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Introduction to R and data exploration

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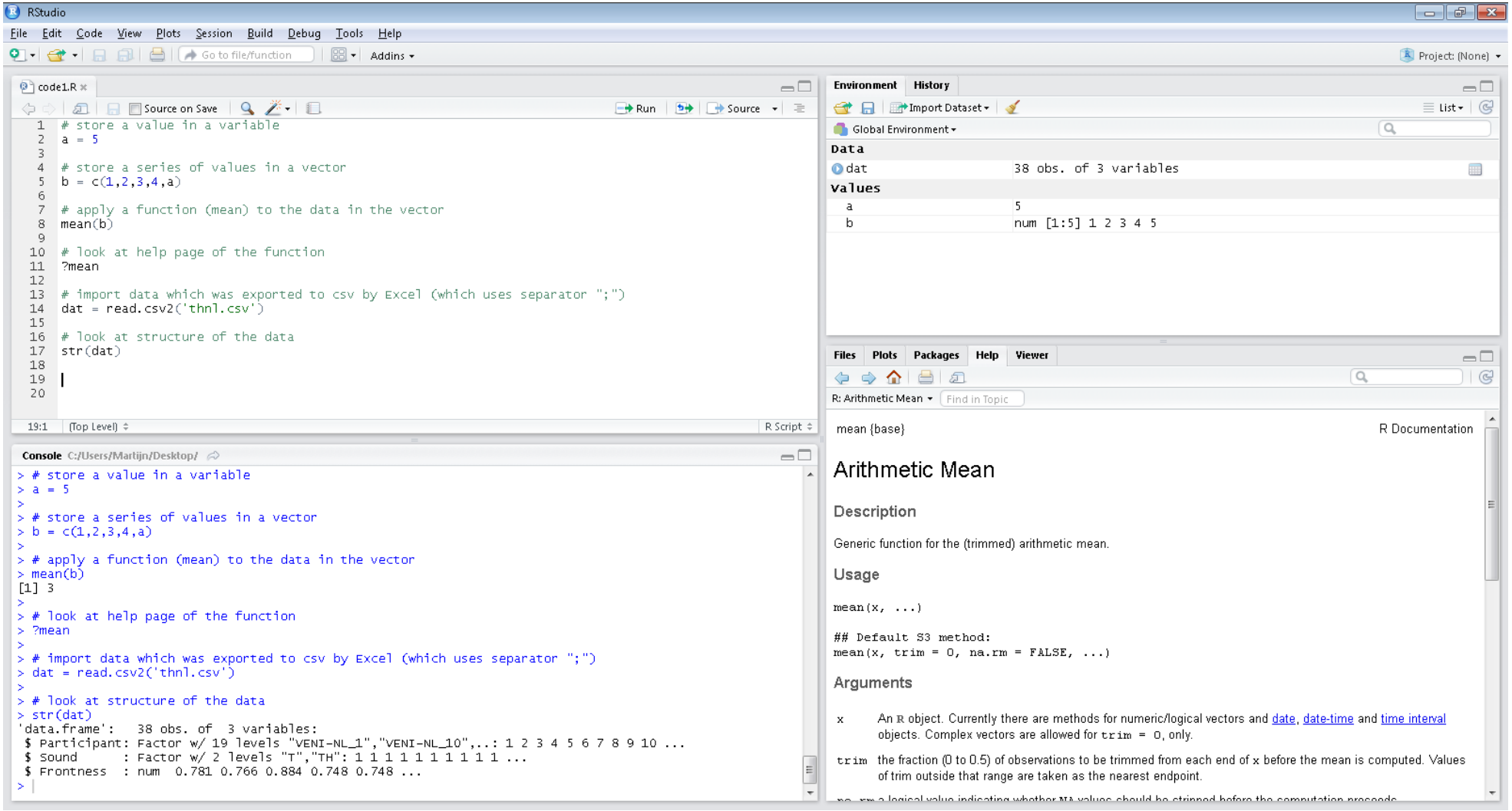
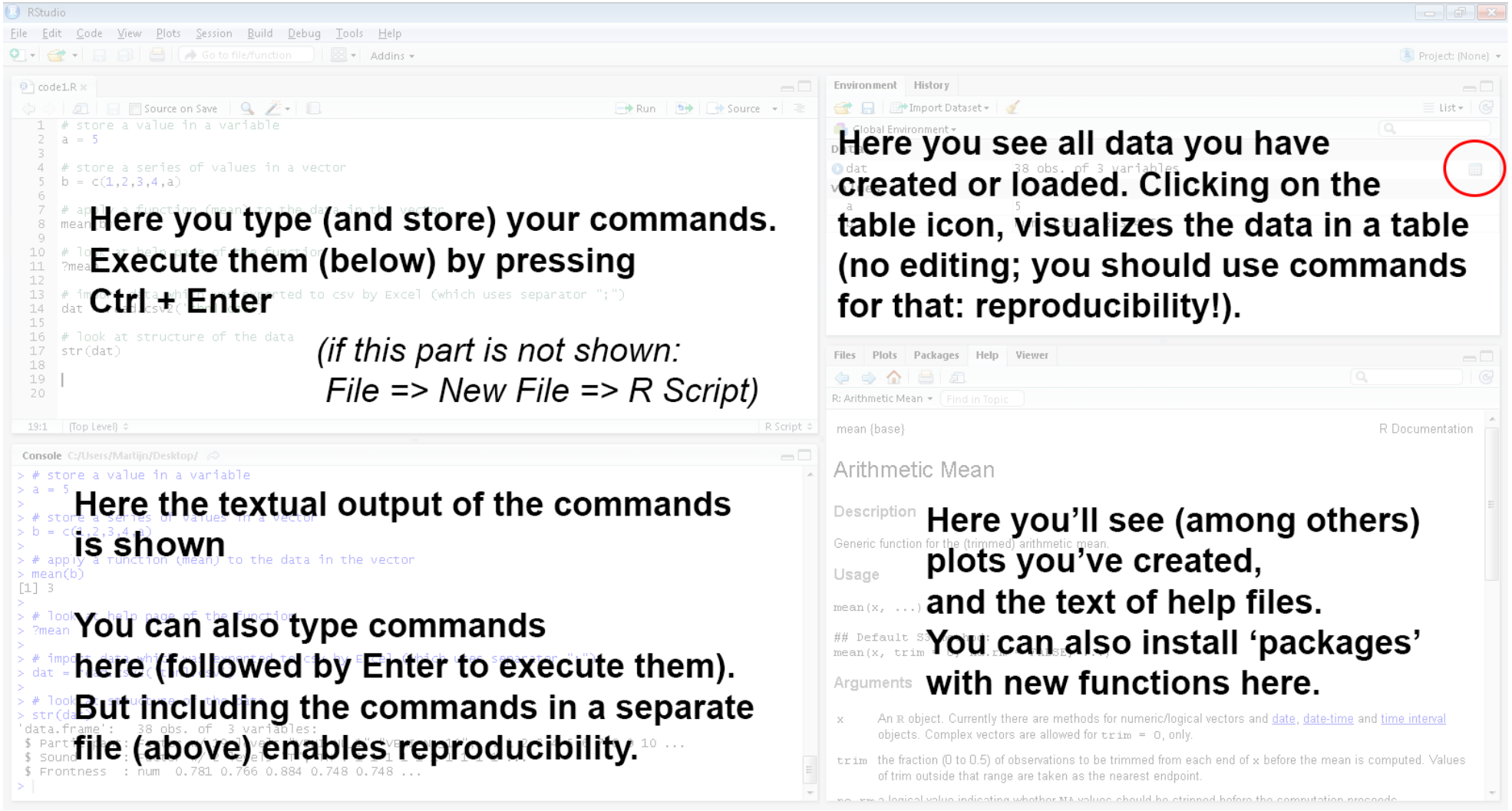
This lecture

- RStudio and R
- R as calculator
- Variables
- Functions and help
- Importing data in R in a dataframe
- Accessing rows and columns
- Adding columns to the data
- Goal of statistics
- Data exploration (descriptive statistics)
    - Numerical measures
    - Visual exploration

Our tool: RStudio (frontend to R)



RStudio: quick overview



Basic functionality: R as calculator

```
# Addition (this is a comment: preceded by '#')
5 + 5
```

```
# [1] 10
```

```
# Multiplication
5 * 3
```

```
# [1] 15
```

```
# Division
5/3
```

```
# [1] 1.6667
```

Basic functionality: using variables

```
a <- 5  # store a single value; instead of '<-' you can also use '='
a  # display the value
```

```
# [1] 5
```

```
b <- c(2, 4, 6, 7, 8)  # store a series of values in a vector
b
```

```
# [1] 2 4 6 7 8
```

```
b[4] <- a  # assign value 5 (stored in 'a') to the 4th element of vector b
b[1] <- NA  # assign NA (missing) to the first element of vector b
b <- b * 10  # multiply all values in vector b with 10
b
```

```
# [1] NA 40 60 50 80
```

Question 1

Go to **www.menti.com/007306**

What is the value of b after the commands: b <- c(1,2,3); b <- c(b,b*2)

Mentimeter

0	0	0	0
c(1,2,3)	c(1,2,3,1,2,3)	c(1,2,3,2,4,6)	?

Press ENTER to show correct

Basic functionality: using functions

```
mn <- mean(b)  # calculating the mean and storing in variable mn
mn
```

```
# [1] NA
```

```
# mn is NA (missing) as one of the values is missing
mean(b, na.rm = TRUE)  # we can use the function parameter na.rm to ignore NAs
```

```
# [1] 57.5
```

```
# But which parameters does a function have: use help!
help(mean)  # alternatively: ?mean
```

Basic functionality: a help file

mean {base} R Documentation

Arithmetic Mean

Description

Generic function for the (trimmed) arithmetic mean.

Usage

```
mean(x, ...)

## Default S3 method:
mean(x, trim = 0, na.rm = FALSE, ...)
```

Arguments

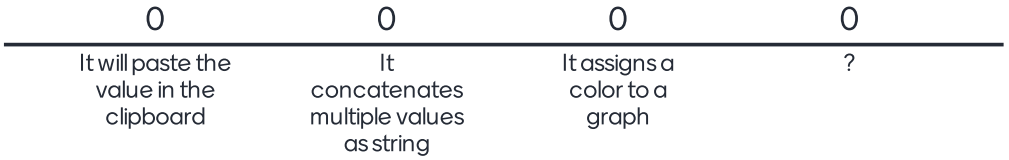
`x`	An `R` object. Currently there are methods for numeric/logical vectors and date, date-time and time interval objects. Complex vectors are allowed for `trim = 0`, only.
`trim`	the fraction (0 to 0.5) of observations to be trimmed from each end of `x` before the mean is computed. Values of trim outside that range are taken as the nearest endpoint.
`na.rm`	a logical value indicating whether `NA` values should be stripped before the computation proceeds.
`...`	further arguments passed to or from other methods.

Question 2

Go to **www.menti.com/007306**

What is the purpose of the R function 'paste'?

Mentimeter



Press ENTER to show correct

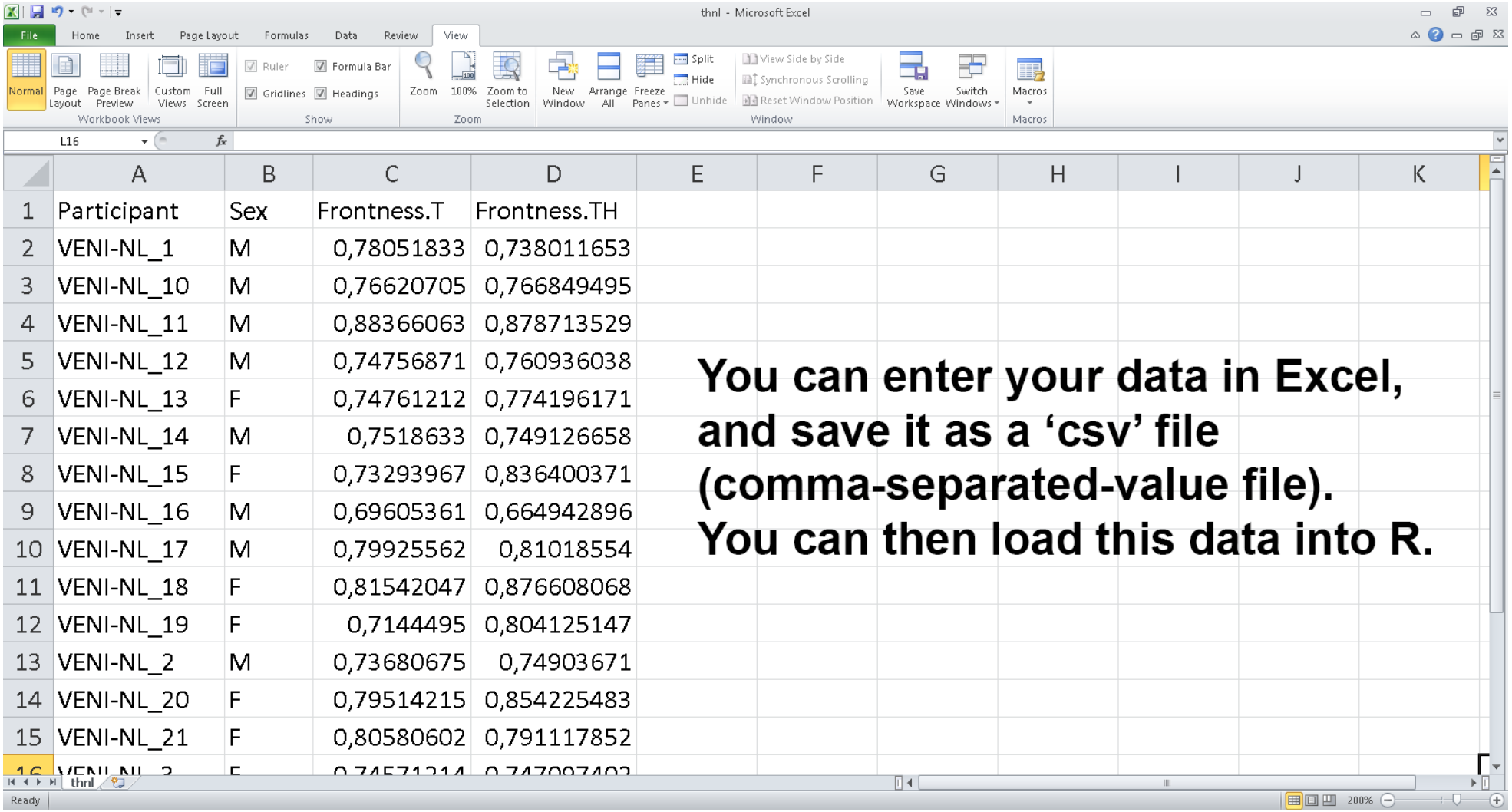
Try it yourself!

- There are many resources for R which you can easily find online
- Here we use “swirl” an online platform for interactive R courses
- Start RStudio, install and start swirl:

```
install.packages("swirl", repos = "http://cran.rstudio.com/")
library(swirl)
swirl()
```

- Follow the prompts and install the course *R programming: The basics of programming in R*
- Choose that course to start with and finish *Lesson 1* of that course

Getting data into R: exporting a data set



You can enter your data in Excel, and save it as a 'csv' file (comma-separated-value file). You can then load this data into R.

Getting data into R: importing a data set

```
setwd("C:/Users/Martijn/Desktop/Statistics/Intro-R")  # set working directory
dat <- read.csv2("thnl.csv")  # read.csv2 reads Excel csv file from work dir
str(dat)  # shows structure of the data frame dat (note: wide format)
```

```
# 'data.frame': 19 obs. of  4 variables:
#  $ Participant : chr  "VENI-NL_1" "VENI-NL_10" "VENI-NL_11" "VENI-NL_12" ...
#  $ Sex         : chr  "M" "M" "M" "M" ...
#  $ Frontness.T : num  0.781 0.766 0.884 0.748 0.748 ...
#  $ Frontness.TH: num  0.738 0.767 0.879 0.761 0.774 ...
```

```
dim(dat)  # number of rows and columns of data set
```

```
# [1] 19  4
```

Investigating imported data set: using head

```
head(dat)  # show first few rows of dat
```

```
#   Participant Sex Frontness.T Frontness.TH
# 1   VENI-NL_1   M     0.78052      0.73801
# 2  VENI-NL_10   M     0.76621      0.76685
# 3  VENI-NL_11   M     0.88366      0.87871
# 4  VENI-NL_12   M     0.74757      0.76094
# 5  VENI-NL_13   M     0.74761      0.77420
# 6  VENI-NL_14   M     0.75186      0.74913
```

Question 3

Go to **www.menti.com/007306**

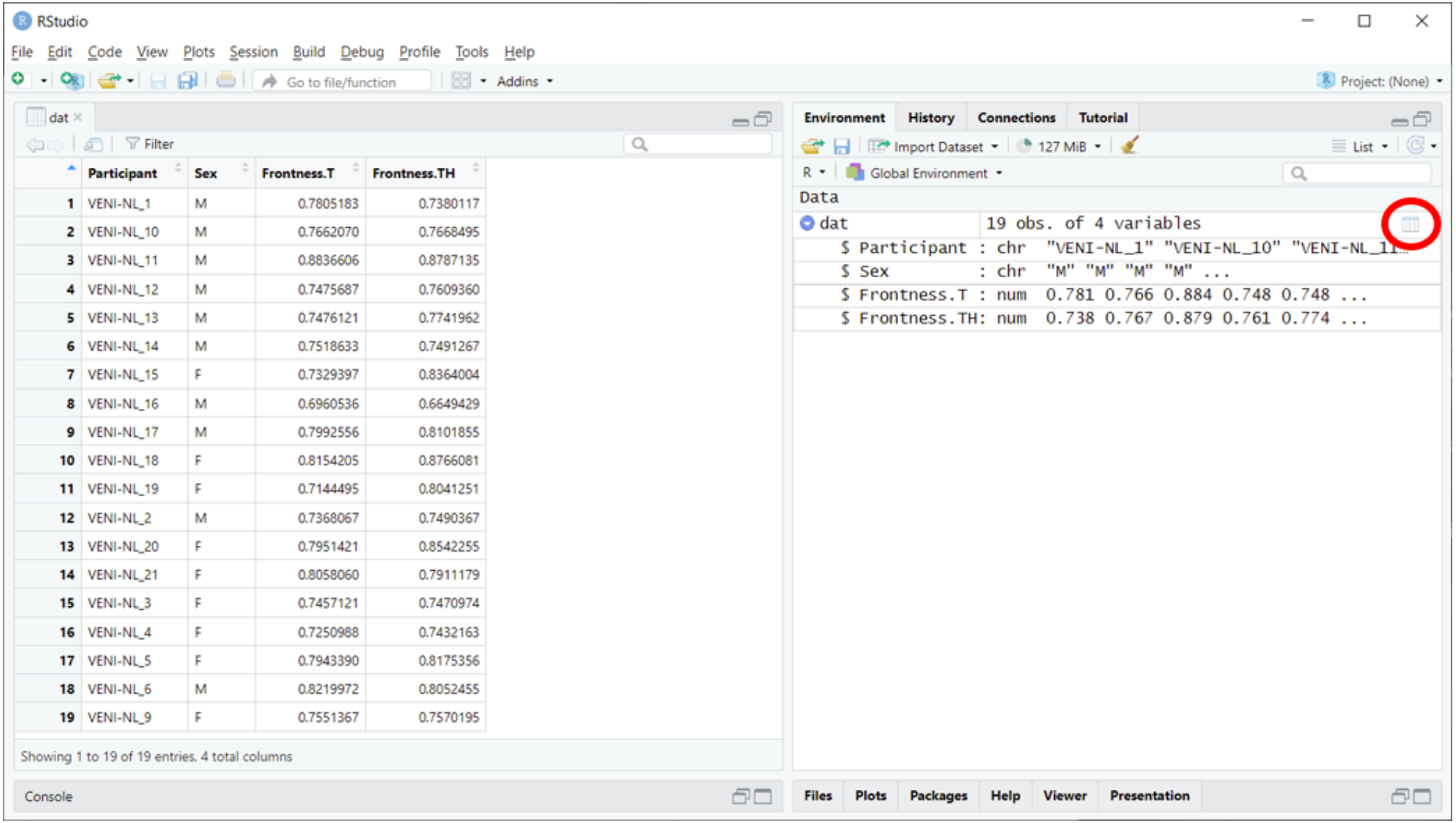
How can you show the first two lines of a dataframe (dat)? (multiple answers possible)

Mentimeter

0	0	0	0	0
head(dat, n=2)	head(dat, 2)	head(dat)	head(dat, nrow=2)	?

Press ENTER to show correct

Investigating imported data set: using RStudio viewer



Subsetting the data: indices and names

```
dat[1, ]  # values in first row
```

```
#   Participant Sex Frontness.T Frontness.TH
# 1   VENI-NL_1   M     0.78052      0.73801
```

```
dat[1:2, c(2, 3)]  # values of first two rows for second and third column
```

```
#   Sex Frontness.T
# 1   M     0.78052
# 2   M     0.76621
```

```
dat[c(1, 2, 3), "Participant"]  # values of first three rows for column 'Participant'
```

```
# [1] "VENI-NL_1"  "VENI-NL_10" "VENI-NL_11"
```

```
tmp <- dat[5:8, c(1, 3)]  # store columns 1 and 3 for rows 5 to 8 in tmp
```

Question 4

Go to **www.menti.com/007306**

How can you view the value in the 3rd colomn and 4th row of dataframe 'dat'?

Mentimeter

0	0	0	0	0
dat[4,3]	dat[3,4]	dat[3,]$4	dat[4,]$3	?

Press ENTER to show correct

Subsetting the data: conditional indexing

```
tmp <- dat[dat$Sex == "M", ]  # only observations for male participants
head(tmp, n = 2)  # show first two rows
```

```
#   Participant Sex Frontness.T Frontness.TH
# 1   VENI-NL_1   M     0.78052      0.73801
# 2  VENI-NL_10   M     0.76621      0.76685
```

```
# more advanced subsetting: include rows for which frontness for the T sound is
# higher than 0.74 AND participant is either 1 or 2 N.B. use '|' instead of '&' for
# logical OR
dat[dat$Frontness.T > 0.74 & dat$Participant %in% c("VENI-NL_1", "VENI-NL_2"), ]
```

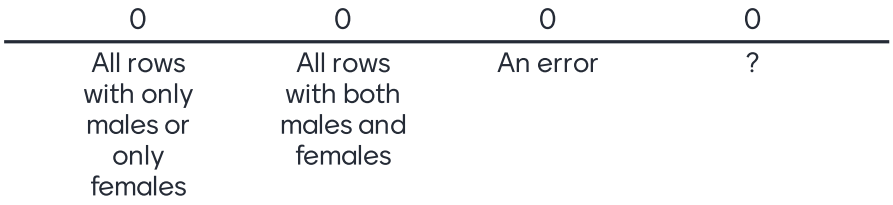
```
#   Participant Sex Frontness.T Frontness.TH
# 1   VENI-NL_1   M     0.78052      0.73801
```

Question 5

Go to **www.menti.com/007306**

Mentimeter

What is the result of: dat[dat$Sex=='M'|dat$Sex=='F']



Press ENTER to show correct

Supplementing the data: adding columns

```
# new column Diff containing difference between TH and T positions
dat$Diff <- dat$Frontness.TH - dat$Frontness.T

# new column DiffClass, initially all observations set to TH0
dat$DiffClass <- "TH0"

# observations with Diff larger than 0.02 are categorized as TH1, negative as TH-
dat[dat$Diff > 0.02, ]$DiffClass <- "TH1"
dat[dat$Diff < 0, ]$DiffClass <- "TH-"

dat$DiffClass <- factor(dat$DiffClass)  # convert string variable to factor

head(dat, 2)
```

```
#   Participant Sex Frontness.T Frontness.TH        Diff DiffClass
# 1   VENI-NL_1   M     0.78052      0.73801 -0.04250668       TH-
# 2  VENI-NL_10   M     0.76621      0.76685  0.00064245       TH0
```

Question 6

Go to **www.menti.com/007306**

What is the effect of: dat$Test = paste(dat$DiffClass,dat$Sex)

Mentimeter

0	0	0	0
A new column with values "TH-M", "TH0F", etc.	A new column with values "TH-M", TH0 F", etc.	Nothing, an error	?

Press ENTER to show correct

Try it yourself!

- Run `swirl()` and finish the following lessons of the *R Programming* course:
  - *Lesson 6*: Subsetting vectors
  - *Lesson 12*: Looking at data

Statistics

- **Goal of statistics** is to gain understanding from data
  - Descriptive statistics (this lecture): describe data without further conclusions
  - Inferential statistics: describe data (**sample**) and its relation to larger group (**population**)

Numerical variables: central tendency and spread

```
mean(dat$Diff)  # mean
```

```
# [1] 0.016263
```

```
median(dat$Diff)  # median
```

```
# [1] 0.01093
```

```
min(dat$Diff)  # minimum value
```

```
# [1] -0.042507
```

```
max(dat$Diff)  # maximum value
```

```
# [1] 0.10346
```

Numerical variables: measures of spread

```
sd(dat$Diff)  # or: sqrt((1/(length(dat$Diff)-1)) * sum((dat$Diff - mean(dat$Diff))^2))
```

```
# [1] 0.038213
```

```
var(dat$Diff)  # or: sd(dat$Diff)^2
```

```
# [1] 0.0014603
```

```
quantile(dat$Diff)  # quantiles
```

```
#         0%        25%        50%        75%       100%
# -0.0425067 -0.0038419  0.0109299  0.0248903  0.1034607
```

```
summary(dat$Diff)  # summary
```

```
#     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
# -0.04251 -0.00384  0.01093  0.01626  0.02489  0.10346
```

Categorical variables: frequency tables

```
table(dat$Sex)
```

```
#
#  F  M
#  9 10
```

```
with(dat, table(Sex))  # alternative
```

```
# Sex
#  F  M
#  9 10
```

```
table(dat$DiffClass)
```

```
#
# TH- TH0 TH1
#   6   7   6
```

Question 7

Go to **www.menti.com/007306**

Mentimeter

What is the effect of table(datSex,datDiffClass)?

0	0	0	0
A table of sex, then difference class	A table of difference class, then sex	A cross table of difference class and sex	?

Press ENTER to show correct

Exploring relationships between pairs of variables

```
# correlation: relation between two numerical variables
cor(dat$Frontness.T, dat$Frontness.TH)
```

```
# [1] 0.71054
```

```
# crosstable: relation between two categorical variables
table(dat$Sex, dat$DiffClass)  # or: with(dat, table(Sex,DiffClass))
```

```
#
#     TH- TH0 TH1
#   F   1   3   5
#   M   5   4   1
```

```
# means per category: relation between numerical and categorical variable
c(mean(dat[dat$Sex == "M", ]$Diff), mean(dat[dat$Sex == "F", ]$Diff))
```

```
# [1] -0.0034299  0.0381446
```

Question 8

Go to **www.menti.com/007306**

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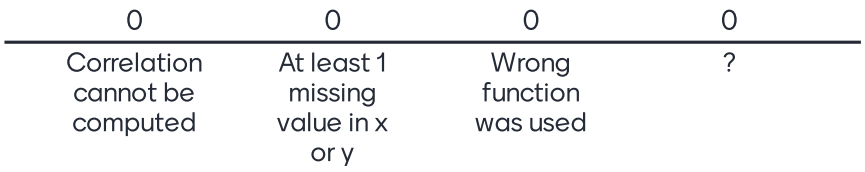
Suppose the result of cor(x,y) = NA, what do you know?



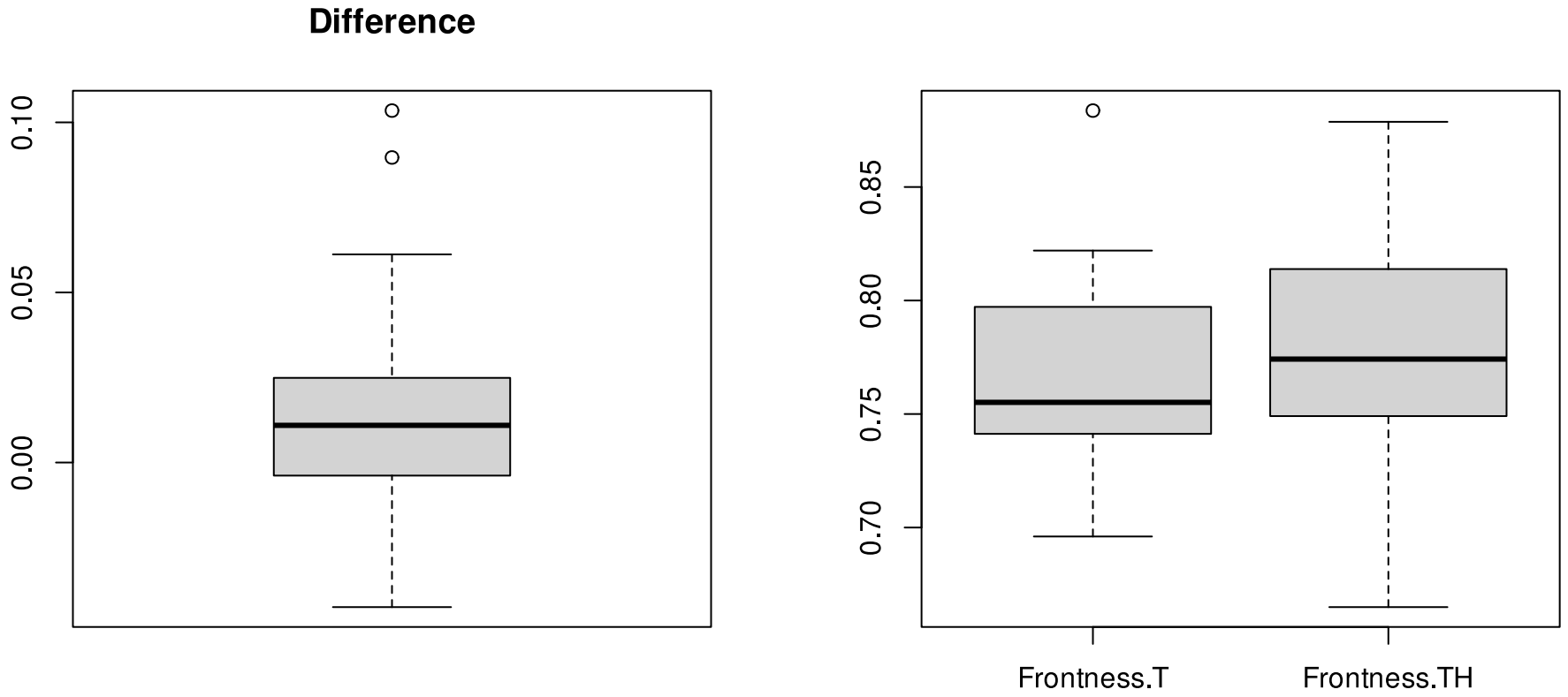
Press ENTER to show correct

Data exploration with visualization

- Many basic visualization options are available in `R`
  - `boxplot()` for a boxplot
  - `hist()` for a histogram
  - `qqnorm()` and `qqline()` for a quantile-quantile plot
  - `plot()` for many types of plots (scatter, line, etc.)
  - `barplot()` for a barplot (plotting frequencies)

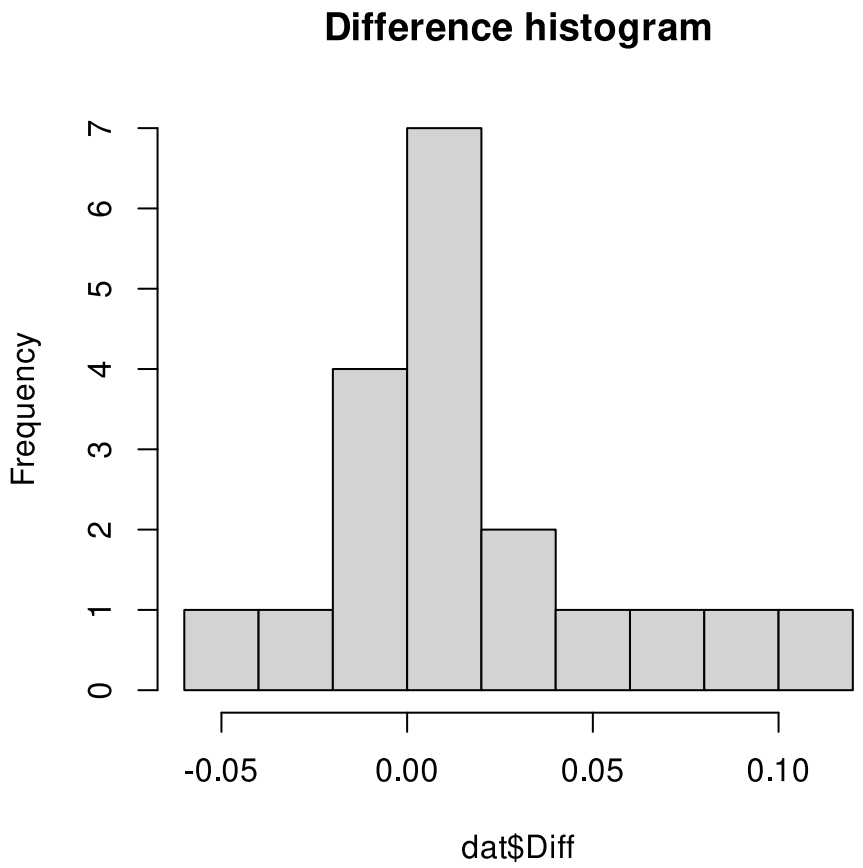
Exploring numerical variables: box plot

```
par(mfrow = c(1, 2))  # set graphics option: 2 graphs side-by-side
boxplot(dat$Diff, main = "Difference")  # boxplot of difference values
boxplot(dat[, c("Frontness.T", "Frontness.TH")])  # frontness per group
```



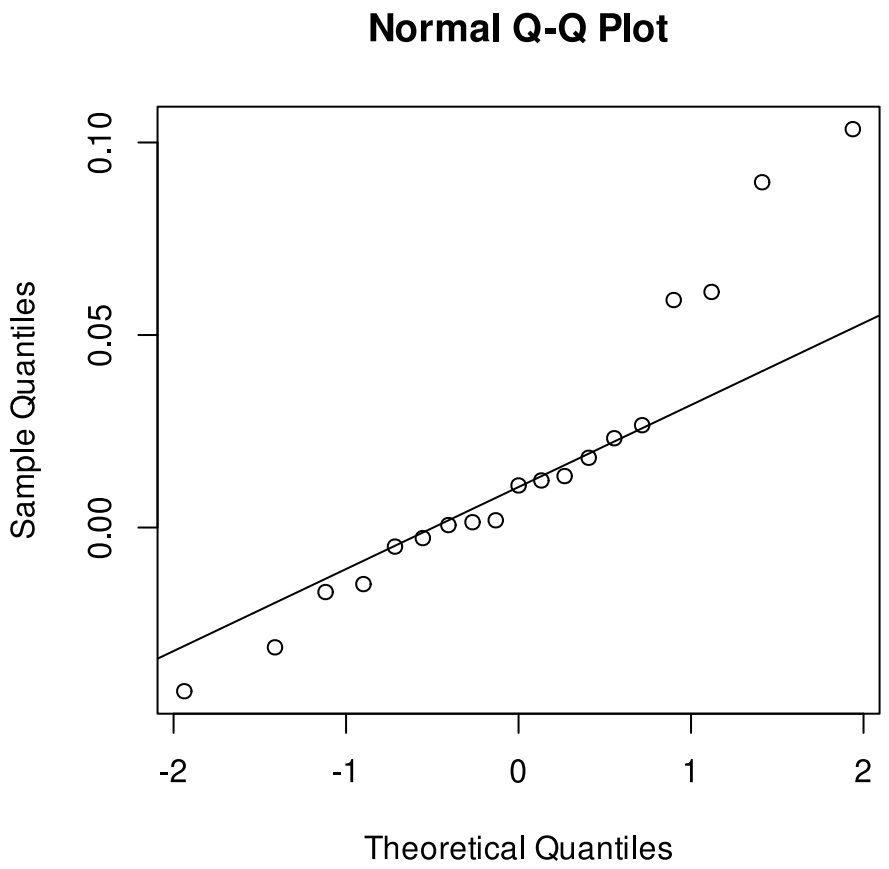
Exploring numerical variables: histogram

```
hist(dat$Diff, main = "Difference histogram")
```



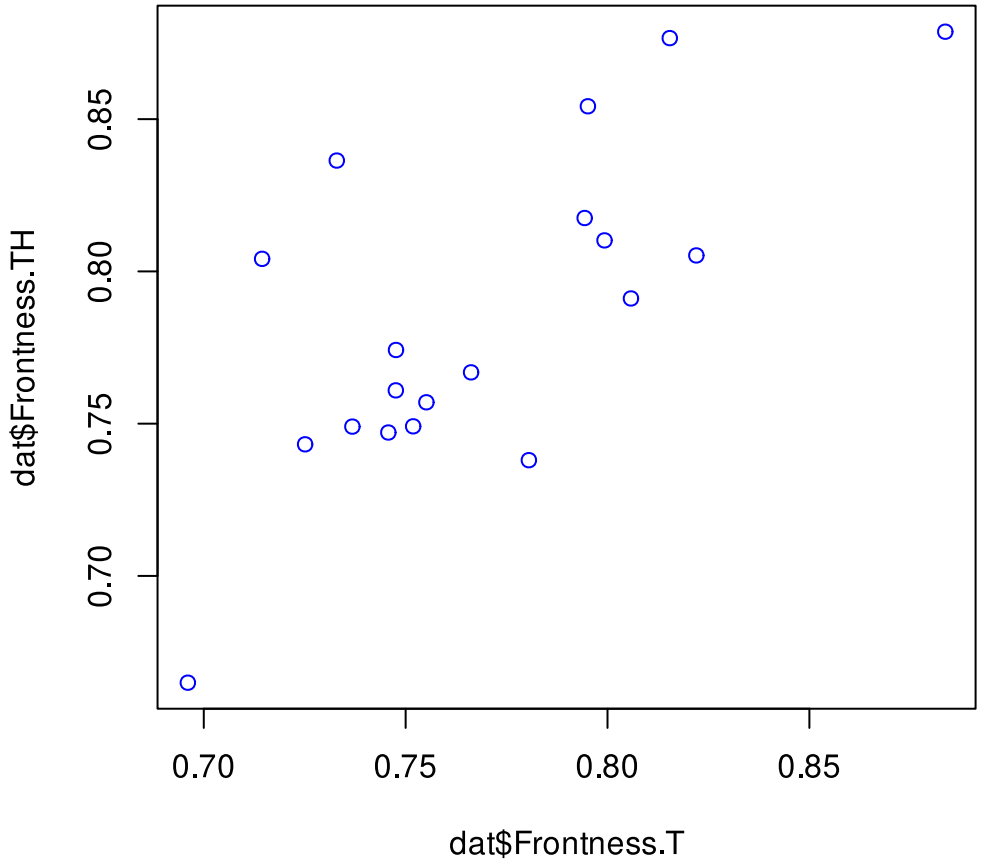
Exploring numerical variables: Q-Q plot

```
qqnorm(dat$Diff)  # plot actual values vs. theoretical quantiles
qqline(dat$Diff)  # plot reference line of normal distribution
```



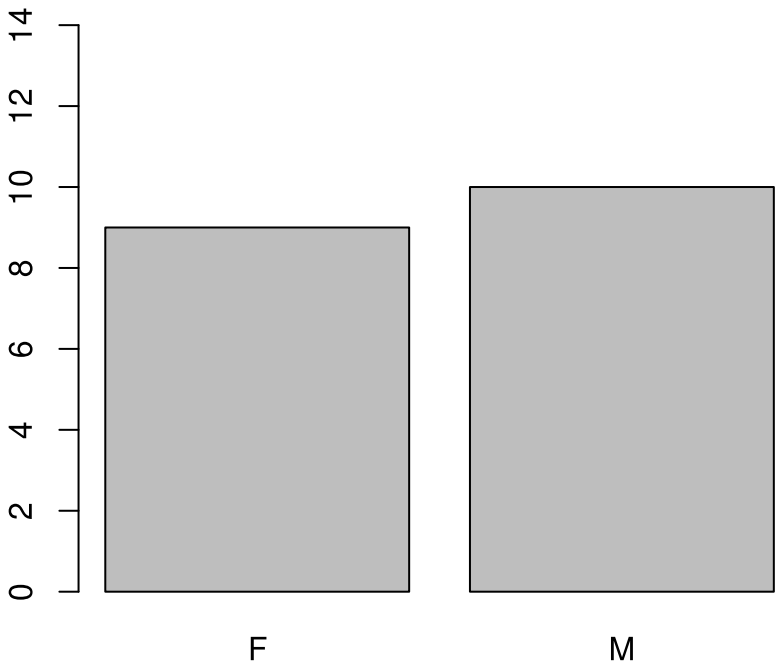
Exploring numerical relations: scatter plot

```
plot(dat$Frontness.T, dat$Frontness.TH, col = "blue")
```



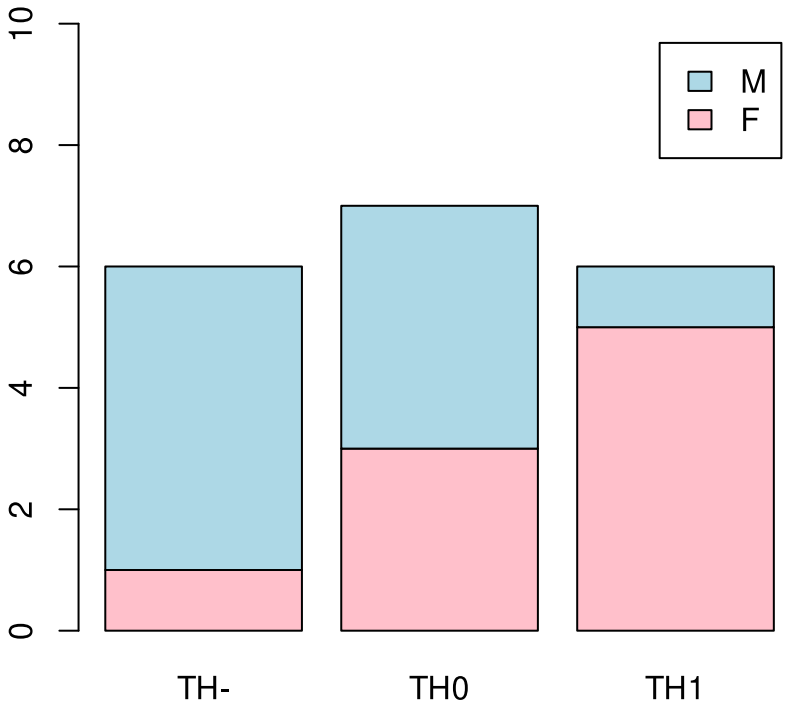
Visualizing categorical variables (frequencies): bar plot

```
counts <- table(dat$Sex)  # frequency table for sex
barplot(counts, ylim = c(0, 15))
```



Exploring categorical relations: segmented bar plot

```
counts <- table(dat$Sex, dat$DiffClass)
barplot(counts, col = c("pink", "lightblue"), legend = rownames(counts), ylim = c(0, 10))
```



Question 9

Go to **www.menti.com/007306**

Which plot parameters can you use to change axis labels?

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Press ENTER to show correct

Try it yourself!

- Run `swirl()` and finish the following lesson of the *R Programming* course:
  - *Lesson 15*: Base graphics

Recap

- In this lecture, we've covered the basics of `R`
- Now you should be able (with help of this presentation) to use `R` for:
  - Data manipulation, exploration and visualization
- Associated lab session and additional swirl resources:
  - https://www.let.rug.nl/wieling/Statistics/Intro-R/lab
  - Install swirl course *Exploratory Data Analysis*
    - `install_from_swirl('Exploratory_Data_Analysis')`
    - Finish *Lessons 1 - 5* (download associated slides)
    - If interested, you can finish the full *Exploratory Data Analysis* course

Evaluation

Go to **www.menti.com/007306**

Please provide your opinion about this lecture in Mentimeter at most 3 words/phrases!

Questions?

Thank you for your attention!

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