R for Stats

Statistics with R

Basel R Bootcamp

🕓 🏠 ✉ in

April 2019

R is a programming language

From **Wikipedia** (emphasis added):

> A programming language is a **formal language** that specifies a set of instructions that can be used to produce various kinds of output. Programming languages generally consist of **instructions for a computer**. Programming languages can be used to create programs that **implement specific algorithms**.

Algorithm

1. Load data
2. Extract variables
3. Run analysis
4. Print result

Implementation in R

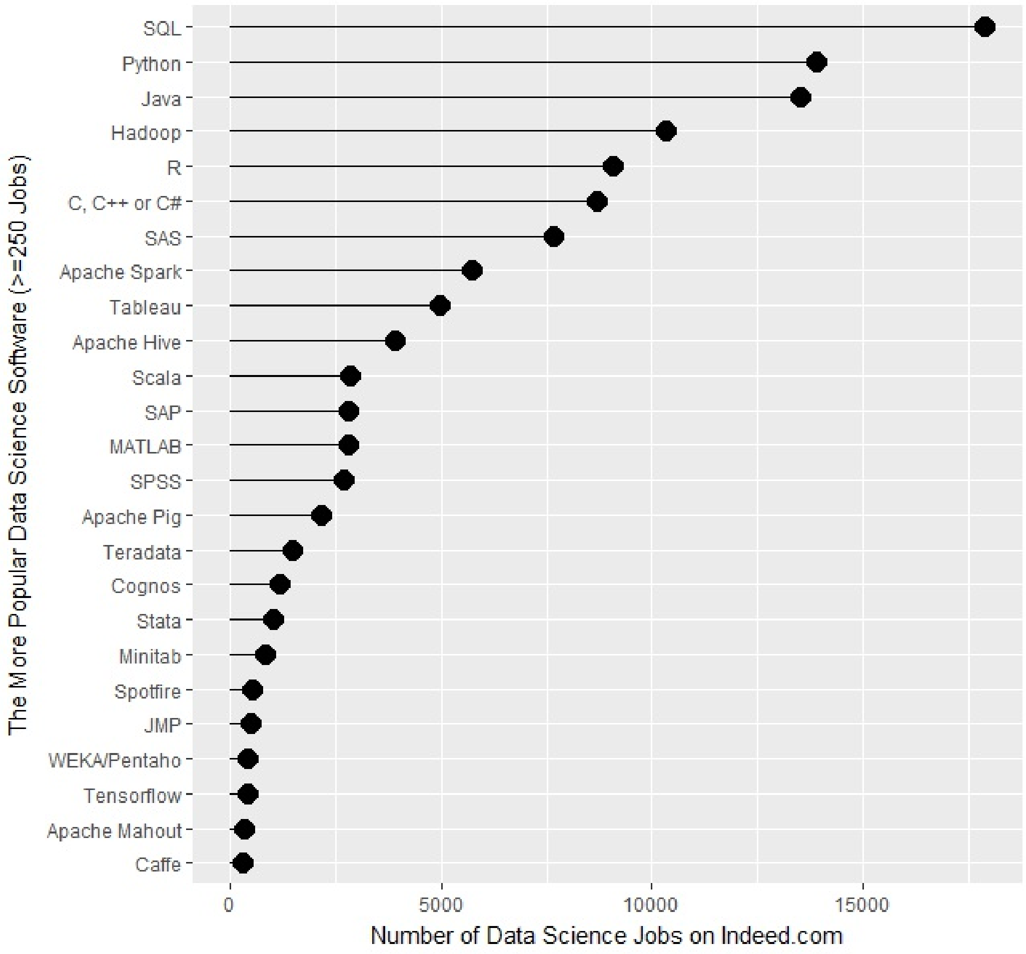
```
data <- read.table(filepath)
variables <- data %>% select(group, variable)
analysis <- lm(variable ~ group, data = variables)
summary(analysis)
```

Why R?

R steadily **grows in popularity**.

Today, R is one of the **most popular languages for data science** and overall.

In terms of the number of data science jobs, **R beats SAS and Matlab**, and is on par with Python.



from r4stats.com

R is so popular because

There are many good reasons to prefer R over superficially more user friendly software such as **Excel** or **SPSS** or more complex programming languages like **C++** or **Python**.

Pro

1. **It's free**
2. Relatively **easy**
3. **Extensibility** (CRAN, packages)
4. **User base** (e.g., stackoverflow)
5. Tidyverse (`dplyr`, `ggplot`, etc.)
6. RStudio
7. **Productivity** options: Latex, Markdown, GitHub

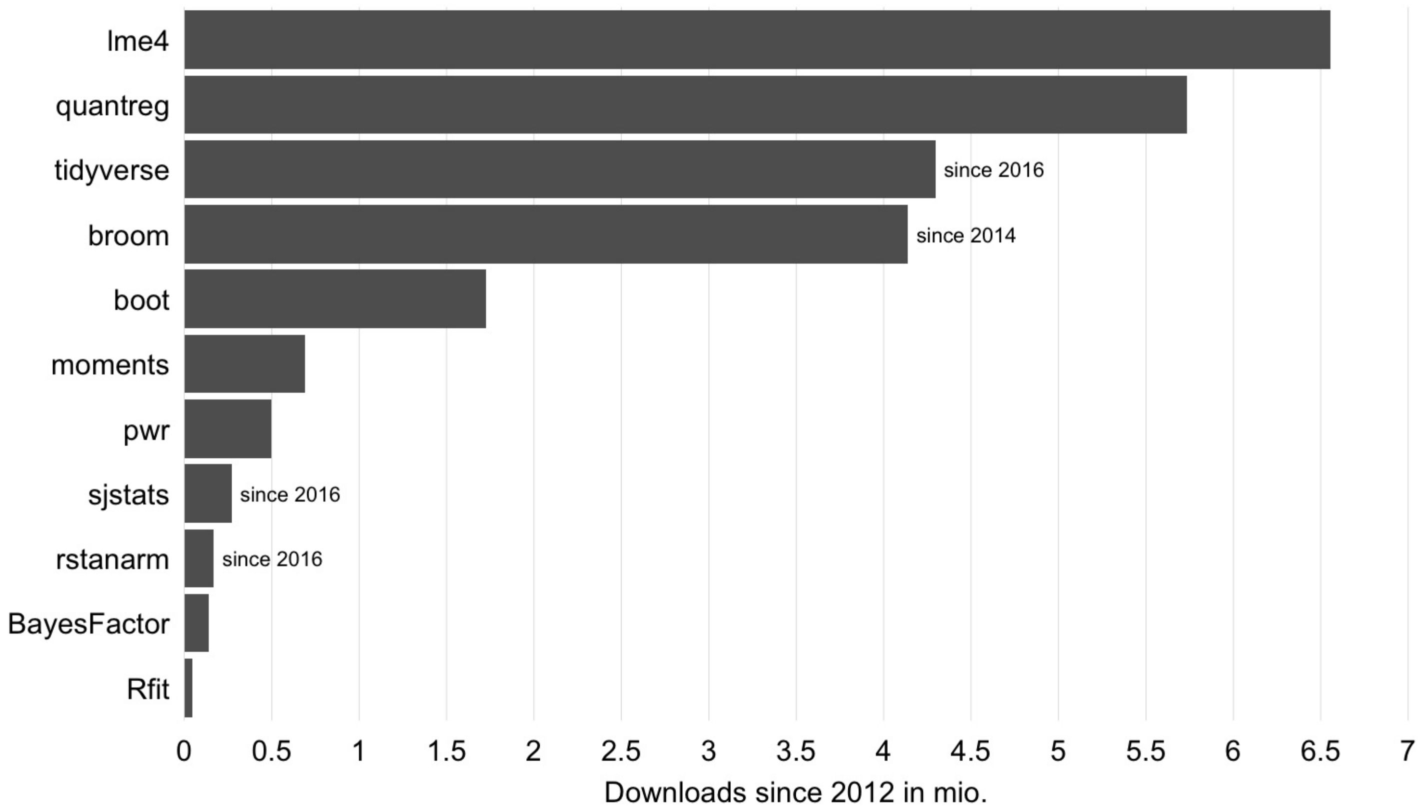
Con

It's slow, but...

Tidyverse Rcpp, BH: Links R to C++ and high-performance C++ libraries
rPython: Links R to Python
RHadoop: Links R to Hadoop for big data applications.

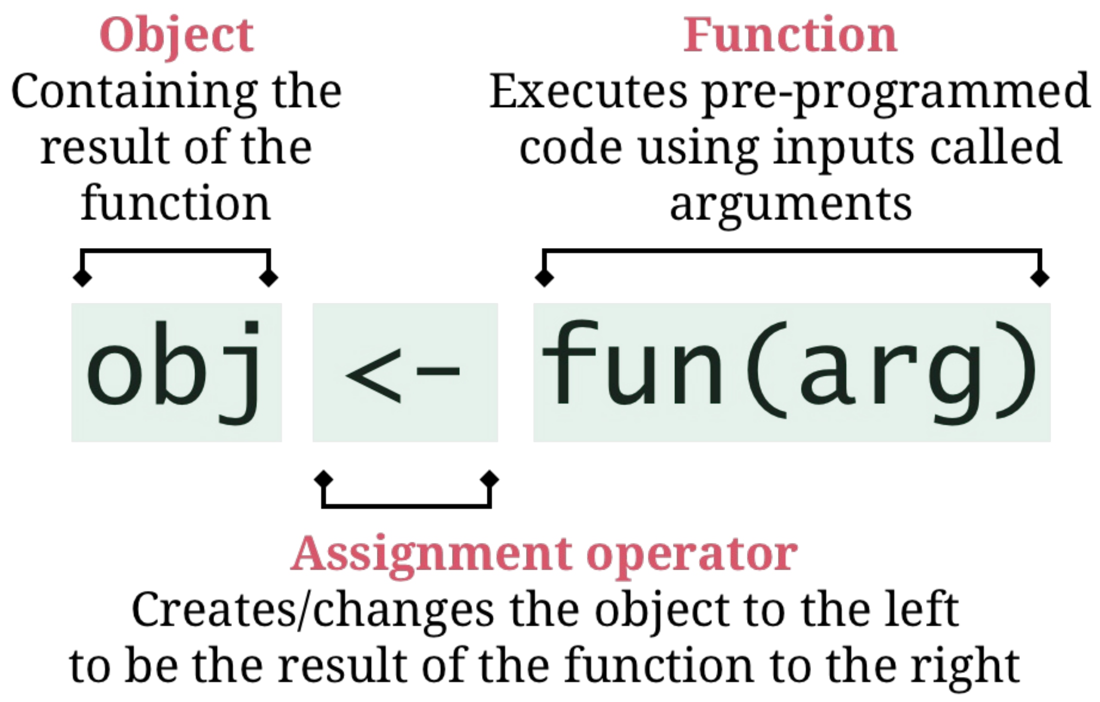
R is great for Statistics

…because of high-performance R packages (extensions) **downloaded and used millions of times**.



Essentials: 11 basic R lessons

1. **Everything is an object**
2. **<- creates/changes objects**
3. Everything happens through functions
4. Functions have (default) arguments
5. Functions live in packages
6. Find help with ?
7. Data lives in data frames
8. 3 data types + factors
9. `formula` and `data` specify a model
10. Use RStudio and projects
11. Use editor, shortcuts, auto-complete



Object
Containing the result of the function

Function
Executes pre-programmed code using inputs called arguments

```
obj <- fun(arg)
```

Assignment operator
Creates/changes the object to the left
to be the result of the function to the right

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```r
# an object called one_two_three
one_two_three <- c(1, 2, 3)

# print object
one_two_three
```

```
## [1] 1 2 3
```

```r
# add 100 to the object's numbers (without <- )
one_two_three + 100
```

```
## [1] 101 102 103
```

```r
# print object (no <-, no change!)
one_two_three
```

```
## [1] 1 2 3
```

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```
# print object
one_two_three
```

```
## [1] 1 2 3
```

```
# make change permanent (with <- )
one_two_three <- one_two_three + 100

# print object (it has changed!)
one_two_three
```

```
## [1] 101 102 103
```

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```r
# function c()
one_two_three <- c(1, 2, 3)

# function `+`()
one_two_three + 100
```

```
## [1] 101 102 103
```

```r
# function print()
one_two_three
```

```
## [1] 1 2 3
```

```r
# function mean()
mean(x = one_two_three)
```

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

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```r
# no argument
mean()
```

```
## Error in mean.default(): argument "x" is missing, with n
```

```r
# one (required) argument
mean(x = c(1, 2, 3))
```

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

```r
# assume a missing value (NA)
mean(x = c(1, 2, 3, NA))
```

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

```r
# changing default to handle NA
mean(x = c(1, 2, 3, NA), na.rm = TRUE)
```

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

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```
# mean with pipe %>%
c(1, 2, 3) %>% mean()
```

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

```
# mean with pipe %>% and NA
c(1, 2, 3, NA) %>% mean()
```

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

```
# changing default to handle NA
c(1, 2, 3, NA) %>% mean(na.rm = TRUE)
```

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

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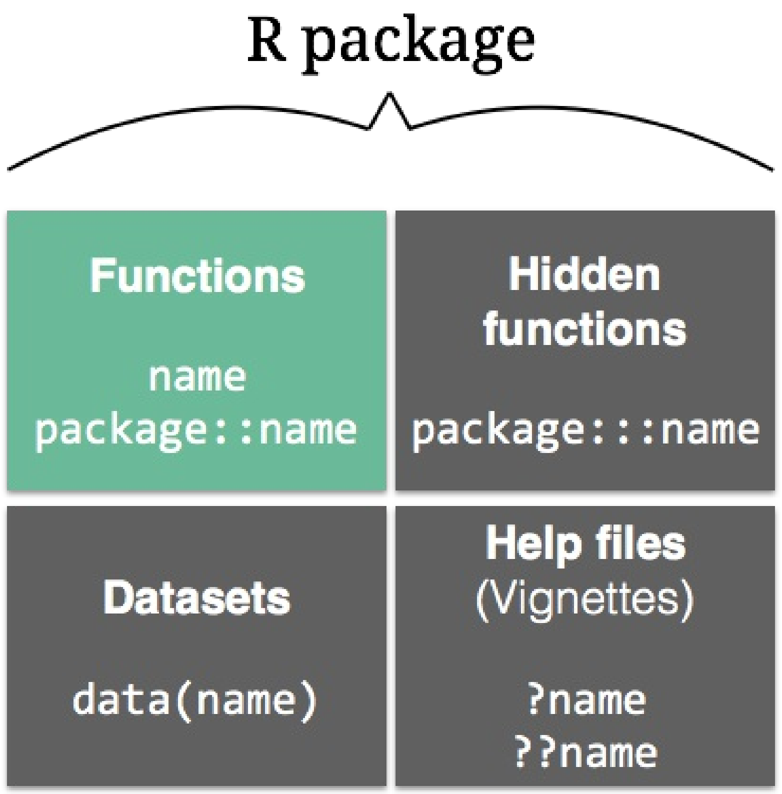

R package

Functions

`name`
`package::name`

Hidden functions

`package:::name`

Datasets

`data(name)`

Help files
(Vignettes)

`?name`
`??name`

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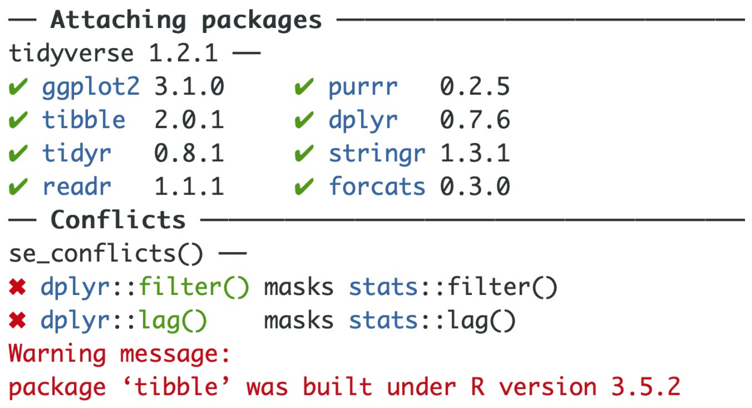
Install new packages with `install.packages()`

```
# install package: Only do this once!
install.packages("tidyverse")
```

Load existing packages with `library()`

```
# load package: EVERY TIME you write code
library(tidyverse)
```



```
— Attaching packages ———————————————————————————
tidyverse 1.2.1 —
✔ ggplot2 3.1.0     ✔ purrr   0.2.5
✔ tibble  2.0.1     ✔ dplyr   0.7.6
✔ tidyr   0.8.1     ✔ stringr 1.3.1
✔ readr   1.1.1     ✔ forcats 0.3.0
— Conflicts ————————————————————————————————————
se_conflicts() —
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
Warning message:
package ‘tibble’ was built under R version 3.5.2
```

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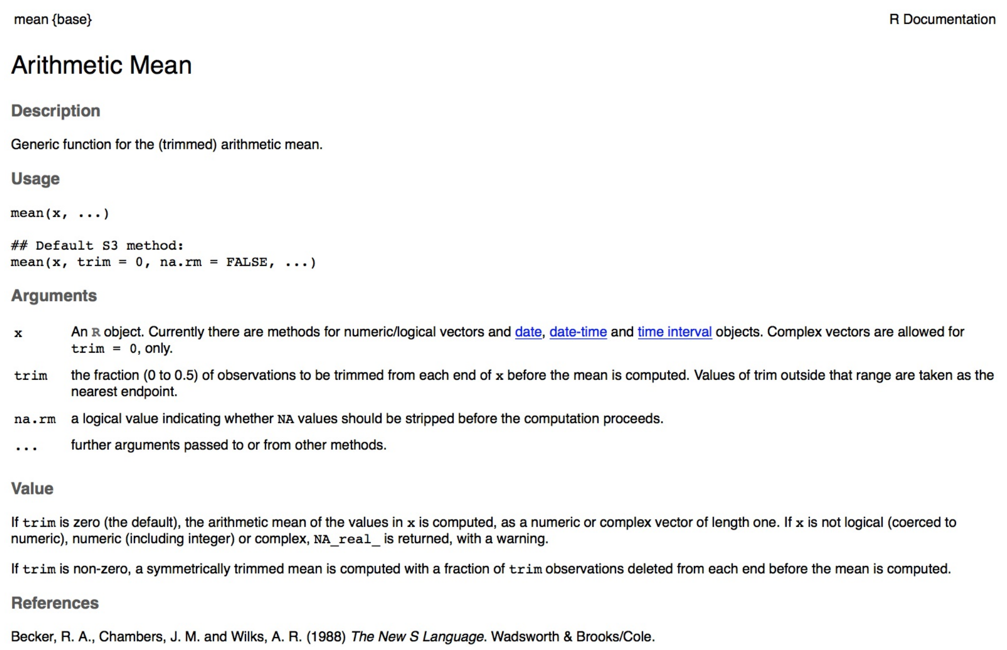
```
?mean
```



mean {base} R Documentation

Arithmetic Mean

Description

Generic function for the (trimmed) arithmetic 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. 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.
`...`	further arguments passed to or from other methods.

Value

If `trim` is zero (the default), the arithmetic mean of the values in `x` is computed, as a numeric or complex vector of length one. If `x` is not logical (coerced to numeric), numeric (including integer) or complex, `NA_real_` is returned, with a warning.

If `trim` is non-zero, a symmetrically trimmed mean is computed with a fraction of `trim` observations deleted from each end before the mean is computed.

References

Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

Essentials: 11 basic R lessons

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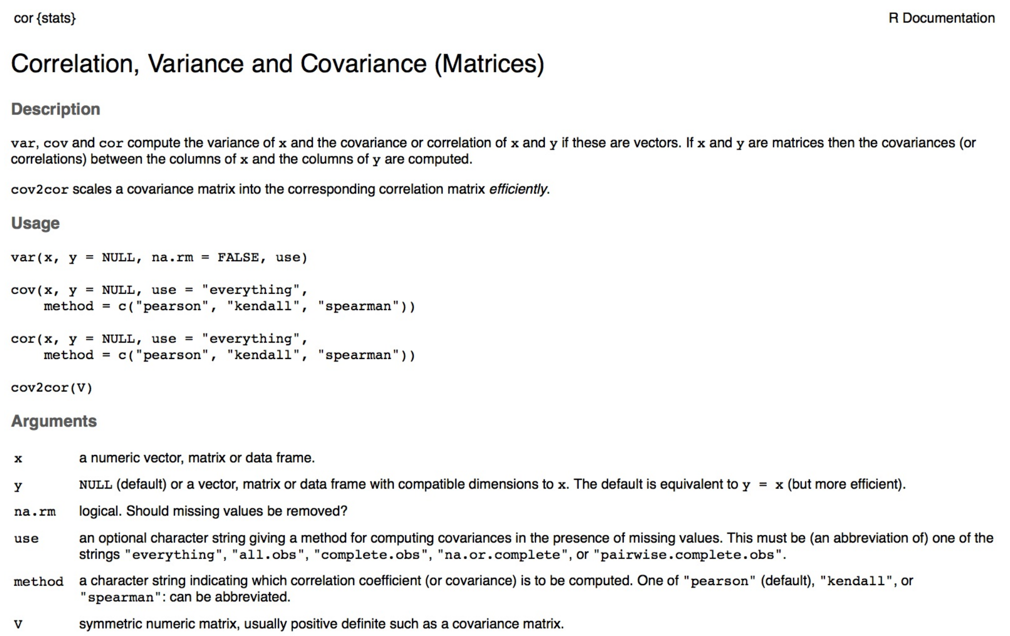
```
?cor
```



cor {stats} R Documentation

Correlation, Variance and Covariance (Matrices)

Description

`var`, `cov` and `cor` compute the variance of `x` and the covariance or correlation of `x` and `y` if these are vectors. If `x` and `y` are matrices then the covariances (or correlations) between the columns of `x` and the columns of `y` are computed.

`cov2cor` scales a covariance matrix into the corresponding correlation matrix *efficiently*.

Usage

```
var(x, y = NULL, na.rm = FALSE, use)

cov(x, y = NULL, use = "everything",
    method = c("pearson", "kendall", "spearman"))

cor(x, y = NULL, use = "everything",
    method = c("pearson", "kendall", "spearman"))

cov2cor(V)
```

Arguments

`x`	a numeric vector, matrix or data frame.
`y`	`NULL` (default) or a vector, matrix or data frame with compatible dimensions to `x`. The default is equivalent to `y = x` (but more efficient).
`na.rm`	logical. Should missing values be removed?
`use`	an optional character string giving a method for computing covariances in the presence of missing values. This must be (an abbreviation of) one of the strings `"everything"`, `"all.obs"`, `"complete.obs"`, `"na.or.complete"`, or `"pairwise.complete.obs"`.
`method`	a character string indicating which correlation coefficient (or covariance) is to be computed. One of `"pearson"` (default), `"kendall"`, or `"spearman"`: can be abbreviated.
`V`	symmetric numeric matrix, usually positive definite such as a covariance matrix.

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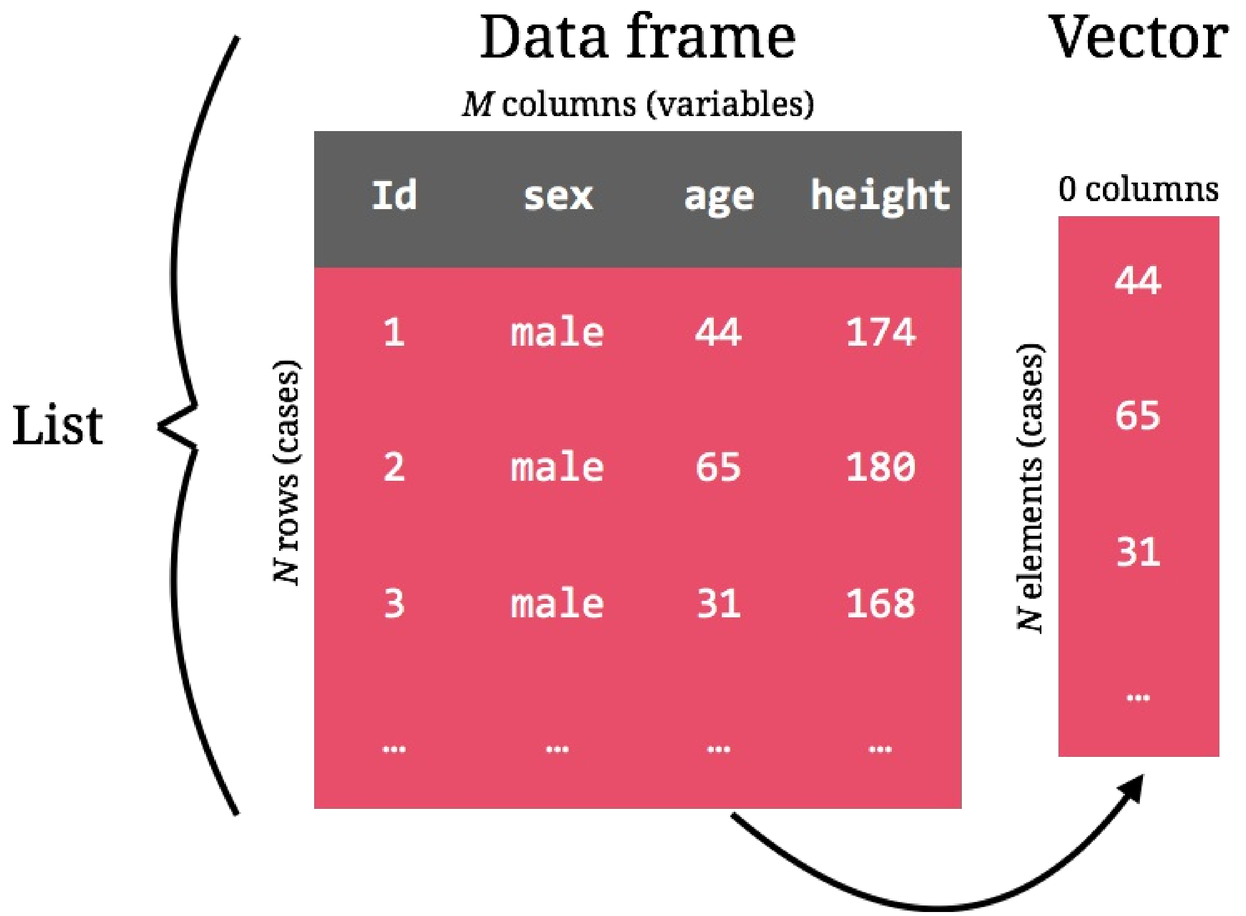

Id	sex	age	height
1	male	44	174
2	male	65	180
3	male	31	168
…	…	…	…

44
65
31
…

Essentials: 11 basic R lessons

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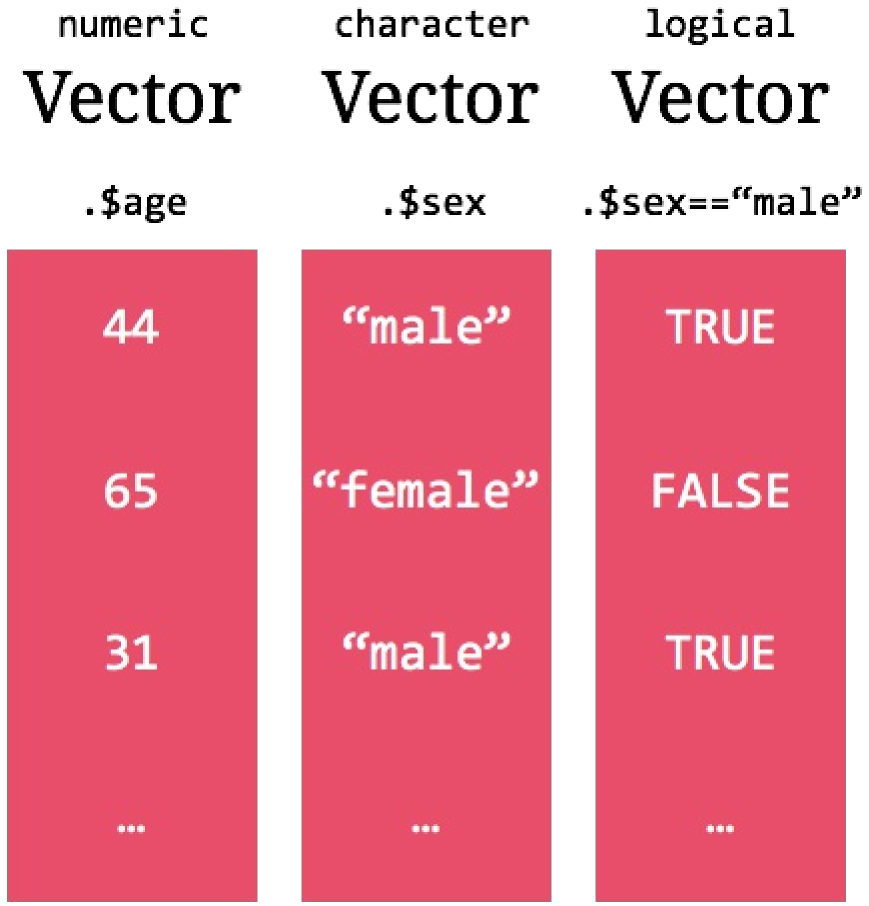

numeric Vector .$age	character Vector .$sex	logical Vector .$sex==“male”
44	“male”	TRUE
65	“female”	FALSE
31	“male”	TRUE
…	…	…

Essentials: 11 basic R lessons

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```r
print(baselers)
```

```
## # A tibble: 10,000 x 20
##       id sex     age height weight income
##    <dbl> <chr> <dbl>  <dbl>  <dbl>  <dbl>
##  1     1 male     44   174.  113.    6300
##  2     2 male     65   180.   75.2  10900
##  3     3 fema…    31   168.   55.5   5100
##  4     4 male     27   209    93.8   4200
##  5     5 male     24   177.   NA     4000
##  6     6 male     63   187.   67.4  11400
##  7     7 male     71   152.   83.3  12000
##  8     8 fema…    41   156.   67.8   7600
##  9     9 male     43   176.   69.3   8500
## 10    10 fema…    31   166.   66.3   6100
## # … with 9,990 more rows, and 14 more variables
```

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```r
# select sex veriable using $
baselers$sex
```

```
## [1] "male"   "male"   "female" "male"   "male"
## [6] "male"   "male"   "female"
##  [ reached getOption("max.print") -- omitted 9992 entrie
```

```r
# select sex veriable using %>% select
baselers %>% select(sex) %>% pull()
```

```
## [1] "male"   "male"   "female" "male"   "male"
## [6] "male"   "male"   "female"
##  [ reached getOption("max.print") -- omitted 9992 entrie
```

```r
# Possible, but less pretty...
baselers[['sex']]
baselers[[2]]
```

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```r
# original sex vector
baselers$sex
```

```
## [1] "male"   "male"   "female" "male"   "male"  
## [6] "male"  
##  [ reached getOption("max.print") -- omitted 9994 entrie
```

```r
as.factor(baselers$sex)
```

```
## [1] male   male   female male   male   male  
##  [ reached getOption("max.print") -- omitted 9994 entrie
## Levels: female male
```

```r
as.factor(baselers$weight)
```

```
## [1] 113.4 75.2  55.5  93.8  <NA>  67.4 
##  [ reached getOption("max.print") -- omitted 9994 entrie
## 719 Levels: 37.9 38.3 39.2 39.6 40.3 ... 125.4
```

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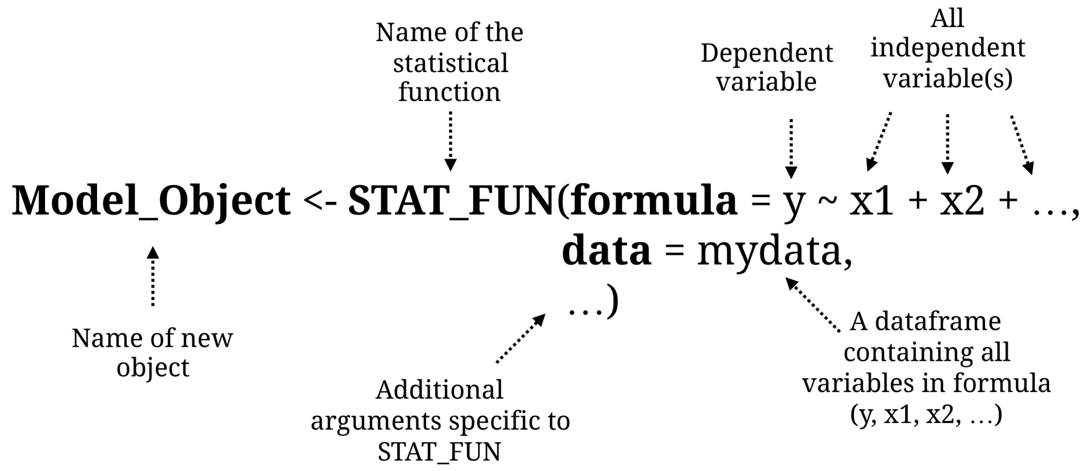
```
# Run a regression and store result in my_lm
my_lm <- lm(formula = income ~ age + height,
             data = baselers)
```



Name of the statistical function

Dependent variable

All independent variable(s)

Model_Object <- **STAT_FUN**(**formula** = y ~ x1 + x2 + …,
data = mydata,
…)

Name of new object

Additional arguments specific to STAT_FUN

A dataframe containing all variables in formula (y, x1, x2, …)

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Add variables using +

```
# Include multiple terms with +
my_lm <- lm(formula = income ~ age + height,
            data = baselers)
```

Include all variables using `formula = y ~ .`

```
# Use  y ~ . to include ALL variables
my_lm <- lm(formula = income ~ .,
            data = baselers)
```

Subtract variables using -

```
# Remove variables with -
my_lm <- lm(formula = income ~ . - id,
            data = baselers)
```

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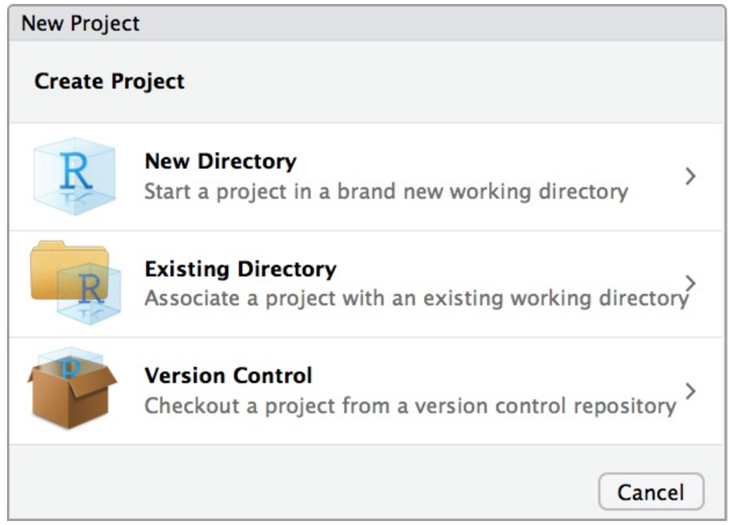
Projects help...

save workspace and history ● set project specific options ● access files ● version control ● etc.



New Project

Create Project

New Directory
Start a project in a brand new working directory

Existing Directory
Associate a project with an existing working directory

Version Control
Checkout a project from a version control repository

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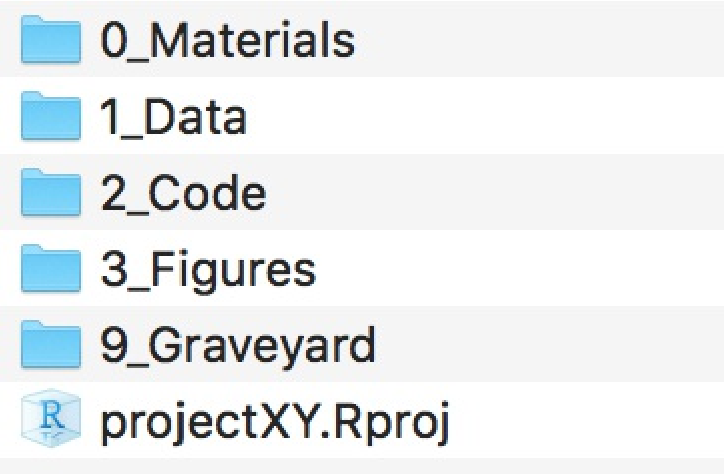
Folder structure

Complement projects by a **folder structure** appropriate for your project.



0_Materials
1_Data
2_Code
3_Figures
9_Graveyard
projectXY.Rproj

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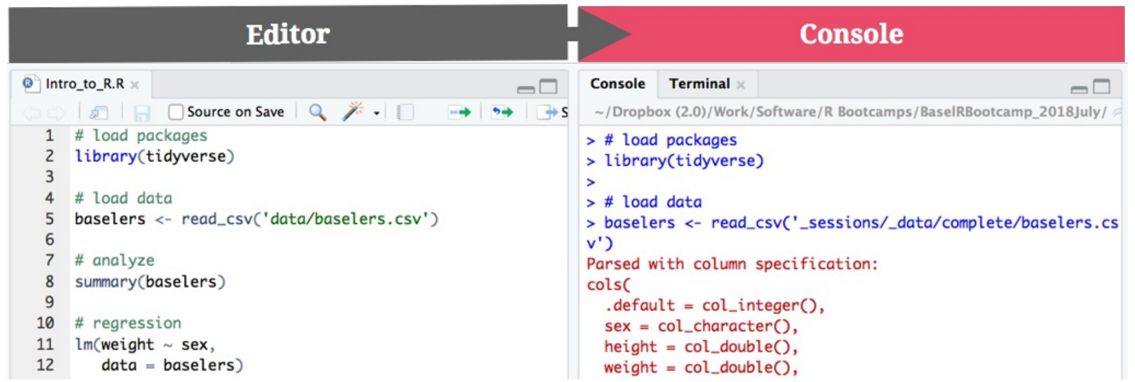
Editor
Console
Intro_to_R.R
Source on Save
Console
Terminal
~/Dropbox (2.0)/Work/Software/R Bootcamps/BaselRBootcamp_2018July/

```r
# load packages
library(tidyverse)

# load data
baselers <- read_csv('data/baselers.csv')

# analyze
summary(baselers)

# regression
lm(weight ~ sex,
   data = baselers)
```

```
> # load packages
> library(tidyverse)
>
> # load data
> baselers <- read_csv('_sessions/_data/complete/baselers.cs
v')
Parsed with column specification:
cols(
  .default = col_integer(),
  sex = col_character(),
  height = col_double(),
  weight = col_double(),
```

Shortcut to **send to console**:

⌘/ctrl + ⏎

Shortcut to **rerun chunk**:

⌘/ctrl + ⇧ + p

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```
# Load packages with library()
library(tidyverse)
library(yarrr)
library(lme4)

# import data with
baselers <- read_delim(file = "baselers.txt",
                       delim = '\t')
```

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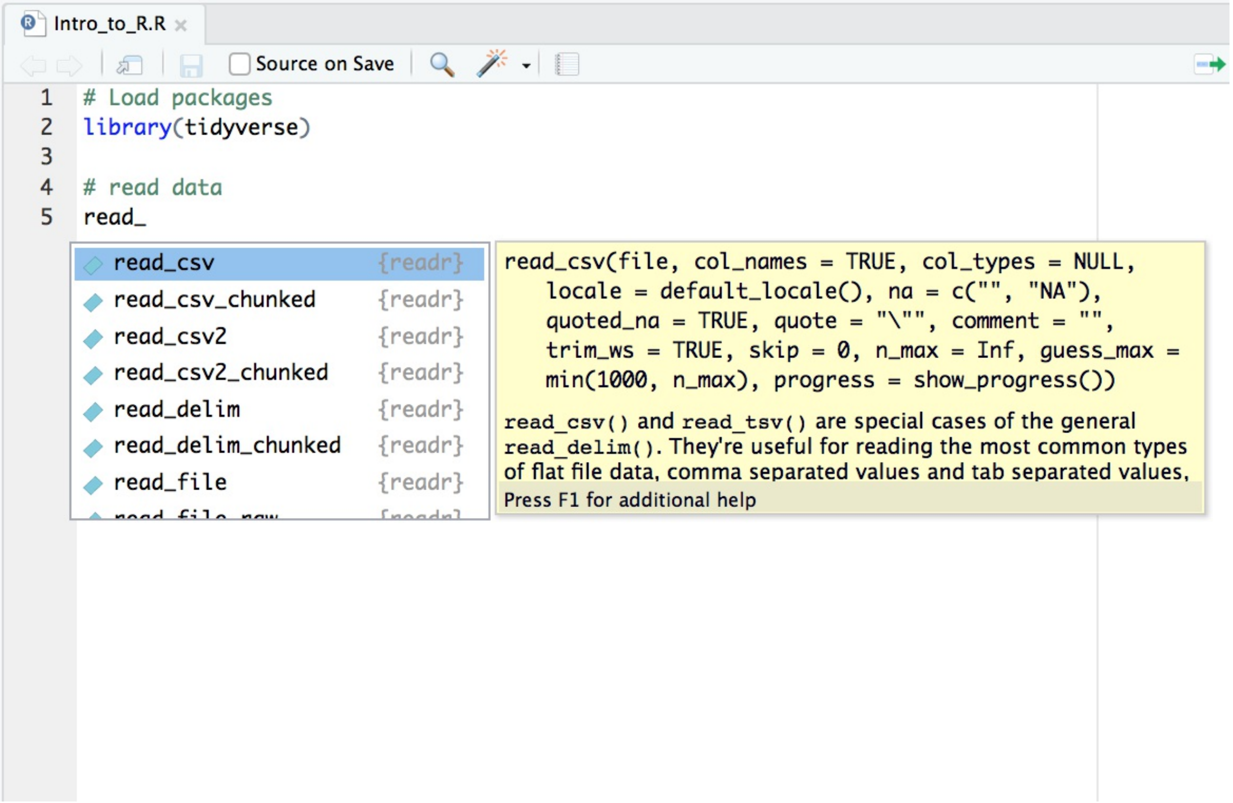

```r
# Load packages
library(tidyverse)

# read data
read_
```

```
read_csv(file, col_names = TRUE, col_types = NULL,
    locale = default_locale(), na = c("", "NA"),
    quoted_na = TRUE, quote = "\"", comment = "",
    trim_ws = TRUE, skip = 0, n_max = Inf, guess_max =
    min(1000, n_max), progress = show_progress())
```

`read_csv()` and `read_tsv()` are special cases of the general `read_delim()`. They're useful for reading the most common types of flat file data, comma separated values and tab separated values,

Press F1 for additional help

Essentials: 11 basic R lessons

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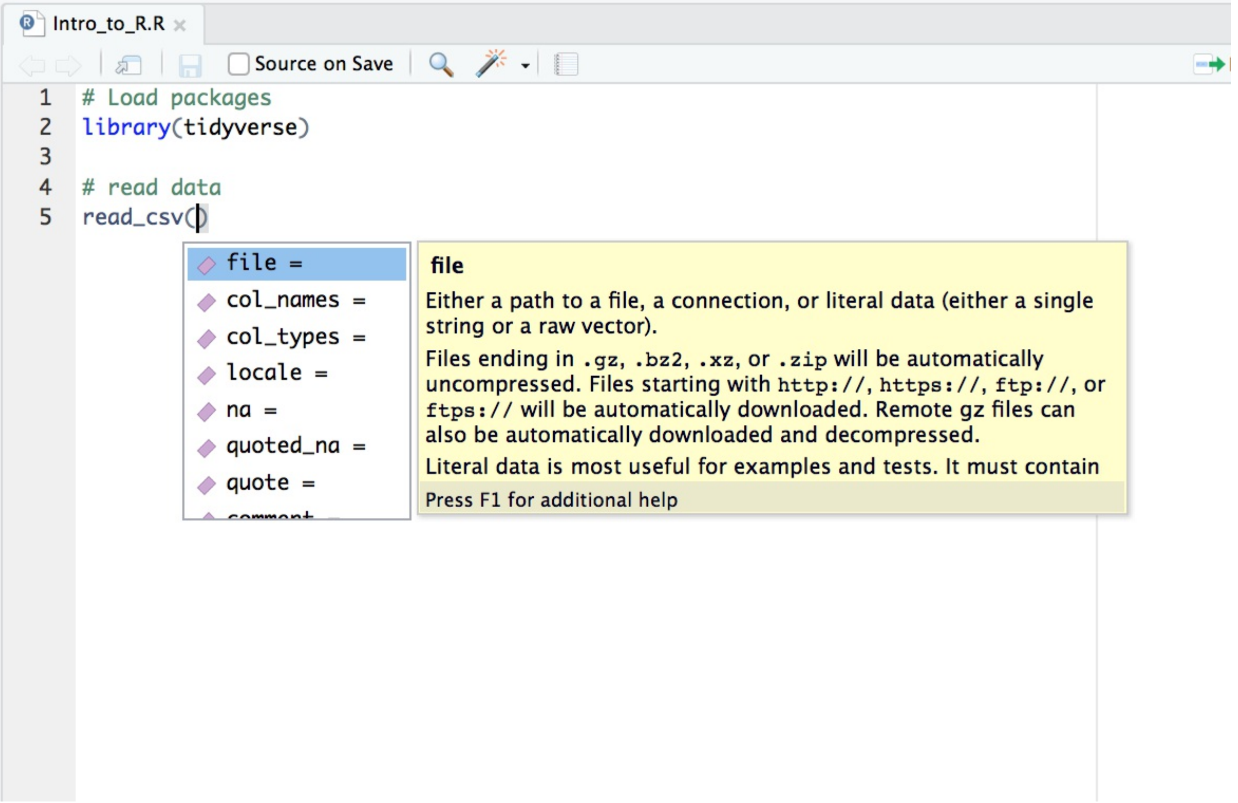
2. `<-` creates/changes objects
3. Everything happens through functions
4. Functions have (default) arguments
5. Functions live in packages
6. Find help with ?
7. Data lives in data frames
8. 3 data types + factors
9. `formula` and `data` specify a model
10. Use RStudio and projects
11. **Use editor, shortcuts, auto-complete**



```
# Load packages
library(tidyverse)

# read data
read_csv()
```

file

Either a path to a file, a connection, or literal data (either a single string or a raw vector).

Files ending in `.gz`, `.bz2`, `.xz`, or `.zip` will be automatically uncompressed. Files starting with `http://`, `https://`, `ftp://`, or `ftps://` will be automatically downloaded. Remote gz files can also be automatically downloaded and decompressed.

Literal data is most useful for examples and tests. It must contain

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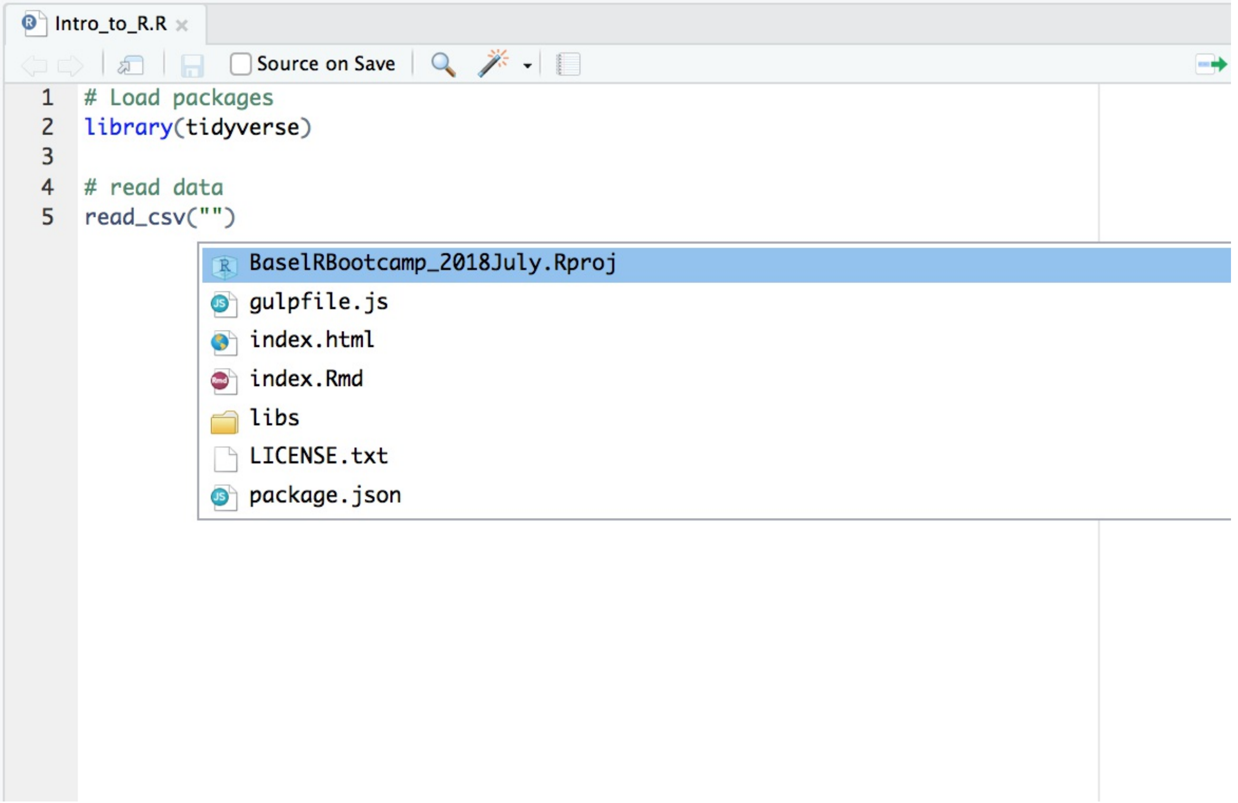

```
# Load packages
library(tidyverse)

# read data
read_csv("")
```

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