R I

Programmierkurs 2 Data Science
WS23/24

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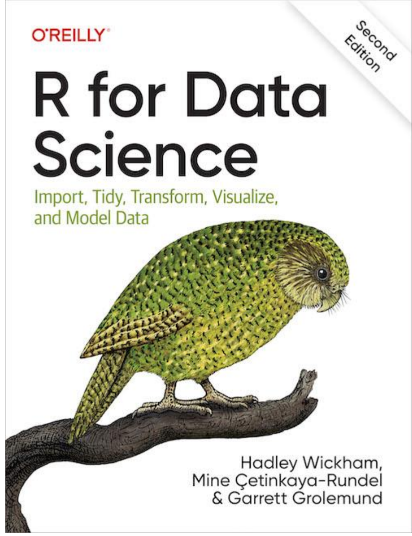

O'REILLY
Second Edition
R for Data Science
Import, Tidy, Transform, Visualize, and Model Data
Hadley Wickham, Mine Çetinkaya-Rundel & Garrett Grolemund

Slides are mainly based on

- https://r4ds.hadley.nz/
- https://www.phonetik.uni-muenchen.de/~jmh/lehre/basic_r/_book/index.html

→ Find everything you need to know there!

Official R cheat sheet:

- https://www.rstudio.com/wp-content/uploads/2015/02/data-wrangling-cheatsheet.pdf

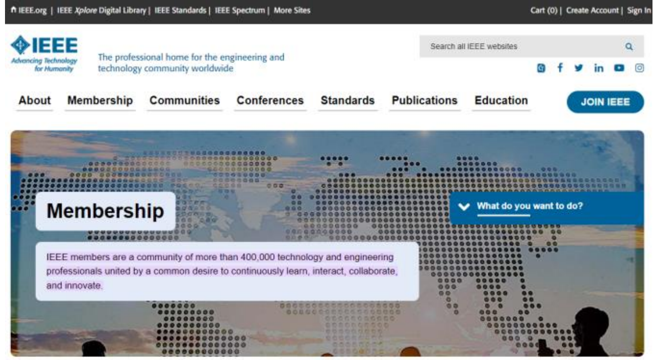
Data Transformation with dplyr:

- https://raw.githubusercontent.com/rstudio/cheatsheets/master/data-transformation.pdf

Learning Goals R I

- **Explain** your personal preference of R and Python as a programming language given by giving a comparitive coding example.
- **List** the development stack and its components for programming in R.
- Install and Import libraries and **use** R as a calculator.
- **Create** variables, vectors, matricies, and simple scatter plots.
- Import tabular files as DataFrames and **apply** exploration, filtering, slicing, selection, mutation, and renaming opreations using the pipe syntax.

Top Programming Languages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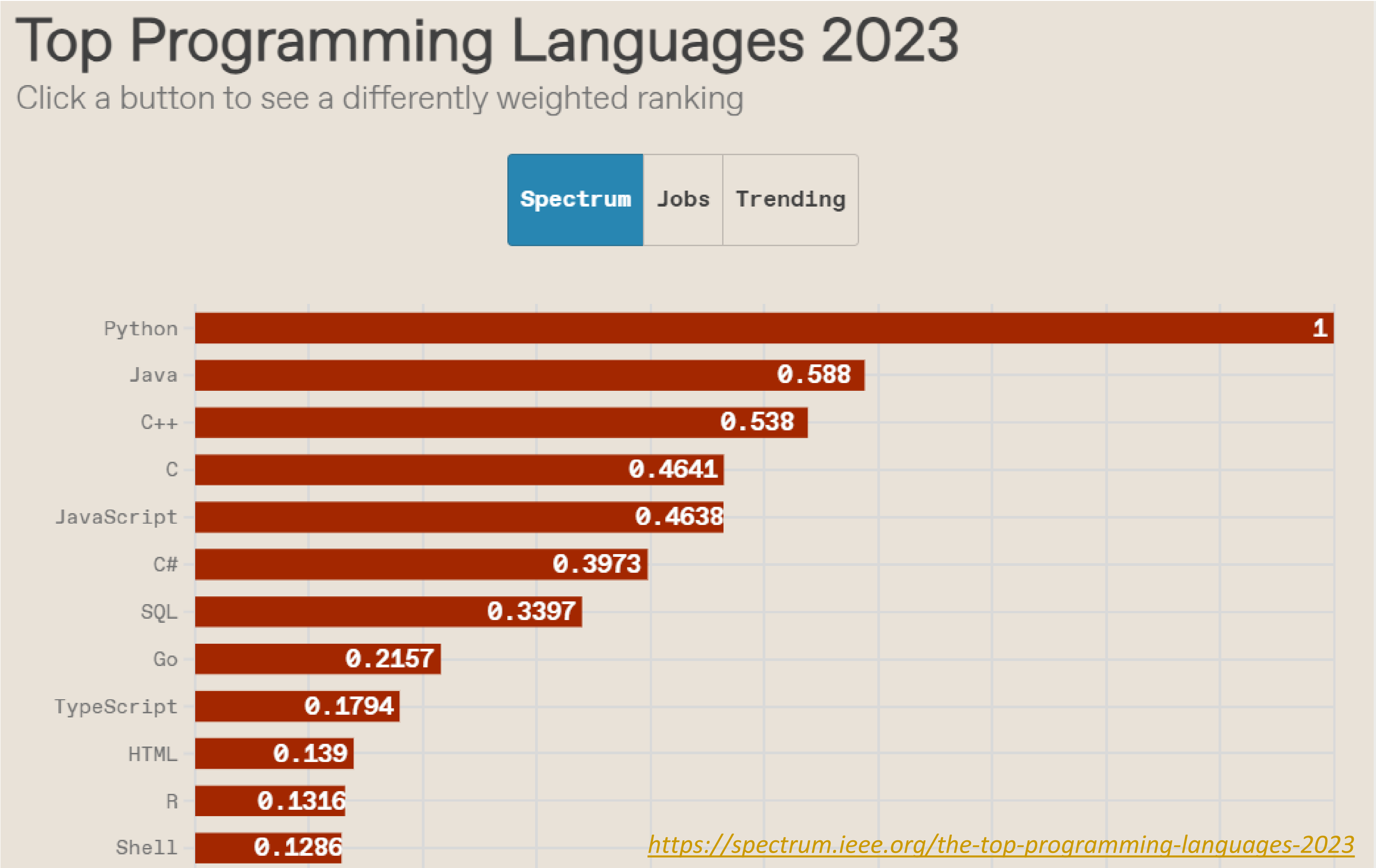
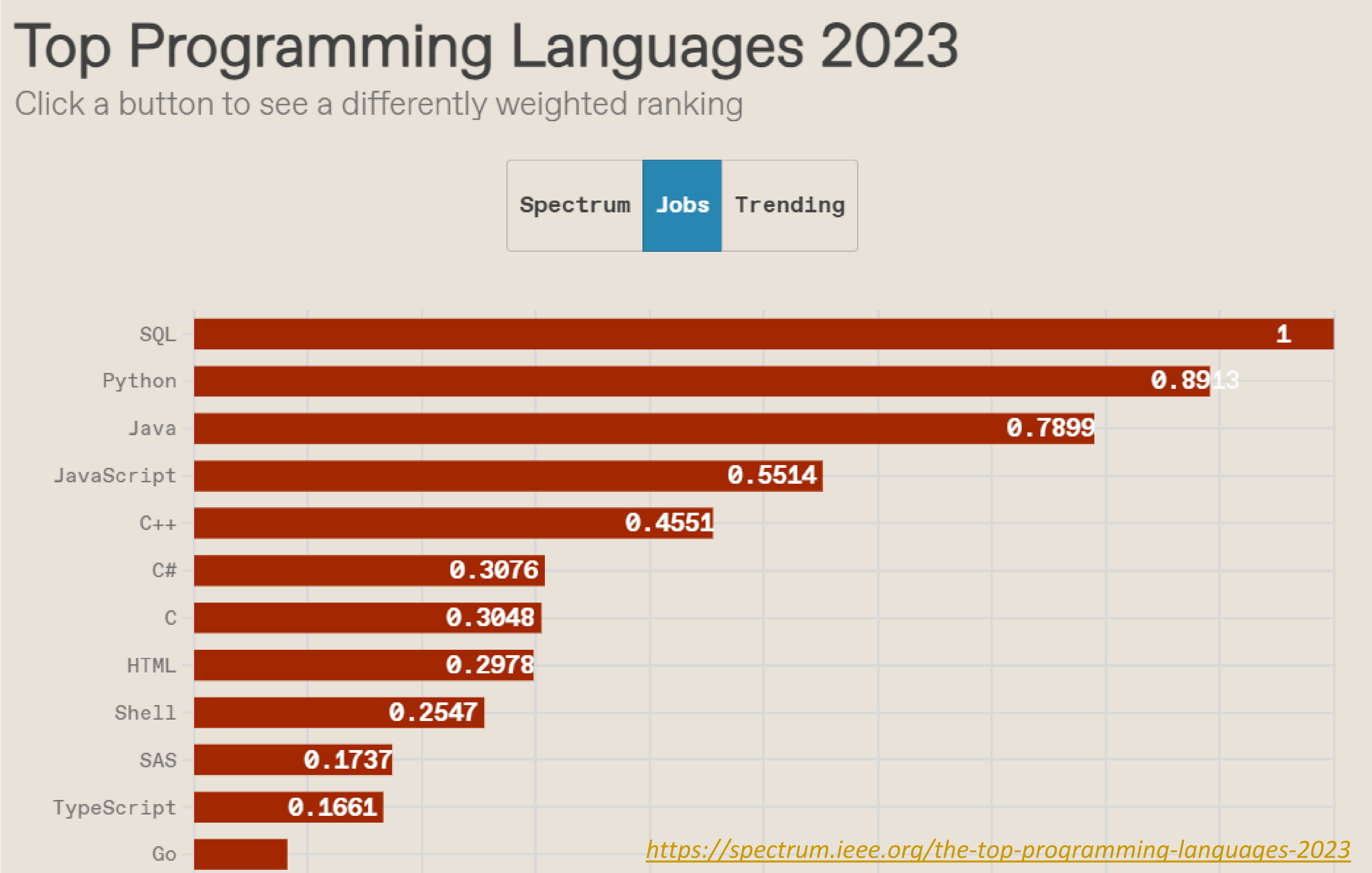


Top Programming Languages 2023

Click a button to see a differently weighted ranking

https://spectrum.ieee.org/the-top-programming-languages-2023

Top Programming Languages



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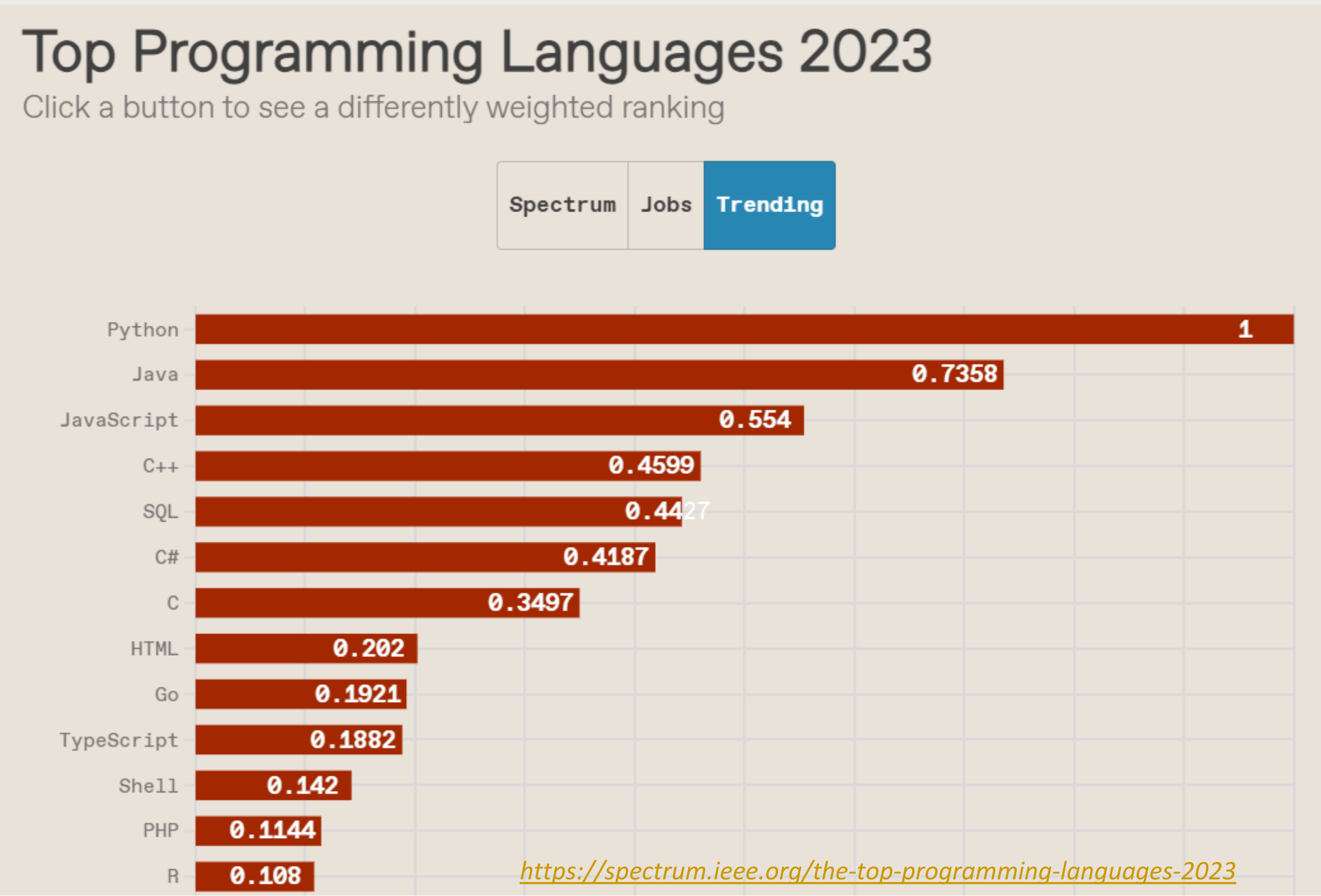
Top Programming Languages



Top Programming Languages 2023

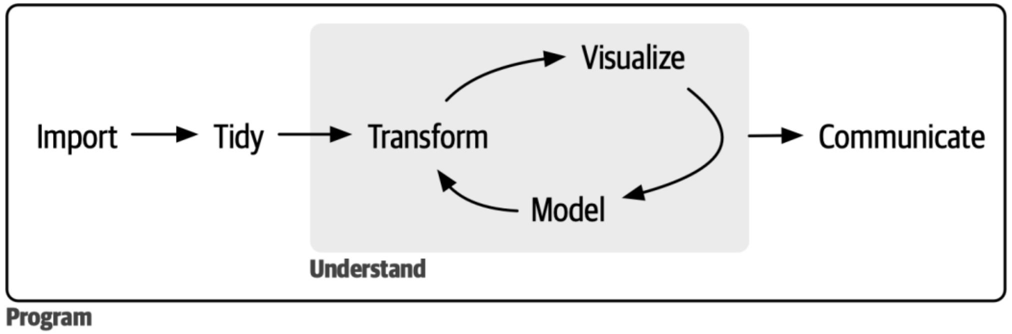
Click a button to see a differently weighted ranking

https://spectrum.ieee.org/the-top-programming-languages-2023

Python is considered to be more of a **general purpose programming language** and suited for **Machine Learning**.

Why R?

- Built to demonstrate the results of statistical analysis quickly.
- Suited for **statistical learning**.
- High level language; used by “non-techy” engineers and scientists.
- Open source, fast growing ecosystem with packages for almost everything in DS:

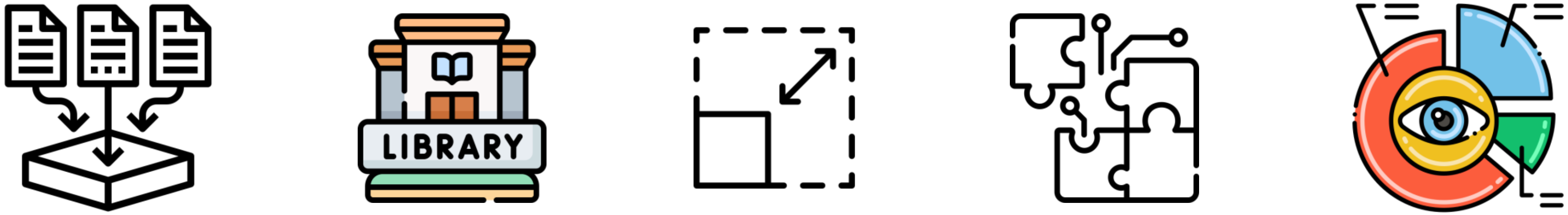


R for Data Science (e2) by Wickham, Çetinkaya-Rundel, and Grolemund

“Much like picking skis or snowboards, try them both and go with the one that feels right for the way you work.”

Python versus R

	Python	**R**
Do you have programming experience?	☺	
Do you care about visualization and graphics?		☺
Do you want to apply Statistical Models?		☺
Do you want to apply Machine Learning?	☺	
What do your colleagues, peers, advisors, industry-area use?	☺	☺



Various decision factors: *data collection, libraries, scale, integration, and many more...*

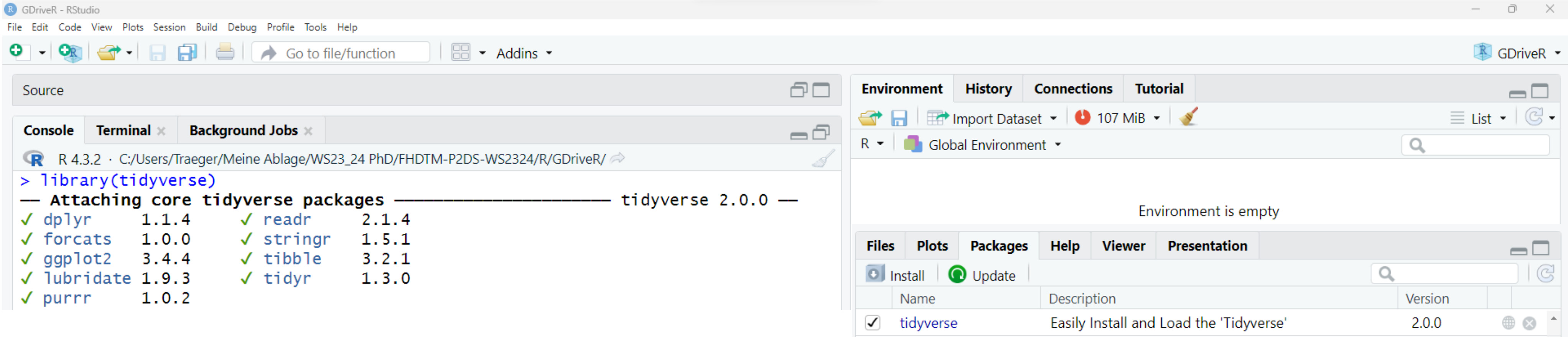
What you will need

R

RStudio: IDE for R programming

Tidyverse: a collection of R packages

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



R 4.3.2 · C:/Users/Traeger/Meine Ablage/WS23_24 PhD/FHDTM-P2DS-WS2324/R/GDriveR/

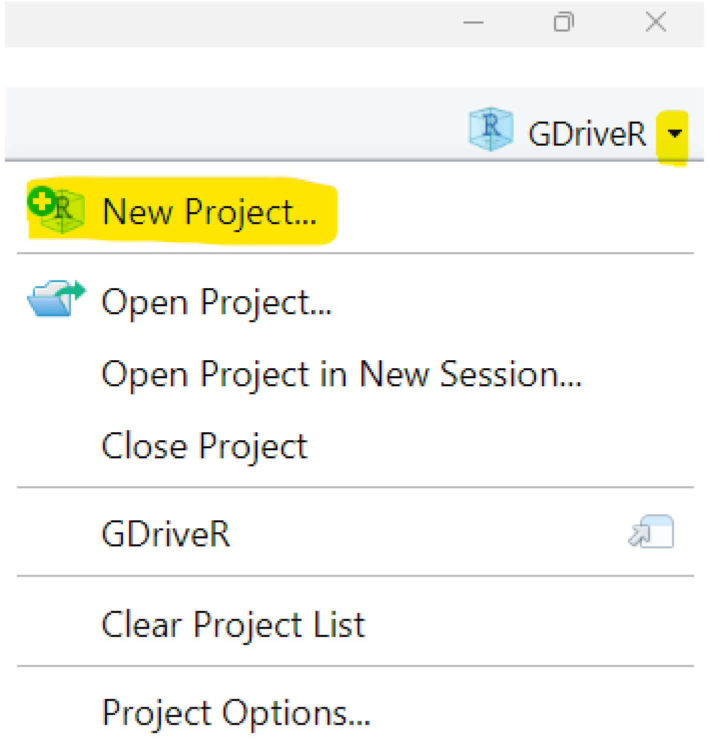
```
> library(tidyverse)
── Attaching core tidyverse packages ──────────────────── tidyverse 2.0.0 ──
✓ dplyr     1.1.4     ✓ readr     2.1.4
✓ forcats   1.0.0     ✓ stringr   1.5.1
✓ ggplot2   3.4.4     ✓ tibble    3.2.1
✓ lubridate 1.9.3     ✓ tidyr     1.3.0
✓ purrr     1.0.2
```

Environment is empty

	Name	Description	Version
☑	tidyverse	Easily Install and Load the 'Tidyverse'	2.0.0

Project in RStudio

File > New Project > Choose Directory



Advantages

- Restores the state of work where you left off.
- Files that you save during the course can be easily opened via the panel.

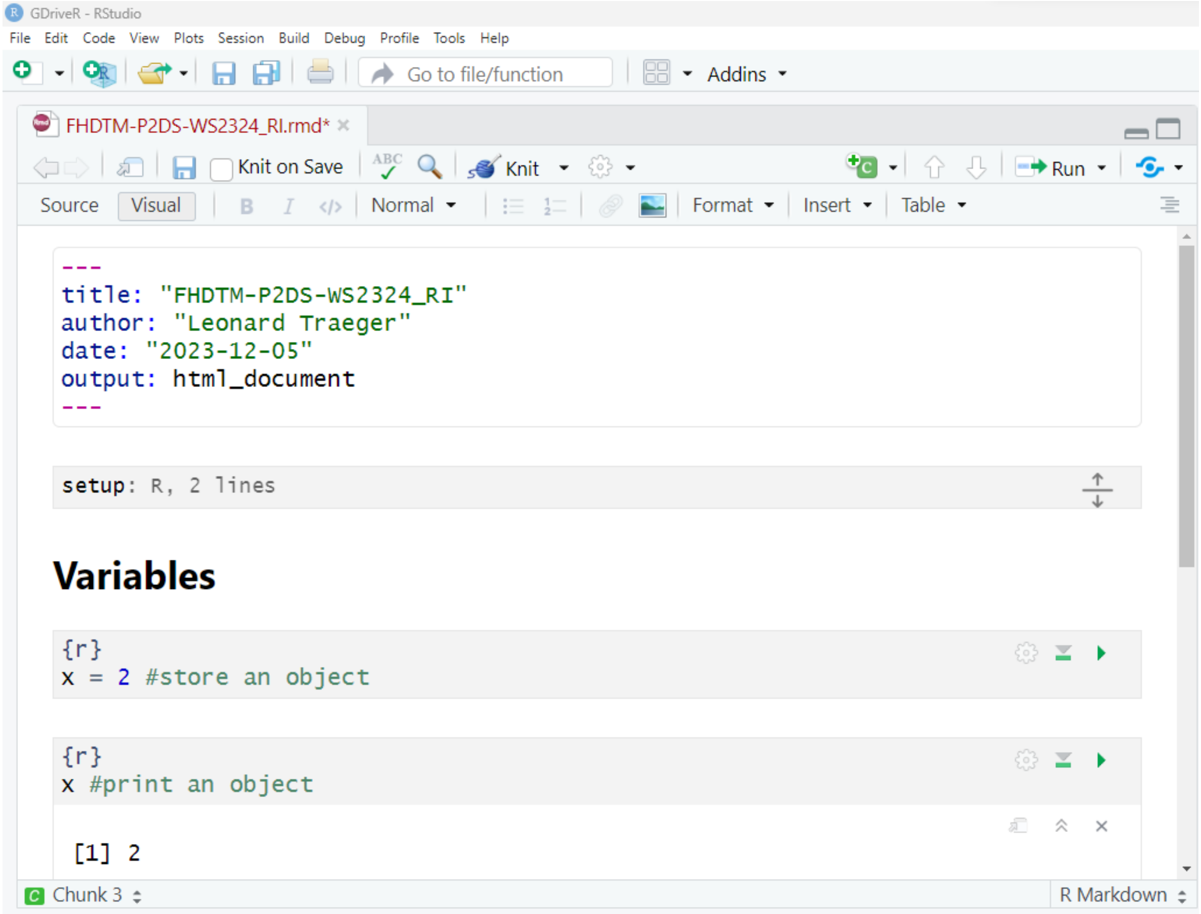
R Markdown

File > New File > R Markdown > …

- Choose HTML type
- Store file as .Rmd

Text annotations

- # headline
- **bold**
- *italics*
- \`code\`



```
---
title: "FHDTM-P2DS-WS2324_RI"
author: "Leonard Traeger"
date: "2023-12-05"
output: html_document
---
```

```
setup: R, 2 lines
```

Variables

```
{r}
x = 2 #store an object
```

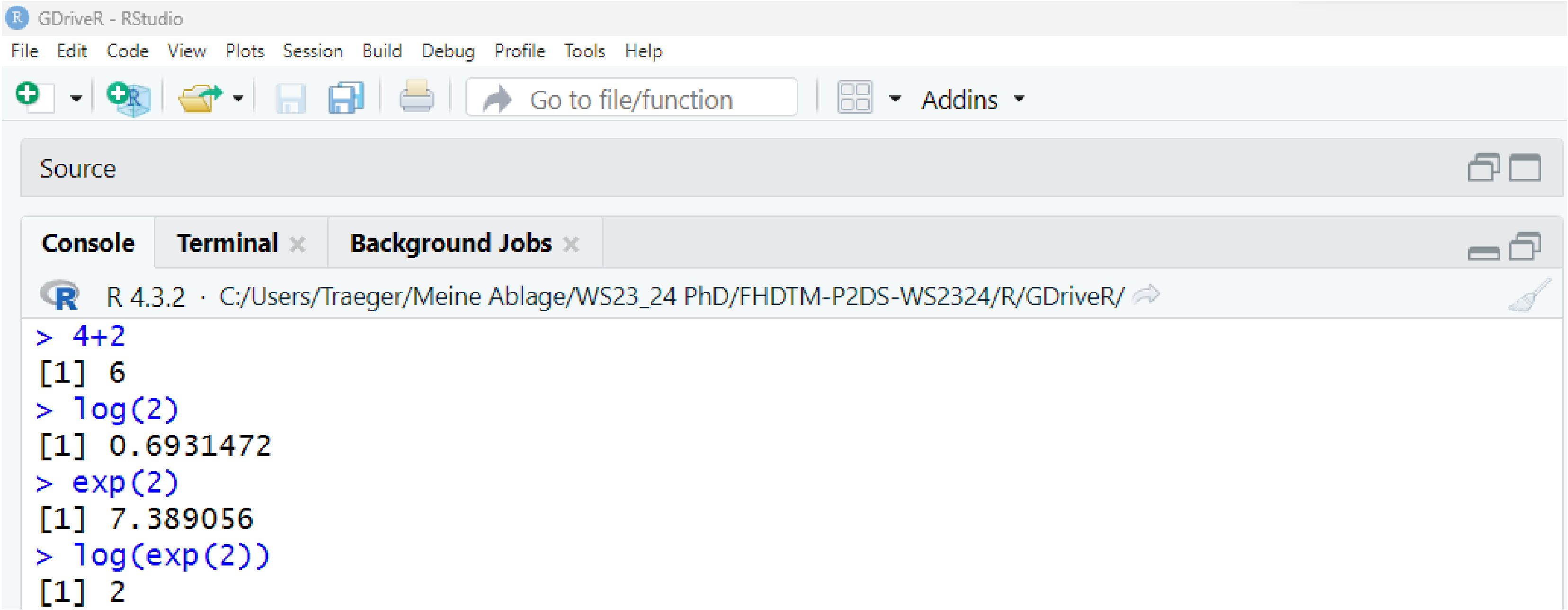
```
{r}
x #print an object
```

```
[1] 2
```

R Markdown documents has become established for the creation of report material (similar to our work in Python scripts).

RStudio Console

- The console is the direct connection between R and the computer that performs the calculations.
- You can use R as a simple calculator:

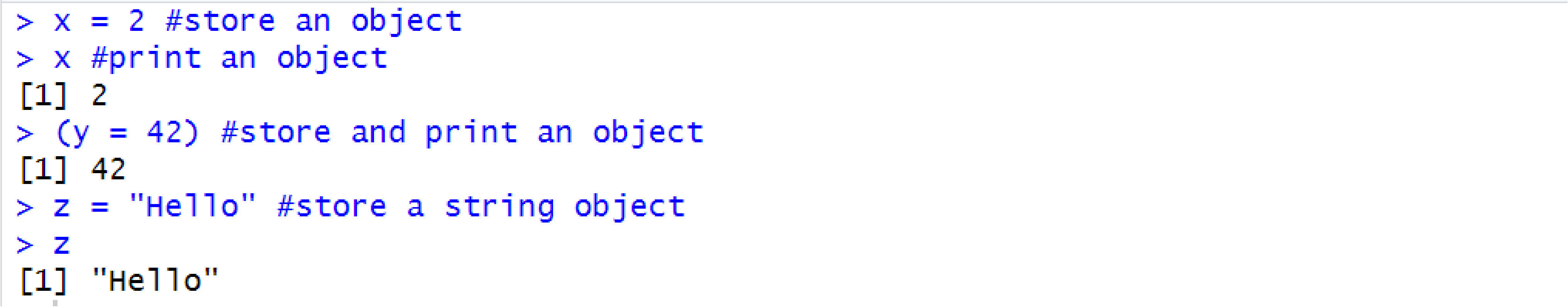


GDriveR - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
Source
Console
Terminal
Background Jobs
R 4.3.2 · C:/Users/Traeger/Meine Ablage/WS23_24 PhD/FHDTM-P2DS-WS2324/R/GDriveR/

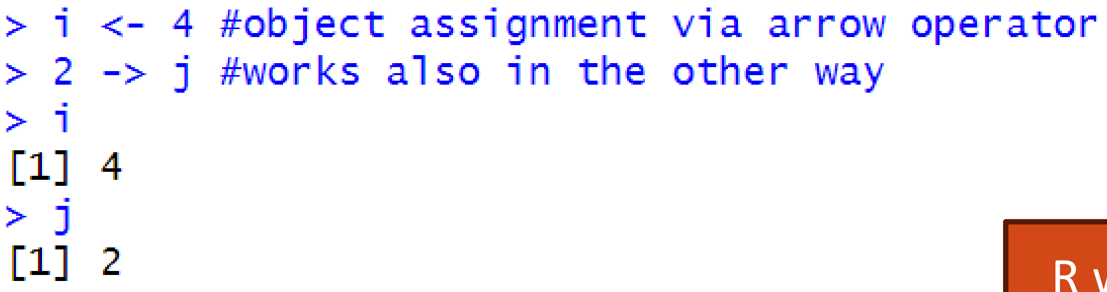
```
> 4+2
[1] 6
> log(2)
[1] 0.6931472
> exp(2)
[1] 7.389056
> log(exp(2))
[1] 2
```

Numeric and string objects

R is a dynamically typed language.



```
> x = 2 #store an object
> x #print an object
[1] 2
> (y = 42) #store and print an object
[1] 42
> z = "Hello" #store a string object
> z
[1] "Hello"
```

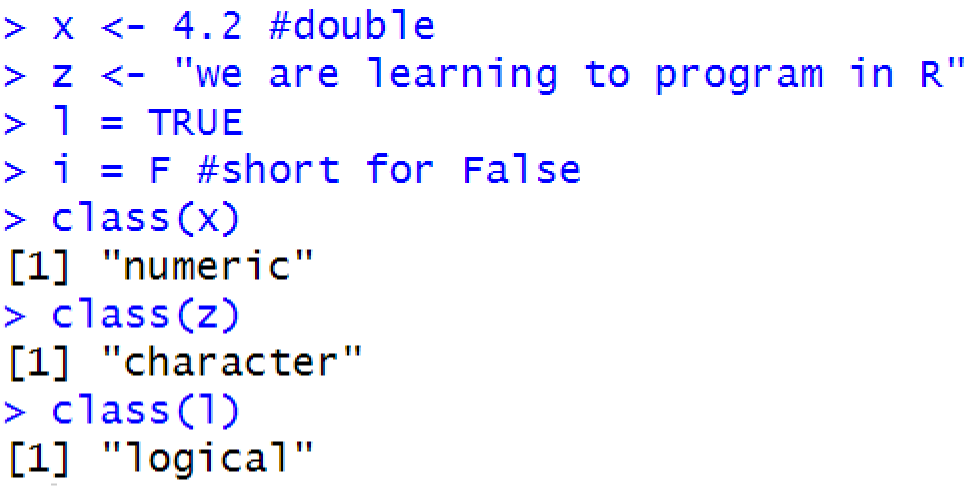


```
> i <- 4 #object assignment via arrow operator
> 2 -> j #works also in the other way
> i
[1] 4
> j
[1] 2
```

R will ignore any text after # for that line.

Objects and Class

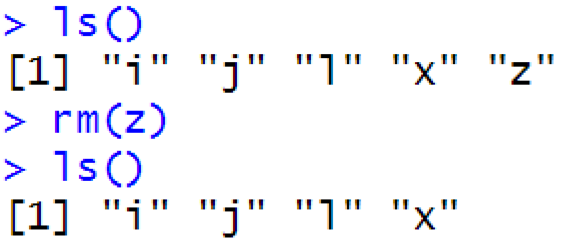
To find out which object class a variable has, use the `class(variable)` function.



```
> x <- 4.2 #double
> z <- "we are learning to program in R"
> l = TRUE
> i = F #short for False
> class(x)
[1] "numeric"
> class(z)
[1] "character"
> class(l)
[1] "logical"
```

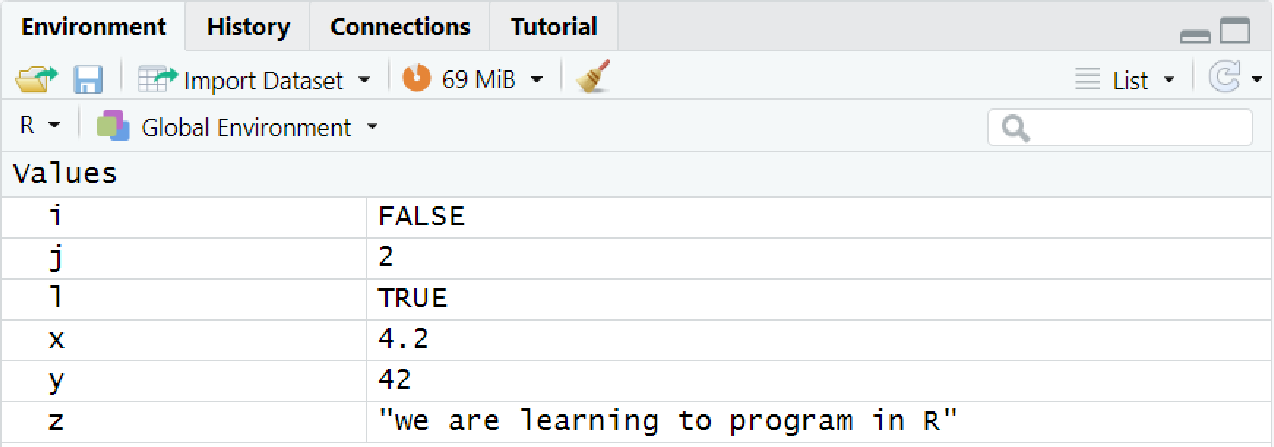
Environment Variables

- List all environment variables with the `ls()` function.
- Remove via `rm(variable)` function.



```
> ls()
[1] "i" "j" "l" "x" "z"
> rm(z)
> ls()
[1] "i" "j" "l" "x"
```

You can also see your environment variables in the top right window.



i	FALSE
j	2
l	TRUE
x	4.2
y	42
z	"we are learning to program in R"

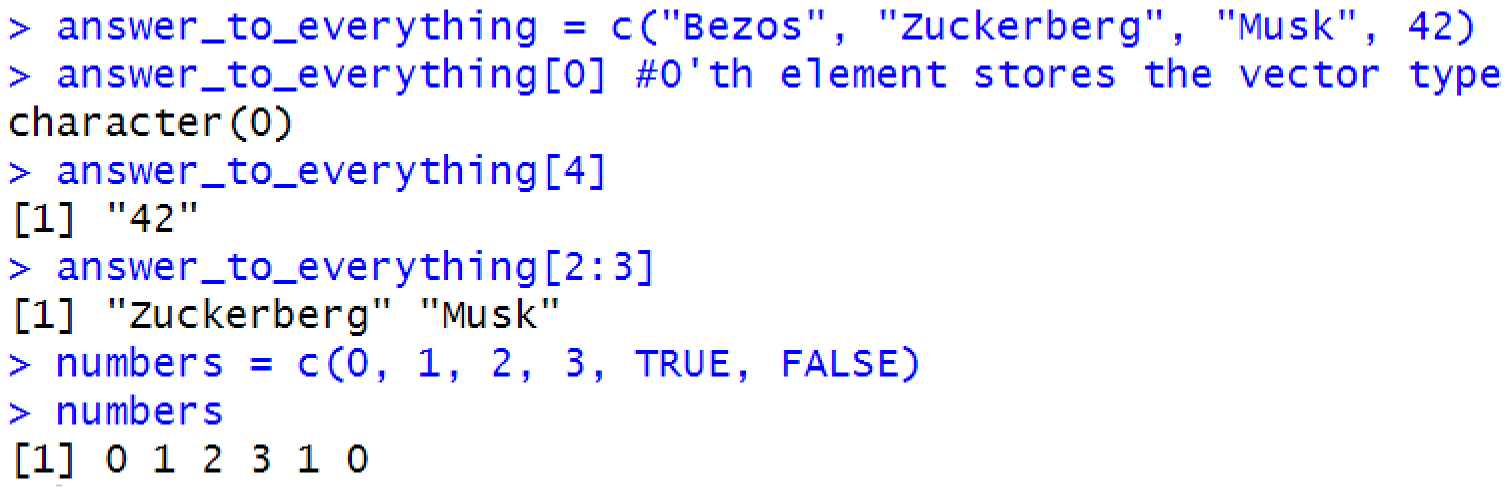
Logical Operators

`a < b`	Less than
`a > b`	Greater than
`a <= b`	Less equal than
`a >= b`	Greater equal than
`a == b`	Equal
`a != b`	Not equal
`!a`	Not
`a | b`	a OR b
`a & b`	a AND b
`isTRUE(a)`	Check whether a is TRUE
`a %in% c`	Check whether a's value is in a vector c

Vectors

Function c() (**concatenate**) creates a vector, a data structure with several elements.

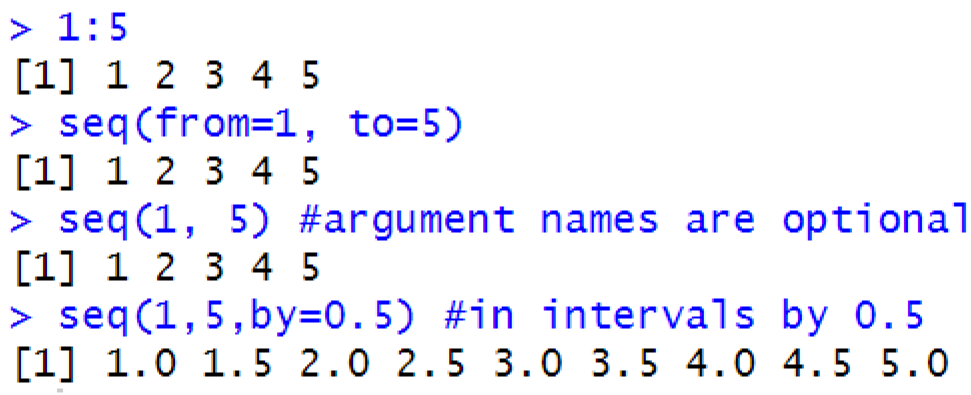
If the elements belong to **different classes** (strings, booleans, numerics), the elements are **converted** to the **same type silently**, i.e. without a warning message.



```
> answer_to_everything = c("Bezos", "Zuckerberg", "Musk", 42)
> answer_to_everything[0] #0'th element stores the vector type
character(0)
> answer_to_everything[4]
[1] "42"
> answer_to_everything[2:3]
[1] "Zuckerberg" "Musk"
> numbers = c(0, 1, 2, 3, TRUE, FALSE)
> numbers
[1] 0 1 2 3 1 0
```

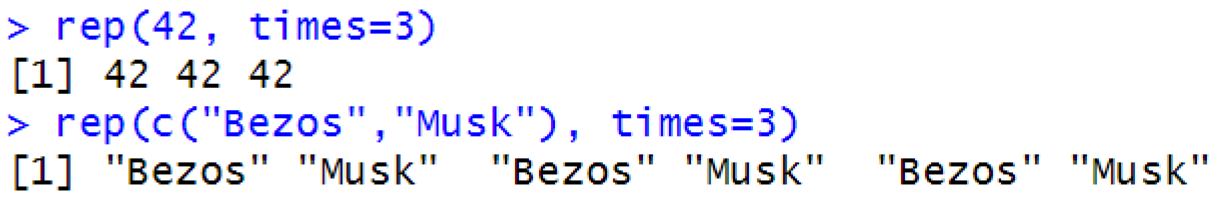
Vectors (cont.)

Use the `seq(from, to, by)` function to create regular sequences of numbers:



```
> 1:5
[1] 1 2 3 4 5
> seq(from=1, to=5)
[1] 1 2 3 4 5
> seq(1, 5) #argument names are optional in R functions
[1] 1 2 3 4 5
> seq(1,5,by=0.5) #in intervals by 0.5
[1] 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
```

Use the `rep()` function to create sequences with repeating values:



```
> rep(42, times=3)
[1] 42 42 42
> rep(c("Bezos","Musk"), times=3)
[1] "Bezos" "Musk"  "Bezos" "Musk"  "Bezos" "Musk"
```

Training #1

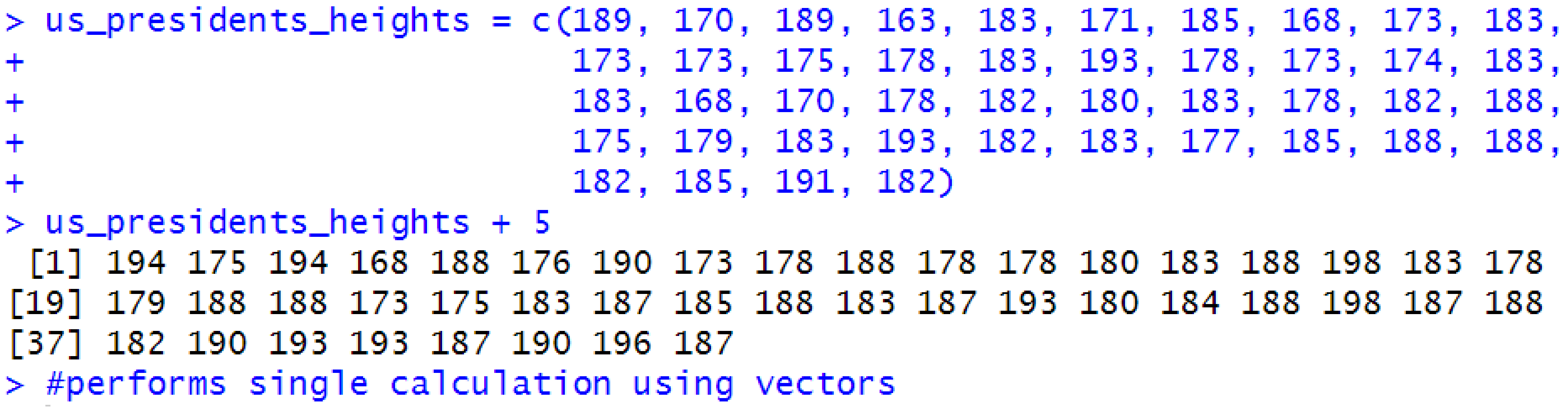
1. Create a new project in Rstudio for this class.
2. Create two variables x = “Hello“ and y = “World“ and use them to print your first “Hello World“ in R.
   Hint: use the `cat(a, b, ...)` function to print multiple variables on one line.
3. Return a vector with interchangble “R“ and “Python“ elements with the length 100.

You can access

- a virtual RStudio environment here: https://jup.labs.inf.fh-dortmund.de/
- RStudio over Anaconda
- Install R https://ftp.fau.de/cran/ and
  Rstudio https://posit.co/download/rstudio-desktop/#download

Vectors (cont.)

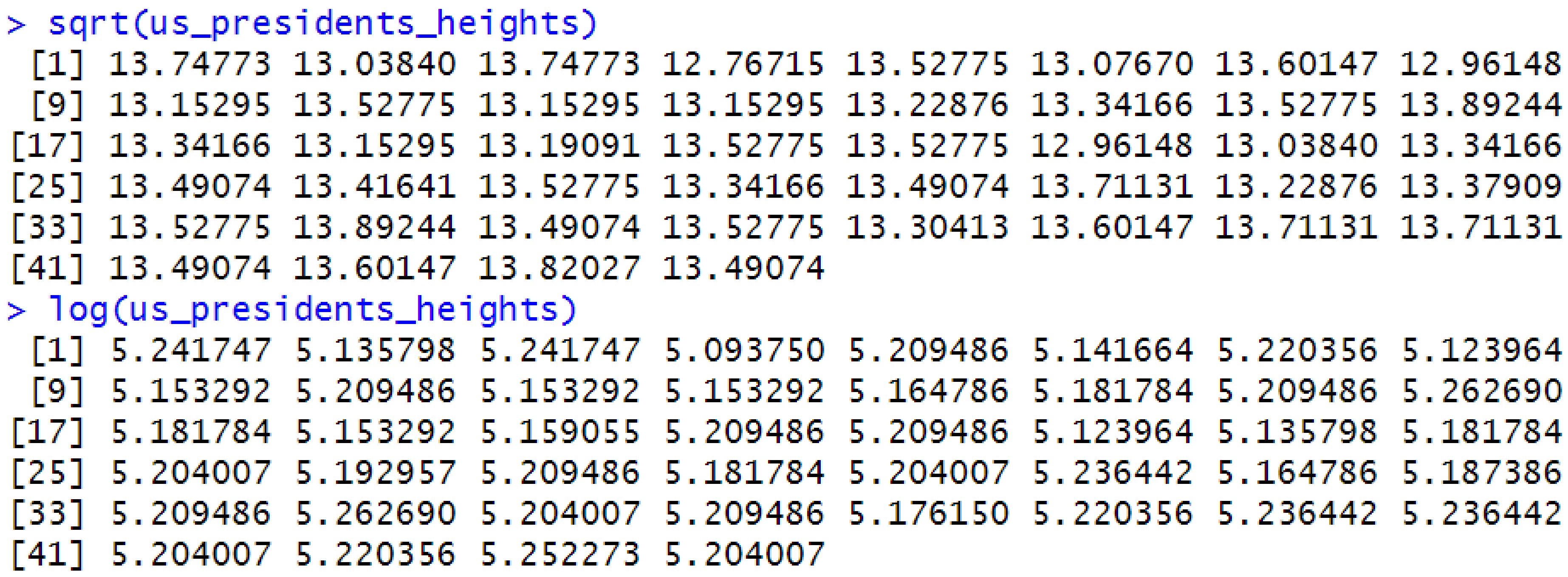
You can apply basic **arithmetic operations** and arithmetic **functions** to numeric vectors:



```
> us_presidents_heights = c(189, 170, 189, 163, 183, 171, 185, 168, 173, 183,
+                           173, 173, 175, 178, 183, 193, 178, 173, 174, 183,
+                           183, 168, 170, 178, 182, 180, 183, 178, 182, 188,
+                           175, 179, 183, 193, 182, 183, 177, 185, 188, 188,
+                           182, 185, 191, 182)
> us_presidents_heights + 5
 [1] 194 175 194 168 188 176 190 173 178 188 178 178 180 183 188 198 183 178
[19] 179 188 188 173 175 183 187 185 188 183 187 193 180 184 188 198 187 188
[37] 182 190 193 193 187 190 196 187
> #performs single calculation using vectors
```

Vectors (cont.)

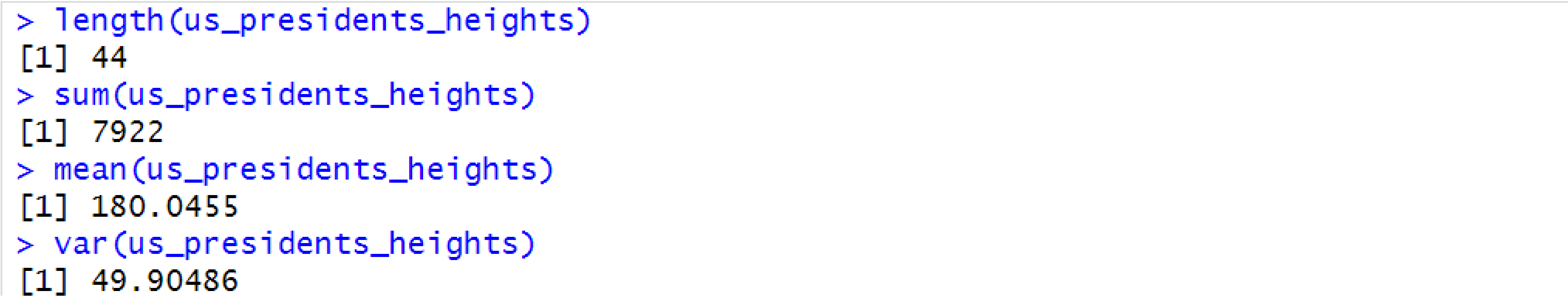
You can apply basic **arithmetic operations** and arithmetic **functions** to numeric vectors:



```
> sqrt(us_presidents_heights)
 [1] 13.74773 13.03840 13.74773 12.76715 13.52775 13.07670 13.60147 12.96148
 [9] 13.15295 13.52775 13.15295 13.15295 13.22876 13.34166 13.52775 13.89244
[17] 13.34166 13.15295 13.19091 13.52775 13.52775 12.96148 13.03840 13.34166
[25] 13.49074 13.41641 13.52775 13.34166 13.49074 13.71131 13.22876 13.37909
[33] 13.52775 13.89244 13.49074 13.52775 13.30413 13.60147 13.71131 13.71131
[41] 13.49074 13.60147 13.82027 13.49074
> log(us_presidents_heights)
 [1] 5.241747 5.135798 5.241747 5.093750 5.209486 5.141664 5.220356 5.123964
 [9] 5.153292 5.209486 5.153292 5.153292 5.164786 5.181784 5.209486 5.262690
[17] 5.181784 5.153292 5.159055 5.209486 5.209486 5.123964 5.135798 5.181784
[25] 5.204007 5.192957 5.209486 5.181784 5.204007 5.236442 5.164786 5.187386
[33] 5.209486 5.262690 5.204007 5.209486 5.176150 5.220356 5.236442 5.236442
[41] 5.204007 5.220356 5.252273 5.204007
```

Vector Aggregation

You can also describe numerical vectors with **aggregate** functions:

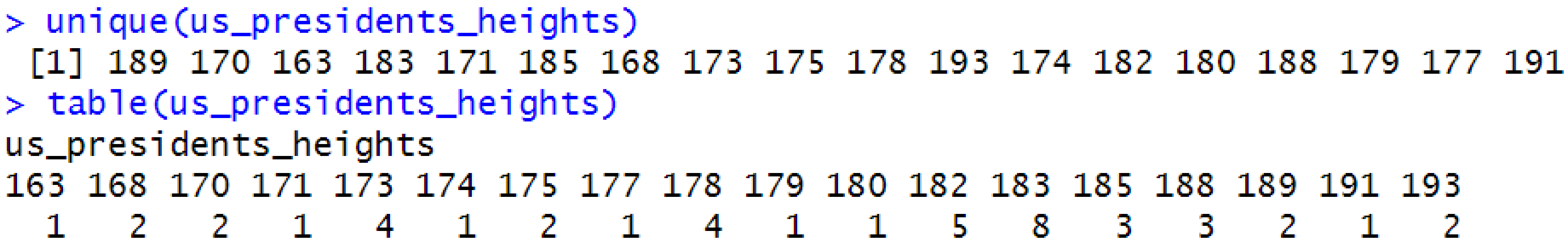


```
> length(us_presidents_heights)
[1] 44
> sum(us_presidents_heights)
[1] 7922
> mean(us_presidents_heights)
[1] 180.0455
> var(us_presidents_heights)
[1] 49.90486
```

Vector Aggregation (cont.)

Use `unique(vector)` to display the unique items of a vector.

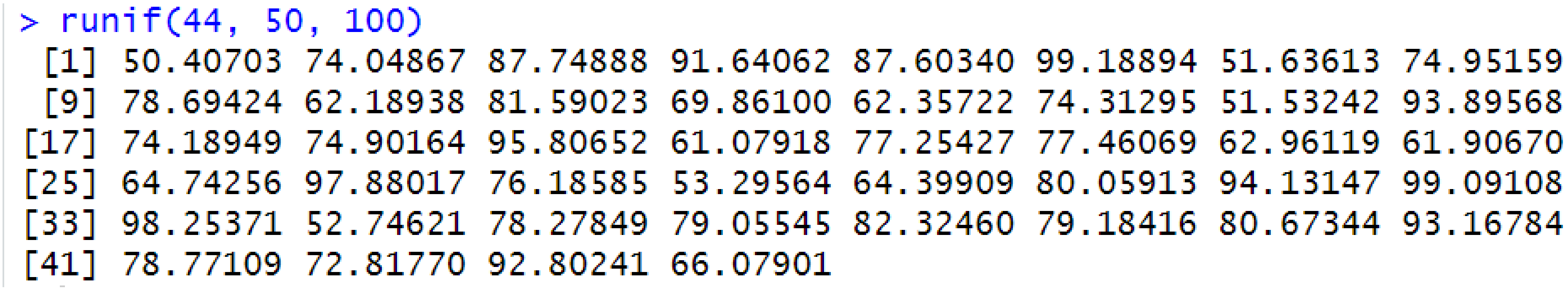
Use `table(vector)` to display a list of unique items and frequency of occurrence.



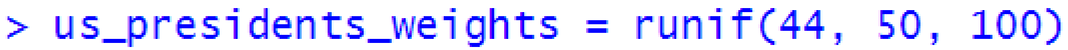
```
> unique(us_presidents_heights)
 [1] 189 170 163 183 171 185 168 173 175 178 193 174 182 180 188 179 177 191
> table(us_presidents_heights)
us_presidents_heights
163 168 170 171 173 174 175 177 178 179 180 182 183 185 188 189 191 193 
  1   2   2   1   4   1   2   1   4   1   1   5   8   3   3   2   1   2 
```

Random Numbers

You can use the `runif(#, min, max)` function to generate random variables:



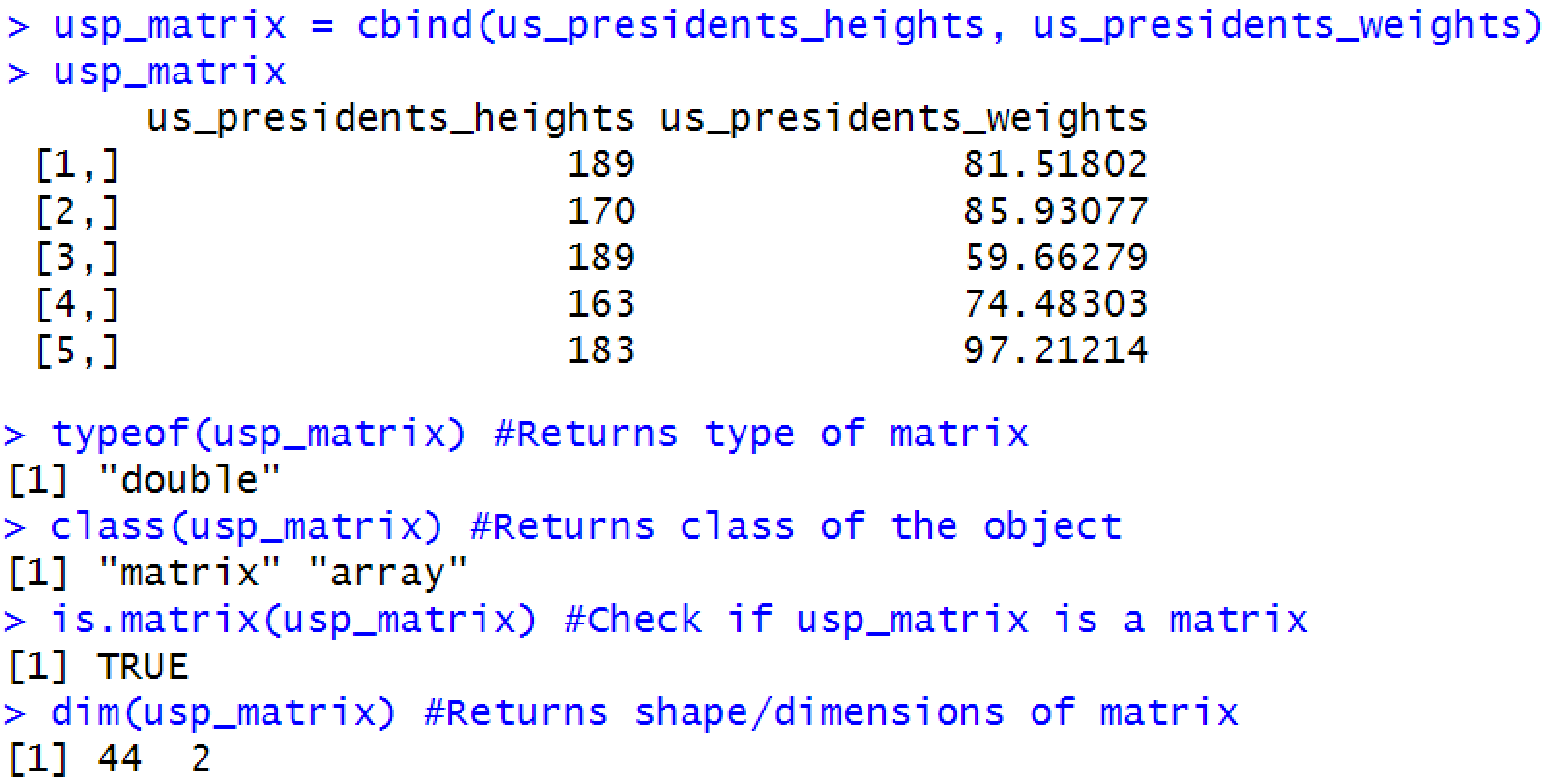
```
> runif(44, 50, 100)
 [1] 50.40703 74.04867 87.74888 91.64062 87.60340 99.18894 51.63613 74.95159
 [9] 78.69424 62.18938 81.59023 69.86100 62.35722 74.31295 51.53242 93.89568
[17] 74.18949 74.90164 95.80652 61.07918 77.25427 77.46069 62.96119 61.90670
[25] 64.74256 97.88017 76.18585 53.29564 64.39909 80.05913 94.13147 99.09108
[33] 98.25371 52.74621 78.27849 79.05545 82.32460 79.18416 80.67344 93.16784
[41] 78.77109 72.81770 92.80241 66.07901
```



```
> us_presidents_weights = runif(44, 50, 100)
```

Matricies

Create matricies via the `cbind(vector**)` function:



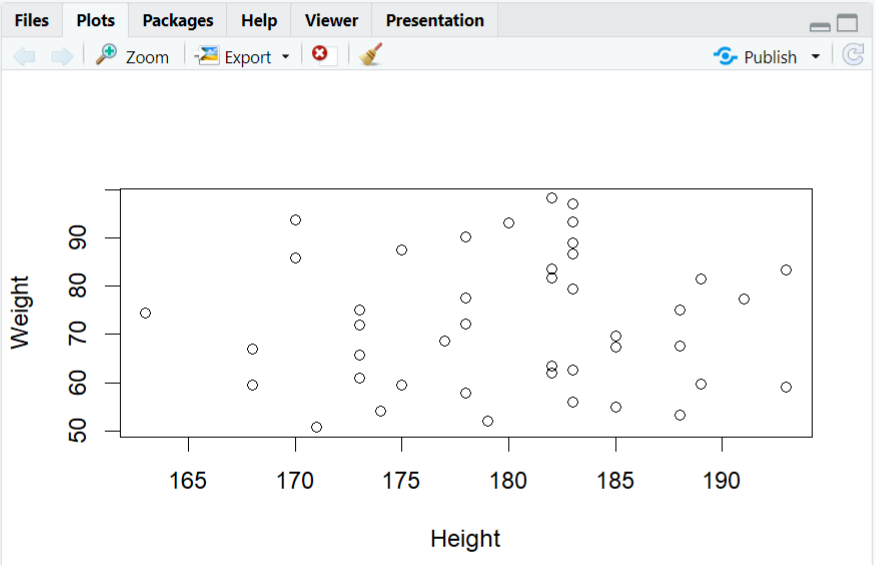
```
> usp_matrix = cbind(us_presidents_heights, us_presidents_weights)
> usp_matrix
      us_presidents_heights us_presidents_weights
 [1,]                   189              81.51802
 [2,]                   170              85.93077
 [3,]                   189              59.66279
 [4,]                   163              74.48303
 [5,]                   183              97.21214

> typeof(usp_matrix) #Returns type of matrix
[1] "double"
> class(usp_matrix) #Returns class of the object
[1] "matrix" "array"
> is.matrix(usp_matrix) #Check if usp_matrix is a matrix
[1] TRUE
> dim(usp_matrix) #Returns shape/dimensions of matrix
[1] 44  2
```

Simple Plotting

Use the `plot(x,y, ylab, xlab)` function for a Scatter Plot:

```
> plot(us_presidents_heights,us_presidents_weights,ylab="Weight",xlab="Height")
```

The plot will appear in the right bottom grid under the tab „Plots“:



For more advanced and attractive data visualizations, use ggplot.

Training #2

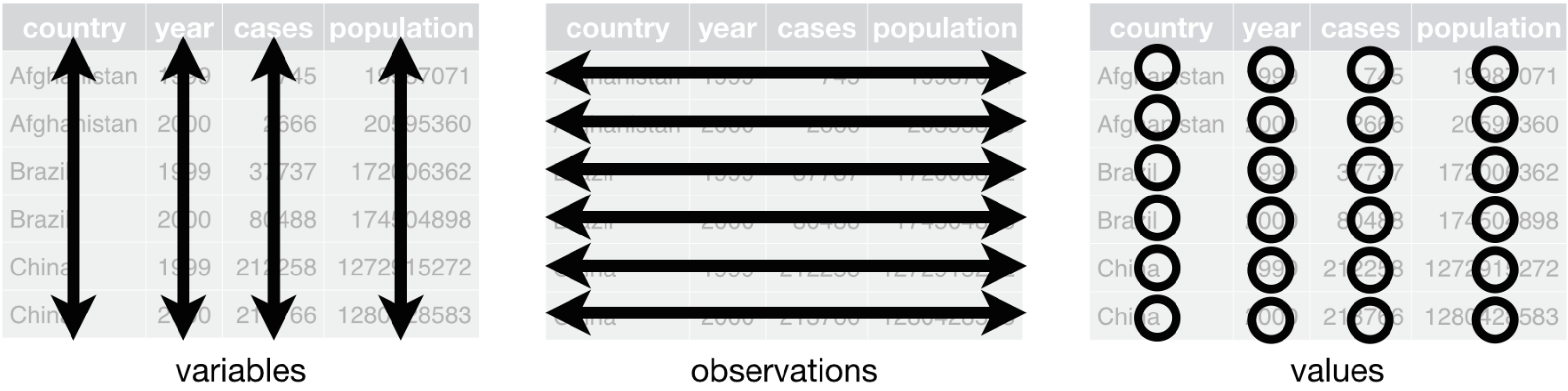
1. Create a vector called **grades** with 100 (random) grades ranging from one to five.
2. Use the `round(vector, digits=0)` method to round the grades to integers.
3. View the frequency of grades using the `table()` function.
4. Compute the mean grade using the `length()` and `sum()` function. Do you receive the same mean grade when using the `mean()` function?

Break

DataFrames

An extremely important data structure in R (two-dimensional table).

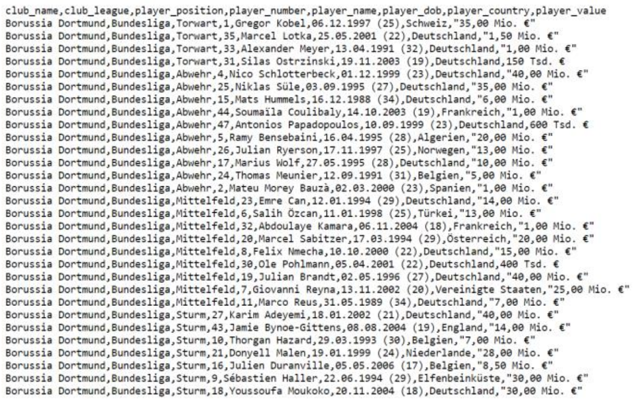
- Rows also called observations.
- Columns also called variables (not to be confused with the variables from before!).



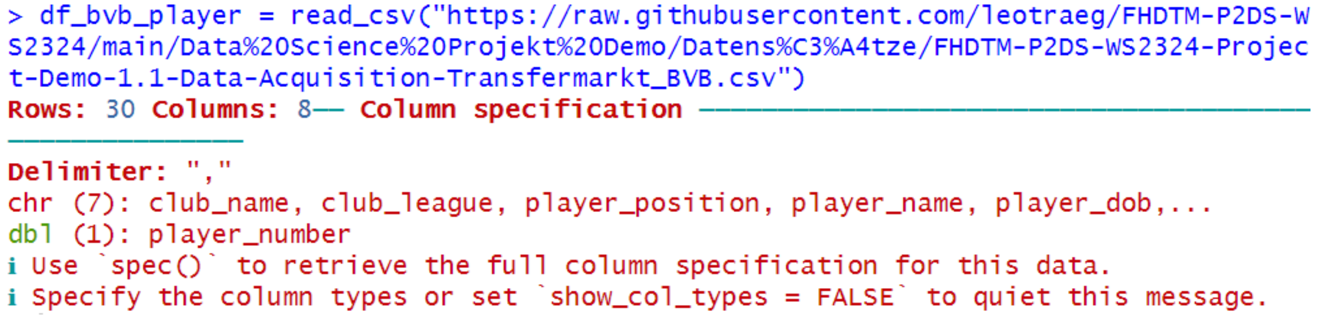
R for Data Science (e2) by Wickham, Çetinkaya-Rundel, and Grolemund library(readr)

Reading data from .csv

Read .csv files into R using `read_csv(path)` :



```
club_name,club_league,player_position,player_number,player_name,player_dob,player_country,player_value
Borussia Dortmund,Bundesliga,Torwart,1,Gregor Kobel,06.12.1997 (25),Schweiz,"35,00 Mio. €"
Borussia Dortmund,Bundesliga,Torwart,35,Marcel Lotka,25.05.2001 (22),Deutschland,"1,50 Mio. €"
Borussia Dortmund,Bundesliga,Torwart,33,Alexander Meyer,13.04.1991 (32),Deutschland,"1,00 Mio. €"
Borussia Dortmund,Bundesliga,Torwart,31,Silas Ostrzinski,19.11.2003 (19),Deutschland,150 Tsd. €
Borussia Dortmund,Bundesliga,Abwehr,4,Nico Schlotterbeck,01.12.1999 (23),Deutschland,"40,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,25,Niklas Süle,03.09.1995 (27),Deutschland,"35,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,15,Mats Hummels,16.12.1988 (34),Deutschland,"6,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,44,Soumaïla Coulibaly,14.10.2003 (19),Frankreich,"1,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,47,Antonios Papadopoulos,10.09.1999 (23),Deutschland,600 Tsd. €
Borussia Dortmund,Bundesliga,Abwehr,5,Ramy Bensebaini,16.04.1995 (28),Algerien,"20,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,26,Julian Ryerson,17.11.1997 (25),Norwegen,"13,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,17,Marius Wolf,27.05.1995 (28),Deutschland,"10,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,24,Thomas Meunier,12.09.1991 (31),Belgien,"5,00 Mio. €"
Borussia Dortmund,Bundesliga,Abwehr,2,Mateu Morey Bauzà,02.03.2000 (23),Spanien,"1,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,23,Emre Can,12.01.1994 (29),Deutschland,"14,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,6,Salih Özcan,11.01.1998 (25),Türkei,"13,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,32,Abdoulaye Kamara,06.11.2004 (18),Frankreich,"1,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,20,Marcel Sabitzer,17.03.1994 (29),Österreich,"20,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,8,Felix Nmecha,10.10.2000 (22),Deutschland,"15,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,30,Ole Pohlmann,05.04.2001 (22),Deutschland,400 Tsd. €
Borussia Dortmund,Bundesliga,Mittelfeld,19,Julian Brandt,02.05.1996 (27),Deutschland,"40,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,7,Giovanni Reyna,13.11.2002 (20),Vereinigte Staaten,"25,00 Mio. €"
Borussia Dortmund,Bundesliga,Mittelfeld,11,Marco Reus,31.05.1989 (34),Deutschland,"7,00 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,27,Karim Adeyemi,18.01.2002 (21),Deutschland,"40,00 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,43,Jamie Bynoe-Gittens,08.08.2004 (19),England,"14,00 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,10,Thorgan Hazard,29.03.1993 (30),Belgien,"7,00 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,21,Donyell Malen,19.01.1999 (24),Niederlande,"28,00 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,16,Julien Duranville,05.05.2006 (17),Belgien,"8,50 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,9,Sébastien Haller,22.06.1994 (29),Elfenbeinküste,"30,00 Mio. €"
Borussia Dortmund,Bundesliga,Sturm,18,Youssoufa Moukoko,20.11.2004 (18),Deutschland,"30,00 Mio. €"
```



```
> df_bvb_player = read_csv("https://raw.githubusercontent.com/leotraeg/FHDTM-P2DS-W
S2324/main/Data%20Science%20Projekt%20Demo/Datens%C3%A4tze/FHDTM-P2DS-WS2324-Projec
t-Demo-1.1-Data-Acquisition-Transfermarkt_BVB.csv")
Rows: 30 Columns: 8── Column specification ──────────────────────────────────────
────────────────
Delimiter: ","
chr (7): club_name, club_league, player_position, player_name, player_dob,...
dbl (1): player_number
ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

In successful .csv read; a log message tells you the

- Number of rows and columns.
- Delimiter in use.
- Column name and type specifications.

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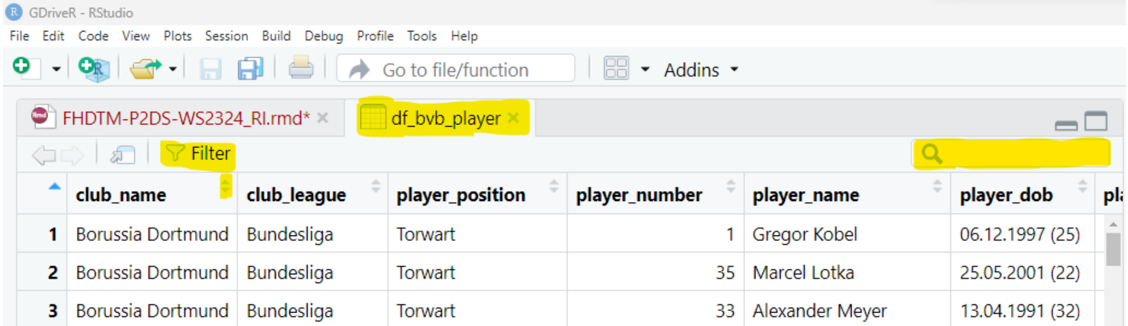
Explore DataFrame

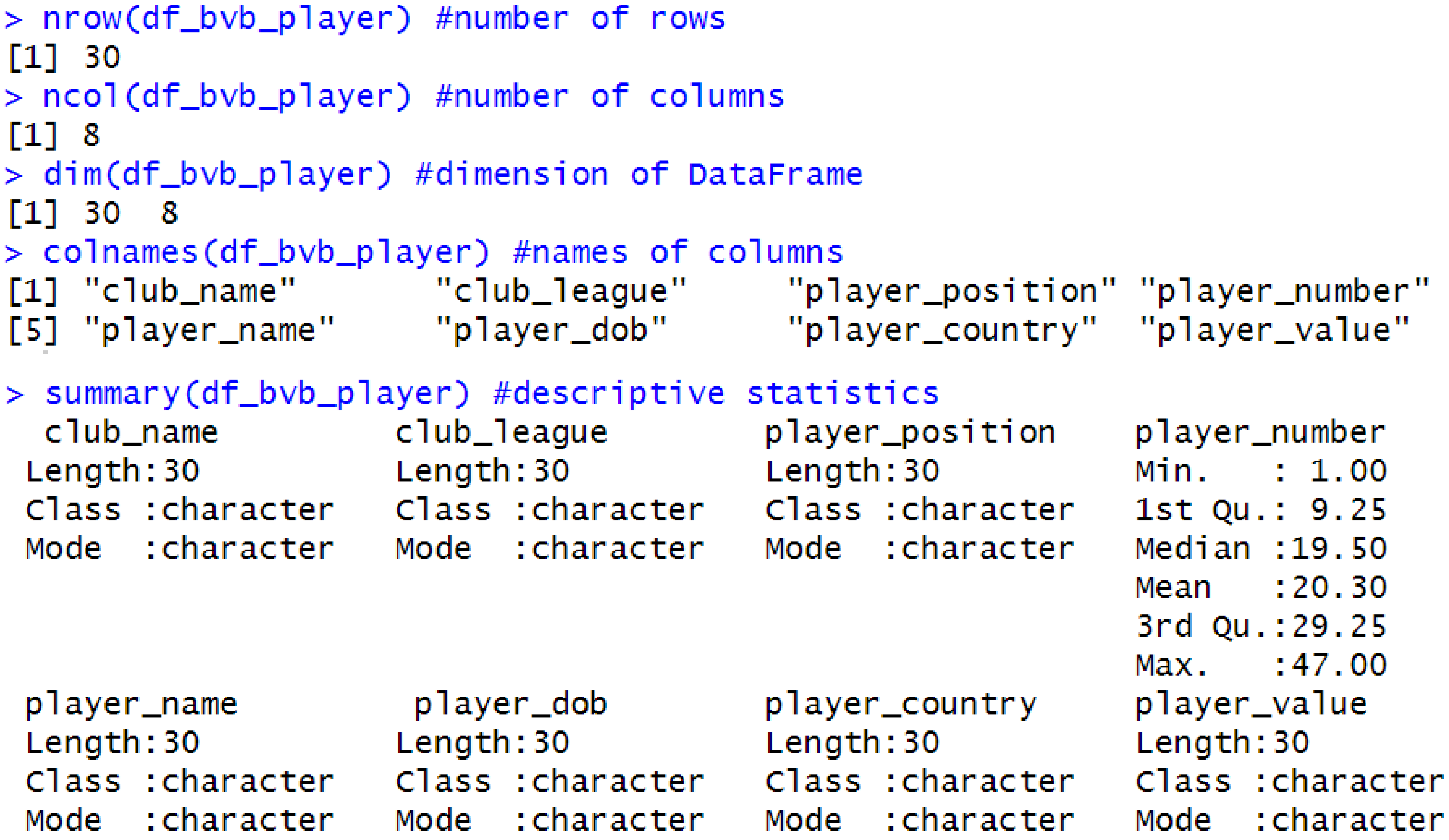
tail(dataframe)
returns the last few rows

```
> head(df_bvb_player) #View the first rows of dataset
# A tibble: 6 × 8
  club_name   club_league player_position player_number player_name player_dob
  <chr>       <chr>       <chr>                   <dbl> <chr>       <chr>
1 Borussia D… Bundesliga  Torwart                     1 Gregor Kob… 06.12.199…
2 Borussia D… Bundesliga  Torwart                    35 Marcel Lot… 25.05.200…
3 Borussia D… Bundesliga  Torwart                    33 Alexander … 13.04.199…
4 Borussia D… Bundesliga  Torwart                    31 Silas Ostr… 19.11.200…
5 Borussia D… Bundesliga  Abwehr                      4 Nico Schlo… 01.12.199…
6 Borussia D… Bundesliga  Abwehr                     25 Niklas Süle 03.09.199…
# ℹ 2 more variables: player_country <chr>, player_value <chr>
> view(df_bvb_player) #View DataFrame in an additional sub-window
```



	club_name	club_league	player_position	player_number	player_name	player_dob	pl
1	Borussia Dortmund	Bundesliga	Torwart	1	Gregor Kobel	06.12.1997 (25)	
2	Borussia Dortmund	Bundesliga	Torwart	35	Marcel Lotka	25.05.2001 (22)	
3	Borussia Dortmund	Bundesliga	Torwart	33	Alexander Meyer	13.04.1991 (32)	

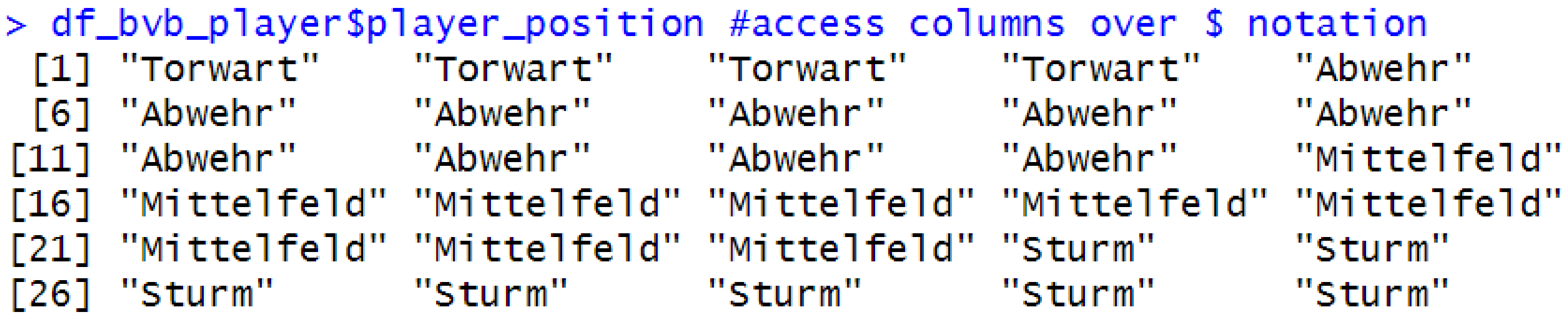
Explore DataFrame (cont.)



```
> nrow(df_bvb_player) #number of rows
[1] 30
> ncol(df_bvb_player) #number of columns
[1] 8
> dim(df_bvb_player) #dimension of DataFrame
[1] 30  8
> colnames(df_bvb_player) #names of columns
[1] "club_name"       "club_league"     "player_position" "player_number"
[5] "player_name"     "player_dob"      "player_country"  "player_value"

> summary(df_bvb_player) #descriptive statistics
  club_name         club_league        player_position    player_number
 Length:30          Length:30          Length:30          Min.   : 1.00
 Class :character   Class :character   Class :character   1st Qu.: 9.25
 Mode  :character   Mode  :character   Mode  :character   Median :19.50
                                                          Mean   :20.30
                                                          3rd Qu.:29.25
                                                          Max.   :47.00
 player_name         player_dob        player_country     player_value
 Length:30          Length:30          Length:30          Length:30
 Class :character   Class :character   Class :character   Class :character
 Mode  :character   Mode  :character   Mode  :character   Mode  :character
```

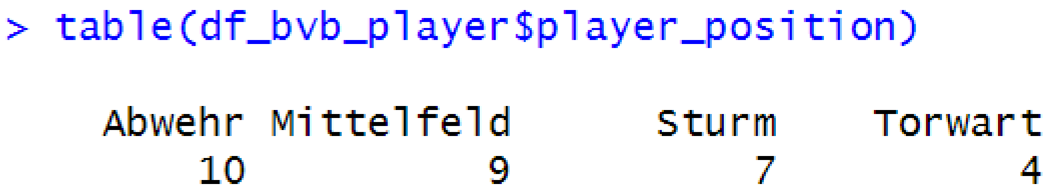
Explore DataFrame (cont.)

You can access columns in a DataFrame via $ notation:



```
> df_bvb_player$player_position #access columns over $ notation
 [1] "Torwart"    "Torwart"    "Torwart"    "Torwart"    "Abwehr"    
 [6] "Abwehr"     "Abwehr"     "Abwehr"     "Abwehr"     "Abwehr"    
[11] "Abwehr"     "Abwehr"     "Abwehr"     "Abwehr"     "Mittelfeld"
[16] "Mittelfeld" "Mittelfeld" "Mittelfeld" "Mittelfeld" "Mittelfeld"
[21] "Mittelfeld" "Mittelfeld" "Mittelfeld" "Sturm"      "Sturm"     
[26] "Sturm"      "Sturm"      "Sturm"      "Sturm"      "Sturm"     
```

In the end, columns of DataFrames or nothing else than a vector (c) – and you can apply vector functions on them such as `table()`:



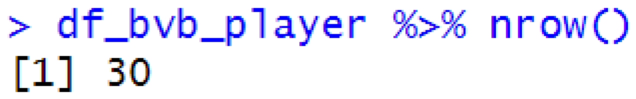
```
> table(df_bvb_player$player_position)

    Abwehr Mittelfeld      Sturm    Torwart 
        10          9          7          4 
```

Pipe %>%

Important tidyverse **syntax** important for Data Wrangling.

From now on, we start our coding with the DataFrame, the pipe %>%, and the function.

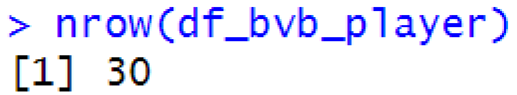
The pipe always takes what is to the left and passes it on to the function to the right:



```
> df_bvb_player %>% nrow()
[1] 30
```

In the code above, the `nrow()` function is applied to the `df_bvb_player`.

This is the same as the following line of code:



```
> nrow(df_bvb_player)
[1] 30
```

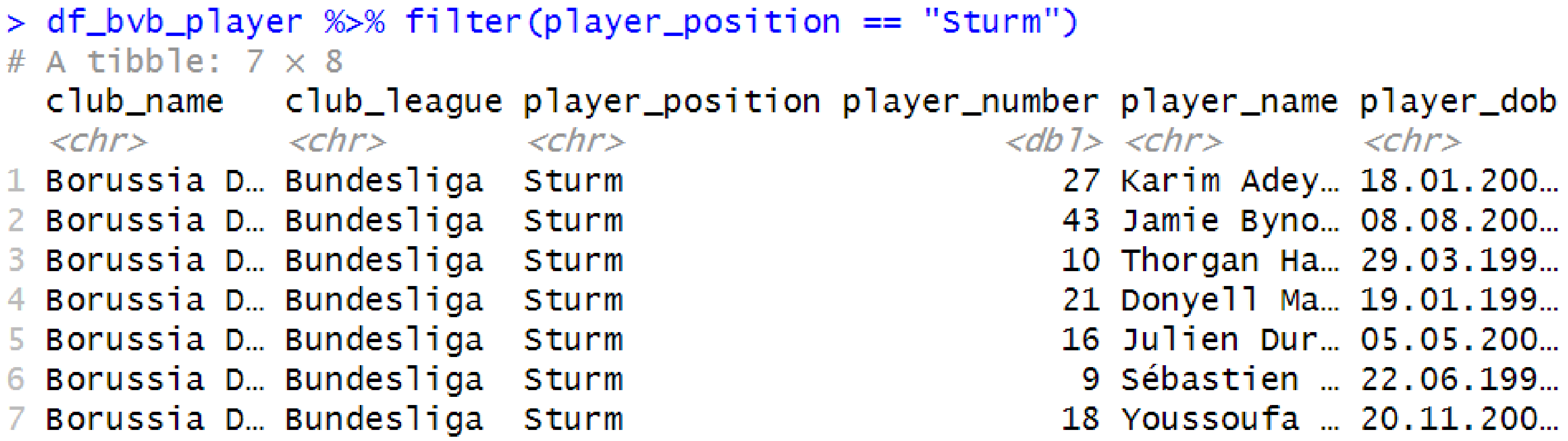
The **advantage** is that you can **connect as many functions** to the pipe **as you want**.

library(dplyr)

DataFrame Filtering

Rows are selected using the `filter(bool_statement)` function.

The function receives one or more logical expressions as argument(s).

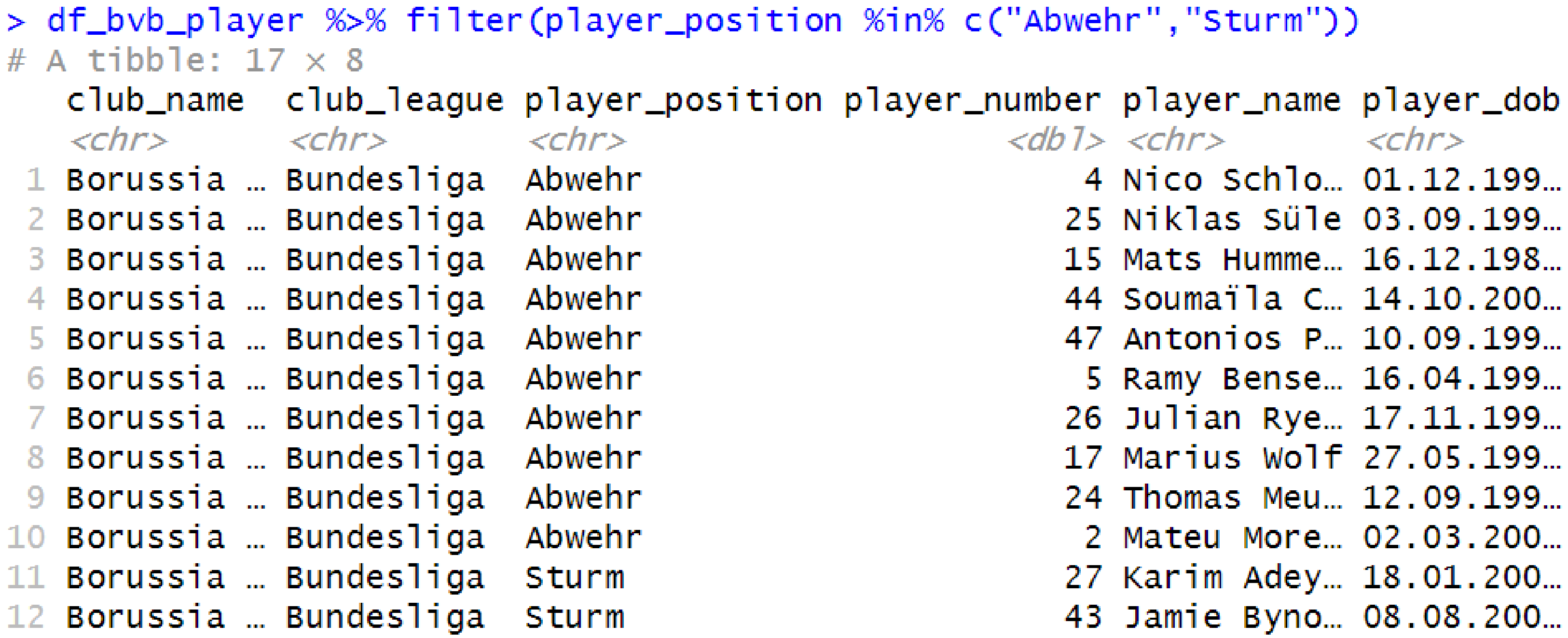


```
> df_bvb_player %>% filter(player_position == "Sturm")
# A tibble: 7 × 8
  club_name   club_league player_position player_number player_name player_dob
  <chr>       <chr>       <chr>                   <dbl> <chr>       <chr>
1 Borussia D… Bundesliga  Sturm                      27 Karim Adey… 18.01.200…
2 Borussia D… Bundesliga  Sturm                      43 Jamie Byno… 08.08.200…
3 Borussia D… Bundesliga  Sturm                      10 Thorgan Ha… 29.03.199…
4 Borussia D… Bundesliga  Sturm                      21 Donyell Ma… 19.01.199…
5 Borussia D… Bundesliga  Sturm                      16 Julien Dur… 05.05.200…
6 Borussia D… Bundesliga  Sturm                       9 Sébastien … 22.06.199…
7 Borussia D… Bundesliga  Sturm                      18 Youssoufa … 20.11.200…
```

DataFrame Filtering (cont.)

Rows are selected using the `filter(bool_statement)` function.

The function receives one or more logical expressions as argument(s).



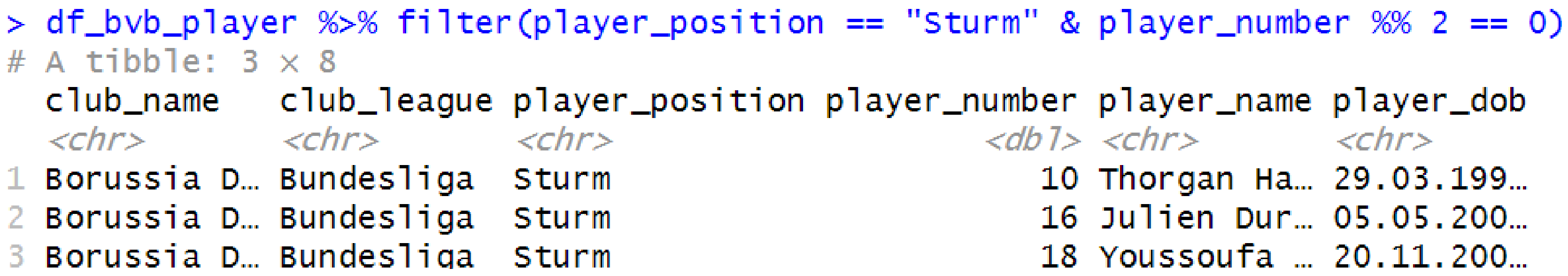
```
> df_bvb_player %>% filter(player_position %in% c("Abwehr","Sturm"))
# A tibble: 17 × 8
   club_name   club_league player_position player_number player_name player_dob
   <chr>       <chr>       <chr>                   <dbl> <chr>       <chr>
 1 Borussia … Bundesliga  Abwehr                      4 Nico Schlo… 01.12.199…
 2 Borussia … Bundesliga  Abwehr                     25 Niklas Süle 03.09.199…
 3 Borussia … Bundesliga  Abwehr                     15 Mats Humme… 16.12.198…
 4 Borussia … Bundesliga  Abwehr                     44 Soumaïla C… 14.10.200…
 5 Borussia … Bundesliga  Abwehr                     47 Antonios P… 10.09.199…
 6 Borussia … Bundesliga  Abwehr                      5 Ramy Bense… 16.04.199…
 7 Borussia … Bundesliga  Abwehr                     26 Julian Rye… 17.11.199…
 8 Borussia … Bundesliga  Abwehr                     17 Marius Wolf 27.05.199…
 9 Borussia … Bundesliga  Abwehr                     24 Thomas Meu… 12.09.199…
10 Borussia … Bundesliga  Abwehr                      2 Mateu More… 02.03.200…
11 Borussia … Bundesliga  Sturm                      27 Karim Adey… 18.01.200…
12 Borussia … Bundesliga  Sturm                      43 Jamie Byno… 08.08.200…
```

library(dplyr)

DataFrame Filtering (cont.)

Rows are selected using the `filter(bool_statement)` function.

The function receives one or more logical expressions as argument(s).

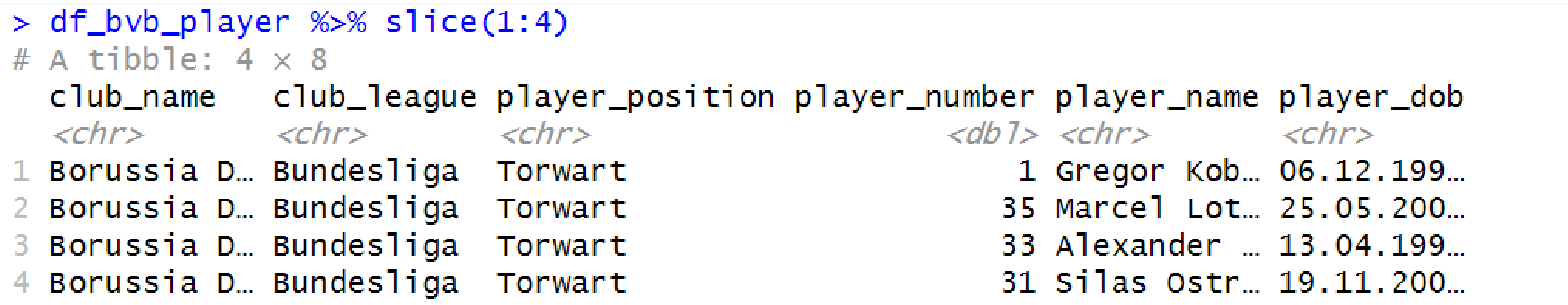


```
> df_bvb_player %>% filter(player_position == "Sturm" & player_number %% 2 == 0)
# A tibble: 3 × 8
  club_name    club_league player_position player_number player_name player_dob
  <chr>        <chr>       <chr>                   <dbl> <chr>       <chr>
1 Borussia D… Bundesliga  Sturm                      10 Thorgan Ha… 29.03.199…
2 Borussia D… Bundesliga  Sturm                      16 Julien Dur… 05.05.200…
3 Borussia D… Bundesliga  Sturm                      18 Youssoufa … 20.11.200…
```

DataFrame Slicing

The rows in a data frame are numbered consecutively, i.e., the rows have an **index**.

Use `slice(index or sequence)` to select rows with the internal index.

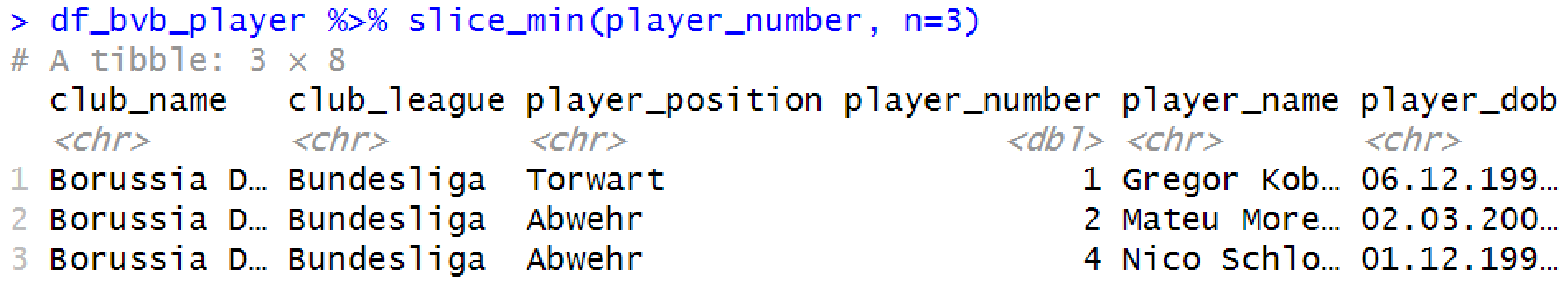


```
> df_bvb_player %>% slice(1:4)
# A tibble: 4 × 8
  club_name   club_league player_position player_number player_name player_dob
  <chr>       <chr>       <chr>                   <dbl> <chr>       <chr>     
1 Borussia D… Bundesliga  Torwart                     1 Gregor Kob… 06.12.199…
2 Borussia D… Bundesliga  Torwart                    35 Marcel Lot… 25.05.200…
3 Borussia D… Bundesliga  Torwart                    33 Alexander … 13.04.199…
4 Borussia D… Bundesliga  Torwart                    31 Silas Ostr… 19.11.200…
```

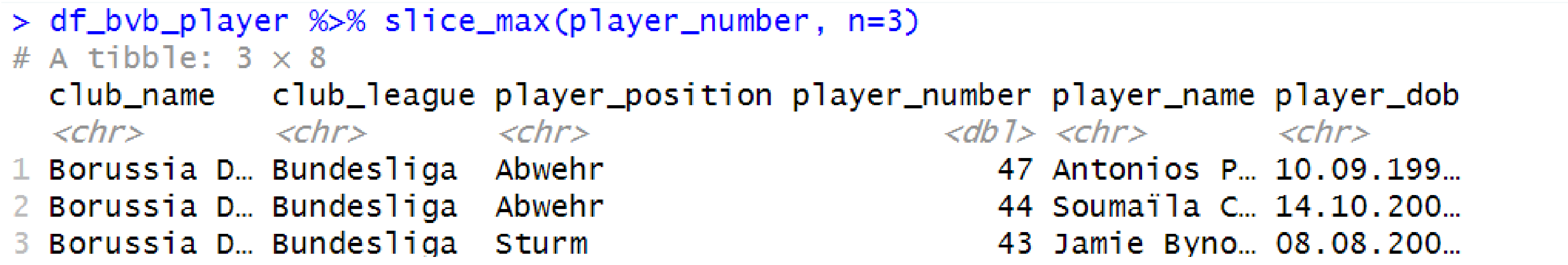
DataFrame Slicing (cont.)

Also works on categorical attributes with alphabetical order

The functions `slice_min(column , n=1)` and `slice_max(column, n=1)` return the n rows that have the **lowest** or **highest** values in a column.



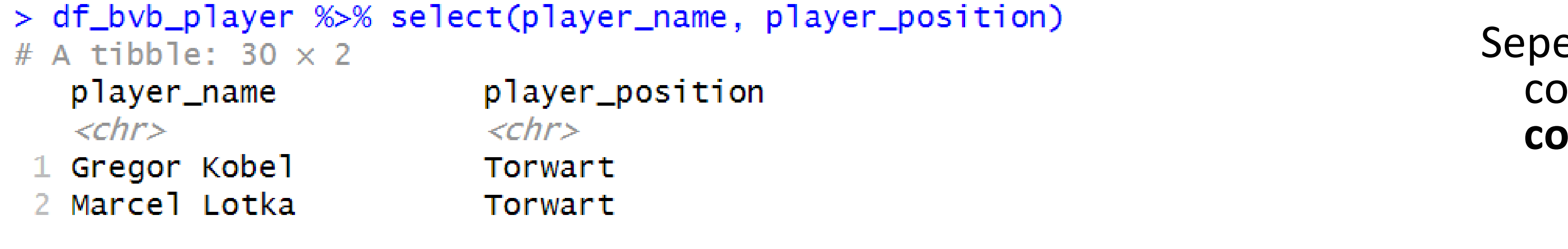
```
> df_bvb_player %>% slice_min(player_number, n=3)
# A tibble: 3 × 8
  club_name   club_league player_position player_number player_name player_dob
  <chr>       <chr>       <chr>                   <dbl> <chr>       <chr>
1 Borussia D… Bundesliga  Torwart                     1 Gregor Kob… 06.12.199…
2 Borussia D… Bundesliga  Abwehr                      2 Mateu More… 02.03.200…
3 Borussia D… Bundesliga  Abwehr                      4 Nico Schlo… 01.12.199…
```



```
> df_bvb_player %>% slice_max(player_number, n=3)
# A tibble: 3 × 8
  club_name   club_league player_position player_number player_name player_dob
  <chr>       <chr>       <chr>                   <dbl> <chr>       <chr>
1 Borussia D… Bundesliga  Abwehr                     47 Antonios P… 10.09.199…
2 Borussia D… Bundesliga  Abwehr                     44 Soumaïla C… 14.10.200…
3 Borussia D… Bundesliga  Sturm                      43 Jamie Byno… 08.08.200…
```

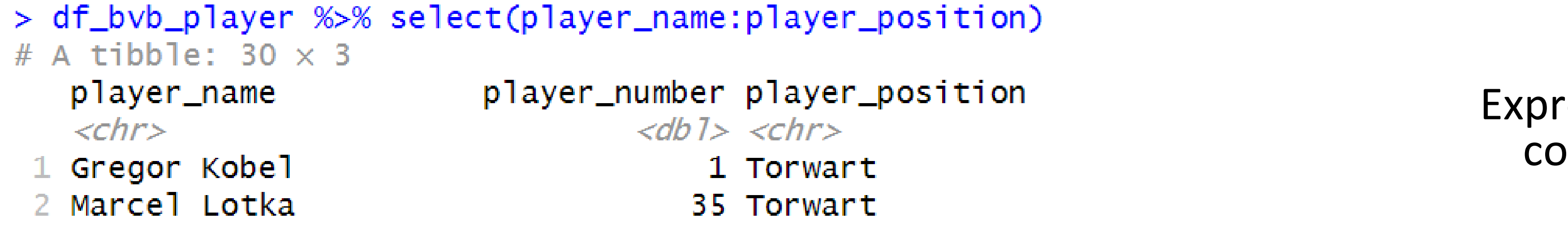
DataFrame Selecting

To select attributes/columns/variables, you can use the function `select()`.



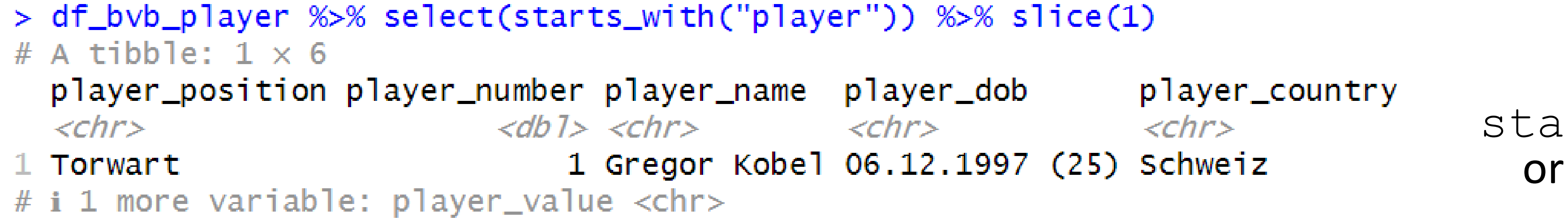
```
> df_bvb_player %>% select(player_name, player_position)
# A tibble: 30 × 2
   player_name          player_position
   <chr>                <chr>
 1 Gregor Kobel         Torwart
 2 Marcel Lotka         Torwart
```

Seperate multiple columns with a **comma**



```
> df_bvb_player %>% select(player_name:player_position)
# A tibble: 30 × 3
   player_name          player_number player_position
   <chr>                        <dbl> <chr>
 1 Gregor Kobel                     1 Torwart
 2 Marcel Lotka                    35 Torwart
```

Express range of columns with **colon**



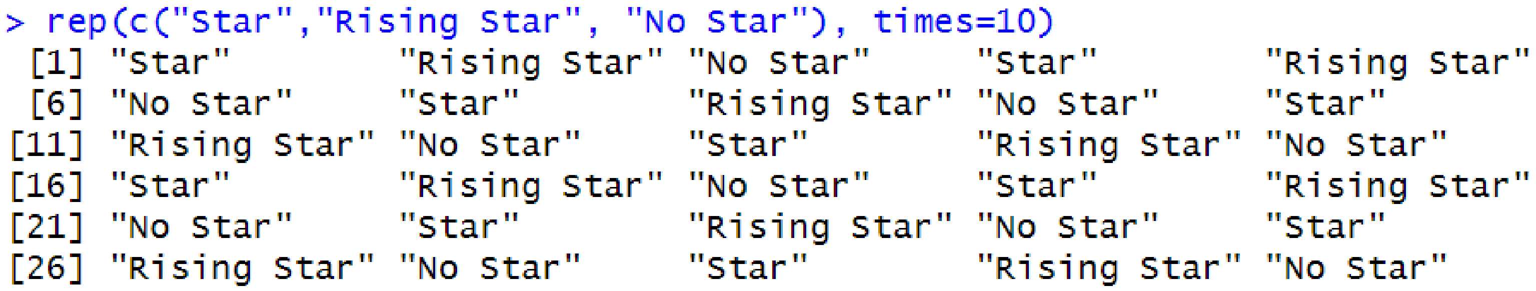
```
> df_bvb_player %>% select(starts_with("player")) %>% slice(1)
# A tibble: 1 × 6
  player_position player_number player_name  player_dob      player_country
  <chr>                   <dbl> <chr>        <chr>           <chr>
1 Torwart                     1 Gregor Kobel 06.12.1997 (25) Schweiz
# ℹ 1 more variable: player_value <chr>
```

`starts_with()` or `end_with()`

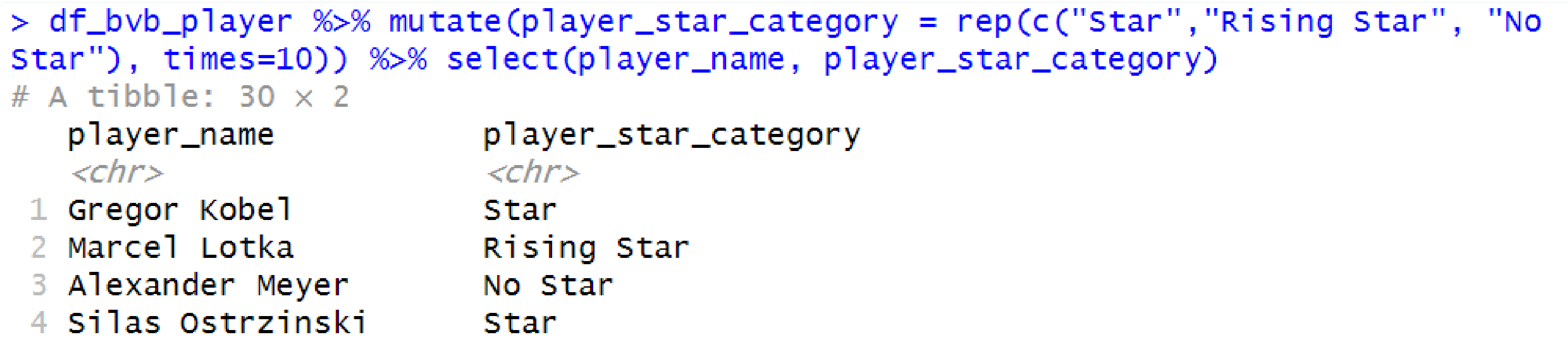
DataFrame Mutating

We can append or change columns to data frames with `mutate()`.

It receives as arguments a new column name with the values as a vector.



```
> rep(c("Star","Rising Star", "No Star"), times=10)
 [1] "Star"        "Rising Star" "No Star"     "Star"        "Rising Star"
 [6] "No Star"     "Star"        "Rising Star" "No Star"     "Star"       
[11] "Rising Star" "No Star"     "Star"        "Rising Star" "No Star"    
[16] "Star"        "Rising Star" "No Star"     "Star"        "Rising Star"
[21] "No Star"     "Star"        "Rising Star" "No Star"     "Star"       
[26] "Rising Star" "No Star"     "Star"        "Rising Star" "No Star"    
```

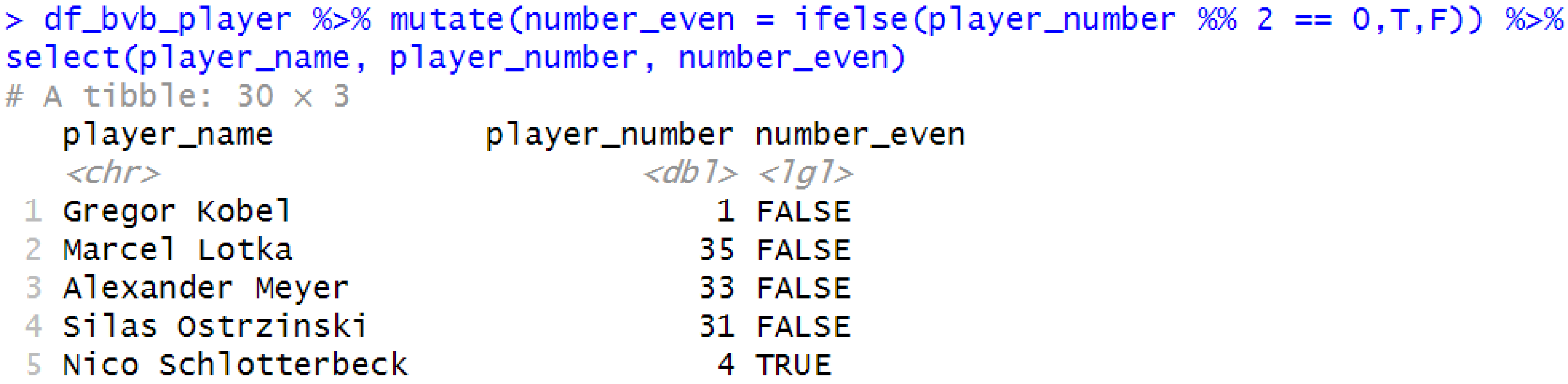


```
> df_bvb_player %>% mutate(player_star_category = rep(c("Star","Rising Star", "No
Star"), times=10)) %>% select(player_name, player_star_category)
# A tibble: 30 × 2
   player_name            player_star_category
   <chr>                  <chr>               
 1 Gregor Kobel           Star                
 2 Marcel Lotka           Rising Star         
 3 Alexander Meyer        No Star             
 4 Silas Ostrzinski       Star                
```

DataFrame Mutating (cont.)

We can append or change columns to data frames with `mutate()`.

It receives as arguments a new column name with the values as a vector.

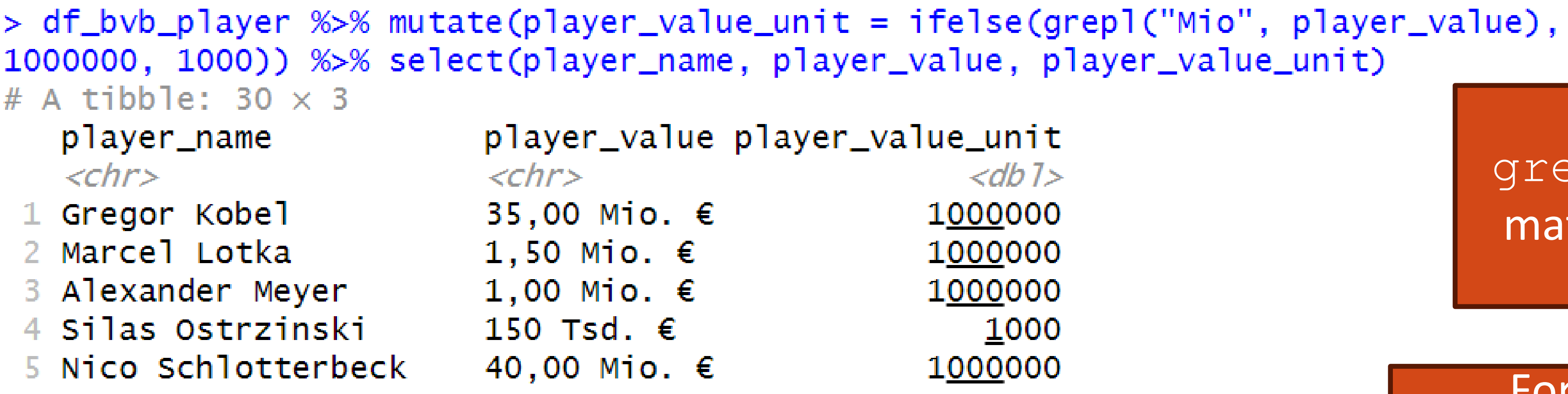


```
> df_bvb_player %>% mutate(number_even = ifelse(player_number %% 2 == 0,T,F)) %>%
select(player_name, player_number, number_even)
# A tibble: 30 × 3
   player_name           player_number number_even
   <chr>                         <dbl> <lgl>
 1 Gregor Kobel                      1 FALSE
 2 Marcel Lotka                     35 FALSE
 3 Alexander Meyer                  33 FALSE
 4 Silas Ostrzinski                 31 FALSE
 5 Nico Schlotterbeck                4 TRUE
```

DataFrame Mutating (cont.)

We can append or change columns to data frames with `mutate()`.

It receives as arguments a new column name with the values as a vector.



```
> df_bvb_player %>% mutate(player_value_unit = ifelse(grepl("Mio", player_value),
1000000, 1000)) %>% select(player_name, player_value, player_value_unit)
# A tibble: 30 × 3
   player_name          player_value player_value_unit
   <chr>                <chr>                    <dbl>
 1 Gregor Kobel         35,00 Mio. €           1000000
 2 Marcel Lotka         1,50 Mio. €            1000000
 3 Alexander Meyer      1,00 Mio. €            1000000
 4 Silas Ostrzinski     150 Tsd. €                1000
 5 Nico Schlotterbeck   40,00 Mio. €           1000000
```

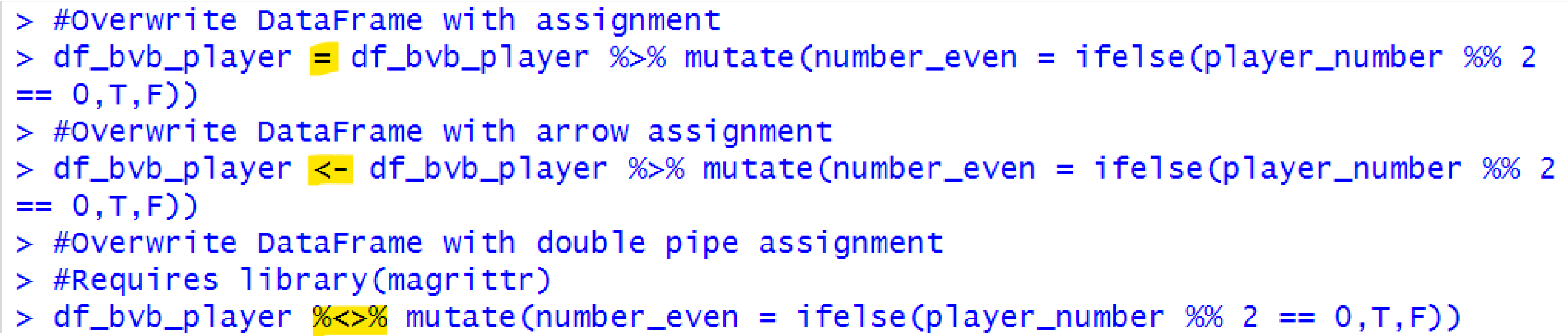
`grepl()` searches for matches in characters

For non-binary decisions, R has the `case_when()` function.

DataFrame Mutating

`mutate()` **does not change** the original **DataFrame**.

If you want, you can **overwrite** it using:



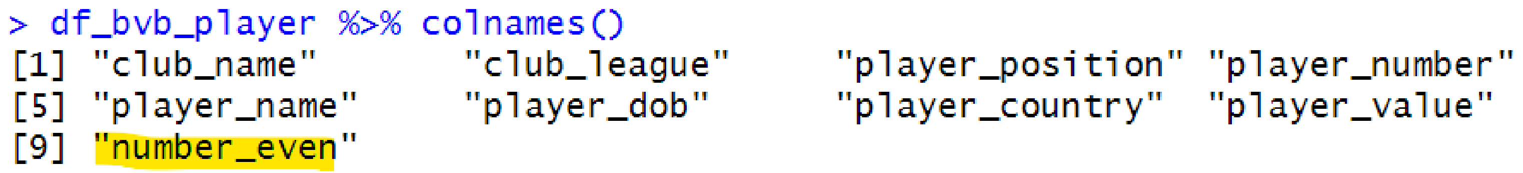
```
> #Overwrite DataFrame with assignment
> df_bvb_player = df_bvb_player %>% mutate(number_even = ifelse(player_number %% 2
== 0,T,F))
> #Overwrite DataFrame with arrow assignment
> df_bvb_player <- df_bvb_player %>% mutate(number_even = ifelse(player_number %% 2
== 0,T,F))
> #Overwrite DataFrame with double pipe assignment
> #Requires library(magrittr)
> df_bvb_player %<>% mutate(number_even = ifelse(player_number %% 2 == 0,T,F))
```

`ifelse(cond, value for True, value for False)`

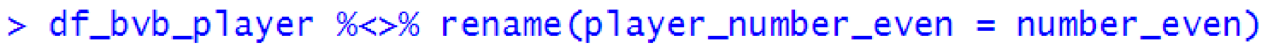
DataFrame Renaming

It often makes sense to **rename** columns and give them **reasonable names**.

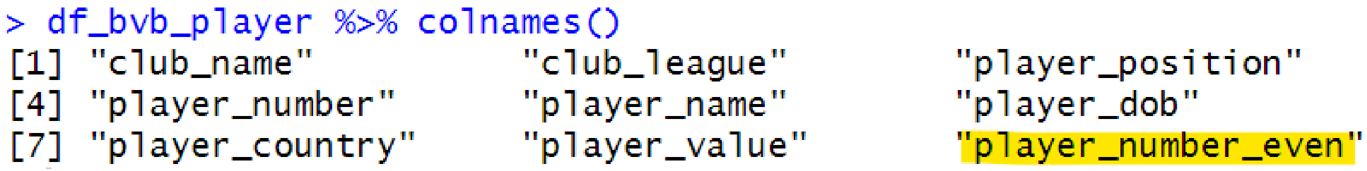
We use the `rename(col_new = col_old)` function and overwrite using the double pipe:



```
> df_bvb_player %>% colnames()
[1] "club_name"        "club_league"      "player_position" "player_number"
[5] "player_name"      "player_dob"       "player_country"  "player_value"
[9] "number_even"
```



```
> df_bvb_player %<>% rename(player_number_even = number_even)
```



```
> df_bvb_player %>% colnames()
[1] "club_name"          "club_league"          "player_position"
[4] "player_number"      "player_name"          "player_dob"
[7] "player_country"     "player_value"         "player_number_even"
```

`library(readr)`

Training #3

1. Import the following .csv dataset: https://raw.githubusercontent.com/leotraeg/FHDTM-P2DS-WS2324/main/Praktikum/FHDTM-P2DS-WS2324_PraktikumII_utf8.csv as a DataFrame called **df_dsa** in R using the readr library.
2. View the column names, dimensions, and generate a summary of df_dsa.
3. Return the frequencies of continents of the countries using table().
4. Compare whether more German students went abroad in 2015 or 2010.
   - Rename the attribute names 2015 to s_2015 and 2010 to s_2010.
   - Fill the NA values of s_2015 and s_2010 using mutate( ) and the ifelse(is.na(vector), 0, vector)) statement.
   - You should be able to use the sum( ) method to compare both years.

Takeaways

- Know both Python and R and decide your toolkit based on your personal and other decision factors.
- R, RStudio, and tidyverse offer a broad range for data analysis.
- Similar to Python’s containers, R has vectors.
- Similar to Python’s DataFrame, R also has a DataFrame with filtering and slicing rows and selecting, mutating, and renaming attributes.

Outlook

Next week we will see how to

- Deploy Functions
- Data Preprocessing
- Data Transformation

with R.

See you again next week.

Questions?