

Polish Language(s) and Digital Humanities Using R

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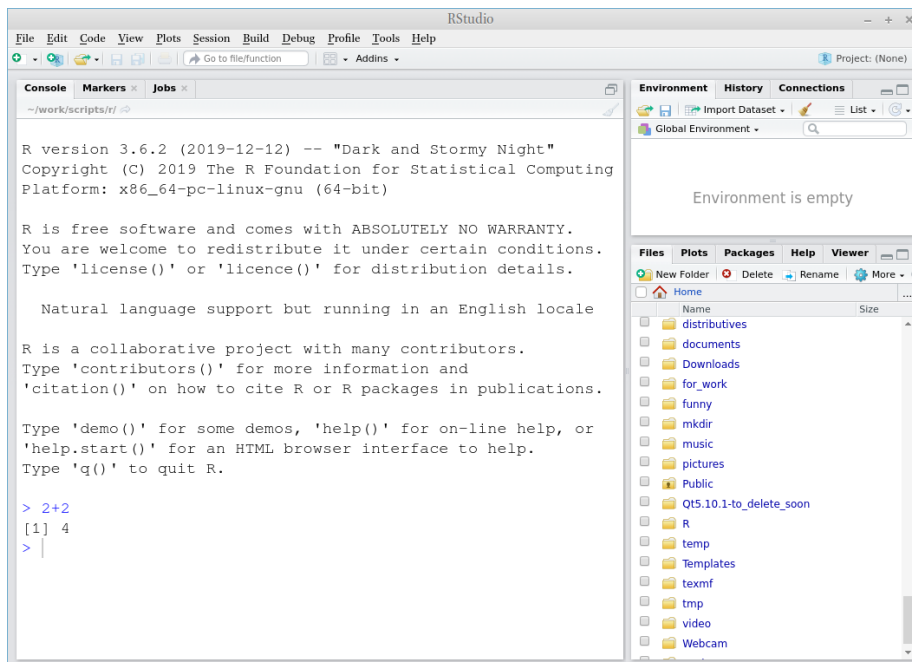
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Chapter 1

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 scientists 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
- ...

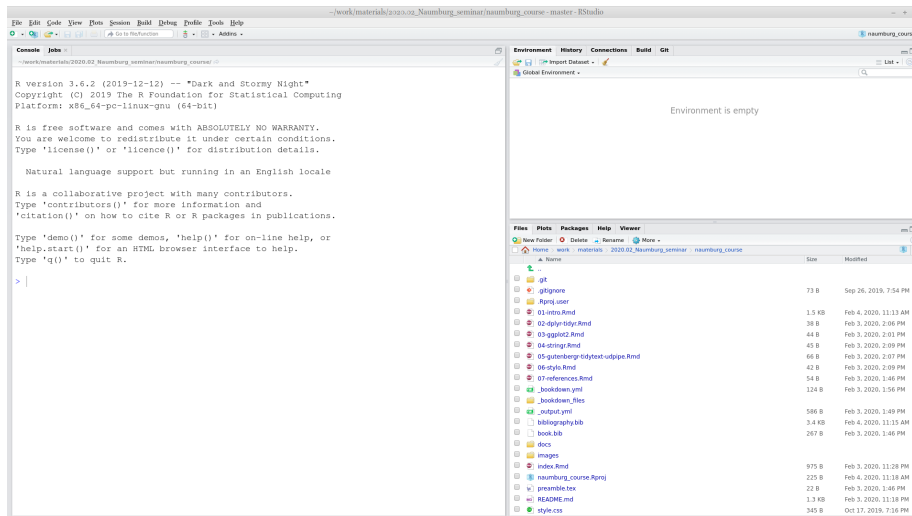
2.2 Introduction to RStudio

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

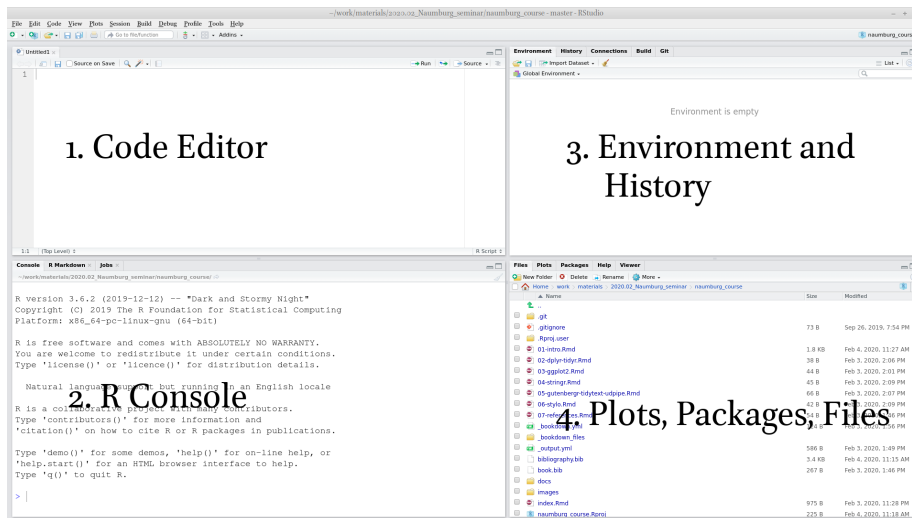
When you open RStudio for the first time you can see something like this:

2.3. R AS A CALCULATOR

5



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 the 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

Any text after a 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 previous!
```

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

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

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

```
## [1] "2020-02-07"
```

```
Sys.Date # wrong
```

```
## function ()
## as.Date(as.POSIXlt(Sys.time()))
## <bytecode: 0x574e79fdd910>
## <environment: namespace:base>
```

Each function in R is documented. You can read its documentation typing a 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 .

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

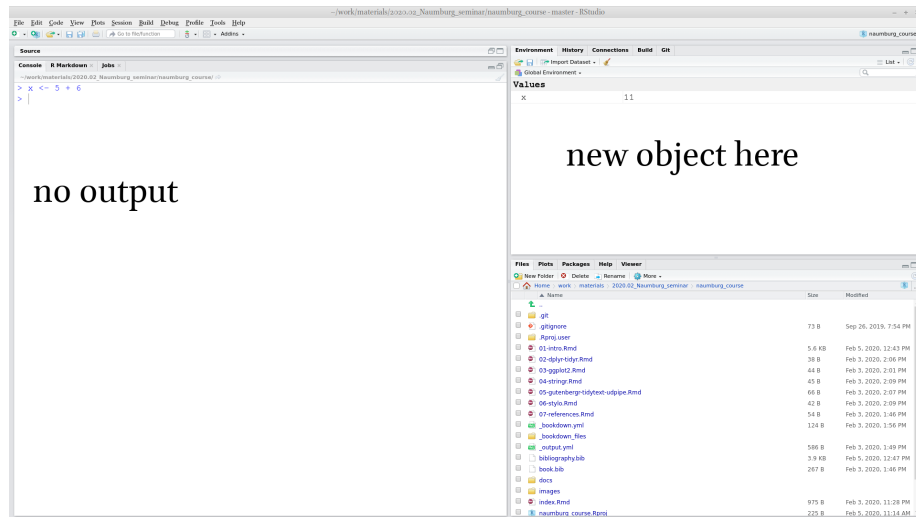
$$n = \log_{10}(1000)$$

What does this small 3 in the task mean? 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()`:

```
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

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

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

```
x >= 18
```

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

```
x < 100
```

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

```
x <= 18
```

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

```
x == 18
```

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

```
x != 18
```

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

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

```
!TRUE
```

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

```
!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 `seq()` 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:

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

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

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

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

The same story could happen during other operations:

```
5+TRUE
```

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

2.7.2 Vector operations

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

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

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

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

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

```
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:

```
1:5 + 7
```

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

```
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 bunch 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:

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

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

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

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

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



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



`library("...")`

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 — analogue 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 something 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

A .csv files (comma-separated values) is a delimited text file that uses a comma (or other delemeters such as tabulation or semicolon) to separate values. It is broadly used because it is possible to parse such a file using computers and people can edit it in the Office programs (Microsoft Excel, LibreOffice Calc, Numbers on Mac). Here is our `moore_filmography` dataset in the .csv format:

```
title,year,director,producer
The Secret of Kells,2009,TRUE,TRUE
Song of the Sea,2014,TRUE,TRUE
Kahlil Gibran's The Prophet,2014,TRUE,FALSE
The Breadwinner,2017,FALSE,TRUE
Wolfwalkers,2020,TRUE,TRUE
```

Let's create a variable with this file:

```
our_csv <- "title,year,director,producer
The Secret of Kells,2009,TRUE,TRUE
Song of the Sea,2014,TRUE,TRUE
Kahlil Gibran's The Prophet,2014,TRUE,FALSE
The Breadwinner,2017,FALSE,TRUE
Wolfwalkers,2020,TRUE,TRUE"
```

Now we are ready to use `read_csv()` function:

```
read_csv(our_csv)
```

```
## # 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
```

It is also possible to read files from your computer. Download this file on your computer (press `Ctrl S` or `Cmd S`) and read into R:

```
read_csv("C:/path/to/your/file/moore_filmography.csv")
```

```
## # 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
```

It is also possible to read files from the Internet:

```
read_csv("https://raw.githubusercontent.com/agricolamz/2020.02_Naumburg_R/master/data/1")
```

```
## Parsed with column specification:
## cols(
##   title = col_character(),
##   year = col_double(),
##   director = col_logical(),
##   producer = col_logical()
```

```
## )

## # 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
```



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

All file manipulations in R connected somehow with space on your computer via working directory. You can get information about your current working directory using `getwd()` function. You can change your working directory using `setwd()` function. If a file you want to read is in the working directory you don't need to write the whole path to file:

```
read_csv("moore_filmography.csv")
```

The same simple function will create your .csv file:

```
write_csv(moore_filmography, "moore_filmography_v2.csv")
```

Sometimes reading .csv files into Microsoft Excel is complicated, please follow the following instructions.

2.10.2 .xls and .xlsx files

There is a package `readxl` that allow to open and save .xls and .xlsx files. Install and load the package:

```
library(readxl)
```

Here is a test file. Download it to your computer and put it to your working directory:

```
read_xlsx("moore_filmography.xlsx")
```

```
## # A tibble: 5 x 4
##   title                                year director producer
##   <chr>                                <dbl> <chr>      <chr>
## 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
```

.xls and .xlsx files could have multiple tables on different sheets:

```
read_xlsx("moore_filmography.xlsx", sheet = "iris")
```

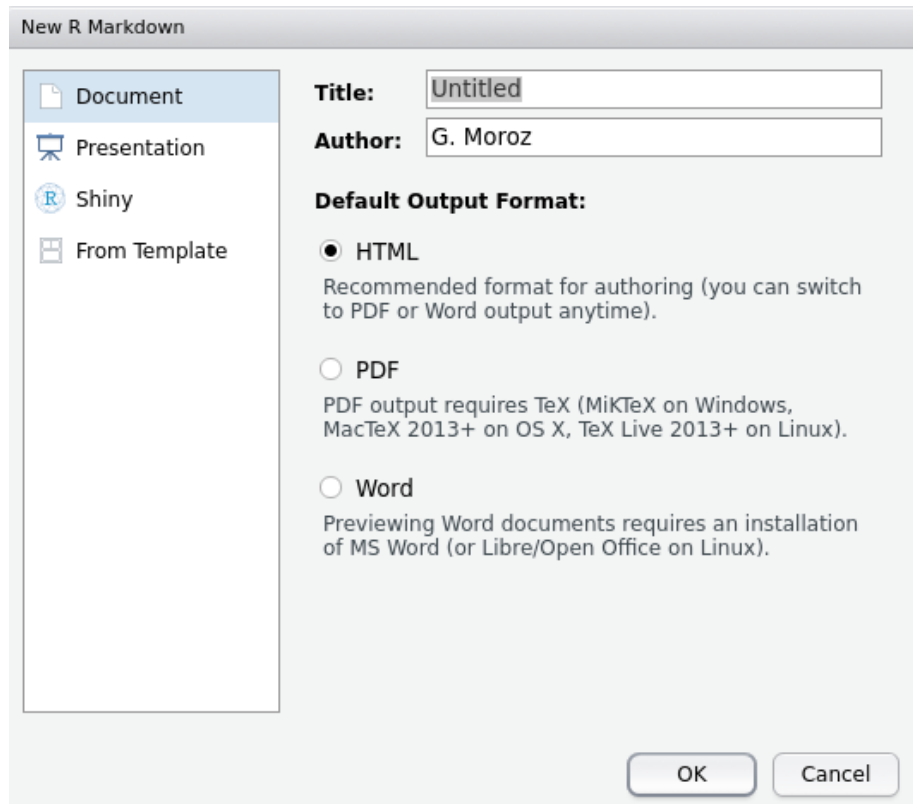
```
## # A tibble: 150 x 5
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
##   <dbl>         <dbl>         <dbl>         <dbl> <chr>
## 1         5.1         3.5         1.4         0.2 setosa
## 2         4.9         3         1.4         0.2 setosa
## 3         4.7         3.2         1.3         0.2 setosa
## 4         4.6         3.1         1.5         0.2 setosa
## 5         5         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         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
## # ... with 140 more rows
```

2.11 Rmarkdown


If you press **Ctrl S** or **Cmd S** then you will save your script. There is also another useful type of coding in R: **rmarkown**. First install this package:

```
install.packages("rmarkdown")
```

Thent will be possible to create a new file: **File > New File > R Markdown....**



Press OK in the following menu and you will get the template of your R Mark-

down file. You can modify it, then press  and the result file will be created in your working directory. `rmarkdown` package is a really popular and well developed package that creates output into:

- markdown
- html
- docx
- pdf
- beamer presentation
- pptx presentation
- epub
- ...
- multiple templates for different scientific journals (package `rticles` and `papaja`)
- ...

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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