Reproducible (and collaborative) science through RStudio

A whirlwind tour with R, RMarkdown, Python, LaTeX, and more

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The big outline

- Part 0: Background
- Part 1: A bit about R
- Part 2: RStudio & Project setup
- Part 3: R, RMarkdown, & more
- Part 4: Advanced, beyond, & our favorites

Part 0: Background

To dive right in

If you want to skip over the background & RStudio, go straight to Part 2: RStudio & Project setup

Background

- This is a taste and to bring you into a bigger world
  - R, Python, SQL, and JavaScript are critical data science tools/languages
- R (language and community) strongly emphasizes
  - Centralization & standards
  - Rigor & reproducibility (packages, RMarkdown)
- An interesting language
  - Functional
  - With a sublanguage (or dialect?): the `tidyverse`

R is a community (actually many communities!)

- Help and resources
- Package development and distribution
- An ideal example
  - Not quite always that way
  - Strong communal presence

R: Help!

- So many websites e.g., 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
- Git
  - With open books (via bookdown)
- Twitter #rstats
- RStudio (website)
  - Videos, cheat sheets

R Packages

- Packages are bundles of code made by someone (or many people) for everyone to use
  - There are packages for everything
  - We'll cover some of the diversity throughout
- Comprehensive & Reproducible
- Available primarily on CRAN
  - But also github (less so: r-forge)

Part 1: A bit about 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 general purpose programming
  - Design around & for statistics
  - "for and by statisticians"
- R is a collection of tools
  - Pre-packaged software at your disposal
- R is free (as in beer and speech)
  - No cost, no restrictions
  - E.g., Microsoft (nee Revolution) R
- R is a functional language
  - Turing complete
  - Mathematical functions
  - Pass expressions and functions to and from functions

R: Data types

- Stored as *vectors*
  - see `class()`
- numeric
  - real or decimal
  - Includes `NaN`, `Inf`, `-Inf`
- integer
- complex
- character
- logical
  - includes `NA`, `TRUE`, `FALSE`
- factor
  - factors are usually not your friends
  - generally: stringsAsFactors = F or convert these

R: factor disasters

```
a_numeric_vector <- c(3, 0, 1, -2, 2, 5,
    5, 2, 1)
(a_numeric_vector + 1)
```

```
## [1]  4  1  2 -1  3  6  6  3  2
```

```
(a_numeric2factor_vector <- as.factor(a_numeric_vector))
```

```
## [1] 3  0  1  -2 2  5  5  2  1
## Levels: -2 0 1 2 3 5
```

```
(as.numeric(a_numeric2factor_vector))
```

```
## [1] 5 2 3 1 4 6 6 4 3
```

```
(as.numeric(as.character(a_numeric2factor_vector)))
```

```
## [1]  3  0  1 -2  2  5  5  2  1
```

R: Data structures

- Starts counting from 1
  - Not 0
- vector[1]
- matrix[1,1]
- array[1,1,1]
- list[[1]]
  - Can contain mixtures of types
  - or list$`name`
- data.frame:
  - Is technically a list but access in three ways
  - data.frame[[1]][1]
  - data.frame[1,1]
  - data.frame$`name`
  - tibbles: tidyverse data.frames

R: Some syntax

```r
# allowed but not preferred
a_variable = 10 + 1

# preferred
a_variable <- 10 + 1

# a bonus
10 + 1 -> a_variable
```

R: Some syntax

```r
# allowed but not preferred
a.variable = 10 + 1
## dots have 2 meanings in R, with a 3rd
## in the tidyverse

# preferred
a_variable <- 10 + 1
```

R: Some reservations

- c, q, t, C, D, F, I, and T (via https://www.johndcook.com/blog/r_language_for_programmers/)
- Except that these can be redefined
  - With great power comes great responsibility (and danger)

Tidyverse

- R is "base R"
- `tidyverse`: "an opinionated collection of R packages designed for data science [that] share an underlying design philosophy, **grammar, and data structures.**"
  - Started(?) with/because of `ggplot2`
  - A sublanguage or dialect
  - Can do so because R is functional language
- Strongly built around a style:
  - objects are nouns
  - functions are verbs
- Learn it!
  - But don't learn *only* the tidyverse, you'll be lost in base R

R cheat sheets

- R to Matlab: https://cran.r-project.org/doc/contrib/Hiebeler-matlabR.pdf
- R for programmers: https://www.johndcook.com/blog/r_language_for_programmers/
- RStudio's giant list: https://www.rstudio.com/resources/cheatsheets/

Part 2: RStudio & Project setup

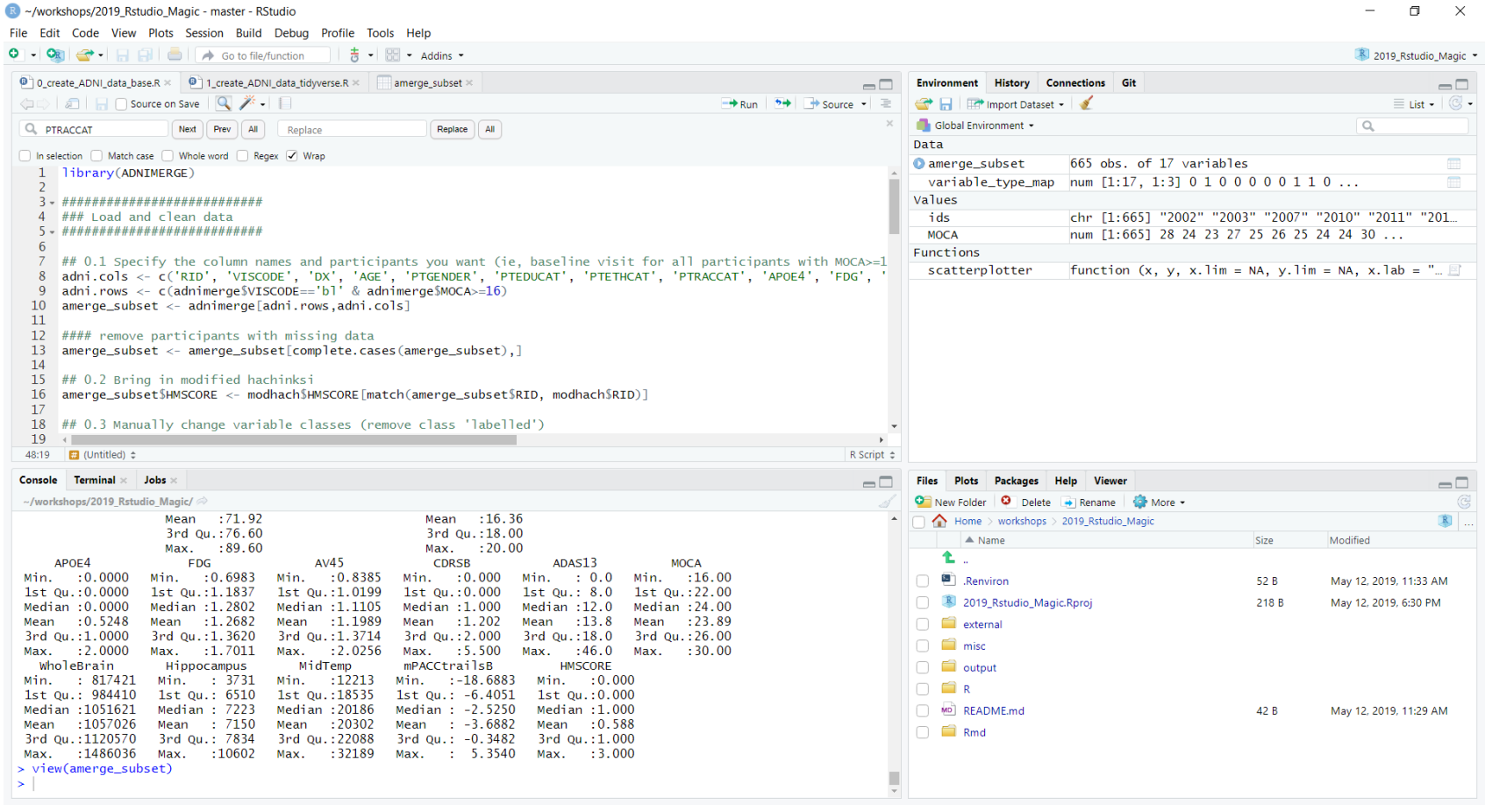
RStudio

- IDE: Integrated development environment
- RStudio: Does so much
  - We scratch the surface here
- Quick walk through
- Followed by specific set up
  - Generally, but
  - Also for this workshop

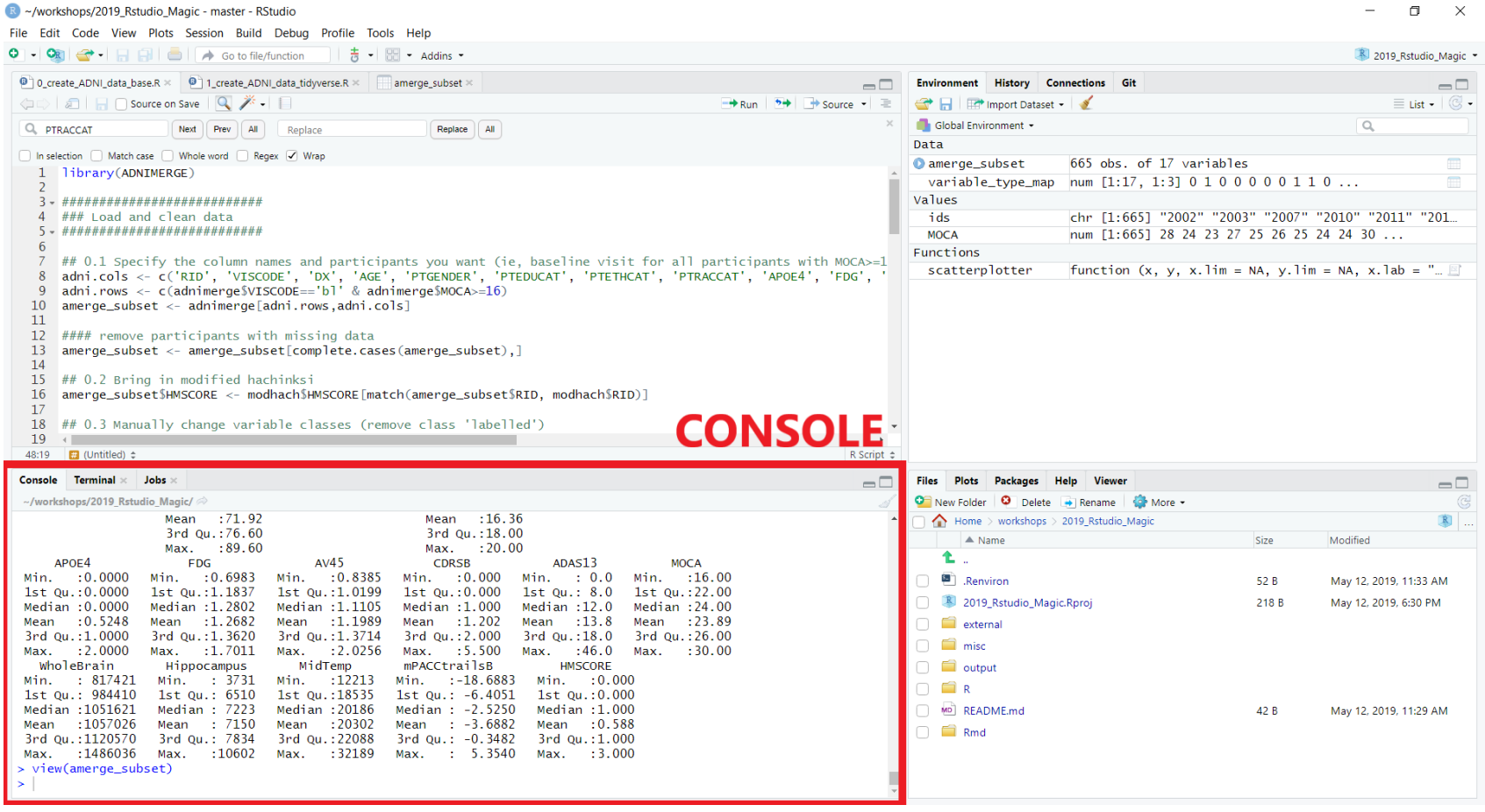
RStudio Setup

- Download R and Rstudio
- Strongly recommend Microsoft R (https://mran.microsoft.com/open)
  - Comes with Intel MKL
- Plain R is fine (https://cran.r-project.org/)
  - Can relink to faster libraries
- Download RStudio (https://www.rstudio.com/)

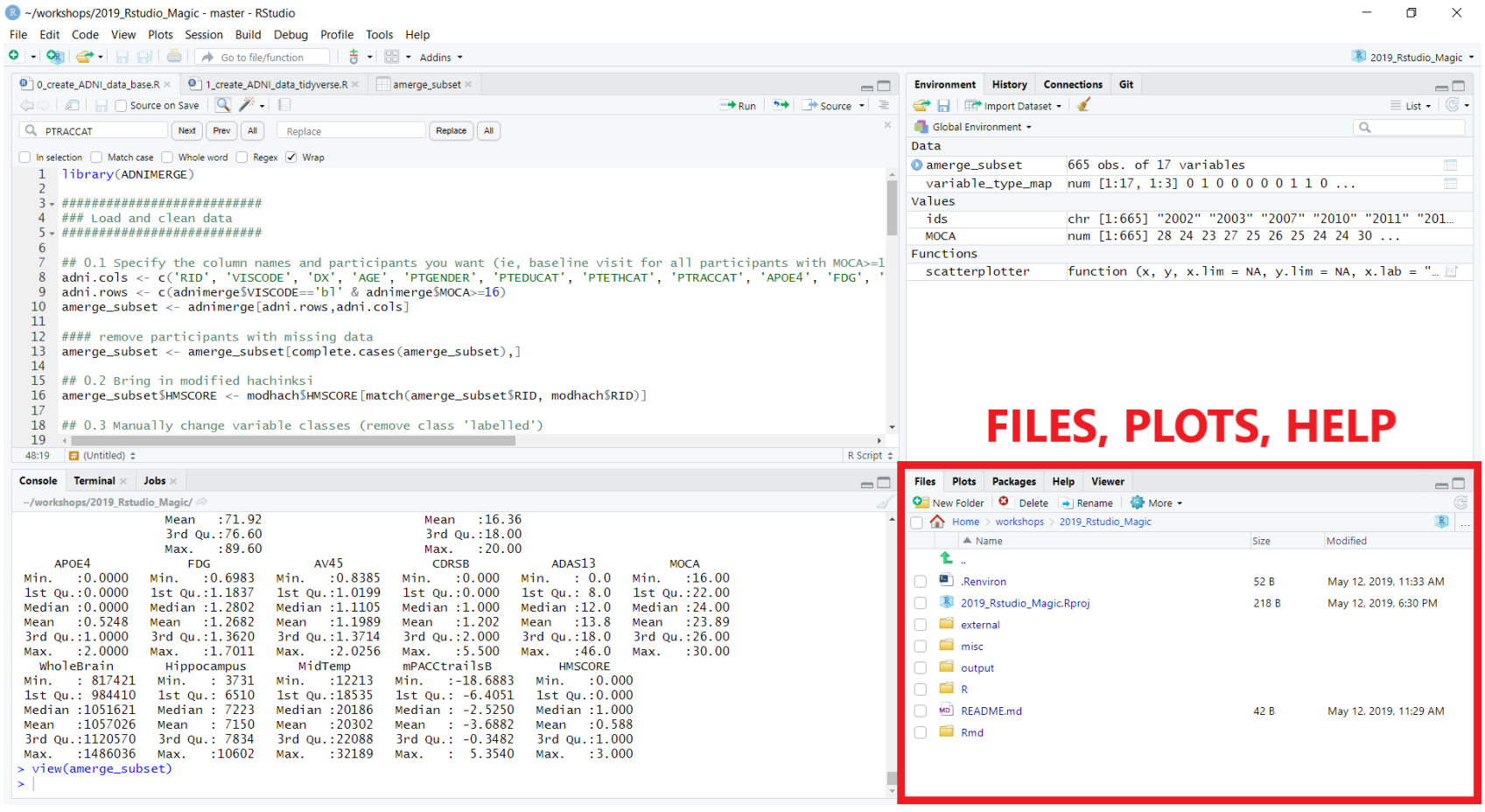
RStudio Environment



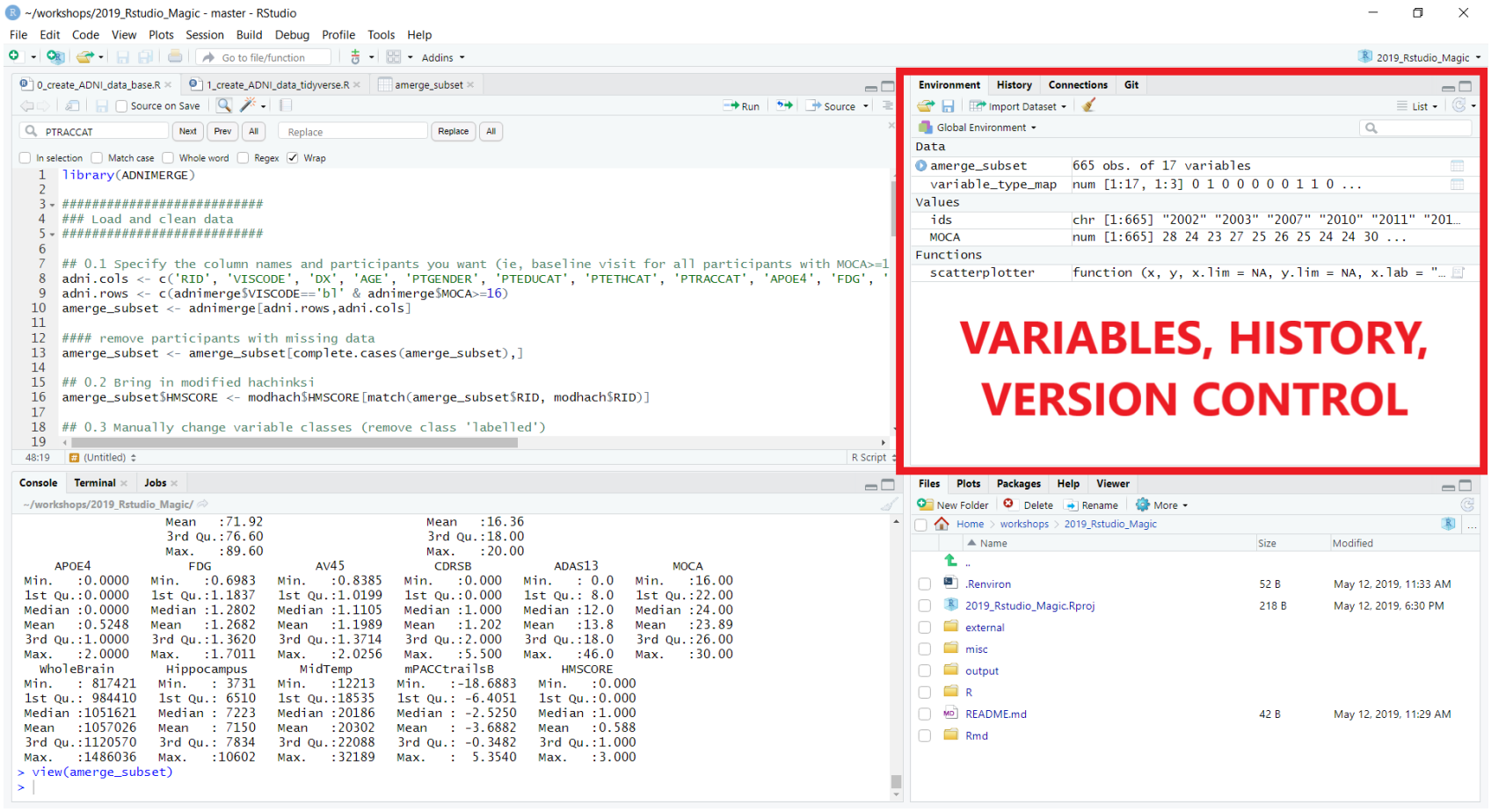
RStudio Environment



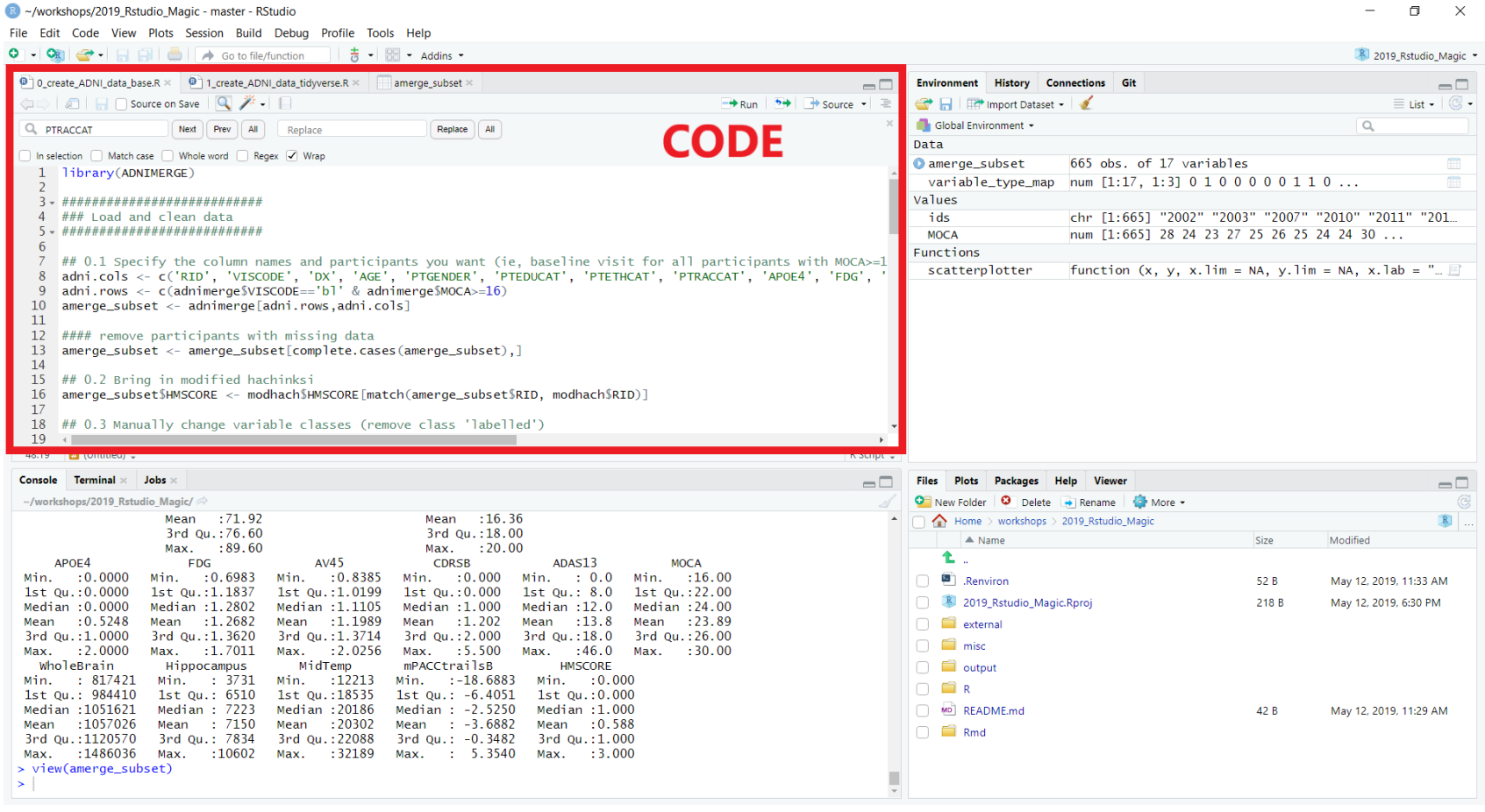
RStudio Environment



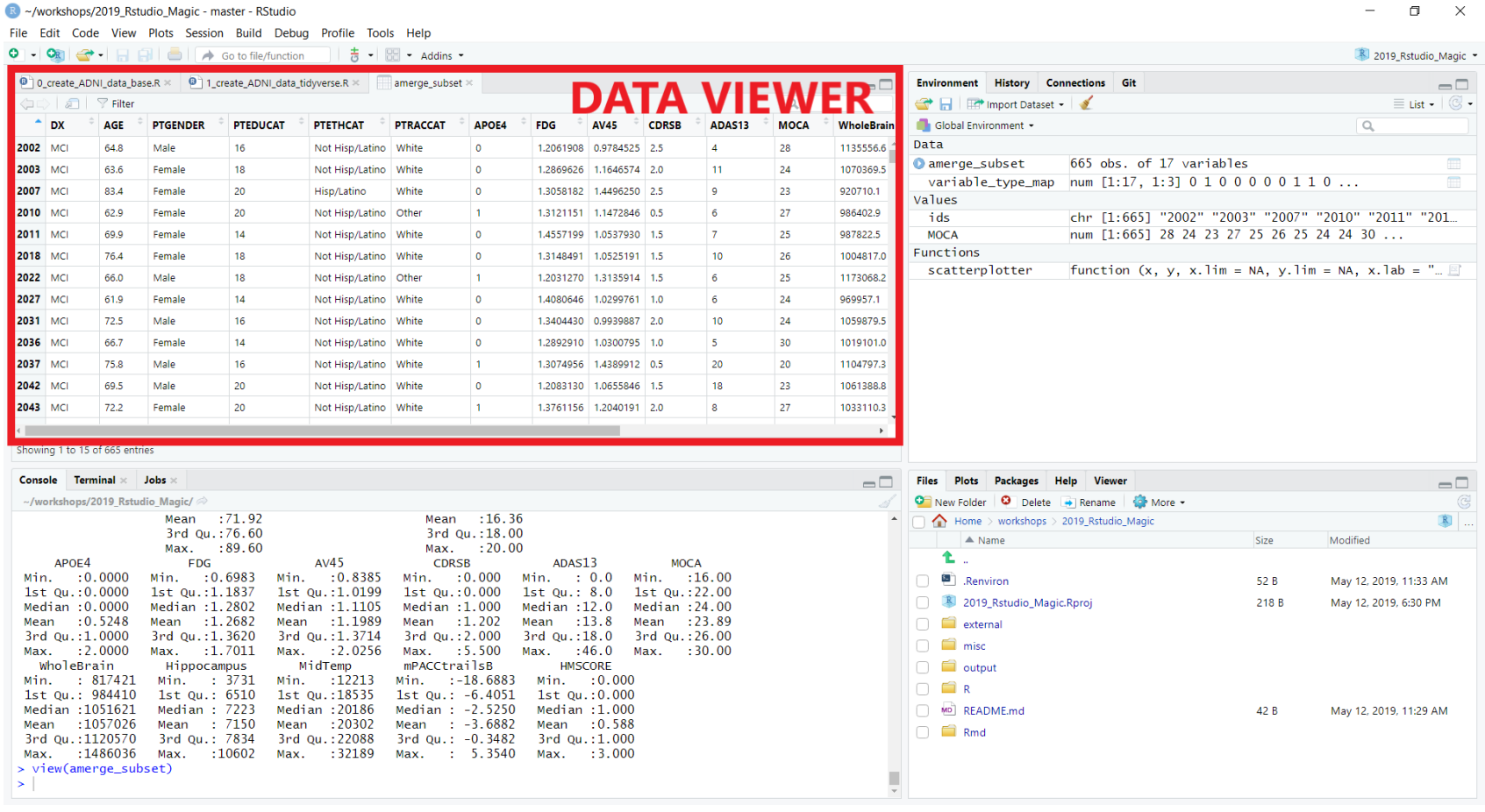
RStudio Environment



RStudio Environment



RStudio Environment



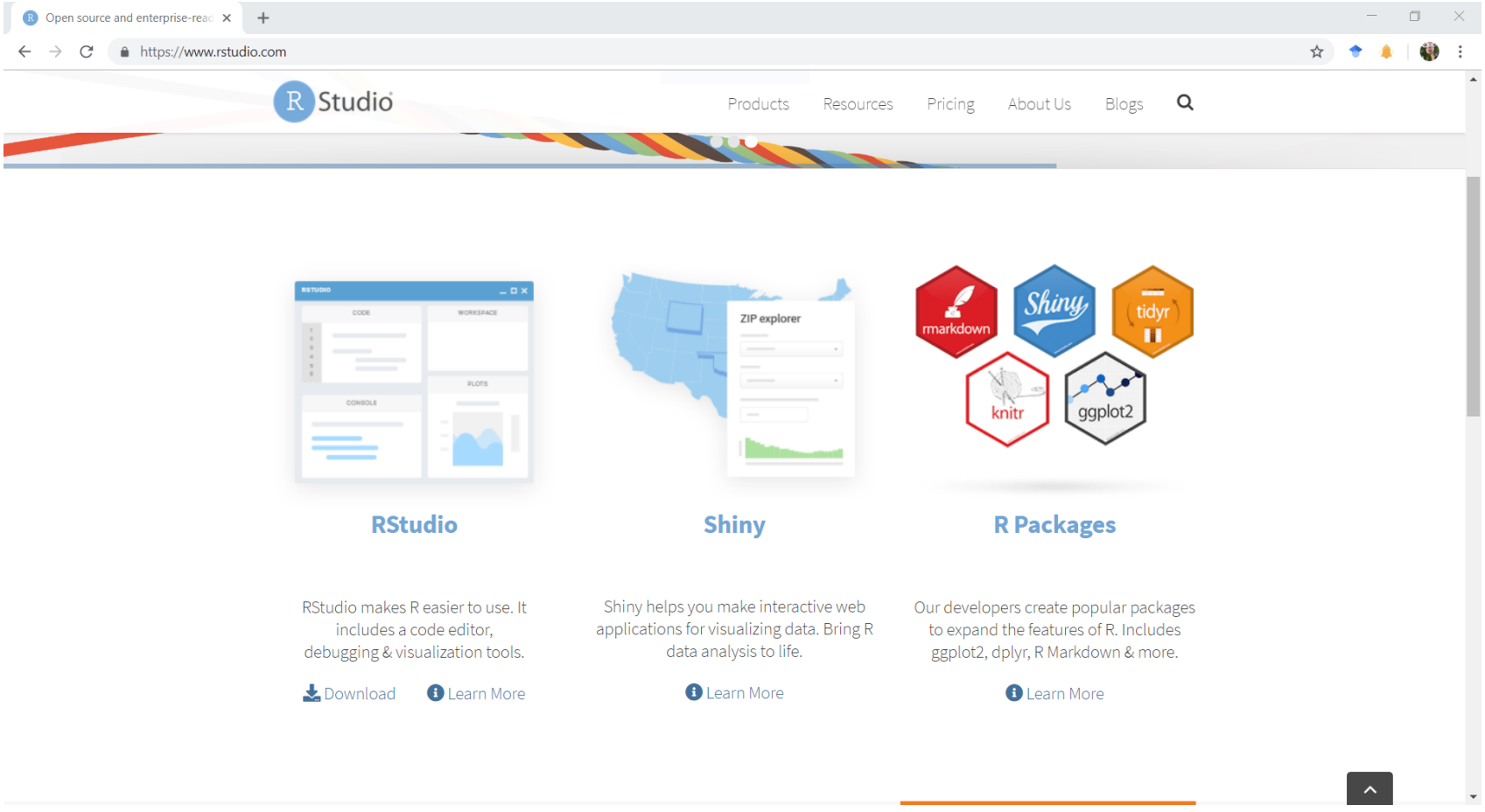
Some benefits of RStudio

- 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
  - Python, D3 (JavaScript), SQL, Shiny, LaTeX, Git/SVN, HTML/CSS, and so much more.
- This workshop
  - Will walk you through some of this (and more)
  - See https://github.com/jennyrieck/workshops/tree/master/2019_Rstudio_Magic

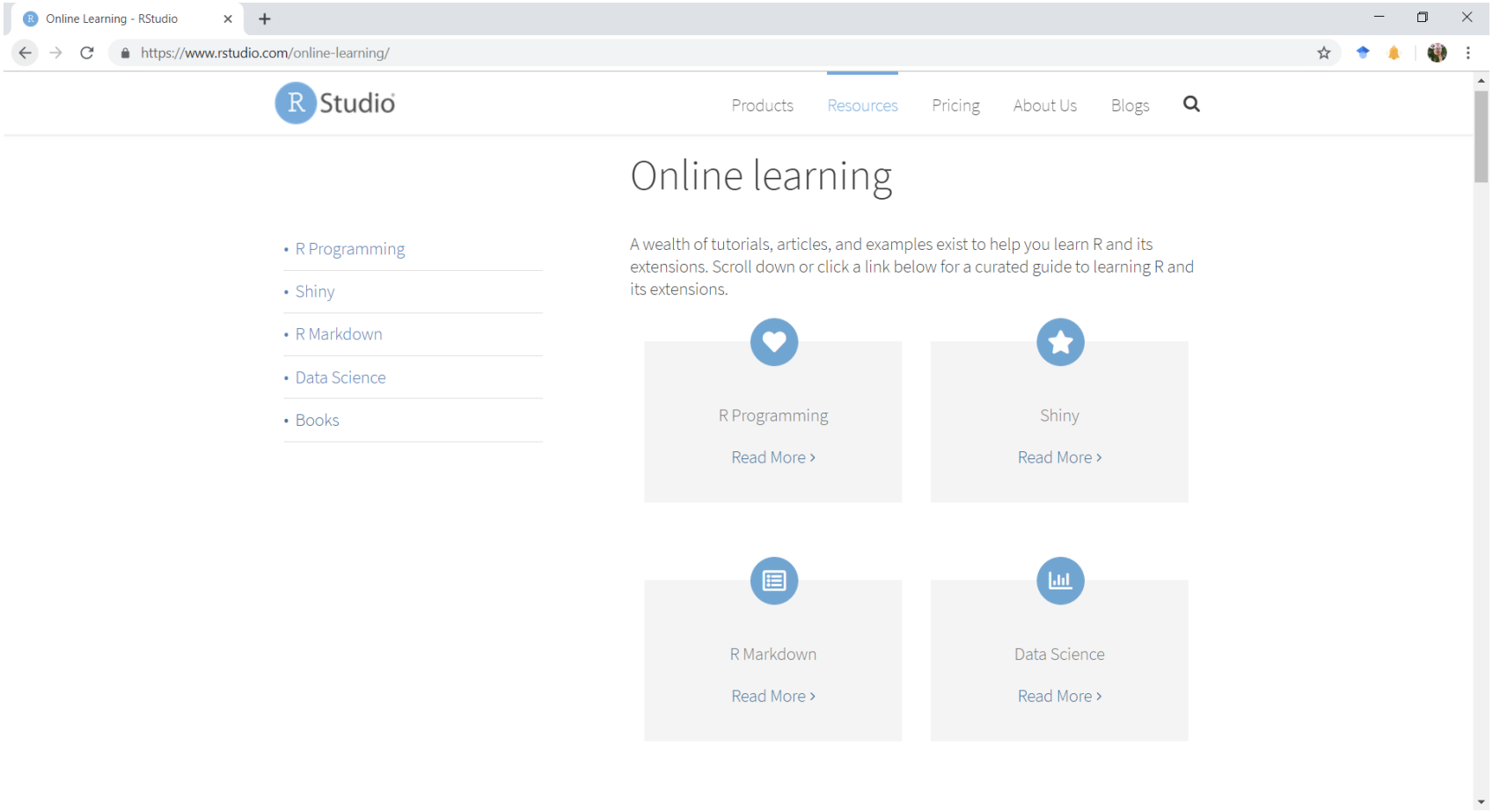
RStudio is more

- Not just an IDE
- A company
- A community
- A conference
- A centralized resource

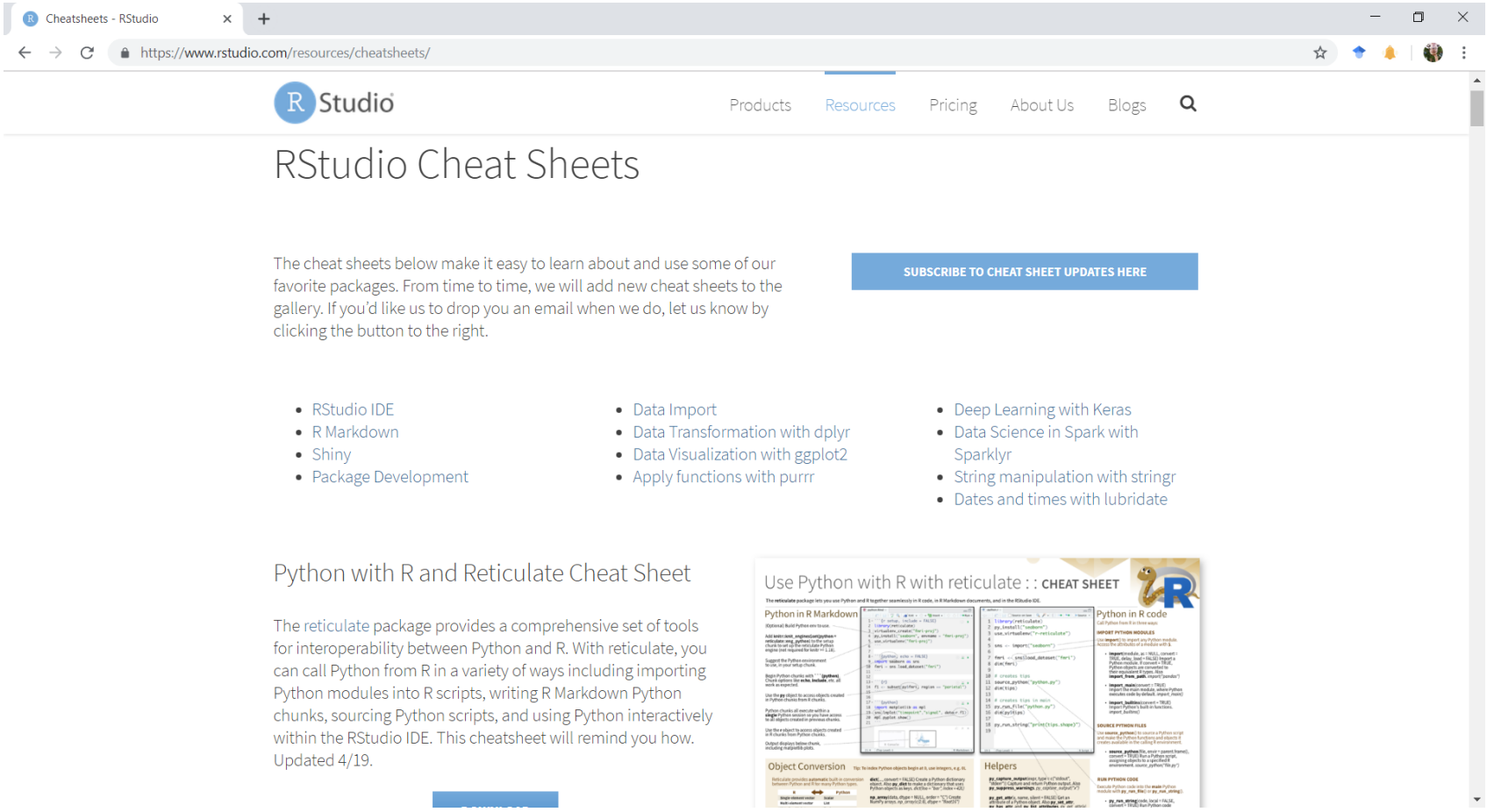
RStudio Resources



RStudio Resources



RStudio Resources



Project and Environment Setup

- NEED CLEAN UP STARTING HERE.
- Special & hidden files
- Having a structure

RStudio Setup

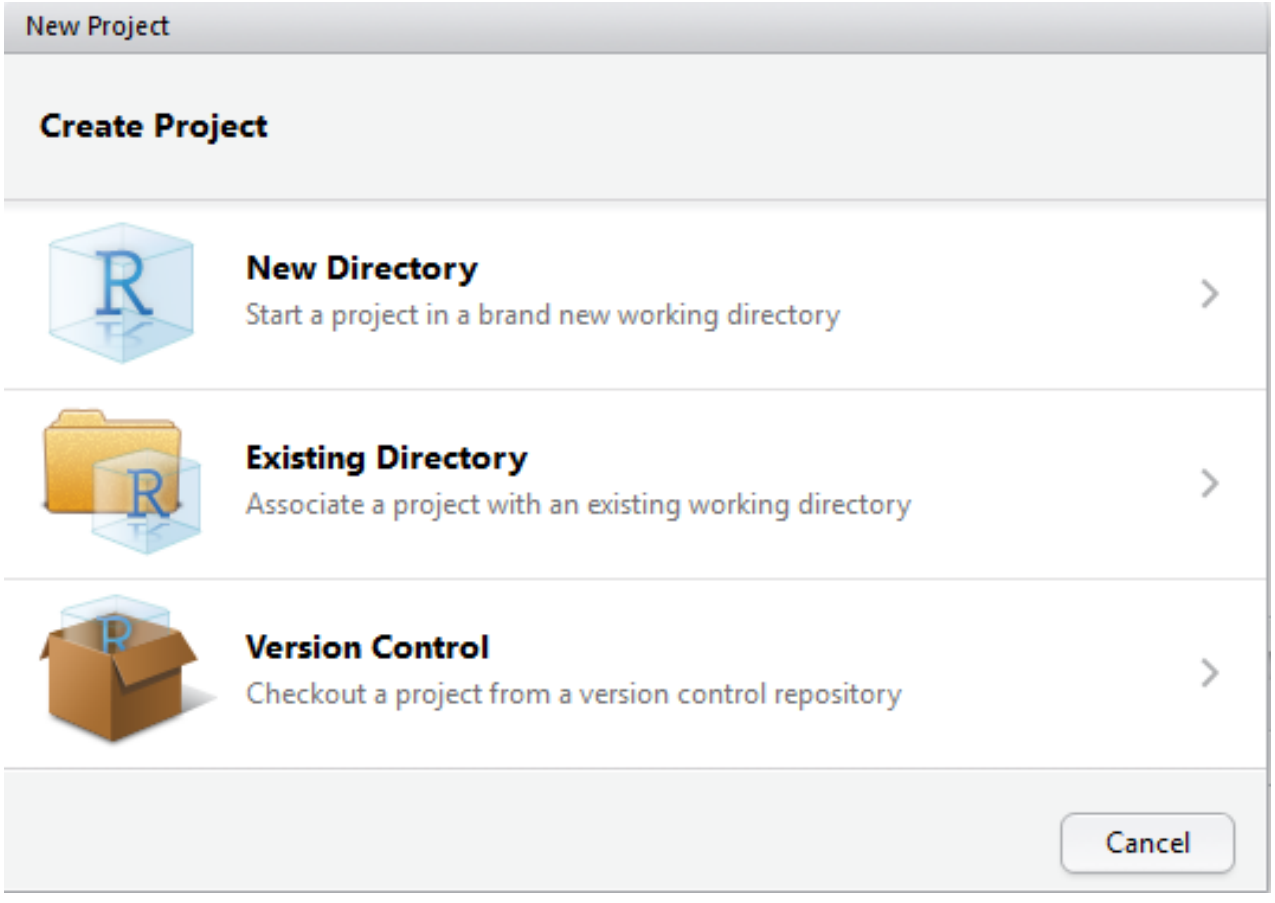
- See https://jennybc.github.io/2014-05-12-ubc/r-setup.html for a detailed guide

For safety & collaboration

- Project(s) files
  - SOMETHING!

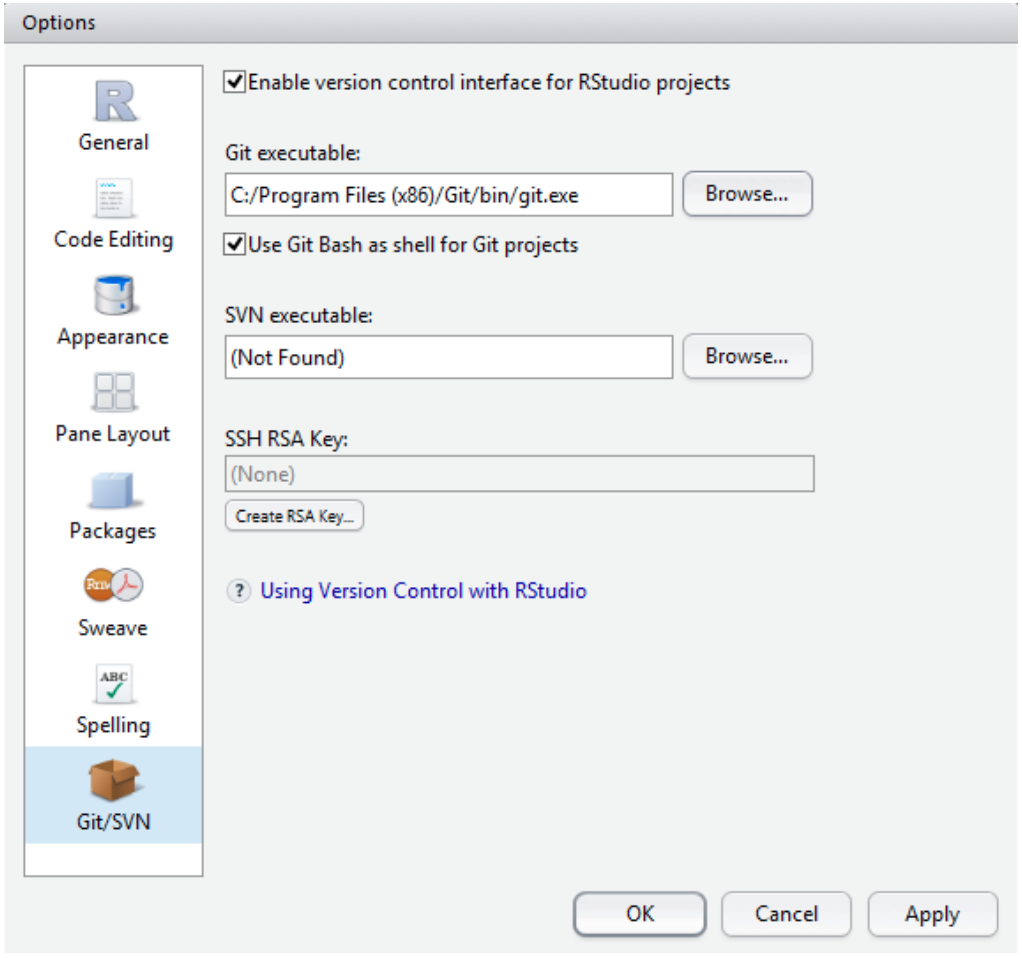
Projects through Git

- Create a new project File



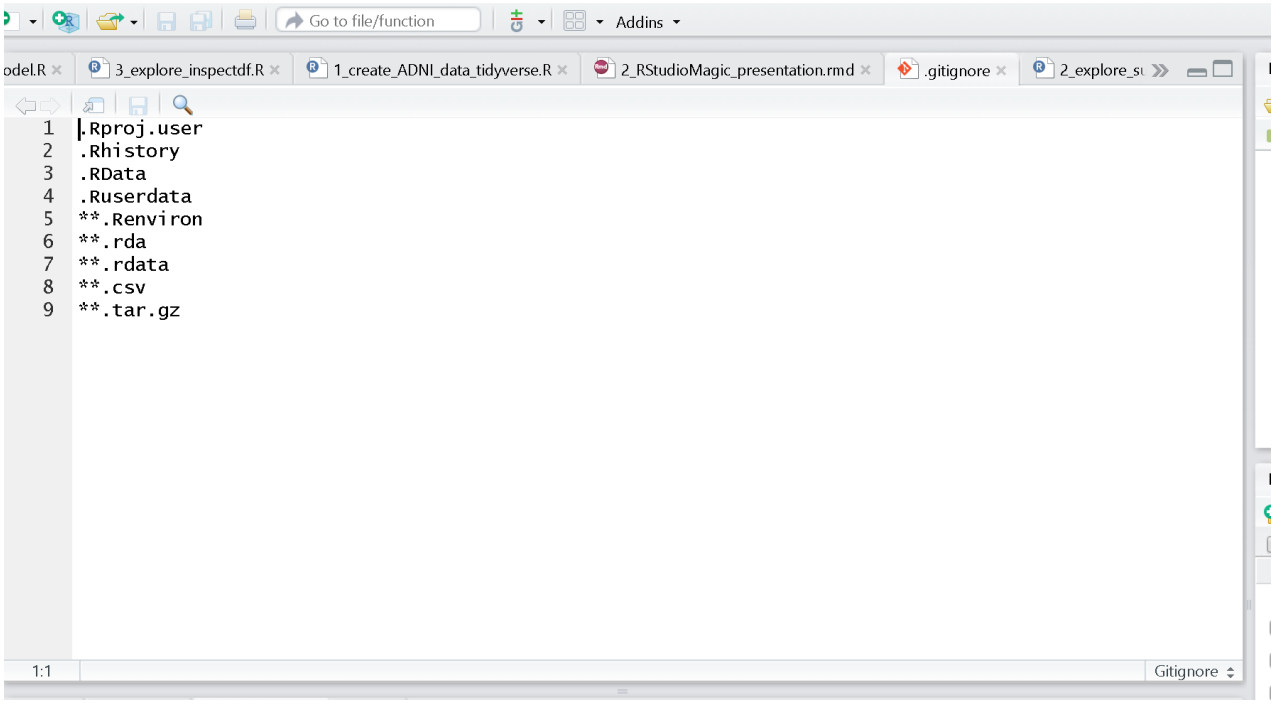
Git & Projects

- Git
  - Download git and link executable within RStudio

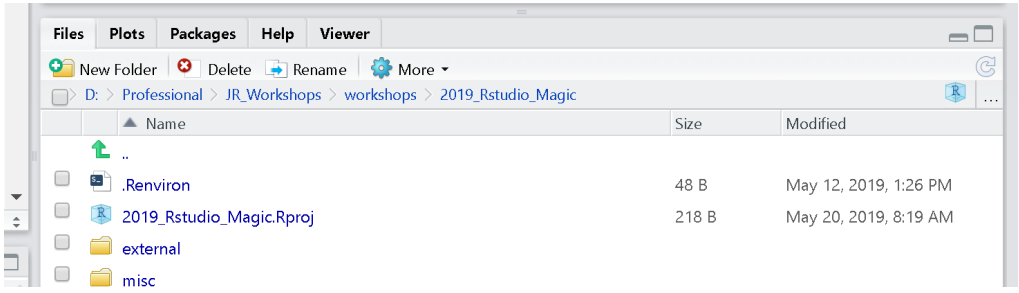


Format .gitignore

- File types to ignore via version control
  - ** before each extentions will match directories anywhere in the repo

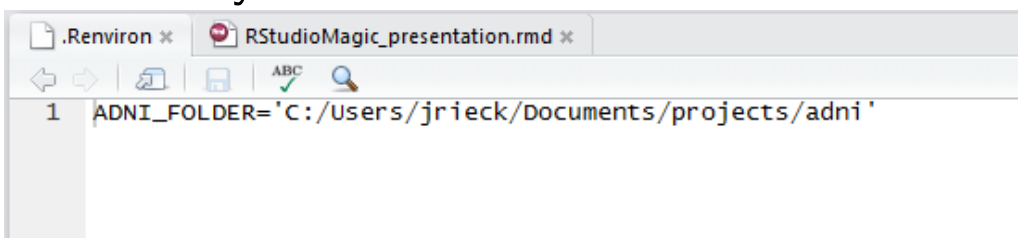


Environment variables

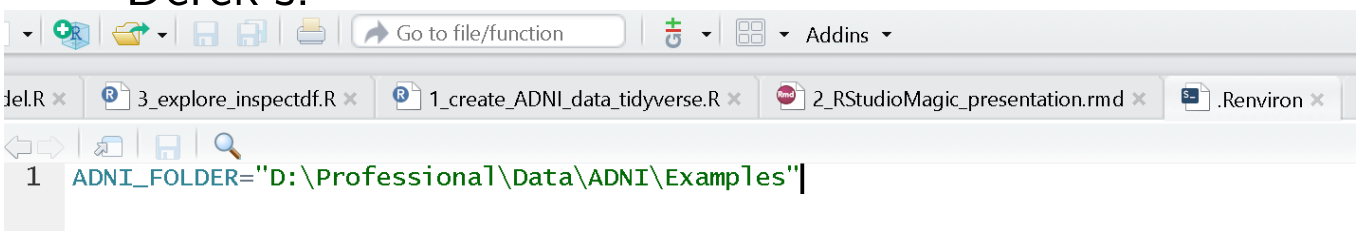


Format environmental variables

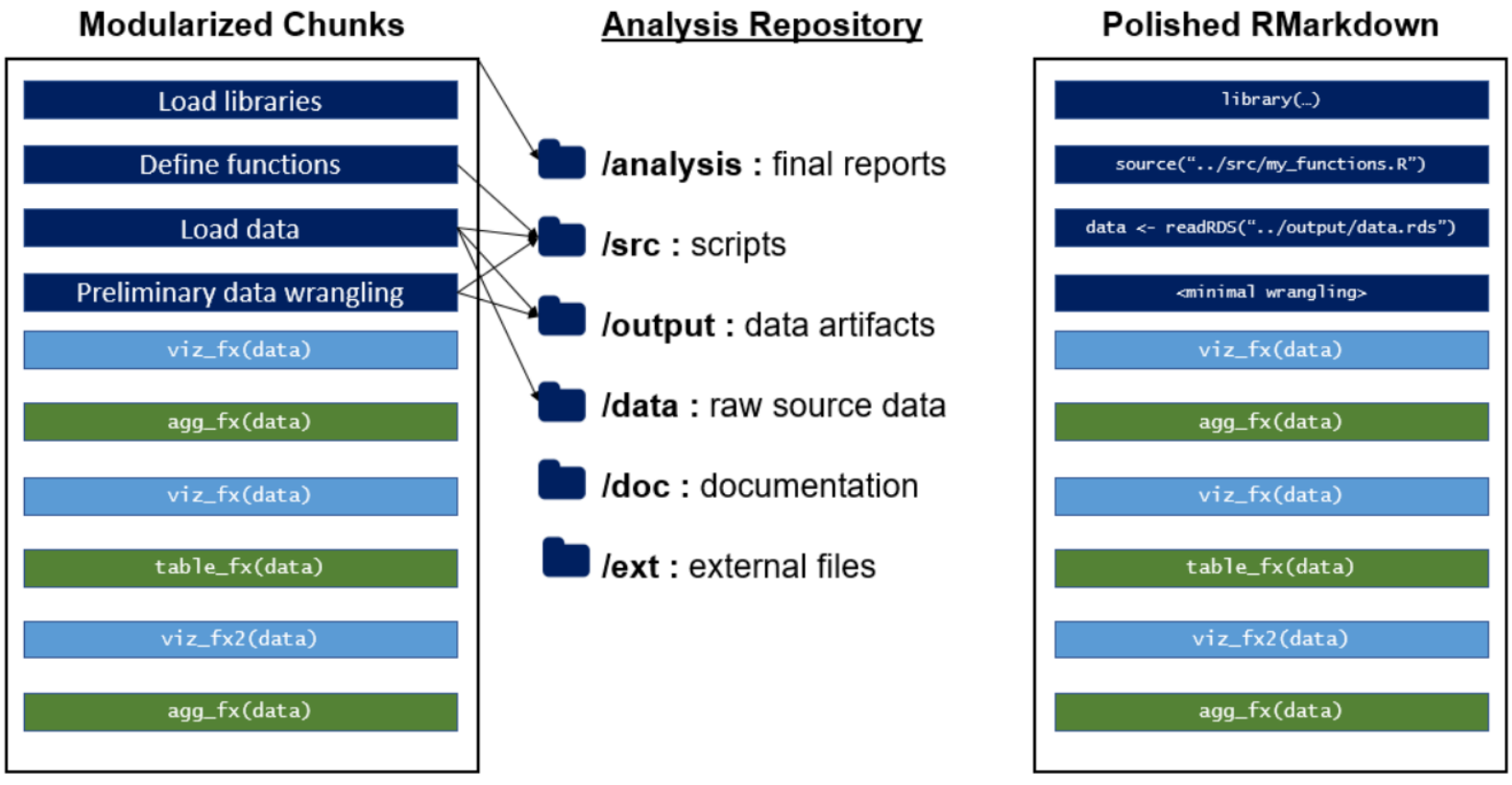
- Set environmental variables (ie, directory location of data) to make code generalizable across computers
  - Don't commit or share these
- In **your** project folder create a `.Renviron` file and define variables
  - Jenny's:



  - Derek's:



Organize your project folders and markdown

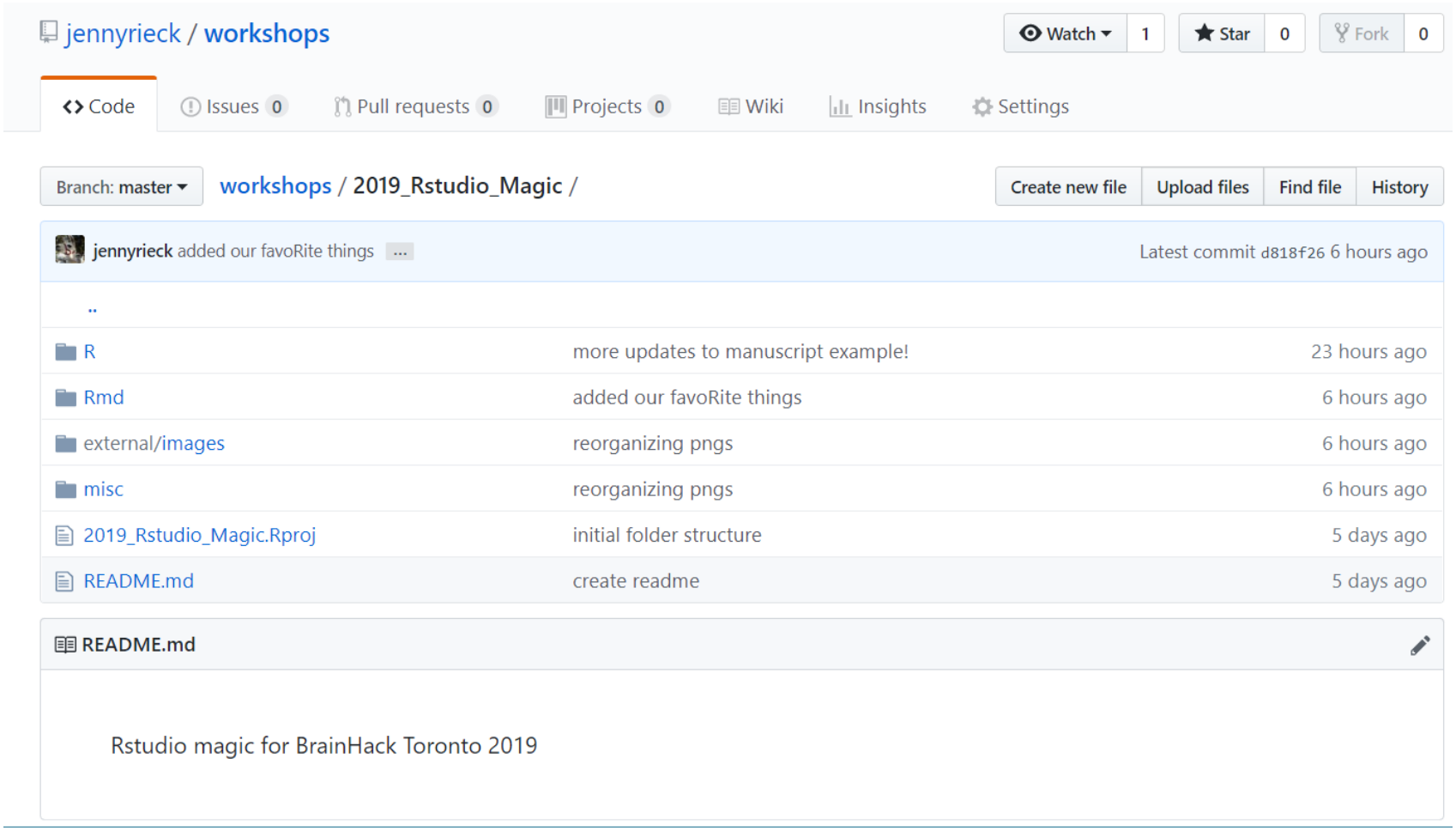


https://emilyriederer.netlify.com/post/rmarkdown-driven-development/

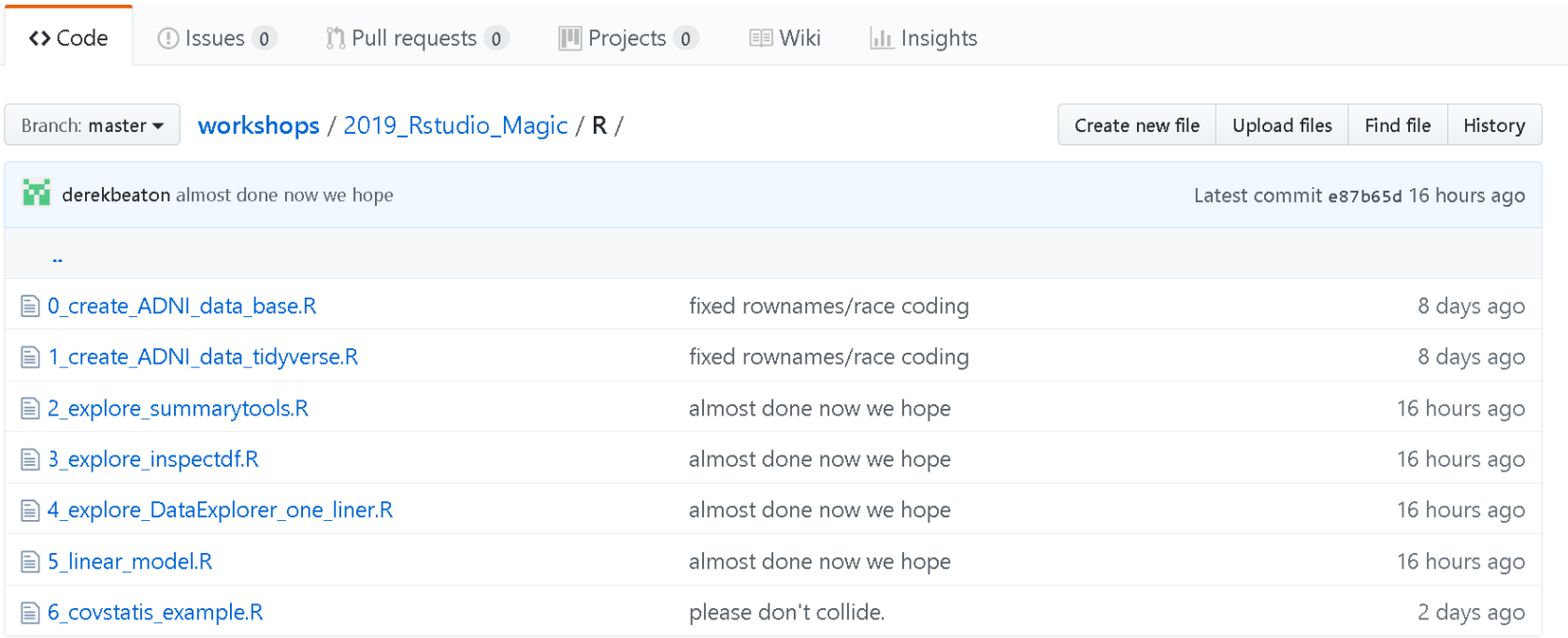
Organize your project folders and markdown

- What works for you?
- What works for your organization or team?
- Maximize utility, minimize complexity

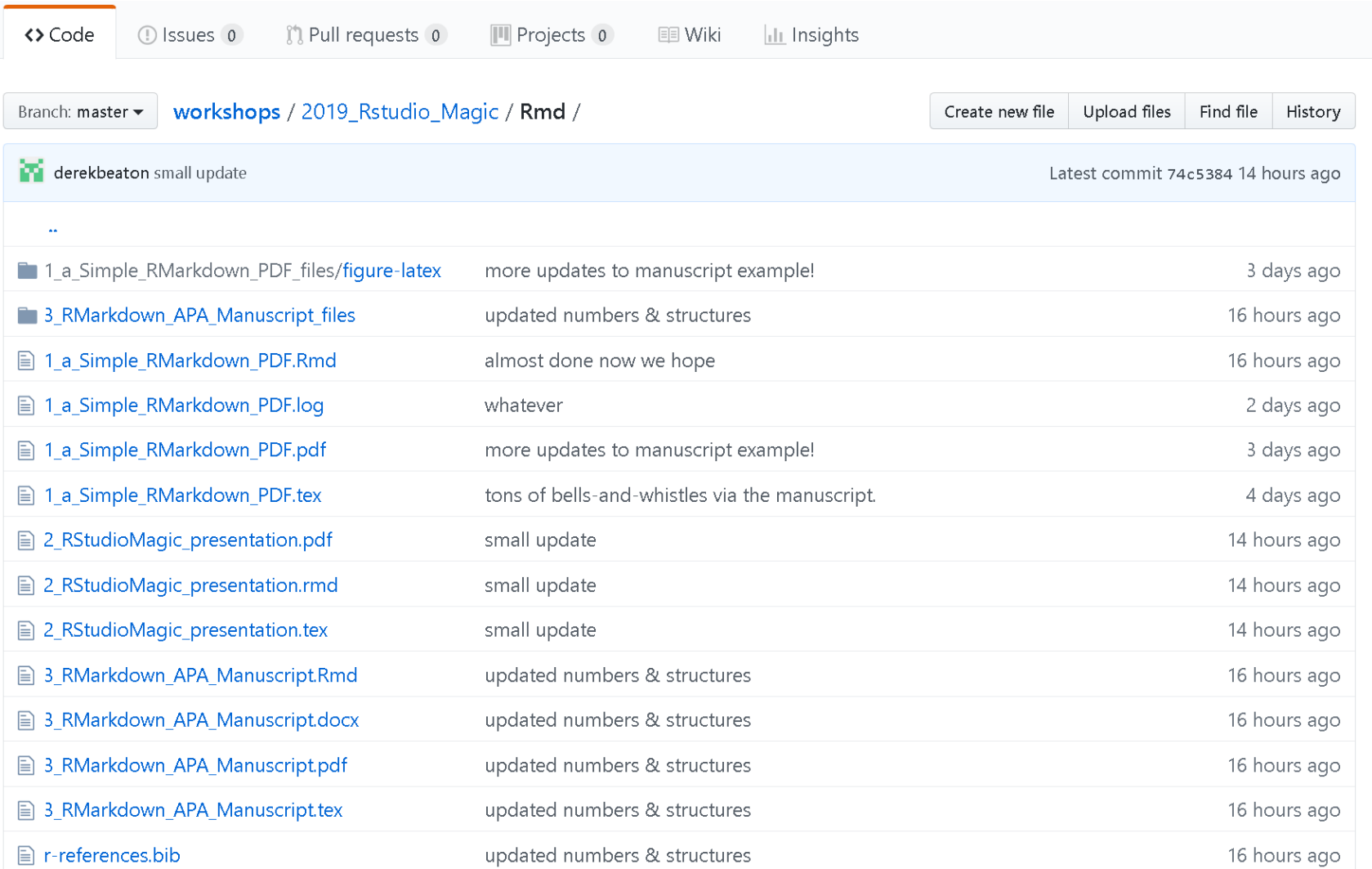
This works for us



This works for us



This works for us



Get the packages you need

```r
# to install from CRAN
install.pacakges("devtools", depenedencies = TRUE)

# to install from a git (requires the
# devtools package)
dev.tools::install_github(Gibbsdavidl/CatterPlots)

# to install from a file
install.packages("/mypath/to/package/ADNIMERGE.tar.gz",
    type = "source", repos = NULL)
```

Read in and create your dataframe

- ADNI Dataset adnimerge package
  - Reduce full dataset to only those participants (rows) and variables (columns) you're interested in
- Two methods to create your dataframe
  - using base R functions: `0_create_ADNI_data_base.R`
  - Using tidyverse functions: `1_create_ADNI_data_tidyverse.R`

ADNI & ADNIMERGE

Cleaning: Base

```
library(ADNIMERGE)
adni.cols <- c('RID', 'VISCODE', 'DX', 'AGE', 'PTGENDER',
adni.rows <- c(adnimerge$VISCODE=='bl' & adnimerge$MOCA>=16
amerge_subset <- adnimerge[adni.rows,adni.cols]
amerge_subset <- amerge_subset[complete.cases(amerge_subset
amerge_subset$HMSCORE <- modhach$HMSCORE[match(amerge_subse
```

Cleaning: tidyverse

```
library(ADNIMERGE)
adnimerge %>%
  dplyr::select(RID, VISCODE, DX, AGE, PTGENDER, PTEDUCAT,
  filter(VISCODE == "bl") %>%
  filter(MOCA >= 16) %>%
  drop_na() -> amerge_subset

amerge_subset %<>% inner_join(modhach[,c("RID","HMSCORE")])
```

Exploring your data

- Many packages to help explore and describe your data:
  - summarytools: `2_explore_summarytools.R`
  - inspectdf: `3_explore_inspectdf.R`
  - DataExplorer: `4_explore_DataExplorer_one_liner.R`

Code w/ eval=F

Hard Break

- DataExplorer is dangerous
- Blind analyses can be *criminal*
  - de Leeuw paper quote
  - DEREK RANTS, PER USUAL.

Analyze you data

- Linear models: `5_linear_model.R`

Screenshots / Code w/ eval=F

Get experimental

- Explain motivation, not method
- covSTATIS: `6_covstatis_example.R`

Part 3: R, RMarkdown, & more

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

RMarkdown Don(u)'ts

- Don't hardcode values
- Don't hardcode absolute file paths
- Don't do complicated database queries
- Don't litter
  - avoid `eval=FALSE`
  - reduce repeated code by making functions
- Don't load unneccesary libraries
- More at: https://emilyriederer.netlify.com/post/rmarkdown-driven-development/

Part 4: Advanced R

Some advanced/other things we're not covering

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

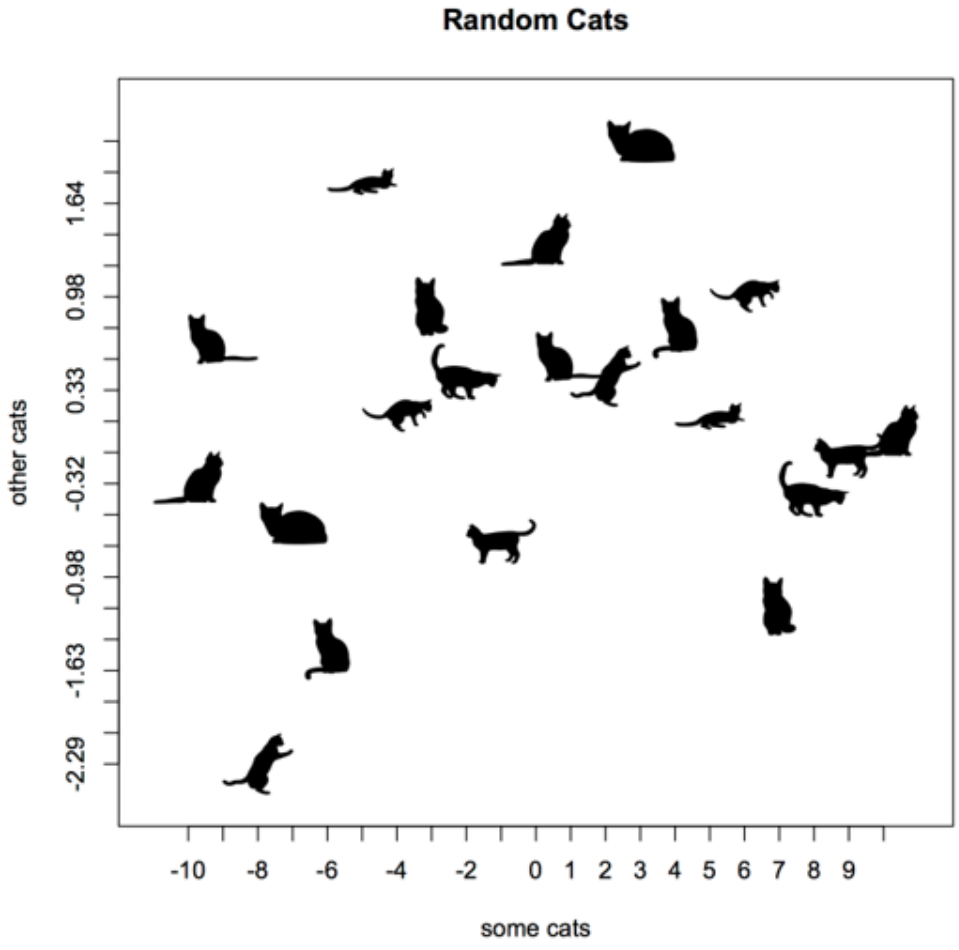
A few of our favorite things

- Fun R do-dads

CatterPlot for feline based graphics:

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

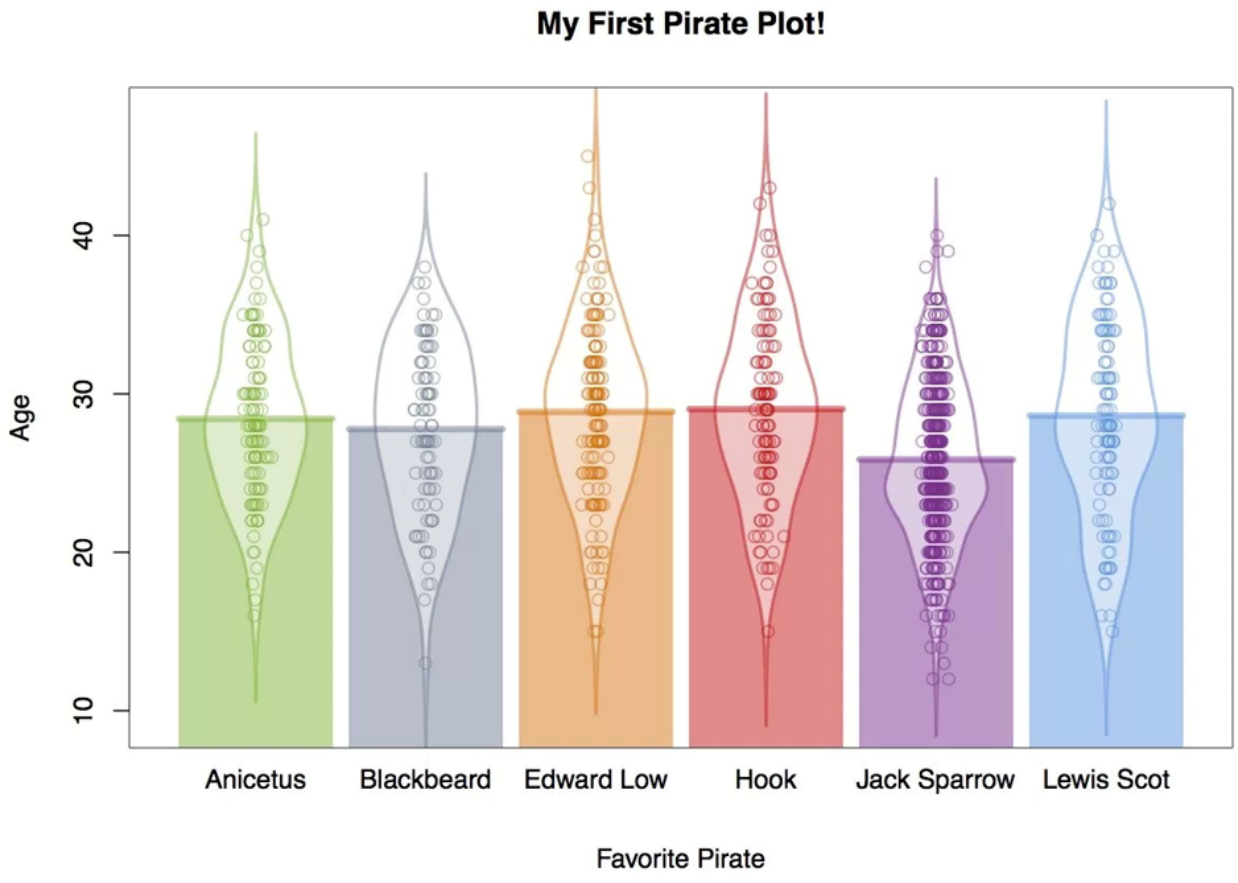
```
dev.tools::install_github(Gibbsdavidl/CatterPlots)
```



What's a pirate's favorite programming language?

- https://cran.r-project.org/web/packages/yarrr/vignettes/pirateplot.html

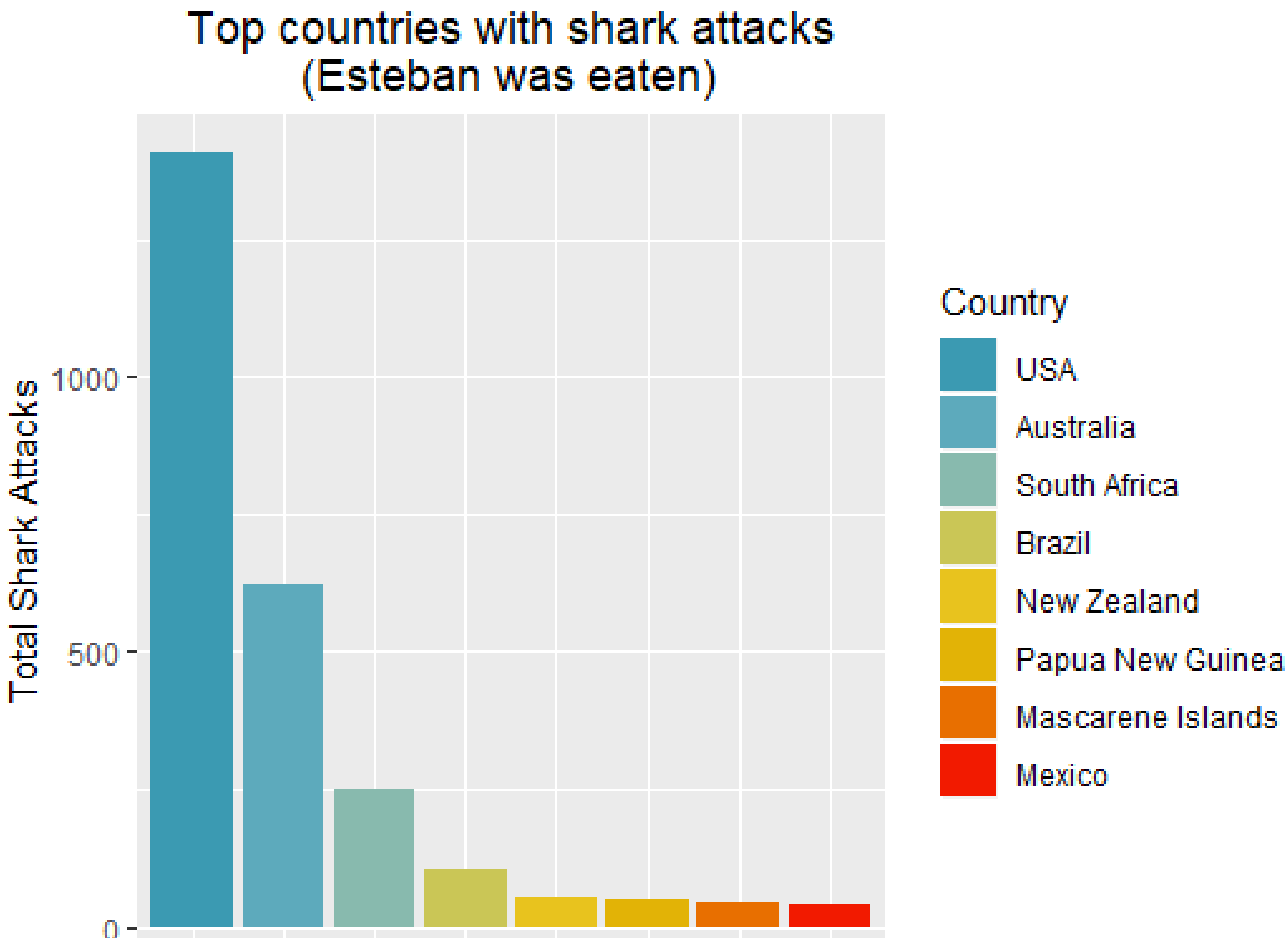
```
install.packages('yarrr')
```



Color palettes to fit your mood

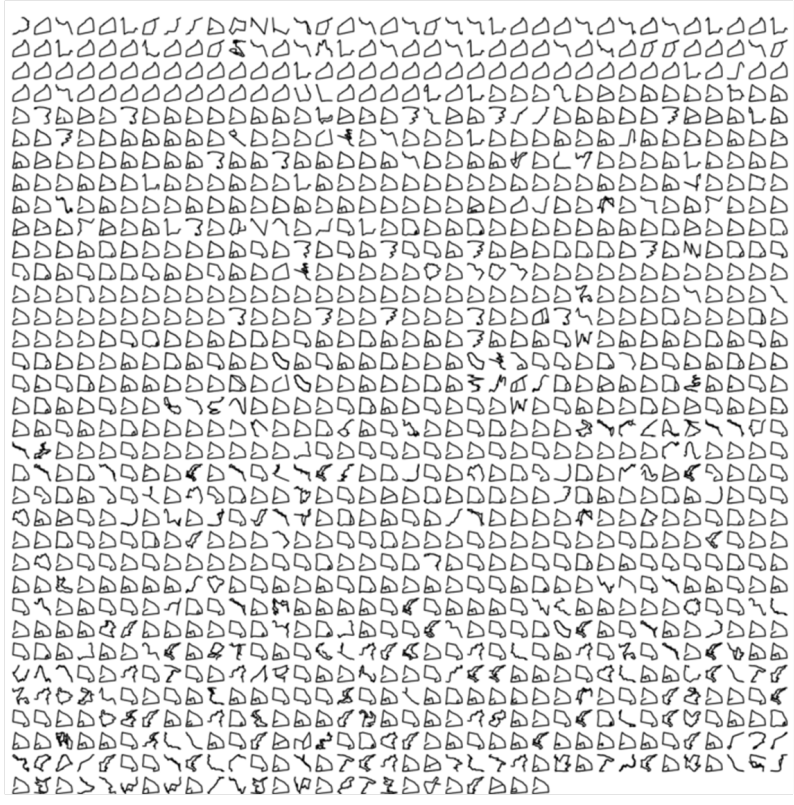
- https://github.com/karthik/wesanderson

```
dev.tools::install_github(karthik/wesanderson)
```



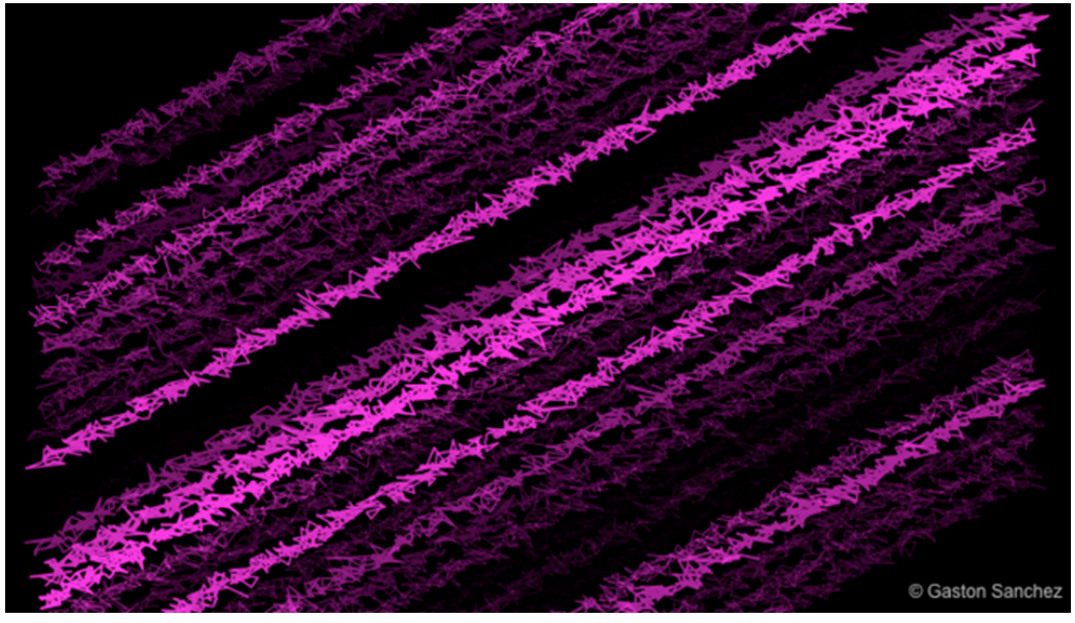
Mapping your Strava routes

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



Make aRt!

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




```
# ============================================================================
# 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 paramters
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(0.3, 2, length = 20), 1))
}
# signature
legend("bottomright", legend = "© Gaston Sanchez", bty = "n",
       text.col = "gray70")
# reset par
par(op)
dev.off()
```