project

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```
library(rJava, warn.conflicts = FALSE, quietly=TRUE)
library(xlsx, warn.conflicts = FALSE, quietly=TRUE)
library(stringr, warn.conflicts = FALSE, quietly=TRUE)
library(dplyr, warn.conflicts = FALSE, quietly=TRUE)
library(readr, warn.conflicts = FALSE, quietly=TRUE)
library(randomForestSRC, warn.conflicts = FALSE, quietly=TRUE)
```

```
##
##  randomForestSRC 2.5.1
##
##  Type rfsrc.news() to see new features, changes, and bug fixes.
##
```

```
library(ggplot2, warn.conflicts = FALSE, quietly=TRUE)
library(caret, warn.conflicts = FALSE, quietly=TRUE)
library(tidyr, warn.conflicts = FALSE, quietly=TRUE)
library(scales, warn.conflicts = FALSE, quietly=TRUE)
library(data.table, warn.conflicts = FALSE, quietly=TRUE)
library(effects, warn.conflicts = FALSE, quietly=TRUE )
```

```
## Use the command
##     lattice::trellis.par.set(effectsTheme())
##   to customize lattice options for effects plots.
## See ?efffectTheme for details.
```

```
library(gridExtra, warn.conflicts = FALSE, quietly=TRUE )
```

```
#Functions


#The AccuracyCutoffInfo function is a modified version of codes from the following github page
#https://github.com/ethen8181/machine-learning/blob/master/unbalanced/unbalanced_code/unbalanced_functi
#All Credit to user ethen8181


# ------------------------------------------------------------------------------------
# [AccuracyCutoffInfo] :
# Obtain the accuracy on the trainining and testing dataset.
# for cutoff value ranging from .4 to .8 ( with a .05 increase )
# @train   : your data.table or data.frame type training data ( assumes you have the predicted score in
# @test    : your data.table or data.frame type testing data
# @predict : prediction's column name (assumes the same for training and testing set)
# @actual  : actual results' column name
# returns  : 1. data : a data.table with three columns.
#                      each row indicates the cutoff value and the accuracy for the
#                      train and test set respectively.
#            2. plot : plot that visualizes the data.table

AccuracyCutoffInfo <- function( train, test, predict, actual )
```

```
{
  # change the cutoff value's range as you please
  cutoff <- seq( .05, 1, by = .025 )

  accuracy <- lapply( cutoff, function(c)
  {
    train_prediction <- as.factor(as.numeric( train[[predict]] > c ))
    test_prediction <- as.factor(as.numeric( test[[predict]] > c ))

    levels(train_prediction) <- c(levels(train[[actual]][1]),levels(train[[actual]])[2])
    levels(test_prediction) <- c(levels(test[[actual]][1]),levels(test[[actual]])[2])


    # use the confusionMatrix from the caret package
    cm_train <- confusionMatrix( train_prediction, train[[actual]] )
    cm_test  <- confusionMatrix( test_prediction, test[[actual]] )

    dt <- data.table( cutoff = c,
                      train  = cm_train$overall[["Accuracy"]],
                      test   = cm_test$overall[["Accuracy"]] )
    return(dt)
  }) %>% rbindlist()

  # visualize the accuracy of the train and test set for different cutoff value
  # accuracy in percentage.
  accuracy_long <- gather( accuracy, "data", "accuracy", -1 )

  plot <- ggplot( accuracy_long, aes( cutoff, accuracy, group = data, color = data ) ) +
    geom_line( size = 1 ) + geom_point( size = 3 ) +
    scale_y_continuous( label = percent ) +
    ggtitle( "Train/Test Accuracy for Different Cutoff" ) +
    scale_x_continuous(breaks=seq(0, 1, 0.1)) +
    theme_bw()

  return( list( data = accuracy, plot = plot ) )
}


#----------------------

#delete_dup

#Some varaibles are forced into the model regardless of variable section result
#If the forced variable ended up being selected, this model will removed the duplicated variable.

delete_dup <- function(subset, data){
  remove <- c()
  for(i in 1:length(subset)){
    result <- str_detect(subset[i],names(data))
    for(j in 1:length(result)){
      if(result[j]){
        remove <- c(remove,i)
      }
```

```
    }
  }
  if(is.null(remove))
    return(subset)
  subset <- subset[-c(remove)]
  return(subset)
}


#data = data file
#Predition: predicted result
#response: The name of response variable
#cut_off: probabilty cut off point

Classify <- function(data, prediction,response, cut_off ){
  for(i in 1:length(prediction)){
    if(prediction[i] < cut_off){
      prediction[i] <- levels(data[[response]])[1]
    } else{
      prediction[i] <- levels(data[[response]])[2]
    }
  }

  prediction <- as.factor(prediction)
  levels(prediction) <- c(levels(data[[response]])[1],levels(data[[response]])[2])
  confuseion_matrix <- table(data[[response]],prediction)
  print(confuseion_matrix)
  Accuracy <- (confuseion_matrix[1,1] + confuseion_matrix[2,2])/sum(confuseion_matrix)
  return(print(paste("The accuracy is", round(Accuracy*100,3),"%")))
}



#K fold K = 10

#data = data using for prediction
#response = name of the response variable
#cut off = probability cut off point
#interaction = you can type addition interaction term in text
#Example
#cv.error(CNP_logi_subset,"Subject_Type","+Age*Auditory.global_eff", 0.8)


cv.error <- function(data, response, interaction = "", cut_off = 0.5){

  #generate random seeds
  r <- runif(1,0,9999)
  set.seed(r)
  folds <- createFolds(data[[response]],k = 10)
  Accuracy <- rep(NA,10)

  for(i in 1:10){
```

```
    #training and testing
    train <- data[-folds[[i]],]
    test <- data[folds[[i]],]

    levels(test[[response]]) <- c(levels(data[[response]])[1],levels(data[[response]])[2])

    logi_cv <-glm(paste(response,"~.",interaction), data = train, family = "binomial")

    prediction <- predict(logi_cv, test, type = "response")
    for(j in 1:length(prediction)){
      if(prediction[j] < cut_off){
        prediction[j] <- levels(test[[response]])[1]
      } else{
        prediction[j] <- levels(test[[response]])[2]
      }
    }
    prediction <- as.factor(prediction)
    levels(prediction) <- c(levels(data[[response]])[1],levels(data[[response]])[2])

    confuseion_matrix <- table(test[[response]],prediction)
    Accuracy[i] <- (confuseion_matrix[1,1] + confuseion_matrix[2,2])/sum(confuseion_matrix)
  }
  return(Accuracy)
}


#Standardized variable

Standarize <- function(data){
  for(i in 1:ncol(data)){
    if(is.numeric(data[1,i])){
      data[,i] <- (data[,i] - mean(data[,i]))/sd(data[,i])
    }
  }
  return(data)
}
```

```
#Load data

setwd("A:/Winter 2018/Stats 141SL/project/")

#load CNP data

CNP_between <- read.table("CNP_between_nets.txt", header =  TRUE)
CNP_within <- read.table("CNP_within_nets.txt", header = TRUE)
CNPDemographic <- read.xlsx("CNPDemographicMeasures.xlsx", sheetName = "SNF")


#load COBRE data


COBRE_between <- read.table("COBRE_between_nets.txt", header = TRUE)

COBRE_within <- read.table("COBRE_within_nets.txt", header = TRUE)
```

```
COBREDemographic <- read.xlsx("COBRE INDI Additional data.xls", sheetName = "NP")

COBRE_phenotypic <- read_csv("COBRE_phenotypic_data.csv")
```

```
## Parsed with column specification:
## cols(
##   X1 = col_integer(),
##   `Current Age` = col_character(),
##   Gender = col_character(),
##   Handedness = col_character(),
##   `Subject Type` = col_character(),
##   Diagnosis = col_character()
## )
```

```
#Data cleaning process

#Removed character string

pattern <- "[a-z]*-"

CNP_within$Subject_ID <- as.numeric(str_replace_all(CNP_within$Subject_ID
, pattern,""))

CNP_between$Subject_ID <- as.numeric(str_replace_all(CNP_between$Subject_ID
, pattern,""))



#Merge data
CNP_within_merge <- left_join(CNP_within,CNPDemographic, by = c("Subject_ID" = "PTID"))

#summary(CNP_within_merge)

CNP_between_merge <- left_join(CNP_between,CNPDemographic, by = c("Subject_ID" = "PTID"))

#summary(CNP_between_merge)



#Revmove character string

COBRE_between$Subject_ID <- as.numeric(str_replace_all(COBRE_between$Subject_ID
, pattern,""))

COBRE_within$Subject_ID <- as.numeric(str_replace_all(COBRE_within$Subject_ID
, pattern,""))



#remove 00
```

```
pattern <- "^00"

COBREDemographic$ID <- as.numeric(str_replace_all(COBREDemographic$ID, pattern,""))


#Merge data

COBRE_within_merge <- left_join(COBRE_within,COBREDemographic, by = c("Subject_ID" = "ID"))


#summary(COBRE_within_merge)

COBRE_between_merge <- left_join(COBRE_between,COBREDemographic, by = c("Subject_ID" = "ID"))

#summary(COBRE_between_merge)

COBRE_phenotypic$Gender <- as.factor(COBRE_phenotypic$Gender)

COBRE_phenotypic <- COBRE_phenotypic %>%
  filter(!(COBRE_phenotypic$Gender == "Disenrolled"))
```

```
## Warning: package 'bindrcpp' was built under R version 3.4.2
```

```
COBRE_phenotypic$Gender <- droplevels(COBRE_phenotypic$Gender)

colnames(COBRE_phenotypic)[1:2] <- c("Subject_ID", "Age")

COBRE_between_merge <- merge(COBRE_between_merge,COBRE_phenotypic, all = TRUE)
COBRE_within_merge <- merge(COBRE_within_merge,COBRE_phenotypic, all = TRUE)


table(COBRE_between_merge$Diagnosis)
```

```
##
##                 290.3                 295.1                 295.2
##                     1                     3                     1
##                 295.3                 295.6                 295.7
##                    41                    12                     5
##   295.70 bipolar type 295.70 depressed type                 295.9
##                     1                     1                     5
##                295.92                296.26                 296.4
##                     1                     1                     1
##                   311                  None
##                     1                    72
```

```
table(COBRE_within_merge$Diagnosis)
```

```
##
##                 290.3                 295.1                 295.2
##                     1                     3                     1
##                 295.3                 295.6                 295.7
##                    41                    12                     5
##   295.70 bipolar type 295.70 depressed type                 295.9
##                     1                     1                     5
##                295.92                296.26                 296.4
```

```
##                     1                     1                     1
##                   311                  None
##                     1                    72
```

```
#CNP filter


CNP_within_merge <- CNP_within_merge %>%
  filter(Subject_Type == "Control" | Subject_Type == "Schizophrenia")

table(CNP_within_merge$Subject_Type)
```

```
##
##          ADHD       Bipolar       Control Schizophrenia
##             0             0           115            42
```

```
CNP_between_merge <- CNP_between_merge %>%
  filter(Subject_Type == "Control" | Subject_Type == "Schizophrenia")

table(CNP_between_merge$Subject_Type)
```

```
##
##          ADHD       Bipolar       Control Schizophrenia
##             0             0           115            42
```

```
#COBRE filter

COBRE_between_merge <- COBRE_between_merge %>%
  filter(!(Diagnosis == 290.3 | Diagnosis == 296.26 | Diagnosis == 296.4 | Diagnosis == 311))

COBRE_within_merge <- COBRE_within_merge %>%
  filter(!(Diagnosis == 290.3 | Diagnosis == 296.26 | Diagnosis == 296.4 | Diagnosis == 311))

table(COBRE_between_merge$Diagnosis)
```

```
##
##                 295.1                 295.2                 295.3
##                     3                     1                    41
##                 295.6                 295.7   295.70 bipolar type
##                    12                     5                     1
## 295.70 depressed type                 295.9                295.92
##                     1                     5                     1
##                  None
##                    72
```

```
table(COBRE_within_merge$Diagnosis)
```

```
##
##                 295.1                 295.2                 295.3
##                     3                     1                    41
##                 295.6                 295.7   295.70 bipolar type
##                    12                     5                     1
## 295.70 depressed type                 295.9                295.92
##                     1                     5                     1
##                  None
##                    72
```

```
#Recoding Patients to Schizophrenia in COBRE

pattern <- "Patient"

COBRE_between_merge$Subject_Type <- str_replace_all(COBRE_between_merge$Subject_Type,  pattern,"Schizopl
COBRE_within_merge$Subject_Type <- str_replace_all(COBRE_within_merge$Subject_Type,  pattern,"Schizophr

table(COBRE_between_merge$Subject_Type)
```

```
##
##       Control Schizophrenia
##            72            70
```

```
table(COBRE_within_merge$Subject_Type)
```

```
##
##       Control Schizophrenia
##            72            70
```

```
CNP_between_merge$Subject_Type <- droplevels(CNP_between_merge$Subject_Type)
levels(CNP_between_merge$Subject_Type)
```

```
## [1] "Control"       "Schizophrenia"
```

```
CNP_within_merge$Subject_Type <- droplevels(CNP_within_merge$Subject_Type)
levels(CNP_within_merge$Subject_Type)
```

```
## [1] "Control"       "Schizophrenia"
```

```
#CNP between
#remove 96:98, 112
CNP_between_merge <- CNP_between_merge %>%
  select(-c(96:98,112))



#CNP within get rid of
#75 #76 #91
CNP_within_merge <- CNP_within_merge %>%
  select(-c(75:77,91))


#Merge both data into CNP

CNP <- merge(CNP_between_merge,CNP_within_merge, all = TRUE)



#Use only the fMRI, MRI, and Age, keep global EFF

CNP_between_RF_subset <- CNP_between_merge %>%
  select(c(1:94))

CNP_within_RF_subset <- CNP_within_merge %>%
  select(c(1:72))
```

```r
CNP_RF_subset <- CNP %>%
  select(-c(1,5:41))
```

```r
#CNP data modeling

set.seed(4321)


rfsrc_m1 <- rfsrc(as.factor(Subject_Type)~.,data = CNP_RF_subset, na.action = c("na.omit"), ntree= 1000)

max_var <- max.subtree(rfsrc_m1, conservative = TRUE)
max_var$topvars
```

```
## [1] "Ventral_Attention.Uncertain"
## [2] "Cingulo.opercular_Task_Control.mod"
```

```r
#delete duplicate entity


#Logistic Regression Model

subset <- as.vector(max_var$topvars)

subset <- delete_dup(subset,CNP_RF_subset[,c(1,137:150)])

CNP_logi_subset <- CNP_RF_subset[,c("Subject_Type",names(CNP_RF_subset[,c(1,137:150)]), subset)]



#Using a previously grown forest, identify pairwise interactions for all pairs of variables from a spec

#method="maxsubtree"

#This invokes a maximal subtree analysis. In this case, a matrix is returned where entries [i][i] are t

#method="vimp"

#This invokes a joint-VIMP approach. Two variables are paired and their paired VIMP calculated (refered


#No interactioin fund base on the result, we don't have to add interaction term

CNP_logi_subset <- na.omit(CNP_logi_subset) %>%
  Standarize()

#Find interaction
find.interaction(rfsrc_m1, xvar.names = names(CNP_logi_subset[,-c(1)]), sorted = FALSE)
```

```
##
##                              Method: maxsubtree
##                      No. of variables: 17
##   Variables sorted by minimal depth?: FALSE
##
##                                          Age Ventral_Attention.Uncertain
## Age                                     0.92                         1.00
```

```
## Ventral_Attention.Uncertain                0.99                          0.86
## Cingulo.opercular_Task_Control.mod         0.99                          0.99
## Auditory.global_eff                        1.00                          1.00
## Cerebellar.global_eff                      1.00                          1.00
## Cingulo.opercular_Task_Control.global_eff 1.00                          0.99
## Default_mode.global_eff                    1.00                          1.00
## Dorsal_attention.global_eff                1.00                          1.00
## Fronto.parietal_Task_Control.global_eff    0.99                          1.00
## Memory_retrieval.global_eff                1.00                          1.00
## Salience.global_eff                        1.00                          1.00
## Sensory.somatomotor_Hand.global_eff        1.00                          0.99
## Sensory.somatomotor_Mouth.global_eff       1.00                          1.00
## Subcortical.global_eff                     0.99                          0.99
## Uncertain.global_eff                       1.00                          1.00
## Ventral_attention.global_eff               1.00                          1.00
## Visual.global_eff                          1.00                          1.00
##                                           Cingulo.opercular_Task_Control.mod
## Age                                                                     1.00
## Ventral_Attention.Uncertain                                             0.99
## Cingulo.opercular_Task_Control.mod                                      0.85
## Auditory.global_eff                                                     1.00
## Cerebellar.global_eff                                                   1.00
## Cingulo.opercular_Task_Control.global_eff                               1.00
## Default_mode.global_eff                                                 1.00
## Dorsal_attention.global_eff                                             1.00
## Fronto.parietal_Task_Control.global_eff                                 1.00
## Memory_retrieval.global_eff                                             1.00
## Salience.global_eff                                                     1.00
## Sensory.somatomotor_Hand.global_eff                                     0.99
## Sensory.somatomotor_Mouth.global_eff                                    1.00
## Subcortical.global_eff                                                  0.99
## Uncertain.global_eff                                                    1.00
## Ventral_attention.global_eff                                            1.00
## Visual.global_eff                                                       1.00
##                                           Auditory.global_eff
## Age                                                      1.00
## Ventral_Attention.Uncertain                              1.00
## Cingulo.opercular_Task_Control.mod                       0.99
## Auditory.global_eff                                      0.96
## Cerebellar.global_eff                                    1.00
## Cingulo.opercular_Task_Control.global_eff                1.00
## Default_mode.global_eff                                  1.00
## Dorsal_attention.global_eff                              1.00
## Fronto.parietal_Task_Control.global_eff                  1.00
## Memory_retrieval.global_eff                              1.00
## Salience.global_eff                                      1.00
## Sensory.somatomotor_Hand.global_eff                      1.00
## Sensory.somatomotor_Mouth.global_eff                     1.00
## Subcortical.global_eff                                   1.00
## Uncertain.global_eff                                     1.00
## Ventral_attention.global_eff                             1.00
## Visual.global_eff                                        1.00
##                                           Cerebellar.global_eff
## Age                                                        1.00
```

```
## Ventral_Attention.Uncertain                                1.00
## Cingulo.opercular_Task_Control.mod                         1.00
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      0.94
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                1.00
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        1.00
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     1.00
## Uncertain.global_eff                                       1.00
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          1.00
##                                          Cingulo.opercular_Task_Control.global_eff
## Age                                                                          1.00
## Ventral_Attention.Uncertain                                                  1.00
## Cingulo.opercular_Task_Control.mod                                           0.99
## Auditory.global_eff                                                          1.00
## Cerebellar.global_eff                                                        1.00
## Cingulo.opercular_Task_Control.global_eff                                    0.92
## Default_mode.global_eff                                                      1.00
## Dorsal_attention.global_eff                                                  1.00
## Fronto.parietal_Task_Control.global_eff                                      1.00
## Memory_retrieval.global_eff                                                  1.00
## Salience.global_eff                                                          1.00
## Sensory.somatomotor_Hand.global_eff                                          1.00
## Sensory.somatomotor_Mouth.global_eff                                         1.00
## Subcortical.global_eff                                                       1.00
## Uncertain.global_eff                                                         1.00
## Ventral_attention.global_eff                                                 1.00
## Visual.global_eff                                                            1.00
##                                          Default_mode.global_eff
## Age                                                         1.00
## Ventral_Attention.Uncertain                                 0.99
## Cingulo.opercular_Task_Control.mod                          1.00
## Auditory.global_eff                                         1.00
## Cerebellar.global_eff                                       1.00
## Cingulo.opercular_Task_Control.global_eff                   1.00
## Default_mode.global_eff                                     0.93
## Dorsal_attention.global_eff                                 1.00
## Fronto.parietal_Task_Control.global_eff                     1.00
## Memory_retrieval.global_eff                                 1.00
## Salience.global_eff                                         1.00
## Sensory.somatomotor_Hand.global_eff                         1.00
## Sensory.somatomotor_Mouth.global_eff                        1.00
## Subcortical.global_eff                                      0.99
## Uncertain.global_eff                                        1.00
## Ventral_attention.global_eff                                1.00
## Visual.global_eff                                           1.00
##                                          Dorsal_attention.global_eff
## Age                                                             1.00
```

```
## Ventral_Attention.Uncertain                                    1.00
## Cingulo.opercular_Task_Control.mod                             1.00
## Auditory.global_eff                                            1.00
## Cerebellar.global_eff                                          1.00
## Cingulo.opercular_Task_Control.global_eff                      1.00
## Default_mode.global_eff                                        1.00
## Dorsal_attention.global_eff                                    0.96
## Fronto.parietal_Task_Control.global_eff                        1.00
## Memory_retrieval.global_eff                                    1.00
## Salience.global_eff                                            1.00
## Sensory.somatomotor_Hand.global_eff                            1.00
## Sensory.somatomotor_Mouth.global_eff                           1.00
## Subcortical.global_eff                                         1.00
## Uncertain.global_eff                                           1.00
## Ventral_attention.global_eff                                   1.00
## Visual.global_eff                                              1.00
##                                          Fronto.parietal_Task_Control.global_eff
## Age                                                                        1.00
## Ventral_Attention.Uncertain                                                0.99
## Cingulo.opercular_Task_Control.mod                                         0.99
## Auditory.global_eff                                                        1.00
## Cerebellar.global_eff                                                      1.00
## Cingulo.opercular_Task_Control.global_eff                                  1.00
## Default_mode.global_eff                                                    1.00
## Dorsal_attention.global_eff                                                1.00
## Fronto.parietal_Task_Control.global_eff                                    0.92
## Memory_retrieval.global_eff                                                1.00
## Salience.global_eff                                                        1.00
## Sensory.somatomotor_Hand.global_eff                                        1.00
## Sensory.somatomotor_Mouth.global_eff                                       1.00
## Subcortical.global_eff                                                     1.00
## Uncertain.global_eff                                                       1.00
## Ventral_attention.global_eff                                               1.00
## Visual.global_eff                                                          1.00
##                                          Memory_retrieval.global_eff
## Age                                                             1.00
## Ventral_Attention.Uncertain                                     1.00
## Cingulo.opercular_Task_Control.mod                              0.99
## Auditory.global_eff                                             1.00
## Cerebellar.global_eff                                           1.00
## Cingulo.opercular_Task_Control.global_eff                       1.00
## Default_mode.global_eff                                         1.00
## Dorsal_attention.global_eff                                     1.00
## Fronto.parietal_Task_Control.global_eff                         1.00
## Memory_retrieval.global_eff                                     0.96
## Salience.global_eff                                             1.00
## Sensory.somatomotor_Hand.global_eff                             1.00
## Sensory.somatomotor_Mouth.global_eff                            1.00
## Subcortical.global_eff                                          1.00
## Uncertain.global_eff                                            1.00
## Ventral_attention.global_eff                                    1.00
## Visual.global_eff                                               1.00
##                                          Salience.global_eff
## Age                                                    1.00
```

```
## Ventral_Attention.Uncertain                                1.00
## Cingulo.opercular_Task_Control.mod                         1.00
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      1.00
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                1.00
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        0.95
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     1.00
## Uncertain.global_eff                                       1.00
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          1.00
##                                          Sensory.somatomotor_Hand.global_eff
## Age                                                                    1.00
## Ventral_Attention.Uncertain                                            1.00
## Cingulo.opercular_Task_Control.mod                                     0.99
## Auditory.global_eff                                                    1.00
## Cerebellar.global_eff                                                  1.00
## Cingulo.opercular_Task_Control.global_eff                              1.00
## Default_mode.global_eff                                                1.00
## Dorsal_attention.global_eff                                            1.00
## Fronto.parietal_Task_Control.global_eff                                1.00
## Memory_retrieval.global_eff                                            1.00
## Salience.global_eff                                                    1.00
## Sensory.somatomotor_Hand.global_eff                                    0.93
## Sensory.somatomotor_Mouth.global_eff                                   1.00
## Subcortical.global_eff                                                 1.00
## Uncertain.global_eff                                                   1.00
## Ventral_attention.global_eff                                           1.00
## Visual.global_eff                                                      1.00
##                                          Sensory.somatomotor_Mouth.global_eff
## Age                                                                     1.00
## Ventral_Attention.Uncertain                                             1.00
## Cingulo.opercular_Task_Control.mod                                      0.99
## Auditory.global_eff                                                     1.00
## Cerebellar.global_eff                                                   1.00
## Cingulo.opercular_Task_Control.global_eff                               1.00
## Default_mode.global_eff                                                 1.00
## Dorsal_attention.global_eff                                             1.00
## Fronto.parietal_Task_Control.global_eff                                 1.00
## Memory_retrieval.global_eff                                             1.00
## Salience.global_eff                                                     1.00
## Sensory.somatomotor_Hand.global_eff                                     1.00
## Sensory.somatomotor_Mouth.global_eff                                    0.95
## Subcortical.global_eff                                                  1.00
## Uncertain.global_eff                                                    1.00
## Ventral_attention.global_eff                                            1.00
## Visual.global_eff                                                       1.00
##                                          Subcortical.global_eff
## Age                                                        1.00
```

```
## Ventral_Attention.Uncertain                                  0.99
## Cingulo.opercular_Task_Control.mod                           0.99
## Auditory.global_eff                                          1.00
## Cerebellar.global_eff                                        1.00
## Cingulo.opercular_Task_Control.global_eff                    1.00
## Default_mode.global_eff                                      1.00
## Dorsal_attention.global_eff                                  1.00
## Fronto.parietal_Task_Control.global_eff                      1.00
## Memory_retrieval.global_eff                                  1.00
## Salience.global_eff                                          1.00
## Sensory.somatomotor_Hand.global_eff                          1.00
## Sensory.somatomotor_Mouth.global_eff                         1.00
## Subcortical.global_eff                                       0.88
## Uncertain.global_eff                                         1.00
## Ventral_attention.global_eff                                 1.00
## Visual.global_eff                                            1.00
##                                            Uncertain.global_eff
## Age                                                        1.00
## Ventral_Attention.Uncertain                                1.00
## Cingulo.opercular_Task_Control.mod                         1.00
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      1.00
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                1.00
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        1.00
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     1.00
## Uncertain.global_eff                                       0.96
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          1.00
##                                            Ventral_attention.global_eff
## Age                                                                1.00
## Ventral_Attention.Uncertain                                        0.99
## Cingulo.opercular_Task_Control.mod                                 0.99
## Auditory.global_eff                                                1.00
## Cerebellar.global_eff                                              1.00
## Cingulo.opercular_Task_Control.global_eff                          0.99
## Default_mode.global_eff                                            1.00
## Dorsal_attention.global_eff                                        1.00
## Fronto.parietal_Task_Control.global_eff                            1.00
## Memory_retrieval.global_eff                                        1.00
## Salience.global_eff                                                1.00
## Sensory.somatomotor_Hand.global_eff                                1.00
## Sensory.somatomotor_Mouth.global_eff                               1.00
## Subcortical.global_eff                                             0.99
## Uncertain.global_eff                                               1.00
## Ventral_attention.global_eff                                       0.92
## Visual.global_eff                                                  1.00
##                                            Visual.global_eff
## Age                                                     1.00
```

```
## Ventral_Attention.Uncertain                              1.00
## Cingulo.opercular_Task_Control.mod                       0.99
## Auditory.global_eff                                      1.00
## Cerebellar.global_eff                                    1.00
## Cingulo.opercular_Task_Control.global_eff                1.00
## Default_mode.global_eff                                  1.00
## Dorsal_attention.global_eff                              1.00
## Fronto.parietal_Task_Control.global_eff                  1.00
## Memory_retrieval.global_eff                              1.00
## Salience.global_eff                                      1.00
## Sensory.somatomotor_Hand.global_eff                      1.00
## Sensory.somatomotor_Mouth.global_eff                     1.00
## Subcortical.global_eff                                   1.00
## Uncertain.global_eff                                     1.00
## Ventral_attention.global_eff                             1.00
## Visual.global_eff                                        0.94
```

```
#find.interaction(rfsrc_m1, xvar.names = names(CNP_logi_subset[,-c(1)]), sorted = FALSE, method = "vimp


#Correlation check
high_cor <- findCorrelation(cor(CNP_logi_subset[,-c(1:2)]),cutoff = 0.75) + 2

#No potential multicollinearity problem

index <- sample(1:nrow(CNP_logi_subset), size = round(nrow(CNP_logi_subset)*0.7,0),replace = FALSE)

CNP_train <- CNP_logi_subset[index,]
CNP_test <- CNP_logi_subset[-index,]
logi_m1 <-glm(Subject_Type~. , data = CNP_train, family = "binomial")
summary(logi_m1)
```

```
##
## Call:
## glm(formula = Subject_Type ~ ., family = "binomial", data = CNP_train)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.6210  -0.6679  -0.3474   0.5809   3.0634
##
## Coefficients:
##                                           Estimate Std. Error z value
## (Intercept)                               -1.73948    0.36956  -4.707
## Age                                        0.83260    0.34036   2.446
## Auditory.global_eff                       -0.09186    0.35094  -0.262
## Cerebellar.global_eff                      0.15612    0.27872   0.560
## Cingulo.opercular_Task_Control.global_eff  0.03363    0.33229   0.101
## Default_mode.global_eff                    0.87062    0.42690   2.039
## Dorsal_attention.global_eff                0.43827    0.31808   1.378
## Fronto.parietal_Task_Control.global_eff    0.38999    0.42524   0.917
## Memory_retrieval.global_eff               -0.02610    0.29618  -0.088
## Salience.global_eff                        0.36833    0.34606   1.064
## Sensory.somatomotor_Hand.global_eff        0.30430    0.50027   0.608
## Sensory.somatomotor_Mouth.global_eff      -0.40188    0.37858  -1.062
## Subcortical.global_eff                     0.56609    0.36193   1.564
```

```
## Uncertain.global_eff                         0.78505    0.34559   2.272
## Ventral_attention.global_eff                -0.20361    0.31489  -0.647
## Visual.global_eff                            0.49797    0.38277   1.301
## Ventral_Attention.Uncertain                 -2.28226    0.67824  -3.365
## Cingulo.opercular_Task_Control.mod           0.88433    0.32735   2.701
##                                             Pr(>|z|)
## (Intercept)                                 2.51e-06 ***
## Age                                         0.014436 *
## Auditory.global_eff                         0.793522
## Cerebellar.global_eff                       0.575381
## Cingulo.opercular_Task_Control.global_eff   0.919375
## Default_mode.global_eff                     0.041408 *
## Dorsal_attention.global_eff                 0.168252
## Fronto.parietal_Task_Control.global_eff     0.359080
## Memory_retrieval.global_eff                 0.929783
## Salience.global_eff                         0.287175
## Sensory.somatomotor_Hand.global_eff         0.543008
## Sensory.somatomotor_Mouth.global_eff        0.288451
## Subcortical.global_eff                      0.117797
## Uncertain.global_eff                        0.023110 *
## Ventral_attention.global_eff                0.517884
## Visual.global_eff                           0.193274
## Ventral_Attention.Uncertain                 0.000766 ***
## Cingulo.opercular_Task_Control.mod          0.006903 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 130.826  on 109  degrees of freedom
## Residual deviance:  91.494  on  92  degrees of freedom
## AIC: 127.49
##
## Number of Fisher Scoring iterations: 6
```

```
round(exp(coef(logi_m1)),3)
```

```
##                                 (Intercept)
##                                       0.176
##                                         Age
##                                       2.299
##                           Auditory.global_eff
##                                       0.912
##                         Cerebellar.global_eff
##                                       1.169
## Cingulo.opercular_Task_Control.global_eff
##                                       1.034
##                        Default_mode.global_eff
##                                       2.388
##                    Dorsal_attention.global_eff
##                                       1.550
##   Fronto.parietal_Task_Control.global_eff
##                                       1.477
##                    Memory_retrieval.global_eff
##                                       0.974
```

```
##                       Salience.global_eff
##                                     1.445
##       Sensory.somatomotor_Hand.global_eff
##                                     1.356
##      Sensory.somatomotor_Mouth.global_eff
##                                     0.669
##                     Subcortical.global_eff
##                                     1.761
##                       Uncertain.global_eff
##                                     2.193
##              Ventral_attention.global_eff
##                                     0.816
##                          Visual.global_eff
##                                     1.645
##               Ventral_Attention.Uncertain
##                                     0.102
##        Cingulo.opercular_Task_Control.mod
##                                     2.421
```

```
anova(logi_m1, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: Subject_Type
##
## Terms added sequentially (first to last)
##
##
##                                           Df Deviance Resid. Df Resid. Dev
## NULL                                                        109    130.826
## Age                                        1   3.5821       108    127.244
## Auditory.global_eff                        1   0.3403       107    126.903
## Cerebellar.global_eff                      1   0.2195       106    126.684
## Cingulo.opercular_Task_Control.global_eff  1   0.0091       105    126.675
## Default_mode.global_eff                    1   0.0117       104    126.663
## Dorsal_attention.global_eff                1   0.2303       103    126.433
## Fronto.parietal_Task_Control.global_eff    1   0.6998       102    125.733
## Memory_retrieval.global_eff                1   0.0689       101    125.664
## Salience.global_eff                        1   0.0166       100    125.647
## Sensory.somatomotor_Hand.global_eff        1   1.5916        99    124.056
## Sensory.somatomotor_Mouth.global_eff       1   6.0241        98    118.032
## Subcortical.global_eff                     1   0.0072        97    118.025
## Uncertain.global_eff                       1   1.8716        96    116.153
## Ventral_attention.global_eff               1   1.1439        95    115.009
## Visual.global_eff                          1   0.1207        94    114.888
## Ventral_Attention.Uncertain                1  13.8856        93    101.003
## Cingulo.opercular_Task_Control.mod         1   9.5089        92     91.494
##                                            Pr(>Chi)
## NULL
## Age                                        0.0584057 .
## Auditory.global_eff                        0.5596684
## Cerebellar.global_eff                      0.6394285
## Cingulo.opercular_Task_Control.global_eff 0.9240192
```

```
## Default_mode.global_eff                    0.9137170
## Dorsal_attention.global_eff                0.6313287
## Fronto.parietal_Task_Control.global_eff    0.4028610
## Memory_retrieval.global_eff                0.7929193
## Salience.global_eff                        0.8975062
## Sensory.somatomotor_Hand.global_eff        0.2071033
## Sensory.somatomotor_Mouth.global_eff       0.0141116 *
## Subcortical.global_eff                     0.9321680
## Uncertain.global_eff                       0.1712969
## Ventral_attention.global_eff               0.2848198
## Visual.global_eff                          0.7282840
## Ventral_Attention.Uncertain                0.0001943 ***
## Cingulo.opercular_Task_Control.mod         0.0020447 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

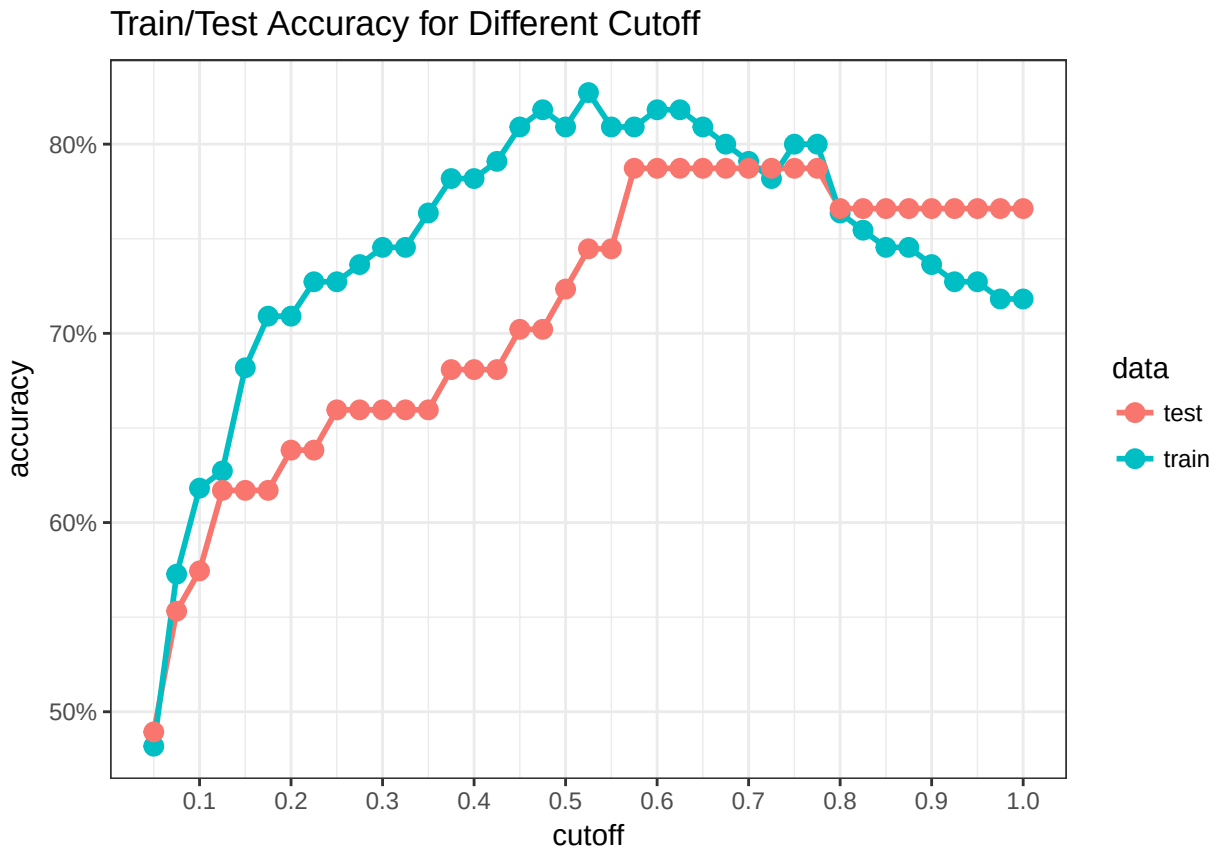
```
#R-squared

R_squared <- 1 - (summary(logi_m1)[[4]]/summary(logi_m1)[[8]])
R_squared
```

```
## [1] 0.3006434
```

```
#70/30 CV check

#Train
CNP_train$prediction <- predict(logi_m1, CNP_train, type = "response")


#Test
CNP_test$prediction <- predict(logi_m1, CNP_test, type = "response")

prop.table(table(CNP$Subject_Type))
```

```
##
##       Control Schizophrenia
##     0.7324841     0.2675159
```

```
accuracy_info <- AccuracyCutoffInfo( train = CNP_train, test = CNP_test,
                                     predict = "prediction", actual = "Subject_Type" )

accuracy_info$plot
```




```
Classify(CNP_train, CNP_train$prediction,"Subject_Type", 0.75 )
```

```
##                prediction
##                 Control Schizophrenia
##   Control            79             0
##   Schizophrenia      22             9
## [1] "The accuracy is 80 %"
```

```
Classify(CNP_test, CNP_test$prediction,"Subject_Type", 0.75 )
```

```
##                prediction
##                 Control Schizophrenia
##   Control            36             0
##   Schizophrenia      10             1
## [1] "The accuracy is 78.723 %"
```

```
#CNP model k fold CV check
set.seed(4321)

Accuracy.k <- cv.error(CNP_logi_subset, "Subject_Type",cut_off = 0.75)
Accuracy.k
```

```
##  [1] 0.6470588 0.6875000 0.7333333 0.8125000 0.7500000 0.8125000 0.7333333
##  [8] 0.6666667 0.8000000 0.6875000
```

```
mean(Accuracy.k)
```

```
## [1] 0.7330392
```

```r
#COBRE data modeling

set.seed(4321)

COBRE <- merge(COBRE_between_merge, COBRE_within_merge, all = TRUE)


COBRE_RF_subset<- COBRE %>%
  select(-c(1,5:111))

COBRE_RF_subset$Subject_Type <- as.factor(COBRE_RF_subset$Subject_Type)

#Random Forest variable section
rfsrc_m2 <- rfsrc(Subject_Type~.,data = COBRE_RF_subset, na.action = c("na.omit"), ntree= 1000)


max_var <- max.subtree(rfsrc_m2, conservative = TRUE)
max_var$topvars
```

```
## [1] "Visual.Subcortical"
```

```r
#delete duplicate entity


subset <- as.vector(max_var$topvars)

subset <- delete_dup(subset,COBRE_RF_subset[,c(1,137:150)])


#Logistic Regression model


COBRE_logi_subset <- COBRE_RF_subset[,c("Subject_Type",names(COBRE_RF_subset[,c(1,137:150)]), subset)]


#No interactioin fund base on the result, we don't have to add interaction term


COBRE_logi_subset <- na.omit(COBRE_logi_subset) %>%
  Standarize()


#Find interaction
find.interaction(rfsrc_m2, xvar.names = names(COBRE_logi_subset[,-c(1)]), sorted = FALSE)
```

```
##
##                              Method: maxsubtree
##                    No. of variables: 16
##   Variables sorted by minimal depth?: FALSE
##
##                                         Age Visual.Subcortical
## Age                                    0.95               1.00
## Visual.Subcortical                     1.00               0.83
## Auditory.global_eff                    1.00               1.00
## Cerebellar.global_eff                  1.00               1.00
```

```
## Cingulo.opercular_Task_Control.global_eff 1.00               0.99
## Default_mode.global_eff                   1.00               0.99
## Dorsal_attention.global_eff               1.00               1.00
## Fronto.parietal_Task_Control.global_eff   1.00               1.00
## Memory_retrieval.global_eff               1.00               1.00
## Salience.global_eff                       1.00               1.00
## Sensory.somatomotor_Hand.global_eff       1.00               1.00
## Sensory.somatomotor_Mouth.global_eff      1.00               0.99
## Subcortical.global_eff                    1.00               1.00
## Uncertain.global_eff                      1.00               1.00
## Ventral_attention.global_eff              1.00               1.00
## Visual.global_eff                         0.99               1.00
##                                           Auditory.global_eff
## Age                                                      1.00
## Visual.Subcortical                                       1.00
## Auditory.global_eff                                      0.95
## Cerebellar.global_eff                                    1.00
## Cingulo.opercular_Task_Control.global_eff                0.99
## Default_mode.global_eff                                  1.00
## Dorsal_attention.global_eff                              1.00
## Fronto.parietal_Task_Control.global_eff                  1.00
## Memory_retrieval.global_eff                              1.00
## Salience.global_eff                                      1.00
## Sensory.somatomotor_Hand.global_eff                      1.00
## Sensory.somatomotor_Mouth.global_eff                     1.00
## Subcortical.global_eff                                   1.00
## Uncertain.global_eff                                     1.00
## Ventral_attention.global_eff                             1.00
## Visual.global_eff                                        1.00
##                                           Cerebellar.global_eff
## Age                                                        1.00
## Visual.Subcortical                                         1.00
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      0.93
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                1.00
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        1.00
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     1.00
## Uncertain.global_eff                                       1.00
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          1.00
##                                           Cingulo.opercular_Task_Control.global_eff
## Age                                                                            1.00
## Visual.Subcortical                                                             0.99
## Auditory.global_eff                                                            1.00
## Cerebellar.global_eff                                                          1.00
## Cingulo.opercular_Task_Control.global_eff                                      0.88
## Default_mode.global_eff                                                        1.00
## Dorsal_attention.global_eff                                                    1.00
```

```
## Fronto.parietal_Task_Control.global_eff                                  1.00
## Memory_retrieval.global_eff                                              1.00
## Salience.global_eff                                                      1.00
## Sensory.somatomotor_Hand.global_eff                                      1.00
## Sensory.somatomotor_Mouth.global_eff                                     1.00
## Subcortical.global_eff                                                   1.00
## Uncertain.global_eff                                                     1.00
## Ventral_attention.global_eff                                             1.00
## Visual.global_eff                                                        1.00
##                                          Default_mode.global_eff
## Age                                                         1.00
## Visual.Subcortical                                          0.99
## Auditory.global_eff                                         1.00
## Cerebellar.global_eff                                       1.00
## Cingulo.opercular_Task_Control.global_eff                   1.00
## Default_mode.global_eff                                     0.93
## Dorsal_attention.global_eff                                 1.00
## Fronto.parietal_Task_Control.global_eff                     1.00
## Memory_retrieval.global_eff                                 1.00
## Salience.global_eff                                         1.00
## Sensory.somatomotor_Hand.global_eff                         1.00
## Sensory.somatomotor_Mouth.global_eff                        1.00
## Subcortical.global_eff                                      1.00
## Uncertain.global_eff                                        1.00
## Ventral_attention.global_eff                                1.00
## Visual.global_eff                                           1.00
##                                          Dorsal_attention.global_eff
## Age                                                             1.00
## Visual.Subcortical                                              0.99
## Auditory.global_eff                                             1.00
## Cerebellar.global_eff                                           1.00
## Cingulo.opercular_Task_Control.global_eff                       1.00
## Default_mode.global_eff                                         1.00
## Dorsal_attention.global_eff                                     0.93
## Fronto.parietal_Task_Control.global_eff                         1.00
## Memory_retrieval.global_eff                                     1.00
## Salience.global_eff                                             1.00
## Sensory.somatomotor_Hand.global_eff                             1.00
## Sensory.somatomotor_Mouth.global_eff                            1.00
## Subcortical.global_eff                                          1.00
## Uncertain.global_eff                                            1.00
## Ventral_attention.global_eff                                    1.00
## Visual.global_eff                                               1.00
##                                          Fronto.parietal_Task_Control.global_eff
## Age                                                                        1.00
## Visual.Subcortical                                                         0.99
## Auditory.global_eff                                                        1.00
## Cerebellar.global_eff                                                      1.00
## Cingulo.opercular_Task_Control.global_eff                                  0.99
## Default_mode.global_eff                                                    1.00
## Dorsal_attention.global_eff                                                1.00
## Fronto.parietal_Task_Control.global_eff                                    0.94
## Memory_retrieval.global_eff                                                1.00
## Salience.global_eff                                                        1.00
```

```
## Sensory.somatomotor_Hand.global_eff                                    1.00
## Sensory.somatomotor_Mouth.global_eff                                   1.00
## Subcortical.global_eff                                                 1.00
## Uncertain.global_eff                                                   1.00
## Ventral_attention.global_eff                                           1.00
## Visual.global_eff                                                      1.00
##                                          Memory_retrieval.global_eff
## Age                                                             1.00
## Visual.Subcortical                                              1.00
## Auditory.global_eff                                             1.00
## Cerebellar.global_eff                                           1.00
## Cingulo.opercular_Task_Control.global_eff                       1.00
## Default_mode.global_eff                                         1.00
## Dorsal_attention.global_eff                                     1.00
## Fronto.parietal_Task_Control.global_eff                         1.00
## Memory_retrieval.global_eff                                     0.93
## Salience.global_eff                                             1.00
## Sensory.somatomotor_Hand.global_eff                             1.00
## Sensory.somatomotor_Mouth.global_eff                            1.00
## Subcortical.global_eff                                          1.00
## Uncertain.global_eff                                            1.00
## Ventral_attention.global_eff                                    1.00
## Visual.global_eff                                               1.00
##                                          Salience.global_eff
## Age                                                    1.00
## Visual.Subcortical                                     1.00
## Auditory.global_eff                                    1.00
## Cerebellar.global_eff                                  1.00
## Cingulo.opercular_Task_Control.global_eff              0.99
## Default_mode.global_eff                                1.00
## Dorsal_attention.global_eff                            1.00
## Fronto.parietal_Task_Control.global_eff                1.00
## Memory_retrieval.global_eff                            1.00
## Salience.global_eff                                    0.95
## Sensory.somatomotor_Hand.global_eff                    1.00
## Sensory.somatomotor_Mouth.global_eff                   1.00
## Subcortical.global_eff                                 1.00
## Uncertain.global_eff                                   1.00
## Ventral_attention.global_eff                           1.00
## Visual.global_eff                                      1.00
##                                          Sensory.somatomotor_Hand.global_eff
## Age                                                                    1.00
## Visual.Subcortical                                                     1.00
## Auditory.global_eff                                                    1.00
## Cerebellar.global_eff                                                  1.00
## Cingulo.opercular_Task_Control.global_eff                              1.00
## Default_mode.global_eff                                                1.00
## Dorsal_attention.global_eff                                            1.00
## Fronto.parietal_Task_Control.global_eff                                1.00
## Memory_retrieval.global_eff                                            1.00
## Salience.global_eff                                                    1.00
## Sensory.somatomotor_Hand.global_eff                                    0.95
## Sensory.somatomotor_Mouth.global_eff                                   1.00
## Subcortical.global_eff                                                 1.00
```

```
## Uncertain.global_eff                                                1.00
## Ventral_attention.global_eff                                        1.00
## Visual.global_eff                                                   1.00
##                                          Sensory.somatomotor_Mouth.global_eff
## Age                                                                 1.00
## Visual.Subcortical                                                  1.00
## Auditory.global_eff                                                 1.00
## Cerebellar.global_eff                                               1.00
## Cingulo.opercular_Task_Control.global_eff                           1.00
## Default_mode.global_eff                                             1.00
## Dorsal_attention.global_eff                                         1.00
## Fronto.parietal_Task_Control.global_eff                             1.00
## Memory_retrieval.global_eff                                         1.00
## Salience.global_eff                                                 1.00
## Sensory.somatomotor_Hand.global_eff                                 1.00
## Sensory.somatomotor_Mouth.global_eff                                0.94
## Subcortical.global_eff                                              1.00
## Uncertain.global_eff                                                1.00
## Ventral_attention.global_eff                                        1.00
## Visual.global_eff                                                   1.00
##                                          Subcortical.global_eff
## Age                                                        1.00
## Visual.Subcortical                                         1.00
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      1.00
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                1.00
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        1.00
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     0.95
## Uncertain.global_eff                                       1.00
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          1.00
##                                          Uncertain.global_eff
## Age                                                      1.00
## Visual.Subcortical                                       0.99
## Auditory.global_eff                                      1.00
## Cerebellar.global_eff                                    1.00
## Cingulo.opercular_Task_Control.global_eff                1.00
## Default_mode.global_eff                                  1.00
## Dorsal_attention.global_eff                              1.00
## Fronto.parietal_Task_Control.global_eff                  1.00
## Memory_retrieval.global_eff                              1.00
## Salience.global_eff                                      1.00
## Sensory.somatomotor_Hand.global_eff                      1.00
## Sensory.somatomotor_Mouth.global_eff                     1.00
## Subcortical.global_eff                                   1.00
## Uncertain.global_eff                                     0.94
## Ventral_attention.global_eff                             1.00
## Visual.global_eff                                        1.00
```

```
##                                          Ventral_attention.global_eff
## Age                                                              1.00
## Visual.Subcortical                                               0.99
## Auditory.global_eff                                              1.00
## Cerebellar.global_eff                                            1.00
## Cingulo.opercular_Task_Control.global_eff                        1.00
## Default_mode.global_eff                                          1.00
## Dorsal_attention.global_eff                                      1.00
## Fronto.parietal_Task_Control.global_eff                          1.00
## Memory_retrieval.global_eff                                      1.00
## Salience.global_eff                                              1.00
## Sensory.somatomotor_Hand.global_eff                              1.00
## Sensory.somatomotor_Mouth.global_eff                             1.00
## Subcortical.global_eff                                           1.00
## Uncertain.global_eff                                             1.00
## Ventral_attention.global_eff                                     0.95
## Visual.global_eff                                                1.00
##                                          Visual.global_eff
## Age                                                   1.00
## Visual.Subcortical                                    0.99
## Auditory.global_eff                                   1.00
## Cerebellar.global_eff                                 1.00
## Cingulo.opercular_Task_Control.global_eff             1.00
## Default_mode.global_eff                               1.00
## Dorsal_attention.global_eff                           1.00
## Fronto.parietal_Task_Control.global_eff               1.00
## Memory_retrieval.global_eff                           1.00
## Salience.global_eff                                   1.00
## Sensory.somatomotor_Hand.global_eff                   1.00
## Sensory.somatomotor_Mouth.global_eff                  1.00
## Subcortical.global_eff                                1.00
## Uncertain.global_eff                                  1.00
## Ventral_attention.global_eff                          1.00
## Visual.global_eff                                     0.92
```

```r
#find.interaction(rfsrc_m2, xvar.names = names(COBRE_logi_subset[,-c(1)]), sorted = FALSE, method = "vi


#Correlation check
high_cor <- findCorrelation(cor(COBRE_logi_subset[,-c(1:2)]),cutoff = 0.75) + 2

#No potential multicollinearity problem


index <- sample(1:nrow(COBRE_logi_subset), size = round(nrow(COBRE_logi_subset)*0.7,0),replace = FALSE)

COBRE_train <- COBRE_logi_subset[index,]
COBRE_test <- COBRE_logi_subset[-index,]
logi_m2 <-glm(Subject_Type~. , data = COBRE_train, family = "binomial")
summary(logi_m2)
```

```
##
## Call:
## glm(formula = Subject_Type ~ ., family = "binomial", data = COBRE_train)
##
```

```
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.7740  -0.8927  -0.3029   0.8723   2.7946
##
## Coefficients:
##                                          Estimate Std. Error z value
## (Intercept)                              -0.13280    0.24848  -0.534
## Age                                      -0.47861    0.31704  -1.510
## Auditory.global_eff                       0.27499    0.28158   0.977
## Cerebellar.global_eff                    -0.02965    0.27095  -0.109
## Cingulo.opercular_Task_Control.global_eff -0.64555    0.33684  -1.916
## Default_mode.global_eff                  -0.41007    0.35894  -1.142
## Dorsal_attention.global_eff              -0.16624    0.28377  -0.586
## Fronto.parietal_Task_Control.global_eff  -0.59059    0.28493  -2.073
## Memory_retrieval.global_eff              -0.13569    0.27979  -0.485
## Salience.global_eff                      -0.20282    0.31132  -0.652
## Sensory.somatomotor_Hand.global_eff       0.10884    0.36779   0.296
## Sensory.somatomotor_Mouth.global_eff     -0.30390    0.31851  -0.954
## Subcortical.global_eff                   -0.27574    0.29112  -0.947
## Uncertain.global_eff                      0.35474    0.28462   1.246
## Ventral_attention.global_eff              0.40859    0.29147   1.402
## Visual.global_eff                        -0.74487    0.38911  -1.914
## Visual.Subcortical                        1.09163    0.34568   3.158
##                                          Pr(>|z|)
## (Intercept)                               0.59303
## Age                                       0.13114
## Auditory.global_eff                       0.32877
## Cerebellar.global_eff                     0.91286
## Cingulo.opercular_Task_Control.global_eff  0.05530 .
## Default_mode.global_eff                   0.25327
## Dorsal_attention.global_eff               0.55801
## Fronto.parietal_Task_Control.global_eff   0.03820 *
## Memory_retrieval.global_eff               0.62769
## Salience.global_eff                       0.51472
## Sensory.somatomotor_Hand.global_eff       0.76728
## Sensory.somatomotor_Mouth.global_eff      0.34001
## Subcortical.global_eff                    0.34356
## Uncertain.global_eff                      0.21263
## Ventral_attention.global_eff              0.16097
## Visual.global_eff                         0.05559 .
## Visual.Subcortical                        0.00159 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 136.42  on 98  degrees of freedom
## Residual deviance: 105.62  on 82  degrees of freedom
## AIC: 139.62
##
## Number of Fisher Scoring iterations: 5
```

```
round(exp(coef(logi_m2)),3)
```

```
##                              (Intercept)
```

```
##                                     0.876
##                                       Age
##                                     0.620
##                         Auditory.global_eff
##                                     1.317
##                       Cerebellar.global_eff
##                                     0.971
## Cingulo.opercular_Task_Control.global_eff
##                                     0.524
##                     Default_mode.global_eff
##                                     0.664
##                Dorsal_attention.global_eff
##                                     0.847
##   Fronto.parietal_Task_Control.global_eff
##                                     0.554
##                Memory_retrieval.global_eff
##                                     0.873
##                          Salience.global_eff
##                                     0.816
##       Sensory.somatomotor_Hand.global_eff
##                                     1.115
##      Sensory.somatomotor_Mouth.global_eff
##                                     0.738
##                      Subcortical.global_eff
##                                     0.759
##                        Uncertain.global_eff
##                                     1.426
##               Ventral_attention.global_eff
##                                     1.505
##                           Visual.global_eff
##                                     0.475
##                         Visual.Subcortical
##                                     2.979
```

```
anova(logi_m2, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: Subject_Type
##
## Terms added sequentially (first to last)
##
##
##                                          Df Deviance Resid. Df Resid. Dev
## NULL                                                        98     136.42
## Age                                       1   0.0417        97     136.38
## Auditory.global_eff                       1   0.3108        96     136.07
## Cerebellar.global_eff                     1   1.8761        95     134.19
## Cingulo.opercular_Task_Control.global_eff 1   3.9597        94     130.24
## Default_mode.global_eff                   1   1.2625        93     128.97
## Dorsal_attention.global_eff               1   0.4660        92     128.51
## Fronto.parietal_Task_Control.global_eff   1   1.0467        91     127.46
## Memory_retrieval.global_eff               1   0.4759        90     126.98
```

```
## Salience.global_eff                          1   0.0280        89     126.96
## Sensory.somatomotor_Hand.global_eff          1   0.0038        88     126.95
## Sensory.somatomotor_Mouth.global_eff         1   1.9567        87     125.00
## Subcortical.global_eff                       1   0.0634        86     124.93
## Uncertain.global_eff                         1   1.4932        85     123.44
## Ventral_attention.global_eff                 1   2.6970        84     120.74
## Visual.global_eff                            1   2.0923        83     118.65
## Visual.Subcortical                           1  13.0328        82     105.62
##                                             Pr(>Chi)
## NULL
## Age                                        0.8382831
## Auditory.global_eff                        0.5771834
## Cerebellar.global_eff                      0.1707794
## Cingulo.opercular_Task_Control.global_eff 0.0466033 *
## Default_mode.global_eff                    0.2611782
## Dorsal_attention.global_eff                0.4948425
## Fronto.parietal_Task_Control.global_eff    0.3062618
## Memory_retrieval.global_eff                0.4902644
## Salience.global_eff                        0.8671524
## Sensory.somatomotor_Hand.global_eff        0.9505287
## Sensory.somatomotor_Mouth.global_eff       0.1618715
## Subcortical.global_eff                     0.8011719
## Uncertain.global_eff                       0.2217196
## Ventral_attention.global_eff               0.1005368
## Visual.global_eff                          0.1480421
## Visual.Subcortical                         0.0003061 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

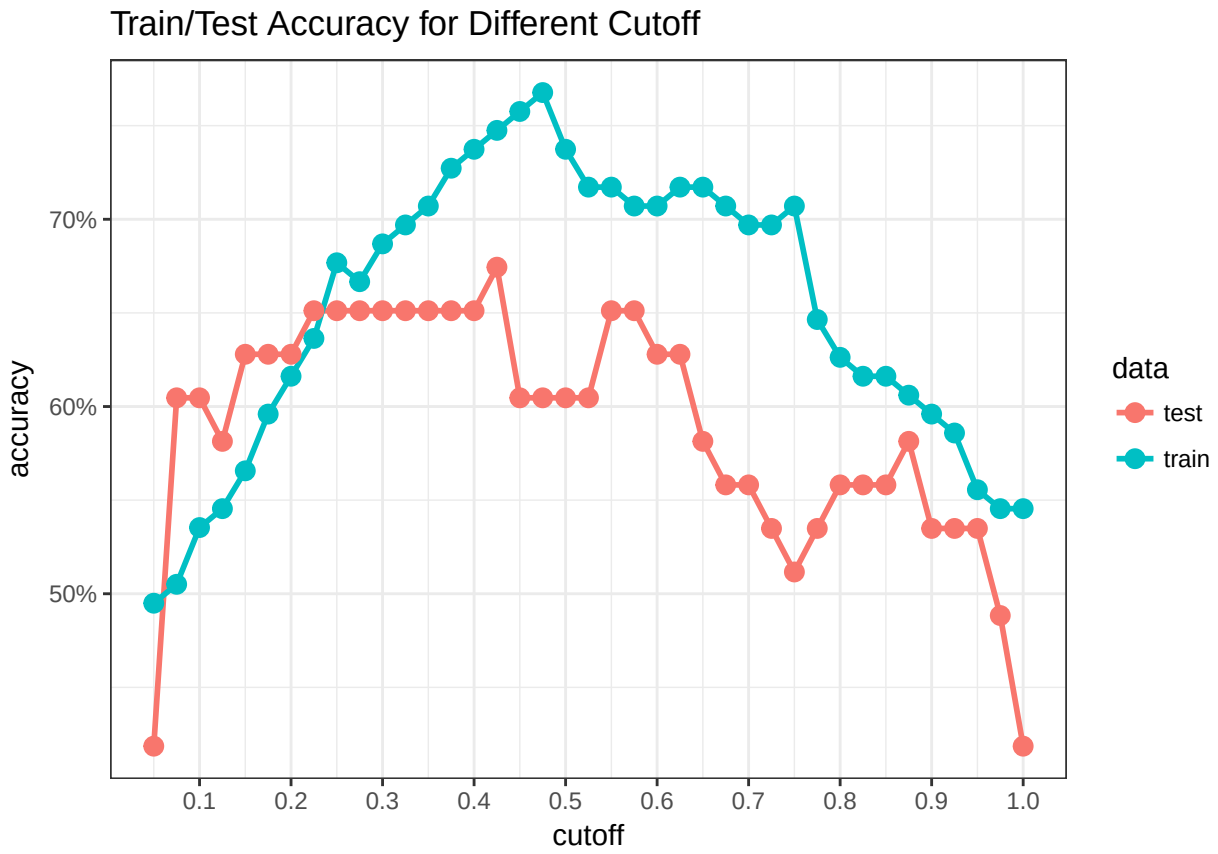
```
#R-squared
R_squared <- 1 - (summary(logi_m2)[[4]]/summary(logi_m2)[[8]])
R_squared
```

```
## [1] 0.2258151
```

```
#70/30 CV check

#Train
COBRE_train$prediction <- predict(logi_m2, COBRE_train, type = "response")


#Test
COBRE_test$prediction <- predict(logi_m2, COBRE_test, type = "response")

prop.table(table(COBRE$Subject_Type))
```

```
##
##       Control Schizophrenia
##     0.5070423     0.4929577
```

```
accuracy_info <- AccuracyCutoffInfo( train = COBRE_train, test = COBRE_test,
                                     predict = "prediction", actual = "Subject_Type" )

accuracy_info$plot
```




```
Classify(COBRE_train, COBRE_train$prediction,"Subject_Type", 0.425)
```

```
##                prediction
##                 Control Schizophrenia
##   Control            37            17
##   Schizophrenia       8            37
## [1] "The accuracy is 74.747 %"
```

```
Classify(COBRE_test, COBRE_test$prediction,"Subject_Type", 0.425)
```

```
##                prediction
##                 Control Schizophrenia
##   Control             9             9
##   Schizophrenia       5            20
## [1] "The accuracy is 67.442 %"
```

```
#COBRE model k fold CV check

set.seed(4321)

Accuracy.k <- cv.error(COBRE_logi_subset, "Subject_Type", cut_off = 0.425)
Accuracy.k
```

```
##  [1] 0.7142857 0.3571429 0.5714286 0.7333333 0.7142857 0.4285714 0.6428571
##  [8] 0.5714286 0.7857143 0.6666667
```

```
mean(Accuracy.k)
```

```
## [1] 0.6185714
```

```r
#Combine data

#Further data cleaning to merge CNP and COBRE data
Study <- rep("CNP",nrow(CNP))

CNP <- data.frame(CNP,Study)

CNP <- CNP %>%
  select(-c(7:41))

colnames(CNP)[5:6] <- c("Ethnicity","Education")

levels(CNP$Gender) <- c("Female","Male")

Study <- rep("COBRE",nrow(COBRE))
COBRE <- data.frame(COBRE,Study)

COBRE <- COBRE %>%
  select(-c(5,8:111))

# CNP Ethinicty
#1=Hispanic origin
#2=Not of Hispanic origin

#COBRE Ethinicty
#Caucasian = 1
#African-American   = 2
#Hispanic   = 3

#Recoding required

table(COBRE$Ethnicity)
```

```
##
##  1  2  3
## 69  9 53
```

```r
for(i in 1:length(COBRE$Ethnicity)){
  if(!is.na(COBRE$Ethnicity[i])){
    if(COBRE$Ethnicity[i] == 1 | COBRE$Ethnicity[i] == 2)
      COBRE$Ethnicity[i] <- 4
  }
}
COBRE$Ethnicity <- COBRE$Ethnicity - 2


table(COBRE$Ethnicity)
```

```
##
##  1  2
## 53 78
```

```r
Data <- merge(CNP,COBRE, all = TRUE) %>%
  select(-c(1))
Data$Ethnicity <- as.factor(Data$Ethnicity)
```

```r
set.seed(4321)

# Combine Data modeling


#Random Forest variable selection

rfsrc_m3 <- rfsrc(Study~.,data = Data, na.action = c("na.omit"), ntree= 1000)


max_var <- max.subtree(rfsrc_m3, conservative = TRUE)

max_var$topvars
```

```
##  [1] "Age"
##  [2] "Education"
##  [3] "Cingulo.opercular.Cerebellar"
##  [4] "Fronto.parietal.Dorsal_Attention"
##  [5] "Subcortical.Cerebellar"
##  [6] "Visual.Fronto.parietal"
##  [7] "Uncertain.char_path_length"
##  [8] "Cingulo.opercular_Task_Control.mod"
##  [9] "Uncertain.mod"
## [10] "Subcortical.global_eff"
## [11] "Uncertain.global_eff"
## [12] "Subcortical.clust_coef"
```

```r
#delete duplicate entity


subset <- as.vector(max_var$topvars)

subset <- delete_dup(subset,Data[,c(1:5,139:152)])



#Logistic Regression model

Data_logi <- Data[,c("Study",names(Data[,c(1:5,139:152)]), subset)]

Data_logi <- na.omit(Data_logi) %>%
  Standarize()


#find interaction
find.interaction(rfsrc_m3, xvar.names = names(Data_logi[,-c(1)]), sorted = FALSE)
```

```
##
##                              Method: maxsubtree
##                    No. of variables: 27
##   Variables sorted by minimal depth?: FALSE
##
##                                          Age Gender Subject_Type
## Age                                     0.78   1.00         0.99
```

```
## Gender                                    1.00   0.96         1.00
## Subject_Type                              0.99   1.00         0.92
## Ethnicity                                 1.00   1.00         1.00
## Education                                 0.96   1.00         0.99
## Cingulo.opercular.Cerebellar              0.99   1.00         0.99
## Fronto.parietal.Dorsal_Attention          0.99   1.00         1.00
## Subcortical.Cerebellar                    0.98   1.00         1.00
## Visual.Fronto.parietal                    0.98   1.00         0.99
## Uncertain.char_path_length                0.98   0.99         0.99
## Cingulo.opercular_Task_Control.mod        0.98   1.00         0.99
## Uncertain.mod                             0.98   0.99         1.00
## Auditory.global_eff                       1.00   1.00         1.00
## Cerebellar.global_eff                     0.99   1.00         1.00
## Cingulo.opercular_Task_Control.global_eff 1.00   1.00         1.00
## Default_mode.global_eff                   1.00   1.00         1.00
## Dorsal_attention.global_eff               0.99   1.00         1.00
## Fronto.parietal_Task_Control.global_eff   1.00   1.00         1.00
## Memory_retrieval.global_eff               1.00   1.00         1.00
## Salience.global_eff                       0.99   1.00         0.99
## Sensory.somatomotor_Hand.global_eff       1.00   1.00         1.00
## Sensory.somatomotor_Mouth.global_eff      1.00   1.00         1.00
## Subcortical.global_eff                    0.99   1.00         1.00
## Uncertain.global_eff                      0.99   1.00         1.00
## Ventral_attention.global_eff              1.00   1.00         1.00
## Visual.global_eff                         0.99   1.00         1.00
## Subcortical.clust_coef                    0.99   1.00         1.00
##                                          Ethnicity Education
## Age                                           1.00      0.97
## Gender                                        1.00      0.99
## Subject_Type                                  1.00      0.99
## Ethnicity                                     0.99      1.00
## Education                                     1.00      0.67
## Cingulo.opercular.Cerebellar                  1.00      0.97
## Fronto.parietal.Dorsal_Attention              1.00      0.99
## Subcortical.Cerebellar                        1.00      0.98
## Visual.Fronto.parietal                        1.00      0.98
## Uncertain.char_path_length                    1.00      0.96
## Cingulo.opercular_Task_Control.mod            1.00      0.97
## Uncertain.mod                                 1.00      0.97
## Auditory.global_eff                           1.00      1.00
## Cerebellar.global_eff                         1.00      0.99
## Cingulo.opercular_Task_Control.global_eff     1.00      1.00
## Default_mode.global_eff                       1.00      1.00
## Dorsal_attention.global_eff                   1.00      0.99
## Fronto.parietal_Task_Control.global_eff       1.00      1.00
## Memory_retrieval.global_eff                   1.00      1.00
## Salience.global_eff                           1.00      0.99
## Sensory.somatomotor_Hand.global_eff           1.00      1.00
## Sensory.somatomotor_Mouth.global_eff          1.00      1.00
## Subcortical.global_eff                        1.00      0.98
## Uncertain.global_eff                          1.00      0.98
## Ventral_attention.global_eff                  1.00      1.00
## Visual.global_eff                             1.00      0.99
## Subcortical.clust_coef                        1.00      0.99
```

```
##                                                 Cingulo.opercular.Cerebellar
## Age                                                                     0.98
## Gender                                                                  1.00
## Subject_Type                                                            0.99
## Ethnicity                                                               1.00
## Education                                                               0.97
## Cingulo.opercular.Cerebellar                                            0.79
## Fronto.parietal.Dorsal_Attention                                        0.99
## Subcortical.Cerebellar                                                  0.99
## Visual.Fronto.parietal                                                  0.99
## Uncertain.char_path_length                                              0.98
## Cingulo.opercular_Task_Control.mod                                      0.98
## Uncertain.mod                                                           0.98
## Auditory.global_eff                                                     1.00
## Cerebellar.global_eff                                                   1.00
## Cingulo.opercular_Task_Control.global_eff                               1.00
## Default_mode.global_eff                                                 1.00
## Dorsal_attention.global_eff                                             1.00
## Fronto.parietal_Task_Control.global_eff                                 1.00
## Memory_retrieval.global_eff                                             1.00
## Salience.global_eff                                                     0.99
## Sensory.somatomotor_Hand.global_eff                                     1.00
## Sensory.somatomotor_Mouth.global_eff                                    1.00
## Subcortical.global_eff                                                  0.99
## Uncertain.global_eff                                                    0.99
## Ventral_attention.global_eff                                            1.00
## Visual.global_eff                                                       1.00
## Subcortical.clust_coef                                                  0.99
##                                                 Fronto.parietal.Dorsal_Attention
## Age                                                                         0.99
## Gender                                                                      1.00
## Subject_Type                                                                0.99
## Ethnicity                                                                   1.00
## Education                                                                   0.98
## Cingulo.opercular.Cerebellar                                                0.98
## Fronto.parietal.Dorsal_Attention                                            0.84
## Subcortical.Cerebellar                                                      0.99
## Visual.Fronto.parietal                                                      0.99
## Uncertain.char_path_length                                                  0.98
## Cingulo.opercular_Task_Control.mod                                          0.98
## Uncertain.mod                                                               0.98
## Auditory.global_eff                                                         1.00
## Cerebellar.global_eff                                                       1.00
## Cingulo.opercular_Task_Control.global_eff                                   1.00
## Default_mode.global_eff                                                     1.00
## Dorsal_attention.global_eff                                                 1.00
## Fronto.parietal_Task_Control.global_eff                                     1.00
## Memory_retrieval.global_eff                                                 1.00
## Salience.global_eff                                                         1.00
## Sensory.somatomotor_Hand.global_eff                                         1.00
## Sensory.somatomotor_Mouth.global_eff                                        1.00
## Subcortical.global_eff                                                      1.00
## Uncertain.global_eff                                                        0.99
## Ventral_attention.global_eff                                                1.00
```

```
## Visual.global_eff                                                    0.99
## Subcortical.clust_coef                                               0.99
##                                          Subcortical.Cerebellar
## Age                                                        0.98
## Gender                                                     1.00
## Subject_Type                                               0.99
## Ethnicity                                                  1.00
## Education                                                  0.96
## Cingulo.opercular.Cerebellar                               0.99
## Fronto.parietal.Dorsal_Attention                           0.99
## Subcortical.Cerebellar                                     0.81
## Visual.Fronto.parietal                                     0.99
## Uncertain.char_path_length                                 0.99
## Cingulo.opercular_Task_Control.mod                         0.99
## Uncertain.mod                                              0.98
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      0.99
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                1.00
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        0.99
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     0.99
## Uncertain.global_eff                                       1.00
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          0.99
## Subcortical.clust_coef                                     0.99
##                                          Visual.Fronto.parietal
## Age                                                        0.98
## Gender                                                     1.00
## Subject_Type                                               0.99
## Ethnicity                                                  1.00
## Education                                                  0.98
## Cingulo.opercular.Cerebellar                               0.99
## Fronto.parietal.Dorsal_Attention                           0.99
## Subcortical.Cerebellar                                     0.98
## Visual.Fronto.parietal                                     0.81
## Uncertain.char_path_length                                 0.98
## Cingulo.opercular_Task_Control.mod                         0.98
## Uncertain.mod                                              0.98
## Auditory.global_eff                                        1.00
## Cerebellar.global_eff                                      0.99
## Cingulo.opercular_Task_Control.global_eff                  1.00
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                0.99
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        0.99
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     0.99
```

```
## Uncertain.global_eff                                    0.99
## Ventral_attention.global_eff                            1.00
## Visual.global_eff                                       0.99
## Subcortical.clust_coef                                  1.00
##                                       Uncertain.char_path_length
## Age                                                         0.98
## Gender                                                      0.99
## Subject_Type                                                0.99
## Ethnicity                                                   1.00
## Education                                                   0.97
## Cingulo.opercular.Cerebellar                                0.98
## Fronto.parietal.Dorsal_Attention                            0.99
## Subcortical.Cerebellar                                      0.99
## Visual.Fronto.parietal                                      0.98
## Uncertain.char_path_length                                  0.74
## Cingulo.opercular_Task_Control.mod                          0.98
## Uncertain.mod                                               0.98
## Auditory.global_eff                                         1.00
## Cerebellar.global_eff                                       0.99
## Cingulo.opercular_Task_Control.global_eff                   1.00
## Default_mode.global_eff                                     1.00
## Dorsal_attention.global_eff                                 0.99
## Fronto.parietal_Task_Control.global_eff                     1.00
## Memory_retrieval.global_eff                                 1.00
## Salience.global_eff                                         0.99
## Sensory.somatomotor_Hand.global_eff                         1.00
## Sensory.somatomotor_Mouth.global_eff                        1.00
## Subcortical.global_eff                                      0.99
## Uncertain.global_eff                                        0.99
## Ventral_attention.global_eff                                1.00
## Visual.global_eff                                           0.99
## Subcortical.clust_coef                                      0.99
##                                       Cingulo.opercular_Task_Control.mod
## Age                                                                 0.99
## Gender                                                              1.00
## Subject_Type                                                        0.99
## Ethnicity                                                           1.00
## Education                                                           0.96
## Cingulo.opercular.Cerebellar                                        0.98
## Fronto.parietal.Dorsal_Attention                                    0.99
## Subcortical.Cerebellar                                              0.99
## Visual.Fronto.parietal                                              0.98
## Uncertain.char_path_length                                          0.98
## Cingulo.opercular_Task_Control.mod                                  0.76
## Uncertain.mod                                                       0.97
## Auditory.global_eff                                                 1.00
## Cerebellar.global_eff                                               0.99
## Cingulo.opercular_Task_Control.global_eff                           1.00
## Default_mode.global_eff                                             1.00
## Dorsal_attention.global_eff                                         0.99
## Fronto.parietal_Task_Control.global_eff                             1.00
## Memory_retrieval.global_eff                                         1.00
## Salience.global_eff                                                 0.99
## Sensory.somatomotor_Hand.global_eff                                 1.00
```

```
## Sensory.somatomotor_Mouth.global_eff                                1.00
## Subcortical.global_eff                                              0.99
## Uncertain.global_eff                                                0.99
## Ventral_attention.global_eff                                        1.00
## Visual.global_eff                                                   0.99
## Subcortical.clust_coef                                              0.99
##                                          Uncertain.mod
## Age                                               0.97
## Gender                                            1.00
## Subject_Type                                      0.99
## Ethnicity                                         1.00
## Education                                         0.97
## Cingulo.opercular.Cerebellar                      0.98
## Fronto.parietal.Dorsal_Attention                  0.99
## Subcortical.Cerebellar                            0.98
## Visual.Fronto.parietal                            0.98
## Uncertain.char_path_length                        0.97
## Cingulo.opercular_Task_Control.mod                0.98
## Uncertain.mod                                     0.74
## Auditory.global_eff                               1.00
## Cerebellar.global_eff                             0.99
## Cingulo.opercular_Task_Control.global_eff         1.00
## Default_mode.global_eff                           1.00
## Dorsal_attention.global_eff                       1.00
## Fronto.parietal_Task_Control.global_eff           1.00
## Memory_retrieval.global_eff                       1.00
## Salience.global_eff                               0.99
## Sensory.somatomotor_Hand.global_eff               1.00
## Sensory.somatomotor_Mouth.global_eff              1.00
## Subcortical.global_eff                            0.99
## Uncertain.global_eff                              0.99
## Ventral_attention.global_eff                      1.00
## Visual.global_eff                                 0.99
## Subcortical.clust_coef                            0.99
##                                          Auditory.global_eff
## Age                                                     0.98
## Gender                                                  1.00
## Subject_Type                                            1.00
## Ethnicity                                               1.00
## Education                                               0.98
## Cingulo.opercular.Cerebellar                            0.99
## Fronto.parietal.Dorsal_Attention                        0.99
## Subcortical.Cerebellar                                  0.99
## Visual.Fronto.parietal                                  0.99
## Uncertain.char_path_length                              0.98
## Cingulo.opercular_Task_Control.mod                      0.99
## Uncertain.mod                                           0.98
## Auditory.global_eff                                     0.90
## Cerebellar.global_eff                                   1.00
## Cingulo.opercular_Task_Control.global_eff               1.00
## Default_mode.global_eff                                 1.00
## Dorsal_attention.global_eff                             1.00
## Fronto.parietal_Task_Control.global_eff                 1.00
## Memory_retrieval.global_eff                             1.00
```

```
## Salience.global_eff                                    1.00
## Sensory.somatomotor_Hand.global_eff                    1.00
## Sensory.somatomotor_Mouth.global_eff                   1.00
## Subcortical.global_eff                                 1.00
## Uncertain.global_eff                                   0.99
## Ventral_attention.global_eff                           1.00
## Visual.global_eff                                      0.99
## Subcortical.clust_coef                                 1.00
##                                          Cerebellar.global_eff
## Age                                                       0.99
## Gender                                                    1.00
## Subject_Type                                              1.00
## Ethnicity                                                 1.00
## Education                                                 0.98
## Cingulo.opercular.Cerebellar                              0.99
## Fronto.parietal.Dorsal_Attention                          0.99
## Subcortical.Cerebellar                                    0.99
## Visual.Fronto.parietal                                    0.99
## Uncertain.char_path_length                                0.99
## Cingulo.opercular_Task_Control.mod                        0.98
## Uncertain.mod                                             0.99
## Auditory.global_eff                                       1.00
## Cerebellar.global_eff                                     0.90
## Cingulo.opercular_Task_Control.global_eff                 1.00
## Default_mode.global_eff                                   1.00
## Dorsal_attention.global_eff                               1.00
## Fronto.parietal_Task_Control.global_eff                   1.00
## Memory_retrieval.global_eff                               1.00
## Salience.global_eff                                       0.99
## Sensory.somatomotor_Hand.global_eff                       1.00
## Sensory.somatomotor_Mouth.global_eff                      1.00
## Subcortical.global_eff                                    0.99
## Uncertain.global_eff                                      0.99
## Ventral_attention.global_eff                              1.00
## Visual.global_eff                                         1.00
## Subcortical.clust_coef                                    1.00
##                                          Cingulo.opercular_Task_Control.global_eff
## Age                                                                           0.99
## Gender                                                                        1.00
## Subject_Type                                                                  1.00
## Ethnicity                                                                     1.00
## Education                                                                     0.98
## Cingulo.opercular.Cerebellar                                                  0.99
## Fronto.parietal.Dorsal_Attention                                              0.99
## Subcortical.Cerebellar                                                        0.99
## Visual.Fronto.parietal                                                        0.99
## Uncertain.char_path_length                                                    0.99
## Cingulo.opercular_Task_Control.mod                                            0.99
## Uncertain.mod                                                                 0.99
## Auditory.global_eff                                                           1.00
## Cerebellar.global_eff                                                         1.00
## Cingulo.opercular_Task_Control.global_eff                                     0.92
## Default_mode.global_eff                                                       1.00
## Dorsal_attention.global_eff                                                   1.00
```

```
## Fronto.parietal_Task_Control.global_eff                                1.00
## Memory_retrieval.global_eff                                            1.00
## Salience.global_eff                                                    0.99
## Sensory.somatomotor_Hand.global_eff                                    1.00
## Sensory.somatomotor_Mouth.global_eff                                   1.00
## Subcortical.global_eff                                                 1.00
## Uncertain.global_eff                                                   0.99
## Ventral_attention.global_eff                                           1.00
## Visual.global_eff                                                      1.00
## Subcortical.clust_coef                                                 1.00
##                                          Default_mode.global_eff
## Age                                                         0.99
## Gender                                                      1.00
## Subject_Type                                                1.00
## Ethnicity                                                   1.00
## Education                                                   0.98
## Cingulo.opercular.Cerebellar                                0.99
## Fronto.parietal.Dorsal_Attention                            0.99
## Subcortical.Cerebellar                                      0.99
## Visual.Fronto.parietal                                      0.99
## Uncertain.char_path_length                                  0.99
## Cingulo.opercular_Task_Control.mod                          0.99
## Uncertain.mod                                               0.98
## Auditory.global_eff                                         1.00
## Cerebellar.global_eff                                       1.00
## Cingulo.opercular_Task_Control.global_eff                   1.00
## Default_mode.global_eff                                     0.91
## Dorsal_attention.global_eff                                 1.00
## Fronto.parietal_Task_Control.global_eff                     1.00
## Memory_retrieval.global_eff                                 1.00
## Salience.global_eff                                         0.99
## Sensory.somatomotor_Hand.global_eff                         1.00
## Sensory.somatomotor_Mouth.global_eff                        1.00
## Subcortical.global_eff                                      1.00
## Uncertain.global_eff                                        0.99
## Ventral_attention.global_eff                                1.00
## Visual.global_eff                                           0.99
## Subcortical.clust_coef                                      1.00
##                                          Dorsal_attention.global_eff
## Age                                                             0.98
## Gender                                                          1.00
## Subject_Type                                                    1.00
## Ethnicity                                                       1.00
## Education                                                       0.98
## Cingulo.opercular.Cerebellar                                    0.99
## Fronto.parietal.Dorsal_Attention                                0.99
## Subcortical.Cerebellar                                          0.99
## Visual.Fronto.parietal                                          0.99
## Uncertain.char_path_length                                      0.98
## Cingulo.opercular_Task_Control.mod                              0.98
## Uncertain.mod                                                   0.98
## Auditory.global_eff                                             1.00
## Cerebellar.global_eff                                           0.99
## Cingulo.opercular_Task_Control.global_eff                       1.00
```

```
## Default_mode.global_eff                                    1.00
## Dorsal_attention.global_eff                                0.88
## Fronto.parietal_Task_Control.global_eff                    1.00
## Memory_retrieval.global_eff                                1.00
## Salience.global_eff                                        0.99
## Sensory.somatomotor_Hand.global_eff                        1.00
## Sensory.somatomotor_Mouth.global_eff                       1.00
## Subcortical.global_eff                                     0.99
## Uncertain.global_eff                                       0.99
## Ventral_attention.global_eff                               1.00
## Visual.global_eff                                          0.99
## Subcortical.clust_coef                                     0.99
##                                      Fronto.parietal_Task_Control.global_eff
## Age                                                                    0.99
## Gender                                                                 1.00
## Subject_Type                                                           1.00
## Ethnicity                                                              1.00
## Education                                                              0.98
## Cingulo.opercular.Cerebellar                                           0.99
## Fronto.parietal.Dorsal_Attention                                       0.99
## Subcortical.Cerebellar                                                 0.99
## Visual.Fronto.parietal                                                 0.99
## Uncertain.char_path_length                                             0.99
## Cingulo.opercular_Task_Control.mod                                     0.99
## Uncertain.mod                                                          0.98
## Auditory.global_eff                                                    0.99
## Cerebellar.global_eff                                                  1.00
## Cingulo.opercular_Task_Control.global_eff                              1.00
## Default_mode.global_eff                                                1.00
## Dorsal_attention.global_eff                                            1.00
## Fronto.parietal_Task_Control.global_eff                                0.90
## Memory_retrieval.global_eff                                            1.00
## Salience.global_eff                                                    0.99
## Sensory.somatomotor_Hand.global_eff                                    1.00
## Sensory.somatomotor_Mouth.global_eff                                   1.00
## Subcortical.global_eff                                                 1.00
## Uncertain.global_eff                                                   0.99
## Ventral_attention.global_eff                                           1.00
## Visual.global_eff                                                      1.00
## Subcortical.clust_coef                                                 1.00
##                                      Memory_retrieval.global_eff
## Age                                                         0.99
## Gender                                                      1.00
## Subject_Type                                                1.00
## Ethnicity                                                   1.00
## Education                                                   0.98
## Cingulo.opercular.Cerebellar                                0.99
## Fronto.parietal.Dorsal_Attention                            1.00
## Subcortical.Cerebellar                                      0.99
## Visual.Fronto.parietal                                      0.99
## Uncertain.char_path_length                                  0.99
## Cingulo.opercular_Task_Control.mod                          0.99
## Uncertain.mod                                               0.99
## Auditory.global_eff                                         1.00
```

```
## Cerebellar.global_eff                                    1.00
## Cingulo.opercular_Task_Control.global_eff                1.00
## Default_mode.global_eff                                  1.00
## Dorsal_attention.global_eff                              1.00
## Fronto.parietal_Task_Control.global_eff                  1.00
## Memory_retrieval.global_eff                              0.92
## Salience.global_eff                                      1.00
## Sensory.somatomotor_Hand.global_eff                      1.00
## Sensory.somatomotor_Mouth.global_eff                     1.00
## Subcortical.global_eff                                   0.99
## Uncertain.global_eff                                     1.00
## Ventral_attention.global_eff                             1.00
## Visual.global_eff                                        1.00
## Subcortical.clust_coef                                   0.99
##                                          Salience.global_eff
## Age                                                     0.99
## Gender                                                  1.00
## Subject_Type                                            0.99
## Ethnicity                                               1.00
## Education                                               0.98
## Cingulo.opercular.Cerebellar                            0.99
## Fronto.parietal.Dorsal_Attention                        0.99
## Subcortical.Cerebellar                                  0.98
## Visual.Fronto.parietal                                  0.99
## Uncertain.char_path_length                              0.98
## Cingulo.opercular_Task_Control.mod                      0.99
## Uncertain.mod                                           0.98
## Auditory.global_eff                                     1.00
## Cerebellar.global_eff                                   1.00
## Cingulo.opercular_Task_Control.global_eff               1.00
## Default_mode.global_eff                                 1.00
## Dorsal_attention.global_eff                             0.99
## Fronto.parietal_Task_Control.global_eff                 1.00
## Memory_retrieval.global_eff                             1.00
## Salience.global_eff                                     0.85
## Sensory.somatomotor_Hand.global_eff                     1.00
## Sensory.somatomotor_Mouth.global_eff                    1.00
## Subcortical.global_eff                                  1.00
## Uncertain.global_eff                                    0.99
## Ventral_attention.global_eff                            1.00
## Visual.global_eff                                       1.00
## Subcortical.clust_coef                                  1.00
##                                          Sensory.somatomotor_Hand.global_eff
## Age                                                                     1.00
## Gender                                                                  1.00
## Subject_Type                                                            1.00
## Ethnicity                                                               1.00
## Education                                                               0.98
## Cingulo.opercular.Cerebellar                                            0.99
## Fronto.parietal.Dorsal_Attention                                        1.00
## Subcortical.Cerebellar                                                  1.00
## Visual.Fronto.parietal                                                  0.99
## Uncertain.char_path_length                                              0.99
## Cingulo.opercular_Task_Control.mod                                      0.99
```

```
## Uncertain.mod                                                    0.99
## Auditory.global_eff                                              1.00
## Cerebellar.global_eff                                            0.99
## Cingulo.opercular_Task_Control.global_eff                        1.00
## Default_mode.global_eff                                          1.00
## Dorsal_attention.global_eff                                      1.00
## Fronto.parietal_Task_Control.global_eff                          1.00
## Memory_retrieval.global_eff                                      1.00
## Salience.global_eff                                              1.00
## Sensory.somatomotor_Hand.global_eff                              0.93
## Sensory.somatomotor_Mouth.global_eff                             1.00
## Subcortical.global_eff                                           0.99
## Uncertain.global_eff                                             0.99
## Ventral_attention.global_eff                                     1.00
## Visual.global_eff                                                1.00
## Subcortical.clust_coef                                           1.00
##                                        Sensory.somatomotor_Mouth.global_eff
## Age                                                                    0.99
## Gender                                                                 1.00
## Subject_Type                                                           1.00
## Ethnicity                                                              1.00
## Education                                                              0.99
## Cingulo.opercular.Cerebellar                                           0.99
## Fronto.parietal.Dorsal_Attention                                       0.99
## Subcortical.Cerebellar                                                 0.99
## Visual.Fronto.parietal                                                 0.99
## Uncertain.char_path_length                                             0.99
## Cingulo.opercular_Task_Control.mod                                     0.99
## Uncertain.mod                                                          0.99
## Auditory.global_eff                                                    1.00
## Cerebellar.global_eff                                                  1.00
## Cingulo.opercular_Task_Control.global_eff                              1.00
## Default_mode.global_eff                                                1.00
## Dorsal_attention.global_eff                                            1.00
## Fronto.parietal_Task_Control.global_eff                                1.00
## Memory_retrieval.global_eff                                            1.00
## Salience.global_eff                                                    0.99
## Sensory.somatomotor_Hand.global_eff                                    1.00
## Sensory.somatomotor_Mouth.global_eff                                   0.92
## Subcortical.global_eff                                                 1.00
## Uncertain.global_eff                                                   0.99
## Ventral_attention.global_eff                                           1.00
## Visual.global_eff                                                      1.00
## Subcortical.clust_coef                                                 1.00
##                                        Subcortical.global_eff
## Age                                                      0.98
## Gender                                                   1.00
## Subject_Type                                             0.99
## Ethnicity                                                1.00
## Education                                                0.96
## Cingulo.opercular.Cerebellar                             0.98
## Fronto.parietal.Dorsal_Attention                         0.99
## Subcortical.Cerebellar                                   0.98
## Visual.Fronto.parietal                                   0.99
```

```
## Uncertain.char_path_length                                    0.98
## Cingulo.opercular_Task_Control.mod                            0.98
## Uncertain.mod                                                 0.97
## Auditory.global_eff                                           0.99
## Cerebellar.global_eff                                         1.00
## Cingulo.opercular_Task_Control.global_eff                     1.00
## Default_mode.global_eff                                       1.00
## Dorsal_attention.global_eff                                   1.00
## Fronto.parietal_Task_Control.global_eff                       1.00
## Memory_retrieval.global_eff                                   1.00
## Salience.global_eff                                           0.99
## Sensory.somatomotor_Hand.global_eff                           1.00
## Sensory.somatomotor_Mouth.global_eff                          1.00
## Subcortical.global_eff                                        0.82
## Uncertain.global_eff                                          0.99
## Ventral_attention.global_eff                                  1.00
## Visual.global_eff                                             0.99
## Subcortical.clust_coef                                        0.99
##                                          Uncertain.global_eff
## Age                                                      0.99
## Gender                                                   1.00
## Subject_Type                                             1.00
## Ethnicity                                                1.00
## Education                                                0.97
## Cingulo.opercular.Cerebellar                             0.98
## Fronto.parietal.Dorsal_Attention                         0.99
## Subcortical.Cerebellar                                   0.99
## Visual.Fronto.parietal                                   0.99
## Uncertain.char_path_length                               0.99
## Cingulo.opercular_Task_Control.mod                       0.99
## Uncertain.mod                                            0.98
## Auditory.global_eff                                      1.00
## Cerebellar.global_eff                                    0.99
## Cingulo.opercular_Task_Control.global_eff                1.00
## Default_mode.global_eff                                  1.00
## Dorsal_attention.global_eff                              1.00
## Fronto.parietal_Task_Control.global_eff                  1.00
## Memory_retrieval.global_eff                              1.00
## Salience.global_eff                                      0.99
## Sensory.somatomotor_Hand.global_eff                      1.00
## Sensory.somatomotor_Mouth.global_eff                     1.00
## Subcortical.global_eff                                   0.99
## Uncertain.global_eff                                     0.84
## Ventral_attention.global_eff                             1.00
## Visual.global_eff                                        0.99
## Subcortical.clust_coef                                   0.99
##                                          Ventral_attention.global_eff
## Age                                                              0.99
## Gender                                                           1.00
## Subject_Type                                                     0.99
## Ethnicity                                                        1.00
## Education                                                        0.99
## Cingulo.opercular.Cerebellar                                     0.99
## Fronto.parietal.Dorsal_Attention                                 1.00
```

```
## Subcortical.Cerebellar                                    0.99
## Visual.Fronto.parietal                                    0.99
## Uncertain.char_path_length                                0.98
## Cingulo.opercular_Task_Control.mod                        0.99
## Uncertain.mod                                             0.98
## Auditory.global_eff                                       1.00
## Cerebellar.global_eff                                     1.00
## Cingulo.opercular_Task_Control.global_eff                 1.00
## Default_mode.global_eff                                   1.00
## Dorsal_attention.global_eff                               0.99
## Fronto.parietal_Task_Control.global_eff                   1.00
## Memory_retrieval.global_eff                               1.00
## Salience.global_eff                                       0.99
## Sensory.somatomotor_Hand.global_eff                       1.00
## Sensory.somatomotor_Mouth.global_eff                      1.00
## Subcortical.global_eff                                    0.99
## Uncertain.global_eff                                      1.00
## Ventral_attention.global_eff                              0.90
## Visual.global_eff                                         1.00
## Subcortical.clust_coef                                    0.99
##                                          Visual.global_eff
## Age                                                   0.99
## Gender                                                1.00
## Subject_Type                                          0.99
## Ethnicity                                             1.00
## Education                                             0.98
## Cingulo.opercular.Cerebellar                          0.99
## Fronto.parietal.Dorsal_Attention                      0.99
## Subcortical.Cerebellar                                0.99
## Visual.Fronto.parietal                                0.99
## Uncertain.char_path_length                            0.99
## Cingulo.opercular_Task_Control.mod                    0.99
## Uncertain.mod                                         0.98
## Auditory.global_eff                                   1.00
## Cerebellar.global_eff                                 1.00
## Cingulo.opercular_Task_Control.global_eff             1.00
## Default_mode.global_eff                               1.00
## Dorsal_attention.global_eff                           0.99
## Fronto.parietal_Task_Control.global_eff               1.00
## Memory_retrieval.global_eff                           1.00
## Salience.global_eff                                   0.99
## Sensory.somatomotor_Hand.global_eff                   1.00
## Sensory.somatomotor_Mouth.global_eff                  1.00
## Subcortical.global_eff                                0.99
## Uncertain.global_eff                                  0.99
## Ventral_attention.global_eff                          1.00
## Visual.global_eff                                     0.87
## Subcortical.clust_coef                                1.00
##                                          Subcortical.clust_coef
## Age                                                        0.98
## Gender                                                     1.00
## Subject_Type                                               1.00
## Ethnicity                                                  1.00
## Education                                                  0.98
```

```
## Cingulo.opercular.Cerebellar                                    0.98
## Fronto.parietal.Dorsal_Attention                                0.99
## Subcortical.Cerebellar                                          0.99
## Visual.Fronto.parietal                                          0.99
## Uncertain.char_path_length                                      0.98
## Cingulo.opercular_Task_Control.mod                              0.98
## Uncertain.mod                                                   0.98
## Auditory.global_eff                                             1.00
## Cerebellar.global_eff                                           0.99
## Cingulo.opercular_Task_Control.global_eff                       1.00
## Default_mode.global_eff                                         1.00
## Dorsal_attention.global_eff                                     0.99
## Fronto.parietal_Task_Control.global_eff                         1.00
## Memory_retrieval.global_eff                                     1.00
## Salience.global_eff                                             0.99
## Sensory.somatomotor_Hand.global_eff                             1.00
## Sensory.somatomotor_Mouth.global_eff                            1.00
## Subcortical.global_eff                                          0.99
## Uncertain.global_eff                                            0.99
## Ventral_attention.global_eff                                    1.00
## Visual.global_eff                                               0.99
## Subcortical.clust_coef                                          0.85
```

```
#find.interaction(rfsrc_m3, xvar.names = names(Data_logi[,-c(1)]), sorted = FALSE, method = "vimp")


#check correlation

high_cor <- findCorrelation(cor(Data_logi[,-c(1,3:5)]),cutoff = 0.75) + 4

#Remove variables to prevent multicollinearity problem
Data_logi <- Data_logi %>%
  select(-c(high_cor))

index <- sample(1:nrow(Data_logi), size = round(nrow(Data_logi)*0.7,0),replace = FALSE)

Data_train <- Data_logi[index,]
Data_test <- Data_logi[-index,]
logi_m3 <-glm(Study~. + Subject_Type*Age , data = Data_train, family = "binomial")
summary(logi_m3)
```

```
##
## Call:
## glm(formula = Study ~ . + Subject_Type * Age, family = "binomial",
##     data = Data_train)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.7700  -0.6746  -0.3092   0.7643   2.4375
##
## Coefficients:
##                                          Estimate Std. Error z value
## (Intercept)                              -0.53169    0.42039  -1.265
## Age                                       0.36891    0.31853   1.158
## GenderMale                                0.46669    0.43638   1.069
```

```
## Subject_TypeSchizophrenia                  0.38913    0.47163   0.825
## Ethnicity2                                -0.21121    0.44299  -0.477
## Education                                 -0.48969    0.24136  -2.029
## Auditory.global_eff                        0.22337    0.23506   0.950
## Cerebellar.global_eff                     -0.29040    0.23386  -1.242
## Cingulo.opercular_Task_Control.global_eff  0.33690    0.26957   1.250
## Default_mode.global_eff                   -0.09649    0.28185  -0.342
## Dorsal_attention.global_eff                0.25471    0.24005   1.061
## Fronto.parietal_Task_Control.global_eff    0.01053    0.23382   0.045
## Memory_retrieval.global_eff               -0.11565    0.21575  -0.536
## Salience.global_eff                        0.33326    0.24352   1.368
## Sensory.somatomotor_Hand.global_eff        0.03733    0.30262   0.123
## Sensory.somatomotor_Mouth.global_eff      -0.12186    0.25212  -0.483
## Subcortical.global_eff                     0.35924    0.26237   1.369
## Uncertain.global_eff                      -0.33765    0.24043  -1.404
## Ventral_attention.global_eff              -0.11511    0.22425  -0.513
## Visual.global_eff                         -0.17071    0.26198  -0.652
## Cingulo.opercular.Cerebellar              -0.59461    0.28980  -2.052
## Subcortical.Cerebellar                    -0.31993    0.31572  -1.013
## Visual.Fronto.parietal                     0.15127    0.31430   0.481
## Cingulo.opercular_Task_Control.mod         0.40354    0.23812   1.695
## Uncertain.mod                              0.39313    0.24439   1.609
## Subcortical.clust_coef                     0.50978    0.23507   2.169
## Age:Subject_TypeSchizophrenia             -0.09416    0.42299  -0.223
##                                           Pr(>|z|)
## (Intercept)                                 0.2060
## Age                                         0.2468
## GenderMale                                  0.2849
## Subject_TypeSchizophrenia                   0.4093
## Ethnicity2                                  0.6335
## Education                                   0.0425 *
## Auditory.global_eff                         0.3420
## Cerebellar.global_eff                       0.2143
## Cingulo.opercular_Task_Control.global_eff   0.2114
## Default_mode.global_eff                     0.7321
## Dorsal_attention.global_eff                 0.2887
## Fronto.parietal_Task_Control.global_eff     0.9641
## Memory_retrieval.global_eff                 0.5919
## Salience.global_eff                         0.1712
## Sensory.somatomotor_Hand.global_eff         0.9018
## Sensory.somatomotor_Mouth.global_eff        0.6289
## Subcortical.global_eff                      0.1709
## Uncertain.global_eff                        0.1602
## Ventral_attention.global_eff                0.6077
## Visual.global_eff                           0.5146
## Cingulo.opercular.Cerebellar                0.0402 *
## Subcortical.Cerebellar                      0.3109
## Visual.Fronto.parietal                      0.6303
## Cingulo.opercular_Task_Control.mod          0.0901 .
## Uncertain.mod                               0.1077
## Subcortical.clust_coef                      0.0301 *
## Age:Subject_TypeSchizophrenia               0.8239
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 265.96  on 193  degrees of freedom
## Residual deviance: 178.00  on 167  degrees of freedom
## AIC: 232
##
## Number of Fisher Scoring iterations: 5
```

```
round(exp(coef(logi_m3)),3)
```

```
##                                  (Intercept)
##                                        0.588
##                                          Age
##                                        1.446
##                                   GenderMale
##                                        1.595
##                   Subject_TypeSchizophrenia
##                                        1.476
##                                   Ethnicity2
##                                        0.810
##                                    Education
##                                        0.613
##                          Auditory.global_eff
##                                        1.250
##                        Cerebellar.global_eff
##                                        0.748
## Cingulo.opercular_Task_Control.global_eff
##                                        1.401
##                      Default_mode.global_eff
##                                        0.908
##                  Dorsal_attention.global_eff
##                                        1.290
##   Fronto.parietal_Task_Control.global_eff
##                                        1.011
##                  Memory_retrieval.global_eff
##                                        0.891
##                           Salience.global_eff
##                                        1.396
##       Sensory.somatomotor_Hand.global_eff
##                                        1.038
##      Sensory.somatomotor_Mouth.global_eff
##                                        0.885
##                       Subcortical.global_eff
##                                        1.432
##                         Uncertain.global_eff
##                                        0.713
##                Ventral_attention.global_eff
##                                        0.891
##                            Visual.global_eff
##                                        0.843
##                Cingulo.opercular.Cerebellar
##                                        0.552
##                      Subcortical.Cerebellar
##                                        0.726
```

```
##                     Visual.Fronto.parietal
##                                      1.163
##        Cingulo.opercular_Task_Control.mod
##                                      1.497
##                                Uncertain.mod
##                                      1.482
##                     Subcortical.clust_coef
##                                      1.665
##             Age:Subject_TypeSchizophrenia
##                                      0.910
```

```
anova(logi_m3, test = "Chisq")
```

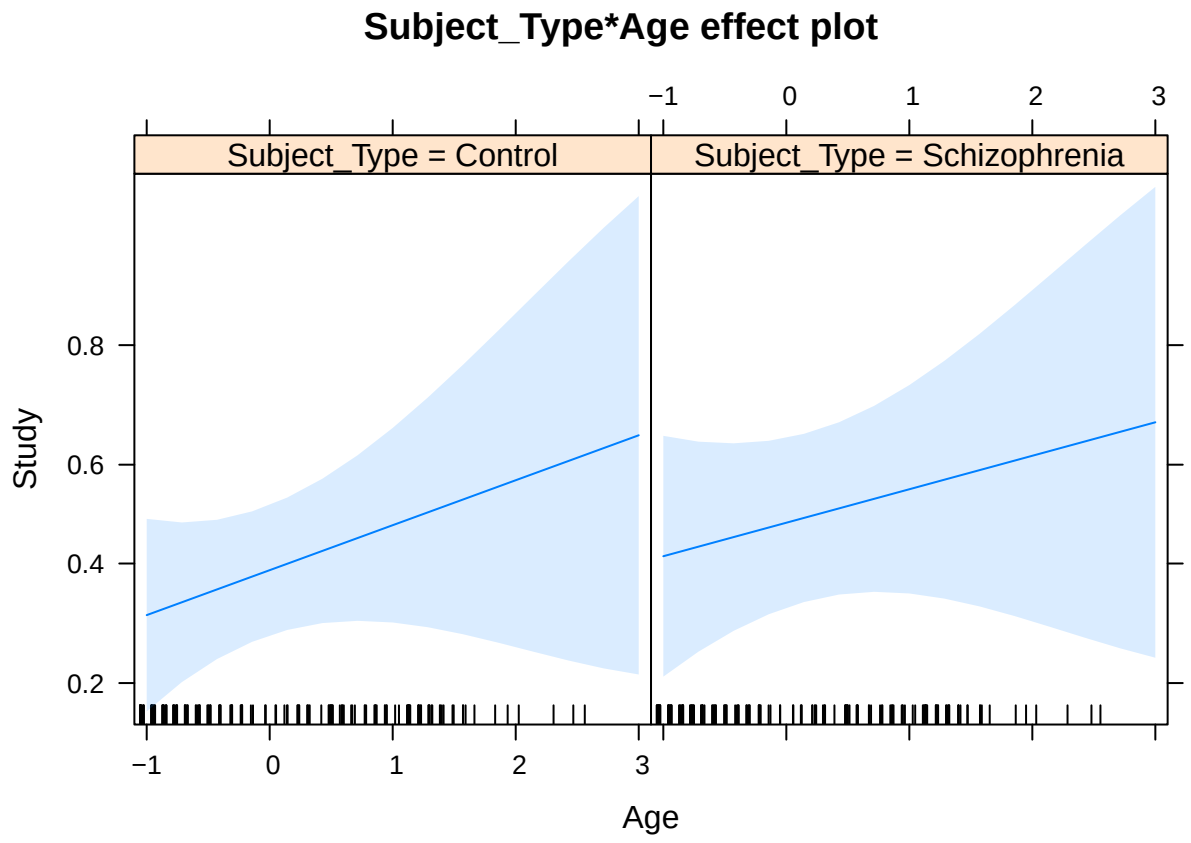
```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: Study
##
## Terms added sequentially (first to last)
##
##
##                                           Df Deviance Resid. Df Resid. Dev
## NULL                                                        193     265.96
## Age                                        1   3.3371       192     262.63
## Gender                                     1   6.2191       191     256.41
## Subject_Type                               1   7.2228       190     249.19
## Ethnicity                                  1   0.5869       189     248.60
## Education                                  1  12.7223       188     235.88
## Auditory.global_eff                        1   3.6053       187     232.27
## Cerebellar.global_eff                      1   6.4624       186     225.81
## Cingulo.opercular_Task_Control.global_eff  1   0.2843       185     225.52
## Default_mode.global_eff                    1   3.6685       184     221.86
## Dorsal_attention.global_eff                1   1.5829       183     220.27
## Fronto.parietal_Task_Control.global_eff    1   0.0726       182     220.20
## Memory_retrieval.global_eff                1   0.0668       181     220.13
## Salience.global_eff                        1   3.7711       180     216.36
## Sensory.somatomotor_Hand.global_eff        1   0.0170       179     216.34
## Sensory.somatomotor_Mouth.global_eff       1   0.4466       178     215.90
## Subcortical.global_eff                     1   3.5802       177     212.32
## Uncertain.global_eff                       1   5.7028       176     206.62
## Ventral_attention.global_eff               1   0.4207       175     206.19
## Visual.global_eff                          1   2.0756       174     204.12
## Cingulo.opercular.Cerebellar               1  14.1765       173     189.94
## Subcortical.Cerebellar                     1   1.8643       172     188.08
## Visual.Fronto.parietal                     1   0.0379       171     188.04
## Cingulo.opercular_Task_Control.mod         1   2.3040       170     185.74
## Uncertain.mod                              1   2.3636       169     183.37
## Subcortical.clust_coef                     1   5.3243       168     178.05
## Age:Subject_Type                           1   0.0495       167     178.00
##                                            Pr(>Chi)
## NULL
## Age                                       0.0677343 .
## Gender                                    0.0126379 *
## Subject_Type                              0.0071985 **
```

```
## Ethnicity                                    0.4436360
## Education                                    0.0003613 ***
## Auditory.global_eff                          0.0575963 .
## Cerebellar.global_eff                        0.0110179 *
## Cingulo.opercular_Task_Control.global_eff 0.5938826
## Default_mode.global_eff                      0.0554491 .
## Dorsal_attention.global_eff                  0.2083497
## Fronto.parietal_Task_Control.global_eff   0.7875658
## Memory_retrieval.global_eff                  0.7959919
## Salience.global_eff                          0.0521457 .
## Sensory.somatomotor_Hand.global_eff       0.8961752
## Sensory.somatomotor_Mouth.global_eff      0.5039533
## Subcortical.global_eff                       0.0584732 .
## Uncertain.global_eff                         0.0169375 *
## Ventral_attention.global_eff                 0.5165702
## Visual.global_eff                            0.1496697
## Cingulo.opercular.Cerebellar                 0.0001664 ***
## Subcortical.Cerebellar                       0.1721237
## Visual.Fronto.parietal                       0.8457015
## Cingulo.opercular_Task_Control.mod        0.1290434
## Uncertain.mod                                0.1241928
## Subcortical.clust_coef                       0.0210304 *
## Age:Subject_Type                             0.8239025
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#R-squared

R_squared <- 1 - (summary(logi_m3)[[4]]/summary(logi_m3)[[8]])
R_squared
```

```
## [1] 0.3307403
```

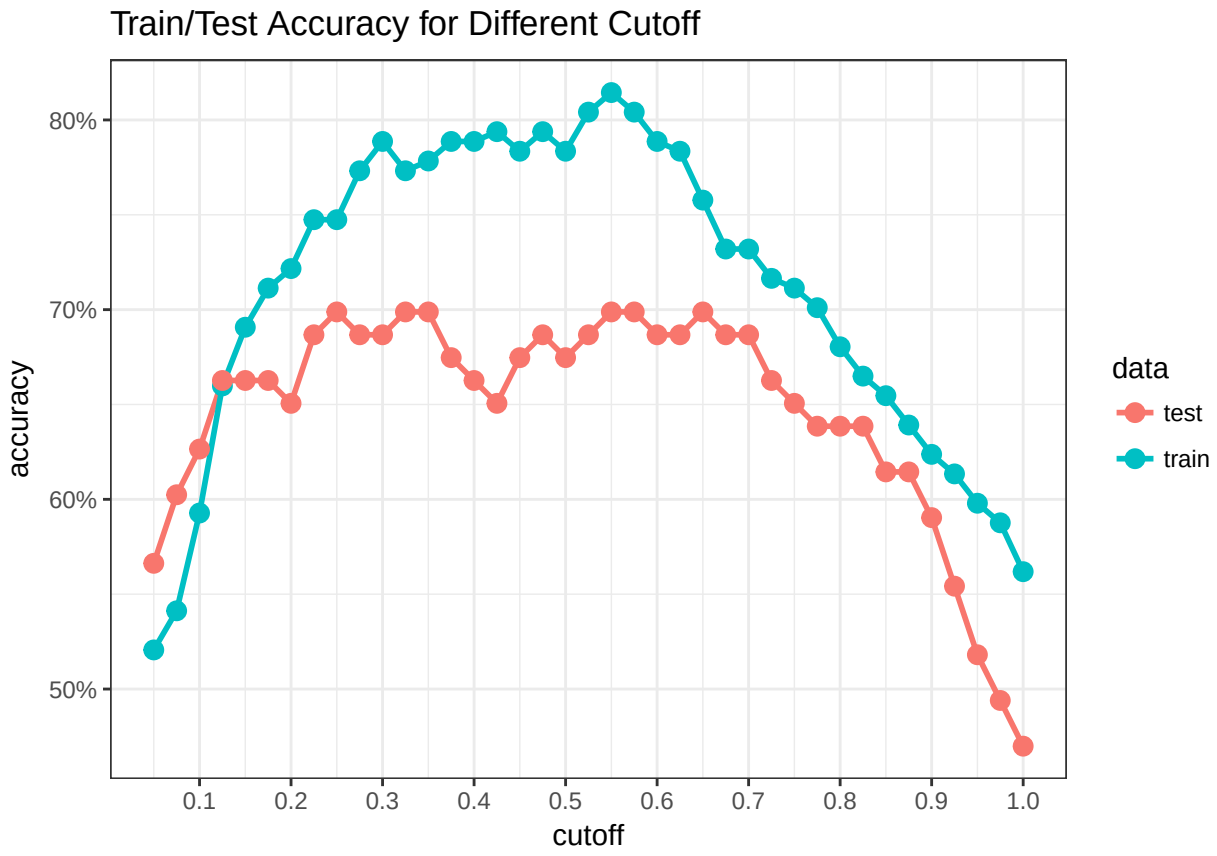
```
#Effect plot
plot(Effect(c("Subject_Type", "Age"), logi_m3),ask = FALSE)
```




```
#70/30 CV check

#Train
Data_train$prediction <- predict(logi_m3, Data_train, type = "response")


#Test
Data_test$prediction <- predict(logi_m3, Data_test, type = "response")

prop.table(table(Data$Subject_Type))
```

```
##
##       Control Schizophrenia
##     0.6254181     0.3745819
```

```
accuracy_info <- AccuracyCutoffInfo( train = Data_train, test = Data_test,
                                     predict = "prediction", actual = "Study" )

accuracy_info$plot
```




```
Classify(Data_train, Data_train$prediction,"Study", 0.55)
```

```
##         prediction
##          CNP COBRE
##   CNP     95    14
##   COBRE   22    63
## [1] "The accuracy is 81.443 %"
```

```
Classify(Data_test, Data_test$prediction,"Study", 0.55)
```

```
##         prediction
##          CNP COBRE
##   CNP     30     9
##   COBRE   16    28
## [1] "The accuracy is 69.88 %"
```

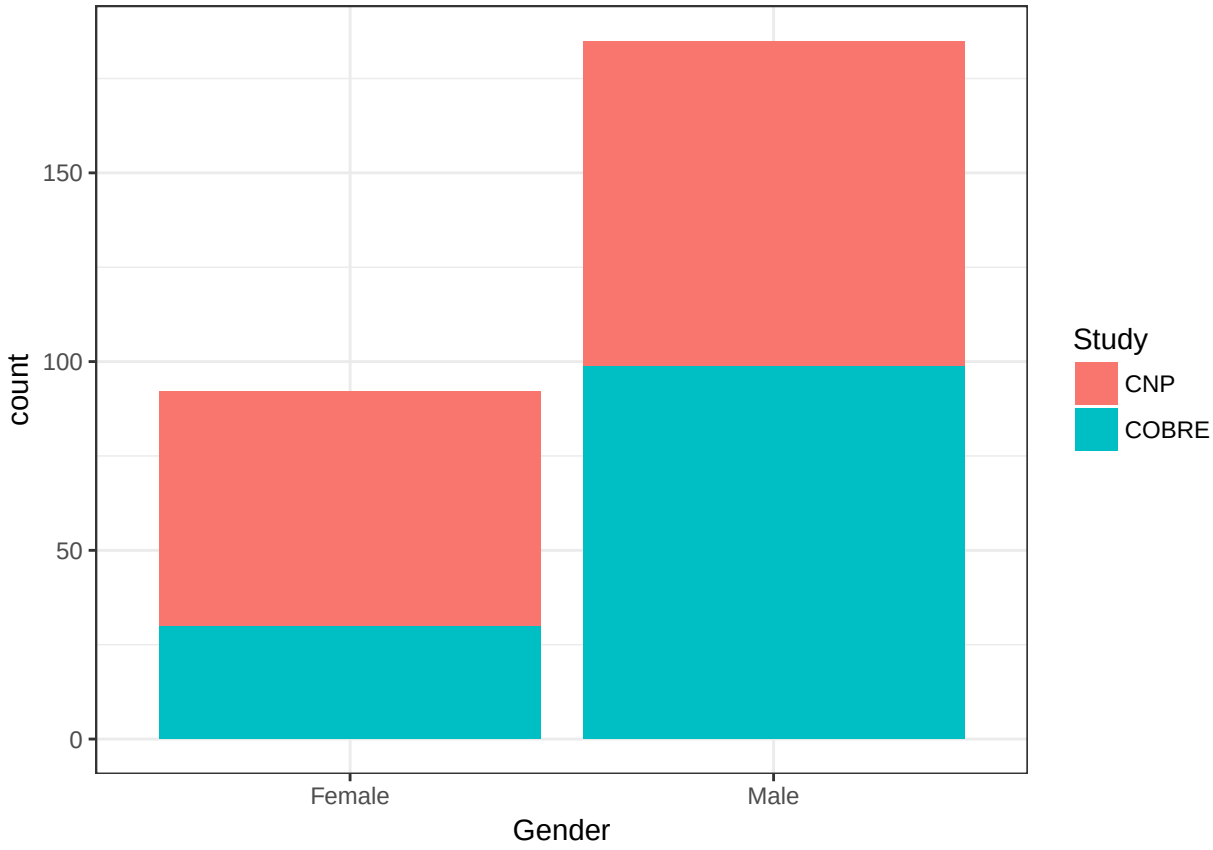
```
#Combine data model k fold CV check
set.seed(4321)

Accuracy.k <- cv.error(Data_logi, "Study", cut_off = 0.55)
Accuracy.k
```

```
##  [1] 0.7142857 0.7857143 0.8518519 0.8571429 0.7500000 0.8214286 0.7777778
##  [8] 0.6666667 0.6428571 0.5714286
```

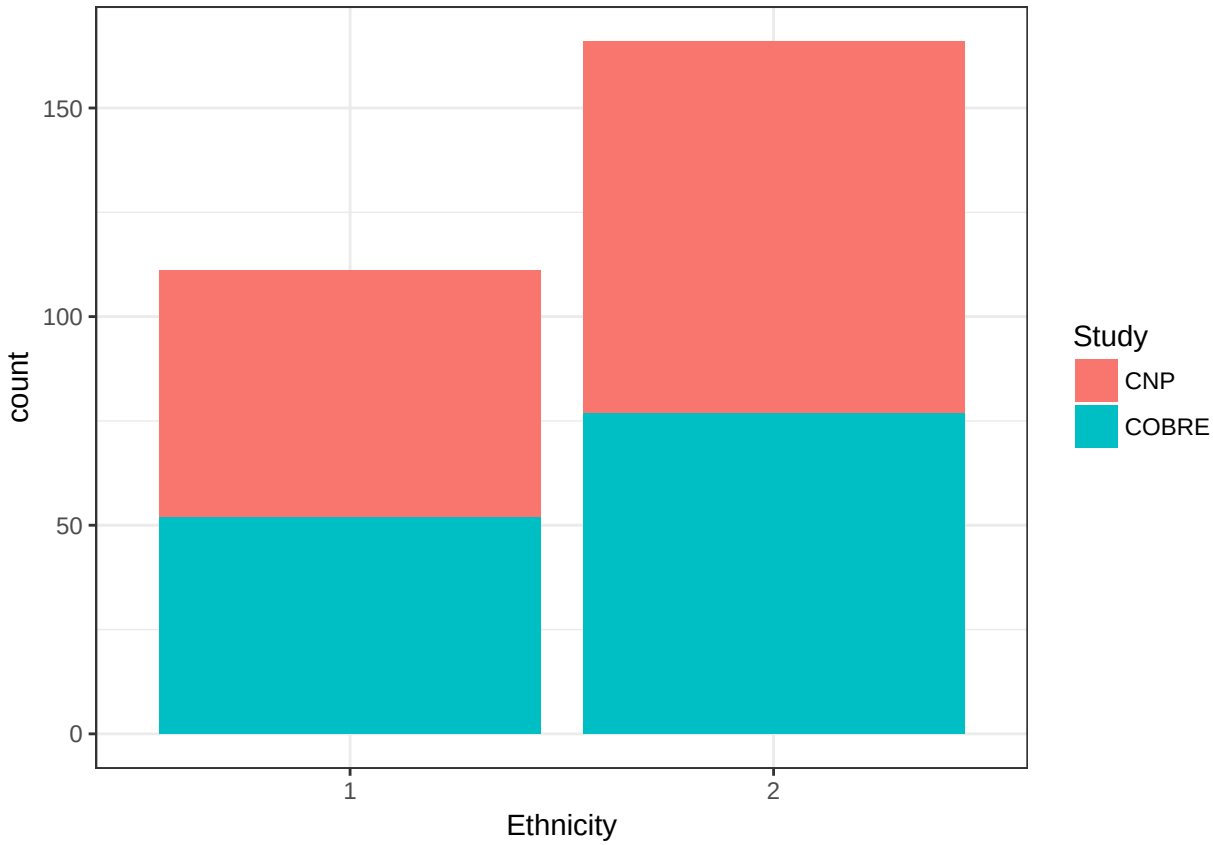
```
mean(Accuracy.k)
```

```
## [1] 0.7439153
```

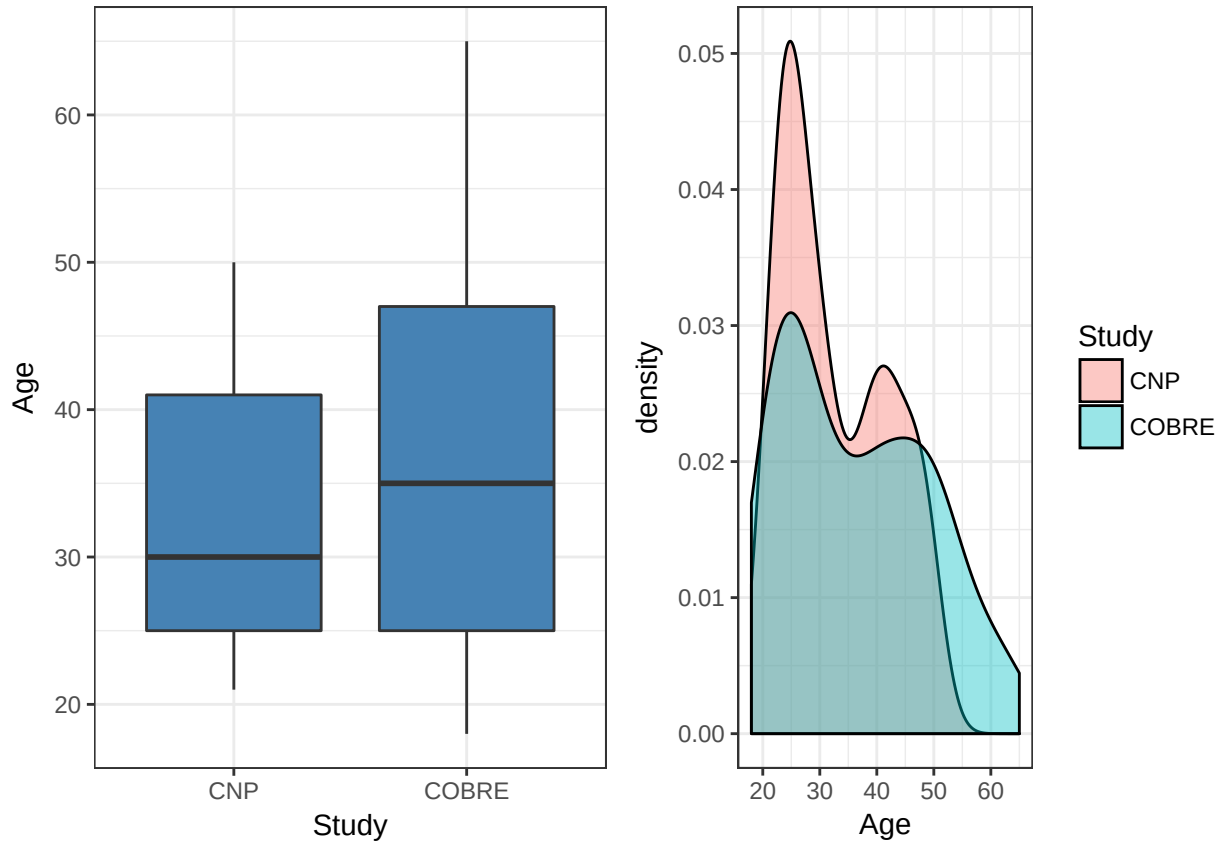
```
par(mfrow = c(2,2))


ggplot(data = na.omit(Data), aes(x = Gender, fill = Study)) +
  geom_bar() +
  theme_bw()
```



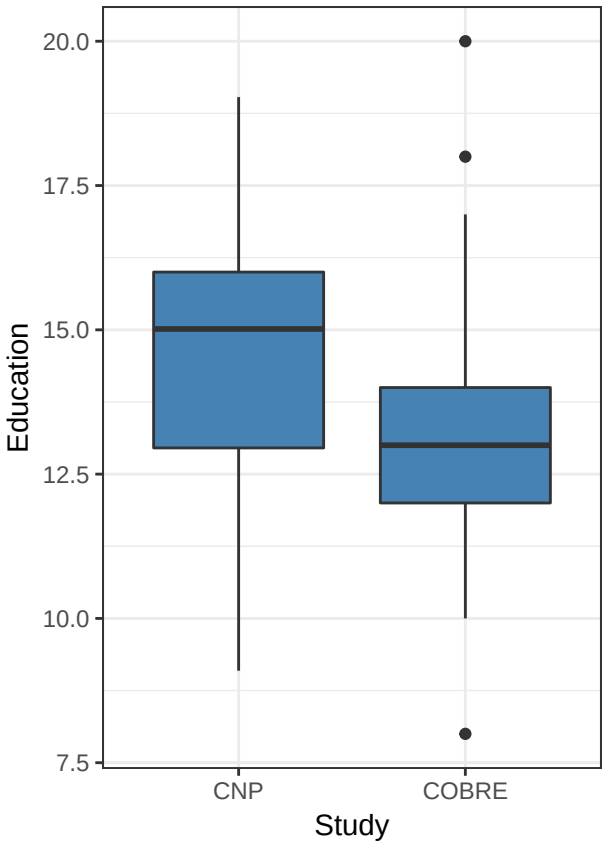

```
ggplot(data = na.omit(Data), aes(x = Ethnicity, fill = Study)) +
  geom_bar() +
  theme_bw()
```

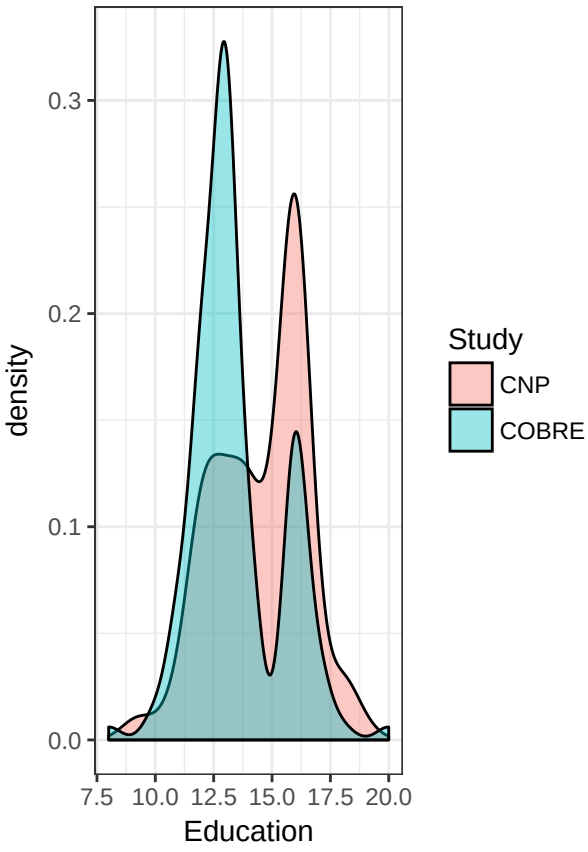



```
plot1 <- ggplot(data = na.omit(Data), aes(x = Study, y = Age)) +
  geom_boxplot(fill = "steelblue") +
  theme_bw()

plot2 <- ggplot(data = na.omit(Data), aes(x = Age, fill = Study)) +
  geom_density(alpha = 0.4) +
  theme_bw()

grid.arrange(plot1,plot2, nrow = 1, ncol = 2)
```




```
plot3 <- ggplot(data = na.omit(Data), aes(x = Study, y = Education)) +
  geom_boxplot(fill = "steelblue") +
  theme_bw()

plot4 <- ggplot(data = na.omit(Data), aes(x = Education, fill = Study)) +
  geom_density(alpha = 0.4) +
  theme_bw()

grid.arrange(plot3,plot4, nrow = 1, ncol = 2)
```


20.0
17.5
15.0
12.5
10.0
7.5
Education
CNP
COBRE
Study


0.3
0.2
0.1
0.0
density
7.5
10.0
12.5
15.0
17.5
20.0
Education
Study
CNP
COBRE