Basic data manipulation

Lecture 3

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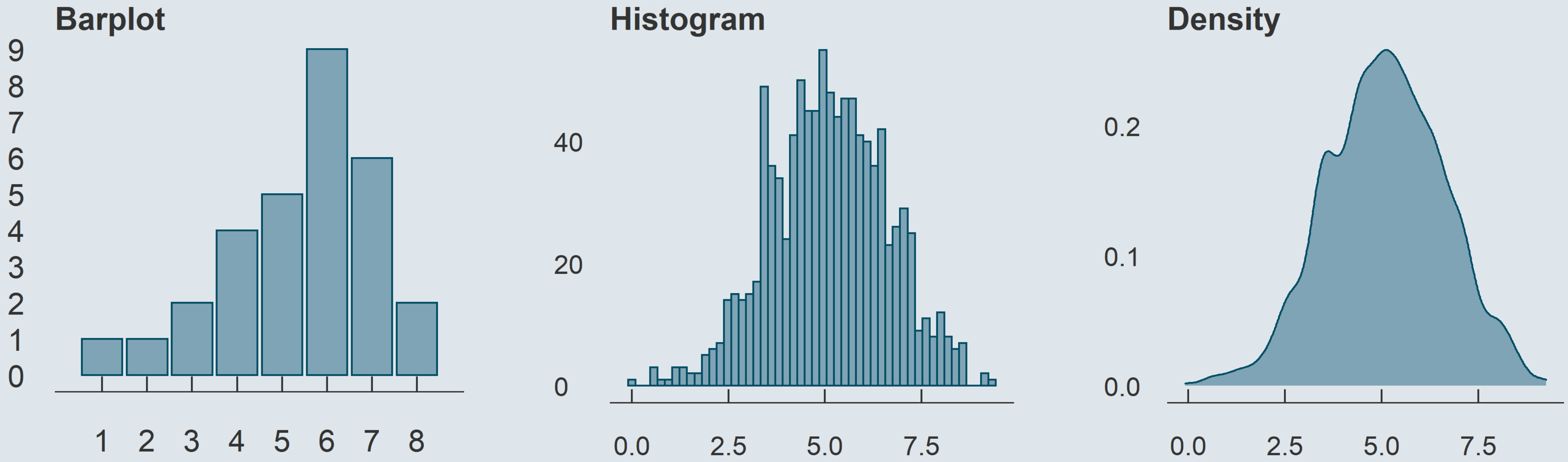
CPES 2 - Fall 2022

Quick reminder

1. Distributions

- The **distribution** of a variable documents all its possible values and how frequent they are



Barplot

Histogram

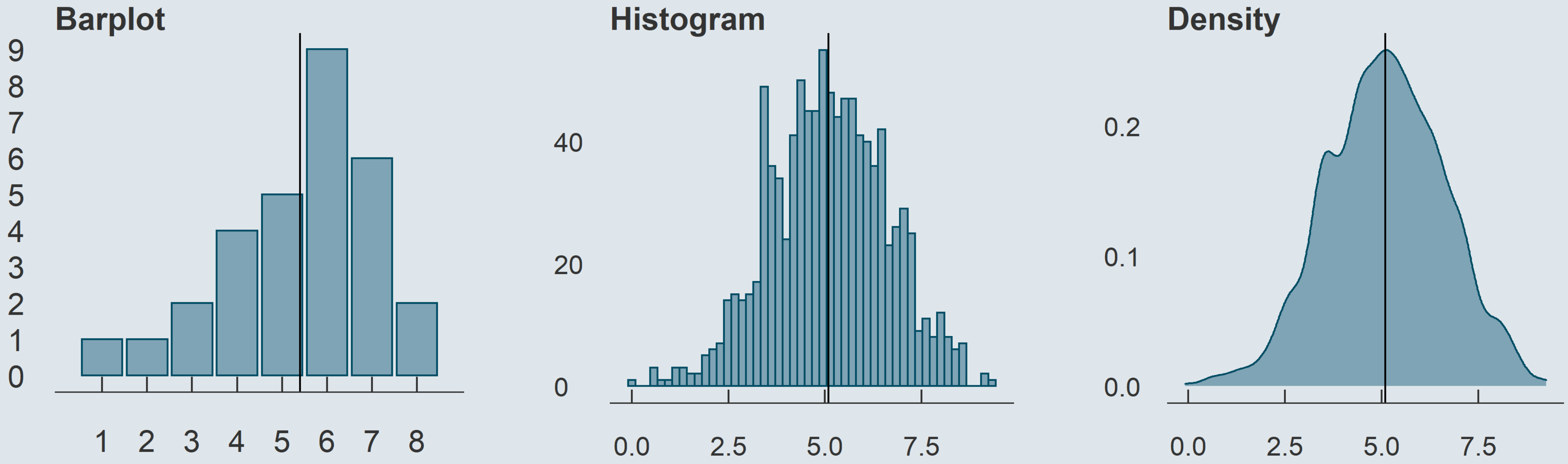
Density

- We can describe a distribution with:

Quick reminder

1. Distributions

- The **distribution** of a variable documents all its possible values and how frequent they are

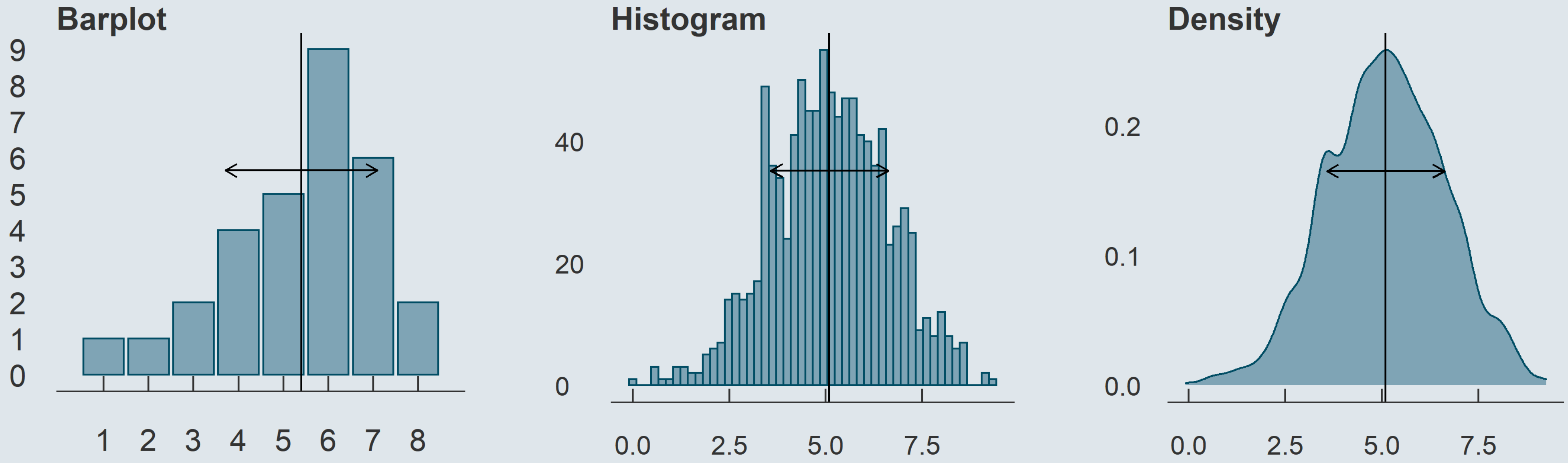


- We can describe a distribution with:
  - Its **central tendency**

Quick reminder

1. Distributions

- The **distribution** of a variable documents all its possible values and how frequent they are



- We can describe a distribution with:
    - Its **central tendency**
    - And its **spread**

Quick reminder

2. Central tendency

- The **mean** is the sum of all values divided by the number of observations

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

- The **median** is the value that divides the (sorted) distribution into two groups of equal size

$$\text{Med}(x) = \begin{cases} x[\frac{N+1}{2}] & \text{if } N \text{ is odd} \\ \frac{x[\frac{N}{2}]+x[\frac{N}{2}+1]}{2} & \text{if } N \text{ is even} \end{cases}$$

3. Spread

- The **standard deviation** is square root of the average squared deviation from the mean

$$\text{SD}(x) = \sqrt{\text{Var}(x)} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

- The **interquartile range** is the difference between the maximum and the minimum value from the middle half of the distribution

$$\text{IQR} = Q_3 - Q_1$$

Quick reminder

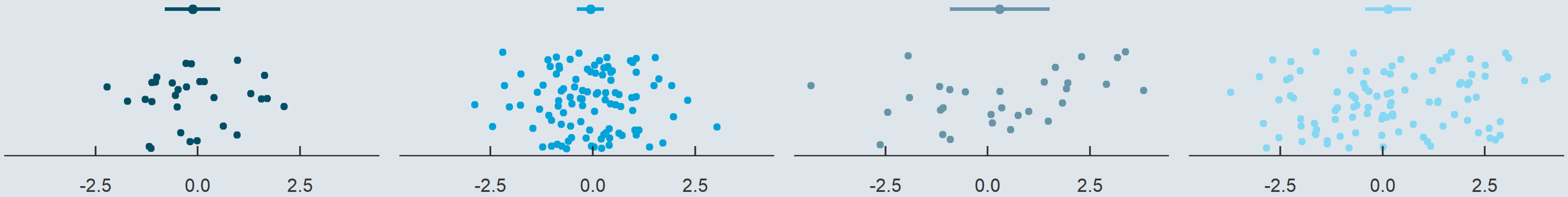
4. Inference

- In Statistics, we view variables as a given realization of a **data generating process**
  - Hence, the **mean** is what we call an **empirical moment**, which is an **estimation**...
  - ... of the **expected value**, the **theoretical moment** of the DGP we're interested in

- To know how confident we can be in this estimation, we need to compute a **confidence interval**

$$[\bar{x} - t_{n-1,\,97.5\%} \times \frac{\text{SD}(x)}{\sqrt{n}};\ \bar{x} + t_{n-1,\,97.5\%} \times \frac{\text{SD}(x)}{\sqrt{n}}]$$

  - It gets **larger** as the **variance** of the distribution of x increases
  - And gets **smaller** as the **sample size** n increases



Warm up practice

05:00

1) Import the `ligue1.csv` dataset and store it in an object called `fb`

2) Create a subset of this dataset containing only matches that took place at 13h

3) Print the number of matches in this subset and compute the average attendance

4) Redo the same exercise on matches that took place at 20h45

You've got 5 minutes!

Solution

1) Import the `ligue1.csv` dataset and store it in an object called `fb`

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

2) Create a subset of this dataset containing only matches that took place at 13h

```r
sub13 <- fb[fb$Time == "13:00", ]
```

3) Print the number of matches in this subset and compute the average attendance

```r
nrow(sub13)
```

```
## [1] 32
```

```r
mean(sub13$Attendance)
```

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

Solution

- When there are **missing values** in a vector, the **mean** function returns **NA**
  - We need to set the **na.rm** option to **TRUE**

3) Print the number of matches in this subset and compute the average attendance

```
mean(sub13$Attendance, na.rm = T)
```

```
## [1] 19038
```

4) Redo the same exercise on matches that took place at 20h45

```
sub2045 <- fb[fb$Time == "20:45", ]
nrow(sub2045)
```

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

```
mean(sub2045$Attendance, na.rm = T)
```

```
## [1] 36418.64
```

Today we learn how to manipulate data

1. The dplyr package

1.1. Packages

1.2. Basic functions

1.3. group_by() and summarise()

2. Merge and reshape

2.1. Merge and append data

2.2. Reshape data

3. A few words on learning R

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

3.2. Where to find help

3.3. When it doesn't work at all

4. Wrap up!

Today we learn how to manipulate data

1. The dplyr package

- 1.1. Packages
- 1.2. Basic functions
- 1.3. group_by() and summarise()

1. The `dplyr` package

1.1. 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

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

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

1. The `dplyr` package

1.1. Packages

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

```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

```r
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()**

1. The `dplyr` package

1.2. 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

1. The dplyr package

1.2. 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  ...
 ...  ... ...        ...   ...           ... ...   ...  ...           ...        ...  ...
```

1. The dplyr package

1.2. 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
 ...             ... ...   ...  ...           ...
```

1. The dplyr package

1.2. 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
 ...             ... ...   ...  ...           ...         ...
```

1. The dplyr package

1.2. 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
         ... ...   ...  ...           ...         ...
```

1. The dplyr package

1.2. Basic functions

```r
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
         ... ...   ...  ...           ...         ...
```

1. The dplyr package

1.2. Basic functions

```r
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
```

1. The dplyr package

1.2. 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
```

1. The dplyr package

1.3. group_by() and summarise()

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

```r
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
```

```r
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
```

1. The dplyr package

1.3. 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() ≠ 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`

```r
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`

```r
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`

```r
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

```r
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

```r
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. The dplyr package ✓

- 1.1. Packages
- 1.2. Basic functions
- 1.3. group_by() and summarise()

2. Merge and reshape

- 2.1. Merge and append data
- 2.2. Reshape data

3. A few words on learning R

- 3.1. When it doesn't work the way you want
- 3.2. Where to find help
- 3.3. When it doesn't work at all

4. Wrap up!

Overview

1. The dplyr package ✓

1.1. Packages
1.2. Basic functions
1.3. group_by() and summarise()

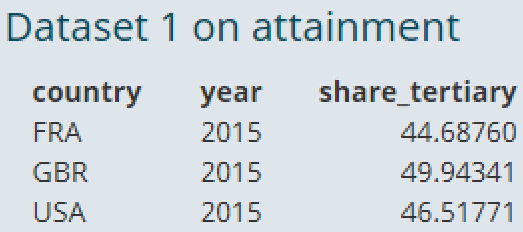
2. Merge and reshape

2.1. Merge and append data
2.2. Reshape data

2. Merge and reshape

2.1. Merge and append data

- Research projects often imply to **combine data** from different sources
  - Either to **add observations** (append rows)
  - Either to **add variables** (merge columns)



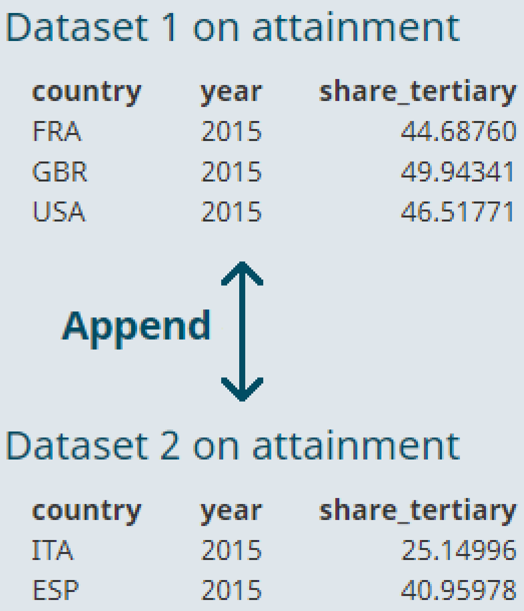
Dataset 1 on attainment

country	year	share_tertiary
FRA	2015	44.68760
GBR	2015	49.94341
USA	2015	46.51771

2. Merge and reshape

2.1. Merge and append data

- Research projects often imply to **combine data** from different sources
  - Either to **add observations** (append rows)
  - Either to **add variables** (merge columns)



Dataset 1 on attainment

country	year	share_tertiary
FRA	2015	44.68760
GBR	2015	49.94341
USA	2015	46.51771

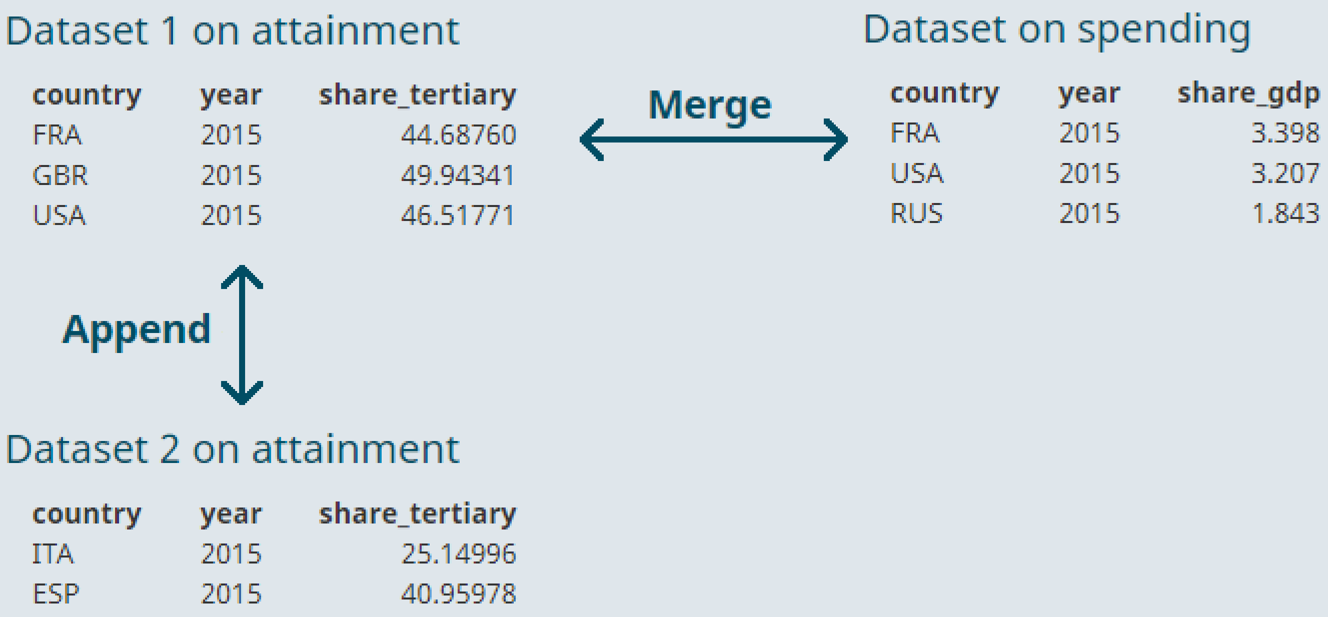
Dataset 2 on attainment

country	year	share_tertiary
ITA	2015	25.14996
ESP	2015	40.95978

2. Merge and reshape

2.1. Merge and append data

- Research projects often imply to **combine data** from different sources
  - Either to **add observations** (append rows)
  - Either to **add variables** (merge columns)



Dataset 1 on attainment

country	year	share_tertiary
FRA	2015	44.68760
GBR	2015	49.94341
USA	2015	46.51771

Dataset on spending

country	year	share_gdp
FRA	2015	3.398
USA	2015	3.207
RUS	2015	1.843

Dataset 2 on attainment

country	year	share_tertiary
ITA	2015	25.14996
ESP	2015	40.95978

2. Merge and reshape

2.1. Merge and append data: The `bind_rows()` function

```r
read.csv("attainment_FR_UK_US.csv")
```

```
##   country year share_tertiary
## 1     FRA 2015       44.68760
## 2     GBR 2015       49.94341
## 3     USA 2015       46.51771
```

```r
read.csv("attainment_IT_SP.csv")
```

```
##   country year share_tertiary
## 1     ITA 2015       25.14996
## 2     ESP 2015       40.95978
```

```r
attainment <- read.csv("attainment_FR_UK_US.csv") %>%
  bind_rows(read.csv("attainment_IT_SP.csv"))
attainment
```

```
##   country year share_tertiary
## 1     FRA 2015       44.68760
## 2     GBR 2015       49.94341
## 3     USA 2015       46.51771
## 4     ITA 2015       25.14996
## 5     ESP 2015       40.95978
```

Variables in the two datasets should be the same:

- **Same name**
- **Same class**

2. Merge and reshape

2.1. Merge and append data: `*_join()` functions

- Join functions all work the same way:
  - A **dataset A** with a **variable X** and other variables
  - A **dataset B** with a **variable X** and other variables
  - X is the common variable, so datasets will be **joined *by* X**

The 4 main join functions

Function	For X in A & B	For X in A only	For X in B only	Summary
A %>% left_join(B, by = "X")	Kept	Kept	Dropped	Only keeps what's in A
A %>% right_join(B, by = "X")	Kept	Dropped	Kept	Only keeps what's in B
A %>% inner_join(B, by = "X")	Kept	Dropped	Dropped	Only keeps what's common
A %>% full_join(B, by = "X")	Kept	Kept	Kept	Keeps everything

2. Merge and reshape

⚠ Beware of NAs! ⚠

- When you have **values** of X that are **not common** to both datasets
  - Any other join than the inner_join() will **generate NAs**

```r
attainment %>% full_join(read.csv("spending.csv"), by = "country")
```

```
##   country year.x share_tertiary year.y share_gdp
## 1     FRA   2015       44.68760   2015     3.398
## 2     GBR   2015       49.94341     NA        NA
## 3     USA   2015       46.51771   2015     3.207
## 4     ITA   2015       25.14996     NA        NA
## 5     ESP   2015       40.95978     NA        NA
## 6     RUS     NA             NA   2015     1.843
```

- Any variable from `A` (`B`) other than those stated in `by=` will be `NA` for observations that are only in `B` (`A`)

- This holds when a variable that is not mentioned in the `by=` argument appears in both datasets:
  - In that case, R adds a data-specific suffix to the names and keeps them both
  - The variable from `B` (here `year.y`) will be `NA` for observations that are only in `A` only (here `GBR`, `ITA`, `ESP`)

2. Merge and reshape

2.1. Merge and append data: example

```
attainment %>% left_join(read.csv("spending.csv"), by = "country")
```

```
##   country year.x share_tertiary year.y share_gdp
## 1     FRA   2015       44.68760   2015     3.398
## 2     GBR   2015       49.94341     NA        NA
## 3     USA   2015       46.51771   2015     3.207
## 4     ITA   2015       25.14996     NA        NA
## 5     ESP   2015       40.95978     NA        NA
```

```
attainment %>% right_join(read.csv("spending.csv"), by = "country")
```

```
##   country year.x share_tertiary year.y share_gdp
## 1     FRA   2015       44.68760   2015     3.398
## 2     USA   2015       46.51771   2015     3.207
## 3     RUS     NA             NA   2015     1.843
```

➜ What would be the result of an inner_join() here?

2. Merge and reshape

2.2. Reshape data

- It is important to be able to **switch from** the ***long*** **to** the ***wide*** format and conversely
    - Some computations should be done in one format or the other

Wide format

country	year	share_tertiary	share_gdp
FRA	2015	44.69	3.40
USA	2015	46.52	3.21

Long format

country	year	Variable	Value
FRA	2015	share_tertiary	44.69
FRA	2015	share_gdp	3.40
USA	2015	share_tertiary	46.52
USA	2015	share_gdp	3.21

2. Merge and reshape

2.2. Reshape data: From wide to long with pivot_longer()

```r
wide <- attainment %>%
  inner_join(read.csv("spending.csv") %>% select(-year),
             by = "country")
wide
```

```
##   country year share_tertiary share_gdp
## 1     FRA 2015       44.68760     3.398
## 2     USA 2015       46.51771     3.207
```

*→ Pivoting to **long format** can be seen as putting **variables on top of each other** rather side to side*

- We need to indicate:
  - **Which variables to stack**
  - The **name of** the variable in which we want the **values** of the stacked variables to be stored
  - The **name of** the variable that will indicate to which **variable** corresponds each value

2. Merge and reshape

2.2. Reshape data: From wide to long with pivot_longer()

```
long <- wide %>%
               # Which variable to should be stacked
  pivot_longer(c(share_tertiary, share_gdp),
               # Where their values should be stored
               values_to = "Value",
               # Where to store which variable corresponds each value
               names_to = "Variable")
long
```

```
## # A tibble: 4 x 4
##   country  year Variable       Value
##   <chr>   <int> <chr>          <dbl>
## 1 FRA      2015 share_tertiary 44.7 
## 2 FRA      2015 share_gdp       3.40
## 3 USA      2015 share_tertiary 46.5 
## 4 USA      2015 share_gdp       3.21
```

2. Merge and reshape

2.2. Reshape data: From long to wide with pivot_wider()

- To **pivot in a wide** format we need to indicate:
  - **Which variable** contains **values** of the variables we want to put side to side
  - **Which variable** indicates which **variable** correspond to each value

```
wide <- long %>%
              # Where the values are
  pivot_wider(values_from = "Value",
              # Where the corresponding variable names are
              names_from = "Variable")
wide
```

```
## # A tibble: 2 x 4
##   country  year share_tertiary share_gdp
##   <chr>   <int>          <dbl>     <dbl>
## 1 FRA      2015           44.7      3.40
## 2 USA      2015           46.5      3.21
```

Practice

10:00

1) From the `fb` dataset, create a variable `league` equal to `"ligue1"` and a variable `season` equal to `"2021-2022"` and save this new data in an object named `full_fb`

2) In data.zip you will find the rest of the data for the seasons 2019-2020 to 2021-2022 for the league 1, the bundesliga and the premier league. Append all these data to `full_fb`. Make sure to create the variables `league` and `season` in each data set before appending.

3) Use the `separate` function from `tidyr` to extract the number of goals scored by the home and away team

4) Convert these variables as numeric and create a variable equal to the sum of the goals from the two teams

5) Summarise your data into the total number of goals score per league/season

6) Reshape your data such that you have 1 row per league and 1 column per season

You've got 10 minutes!

Solution

1) From the `fb` dataset, create a variable `league` equal to `"ligue1"` and a variable `season` equal to `"2021-2022"` and save this new data in an object named `full_fb`

```
full_fb <- fb %>% mutate(league = "ligue1", season = "2021-2022")
```

2) In data.zip you will find the rest of the data for the seasons 2019-2020 to 2021-2022 for the league 1, the bundesliga and the premier league. Append all these data to `full_fb`. Make sure to create the variables `league` and `season` in each data set before appending.

```
full_fb <- full_fb %>%
  bind_rows(read.csv("ligue1_2021.csv") %>% mutate(league = "ligue1", season = "2020-2021")) %>%
  bind_rows(read.csv("ligue1_1920.csv") %>% mutate(league = "ligue1", season = "2019-2020")) %>%
  bind_rows(read.csv("preml_2122.csv") %>% mutate(league = "preml", season = "2021-2022")) %>%
  bind_rows(read.csv("preml_2021.csv") %>% mutate(league = "preml", season = "2020-2021")) %>%
  bind_rows(read.csv("preml_1920.csv") %>% mutate(league = "preml", season = "2019-2020")) %>%
  bind_rows(read.csv("bundes_2122.csv") %>% mutate(league = "bundes", season = "2021-2022")) %>%
  bind_rows(read.csv("bundes_2021.csv") %>% mutate(league = "bundes", season = "2020-2021")) %>%
  bind_rows(read.csv("bundes_1920.csv") %>% mutate(league = "bundes", season = "2019-2020"))
```

Solution

3) Use the `separate` function from `tidyr` to extract the number of goals scored by the home and away team

```
full_fb <- full_fb %>%
  separate(Score, c("home_score", "away_score"), "-")
```

4) Convert these variables as numeric and create a variable equal to the sum of the goals from the two teams

```
full_fb <- full_fb %>%
  mutate(home_score = as.numeric(home_score),
         away_score = as.numeric(away_score),
         goals = home_score + away_score)
```

5) Summarise your data into the total number of goals score per league/season

```
full_fb <- full_fb %>%
  group_by(league, season) %>%
  summarise(goals = sum(goals))
```

Solution

6) Reshape your data such that you have 1 row per league and 1 column per season

```
full_fb %>%
  pivot_wider(names_from = "season", values_from = "goals")
```

```
## # A tibble: 3 x 4
## # Groups:   league [3]
##   league `2019-2020` `2020-2021` `2021-2022`
##   <chr>        <dbl>       <dbl>       <dbl>
## 1 bundes         982         928         954
## 2 ligue1         704        1049        1067
## 3 preml         1034        1024        1071
```

Overview

1. The dplyr package ✓

1.1. Packages
1.2. Basic functions
1.3. group_by() and summarise()

2. Merge and reshape ✓

2.1. Merge and append data
2.2. Reshape data

3. A few words on learning R

3.1. When it doesn't work the way you want
3.2. Where to find help
3.3. When it doesn't work at all

4. Wrap up!

Overview

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3. A few words on learning R

3.1. 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
```

3. A few words on learning R

3.1. 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
```

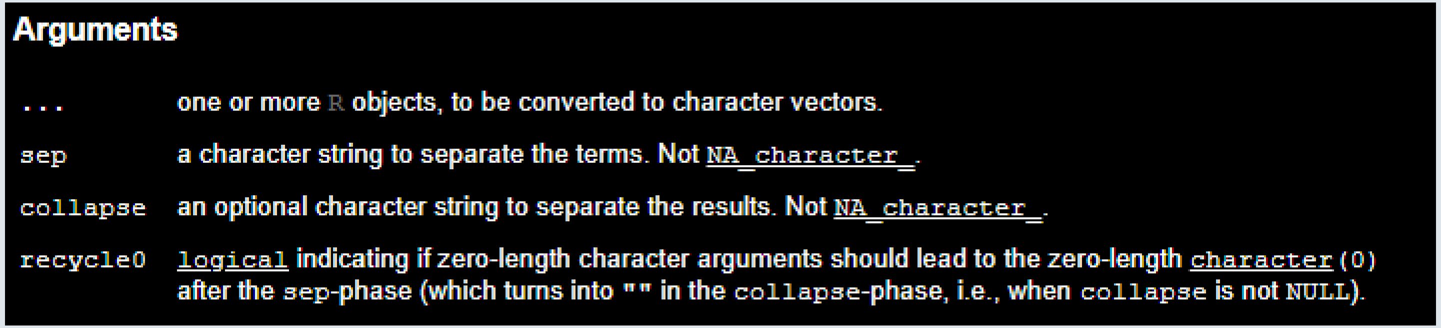
3. A few words on learning R

3.2. 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
```



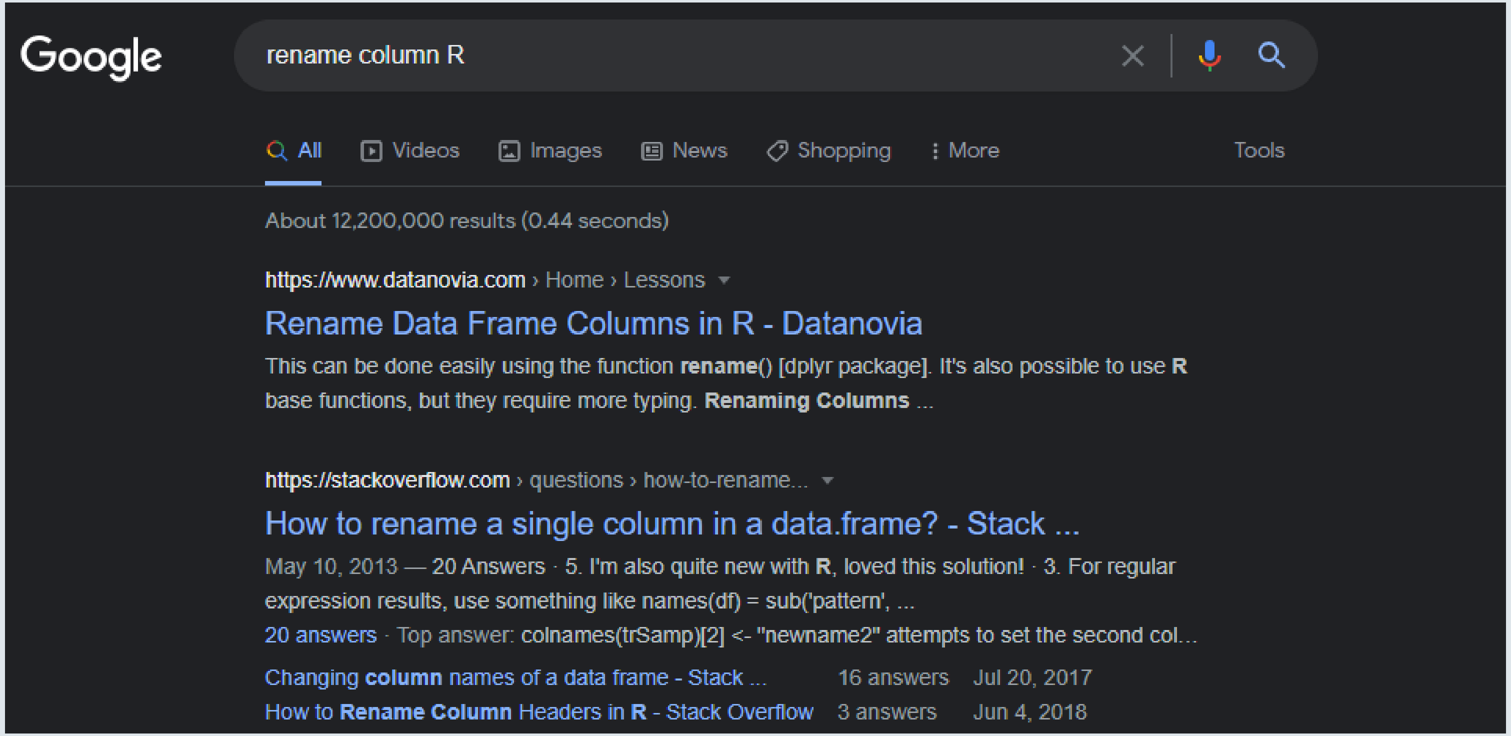
Arguments

`...`	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`).

3. A few words on learning R

3.2. Where to find help

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



About 12,200,000 results (0.44 seconds)

https://www.datanovia.com › Home › Lessons

Rename Data Frame Columns in R - Datanovia

This can be done easily using the function **rename**() [dplyr package]. It's also possible to use **R** base functions, but they require more typing. **Renaming Columns** ...

https://stackoverflow.com › questions › how-to-rename...

How to rename a single column in a data.frame? - Stack ...

May 10, 2013 — 20 Answers · 5. I'm also quite new with **R**, loved this solution! · 3. For regular expression results, use something like names(df) = sub('pattern', ...

20 answers · Top answer: colnames(trSamp)[2] <- "newname2" attempts to set the second col...

Changing **column** names of a data frame - Stack ...	16 answers	Jul 20, 2017
How to **Rename Column** Headers in **R** - Stack Overflow	3 answers	Jun 4, 2018

3. A few words on learning R

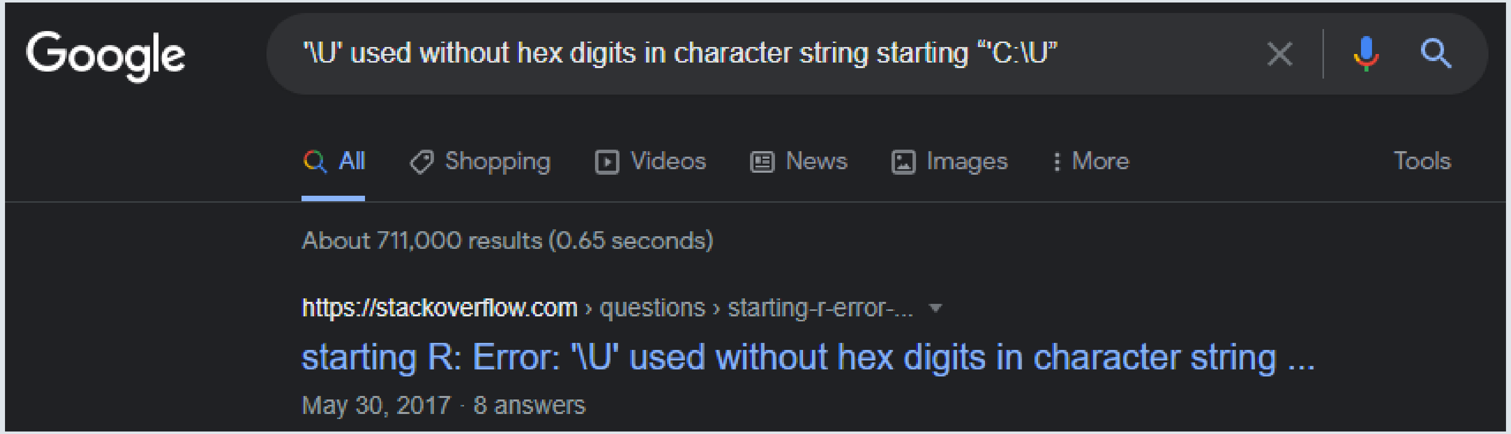
3.3. When it doesn't work at all

- 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



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

About 711,000 results (0.65 seconds)

https://stackoverflow.com › questions › starting-r-error-...

starting R: Error: '\U' used without hex digits in character string ...

May 30, 2017 · 8 answers

Overview

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- 3.1. When it doesn't work the way you want
- 3.2. Where to find help
- 3.3. When it doesn't work at all

4. Wrap up!

4. Wrap up!

1. Packages

```
library(dplyr)
```

2. Main dplyr functions

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

4. Wrap up!

3. Merge data

```
a <- data.frame(x = c(1, 2, 3), y = c("a", "b", "c"))
b <- data.frame(x = c(4, 5, 6), y = c("d", "e", "f"))
c <- data.frame(x = 1:6, z = c("alpha", "bravo", "charlie", "delta", "echo", "foxtrot"))
```

```
a %>% bind_rows(b) %>% left_join(c, by = "x")
```

x	y	z
1	a	alpha
2	b	bravo
3	c	charlie
4	d	delta
5	e	echo
6	f	foxtrot

4. Wrap up!

4. Reshape data

country	year	share_tertiary	share_gdp
FRA	2015	44.69	3.40
USA	2015	46.52	3.21

```r
data %>% pivot_longer(c(share_tertiary, share_gdp), names_to = "Variable", values_to = "Value")
```

country	year	Variable	Value
FRA	2015	share_tertiary	44.69
FRA	2015	share_gdp	3.40
USA	2015	share_tertiary	46.52
USA	2015	share_gdp	3.21

For next time

Install the R packages needed for Part I of the course:

ggplot2

rmarkdown

knitr

DT