

Getting started with R

Alexandre Courtiol

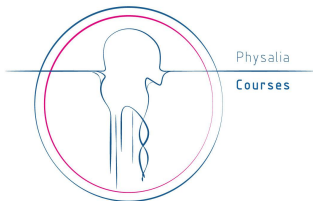
Leibniz Institute of Zoo and Wildlife Research

June 2018



**Leibniz Institute for Zoo
and Wildlife Research**

IN THE FORSCHUNGSVERBUND BERLIN E.V.



Getting started with R

1 Before we start

2 What is R?

3 First steps in R

About this course

I will:

- give you all the slides (so write only what is not being displayed)
- explain you the main principles of the **R** language, so to give you good basics
- provide you with short examples on how to use some of the most useful functions in **R**
- provide you with suggestions on how to learn more about **R** on your own

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You should:

- accept that, at the beginning, it will be a little abstract
- focus on the big picture (try to understand the logic) → consider the long term gains
- ask any silly question that pops up in your creative minds
- let me know immediately when you stop following

Who am I?

- evolutionary biologist / statistician
- studies in France (Montpellier), postdoc in the UK (Sheffield)
- senior researcher at Leibniz IZW / lecturer at Freie University (Berlin)

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- experience with **R**:
 - since 2003: studying **R** (still ongoing)
 - since 2008: using **R** most days
 - since 2010: teaching **R**
 - since 2013: debugging **R** packages
 - since 2016: developing **R** packages
 - since 2018: debugging **R**

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- **R in brief**
- the history and pre-history of R
- why use R?
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- installing R
- arithmetic
- script
- objects
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- housekeeping
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R in brief

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- rich (tons of **R** packages out there)
- cutting edge (check updates for today: <http://dirk.eddelbuettel.com/cranberries/cran/updated/>)
- used by millions
- **R** is the best software environment for statistical computing, but it is far from perfect!

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A short history of S/R

S (<http://ect.bell-labs.com/sl/S/>)

- 1976-1980: version 1: interactive statistical system, Fortran based (Becker, Chambers, & al. at Bell Labs)
- 1980-1988: version 2: portable version (thanks to Unix)
- 1988: version 3 (**S3**): “everything is an object” paradigm, C-based (very much like R)
- 1991: a large statistical modeling toolbox is added to **S3**
- 1993: **S+** exclusive license (to StatSci, later MathSoft, later SolutionMetrics)
- 1998: version 4 (**S4**): advanced object-oriented features
- 2012: **S+** becomes TIBCO Enterprise Runtime for **R** (TERR)

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R (<https://www.r-project.org/about.html>)

- 1993: the replication of **S** as the **R** project starts (Ihaka & Gentleman at University of Auckland)
- 23/04/1997: first version of **R** archived on The Comprehensive R Archive Network (CRAN)
- 05/12/1997: **R** version 0.6 is part of GNU project (“freedom to share, freedom to change”)
- 29/02/2000: **R** version 1.0 (judged stable enough for production use by the R Development Core Team)

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Is R good for you?

Good for:

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- plots, including GIS
- analysing small, medium and big data
- programming around data

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- analysing small, medium and big data
- programming around data

Not optimal for:

- beginners
- data entry
- formal algebra

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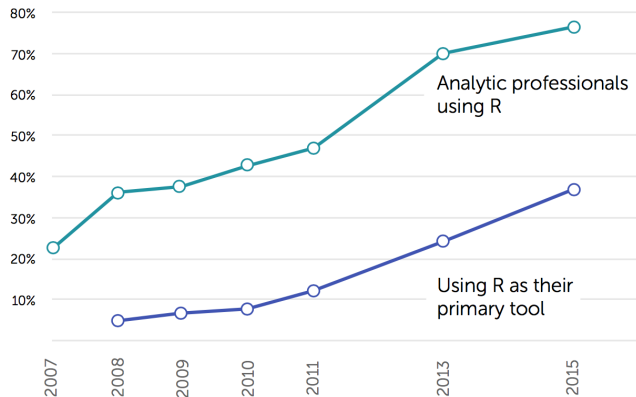
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Who uses R?

RISE OF R USAGE

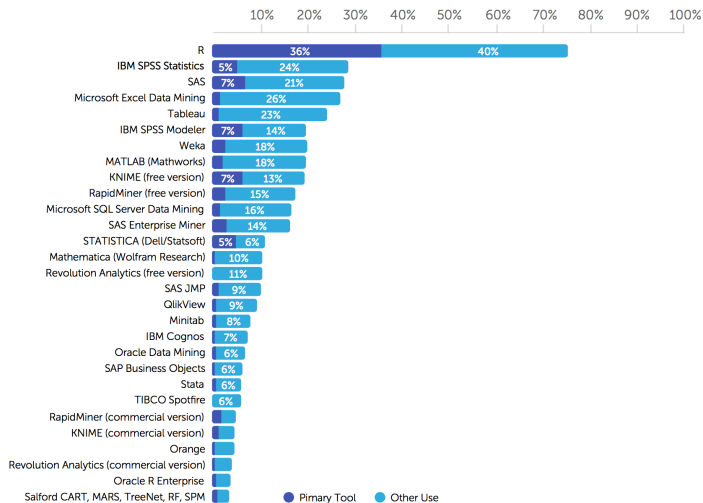


Rexer Analytics

[1220 analytic professionals from 72 countries participated in this survey]

What else?

TOOL USE

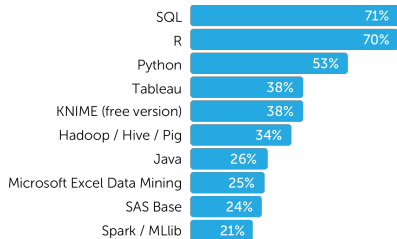


Most Data Scientists use Multiple Tools

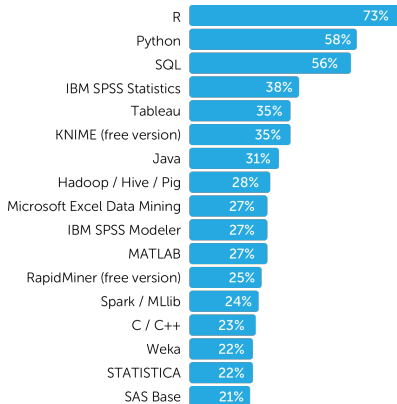


What data science / analytic tools, technologies, and languages did you use in the past year?

Corporate



Consultants

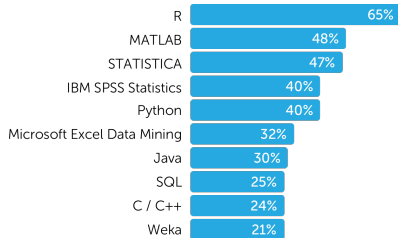


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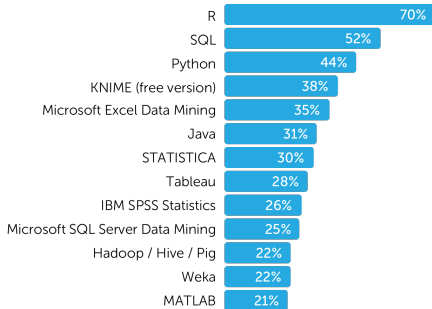


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Academics



NGO / Gov't



Rich companies rely on R too!

Some examples:

(<http://blog.revolutionanalytics.com/2014/05/companies-using-r-in-2014.html>)

- Facebook (data analysis, big-data visualization, user behaviour analysis)
- Google (advertising effectiveness, economic forecasting, and big-data statistical modeling)
- Twitter (data visualization and semantic clustering)
- The City of Chicago (food poisoning monitoring)
- The New York Times (interactive features such as the Dialect Quiz and the Election Forecast)
- Microsoft (Xbox matchmaking + plus much more these days!!)
- The Human Rights Data Analysis Group (counts of casualties in war zones)
- ANZ Bank (credit risk analysis)
- The FDA (regulatory drug approvals process)
- Monsanto (statistical analysis in plant breeding, fertility mapping and yield forecasting)
- Lloyds of London (risk analysis and catastrophe modeling)
- RealClimate.org (climate change analysis)
- NOAA (flood warnings)

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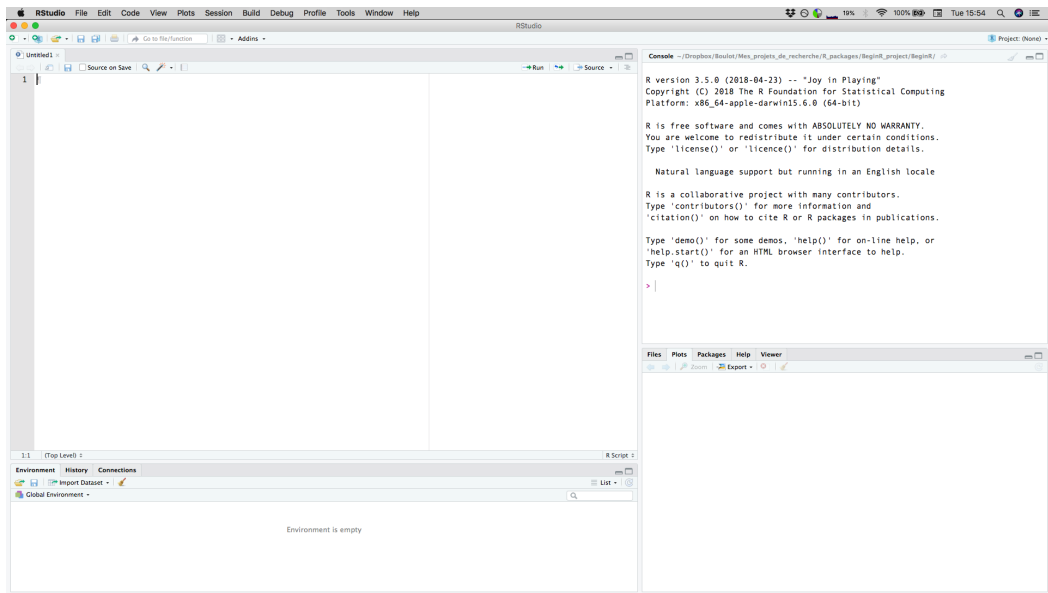
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Installation steps

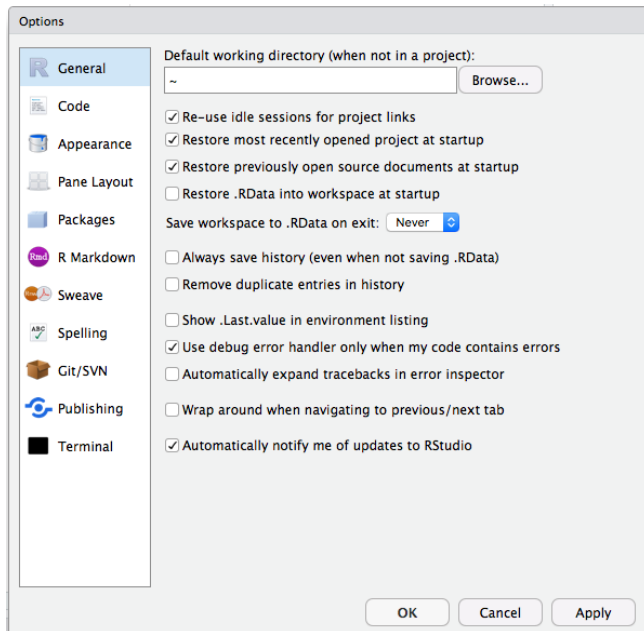
- 1 check that you do get internet access
- 2 install **R**: <https://cran.r-project.org/>
- 3 install the RStudio IDE: <https://www.rstudio.com/products/rstudio/download/>
- 4 open RStudio

Note: we will use RStudio but you don't have to (the RStudio IDE is free and open source).

RStudio



Better default setting for RStudio



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Basic arithmetic

Try in the following in the “Console” pannel:

```
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!

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The concept of an **R** script

All instructions must be written as a computer script!

- it is just a text file (no need for **R** to read it, it never gets corrupted)
- the script must be saved at a known location
- all non-**R** instruction must be preceded by the character `#` (called number sign, hash, or pound sign)

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```
#####  
## this is my first R script ##  
#####  
  
### simple arithmetic  
1 + 1 ## compute 1 + 1  
## [1] 2  
  
#1 + 2 ## commented lines of code won't run!  
  
## Note: I personally use ## (or more) for explanation and # for preventing code to run because if you uncomment using the menu or shortcut,  
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Why bother writing a script?

- transparent & reproducible
- easy to share & modify

Good practice

- 1 only use the “Console” pannel to mess around
- 2 write a script and comment it thoroughly
- 3 make sure your script always work by re-running the whole script often
- 4 name objects with useful names

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Creating objects

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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
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Tip:

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(one.times.two <- 1 * 2) ## storing and displaying the result at once
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Tip:

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(one.times.two <- 1 * 2) ## storing and displaying the result at once  
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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
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```
one.plus.One  
## Error in eval(expr, envir, enclos): object 'one.plus.One' not found
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```

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

The concept of an R object

What is an object?

- everything in **R** is an object
- objects have names
- objects allow abstraction
- objects belongs to classes for which specific methods exist (and can be created)

Note: we will come back on that later (for the programming session).

Note for geeks who know other computer languages

R objects are (by default) not mutable (there is copy on demand):

```
a <- 1
b <- a
b <- b + 1
b
## [1] 2
a ## although 'b' derives from 'a' changing 'b' has no impact on 'a' (because 'a' and 'b' share different physical memory addresses)
## [1] 1
```

Note: if you don't know other computer languages, it just behaves as you would expect while most other programming languages don't.

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Functions

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

```
##
## To cite R in publications use:
##
## R Core Team (2018). 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
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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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But not inside functions:

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sign(x = y <- -5) ## same as above
## [1] -1
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So better to stick to arrows for creating objects and to equal signs for defining arguments!

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Calling a function without its parentheses reveals its definition:

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

Key principles of the R language

- Everything that exists in R is an object
- Everything that happens in R is a function call

John M. Chambers

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
```

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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. `IsoriX`
- for developers; eg. `Rcpp`

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- for developers; eg. `Rcpp`

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:
 - 13009 packages are available on `cran.r-project.org`
 - ~ 1500 packages aimed at bioinformatics on `bioconductor.org`
 - many more on `github.com`
 - many more shared between users in other ways

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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:
 - 13009 packages are available on `cran.r-project.org`
 - ~ 1500 packages aimed at bioinformatics on `bioconductor.org`
 - many more on `github.com`
 - many more shared between users in other ways

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

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install.packages("dplyr") ## install dplyr
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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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library(drat)              ## load the package drat
addRepo("courtiol")        ## use drat to declare my GitHub account
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 latest version of this course.

Loading a package

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

Example:

```
library(BeginR)

##
## The package for the course 'Getting Started with R'
## by @alexcourtio1 (version 20180908.1), is now loaded!
## To access the slides, just type browseVignettes(package = 'BeginR'),
## [or get_vignettes() if you also need to see the sources of the vignettes].
##
## All sources for this package are available at https://github.com/courtio1/BeginR
## where you can find more information on how to use this package
## and where you can also leave comments (under 'Issues').
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```

You can check the (exported) content of a package:

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


Getting started with R

1 Before we start

2 What is R?

- R in brief
- the history and pre-history of R
- why use R?
- who uses R?

3 First steps in R

- installing R
- arithmetic
- script
- objects
- functions
- packages
- **housekeeping**
- learning R on your own

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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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 reproducible 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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Updating **R** itself

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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:

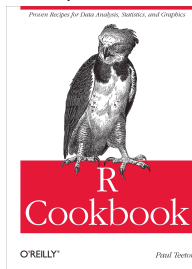
- the help files: every single (exported) function has a help file associated with it!
- official manuals (boring and difficult but thorough: <https://cran.r-project.org/manuals.html>)

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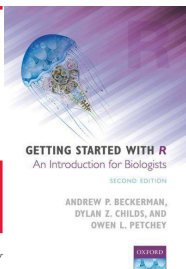
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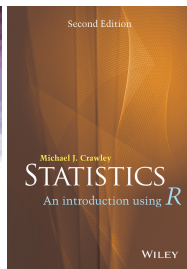
Books (roughly sorted by amount of conceptual content):



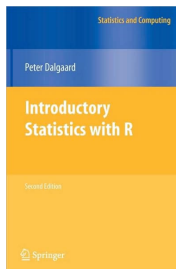
~ 30 €



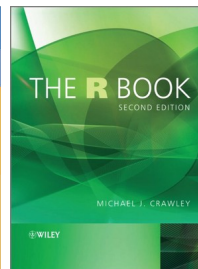
~ 30 €



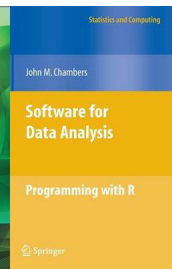
~ 35 €



~ 40 €



~ 60 €



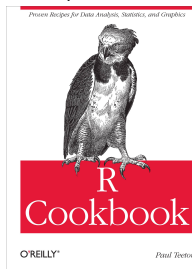
~ 90 €

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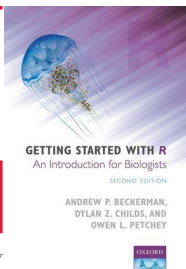
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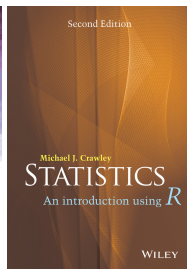
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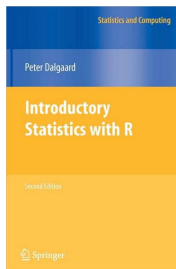
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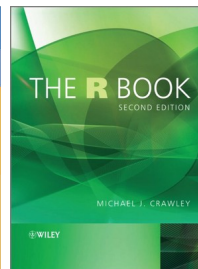
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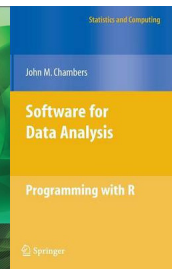
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Journals:

- 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 of 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

c(2, 4, 6) Join elements into a vector.
2:6 An integer sequence.
seq(2, 3, by=0.5) A complex sequence.
rep(1:2, times=3) Repeat a vector.
rep(1:2, each=3) Repeat elements of a vector.

Vector Functions

sort(x) Return a sorted.
table(x) See counts of values.
rev(x) Return a reversed.
unique(x) See unique values.

Selecting Vector Elements

By Position

x[4] The fourth element.
x[-4] All but the fourth.
x[2:4] Elements two to four.
x[-(2:4)] All elements except two to four.
x[c(1, 5)] Elements one and five.

By Value

x[x == 10] Elements which are equal to 10.
x[x < 0] All elements less than zero.
x[x %in% c(1, 2, 5)] Elements in the set 1, 2, 5.

Named Vectors

x["apple"] Element with name 'apple'.

Programming

For Loop

for (variable in sequence) {
 Do something
}

Example

```
for (i in 1:4){
  i <- i + 10
  print(i)
}
```

While Loop

while (condition){
 Do something
}

Example

```
while (i < 5){
  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){
  print("x")
  x <- x * x
  return(squared)
}
```

Reading and Writing Data

Also see the [readr](#) package.

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

Conditions	Are equal	Are equal	Greater than	Greater than or equal to	Less than	Less than or equal to	is missing
a == b	a != b	a > b	a >= b	a < b	a <= b	is.na(x)	is.null

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Learn more at [web page](#) or [video](#) • package version: 1.0.0 (2018.05.18)

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

Useful resources

Blogs:

- <http://www.r-bloggers.com>
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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!!!