

# R and RStudio



UNIVERSITY OF  
SAN FRANCISCO

Abbie M Popa

BSDS 100 - Intro to Data Science with R



- In Class: Mix of Lecture and "Coding Challenges"
  - Not "graded" (though attendance is worth 20% of your grade), but you will do better on the homework if you attempt the activities!
- 8 Homework assignments (40% of your grade)
  - Based on in-class activities, completed **individually** at home
  - 30 points each, 10 points deducted automatically if turned in late
  - Attempt all questions! Even wrong answer may receive partial credit



- 2 Case Studies (20% of your grade)
  - Like homework assignments, but longer
  - Completed in pairs
  - You will receive **some** in-class time to work on these to help with scheduling issues
- Final Project (20% of your grade)
  - Similar to case studies, but more open-ended (you will pick the data and goals)
  - Completed in groups of 3 or 4



- The R Programming Language and RStudio
  - Comparison with other programming languages
  - Installation
  - Handy Shortcuts



[From the R website]: “R is a language and environment for statistical computing and graphics. It is a GNU project which is similar to the S language and environment which was developed at Bell Laboratories by John Chambers and colleagues. R can be considered as a different implementation of S. There are some important differences, but much code written for S runs unaltered under R.

R provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering, etc.) and graphical techniques, and is highly extensible. The S language is often the vehicle of choice for research in statistical methodology, and R provides an Open Source”



- R is a user-friendly integrated development environment (IDE) that is open source.
- Has many packages and functions for statistical analyses
- You can even run R from a terminal window if you wish (using BASH scripting)



- Open source (free)
- Runs on just about any platform
- Great visualization capabilities (`ggplot2`)
- Read/write from/to various data sources
- Scripting language (interpreted)
- Massive library of data manipulation and statistical packages

# But... what about Excel?





# Excel is Great for Certain Things...



grades													
Home Insert Page Layout Formulas Data Review View													
Paste		Cut	Copy	Format	Calibri (Body)	16	A	A				Wrap Text	General
					B	I	U					Merge & Center	\$ %
													Conditional Formatting Format as Table
C11 82.19													
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Student	Midterm	Final	Asn #1	Asn #2	Asn #3	Asn #4	Asn #5	Asn #6	V1	V2	Final Points	Letter Grade
2	Student 1	95.5	91.78	100	100	100	100	100	100	94.54	93.42	94.54	A
3	Student 2	93.2	89.04	100	100	100	100	100	100	92.48	91.23	92.48	A
4	Student 3	95.5	86.3	100	100	100	100	100	100	91.80	89.04	91.80	A
5	Student 4	94.3	86.3	100	100	100	100	100	100	91.44	89.04	91.44	A
6	Student 5	95.5	82.88	100	100	75	100	100	100	89.26	85.47	89.26	A
7	Student 6	79.5	86.3	100	100	100	100	100	100	87.00	89.04	89.04	A
8	Student 7	84.1	85.6	100	100	100	100	100	100	88.03	88.48	88.48	A
9	Student 8	94.3	80.14	100	100	100	100	100	100	88.36	84.11	88.36	A
10	Student 9	94.3	80	100	100	100	100	100	100	88.29	84.00	88.29	A
11	Student 10	89.8	82.19	100	100	100	100	100	100	88.04	85.75	88.04	A
12	Student 11	90.9	81.51	100	100	100	100	100	100	88.03	85.21	88.03	A
13	Student 12	93.2	78.77	100	100	100	100	100	100	87.35	83.02	87.35	A
14	Student 13	89.8	81.5	100	75	100	100	100	100	86.86	84.37	86.86	A
15	Student 14	86.4	81.5	100	100	100	100	100	100	86.67	85.20	86.67	A
16	Student 15	93.2	76.71	100	100	100	100	100	100	86.32	81.37	86.32	A
17	Student 16	97.7	71.23	100	100	100	100	100	100	84.93	76.98	84.93	A-
18	Student 17	86.4	76.71	100	100	100	100	100	100	84.28	81.37	84.28	A-
19	Student 18	87.5	77.4	100	100	100	100	75	100	84.12	81.09	84.12	A-
20	Student 19	90.9	75.34	100	100	100	75	100	100	84.11	79.44	84.11	A-
21	Student 20	81.8	78.77	100	100	100	100	100	100	83.93	83.02	83.93	A-
22	Student 21	76.1	78.77	100	100	100	100	100	100	82.22	83.02	83.02	B+
23	Student 22	84.1	71.92	100	100	100	100	100	100	81.19	77.54	81.19	B+
24	Student 23	85.2	71.23	100	100	100	100	100	100	81.18	76.98	81.18	B+
25	Student 24	67	76.03	100	100	100	100	100	100	78.12	80.82	80.82	B+
26	Student 25	85.2	69.18	100	100	100	100	100	100	80.15	75.34	80.15	B+
27	Student 26	81.8	70.55	100	100	100	100	100	100	79.82	76.44	79.82	B+
28	Student 27	81.8	70.55	100	100	100	100	100	100	79.82	76.44	79.82	B+



## Sample Data

- Six columns of data with ~ 1.05 million rows
- Column 5: `startDate`
- Column 6: `endDate`
- **Objective:** test to see if `endDate < startDate`

## RESULTS

- **Excel:** good luck...
- R: 33 min (poor coding technique)
- R: 58.5 sec (improved coding technique)



## Sample Data

- Six columns of data with ~ 1.05 million rows
- Column 5: `startDate`
- Column 6: `endDate`
- **Objective:** test to see if `endDate < startDate`

## RESULTS

- **Excel:** good luck...
- R: 33 min (poor coding technique)
- R: 58.5 sec (improved coding technique)

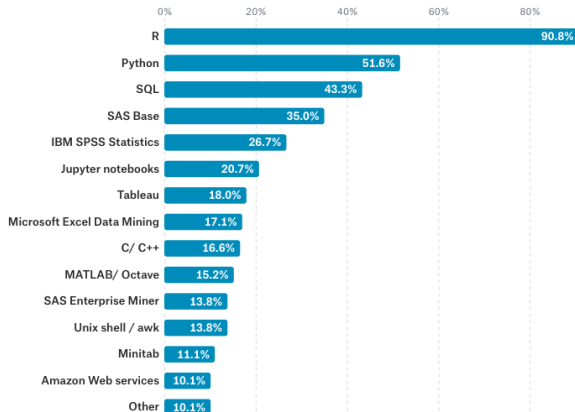
# How about Python?





- Vectorization: a style of coding where an operation is applied to all elements in an array, rather than looping
- Vectorized code saves time asking `type` questions
- There is an optimized engine—a basic linear algebra system (BLAS)—that is highly efficient at solving linear algebra problems
- A lot of R functions are written in C (or variants)
- MATLAB, Mathematica and the NumPy package for Python are also vectorized

[http://www.noamross.net/blog/2014/4/16/  
vectorization-in-r--why.html](http://www.noamross.net/blog/2014/4/16/vectorization-in-r--why.html)



R wins at statistics



- Download and install at this website:

<https://www.r-project.org>

- **Important:** You will have to re-install R from time-to-time to maintain the newest version so that code remains compatible! New versions generally come out every 4 - 6 months.

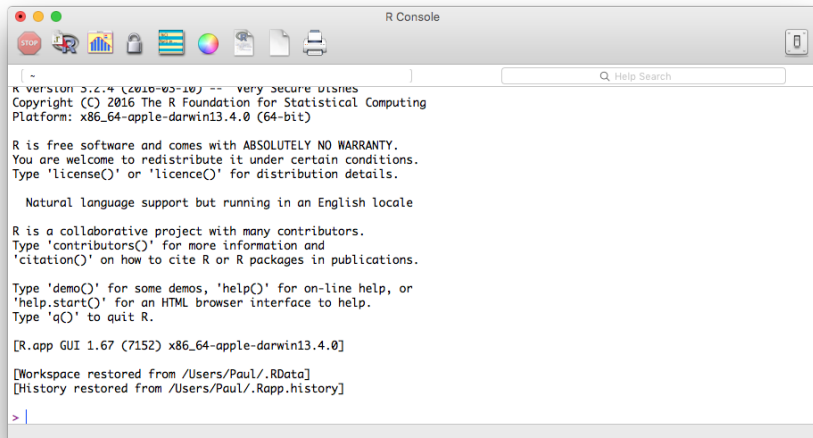


- RStudio has a very nice graphical user interface (GUI) that is easier to use than base R
- We will be using this throughout the course
- Make sure that you have R installed first. Then, download and install at this website:

<https://www.rstudio.com/products/RStudio/>



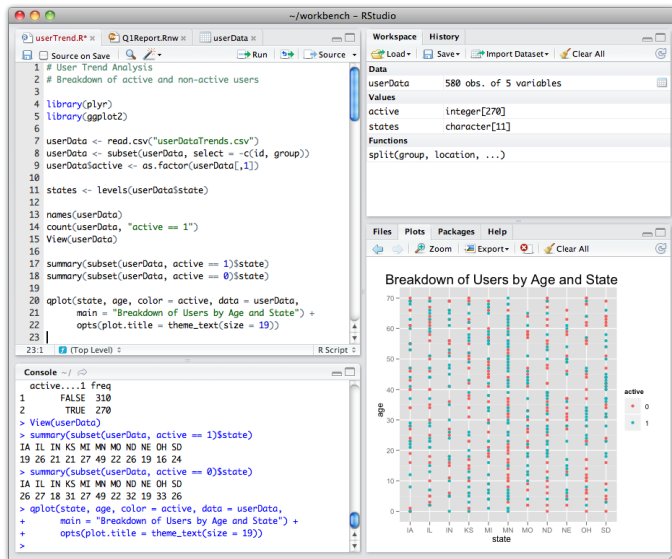
# The R Graphical User Interface (GUI)



The screenshot shows the R Console window with a standard macOS title bar and a toolbar containing icons for stop, undo, redo, zoom in, zoom out, lock, window management, color picker, help, and print. The console text includes the R version (3.2.4), copyright information (© 2016 The R Foundation), platform details (x86\_64-apple-darwin13.4.0), a disclaimer about warranty, and instructions for using R. It also shows the R.app GUI version (1.67) and workspace/history restoration status.

```
[ ~ ]  
R version 3.2.4 (2016-05-18) -- very secure buties  
Copyright (C) 2016 The R Foundation for Statistical Computing  
Platform: x86_64-apple-darwin13.4.0 (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.  
  
[R.app GUI 1.67 (7152) x86_64-apple-darwin13.4.0]  
  
[Workspace restored from /Users/Paul/.RData]  
[History restored from /Users/Paul/.Rapp.history]  
> |
```

# The RStudio GUI





## RStudio has Four Panels

- Console (bottom left) - where all calculations are performed
- Scripting/Viewing (top left) - where writing of new functions / scripts should be done
- Files/Packages/Help/Plots (bottom right) - for easy analysis
- Variables/Data/Functions (top right) - what is stored in your current Rsession



At their core, R and RStudio are just calculators! Try the following

$$3 + 2 = ? \quad \log(10) = ? \quad \sqrt{32} = ?$$

```
> 3 + 2
```

```
> log(10)
```

```
> sqrt(32)
```



- command: tell R to do something (e.g., add, subtract, print)
- variable: assign a value to an identifier

```
> my_cool_integer <- 5
```

```
> my_cool_string <- "hedgehog"
```

- object: often used interchangeably with variable
- script: a file documenting many commands, can be rerun

# Why do we write scripts?



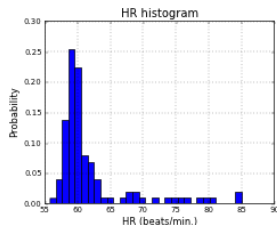
- reproducibility
- share-ability
- automate the boring stuff

# Example:



I compare 60 participants' heart rates before and after a stimulus

## Global analysis (time-domain parameters)



No. of beats: 105.00  
Mean HR: 62.15 bps  
STD HR: 5.96 bps  
Mean RR (AVNN): 972.81 msec.  
STD RR (SDNN): 77.66 msec.  
SDANN: --  
SDNNIDX: --

pNN50: 25.96%  
rMSSD: 74.99 msec.  
IRRR: 46.75 msec.  
MADRR: 24.00 msec.  
TINN: 48.25 msec.  
HRV index: 6.18

C	D	E	F	G	H
signal_length	lf_hf_ratio	percent_lf	percent_hf	stim	cond
263.24	1.066	0.24372817	0.27757109	none	rest
290.18	1.133	0.33410858	0.29051973	none	rest
304.81	0.616	0.18962122	0.33726336	none	rest
302.69	0.752	0.2117973	0.28170506	none	rest

- function: often used interchangeably with "command"
  - though generally we would call "add(2, 3)" a function but wouldn't call "2 + 3" a function
  - you will eventually be able to write your own functions!
  - very flexible
- argument: a function takes arguments to perform it's task (e.g., in "add(2, 3)" the "2" and the "3" are arguments)
  - an argument can be a variable or an option (e.g.,  
number\_of\_decimals = 2)
- working directory: where you are in the computers file structure





- R is case-sensitive
- I require you to use the assignment operator '`<-`' instead of the equality operator '`=`' for all submitted code, even though both work, e.g.,

Syntax	<i>Comments</i>
<code>x &lt;- 5</code>	standard syntax, required
<code>x = 5</code>	poor syntax, not permitted
<code>5 -&gt; x</code>	awkward syntax, not permitted (but it works)



---

Function	Action
<code>?foo</code>	Help on the function <code>foo</code>
<code>??foo</code>	Search the help system for instances of the function <code>foo</code>
<code>data()</code>	List all available example datasets contained in currently loaded packages
<code>getwd()</code>	List the current working directory
<code>ls()</code>	List the objects in the current directory

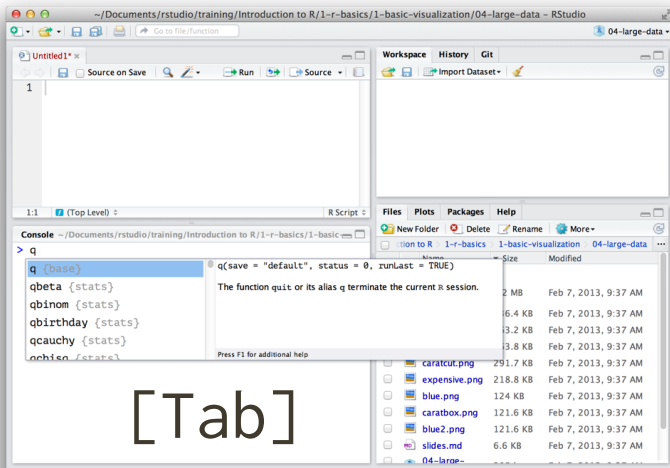
---

# Basic R Workspace Functions



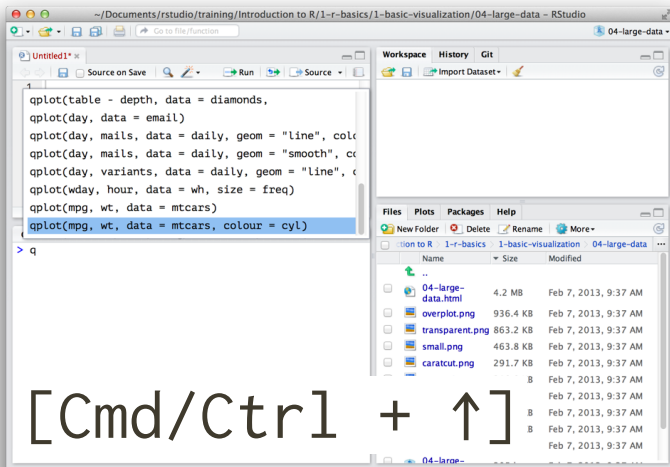
Function	Action
<code>getwd()</code>	List the current working directory.
<code>setwd("mydirectory")</code>	Change the current working directory to <i>mydirectory</i> .
<code>ls()</code>	List the objects in the current workspace.
<code>rm(objectlist)</code>	Remove (delete) one or more objects.
<code>help(options)</code>	Learn about available options.
<code>options()</code>	View or set current options.
<code>history(#)</code>	Display your last # commands (default = 25).
<code>savehistory("myfile")</code>	Save the commands history to <i>myfile</i> ( default = <i>.Rhistory</i> ).
<code>loadhistory("myfile")</code>	Reload a command's history (default = <i>.Rhistory</i> ).
<code>save.image("myfile")</code>	Save the workspace to myfile (default = <i>.RData</i> ).
<code>save(objectlist, file="myfile")</code>	Save specific objects to a file.
<code>load("myfile")</code>	Load a workspace into the current session (default = <i>.RData</i> ).
<code>q()</code>	Quit R. You'll be prompted to save the workspace.

# Useful R Keyboard Shortcuts: Autocomplete

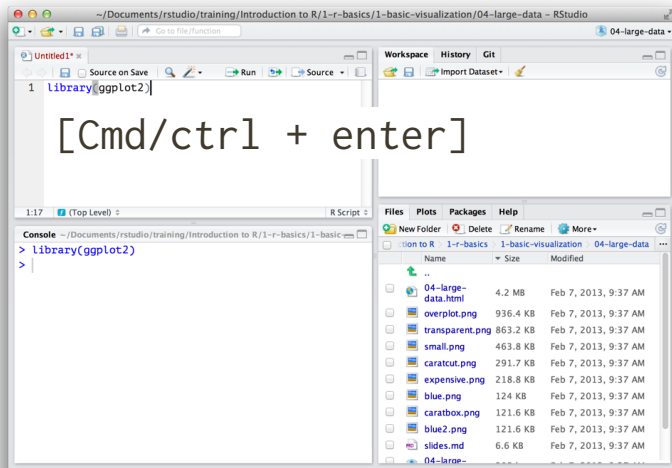


[Tab]

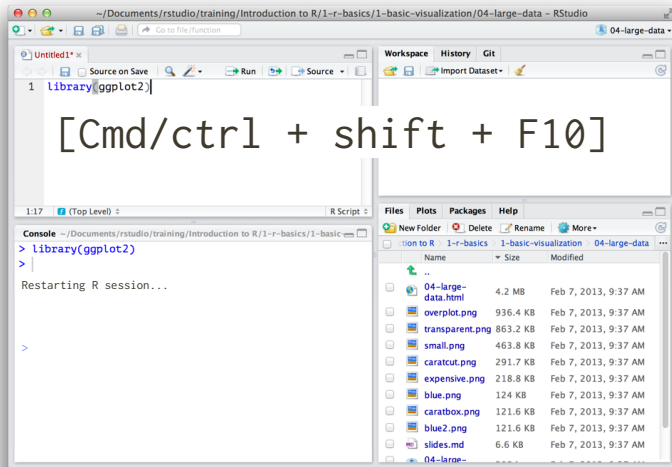
# Useful R Keyboard Shortcuts: History



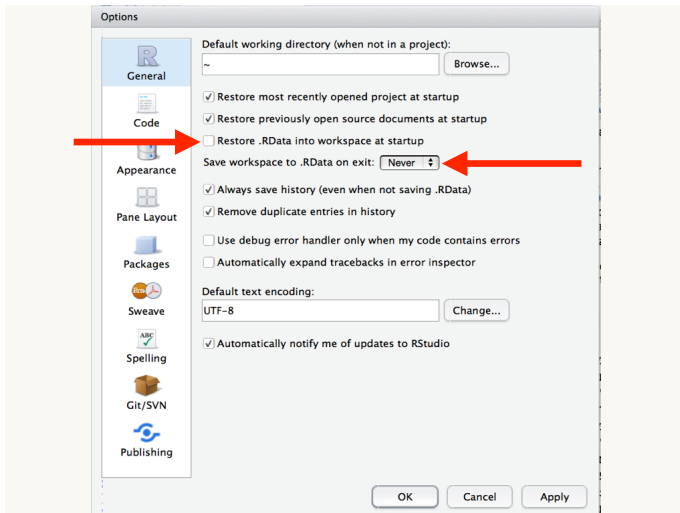
# Useful R Keyboard Shortcuts: Execute Code



# Useful R Keyboard Shortcuts: Restarting an R Sess



# IMPORTANT R Setting







- When writing code, you want to clear your environment to ensure the fidelity of your results
- If your previous setting is correct, one way to do this is to close and re-open your R environment
- You can also run the following two lines of code

```
rm(list=ls())  
cat("\014")
```

- 1 `rm(list=ls())` removes all objects in the current environment
- 2 On a Mac, `cat("\014")` clear the console windows (same as `ctrl + l`)

If you are sharing code you may not want to include this in your script



- R comes built in with multiple data sets you can play with
- Many (most?) packages also have data sets
- `data()` will bring up a list of all data sets available across all loaded packages
- `help(<nameOfDataSet>)` will provide you a detailed description of the data set in question

# How Big is *Big Data* in R?



- R holds data in memory, effectively limiting data to the amount of RAM a computer has access to
- It is not uncommon to work with a data set containing 100,000,000 elements (e.g., 100,000 observations of 1,000 variables or 1,000,000 observations of 100 variables) without difficulty
- Approximations depend on what type of data is contained in each variable, e.g., a data set with 2.2 million records and twenty variables, which takes approximately one minute to load into memory



- Also depends on what techniques and/or functions will be applied to the data
- The more complex and memory intensive the task, the smaller the data will be required to be
- Basic plotting requires far less computational exertion than a complex statistical learning model
- **Common Definition:** *Big Data* refers to any data set that cannot be loaded into working memory on your personal computer