

A whirlwind tour of Rstudio, R, and Rmarkdown Magic for behavioral and brain scientists

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May 17 2019

The big outline

- Part 0: Background and Community
- Part 1: Rstudio
- Part 2: Project and environment setup
- Part 3: R (et al., eg Python)
- Part 4: Rmarkdown
- Part 5: Advanced R and beyond
- Part 6: A few of our favorite things

- Part 0: Background and Community**
 - Part 1: Rstudio
 - Part 2: Setup
 - Part 3: R et al
 - Part 4: RMarkdown
 - Part 5: Advanced R
 - Part 6: Extras

Section 1

Part 0: Background and Community

Part 0: Background and Community

- What this is & isn't; a bunch of things we aren't covering but you should be aware of
 - This is a taste and to bring you into a bigger world
- Centralization, standards
- Help
- Including rigor & reproducibility of packages
- The “tidyverse”
 - Learn it. But don't learn *only* the tidyverse; you'll be lost in base R

R Background

- Created in 1992 by Gentleman & Ihaka

[we] considered the problem of obtaining decent statistical software for our undergraduate Macintosh lab. After considering the options, we decided that the most satisfactory alternative was to write our own. [...] Finally we added some syntactic sugar to make it look somewhat like S. We call the result “R”.

What is R?

- R is for stats and general purpose programming
- R is a functional language
 - Turing complete – can do anything other languages can do
- R is an environment to interface with the language
 - Console based
 - Type in commands
 - No point-and-click
- R is a collection of tools
 - Pre-packaged software at your disposal
- R is free (as in beer and speech)
 - No cost, no restrictions

R is a bit ugly

The screenshot shows the RGui interface. The R Console window displays the R startup message and basic usage information. The R Editor window shows a script named C:\Users\jrieck\Documents\workshops\2019_Rstudio_Magic\R\0_create_ADNI_data_base.R containing R code for data manipulation.

```
R version 3.3.1 (2016-06-21) -- "Bug in Your Hair"
Copyright (C) 2016 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (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.

> citation()

To cite R in publications use:

  R Core Team (2016). R: A language and environment for statisti
  computing. R Foundation for Statistical Computing, Vienna, Au
```

```
## Load and clean data
#####
## 0.1 Specify the column names and participants you want (ie, baseline visit 1)
adni.cols <- c('RID', 'VISCODE', 'DX', 'AGE', 'PTIGENDER', 'PTEDUCAT', 'PTETHCAT')
adni.rows <- c(adnimerge$VISCODE=='bl' & adnimerge$MOCA>=16)
merge_subset <- adnimerge[adni.rows,adni.cols]

## remove participants with missing data
merge_subset <- merge_subset[complete.cases(merge_subset),]

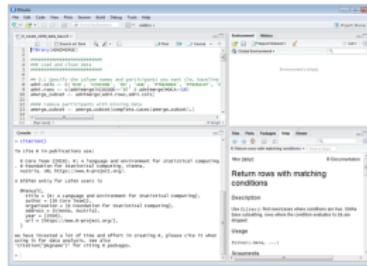
## 0.2 Bring in modified hachinski
merge_subset$HMSCORE <- modhach$HMSCORE[match(merge_subset$RID, modhach$RID)]

## 0.3 Manually change variable classes (remove class 'labelled')
merge_subset$RID <- as.character(merge_subset$RID)
merge_subset$VISCODE <- as.character(merge_subset$VISCODE)
merge_subset$DX <- as.character(merge_subset$DX)
merge_subset$AGE <- as.numeric(merge_subset$AGE)
merge_subset$PTGENDER <- as.character(merge_subset$PTGENDER)
merge_subset$PTEDUCAT <- as.numeric(merge_subset$PTEDUCAT)
```

But R has many interfaces

- Today we focus on RStudio (MatLab-like)
- But see also Deducer, RCommander (SPSS-like)

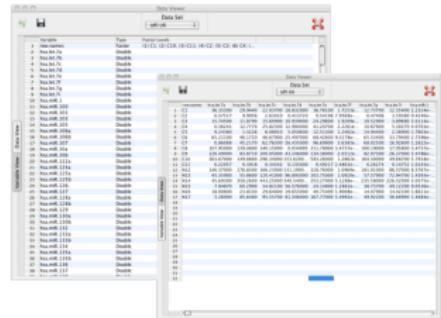
RStudio



RCommander



Deducer



R is a community (actually many communities!)

- Help and resources
- Package development and distribution

R: Help!

- <https://www.statmethods.net/>
- Online forums (Stack Exchange, r-lists)
- SpringerLink
 - All R books for free (pdf format) or for minimal cost (printed)
- Vignettes
 - step-by-step instruction guides for packages

R Packages

- Packages are bundles of code made by someone (or many people) for everyone to use
 - If you can think of a stats problem, there is a package for it
- Available primarily on CRAN
 - But also github, r-forge

Part 0: Background and Community
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Part 4: RMarkdown
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Part 6: Extras

Tidyverse

- something here about tidy

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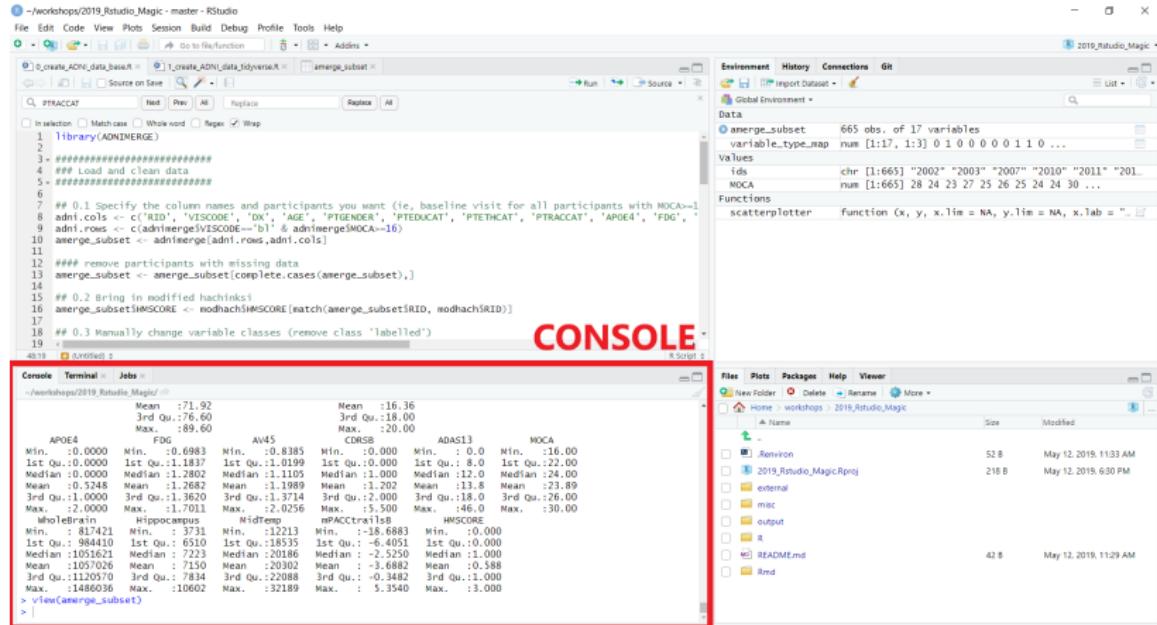
Section 2

Part 1: Rstudio

Part 1: RStudio

- Settings, a quit tour through stuff, features
- Examples on getting setup

RStudio Environment



The screenshot shows the RStudio interface with the following components:

- Code Editor:** Displays R code for creating an ADNI data subset. The code includes sections for specifying column names, loading and cleaning data, and merging datasets. It also handles missing data and manually changes variable classes.
- Console:** Shows the output of the R code execution. The output includes summary statistics for variables like APOE4, FDG, AV45, CDRSB, ADAS13, and MMSE across different groups (e.g., 1st Qu., Median, Mean, Max.).
- File Browser:** Shows the directory structure under "workshops/2019_Rstudio_Magic". It includes files like .Renviron, 2019_Rstudio_Magic.Rproj, mac, output, R, README.md, and Rmd.

```

#> library(ADNImerge)
#> #####
#> #### Load and clean data
#> #########
#> ## 0.1 Specify the column names and participants you want (ie, baseline visit for all participants with MOCA==1
#> adm1.cols <- c("MDID", "VISCODE", "DX", "AGE", "PTGENDER", "PTEDUCAT", "PTETHCAT", "PTRACCAT", "APOE4", "FDG", "MMSE")
#> adm1.rows <- (admireg[!(viscode %in% b)] & admireg$MOCA == 1)
#> amerge_subset <- admireg[adm1.rows, adm1.cols]
#>
#> #### remove participants with missing data
#> amerge_subset <- amerge_subset[complete.cases(merge_subset),]
#>
#> ## 0.2 Bring in modified hachinski
#> amerge_subset$HMSCORE <- modhach$HMSCORE[match(merge_subset$RID, modhach$RID)]
#>
#> ## 0.3 Manually change variable classes (remove class 'labelled')
#> 
```

	APOE4	FDG	AV45	CDRSB	ADAS13	MMSE
Min.	-0.0000	Min.: -0.6983	Min.: -0.8385	Min.: 0.0000	Min.: 0.0	Min.: -16.00
1st Qu.	0.0000	1st Qu.: 11.1837	1st Qu.: 11.0189	1st Qu.: 0.0000	1st Qu.: 8.0	1st Qu.: 22.00
Median	0.0000	Median : 11.2802	Median : 11.1105	Median : 1.0000	Median : 12.0	Median : 24.00
Mean	0.5248	Mean : 11.2682	Mean : 11.1989	Mean : 1.202	Mean : 13.8	Mean : 23.89
3rd Qu.	1.0000	3rd Qu.: 11.3620	3rd Qu.: 11.3714	3rd Qu.: 2.0000	3rd Qu.: 18.0	3rd Qu.: 26.00
Max.	2.0000	Max.: 11.7011	Max.: 12.0256	Max.: 15.5000	Max.: 20.00	Max.: 30.00
Wholetree		Hippocampus	Widespread	HMSCORE		
Min.	817421	Min.: 3731	Min.: 12213	Min.: -18.6883	Min.: 0.0000	
1st Qu.	984410	1st Qu.: 6510	1st Qu.: 18553	1st Qu.: -6.4051	1st Qu.: 0.0000	
Median	1051621	Median : 7223	Median : 20186	Median : -2.5250	Median : 1.0000	
Mean	1057026	Mean : 7150	Mean : 20302	Mean : -3.6882	Mean : 0.588	
3rd Qu.	1120573	3rd Qu.: 7834	3rd Qu.: 22088	3rd Qu.: -0.3482	3rd Qu.: 1.0000	
Max.	1486036	Max.: 10602	Max.: 32189	Max.: 5.3540	Max.: 3.000	

```

> vfeatmerge_subset
> 
```

RStudio Environment

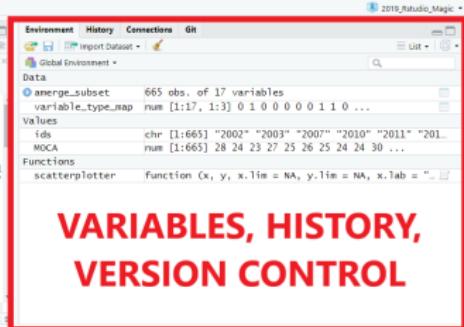
The screenshot shows the RStudio interface with the following components:

- Script Editor:** Displays R code for creating an ADNI data subset. The code includes library imports, data loading, cleaning, and merging steps. It also handles missing data and manually changes variable classes.
- Global Environment:** Shows the global environment with objects like `anmerge_subset`, `variable_type_map`, `ids`, `MOCA`, and `Functions`.
- File Browser:** A red box highlights the file browser pane, which shows the project structure under "workshops/2019_Rstudio_Magic".

FILES, PLOTS, HELP

```
## ~/workshops/2019_Rstudio_Magic - master - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to Reference Run Source
In selection Match case Whole word Replace Wrap
1 library(ADNImerge)
2
3 #####
4 ### Load and clean data
5 #####
6
7 ## 0.1 Specify the column names and participants you want (ie, baseline visit for all participants with MOCA==1
8 adm1.cols <- c("RID", "VISCODE", "DX", "AGE", "PTGENDER", "PTEDUCAT", "PTETHCAT", "PTRACCAT", "APOE4", "FDG", "MMSE", "MOCA")
9 adm1.rows <- adm1merge[!(adm1merge$VISCODE=="b") & adm1merge$MOCA==1]
10 anmerge_subset <- adm1merge[adm1.rows,adm1.cols]
11
12 #### remove participants with missing data
13 anmerge_subset <- anmerge_subset[complete.cases(anmerge_subset),]
14
15 ## 0.2 Bring in modified hachinski
16 anmerge_subset$HMSCORE <- modhachis$HMSCORE[match(anmerge_subset$RID, modhachis$RID)]
17
18 ## 0.3 Manually change variable classes (remove class 'labelled')
19
48:19 [1] (Unbound) 5
Console Terminal Jobs
~/workshops/2019_Rstudio_Magic>
      Mean :71.92      Mean :16.36
      3rd Qu.:76.60    3rd Qu.:18.00
      Max. :89.60     Max. :20.00
ADPOE4 FDG AV45 CDRSB ADAS13 MOCA
Min. :0.0000 Min. :0.6983 Min. :-0.8385 Min. :0.0000 Min. : 0.0 Min. :-16.00
1st Qu.:0.0000 1st Qu.:11.8337 1st Qu.:1.0189 1st Qu.:0.0000 1st Qu.: 8.0 1st Qu.:22.00
Median :0.0000 Median :11.2802 Median :1.1105 Median :1.0000 Median :12.0 Median :24.00
Mean : 0.5248 Mean : 11.2682 Mean : 1.1989 Mean : 1.202 Mean : 13.8 Mean : 23.89
3rd Qu.:1.0000 3rd Qu.:11.3620 3rd Qu.:1.3714 3rd Qu.:2.0000 3rd Qu.:18.0 3rd Qu.:26.00
Max. :2.0000 Max. : 11.7011 Max. : 12.0256 Max. : 15.5000 Max. : 18.00 Max. : 30.00
Wholetime Hippocampus Nidkrantz HSCORE
Min. : 817421 Min. : 3731 Min. : -12213 Min. : -18.6883 Min. : 0.0000
1st Qu.: 984410 1st Qu.: 6510 1st Qu.: 18535 1st Qu.: -6.4051 1st Qu.: 0.0000
Median :1051621 Median : 7223 Median : 20186 Median : -2.5250 Median : 1.0000
Mean :1070268 Mean : 7150 Mean : 20303 Mean : -3.6882 Mean : 0.588
3rd Qu.:1120521 3rd Qu.: 7834 3rd Qu.:22088 3rd Qu.: -0.3482 3rd Qu.: 1.0000
Max. :1486036 Max. : 10602 Max. : 32189 Max. : 5.3540 Max. : 3.000
> vleeranmerge_subset
```

RStudio Environment



The screenshot shows the RStudio interface with several windows open:

- Code Editor:** Shows R code for creating an ADNI data subset. The code includes library(ADNImerge), loading data from 'PTRECAT', 'PTEDUCAT', 'PTETHCAT', 'PTRACCAT', 'APOE4', 'FDG', and 'MOCA'. It handles missing data and merges rows from 'modhachscore' and 'modhachRID'. Finally, it manually changes variable classes.
- Console:** Displays statistical summaries for variables like 'APOE4', 'FDG', 'AV45', 'CDRSEB', 'ADAS13', and 'MOCA', including min, max, mean, median, and quartiles.
- Environment:** Shows the global environment with objects like 'anmerge_subset', 'variable_type_map', 'ids', 'MOCA', and 'Functions'.
- History:** Shows the history of commands run in the session.
- Version Control:** Shows the file structure under 'Home / workshops / 2019_Rstudio_Magic' with files like '.Renviron', '2019_Rstudio_Magic.Rproj', 'external', 'mac', 'output', 'R', 'README.md', and 'Rmd'.

RStudio Environment

The screenshot shows the RStudio interface with several windows open:

- Environment:** Shows the global environment with objects like `merge_subset`, `variable_type_map`, `ids`, `MOCA`, and `Functions`.
- Code Editor:** The main window displays R code for data manipulation, specifically merging datasets and cleaning MOCA data. A red box highlights the code area.
- File Browser:** Shows the project structure under "Home / workshops / 2019_Rstudio_Magic".
- Console:** Displays statistical summaries for variables like `AP004`, `FDG`, `AV45`, `CDRSB`, `ADAS13`, and `MOCA`. It also shows the results of the `merge_subset` command.
- Terminal:** Shows the command `> vfeatmerge_subset()`.

```
## 0.1 specify the column names and participants you want (ie, baseline visit for all participants with MOCA==1
1 admin.cols <- c("RID", "VISCODE", "DX", "PTGENDER", "PTEDUCAT", "PTETHCAT", "PTRACCAT", "APOE4", "FDG", "ADAS13", "CDRSB", "MOCA")
2 admin.rows <- cadminmerge$VISCODE=="b" & adm.adminmerge$MOCA==1)
3 admin.merge <- adminmerge[admin.rows,admin.cols]
4
5 #### remove participants with missing data
6 merge_subset <- merge_subset[complete.cases(merge_subset),]
7
8 ## 0.2 Bring in modified hachinski
9 merge_subset$HMSCORE <- modhach$HMSCORE[match(merge_subset$RID, modhach$RID)]
10
11 ## 0.3 Manually change variable classes (remove class 'labelled')
12
13
14
15
16
17
18
19 :)
```

Variable	Min.	Q1	Median	Q3	Max.								
AP004	-0.0000	Min.: -0.6983	Min.: -0.8385	Min.: -0.0000	Min.: 0.0	Mean: .71.92	Mean: .16.36	Mean: .16.00	Mean: .16.00	3rd Qu.: .76.60	3rd Qu.: .18.00	Max.: .89.60	Max.: .20.00
FDG													
AV45													
CDRSB													
ADAS13													
MOCA													

Variable	Min.	Q1	Median	Q3	Max.
HMSCORE	Min.: -817421	Min.: -3731	Min.: -12213	Min.: -18.6883	Min.: 0.0000
	1st Qu.: 984410	1st Qu.: 6510	1st Qu.: 18535	1st Qu.: -6.4051	1st Qu.: 0.0000
	Median : 1051621	Median : 7223	Median : 20186	Median : -2.5250	Median : 1.0000
	Mean : 1057026	Mean : 7150	Mean : 20306	Mean : -3.6882	Mean : 0.588
	3rd Qu.: 1020520	3rd Qu.: 7834	3rd Qu.: 22088	3rd Qu.: -0.3482	3rd Qu.: 1.0000
	Max. : 1486036	Max. : 10602	Max. : 32189	Max. : 5.3540	Max. : 3.000

RStudio Environment

The screenshot displays the RStudio interface with several windows open:

- Data Viewer:** A red box highlights this window, showing a table of data for 15 rows. The columns include DX, AGE, PTGENDER, PTEDUCAT, PTETHCAT, PTREACCAT, AP0E4, FDG, AV45, CDRSB, ADAS13, MOCA, and WholeBrain.
- Global Environment:** Shows the global variables defined in the workspace, such as `anmerge_subset`, `variable_type_map`, `ids`, `MOCA`, and `scatterplotter`.
- File Browser:** Shows the project structure under "Home / workshops / 2019_Rstudio_Magic".
- Console:** Displays various R commands and their output, including descriptive statistics for columns like AP0E4, FDG, AV45, CDRSB, ADAS13, and MOCA, and a warning message about hippocampus.

Benefits of RStudio

- Built-in integration with version control (git or SVN)
- Package and documentation generation
- Reproducible science!
 - R Markdown documents
 - Save and execute code
 - Generate high quality reports that can be shared
 - Create presentations (like this one!)
 - Even write papers

RStudio Resources

The screenshot shows the RStudio website homepage. At the top, there's a navigation bar with links for Products, Resources, Pricing, About Us, Blogs, and a search icon. Below the navigation, there are three main sections: 'RStudio' (showing a screenshot of the IDE interface), 'Shiny' (showing a screenshot of a Shiny app with a map of the US and a bar chart), and 'R Packages' (showing icons for six popular R packages: rmarkdown, shiny, dplyr, knitr, ggplot2, and tidyverse). Each section has a 'Learn More' button.

RStudio

RStudio makes R easier to use. It includes a code editor, debugging & visualization tools.

[Download](#) [Learn More](#)

Shiny

Shiny helps you make interactive web applications for visualizing data. Bring R data analysis to life.

[Learn More](#)

R Packages

Our developers create popular packages to expand the features of R. Includes `ggplot2`, `dplyr`, `R Markdown` & more.

[Learn More](#)

RStudio Resources

Online Learning - RStudio

https://www.rstudio.com/online-learning/

R Studio

Products Resources Pricing About Us Blogs

Online learning

- R Programming
- Shiny
- R Markdown
- Data Science
- Books

A wealth of tutorials, articles, and examples exist to help you learn R and its extensions. Scroll down or click a link below for a curated guide to learning R and its extensions.

R Programming

Read More >

Shiny

Read More >

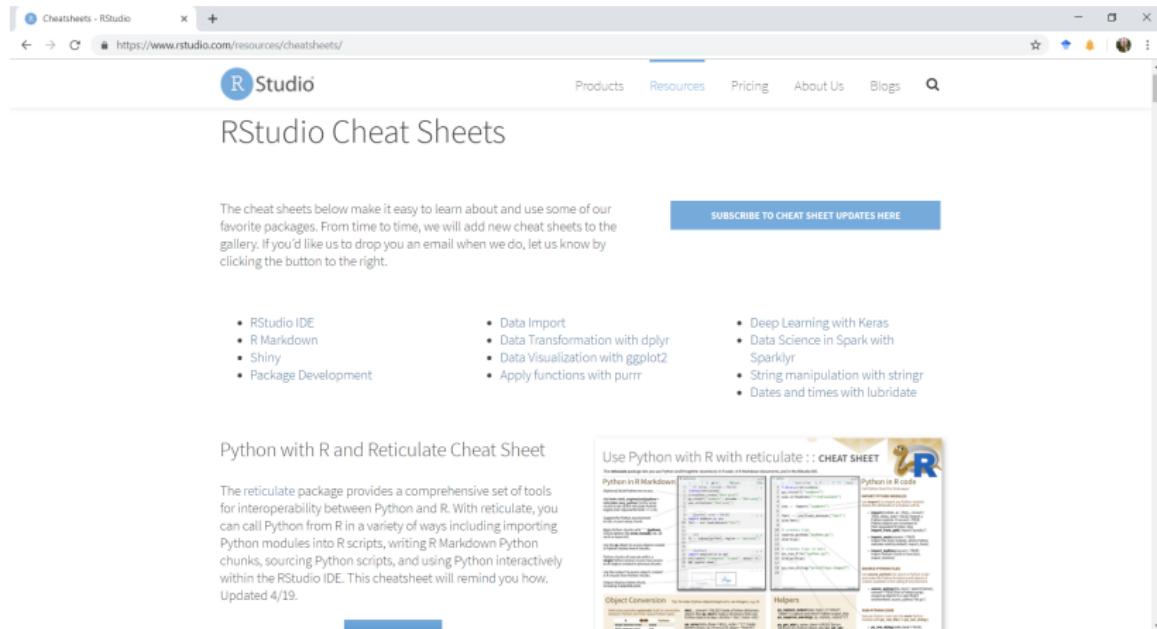
R Markdown

Read More >

Data Science

Read More >

RStudio Resources



The screenshot shows a browser window displaying the RStudio Cheat Sheets page at <https://www.rstudio.com/resources/cheatsheets/>. The page has a dark blue header with the RStudio logo and navigation links for Products, Resources (which is underlined), Pricing, About Us, Blogs, and a search icon. Below the header is a large section titled "RStudio Cheat Sheets". To the left, there's a text block about the purpose of the cheat sheets, and to the right, a blue button that says "SUBSCRIBE TO CHEAT SHEET UPDATES HERE". The main content area is divided into three columns of bullet points:

- RStudio IDE
- R Markdown
- Shiny
- Package Development
- Data Import
- Data Transformation with dplyr
- Data Visualization with ggplot2
- Apply functions with purrr
- Deep Learning with Keras
- Data Science in Spark with Sparklyr
- String manipulation with stringr
- Dates and times with lubridate

Below this, there's a section for "Python with R and Reticulate Cheat Sheet". It includes a text block about the package, a note that it was updated on 4/19, and a link to the full cheat sheet which is shown as a grid of four panels: Python in R Markdown, Python in R Code, Object Conversion, and Helpers.

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Section 3

Part 2: Setup

Part 2: Project and Environment Setup

- Hidden files & whatnot
- Have a structure ready to go on Github
- Explain/walk through
- Discuss the helpful packages above

RStudio Setup

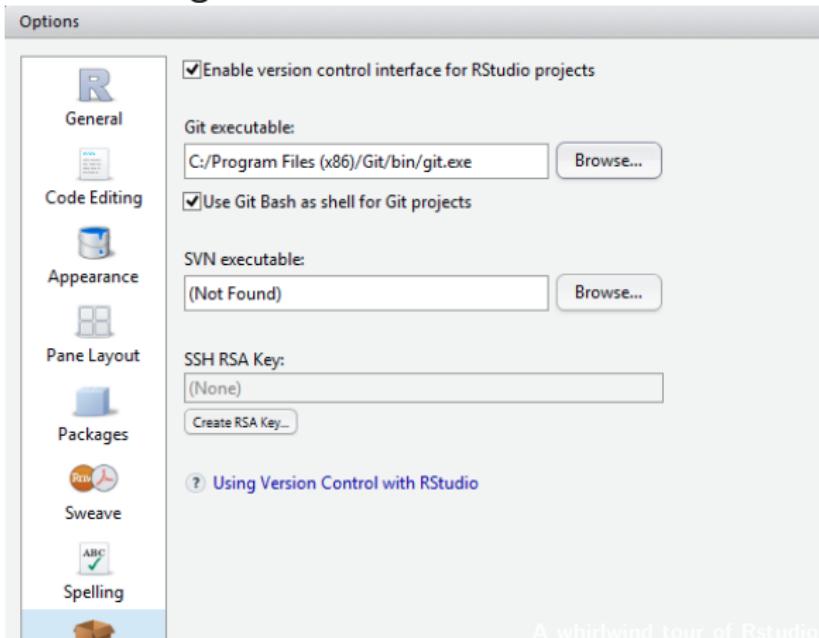
- Download R and Rstudio
- Add-on packages

```
#to install from CRAN
install.packages('devtools', dependencies = TRUE)
#to install from a file
install.packages('/mypath/to/package/ADNIMERGE.tar.gz',
                 type='source', repos=NULL)
#to install from a git  (requires the devtools package)
dev.tools::install_github(Gibbsdavidl/CatterPlots)
```

- See <https://jennybc.github.io/2014-05-12-ubc/r-setup.html> for a detailed guide

Rstudio Setup: Projects & Git

- Download git and link to RStudio



Rstudio Setup: Projects & Git

- Create a new project File

New Project

Create Project

 **New Directory**
Start a project in a brand new working directory >

 **Existing Directory**
Associate a project with an existing working directory >

 **Version Control**
Checkout a project from a version control repository >

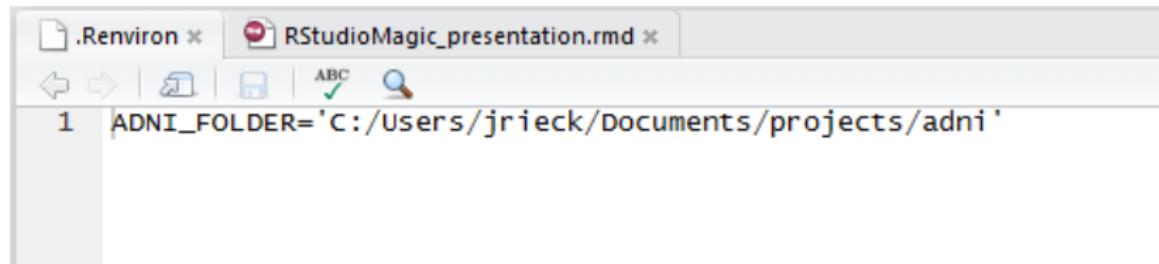
Cancel

Format .gitignore

- File types to ignore:
 - `.Rproj.user`
 - `.Rhistory`
 - `.Ruserdata`
 - `.Renviron`
 - `.rda & .Rdata` (to avoid pushing potentially sensitive data files to git)
 - `**` before each extention will match directories anywhere in the repo

Format environmental variables

- Set environmental variables (ie, directory location of data) to make code generalizable across computers
 - In your project folder create a `.Renvironment` file and define variables

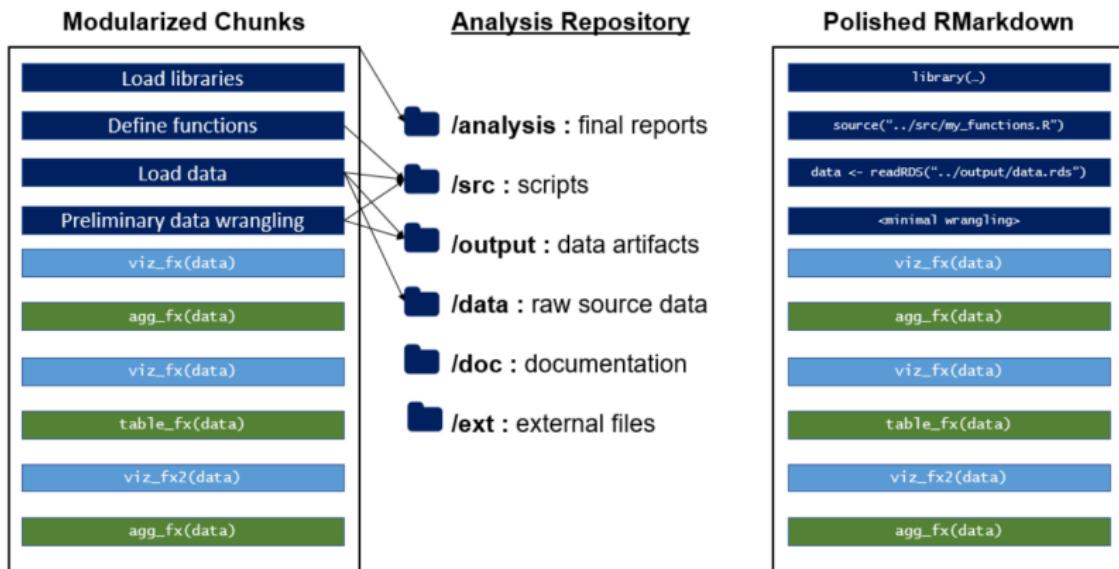


The screenshot shows the RStudio interface. The top bar has two tabs: ".Renvironment" and "RStudioMagic_presentation.rmd". Below the tabs are standard file navigation icons. The main workspace shows the following code in a text editor:

```
1 ADNI_FOLDER='C:/users/jrieck/Documents/projects/adni'
```

Organize your project folders and markdown

*<https://emilyriederer.netlify.com/post/rmarkdown-driven-development/>



Organize your project folders and markdown

[jennyrieck / workshops](#)

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Branch: master [workshops / 2019_Rstudio_Magic /](#) [Create new file](#) [Upload files](#) [Find file](#) [History](#)

jennyrieck added our favoRite things [...](#) Latest commit d818f26 6 hours ago

..

R more updates to manuscript example! 23 hours ago

Rmd added our favoRite things 6 hours ago

external/images reorganizing pngs 6 hours ago

misc reorganizing pngs 6 hours ago

2019_Rstudio_Magic.Rproj initial folder structure 5 days ago

README.md create readme 5 days ago

README.md

Rstudio magic for BrainHack Toronto 2019

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Section 4

Part 3: R et al

Part 3: R et al

- A bit of background, including idiosyncrasies and unique things about R
 - Especially packages & three ways to install (somewhat covered above) CRAN, Locally, Git & others (devtools)
 - It's a functional language
 - Data types Including data frames & alts like tibbles
- Read/explore
 - explore .R scripts
- Clean/export
 - Show 0_Create from PCA/MCA with Base, Tidyverse, Plyr (NOT dplyr), data.table
 - Reimport?
 - Analyze With MCA & covstatis

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Section 5

Part 4: RMarkdown

Part 4: RMarkdown

- What it is /why to use it
- A short deviation for LaTeX, and new helpers: kable & kableExtra
 - A taxonomy and how to approach this *Tying it all together through here 1: simple RMD* Plot-based visuals
 - Base, gt, ggplot, grobTable()/grid/gridExtra
 - 2: Slides (these ones here)
 - 3: Manuscripts!!
- Reporting/presentin

Section 6

Part 5: Advanced R

Part 5: Some advanced/other things we're not covering

- package development
- Shiny
- SQL
- C/C++
- R2D3

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Section 7

Part 6: Extras

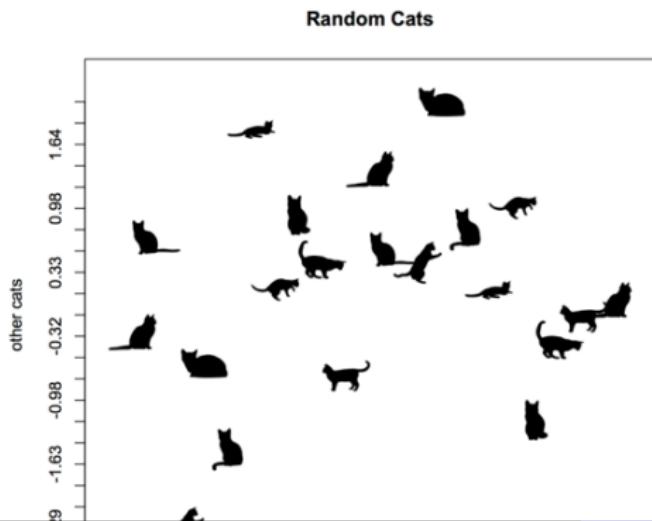
Part 6: A few of our favorite things

- Fun R do-dads

CatterPlot for feline based graphics:

- <https://github.com/Gibbsdavidl/CatterPlots>

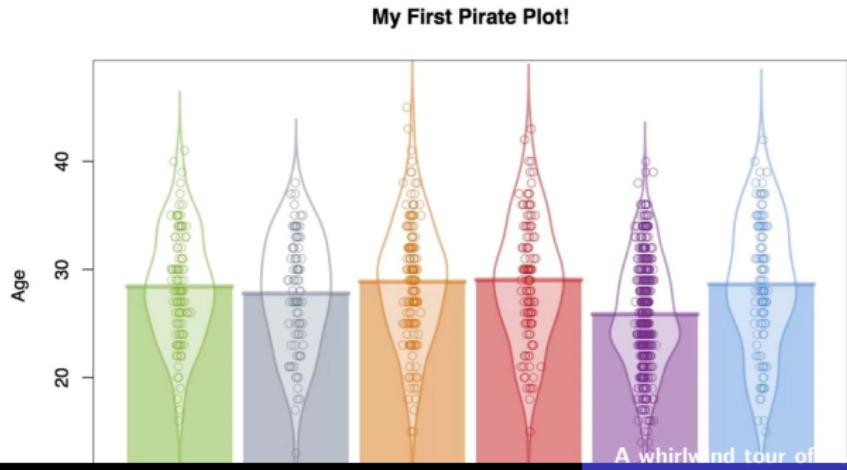
```
devtools::install_github(Gibbsdavidl/CatterPlots)
```



What's a pirate's favorite programming language?

- <https://cran.r-project.org/web/packages/yarr/vignettes/pirateplot.html>

```
install.packages('yarr')
```



Color palettes to fit your mood

- <https://github.com/karthik/wesanderson>

```
devtools::install_github(karthik/wesanderson)
```

The Life Aquatic with Steve Zissou (2004)

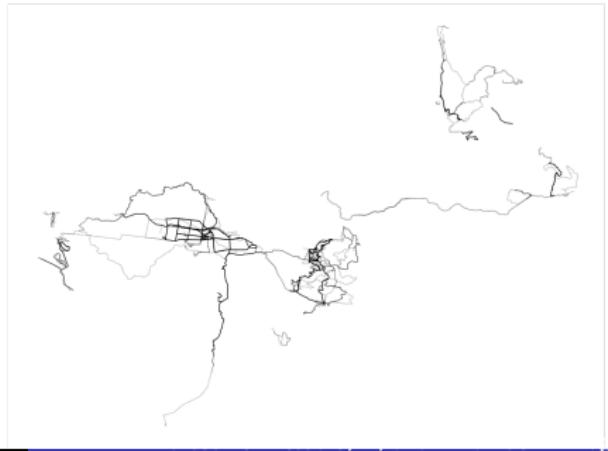
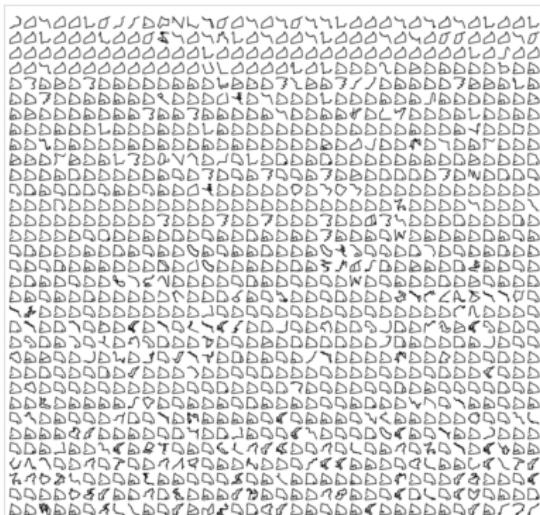
```
wes_palette("Zissou1")
```



```
pal <- wes_palette("Zissou1", 21, type = "continuous")
image(volcano, col = pal)
```

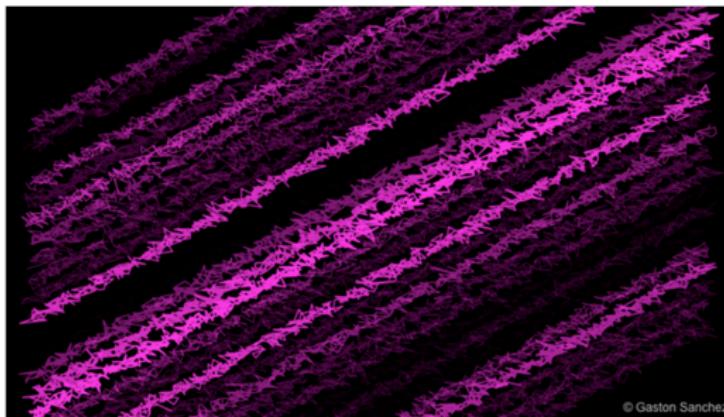
Mapping your Strava routes

- <https://www.r-bloggers.com/strava-rides-map-in-r/>
- ALSO <https://marcusvolz.com/?p=4068>
 - `devtools::install_github(marcusvolz/strava)`



Make aRt!

- R Graph Gallery
 - <http://www.r-graph-gallery.com/>
- Rtist: Gaston Sanchez
 - <http://gastonsanchez.com/Rtist/>



© Gaston Sanchez

```
# pink_barbs
# generate pairs of x-y values
x <- seq(1, 100, length = 1000)
y <- x + rnorm(1000)

png("pink_barbs.png", width = 700, height = 400)
# set graphical parameters
op <- par(bg = "black", mar = rep(0, 4))
# plot
plot(x, y, type = "n")
for (i in seq(-80, 70, by = 5)) {
  lines(x + rnorm(1000), x + i + rnorm(1000, 2), pch = 19,
        col = hsv(0.85, 1, 1, runif(1000)),
        lwd = sample(seq(0.5, 2, length = 20), 1))
}
# signature
legend("bottomright", legend = "@ Gaston Sanchez", bty = "n",
       col = "pink_barbs", cex = 0.8)
# reset par
par(op)
dev.off()
```