R for ML

Machine Learning with R

Basel R Bootcamp

October 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(link)
#variables <- data[,c('group','variable')]
#analysis <- lm(variable ~ group, data = variables)
#summary(analysis)
```

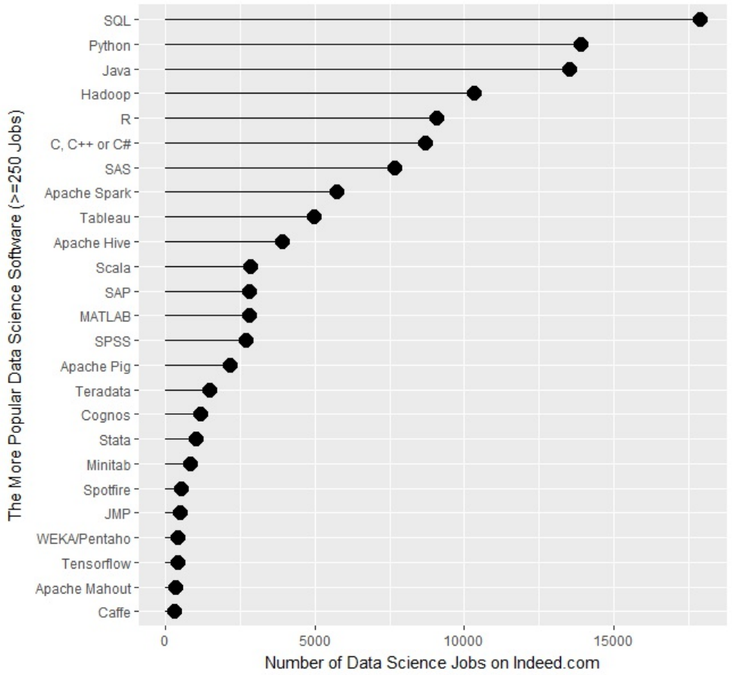
Why R?

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.

Image source: https://i0.wp.com/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

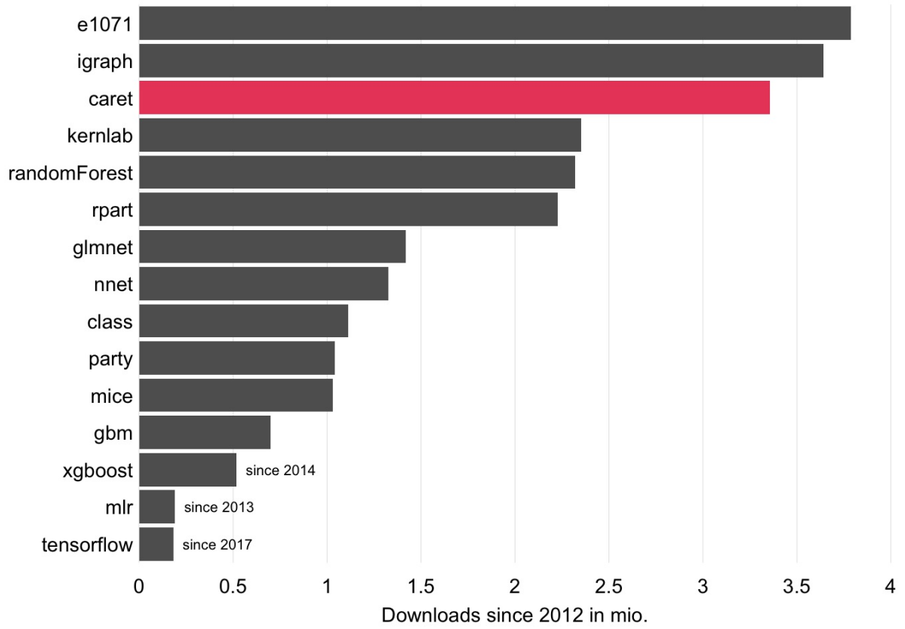
Con (?)

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 ML

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



caret

The **C**lassification **A**nd **RE**gression **T**raining package is a meta-package to streamline the application of R's best machine learning tools.

`caret` facilitates...

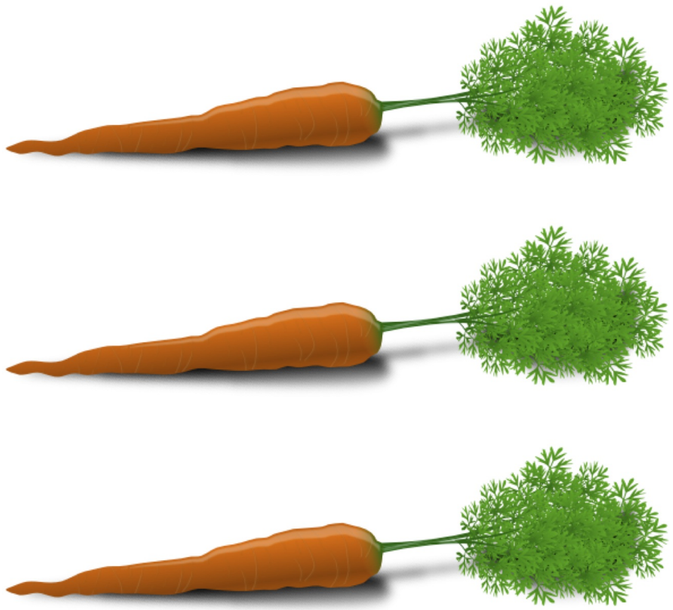
1) **data pre-processing**

2) **feature selection**

3) **fitting, tuning, & model prediction**

Includes dozens of algorithms/models including...

regression, **decision trees**, **random forests**, neural nets, AdaBoost, elastic nets, **lasso & ridge regression**, support vector machines, etc.



6+3+2 basic R lessons

6+3+2 basic R lessons

R essentials

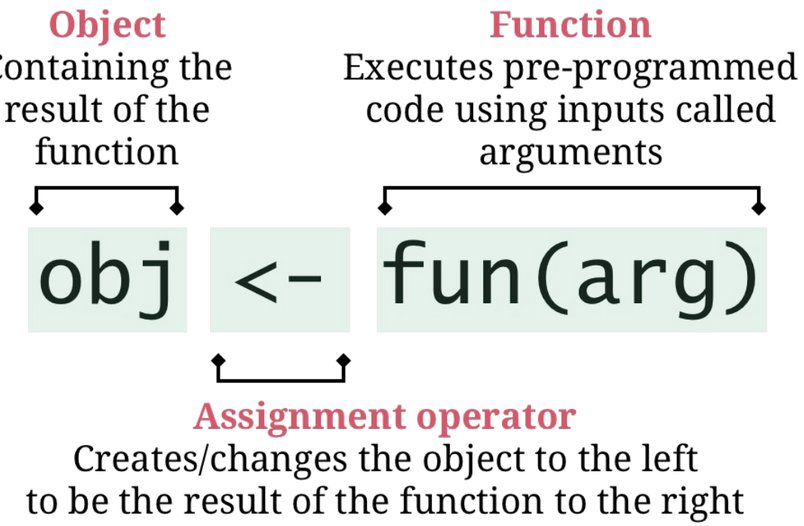
1. **Everything is an object**
2. **<- creates/changes objects**
3. Everything happens through functions
4. Functions have (default) arguments
5. Functions live in packages
6. Find help with ?

Analytic essentials

1. Data lives in data frames
2. 3 data types + factors
3. `formula` and `data` specify a model

Productivity essentials

1. Use RStudio and projects
2. Use editor, shortcuts, auto-complete



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

# print object
one_two_three
```

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
# changing default to handle NA
mean(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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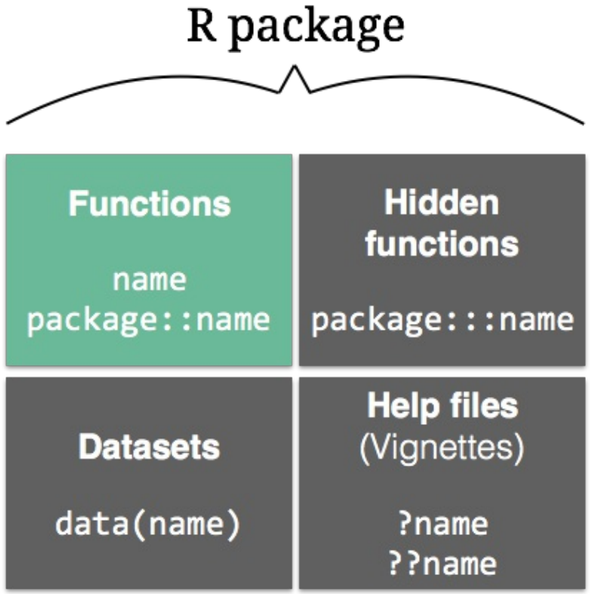

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Install new packages with `install.packages()`

```
# 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.

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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.

Interactive

6+3+2 basic R lessons

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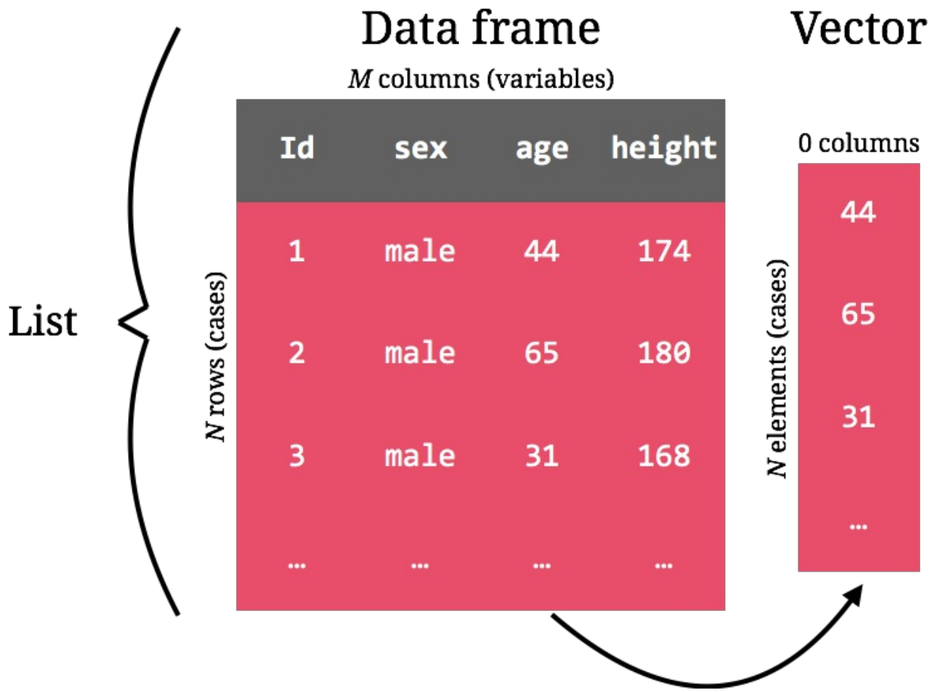

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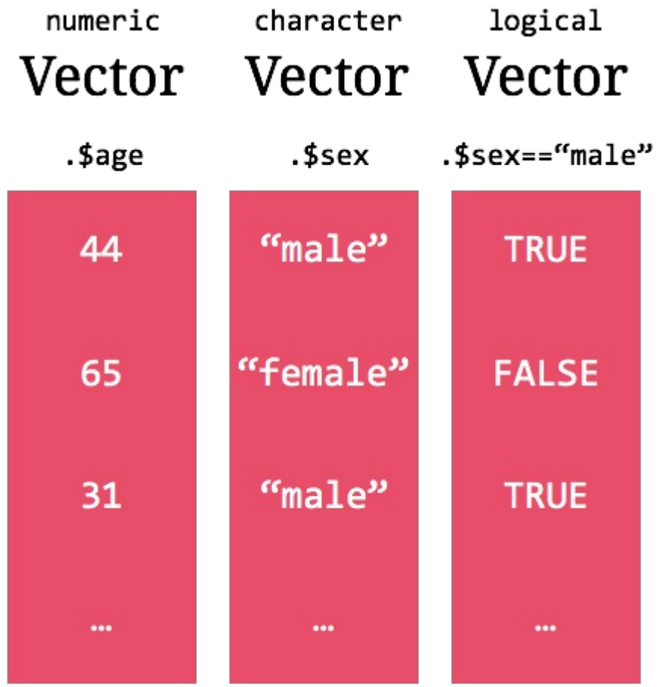

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```
print(baselers)
```

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

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

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

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

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

6+3+2 basic R lessons

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

```
## [1] "male"   "male"   "female" "male"   "male"
##  [ reached getOption("max.print") -- omitted 9995 entries
```

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

```
## [1] male   male   female male   male
##  [ reached getOption("max.print") -- omitted 9995 entries
## Levels: female male
```

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

```
## [1] 113.4 75.2  55.5  93.8  <NA>
##  [ reached getOption("max.print") -- omitted 9995 entries
## 719 Levels: 37.9 38.3 39.2 39.6 40.3 ... 125.4
```

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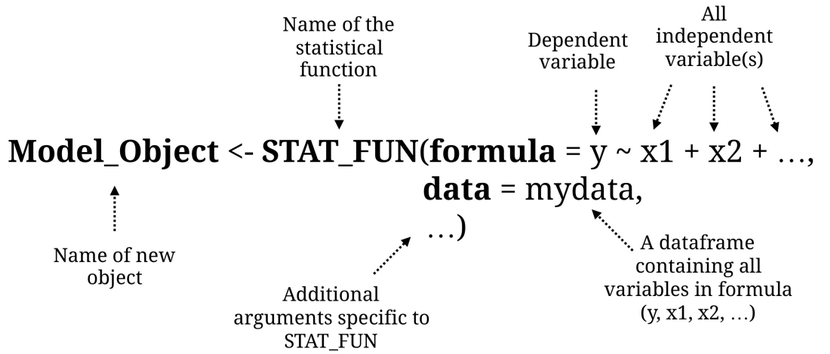
```
# Run a regression and store result in my_lm
my_lm <- lm(formula = income ~ age + height,
            data = baselers)
```



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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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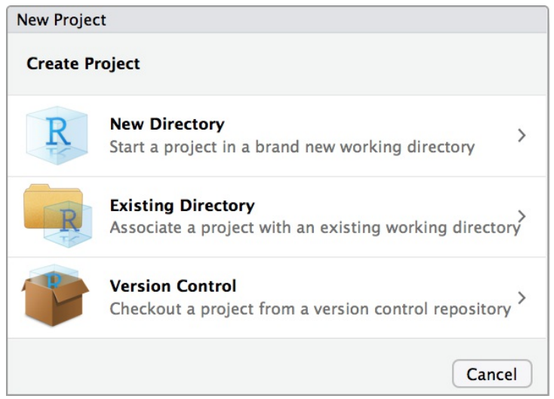
Projects help...

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



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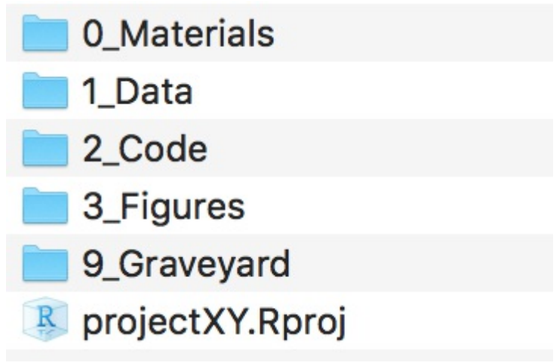
Folder structure

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



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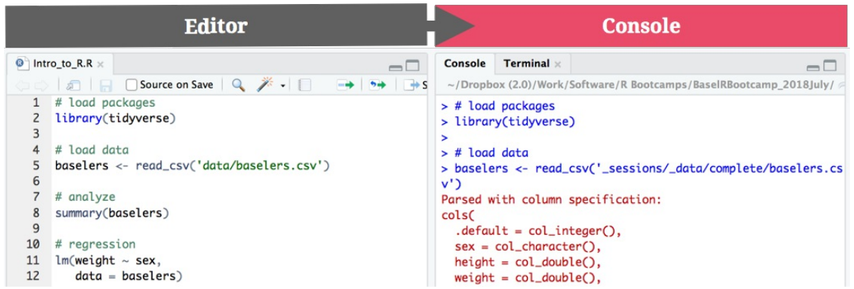

Shortcut to **send to console**:

⌘/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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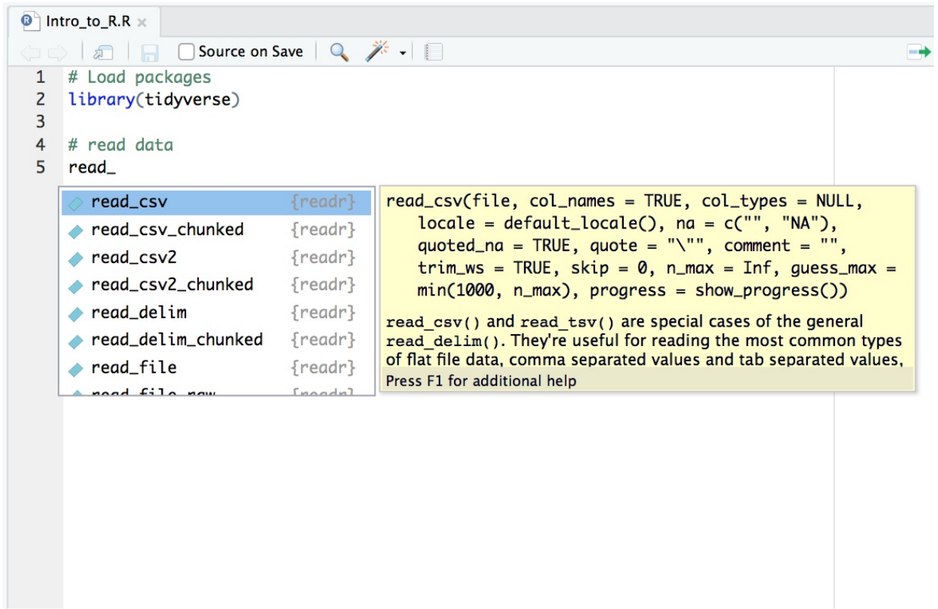

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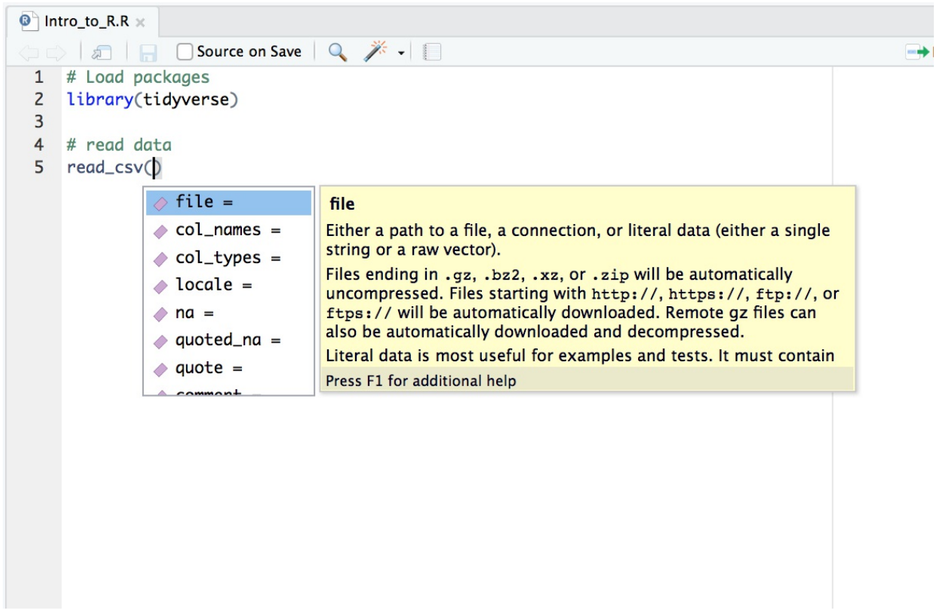


6+3+2 basic R lessons

R essentials

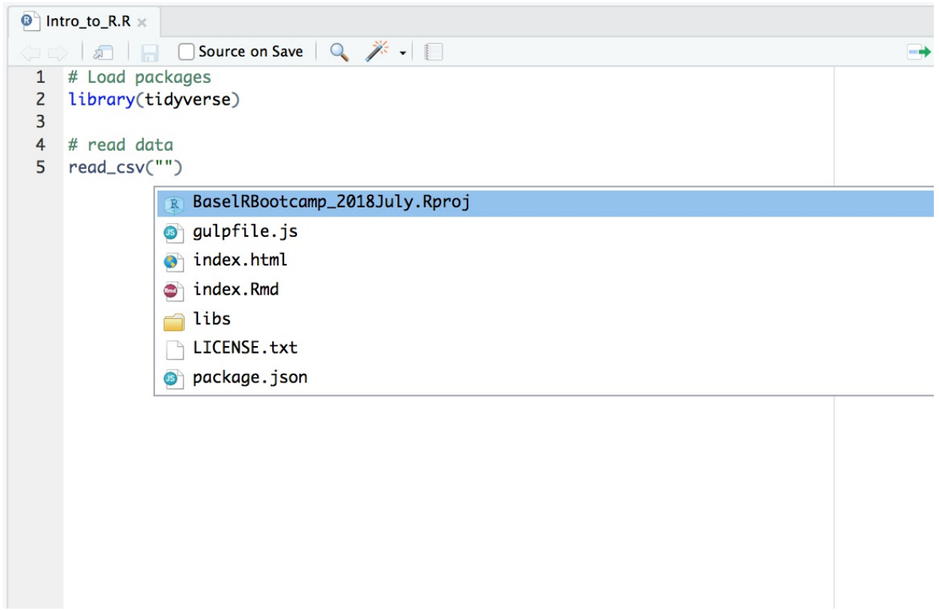
1. Everything is an object
2. <- creates/changes objects
3. Everything happens through functions
4. Functions have (default) arguments
5. Functions live in packages
6. Find help with ?

Analytic essentials

1. Data lives in data frames
2. 3 data types + factors
3. `formula` and `data` specify a model

Productivity essentials

1. Use RStudio and projects
2. **Use editor, shortcuts, auto-complete**



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