R for ML

Applied Machine Learning with R
www.therbootcamp.com
@therbootcamp

January 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)
```

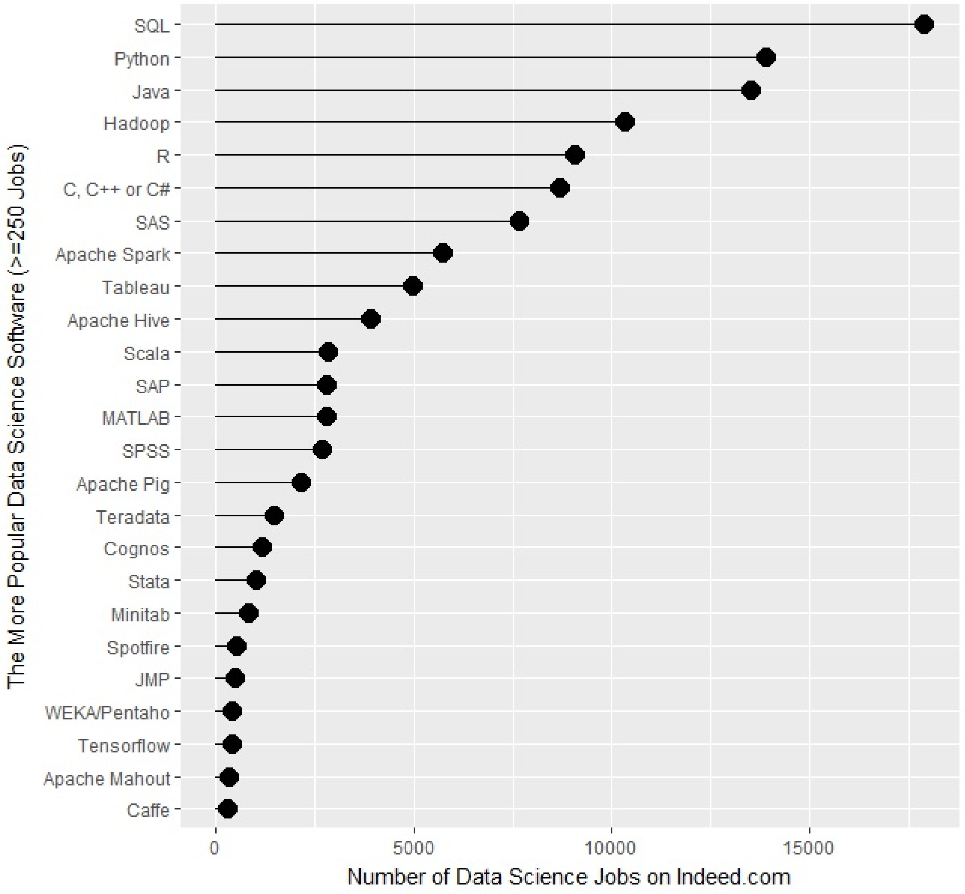
Why R?

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

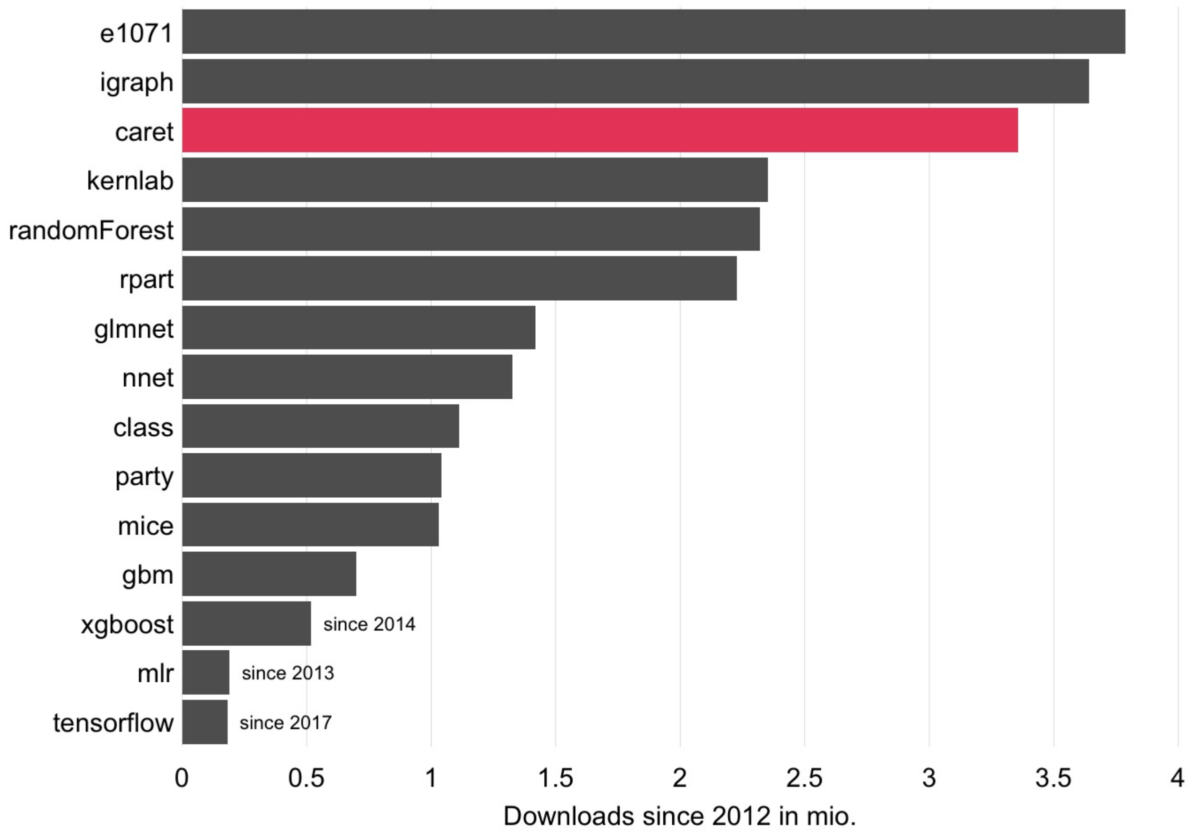
Con

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...

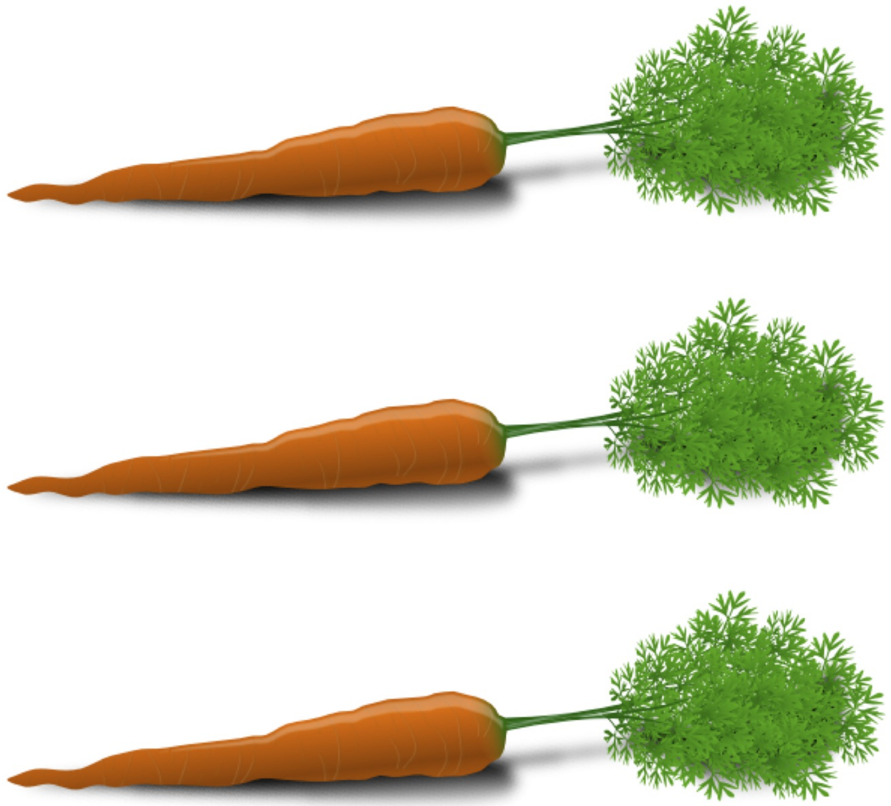
1) **data pre-processing**

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.



10 basic R lessons

Essentials: 10 basic R lessons

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

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

# add 2 to the object's numbers
some_name + 2
```

```
## [1] 3 4 5
```

```
# print object
some_name
```

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

```
# make change permanent
some_name <- some_name + 2

# print object
some_name
```

```
## [1] 3 4 5
```

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

# function `+`()
some_name + 2
```

```
## [1] 3 4 5
```

```r
# function print()
some_name
```

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

```r
# function mean()
mean(some_name)
```

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

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

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

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

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

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

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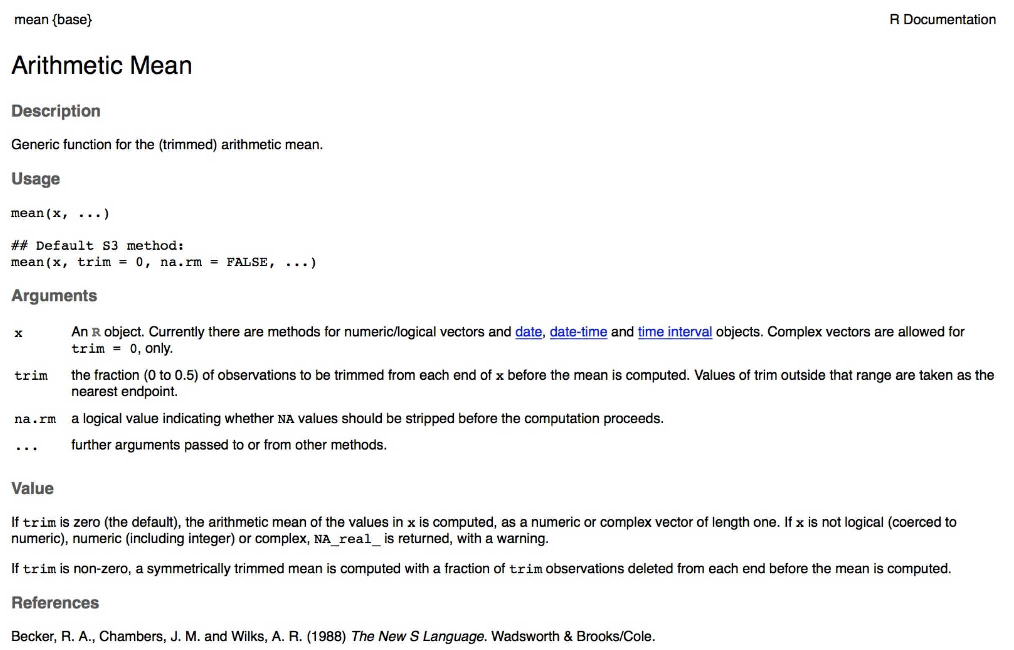
```
?mean
```



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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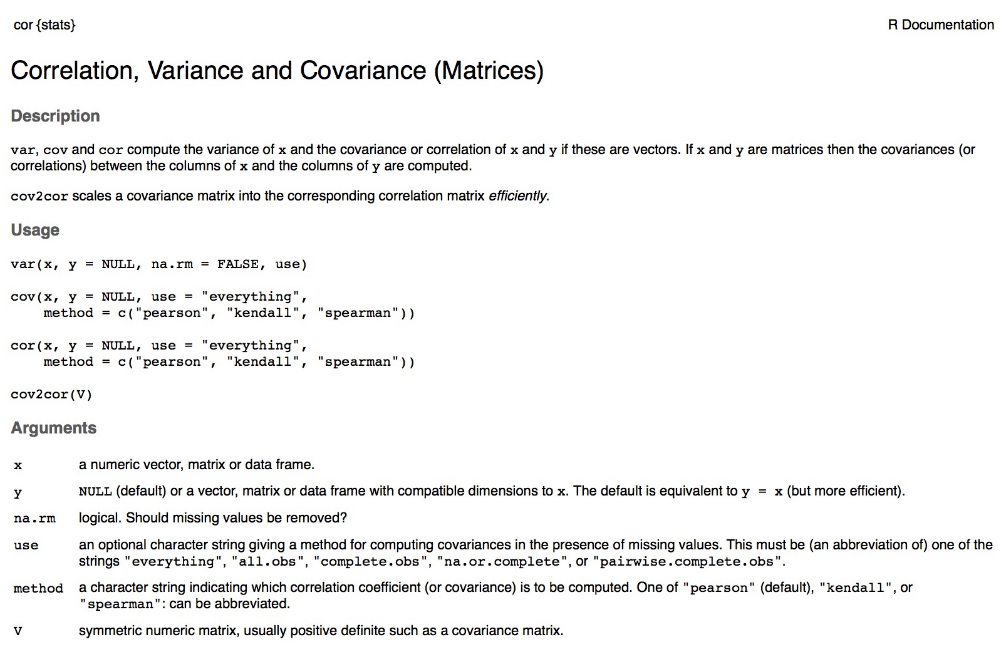
```
?cor
```



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.

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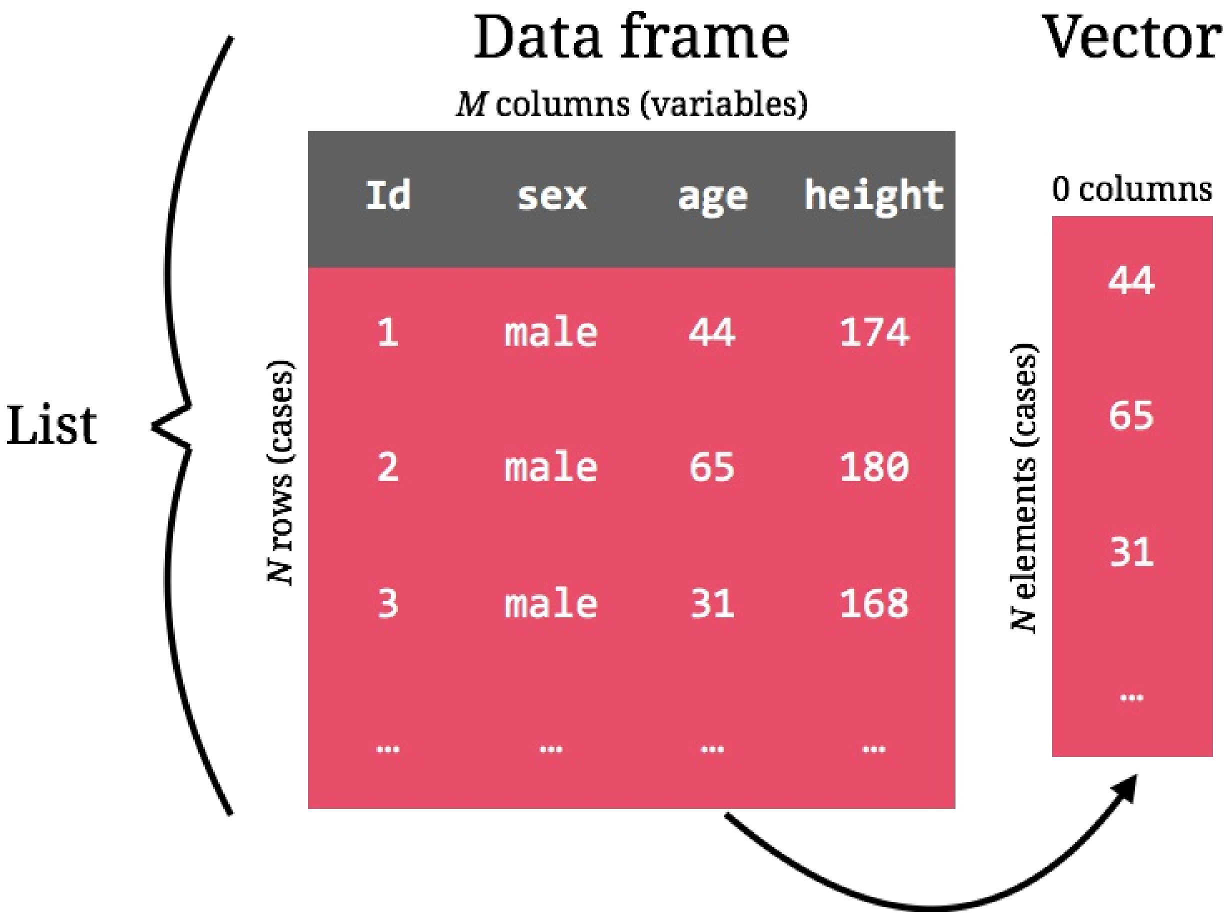

Id	sex	age	height
1	male	44	174
2	male	65	180
3	male	31	168
…	…	…	…

44
65
31
…

Essentials: 10 basic R lessons

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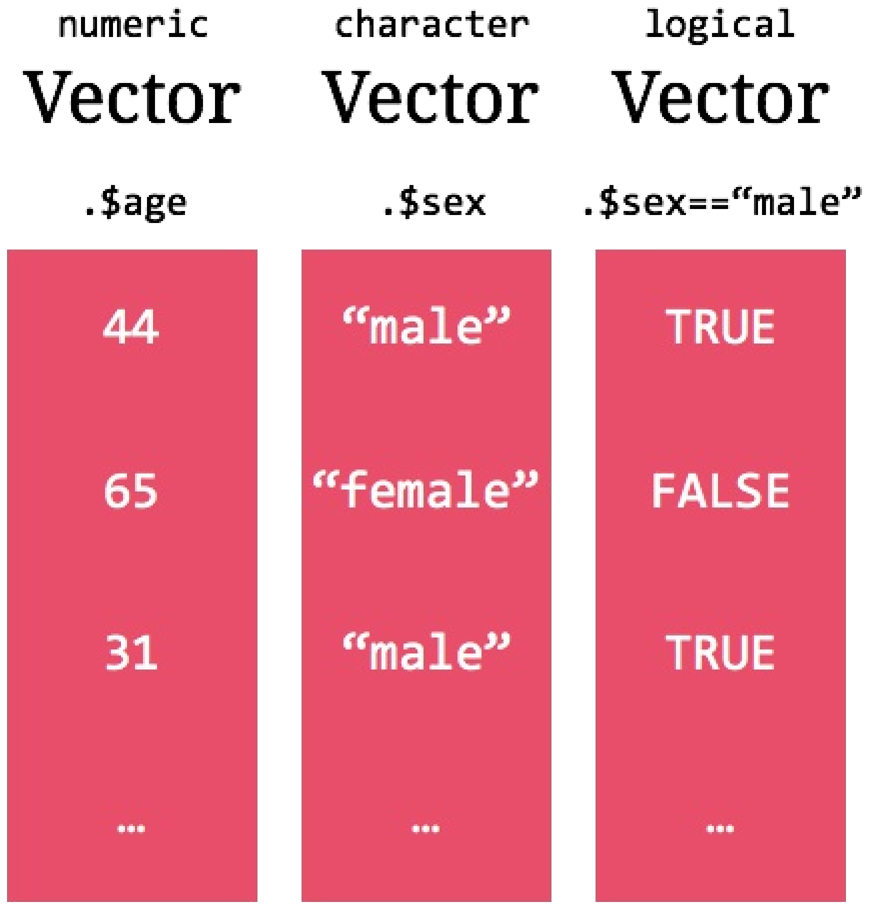

numeric Vector	character Vector	logical Vector
.$age	.$sex	.$sex==“male”
44	“male”	TRUE
65	“female”	FALSE
31	“male”	TRUE
…	…	…

Essentials: 10 basic R lessons

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```
print(baselers)
```

```
## # A tibble: 10,000 x 20
##       id sex     age height weight income
##    <int> <chr> <int>  <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"   "male"
## [6] "male"   "male"   "female"
##  [ reached getOption("max.print") -- omitted 9992 entrie
```

```
# 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
```

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

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5. Find help with ?
6. Data lives in data frames
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8. `formula` and `data` specify a model
9. Use RStudio and projects
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```
# original sex vector
baselers$sex
```

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

```
# original sex vector
as.factor(baselers$sex)
```

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

```
# original sex vector
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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8. `formula` **and** `data` **specify a model**
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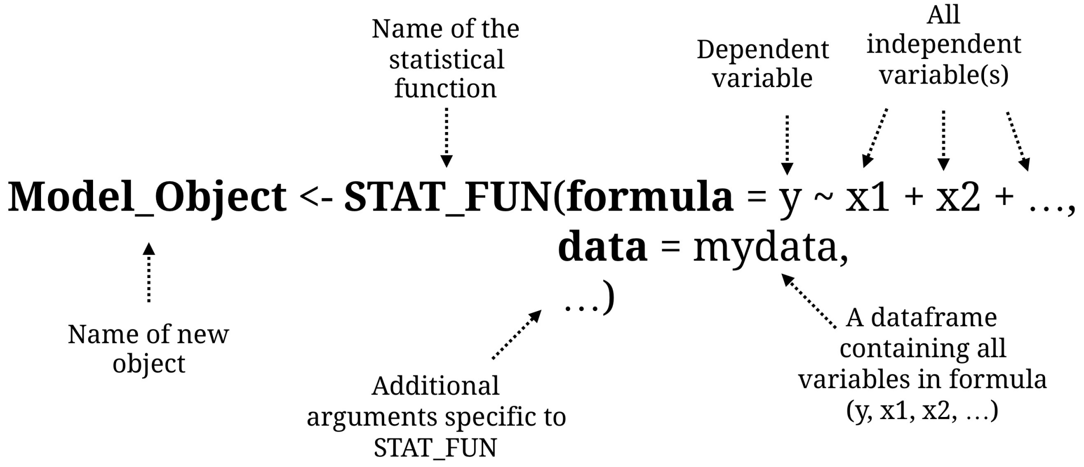
```
# Run a regression and store result in my_lm
my_lm <- lm(formula = income ~ age + height,
            data = baselers)
```



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 -

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

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4. Functions have (default) arguments
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6. Data lives in data frames
7. 4 types of data
8. `formula` and `data` specify a model
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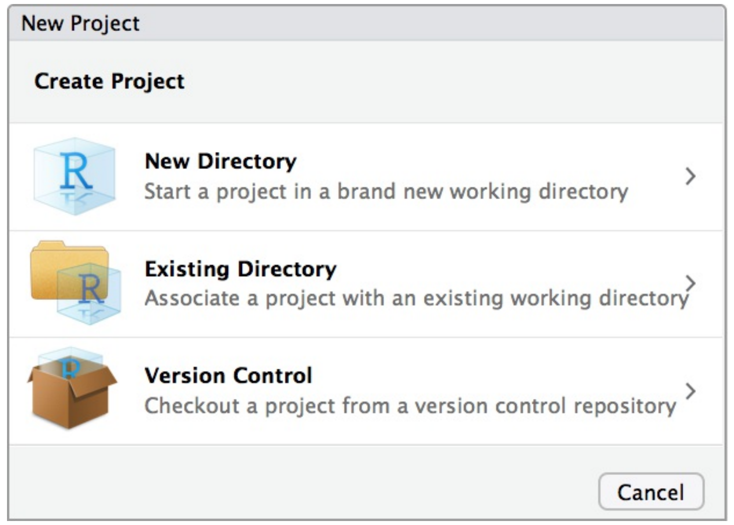
Projects help...

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

Cancel

Essentials: 10 basic R lessons

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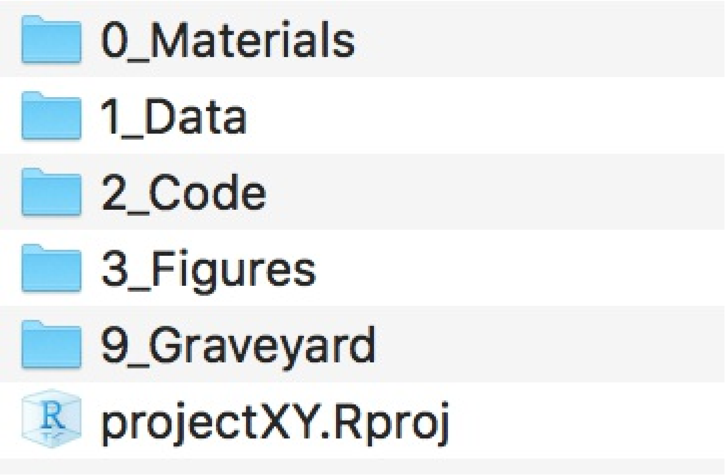
Folder structure

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



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

Essentials: 10 basic R lessons

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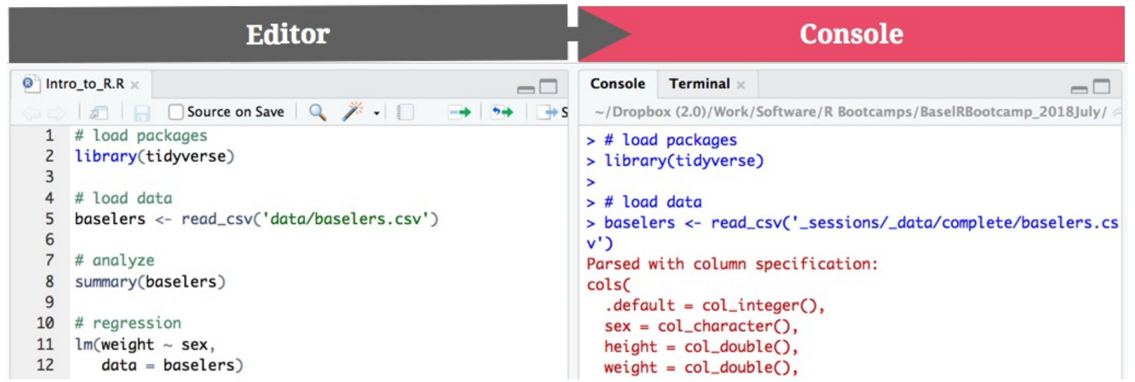

```
# load packages
library(tidyverse)

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

# analyze
summary(baselers)

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

```
~/Dropbox (2.0)/Work/Software/R Bootcamps/BaselRBootcamp_2018July/
> # 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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```r
# import packages
library(tidyverse)
library(yarrr)
library(lme4)

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

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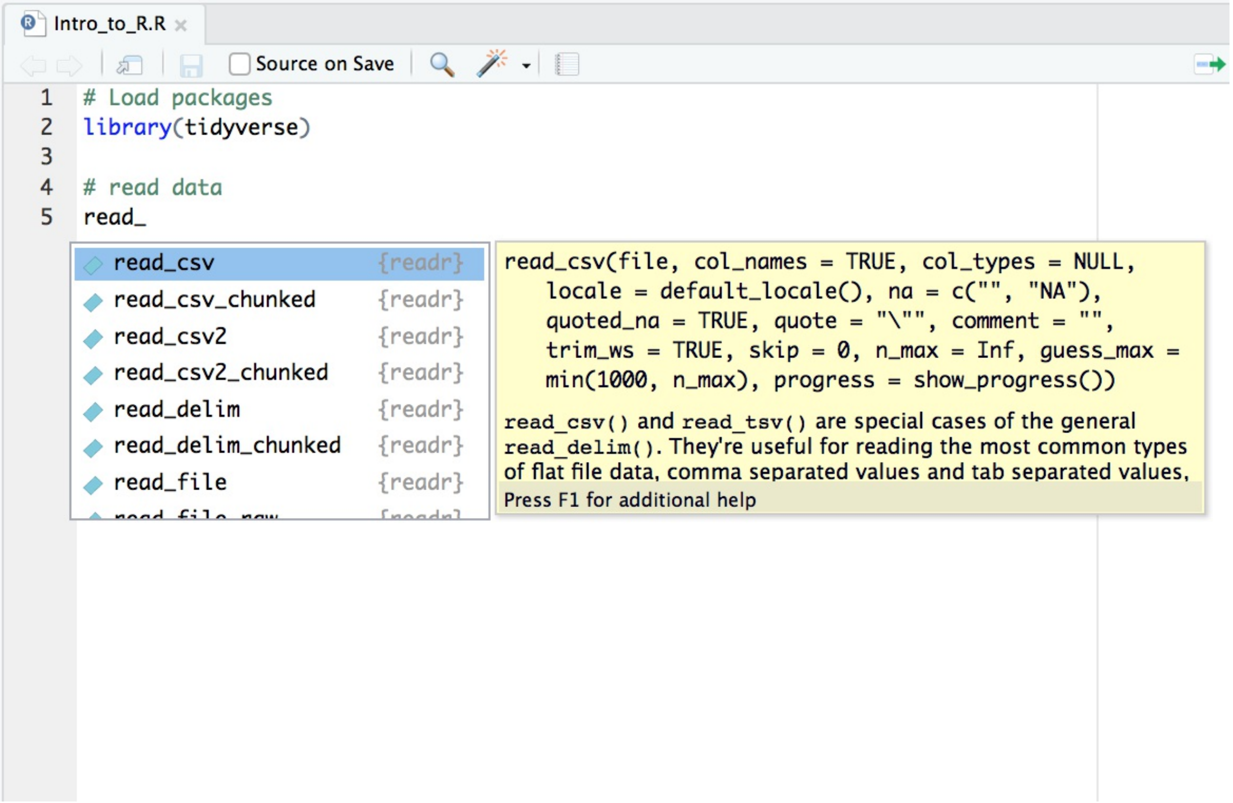

```
# Load packages
library(tidyverse)

# 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

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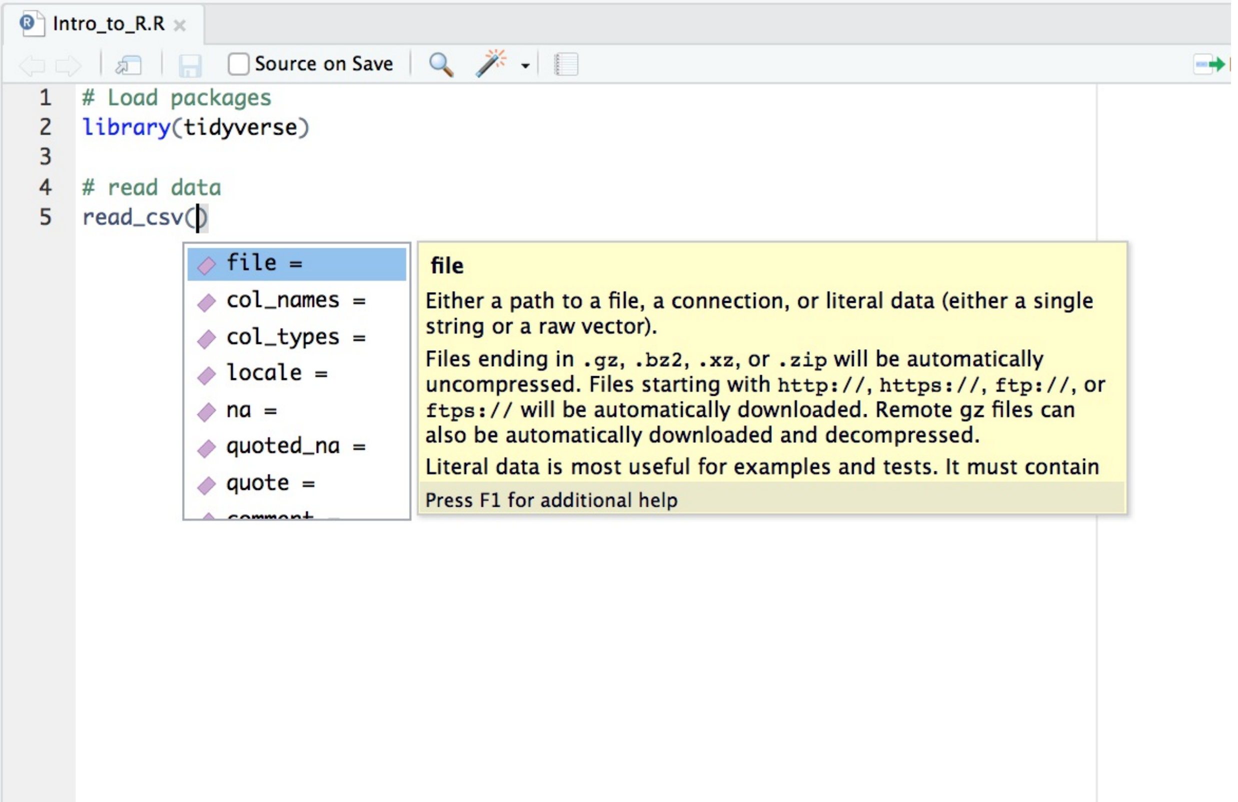

```
# Load packages
library(tidyverse)

# 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

Press F1 for additional help

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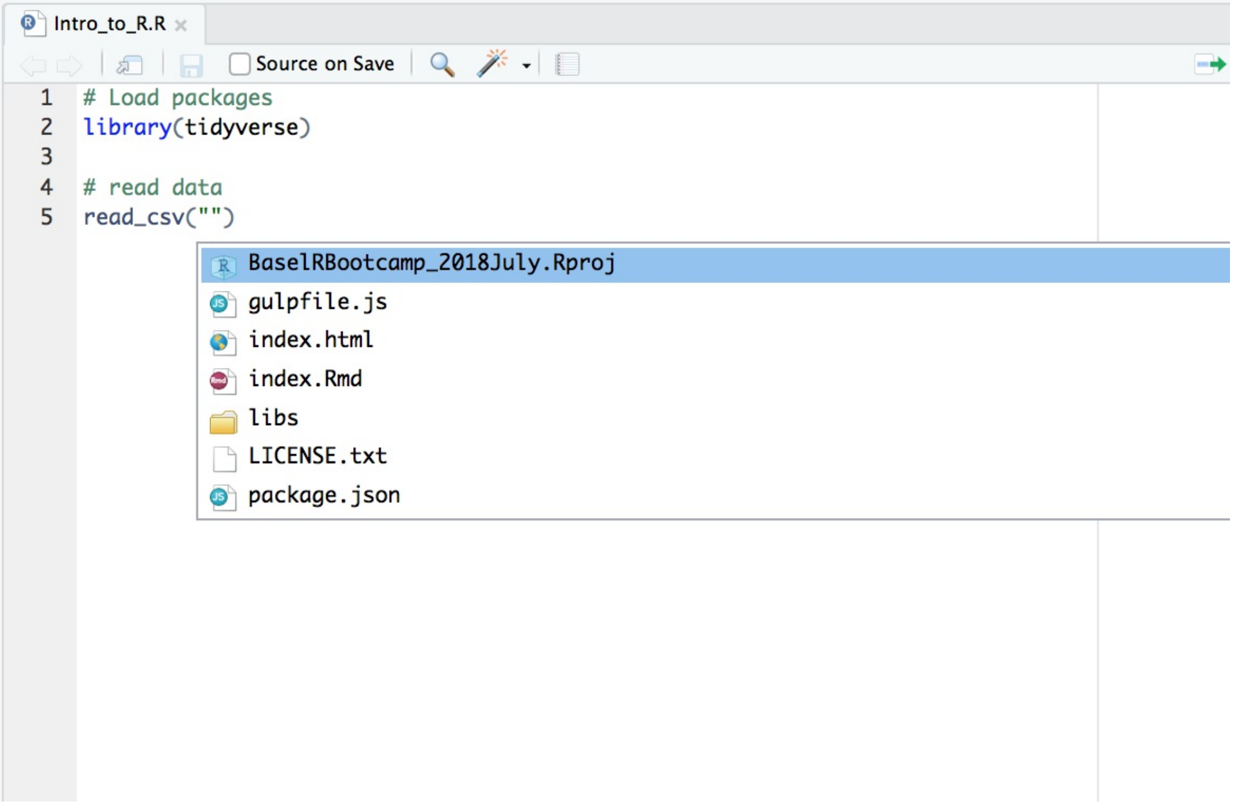

```
# Load packages
library(tidyverse)

# read data
read_csv("")
```

Download data sets

Interactive