

Quantitative Methods in R

2 – Meet R

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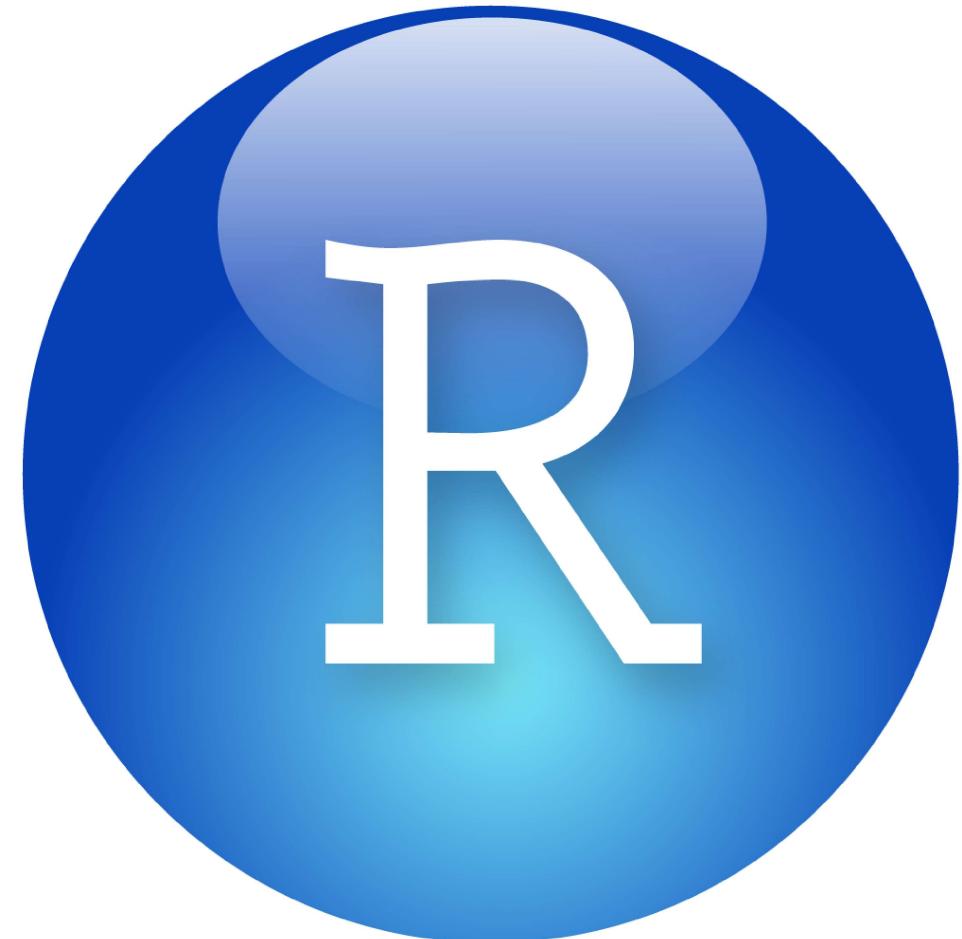
Data Science

For more details visit [Ryan Safner page](#)

- **You go into data analysis with the tools you know, not the tools you need**
- The next 2-3 lectures are all about giving you the tools you need
 - Admittedly, a bit before you know what you need them *for*
- We will extend them as we learn specific models

R

- Free and open source
- A very large community
 - Written by statisticians for statistics
 - Most packages are written for R first
- Can handle virtually any data format
- Makes replication easy
- Can integrate into documents (with Quarto)
- R is a *language* so it can do *everything*
 - A good stepping stone to learning other languages like Python



Excel (or Stata) Can't Do This

Code Output

```
1 ggplot(data = gapminder,
2         aes(x = gdpPercap,
3               y = lifeExp,
4               color = continent))+  
5   geom_point(alpha=0.3)+  
6   geom_smooth(method = "lm") +  
7     scale_x_log10(breaks=c(1000,10000, 100000),
8                     label=scales::dollar) +  
9   labs(x = "GDP/Capita",
10        y = "Life Expectancy (Years)") +  
11  facet_wrap(~continent) +  
12  guides(color = F) +  
13  theme_light()
```

Or This

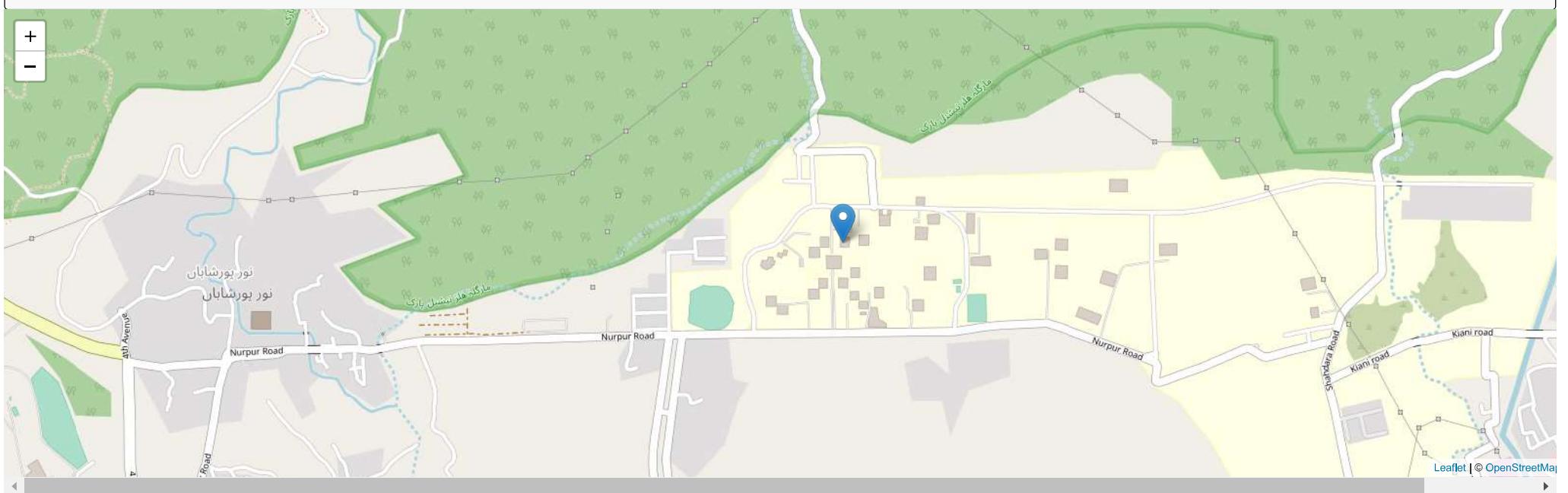
Input

Output

The average GDP per capita is ` r dollar(mean(gapminder\$gdpPercap)) ` with a standard deviation of ` r dollar(sd(gapminder\$gdpPercap)) `.

Or This

```
1 library(leaflet)
2 leaflet() %>%
3   addTiles() %>%
4   addMarkers(lng = 73.136946, lat = 33.748294 ,
5             popup = "School of Economics, QAU, Islamabad")
```



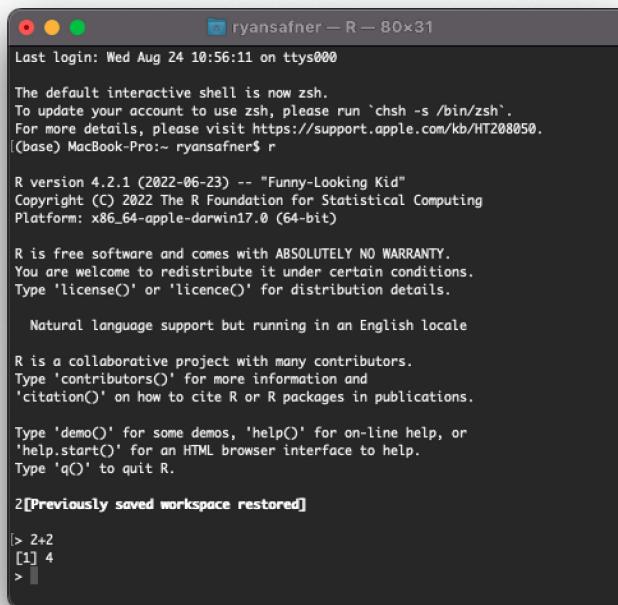
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Meet R and R Studio

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R and R Studio

- **R** is the programming language that executes commands
- Could run this from your computer's shell
 - On Windows: **Command prompt**
 - On Mac/Linux: **Terminal**



A screenshot of a macOS Terminal window titled "ryansafner — R — 80x31". The window shows the R command-line interface. The output includes:

```
Last login: Wed Aug 24 10:56:11 on ttys000
The default interactive shell is now zsh.
To update your account to use zsh, please run `chsh -s /bin/zsh`.
For more details, please visit https://support.apple.com/kb/HT208050.
(base) MacBook-Pro:~ ryansafner$ r

R version 4.2.1 (2022-06-23) -- "Funny-Looking Kid"
Copyright (C) 2022 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin17.0 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

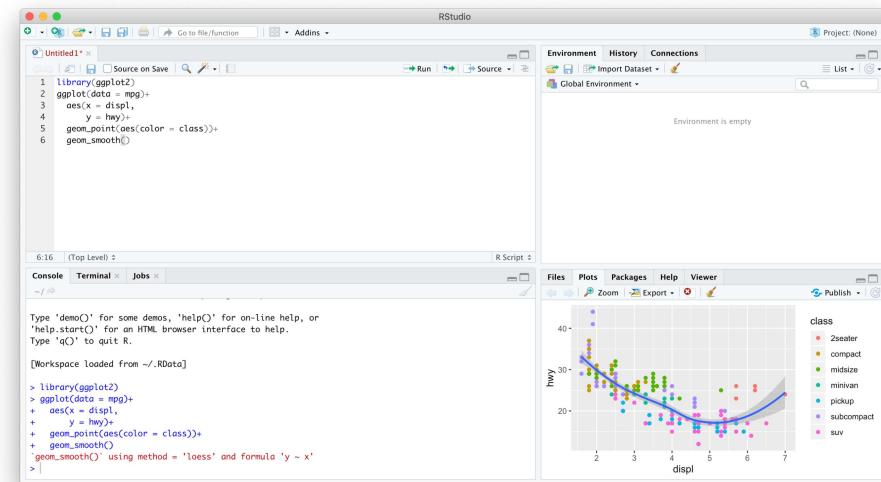
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

2 [Previously saved workspace restored]

[> 2+2
[1] 4
>
```

R and R Studio

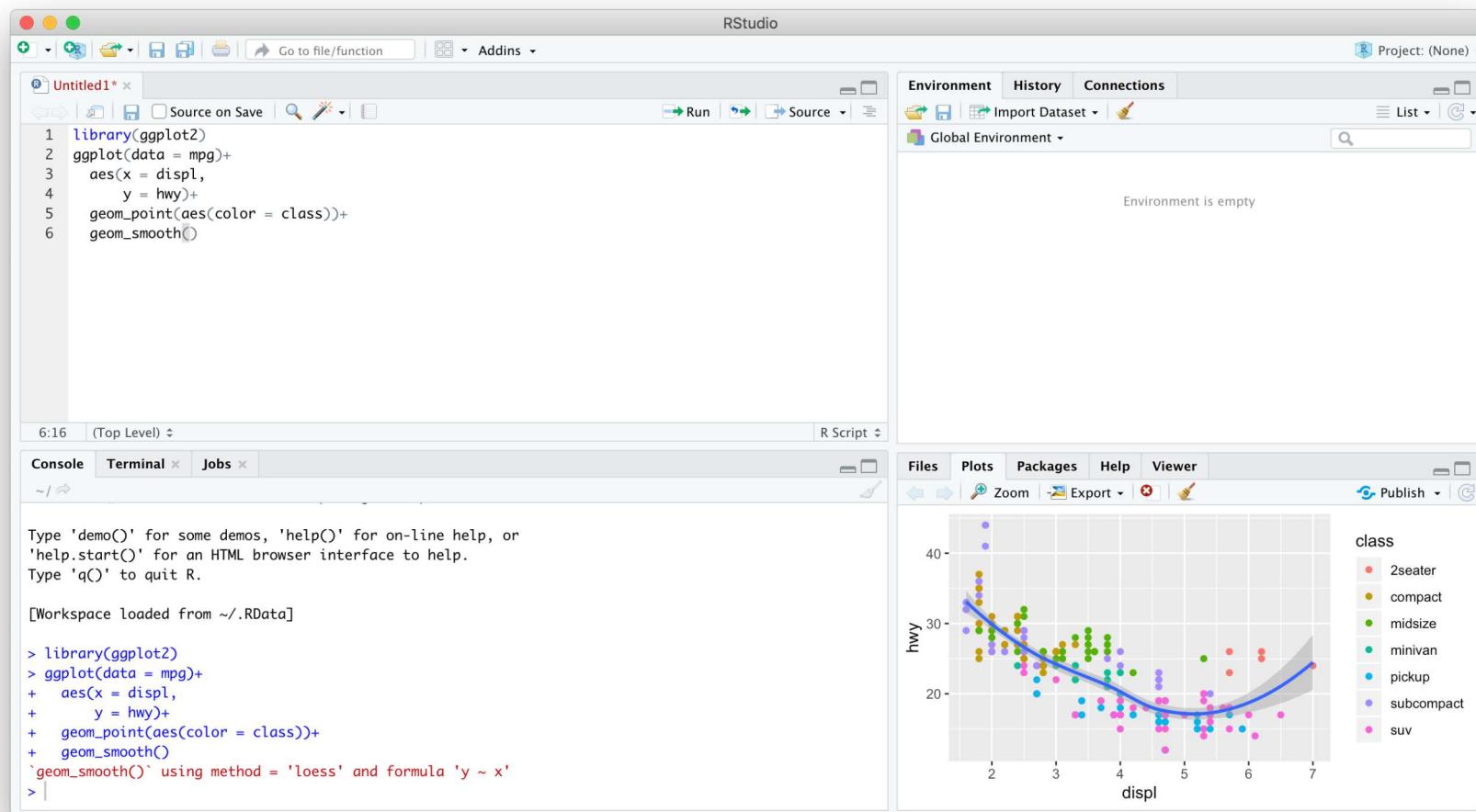
- **R Studio¹** is an **integrated development environment (IDE)** that makes your coding life a lot easier
 - Write code in scripts
 - Execute individual commands & scripts
 - Auto-complete, highlight syntax
 - View data, objects, and plots
 - Get help and documentation on commands and functions
 - Integrate code into documents with **Quarto**



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¹ The company R Studio has now announced they have now branded itself Rocsit

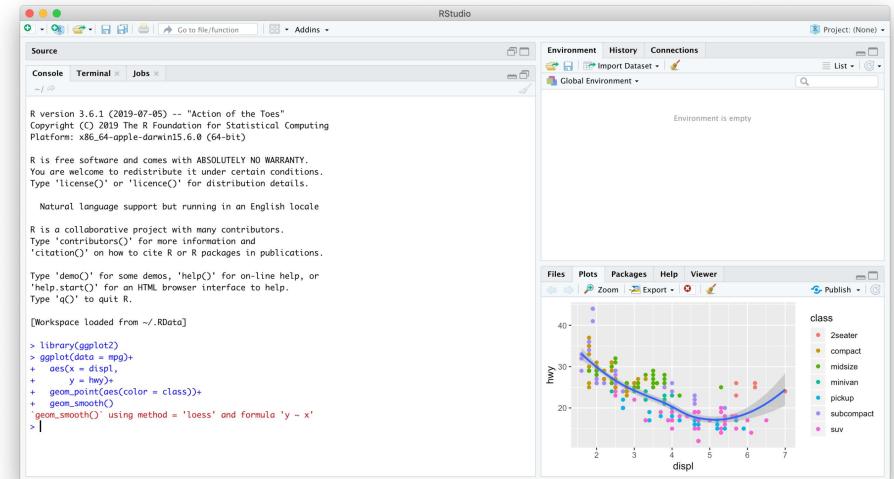
R Studio – Four Panes



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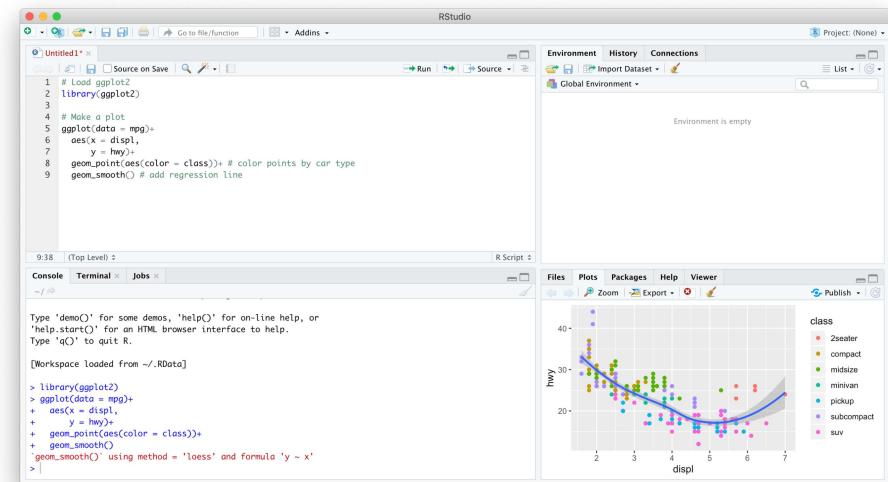
Ways to Use R Studio: Using the Console

- Type individual commands into the console pane (bottom left)
- Great for testing individual commands to see what happens
- Not saved! Not reproducible! Not recommended!



Ways to Use R Studio: Writing a .R Script

- Source pane is a text-editor
- Make **.R** files: all input commands in a single script
- Comment with **#**
- Can run any or all of script at once
- Can save, reproduce, and send to others!



Ways to Use R Studio: Quarto Documents

The screenshot shows the R Studio interface with the Quarto extension loaded. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. A toolbar below the menu has icons for file operations like Open, Save, and Print, along with a 'Go to file/function' search bar and an 'Addins' dropdown.

The main workspace contains a code editor for an 'Untitled1' document. The code is:---
title: "Untitled"
format: html
editor: visual

Below the code editor, there's a section titled 'Quarto' with a brief introduction: 'Quarto enables you to weave together content and executable code into a finished document. To learn more about Quarto see <https://quarto.org>'. There's also a 'Running Code' section with an example of executable code:{r}
1 + 1

Further down, there's a note about adding options to executable code:{r}
#| echo: false
2 * 2

A message states: 'The `echo: false` option disables the printing of code (only output is displayed).'

The right side of the interface features the RStudio environment pane, which displays the 'Environment' tab. It shows the message 'Environment is empty'. Below it is a file browser pane with tabs for Files, Plots, Packages, Help, Viewer, and Presentation. The 'Files' tab is selected, showing a list of files in the 'project' folder:

Name	Size	Modified
..	0 B	Aug 24, 2022, 11:07 AM
.Rhistory	0 B	Aug 24, 2022, 11:07 AM
project.Rproj	205 B	Aug 24, 2022, 11:07 AM

At the bottom, there are 'Console' and 'Quarto' tabs, and a status bar indicating '(Top Level)'.

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Getting to Know Your Computer

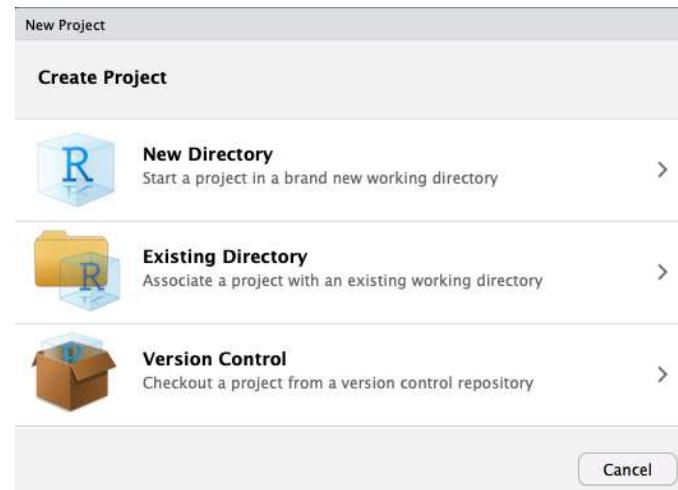
- R assumes a default (often inconvenient) “**working directory**” on your computer
 - The first place it looks to `open` or `save` files
- Find out where R this is with `getwd()`
- Change it with `setwd(path/to/folder)`¹

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¹ Note the path is OS specific. For Windows it might be `C:/Documents/`. For Mac it is often your `username` folder.

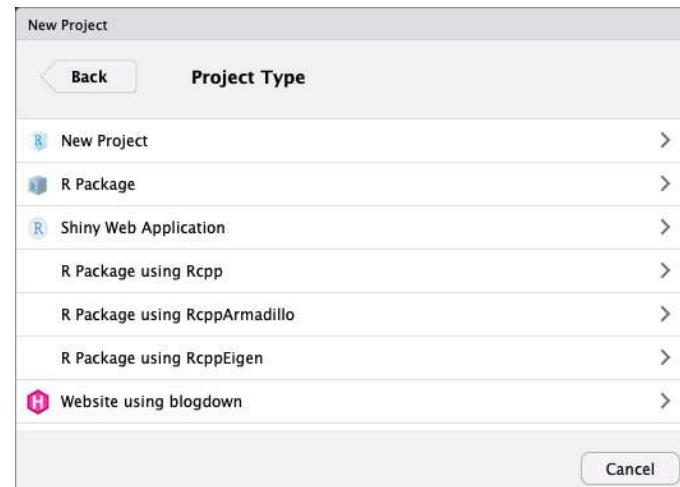
Avoid this Hassle with R Projects

- A [R Project](#) is a way of systematically organizing your [R](#) history, working directory, and related files in a single, self-contained directory
- Can easily be sent to others who can reproduce your work easily
- Connects well with version control software like GitHub
- Can open multiple projects in multiple windows



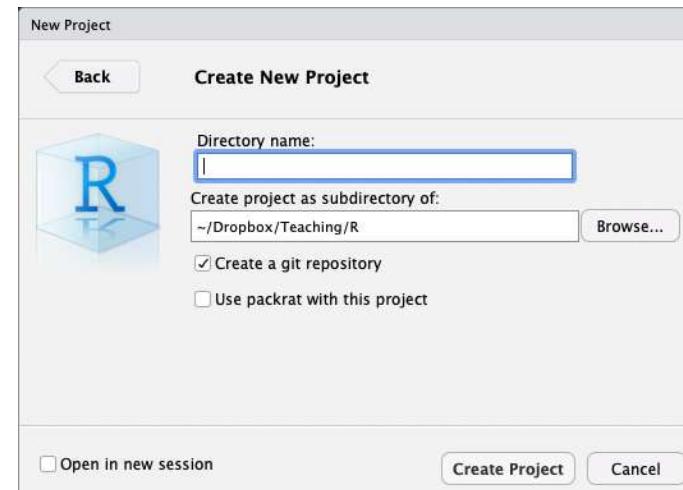
Avoid this Hassle with R Projects

- In almost all cases, you simply want a [New Project](#)
- For more advanced uses, your project can be an [R Package](#) or a [Shiny Web Application](#)
- If you have other packages that create templates installed (as I do, in the previous image), they will also show up as options



Avoid this Hassle with R Projects

- Enter a name for the project in the top field
 - Also creates a folder on your computer with the name you enter into the field
- Choose the location of the folder on your computer
- Depending on if you have other packages or utilities installed (such as [git](#), see below!), there may be additional options, do not check them unless you know what you are doing
- Bottom left checkbox allows you to open a new instance (window) of [R](#) just for this project (and keep existing windows open)



An Intro to Coding

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Learning...

- You don't “*learn R*”, you learn *how to do things in R*
- In order to do learn this, you need to learn *how to search for what you want to do*

Learning...

Jesse Mostipak  
@kierisi · [Follow](#)

My #rstats learning path:

1. Install R
2. Install RStudio
3. Google "How do I [THING I WANT TO DO] in R?"

Repeat step 3 ad infinitum.

6:19 PM · Aug 18, 2017 

 2.4K  Reply  Share

[Read 72 replies](#)

Katie Mack  
@AstroKatie · [Follow](#)

A surprisingly large part of having expertise in a topic is not so much knowing everything about it but learning the language and sources well enough to be extremely efficient in google searches.

9:34 PM · Dec 8, 2018 

 14.9K  Reply  Share

[Read 184 replies](#)

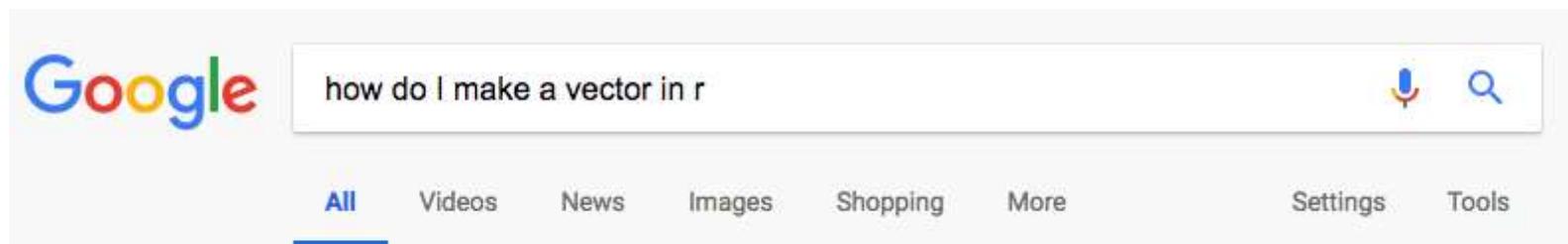
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...and Sucking



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Say Hello To My Little Friend



A screenshot of a Google search results page. The search bar at the top contains the query "how do I make a vector in r". Below the search bar, the "All" tab is selected, along with other categories like Videos, News, Images, Shopping, More, Settings, and Tools. A status message indicates "About 395,000,000 results (0.60 seconds)". The first result is a link to "R Vector: Create, Modify and Access Vector Elements - DataMentor" from <https://www.datamentor.io/r-programming/vector>. The snippet describes vectors in R. The second result is a link to "Vector | R Tutorial" from www.r-tutor.com/r-introduction/vector. The snippet describes vectors in R. The third result is a link to "2. Basic Data Types – R Tutorial - Cyclismo" from <https://www.cyclismo.org/tutorial/R/types.html>. The snippet describes basic data types in R.

R Vector: Create, Modify and Access Vector Elements - DataMentor

<https://www.datamentor.io/r-programming/vector> ▾

In this article, you'll learn about **vector** in R programming. You'll learn to create them, access their elements using different methods, and modify them in your program. **Vector** is a basic data structure in R. It contains element of the same type.

Vector | R Tutorial

www.r-tutor.com/r-introduction/vector ▾

An R tutorial on the concept of vectors in R. Discuss how to create vectors of numeric, logical and character string data types.

2. Basic Data Types – R Tutorial - Cyclismo

<https://www.cyclismo.org/tutorial/R/types.html> ▾

We look at some of the ways that R can store and organize data. This is a ... You can create a list (also called a "vector") using the `c` command: `> a <- c(1,2,3,4,5) > ...`

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Say Hello to My Better Friend

stack**overflow** Questions Developer Jobs Tags Users [r] how do I make a vector

Search

results found containing how do I make a vector tagged with r

[r] how do I make a vector search

500 results relevance newest votes active

R is a free, open-source programming language and software environment for statistical computing, bioinformatics, visualization and general computing. Provide minimal, reproducible, representative example(s) with your questions. Use dput() for data and specify all non-base packages with library ...

Learn more... Top users Synonyms (2) r jobs

2 votes 2 answers r

Q: How do I make a specific factor in a vector have a higher level than every other factor?

Given a **vector** for which "b" will always be an element of, how do I make "b" have a higher level than all the other factors (without reordering the other factors relative to each other)? For example ... , but how do I make it so levels(df\$x) = "c", "d", "b" In other words, I want "b" to always show up last ...

asked Dec 26 '13 by Ben

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R Is Helpful Too!

- Type `help(function_name)` or `?(function_name)` to get documentation on a function

```
1 help(mean)
2
3 ?mean() # does the same thing
```

The name of the function, and the library it is in.

Description

What it does.

Generic function for the (trimmed) arithmetic mean.

Usage

```
mean(x, ...)
```

Default S3 method:
mean(x, trim = 0, na.rm = FALSE, ...)

Arguments

- x An R object. Currently there are methods for numeric/logical vectors and [date](#), [date-time](#) and [time interval](#) objects. Complex vectors are allowed for `trim = 0`, only.
- trim the fraction (0 to 0.5) of observations to be trimmed from each end of `x` before the mean is computed. Values of `trim` outside that range are taken as the nearest endpoint.
- na.rm a logical value indicating whether `NA` values should be stripped before the computation proceeds.
- ... further arguments passed to or from other methods.

The ellipsis allows other arguments to be passed to and from the function.

Value

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

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

References

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

See Also

[weighted.mean](#), [mean.POSIXct](#), [colMeans](#) for row and column means.

Other related functions

Examples

```
x <- c(0:10, 50)
xm <- mean(x)
c(xm, mean(x, trim = 0.10))
```

Self-contained examples that you can run at the console. These may use built-in datasets or other R functions.

[Package `base` version 3.4.3 [Index](#)] Visit the package's Index page to look for Demos and Vignettes detailing how it works.

From Kieran Healy, [Data Visualization](#).

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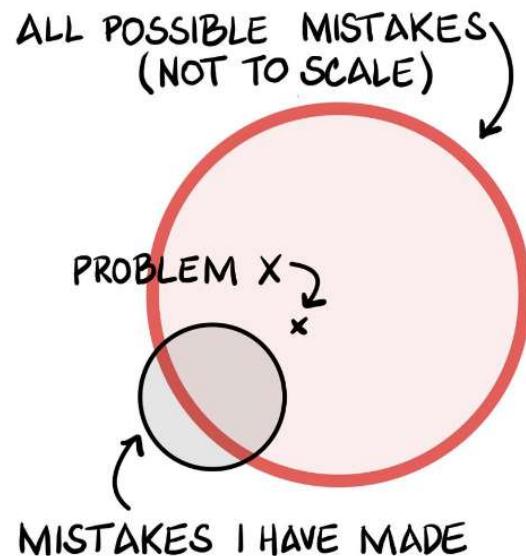
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I've Failed More Times Than You

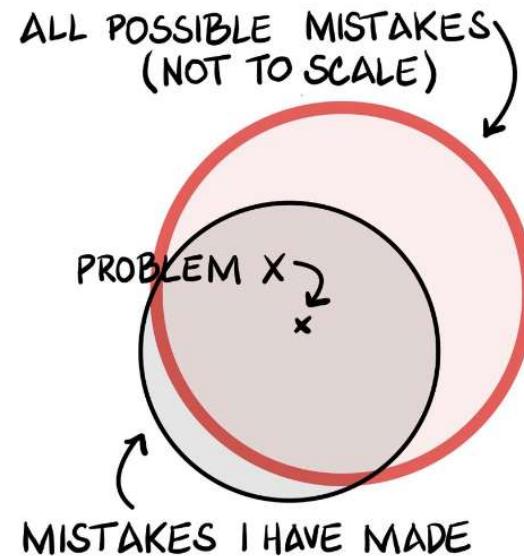
©Victoria Grinberg

WHY YOUR PHD ADVISOR CAN SOLVE YOUR PROBLEM SO "EASILY"

EARLY CAREER



MID CAREER



(YES, A GOOD RESEARCHER WILL MAKE MISTAKES OUTSIDE OF
WHAT HAS BEEN CONSIDERED POSSIBLE PREVIOUSLY)

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Tips for Writing Code

- Comment, comment, comment!
- The hashtag `#` starts a comment, R will ignore everything on the rest of that line
- Save often!
 - Write scripts that save the commands that did what you wanted (and comment them!)
 - Better yet, use a version control system like Git (I may cover this later)

Style and Naming

- Once we start writing longer blocks of code, it helps to have a consistent (and human-readable!) style
- I follow [this style guide](#) (you are not required to)¹
- Naming objects and files will become important
 - DO NOT USE SPACES! You've seen seen webpages intended to be called `my webpage in html` turned into `http://my%20webpage%20in%20html.html`

```
1 i_use_underscores
2 some.people.use.snake.case
3 othersUseCamelCase
```

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¹ Consider your folders on your computer as well

Simple Commands

- You'll have to get used to the fact that you are coding in commands to execute
- Start with the easiest: simple math operators and calculations:

```
1 > 2+2
```

```
[1] 4
```

- Note that R will ask for **input** with `>` and give you **output** starting with `[1]`

Simple Commands

- We can start using more fancy commands

```
1 2^3
```

```
[1] 8
```

```
1 sqrt(25)
```

```
[1] 5
```

```
1 log(6)
```

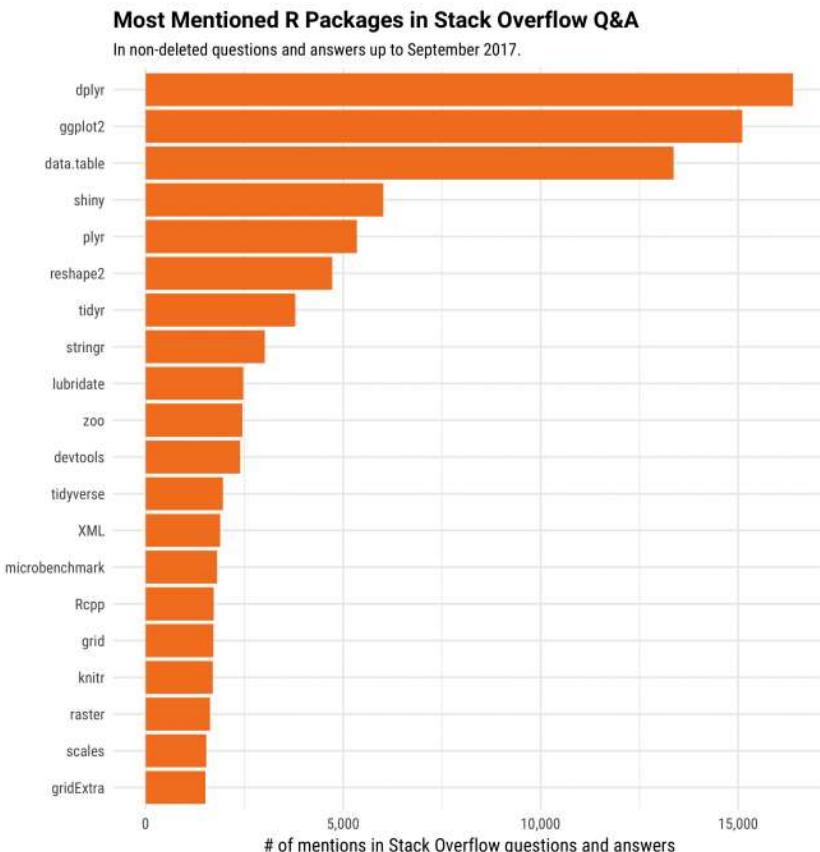
```
[1] 1.791759
```

```
1 pi/2
```

```
[1] 1.570796
```

Packages and Libraries

- Since R is open source, users contribute packages
 - Really it's just users writing custom functions and saving them for others to use
- Load packages with `library()`¹
 - e.g. `library("ggplot2")`
- If you don't have a package, you must first `install.packages()`²
 - e.g. `install.packages("ggplot2")`



1. You can run a function from a previously-installed package without loading it with the syntax `package_name::function_name()`.
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2. Yes, note the plural, even if it's just for one package.

Objects & Functions

- R is an **object-oriented** programming language, meaning you will always be:

1. creating objects

- assign values to an object with = (or <-)¹

2. running functions on objects

- syntax: my_function(my_object)

```
1 # make an object
2 my_object = c(1,2,3,4,5)
3
4 # look at it
5 my_object
```

```
[1] 1 2 3 4 5
```

```
1 # find the sum
2 sum(my_object)
```

```
[1] 15
```

```
1 # find the mean
2 mean(my_object)
```

```
[1] 3
```

¹ You can read this as “sets”

More About Functions

- Functions have **arguments**, the input(s)
- Some functions may have multiple arguments
- The argument of a function can be *another* function!

```
1 # find the sd  
2 sd(my_object)
```

```
[1] 1.581139
```

```
1 # round everything in my object to two decimals  
2 round(my_object, 2)
```

```
[1] 1 2 3 4 5
```

```
1 # round the sd to two decimals  
2 round(sd(my_object), 2)
```

```
[1] 1.58
```

Types of R Objects

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Numeric

- `numeric` objects are just numbers¹
- Can be mathematically manipulated

```
1 x <- 2  
2 y <- 3  
3 x+y
```

```
[1] 5
```

```
1 x*y
```

```
[1] 6
```

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¹ If you want to get technical, R calls these `integer` (for whole numbers) or `double` if there are decimal values.

Character

- `character` objects are “strings” of text **contained inside quote marks**
- Can contain spaces, so long as contained within quote marks

```
1 name <- "Ryan Safner"  
2 address <- "Hood College"
```

```
3  
4 name
```

```
[1] "Ryan Safner"
```

```
1 address
```

```
[1] "Hood College"
```

Logical

- logical objects are **boolean/binary** TRUE or FALSE indicators¹
- Used a lot to evaluate **conditionals**:
 - >, <: greater than, less than
 - >=, <=: greater than or equal to, less than or equal to
 - ==, !=: is equal to, is not equal to²
 - &in& : is a member of the set of (\in)
 - &: “AND”
 - |: “OR”

```
1 z = 10 # set z equal to 10  
2  
3 z==10 # test is z equal to 10?  
[1] TRUE
```

```
1 "red"=="blue" # test is red equal to blue?  
[1] FALSE
```

```
1 z > 1 & z < 12 # test is z > 1 AND < 12?  
[1] TRUE
```

```
1 z <= 1 | z==10 # test is z >= 1 OR equal to 10?  
[1] TRUE
```

1. Technically, under the hood, R is actually storing them as numeric: 1 = TRUE, 0 = FALSE!
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2. One -- assigns a value (like `x = 1`). Two -- evaluates a conditional statement!

Factor

- factor objects contain **categorical** data - membership in mutually exclusive groups
- Look like **character** strings, behave more like **logicals**, but with *more than two options*

```
[1] senior      sophomore sophomore junior      senior      sophomore senior  
[8] junior      freshman   sophomore  
Levels: freshman sophomore junior senior
```

- We'll make much more extensive use of them later

```
[1] senior      sophomore sophomore junior      senior      sophomore senior  
[8] junior      freshman   sophomore  
Levels: freshman < sophomore < junior < senior
```

Data Structures

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Vectors

- **vector** the simplest type of object, just a collection of elements
 - All elements must be the same data type!
- Make a vector using the **combine/concatenate c()** function

```
1 # create a vector named vec
2 vec <- c(1,"orange", 83.5, pi)
3
4 # look at vec
5 vec
[1] "1"                 "orange"           "83.5"
"3.14159265358979"
```

Dataframes I

- `data.frame` or `tibble`: what we'll always be using; think like a “**spreadsheet**”:
 - Each **column** is a vector (variable) of data all the same type
 - Each **row** is an observation (pair of values for all variables)

```
1 library(ggplot2)
2 diamonds

# A tibble: 53,940 × 10
  carat cut       color clarity depth table price     x     y     z
  <dbl> <ord>    <ord> <ord>   <dbl> <dbl> <int> <dbl> <dbl> <dbl>
1 0.23 Ideal      E     SI2     61.5    55    326  3.95  3.98  2.43
2 0.21 Premium   E     SI1     59.8    61    326  3.89  3.84  2.31
3 0.23 Good      E     VS1     56.9    65    327  4.05  4.07  2.31
4 0.29 Premium   I     VS2     62.4    58    334  4.2   4.23  2.63
5 0.31 Good      J     SI2     63.3    58    335  4.34  4.35  2.75
6 0.24 Very Good J     VVS2    62.8    57    336  3.94  3.96  2.48
7 0.24 Very Good I     VVS1    62.3    57    336  3.95  3.98  2.47
8 0.26 Very Good H     SI1     61.9    55    337  4.07  4.11  2.53
9 0.22 Fair       E     VS2     65.1    61    337  3.87  3.78  2.49
10 0.23 Very Good H     VS1    59.4    61    338   4    4.05  2.39
# ... with 53,930 more rows
```

Dataframes II

- Dataframes are really just combinations of (column) vectors
- You can make data frames by combining named vectors with `data.frame()` or creating each column/vector in each argument

```
1 # make two vectors
2 fruits = c("apple", "orange", "pear", "kiwi", "pineapple")
3 numbers = c(3.3, 2.0, 6.1, 7.5, 4.2)
4
5 # combine into dataframe
6 df = data.frame(fruits, numbers)
7
8 # do it all in one step (note the = instead of <-)
9 df = data.frame(fruits=c("apple", "orange", "pear", "kiwi", "pineapple"),
10                  numbers=c(3.3, 2.0, 6.1, 7.5, 4.2))
11
12 # look at it
13 df
```

	fruits	numbers
1	apple	3.3
2	orange	2.0
3	pear	6.1
4	kiwi	7.5
5	pineapple	4.2

Working with Objects

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Objects: Storing, Viewing, and Overwriting

- We want to store things in objects to run functions on them later
- Recall, any object is created with the assignment operator `=` or `<-`

```
1 my_vector = c(1, 2, 3, 4, 5)
```

- R will not give any output after an assignment

Objects: Storing, Viewing, and Overwriting

- View an object (and list its contents) by typing its name

```
1 my_vector  
[1] 1 2 3 4 5
```

- objects maintain their values until they are assigned different values that will *overwrite* the object

```
1 my_vector = c(2, 7, 9, 1, 5)  
2 my_vector  
[1] 2 7 9 1 5
```

Objects: Checking and Changing Classes

- Check what type of object something is with `class()`

```
1 class("six")
[1] "character"
1 class(6)
[1] "numeric"
```

- Can also use logical tests of `is.()`

```
1 is.numeric("six")
[1] FALSE
1 is.character("six")
[1] TRUE
```

Objects: Checking and Changing Classes

- Convert objects from one class to another with `as.object_class()`
 - Pay attention: you can't convert non-numbers to `numeric`, etc!

```
1 as.character(6)
[1] "6"
1 as.numeric("six")
[1] NA
```

Objects: Different Classes and Coercion I

- Different types of objects have different rules about mixing classes
- Vectors can *not* contain different types of data
 - Different types of data will be “**coerced**” into the lowest-common denominator type of object

```
1 mixed_vector = c(pi, 12, "apple", 6.32)
2 class(mixed_vector)
[1] "character"
1 mixed_vector
[1] "3.14159265358979" "12"                 "apple"                "6.32"
```

Objects: Different Classes and Coercion II

- Data frames can have columns with different types of data, so long as all the elements in each column are the same class¹

```
1 df
fruits numbers
1  apple      3.3
2  orange     2.0
3  pear       6.1
4  kiwi      7.5
5 pineapple  4.2
```

```
1 class(df$fruits)
[1] "character"
1 class(df$numbers)
[1] "numeric"
```

¹ Remember each column in a data frame is a vector!

More on Dataframes I

- Learn more about a data frame with the `str()` command to view its structure

```
1 class(df)
[1] "data.frame"
1 str(df)
'data.frame': 5 obs. of 2 variables:
$ fruits : chr "apple" "orange" "pear" "kiwi" ...
$ numbers: num 3.3 2 6.1 7.5 4.2
```

More on Dataframes II

- Take a look at the first 5 (or `n`) rows with `head()`

```
1 head(df)
```

```
fruits numbers
1   apple     3.3
2 orange     2.0
3   pear      6.1
4   kiwi      7.5
5 pineapple  4.2
```

```
1 head(df, n=2)
```

```
fruits numbers
1 apple     3.3
2 orange    2.0
```

More on Dataframes III

Get summary statistics¹ by column (variable) with `summary()`

```
1 summary(df)
```

```
fruits           numbers
Length:5          Min.   :2.00
Class  :character 1st Qu.:3.30
Mode   :character Median  :4.20
                  Mean   :4.62
                  3rd Qu.:6.10
                  Max.   :7.50
```

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¹ For numeric data only a frequency table is displayed for `character` or `factor` data

More on Dataframes IV

- Note, once you save an object, it shows up in the **Environment Pane** in the upper right window
- Click the blue arrow button in front of the object for some more information

The screenshot shows the RStudio interface with the Environment tab selected in the top navigation bar. Below the tabs, there are several icons: a folder with a green arrow, a blue square, a white square with a blue border, an 'Import Dataset' button with a grid icon, and a paintbrush icon. To the right of these are buttons for 'List' (with a grid icon) and 'Global Environment' (with a cube icon). A search bar with a magnifying glass icon is also present. The main pane displays a data frame named 'df'. The first row shows the object name 'df' followed by its description '5 obs. of 2 variables'. Below this, two variables are listed: 'fruits' (Factor with 5 levels: "apple", "kiwi", ...) and 'numbers' (numeric vector: 3.3, 2, 6.1, 7.5, 4.2). The entire screenshot is framed by a dark grey border.

Environment History Connections Build Git

Import Dataset

Global Environment

df 5 obs. of 2 variables

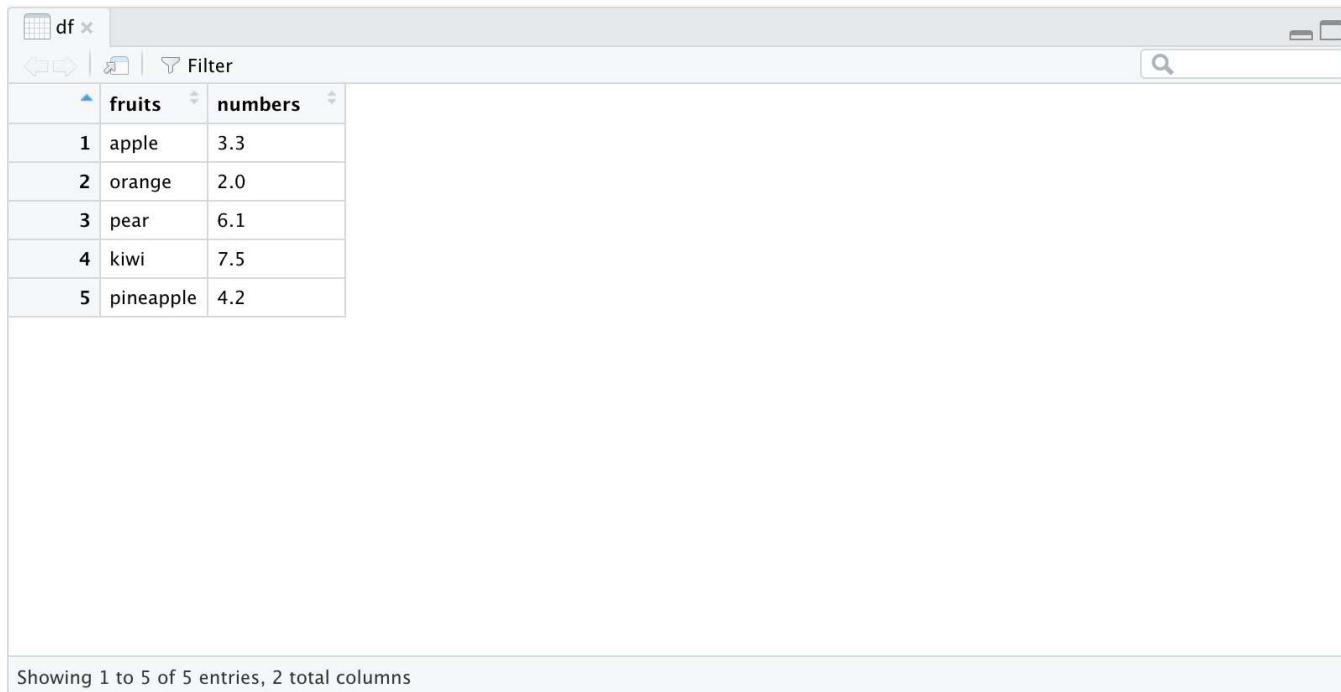
fruits : Factor w/ 5 levels "apple", "kiwi", ... : 1 3 4 2 5

numbers: num 3.3 2 6.1 7.5 4.2

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More on Dataframes V

- `data.frame` objects can be viewed in their own panel by clicking on the name of the object in the environment pane
- Note you cannot edit anything in this pane, it is for viewing only



The screenshot shows a data frame named "df" in the RStudio environment pane. The data frame has two columns: "fruits" and "numbers". The rows are numbered 1 to 5. The data is as follows:

	fruits	numbers
1	apple	3.3
2	orange	2.0
3	pear	6.1
4	kiwi	7.5
5	pineapple	4.2

Showing 1 to 5 of 5 entries, 2 total columns

Functions Again I

- Functions in R are **vectorized**, meaning running a function on a vector applies it to *each* element

```
1 my_vector = c(2, 4, 5, 10) # create object called my_vector  
2 my_vector # look at it
```

```
[1] 2 4 5 10
```

```
1 my_vector+4 # add 4 to all elements of my_vector
```

```
[1] 6 8 9 14
```

```
1 my_vector^2 # square all elements of my_vector
```

```
[1] 4 16 25 100
```

Functions Again II

- But often we want to run functions on vectors that *aggregate* to a result (e.g. a statistic):

```
1 length(my_vector) # how many elements?
```

```
[1] 4
```

```
1 sum(my_vector) # add all elements together
```

```
[1] 21
```

```
1 max(my_vector) # find largest element
```

```
[1] 10
```

```
1 min(my_vector) # find smallest element
```

```
[1] 2
```

```
1 mean(my_vector) # mean of all elements
```

```
[1] 5.25
```

```
1 median(my_vector) # median of all elements
```

```
[1] 4.5
```

```
1 var(my_vector) # variance of object
```

```
[1] 11.58333
```

```
1 sd(my_vector) # standard deviation of object
```

```
[1] 3.40343
```

Some Common Errors

- If you make a coding error (e.g. forget to close a parenthesis), R might show a `+` sign waiting for you to finish the command

```
1 > 2+(2*3  
2 +
```

- Either finish the command—e.g. add `)`—or hit `Esc` to cancel