Polish Language(s) and Digital Humanities Using R

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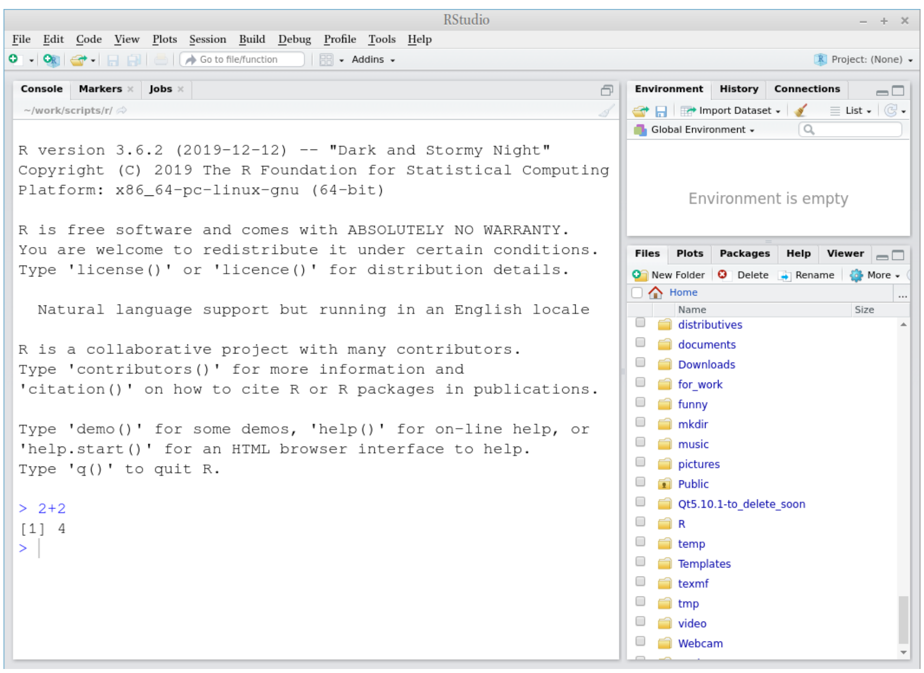
Contents

Chapter 1

Prerequisites

Before the classes I would like to ask you to follow the instructions mentioned below to prepare your device for the class work:

- install **R** from the following link: https://cloud.r-project.org/
- install **RStudio** from the following link: https://rstudio.com/products/rstudio/download/#download (FREE version, no need to pay!)
- after the installation run the RStudio program, type `2+2`, and press `Enter`.



If you see something like this, then you are well prepared for classes.

- Go to the https://rstudio.cloud/ website and sign up there. This is optional, but it will be a backup version, if something will not work on your computer.

Chapter 2

Introduction to R and RStudio

2.1 Introduction

2.1.1 Why data science?

Data science is a new field that is actively developing lately. This field merges computer science, mathematics, statistics, and it is hard to say how much science in data science. In many scientific fields a new data science paradigm arises and even forms a new sub-field:

- Bioinformatics
- Crime data analysis
- Digital humanities
- Data journalism
- Data driven medicine
- …

There are a lot of new books "Data Science for …":

- psychologists (Hansjörg, 2019)
- immunologists (Thomas and Pallett, 2019)
- business (Provost and Fawcett, 2013)
- public policy (Brooks and Cooper, 2013)
- fraud detection (Baesens et al., 2015)
- …

Data scientist need to be able to:

- gather data
- transform data

- visualize data
- create a statistical model based on data
- share and represent the results of this work
- organize the whole workflow in a reproducible way

2.1.2 Why R?

R (R Core Team, 2019) is a programming language with a big infrastructure of packages that helps to work in different fields of science and computer technology.

There are several alternatives:

- Python (VanderPlas, 2016; Grus, 2019)
- Julia (Bezanson et al., 2017)
- bash (Janssens, 2014)
- java (Brzustowicz, 2017)
- ...

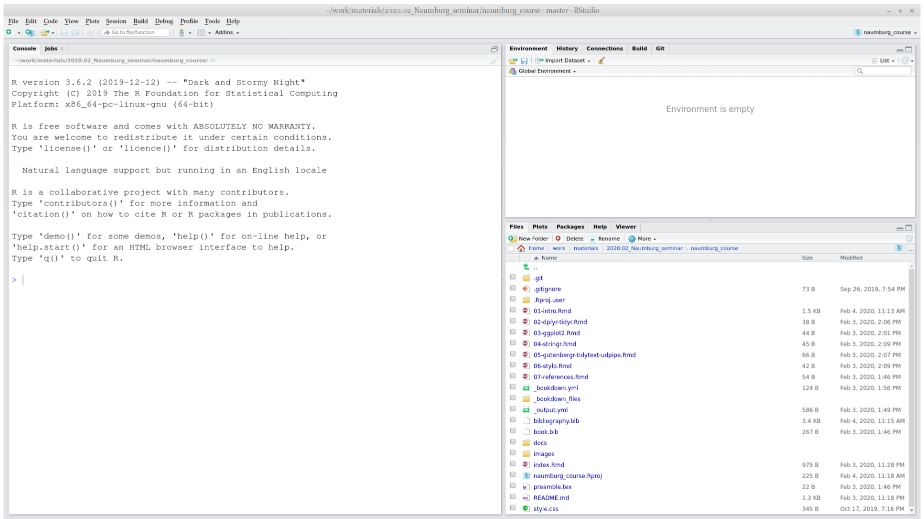
You can find some R answers here:

- R for data science (Wickham and Grolemund, 2016), it is online
- R community
- stackoverflow
- any search engine you use
- ...

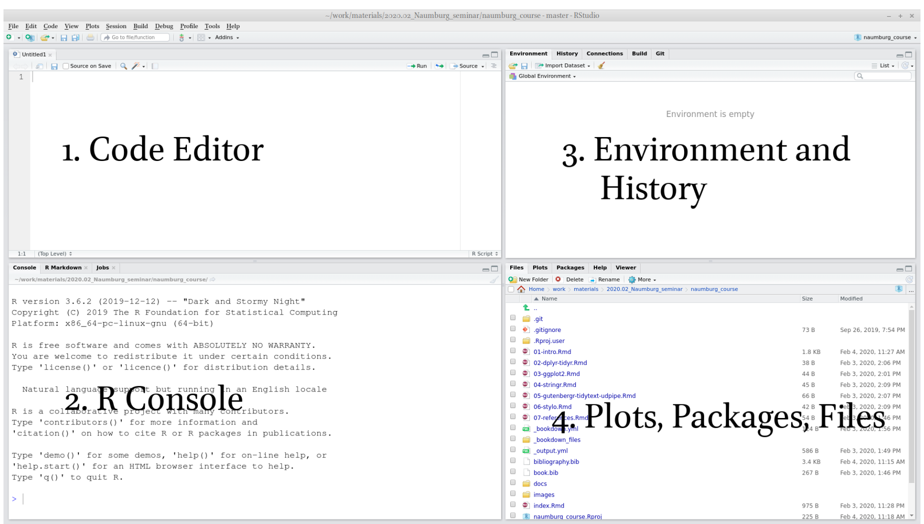
2.2 Introduction to RStudio

R is the programming language. RStudio is the most popular IDE (Integrated Development Environment) for R language.

When you open RStudio for the first time you can see something like this:



When you press  button at the top of the left window you will be able to see all four panels of RStudio.



2.3 R as a calculator

Lets first start with a calculator. Press in R console

```
2+9
```

```
## [1] 11
```

```
50*(9-20)
```

```
## [1] -550
```

```
3^3
```

```
## [1] 27
```

```
9^0.5
```

```
## [1] 3
```

```
9+0.5
```

```
## [1] 9.5
```

```
9+.5
```

```
## [1] 9.5
```

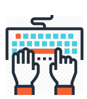
```
pi
```

```
## [1] 3.141593
```

Reminder after division

```
10 %% 3
```

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



So you are ready to solve some really hard equations (round it four decimal places):

$$\frac{\pi + 2}{2^{3-\pi}}$$

list of hints

Are you sure that you rounded the result? I expect the answer to be rounded to four decimal places: `0.87654321` becomes `0.8765`.

Are you sure you didn't get into the brackets trap? Even though there isn't any brackets in the mathematical notation, you need to add them in R, otherwise the operation order will be wrong.

2.4 Comments

The whole text after the hash # within the same line is considered a comment.

```
2+2 # it is four
```

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

```
# you can put any comments here
3+3
```

```
## [1] 6
```

2.5 Functions

The most important part of R is functions: here are some of them:

```
sqrt(4)
```

```
## [1] 2
```

```
abs(-5)
```

```
## [1] 5
```

```
sin(pi/2)
```

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

```
cos(pi)
```

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

```
sum(2, 3, 9)
```

```
## [1] 14
```

```
prod(5, 3, 9)
```

```
## [1] 135
```

```
sin(cos(pi))
```

```
## [1] -0.841471
```

Each function has a name and zero or more arguments. All arguments of the function should be listed in parenthesis and separated by comma:

```
pi
```

```
## [1] 3.141593
```

```
round(pi, 2)
```

```
## [1] 3.14
```

Each function's argument has its own name and serial number. If you use names of the function's arguments, you can put them in any order. If you do not use names of the function's arguments, you should put them according the serial number.

```
round(x = pi, digits = 2)
```

```
## [1] 3.14
```

```
round(digits = 2, x = pi)
```

```
## [1] 3.14
```

```
round(x = pi, d = 2)
```

```
## [1] 3.14
```

```
round(d = 2, x = pi)
```

```
## [1] 3.14
```

```
round(pi, 2)
```

```
## [1] 3.14
```

```
round(2, pi) # this is not the same as all previouse!
```

```
## [1] 2
```

There are some functions without any arguments, but you still should use parenthesis:

```
Sys.Date() # correct
```

```
## [1] "2020-02-06"
```

```
Sys.Date # wrong
```

```
## function ()
## as.Date(as.POSIXlt(Sys.time()))
## <bytecode: 0x595fdf5d5438>
## <environment: namespace:base>
```

Each function in R is documented. You can read its documentation typing question mark before the function name:

```
?Sys.Date
```

Explore the function `log()` and calculate the following logarithm:

$$\log_3(3486784401)$$

list of hints

A-a-a! I don't remember anything about logarithms... The logarithm is the inverse function to exponentiation. That means the logarithm of a given number x is the exponent to which another fixed number, the base b, must be raised, to produce that number x.

$$10^n = 1000,\ \text{what is n?}$$

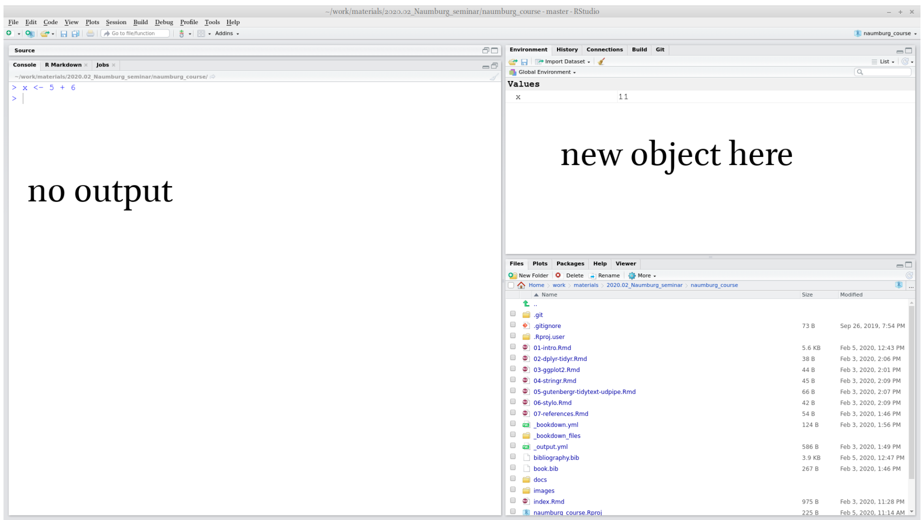
$$n = \log_{10}(1000)$$

What is this small 3 in the task means? This is the base of the logarithm. So the task is: what is the exponent to which another fixed number, the base *3*, must be raised, to produce that number *3486784401*.

2.6 Variables

Everything in R can be stored in a variable:

```
x <- 5 + 6
```



As a result, no output in the Console, and a new variable x appear in the Environment window. From now on I can use this new variable:

```
x + x
```

```
## [1] 22
```

```
sum(x, x, 7)
```

```
## [1] 29
```

All those operations don't change the variable value. In order to change the variable value you need to make a new assignment:

```
x <- 5 + 6 + 7
```

The fast way for creating `<-` in RStudio is to press `Alt -` on your keyboard.

It is possible to use equal sign `=` for assignment operation, but the recommendations are to use arrow `<-` for the assignment, and equal sign `=` for giving arguments' value inside the functions.

For removing vector you need to use the function `rm()`:

```r
rm(x)
x
```

```
## Error in eval(expr, envir, enclos): object 'x' not found
```

2.6.1 Variable comparison

It is possible to compare different variables

```r
x <- 18
x > 18
```

```
## [1] FALSE
```

```r
x >= 18
```

```
## [1] TRUE
```

```r
x < 100
```

```
## [1] TRUE
```

```r
x <= 18
```

```
## [1] TRUE
```

```r
x == 18
```

```
## [1] TRUE
```

```r
x != 18
```

```
## [1] FALSE
```

Operator `!` can work by itself changing logical values into reverse:

```r
!TRUE
```

```
## [1] FALSE
```

```r
!FALSE
```

```
## [1] TRUE
```

2.6.2 Variable types

There are several types of variables in R. In this course the only important types will be `double` (all numbers), `character` (or strings), and `logical`:

```
x <- 2+3
typeof(x)
```

```
## [1] "double"
```

```
y <- "Cześć"
typeof(y)
```

```
## [1] "character"
```

```
z <- TRUE
typeof(z)
```

```
## [1] "logical"
```

2.7 Vector

An R object that contains multiple values of the same type is called **vector**. It could be created with the command `c()`:

```
c(3, 0, pi, 23.4, -53)
```

```
## [1]   3.000000   0.000000   3.141593  23.400000 -53.000000
```

```
c("Kraków", "Warszawa", "Cieszyn")
```

```
## [1] "Kraków"   "Warszawa" "Cieszyn"
```

```
c(FALSE, FALSE, TRUE)
```

```
## [1] FALSE FALSE  TRUE
```

```
a <- c(2, 3, 4)
b <- c(5, 6, 7)
c(a, b)
```

```
## [1] 2 3 4 5 6 7
```

For the number sequences there is an easy way:

```
1:10
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```
3:-5
```

```
## [1]  3  2  1  0 -1 -2 -3 -4 -5
```

From now on you can understand that everything we have seen before is a vector of length one. That is why there is `[1]` in all outputs: it is just an index of elements in a vector. Have a look here:

```
1:60
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
## [26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
## [51] 51 52 53 54 55 56 57 58 59 60
```

```
60:1
```

```
##  [1] 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36
## [26] 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11
## [51] 10  9  8  7  6  5  4  3  2  1
```

There is also a function `sec()` for creation of arithmetic progressions:

```
1:20
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
```

```
seq(from = 1, to = 20, by = 1)
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
```

```
seq(from = 2, to = 100, by = 13)
```

```
## [1]  2 15 28 41 54 67 80 93
```

Use the argument `length.out` of function `seq()` and create an arithmetic sequence from π to 2π of length 50.

There are also some built-in vectors:

```
letters
```

```
##  [1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j" "k" "l" "m" "n" "o" "p" "q" "r" "s"
## [20] "t" "u" "v" "w" "x" "y" "z"
```

```
LETTERS
```

```
##  [1] "A" "B" "C" "D" "E" "F" "G" "H" "I" "J" "K" "L" "M" "N" "O" "P" "Q" "R" "S"
## [20] "T" "U" "V" "W" "X" "Y" "Z"
```

```
month.name
```

```
##  [1] "January"   "February"  "March"     "April"     "May"       "June"
##  [7] "July"      "August"    "September" "October"   "November"  "December"
```

```
month.abb
```

```
##  [1] "Jan" "Feb" "Mar" "Apr" "May" "Jun" "Jul" "Aug" "Sep" "Oct" "Nov" "Dec"
```

2.7.1 Vector coercion

Vectors are R objects that contain multiple values of **the same type**. But what if we merged together different types?

```
c(1, "34")
```

```
## [1] "1"  "34"
```

```
c(1, TRUE)
```

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

```
c(TRUE, "34")
```

```
## [1] "TRUE" "34"
```

It is clear that there is a hierarchy: strings > double > logical. It is not universal across different programming languages. It doesn't correspond to the amount of values of particular type:

```r
c(1, 2, 3, "34")
```

```
## [1] "1"  "2"  "3"  "34"
```

```r
c(1, TRUE, FALSE, FALSE)
```

```
## [1] 1 1 0 0
```

The same story could happen during other operations:

```r
5+TRUE
```

```
## [1] 6
```

2.7.2 Vector operations

All operations, that we discussed earlier, could be done with vectors of the same length:

```r
1:5 + 6:10
```

```
## [1]  7  9 11 13 15
```

```r
1:5 - 6:10
```

```
## [1] -5 -5 -5 -5 -5
```

```r
1:5 * 6:10
```

```
## [1]  6 14 24 36 50
```

There are operations where the vector of any length and vector of length one is involved:

```r
1:5 + 7
```

```
## [1]  8  9 10 11 12
```

```r
1:5 - 7
```

```
## [1] -6 -5 -4 -3 -2
```

```
1:5 / 7
```

```
## [1] 0.1428571 0.2857143 0.4285714 0.5714286 0.7142857
```

There are a lot of functions in R that are **vectorised**. That means that applying this function to a vector is the same as applying this function to each element of the vector:

```
sin(1:5)
```

```
## [1]  0.8414710  0.9092974  0.1411200 -0.7568025 -0.9589243
```

```
sqrt(1:5)
```

```
## [1] 1.000000 1.414214 1.732051 2.000000 2.236068
```

```
abs(-5:3)
```

```
## [1] 5 4 3 2 1 0 1 2 3
```

2.7.3 Indexing vectors

How to get some value or banch of values from a vector? You need to index them:

```
x <- c(3, 0, pi, 23.4, -53)
y <- c("Kraków", "Warszawa", "Cieszyn")

x[4]
```

```
## [1] 23.4
```

```
y[2]
```

```
## [1] "Warszawa"
```

It is possible to have a vector as index:

```
x[1:2]
```

```
## [1] 3 0
```

```
y[c(1, 3)]
```

```
## [1] "Kraków"  "Cieszyn"
```

It is possible to index something that you **do not** want to see in the result:

```
y[-2]
```

```
## [1] "Kraków"  "Cieszyn"
```

```
x[-c(1, 4)]
```

```
## [1]   0.000000   3.141593 -53.000000
```

It is possible to have other variables as an index

```
z <- c(3, 2)
x[z]
```

```
## [1] 3.141593 0.000000
```

```
y[z]
```

```
## [1] "Cieszyn"  "Warszawa"
```

It is possible to index with a logical vector:

```
x[c(TRUE, FALSE, TRUE, TRUE, FALSE)]
```

```
## [1]  3.000000  3.141593 23.400000
```

That means that we could use `TRUE/FALSE`-vector produced by comparison:

```
x[x > 2]
```

```
## [1]  3.000000  3.141593 23.400000
```

It works because `x > 2` is a vector of logical values:

```
x > 2
```

```
## [1]  TRUE FALSE  TRUE  TRUE FALSE
```

It is possible to use `!` operator here changing all `TRUE` values to `FALSE` and vice versa.

```
x[!(x > 2)]
```

```
## [1]   0 -53
```

How many elements in the vector `g` if expression `g[pi < 1000]` does not return an error?

2.7.4 NA

Sometimes there are some missing values in the data, so it is represented with `NA`

```
NA
```

```
## [1] NA
```

```
c(1, NA, 9)
```

```
## [1]  1 NA  9
```

```
c("Kraków", NA, "Cieszyn")
```

```
## [1] "Kraków"  NA        "Cieszyn"
```

```
c(TRUE, FALSE, NA)
```

```
## [1]  TRUE FALSE    NA
```

It is possible to check, whether there are missing values or not

```
x <- c("Kraków", NA, "Cieszyn")
y <- c("Kraków", "Warszawa", "Cieszyn")
is.na(x)
```

```
## [1] FALSE  TRUE FALSE
```

```
is.na(y)
```

```
## [1] FALSE FALSE FALSE
```

Some functions doesn't work with vecotors that contain missed values, so you need to add argument `na.rm = TRUE`:

```
x <- c(1, NA, 9, 5)
mean(x)
```

```
## [1] NA
```

```
mean(x, na.rm = TRUE)
```

```
## [1] 5
```

```
min(x, na.rm = TRUE)
```

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

```
max(x, na.rm = TRUE)
```

```
## [1] 9
```

```
median(x, na.rm = TRUE)
```

```
## [1] 5
```

```
range(x, na.rm = TRUE)
```

```
## [1] 1 9
```

2.8 Packages

The most important and useful part of R is hidden in its packages. Everything that we discussed so far is basic R functionality invented back in 1979. Since then a lot of different things changed, so all new practices for data analysis, visualisation and manipulation are packed in packages. During our class we will learn the most popular *"dialect"* of R called `tidyverse`.

In order to install packages you need to use a command. Let's install the `tidyverse` package:

```
install.packages("tidyverse")
```

For today we also will need the `readxl` package:

```r
install.packages("tidyverse")
```

After you have downloaded packages nothing will change. You can not use any fucntionality from packages unless you load the package with the `library()` function:

```r
library("tidyverse")
```

Not turning on an R package is the most popular mistake of my students. So remmember:

- `install.packages("...")` is like you are buying a screwdriver set;
- `library("...")` is like you are start using your screwdriver.

For the further lectures we will need `tidyverse` package.

Please install `tidyverse` package and load it.

2.8.1 `tidyverse`

The `tidyverse` is a set of packages:

- `tibble`, for tibbles, a modern re-imagining of data frames — analugue of tables in R
- `readr`, for data import
- `dplyr`, for data manipulation
- `tidyr`, for data tidying (we will discuss it later today)

- ggplot2, for data visualisation
- purrr, for functional programming

2.9 Dataframe (tibble)

A data frame is a collection of variables of the same number of rows with unique row names. Here is an example dataframe with the Tomm Moore filmography:

```
moore_filmography <- tibble(title = c("The Secret of Kells",
                                      "Song of the Sea",
                                      "Kahlil Gibran's The Prophet",
                                      "The Breadwinner",
                                      "Wolfwalkers"),
                            year = c(2009, 2014, 2014, 2017, 2020),
                            director = c(TRUE, TRUE, TRUE, FALSE, TRUE))
moore_filmography
```

```
## # A tibble: 5 x 3
##   title                        year director
##   <chr>                       <dbl> <lgl>
## 1 The Secret of Kells          2009 TRUE
## 2 Song of the Sea              2014 TRUE
## 3 Kahlil Gibran's The Prophet  2014 TRUE
## 4 The Breadwinner              2017 FALSE
## 5 Wolfwalkers                  2020 TRUE
```

There are a lot of built-in dataframes:

```
mtcars
```

```
##                      mpg cyl  disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4           21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag       21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710          22.8   4 108.0  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive      21.4   6 258.0 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout   18.7   8 360.0 175 3.15 3.440 17.02  0  0    3    2
## Valiant             18.1   6 225.0 105 2.76 3.460 20.22  1  0    3    1
## Duster 360          14.3   8 360.0 245 3.21 3.570 15.84  0  0    3    4
## Merc 240D           24.4   4 146.7  62 3.69 3.190 20.00  1  0    4    2
## Merc 230            22.8   4 140.8  95 3.92 3.150 22.90  1  0    4    2
## Merc 280            19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
## Merc 280C           17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
## Merc 450SE          16.4   8 275.8 180 3.07 4.070 17.40  0  0    3    3
## Merc 450SL          17.3   8 275.8 180 3.07 3.730 17.60  0  0    3    3
## Merc 450SLC         15.2   8 275.8 180 3.07 3.780 18.00  0  0    3    3
```

```
## Cadillac Fleetwood  10.4   8 472.0 205 2.93 5.250 17.98  0  0    3    4
## Lincoln Continental 10.4   8 460.0 215 3.00 5.424 17.82  0  0    3    4
## Chrysler Imperial   14.7   8 440.0 230 3.23 5.345 17.42  0  0    3    4
## Fiat 128            32.4   4  78.7  66 4.08 2.200 19.47  1  1    4    1
## Honda Civic         30.4   4  75.7  52 4.93 1.615 18.52  1  1    4    2
## Toyota Corolla      33.9   4  71.1  65 4.22 1.835 19.90  1  1    4    1
## Toyota Corona       21.5   4 120.1  97 3.70 2.465 20.01  1  0    3    1
## Dodge Challenger    15.5   8 318.0 150 2.76 3.520 16.87  0  0    3    2
## AMC Javelin         15.2   8 304.0 150 3.15 3.435 17.30  0  0    3    2
## Camaro Z28          13.3   8 350.0 245 3.73 3.840 15.41  0  0    3    4
## Pontiac Firebird    19.2   8 400.0 175 3.08 3.845 17.05  0  0    3    2
## Fiat X1-9           27.3   4  79.0  66 4.08 1.935 18.90  1  1    4    1
## Porsche 914-2       26.0   4 120.3  91 4.43 2.140 16.70  0  1    5    2
## Lotus Europa        30.4   4  95.1 113 3.77 1.513 16.90  1  1    5    2
## Ford Pantera L      15.8   8 351.0 264 4.22 3.170 14.50  0  1    5    4
## Ferrari Dino        19.7   6 145.0 175 3.62 2.770 15.50  0  1    5    6
## Maserati Bora       15.0   8 301.0 335 3.54 3.570 14.60  0  1    5    8
## Volvo 142E          21.4   4 121.0 109 4.11 2.780 18.60  1  1    4    2
```

```
iris
```

```
##     Sepal.Length Sepal.Width Petal.Length Petal.Width    Species
## 1            5.1         3.5          1.4         0.2     setosa
## 2            4.9         3.0          1.4         0.2     setosa
## 3            4.7         3.2          1.3         0.2     setosa
## 4            4.6         3.1          1.5         0.2     setosa
## 5            5.0         3.6          1.4         0.2     setosa
## 6            5.4         3.9          1.7         0.4     setosa
## 7            4.6         3.4          1.4         0.3     setosa
## 8            5.0         3.4          1.5         0.2     setosa
## 9            4.4         2.9          1.4         0.2     setosa
## 10           4.9         3.1          1.5         0.1     setosa
## 11           5.4         3.7          1.5         0.2     setosa
## 12           4.8         3.4          1.6         0.2     setosa
## 13           4.8         3.0          1.4         0.1     setosa
## 14           4.3         3.0          1.1         0.1     setosa
## 15           5.8         4.0          1.2         0.2     setosa
## 16           5.7         4.4          1.5         0.4     setosa
## 17           5.4         3.9          1.3         0.4     setosa
## 18           5.1         3.5          1.4         0.3     setosa
## 19           5.7         3.8          1.7         0.3     setosa
## 20           5.1         3.8          1.5         0.3     setosa
## 21           5.4         3.4          1.7         0.2     setosa
## 22           5.1         3.7          1.5         0.4     setosa
## 23           4.6         3.6          1.0         0.2     setosa
```

```
## 24          5.1         3.3          1.7         0.5     setosa
## 25          4.8         3.4          1.9         0.2     setosa
## 26          5.0         3.0          1.6         0.2     setosa
## 27          5.0         3.4          1.6         0.4     setosa
## 28          5.2         3.5          1.5         0.2     setosa
## 29          5.2         3.4          1.4         0.2     setosa
## 30          4.7         3.2          1.6         0.2     setosa
## 31          4.8         3.1          1.6         0.2     setosa
## 32          5.4         3.4          1.5         0.4     setosa
## 33          5.2         4.1          1.5         0.1     setosa
## 34          5.5         4.2          1.4         0.2     setosa
## 35          4.9         3.1          1.5         0.2     setosa
## 36          5.0         3.2          1.2         0.2     setosa
## 37          5.5         3.5          1.3         0.2     setosa
## 38          4.9         3.6          1.4         0.1     setosa
## 39          4.4         3.0          1.3         0.2     setosa
## 40          5.1         3.4          1.5         0.2     setosa
## 41          5.0         3.5          1.3         0.3     setosa
## 42          4.5         2.3          1.3         0.3     setosa
## 43          4.4         3.2          1.3         0.2     setosa
## 44          5.0         3.5          1.6         0.6     setosa
## 45          5.1         3.8          1.9         0.4     setosa
## 46          4.8         3.0          1.4         0.3     setosa
## 47          5.1         3.8          1.6         0.2     setosa
## 48          4.6         3.2          1.4         0.2     setosa
## 49          5.3         3.7          1.5         0.2     setosa
## 50          5.0         3.3          1.4         0.2     setosa
## 51          7.0         3.2          4.7         1.4 versicolor
## 52          6.4         3.2          4.5         1.5 versicolor
## 53          6.9         3.1          4.9         1.5 versicolor
## 54          5.5         2.3          4.0         1.3 versicolor
## 55          6.5         2.8          4.6         1.5 versicolor
## 56          5.7         2.8          4.5         1.3 versicolor
## 57          6.3         3.3          4.7         1.6 versicolor
## 58          4.9         2.4          3.3         1.0 versicolor
## 59          6.6         2.9          4.6         1.3 versicolor
## 60          5.2         2.7          3.9         1.4 versicolor
## 61          5.0         2.0          3.5         1.0 versicolor
## 62          5.9         3.0          4.2         1.5 versicolor
## 63          6.0         2.2          4.0         1.0 versicolor
## 64          6.1         2.9          4.7         1.4 versicolor
## 65          5.6         2.9          3.6         1.3 versicolor
## 66          6.7         3.1          4.4         1.4 versicolor
## 67          5.6         3.0          4.5         1.5 versicolor
## 68          5.8         2.7          4.1         1.0 versicolor
## 69          6.2         2.2          4.5         1.5 versicolor
```

```
## 70          5.6         2.5          3.9         1.1 versicolor
## 71          5.9         3.2          4.8         1.8 versicolor
## 72          6.1         2.8          4.0         1.3 versicolor
## 73          6.3         2.5          4.9         1.5 versicolor
## 74          6.1         2.8          4.7         1.2 versicolor
## 75          6.4         2.9          4.3         1.3 versicolor
## 76          6.6         3.0          4.4         1.4 versicolor
## 77          6.8         2.8          4.8         1.4 versicolor
## 78          6.7         3.0          5.0         1.7 versicolor
## 79          6.0         2.9          4.5         1.5 versicolor
## 80          5.7         2.6          3.5         1.0 versicolor
## 81          5.5         2.4          3.8         1.1 versicolor
## 82          5.5         2.4          3.7         1.0 versicolor
## 83          5.8         2.7          3.9         1.2 versicolor
## 84          6.0         2.7          5.1         1.6 versicolor
## 85          5.4         3.0          4.5         1.5 versicolor
## 86          6.0         3.4          4.5         1.6 versicolor
## 87          6.7         3.1          4.7         1.5 versicolor
## 88          6.3         2.3          4.4         1.3 versicolor
## 89          5.6         3.0          4.1         1.3 versicolor
## 90          5.5         2.5          4.0         1.3 versicolor
## 91          5.5         2.6          4.4         1.2 versicolor
## 92          6.1         3.0          4.6         1.4 versicolor
## 93          5.8         2.6          4.0         1.2 versicolor
## 94          5.0         2.3          3.3         1.0 versicolor
## 95          5.6         2.7          4.2         1.3 versicolor
## 96          5.7         3.0          4.2         1.2 versicolor
## 97          5.7         2.9          4.2         1.3 versicolor
## 98          6.2         2.9          4.3         1.3 versicolor
## 99          5.1         2.5          3.0         1.1 versicolor
## 100         5.7         2.8          4.1         1.3 versicolor
## 101         6.3         3.3          6.0         2.5  virginica
## 102         5.8         2.7          5.1         1.9  virginica
## 103         7.1         3.0          5.9         2.1  virginica
## 104         6.3         2.9          5.6         1.8  virginica
## 105         6.5         3.0          5.8         2.2  virginica
## 106         7.6         3.0          6.6         2.1  virginica
## 107         4.9         2.5          4.5         1.7  virginica
## 108         7.3         2.9          6.3         1.8  virginica
## 109         6.7         2.5          5.8         1.8  virginica
## 110         7.2         3.6          6.1         2.5  virginica
## 111         6.5         3.2          5.1         2.0  virginica
## 112         6.4         2.7          5.3         1.9  virginica
## 113         6.8         3.0          5.5         2.1  virginica
## 114         5.7         2.5          5.0         2.0  virginica
## 115         5.8         2.8          5.1         2.4  virginica
```

```
## 116          6.4         3.2          5.3         2.3  virginica
## 117          6.5         3.0          5.5         1.8  virginica
## 118          7.7         3.8          6.7         2.2  virginica
## 119          7.7         2.6          6.9         2.3  virginica
## 120          6.0         2.2          5.0         1.5  virginica
## 121          6.9         3.2          5.7         2.3  virginica
## 122          5.6         2.8          4.9         2.0  virginica
## 123          7.7         2.8          6.7         2.0  virginica
## 124          6.3         2.7          4.9         1.8  virginica
## 125          6.7         3.3          5.7         2.1  virginica
## 126          7.2         3.2          6.0         1.8  virginica
## 127          6.2         2.8          4.8         1.8  virginica
## 128          6.1         3.0          4.9         1.8  virginica
## 129          6.4         2.8          5.6         2.1  virginica
## 130          7.2         3.0          5.8         1.6  virginica
## 131          7.4         2.8          6.1         1.9  virginica
## 132          7.9         3.8          6.4         2.0  virginica
## 133          6.4         2.8          5.6         2.2  virginica
## 134          6.3         2.8          5.1         1.5  virginica
## 135          6.1         2.6          5.6         1.4  virginica
## 136          7.7         3.0          6.1         2.3  virginica
## 137          6.3         3.4          5.6         2.4  virginica
## 138          6.4         3.1          5.5         1.8  virginica
## 139          6.0         3.0          4.8         1.8  virginica
## 140          6.9         3.1          5.4         2.1  virginica
## 141          6.7         3.1          5.6         2.4  virginica
## 142          6.9         3.1          5.1         2.3  virginica
## 143          5.8         2.7          5.1         1.9  virginica
## 144          6.8         3.2          5.9         2.3  virginica
## 145          6.7         3.3          5.7         2.5  virginica
## 146          6.7         3.0          5.2         2.3  virginica
## 147          6.3         2.5          5.0         1.9  virginica
## 148          6.5         3.0          5.2         2.0  virginica
## 149          6.2         3.4          5.4         2.3  virginica
## 150          5.9         3.0          5.1         1.8  virginica
```

You can find information about them:

```
?mtcars
?iris
```

Dataframe consists of vectors that could be called using `$` sign:

```
moore_filmography$year
```

```
## [1] 2009 2014 2014 2017 2020
```

```
moore_filmography$title
```

```
## [1] "The Secret of Kells"          "Song of the Sea"
## [3] "Kahlil Gibran's The Prophet" "The Breadwinner"
## [5] "Wolfwalkers"
```

It is possible to add a vector to an existing dataframe:

```
moore_filmography$producer <- c(TRUE, TRUE, FALSE, TRUE, TRUE)
moore_filmography
```

```
## # A tibble: 5 x 4
##   title                        year director producer
##   <chr>                       <dbl> <lgl>    <lgl>
## 1 The Secret of Kells          2009 TRUE     TRUE
## 2 Song of the Sea              2014 TRUE     TRUE
## 3 Kahlil Gibran's The Prophet  2014 TRUE     FALSE
## 4 The Breadwinner              2017 FALSE    TRUE
## 5 Wolfwalkers                  2020 TRUE     TRUE
```

There some useful functions that tell you somethig about dataframe:

```
nrow(moore_filmography)
```

```
## [1] 5
```

```
ncol(moore_filmography)
```

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

```
summary(moore_filmography)
```

```
##     title                year       director        producer
##  Length:5           Min.   :2009   Mode :logical   Mode :logical
##  Class :character   1st Qu.:2014   FALSE:1         FALSE:1
##  Mode  :character   Median :2014   TRUE :4         TRUE :4
##                     Mean   :2015
##                     3rd Qu.:2017
##                     Max.   :2020
```

```
str(moore_filmography)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    5 obs. of  4 variables:
##  $ title   : chr  "The Secret of Kells" "Song of the Sea" "Kahlil Gibran's The Prophet" "The E
##  $ year    : num  2009 2014 2014 2017 2020
##  $ director: logi  TRUE TRUE TRUE FALSE TRUE
##  $ producer: logi  TRUE TRUE FALSE TRUE TRUE
```

We will work exclusively with dataframes. But it is not the only data structure in R.

How many rows in the `iris` dataframe?

How many columns in the `mtcars` dataframe?

2.9.1 Indexing dataframes

Since dataframes are two-dimensional objects it is possible to index its rows and columns. Rows are the first index, columns are the second index:

```
moore_filmography[3, 2]
```

```
## # A tibble: 1 x 1
##    year
##   <dbl>
## 1  2014
```

```
moore_filmography[3,]
```

```
## # A tibble: 1 x 4
##   title                        year director producer
##   <chr>                       <dbl> <lgl>    <lgl>
## 1 Kahlil Gibran's The Prophet  2014 TRUE     FALSE
```

```
moore_filmography[,2]
```

```
## # A tibble: 5 x 1
##    year
##   <dbl>
## 1  2009
## 2  2014
```

```
## 3  2014
## 4  2017
## 5  2020
```

```
moore_filmography[,1:2]
```

```
## # A tibble: 5 x 2
##   title                        year
##   <chr>                       <dbl>
## 1 The Secret of Kells          2009
## 2 Song of the Sea              2014
## 3 Kahlil Gibran's The Prophet  2014
## 4 The Breadwinner              2017
## 5 Wolfwalkers                  2020
```

```
moore_filmography[,-3]
```

```
## # A tibble: 5 x 3
##   title                        year producer
##   <chr>                       <dbl> <lgl>
## 1 The Secret of Kells          2009 TRUE
## 2 Song of the Sea              2014 TRUE
## 3 Kahlil Gibran's The Prophet  2014 FALSE
## 4 The Breadwinner              2017 TRUE
## 5 Wolfwalkers                  2020 TRUE
```

```
moore_filmography[,-c(1:2)]
```

```
## # A tibble: 5 x 2
##   director producer
##   <lgl>    <lgl>
## 1 TRUE     TRUE
## 2 TRUE     TRUE
## 3 TRUE     FALSE
## 4 FALSE    TRUE
## 5 TRUE     TRUE
```

```
moore_filmography[,"year"]
```

```
## # A tibble: 5 x 1
##    year
##   <dbl>
## 1  2009
```

```
## 2  2014
## 3  2014
## 4  2017
## 5  2020
```

```
moore_filmography[,c("title", "year")]
```

```
## # A tibble: 5 x 2
##   title                         year
##   <chr>                        <dbl>
## 1 The Secret of Kells           2009
## 2 Song of the Sea               2014
## 3 Kahlil Gibran's The Prophet  2014
## 4 The Breadwinner               2017
## 5 Wolfwalkers                   2020
```

```
moore_filmography[moore_filmography$year > 2014,]
```

```
## # A tibble: 2 x 4
##   title            year director producer
##   <chr>           <dbl> <lgl>    <lgl>
## 1 The Breadwinner  2017 FALSE    TRUE
## 2 Wolfwalkers      2020 TRUE     TRUE
```

2.10 Data import

2.10.1 `.csv` files

Because of 2019–20 Wuhan coronavirus outbreak the city of Wuhan is everywhere on media. In Russian for some reason Wuhan is masculine sometimes and sometimes it's feminin. I looked into other Slavic languages and recorded obtained data into the `.csv` file. Download this files to R. What variables does it have?

2.10.2 `.xls` and `.xlsx` files

2.11 Rmarkdown

Chapter 3

Data manipulation: `dplyr`

Chapter 4

Data visualisation: `ggplot2`

Chapter 5

Strings manipulation: `stringr`

Chapter 6

Text manipulation: `gutenbergr`, `tidytext`, `udpipe`

Chapter 7

Stylometric analysis: `stylo`

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