Lecture 1: An Introduction & Motivation for R Programming

Harris Coding Camp – Standard Track

Summer 2022

Welcome to Coding Camp!

- Why are we here?
- What are we going to do?
- A quick introduction to R and RStudio

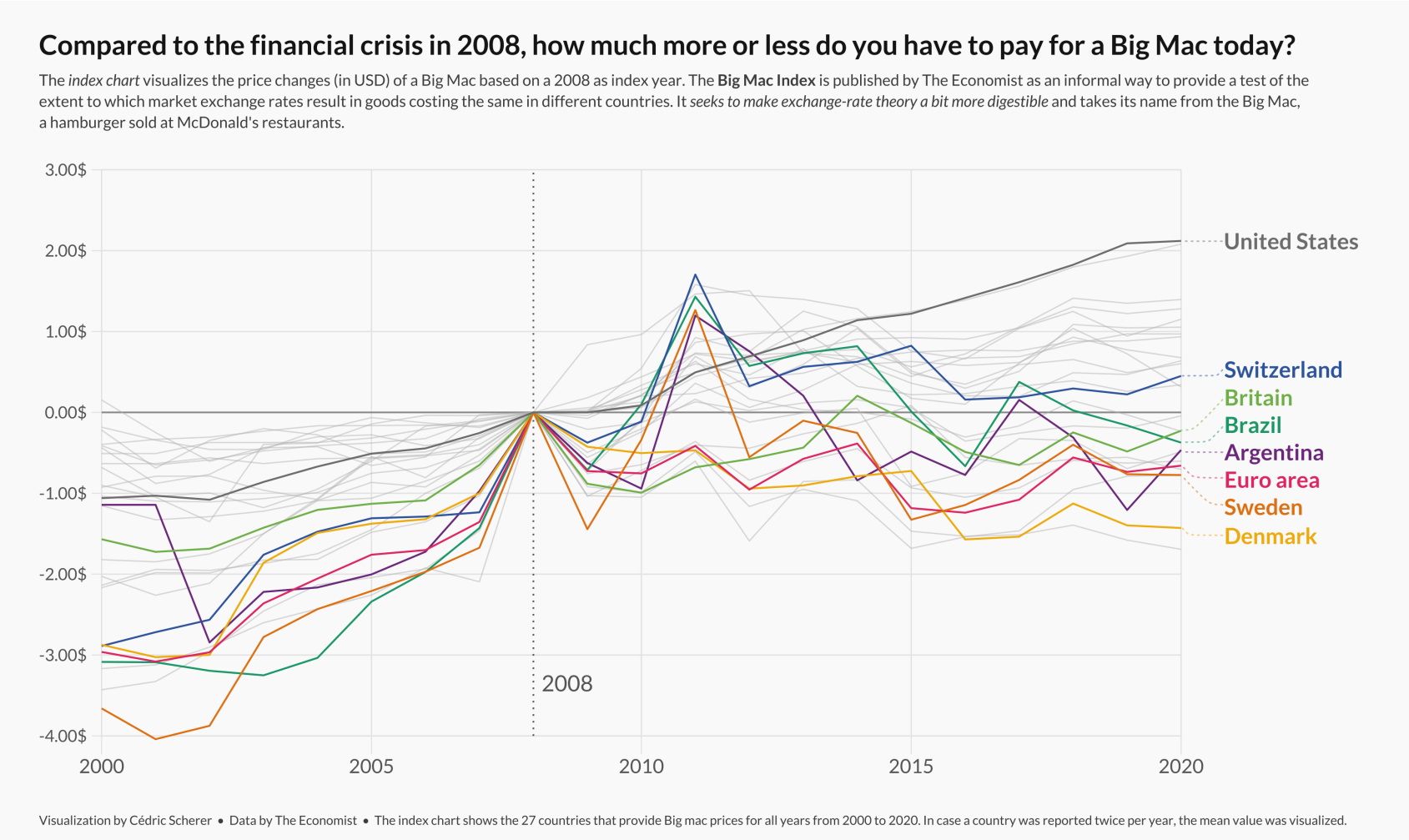
Teaching Members

- Instructors
  - Standard Track: Arthur Cheib, Sheng-Hao Lo
  - Accelerated Track: Ari Anisfeld
- Head TA: Rubina Hundal
  - All logistics issues
- You will also have several TAs who will be helping you along the way!
  - TA sessions
  - Canvas Discussion Board

Why learn coding?

- Computation is an essential party of modern-day applied statistics and *quantitative* policy analysis
- Many public policy jobs and the Harris curriculum rely on programming
  - to quickly engage with policy data
  - to complete statistical analyses
- Examples
  - Change in test scores among different groups due to online education
  - Change in unemployment rate due to CARES Act
  - Change in expenses of a certain good compared to a specific time period

An Example


Compared to the financial crisis in 2008, how much more or less do you have to pay for a Big Mac today?
The index chart visualizes the price changes (in USD) of a Big Mac based on a 2008 as index year. The Big Mac Index is published by The Economist as an informal way to provide a test of the extent to which market exchange rates result in goods costing the same in different countries. It seeks to make exchange-rate theory a bit more digestible and takes its name from the Big Mac, a hamburger sold at McDonald's restaurants.
3.00$
2.00$
1.00$
0.00$
-1.00$
-2.00$
-3.00$
-4.00$
2000
2005
2008
2010
2015
2020
United States
Switzerland
Britain
Brazil
Argentina
Euro area
Sweden
Denmark
Visualization by Cédric Scherer • Data by The Economist • The index chart shows the 27 countries that provide Big mac prices for all years from 2000 to 2020. In case a country was reported twice per year, the mean value was visualized.

Why R?

- R is an extremely powerful programming language and statistical software environment
  - Great data manipulation and visualization suite
  - Strong statistical packages (e.g. program evaluation, machine learning)
- Complete programming language with low barriers to entry
- Open source and free

A bit More about R

- We will use R for the entire Stats sequence in Fall and Winter
- We will use R through RStudio, which is a more user-friendly interface that "sits atop" R
- In order to use RStudio, you must also have both RStudio and R installed on your computer (R is the "engine" for RStudio)
- When working in RStudio, you can either:
  - Work **interactively** by entering each line of code into the console
  - Write a **script** (a .R file) in which you save your code in a file and submit multiple lines of code at once

What will we cover?

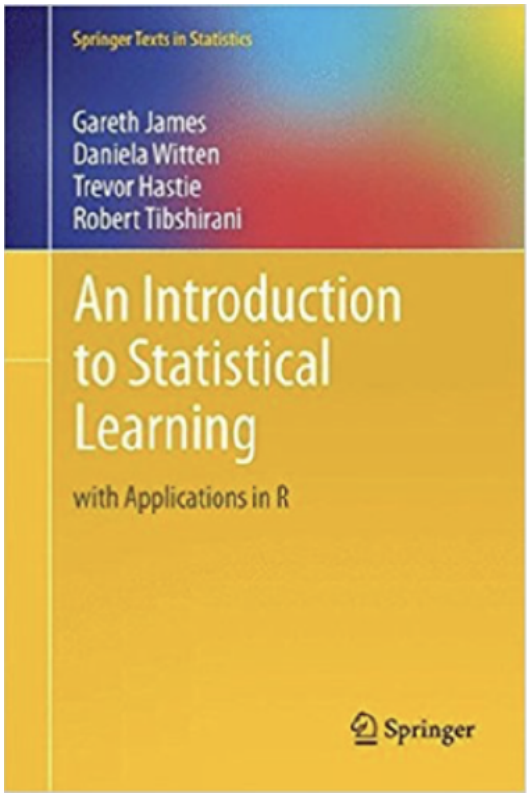
0. Motivation/Installation of R
1. Installing Packages and Reading Data
2. Basic Data Manipulation and Analysis
3. Data Visualization
4. More on Data Manipulation
   - Grouped Analysis, Iteration, Functions

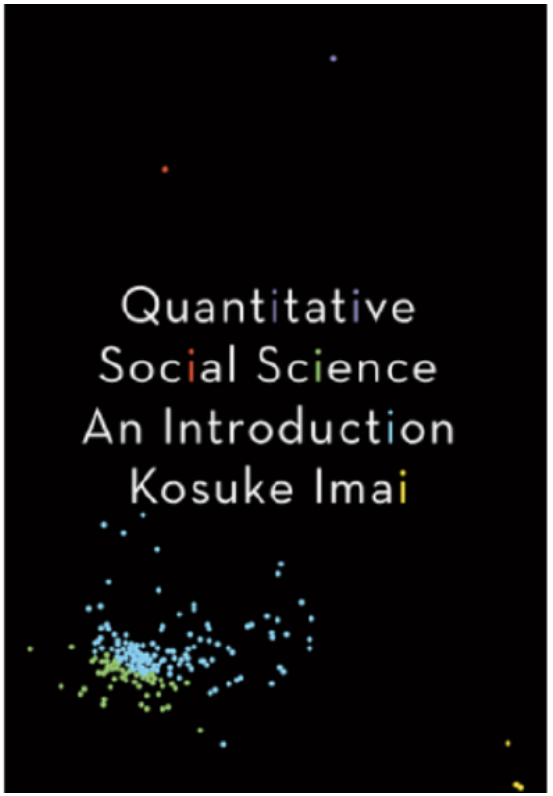
- In Stats 1/2 and other courses, you will build off of these lessons:
  - extend your capabilities with the functions we teach you
  - introduce statistics functions
  - introduce new packages and tools based on needs

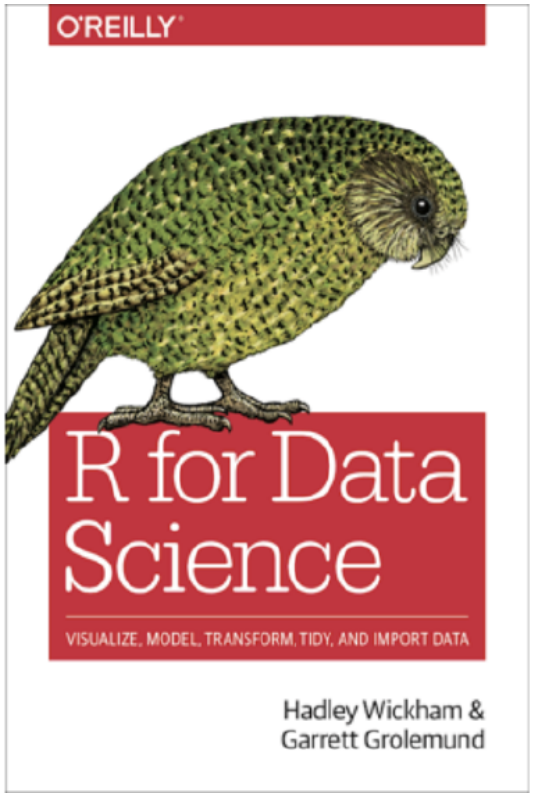
Learning philosophy

- We learn coding by experimenting with code
- Coding requires a different modality of thinking
- Coding can be frustrating
- We develop self-sufficiency by learning where to get help and how to ask for help
- Coding lab is for you
- This is just the beginning of your programming journey!

Textbooks and Resources





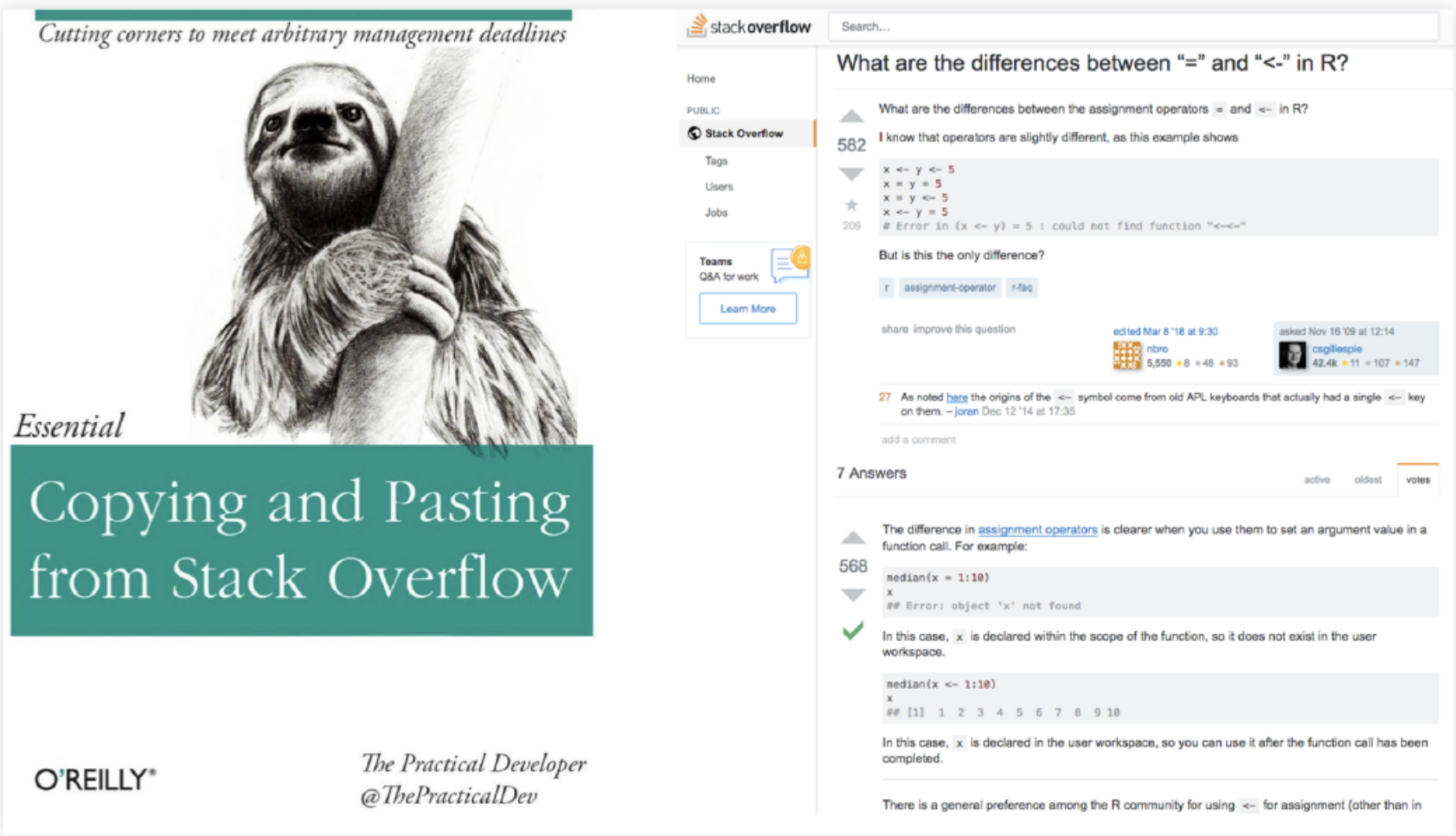


- Get situated with R for Data Science https://r4ds.had.co.nz/

Textbooks and Resources

- Google is your friend for idiosyncratic problems

Textbooks and Resources



- Stack Overflow is your another friend!

How will we progress?

1. Live lectures:

- Focus on main idea first
- Try it yourself – you learn coding by coding! (work on short problems with TA support)

2. Practice in TA sessions (Most important part!):

- Again – you learn coding by coding!
- Break up into small groups and work on problems with peer and TA support

3. Additional help:

- Send emails to Head TA for logistics issues
- Post questions to Canvas Discussion Board (Teaching team will monitor and reply)

4. Final project:

- It's optional; more details on next slide

Final project (optional)

You'll know you're ready for policy school coding, if you can open a data set of interest to you and produce meaningful analysis. For the final project, you will:

- Pick a data set aligned with your policy interests (or not)
- Use programming skills to engage with data and make a data visualization showing something you learned from the data

A quick introduction to R and R Studio

We will

- Discuss what RStudio is
- Introduce minimal information to get started working with R
- Expose you to the different data types in R
- Learn different types of operators

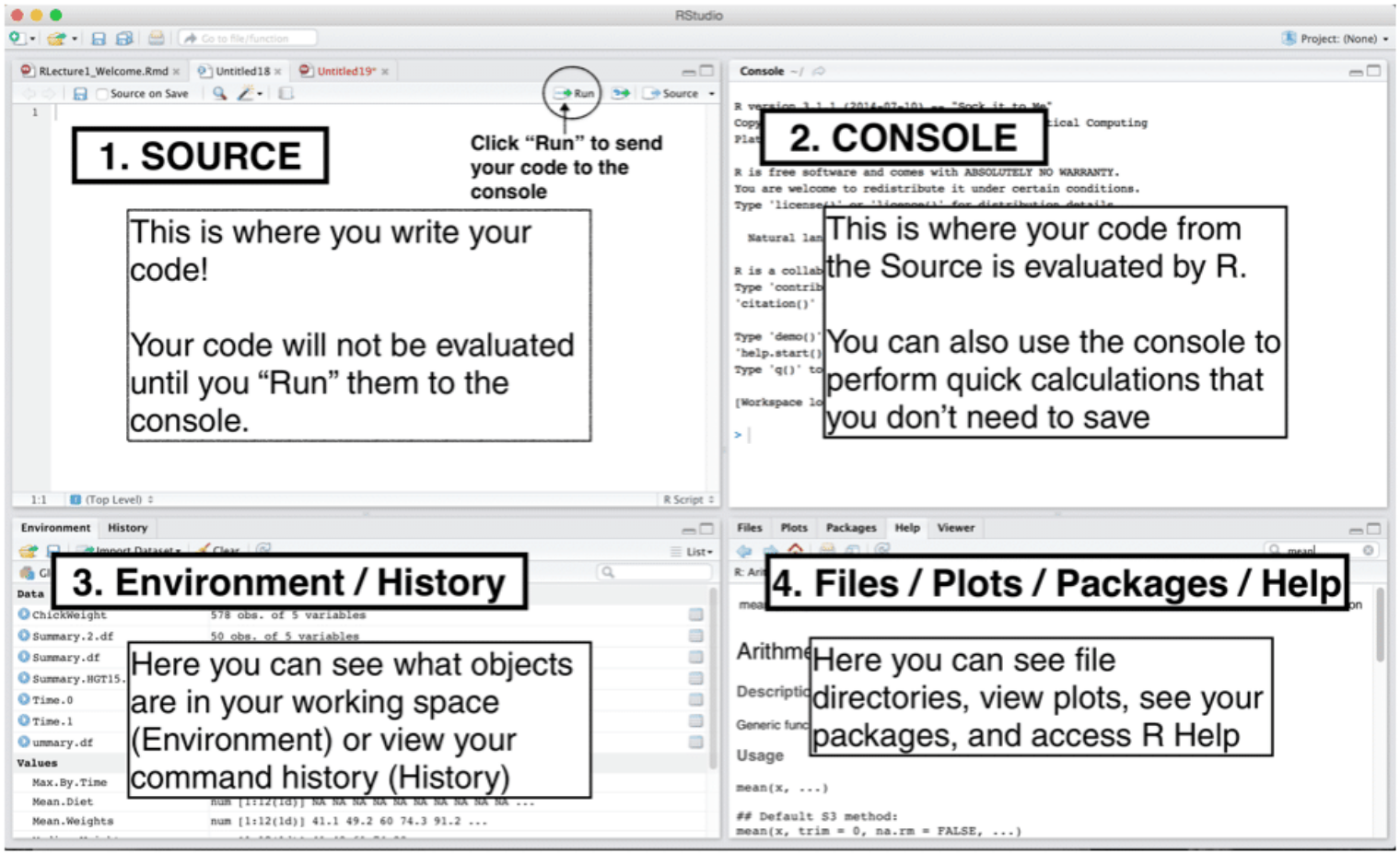
What is RStudio?

R Studio is an "integrated development environment" for R.

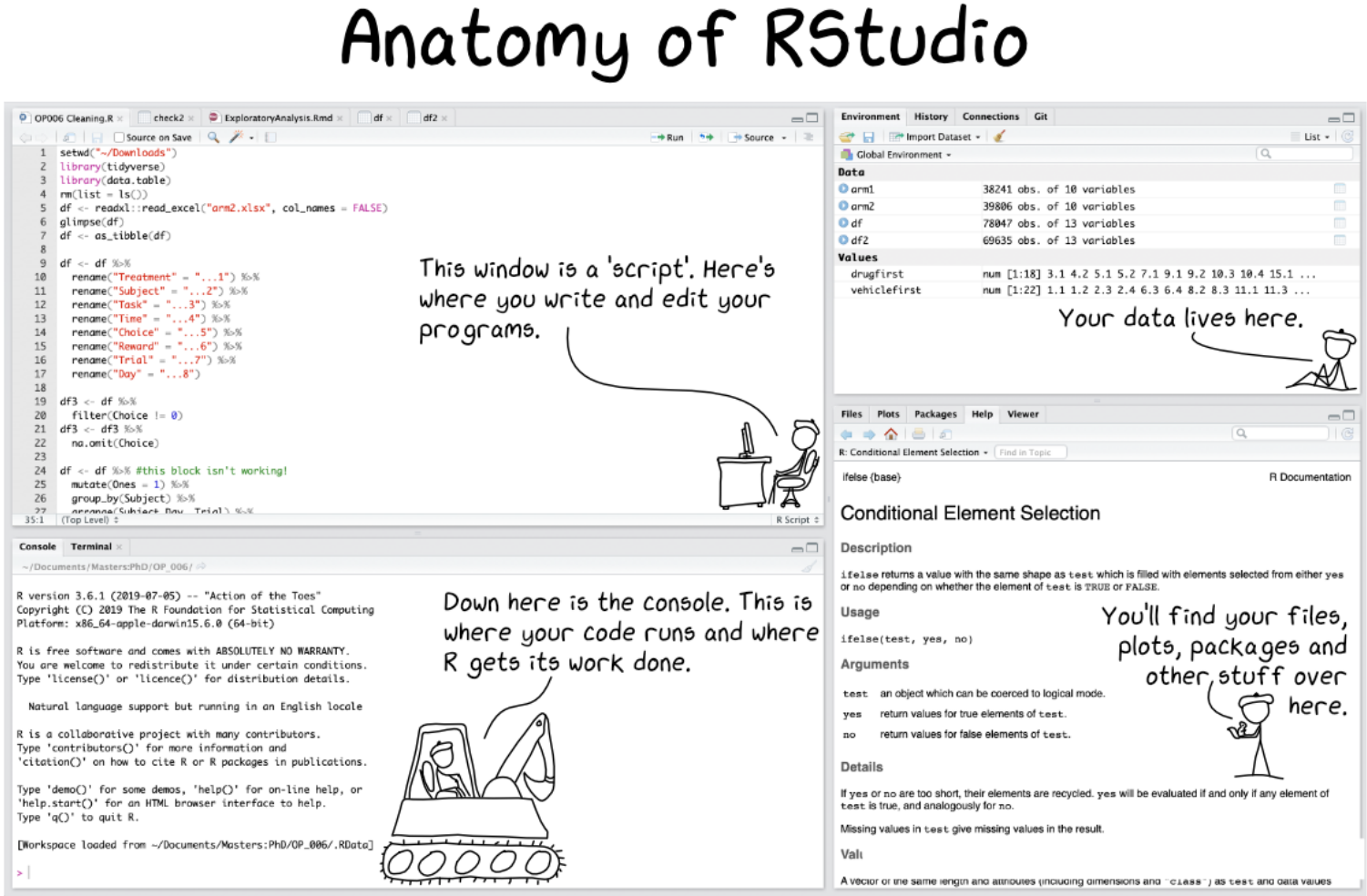
- It provides a console to access R directly
- A text editor to write R scripts and work with Rmds
- An environment and history tab that provide useful information about what objects you have in your R session
- A help / plots / files / packages etc. section

Let's take a tour in RStudio!

RStudio Layout



RStudio Layout



Basic syntax: Variable assignment

We can think of a variable as a *container* with a name, such as

- `x`
- `stats_score`
- `harris_gpa_average`

Each container can contain *one or more* values (more to come in Lecture 3)

Basic syntax: Variable assignment

We can create a new variable and assign a value to it using = or <-.

```
x = 7
x
```

```
## [1] 7
```

In the above bit of code, we created a variable called `x` and stored the value 7 inside of it.

Basic syntax: Variable assignment

We can create a new variable and assign a value to it using = or <-.

```
my_number <- 3
my_number
```

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

In the above bit of code, we created a variable called `my_number` and stored the value 3 inside of it.

Basic syntax: Variable assignment

We can treat our variable like a regular number, and do arithmetic with it:

```
my_number <- 3
my_number
```

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

```
my_output <- 12 * my_number + 2
my_output
```

```
## [1] 38
```

Basic syntax: Variable assignment

Variables can be reassigned if needed:

```
my_number <- 4
my_number # Now it becomes 4
```

```
## [1] 4
```

```
my_output <- 12 * my_number + 2
my_output # Its value changes accordingly
```

```
## [1] 50
```

Basic syntax: Add comments

- We can add comments to our code using the # character
- It is useful to document our code in this way so that others (and us the next time we read it) have an easier time following what the code is doing
- Anything after # is ignored by R when executes code

```
#my_number is the variable I set equal to 4
my_number - 10 # This should be equal to -6
```

```
## [1] -6
```

Functions

Functions are procedures that take an input and provide an output. Let's see some already defined functions:

```
x <- sqrt(4)
x
```

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

```
y <- mean(c(3, 4, 5, 6, 7))
y
```

```
## [1] 5
```

- We can combine values/objects in a new object with the function `c()` (c for combine). When objects are combined, they are called a *vector* (more details later)
- We can also define new functions by ourselves (more details later)

Using R as a calculator

+, -, *, and /. Also, ^ (Exponent).

```
7 + 5
```

```
## [1] 12
```

```
(4 + 6) * 3 - 2
```

```
## [1] 28
```

```
7 / 5
```

```
## [1] 1.4
```

```
2^4
```

```
## [1] 16
```

Using R as a calculator

- R has many built-in mathematical functions
- To call a function, we type its *name*, followed by parentheses
- Anything we type inside the parentheses is called the function's *arguments*

```
sin(1)   # trigonometric functions
```

```
## [1] 0.841471
```

```
log(1)   # natural logarithm
```

```
## [1] 0
```

```
exp(0.5) # e^(1/2)
```

```
## [1] 1.648721
```

- Typing a ? before the name of a function will open the help page for that function

Detour: Executing commands in R

Three ways to execute commands in R:

1. Type/copy commands directly into the console
2. R scripts (.R files)

- This is just a text file full of R commands
- Can execute one command at a time, several commands at a time, or the entire script

3. 'code chunks' in RMarkdown (.Rmd files)

- Can execute one command at a time, one chunk at a time, or "knit" the entire document
- More on this later

Operators can return special values

`Inf` is infinity. You can have either positive or negative infinity.

```
1 / 0
```

```
## [1] Inf
```

```
-5 / 0
```

```
## [1] -Inf
```

`NaN` means Not a Number. It's an undefined value.

```
0 / 0
```

```
## [1] NaN
```

Try it yourself

1. $30 + 6 \times 5^8 - log(50) = ?$
2. $568 \times \frac{135}{log(1)} = ?$
3. $\frac{15^0 - 1}{sin(0)} = ?$

Logical Operations

operator	definition	operator	definition
<	less than	x | y	x OR y
<=	less than or equal to	is.na(x)	test if x is NA
>	greater than	!is.na(x)	test if x is not NA
>=	greater than or equal to	x %in% y	test if x is in y
==	exactly equal to	!(x %in% y)	test if x is not in y
!=	not equal to	!x	not x
x & y	x AND y		

Comparison Operators

These are also binary operators; they take two objects, and give back a *Boolean*

```
7 > 5  # greater than
```

```
## [1] TRUE
```

```
7 < 5  # less than
```

```
## [1] FALSE
```

```
7 >= 5 # greater than or equal to
```

```
## [1] TRUE
```

Comparison Operators

```
7 <= 5 # less than or equal to
```

```
## [1] FALSE
```

```
7 == 5 # equality (two equals signs, read as "is equal to")
```

```
## [1] FALSE
```

```
7 != 5 # inequality (read as "is not equal to")
```

```
## [1] TRUE
```

Reminder: $==$ is a comparison operator, $=$ is an assignment operator

& (and)

- TRUE & TRUE -> `TRUE`
- TRUE & FALSE -> `FALSE`
- FALSE & TRUE -> `FALSE`
- FALSE & FALSE -> `FALSE`

```
(5 < 7) & (6 * 7 == 42)
```

```
## [1] TRUE
```

```
(5 < 7) & (6 * 7 < 42)
```

```
## [1] FALSE
```

```
(5 > 7) & (6 * 7 == 42)
```

```
## [1] FALSE
```

| (or)

- TRUE | FALSE -> `TRUE`
- FALSE | TRUE -> `TRUE`
- TRUE | TRUE -> `TRUE`
- FALSE | FALSE -> `FALSE`

```
(5 < 7) | (6 * 7 < 42)
```

```
## [1] TRUE
```

```
(5 > 7) | (6 * 7 == 42)
```

```
## [1] TRUE
```

```
(5 < 7) | (6 * 7 == 42)
```

```
## [1] TRUE
```

Try it yourself

Guess the output of the following codes, and then run the codes to check your answer:

```
x <- 6
(x < 9) & (x > 3)
(x < 9) | (x > 7)
(x > 8) | (x > 9)
```

```
x = 20
y = 30
(x == 20) & (y == 30)
(x == 20) | (y == 50)
(x + 5^{8} - log(50) < 2000000) | (3*y - log(500) == 0)
```

Recap

Now you should understand how to:

- navigate and use RStudio's features
  - particularly, the console, the text editor and help
- assign objects to names with <- or =
- learn basic syntax
  - Variable assignment
  - Add comments
  - Built-in Functions
  - Logical Operators