Data manipulation

Lecture 1

Louis SIRUGUE

M1 APE - Fall 2022

Welcome to the course!

About me

- PhD student at the Paris School of Economics
- I work primarily on:
  - Intergenerational (income) mobility
  - Residential segregation
  - Discrimination
- I do empirical research, so I use Econometrics and (R) programming on a daily basis
- You can reach me at louis.sirugue@psemail.eu for any question or comment about the course

About the course

- **Objective:** Learning R programming to carry out your empirical homeworks and research projects
- 4×2 hours:
  1. Data manipulation
  2. Data visualization
  3. R Markdown & LaTeX
  4. Econometrics in R
- Lectures 1 to 3 are about learning R

1-month break for you to follow the first lectures/tutorials in Econometrics I

- Lectures 4 is about Econometrics using R

Let's delve into it!

Let's delve into it!

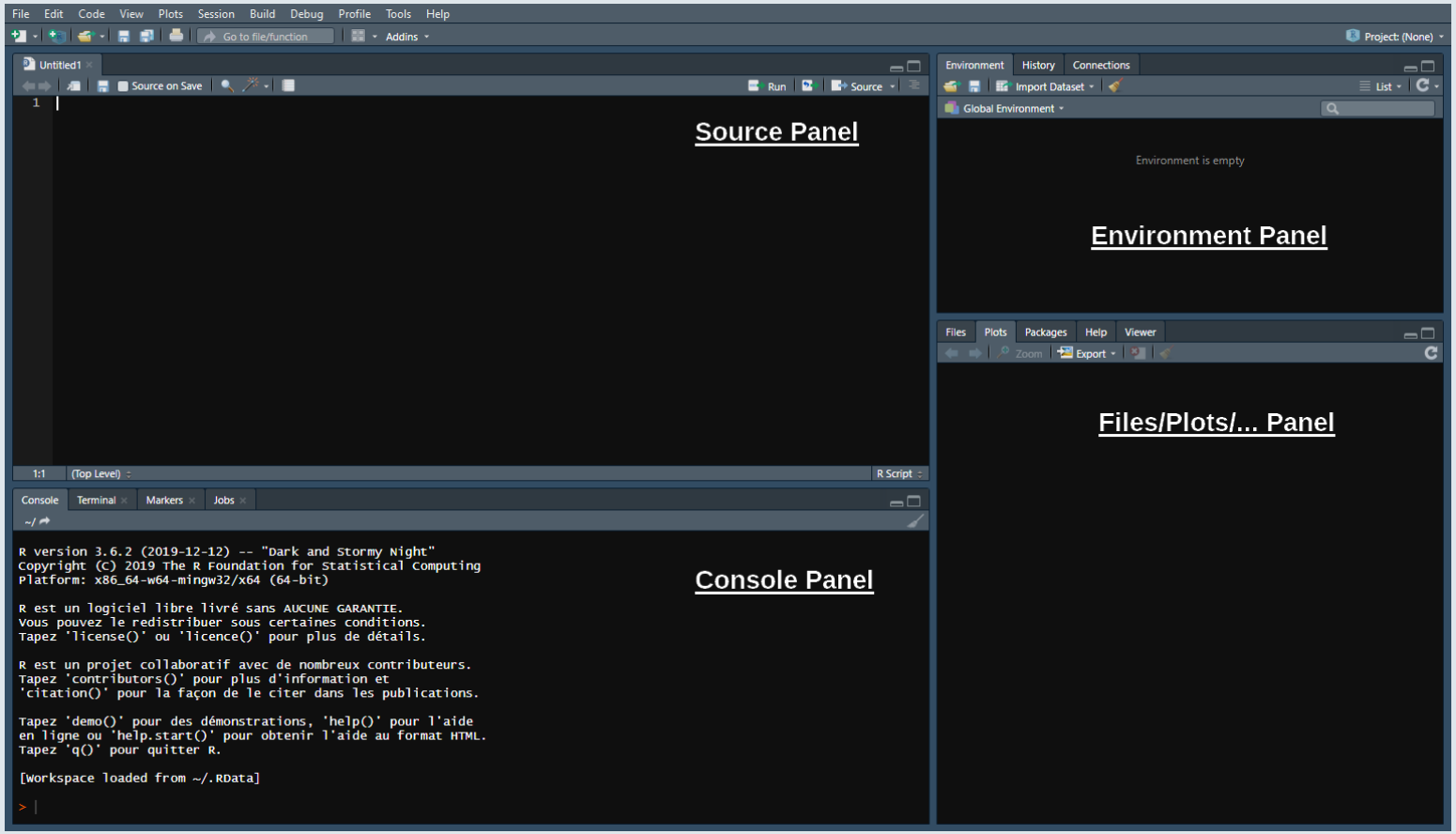
1. Getting started

1.1. About R

- R is a **programming language** and free software environment for **statistical computing and graphics**
- The R language is widely (and increasingly) used in **academic and non-academic research** in fields like:
  - Economics
  - Statistics
  - Biostats
- Things you can do with R:
  - Reports
  - Nice plots
  - All the material of this course
  - Academic research
  - Win kaggle competitions
  - Interactive data visualization
  - Art

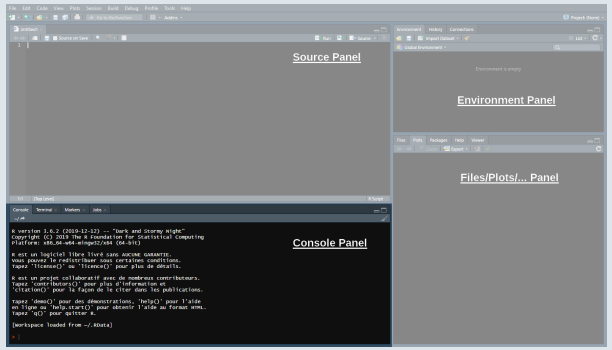
1. Getting started

1.2. The R Studio IDE



1. Getting started

1.2. The R Studio IDE



➜ The Console panel

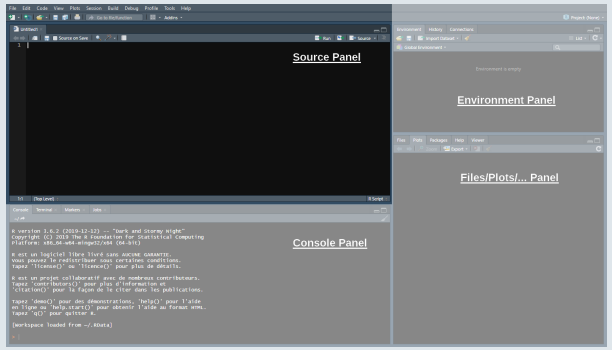
- This is where you **communicate with R**
  - You can write instructions after the **>**, **press enter** and R will **execute**
  - Try with **1+1:**

```
1+1
```

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

1. Getting started

1.2. The R Studio IDE



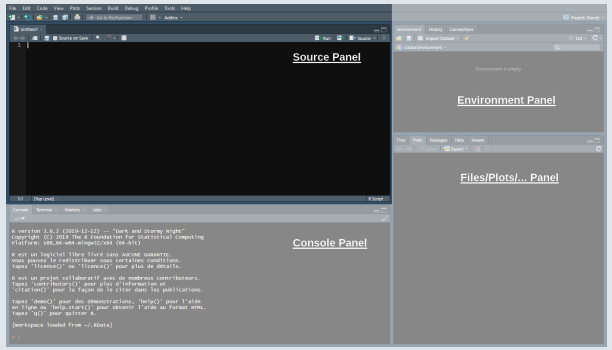
➜ The Source panel

- This is where you **write and save your code** (File > New File > R Script)
  - **Separate** different commands with a **line break**
  - The **#** symbol allows to **comment** your code
  - Everything after **#** will be **ignored** by R until the next line break

```
1+1 # Do not put 2+2 on the same line, press enter to go to next line
2+2
```

1. Getting started

1.2. The R Studio IDE



→ The Source panel

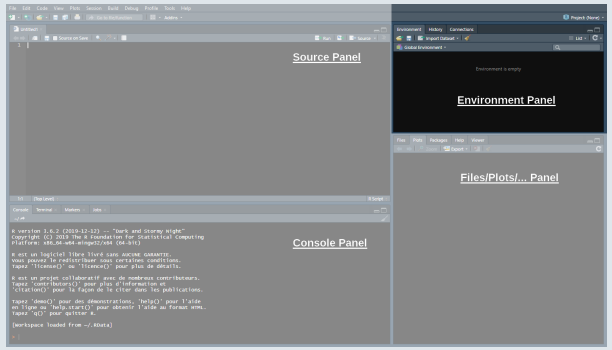
- To send the command from the source panel to the console panel:
  1. **Highlight** the lines you want to execute
  2. Press **ctrl + enter**

- If you do not highlight anything the line of code where your cursor stands will be executed

- Check the console to see the output of your code

1. Getting started

1.2. The R Studio IDE



➜ The Environment panel

- Data analysis requires manipulating datasets, vectors, functions, etc.
  - These **elements are stored in the environment** panel

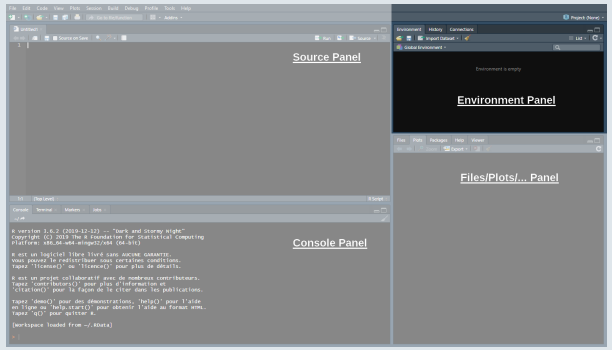
- For instance we can assign a value to an object using `<-`

```
x <- 1
```

➜ You now have an object called 'x' in your environment, which takes the value 1

1. Getting started

1.2. The R Studio IDE



➜ The Environment panel

- Now that the object `x` is stored in your environment, you can use it:

```
x + 1
```

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

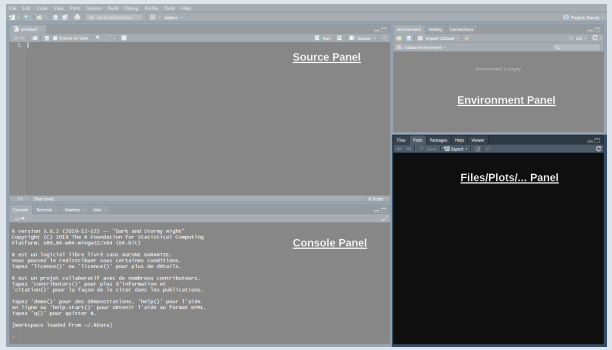
- You can also modify that object at any point:

```
x <- x + 1
x
```

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

1. Getting started

1.2. The R Studio IDE

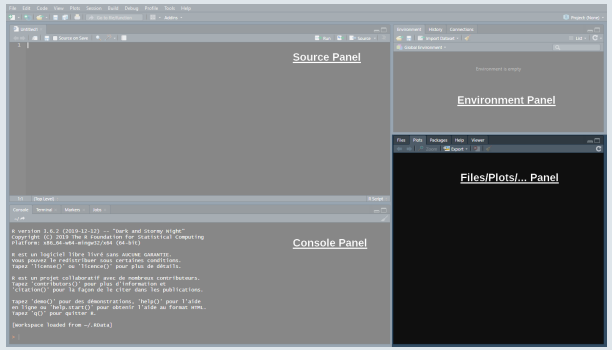


→ The Files/Plots/... panel

- In this panel we'll mainly be interested in the following 4 tabs
  - **Files:** Shows your working directory
  - **Plots:** Where R returns plots
  - **Packages:** A library of tools that we can load if needed
  - **Help:** Where to look for documentation on R functions

1. Getting started

1.2. The R Studio IDE

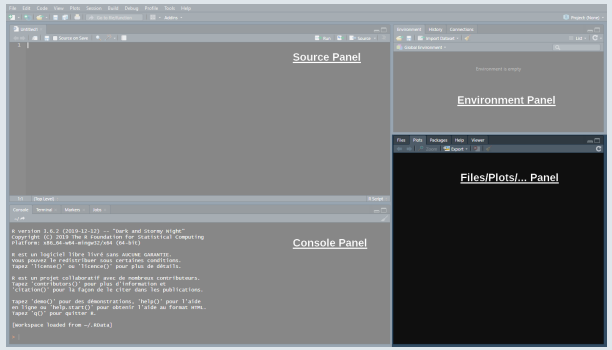


→ The Files/Plots/... panel

- Enter `?getwd()` in the console to see what a **help file** looks like

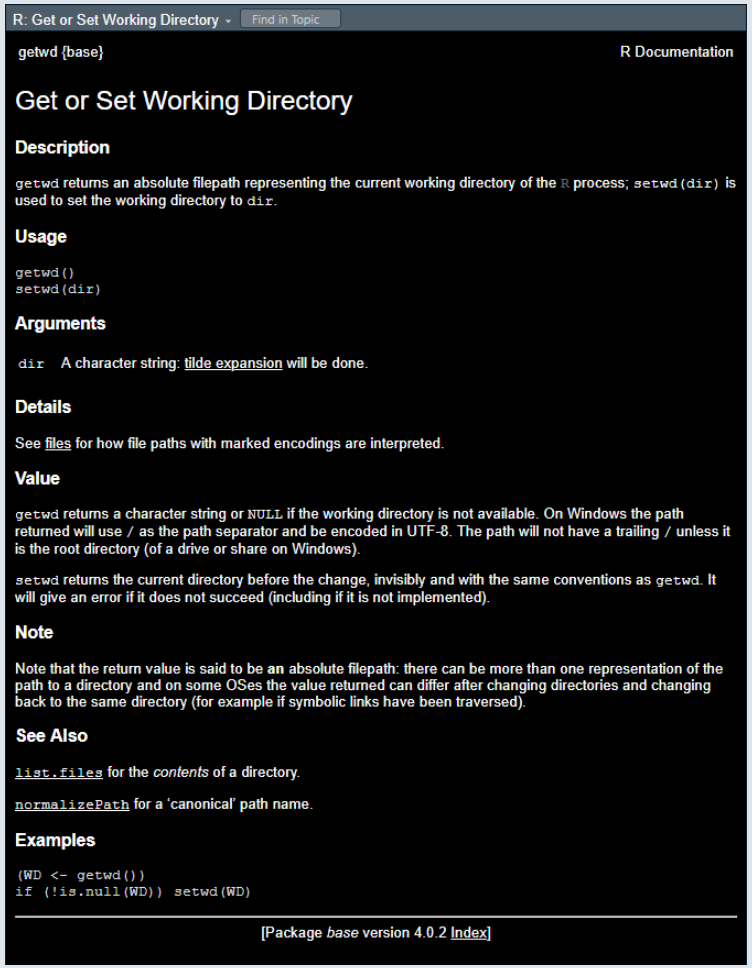
1. Getting started

1.2. The R Studio IDE



→ The Files/Plots/... panel

- Enter `?getwd()` in the console to see what a **help file** looks like
  - It **describes** what the command does
  - It **explains** the different parameters of the command
  - It **gives examples** of how to use the command



R: Get or Set Working Directory — Find in Topic

getwd {base} — R Documentation

Get or Set Working Directory

Description

`getwd` returns an absolute filepath representing the current working directory of the `R` process; `setwd(dir)` is used to set the working directory to `dir`.

Usage

```
getwd()
setwd(dir)
```

Arguments

`dir`	A character string: tilde expansion will be done.

Details

See files for how file paths with marked encodings are interpreted.

Value

`getwd` returns a character string or `NULL` if the working directory is not available. On Windows the path returned will use `/` as the path separator and be encoded in UTF-8. The path will not have a trailing `/` unless it is the root directory (of a drive or share on Windows).

`setwd` returns the current directory before the change, invisibly and with the same conventions as `getwd`. It will give an error if it does not succeed (including if it is not implemented).

Note

Note that the return value is said to be an absolute filepath: there can be more than one representation of the path to a directory and on some OSes the value returned can differ after changing directories and changing back to the same directory (for example if symbolic links have been traversed).

See Also

`list.files` for the *contents* of a directory.

`normalizePath` for a 'canonical' path name.

Examples

```
(WD <- getwd())
if (!is.null(WD)) setwd(WD)
```

[Package *base* version 4.0.2 Index]

Practice

03:00

1) Open a new R script (`Ctrl + Shift + N`) and write a code to create these objects:

Objects to create

Object name:	a	b	c
Assigned value:	2	4	5

2) Run this code and create a new object named `result` that takes the value $\frac{b \times c}{a} + (b - a)^c$

Basic operations in R

Operation:	Addition	Subtraction	Multiplication	Division	Exponentiation	Parentheses
Symbol in R:	+	-	*	/	^	()

3) Print `result` in your console and save your script somewhere in your computer (`Ctrl+S`)

You've got 3 minutes!

Solution

1) Open a new R script (`Ctrl + Shift + N`) and write a code to create these objects:

Objects to create			
Object name:	a	b	c
Assigned value:	2	4	5

```
a <- 2
b <- 4
c <- 5
```

2) Run this code and create a new object named `result` that takes the value $\frac{b \times c}{a} + (b - a)^c$

```
result <- b*c/a + (b-a)^c
```

3) Print `result` in your console and save your script somewhere in your computer (`Ctrl + S`)

```
result
```

```
## [1] 42
```

1. Getting started

1.3. Import and eyeball data

- We now know how to **use R** as a calculator, but our goal is **to analyze data!**

  ➜ *Take for instance the statistics from the last season of Ligue 1 available at fbref.com*

Scores & Fixtures 2021-2022 Ligue 1 Share & Export ▾ Glossary

All Rounds | Regular Season | French 1/2 Relegation/Promotion Play-offs

Wk	Day	Date	Time	Home	xG	Score	xG	Away	Attendance	Venue	Referee	Match Report	Notes
1	Fri	2021-08-06	21:00	Monaco	2.0	1–1	0.3	Nantes	7,500	Stade Louis II.	Antony Gautier	Match Report	
	Sat	2021-08-07	17:00	Lyon	1.4	1–1	0.8	Brest	29,018	Groupama Stadium	Mikael Lesage	Match Report	
			21:00	Troyes	0.8	1–2	1.2	**Paris S-G**	15,248	Stade de l'Aube	Amaury Delerue	Match Report	
	Sun	2021-08-08	13:00	Rennes	0.6	1–1	2.0	Lens	22,567	Roazhon Park	Bastien Dechepy	Match Report	
			15:00	Bordeaux	0.7	0–2	3.3	**Clermont Foot**	18,748	Stade Matmut-Atlantique	Florent Batta	Match Report	
			15:00	Strasbourg	0.4	0–2	0.9	**Angers**	23,250	Stade de la Meinau	Jeremy Stinat	Match Report	
			15:00	Nice	0.8	0–0	0.2	Reims	18,030	Stade de Nice	Johan Hamel	Match Report	
			15:00	Saint-Étienne	2.1	1–1	1.3	Lorient	20,461	Stade Geoffroy-Guichard	Thomas Léonard	Match Report	
			17:00	Metz	0.7	3–3	1.4	Lille	15,551	Stade Saint-Symphorien	Eric Wattellier	Match Report	
			20:45	Montpellier	0.5	2–3	2.0	**Marseille**	13,500	Stade de la Mosson	Jérémie Pignard	Match Report	
2	Fri	2021-08-13	21:00	**Lorient**	0.8	1–0	0.9	Monaco	12,149	Stade Yves Allainmat - Le Moustoir	Hakim Ben El Hadj Salem	Match Report	
	Sat	2021-08-14	17:00	Lille	1.0	0–4	2.2	**Nice**	30,144	Stade Pierre-Mauroy	Jérôme Brisard	Match Report	
			21:00	**Paris S-G**	2.5	4–2	0.6	Strasbourg	46,962	Parc des Princes	Willy Delajod	Match Report	
	Sun	2021-08-15	13:00	**Angers**	1.4	3–0	0.9	Lyon	6,154	Stade Raymond Kopa	Clément Turpin	Match Report	
			15:00	**Clermont Foot**	2.3	2–0	0.5	Troyes	11,005	Stade Gabriel Montpied	Romain Lissorgue	Match Report	
			15:00	Brest	1.5	1–1	0.9	Rennes	14,271	Stade Francis-Le Blé	Benoît Bastien	Match Report	

1. Getting started

1.3. Import and eyeball data

- You can **download** this dataset here or from the course webpage
  - Note that the extension of the file is **.csv** (for ***C**omma **S**eparated **V**alues*)
  - Let's have a look at **first 5 lines** of the raw csv file

```
Wk,Day,Date,Time,Home,xG,Score,xG,Away,Attendance,Venue,Referee,Match Report,Notes
1,Fri,2021-08-06,21:00,Monaco,2.0,1–1,0.3,Nantes,7500,Stade Louis II.,Antony Gautier,Match Report,
1,Sat,2021-08-07,17:00,Lyon,1.4,1–1,0.8,Brest,29018,Groupama Stadium,Mikael Lesage,Match Report,
1,Sat,2021-08-07,21:00,Troyes,0.8,1–2,1.2,Paris S-G,15248,Stade de l'Aube,Amaury Delerue,Match Report,
1,Sun,2021-08-08,13:00,Rennes,0.6,1–1,2.0,Lens,22567,Roazhon Park,Bastien Dechepy,Match Report,
```

- The **.csv format** is very common and has a very **codified structure**
  - We can see that **each line** corresponds to **a row** (the first row generally contains column names)
  - And for each row the **values** of each column are **separated by commas**

➜ But how to get it in our R studio environment?

1. Getting started

1.3. Import and eyeball data

- To **import** stuff in R we use ***read* functions**
  - They take the **file directory** as an **input**
  - And give the **file content** as an **output**

```
function(input)
```

```
## [1] "output"
```

- The read function dedicated to .csv files is **read.csv()**

```
fb <- read.csv("C:\User\Documents\ligue1.csv")
```

```
## Error: '\U' used without hex digits in character string starting ""C:\U"
```

Oops, slashes must be the other way around!

```
fb <- read.csv("C:/User/Documents/ligue1.csv")
```

➜ *Let's **inspect** this new object to check that it worked*

1. Getting started

1.3. Import and eyeball data

- The first thing we can do is to use `head()` to print the **top rows**

```
head(fb, 4)
```

```
##   Wk Day       Date  Time   Home  xG Score xG.1      Away Attendance
## 1  1 Fri 2021-08-06 21:00 Monaco 2.0   1-1  0.3    Nantes       7500
## 2  1 Sat 2021-08-07 17:00   Lyon 1.4   1-1  0.8     Brest      29018
## 3  1 Sat 2021-08-07 21:00 Troyes 0.8   1-2  1.2 Paris S-G      15248
## 4  1 Sun 2021-08-08 13:00 Rennes 0.6   1-1  2.0      Lens      22567
##              Venue         Referee Match.Report Notes
## 1  Stade Louis II.  Antony Gautier Match Report    NA
## 2 Groupama Stadium   Mikael Lesage Match Report    NA
## 3  Stade de l'Aube  Amaury Delerue Match Report    NA
## 4     Roazhon Park Bastien Dechepy Match Report    NA
```

- `tail()` would print the **bottom rows**
- We can also run **`View(fb)`** *(a new tab will pop-up in your Source panel)*

1. Getting started

1.3. Import and eyeball data

	Wk	Day	Date	Time	Home	xG	Score	xG.1	Away	Attendance	Venue	Referee	Match.Report	Notes
1	1	Fri	2021-08-06	21:00	Monaco	2.0	1-1	0.3	Nantes	7500	Stade Louis II.	Antony Gautier	Match Report	*NA*
2	1	Sat	2021-08-07	17:00	Lyon	1.4	1-1	0.8	Brest	29018	Groupama Stadium	Mikael Lesage	Match Report	*NA*
3	1	Sat	2021-08-07	21:00	Troyes	0.8	1-2	1.2	Paris S-G	15248	Stade de l'Aube	Amaury Delerue	Match Report	*NA*
4	1	Sun	2021-08-08	13:00	Rennes	0.6	1-1	2.0	Lens	22567	Roazhon Park	Bastien Dechepy	Match Report	*NA*
5	1	Sun	2021-08-08	15:00	Bordeaux	0.7	0-2	3.3	Clermont Foot	18748	Stade Matmut-Atlantique	Florent Batta	Match Report	*NA*
6	1	Sun	2021-08-08	15:00	Strasbourg	0.4	0-2	0.9	Angers	23250	Stade de la Meinau	Jeremy Stinat	Match Report	*NA*
7	1	Sun	2021-08-08	15:00	Nice	0.8	0-0	0.2	Reims	18030	Stade de Nice	Johan Hamel	Match Report	*NA*
8	1	Sun	2021-08-08	15:00	Saint-Ã‰tienne	2.1	1-1	1.3	Lorient	20461	Stade Geoffroy-Guichard	Thomas LÃ©onard	Match Report	*NA*
9	1	Sun	2021-08-08	17:00	Metz	0.7	3-3	1.4	Lille	15551	Stade Saint-Symphorien	Eric Wattellier	Match Report	*NA*
10	1	Sun	2021-08-08	20:45	Montpellier	0.5	2-3	2.0	Marseille	13500	Stade de la Mosson	JÃ©rÃ©mie Pignard	Match Report	*NA*
11	2	Fri	2021-08-13	21:00	Lorient	0.8	1-0	0.9	Monaco	12149	Stade Yves Allainmat - Le Moustoir	Hakim Ben El Hadj Salem	Match Report	*NA*
12	2	Sat	2021-08-14	17:00	Lille	1.0	0-4	2.2	Nice	30144	Stade Pierre-Mauroy	JÃ©rÃ´me Brisard	Match Report	*NA*
13	2	Sat	2021-08-14	21:00	Paris S-G	2.5	4-2	0.6	Strasbourg	46962	Parc des Princes	Willy Delajod	Match Report	*NA*
14	2	Sun	2021-08-15	13:00	Angers	1.4	3-0	0.9	Lyon	6154	Stade Raymond Kopa	ClÃ©ment Turpin	Match Report	*NA*
15	2	Sun	2021-08-15	15:00	Clermont Foot	2.3	2-0	0.5	Troyes	11005	Stade Gabriel Montpied	Romain Lissorgue	Match Report	*NA*
16	2	Sun	2021-08-15	15:00	Brest	1.5	1-1	0.9	Rennes	14271	Stade Francis-Le BlÃ©	BenoÃ®t Bastien	Match Report	*NA*
17	2	Sun	2021-08-15	15:00	Nantes	1.4	2-0	1.1	Metz	12054	Stade de la Beaujoire - Louis Fonteneau	Johan Hamel	Match Report	*NA*

Seems like it worked!

1. Getting started

1.3. Import and eyeball data

	Wk	Day	Date	Time	Home	xG	Score	xG.1	Away	Attendance	Venue	Referee	Match.Report	Notes
1	1	Fri	2021-08-06	21:00	Monaco	2.0	1-1	0.3	Nantes	7500	Stade Louis II.	Antony Gautier	Match Report	*NA*
2	1	Sat	2021-08-07	17:00	Lyon	1.4	1-1	0.8	Brest	29018	Groupama Stadium	Mikael Lesage	Match Report	*NA*
3	1	Sat	2021-08-07	21:00	Troyes	0.8	1-2	1.2	Paris S-G	15248	Stade de l'Aube	Amaury Delerue	Match Report	*NA*
4	1	Sun	2021-08-08	13:00	Rennes	0.6	1-1	2.0	Lens	22567	Roazhon Park	Bastien Dechepy	Match Report	*NA*
5	1	Sun	2021-08-08	15:00	Bordeaux	0.7	0-2	3.3	Clermont Foot	18748	Stade Matmut-Atlantique	Florent Batta	Match Report	*NA*
6	1	Sun	2021-08-08	15:00	Strasbourg	0.4	0-2	0.9	Angers	23250	Stade de la Meinau	Jeremy Stinat	Match Report	*NA*
7	1	Sun	2021-08-08	15:00	Nice	0.8	0-0	0.2	Reims	18030	Stade de Nice	Johan Hamel	Match Report	*NA*
8	1	Sun	2021-08-08	15:00	Saint-Ã‰tienne	2.1	1-1	1.3	Lorient	20461	Stade Geoffroy-Guichard	Thomas LÃ©onard	Match Report	*NA*
9	1	Sun	2021-08-08	17:00	Metz	0.7	3-3	1.4	Lille	15551	Stade Saint-Symphorien	Eric Wattellier	Match Report	*NA*
10	1	Sun	2021-08-08	20:45	Montpellier	0.5	2-3	2.0	Marseille	13500	Stade de la Mosson	JÃ©rÃ©mie Pignard	Match Report	*NA*
11	2	Fri	2021-08-13	21:00	Lorient	0.8	1-0	0.9	Monaco	12149	Stade Yves Allainmat - Le Moustoir	Hakim Ben El Hadj Salem	Match Report	*NA*
12	2	Sat	2021-08-14	17:00	Lille	1.0	0-4	2.2	Nice	30144	Stade Pierre-Mauroy	JÃ©rÃ´me Brisard	Match Report	*NA*
13	2	Sat	2021-08-14	21:00	Paris S-G	2.5	4-2	0.6	Strasbourg	46962	Parc des Princes	Willy Delajod	Match Report	*NA*
14	2	Sun	2021-08-15	13:00	Angers	1.4	3-0	0.9	Lyon	6154	Stade Raymond Kopa	ClÃ©ment Turpin	Match Report	*NA*
15	2	Sun	2021-08-15	15:00	Clermont Foot	2.3	2-0	0.5	Troyes	11005	Stade Gabriel Montpied	Romain Lissorgue	Match Report	*NA*
16	2	Sun	2021-08-15	15:00	Brest	1.5	1-1	0.9	Rennes	14271	Stade Francis-Le BlÃ©	BenoÃ®t Bastien	Match Report	*NA*
17	2	Sun	2021-08-15	15:00	Nantes	1.4	2-0	1.1	Metz	12054	Stade de la Beaujoire - Louis Fonteneau	Johan Hamel	Match Report	*NA*

... or kind of worked?

1. Getting started

1.4. Use functions

- That kind of **weird characters** kicks in when there is an **encoding issue**
  - Thankfully, **read.csv()** can take many **other inputs**, including encoding!
  - Usually the UTF-8 encoding is the solution to French characters

```
fb <- read.csv("C:/User/Documents/ligue1.csv", encoding = "UTF-8")
```

- When you will be facing **similar issues**, check out the arguments of read.csv() using **?read.csv**

Arguments

`file`	the name of the file which the data are to be read from. Each row of the table appears as one line of the file. If it does not contain an *absolute* path, the file name is *relative* to the current working directory, `getwd()`. Tilde-expansion is performed where supported. This can be a compressed file (see `file`). Alternatively, `file` can be a readable text-mode connection (which will be opened for reading if necessary, and if so `closed` (and hence destroyed) at the end of the function call). (If `stdin()` is used, the prompts for lines may be somewhat confusing. Terminate input with a blank line or an EOF signal, `Ctrl-D` on Unix and `Ctrl-Z` on Windows. Any pushback on `stdin()` will be cleared before return.) `file` can also be a complete URL. (For the supported URL schemes, see the 'URLs' section of the help for `url`.)
`header`	a logical value indicating whether the file contains the names of the variables as its first line. If missing, the value is determined from the file format: `header` is set to `TRUE` if and only if the first row contains one fewer field than the number of columns.
`sep`	the field separator character. Values on each line of the file are separated by this character. If `sep = ""` (the default for `read.table`) the separator is 'white space', that is one or more spaces, tabs, newlines or carriage returns.
`quote`	the set of quoting characters. To disable quoting altogether, use `quote = ""`. See `scan` for the behaviour on quotes embedded in quotes. Quoting is only considered for columns read as character, which is all of them unless `colClasses` is specified.
`dec`	the character used in the file for decimal points.

1. Getting started

1.4. Use functions

- From the **documentation** you can see that functions have **many arguments**
  - Some **without default** values: You need to specify the argument for the function to work
  - Some **with default** values: If you don't specify these arguments, defaults will be used

```
read.csv(file, header = TRUE, sep = ",", quote = "\"",
         dec = ".", fill = TRUE, comment.char = "", ...)
```

- You don't need to write the argument names only for those written in the **correct order**

```
read.csv(file = "dt.csv")
```

$\Longleftrightarrow$

```
read.csv("dt.csv")
```

```
read.csv("dt.csv")
```

$\overset{?}{\Longleftrightarrow}$

```
read.csv("dt.csv", sep = ",")
```

1. Getting started

1.4. Use functions

- From the **documentation** you can see that functions have **many arguments**
  - Some **without default** values: You need to specify the argument for the function to work
  - Some **with default** values: If you don't specify these arguments, defaults will be used

```
read.csv(file, header = TRUE, sep = ",", quote = "\"",
         dec = ".", fill = TRUE, comment.char = "", ...)
```

- You don't need to write the argument names only for those written in the **correct order**

```
read.csv(file = "dt.csv")
```
$\iff$
```
read.csv("dt.csv")
```

```
read.csv("dt.csv")
```
$\iff$
```
read.csv("dt.csv", sep = ",")
```

```
read.csv("dt.csv", sep = ",")
```
$\overset{?}{\iff}$
```
read.csv("dt.csv", ",")
```

1. Getting started

1.4. Use functions

- From the **documentation** you can see that functions have **many arguments**
  - Some **without default** values: You need to specify the argument for the function to work
  - Some **with default** values: If you don't specify these arguments, defaults will be used

```
read.csv(file, header = TRUE, sep = ",", quote = "\"",
         dec = ".", fill = TRUE, comment.char = "", ...)
```

- You don't need to write the argument names only for those written in the **correct order**

```
read.csv(file = "dt.csv")
```
$\iff$
```
read.csv("dt.csv")
```

```
read.csv("dt.csv")
```
$\iff$
```
read.csv("dt.csv", sep = ",")
```

```
read.csv("dt.csv", sep = ",")
```
$\not\iff$
```
read.csv("dt.csv", ",")
```

```
read.csv("dt.csv", sep = ",")
```
$\overset{?}{\iff}$
```
read.csv("dt.csv", TRUE, ",")
```

1. Getting started

1.4. Use functions

- From the **documentation** you can see that functions have **many arguments**
  - Some **without default** values: You need to specify the argument for the function to work
  - Some **with default** values: If you don't specify these arguments, defaults will be used

```
read.csv(file, header = TRUE, sep = ",", quote = "\"",
         dec = ".", fill = TRUE, comment.char = "", ...)
```

- You don't need to write the argument names only for those written in the **correct order**

```
read.csv(file = "dt.csv")
```
$\iff$
```
read.csv("dt.csv")
```

```
read.csv("dt.csv")
```
$\iff$
```
read.csv("dt.csv", sep = ",")
```

```
read.csv("dt.csv", sep = ",")
```
$\not\iff$
```
read.csv("dt.csv", ",")
```

```
read.csv("dt.csv", sep = ",")
```
$\iff$
```
read.csv("dt.csv", TRUE, ",")
```

Overview

Overview

2. Anatomy of a `data.frame`

2.1. Data structure

- Now that we imported the data properly, we can check out its **`str()`ucture** in more details

```
str(fb)
```

2. Anatomy of a `data.frame`

2.1. Data structure

- *Don't be scared of the output!*

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk          : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ Day         : chr  "Fri" "Sat" "Sat" "Sun" ...
##  $ Date        : chr  "2021-08-06" "2021-08-07" "2021-08-07" "2021-08-08" ...
##  $ Time        : chr  "21:00" "17:00" "21:00" "13:00" ...
##  $ Home        : chr  "Monaco" "Lyon" "Troyes" "Rennes" ...
##  $ xG          : num  2 1.4 0.8 0.6 0.7 0.4 0.8 2.1 0.7 0.5 ...
##  $ Score       : chr  "1-1" "1-1" "1-2" "1-1" ...
##  $ xG.1        : num  0.3 0.8 1.2 2 3.3 0.9 0.2 1.3 1.4 2 ...
##  $ Away        : chr  "Nantes" "Brest" "Paris S-G" "Lens" ...
##  $ Attendance  : int  7500 29018 15248 22567 18748 23250 18030 20461 15551 13500 ...
##  $ Venue       : chr  "Stade Louis II." "Groupama Stadium" "Stade de l'Aube" "Roazhon Park" ...
##  $ Referee     : chr  "Antony Gautier" "Mikael Lesage" "Amaury Delerue" "Bastien Dechepy" ...
##  $ Match.Report: chr  "Match Report" "Match Report" "Match Report" "Match Report" ...
##  $ Notes       : logi  NA NA NA NA NA NA ...
```

2. Anatomy of a `data.frame`

2.1. Data structure

- `str()` says that `fb` is a `data.frame`, and gives its numbers of **observations** (rows) and **variables** (columns)

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
```

2. Anatomy of a `data.frame`

2.1. Data structure

- It also gives the **variables names**

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk
##  $ Day
##  $ Date
##  $ Time
##  $ Home
##  $ xG
##  $ Score
##  $ xG.1
##  $ Away
##  $ Attendance
##  $ Venue
##  $ Referee
##  $ Match.Report
##  $ Notes
```

2. Anatomy of a `data.frame`

2.1. Data structure

- The **first values** of each variable

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk          :      1 1 1 1 1 1 1 1 1 1 ...
##  $ Day         :      "Fri" "Sat" "Sat" "Sun" ...
##  $ Date        :      "2021-08-06" "2021-08-07" "2021-08-07" "2021-08-08" ...
##  $ Time        :      "21:00" "17:00" "21:00" "13:00" ...
##  $ Home        :      "Monaco" "Lyon" "Troyes" "Rennes" ...
##  $ xG          :      2 1.4 0.8 0.6 0.7 0.4 0.8 2.1 0.7 0.5 ...
##  $ Score       :      "1-1" "1-1" "1-2" "1-1" ...
##  $ xG.1        :      0.3 0.8 1.2 2 3.3 0.9 0.2 1.3 1.4 2 ...
##  $ Away        :      "Nantes" "Brest" "Paris S-G" "Lens" ...
##  $ Attendance  :      7500 29018 15248 22567 18748 23250 18030 20461 15551 13500 ...
##  $ Venue       :      "Stade Louis II." "Groupama Stadium" "Stade de l'Aube" "Roazhon Park" ...
##  $ Referee     :      "Antony Gautier" "Mikael Lesage" "Amaury Delerue" "Bastien Dechepy" ...
##  $ Match.Report:      "Match Report" "Match Report" "Match Report" "Match Report" ...
##  $ Notes       :       NA NA NA NA NA NA ...
```

2. Anatomy of a `data.frame`

2.1. Data structure

- As well as the **class** of each variable

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk          : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ Day         : chr  "Fri" "Sat" "Sat" "Sun" ...
##  $ Date        : chr  "2021-08-06" "2021-08-07" "2021-08-07" "2021-08-08" ...
##  $ Time        : chr  "21:00" "17:00" "21:00" "13:00" ...
##  $ Home        : chr  "Monaco" "Lyon" "Troyes" "Rennes" ...
##  $ xG          : num  2 1.4 0.8 0.6 0.7 0.4 0.8 2.1 0.7 0.5 ...
##  $ Score       : chr  "1-1" "1-1" "1-2" "1-1" ...
##  $ xG.1        : num  0.3 0.8 1.2 2 3.3 0.9 0.2 1.3 1.4 2 ...
##  $ Away        : chr  "Nantes" "Brest" "Paris S-G" "Lens" ...
##  $ Attendance  : int  7500 29018 15248 22567 18748 23250 18030 20461 15551 13500 ...
##  $ Venue       : chr  "Stade Louis II." "Groupama Stadium" "Stade de l'Aube" "Roazhon Park" ...
##  $ Referee     : chr  "Antony Gautier" "Mikael Lesage" "Amaury Delerue" "Bastien Dechepy" ...
##  $ Match.Report: chr  "Match Report" "Match Report" "Match Report" "Match Report" ...
##  $ Notes       : logi  NA NA NA NA NA NA ...
```

2. Anatomy of a `data.frame`

2.1. Data structure

- But what does the **class** correspond to?

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk          : int  ?
##  $ Day         : chr  ?
##  $ Date        : chr  ?
##  $ Time        : chr  ?
##  $ Home        : chr  ?
##  $ xG          : num  ?
##  $ Score       : chr  ?
##  $ xG.1        : num  ?
##  $ Away        : chr  ?
##  $ Attendance  : int  ?
##  $ Venue       : chr  ?
##  $ Referee     : chr  ?
##  $ Match.Report: chr  ?
##  $ Notes       : logi  ?
```

2. Anatomy of a `data.frame`

2.2. Classes

Numeric	Character	Logical

2. Anatomy of a `data.frame`

2.2. Classes

Numeric **Character** **Logical**

These are simply numbers:

```
class(3)
```

```
## [1] "numeric"
```

```
class(-1.6180339)
```

```
## [1] "numeric"
```

Numeric variable classes include:

- **int** for round numbers
- **dbl** for 2-decimal numbers

2. Anatomy of a `data.frame`

2.2. Classes

Numeric

These are simply numbers:

```
class(3)
```

```
## [1] "numeric"
```

```
class(-1.6180339)
```

```
## [1] "numeric"
```

Numeric variable classes include:

- **int** for round numbers
- **dbl** for 2-decimal numbers

Character

They must be surrounded by `"`:

```
class("Roazhon Park")
```

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

```
class("35")
```

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

We also call these values:

- Character strings
- Or just strings

Logical

2. Anatomy of a `data.frame`

2.2. Classes

Numeric

These are simply numbers:

```
class(3)
```

```
## [1] "numeric"
```

```
class(-1.6180339)
```

```
## [1] "numeric"
```

Numeric variable classes include:

- **int** for round numbers
- **dbl** for 2-decimal numbers

Character

They must be surrounded by `"`:

```
class("Roazhon Park")
```

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

```
class("35")
```

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

We also call these values:

- Character strings
- Or just strings

Logical

Something either `TRUE` of `FALSE`:

```
3 >= 4
```

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

```
class(T)
```

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

Most common logical operators:

- == > < <= >=
- & (and) | (or) ! (opposite)

2. Anatomy of a `data.frame`

2.2. Classes

Guess the output!

```
as.numeric("2022")
```

```
## [1] 2022
```

What about this one?

```
as.character(2022-2023)
```

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

A final one:

```
as.character(2022>2023)
```

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

2. Anatomy of a `data.frame`

2.2. Classes

- To know everything:

Class conversion table:

	numeric	**character**	**logical**
as.numeric()	No effect	Converts strings of numbers into numeric values Returns NA if characters in the string	Returns 1 if TRUE Returns 0 if FALSE
as.character()	Converts numeric values into strings of numbers	No effect	Returns "TRUE" if TRUE Returns "FALSE" if FALSE
as.logical()	Returns TRUE if != 0 Returns FALSE if 0	Returns TRUE if "T" or"TRUE" Returns FALSE if "F" or "FALSE" Returns NA otherwise	No effect

NA stands for *'Not Available'*, it corresponds to a **missing value**

2. Anatomy of a `data.frame`

2.2. Classes

- Great! But there is one last mystery...

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk          : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ Day         : chr  "Fri" "Sat" "Sat" "Sun" ...
##  $ Date        : chr  "2021-08-06" "2021-08-07" "2021-08-07" "2021-08-08" ...
##  $ Time        : chr  "21:00" "17:00" "21:00" "13:00" ...
##  $ Home        : chr  "Monaco" "Lyon" "Troyes" "Rennes" ...
##  $ xG          : num  2 1.4 0.8 0.6 0.7 0.4 0.8 2.1 0.7 0.5 ...
##  $ Score       : chr  "1-1" "1-1" "1-2" "1-1" ...
##  $ xG.1        : num  0.3 0.8 1.2 2 3.3 0.9 0.2 1.3 1.4 2 ...
##  $ Away        : chr  "Nantes" "Brest" "Paris S-G" "Lens" ...
##  $ Attendance  : int  7500 29018 15248 22567 18748 23250 18030 20461 15551 13500 ...
##  $ Venue       : chr  "Stade Louis II." "Groupama Stadium" "Stade de l'Aube" "Roazhon Park" ...
##  $ Referee     : chr  "Antony Gautier" "Mikael Lesage" "Amaury Delerue" "Bastien Dechepy" ...
##  $ Match.Report: chr  "Match Report" "Match Report" "Match Report" "Match Report" ...
##  $ Notes       : logi  NA NA NA NA NA NA ...
```

2. Anatomy of a `data.frame`

2.2. Classes

- Are these dollar signs here for a reason?

```
str(fb)
```

```
## 'data.frame':    380 obs. of  14 variables:
##  $ Wk
##  $ Day
##  $ Date
##  $ Time
##  $ Home
##  $ xG
##  $ Score
##  $ xG.1
##  $ Away
##  $ Attendance
##  $ Venue
##  $ Referee
##  $ Match.Report
##  $ Notes
```

2. Anatomy of a `data.frame`

2.3. Vectors

- It's actually just a reference to the fact that `$` allows to **extract a variable** from a dataset

```
fb$Wk
```

```
##   [1]  1  1  1  1  1  1  1  1  1  1  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3
##  [30]  4  4  4  4  4  4  4  4  4  4  5  5  5  5  5  5  5  5  5  5  6  6  6  6  6  6  6  6  6
##  [59]  6  7  7  7  7  7  7  7  7  7  7  8  8  8  8  8  8  8  8  8  8  8  9  9  9  9  9  9  9  9
##  [88]  9  9 10 10 10 10 10 10 10 10 10 10 11 11 11 11 11 11 11 11 11 11 11  3 12 12 12 12 12 12
## [117] 12 12 12 12 13 13 13 13 13 13 13 13 13 13 14 14 14 14 14 14 14 14 14 14 15 15 15 15 15 15
## [146] 15 15 15 15 16 16 16 16 16 16 16 16 16 16 17 17 17 17 17 17 17 17 17 17 18 18 18 18 18
## [175] 18 18 18 18 18 19 19 19 19 19 19 19 19 19 20 20 20 20 20 20 20 21 21 21 21 21 21 21 21
## [204] 21 21 19 20 20 22 22 22 22 22 22 22 22 22 22 22 20 14 23 23 23 23 23 23 23 23 23 23 24 24
## [233] 24 24 24 24 24 24 24 24 25 25 25 25 25 25 25 25 25 25 25 26 26 26 26 26 26 26 26 26 26 27
## [262] 27 27 27 27 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29
## [291] 30 30 30 30 30 30 30 30 30 30 31 31 31 31 31 31 31 31 31 31 32 32 32 32 32 32 32 32 32
## [320] 32 33 33 33 33 33 33 33 33 33 33 34 34 34 34 34 34 34 34 34 34 35 35 35 35 35 35 35 35
## [349] 35 35 36 36 36 36 36 36 36 36 36 36 37 37 37 37 37 37 37 37 37 37 38 38 38 38 38 38 38
## [378] 38 38 38
```

2. Anatomy of a `data.frame`

2.3. Vectors

- We call these objects **vectors**
  - Vectors are basically **sequences of values that have the same class**
  - R won't let you create a vector containing elements of different classes

- We make our own vectors using the **`c()`oncatenate** function

```
c("Hello world", 35, FALSE)
```

```
## [1] "Hello world" "35"          "FALSE"
```

- The fact that vectors are homogeneous in class allows that **operations apply to all their elements**

```
c(1, 2, 3) / 3
```

```
## [1] 0.3333333 0.6666667 1.0000000
```

```
3 / c(1, 2, 3)
```

```
## [1] 3.0 1.5 1.0
```

2. Anatomy of a `data.frame`

2.4. Subsetting

- But **$** is not the only way to **extract** a variable from a dataset
  - You can also make use of the **[ ]** subsetting operator

$$\text{data}[\text{row},\ \ \text{columns}]$$

- Inside the **brackets**, indicate what you want to **keep using:**
  - **Indices:** e.g., the third column has index 3
  - **Logical:** A vector of TRUE and FALSE
  - **Names:** They must be in quotation marks

- Example:

```
fb[1, c("Venue", "Attendance")]
```

```
##             Venue Attendance
## 1 Stade Louis II.       7500
```

- Brackets also work for vectors:

```
vec <- c(3, 2, 1)
vec[c(T, F, T)]
```

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

Practice

06:00

1) Download and import the dataset if you haven't already

2) Combine the use of `[ ]` and `nrow()` to obtain the last value of the `Wk` variable

3) Subset the home team, the score, and the away team for matches that occured during the last week

You've got 6 minutes!

Solution

1) Download and import the dataset if you haven't already

```
fb <- read.csv("C:/User/Documents/ligue1.csv", encoding = "UTF-8")
```

2) Combine the use of `[ ]` and `nrow()` to obtain the last value of the `Wk` variable

```
last_week <- fb[nrow(fb), "Wk"]
last_week
```

```
## [1] 38
```

Solution

3) Subset the home team, the score, and the away team for matches that occured during the last week

```
fb[Wk == last_week, c("Home", "Score", "Away")]
```

```
## Error in `[.data.frame`(fb, Wk == last_week, c("Home", "Score", "Away")): object 'Wk' not found
```

- Oops! Seems like **R couldn't find** the Wk variable
  - R was looking for Wk **in our environment**
  - But there is no Wk there

- We must **refer to fb** which is in our environment
  - Then we can **access Wk using the $** symbol

```
fb[fb$Wk == 38, c("Home", "Score", "Away")]
```

```
##                Home Score          Away
## 371           Lille   2-2        Rennes
## 372           Brest   2-4      Bordeaux
## 373         Nantes    1-1 Saint-Étienne
## 374 Clermont Foot     1-2          Lyon
## 375         Angers    2-0   Montpellier
## 376        Lorient    1-1        Troyes
## 377     Paris S-G     5-0          Metz
## 378          Reims    2-3          Nice
## 379     Marseille     4-0    Strasbourg
## 380           Lens    2-2        Monaco
```

Overview

Overview

1. Getting started ✓
- 1.1. About R
- 1.2. The R Studio IDE
- 1.3. Import and eyeball data
- 1.4. Use functions

2. Anatomy of a data.frame ✓
- 2.1. Data structure
- 2.2. Classes
- 2.3. Vectors
- 2.4. Subsetting

3. The dplyr grammar
- 3.1. Packages
- 3.2. Basic functions
- 3.3. group_by() and summarise()

3. The `dplyr` grammar

3.1. Packages

- So far we only used functions that are directly available in R
  - But there are tons of **user-created functions** out there that can make your life so much easier
  - These functions are shared in what we call **packages**

- Packages are **bundles of functions** that R users put at the disposal of other R users
  - Packages are **centralized** on the Comprehensive R Archive Network (CRAN)
  - To **download** and install a CRAN package you can simply use **install.packages()**

- All the functions of the dplyr grammar are gathered in the **dplyr package**
  - We can download these functions and make them ready to use with the install.packages() function

```
install.packages("dplyr") # Requires an internet connection
```

- The tidyverse package is **now installed** on your computer
  - You won't have to do it again

3. The `dplyr` grammar

3.1. Packages

- The `dplyr` package is now **on your computer**, but it is **not loaded in R**

```
ls("package:dplyr")
```

```
## Error in as.environment(pos): no item called "package:dplyr" on the search list
```

- You need to use the **library()** command to load it

```
library(dplyr)
ls("package:dplyr")[1:5]
```

```
## [1] "%>%"        "across"     "add_count"  "add_count_" "add_row"
```

- But even though the package is permanently installed, it is **loaded only for your current session**
  - Each time you start a **new R session**, you'll have to load the packages you need with **library()**

3. The `dplyr` grammar

3.2. Basic functions

`dplyr` is a **grammar** of data manipulation providing very **user-friendly functions** to handle the most common **data manipulation** tasks:

- `mutate()`: add/modify variables
- `select()`: keep/drop variables (columns)
- `filter()`: keep/drop observations (rows)
- `arrange()`: sort rows according to the values of given variable(s)
- `summarise()`: aggregate the data into descriptive statistics

- A very handy **operator** to use with the **dplyr** grammar is the **pipe %>%**
  - You can basically read **a %>% b()** as *"apply function b() to object a"*
  - With this operator you can easily **chain the operations** you apply to an object

3. The `dplyr` grammar

3.2. Basic functions

```
fb
#
#
#
#
#
#
```

```
##     Wk Day       Date  Time           Home  xG Score xG.1          Away Attendance  ...
## 1    1 Fri 2021-08-06 21:00         Monaco 2.0   1-1  0.3        Nantes       7500  ...
## 2    1 Sat 2021-08-07 17:00           Lyon 1.4   1-1  0.8         Brest      29018  ...
## 3    1 Sat 2021-08-07 21:00         Troyes 0.8   1-2  1.2     Paris S-G      15248  ...
## 4    1 Sun 2021-08-08 13:00         Rennes 0.6   1-1  2.0          Lens      22567  ...
## 5    1 Sun 2021-08-08 15:00       Bordeaux 0.7   0-2  3.3 Clermont Foot      18748  ...
## 6    1 Sun 2021-08-08 15:00     Strasbourg 0.4   0-2  0.9        Angers      23250  ...
## 7    1 Sun 2021-08-08 15:00           Nice 0.8   0-0  0.2         Reims      18030  ...
## 8    1 Sun 2021-08-08 15:00 Saint-Étienne 2.1   1-1  1.3       Lorient      20461  ...
## 9    1 Sun 2021-08-08 17:00           Metz 0.7   3-3  1.4         Lille      15551  ...
 ...   ... ...        ...   ...            ... ...   ...  ...           ...        ...  ...
```

3. The `dplyr` grammar

3.2. Basic functions

```
fb %>%
  select(Home, xG, Score, xG.1, Away)                # Keep/drop certain columns
                                                     #
                                                     #
                                                     #
                                                     #
                                                     #
```

```
##              Home  xG Score xG.1          Away
## 1          Monaco 2.0   1-1  0.3        Nantes
## 2            Lyon 1.4   1-1  0.8         Brest
## 3          Troyes 0.8   1-2  1.2     Paris S-G
## 4          Rennes 0.6   1-1  2.0          Lens
## 5        Bordeaux 0.7   0-2  3.3 Clermont Foot
## 6      Strasbourg 0.4   0-2  0.9        Angers
## 7            Nice 0.8   0-0  0.2         Reims
## 8   Saint-Étienne 2.1   1-1  1.3       Lorient
## 9            Metz 0.7   3-3  1.4         Lille
##  ...             ... ...   ...  ...          ...
```

3. The `dplyr` grammar

3.2. Basic functions

```
fb %>%
  select(Home, xG, Score, xG.1, Away) %>%          # Keep/drop certain columns
  mutate(home_winner = xG > xG.1)                  # Create a new variable
                                                   #
                                                   #
                                                   #
                                                   #
```

```
##              Home  xG Score xG.1          Away home_winner
## 1          Monaco 2.0   1-1  0.3        Nantes        TRUE
## 2            Lyon 1.4   1-1  0.8         Brest        TRUE
## 3          Troyes 0.8   1-2  1.2     Paris S-G       FALSE
## 4          Rennes 0.6   1-1  2.0          Lens       FALSE
## 5        Bordeaux 0.7   0-2  3.3 Clermont Foot       FALSE
## 6      Strasbourg 0.4   0-2  0.9        Angers       FALSE
## 7            Nice 0.8   0-0  0.2         Reims        TRUE
## 8   Saint-Étienne 2.1   1-1  1.3       Lorient        TRUE
## 9            Metz 0.7   3-3  1.4         Lille       FALSE
##  ...             ... ...   ...  ...           ...         ...
```

3. The `dplyr` grammar

3.2. Basic functions

```
fb %>%
  select(Home, xG, Score, xG.1, Away) %>%          # Keep/drop certain columns
  mutate(home_winner = xG > xG.1) %>%              # Create a new variable
  filter(Home == "Rennes")                         # Keep/drop certain rows
                                                   #
                                                   #
                                                   #
```

```
##      Home  xG Score xG.1          Away home_winner
## 1  Rennes 0.6   1-1  2.0          Lens       FALSE
## 2  Rennes 0.9   1-0  0.5        Nantes        TRUE
## 3  Rennes 1.0   0-2  0.5         Reims        TRUE
## 4  Rennes 2.4   6-0  0.3 Clermont Foot        TRUE
## 5  Rennes 0.8   2-0  1.4     Paris S-G       FALSE
## 6  Rennes 1.5   1-0  0.6    Strasbourg        TRUE
## 7  Rennes 3.8   4-1  1.1          Lyon        TRUE
## 8  Rennes 3.1   2-0  0.7   Montpellier        TRUE
## 9  Rennes 0.8   1-2  0.6         Lille        TRUE
         ... ...   ...  ...           ...         ...
```

3. The `dplyr` grammar

3.2. Basic functions

```
fb %>%
  select(Home, xG, Score, xG.1, Away) %>%          # Keep/drop certain columns
  mutate(home_winner = xG > xG.1) %>%              # Create a new variable
  filter(Home == "Rennes") %>%                     # Keep/drop certain rows
  arrange(-xG)                                     # Sort rows
                                                   #
                                                   #
```

```
##      Home  xG Score xG.1          Away home_winner
## 1  Rennes 3.8   4-1  1.1          Lyon        TRUE
## 2  Rennes 3.3   6-0  0.4      Bordeaux        TRUE
## 3  Rennes 3.3   6-1  0.9          Metz        TRUE
## 4  Rennes 3.1   2-0  0.7   Montpellier        TRUE
## 5  Rennes 2.7   2-0  0.3         Brest        TRUE
## 6  Rennes 2.6   4-1  0.4        Troyes        TRUE
## 7  Rennes 2.4   6-0  0.3 Clermont Foot        TRUE
## 8  Rennes 1.9   2-3  2.9        Monaco       FALSE
## 9  Rennes 1.7   2-0  0.3        Angers        TRUE
         ... ...   ...  ...           ...         ...
```

3. The `dplyr` grammar

3.2. Basic functions

```
fb %>%
  select(Home, xG, Score, xG.1, Away) %>%          # Keep/drop certain columns
  mutate(home_winner = xG > xG.1) %>%              # Create a new variable
  filter(Home == "Rennes") %>%                     # Keep/drop certain rows
  arrange(-xG) %>%                                 # Sort rows
  summarise(expected_wins = mean(home_winner),     # Aggregate into statistics
            expected_goals = sum(xG))              #
```

```
##   expected_wins expected_goals
## 1     0.8421053           36.6
```

3. The `dplyr` grammar

3.2. Basic functions

- Here are two very **handy functions** to use within `mutate()`

ifelse

```
fb %>%
  select(Home, Attendance) %>%
  mutate(att_bin = ifelse(Attendance > 10000,
                          "Large",
                          "Low")
         ) %>% head()
```

```
##          Home Attendance att_bin
## 1      Monaco       7500     Low
## 2        Lyon      29018   Large
## 3      Troyes      15248   Large
## 4      Rennes      22567   Large
## 5    Bordeaux      18748   Large
## 6 Strasbourg      23250   Large
```

case_when

```
fb %>%
  select(Home, xG, xG.1, Away) %>%
  mutate(xWin = case_when(xG > xG.1 ~ "Home",
                          xG == xG.1 ~ "Draw",
                          xG < xG.1 ~ "Away")
         ) %>% head()
```

```
##          Home  xG xG.1          Away xWin
## 1      Monaco 2.0  0.3        Nantes Home
## 2        Lyon 1.4  0.8         Brest Home
## 3      Troyes 0.8  1.2     Paris S-G Away
## 4      Rennes 0.6  2.0          Lens Away
## 5    Bordeaux 0.7  3.3 Clermont Foot Away
## 6 Strasbourg 0.4  0.9        Angers Away
```

3. The `dplyr` grammar

3.3. group_by() and summarise()

- With `group_by()` you can perform **computations separately** for the different **categories of a variable**

```
fb %>%
  select(Wk, Home, xG) %>%
  mutate(all.xG = mean(xG)) %>%
  head(10)
```

```
##    Wk          Home  xG   all.xG
## 1   1        Monaco 2.0 1.473421
## 2   1          Lyon 1.4 1.473421
## 3   1        Troyes 0.8 1.473421
## 4   1        Rennes 0.6 1.473421
## 5   1      Bordeaux 0.7 1.473421
## 6   1    Strasbourg 0.4 1.473421
## 7   1          Nice 0.8 1.473421
## 8   1 Saint-Étienne 2.1 1.473421
## 9   1          Metz 0.7 1.473421
## 10  1   Montpellier 0.5 1.473421
```

```
fb %>%
  select(Wk, Home, xG) %>%
  group_by(Home) %>%
  mutate(home.xG = mean(xG)) %>%
  head(6)
```

```
## # A tibble: 6 x 4
## # Groups:   Home [6]
##      Wk Home          xG home.xG
##   <int> <chr>      <dbl>   <dbl>
## 1     1 Monaco       2      1.69
## 2     1 Lyon         1.4    2.07
## 3     1 Troyes       0.8    1.21
## 4     1 Rennes       0.6    1.93
## 5     1 Bordeaux     0.7    1.23
## 6     1 Strasbourg   0.4    1.73
```

3. The `dplyr` grammar

3.3. group_by() and summarise()

- It is particularly **useful with summarise()**
  - summarise keeps the grouping variable
  - and computes **statistics for each category**

```
fb %>%
  group_by(Wk) %>%
  summarise(n = n(),
            tot_xG = sum(xG)+sum(xG.1),
            avg_WG = tot_xG/n) %>%
  head(4)
```

```
## # A tibble: 4 x 4
##      Wk     n tot_xG avg_WG
##   <int> <int>  <dbl>  <dbl>
## 1     1    10   23.4   2.34
## 2     2    10   26.6   2.66
## 3     3    10   25.7   2.57
## 4     4    10   30.4   3.04
```

mutate() $\neq$ summarise()

- **mutate()** takes an operation that converts:
  - **A vector into another vector**
- **summarise()** takes an operation that converts:
  - **A vector into a value**

Ungrouping

- **group_by()** applies to all subsequent operations
- To cancel its effect you must **ungroup()** the data

```
fb %>%
  group_by(Wk) %>%
  mutate(test = mean(xG)) %>%
  ungroup() %>%
  ...
```

Practice

10:00

1) Start from the `fb` dataset and keep only the variables `Home`, `Score` and `Away`

2) Use the `separate()` function from `tidyr` to split the `Score` variable into `home_score` and `away_score`

```
data.frame(x = "a_b") %>%
  separate(x, c("x", "y"), "_")
```

```
##   x y
## 1 a b
```

3) Convert these two variables into numeric vectors

4) Create a variable named `winner` that takes the values `Home`, `Draw` and `Away` depending on the score

5) Use `group_by()` and `summarise()`to compute the percentage of draws, home wins and away wins

You've got 10 minutes!

Solution

1) Start from the `fb` dataset and keep only the variables `Home`, `Score` and `Away`

```
fb %>%
  select(Home, Score, Away) %>%
  head(2)
```

```
##     Home Score   Away
## 1 Monaco   1-1 Nantes
## 2   Lyon   1-1  Brest
```

2) Use the `separate()` function from `tidyr` to split the `Score` variable into `home_score` and `away_score`

```
fb %>%
  select(Home, Score, Away) %>%
  separate(Score, c("home_score", "away_score"), "-") %>%
  head(2)
```

```
##     Home home_score away_score   Away
## 1 Monaco          1          1 Nantes
## 2   Lyon          1          1  Brest
```

Solution

3) Convert these two variables into numeric vectors

4) Create a variable named `winner` that takes the values `Home`, `Draw` and `Away` depending on the score

```
fb %>%
  select(Home, Score, Away) %>%
  separate(Score, c("home_score", "away_score"), "-") %>%
  mutate(home_score = as.numeric(home_score),
         away_score = as.numeric(away_score),
         winner = case_when(home_score < away_score ~ "Away",
                            home_score == away_score ~ "Draw",
                            home_score > away_score ~ "Home")) %>%
  head()
```

```
##         Home home_score away_score          Away winner
## 1     Monaco          1          1        Nantes   Draw
## 2       Lyon          1          1         Brest   Draw
## 3     Troyes          1          2     Paris S-G   Away
## 4     Rennes          1          1          Lens   Draw
## 5   Bordeaux          0          2 Clermont Foot   Away
## 6 Strasbourg          0          2        Angers   Away
```

Solution

5) Use `group_by()` and `summarise()` to compute the percentage of draws, home wins and away wins

```
fb %>%
  select(Home, Score, Away) %>%
  separate(Score, c("home_score", "away_score"), "-") %>%
  mutate(home_score = as.numeric(home_score),
         away_score = as.numeric(away_score),
         winner = case_when(home_score < away_score ~ "Away",
                            home_score == away_score ~ "Draw",
                            home_score > away_score ~ "Home")) %>%
  group_by(winner) %>%
  summarise(pct = 100 * (n() / nrow(fb)))
```

```
## # A tibble: 3 x 2
##   winner   pct
##   <chr>  <dbl>
## 1 Away    30.5
## 2 Draw    26.8
## 3 Home    42.6
```

Overview

1. Getting started ✓
- 1.1. About R
- 1.2. The R Studio IDE
- 1.3. Import and eyeball data
- 1.4. Use functions

2. Anatomy of a data.frame ✓
- 2.1. Data structure
- 2.2. Classes
- 2.3. Vectors
- 2.4. Subsetting

3. The dplyr grammar ✓
- 3.1. Packages
- 3.2. Basic functions
- 3.3. group_by() and summarise()

4. A few words on learning R
- 4.1. When it doesn't work the way you want
- 4.2. Where to find help
- 4.3. When it doesn't work at all

5. Wrap up!

Overview

1. Getting started ✓
- 1.1. About R
- 1.2. The R Studio IDE
- 1.3. Import and eyeball data
- 1.4. Use functions

2. Anatomy of a data.frame ✓
- 2.1. Data structure
- 2.2. Classes
- 2.3. Vectors
- 2.4. Subsetting

3. The dplyr grammar ✓
- 3.1. Packages
- 3.2. Basic functions
- 3.3. group_by() and summarise()

4. A few words on learning R
- 4.1. When it doesn't work the way you want
- 4.2. Where to find help
- 4.3. When it doesn't work at all

4. A few words on learning R

4.1. When it doesn't work the way you want

- When things do not work the way you want, **NAs are the usual suspects**
  - For instance, this is how the mean function reacts to NAs:

```
mean(c(1, 2, NA))
```

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

```
mean(c(1, 2, NA), na.rm = T)
```

```
## [1] 1.5
```

- You should systematically **check for NAs!**

```
is.na(c(1, 2, NA))
```

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

4. A few words on learning R

4.1. When it doesn't work the way you want

- **Don't pipe blindfolded!**
  - **Check** that each command does what it's expected to do
  - View or print your data **at each step**

```
fb %>%
  select(Home, Score, Away) %>%
  head(1)
```

```
##     Home Score   Away
## 1 Monaco   1-1 Nantes
```

```
fb %>%
  select(Home, Score, Away) %>%
  separate(Score, c("home_score", "away_score"), "-") %>%
  head(1)
```

```
##     Home home_score away_score   Away
## 1 Monaco          1          1 Nantes
```

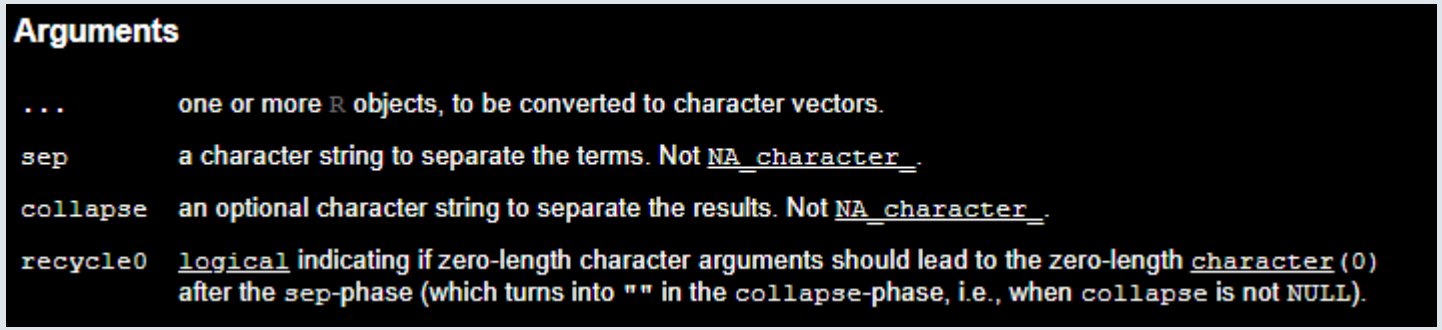
4. A few words on learning R

4.2. Where to find help

- Oftentimes things don't work either because:
  - **You don't understand** a function's argument
  - Or **you don't know** that there exists an argument that you should use

- This is precisely what **help files** are made for
  - Every function has a help file, just enter **?** and the name of your **function** in the console
  - The help file will **pop up in the Help tab** of R studio

```
?paste
```



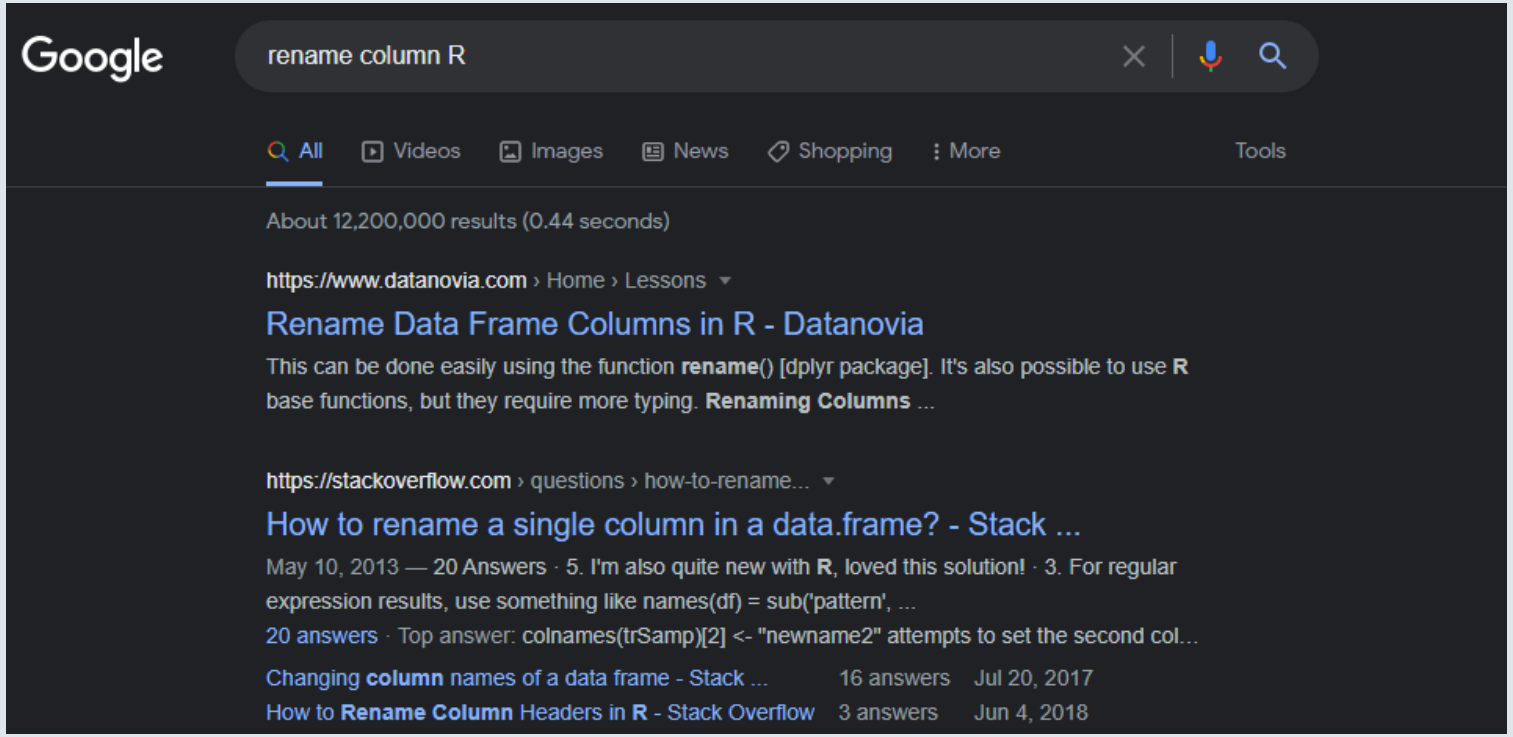
Arguments

`...`	one or more R objects, to be converted to character vectors.
`sep`	a character string to separate the terms. Not `NA_character_`.
`collapse`	an optional character string to separate the results. Not `NA_character_`.
`recycle0`	`logical` indicating if zero-length character arguments should lead to the zero-length `character(0)` after the `sep`-phase (which turns into `""` in the `collapse`-phase, i.e., when `collapse` is not `NULL`).

4. A few words on learning R

4.2. Where to find help

- Search on the internet!
  - Your question is for sure already asked and answered on stackoverflow



4. A few words on learning R

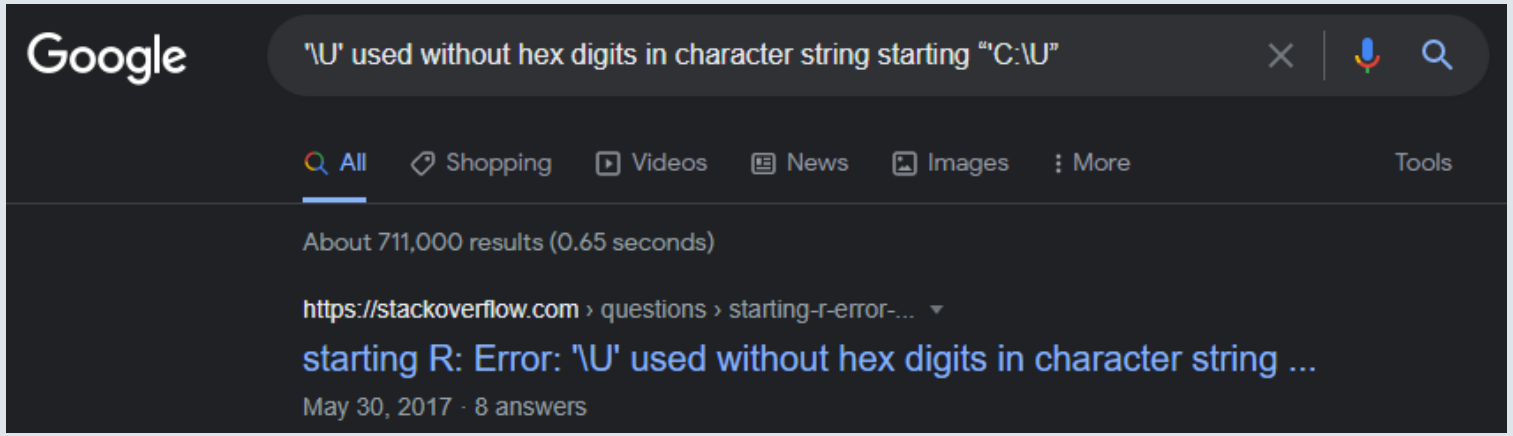
4.3. When it doesn't work at all

- Sometimes R breaks and returns an **error** (usually kind of cryptic)

```
read.csv("C:\Users\Documents\R")
```

```
## Error: '\U' used without hex digits in character string starting ""C:\U"
```

1. Look for **keywords** that might help you understand where it comes from
2. Paste in on **Google** with the name of your command



Overview

1. Getting started ✓
- 1.1. About R
- 1.2. The R Studio IDE
- 1.3. Import and eyeball data
- 1.4. Use functions

2. Anatomy of a data.frame ✓
- 2.1. Data structure
- 2.2. Classes
- 2.3. Vectors
- 2.4. Subsetting

3. The dplyr grammar ✓
- 3.1. Packages
- 3.2. Basic functions
- 3.3. group_by() and summarise()

4. A few words on learning R ✓
- 4.1. When it doesn't work the way you want
- 4.2. Where to find help
- 4.3. When it doesn't work at all

5. Wrap up!

5. Wrap up!

1. Import data

```
fb <- read.csv("C:/User/Documents/ligue1.csv", encoding = "UTF-8")
```

2. Class

```
is.numeric("1.6180339") # What would be the output?
```

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

3. Subsetting

```
fb$Home[3]
```

```
## [1] "Troyes"
```

5. Wrap up!

4. Packages

```
library(dplyr)
```

5. The dplyr grammar

Function	Meaning
mutate()	Modify or create a variable
select()	Keep a subset of variables
filter()	Keep a subset of observations
arrange()	Sort the data
group_by()	Group the data
summarise()	Summarizes variables into 1 observation per group