Gov 50: 2. R, RStudio, and Rmarkdown

Matthew Blackwell

Harvard University

Roadmap

1. Working in Plain Text
2. Let's take a touR
3. Using Rmarkdown
4. Getting R bearings
5. Our first visualizations

1/ Working in Plain Text

The two computer revolutions

The frontier of computing

- Touch-based interfaces

Where statistical computing lives

The two computer revolutions

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- Single app at a time

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- Windows and pointers
- Multi-tasking, multiple windows

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- Windows and pointers
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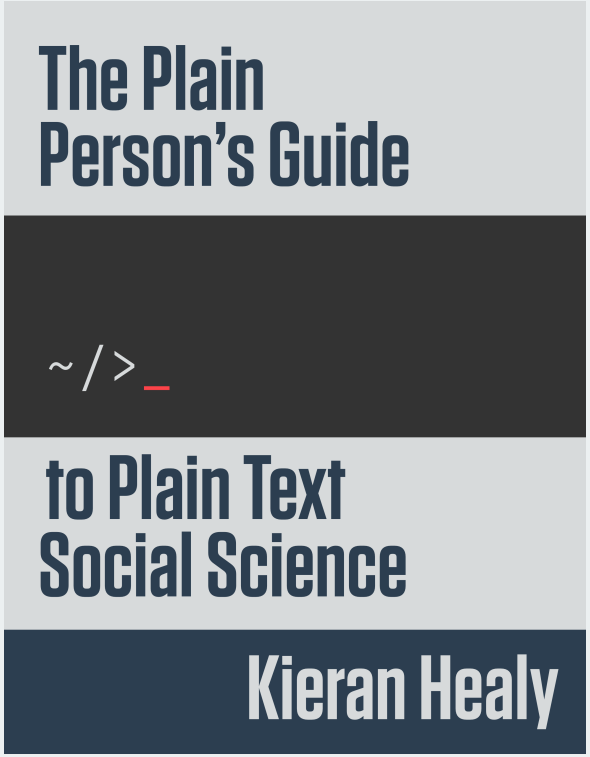
Where statistical computing lives

- Windows and pointers
- Multi-tasking, multiple windows
- Works heavily with the file system
- Underneath it's UNIX and the command line

Plain-text tools for data analysis



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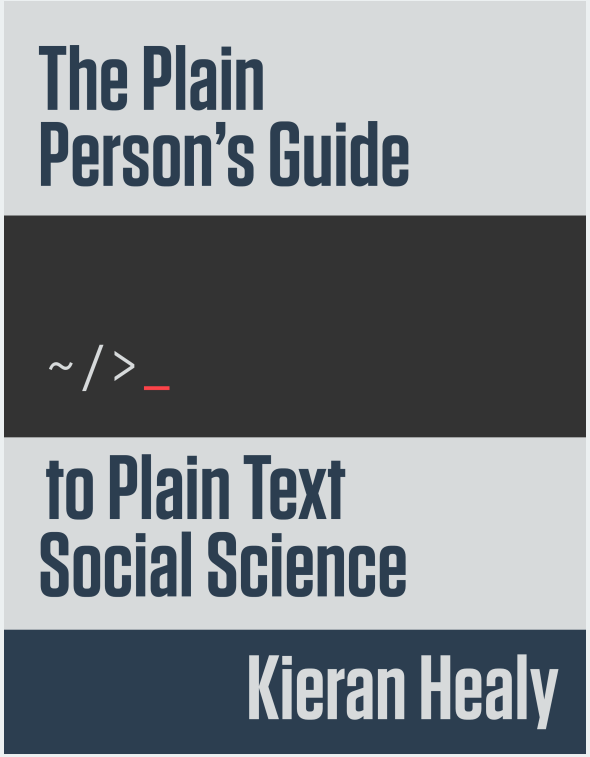

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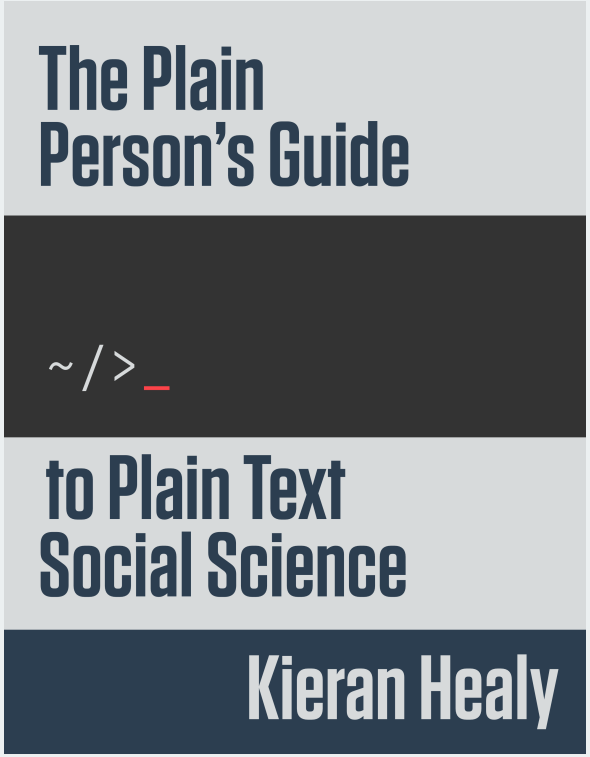

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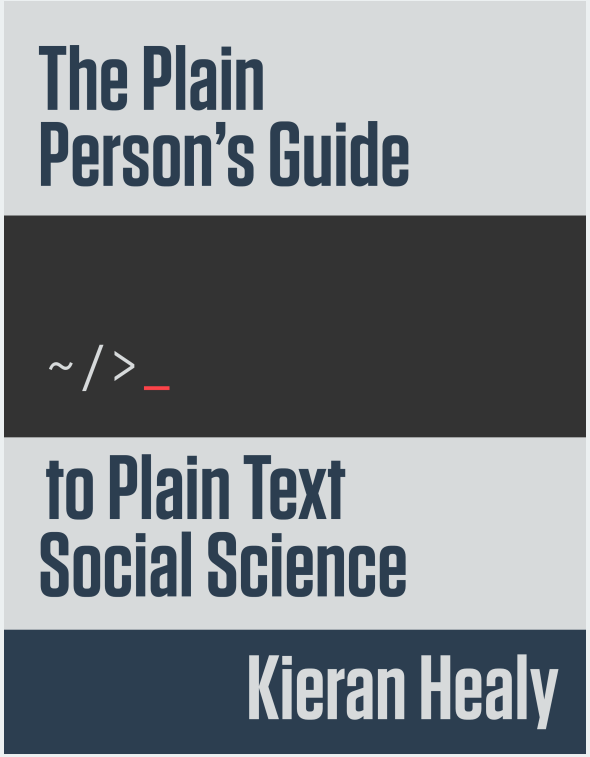

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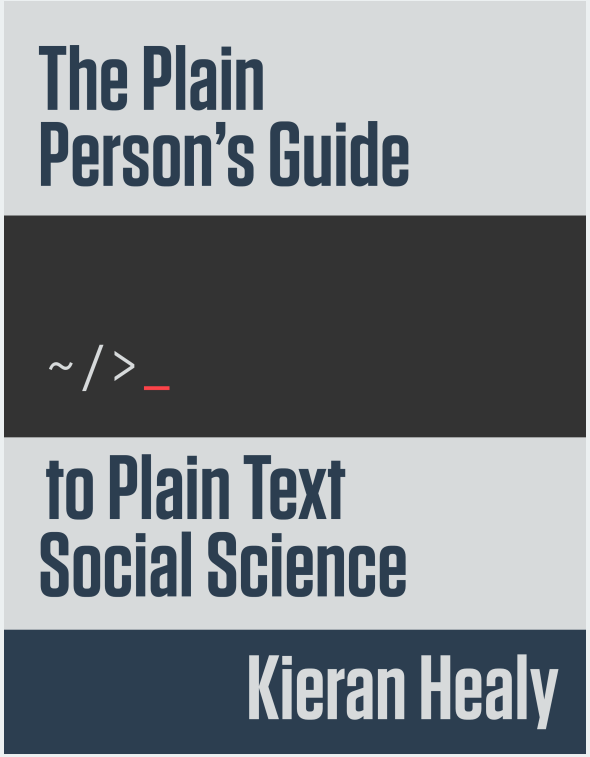

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- But... far from the touch-based paradigm of modern computing
- So why use them?

The process of data science is instrinsically messy

Office vs engineering model of computing

What's real in the project? How are changes managed?

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Pros and cons to each approach

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We’ll tend toward the Engineering model because it’s better suited to keep the mess in check.

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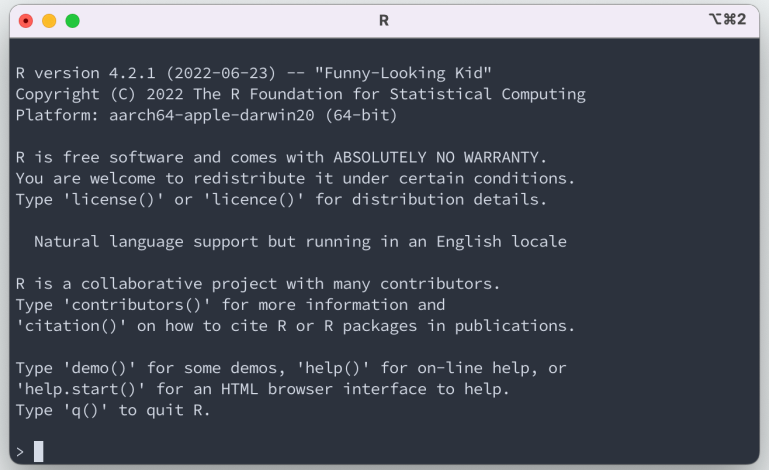

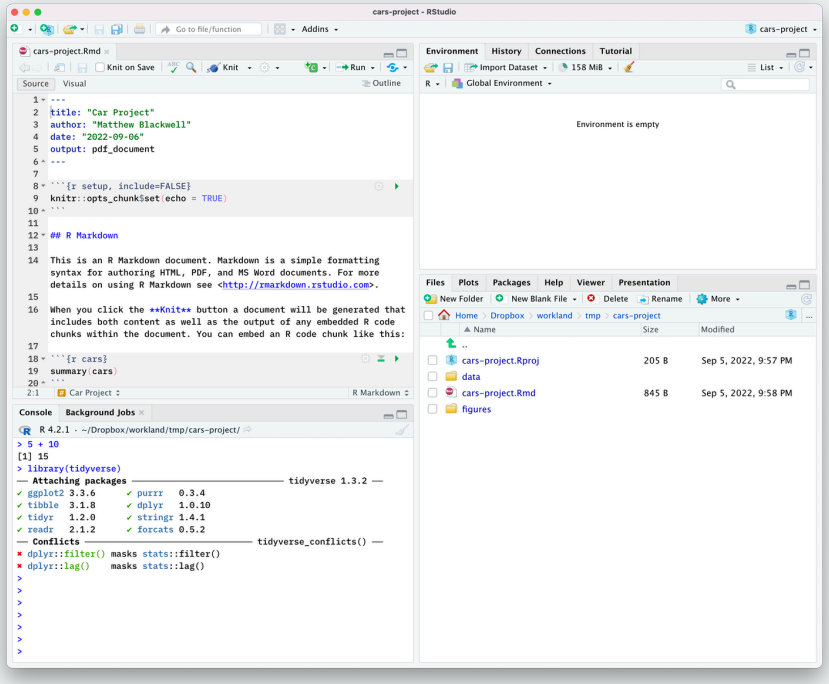

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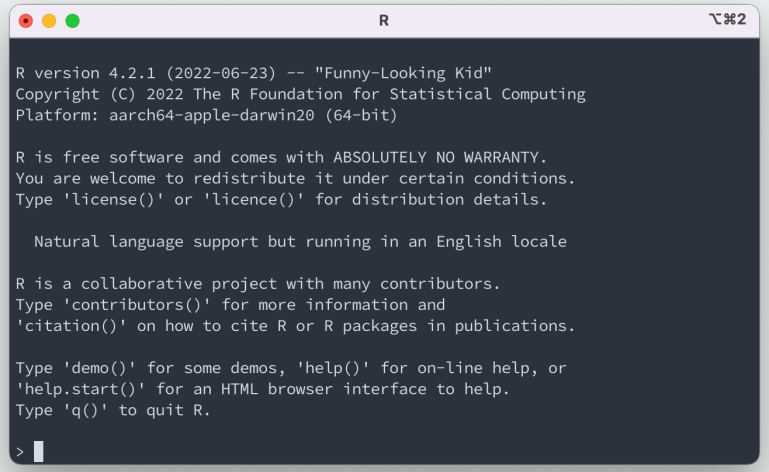

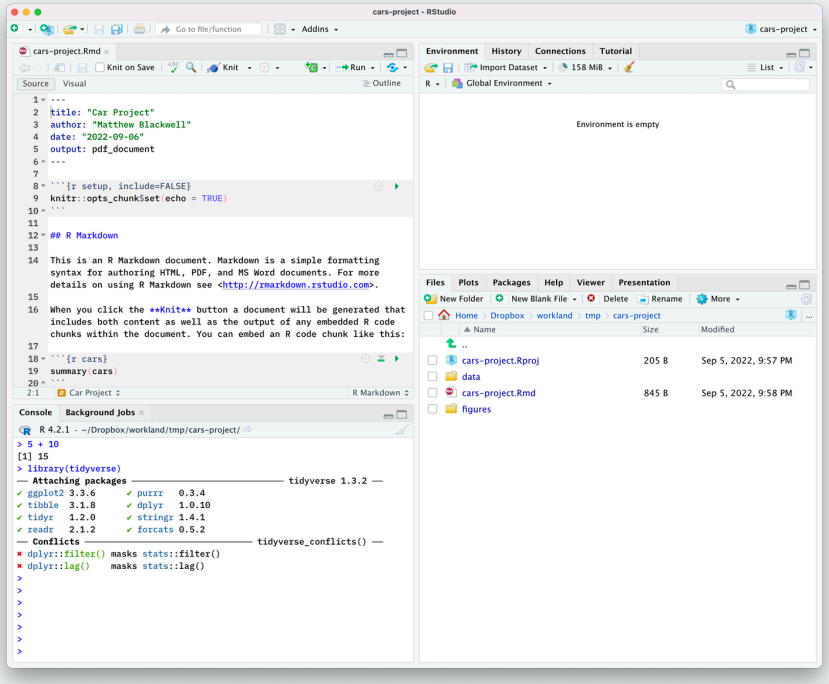

cars-project - RStudio

Go to file/function | Addins | cars-project

cars-project.Rmd

Knit on Save | Knit | Run

Source | Visual | Outline

```
1  ---
2  title: "Car Project"
3  author: "Matthew Blackwell"
4  date: "2022-09-06"
5  output: pdf_document
6  ---
7
8  ```{r setup, include=FALSE}
9  knitr::opts_chunk$set(echo = TRUE)
10 ```
11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a simple formatting
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16 When you click the **Knit** button a document will be generated that
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18 ```{r cars}
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2:1 | Car Project | R Markdown

Console | Background Jobs

R 4.2.1 · ~/Dropbox/workland/tmp/cars-project/

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> 5 + 10
[1] 15
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── Attaching packages ─────────────────────────── tidyverse 1.3.2 ──
✓ ggplot2 3.3.6     ✓ purrr   0.3.4
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✓ readr   2.1.2     ✓ forcats 0.5.2
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✖ dplyr::filter() masks stats::filter()
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>
>
>
>
>
>
```

Environment | History | Connections | Tutorial

Import Dataset | 158 MiB | List

R | Global Environment

Environment is empty

Files | Plots | Packages | Help | Viewer | Presentation

New Folder | New Blank File | Delete | Rename | More

Home > Dropbox > workland > tmp > cars-project

Name	Size	Modified
..		
cars-project.Rproj	205 B	Sep 5, 2022, 9:57 PM
data		
cars-project.Rmd	845 B	Sep 5, 2022, 9:58 PM
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cars-project - RStudio

Write notes, paper in Rmarkdown

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Console: run code, send code to here, inspect output

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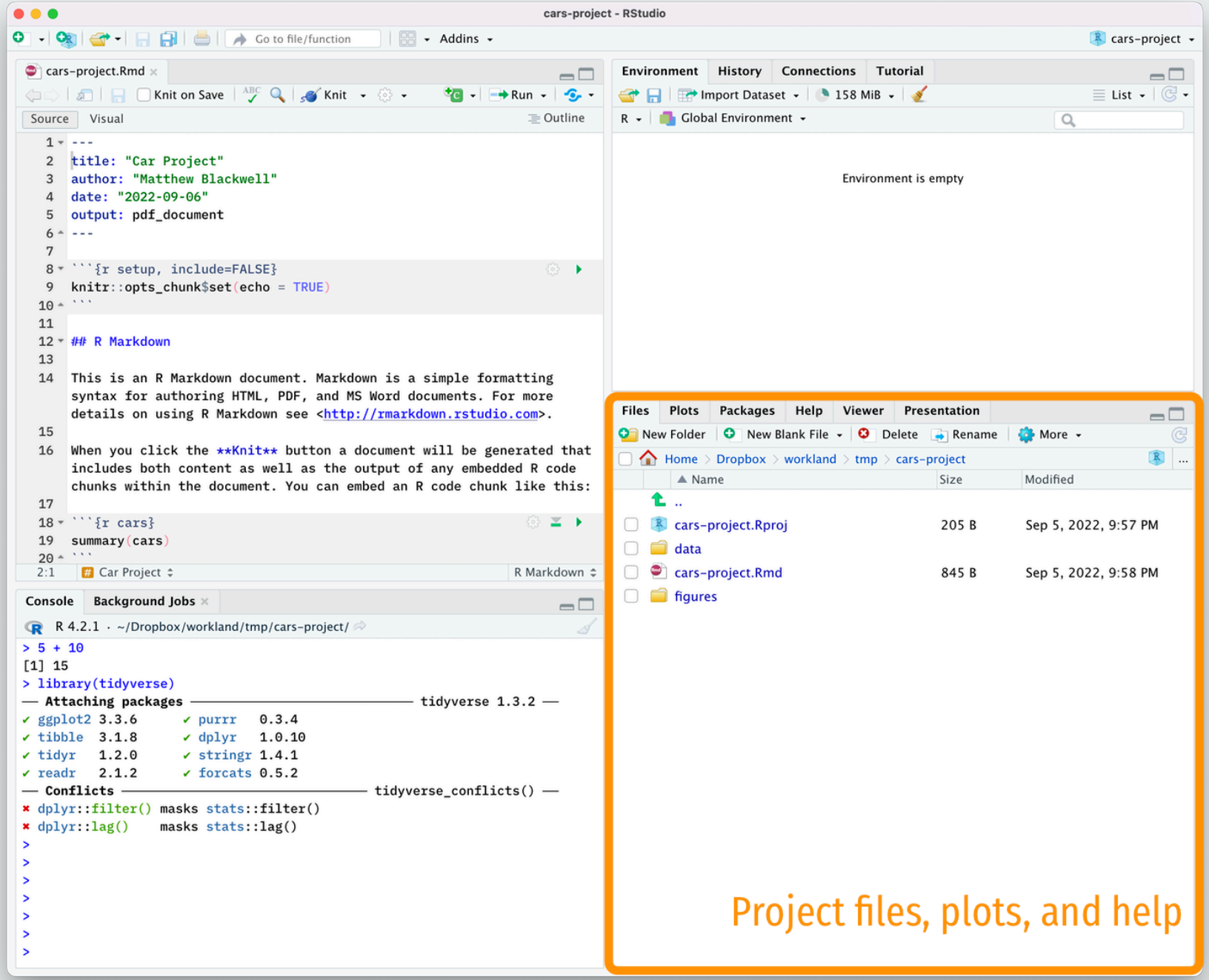
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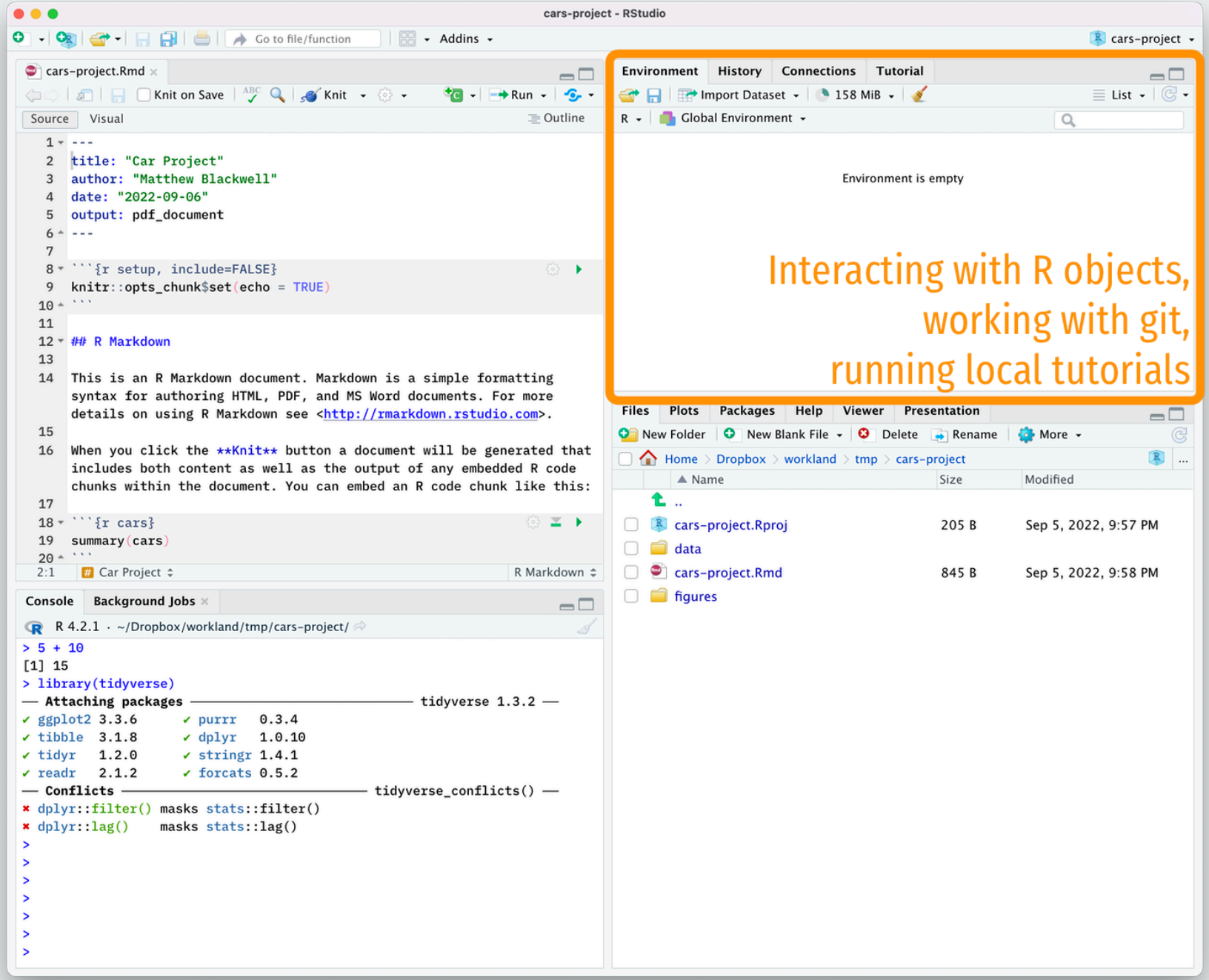
Project files, plots, and help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3/ Using Rmarkdown

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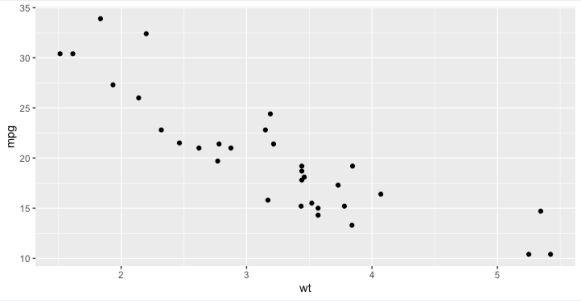

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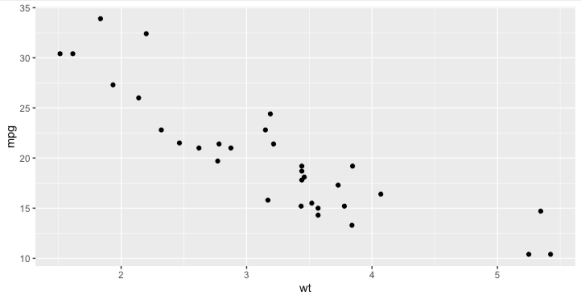

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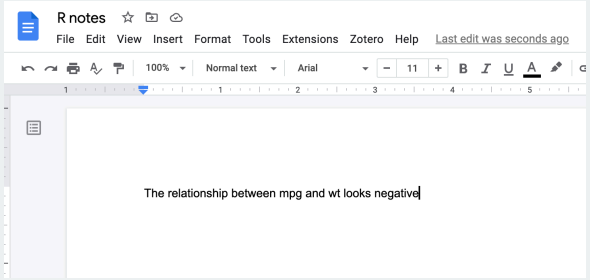

Figure: 3. Taking notes

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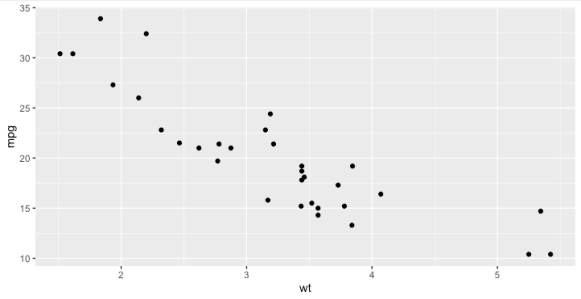

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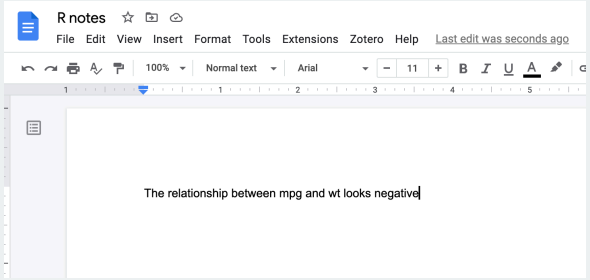

Figure: 3. Taking notes

How to do all of these efficiently?

Rmarkdown files to the rescue

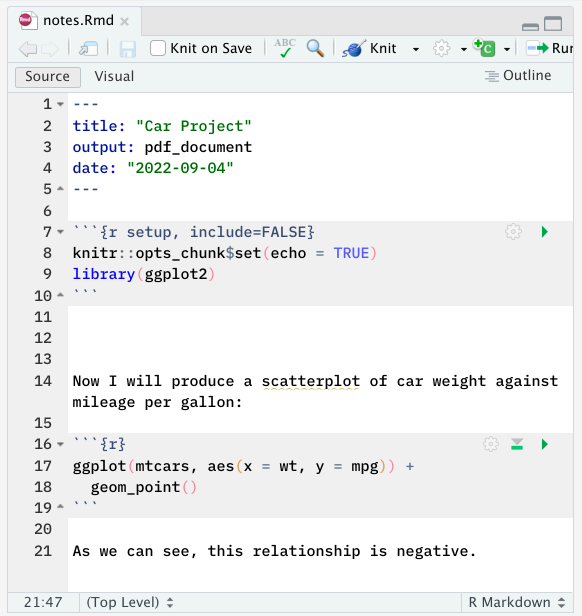

Figure: Rmarkdown file

Keep code and notes together in plain text

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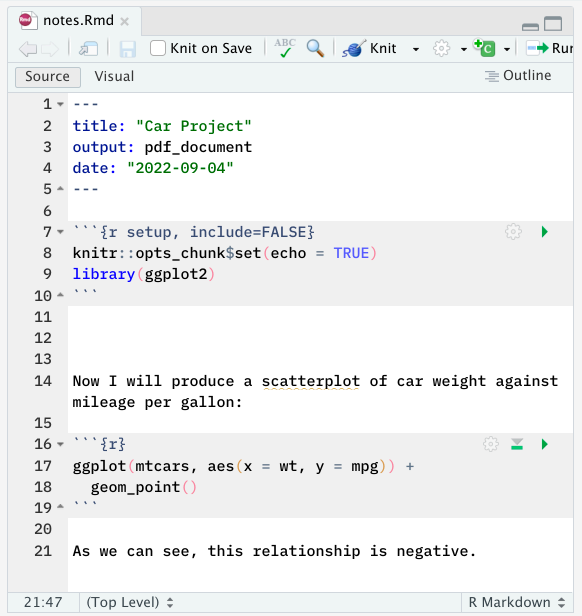

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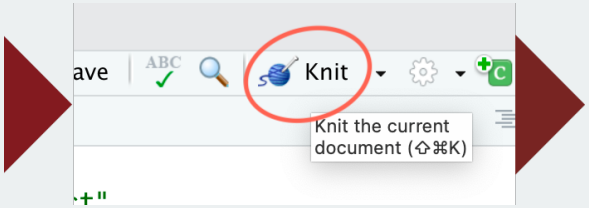

Figure: Knit in R

Keep code and notes together in plain text

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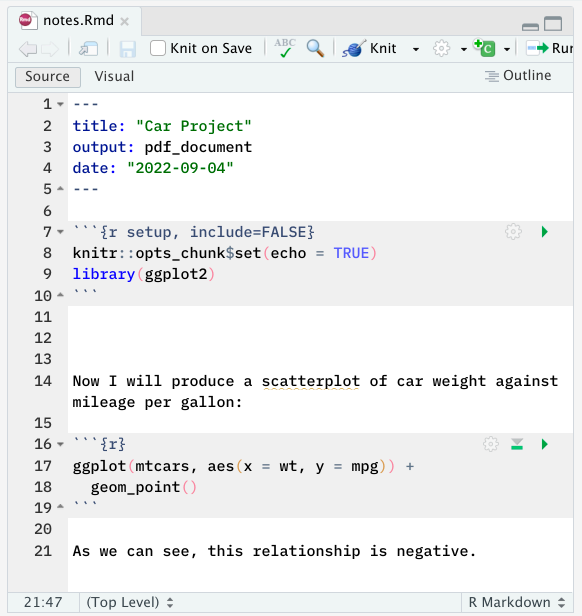

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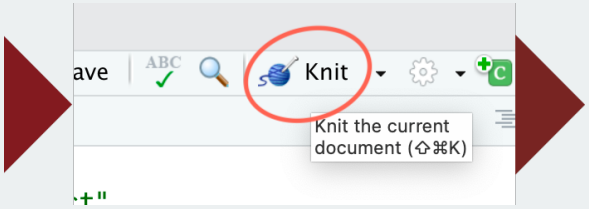

Figure: Knit in R

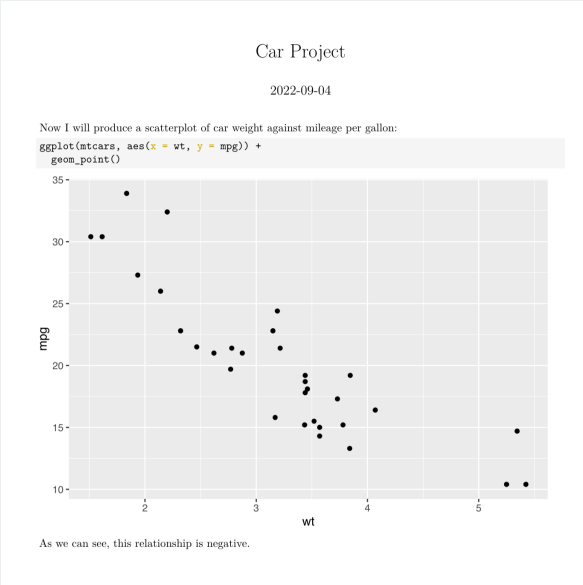

Figure: PDF output

Produce nice-looking outputs in different formats

Markdown: formatting in plain text

Non-code text in Rmd files is plain text with formatting instructions

syntax

```
Plain text
End a line with two spaces to start a new paragraph.
*italics* and _italics_
**bold** and __bold__
superscript^2^
~~strikethrough~~
[link](www.rstudio.com)

# Header 1

## Header 2

### Header 3

#### Header 4

##### Header 5

###### Header 6

endash: --
emdash: ---
ellipsis: ...
inline equation: $A = \pi*r^{2}$
image: ![](path/to/smallorb.png)

horizontal rule (or slide break):

***

> block quote

* unordered list
* item 2
    + sub-item 1
    + sub-item 2

1. ordered list
2. item 2
    + sub-item 1
    + sub-item 2
```

becomes

Plain text
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- unordered list
- item 2
  - sub-item 1
  - sub-item 2

1. ordered list
2. item 2
   - sub-item 1
   - sub-item 2

```
---
title: "Car Project"
author: "Matthew Blackwell"
date: "2022-09-06"
output: pdf_document
---
```

Header contains metadata and sets options about the whole document

```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```

Code Chunk

```
## R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for
authoring HTML, PDF, and MS Word documents. For more details on using R
Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes
both content as well as the output of any embedded R code chunks within the
document. You can embed an R code chunk like this:
```

Plain text with markdown formatting

```{r cars}
summary(cars)
```

Can "play" chunks interactively

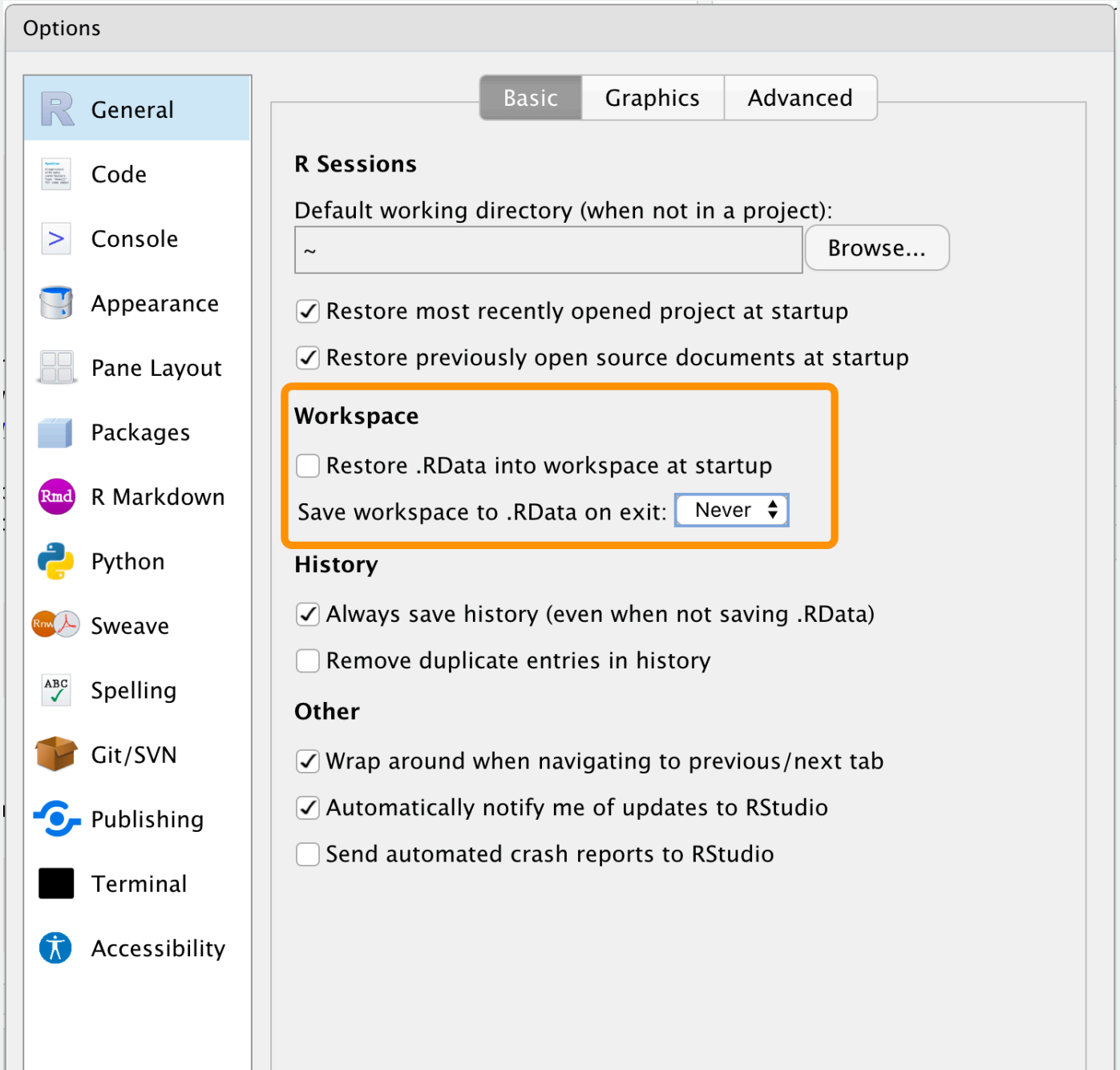
```
## Including Plots

You can also embed plots, for example:
```

Chunks can have names and options

```{r pressure, echo=FALSE}
plot(pressure)
```

Code chunks replaced with output when Knitted

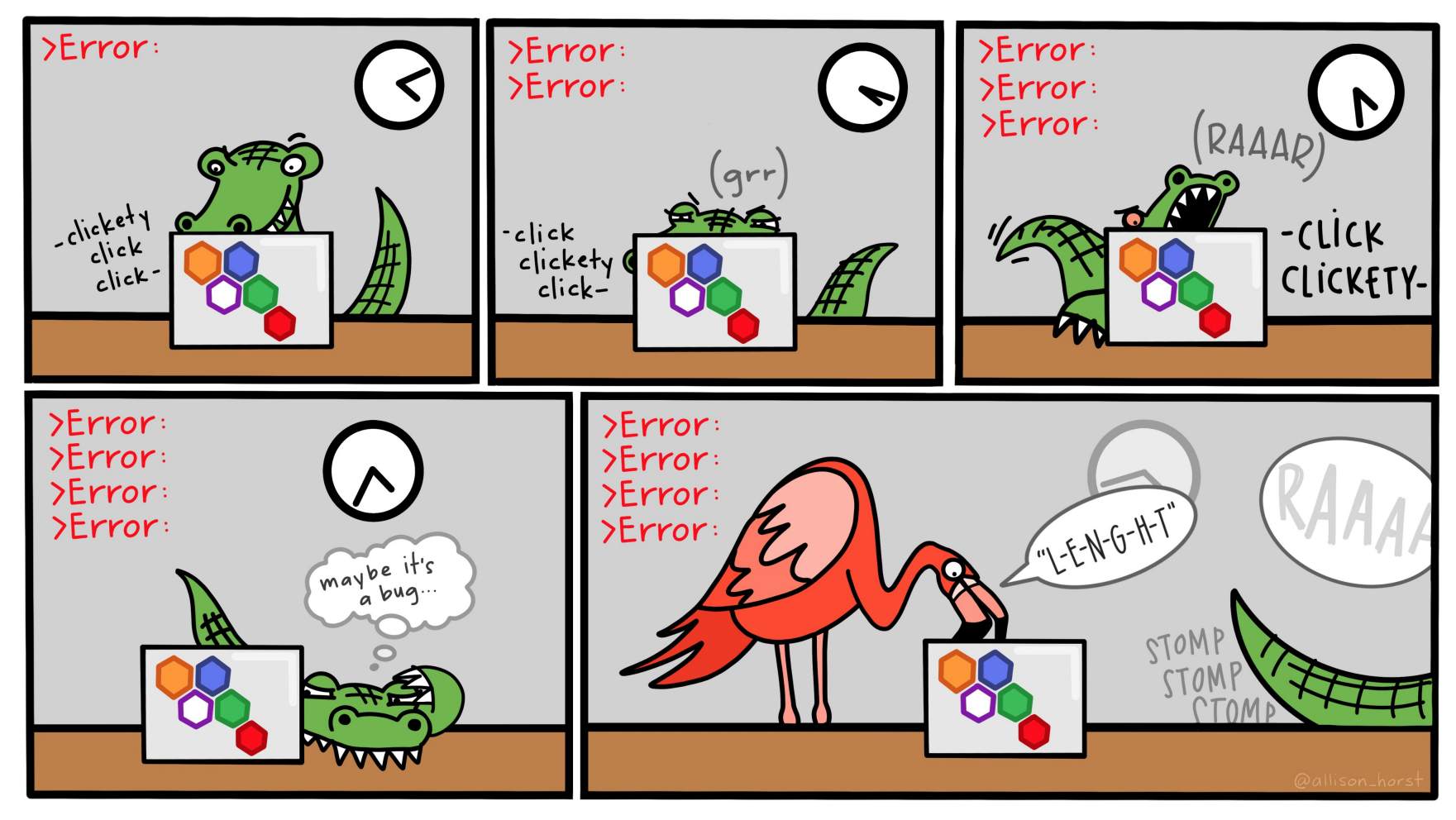
Remember what's real



4/ Getting R bearings

Try to type your code by hand

Typing speeds up the try-fail cycle



Physically typing the code is best way to familiarize yourself with R and the try-fail-try-fail-try-succeed cycle

Credit: Allison Horst

What R looks like

Code that you can type and run:

```
## Any R code that begins with the # character is a comment
## Comments are ignored by R

my_numbers <- c(4, 8, 15, 16, 23, 42) # Anything after # is also a comment
```

What R looks like

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Output from code prefixed by ## by convention:

```
my_numbers
```

```
## [1]  4  8 15 16 23 42
```

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Output from code prefixed by ## by convention:

```
my_numbers
```

```
## [1]  4  8 15 16 23 42
```

Output also has a counter in brackets when over one line:

```
letters
```

```
##  [1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j" "k" "l" "m" "n"
## [15] "o" "p" "q" "r" "s" "t" "u" "v" "w" "x" "y" "z"
```

Everything in R has a name

```r
my_numbers # just created this
```

```
## [1]  4  8 15 16 23 42
```

```r
letters # this is built into R
```

```
##  [1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j" "k" "l" "m" "n"
## [15] "o" "p" "q" "r" "s" "t" "u" "v" "w" "x" "y" "z"
```

```r
pi # also built in
```

```
## [1] 3.14
```

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```r
pi # also built in
```

```
## [1] 3.14
```

Some names are forbidden (`NA`, `TRUE`, `FALSE`, etc) or strongly not recommended (`c`, `mean`, `table`)

We do things in R with functions

Functions take in objects, perform actions, and return outputs:

```
mean(x = my_numbers)
```

```
## [1] 18
```

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- x is the argument name,
- `my_numbers` is what we're passing to the that argument

If you omit the argument name, R will assume the default order:

```
mean(my_numbers)
```

```
## [1] 18
```

Getting help with R

How do we know the default argument order? Look to help files:

```
help(mean)
?mean # shorter
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- Get help **early** before becoming too frustrated!
  - Easy to overlook small issues like missing commas, etc.

Functions live in packages

Packages are bundles of functions written by other users that we can use.

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Install packages using `install.packages()` to have them on your machine:

```
install.packages("ggplot2")
```

Load them into your R session with `library()`:

```
library(ggplot2)
```

Now we can use any function provided by `ggplot2`.

Functions live in packages

We can also use the `mypackage::` prefix to access package functions without loading:

```
knitr::kable(head(mtcars))
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Mazda RX4	21.0	6	160	110	3.90	2.62	16.5	0	1	4	4
Mazda RX4 Wag	21.0	6	160	110	3.90	2.88	17.0	0	1	4	4
Datsun 710	22.8	4	108	93	3.85	2.32	18.6	1	1	4	1
Hornet 4 Drive	21.4	6	258	110	3.08	3.21	19.4	1	0	3	1
Hornet Sportabout	18.7	8	360	175	3.15	3.44	17.0	0	0	3	2
Valiant	18.1	6	225	105	2.76	3.46	20.2	1	0	3	1

5/ Our first visualizations

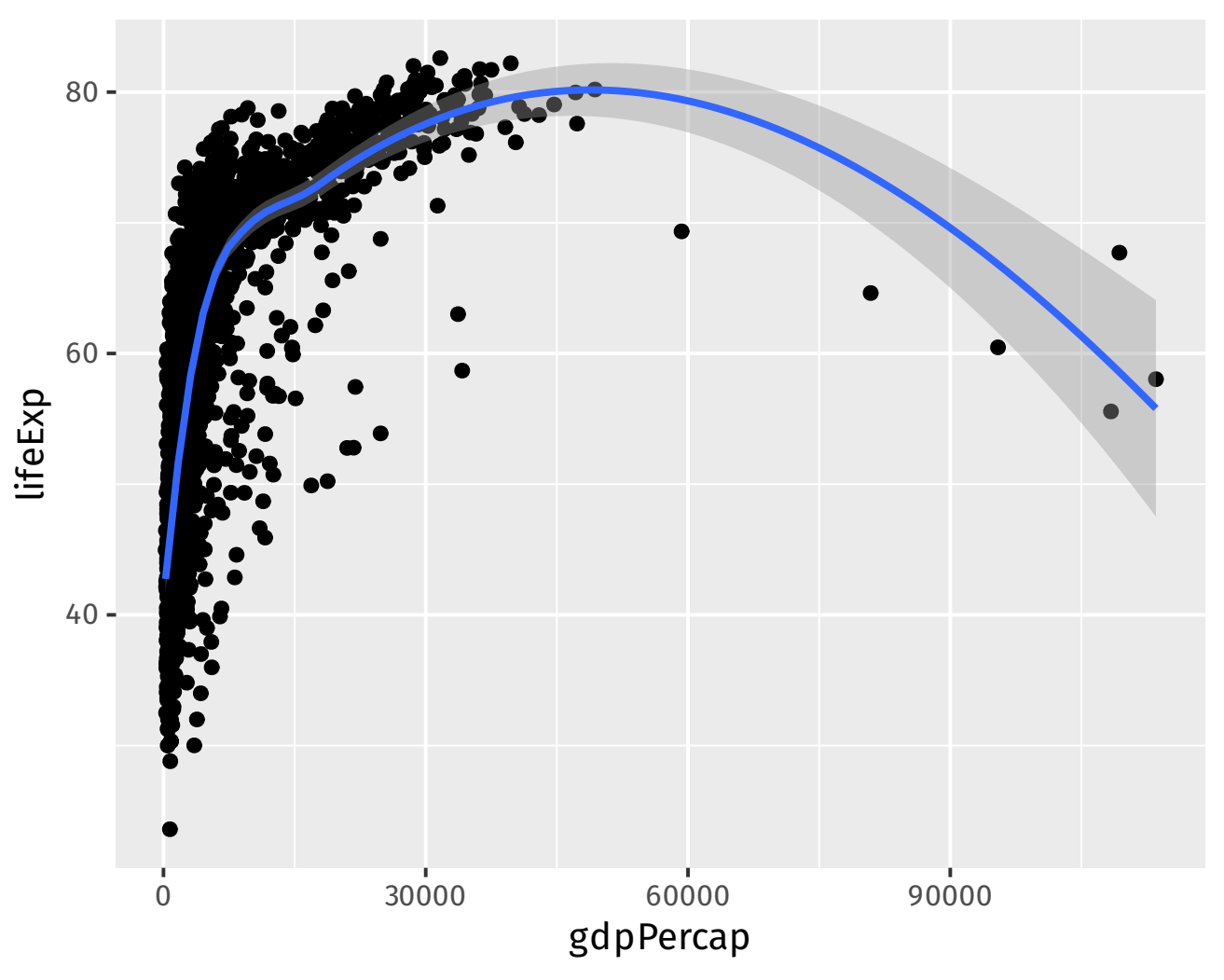
Gapminder data

```r
library(gapminder)
gapminder
```

```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Afghanistan Asia       1957    30.3  9240934      821.
##  3 Afghanistan Asia       1962    32.0 10267083      853.
##  4 Afghanistan Asia       1967    34.0 11537966      836.
##  5 Afghanistan Asia       1972    36.1 13079460      740.
##  6 Afghanistan Asia       1977    38.4 14880372      786.
##  7 Afghanistan Asia       1982    39.9 12881816      978.
##  8 Afghanistan Asia       1987    40.8 13867957      852.
##  9 Afghanistan Asia       1992    41.7 16317921      649.
## 10 Afghanistan Asia       1997    41.8 22227415      635.
## # i 1,694 more rows
```

Plotting life expectancy over time

```
ggplot(gapminder, mapping = aes(x = gdpPercap, y = lifeExp)) +
  geom_point() + geom_smooth(method = "loess")
```



A histogram of GDP per capita

```
ggplot(gapminder, mapping = aes(x = gdpPercap)) +
  geom_histogram()
```