Introduction to R & RStudio: Day 1

Tuesday, August 20, 2019

About Us

Kendra Smith – 5th Year

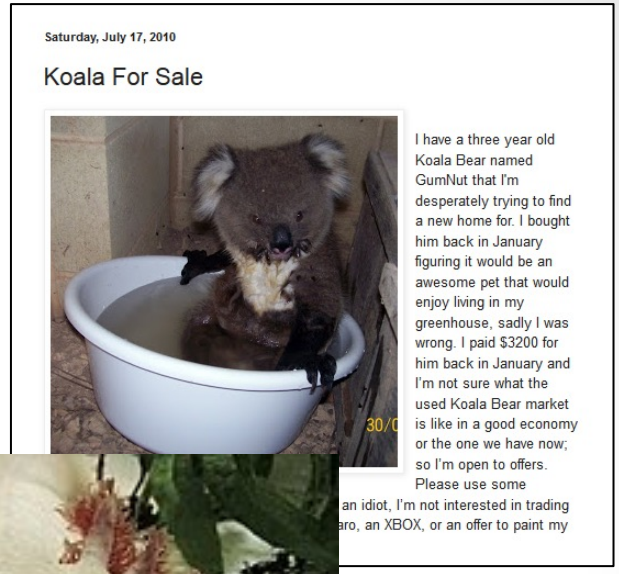
- Cognitive psychology
- GumNut

Emorie Beck – 4th Year

- Personality psychology
- Axolotl

Zoë Hawks – 5th Year

- Clinical psychology
- Okapi



This Workshop

2 sessions

- We will send out slides at the end of each class.
- You will have access to all code we write in class – don't worry if you don't get every single thing down.
- End of second session: bring data if you have research questions!

Post-its for exercises in RStudio

- **Blue** = write your name
- **Red** = I need help!
- **Green** = done with exercise

Why R?

FREE!

Open source

Learning R will help you learn other programming languages

- Example: MATLAB, Python, web programming

Flexible

- Can do anything you want it to do

(Did we mention it's free?)

What is R?

R is a programming language

- Statistics & graphing

RStudio is an environment that makes it easy to actually use R

Ask questions

Make mistakes!

When in doubt, Google

SETTING UP R & RSTUDIO

Installing R & RStudio

1. Install R first

   - **Mac users:**
     1) Go to: http://cran.wustl.edu/ → download R for (Mac) OS X
     2) Choose the correct version of R to install:
     - **R-latest.pkg** will likely be the case for most of you

   - **Windows users**:
     1) Go to: http://cran.wustl.edu/ → download R for Windows
     2) Click on the **base** folder --> click on **R-3.5.1-win.exe**

2. Then, install RStudio

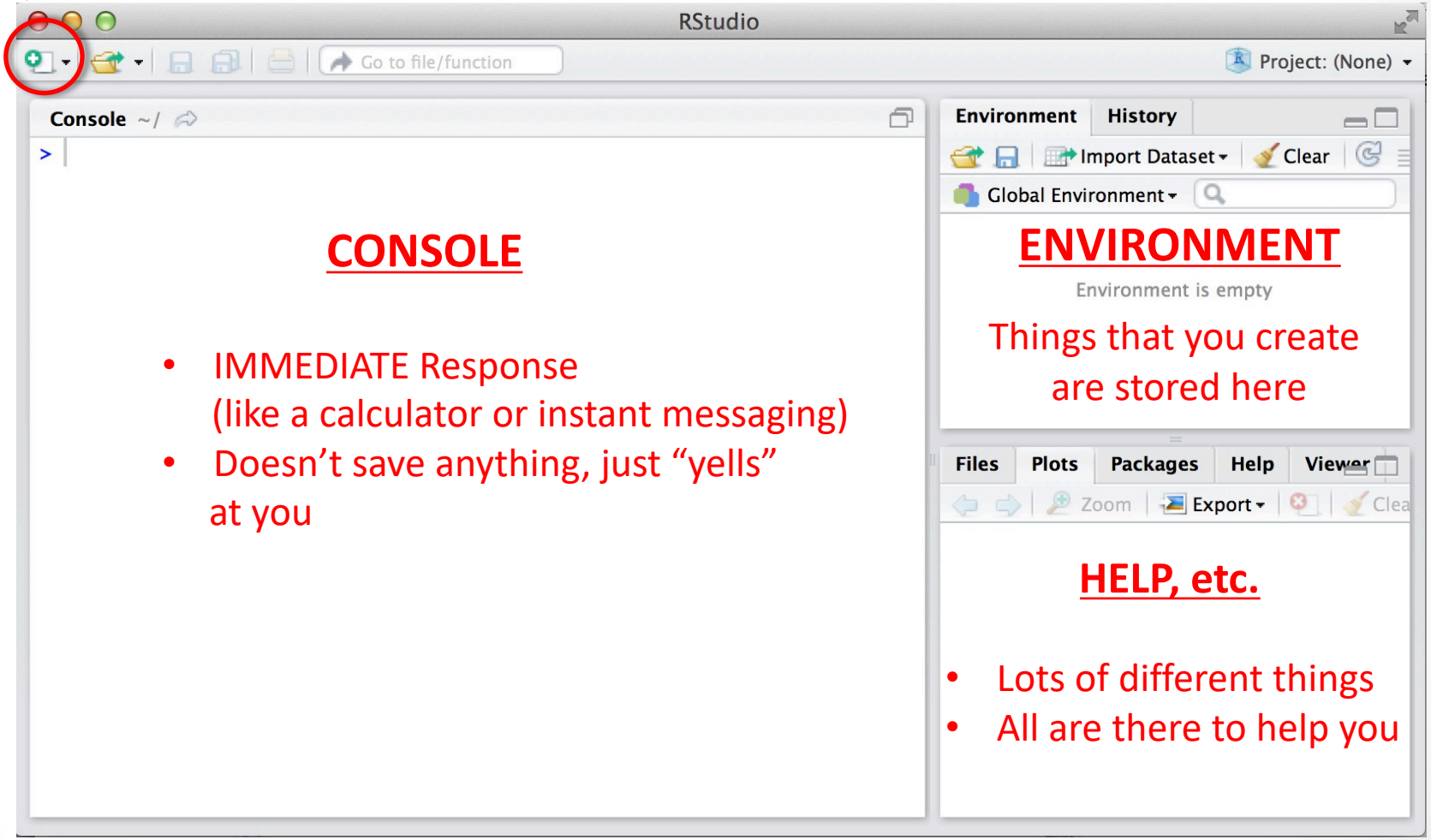
   1) Go to https://www.rstudio.com/products/rstudio/download/

   2) Scroll to the bottom, to **"Installers for Supported Platforms"**

   3) Click the first link to download the installer for Windows, OR click the second link to download the installer for Mac

R Script

Getting Oriented with RStudio



CONSOLE

- IMMEDIATE Response
  (like a calculator or instant messaging)
- Doesn't save anything, just "yells"
  at you

ENVIRONMENT

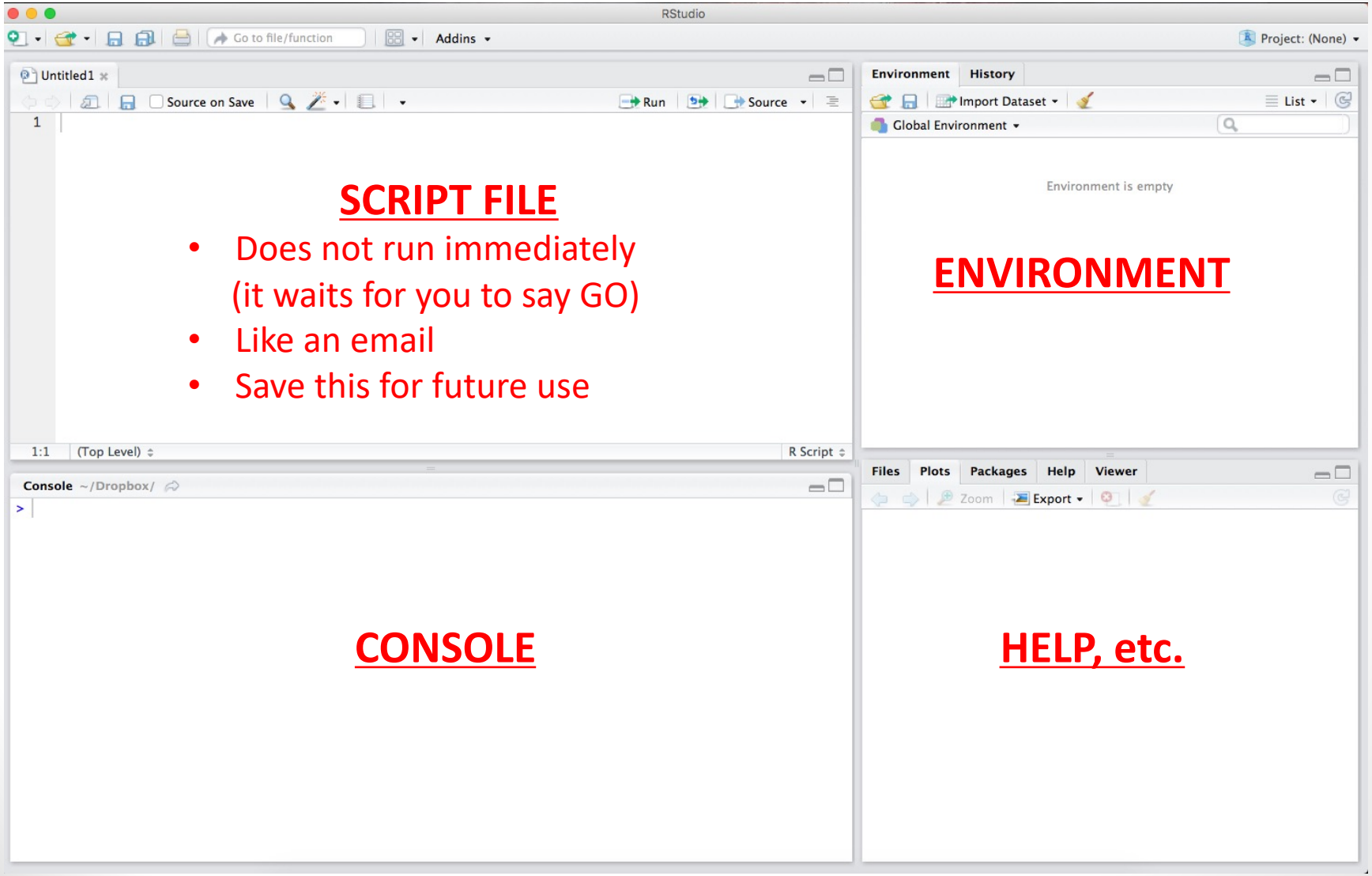
Environment is empty

Things that you create are stored here

HELP, etc.

- Lots of different things
- All are there to help you

Getting Oriented with RStudio



How to run code from your .R file

Highlight the lines that you want to run, then…

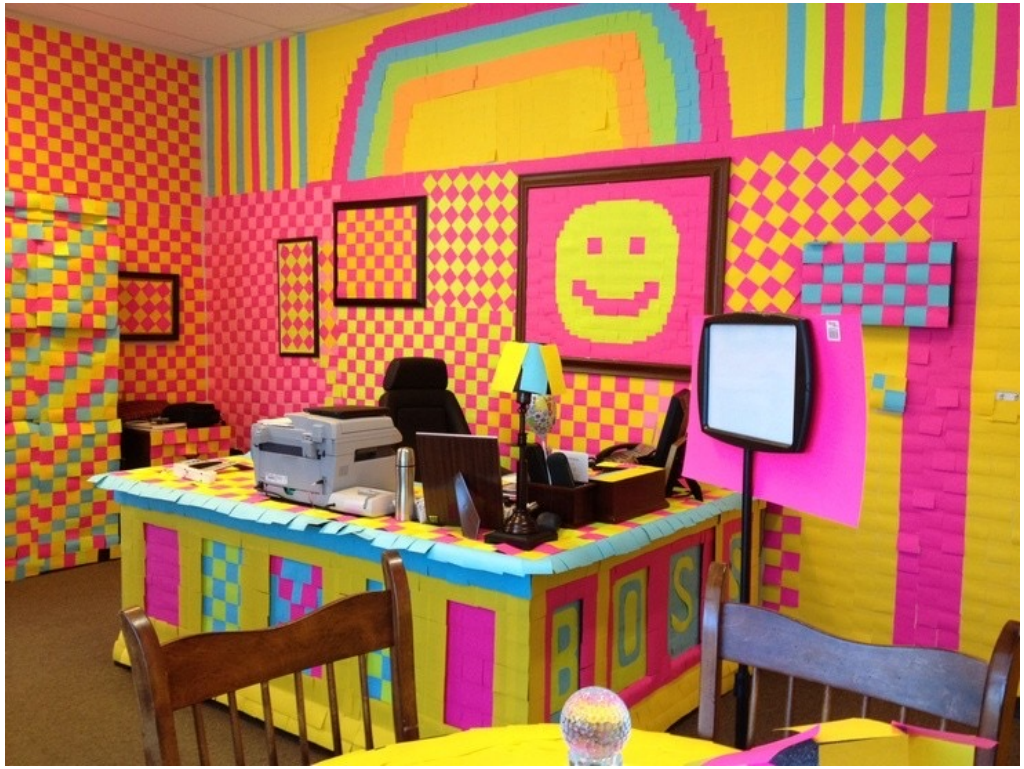
- Click on **Run** button

OR

- Ctrl + Enter (Windows)
- Command + Enter (Mac)

EXAMPLE 1 IN R

REMOVE POST-ITS!!



(and save!)

DATA FRAMES

How does R make sense of data?

- What “words” does R use?
- We are going to give you a vocabulary so that you can talk to R (and R can understand you)
- **To be clear, your experiment data is in a separate file that you will put into R**

Data Frames

- Used for storing variables of equal length.
- In Excel, you would call this a “spreadsheet”.
- Many researchers might simply call this “data”.

Data Frames

	name	height	mass	gender	homeworld	species
1	Luke Skywalker	172	77.0	male	Tatooine	Human
2	C-3PO	167	75.0	*NA*	Tatooine	Droid
3	R2-D2	96	32.0	*NA*	Naboo	Droid
4	Darth Vader	202	136.0	male	Tatooine	Human
5	Leia Organa	150	49.0	female	Alderaan	Human
6	Obi-Wan Kenobi	182	77.0	male	Stewjon	Human
7	Chewbacca	228	112.0	male	Kashyyyk	Wookiee
8	Han Solo	180	80.0	male	Corellia	Human
9	Yoda	66	17.0	male	*NA*	Yoda's species
10	Boba Fett	183	78.2	male	Kamino	Human

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Data Frames

The way to create a data.frame:

- `data.frame()`

Exercise

Create a data.frame named `workshop`.

- Variables:
  - `sub: "Subject##"`
  - `bip: T/F`
  - `cty: ##`
  - `pt: "dog" vs. "ant"`

OBJECTS

Object

- A basic concept in (statistical) programming is called an **object**.
- An object allows you to store a value or a thing in R.
- You use the object's name to easily access this value or thing.

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Object

```
pi
[1] 3.141593
```

Referencing objects

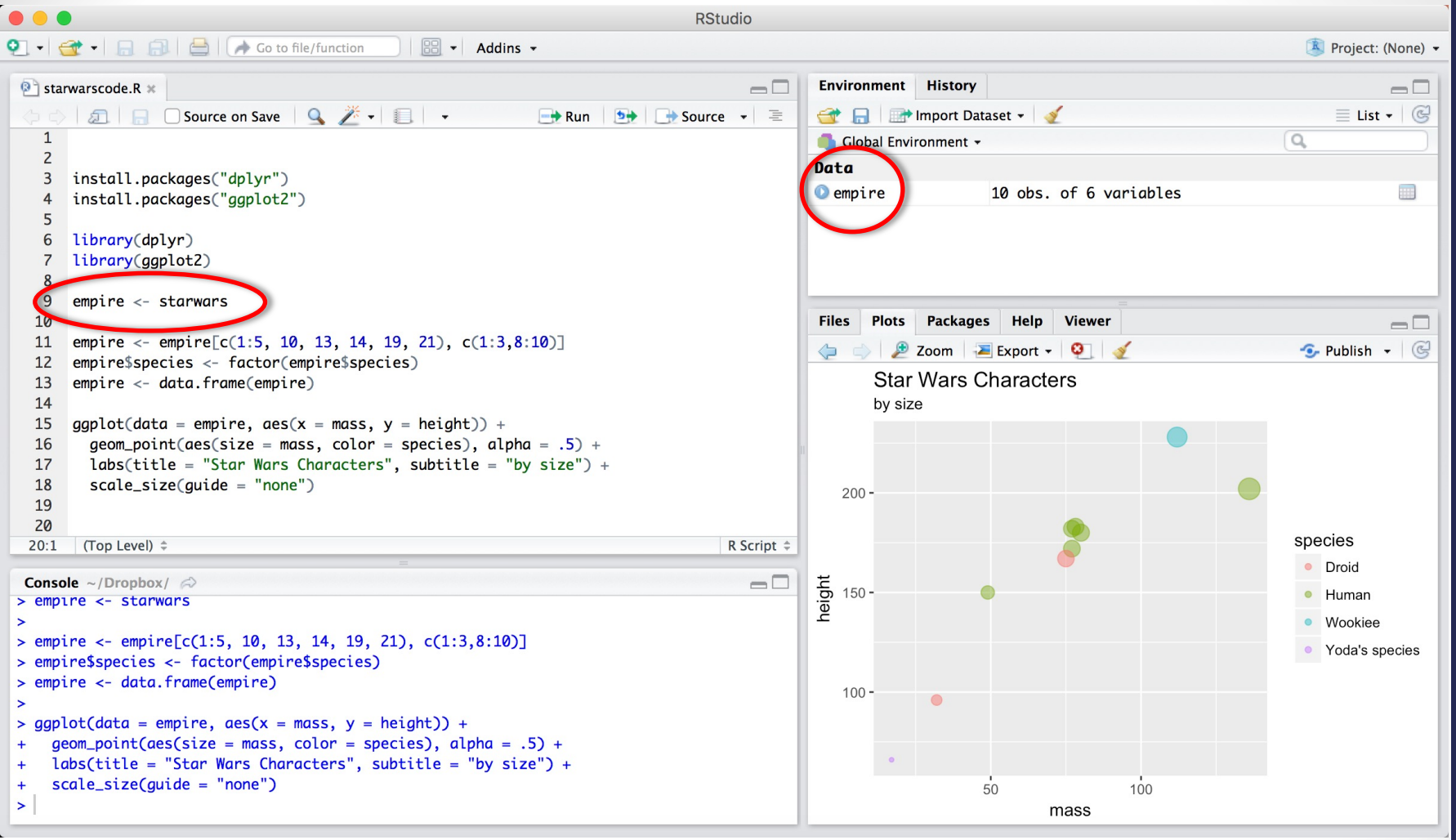
If you want to use an object later on, you have to name it.

```
my_object = thingtoassign
```

```
my_object <- thingtoassign
```

```
Ex) pi <- 3.141593
```

WE RECOMMEND USING THE SECOND WAY!

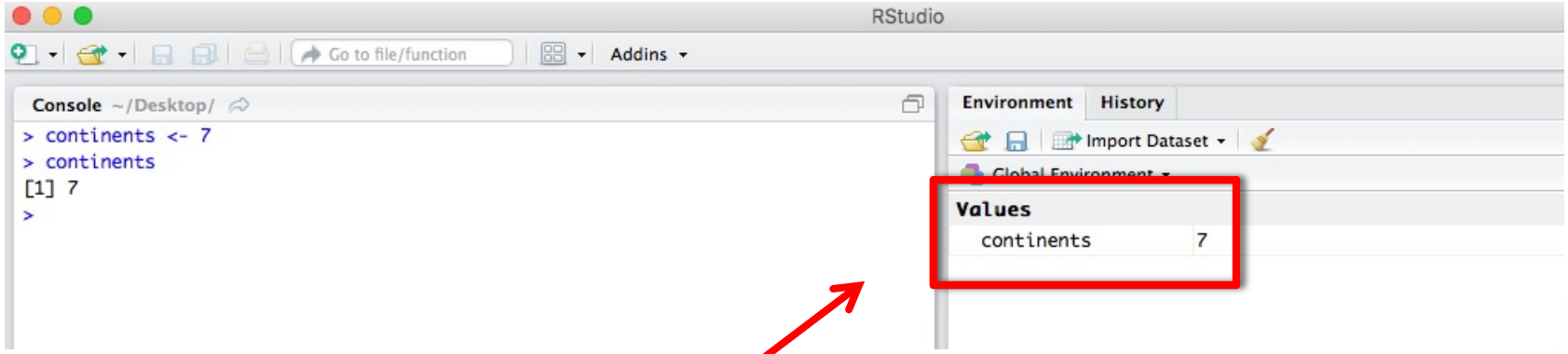


- **Objects** can be used later!
- You can see them in your **Global Environment.**

Exercise

Try creating your own object!

1. In the console, assign the number `7` to `continents`
2. Then type `continents` in the console to print out the assigned value



Look!
Your environment has stored your object!

BONUS: What is the difference between typing in the console or in a script file?

Exercise

Now, let's try adding together two objects.

In your **script**:

- Assign the value of `5` to an object called `chickens`.
- Assign the value of `4` to an object called `cows`.
- Give the command `chickens + cows` to find out how many animals you have!

  - ***BONUS: where is your answer stored?***

REMOVE POST-ITS!!

(and save!)

Basic Object Classes

Numeric: Decimals (3.141593)

Integer: Natural numbers (0, 1, 2…)

Character: Text or string characters

- Always inside quotations.
- **Factors** (or categories. TBC…)

Logical: Boolean values (True or False)

- No quotations.
- 2 possible values: **TRUE** or **FALSE**

Factors

Character objects

- Compare factors to categorical variables
- Character strings represent distinct groups.
  - Control, Treatment
  - Dog, Ant

Basic Data Class

To check what data class your object is, you can type `class()` into the console.

```
class(cty)
[1] "numeric"
```

Vectors

A group of objects is a **vector.**

Vectors are ONE-DIMENSIONAL.

Vectors

	name	height	mass	gender	homeworld	species
1	Luke Skywalker	172	77.0	male	Tatooine	Human
2	C-3PO	167	75.0	*NA*	Tatooine	Droid
3	R2-D2	96	32.0	*NA*	Naboo	Droid
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Vectors

	name	height	mass	gender	homeworld	species
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9	Yoda	66	17.0	male	*NA*	Yoda's species
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Indexing

Having a group of objects is great, but sometimes you only want one or a few of those objects.

How do we ACCESS our data?

Indexing a vector

To index a vector

- `[ ]`

For example, how many cities has the **3rd** person been to?

- `cty[3]`

Indexing

You can select multiple objects within a vector

To select objects that are sequential (in a row):

- `cty[3:5]`
- You can think of `:` as “through”
  - `[3:5]` = “three ***through*** five”

To select objects that are not in a row:

- `cty[c(1,2,5)]`

Indexing

You can go crazy and combine these!

- `cty[c(1:3, 5)]`

Indexing

Data frames can be indexed just like vectors

EXCEPT: data frames have **2** dimensions

- Rows and columns

Indexing data frames

`data.frame[rows, columns]`

`Ex: empire[1:6,5]`

```
> empire
                name height  mass gender homeworld          species
1  Luke Skywalker    172  77.0   male  Tatooine            Human
2           C-3PO    167  75.0   <NA>  Tatooine            Droid
3           R2-D2     96  32.0   <NA>     Naboo            Droid
4     Darth Vader    202 136.0   male  Tatooine            Human
5     Leia Organa    150  49.0 female  Alderaan            Human
6  Obi-Wan Kenobi    182  77.0   male   Stewjon            Human
7       Chewbacca    228 112.0   male  Kashyyyk          Wookiee
8        Han Solo    180  80.0   male  Corellia            Human
9            Yoda     66  17.0   male      <NA> Yoda's species
10      Boba Fett    183  78.2   male    Kamino            Human
```

Indexing data frames

```
empire[1:6,]
```

```
**If you want all of something, leave it blank.
```

```
Console ~/Dropbox/
> empire[1:6,]
             name height mass gender homeworld species
1 Luke Skywalker    172   77   male  Tatooine   Human
2          C-3PO    167   75   <NA>  Tatooine   Droid
3          R2-D2     96   32   <NA>     Naboo   Droid
4    Darth Vader    202  136   male  Tatooine   Human
5    Leia Organa    150   49 female  Alderaan   Human
6 Obi-Wan Kenobi    182   77   male   Stewjon   Human
```

Finding Your Data

Most of the time, your data are stored in a data.frame…

…BUT you're not doing something with the entire data.frame.

In a data.frame, our **columns** have names—we can use these names instead of memorizing what the column number is!

You can access just one column at a time by using $

Finding Your Data

$ means you are accessing just one column within your data frame

```
Console ~/Dropbox/
> empire
                name height  mass gender homeworld        species
1  Luke Skywalker    172  77.0   male  Tatooine          Human
2            C-3PO    167  75.0   <NA>  Tatooine          Droid
3            R2-D2     96  32.0   <NA>     Naboo          Droid
4      Darth Vader    202 136.0   male  Tatooine          Human
5      Leia Organa    150  49.0 female  Alderaan          Human
6  Obi-Wan Kenobi    182  77.0   male   Stewjon          Human
7        Chewbacca    228 112.0   male  Kashyyyk        Wookiee
8         Han Solo    180  80.0   male  Corellia          Human
9             Yoda     66  17.0   male      <NA> Yoda's species
10       Boba Fett    183  78.2   male    Kamino          Human
```

```
Console ~/Dropbox/
> empire$height
 [1] 172 167  96 202 150 182 228 180  66 183
```

BONUS: What's an alternative way we could access the entire "height" vector using only numbers?

A NOTE ON ACCESSING DATA

Sometimes (*like now!*), objects can exist in two places in your environment:

- **Values**
  - You'll see **PT** here, too!
- **Data**
  - Click on the arrow next to **workshop** → you'll see **personType**

Once your data has a "home", always use its "address". We refer to this as "calling" a variable from your data frame.

Ex) If I wanted to use my "dog vs. ant person" variable, I could type:

PT – like yelling KENDRA (loudly) in the middle of a busy street to try and get a hold of my friend. Any random person could walk up.

`workshop$personType` – like knocking on my friend Kendra's front door if I want to talk to her.

ACTING ON VARIABLES

Acting on variables

In the previous section, we talked about objects and data sets.

Now let’s do something with them!

Actions

- Operators
- Functions

Operators

An **operator** is a simple calculation.

Operators

+	addition
-	subtraction
*	multiplication
/	division
^	taking powers

Order of Operations

Important note: Order of operations matters!

```
(8-4)/2
[1] 2
```

```
8-(4/2)
[1] 6
```

PEMDAS, anyone?

Logical Operators

==	equality
!=	inequality
>	greater than
>=	greater than or equal to
<	less than
<=	less than or equal to

Logical Operators

- Return a value of **TRUE** or **FALSE**
- `workshop$personType == “ant”`

Example

- Test whether `cities` is greater than 2.

Logical Operators

Has anyone in our data.frame lived in more than 2 cities?

```
workshop$cities > 2
```

Has anyone in our data.frame lived in exactly 2 cities?

```
workshop$cities == 2
```

```
workshop$cities  = 2
```

→ WARNING: a SINGLE equals sign will change your data!

ACTING ON VARIABLES: FUNCTIONS

Functions

- Sometimes, you want to do more than add or multiply variables.

- To perform more complicated actions, use *functions.*
  - Functions are commands that describe, manipulate or analyze objects.

Functions have three parts

1. Function name
   - *Ex:* `log(10)`

     `[1] 2.302`
2. Arguments
   - *Ex:* `log(10)`

     `[1] 2.302`
3. Output
   - *Ex:* `log(10)`

     `[1] 2.302`

Each function has one and only one name.

Functions have three parts

1. Function name
   - *Ex:* `log(10)`
     `[1] 2.302`

2. Arguments
   - *Ex:* `log(10)`
     `[1] 2.302`

3. Output
   - *Ex:* `log(10)`
     `[1] 2.302`

One argument is always specified: the input. This is the object that the function acts on.

Other arguments control **how** the function acts. For example, do you want the natural log? Or log base 10?

Each function has defaults for its arguments. You should know what those are and how to change them.

Functions have three parts

1. Function name
   - *Ex:* `log(10)`
     `[1] 2.302`
2. Arguments
   - *Ex:* `log(10)`
     `[1] 2.302`
3. Output
   - *Ex:* `log(10)`
     `[1] 2.302`

Output can be a:
- number/integer
- a TRUE/FALSE statement
- a character value
- all of the above

Output can be a:
- single value
- vector
- data frame
- matrix
- list

You can store the output by assigning it to another object!

Mathematical functions

`sqrt()`	square root
`round()`	round a number
`log()`	logarithm
`exp()`	exponentiation
`abs()`	absolute value

Example

1. Find the `square root` of `85`.
2. Take the `log` of `100`.

Example

```
sqrt(85)
[1] 9.219544
log(100)
[1] 4.60517
```

Functions you'll use a lot!

`c()` – combine or concatenate

`class()` – check the class of an object

`factor()` – change a character vector into a factor vector (is there meaning? Ex: Treatment vs. Control, Male vs. Female, Session 1 vs. Session 2)

`table()` – really nice for getting quick counts (Ex: how many males and females are there?)

Exercise

Get the `mean()` of the everyone's # of `cities` visited in our `workshop` data.frame.

What is the name of the function?

What is the input argument?

What is the output?

Multiple arguments

Most functions take more than one argument.

Separate arguments with commas.

```
round (x = 5.86921, digits = 3)
[1] 5.869
```

Number that needs to be rounded.

Multiple arguments

Most functions take more than one argument.

Separate arguments with commas.

```
round (x = 5.86921, digits = 3)
[1] 5.869
```

Number of digits to round to.

Arguments have Names

Most arguments in functions have names.

USE THE NAMES!!!

```
round (x = 5.86921, digits = 3)
[1] 5.869
```

Exercise

1. Use the `seq()` function to list numbers `0` to `100`.

   Arguments:

   - `from` = starting value of sequence
   - `to` = end value of sequence

2. Use the `seq()` function to list numbers `0` to `100`, by intervals of `10`.

   Arguments:

   - `from` = starting value of sequence
   - `to` = end value of sequence
   - `by` = increment of the sequence

Exercise

1. Use the `seq()` function to list numbers `0` to `100`

   - `seq(from = 0, to = 100)`

2. Use the `seq()` function to list numbers `0` to `100`, by intervals of `10`

   - `seq(from = 0, to = 100, by = 10)`

RStudio

starwarscode.R

```
1
2
3  install.packages("dplyr")
4  install.packages("ggplot2")
5
6  library(dplyr)
7  library(ggplot2)
8
9  empire <- starwars
10
11 empire <- empire[c(1:5, 10, 13, 14, 19, 21), c(1:3,8:10)]
12 empire$species <- factor(empire$species)
13 empire <- data.frame(empire)
14
15 ggplot(data = empire, aes(x = mass, y = height)) +
16   geom_point(aes(size = mass, color = species), alpha = .5) +
17   labs(title = "Star Wars Characters", subtitle = "by size") +
18   scale_size(guide = "none")
19
20
```

20:1 (Top Level) R Script

Console ~/Dropbox/

```
> empire <- starwars
>
> empire <- empire[c(1:5, 10, 13, 14, 19, 21), c(1:3,8:10)]
> empire$species <- factor(empire$species)
> empire <- data.frame(empire)
>
> ggplot(data = empire, aes(x = mass, y = height)) +
+   geom_point(aes(size = mass, color = species), alpha = .5) +
+   labs(title = "Star Wars Characters", subtitle = "by size") +
+   scale_size(guide = "none")
>
```

Environment History

Import Dataset List

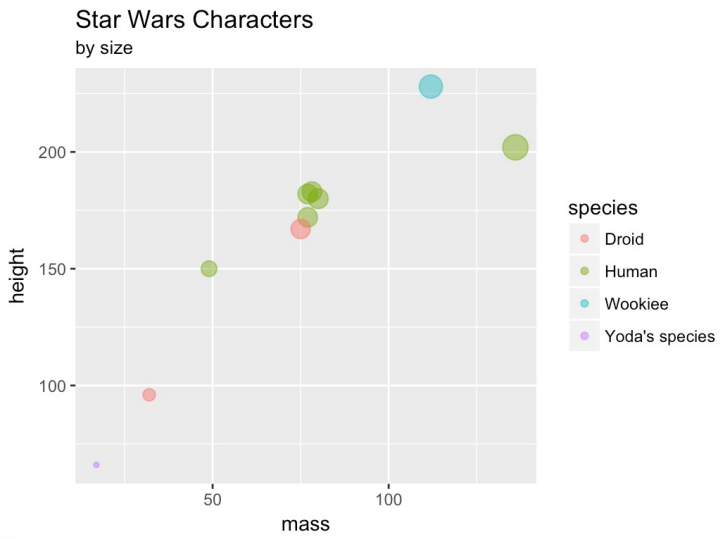
Global Environment

Data

empire	10 obs. of 6 variables

Files Plots Packages Help Viewer

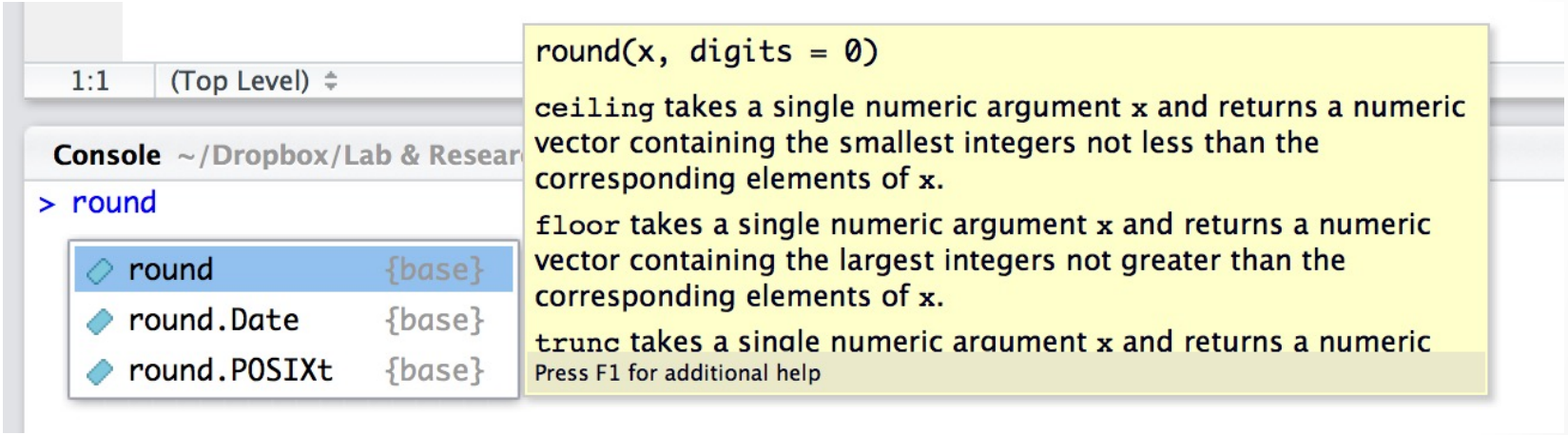
Zoom Export Publish



Great, but how do I know what the arguments are for a function?

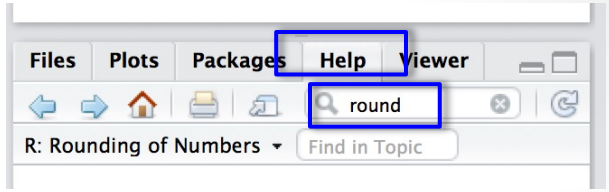
Two ways:

1) In RStudio, press the **tab** key to see names of arguments and descriptions.

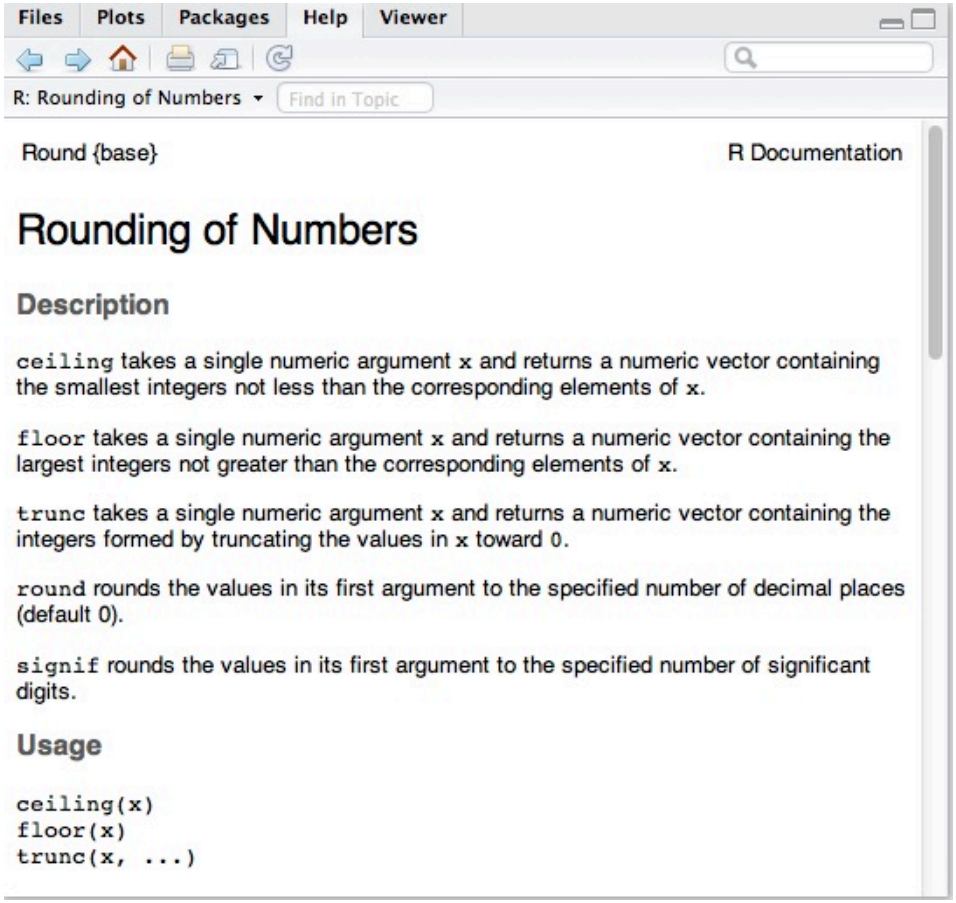


2) Look in the R documentation!

- Go to Help tab



- Or just type `?round` into the console



You try!

Type code to look up the R documentation for the correlation function, `cor`

```
?cor
```

R: Correlation, Variance and Covariance (Matrices)

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.

Details

For `cov` and `cor` one must *either* give a matrix or data frame for `x` *or* give both `x` and `y`.

The inputs must be numeric (as determined by `is.numeric`: logical values are also allowed for historical compatibility): the `"kendall"` and `"spearman"` methods make sense for ordered inputs but `xtfrm` can be used to find a suitable prior transformation to numbers.

`var` is just another interface to `cov`, where `na.rm` is used to determine the default for `use` when that is unspecified. If `na.rm` is `TRUE` then the complete observations (rows) are used (`use = "na.or.complete"`) to compute the variance. Otherwise, by default `use = "everything"`.

If `use` is `"everything"`, `NA`s will propagate conceptually, i.e., a resulting value will be `NA` whenever one of its contributing observations is `NA`.

cor {stats}

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?
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`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.

Details

For `cov` and `cor` one must *either* give a matrix or data frame for `x` *or* give both `x` and `y`.

The inputs must be numeric (as determined by `is.numeric`: logical values are also allowed for historical compatibility): the `"kendall"` and `"spearman"` methods make sense for ordered inputs but `xtfrm` can be used to find a suitable prior transformation to numbers.

Value

For `r <- cor(*, use = "all.obs")`, it is now guaranteed that `all(r <= 1)`.

Examples

```
var(1:10)  # 9.166667

var(1:5, 1:5) # 2.5

## Two simple vectors
cor(1:10, 2:11) # == 1

## Correlation Matrix of Multivariate sample:
(Cl <- cor(longley))
## Graphical Correlation Matrix:
symnum(Cl) # highly correlated
```

Exercise

1. Look up documentation for `scale` and `plot`.
2. Using the `height` variable from our `empire` data.frame, make a new variable called `height_z`, using `scale.`
3. Do the same thing for `mass.`
4. Combine `height_z` vector and `mass_z` vector into a new data.frame called `empire_z`.
5. Make a scatter plot of standardized height (*hint: y-axis*) by standardized mass, using the `plot` function.
6. Add a title to your plot.
7. Add labels to the x and y axes.

What happens if you add `type = "l"` ?

What is the default for type?

REMOVE POST-ITS!!

(and save!)

PACKAGES

Packages

R automatically loads some basic functions

- Generally useful!
- But sometimes, maybe you want something better.

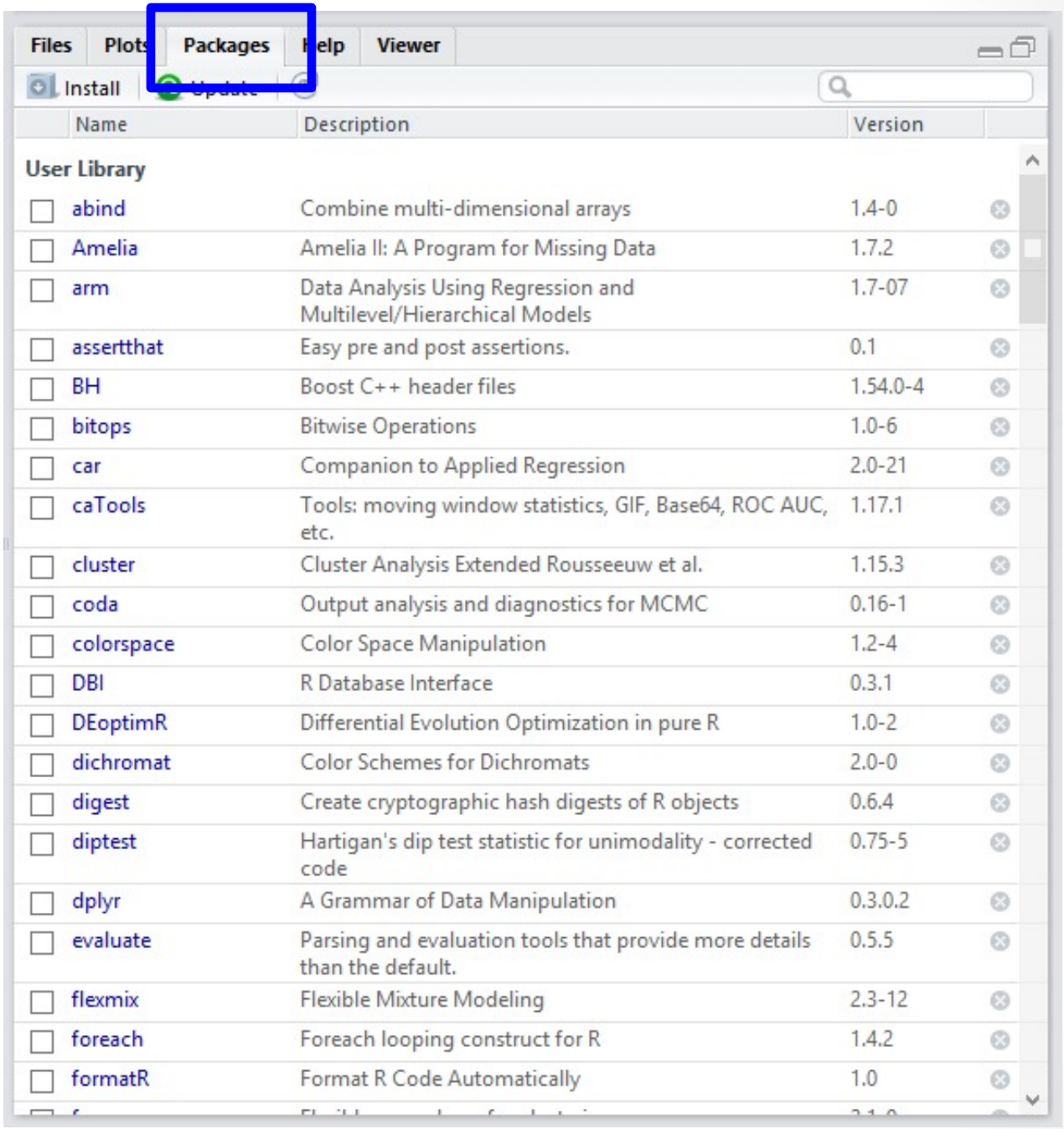
Packages

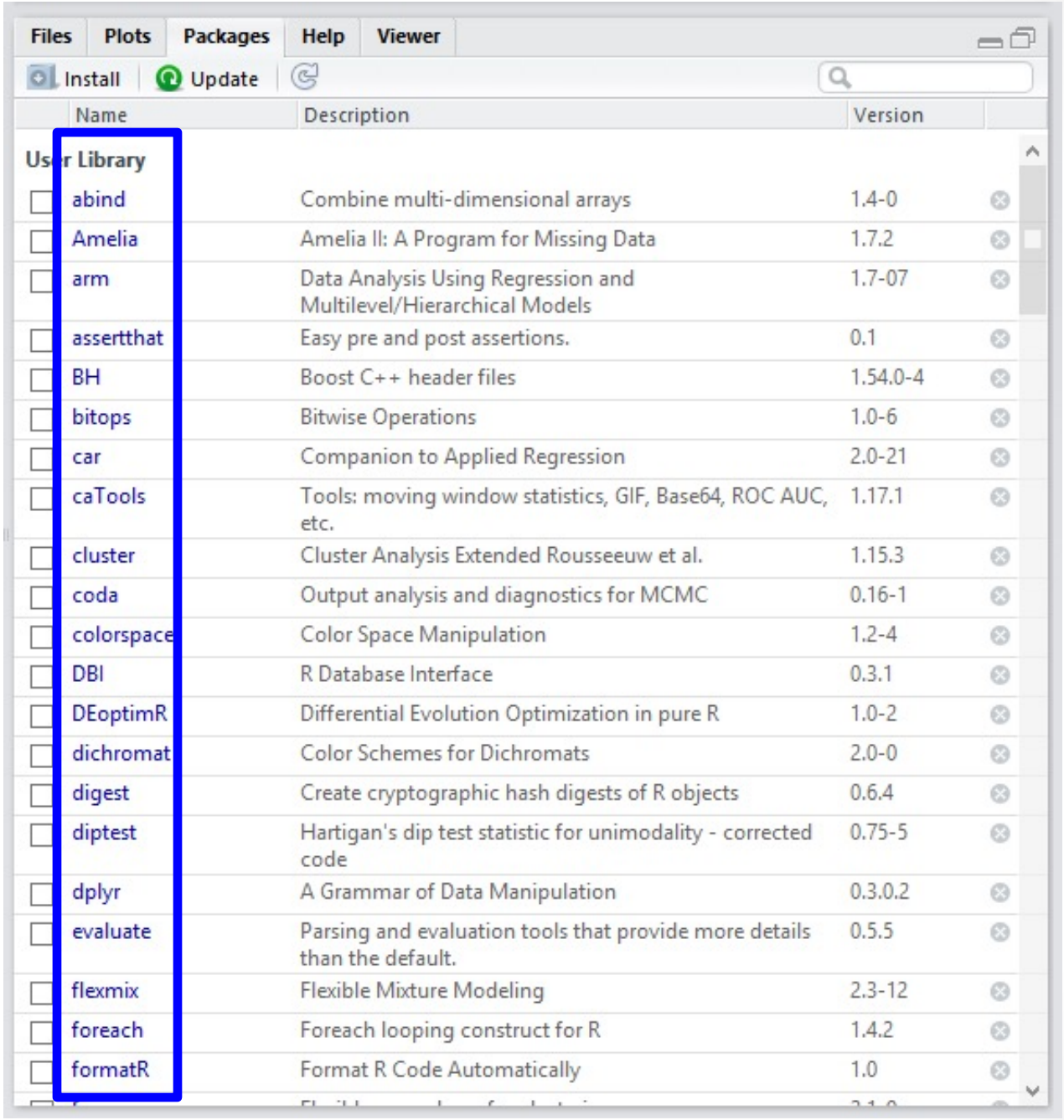
What is a package?

- A collection of functions and datasets.
- Open source (free!)

Packages are the reason R is so powerful.

- And why it will never be out-of-date.


Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
evaluate
Parsing and evaluation tools that provide more details than the default.
0.5.5
flexmix
Flexible Mixture Modeling
2.3-12
foreach
Foreach looping construct for R
1.4.2
formatR
Format R Code Automatically
1.0


Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
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Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
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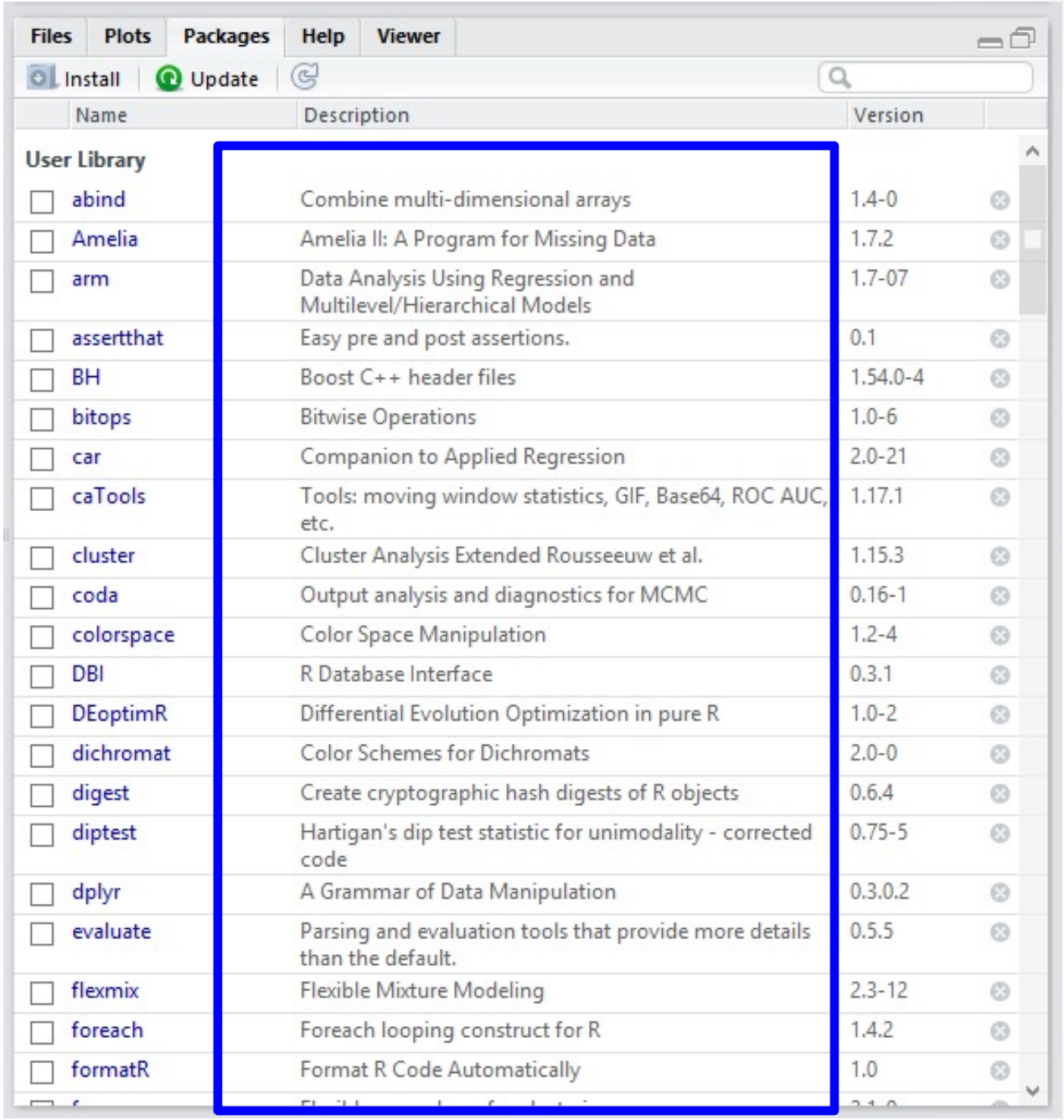
Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
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A Grammar of Data Manipulation
0.3.0.2
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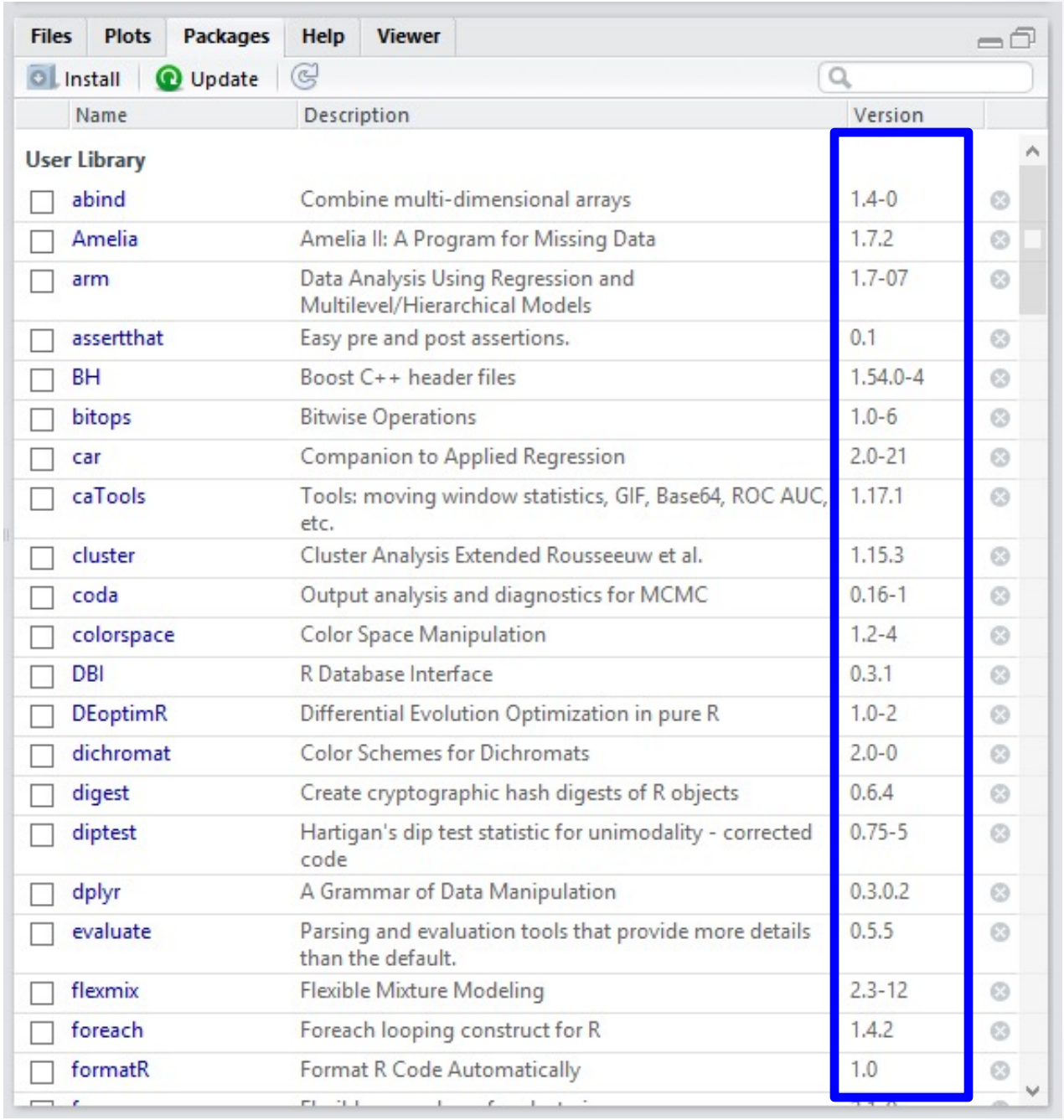
Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
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Color Schemes for Dichromats
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digest
Create cryptographic hash digests of R objects
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Hartigan's dip test statistic for unimodality - corrected code
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dplyr
A Grammar of Data Manipulation
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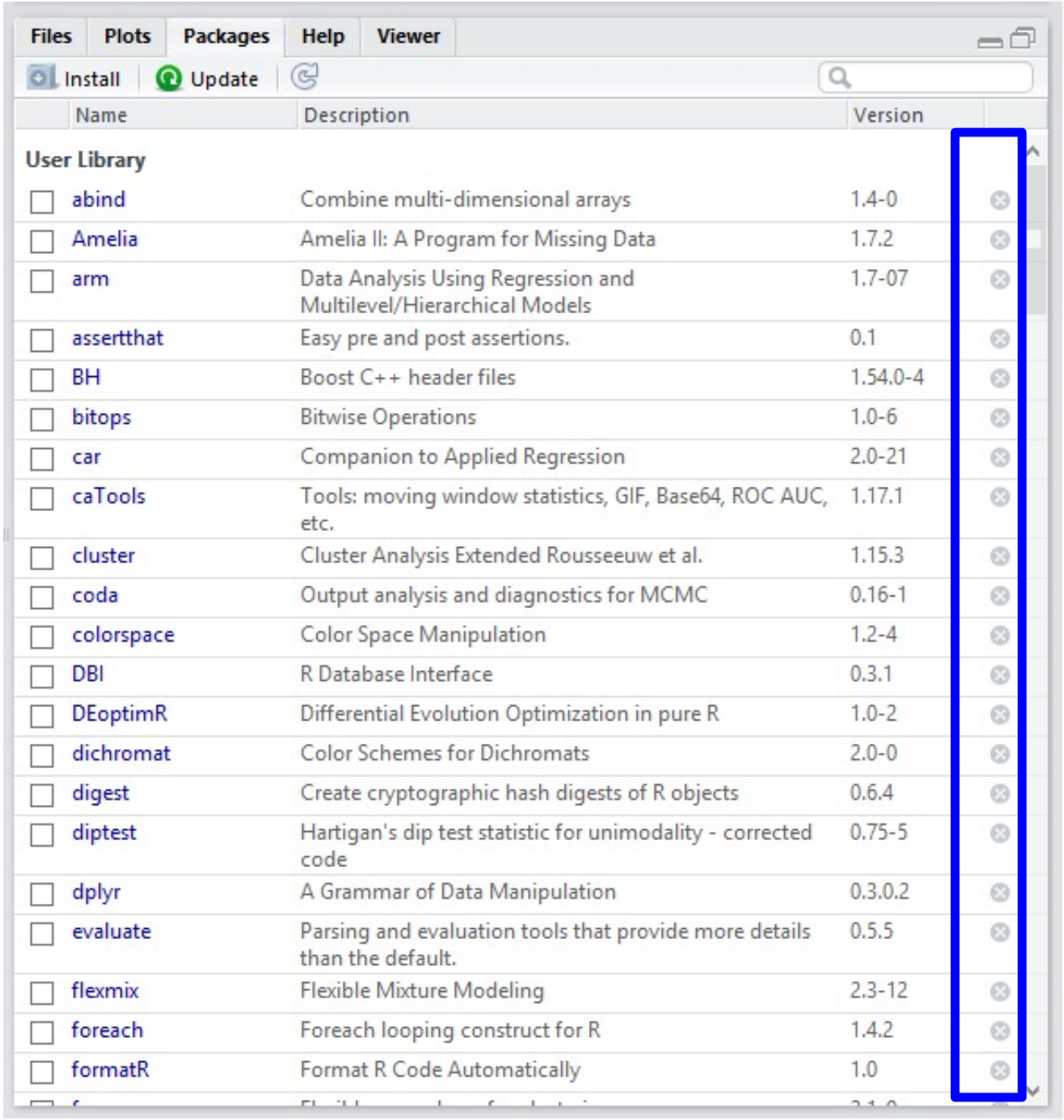
Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
evaluate
Parsing and evaluation tools that provide more details than the default.
0.5.5
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Flexible Mixture Modeling
2.3-12
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formatR
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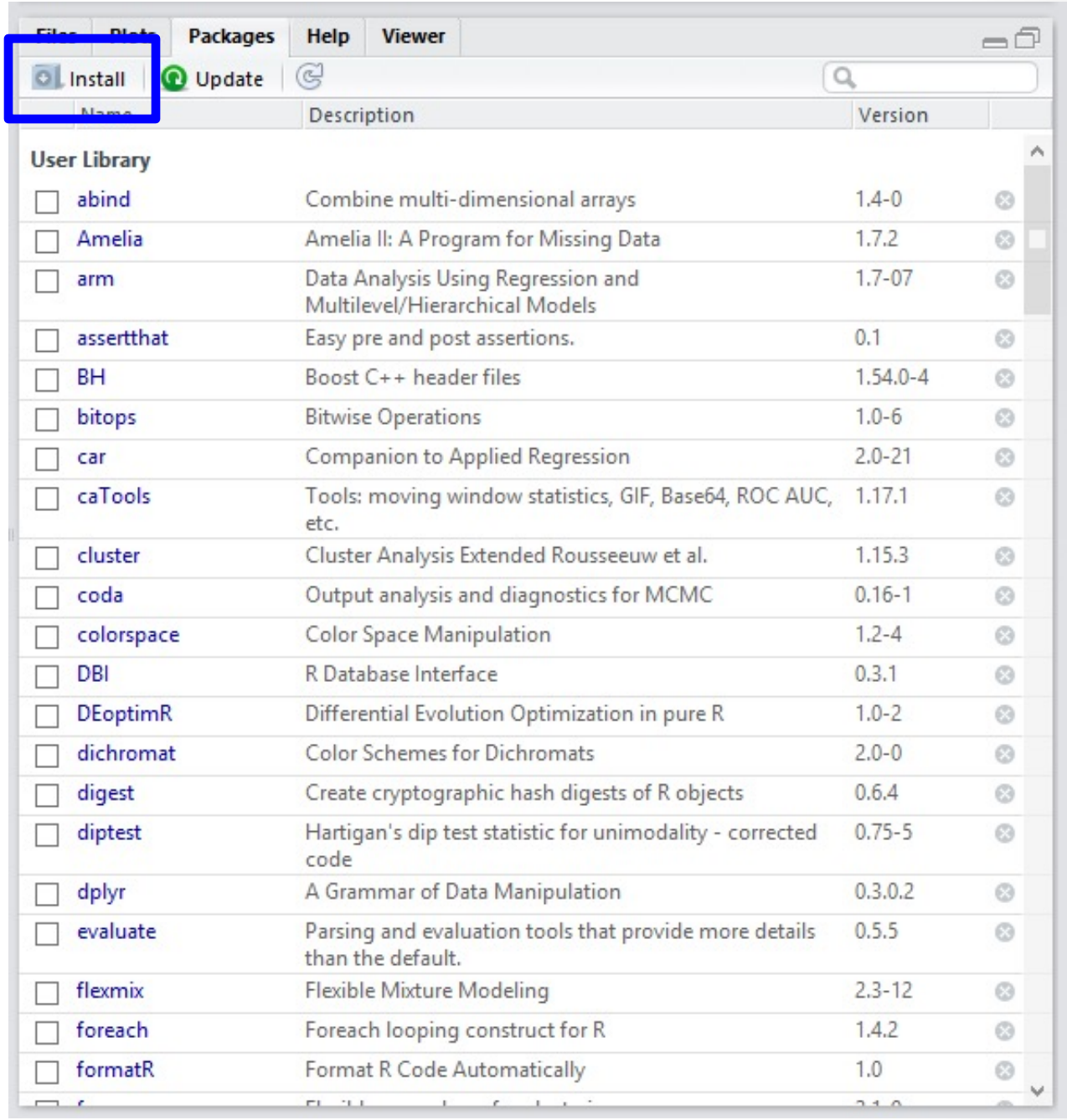
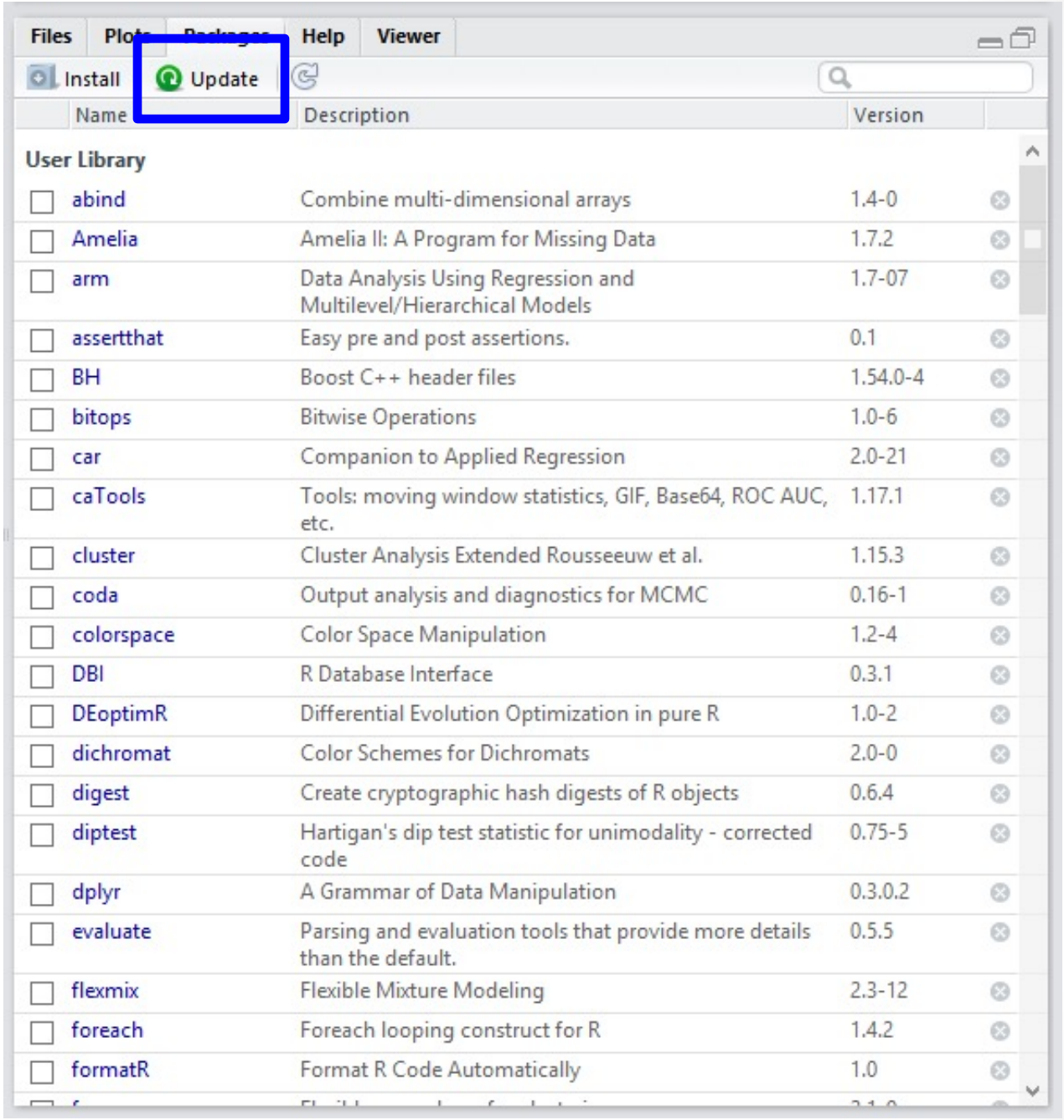

Packages
Help
Viewer
Install
Update
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
evaluate
Parsing and evaluation tools that provide more details than the default.
0.5.5
flexmix
Flexible Mixture Modeling
2.3-12
foreach
Foreach looping construct for R
1.4.2
formatR
Format R Code Automatically
1.0


Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
evaluate
Parsing and evaluation tools that provide more details than the default.
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2.3-12
foreach
Foreach looping construct for R
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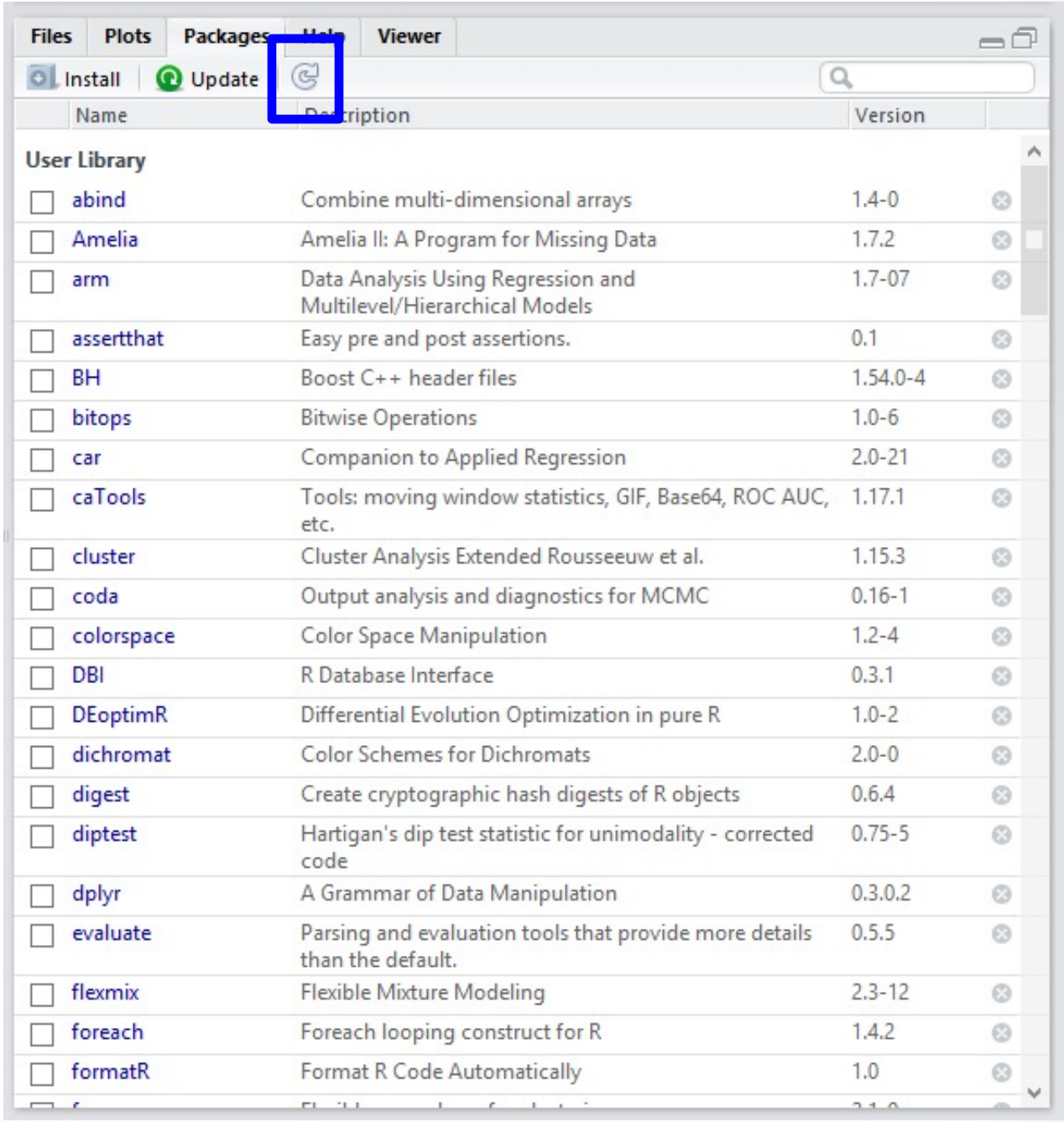
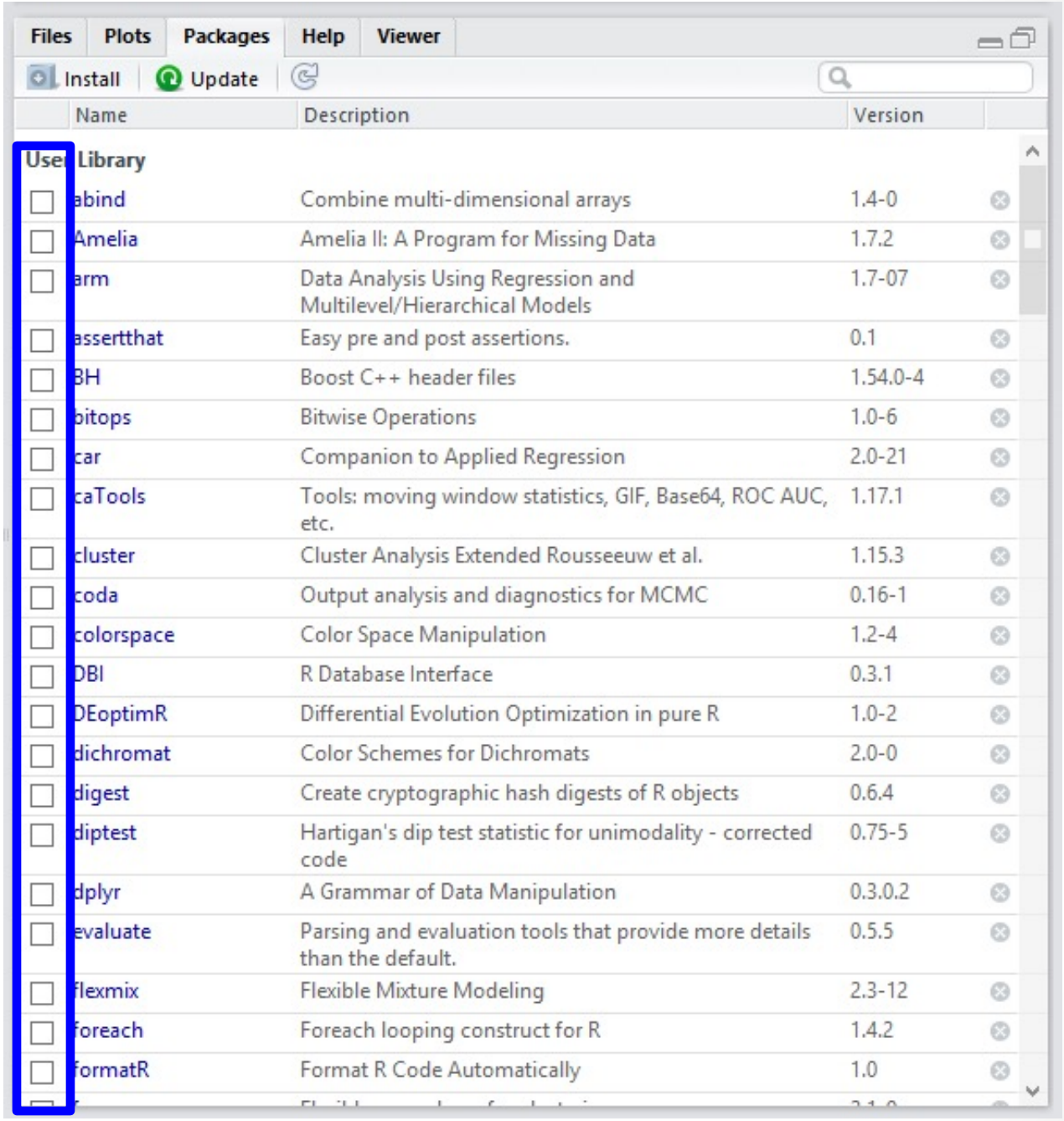

Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
evaluate
Parsing and evaluation tools that provide more details than the default.
0.5.5
flexmix
Flexible Mixture Modeling
2.3-12
foreach
Foreach looping construct for R
1.4.2
formatR
Format R Code Automatically
1.0


Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
User Library
abind
Combine multi-dimensional arrays
1.4-0
Amelia
Amelia II: A Program for Missing Data
1.7.2
arm
Data Analysis Using Regression and Multilevel/Hierarchical Models
1.7-07
assertthat
Easy pre and post assertions.
0.1
BH
Boost C++ header files
1.54.0-4
bitops
Bitwise Operations
1.0-6
car
Companion to Applied Regression
2.0-21
caTools
Tools: moving window statistics, GIF, Base64, ROC AUC, etc.
1.17.1
cluster
Cluster Analysis Extended Rousseeuw et al.
1.15.3
coda
Output analysis and diagnostics for MCMC
0.16-1
colorspace
Color Space Manipulation
1.2-4
DBI
R Database Interface
0.3.1
DEoptimR
Differential Evolution Optimization in pure R
1.0-2
dichromat
Color Schemes for Dichromats
2.0-0
digest
Create cryptographic hash digests of R objects
0.6.4
diptest
Hartigan's dip test statistic for unimodality - corrected code
0.75-5
dplyr
A Grammar of Data Manipulation
0.3.0.2
evaluate
Parsing and evaluation tools that provide more details than the default.
0.5.5
flexmix
Flexible Mixture Modeling
2.3-12
foreach
Foreach looping construct for R
1.4.2
formatR
Format R Code Automatically
1.0

How do I get packages?

Packages can be downloaded from the CRAN (**C**omprehensive **R** **A**rchive **N**etwork).

You do this from inside R!

- Need to be connected to the internet

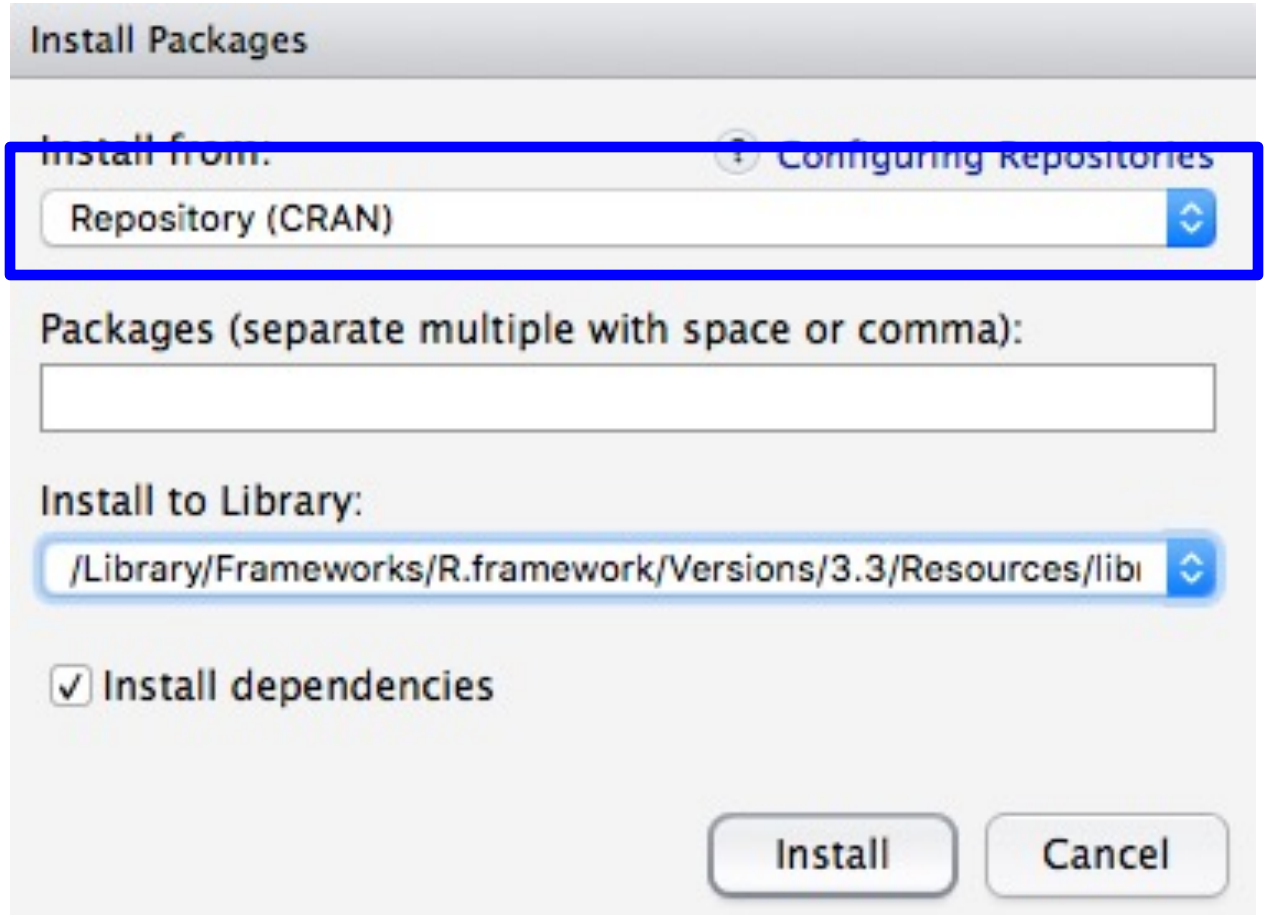
2 ways to install packages

1) Install button in the Packages window

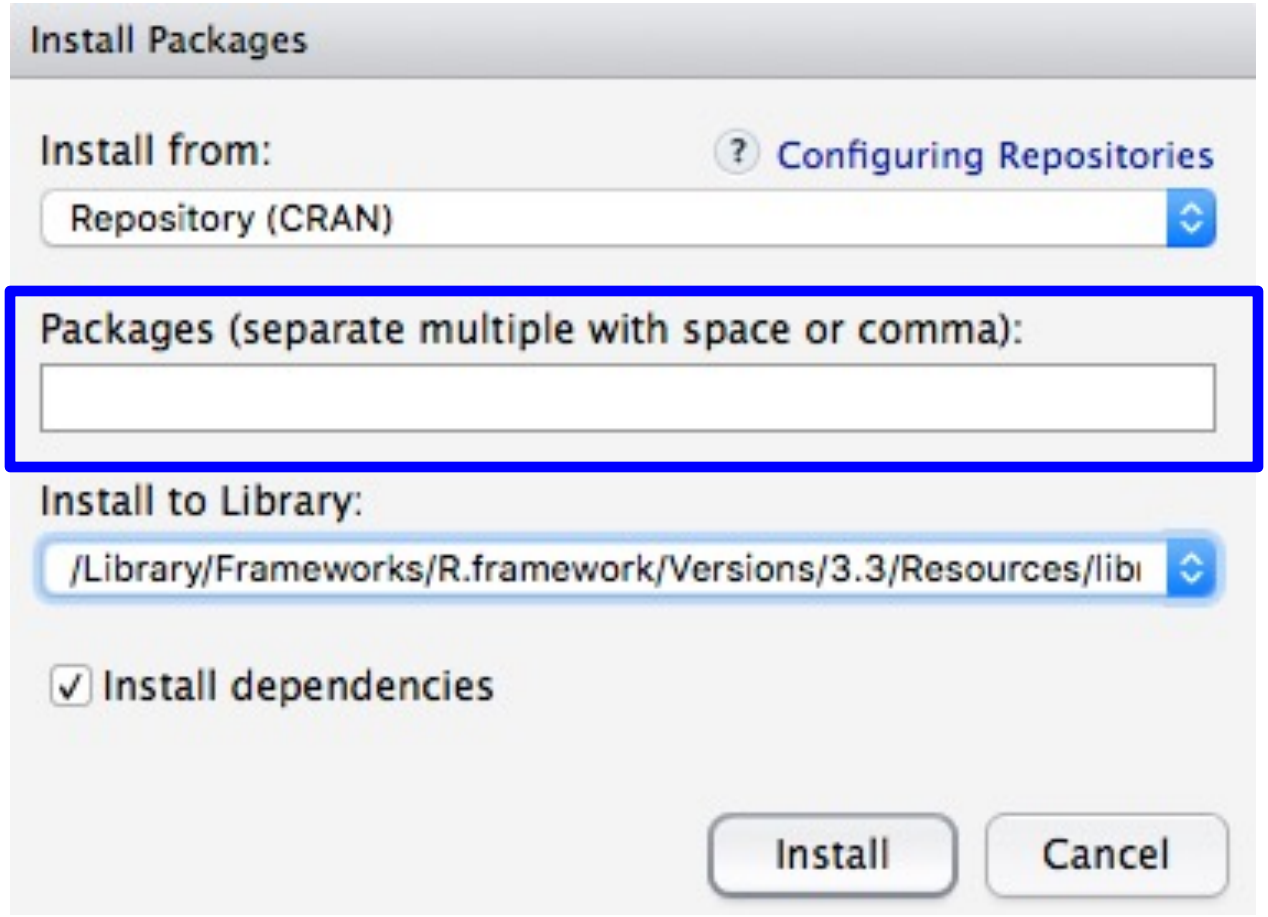
2) R Code

Either way, you'll need to know the name of the package.

Install Button



Install Button



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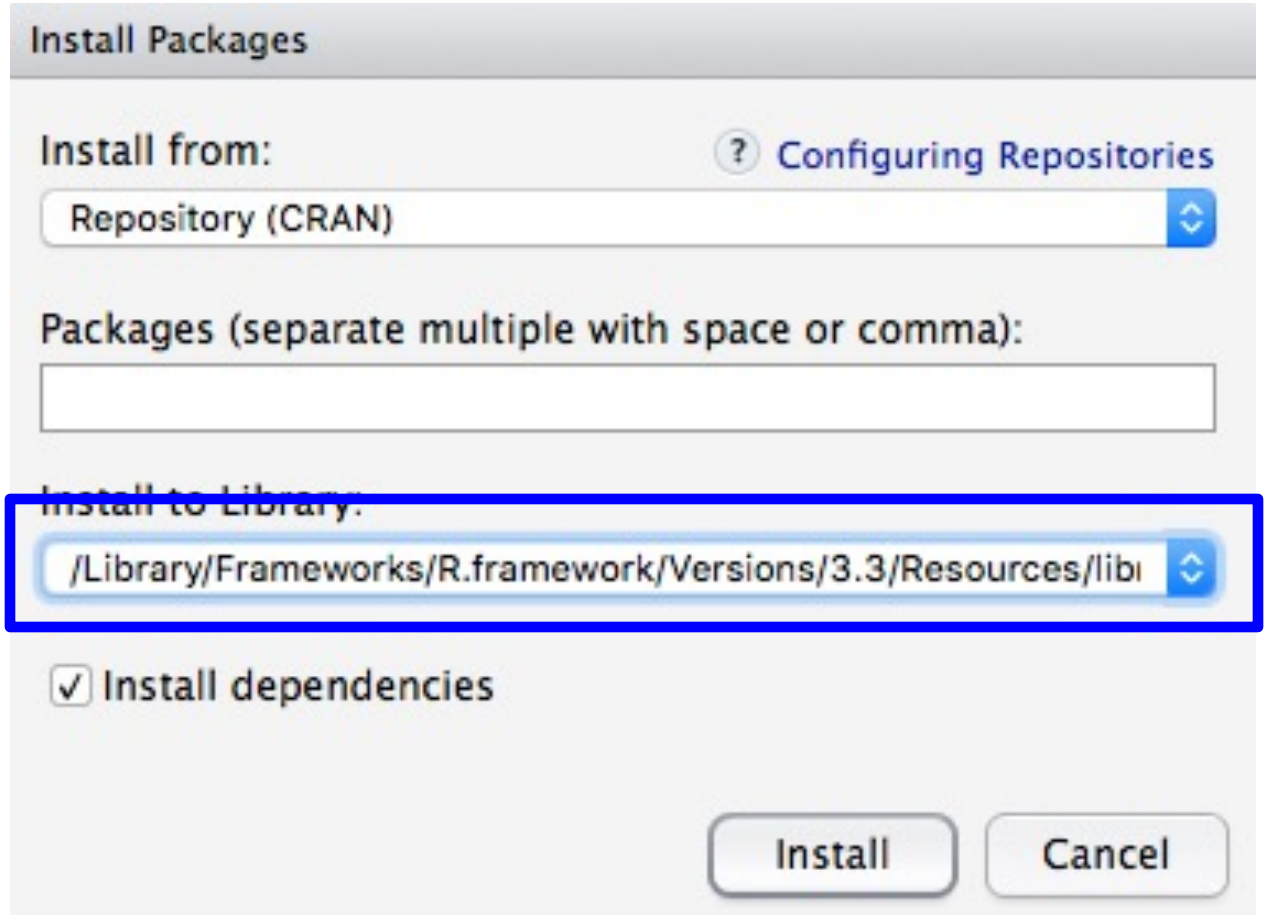
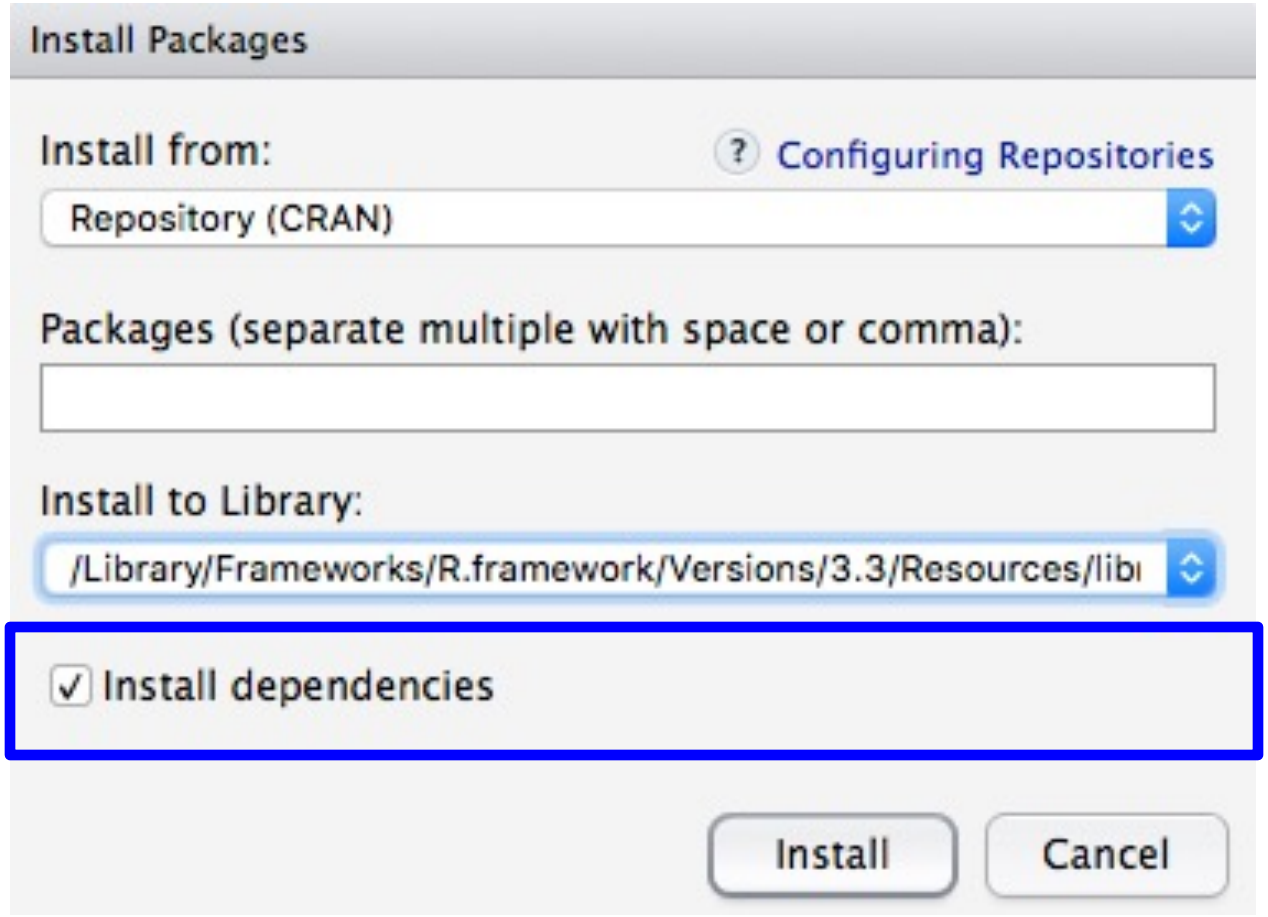


Install Button



R Code to Install Packages

Note the quotation marks!

```
install.packages("psych")
```

Packages

INSTALLING

- Downloading the package and saving it to your computer.
- The package is available for use.
- Do this ONCE

LOADING

- Calling the package from your computer and reading its contents.
- R is ready to use the functions in the package.
- Do this EVERY TIME you open an R session

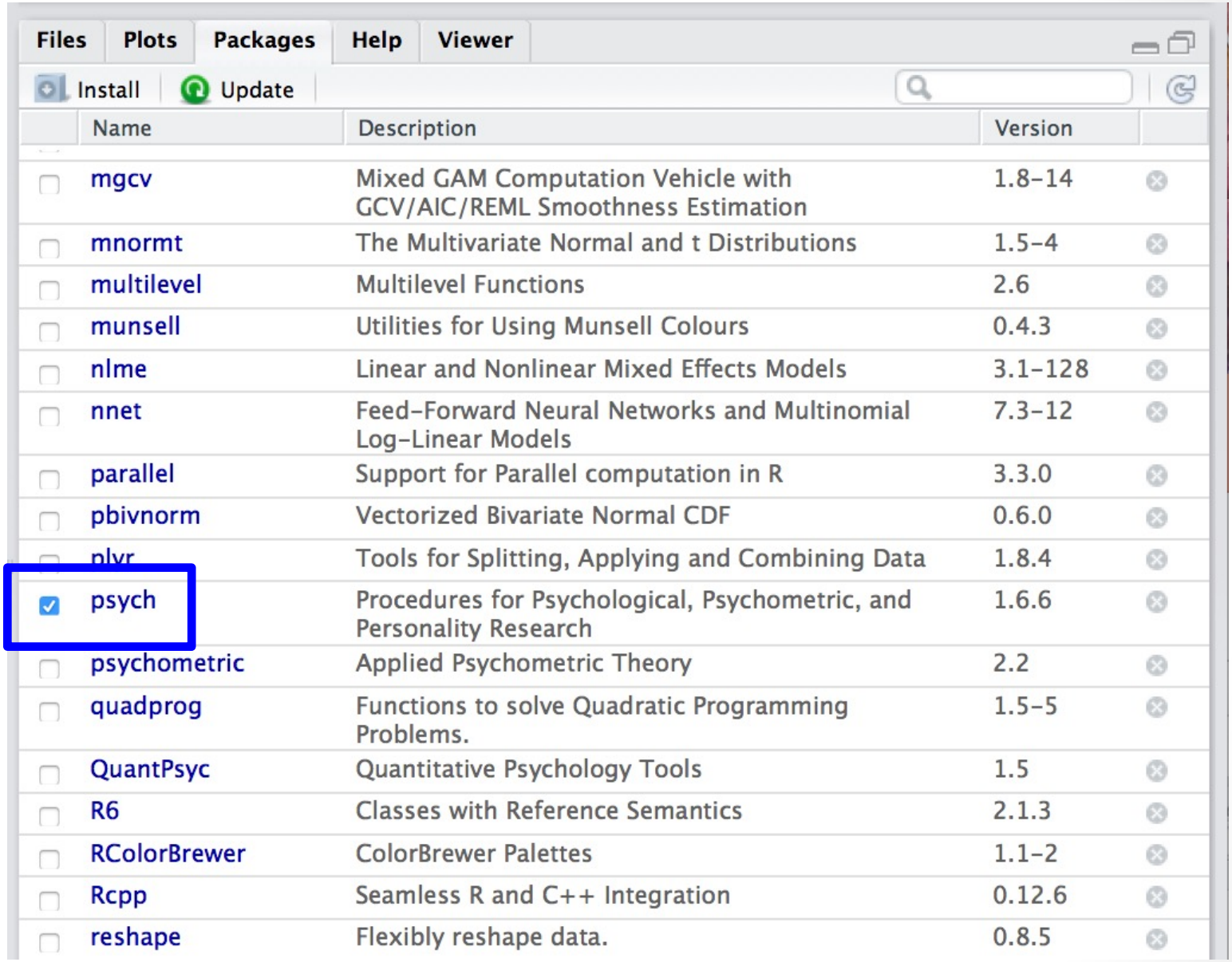
2 ways to load packages

1) Checkbox in the Packages window

2) R Code

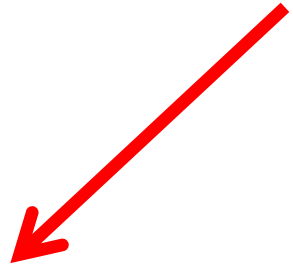
Either way, you'll need to know the name of the package.

Highly recommend option (2)


Files
Plots
Packages
Help
Viewer
Install
Update
Name
Description
Version
mgcv
Mixed GAM Computation Vehicle with GCV/AIC/REML Smoothness Estimation
1.8-14
mnormt
The Multivariate Normal and t Distributions
1.5-4
multilevel
Multilevel Functions
2.6
munsell
Utilities for Using Munsell Colours
0.4.3
nlme
Linear and Nonlinear Mixed Effects Models
3.1-128
nnet
Feed-Forward Neural Networks and Multinomial Log-Linear Models
7.3-12
parallel
Support for Parallel computation in R
3.3.0
pbivnorm
Vectorized Bivariate Normal CDF
0.6.0
plyr
Tools for Splitting, Applying and Combining Data
1.8.4
psych
Procedures for Psychological, Psychometric, and Personality Research
1.6.6
psychometric
Applied Psychometric Theory
2.2
quadprog
Functions to solve Quadratic Programming Problems.
1.5-5
QuantPsyc
Quantitative Psychology Tools
1.5
R6
Classes with Reference Semantics
2.1.3
RColorBrewer
ColorBrewer Palettes
1.1-2
Rcpp
Seamless R and C++ Integration
0.12.6
reshape
Flexibly reshape data.
0.8.5

R Code to Load Packages

Note: NO quotation marks!



```
library(psych)
```

Dependencies

```
> library(lme4)
Loading required package: Matrix
Loading required package: Rcpp
```

Uses functions from another packages.

Installed automatically.

Loaded automatically.

RStudio

starwarscode.R

```
install.packages("dplyr")
install.packages("ggplot2")

library(dplyr)
library(ggplot2)

empire <- starwars

empire <- empire[c(1:5, 10, 13, 14, 19, 21), c(1:3,8:10)]
empire$species <- factor(empire$species)
empire <- data.frame(empire)

ggplot(data = empire, aes(x = mass, y = height)) +
  geom_point(aes(size = mass, color = species), alpha = .5) +
  labs(title = "Star Wars Characters", subtitle = "by size") +
  scale_size(guide = "none")
```

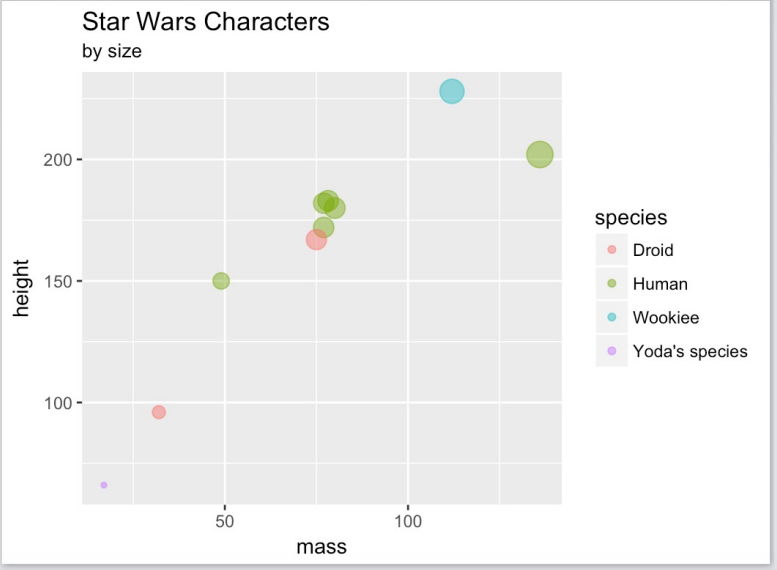
Console ~/Dropbox/

```
> empire <- starwars
>
> empire <- empire[c(1:5, 10, 13, 14, 19, 21), c(1:3,8:10)]
> empire$species <- factor(empire$species)
> empire <- data.frame(empire)
>
> ggplot(data = empire, aes(x = mass, y = height)) +
+   geom_point(aes(size = mass, color = species), alpha = .5) +
+   labs(title = "Star Wars Characters", subtitle = "by size") +
+   scale_size(guide = "none")
>
```

Environment | History

Data

empire 10 obs. of 6 variables



Exercise

1) Check your **Packages** tab to see if the following three packages are listed there:

- psych
- tidyr
- lsr

- If NO, proceed to Step 2! If YES, put up your pink post-it.

2) INSTALL the above three packages.

3) LOAD the above three packages.

Remember:

- **Need quotes** to install. **No quotes** to load.
- **Install** in console. **Load** in script.
- Spelling and capitalization matter.

```
install.packages("psych")
install.packages("tidyr")
install.packages("lsr")

library(psych)
library(tidyr)
library(lsr)
```

Help! (again)

Ways to find documentation:

`?psych` – opens documentation specific to that package or function

`??psych` – searches for this in all documentation

**Only looks in documentation for packages you have installed and loaded.

To find a package that does what you need: Google ☺

Help! (again)

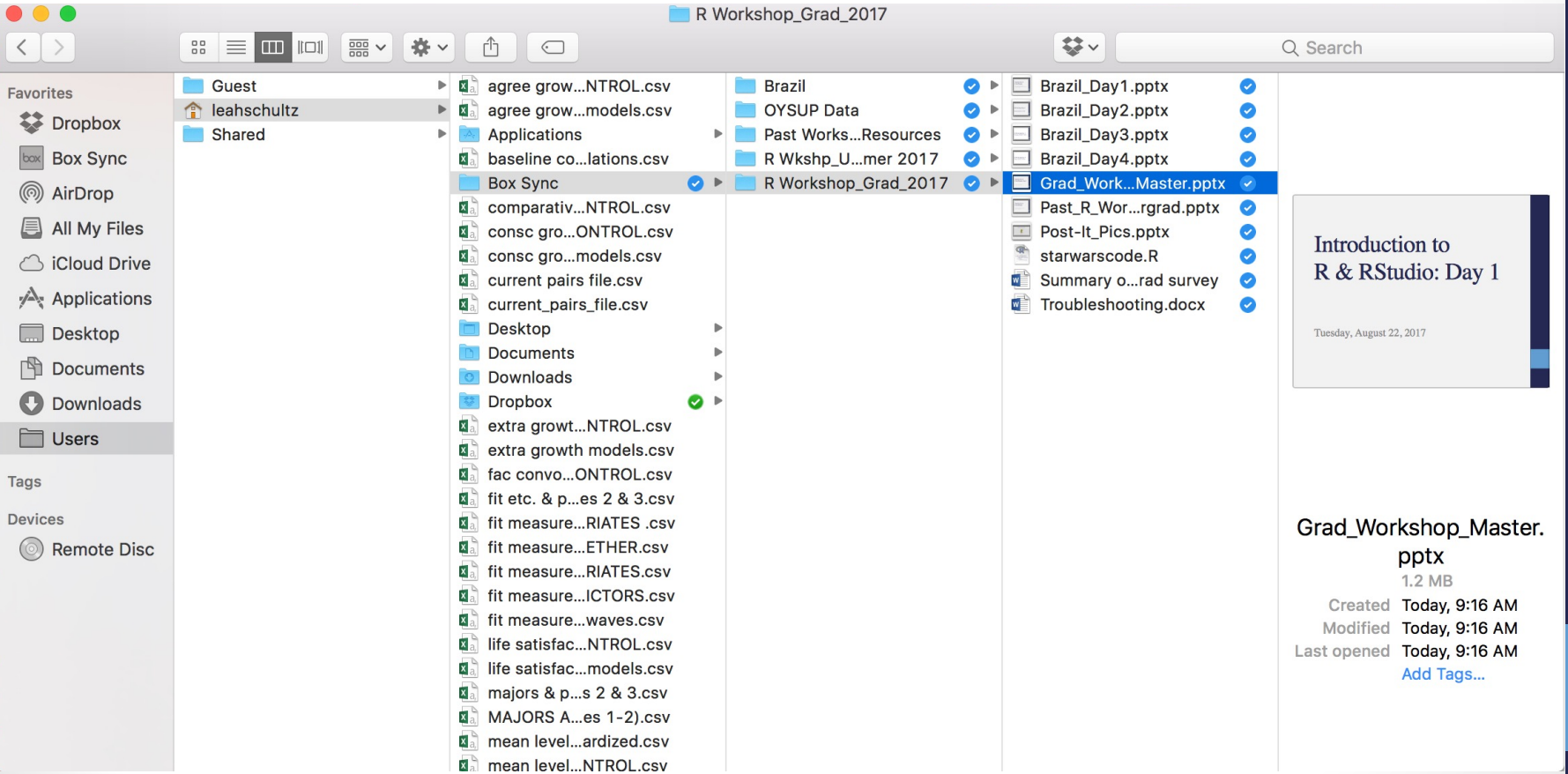
To find functions available in a package:

In the packages tab, click on the name of the package to see what functions are available!

DIRECTORIES

Directories

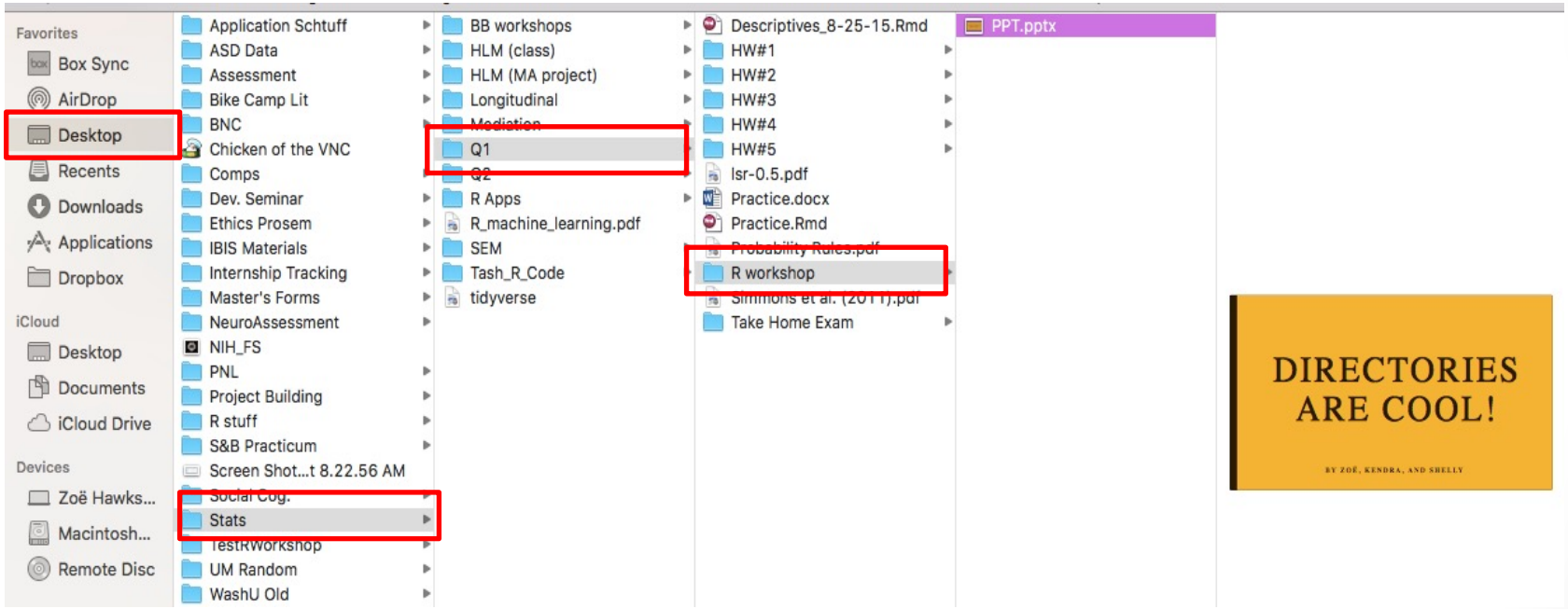
Your computer is made up of a series of folders.



Directories

This file path is the directory that contains the file “PPT.pptx”

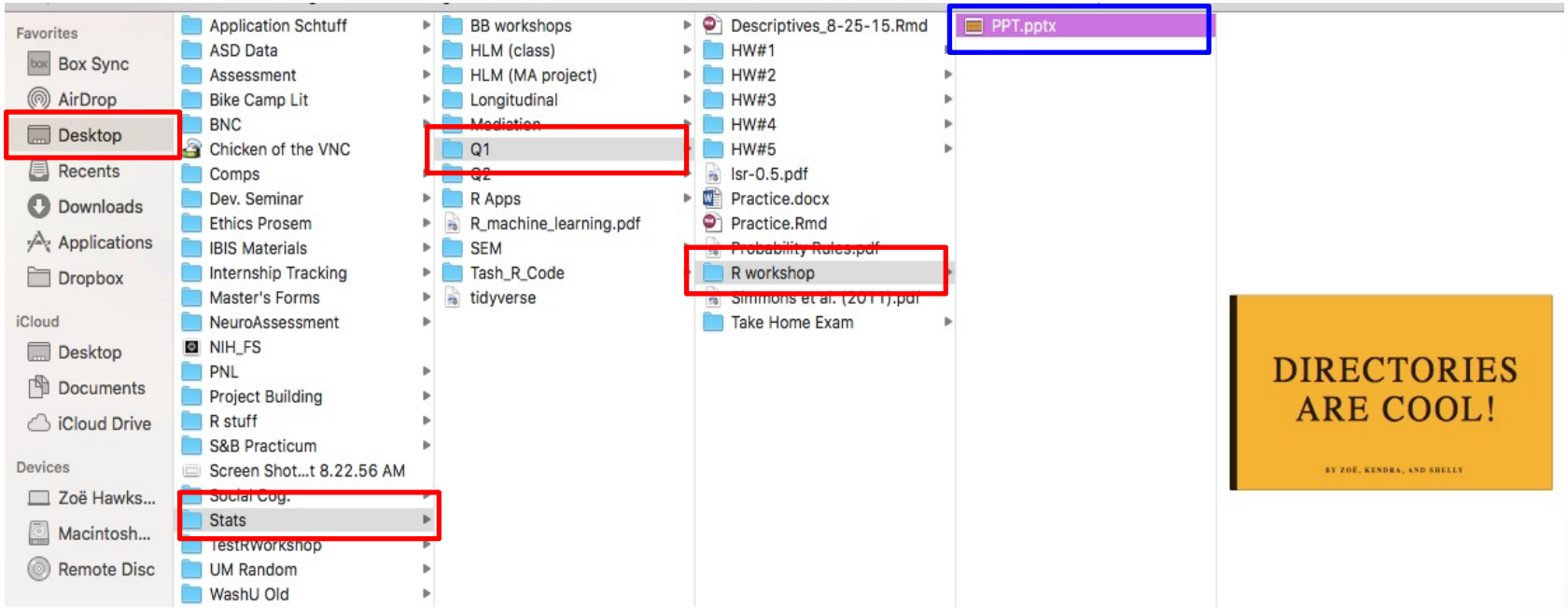
/Users/emoriebeck/Desktop/Stats/Q1/R workshop/PPT.pptx



Directories

This is the actual file “PPT.pptx”

/Users/emoriebeck/Desktop/Stats/Q1/R workshop/PPT.pptx



Setting your working directory

R will only look in one folder to read your files.

Working Directory

- Where R is going to ***look for*** files
- Where R is going to ***save*** files

Setting your working directory

```
getwd()
```

```
setwd("/yourpath/goes/here")
```

Hint: press tab within the quotes and see what happens

(unimportant bonus info):

In R, ~ points to a very general directory by default. On Macs, this is usually /Users/YourName. On PCs, this is C:/Users/YourName. If the directory you want is located within this general directory, then you can use the ~ to shorten the file path. Ex:

```
setwd("~/goes/here")
```

Exercise

1. Create a folder on your desktop for today's R workshop.

2. `Set` your working directory to that folder

3. Try the `getwd()` function

REMOVE POST-ITS!!

(and save!)

TYPES OF FILES

Types of files

.R

Your data

.Rdata

.R files

.R files are text files.

- They contain the code that you've written – the commands that you want R to run.

Equivalent to syntax files in SPSS.

Also called **scripts**.

.R files – why use them?

Keep track of what commands you use.

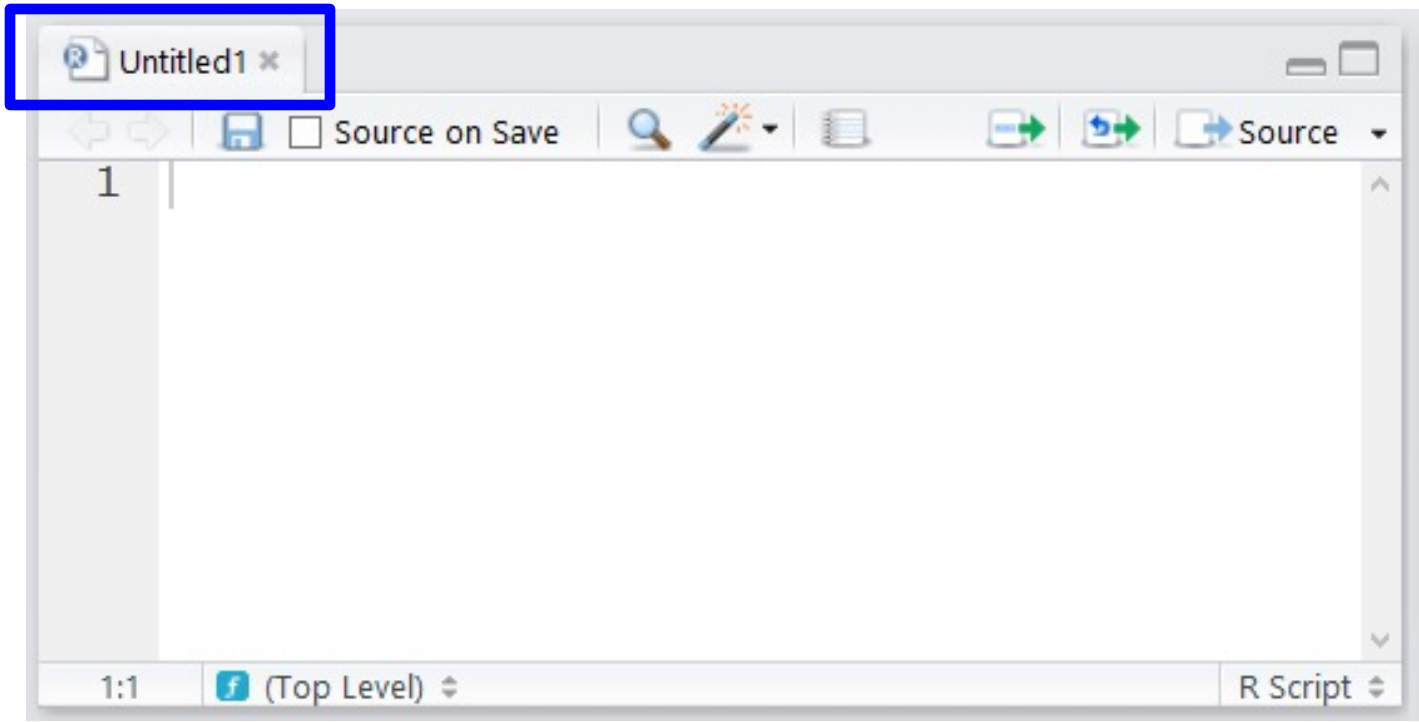
Save only the commands that are useful.

Make notes to yourself!

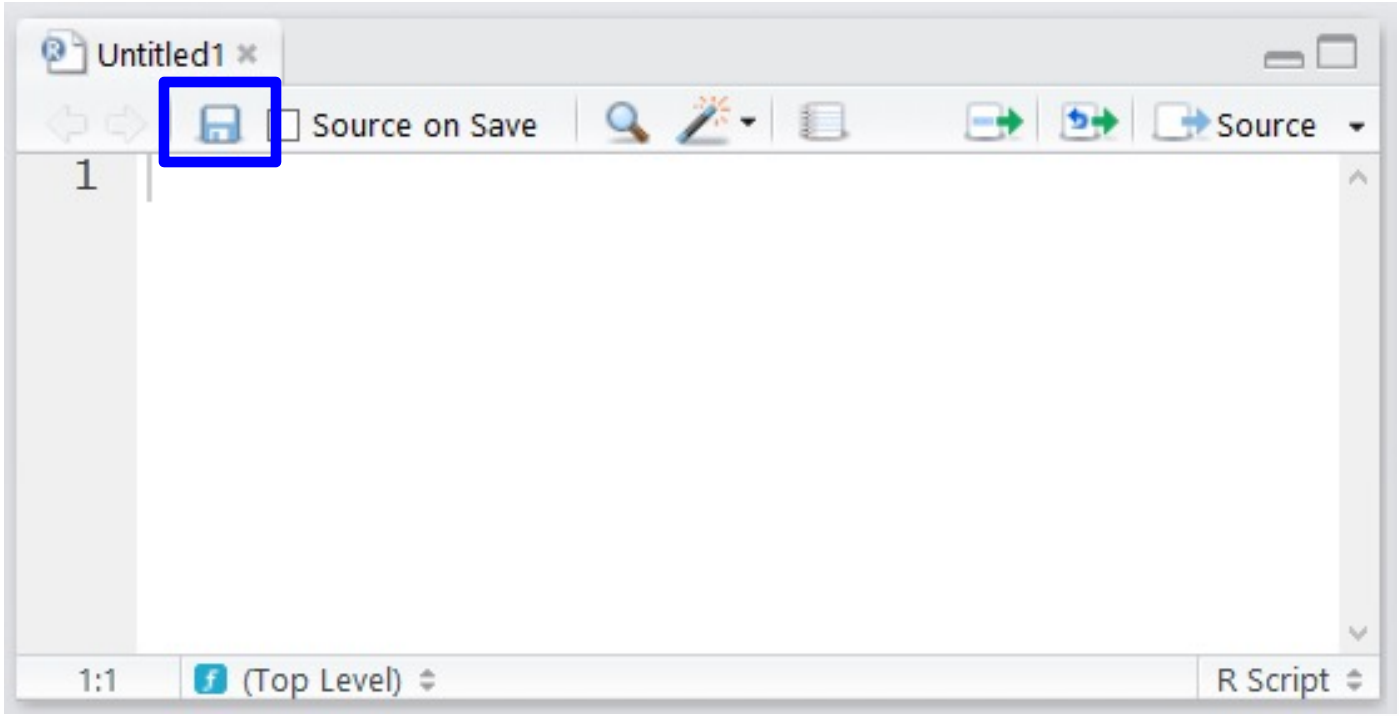
- `#Updated code for R workshop!`
- `#reliability estimates for depression scale`
- `#scatter plot for BMI predicting diabetes diagnosis`

Share your analyses with collaborators and readers.

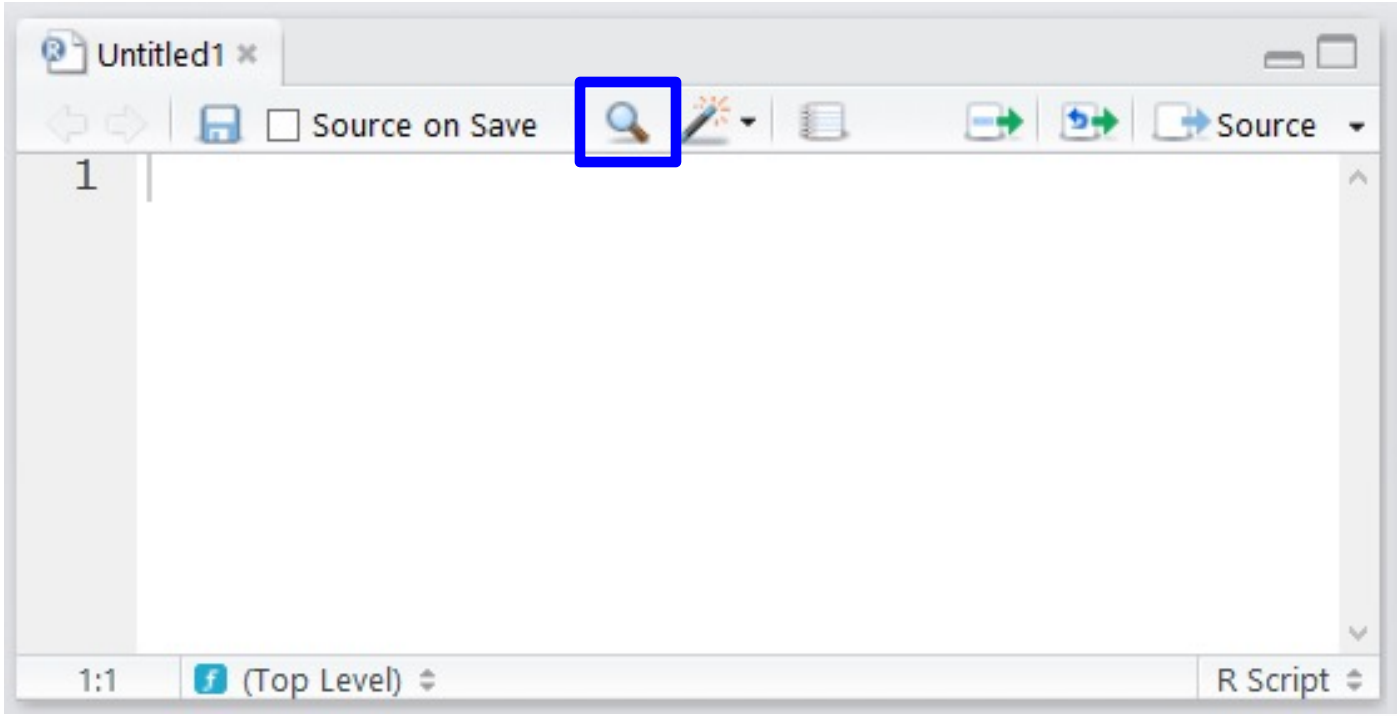
.R files



.R files



.R files



Open your file

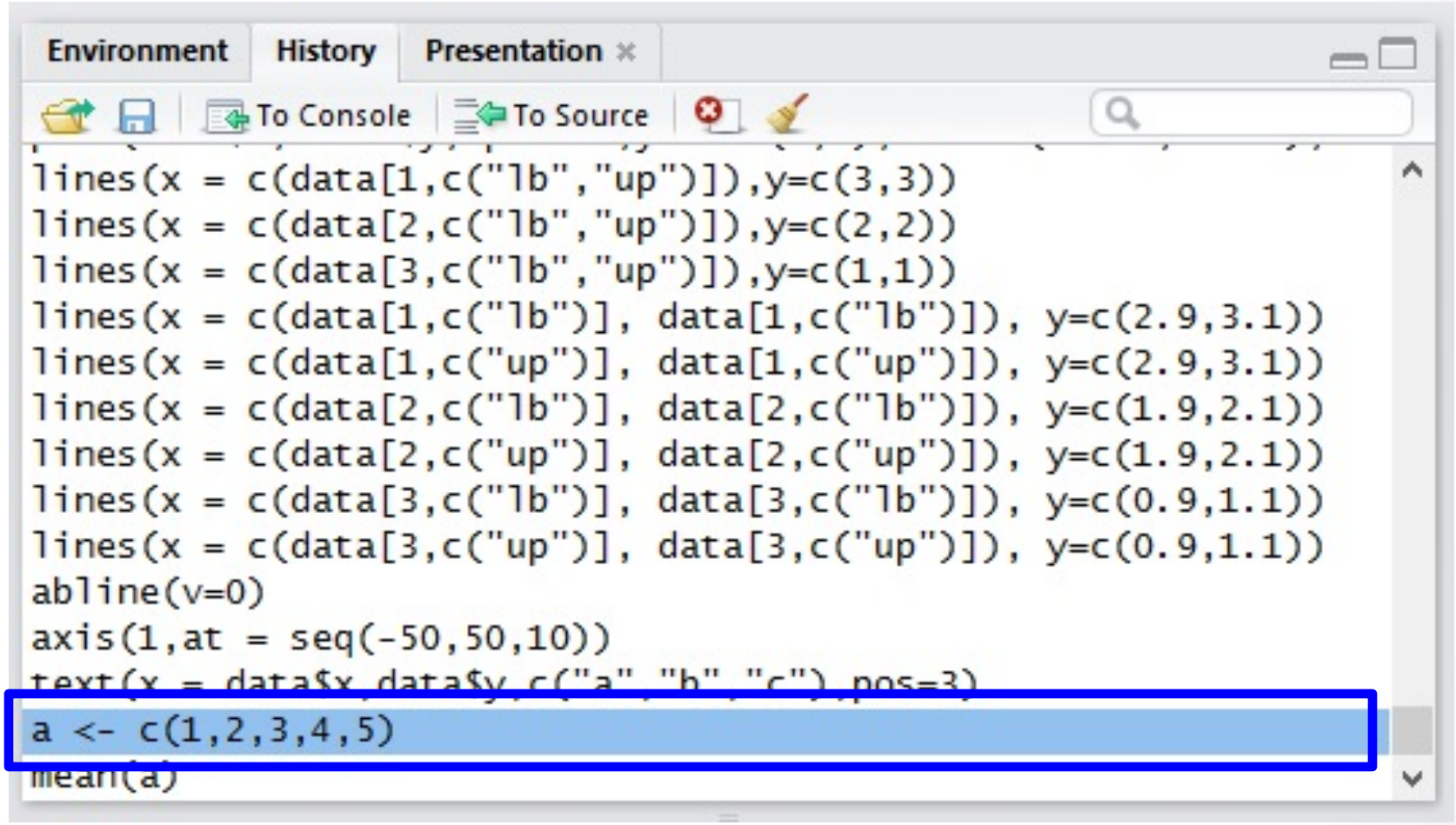
Open a file like you would any other document.

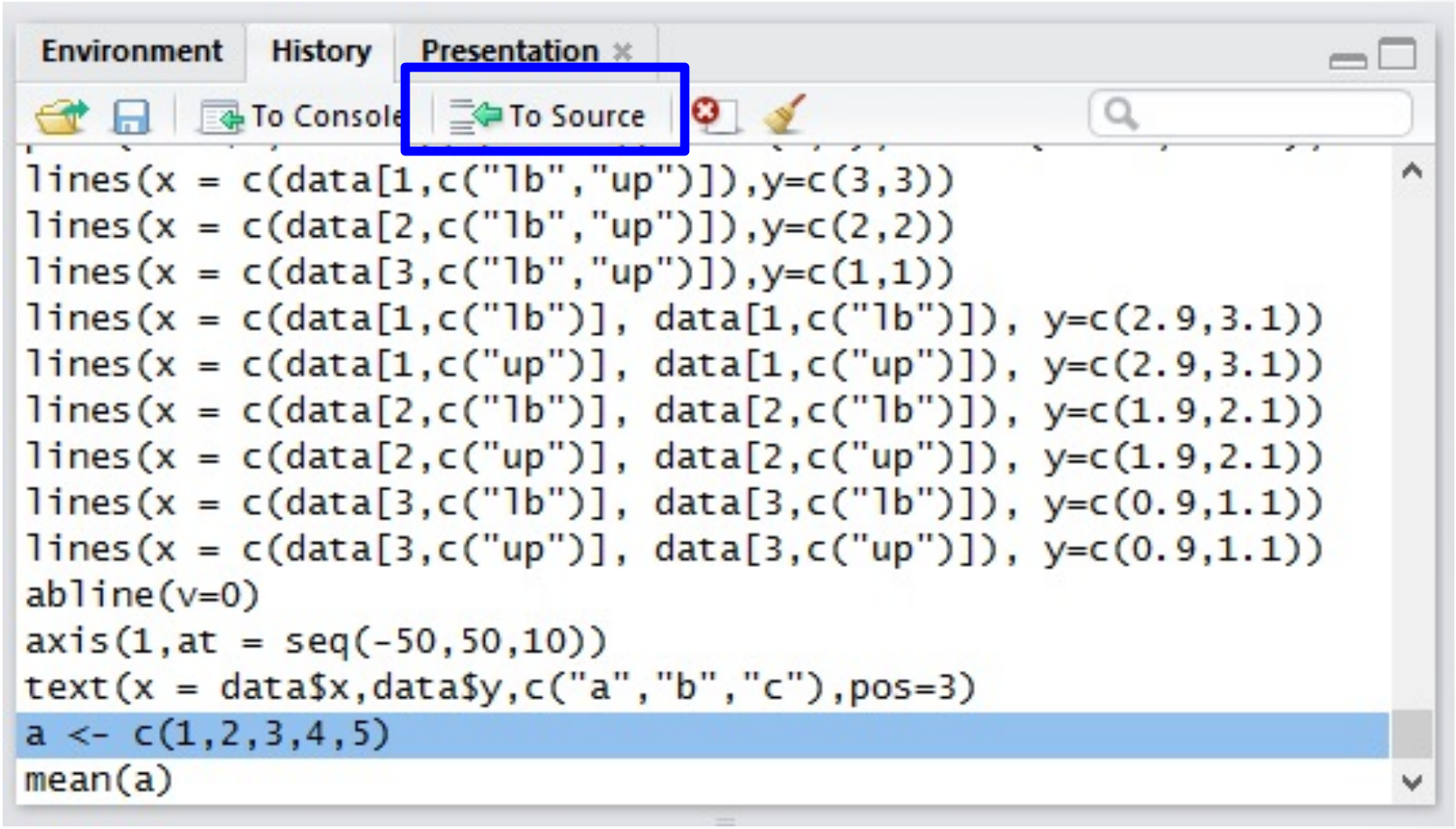
How to add things to your .R file

- Type into it!

OR

- Copy over from the History tab.


Environment
History
Presentation
To Console
To Source
lines(x = c(data[1,c("lb","up")]),y=c(3,3))
lines(x = c(data[2,c("lb","up")]),y=c(2,2))
lines(x = c(data[3,c("lb","up")]),y=c(1,1))
lines(x = c(data[1,c("lb")], data[1,c("lb")]), y=c(2.9,3.1))
lines(x = c(data[1,c("up")], data[1,c("up")]), y=c(2.9,3.1))
lines(x = c(data[2,c("lb")], data[2,c("lb")]), y=c(1.9,2.1))
lines(x = c(data[2,c("up")], data[2,c("up")]), y=c(1.9,2.1))
lines(x = c(data[3,c("lb")], data[3,c("lb")]), y=c(0.9,1.1))
lines(x = c(data[3,c("up")], data[3,c("up")]), y=c(0.9,1.1))
abline(v=0)
axis(1,at = seq(-50,50,10))
a <- c(1,2,3,4,5)


Environment
History
Presentation
To Console
To Source
lines(x = c(data[1,c("lb","up")]),y=c(3,3))
lines(x = c(data[2,c("lb","up")]),y=c(2,2))
lines(x = c(data[3,c("lb","up")]),y=c(1,1))
lines(x = c(data[1,c("lb")], data[1,c("lb")]), y=c(2.9,3.1))
lines(x = c(data[1,c("up")], data[1,c("up")]), y=c(2.9,3.1))
lines(x = c(data[2,c("lb")], data[2,c("lb")]), y=c(1.9,2.1))
lines(x = c(data[2,c("up")], data[2,c("up")]), y=c(1.9,2.1))
lines(x = c(data[3,c("lb")], data[3,c("lb")]), y=c(0.9,1.1))
lines(x = c(data[3,c("up")], data[3,c("up")]), y=c(0.9,1.1))
abline(v=0)
axis(1,at = seq(-50,50,10))
text(x = data$x,data$y,c("a","b","c"),pos=3)
a <- c(1,2,3,4,5)
mean(a)

How to run code from your .R file

Highlight the lines that you want to run, then…

- Click on **Run** button

OR

- Ctrl + Enter (Windows)
- Command + Enter (Mac)

Your Data

Original data files

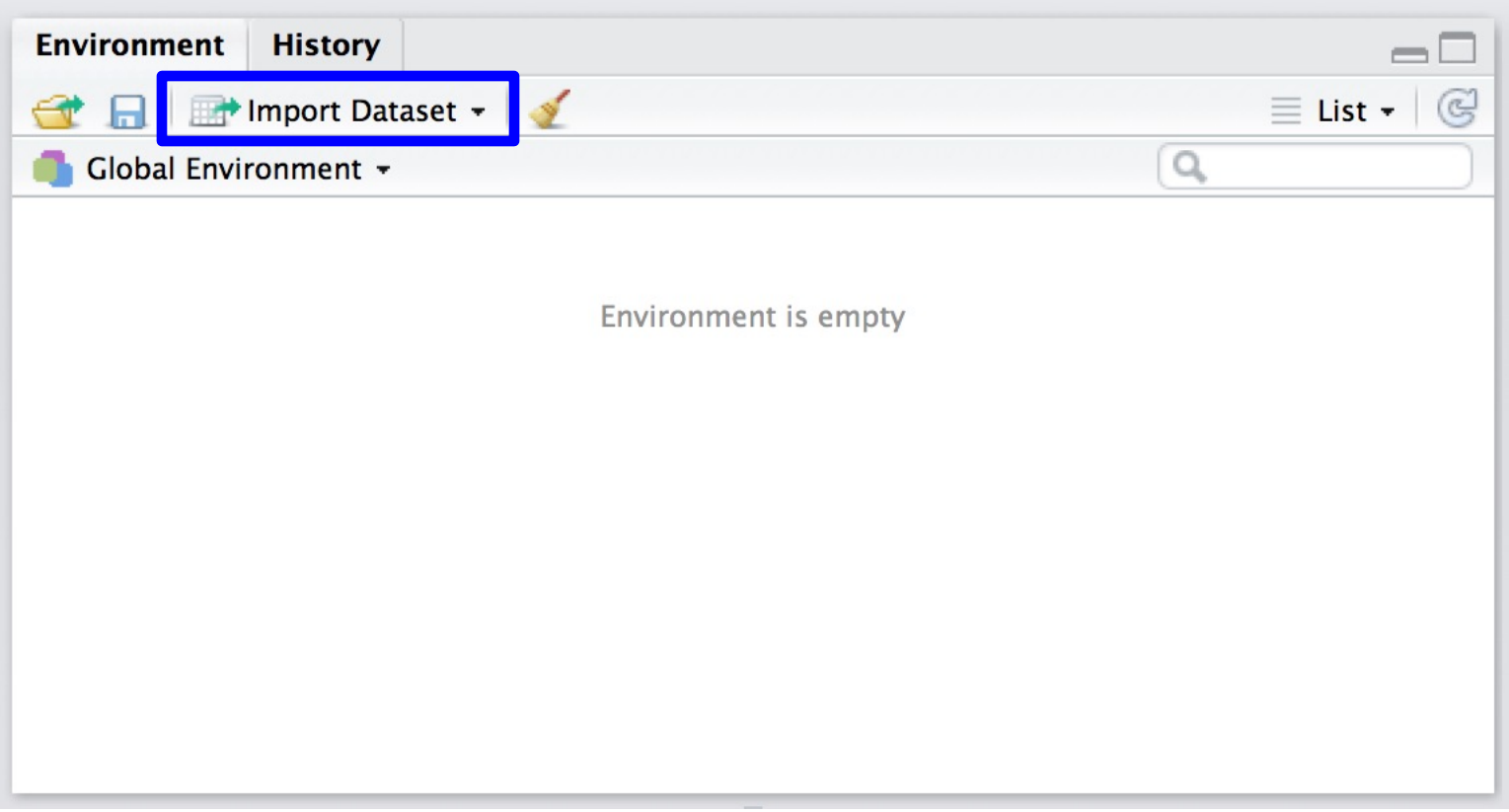
- Most of the time, these are going to be either .csv or .txt, depending on how you collect data.

These are not altered by R!

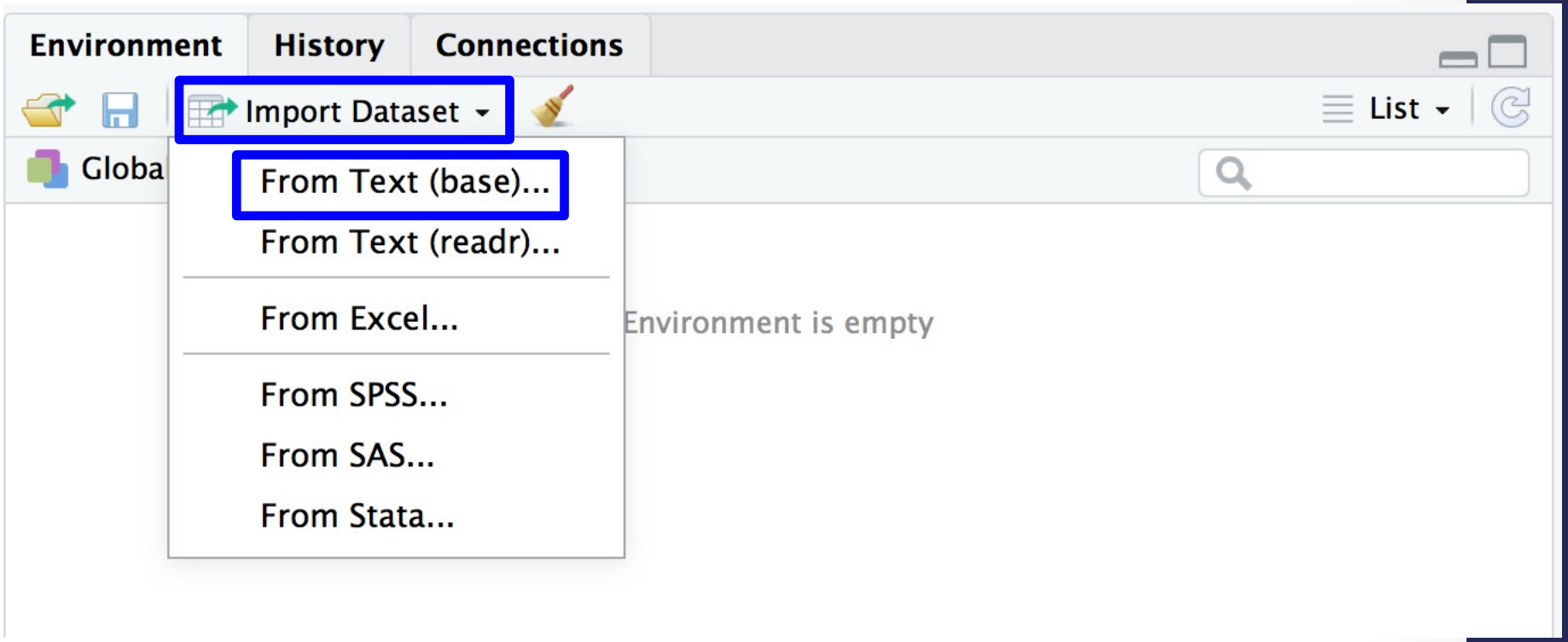
If your data is not a **.csv** or **.txt** file, don't worry! R can do a lot of stuff!

We will work with .csv, just to keep things simple.

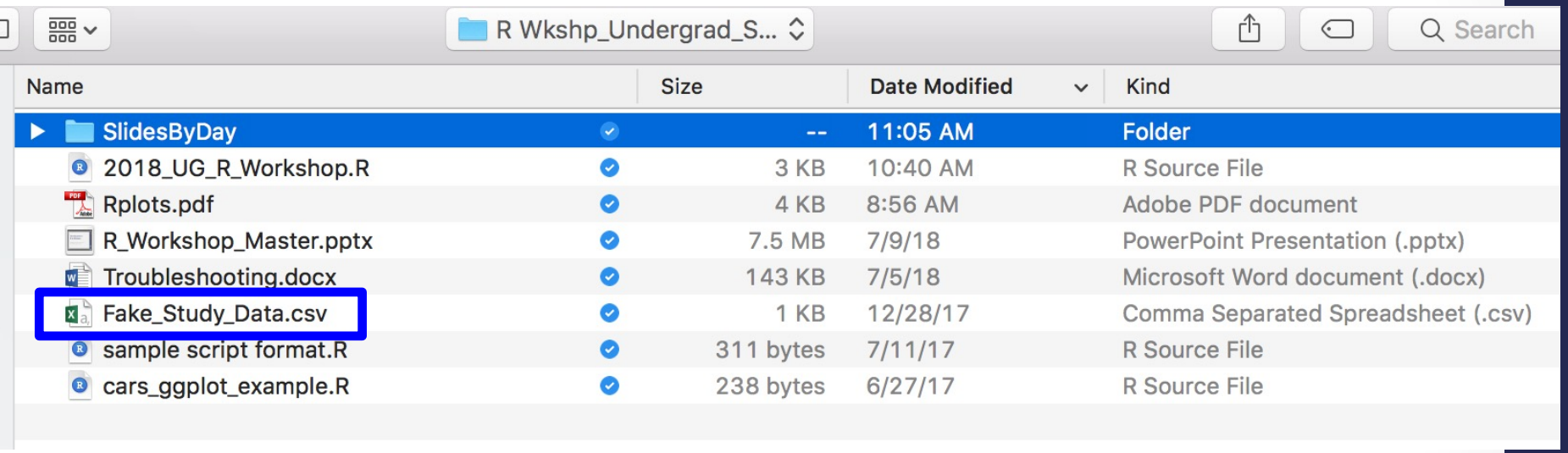
Loading .csv files

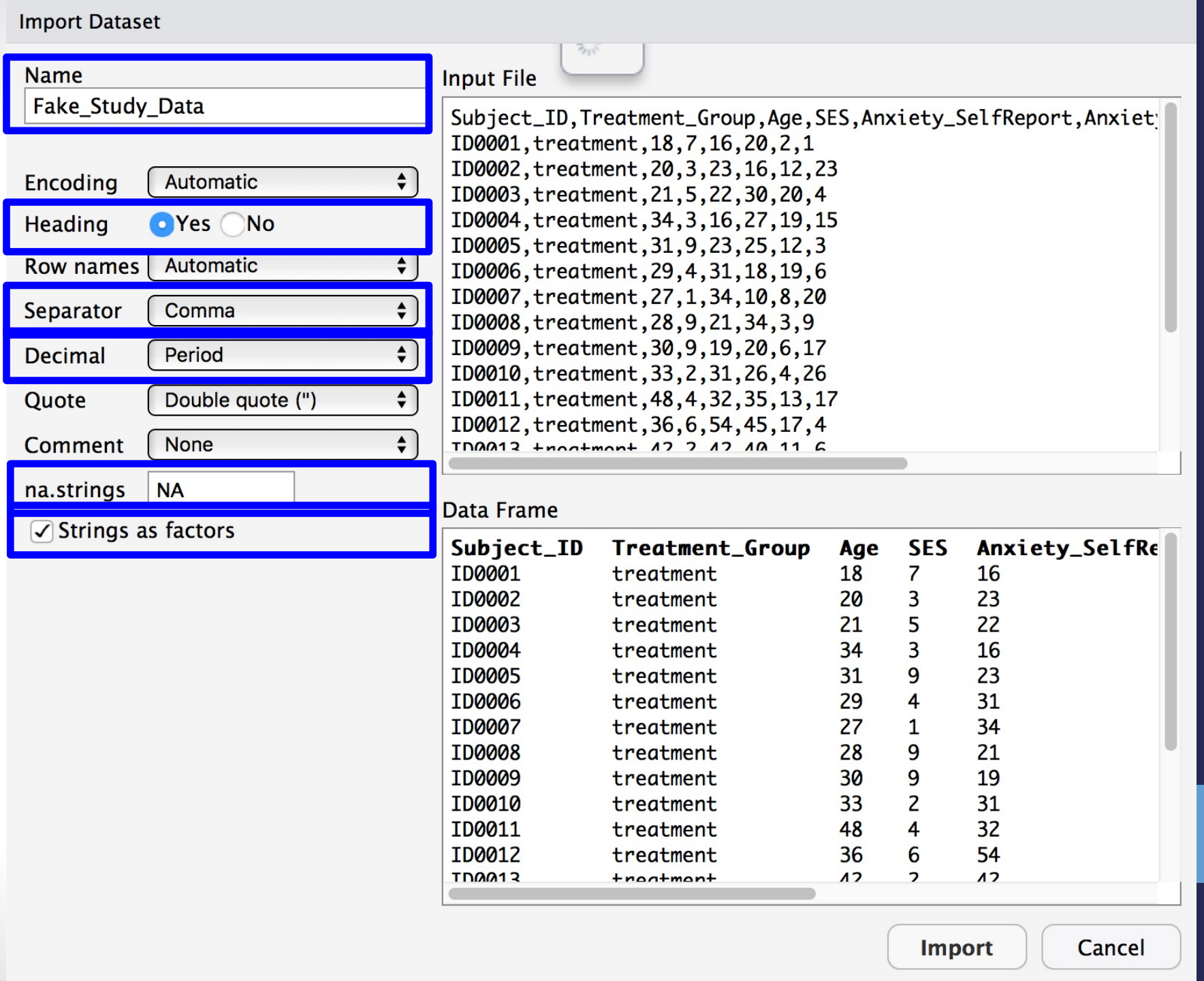


Loading .csv files



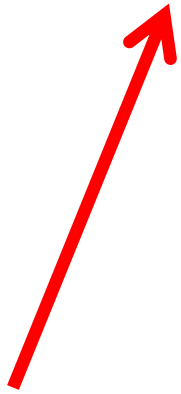
Loading .csv files




Import Dataset
Name
Fake_Study_Data
Encoding
Automatic
Heading
Yes
No
Row names
Automatic
Separator
Comma
Decimal
Period
Quote
Double quote (")
Comment
None
na.strings
NA
Strings as factors
Input File
Subject_ID,Treatment_Group,Age,SES,Anxiety_SelfReport,Anxiet
ID0001,treatment,18,7,16,20,2,1
ID0002,treatment,20,3,23,16,12,23
ID0003,treatment,21,5,22,30,20,4
ID0004,treatment,34,3,16,27,19,15
ID0005,treatment,31,9,23,25,12,3
ID0006,treatment,29,4,31,18,19,6
ID0007,treatment,27,1,34,10,8,20
ID0008,treatment,28,9,21,34,3,9
ID0009,treatment,30,9,19,20,6,17
ID0010,treatment,33,2,31,26,4,26
ID0011,treatment,48,4,32,35,13,17
ID0012,treatment,36,6,54,45,17,4
Data Frame
Subject_ID Treatment_Group Age SES Anxiety_SelfRe
ID0001 treatment 18 7 16
ID0002 treatment 20 3 23
ID0003 treatment 21 5 22
ID0004 treatment 34 3 16
ID0005 treatment 31 9 23
ID0006 treatment 29 4 31
ID0007 treatment 27 1 34
ID0008 treatment 28 9 21
ID0009 treatment 30 9 19
ID0010 treatment 33 2 31
ID0011 treatment 48 4 32
ID0012 treatment 36 6 54
Import
Cancel

Loading .csv files

```
anxiety <- read.csv("~/Box Sync/R Wkshp_Summer 2018/Fake_Study_Data.csv")
```



This will appear in your console

We strongly recommend copying and pasting this code into your script file!

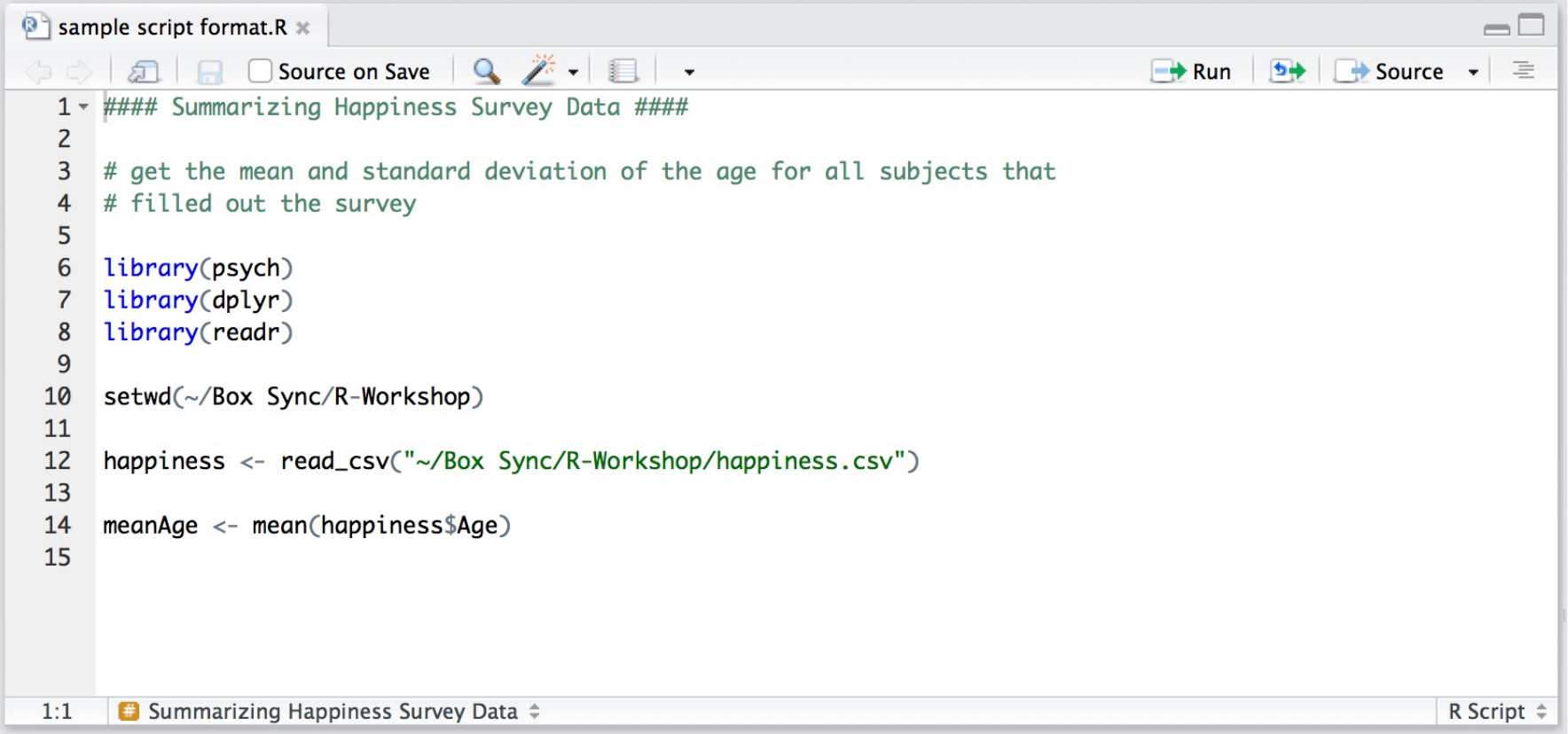
Typical workflow in R

1. Open your data (usually from a .csv file)

2. Run analyses in the console (or in your script file)

3. Save the stuff you want to be able to run again later
   - Save to a .R file
   - Make sure that this includes the code to pull your .csv from your **Dropbox/Box**/etc.
     - Note: R doesn't change this original file!

Typical Format of .R File



Exercise

1. Clear your Global Environment using the broom icon.
2. Open a new .R script file.

FOR THE FOLLOWING STEPS, TYPE ANY CODE DIRECTLY INTO YOUR SCRIPT FILE:

3. Load the following packages:
   - psych
   - dplyr
   - ggplot2

4. `Get` your `w`orking `d`irectory: make sure it's the folder on your Desktop that you made earlier.

5. Drag and drop the Fake_Study_Data.csv file into that same folder.

Exercise, continued:

6. Import data file and rename as **anxiety**.

7. Make sure that the import code ends up in your SCRIPT file.

*Note: If you don't want to use the Import Dataset button every time, you can use a function called read.csv so that it looks like this:

```
anxiety <-
      read.csv("~/Desktop/TestRWorkshop/Fake_Study_Data.csv")
```

Exercise, continued:

Now…

Clear your global environment again

Select entire script file and RUN!

Hint: You can also click “Source” in the upper right corner of your script file in order to run the entire script (rather than highlighting everything)

REMOVE POST-ITS!!

(and save!)

Anxiety Data

Clinical trial for a new anxiety treatment

- Participants 18 to 50 years old
- Randomly assigned “treatment” or “placebo” group
- Socioeconomic status (SES)
  - Scale: 0 (low SES) to 10 (high SES)
- Anxiety scores: **Self**-Reported and **Relative**-Reported
  - Scale: 0 (no anxiety) to 100 (severe anxiety)
- Stress
  - Scale: 0 (no stress) to 30 (high stress)
- Drug Use
  - Scale: 0 (no drug use) to 50 (high drug use)

Quick review

What sign would you use if you wanted to access the Stress variable from your anxiety data.frame?

```
anxiety$Stress
```

Indexing…continued!

Indexing a **vector** (1 dimension):

```
anxiety$Age[1]
```

- The number `1` gives us the **1st** item in the Age vector.

Indexing a **data.frame** (2 dimensions):

```
anxiety[1, 2:3]
```

- This gives us the 1st row and the 2nd thru 3rd column of this data.frame.

Recap #1

What's the correct way to subset all rows of columns 3, 5, 7 of my anxiety data.frame – *without* changing the data.frame?

A) `anxiety <- anxiety[ ,c(3, 5, 7)]`

B) `anxiety2 <- anxiety[ ,c(3, 5, 7)]`

C) `anxiety2 <- anxiety[3, 5, 7, ]`

D) `anxiety <- anxiety[c(3, 5, 7), ]`

Recap #1

What's the correct way to subset all rows of columns 3, 5, 7 of my anxiety data.frame – *without* changing the data.frame?

A) `anxiety <- anxiety[ ,c(3, 5, 7)]`

B) `anxiety2 <- anxiety[ ,c(3, 5, 7)]`

C) `anxiety2 <- anxiety[3, 5, 7, ]`

D) `anxiety <- anxiety[c(3, 5, 7), ]`

Recap #2

How would you read this code?

- `(Age >= 35 | Anxiety == 50)`
  - Age is greater than or equal to 35, OR age equals 50
- `anxiety_score != 99`
  - Anxiety score is not equal to 99
- `data.frame[1:5,]`
  - Calls all columns for rows 1 through 5 of our data frame

Bonus Qs!

- If we ran any of the above output, would we be able to access the result later without re-running that code?
  - No! Need to assign it to something.
- What kind of output would the first 2 pieces of code generate?
  - Logical operators return vectors of TRUE / FALSE values.

Recap #3

Consider the following piece of code:

```
bestanimal <- "red panda"
```

- What does this code do?
  - **Creates an object**
  - **Assigns a value to the object**
- What class is the object?
  - **Character**
- How can we verify this?
  - `class(bestanimal)`
- Name two ways that character values look different than other values (i.e., numeric, integer, and boolean values)?
  - **Numeric, integer, and boolean values show up as** `blue`
  - **Numeric, integer, and boolean values don't need quotation marks**
- What happens if we type in `bestanimal` to our console?
  - **It will print "red panda"**

FUNCTIONS, REVISITED

Functions within Functions

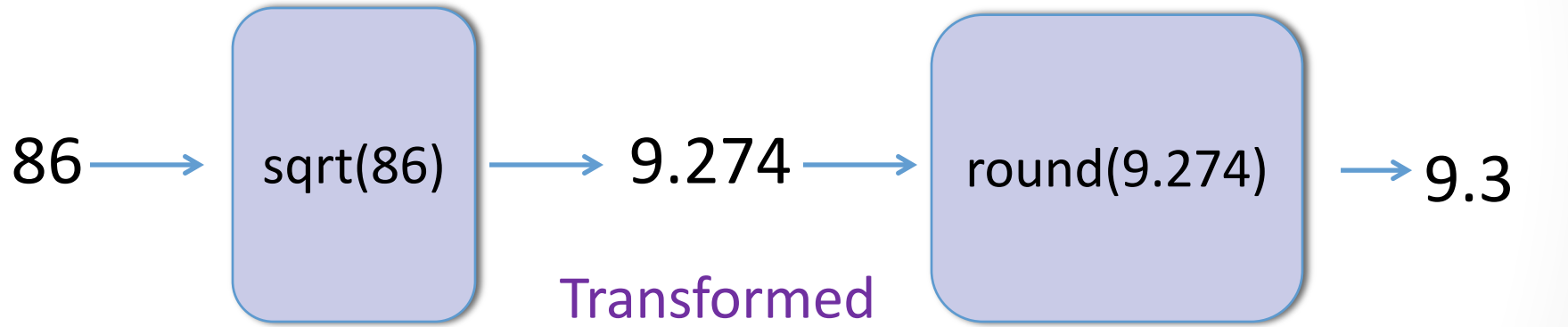
Often, you can wrap functions within functions.

This is called “nesting”.

```
round(x = sqrt(86), digits = 1)
[1] 9.3
```

Visualizing Nested Functions

```
round(x = sqrt(86), digits = 1)
```



Object (Argument)

FIRST function (Transformation)

Transformed Object #1 (Output 1)

SECOND function (Transformation)

Transformed Object #2 (Output 2)

Exercise

Use nested functions to create a subset of the data.frame which `filter`s participants who have `Anxiety_SelfReport` scores above the `mean`.

Hint: Name this new data.frame!

Adding and Filtering Data

Why would you **add** data?

- New variable
- Collected new subjects
- Etc.

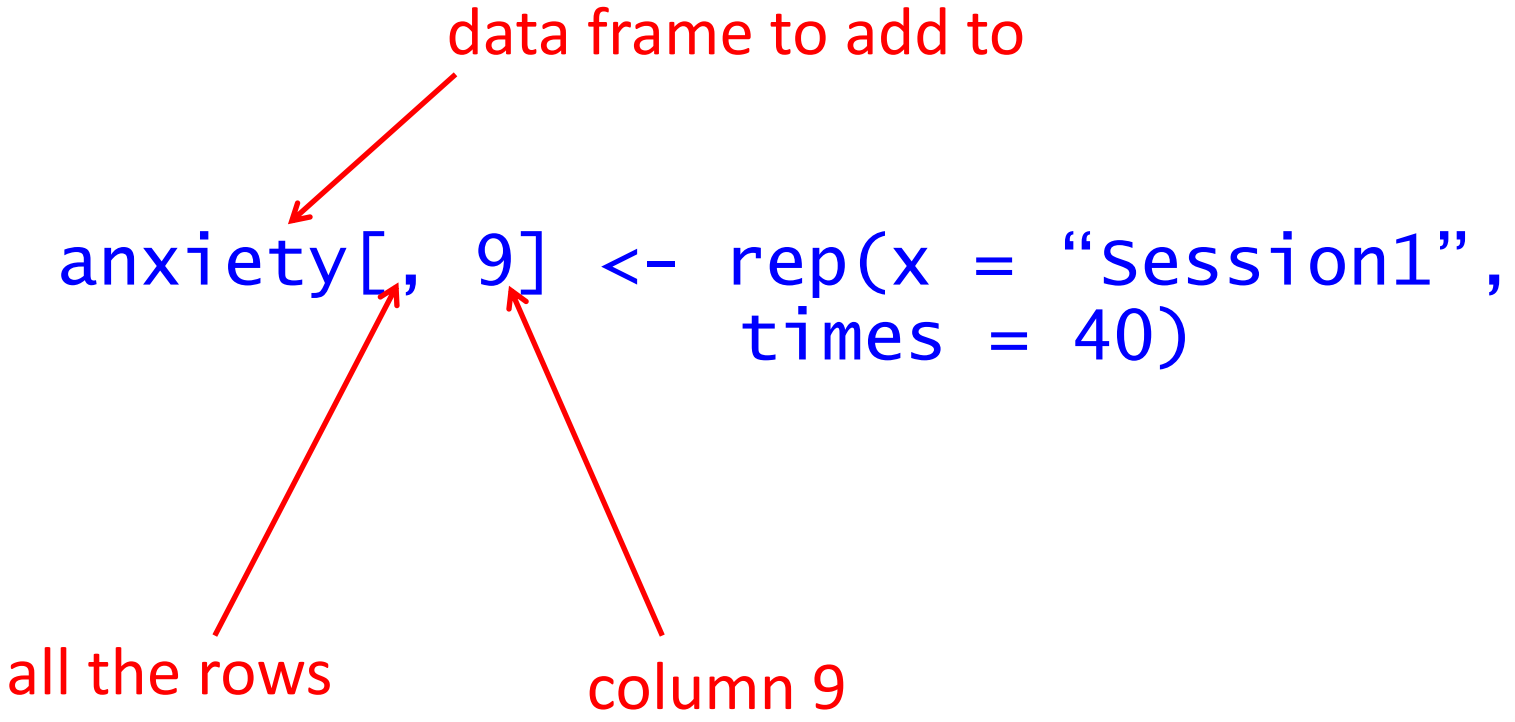
Why would you **filter (e.g. exclude)** data?

- Outliers
- Data file has lots of variables that are not of interest to you
- Etc.

Note: Adding/filtering NEVER changes your original .csv file!

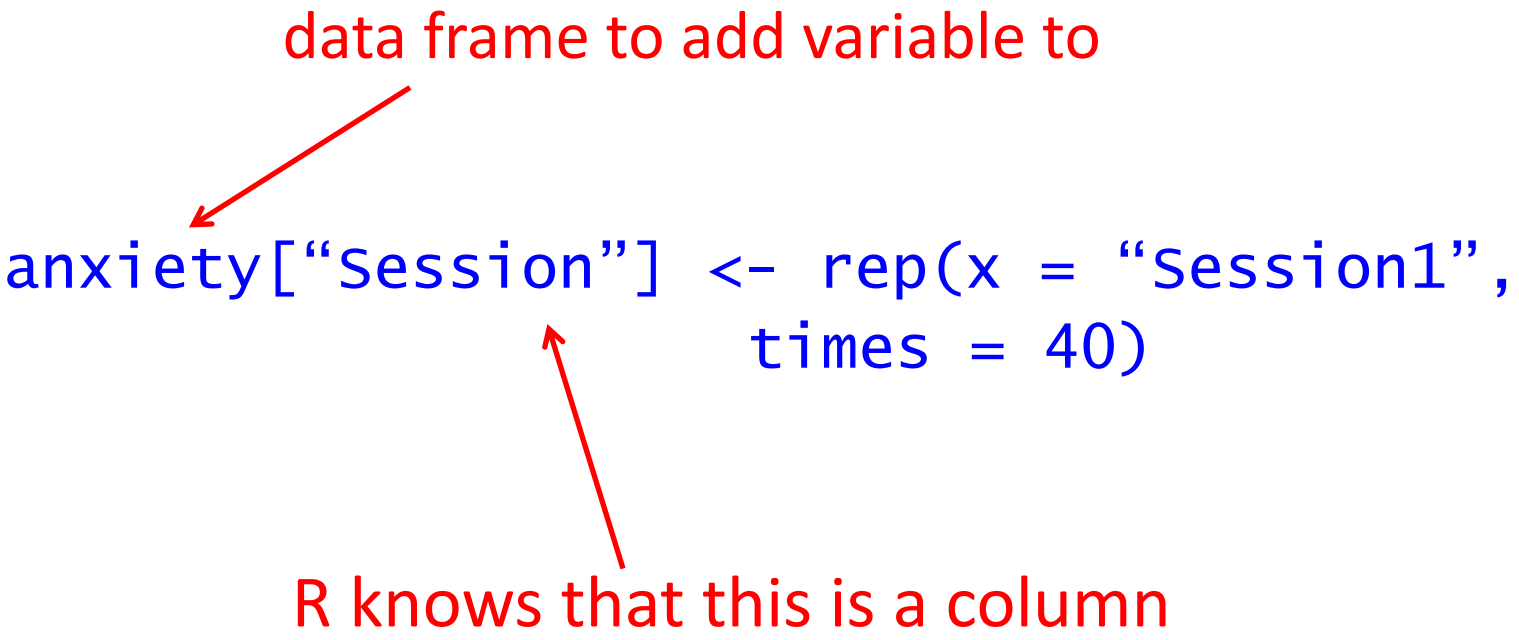
Remember Indexing?

Selecting variables to **ADD** by indexing:



What did R name this column?

Remember Indexing?

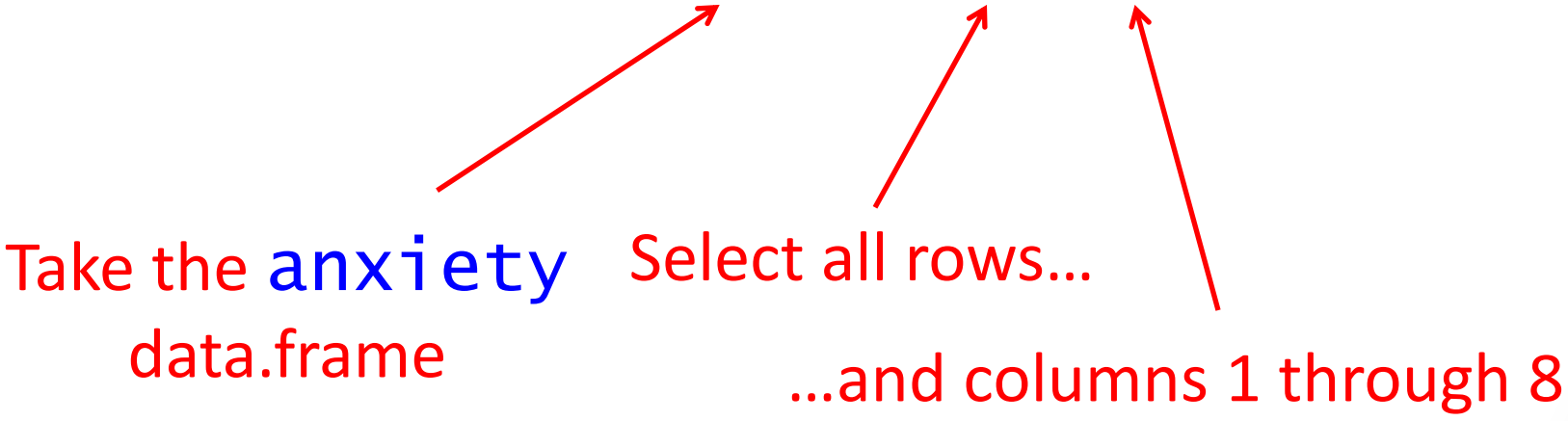


What did R name this column?

Remember Indexing?

Selecting variables to **REMOVE** by indexing:

```
anxiety2 <- anxiety[, 1:8]
```

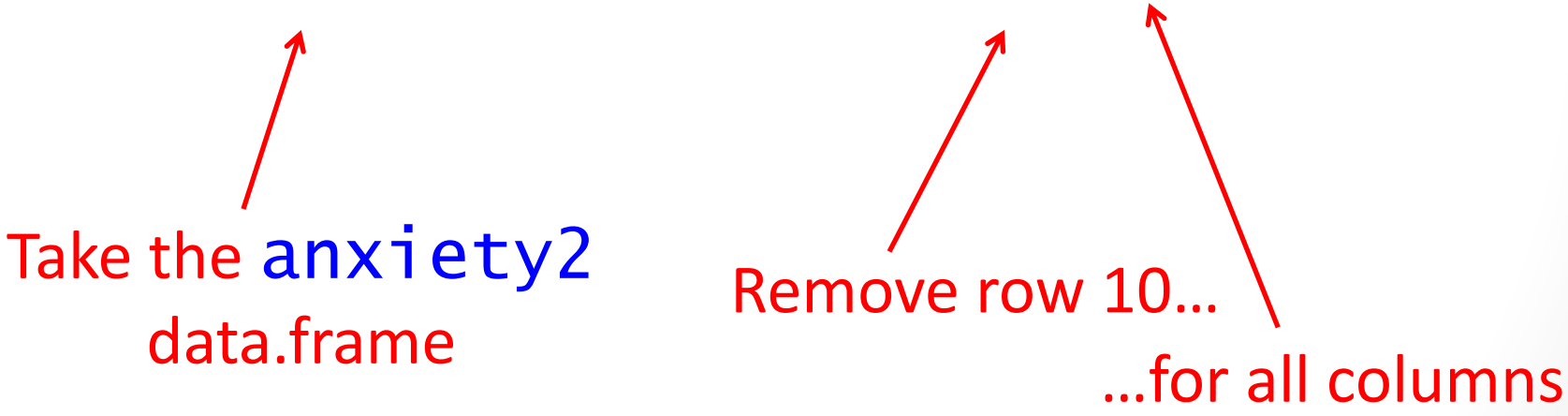


Did `anxiety` change at all? Why?

Remember Indexing?

Let's say Subject 10 is an outlier that we'd like to remove…

```
anxiety2 <- anxiety2[-10, ]
```



Did `anxiety2` change at all? Why?

Logical Operator Review

- Returns a value of TRUE or FALSE (Boolean)

==	equality
!=	inequality
>	greater than
>=	greater than or equal to
<	less than
<=	less than or equal to

A = 3 – "A is an object that stores the number 3."

A == 3 – "Is A equal to 3?"

Logical Operators

- Multiple conditions

&	and
|	or
!	not

Is this true? AND Is this true?

```
(10 < 100  &  24 == 23 + 1)
```

TRUE

```
(5 > 4  &  5 > 10)
```

FALSE

Is this true? OR Is this true?

```
(5 > 4  |  5 > 10)
```

TRUE

```
(A == B  |  C != D)
```

Subset your data

Sometimes, you will want to perform functions on only some of your data points

You can subset your data to identify subjects in a certain subgroup (e.g., females, persons over 40)

```
filter(.data = empire, (mass > 100))
```

Notes:

- Some functions have a “data” argument, where you name your data.frame. Here, you don’t need to use the dollar $ign.
- `()` around `mass > 100` aren’t necessary, but as logical expressions become more complicated they can be helpful…

Exercise

1) Make a new data.frame that only includes the treatment group, not the placebos.

   Hint: Give a new name to your new data.frame.

2) Make a new data.frame that only includes people in the placebo group that are younger than 35.

   Hint: Give a new name to your new data.frame.

3) In the original `anxiety` data.frame, find the number of people in the placebo group and the number of people in the treatment group. Use `table()`.

4) **BONUS:** `Select` all ages from the original `anxiety` data.frame; name the new data.frame `Age_vect`

What if I don't remember the arguments?

Check the R documentation

```
?filter
```

When in doubt, you can always search the "Help" tab or the Internet.

Remember Subsetting?

Remove one subject:

```
filter(.data = anxiety,
          Subject_ID != “ID0001”)
```

Remember Subsetting?

Subsetting an entire group:

```
filter(.data = anxiety,
          Treatment_Group == “placebo”)

filter(.data = anxiety,
          Treatment_Group != “treatment”)
```

What are each of these function calls doing?

Cleaning Global Environment

Sometimes your Global Environment can fill up with stuff that you don't need. You can clean this!

One option: Delete EVERYTHING using the broom (we've done this several times)

Another option: Switch to GRID view, check boxes of individual objects you DON'T want, then press the broom button

Exercise

Clean the global environment so that the only thing remaining in the global environment is `anxiety`. Nothing else should be there.

Remove the last 2 columns of the `anxiety` data.frame. (Remove `V9` and `Session`)

Hint: `V9` is column 9; `Session` is column 10.

SUMMARIZING DATA

Summarizing Data

Before you start to run any real analyses, most of the time you want to get a feel for what's happening in your data.

Summarizing Data

For really quick viewing of what you have: `describe()`

For count/frequency information: `table()`

Try:

```
describe(anxiety)
table(anxiety$Treatment_Group)
```

Note: We recommend `dplyr` and `tidyr` (both part of the "tidyverse").

PLOTTING

Plotting

R can plot without the help of any packages, but they're very ugly.

We will use the `ggplot2` package because it is much more flexible.

Plotting

ggplot2 has the following structure:

```
ggplot(things that impact entire plot) +
    geom_something (things that
    impact just the something)
```

Plotting

A `geom_` normally means shape. What shapes do you want to use to represent your plot?

- `geom_histogram` (1 variable)
- `geom_density` (1 variable)
- `geom_boxplot` (1 variable)
- `geom_point` (2 variables, scatter plot)
- `geom_col` (2 variables, barplot)

Plotting

`ggplot()` and each `geom_()` can take on different aesthetics as an `aes()` argument.

What do you want your plot to look like? How can you make it pretty?

- Which variables are the `x-axis` and `y-axis?`
- `color` (should you color the plot by some variable?)
- `fill` (very similar to color, should you fill the plot in somehow – used for bar graphs, box plots)
- `shape` (represent groups using different shapes)
- `size` (represent groups using different sizes)

Plotting

- Usually `aes()` contains some information from the data.
- If the information isn't based on the data, it doesn't need to be inside an `aes()`

```
ggplot(data = anxiety, aes(x = Age, y = SES)) +
    geom_point()

ggplot(data = anxiety, aes(x = Age, y = SES)) +
    geom_point(color = "cornflowerblue"))

ggplot(data = anxiety, aes(x = Age, y = SES)) +
    geom_point(aes(color = Treatment_Group))
```

Reminder: Anxiety Data

Clinical trial for a new anxiety treatment

- Participants 18 to 50 years old
- Randomly assigned “treatment” or “placebo” group.
- Socioeconomic status (SES)
  - Scale: 0 (low SES) to 10 (high SES)
- Anxiety scores: **Self**-Reported and **Relative**-Reported
  - Scale: 0 (no anxiety) to 100 (severe anxiety)
- Stress
  - Scale: 0 (no stress) to 30 (high stress)
- Drug_Use
  - Scale: 0 (no drug use) to 50 (high drug use)

Exercise

Make a scatter plot of `Anxiety_SelfReport` (x-axis) against `Drug_Use` (y-axis).

Make the points of the scatter plot different `shape`s based on `Treatment_Group` (for example, placebo might be circles and treatment might be squares).

Make the `color` of the points different based on `Treatment_Group`.

Set the `size` of all points equal to 3

HINT: one of these…

- `geom_boxplot`
- `geom_point`
- `geom_col`

Exercise

1. Find the mean and standard deviation of self-reported anxiety for the treatment group, then for the placebo group.

Make sure to save each result as a new variable!
****BONUS:** Calculate each variable using a single line of code; so, 4 total lines of code**

2. Make a new data.frame to use for plotting.

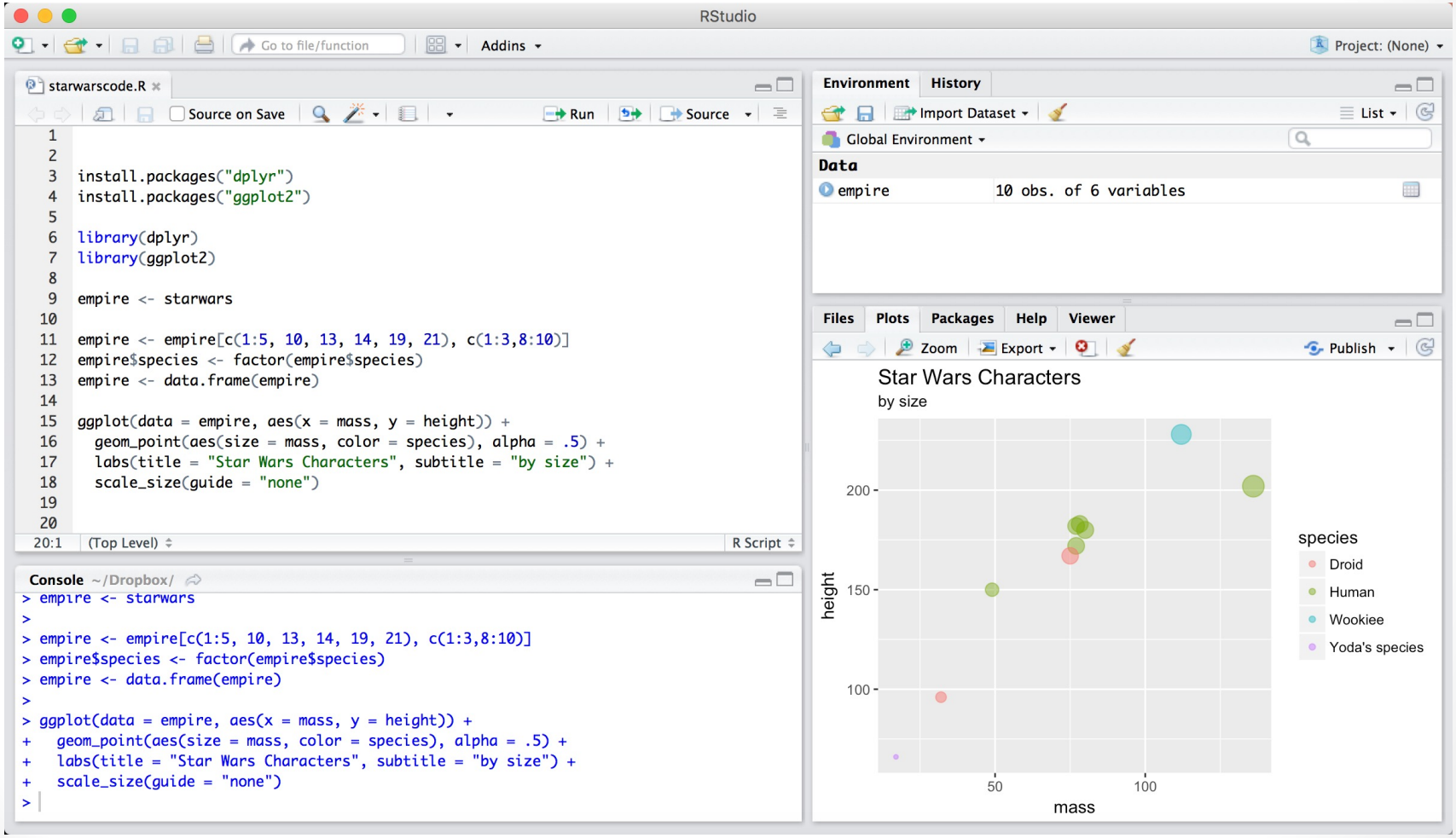
```
newDF <- data.frame(Group = c("Treatment",
   "Placebo"),
    meanAnx = c(_____, _____),
    sdAnx = c(_____, _____))
```

Exercise

- Make a bar plot of mean anxiety by treatment group. Use your new data.frame.
  - Fill in the color of the bars by Group.
  - Include error bars, using the standard deviations.
  - Change the labels to be descriptive.
  - Anxiety is on a scale of 0 to 100. Make sure that the limits of the y-axis include the full range.
  - **BONUS:** center the title and subtitle; change the colors of the bars; remove the gray background

```
ggplot(data = ____, aes(x = ____, y = ____ )) +
  geom_col(aes(fill = ____ )) +
  geom_errorbar(aes(ymin = meanAnx - sdAnx,
                    ymax = ____ + ____ ), width = .25) +
  labs(x = "Treatment Group", y = ____, title =
                ___, subtitle = ____ ) +
  _______ # change y-axis limits here
```

Remember this???



Other things you might need…

Data Transformation:

- Renaming columns
- Save the output

These are all things that you may one day find interesting!

Renaming columns

```
colnames(data.frame)[columnNumber]
    <- “NewName”

colnames(anxiety)[5] <- “Session1”
colnames(anxiety)[6] <- “Session2”
```

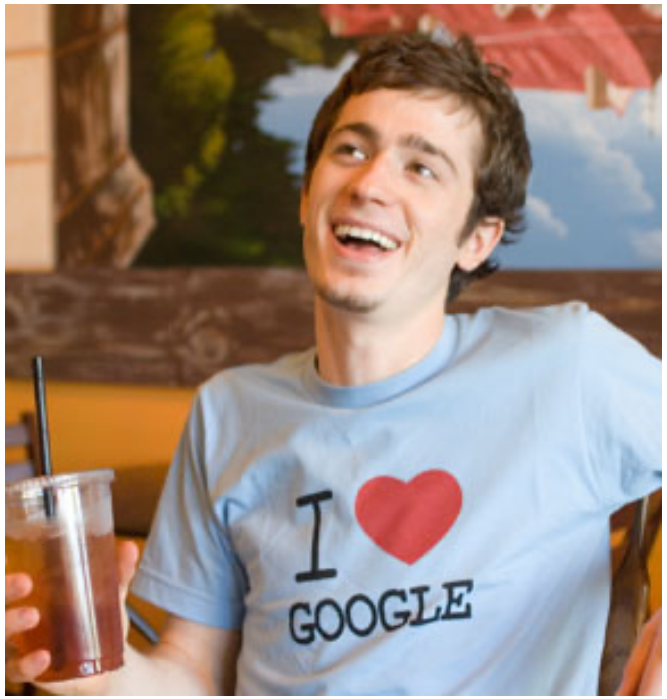
Saving output

It’s very easy to export data.frames once you have manipulated them in R. You can use this to your advantage!

```
write.csv(x = R object,
          file = “newfile.csv”,
          row.names = FALSE)
```

What if I don't remember how to use a function?

Use the internet!



Any problem you have, the internet has already solved it!

Google is your best friend!

R RESOURCES

- **Learning Statistics with R** – free, well-written book available in PDF format; integrates learning R with learning basic stats
  - https://health.adelaide.edu.au/psychology/ccs/teaching/lsr/
- **DataCamp** – online tutorials to teach R
  - https://www.datacamp.com/introduction-to-statistics
  - (also try Coursera and Code School)
- **Favorite websites for Reference:**
  - Quick-R
  - Cookbook for R
  - Institute for Digital Research and Education (UCLA)
  - Stack Overflow
- **swirl** package inside RStudio: learn R, in R!
- **Email us!**
  - Emorie Beck – emorie_beck@alumni.brown.edu
  - Kendra Smith – kendrasmith@wustl.edu
  - Zoë Hawks – hawksz@wustl.edu
- **Google, Google, Google!!!!!**