

Getting ready to work with R

Alexandre Courtiol

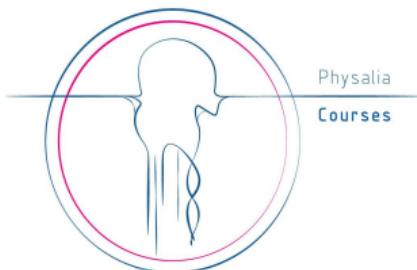
Leibniz Institute of Zoo and Wildlife Research

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**Leibniz Institute for Zoo
and Wildlife Research**

IN THE FORSCHUNGSVERBUND BERLIN E.V.



Getting ready to work with R

1 Installation

2 The RStudio IDE

3 R markdown

4 Basics of the R language

5 R packages

6 Housekeeping

7 Learning R on your own

Practice

- ① check that you do get internet access
- ② install R: <https://cran.r-project.org/>
- ③ install the RStudio IDE: <https://www.rstudio.com/products/rstudio/download/>
- ④ open the RStudio IDE

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- objects
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The RStudio Integrated Desktop Environment

The screenshot shows the RStudio IDE interface. The top menu bar includes RStudio, File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Window, and Help. The title bar indicates the current project is "My_first_project".

Code Editor: The left panel displays an R Markdown script named "Untitled1". The code includes YAML front matter, a chunk setup, and a note about R Markdown. It also contains a warning about the Knit button generating a document with both content and R code output.

```
1 ---  
2 title: "My_first_R_script"  
3 author: "Alexandre Courtiol"  
4 date: "5/15/2019"  
5 output: html_document  
---  
~  
8 ```{r setup, include=FALSE}  
9 knitr::opts_chunk$set(echo = TRUE)  
10 ~  
11 ~  
12 ## R Markdown  
13 ~  
14 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.  
15 ~  
16 When you click the Knit button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document.  
2:1 My_first_R_script : R Markdown
```

Console: The right panel shows the R environment. It displays the R version information, the license notice, natural language support, and information about the R project. It also shows the command history starting with ">".

```
R version 3.6.0 (2019-04-26) -- "Planting of a Tree"  
Copyright (C) 2019 The R Foundation for Statistical Computing  
Platform: x86_64-apple-darwin15.6.0 (64-bit)  
  
R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.  
  
Natural language support but running in an English locale  
  
R is a collaborative project with many contributors.  
Type 'contributors()' for more information and  
'citation()' on how to cite R or R packages in publications.  
  
Type 'demo()' for some demos, 'help()' for on-line help, or  
'help.start()' for an HTML browser interface to help.  
Type 'q()' to quit R.  
  
>
```

Environment: The bottom-left panel shows the global environment, which is currently empty.

File Browser: The bottom-right panel shows the file structure of the project "My_first_project" located at "/Desktop/My_first_project". It lists a single file "My_first_project.Rproj".

Why using the RStudio IDE?

You can use **R** without RStudio, but RStudio is:

- provided with more functionalities than the official **R** IDE
- integrated with several key **R** packages developed by RStudio (e.g. `rmarkdown`)
- suitable for both desktop and remote computers (web server)
- free and open source

Overall structure

- Top menu
- Toolbar (small subset from the top menu)
- 4 visible panes

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The top menu

File Edit Code View Plots Session Build Debug Profile Tools Window Help

10 most useful items:

- File → New File
- File → New Project
- File → Import Dataset
- File → Save
- Edit → Undo
- Edit → Clear console
- Code → Comment/Uncomment Lines
- Tools → Global Options...
- Help → Check for Updates (for updating RStudio, not R, nor R packages)
- Help → Cheatsheets

Practice

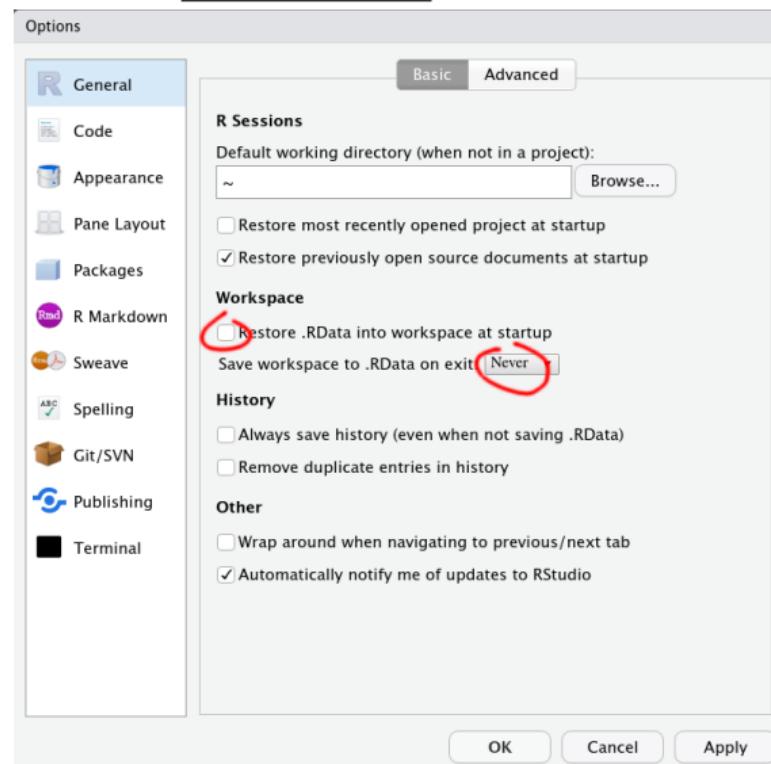
- ① create a new project
- ② create a new **R** markdown file
- ③ save the created **R** markdown file into the project folder directory
- ④ have a look at the RStudio cheatsheet

Notes:

- a project is defined by a simple (text) file. Its main benefit is to open RStudio with the correct working directory set (that is, the one where the project file is)
- an **R** markdown file is a (text) file where we can write text together with code (more later)

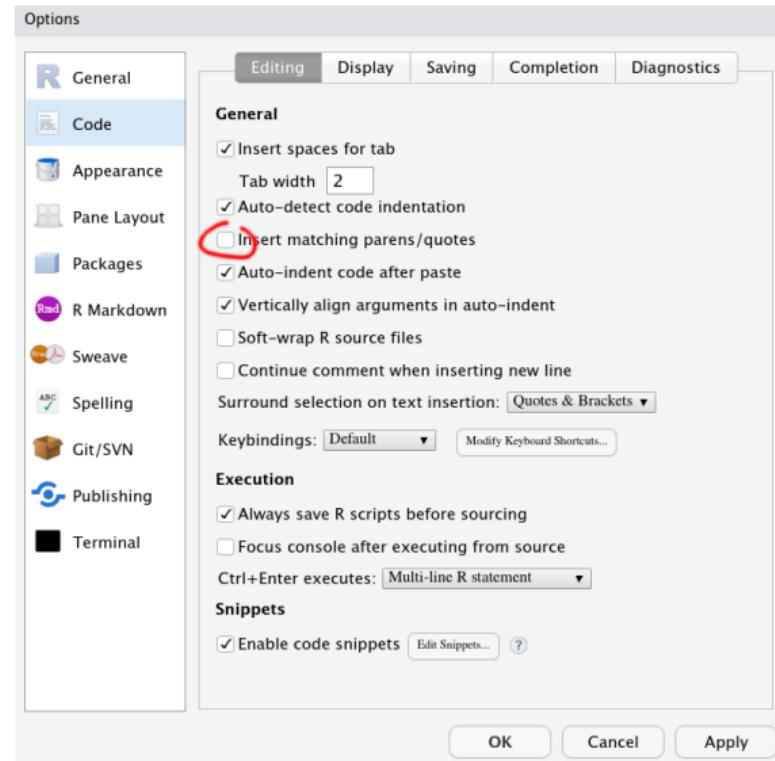
My tips about the global options

1. I never save or restore the workspace and so should you (default settings are a receipe for disasters)



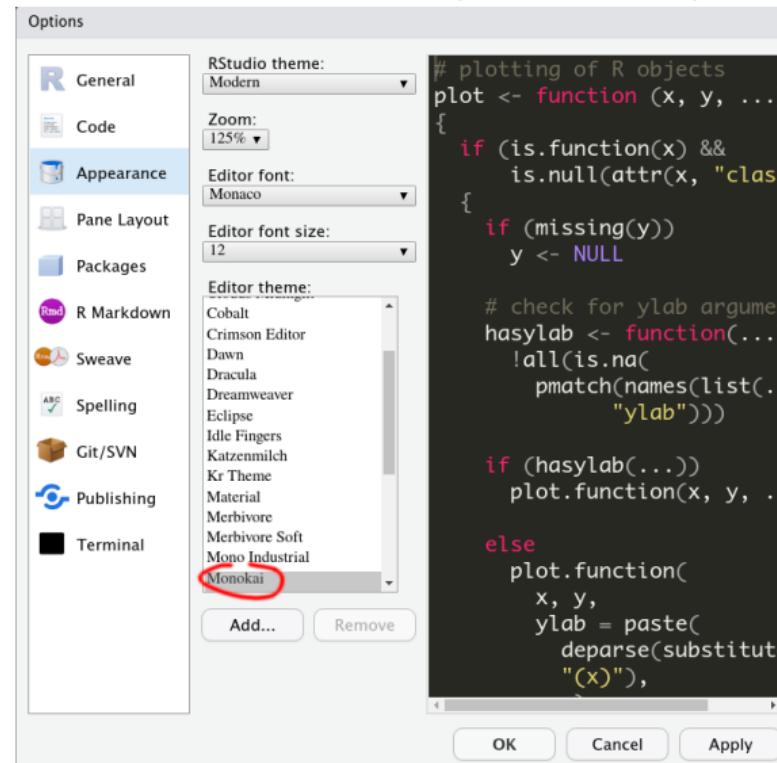
My tips about the global options

2. I don't like parentheses and quotes auto-completion, but you may



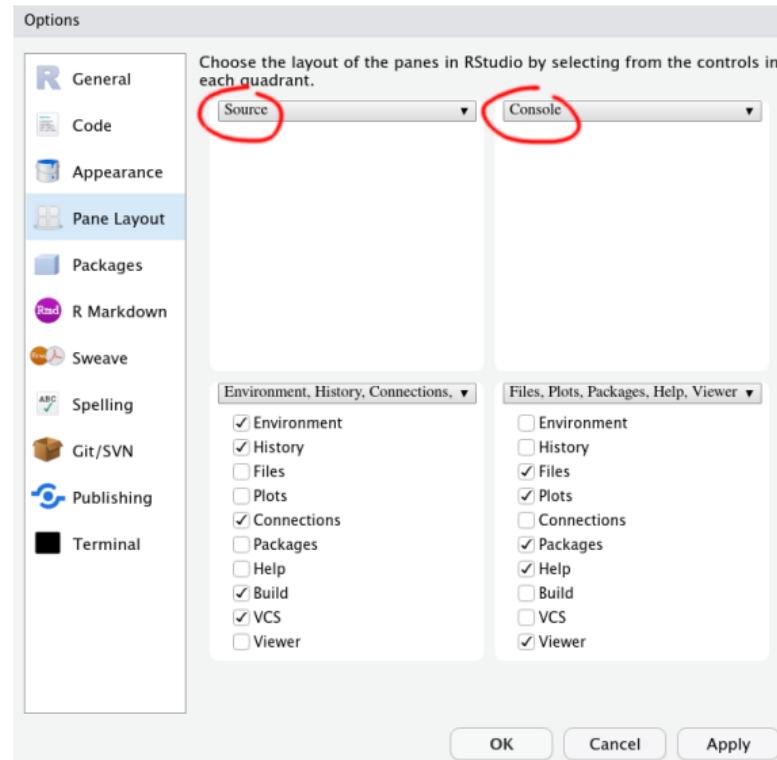
My tips about the global options

3. I use a black theme except when using a video projector (do as you please)



My tips about the global options

4. I like to put the source and the console panes side-by-side to give them more vertical space on the screen



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The Source pane

This is where you type the code you want to keep

The screenshot shows the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Window, Help, and a status bar indicating R version 3.6.0 (2019-04-26) -- "Planting of a Tree". The Source pane (highlighted with a red border) contains an R Markdown script with code and explanatory text. The right pane displays the R console output, showing the R version information and a welcome message. The bottom panes show the Environment and Files panes.

```
1: ---  
2: title: "My_first_R_script"  
3: author: "Alexandre Courtiol"  
4: date: "5/15/2019"  
5: output: html_document  
6: ---  
7:  
8: ```{r setup, include=FALSE}  
9: knitr::opts_chunk$set(echo = TRUE)  
10: ```  
11:  
12: ## R Markdown  
13:  
14: This is an R Markdown document. Markdown is a simple formatting syntax for  
authoring HTML, PDF, and MS Word documents. For more details on using R Markdown,  
see <http://rmarkdown.rstudio.com>.  
15:  
16: When you click the Knit button a document will be generated that includes both  
content as well as the output of any embedded R code chunks within the document.  
2:1 My First R Script.Rmd R Markdown
```

R version 3.6.0 (2019-04-26) -- "Planting of a Tree"
Copyright (C) 2019 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin15.6.0 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

Environment is empty

Name	Size	Modified
My_first_project.Rproj	204 B	May 15, 2019, 5:51 PM

Notes: tabs give you access to different files (if several files are open)

The Console pane

This is where you can run R code directly

The screenshot shows the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Window, Help, and a status bar showing the current project path (~/Desktop/My_first_project - RStudio) and system information (17%, 72%, Wed 17:53). The main window has several panes:

- Code pane:** Displays an R Markdown script named "Untitled1.Rmd". The code includes setup instructions for knitr, a note about R Markdown, and a warning about clicking the Knit button.
- Console pane (highlighted with a red border):** Shows the R startup message, including the version (3.6.0), copyright (2019), platform (x86_64-apple-darwin15.6.0), and a note about no warranty. It also displays a natural language support message and information about R being a collaborative project.
- Environment pane:** Shows the Global Environment tab with the message "Environment is empty".
- Files pane:** Shows the file structure under the project directory, including "My_first_project.Rproj".

Notes: tabs give you access to other panes depending on the context. They are all used to run code!

The other panes

This is where everything else is

The screenshot shows the RStudio IDE interface with several panes open:

- Editor:** The main pane displays an R Markdown script titled "My_first_R_script.Rmd". The code includes metadata (title, author, date, output), setup code for knitr, and two R code chunks. The second chunk contains explanatory text about R Markdown and a link to the official website.
- Console:** Shows the R version information and the standard "Planting of a Tree" copyright notice.
- Terminal:** Displays the R command-line interface with basic help information and locale settings.
- Environment:** Shows the global environment with an empty list of objects.
- Plots:** No plots are currently displayed.
- Packages:** No packages are currently displayed.
- Help:** No help topics are currently displayed.
- Viewer:** No files are currently displayed.
- Files:** Shows the file structure of the project "My_first_project" located at "/Desktop/My_first_project". It lists a single file "My_first_project.Rproj" with a size of 204 B and a modified date of May 15, 2019, 5:51 PM.

Notes: tabs give you access to various panes

The other panes

You should have at least access to:

- **Environment**: the list of objects known to the console
- **History**: all the code that has been run in the console
- **Connections**: connections to databases
- **Files**: the integrated file manager
- **Plots**: display plots
- **Packages**: tools for installing, loading and updating **R** packages
- **Help**: display help about **R** functions and packages
- **Viewer**: a html/pdf viewer

The other panes

You should have at least access to:

- Environment: the list of objects known to the console
- History: all the code that has been run in the console
- Connections: connections to databases
- Files: the integrated file manager
- Plots: display plots
- Packages: tools for installing, loading and updating **R** packages
- Help: display help about **R** functions and packages
- Viewer: a html/pdf viewer

But other panes will appear depending on the context

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What is R markdown?

It is a framework to write reproducible reports, which combines . . .

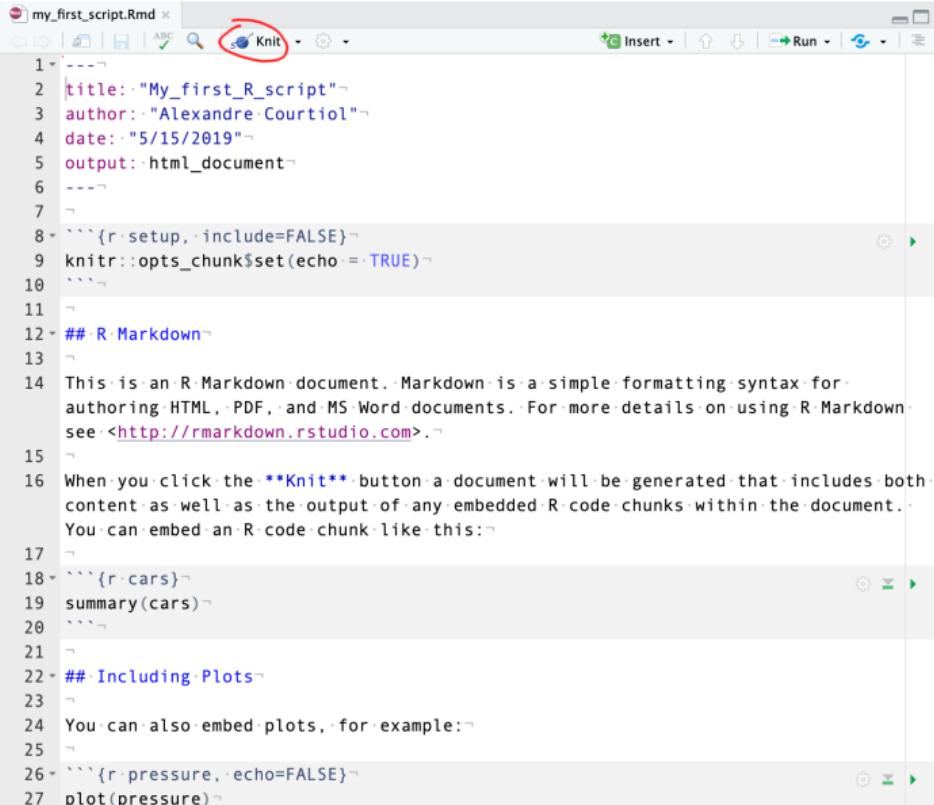
- text
- R code
- R outputs (e.g. plots, tables)

. . . to form a document (e.g. html page, PDF, Microsoft Word, Libre Office, website . . .)

Alternative frameworks are available (e.g. these slides are created using a combination of L^AT_EX and R, but R markdown remains simple)

Practice

Render the R markdown file using knitr and observe the outcome

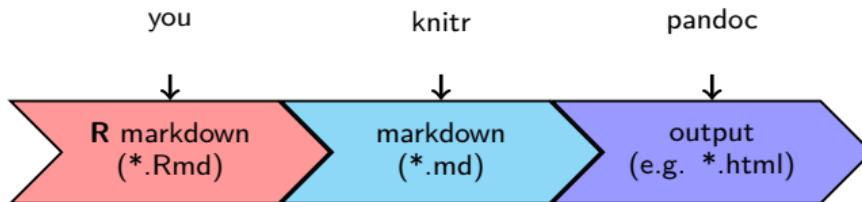


```
my_first_script.Rmd x
[...] Knit [...]
1 ----
2 title: "My_first_R_script"
3 author: "Alexandre.Courtiol"
4 date: "5/15/2019"
5 output: html_document
6 ----
7
8 ```{r, setup, include=FALSE}
9 knitr:::opts_chunk$set(echo = TRUE)
10 ``
11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a simple formatting syntax for
authoring HTML, PDF, and MS Word documents. For more details on using R Markdown
see <http://rmarkdown.rstudio.com>.
15
16 When you click the Knit button a document will be generated that includes both
content as well as the output of any embedded R code chunks within the document.
You can embed an R code chunk like this:
17
18 ```{r cars}
19 summary(cars)
20 ``
21
22 ## Including Plots
23
24 You can also embed plots, for example:
25
26 ```{r pressure, echo=FALSE}
27 plot(pressure)
```

Why using R markdown?

- clear: text, R code, and output are not dispatched in different files
- structured: the document can be divided in sections and the R code into chunks
- transparent: all the R code must be in the R markdown file(s)
- reproducible: enforce that the R code must run (unlike notebooks and pure R script)
- adaptable: you can change one thing and everything else will adjust
- dynamic: you can create so-called dynamic html documents (with buttons, menus. . .)
- easy to communicate: outputs look quite nice out-of-the-box

How does it work?



Notes:

- **knitr** is an **R** package that turns the **R** code and its outputs into markdown syntax
- **pandoc** is an external program that turns markdown documents into many possible outputs
- the calls to **knitr** and **pandoc** are orchestrated by the **R** package **rmarkdown**

General structure of a R markdown file

3 parts:

The screenshot shows the RStudio interface with the title bar "my_first_script.Rmd". The main pane displays the following R Markdown code:

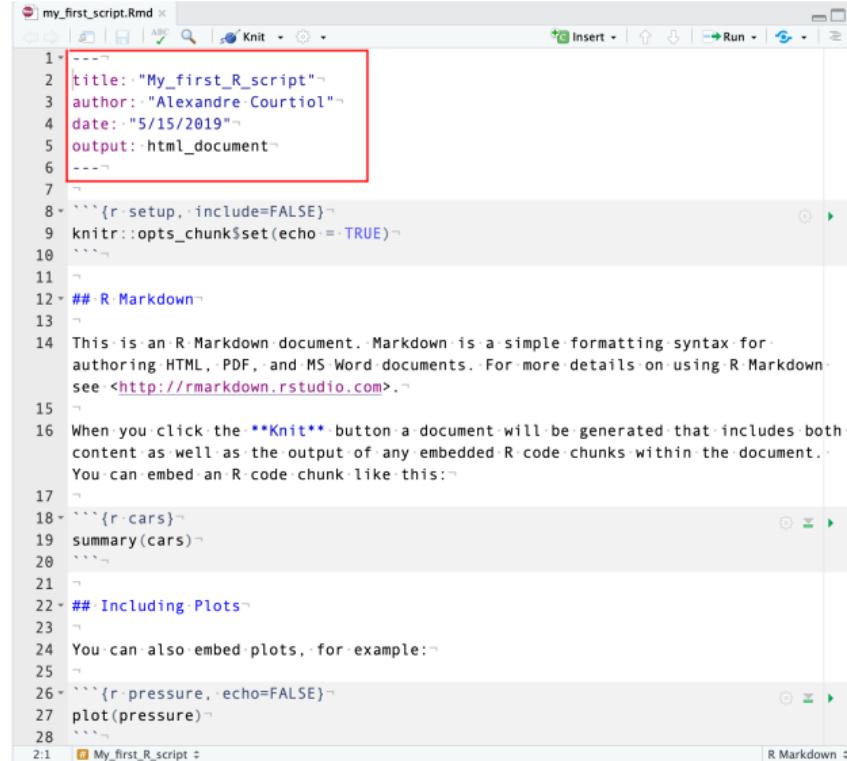
```
1 ---  
2 title: "My_first_R_script"  
3 author: "Alexandre Courtiol"  
4 date: "5/15/2019"  
5 output: html_document  
6 ---  
7  
8 ```{r setup, include=FALSE}  
9 knitr::opts_chunk$set(echo = TRUE)  
10 ```  
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12 ## R Markdown  
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14 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.  
15  
16 When you click the Knit button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:  
17  
18 ```{r cars}  
19 summary(cars)  
20 ```  
21  
22 ## Including Plots  
23  
24 You can also embed plots, for example:  
25  
26 ```{r pressure, echo=FALSE}  
27 plot(pressure)  
28 ```
```

The status bar at the bottom right indicates "R Markdown".

General structure of a R markdown file

3 parts:

- the header (written in YAML)



The screenshot shows the RStudio interface with a code editor window titled "my_first_script.Rmd". The code is written in R Markdown. A red box highlights the first six lines, which define the document's metadata in YAML format:

```
1 ---  
2 title: "My_first_R_script"  
3 author: "Alexandre Courtiol"  
4 date: "5/15/2019"  
5 output: html_document  
6 ---
```

The rest of the file contains R code chunks and explanatory text. Lines 14 and 15 provide a brief overview of R Markdown. Lines 16 through 28 show how to embed R code and plots.

```
7  
8 `r`{r setup, include=FALSE}  
9 knitr:::opts_chunk$set(echo = TRUE)  
10  
11 ## R Markdown  
12  
13 This is an R Markdown document. Markdown is a simple formatting syntax for  
authoring HTML, PDF, and MS Word documents. For more details on using R Markdown  
see <http://rmarkdown.rstudio.com>.  
15  
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22  
23 You can also embed plots, for example:  
24  
25 `r`{r pressure, echo=FALSE}  
26 plot(pressure)  
27  
28
```

General structure of a R markdown file

3 parts:

- the header (written in YAML)
- the text (written in markdown)

```

1 ---  

2 title: "My_first_R_script"  

3 author: "Alexandre Courtiol"  

4 date: "5/15/2019"  

5 output: html_document  

6 ---  

7  

8 ```{r setup, include=FALSE}  

9 knitr::opts_chunk$set(echo = TRUE)  

10 ```  

11  

12 ## R Markdown  

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14 This is an R Markdown document. Markdown is a simple formatting syntax for  

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see <http://rmarkdown.rstudio.com>.  

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22 ## Including Plots  

23  

24 You can also embed plots, for example:  

25  

26 ```{r pressure, echo=FALSE}  

27 plot(pressure)  

28 ```  

2:1 My_first_R_script
  
```

General structure of a R markdown file

3 parts:

- the header (written in YAML)
- the text (written in markdown)
- the code chunks (written in R or alternatives)

```

1 ---  

2 title: "My_first_R_script"  

3 author: "Alexandre Courtiol"  

4 date: "5/15/2019"  

5 output: html_document  

6 ---  

7  

8 ```{r setup, include=FALSE}  

9 knitr::opts_chunk$set(echo = TRUE)  

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```

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The YAML header

The header sets the configuration for pandoc, so it is used to influence the format and style of the output file
(It is also be used to set some options for `rmarkdown`)

A simple YAML header:

```
---
```

```
title: "My_first_R_script"
author: "Alexandre Courtiol"
date: "5/15/2019"
output: html_document
---
```

The YAML header

The header sets the configuration for pandoc, so it is used to influence the format and style of the output file
(It is also be used to set some options for rmarkdown)

A simple YAML header:

```
---
```

```
title: "My_first_R_script"
author: "Alexandre Courtiol"
date: "5/15/2019"
output: html_document
---
```

A slightly more complex YAML header:

```
---
```

```
title: "My_first_R_script"
author: "Alexandre Courtiol"
date: "5/15/2019"
output:
  html_document:
    toc: true
    toc_float: true
    theme: journal
    keep_md: yes
---
```

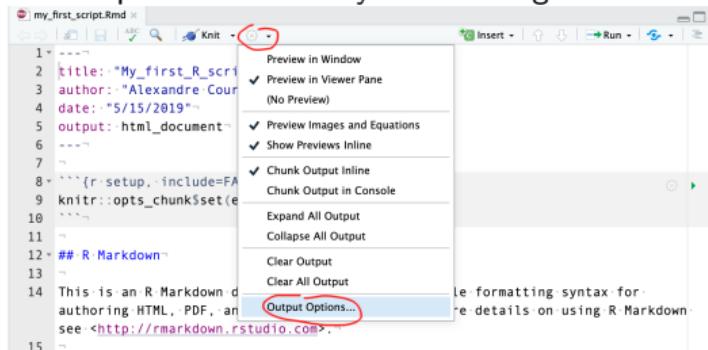
Notes:

- indentation matters in YAML!!! (beware while copy & pasting with RStudio autoindentation)
- not all settings work for all types of documents
- YAML = YAML Ain't Markup Language

Practice

Modify the YAML options in the header and observe how the output changes accordingly

A few options can directly be set using RStudio:



For info on what you can change, check:

- The **R Markdown Cheat Sheet**
- <https://rmarkdown.rstudio.com>
- <https://bookdown.org/yihui/rmarkdown>

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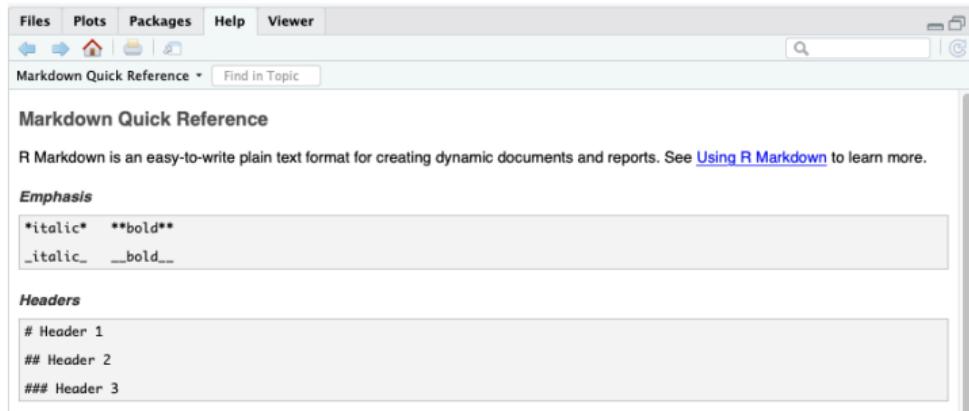
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Markdown

Markdown is a very simple plain text formatting syntax that can be learned in minutes
Check Help/Markdown Quick Reference for (almost) all there is to know!



You can directly embed raw html code for more functionalities

For example, this is useful for commenting text that you don't want to appear in the output:

This text will show in the output <!-- but this one will not -->

Practice

- notice that the structure of the document appears at the bottom of the Source pane
- try to experiment a bit with the syntax
- edit the markdown text of your R markdown file, so to prepare the file to take notes about the course (but don't trash the chunk of R code yet)

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Anatomy of a code chunk

```
```{language_name chunk name, option1=argument1, option2=argument2, ...}
some code ## a comment
```
```

Examples:

```
```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```
```

```
```{r cars}
summary(cars)
```
```

```
```{r pressure, echo=FALSE}
plot(pressure)
```
```

Anatomy of a code chunk

```
```{language_name chunk name, option1=argument1, option2=argument2, ...}
some code ## a comment
```
```

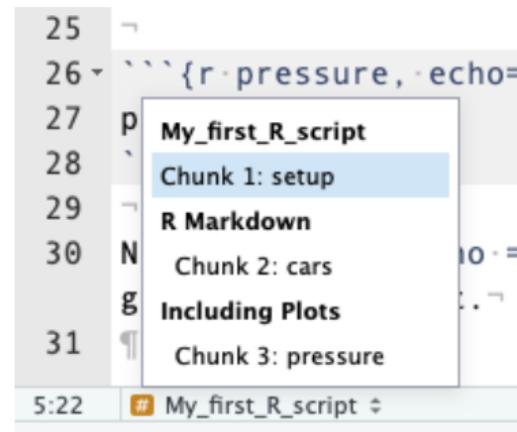
Examples:

```
```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```

```{r cars}
summary(cars)
```

```{r pressure, echo=FALSE}
plot(pressure)
```

```



Examples of code chunk options

Some options good to know:

| Option | what for? | default |
|--------|------------------|---------|
| echo | display the code | TRUE |
| error | stop on error | TRUE |
| eval | run the chunk | TRUE |

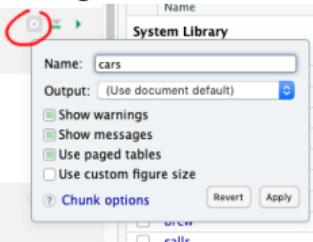
Examples of code chunk options

Some options good to know:

| Option | what for? | default |
|--------|------------------|---------|
| echo | display the code | TRUE |
| error | stop on error | TRUE |
| eval | run the chunk | TRUE |

You can set some of them directly using RStudio:

```
18 ~~~{r cars}~  
19 summary(cars)~  
20 ~~~~  
21 ~  
22 ## Including Plots~  
23 ~  
24 You can also embed plots, for example:~  
25 ~  
26 ~~~{r pressure, echo=FALSE}~  
27 plot(pressure)~  
28 ~~~~
```



Examples of code chunk options

Some options good to know:

| Option | what for? | default |
|--------|------------------|---------|
| echo | display the code | TRUE |
| error | stop on error | TRUE |
| eval | run the chunk | TRUE |

You can set some of them directly using RStudio:

The screenshot shows a code editor with R code and a 'Chunk options' dialog box. The code editor contains:

```
18 ~~~{r cars}~  
19 summary(cars)~  
20 ~~~~  
21 ~  
22 ## Including Plots~  
23 ~  
24 You can also embed plots, for example:~  
25 ~  
26 ~~~{r pressure, echo=FALSE}~  
27 plot(pressure)~  
28 ~~~~
```

The 'Chunk options' dialog box is open, with the 'Name' field set to 'cars'. A red circle highlights the 'Output' dropdown menu, which is currently set to '(Use document default)'. Other options shown include:

- Show warnings
- Show messages
- Use paged tables
- Use custom figure size

Buttons at the bottom of the dialog are 'Revert' and 'Apply'.

For more options, check:

- The **R Markdown Cheat Sheet** (for a few more)
- <https://yihui.name/knitr/options> (for all of them)

Examples of code chunk options

Some options good to know:

| Option | what for? | default |
|--------|------------------|---------|
| echo | display the code | TRUE |
| error | stop on error | TRUE |
| eval | run the chunk | TRUE |

You can set some of them directly using RStudio:

The screenshot shows a portion of an RStudio session. On the left, there is a code editor window with the following R code:

```
18 ~~~{r cars}~  
19 summary(cars)~  
20 ~~~~  
21 ~  
22 ## Including Plots~  
23 ~  
24 You can also embed plots, for example:~  
25 ~  
26 ~~~{r pressure, echo=FALSE}~  
27 plot(pressure)~  
28 ~~~~
```

To the right of the code editor is a floating 'Chunk options' dialog box. This dialog box has a red circle drawn around its title bar. It contains the following settings:

- Name: cars
- Output: (Use document default)
- Show warnings
- Show messages
- Use paged tables
- Use custom figure size
- Chunk options
- Revert
- Apply

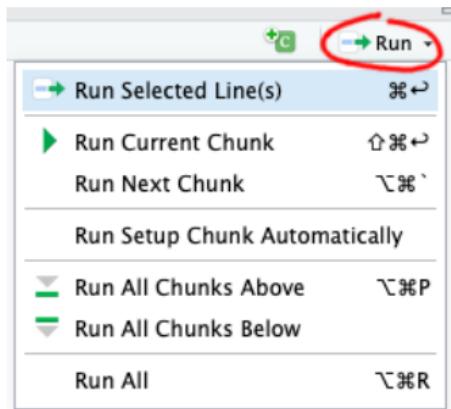
For more options, check:

- The **R Markdown Cheat Sheet** (for a few more)
- <https://yihui.name/knitr/options> (for all of them)

Note: if you want the option to be set in all chunks, put it in `knitr:::opts_chunk$set(...)` in the first chunk.

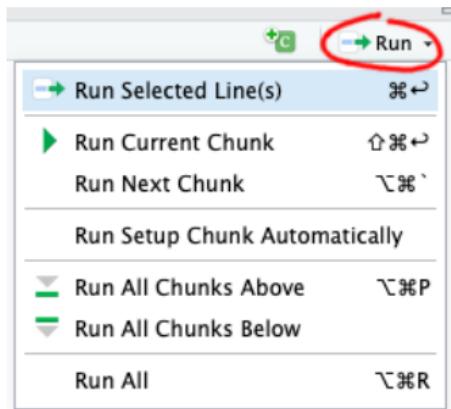
Running a code chunk without knitting

You can run a chunk using the mouse or the keyboard:

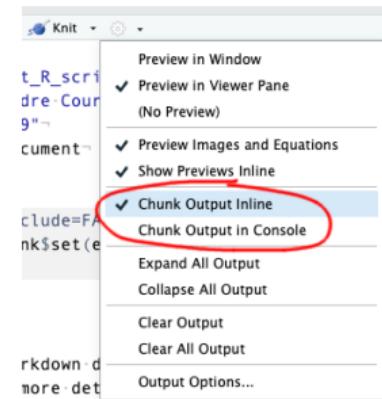


Running a code chunk without knitting

You can run a chunk using the mouse or the keyboard:



All **R** chunks are run in the **Console** pane (unless when knitting), but you can decide if you want to copy the output within the **Source** pane too!



Practice

Experiment a little by knitting existing chunks using different options!

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2 The RStudio IDE

3 R markdown

4 Basics of the R language

5 R packages

6 Housekeeping

7 Learning R on your own

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- objects
- functions

5 R packages

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Arithmetic

R can perform basic arithmetic:

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

1 - 1
## [1] 0

2 * pi
## [1] 6.283185

3 / 2
## [1] 1.5

10 %% 3
## [1] 1

5^2
## [1] 25

5^2 + 1
## [1] 26

5^(2 + 1)
## [1] 125
```

Conclusion: you may never need a hand calculator anymore!

Practice

Delete all existing chunks and create a new chunk with some arithmetic

Note: to create a new chunk, you can use Code → Insert chunk (or just type)

Tips

- ❶ only use the **Console** pane to mess around
- ❷ write proper **R** code inside a chunk in your Rmd document
- ❸ knit chunks one by one before knitting the whole Rmd document
- ❹ name objects with useful names

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Creating objects

Objects are being assigned using the “arrow” operator:

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one.plus.one <- 1 + 1 ## storing the result
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Objects are being used through their name (that is the whole point):

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one.plus.one ## displaying the result
## [1] 2
one.plus.one.plus.one <- one.plus.one + 1
one.plus.one.plus.one
## [1] 3
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Tip:

```
(one.times.two <- 1 * 2) ## storing and displaying the result at once  
## [1] 2
```

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one.plus.one.plus.one
## [1] 3
```

Tip:

```
(one.times.two <- 1 * 2) ## storing and displaying the result at once
## [1] 2
```

Note 1: avoid spaces & weird characters in object names to avoid troubles (but “_” and “.” are OK).

Note 2: names are case sensitive.

Common mistakes

The huge majority of beginner's problems are typos:

```
one.plus.one  
## [1] 2
```

```
one.plus.One  
## Error in eval(expr, envir, enclos): object 'one.plus.One' not found
```

Common mistakes

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

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

Common mistakes

The huge majority of beginner's problems are typos:

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one.plus.one  
## [1] 2
```

```
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```

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

```
1 +  
one.plus.one <- 1 + 1  
## Error in 1 + one.plus.one <- 1 + 1: target of assignment expands to non-language object
```

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- objects
- **functions**

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Functions

```
citation() ## function showing how to cite R

##
## To cite R in publications use:
##
##   R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical
##   Computing, Vienna, Austria. URL https://www.R-project.org/.
##
## A BibTeX entry for LaTeX users is
##
## @Manual{,
##   title = {R: A Language and Environment for Statistical Computing},
##   author = {{R Core Team}},
##   organization = {R Foundation for Statistical Computing},
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##
## We have invested a lot of time and effort in creating R, please cite it when using it for data analysis.
## See also 'citation("pkgname")' for citing R packages.
```

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```

```
help(citation) ## getting help for this function
```

```
?citation() ## same but shorter (syntactic sugar)
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```

```
help(citation) ## getting help for this function
```

```
?citation() ## same but shorter (syntactic sugar)
```

Note: always look at the help before using a function new to you!

Functions

```
mean()
```

```
?mean()
```

Usage:

```
mean(x, ...)  
## Default S3 method:  
mean(x, trim = 0, na.rm = FALSE, ...)
```

Arguments:

x: An R object. Currently there are methods for numeric/logical vectors and date, date-time and time interval objects, and for data frames all of whose columns have a method. Complex vectors are allowed for 'trim = 0', only.

trim: the fraction (0 to 0.5) of observations to be trimmed from each end of 'x' before the mean is computed. Values of trim outside that range are taken as the nearest endpoint.

na.rm: a logical value indicating whether 'NA' values should be stripped before the computation proceeds.

[...]

Syntax for functions

Basic syntax:

```
sign(x = -5)
## [1] -1
sign(-5) ## dangerous: try to avoid!
## [1] -1
sign(y = -5)
## Error in sign(y = -5): supplied argument name 'y' does not match 'x'
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Note: equal signs and arrows are only equivalent in the so-called “global environment”:

```
y = 2
y
## [1] 2
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y
## [1] 3
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But not inside functions:

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sign(y <- -5) ## dangerous: avoid!
## [1] -1
y
## [1] -5
sign(x = y <- -5) ## same as above
## [1] -1
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## [1] -1
y
## [1] -5
sign(x = y <- -5) ## same as above
## [1] -1
```

So better to stick to arrows for creating objects and to equal signs for defining arguments!

Syntax for functions

Calling a function without its parentheses reveals its definition:

```
sign  
## function (x) .Primitive("sign")
```

Syntax for functions

Calling a function without its parentheses reveals its definition:

```
sign
## function (x) .Primitive("sign")
```

All functions need parentheses to work and exceptions correspond to short-cuts (called “syntactic sugar”):

```
1 + 1
## [1] 2
`+` (1, 1)
## [1] 2
a <- 1
a
## [1] 1
`<-` (a, 1)
a
## [1] 1
```

Finding functions

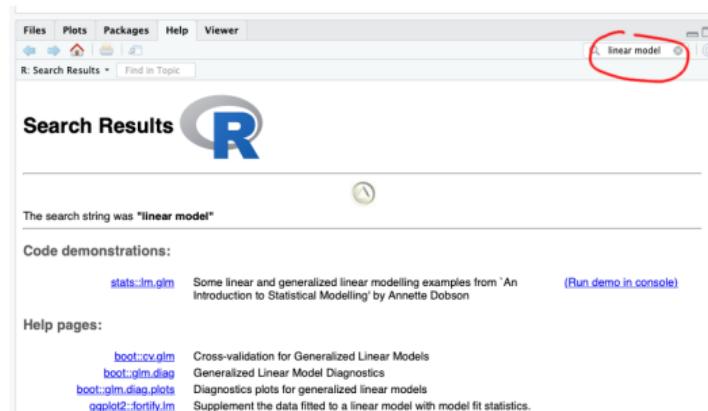
To find the name of the function you are look for, you may try:

```
??"linear model"
```

or

```
help.search(pattern = "linear model", package = "stats") ## if you know where to look for
```

or



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The concept of an **R** package

Packages extend **R** functionalities:

- for most users; e.g. ggplot2
- for specific users; e.g. IsoreX
- for developers; eg. Rcpp

The concept of an R package

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Key facts about packages:

- a package is just a folder (often compressed) containing R functions, data & documentation
- a library is the installed version of the package (also a folder)
- there are tons of packages out there:
 - 14233 packages are available on cran.r-project.org
 - ~ 1500 packages aimed at bioinformatics on bioconductor.org
 - many more on github.com
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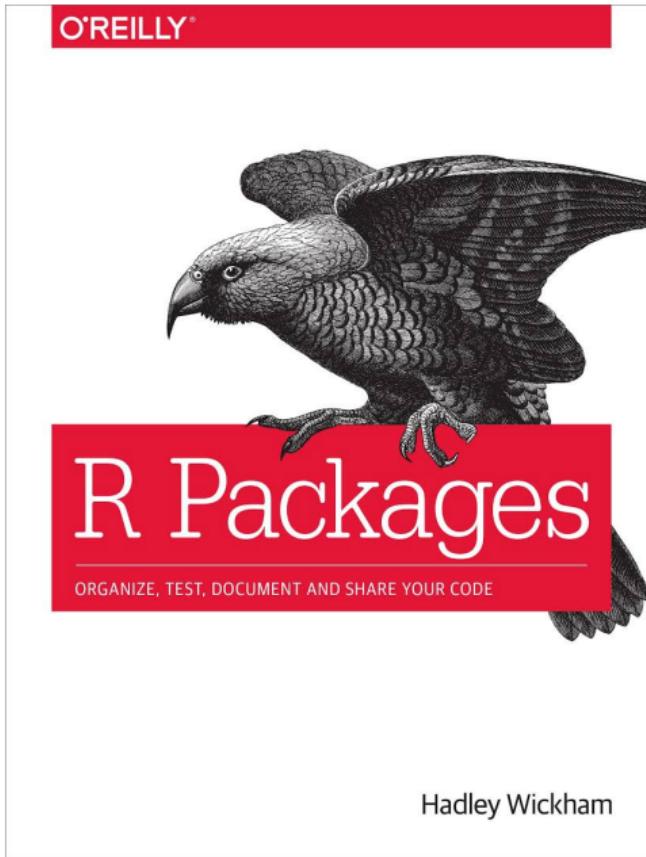
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Note: packages can be used to create research compendia!

Creating your own package is actually quite easy once you know R



Installing a package

Simple situation: the package is available as a binary file prepared for your system on CRAN

```
install.packages("dplyr") ## install dplyr
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In general, the installation procedure depends on:

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- if the package contains sources in another language that have been compiled or not

In order to be able to install packages that require compilation (and thus have access to more or newer version of packages), you need to install:

- Rtools if you use Windows (<https://cran.r-project.org/bin/windows/Rtools/>)
- Xcode if you use macOS (<https://developer.apple.com/xcode/>)
- nothing if you use Linux or other Unix-based system

Installing the package for this course

The package is not on CRAN as I want to be able to update it instantaneously and have potentially large files.

I host the package here: <https://github.com/courtiol/BeginR>

You should install it using drat as follows:

```
install.packages("drat")      ## install drat from CRAN; only run once per R lifetime
library(drat)                  ## load the package drat
addRepo("courtiol")            ## use drat to declare my GitHub account
install.packages("BeginR")     ## install the package
```

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install.packages("BeginR")     ## install the package
```

Note: every morning of the course you may have to rerun the last 3 lines of code to get the lastest version of this course.

Loading a package

Loading a package makes new functions and data available to the user:

Example:

```
library(BeginR)
## Error in library(BeginR): there is no package called 'BeginR'
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You can check the (exported) content of a package:

```
library(help = "BeginR")
```

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Updating R packages

Some things to know:

- R packages evolve quickly
- young R packages can be very buggy
- packages are not reviewed
(CRAN tests that they can install and that the examples run without generating error or warning messages)

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- R packages evolve quickly
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(CRAN tests that they can install and that the examples run without generating error or warning messages)

Good practice:

- update your R packages frequently (I do it daily)

```
update.packages(ask = FALSE) ## or use RStudio menus
```

- check what is being changed if you heavily rely on a recent package
(see file called NEWS easily shown if you use RStudio to update)
- contact the maintainer when you spot bugs
(but write minimal reproductive examples otherwise they will most likely not be able to help you)

Updating R itself

Some things to know:

- R has many bugs (like all other software)
- R bugs are reported, discussed and solved in the open (unlike most other software):
<https://bugs.r-project.org/bugzilla3/>
- each new version of R is more efficient and less buggy

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What to do?

- check for R new versions on CRAN
- check for what has changed if you fancy
(<http://cran.r-project.org/doc/manuals/r-release/NEWS.html>)
- install the new version of R (unless it is not a minor update that you don't need)
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- install the new version of R (unless it is not a minor update that you don't need)
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Note 1: some packages can help to do this: `InstallR` on Windows and `UpdateR` on macOS.

Note 2: also update RStudio for full compatibility with R.

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Useful resources

Official documentation:

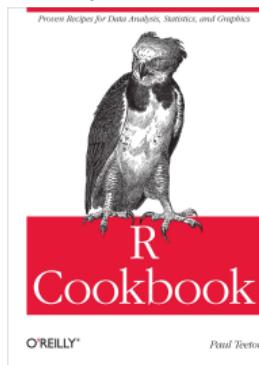
- the help files: every single (exported) function has a help file associated with it!
- official manuals (boring and difficult but thorough: <https://cran.r-project.org/manuals.html>)

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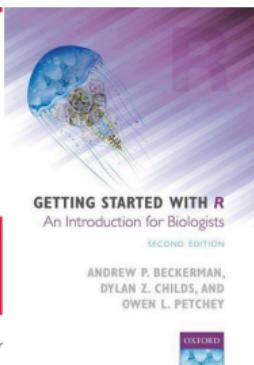
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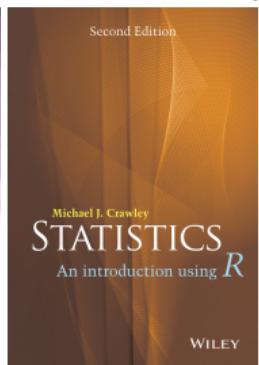
Books (roughly sorted by amount of conceptual content):



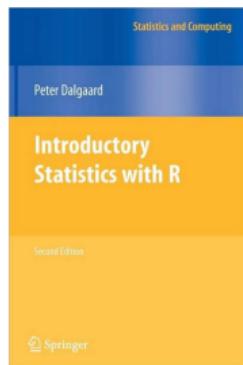
~ 30 €



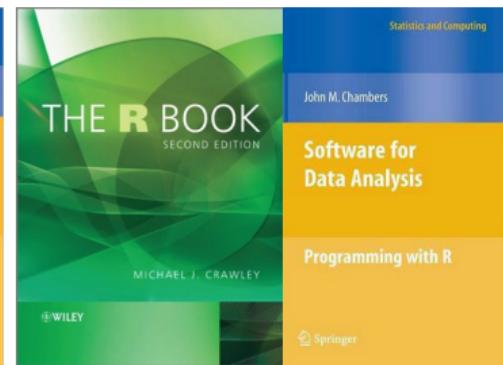
~ 30 €



~ 35 €



~ 40 €



~ 60 €

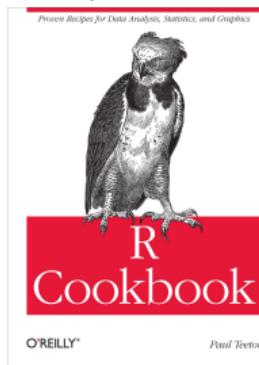
~ 90 €

Useful resources

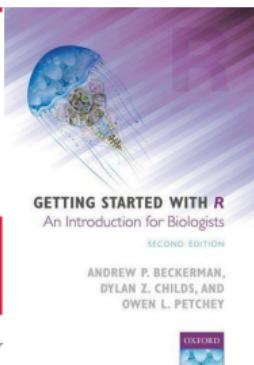
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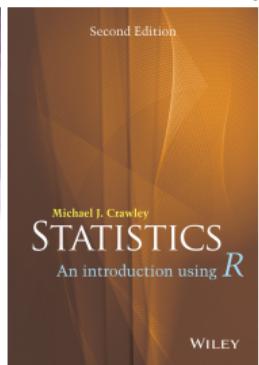
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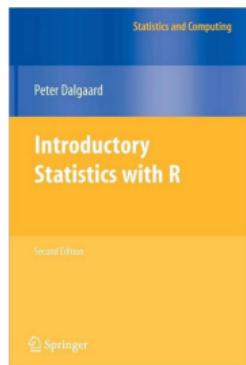
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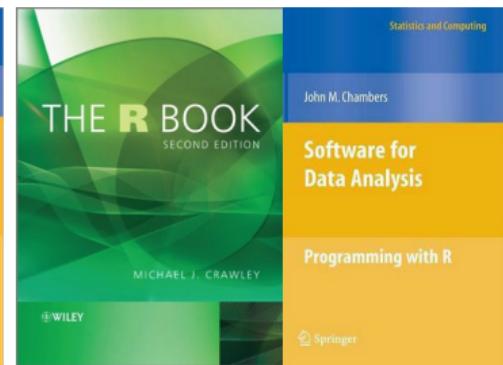
~ 30 €



~ 35 €



~ 40 €



~ 60 €

~ 90 €

Journals:

- Journal of Statistical Software (<https://www.jstatsoft.org/index>)
- The R Journal (<https://journal.r-project.org>)

Useful resources

RStudio cheatsheets (<https://www.rstudio.com/resources/cheatsheets/>):

Base R Cheat Sheet

Getting Help

- Accessing the help files**

mean
Get help for a particular function.
`help.search("weighted.mean")`
Search the help files for a word or phrase.
`help(package = "dplyr")`
Find help for a package.

More about an object

str(iris)
Get a summary of an object's structure.
class(iris)
Find the class an object belongs to.

Using Packages

install.packages("dplyr")
Download and install a package from CRAN.

library(dplyr)
Load the package into the session, making all its functions available to use.

dplyr::select
Use a particular function from a package.

data(iris)
Load a built-in dataset into the environment.

Working Directory

getwd()
Find the current working directory (where inputs are found and outputs are sent).
setwd("C:/file/path")
Change the current working directory.

Use projects in RStudio to set the working directory to the folder you are working in.

Vectors

Creating Vectors

| | | |
|--------------------------------|--------------------------|-----------------------------------|
| <code>c(2, 4, 6)</code> | <code>2 4 6</code> | All elements enclosed in a vector |
| <code>2:6</code> | <code>2 3 4 5 6</code> | An integer sequence |
| <code>seq(2, 3, by=0.5)</code> | <code>2.0 2.5 3.0</code> | A complex sequence |
| <code>rep(1:2, times=3)</code> | <code>1 2 1 2 1 2</code> | Repeat a vector |
| <code>rep(1:2, each=3)</code> | <code>1 1 1 2 2 2</code> | Repeat elements of a vector |

Programming

For Loop

```
for (variable in sequence){
  Do something
}
```

Example

```
for (i in 1:k){
  i <- i + 2k
  print(i)
  i <- i + 1
}
```

While Loop

```
while (condition){
  Do something
}
```

Example

```
while (i < n){
  print(i)
  i <- i + 1
}
```

If Statements

```
if (condition){
  Do something
} else {
  Do something different
}
```

Example

```
if (i > 3) {
  print("Yes")
} else {
  print("No")
}
```

Functions

```
function_name <- function(var){
  Do something
  return(new_variable)
}
```

Example

```
square <- function(x){
  squared <- x*x
  return(squared)
}
```

Reading and Writing Data

Also see the [readr package](#)

| Input | Output | Description |
|----------------------------------------------|--------------------------------------------|------------------------------------------------------------------------------------------------|
| <code>df <- read.table("file.txt")</code> | <code>write.table(df, "file.txt")</code> | Read and write a delimited text file. |
| <code>df <- read.csv("file.csv")</code> | <code>write.csv(df, "file.csv")</code> | Read and write a comma-separated value file. This is a special case of read.table/write.table. |
| <code>load("file.RData")</code> | <code>save(df, file = "file.Rdata")</code> | Read and write an R data file, a file type special for R. |

Conditions

| | | | | | | | |
|---------------------|-----------|-----------------------|--------------|------------------------|--------------------------|-----------------------------|----------|
| <code>a == b</code> | Are equal | <code>a > b</code> | Greater than | <code>a >= b</code> | Greater than or equal to | <code>isTRUE(a == b)</code> | is TRUE |
| <code>a != b</code> | Not equal | <code>a < b</code> | Less than | <code>a <= b</code> | Less than or equal to | <code>isTRUE(a != b)</code> | is FALSE |

Note: there are many cheatsheets covering many aspects of R and several packages developed by RStudio!

Useful resources

Blogs:

- <http://www.r-bloggers.com>
- <https://rweekly.org>
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Twitter:

- #rstats

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Conferences:

- useR (<https://user2018.r-project.org>)
- European R User meetings (<https://erum.io>)

The best person who can teach you **R** is YOU!

After having learned some basics, just open the console and test your understanding by performing experiments!

Do not copy and paste stuff from internet without trying to understand!!!