

SIRE516

Week1: Introduction to R programming

Let's get R

- Download the latest version of R at <https://cran.r-project.org/>



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The Comprehensive R Archive Network

Download and Install R

Precompiled binary distributions of the base system and contributed packages. **Windows and Mac** users most likely want one of these versions of R:

- [Download R for Linux \(Debian, Fedora/Redhat, Ubuntu\)](#)
- [Download R for macOS](#)
- [Download R for Windows](#)

R is part of many Linux distributions, you should check with your Linux package management system in addition to the link above.

Source Code for all Platforms

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

- The latest release (2024-06-14, Race for Your Life) [R-4.4.1.tar.gz](#), read [what's new](#) in the latest version.
- Sources of [R alpha and beta releases](#) (daily snapshots, created only in time periods before a planned release).
- Daily snapshots of current patched and development versions are [available here](#). Please read about [new features and bug fixes](#) before filing corresponding feature requests or bug reports.
- Source code of older versions of R is [available here](#).
- Contributed extension [packages](#)

Questions About R

- If you have questions about R like how to download and install the software, or what the license terms are, please read our [answers to frequently asked questions](#) before you send an email.

Supporting CRAN

- CRAN operations, most importantly hosting, checking, distributing, and archiving of R add-on packages for various platforms, crucially rely on technical, emotional, and financial support by the R community.

Please consider making [financial contributions](#) to the R Foundation for Statistical Computing.

What are R and CRAN?

R is 'GNU S' a freely available language and environment for statistical computing and graphics which provides a wide variety of statistical and graphical techniques: linear and nonlinear modelling, statistical tests, time

Let's get R

- Choose your OS



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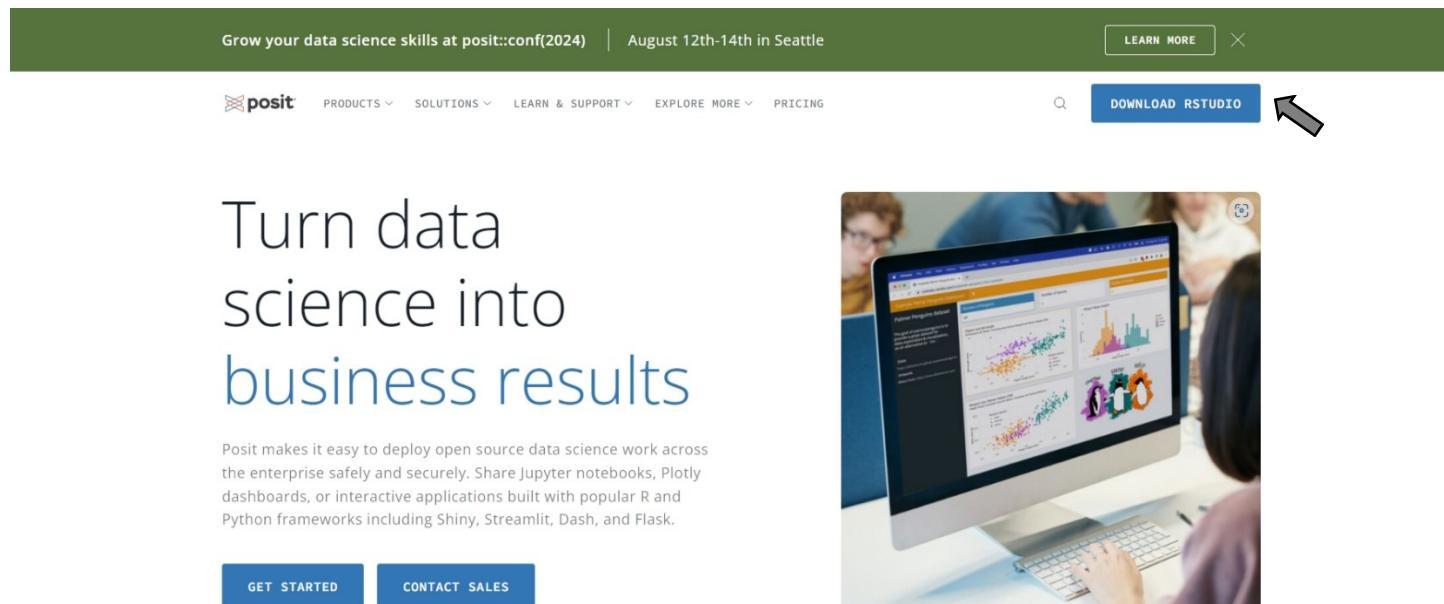
RStudio

- Integrated development environment (IDE) for R
- Organizing your R coding environment
- Facilitate datasets loading
- Facilitate graph and plot resizing and saving

*****ALWAYS install R before Rstudio*****

Let's get RStudio

- Download the latest version of RStudio at <https://posit.co/>



The screenshot shows the posit.co homepage. At the top, there is a green banner with the text "Grow your data science skills at posit::conf(2024)" and "August 12th-14th in Seattle". Below the banner, the posit logo is on the left, followed by navigation links: PRODUCTS, SOLUTIONS, LEARN & SUPPORT, EXPLORE MORE, and PRICING. To the right of these are a search bar and a blue "DOWNLOAD RSTUDIO" button, which is highlighted with a red arrow. The main content area features a large blue heading "Turn data science into business results" and a subtext about Posit making it easy to deploy open source data science work across the enterprise. Below this are two blue buttons: "GET STARTED" and "CONTACT SALES". To the right of the text is a photograph of a person working on a computer displaying a dashboard with various data visualizations. At the bottom of the page is a decorative illustration of a city skyline with the Space Needle, a Ferris wheel, and other buildings, along with small birds and flowers.

posit::conf(2024)

See you in Seattle August 12-14!

[LEARN MORE ABOUT CONF](#)

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Let's get RStudio

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RStudio IDE

The most popular coding environment for R, built with love by Posit.

Used by millions of people weekly, the RStudio integrated development environment (IDE) is a set of tools built to help you be more productive with R and Python. It includes a console, syntax-highlighting editor that supports direct code execution. It also features tools for plotting, viewing history, debugging and managing your workspace.

If you're a professional data scientist and want guidance on adopting open-source tools at your organization, don't hesitate to [book a call with us](#).

[DOWNLOAD RSTUDIO](#)[DOWNLOAD RSTUDIO SERVER](#)

Let's get RStudio

- Choose a “Desktop” version



1: Install R

RStudio requires R 3.6.0+. Choose a version of R that matches your computer's operating system.

R is not a Posit product. By clicking on the link below to download and install R, you are leaving the Posit website. Posit disclaims any obligations and all liability with respect to R and the R website.

[DOWNLOAD AND INSTALL R](#)

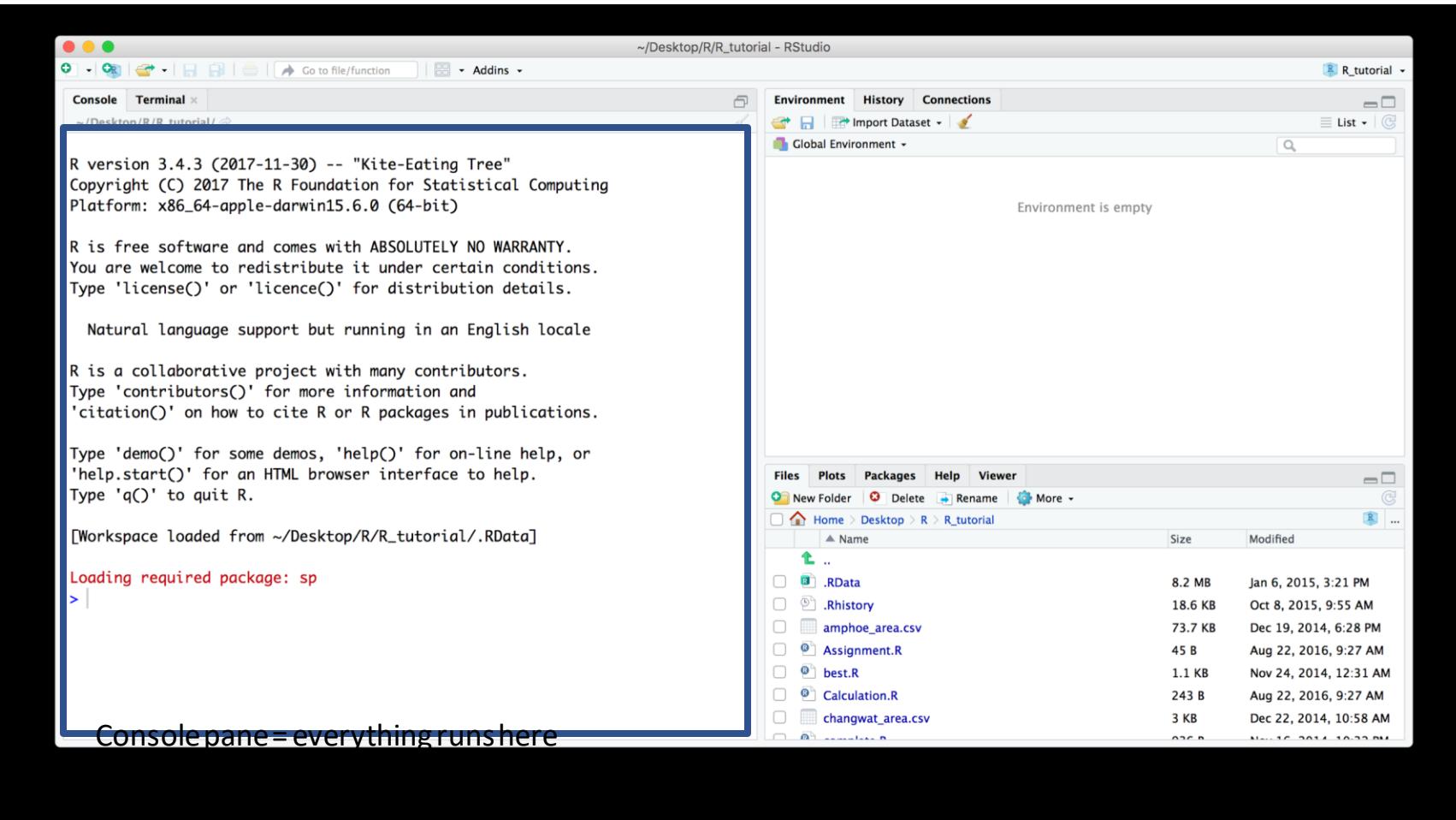
2: Install RStudio

[DOWNLOAD RSTUDIO DESKTOP FOR WINDOWS](#)

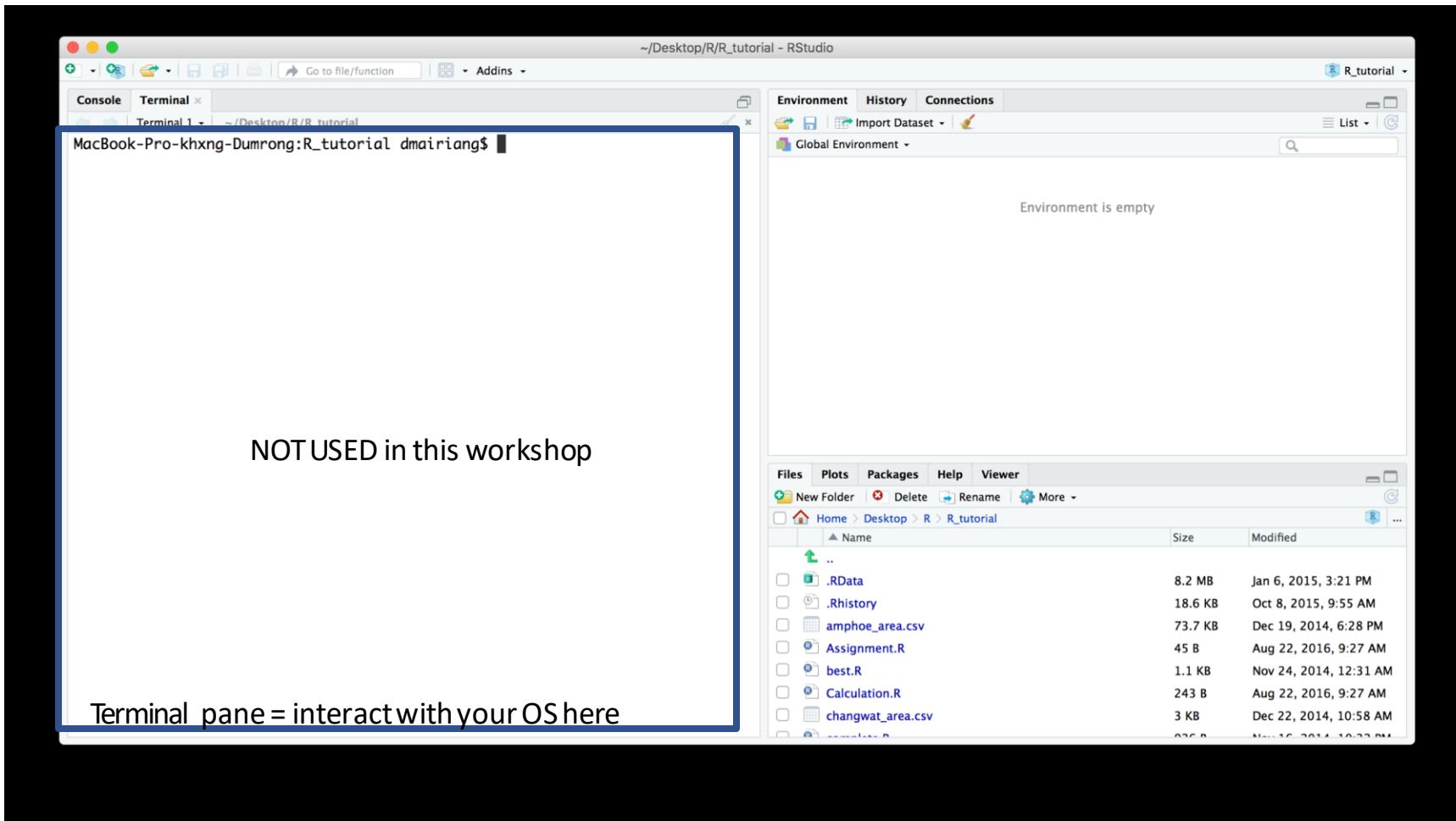


Size: 262.79 MB | [SHA-256: 09E1E38A](#) | Version: 2024.04.2+764 | Released: 2024-06-10

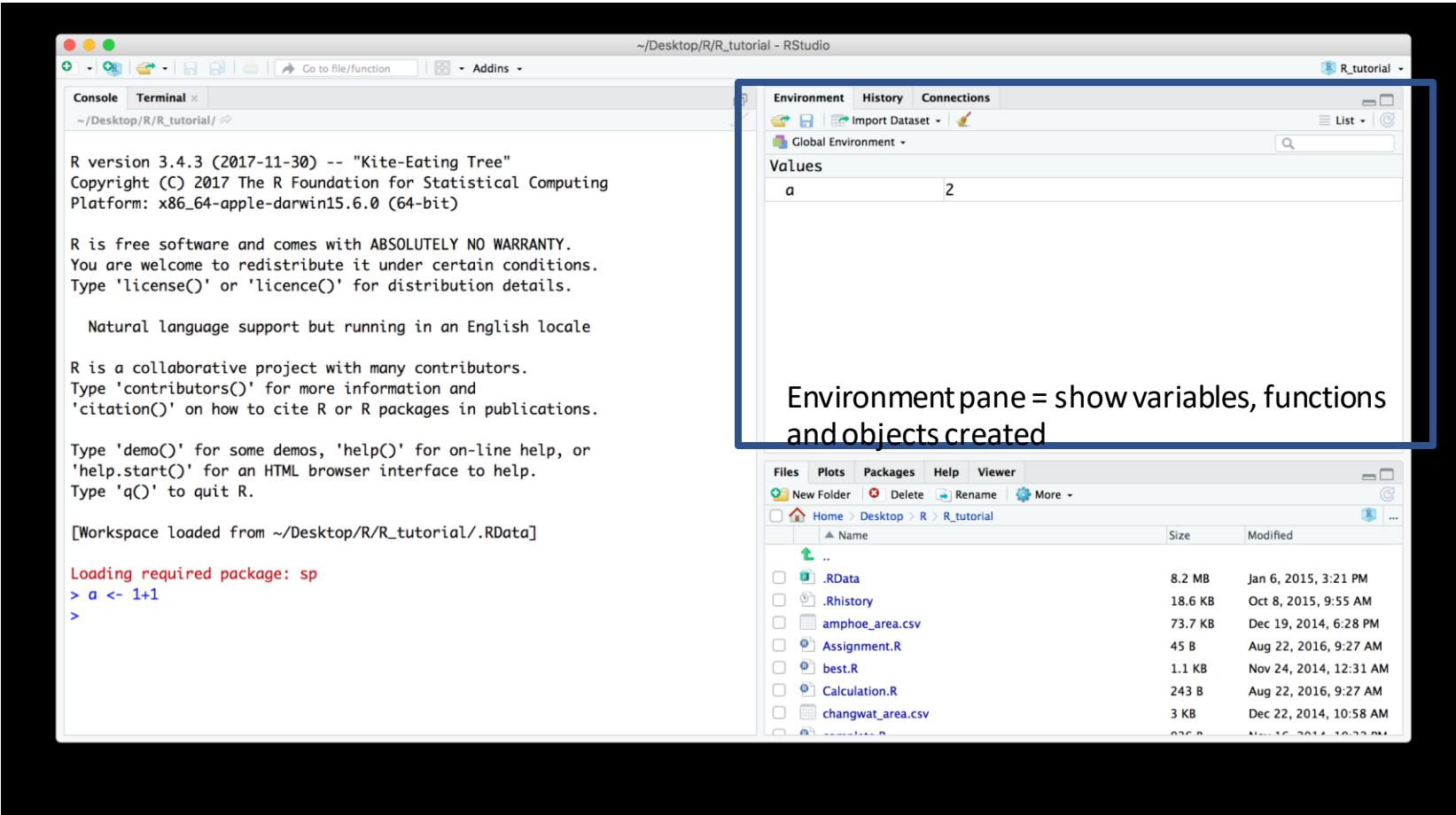
Panes of RStudio



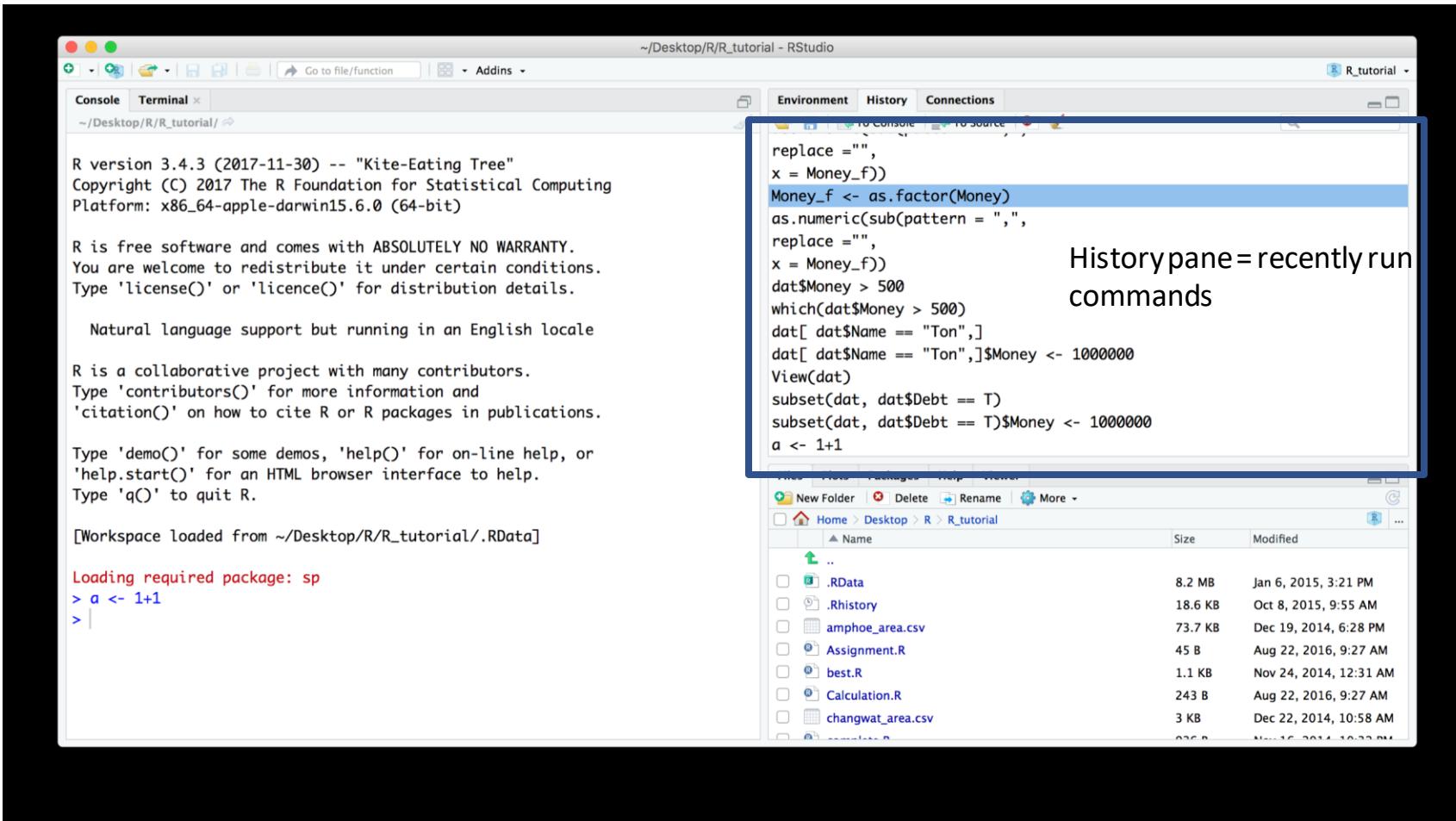
Panes of RStudio



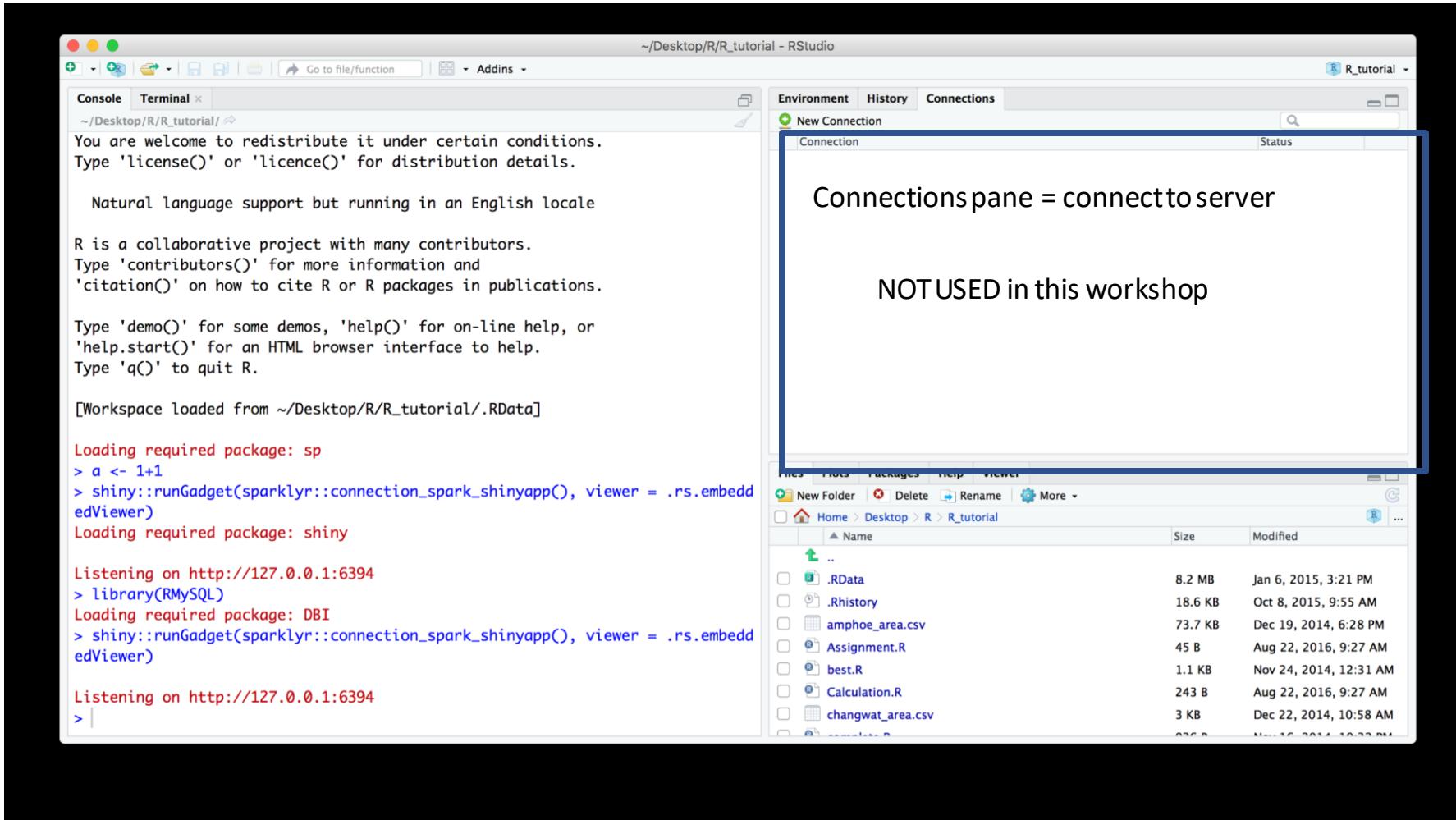
Panes of RStudio



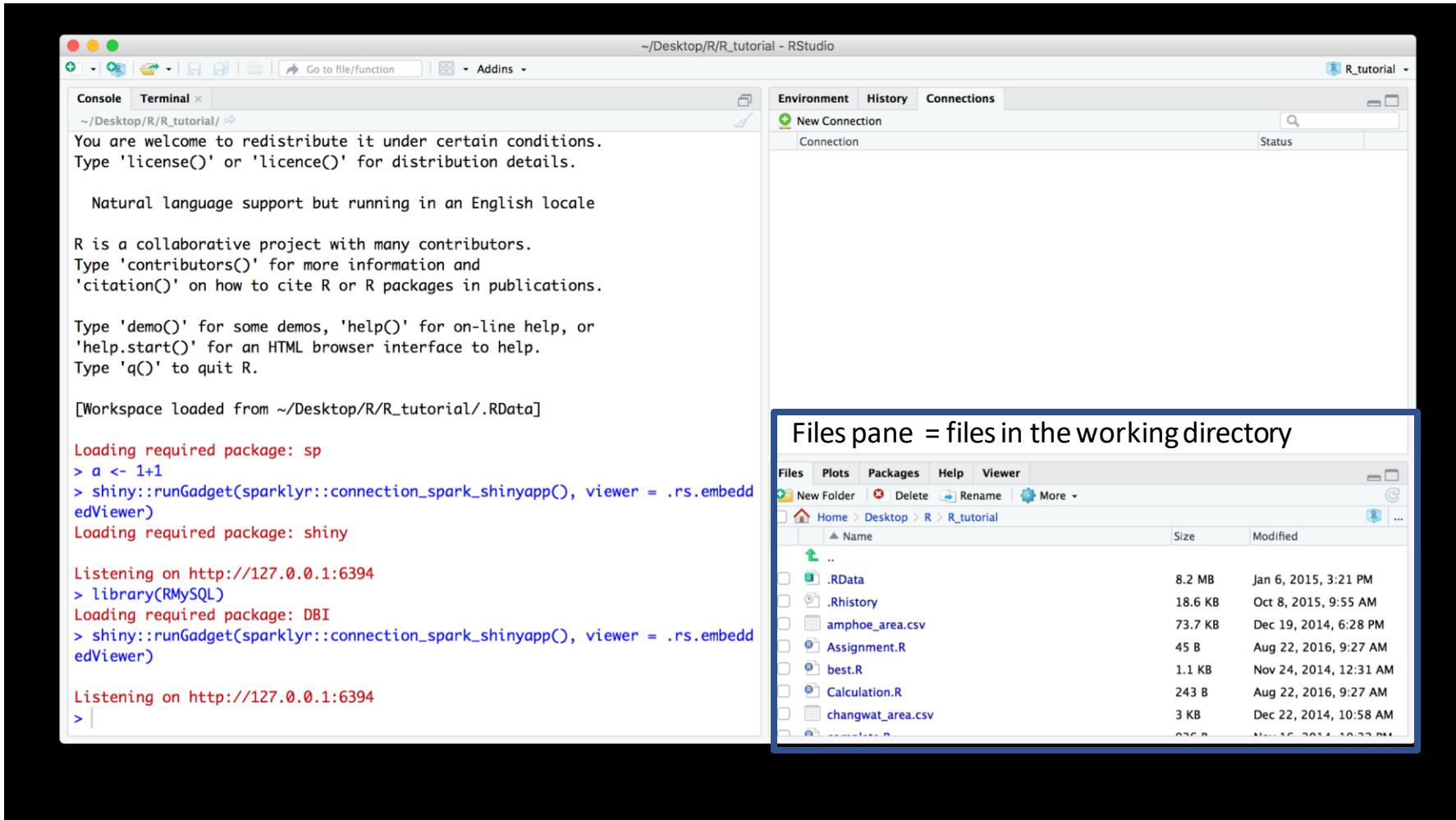
Panes of RStudio



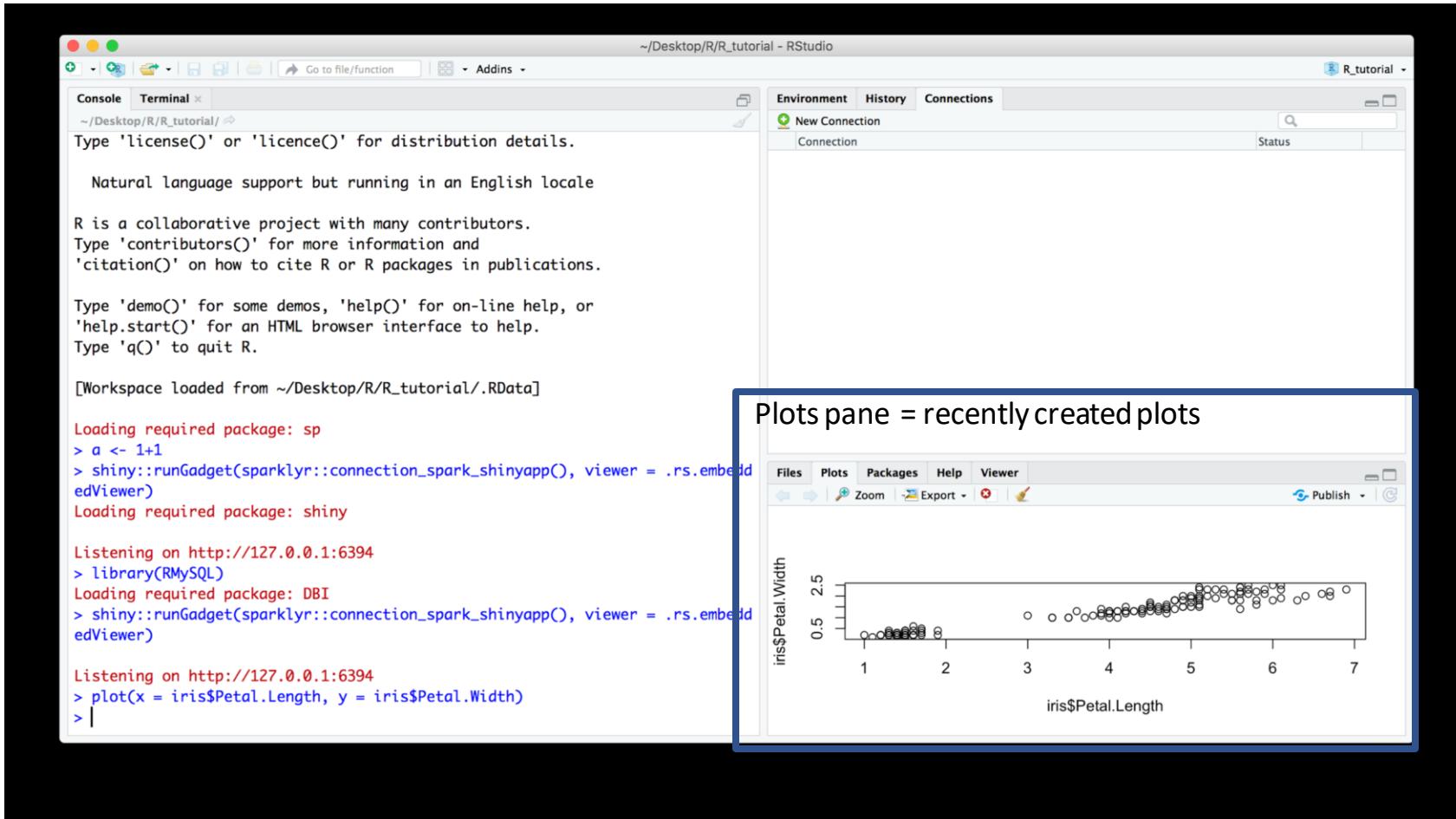
Panes of RStudio



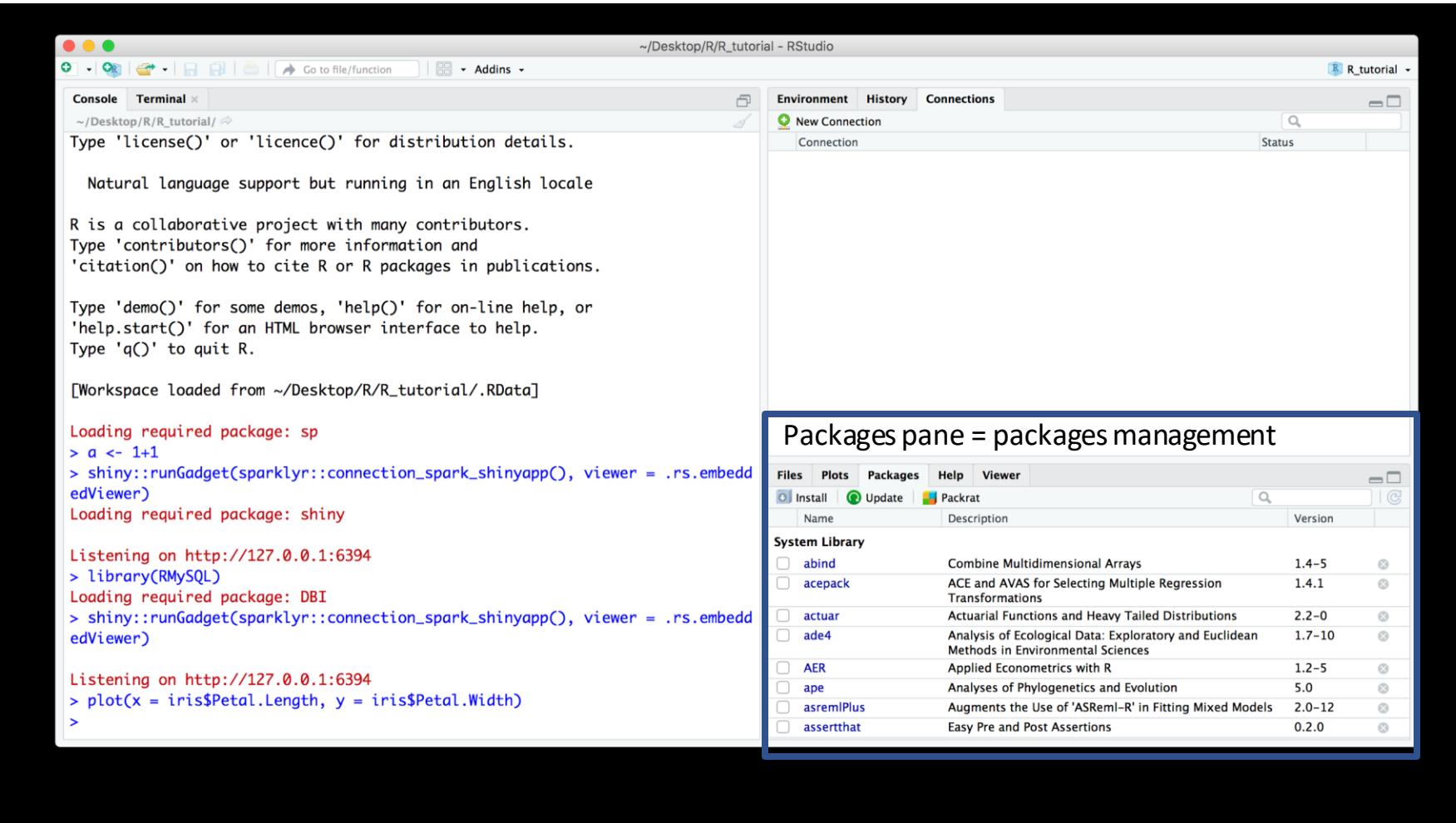
Panes of RStudio



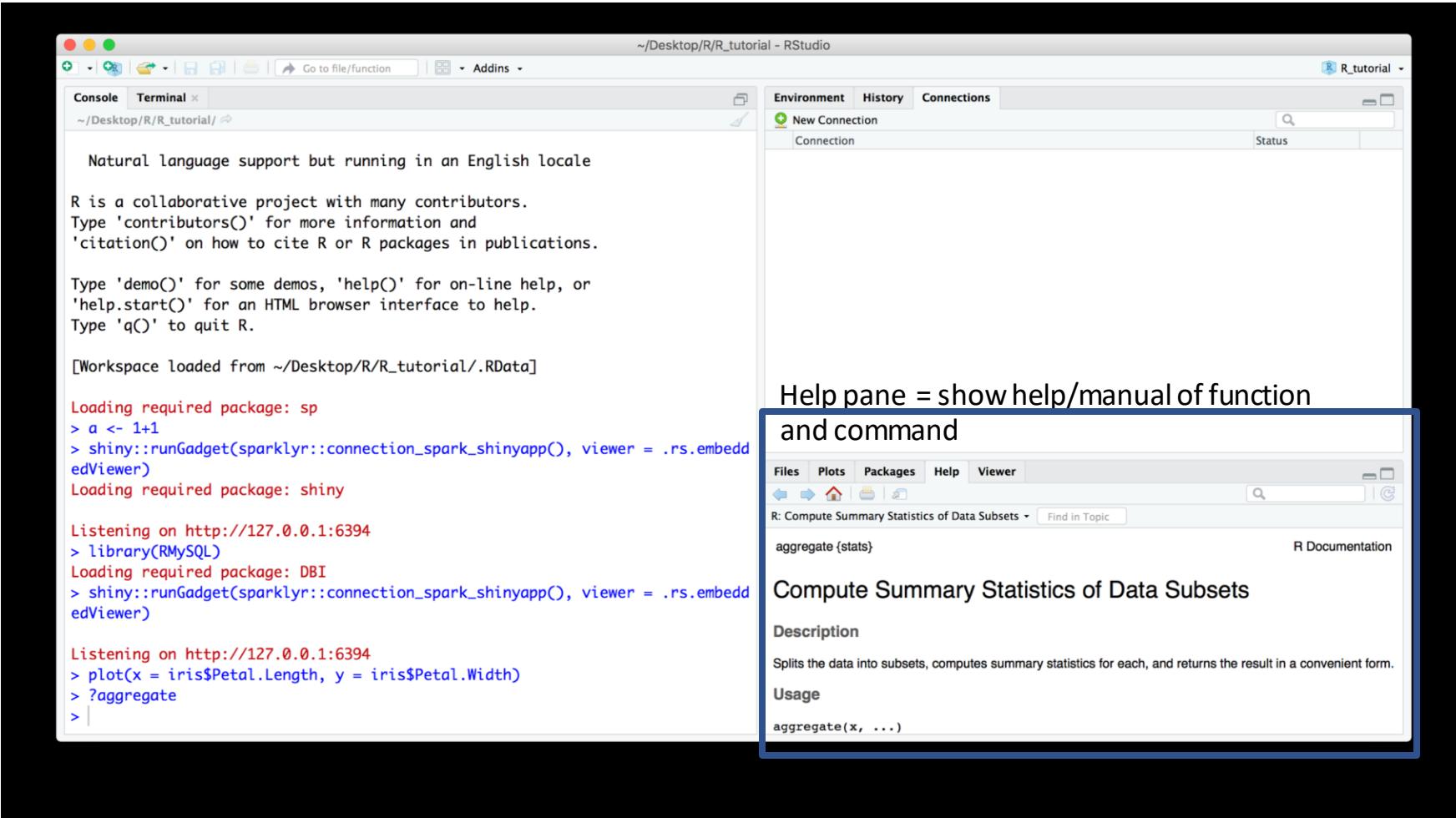
Panes of RStudio



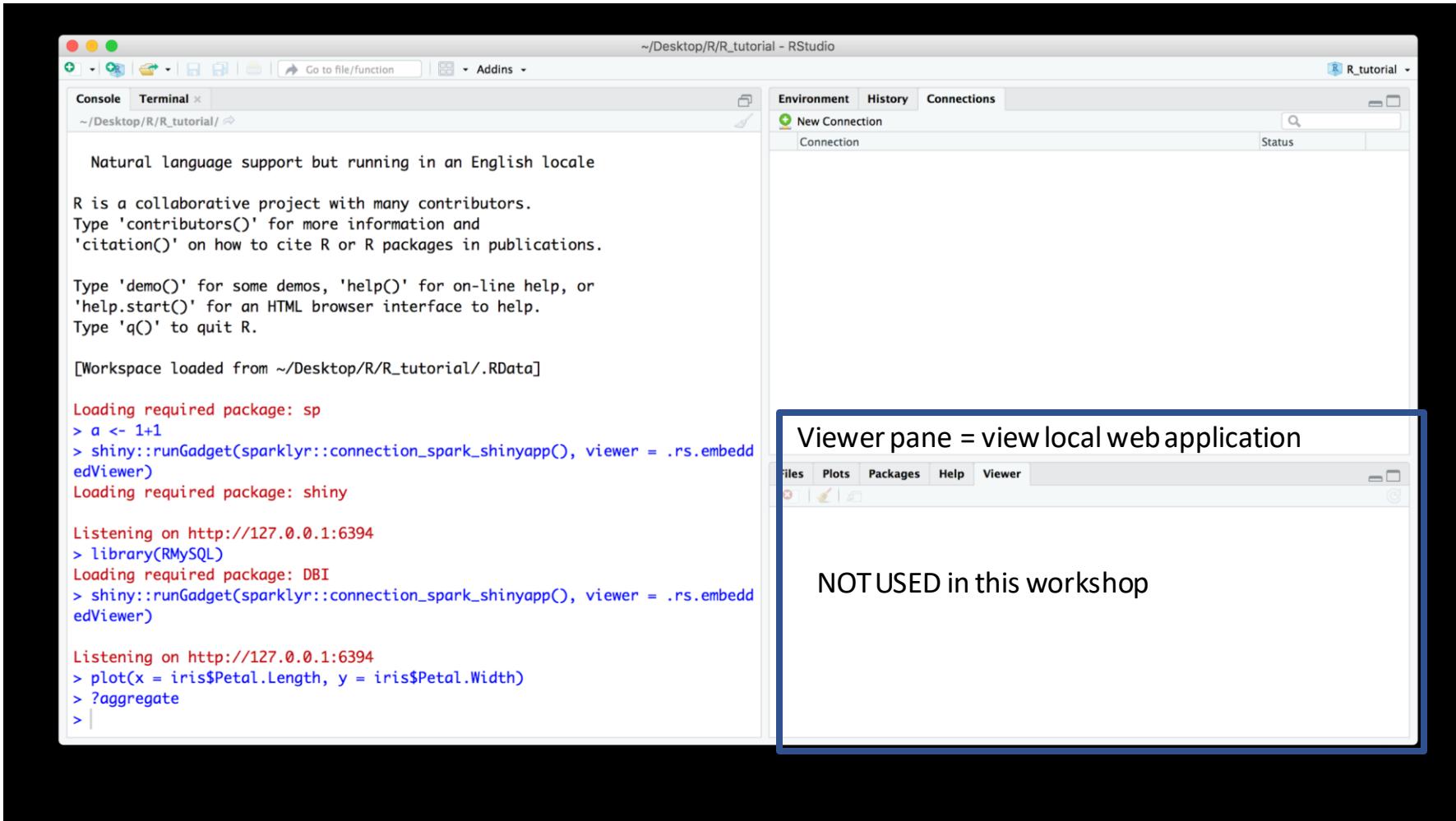
Panes of RStudio



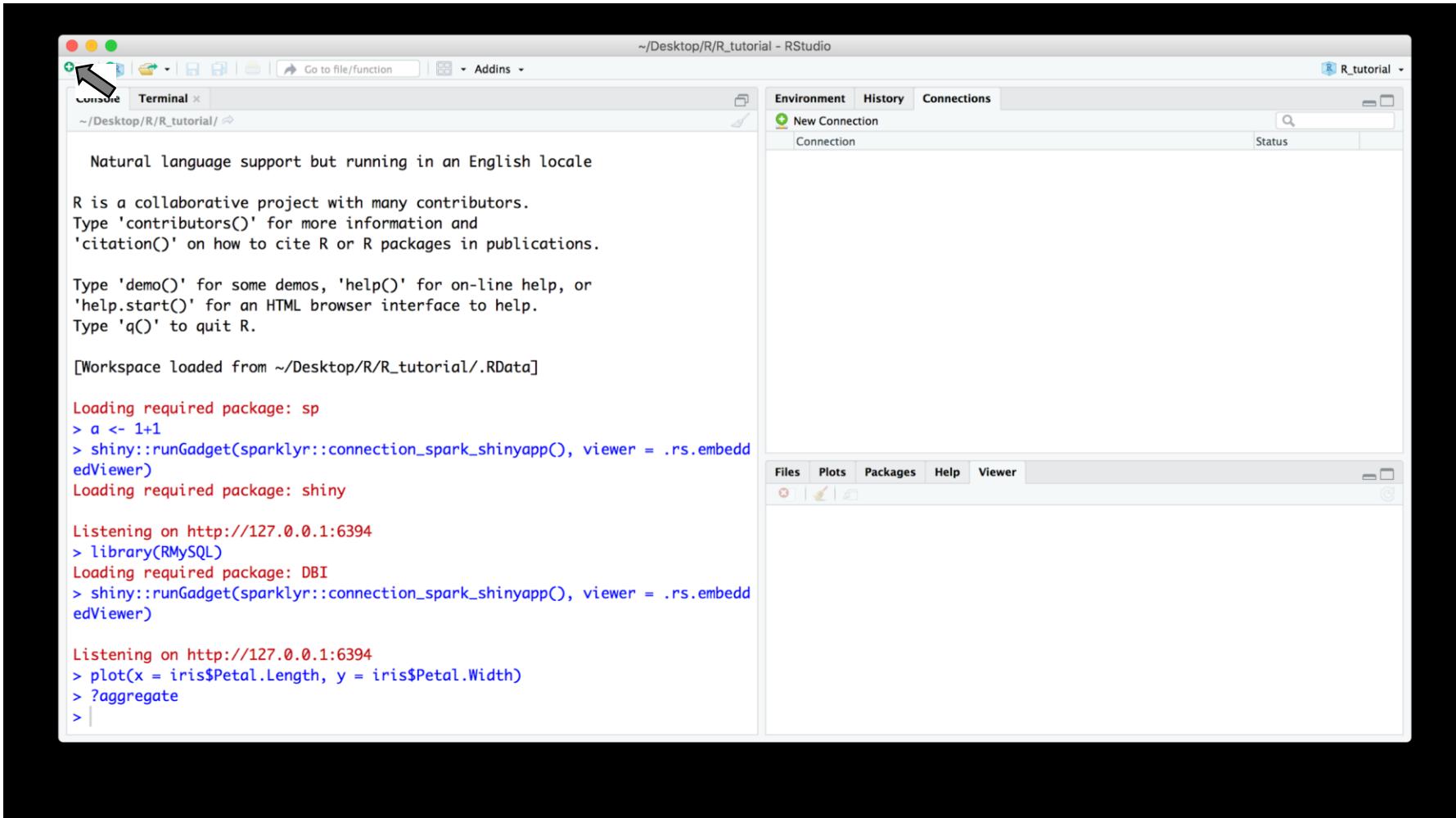
Panes of RStudio



Panes of RStudio



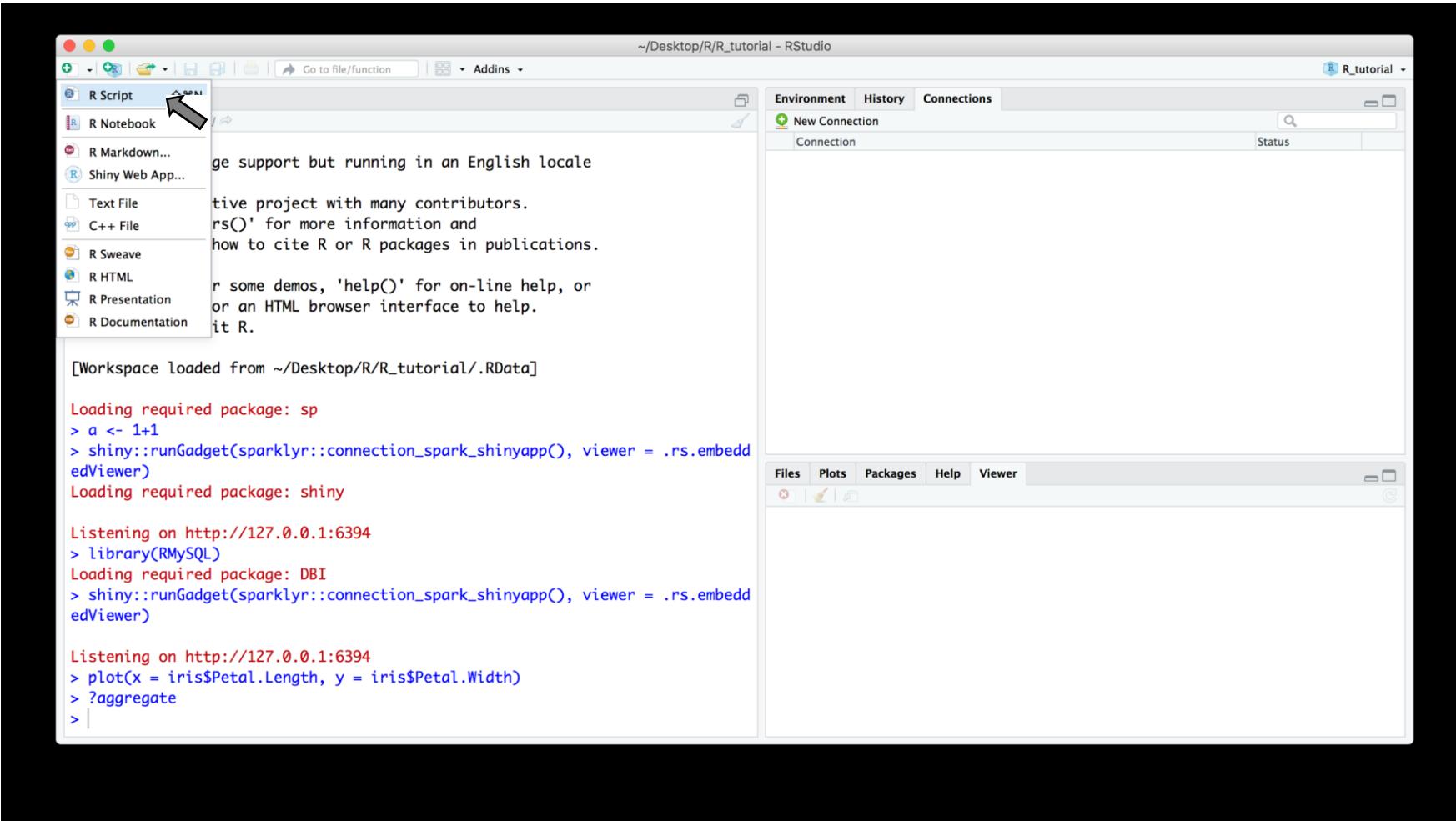
Panes of RStudio



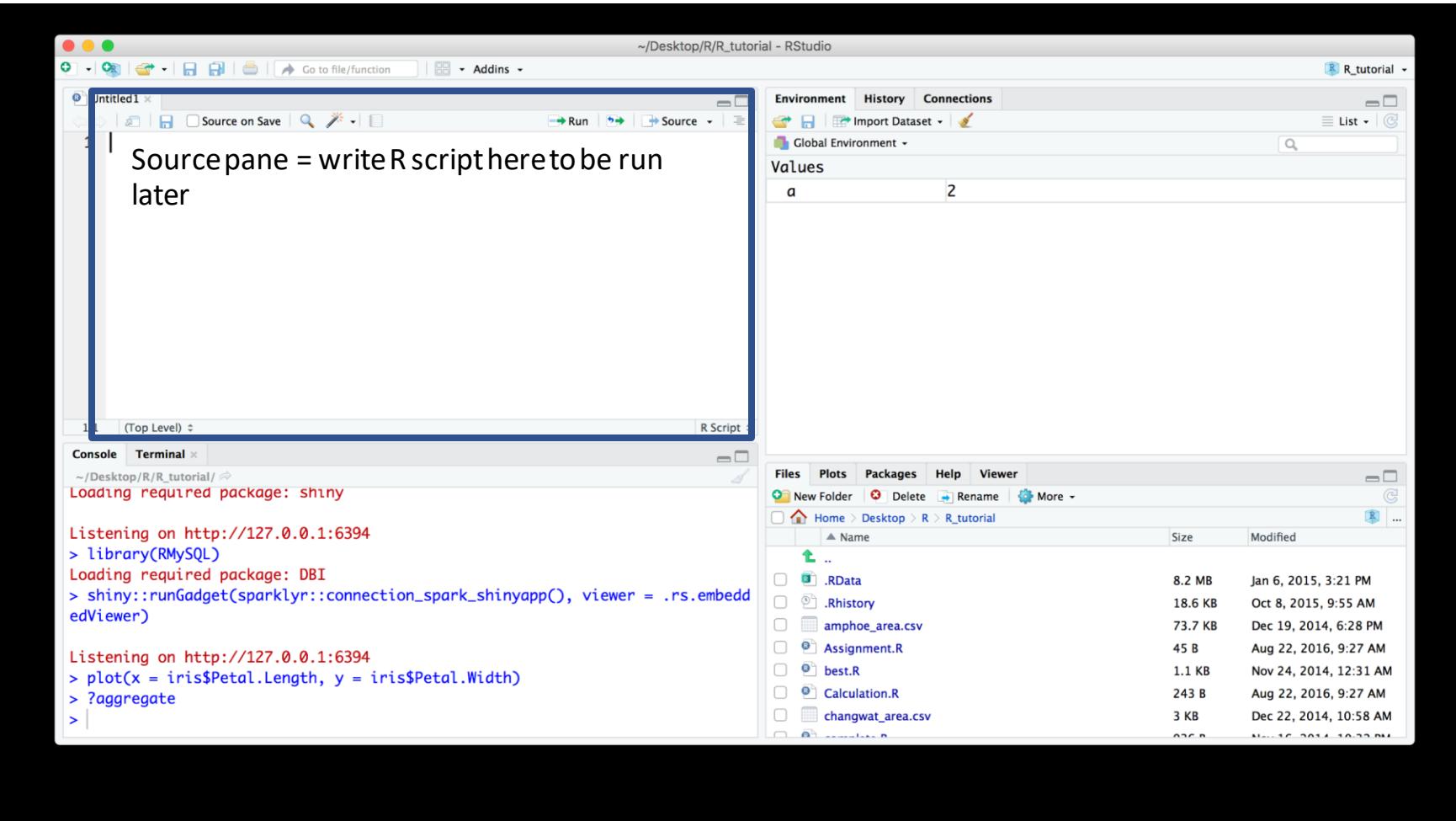
Source Panes

- Commands entered in the Console Pane will be immediately executed.
- To rerun the commands, they must be retyped in the Console Pane or reloaded from the History Pane
- Source pane
 - Write commands in this pane to be saved and executed later.
 - Develop R script here

Open Source Pane



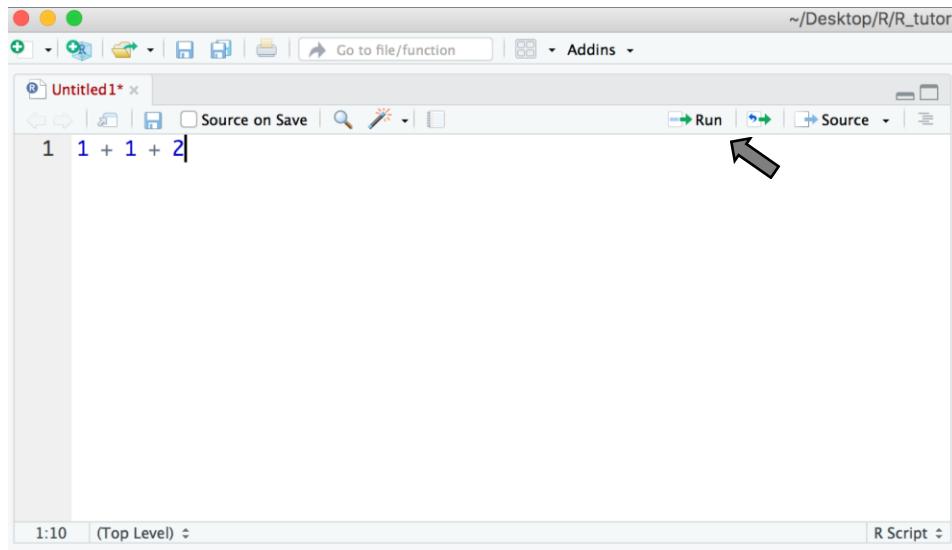
Open Source Pane



Run scripts in Source Pane

Run a single line of the script

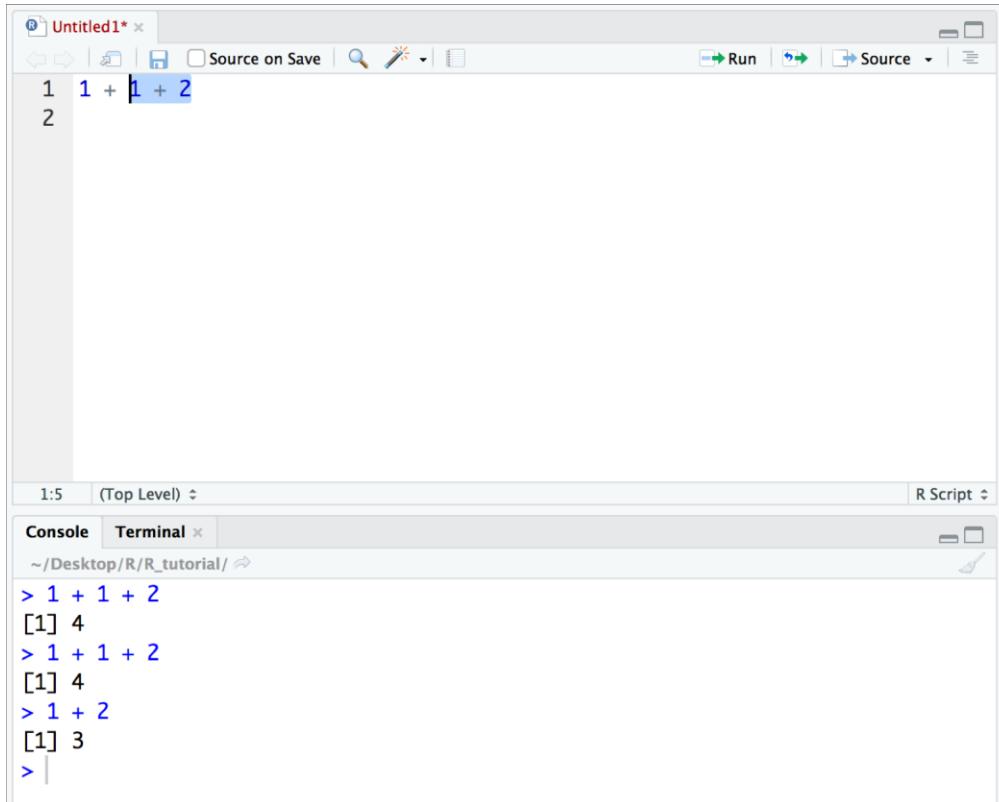
- Leave a cursor at a line
- Click  or 
- Ctrl + Enter or
- Mac: Command + Enter



Run scripts in Source Pane

Run a part of the script

- Highlight the part
- Click  or 
- Ctrl + Enter or
- Mac: Command + Enter



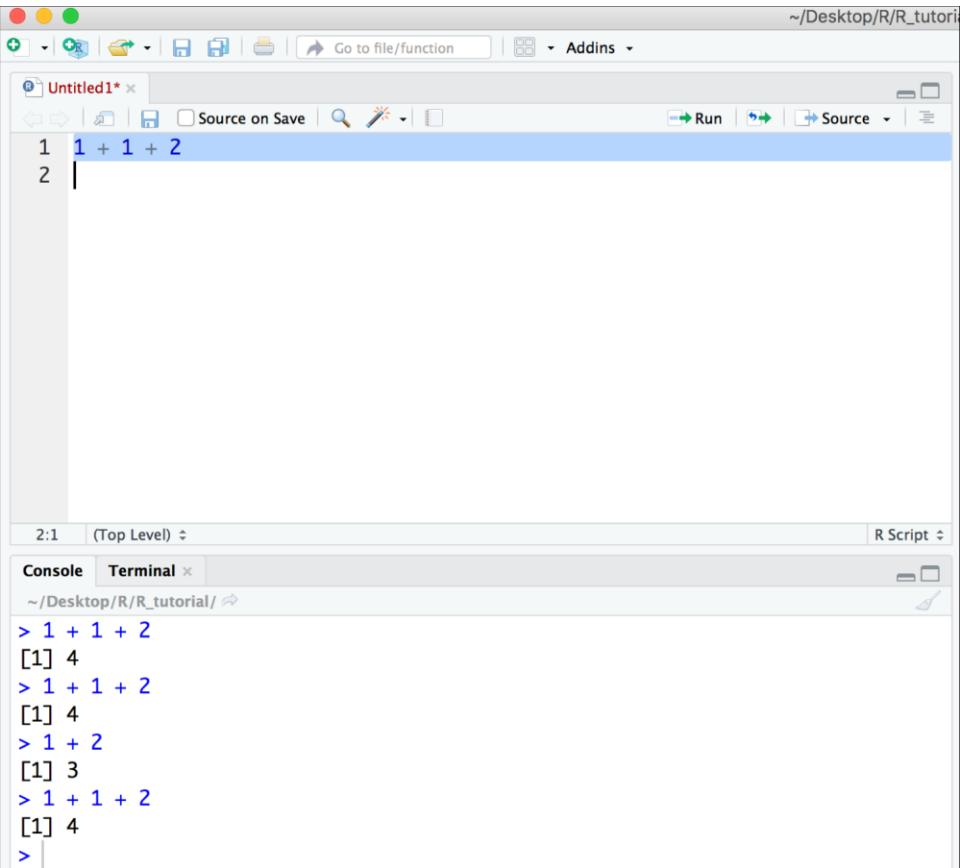
The screenshot shows the RStudio interface. In the Source pane (top), the code `1 1 + 1 + 2` is displayed, with the segment `1 + 1 + 2` highlighted in blue. In the Console pane (bottom), the output of running this code is shown:

```
1:5 (Top Level) > 1 + 1 + 2
[1] 4
> 1 + 1 + 2
[1] 4
> 1 + 2
[1] 3
>
```

Run scripts in Source Pane

Run all lines of the script

- Click the source pane
- Ctrl/Command + A
- Click  or 
- Ctrl/Command + Enter



The screenshot shows the RStudio interface. The top panel is the Source pane, titled "Untitled1*", containing the R code `1 + 1 + 2`. Below it is the Console pane, titled "2:1 (Top Level)", which displays the output of running the script: `> 1 + 1 + 2
[1] 4
> 1 + 1 + 2
[1] 4
> 1 + 2
[1] 3
> 1 + 1 + 2
[1] 4
>`.

Useful keyboard shortcuts

- Ctrl + S = Save the script
- Ctrl + L = Clear the console pane
- Ctrl + Z = Undo and Ctrl + Y = Redo
- Ctrl + X =Cut, Ctrl + C = Copy, Ctrl + V =Paste
- **Tab** = ***Autofill***
- **↑** = ***Recall previously executed command***
- Ctrl + Shift + F10 = Restart R session
- Ctrl + Q = Quit R

More shortcuts: Tools → Keyboard Shortcuts Help

Practical: Packages

- R is powerful and versatile because of “Packages”
- “Packages” are codes/scripts created by users and shared to the R community
- 21,099 available packages deposited at CRAN (As of July 2024)

Practical: Packages

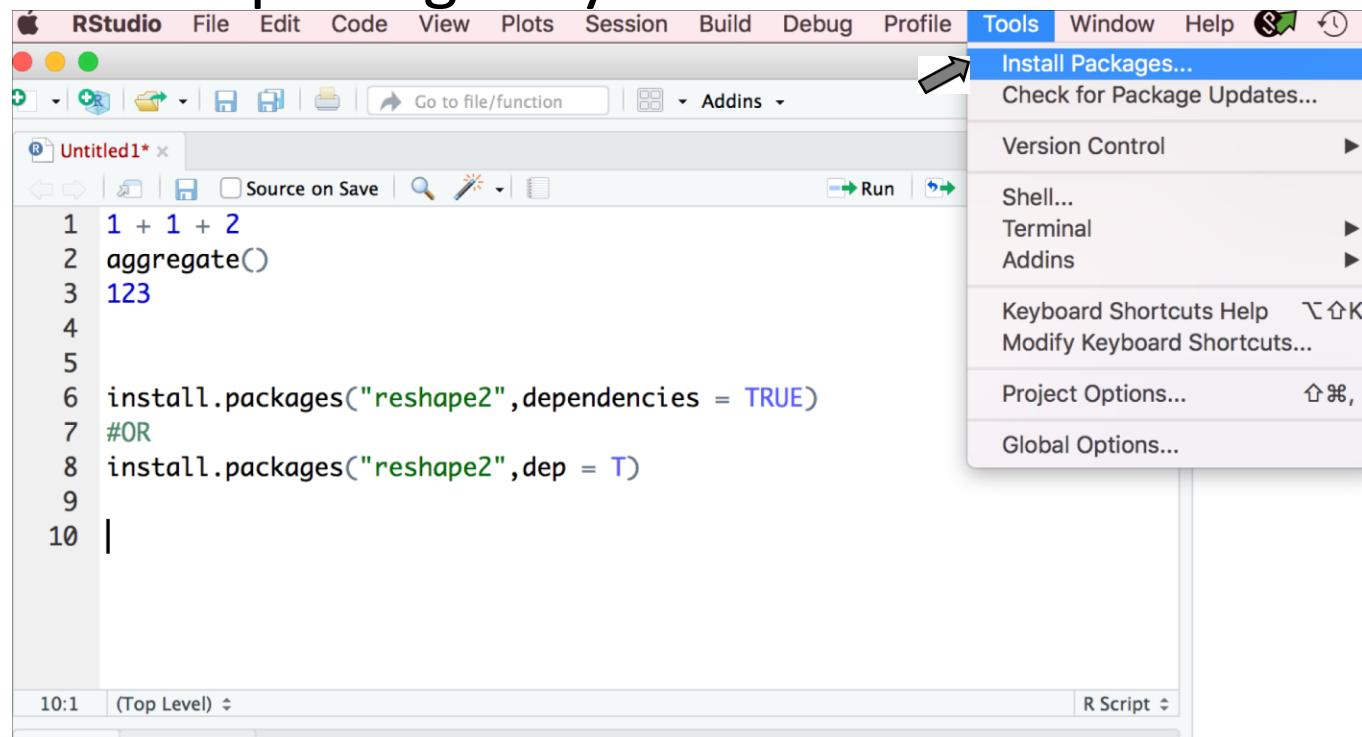
- To install packages by a command line

```
install.packages("reshape2",dependencies = TRUE)  
#OR  
install.packages("reshape2",dep = T)
```

- `install.packages("name of the package in quotation marks", dependencies = TRUE)`
- “`dependencies = TRUE`” means other packages required by this package will also be downloaded

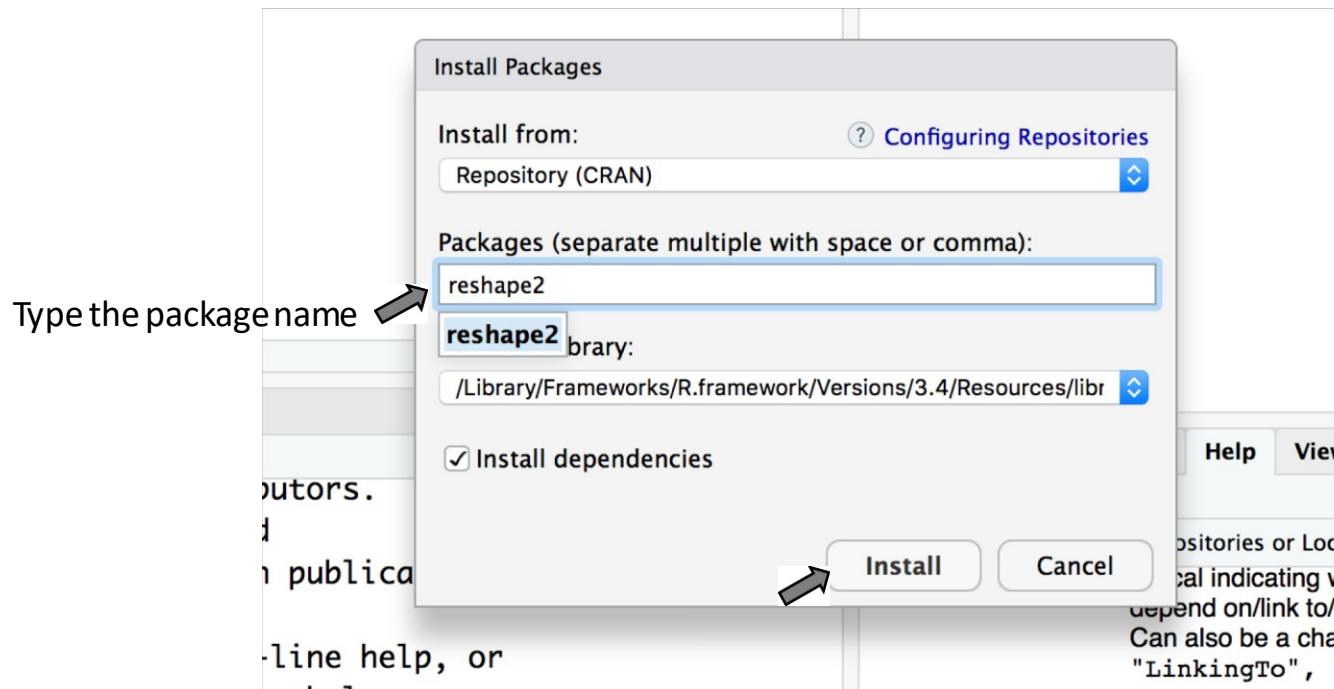
Practical: Packages

- To install packages by RStudio



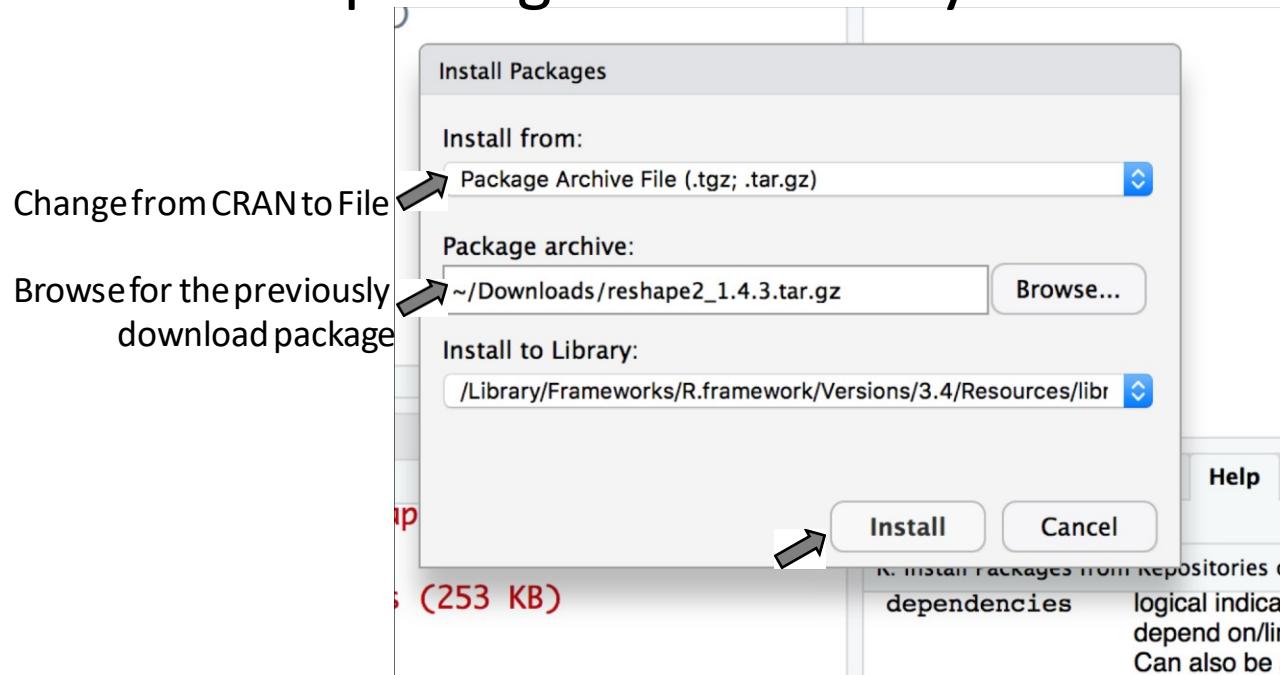
Practical: Packages

- To install packages by RStudio



Practical: Packages

- To install packages “offline” by RStudio

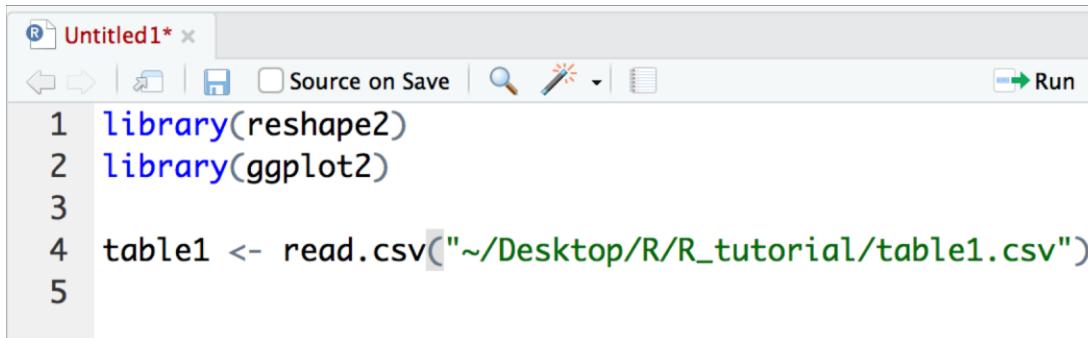


Practical: Packages

- To invoke the package

```
library(reshape2) #In your script  
#OR  
require(rehape2) #In the function/package
```

- Usually at the top of your script/code



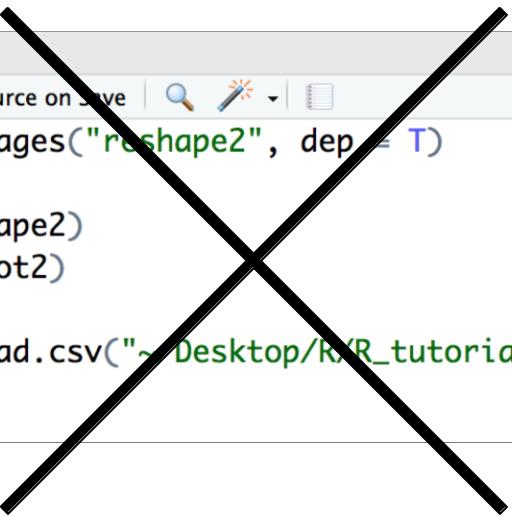
The screenshot shows the RStudio interface with a script window titled "Untitled1". The code in the window is:

```
1 library(reshape2)  
2 library(ggplot2)  
3  
4 table1 <- read.csv("~/Desktop/R/R_tutorial/table1.csv")  
5
```

The "Run" button is visible in the toolbar above the code editor.

Practical: Packages

- DO NOT include “install.packages()” in your script/code
- This will result in reinstalling packages every time the script is run



```
R Untitled1* x
Source on Save | Run | Stop | Save
1 install.packages("reshape2", dep = T)
2
3 library(reshape2)
4 library(ggplot2)
5
6 table1 <- read.csv("~/Desktop/R/R_tutorial/table1.csv")
7 |
```

Practical: Packages

- Your turn:
 - Install and invoke the following packages:
 - reshape2
 - lubridate
 - MASS
 - car
 - Exact
 - hflights
 - readr
 - readxl

Programming Concepts in R

FILE:R2018_Programming_Concepts.R

Before we start...

- R scripts for demonstration are prepared
 - Run scripts and see what happens in your machine
 - Tell us if you see any strange or different results
 - Feel free to copy and modify the scripts for your own work

Calculator

Basic Mathematical Operations

```
1 - #####Basic Mathematical Operations pt 1#####
2 1 + 2 #Addition
3 1 - 2 #Substraction
4 1 / 2 #Division
5 1 * 2 #Multiplication
6 2 ^ 5 #Power
7 sqrt(4) #Square root
8 5 %/% 2 #Integer division
9 5 %% 2 #Modulo
```

- TIP: '#' = comment sign; Nothing after # to the end of the line will be run!!!

Basic Mathematical Operations

```
11 - #####Basic Mathematical Operations pt 2#####
12 log10(100) #Logarithm base 10
13 log(100, base = 10) #Logarithm base 10
14 log(100) #Natural logarithm
15 exp(1) #Exponential i.e. e^1
16 round(2.111, digits = 1) #Rounding
17 floor(2.111) #Round down to integer
18 ceiling(2.111) #Round up to integer
19 abs(-123) #Absolute value
```

Basic Logical Operations

```
21 - #####Basic Logical Operations pt 1#####
22 20 == 18 #Comparing whether 'left' equals to 'right.'
23
24 20 = 18 #This is wrong. Try and see what happens.
25
26 20 != 18 #Comparing whether 'left' does not equal to 'right.'
27 20 < 18 #Comparing whether 'left' is less than 'right.'
28 20 > 18 #Comparing whether 'left' is greater than 'right.'
29 20 <= 18 #Comparing whether 'left' is less than or equal to 'right.'
30 20 >= 18 #Comparing whether 'left' is greater than or equal to 'right.'
31
32 20 =~ 18 #This is wrong. Try and see what happens.
33 20 =>~ 18 #This is wrong. Try and see what happens.
```

Basic Logical Operations

```
35 - #####Basic Logical Operations pt 2#####
36 (20 > 18) & (20 < 18) #'AND' operation
37 (20 > 18) | (20 < 18) #'OR' operation
38 !(20 < 18) #'NOT' operation
```

Variable Assignment

Variable assignment

```
40 ####Variable assignment pt 1####
41 (20 > 18) & (20 < 18)
42 #Versus
43 a <- (20 > 18)
44 b <- (20 < 18)
45 c <- a & b
46 print(c) #'print()' is to show the values of the variable
47
48 d <- (20 == 18)
49 e <- c | d #Versus ((20 > 18) & (20 < 18)) | (20 == 18)
50 print(e)
```

- Critical concept in programming
- Save results/outputs for later
- Make your code more legible
- More legible = Easier for debugging

Variable assignment

- How to assign values to variables

```
52 - #####Variable assignment pt 2#####
53 a = 1 #Generic: Assign the 'right' value to the 'left' variable
54
55 a <- 1 #R: Assign the 'right' value to the 'left' variable
56 1 -> a #R: Assign the 'left' value to the 'right' variable
57 a <- 1 -> b #R: Multiple assignments
58 a <- b <- 1 #R: Multiple assignments
```

- ‘=’ and ‘<-’ are mostly interchangeable
- Personally, I prefer ‘<-’ to avoid the confusion between ‘=’ and ‘==’

Variable assignment

- Naming your variables
 - Start with alphabet or ‘.’
 - No space or special character in the name except ‘.’ and ‘_’
 - Be careful! R is case-sensitive

```
60 ####Variable assignment pt 3####
61 a <- 123 #Correct
62 a1 <- 123 #Correct
63 1a <- 123 #Incorrect
64 a 1 <- 123 #Incorrect
65 a_1 <- 123 #Correct
66 a.1 <- 123 #Correct #Different meaning in Java or Python
67 a! <- 123 #Incorrect
68 a? <- 123 #Incorrect
69 .a <- 123 #Correct
70 print(a1) #R is case-sensitive
71 print(A1) #R is case-sensitive
```

Types of Data

Basic types of data

```
73 - #####Types of data pt 1#####
74 a <- 2 #numeric
75 b <- TRUE #logical
76 c <- "Hello, World!" #character #Must be in " " or '
77 c <- Hello, World! #Try and see
78 d <- NA #missing (logical)
79 e <- NaN #'Not a Number' = ill-defined e.g. 0/0 (logical)
80
81 typeof(a) #Check the 'R internal' type of data by 'typeof()'
82 class(a) #Check the 'customized' type of data by 'class()'
83 #class() is used more often.
84
85 is.logical(b) #'is.logical()' is for checking if the data is 'logical'
86 is.logical(d)
87 is.na(b) #'is.na()' is an essential function for managing missing data.
88 is.na(d)
89 #is.nan(); is.numeric(); is.character() and others
```

Complex types of data

- More complex types of data or ‘objects’
- Containing multiple elements of basic data types
(i.e. They are still based on basic types of data).
- Some types were developed for certain applications
(e.g. spatial objects, survival objects)
- They might be converted to basic types of data.

Factor

- Recoding ‘categorical’ or ‘ordinal’ values to calculable values
 - Character + Numeric
- Example: Categorical variables in regression analysis

```
90 - #####Types of data pt 2#####
91 a <- "good"
92 class(a)
93 typeof(a)
94 af <- factor(a, levels = c("terrible", "bad", "neutral", "good", "excellent"))
95 print(af)
96 class(af)
97 typeof(af)
98 as.numeric(af) #Convert to numeric, i.e. extracting numerical elements
99 as.character(af) #Convert to character, i.e. extracting character elements
```

Date' and 'Time'

- Recoding texts of 'date', 'time' or 'datetime' data to calculable values
- Example: Used in time series analyses, survival analyses

```
101 - #####Types of data pt 3#####
102 library(lubridate)
103
104 a <- "27-3-2018"
105 class(a)
106 typeof(a)
107 ad <- dmy(a) #function in lubridate package converting 'character' to 'date'
108 print(ad)
109 class(ad)
110 typeof(ad)
111 as.numeric(ad) #Convert to numeric (i.e. Days since 1-1-1970)
112 as.character(ad) #Convert to character, i.e. extracting character elements
```

Data type conversion

- Frequently used commands for data type conversion

```
114 ####Conversion#####
115 a <- 1
116 print(a)
117 as.character(a) #Convert to character
118 as.factor(a) #Convert to factor; cannot change levels or labels
119 factor(a, levels = c(3,2,1)) #Specify levels
120 factor(a, levels = c(1,2,3), labels = c("one","two","three")) #Specify labels
121
122 b <- "111"
123 as.numeric(b)
124 c <- "1,111"
125 as.numeric(c) #CAUTION: Data conversion may introduce missing data
126 d <- "1111"
127 as.numeric(d)
```

Data Structure
(Data container)

Vector

- One-dimensional container
- Every member in the vector must be the same type
- `c()` to construct a vector

```
114 ####Vector pt 1####
115 A <- c(1,2,3,4)
116 print(A)
117 class(A)
118
119 B <- c("a","b","c","d")
120 print(B)
121 class(B)
122
123 C <- c(TRUE, FALSE, T, F)
124 print(C)
125 class(C)
```

```
127 ####Vector pt 2####
128 D <- c(1,NA,3,0/0)
129 print(D)
130 class(D)
131
132 E <- c(1,TRUE,0/0,"a")
133 print(E)
134 class(E)
```

Matrix

- Two-dimensional container
- Every member in the matrix must be the same type
- `matrix()` to construct a matrix

```
136 ####Matrix pt 1#####
137 a <- 1:8 #a <- c(1,2,3,4,5,6,7,8) or a <- seq(from=1,to=8,by=1)
138 print(a) #vector of data
139 A <- matrix(data = a,nrow = 4)
140 #load 'a' vector into a matrix
141 #nrow' indicates number of rows
142 print(A)
143
144 B <- matrix(data = a,ncol = 4) #'ncol' indicates number of columns
145 print(B)
146
147 C <- matrix(data = a,ncol = 4, byrow = T)
148 #'byrow' fill values by row
149 # Default is by column (i.e. byrow = F)
150 print(C)
```

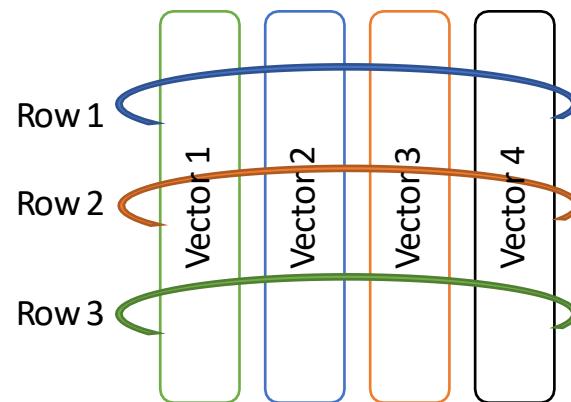
Matrix

- Two-dimensional container
- Every member in the matrix must be the same type
- `matrix()` to construct a matrix

```
152 - #####Matrix pt 2#####
153 D <- matrix(data = c(1:6,NA,T),ncol = 4, byrow = T)
154 print(D) #Look at the last member of the matrix
155
156 E <- matrix(data = c(1:6,T,"a"),ncol = 4, byrow = T)
157 print(E) #Look at the type of data in the matrix
```

Data frame

- Two-dimensional container
- In the “data handling” section of this workshop, we will mostly use data frames
- Every member in each “column” of the data frame must be the same type
- Each row can contain different types of data
- Imagine multiple vectors with identical lengths with each member at the same position bound together as a ‘row.’



Data frame

- `data.frame()` to construct a data frame

```
159 ####Data frame pt 1####
160 A <- data.frame( name = c("A", "B", "C"), #Vector 1 assigned as 'name' column
161           weight = c(50,60,55), #Vector 2 assigned as 'weight' column
162           height = c(150,166,162)) #Vector 3 assigned as 'height' column
163 print(A)
164
165 A2 <- data.frame(c("A", "B", "C"), #No column names assignment
166                   c(50,60,55),
167                   c(150,166,162))
168 print(A2)
169
170 B <- data.frame( name = c("B", "C"),
171           weight = c(50,60,55),
172           height = c(150,166,162)) #Try and see what happens
```

Data frame

- `data.frame()` to construct a data frame

```
175 #####Data frame pt 2#####
176 C <- data.frame( name = c("A", "B", "C"),
177                   weight = c(50, 60, "Not measured"),
178                   height = c(150, 166, 162))
179 print(C) #Try and see
180 A$weight #'A$weight' is for calling the 'weight' column of 'A' data frame
181 #We will get into how to access data in the data frame in the later session
182 class(A$weight)
183
184 C$weight
185 class(C$weight)
```

List

- Multi-dimensional container
- Each member in the list can be any type of data, or even data container (i.e. a data frame in a list > two dimensions)
- No restriction of length for each member
- Used as a container of results of analysis (e.g. regression results)

List

- `list()` to construct a list

```
188 ####List####
189 a <- c(T,F)
190 b <- 1:6
191 c <- c("A","E","I","O","U")
192
193 A <- list(a,b,c) #Combine vectors as a list
194 print(A)
195
196 A2 <- list(col1 = a, col2 = b, col3 = c) #'name' can be assigned to each member
197 print(A2)
198
199 d <- data.frame( name = c("A","B","C"),
200                               weight = c(50,60,55),
201                               height = c(150,166,162))
202 B <- list(A,d) #list and data frame in the list
203 print(B)
```

Practical 1

Practical 1: Data type conversion

- Numerical data are sometimes created or imported to R as ‘factor’ data.
- Incorrectly using factor data can be problematic

```
1 C <- data.frame( name = c("A", "B", "C"),
2                   weight = c(50, 60, "Not measured"),
3                   height = c(150, 166, 162))
4 weight <- C$weight
5 #Convert weight from kilograms to pounds
6 #1 Kilo = 2.2 pounds
7 weight * 2.2 #Try and see
```

Practical 1: Data type conversion

1. Convert 'weight' to numerical data
2. Convert 'weight' to pound (1 kilo ~ 2.2 pound)
 - HINT1: Correct answer = c(110, 132, NA)
 - HINT2: as.numeric(); as.character() for data type conversion

```
1 C <- data.frame( name = c("A", "B", "C"),
2                   weight = c(50, 60, "Not measured"),
3                   height = c(150, 166, 162))
4 weight <- C$weight
5 #Convert weight from kilograms to pounds
6 #1 Kilo = 2.2 pounds
7 weight * 2.2 #Try and see
```

Flow Control

Curly brackets { }

- ‘if-else’, ‘for’, ‘while’ and ‘function’

```
command (conditions or values) {  
    do something  
    do something  
    do something  
}
```

If and Else

- Modify the behavior of the code based on the input
- Evaluate the input -> Select what to do -> Generate the output
- Note: If-Else must address all possible conditions

```
192 - #####If and else#####
193 A <- 1 #Assign the input here
194
195 - if(!is.numeric(A)){
196   print("A is not a number")
197 - }else if(A %% 2 == 0){
198   print("A is even")
199 - }else if(A %% 2 == 1){
200   print("A is odd")
201 - }else{
202   print("A is not an integer")
203 }
204
205 #Try changing A to 2, 1.1, NA and 0/0
```

For loop

- Repeating an operations with changing inputs
- NOTE: ‘For loop’ in R is slow (try row/column operations and apply())

```
220 - #####For loop#####
221 A <- c(1,2,3,4,5,6,7)
222 for(i in A){
223   #'i' is a temporary variable with its value = each member of A
224   #Reassignment of 'i' occurred at every new round
225   print(i)
226 }
227
228 B <- letters #letters and LETTERS are built-in vectors containing alphabets
229 for(j in B){
230   #'j' is a temporary variable with its value = each member of A
231   #Reassignment of 'j' occurred at every new round
232   print(j)
233 }
```

While loop

- Repeating an operations until the ‘breaking condition’ is triggered
- CAUTION: ‘Infinite loop’ = the ‘breaking condition’ is never triggered
- NOTE: ‘While loop’ in R is slow

```
222 - #####While loop#####
223 i <- 1
224
225 - while(i < 100){ #Breaking/Exiting condition
226   print(i) #Do something here
227   i <- i + 1 #DO NOT forget to change breaking condition!!!
228 }
```

Practical 2

Practical 2: For loop

- ‘paste()’ is a function that combines two or more text data into one
- Try `paste("I", "love", "you.")`
- ‘paste0()’ is a function that combines two or more text data into one without adding a space between texts
- Try `paste0("I", "love", "you.")`

Practical 2: For loop

1. Our input is 2005:2018 (i.e. 2005, 2006,...,2017, 2018)
2. We will use the for loop and the ‘paste’ function to generate the following sentences:
 - This year is 2005.
 - This year is 2006.
 - This year is 2007.
 - ...
 - ...
 - This year is 2018.

```
1 - for(k in 2005:2018){  
2   #Do something with k  
3   #print(something)  
4 }
```

Practical 2: For loop

CHALLENGE

1. Leap years are divisible by 4
2. For leap years, add 'This is a leap year.' at the end of the sentence
3. Generate the following sentences:
 - This year is 2005.
 - ...
 - This year is 2008. This is a leap year.
 - ...
 - This year is 2018.
- HINT 1: If-else
- HINT 2: Modulo

Function

Function

- You can customize your own function
- Function calls multiple lines of code in a simple command
- NOTE: “Package” is a bundle of functions, manual/documentations and sample datasets

```
192 - #####If and else#####
193 A <- 1 #Assign the input here
194
195 - if(!is.numeric(A)){
196   print("A is not a number")
197 - }else if(A %% 2 == 0){
198   print("A is even")
199 - }else if(A %% 2 == 1){
200   print("A is odd")
201 - }else{
202   print("A is not an integer")
203 }
```

Function

- Function should be defined at the beginning of the code after loading packages

```
230 - #####Function pt 1#####
231 library(reshape2) #Nothing to do with the code
232 #Just demo how the code should look like
233 odd_even <- function(A){ #Define the 'odd_even' function
234   if(!is.numeric(A) | is.nan(A)){#Debugged for NaN
235     result <- "Your input is not a number"
236   }else if(A %% 2 == 0){
237     result <- "Your input is even"
238   }else if(A %% 2 == 1){
239     result <- "Your input is odd"
240   }else{
241     result <- "Your input is not an integer"
242   }
243   return(result)
244 }
245
246 odd_even(A = 12) #Call the function by name
247 odd_even(0/0)
```

Function

- Function can take multiple arguments
- Default value may be defined

```
249 - #####Function pt 2#####
250 - testFn <- function(A,B,C = 2){#C is 2 by default
251   result <- (A+B)*C
252   return(result)
253 }
254
255 testFn(A = 1, B = 2) #C is 2 by default
256 testFn(A = 2, B = 3, C = 4)
257 testFn(0,4,1) #A = 0, B = 4, C = 1 -> Assign by the order of arguments
258 testFn(C = 0,B = 4, A = 1) #Specifically assign value to A,B,C
```

Help!!!

Help!!!

- General programming concepts in R are similar to other languages
- Tough parts are ‘function’
- Find the right function and learn to use it can be difficult

```
260 - #####Help#####
261 help("shapiro.test")
262 ?shapiro.test
263 ??shapiro.test
```

Prepare your workspace

Working directory

- `getwd()` = the current working directory
 - Anything saved without a specified path will be here
- `setwd()` = change to the new working directory
 - Organizing the location in which files will be read and written

Before running your codes

- Restart “R session”: Session -> Restart R
- Clear the environment
- Check your working directory



Practical 3

Practical 3: Customize your function

- Quadratic equation
 - $ax^2 + bx + c = 0$
- Quadratic formula is the solution of the quadratic equation
 - $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Practical 3: Customize your function

1. Create a function 'quardForm()' that takes input a, b, c from a quadratic equation to solve for x
2. Test your function with the following equations:
 - $x^2 + 4x - 21 = 0$
 - $10x^2 + 13x - 3 = 0$
 - $x^2 - 25 = 0$
 - $x^2 + 4 = 0$

Practical 3: Customize your function

- HINT: quadratic formula needs to return two values

```
1 quadForm <- function(A,B,C){  
2   #answer1 <- ???  
3   #answer2 <- ???  
4   return(c(answer1, answer2))  
5 }
```