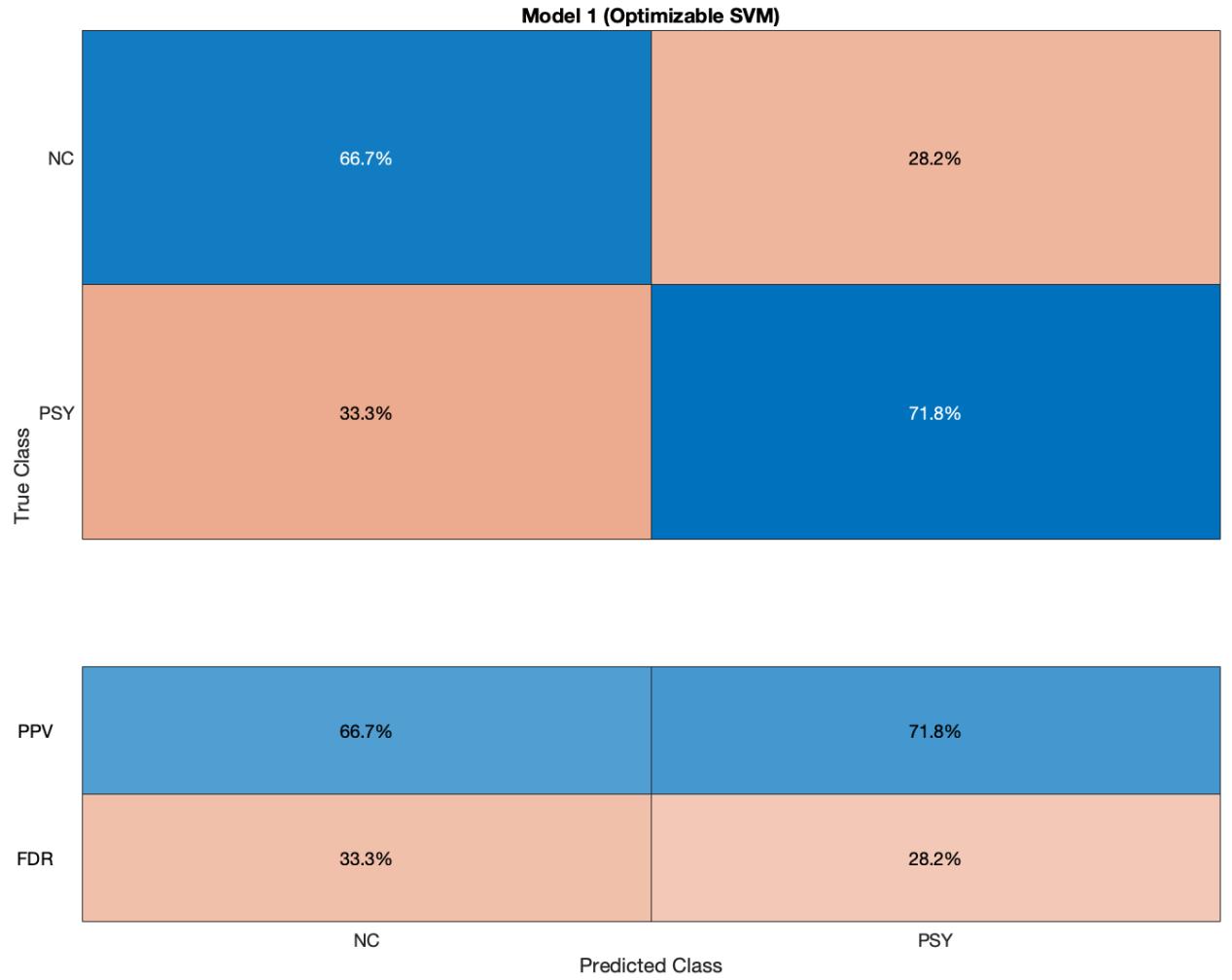
Classification Modeling – Hyperparameter Tuning

K – Fold Cross Validation



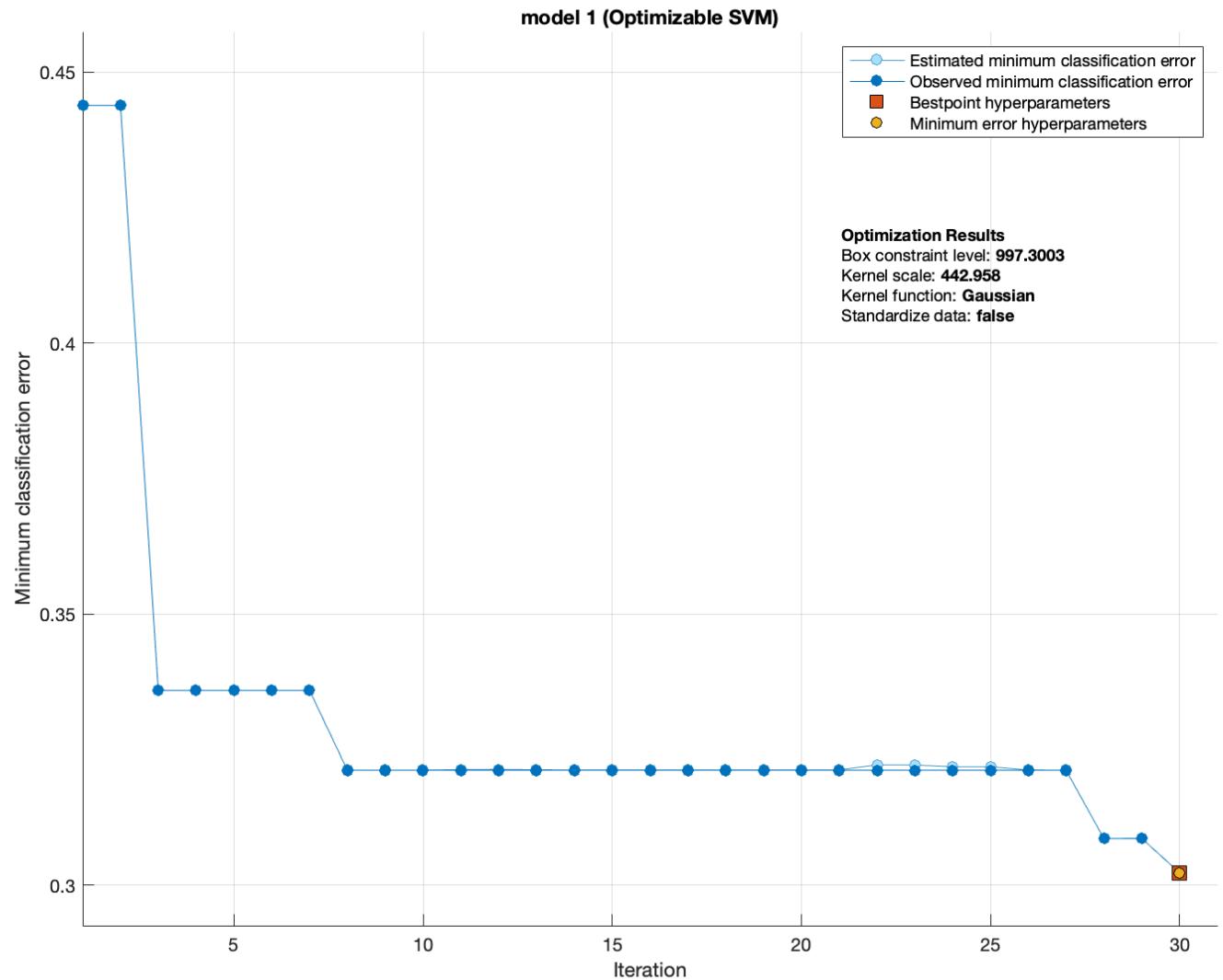
Classification Modeling – Hyperparameter Tuning

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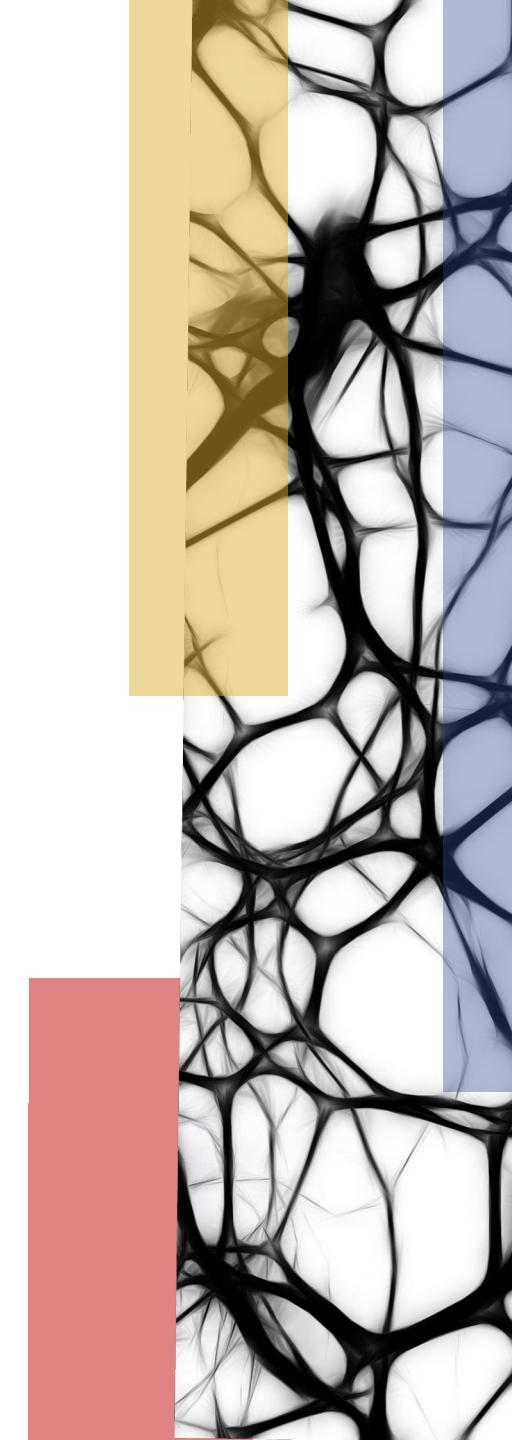
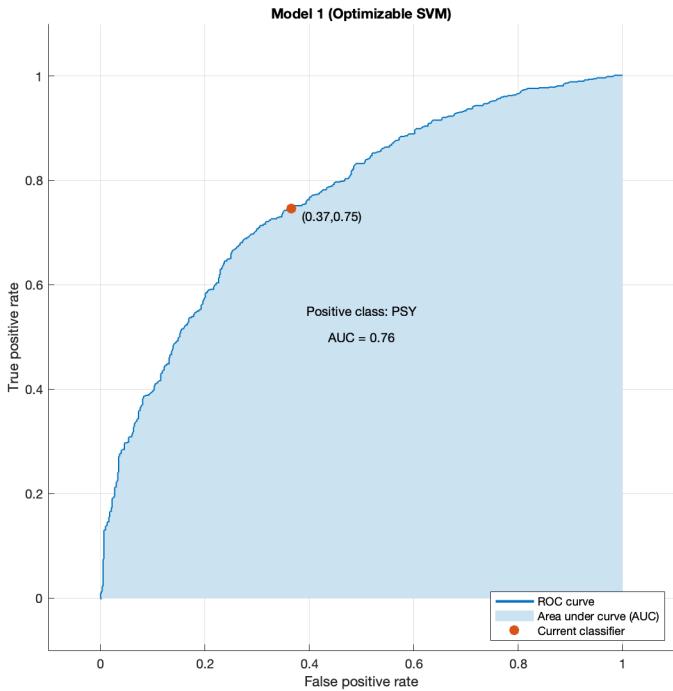
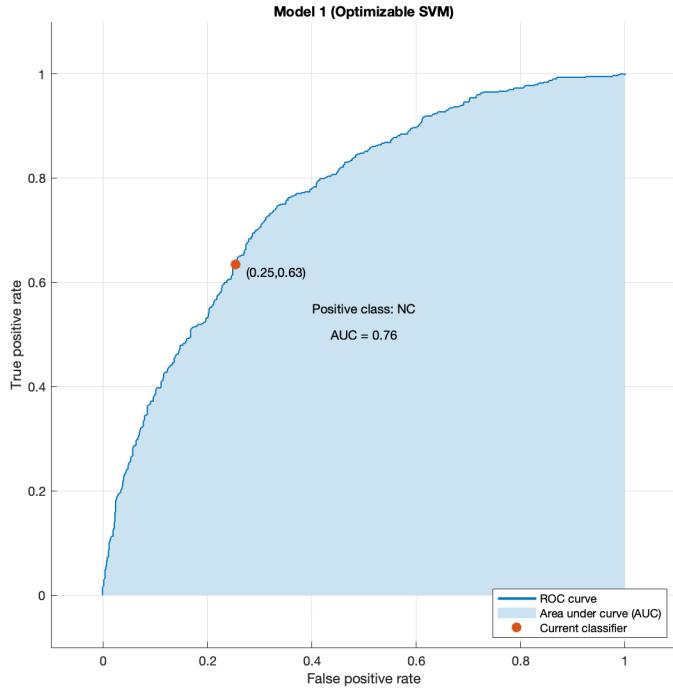
Classification Modeling – Hyperparameter Tuning

K – Fold Cross Validation



Classification Modeling – Hyperparameter Tuning

K – Fold Cross Validation



Next Steps

SVM Classifier

- Outlier Rate
- Misclassification Cost
- Separable / Non Separable

Clustering Techniques

- K – means

