

Getting starting with R

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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 slide (so write only what is not being displayed)
- explain 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**
- sometimes show you different ways of doing the same things
- 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 mind

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

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

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- **R in brief**
- The history and pre-history of R
- Why using R?
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- Installing R
- Arithmetic
- Script
- Objects
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R in brief

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Key points about **R**:

- free for all
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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:

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

Is R good for you?

Good for:

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

Not optimal for:

- beginners
- data entry
- formal algebra

Getting started with R

1 Before we start

2 What is R?

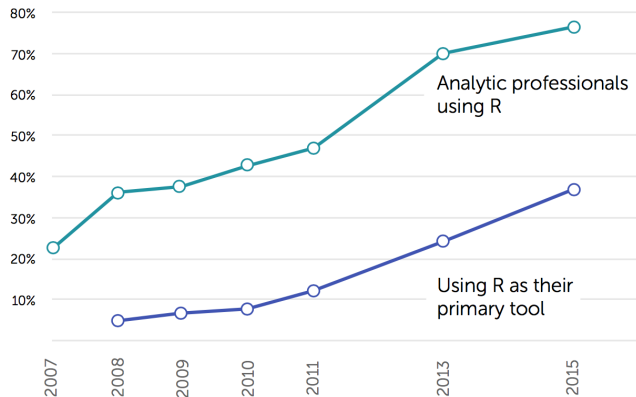
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Who uses R?

RISE OF R USAGE

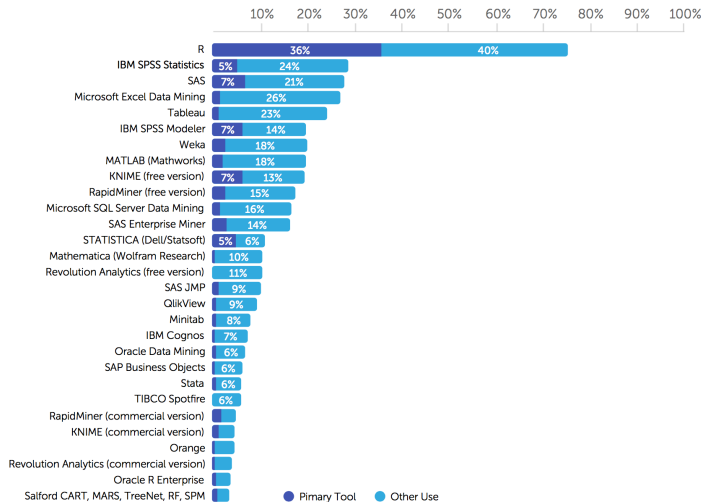


Rexer Analytics

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

What else?

TOOL USE

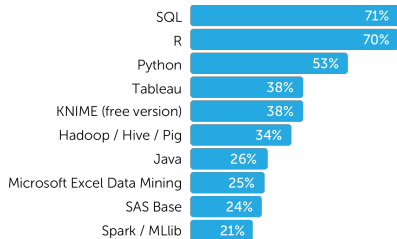


Most Data Scientists use Multiple Tools

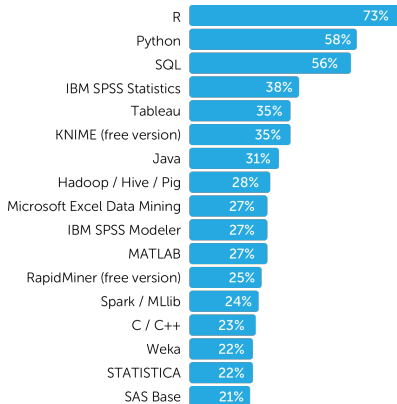


What data science / analytic tools, technologies, and languages did you use in the past year?

Corporate



Consultants

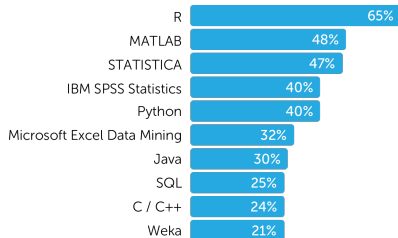


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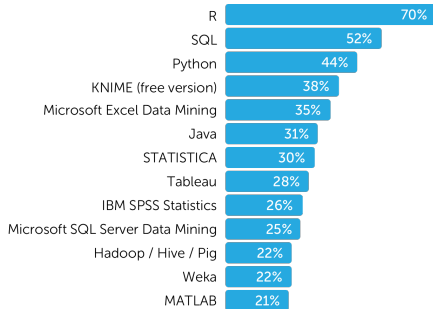


What data science / analytic tools, technologies, and languages did you use in the past year?

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)
- 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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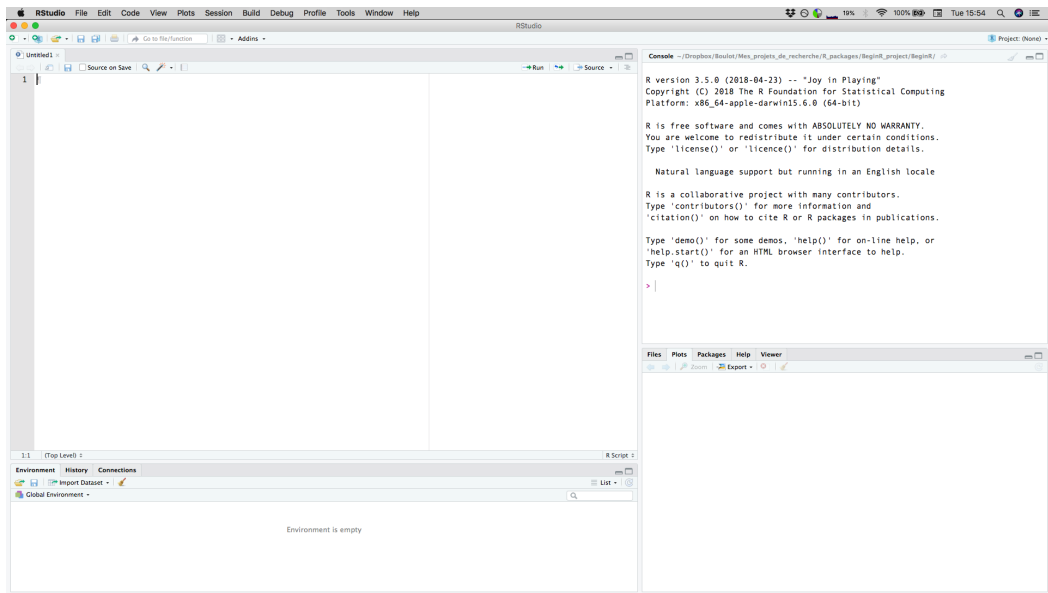
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Installation steps

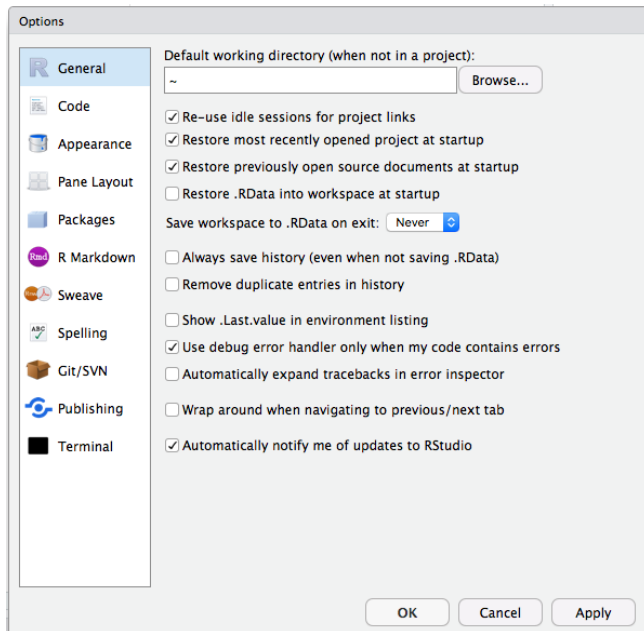
- 1 check that you do get internet access
- 2 install **R**: <https://cran.r-project.org/>
- 3 install RStudio: <https://www.rstudio.com/products/rstudio/download/>
- 4 open RStudio

Note: we will use RStudio but you don't have to (RStudio is free but not for all).

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 preceeded by `#`

Why bother?

- transparent & reproducible
- easy to share & modify

Good practice

- 1 only use the “Console” pannel to mess around
- 2 write a script and comment it properly
- 3 make sure your script always work
- 4 store each result as an object with a useful name

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Creating objects

Objects are being assigned using the “arrow” operator:

```
one.plus.one <- 1 + 1 # storing the result
```

Objects are being used through their name (that is the whole point):

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

Tip:

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

Note 1: avoid spaces & weird characters in object names to avoid troubles.

Note 2: names are case sensitive.

Common mistakes

The huge majority of beginners problems are typos:

```
one.plus.one
## [1] 2
one.plus.two
## Error in eval(expr, envir, enclos): object 'one.plus.two' not found
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
```

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
## [1] 1
```


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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  
##  
## @Manual{,  
##   title = {R: A Language and Environment for Statistical Computing},  
##   author = {{R Core Team}},  
##   organization = {R Foundation for Statistical Computing},  
##   address = {Vienna, Austria},  
##   year = {2018},  
##   url = {https://www.R-project.org/},  
## }  
##  
## 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.
```

```
help(citation) # getting help for this function  
?citation() # same but shorter (syntactic sugar)
```

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: avoid!
## [1] -1
sign(y = -5)
## Error in sign(y = -5): supplied argument name 'y' does not match 'x'
```

Equal signs and arrows are not the same:

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

Syntax for functions

Not putting the parentheses shows the definition of the function:

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

All functions need parentheses and exceptions correspond to 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 developpers; eg. `Rcpp`

Key facts about packages:

- a package is a folder (often compressed) containing **R** functions, data & documentation
- a library is an installed package
- there are tons of packages out there:
 - 12617 packages are available on `cran.r-project.org`
 - ~ 1500 packages aimed at bioinformatic 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!

Installing a package

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

```
install.packages("dplyr")
```

In general, the installation procedure depends on:

- where the package is being hosted (local, CRAN, bioconductor, GitHub, other)
- if the package contains sources in another language that have been compiled or not (yes, no)

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 as follows:

```
install.packages("drat")  
drat::addRepo("courtiol")  
install.packages("BeginR")
```

Loading a package

Loading a package makes the exported functions of the package and its data (if lazy-loaded) available to the user.

Example:

```
library(BeginR)
```

```
##  
## #####  
## #  
## # This is the package for the course #  
## #  
## # 'Getting Started with R' #  
## #  
## # Version 0.0.0.9000 installed #  
## #  
## # To access the slides, just type #  
## #  
## # browseVignettes(package = '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

Good practice:

- update your R packages daily

```
update.packages(ask = FALSE)
```

- check what is being changed if you heavily rely on a recent package
- contact the maintainer when you spot bugs (but write minimal reproducible examples!)

Updating R

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 in general more efficient, richer, and less buggy

What to do?

- check for **R** new versions on CRAN
- check for what has changed if you fancy (<https://cran.r-project.org/index.html>)
- install the new version of **R** (unless it is not a minor update that you don't need)
- re-install all your packages

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:

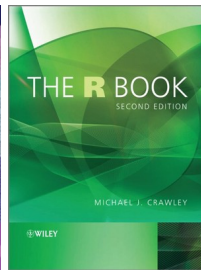
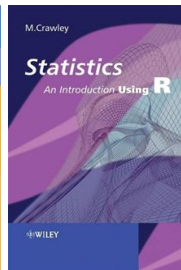
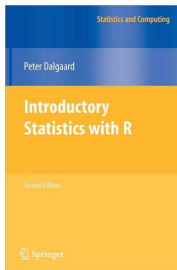
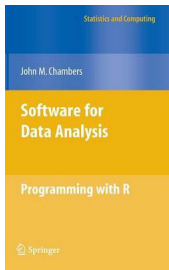
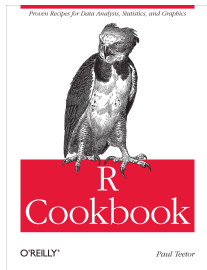
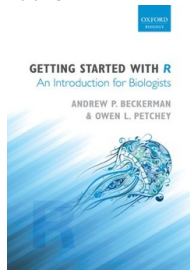
- the help files: every single (exported) function has an help file associated to it!
- official manuals (boring but very thorough <https://cran.r-project.org/manuals.html>)

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Books:

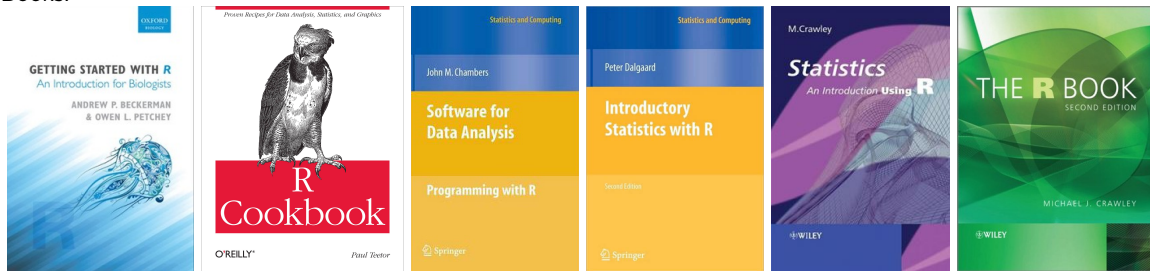


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Books:



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

?
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) **5 + 6** Join elements into a vector.
2:6 **2, 3 + 5, 6** An integer sequence.
seq(2, 3, by=0.5) **2.0, 2.5, 3.0** A complete sequence.
rep(1:2, times=3) **1, 2, 1, 2, 1, 2** Repeat a vector.
rep(1:2, each=3) **1, 1, 1, 2, 2, 2** 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

a == b Are equal
a != b Not equal

a > b Greater than
a < b Less than

a >= b Greater than or equal to
a <= b Less than or equal to

is.na(x) Is missing
is.null(x) Is null

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Learn more at [web page](#) or [vignette](#) • package version: 1.0.0 • updated: 3/18

Note: there are many cheatsheets covering many aspects of R and several tidyverse packages!

Useful resources

Blogs:

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

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Twitter:

- [#rstats](#)

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- <https://www.meetup.com/Berlin-R-Users-Group/>
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Courses & Workshop:

- Physalia (<https://www.physalia-courses.org>)
- PR statistics (<https://www.prstatistics.com>)
- DataCamp (online: <https://www.datacamp.com/courses/tech:r>)

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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? 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!!!