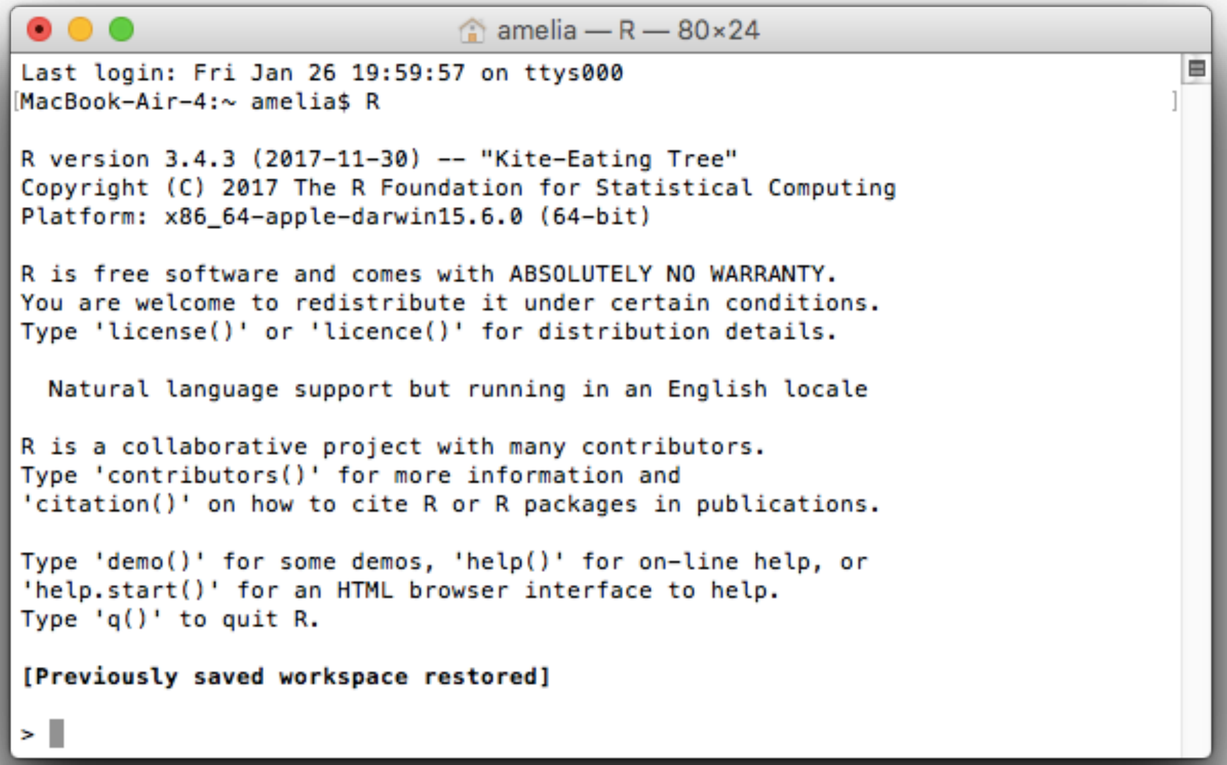
These materials adapted by Amelia McNamara from the RStudio CC BY-SA materials Introduction to R (2014) and Master the Tidyverse (2017).

Introduction to R & RStudio:

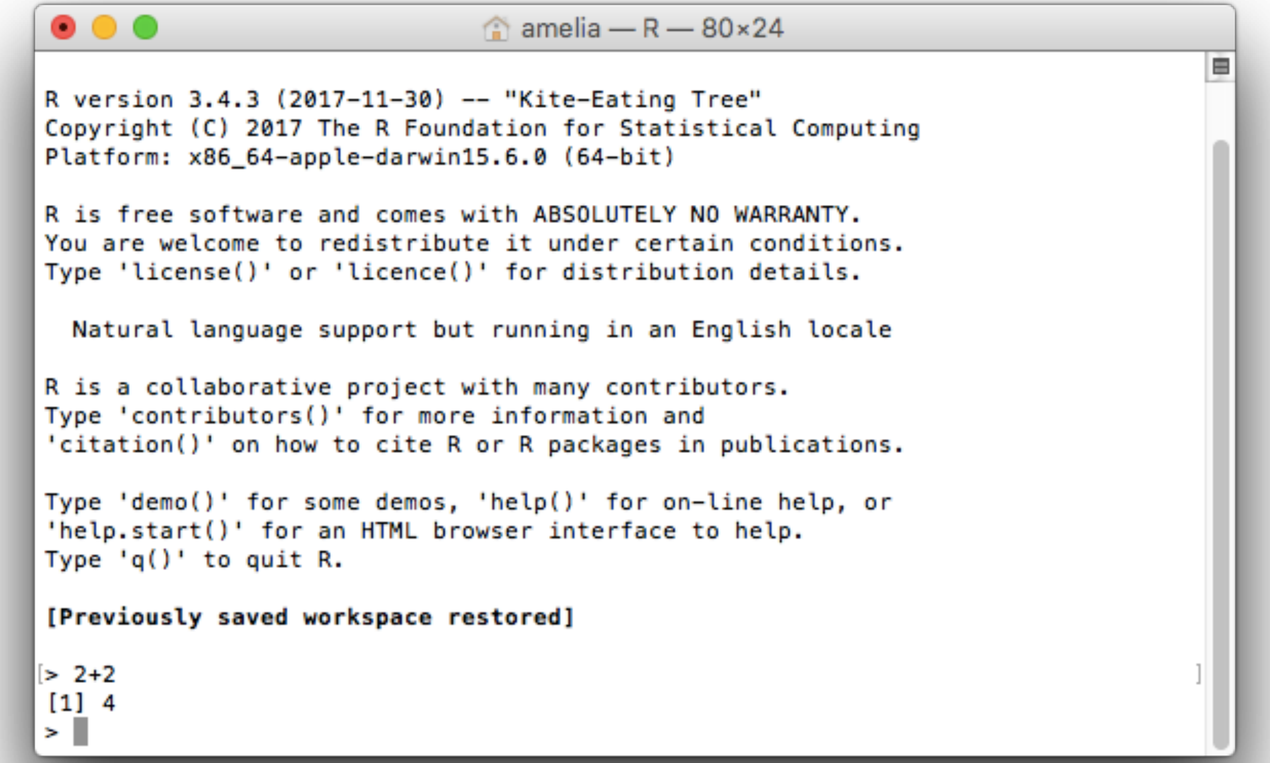
deck 01: Getting started

Amelia McNamara

R: a computer programming language



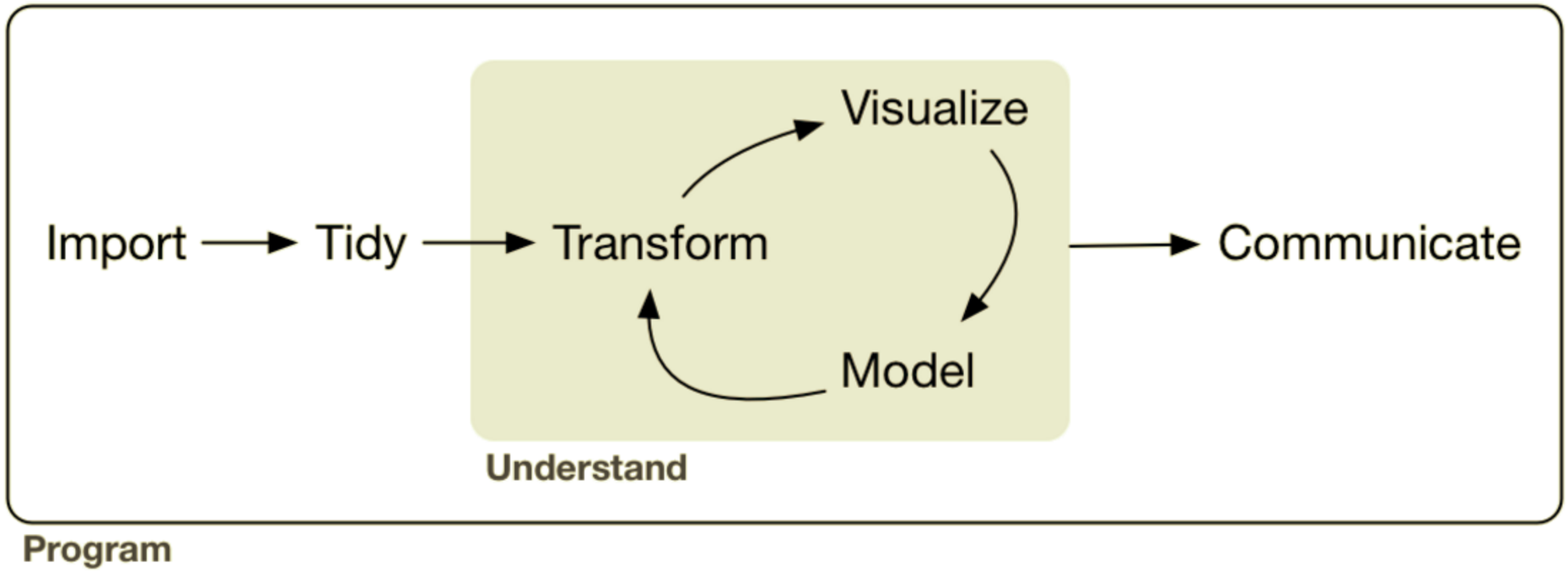
R: a computer programming language



R: a computer programming language

1. Descends from S, Bell Labs
2. Evolved in university environment
3. Full language
4. ...but can be used as a simple application
5. Designed for use with data

R: designed for data



From *R for Data Science* by Hadley Wickham and Garrett Grolemund.

```
> bechdel
# A tibble: 1,794 x 15
    year      imdb                  title             test clean_test binary   budget domgross intgross
   <int>     <chr>                  <chr>            <chr>     <fctr>  <chr>    <int>    <dbl>    <dbl>
 1  2009 tt1003034      Perrier's Bounty          nowomen    nowomen   FAIL  6600000      828      828
 2  2008 tt1226681             Pontypool nowomen-disagree    nowomen   FAIL  1500000     3865    31916
 3  2012 tt1874789 Supporting Characters              men        men   FAIL    60000     4917     4917
 4  2007 tt0861739        Tropa de Elite      ok-disagree         ok   PASS  6537890     8744 14319195
 5  2007 tt0964587         St. Trinian's               ok         ok   PASS 11400000    15000 22446568
 6  2011 tt1535616            The Divide               ok         ok   PASS  3000000    18000    18000
 7  1996 tt0115591                August          dubious    dubious   FAIL  3400000    12636    12636
 8  2006 tt0783238         The Dead Girl               ok         ok   PASS  3300000    19875    19875
 9  2005 tt0342272            Dear Wendy           notalk     notalk   FAIL  8000000    23106   446438
10  2011 tt1788391             Kill List          dubious    dubious   FAIL   800000    29063   462206
# ... with 1,784 more rows, and 6 more variables: code <chr>, budget_2013 <int>, domgross_2013 <dbl>,
#   intgross_2013 <dbl>, period_code <int>, decade_code <int>
```

```
> bechdel %>% skim(domgross_2013)
```

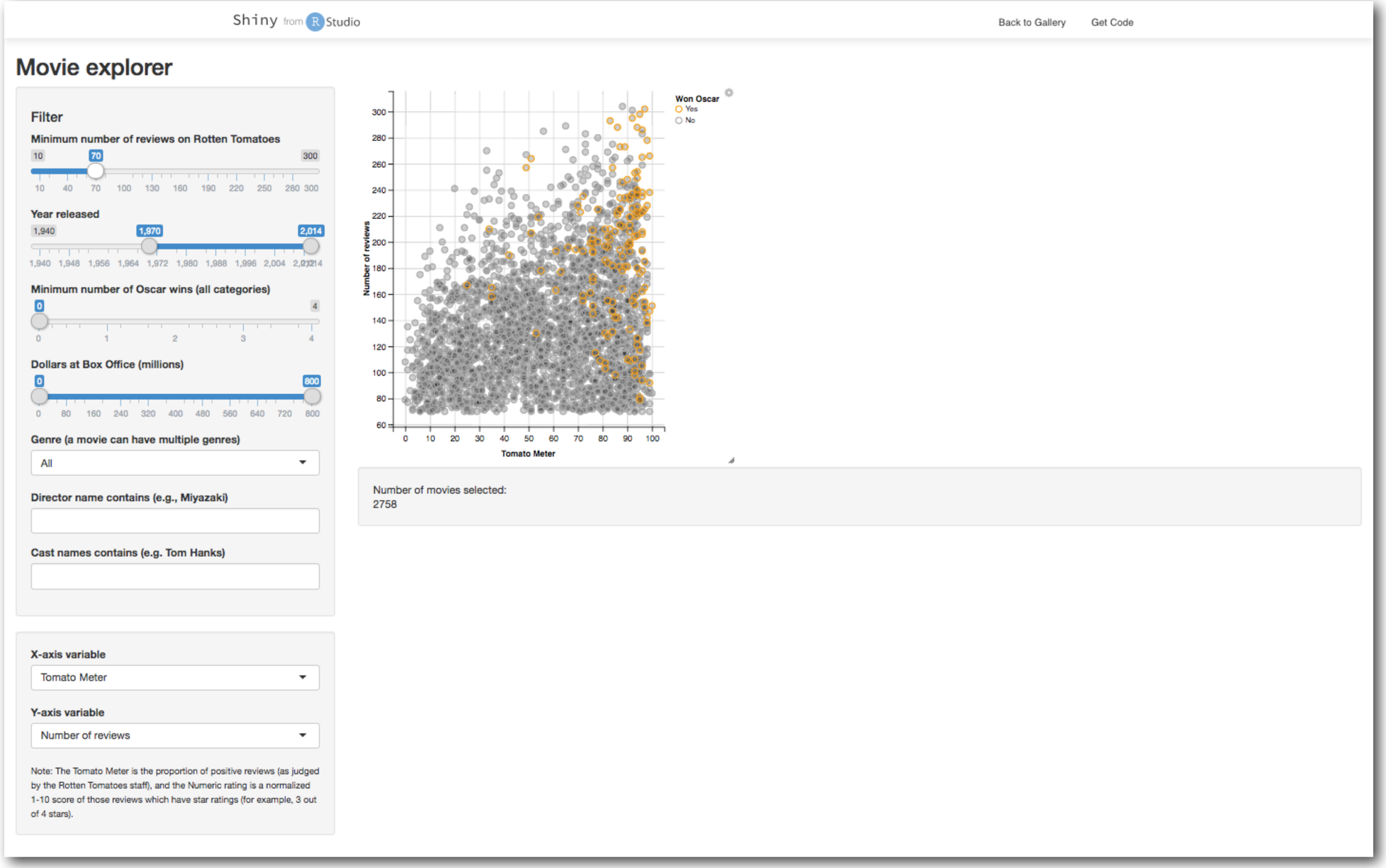
```
Skim summary statistics
 n obs: 1794
 n variables: 15


Variable type: numeric
      variable missing complete    n    mean      sd     p25  median     p75     hist
 domgross_2013      18     1776 1794 9.5e+07 1.3e+08 2.1e+07 5.6e+07 1.2e+08 ▇▂▁▁▁▁▁▁
```

```
> bechdel %>% skim(clean_test)
```

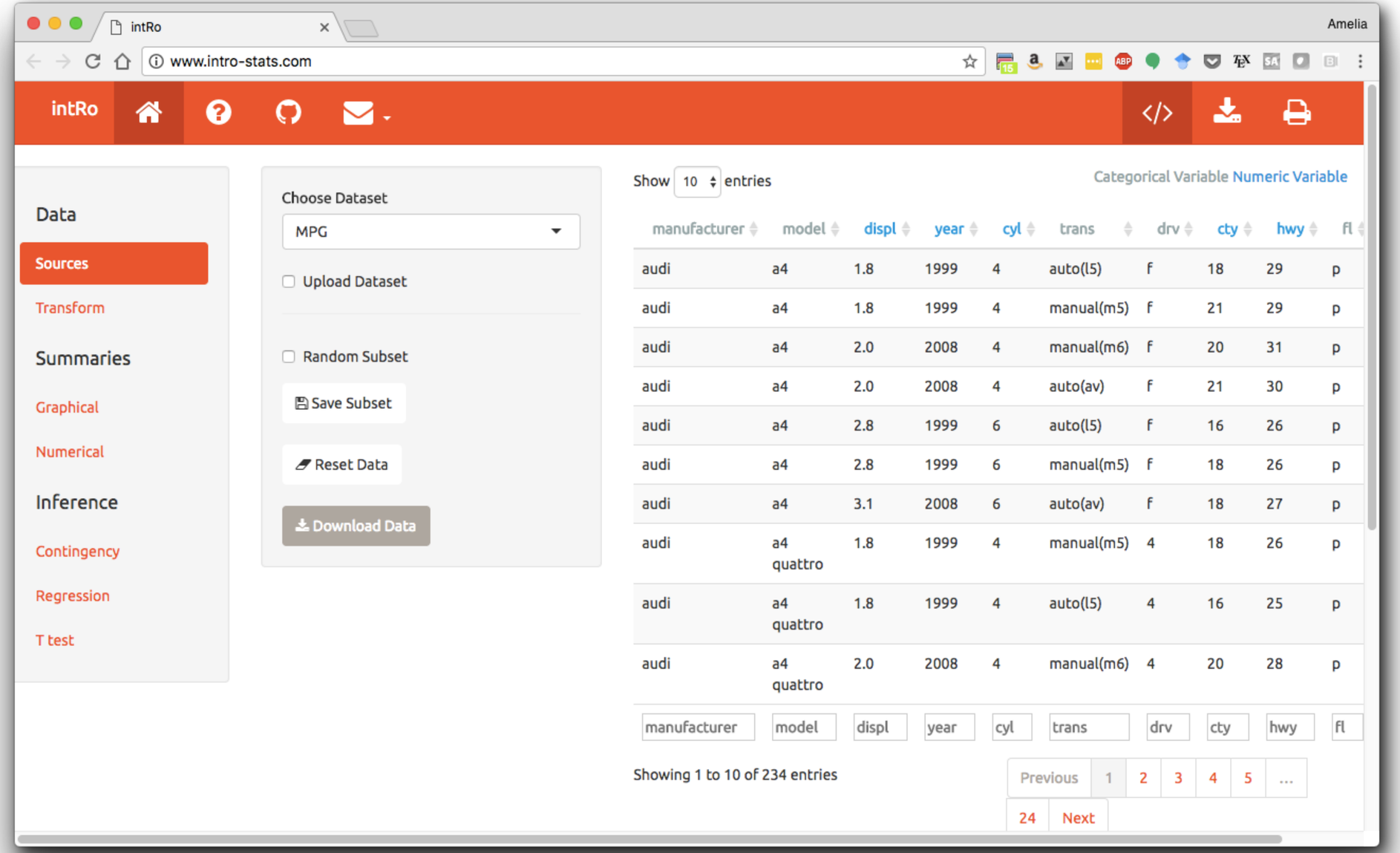
```
Skim summary statistics
 n obs: 1794
 n variables: 15


Variable type: factor
   variable missing complete    n n_unique                              top_counts ordered
 clean_test       0     1794 1794        5 ok: 803, not: 514, men: 194, dub: 142   FALSE
```

```
> qplot(budget_2013, domgross_2013, data=bechdel, color = binary)
```

```
> lm(domgross_2013~budget_2013, data=bechdel)

Call:
lm(formula = domgross_2013 ~ budget_2013, data = bechdel)

Residuals:
       Min          1Q      Median          3Q         Max
-256686756  -47529500  -27186696   15143559 1690886212

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 3.615e+07  3.782e+06   9.559   <2e-16 ***
budget_2013 1.056e+00  4.823e-02  21.896   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 111800000 on 1774 degrees of freedom
  (18 observations deleted due to missingness)
Multiple R-squared:  0.2128,	Adjusted R-squared:  0.2123
F-statistic: 479.4 on 1 and 1774 DF,  p-value: < 2.2e-16
```



https://shiny.rstudio.com/gallery/movie-explorer.html



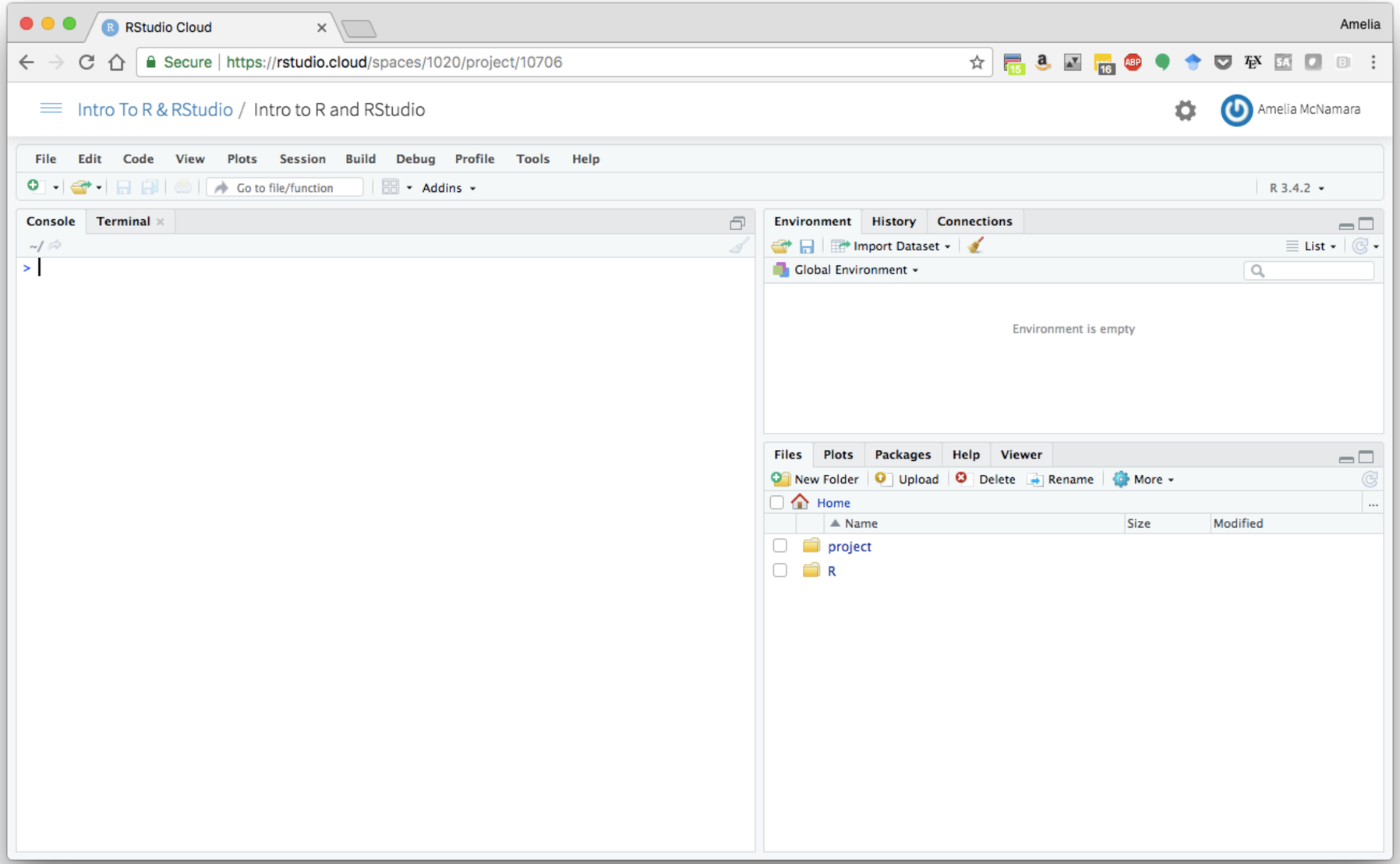
http://www.intro-stats.com/


R

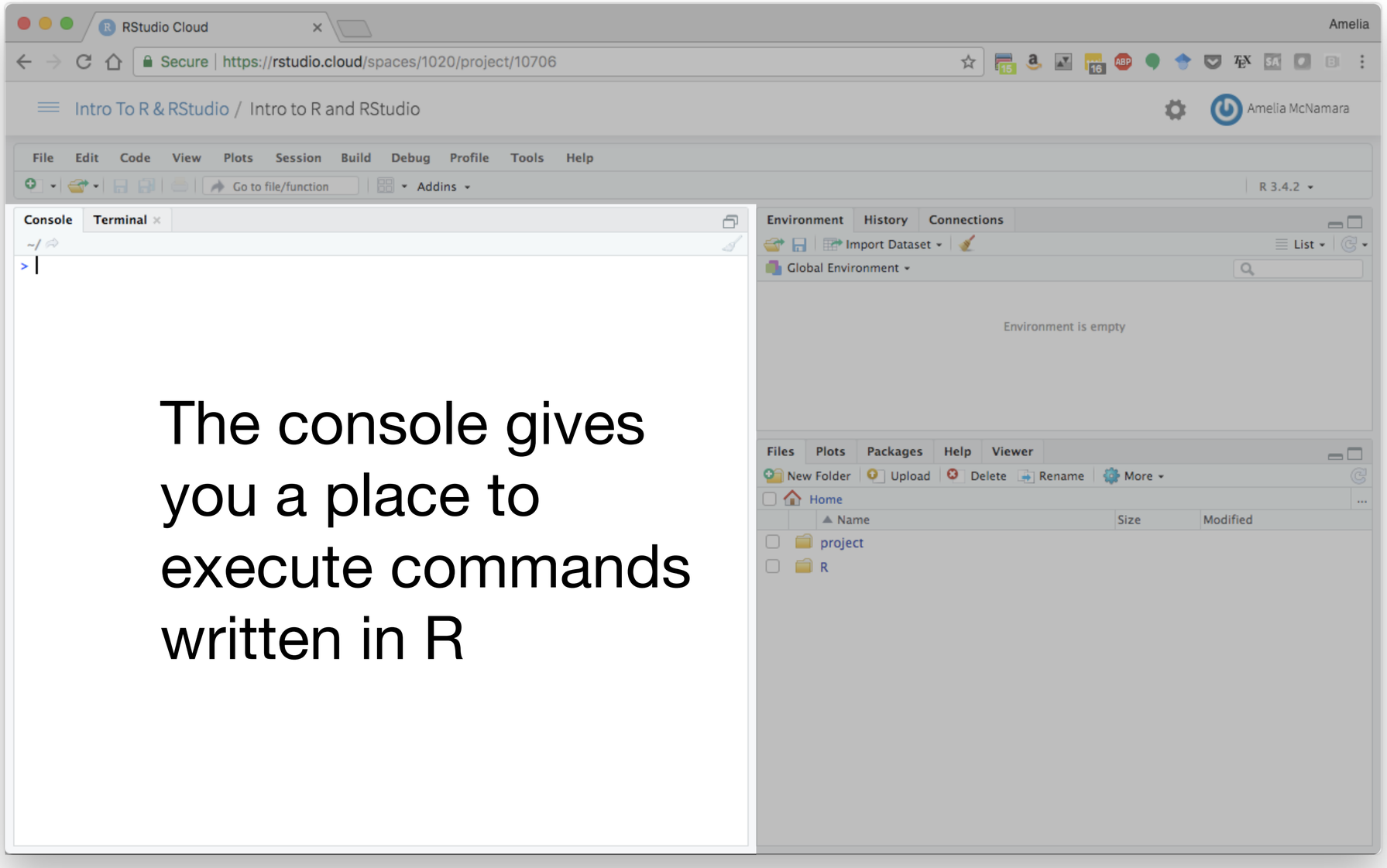
RStudio: a software program

1. like Microsoft Word, Excel, etc.
2. built to help you write R code, run R code, and analyze data with R
3. text editor, version control, keyboard shortcuts, debugging tools, and much more

RStudio

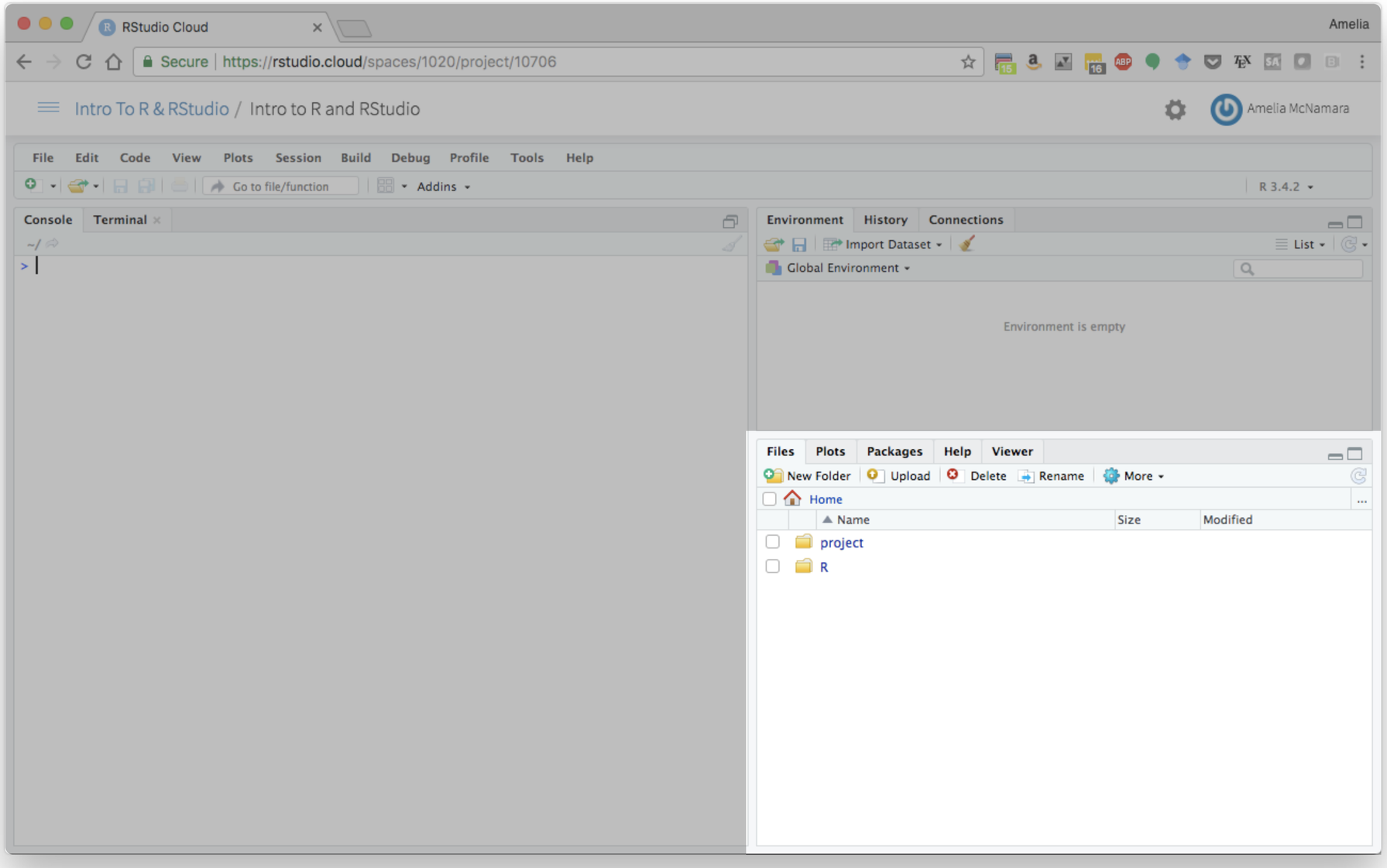

RStudio Cloud
Amelia
Secure | https://rstudio.cloud/spaces/1020/project/10706
Intro To R & RStudio / Intro to R and RStudio
Amelia McNamara
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 3.4.2
Console
Terminal
~/
>
Environment
History
Connections
Import Dataset
List
Global Environment
Environment is empty
Files
Plots
Packages
Help
Viewer
New Folder
Upload
Delete
Rename
More
Home
Name
Size
Modified
project
R

RStudio



The console gives you a place to execute commands written in R

RStudio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File Edit Code View Plots Session Build Debug Profile Tools Help
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Addins
R 3.4.2
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Rename
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Home
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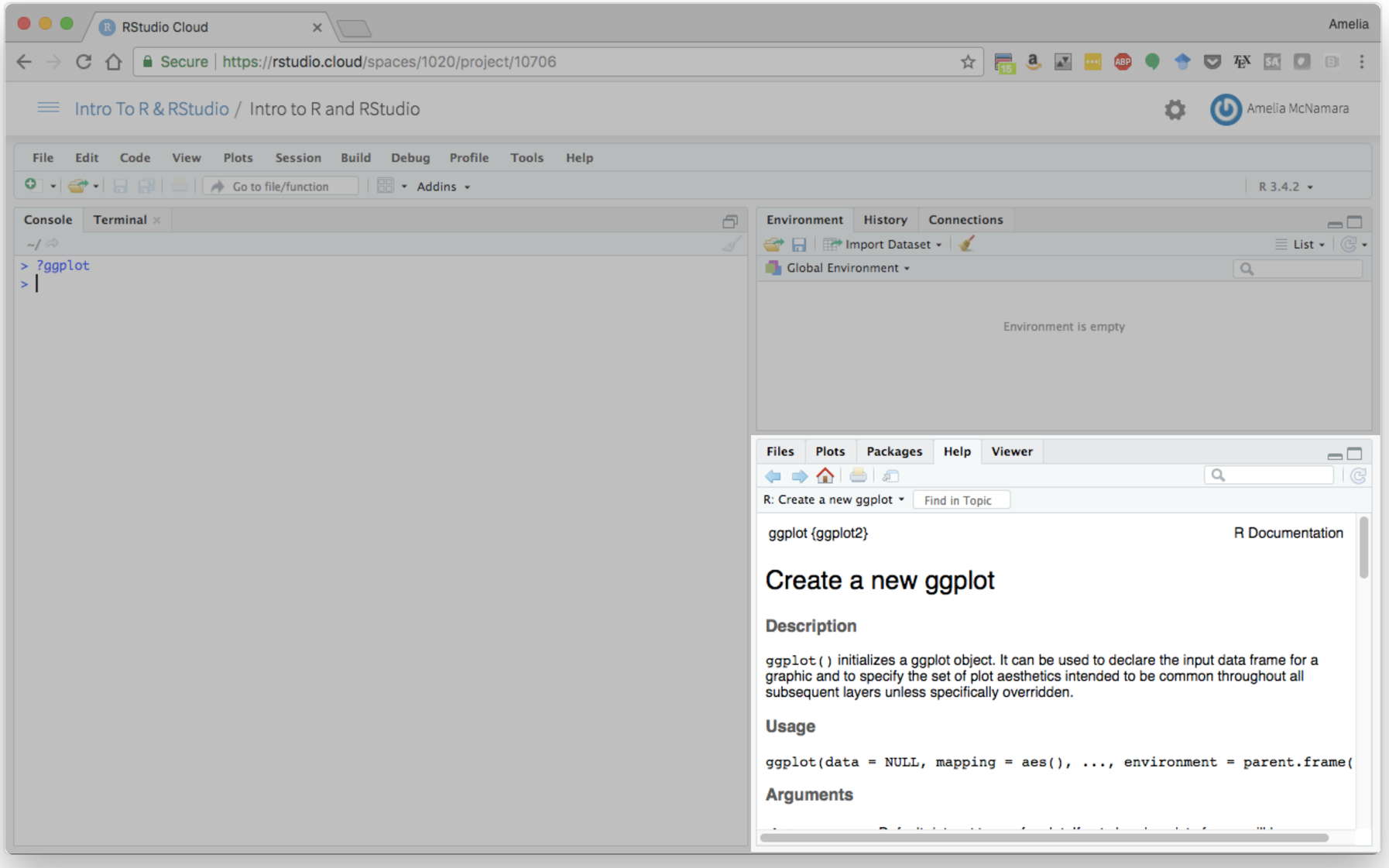
Size
Modified
project
R

RStudio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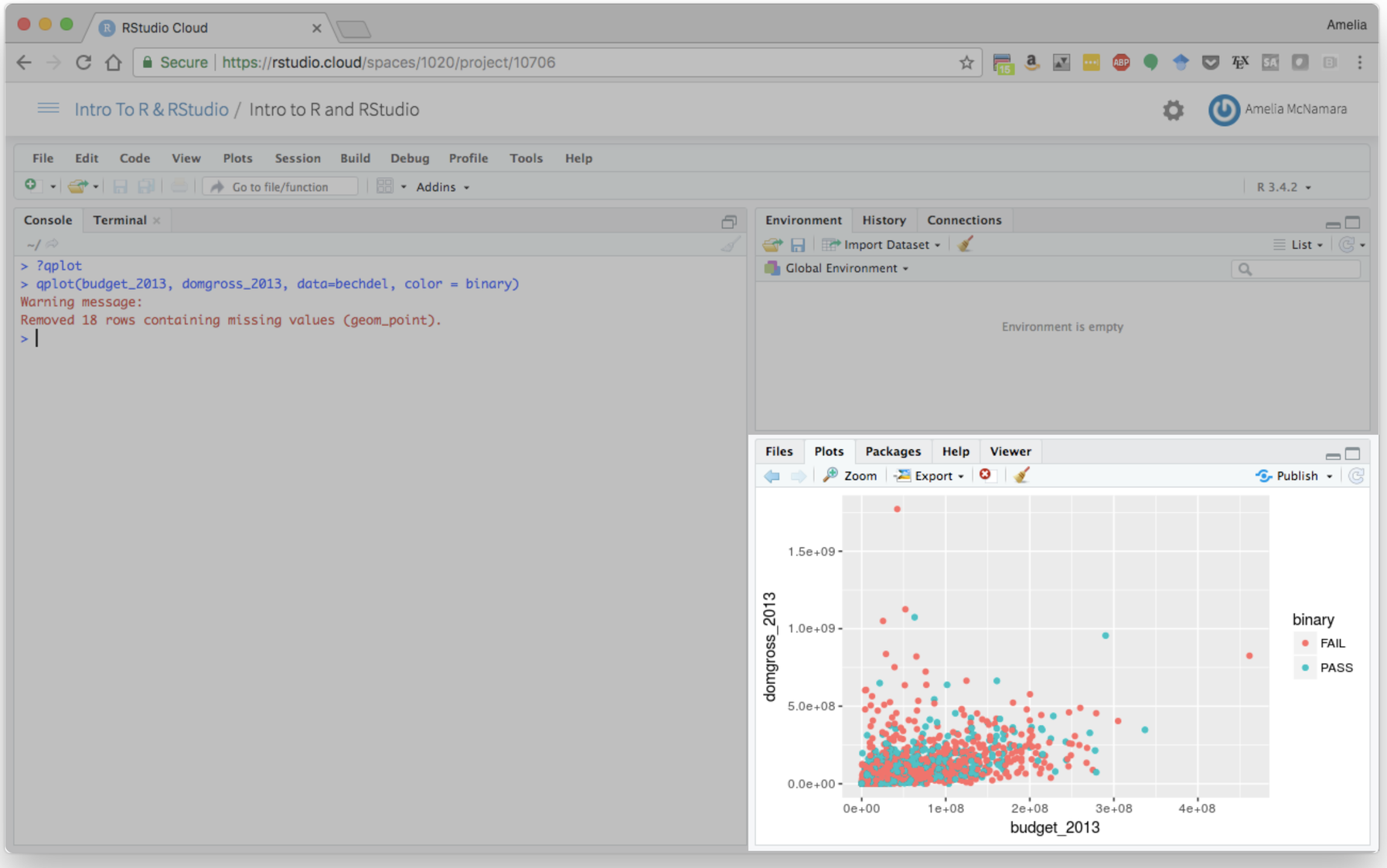
Amelia McNamara
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 3.4.2
Console Terminal
~/
> ?ggplot
>
Environment History Connections
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
R: Create a new ggplot
Find in Topic
ggplot {ggplot2}
R Documentation
Create a new ggplot
Description
ggplot() initializes a ggplot object. It can be used to declare the input data frame for a graphic and to specify the set of plot aesthetics intended to be common throughout all subsequent layers unless specifically overridden.
Usage
ggplot(data = NULL, mapping = aes(), ..., environment = parent.frame(
Arguments

RStudio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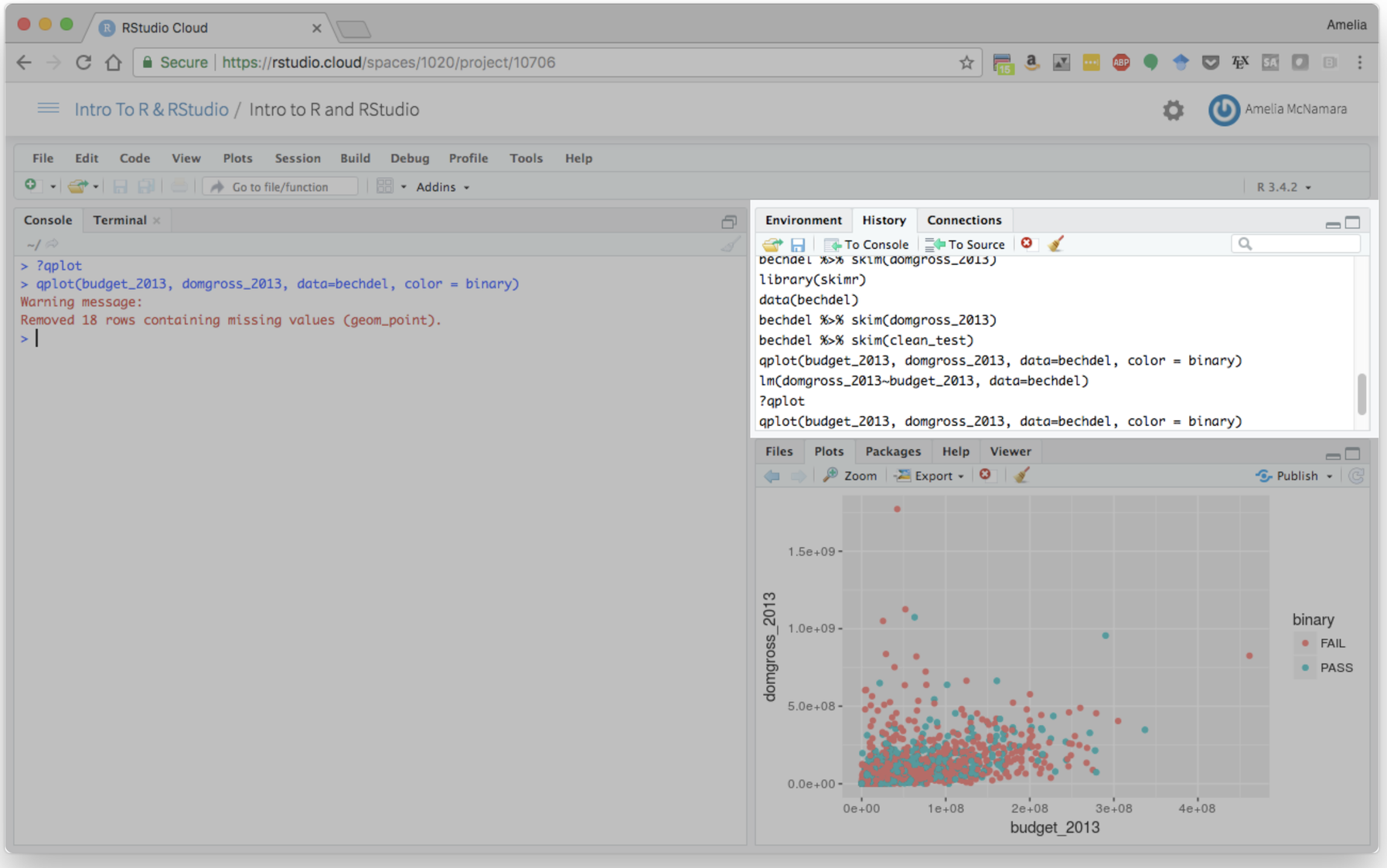
Intro To R & RStudio / Intro to R and RStudio
Amelia McNamara
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 3.4.2
Console Terminal
> ?qplot
> qplot(budget_2013, domgross_2013, data=bechdel, color = binary)
Warning message:
Removed 18 rows containing missing values (geom_point).
>
Environment History Connections
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
Zoom
Export
Publish
1.5e+09
1.0e+09
5.0e+08
0.0e+00
domgross_2013
0e+00
1e+08
2e+08
3e+08
4e+08
budget_2013
binary
FAIL
PASS

RStudio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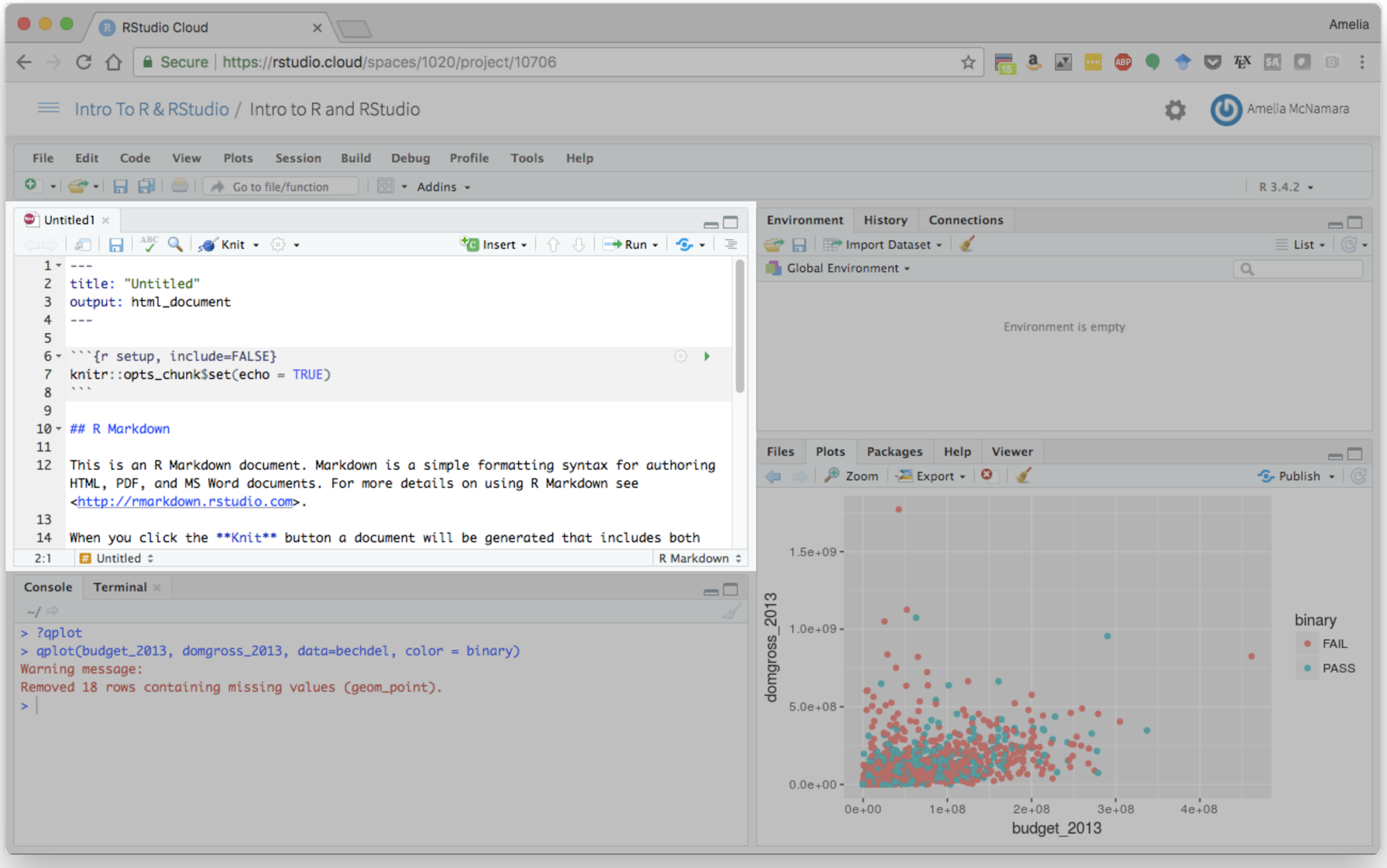
Warning message:
Removed 18 rows containing missing values (geom_point).
>
Environment
History
Connections
To Console
To Source
library(skimr)
data(bechdel)
bechdel %>% skim(domgross_2013)
bechdel %>% skim(clean_test)
qplot(budget_2013, domgross_2013, data=bechdel, color = binary)
lm(domgross_2013~budget_2013, data=bechdel)
?qplot
qplot(budget_2013, domgross_2013, data=bechdel, color = binary)
Files
Plots
Packages
Help
Viewer
Zoom
Export
Publish
1.5e+09
1.0e+09
5.0e+08
0.0e+00
domgross_2013
0e+00
1e+08
2e+08
3e+08
4e+08
budget_2013
binary
FAIL
PASS

RStudio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Intro To R & RStudio / Intro to R and RStudio
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File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 3.4.2
Untitled1
Knit
Insert
Run
1 ---
2 title: "Untitled"
3 output: html_document
4 ---
5
6 ```{r setup, include=FALSE}
7 knitr::opts_chunk$set(echo = TRUE)
8 ```
9
10 ## R Markdown
11
12 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>.
13
14 When you click the **Knit** button a document will be generated that includes both
2:1 Untitled
R Markdown
Console Terminal
~/
> ?qplot
> qplot(budget_2013, domgross_2013, data=bechdel, color = binary)
Warning message:
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1.5e+09
1.0e+09
5.0e+08
0.0e+00
domgross_2013
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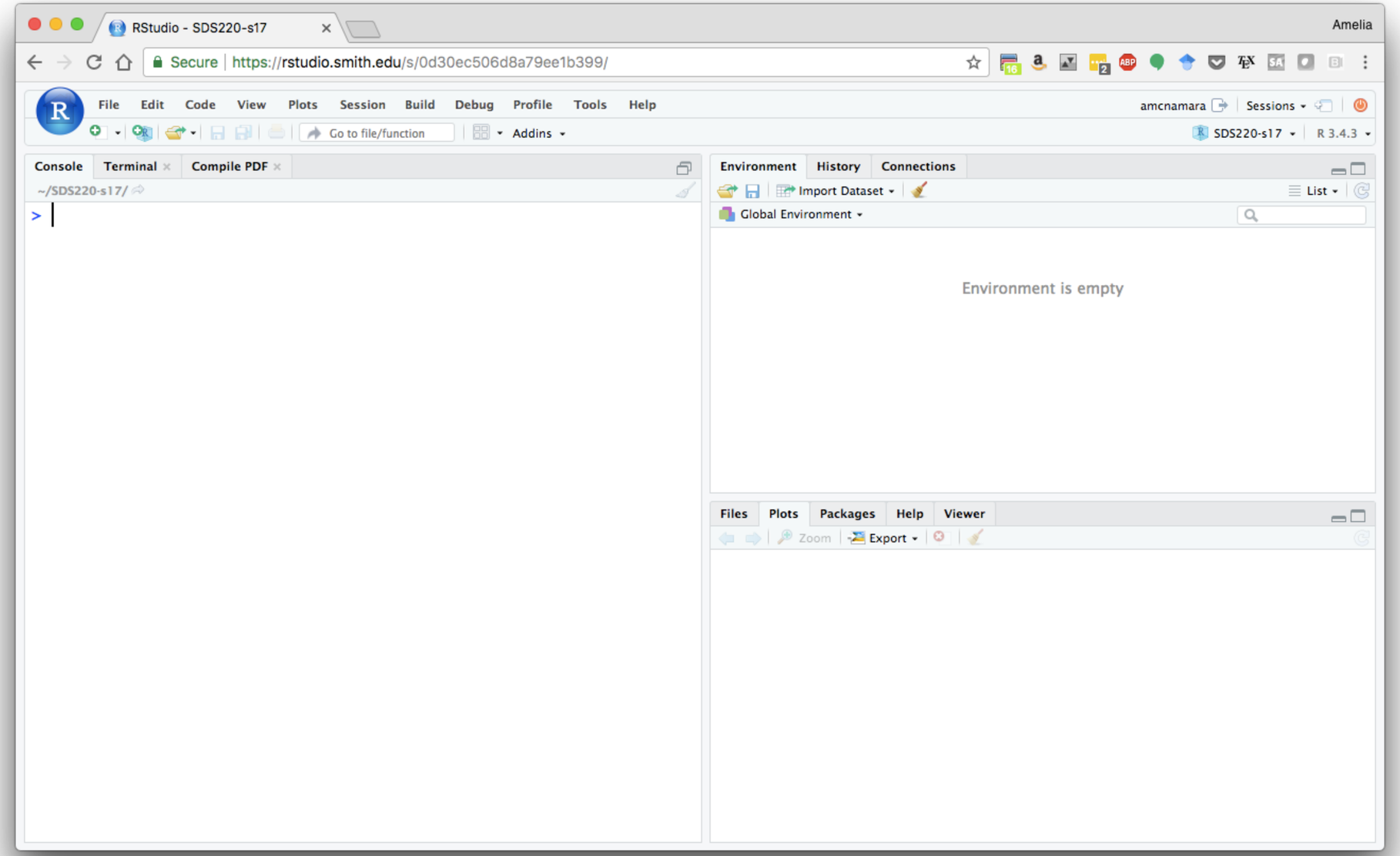
1e+08
2e+08
3e+08
4e+08
budget_2013
binary
FAIL
PASS

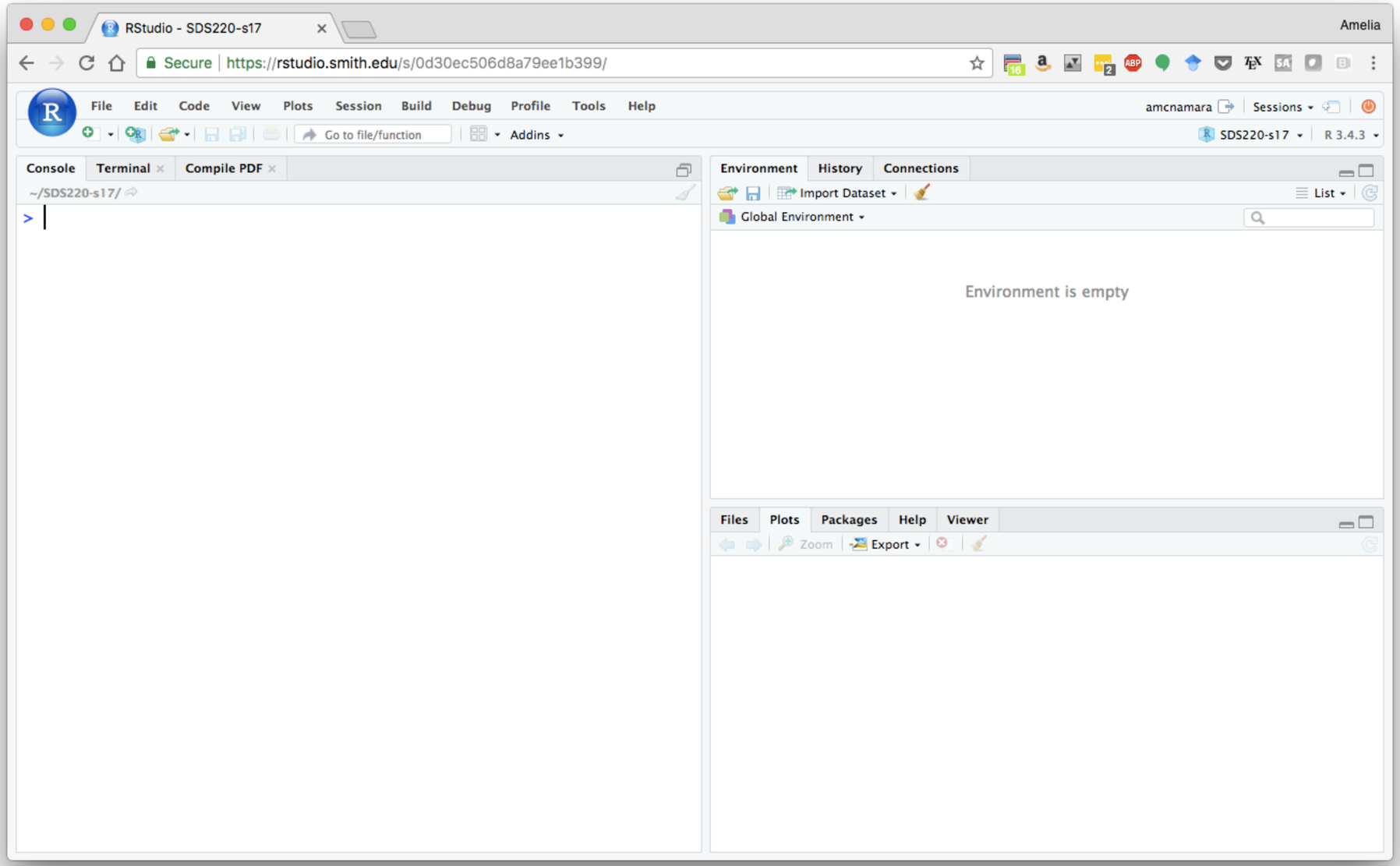
RStudio


RStudio - SDS220-s17
Amelia
Secure | https://rstudio.smith.edu/s/0d30ec506d8a79ee1b399/
File Edit Code View Plots Session Build Debug Profile Tools Help
amcnamara | Sessions
Go to file/function | Addins
SDS220-s17 | R 3.4.3
Console Terminal Compile PDF
~/SDS220-s17/
>
Environment History Connections
Import Dataset | List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
Zoom | Export

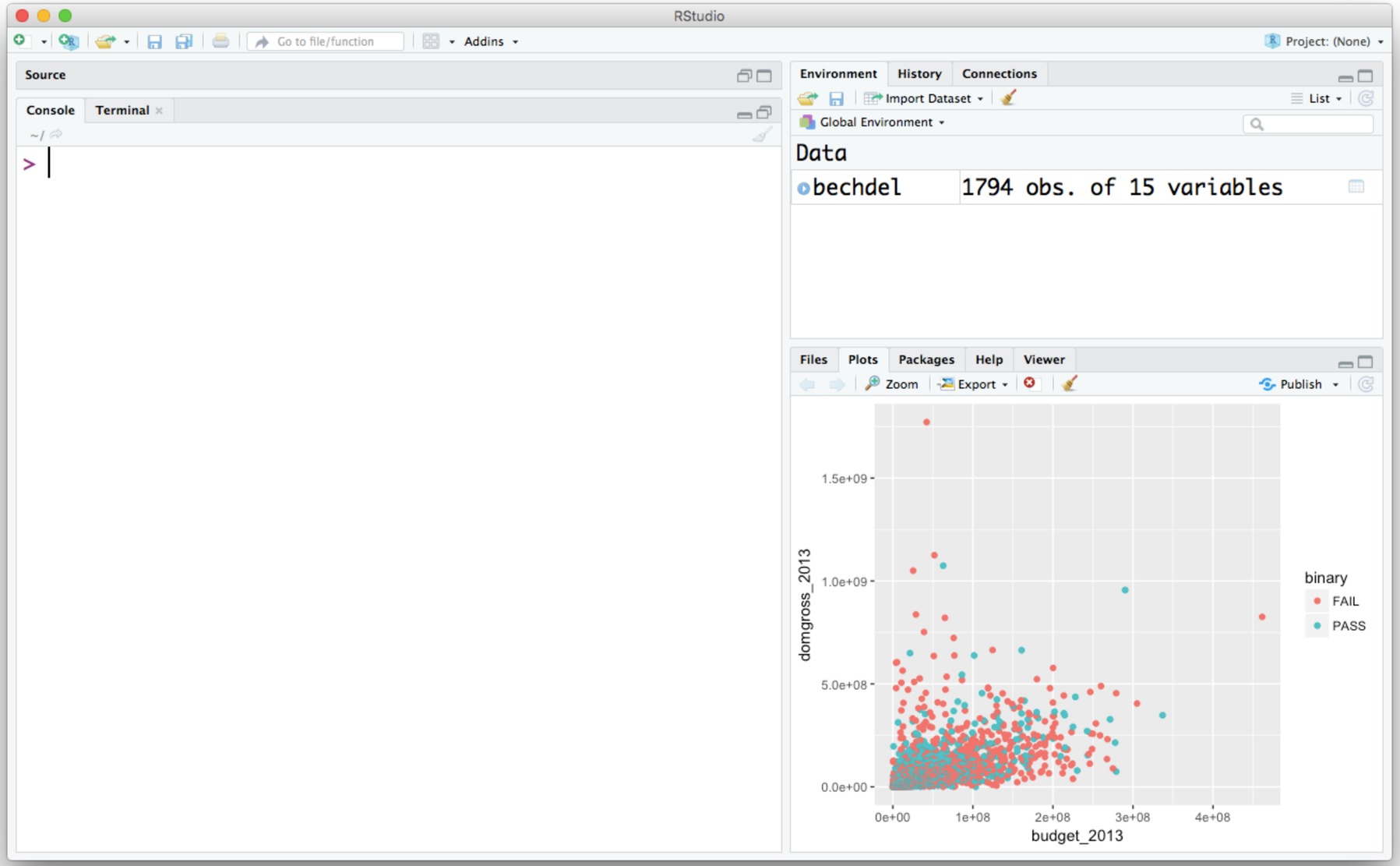
RStudio: ways to use

We're using RStudio Cloud, which allows you to log in through a web browser and do your work there.
But, there are other versions of RStudio.

RStudio: server edition



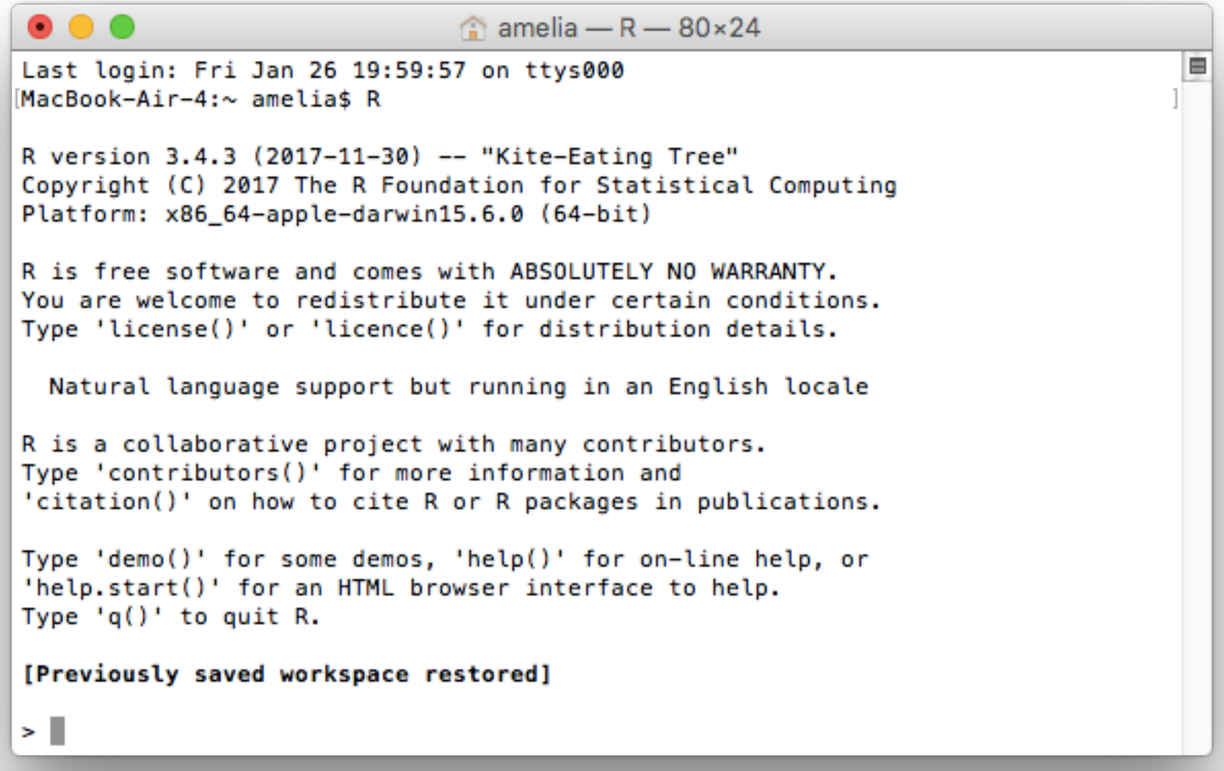
RStudio: desktop edition



Transferability

Everything you learn here will work in any version of RStudio

It will even work in the basic console version of R



Tips

Learning things can be frustrating!

Ask questions!

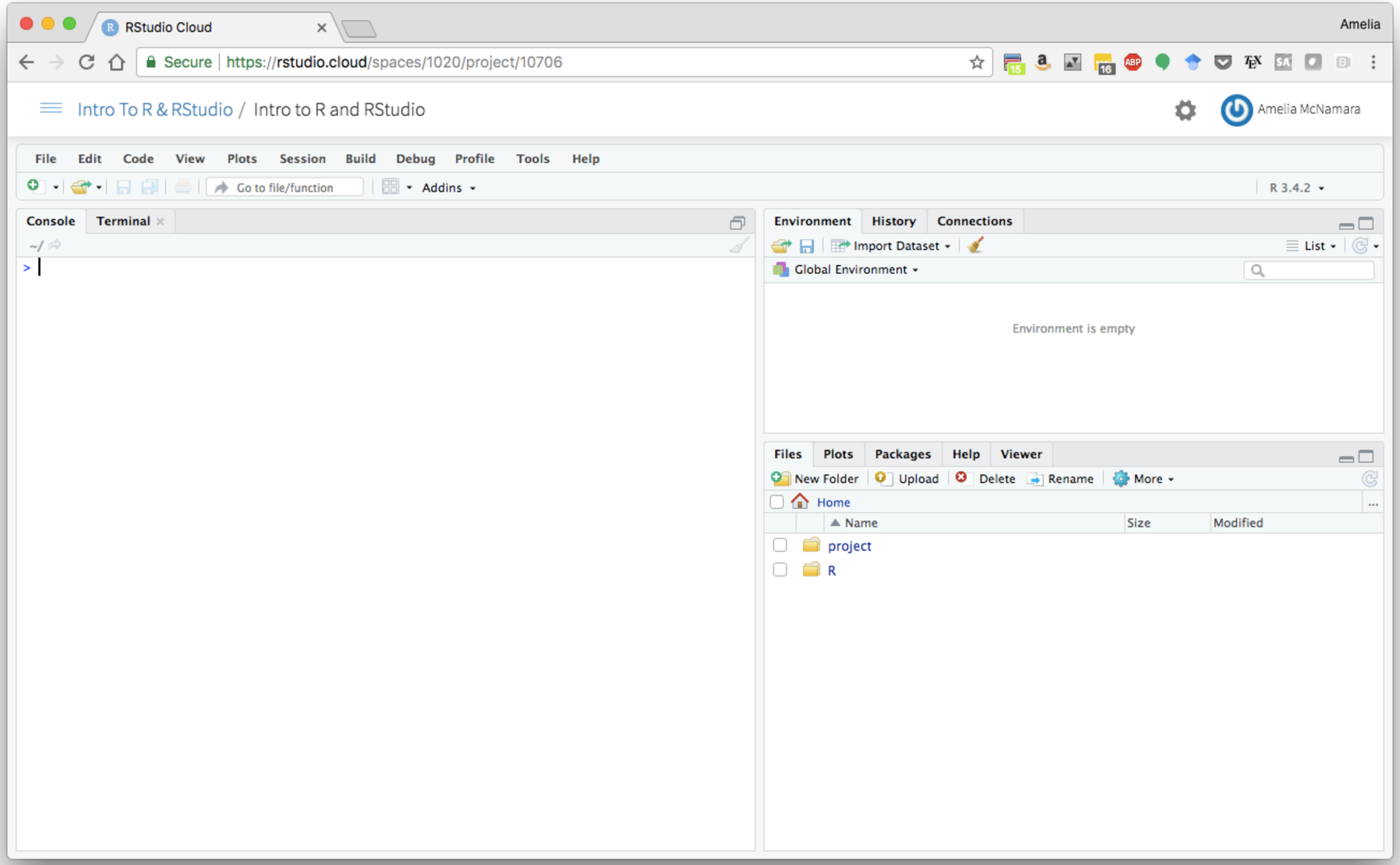
Practice!

Seriously: practice!

And practice consciously: make a prediction, then test it, then reflect.

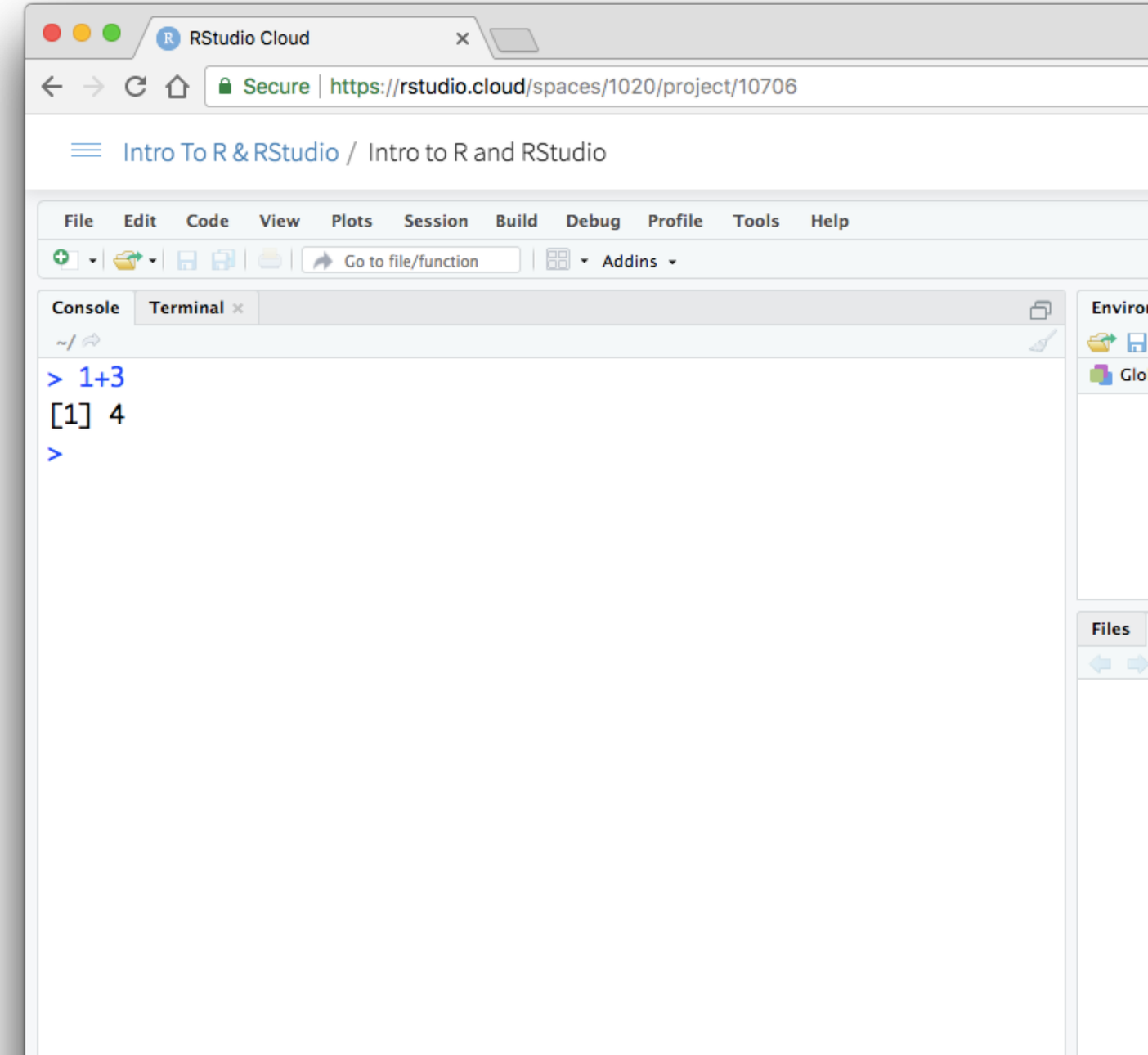
RStudio

Getting started

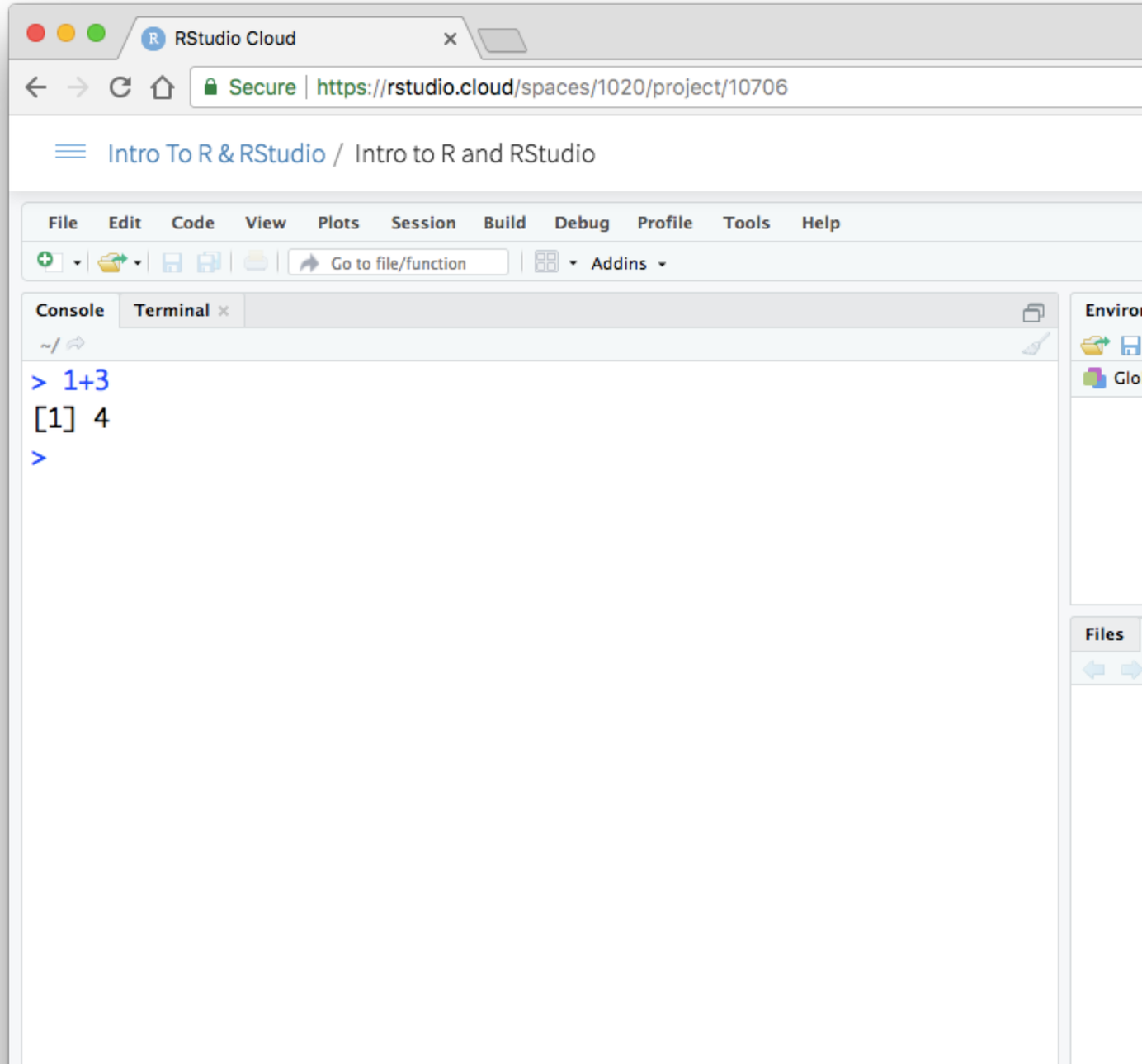


The console gives you a place to execute commands written in R

Type commands on the line that begins with a > sign (known as the prompt)



Output



Output

New prompt

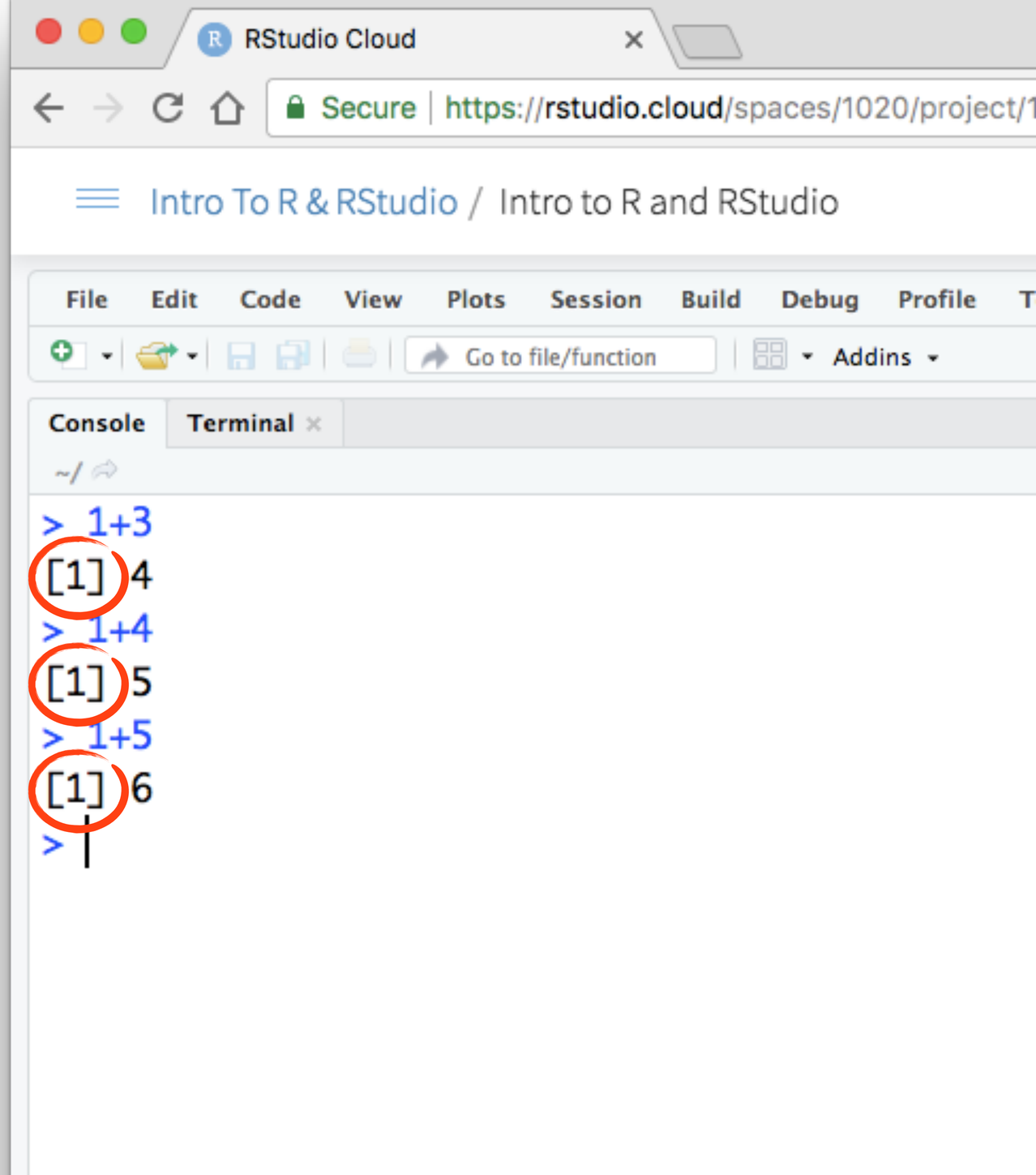
When you hit enter, RStudio will run your command and display any output below it

[1]

R displays an index next to the output.

Just ignore this.

Somewhat helpful when R returns more than one value in the output.



R is like a fancy calculator on your computer

```
5 + 5
# 10

4 - 1
# 3

1 * 2
# 2

4 ^ 2
# 16
```

It can do algebra

```
a <- 1
b <- 2

a + b
# 3

A <- 3

a + b - A
# 0
```

It cares about capitalization

And it has functions that let you do more sophisticated manipulations

round(3.1415)

3

factorial(3)

3! = 3 x 2 x 1

6

sqrt(9)

square root

3

Most of the cool stuff in R comes from functions. Like f(x) (“f of x”) functions in R have names, parentheses, and arguments

factorial of 3

```
factorial(3)
# 6
```

square root of 9

```
sqrt(9)
# 3
```

Your turn

What do you think this will return?

Your turn

What do you think this will return?

```
factorial(round(2.0015) + 1)
```

R always works from the innermost parenthesis to the outermost (just like a calculator).

```
factorial(round(2.0015) + 1)
```



```
factorial(2 + 1)
```



```
factorial(3)
```



```
6
```

R always works from the innermost parenthesis to the outermost (just like a calculator).

```
factorial(round(2.0015) + 1)
```



```
factorial(2 + 1)
```

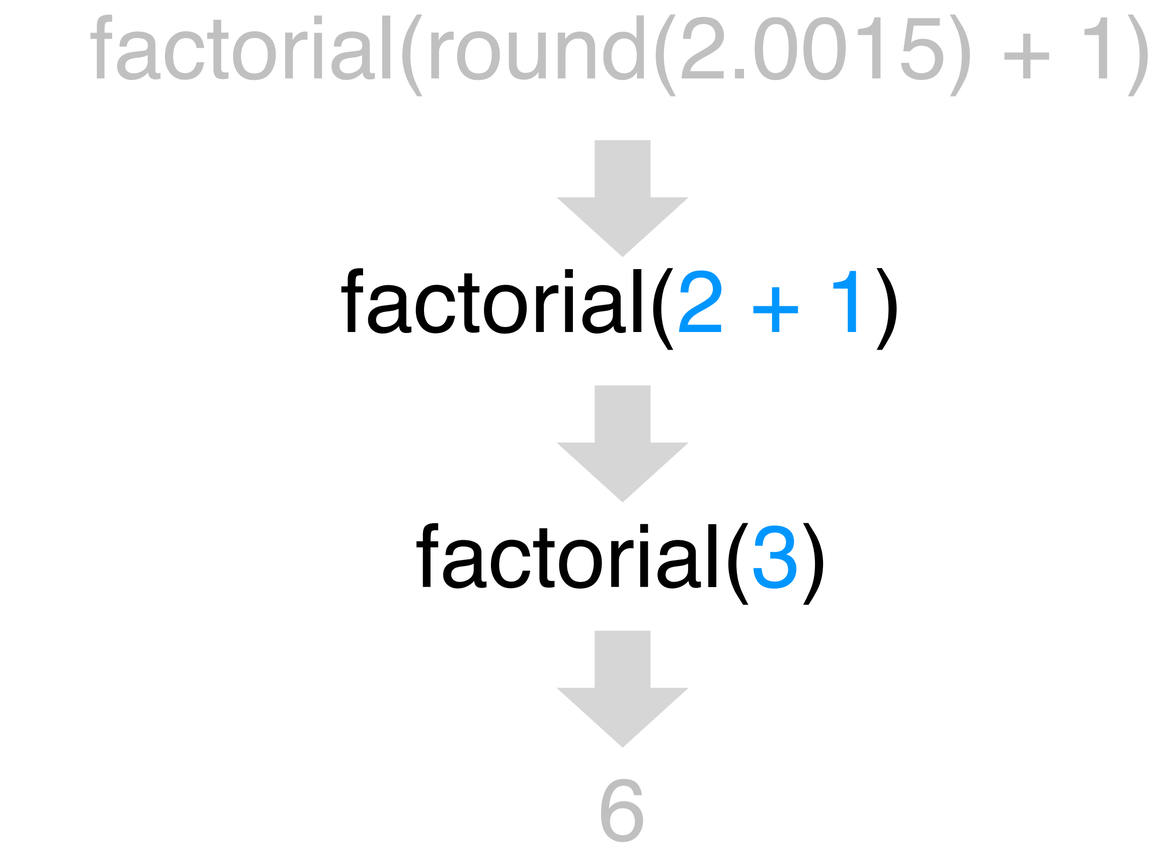


```
factorial(3)
```

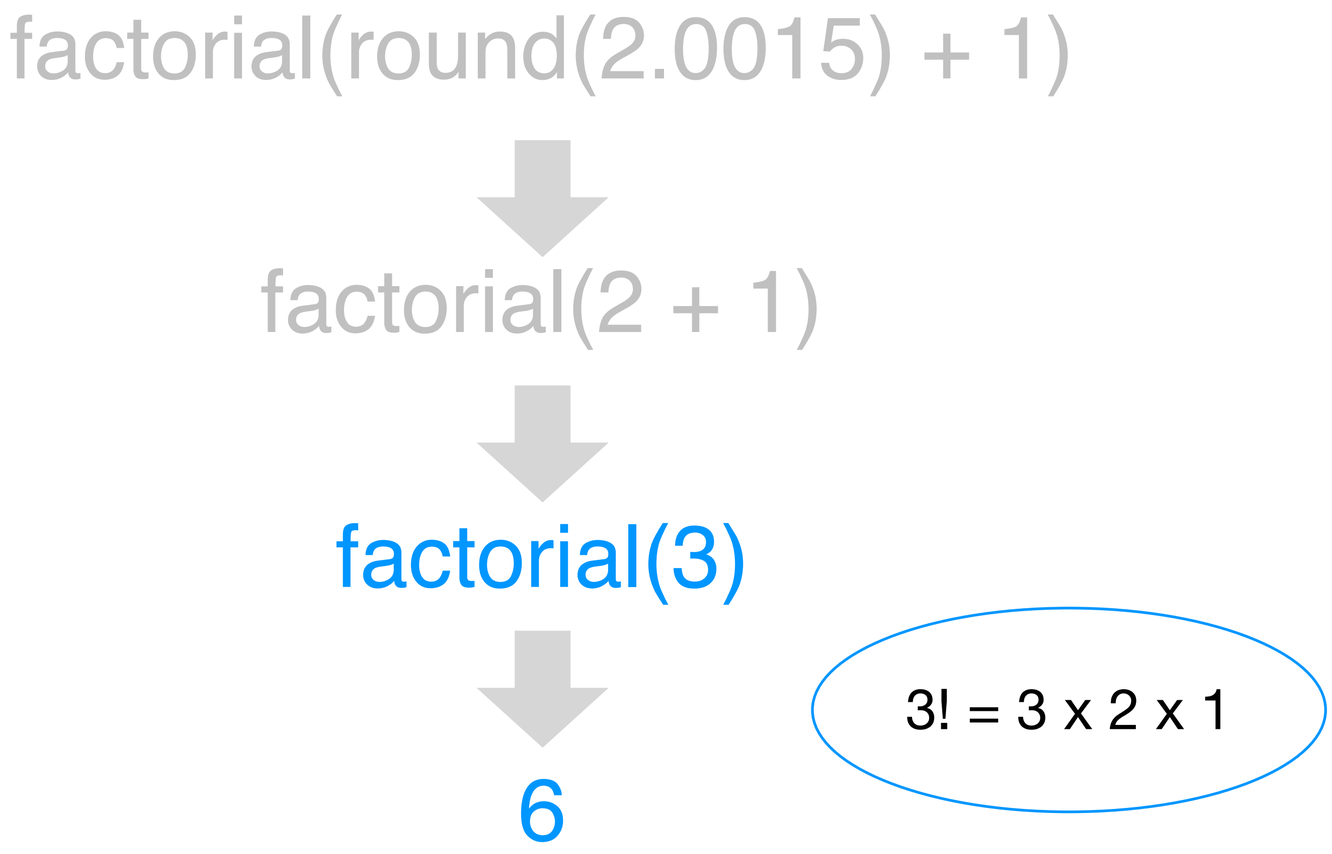


```
6
```

R always works from the innermost parenthesis to the outermost (just like a calculator).



R always works from the innermost parenthesis to the outermost (just like a calculator).



+ prompt

If your prompt turns into a "+", R thinks you haven't finished your previous command.

Either finish the command, or press escape.

+ prompt

If your prompt turns into a "+", R thinks you haven't finished your previous command.

Either finish the command, or press escape.

Your turn

Open RStudio and try the following tasks:

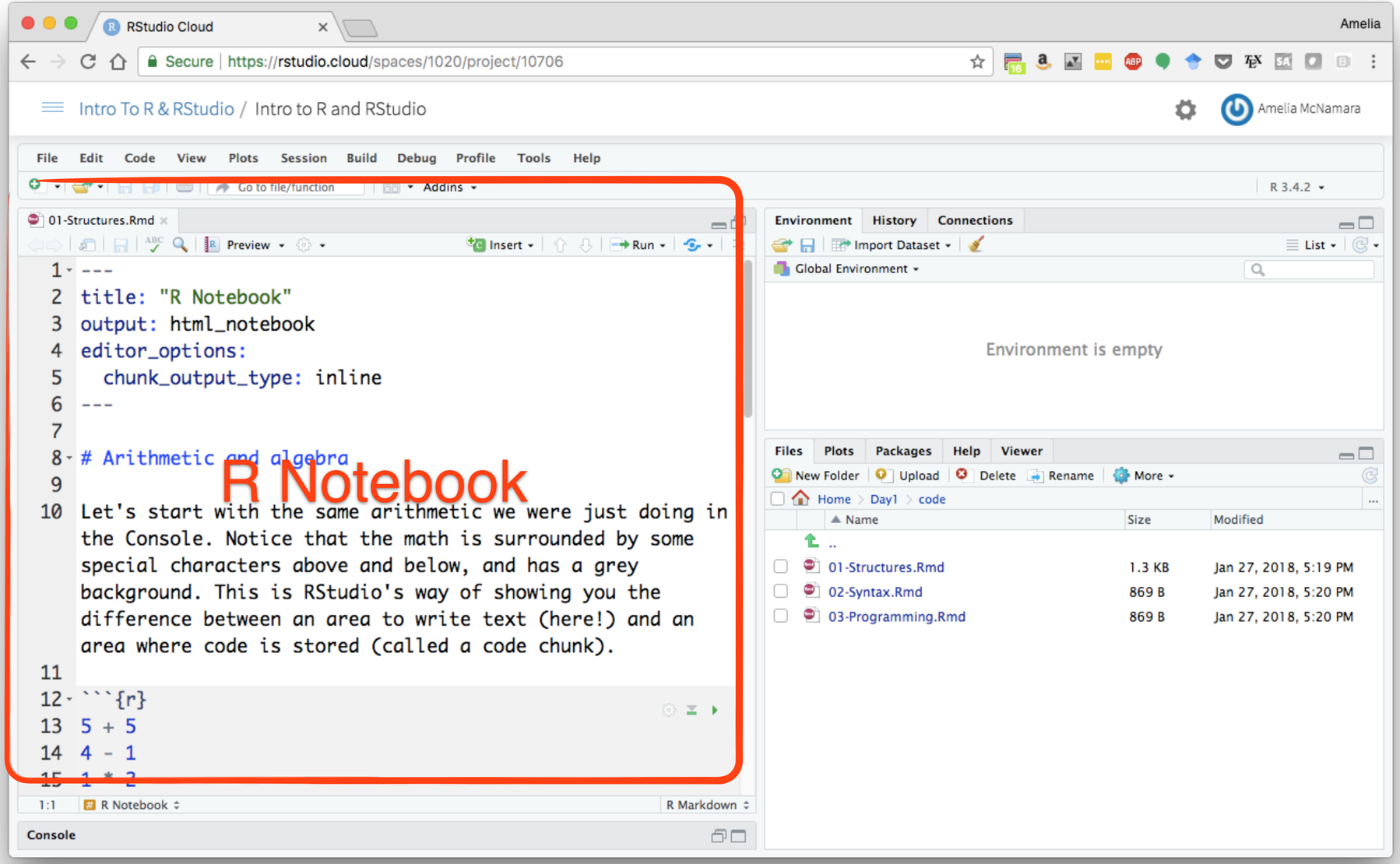
1. Pick a number and add 2 to it
2. Multiply the result by 3
3. Subtract 6 from the result of step 2
4. Divide the result of step 3 by 3

```
10 + 2
# 12

12 * 3
# 36

36 - 6
# 30

30 / 3
# 10
```

Workflow

rmarkdown

It is easier to compose your code in an rmarkdown document than in the command line, and rmarkdown allows you to keep text with your code.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Intro To R & RStudio / Intro to R and RStudio
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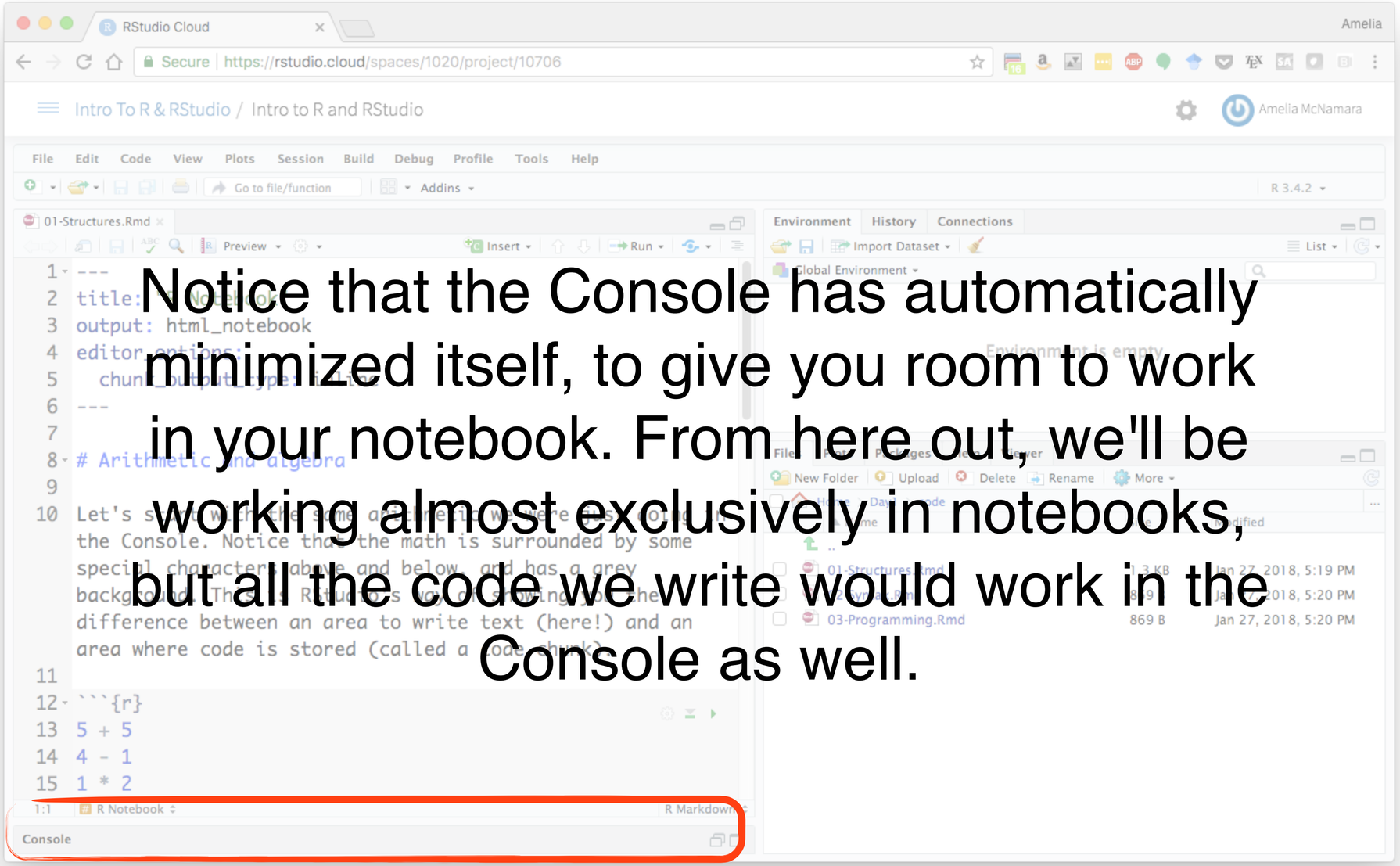
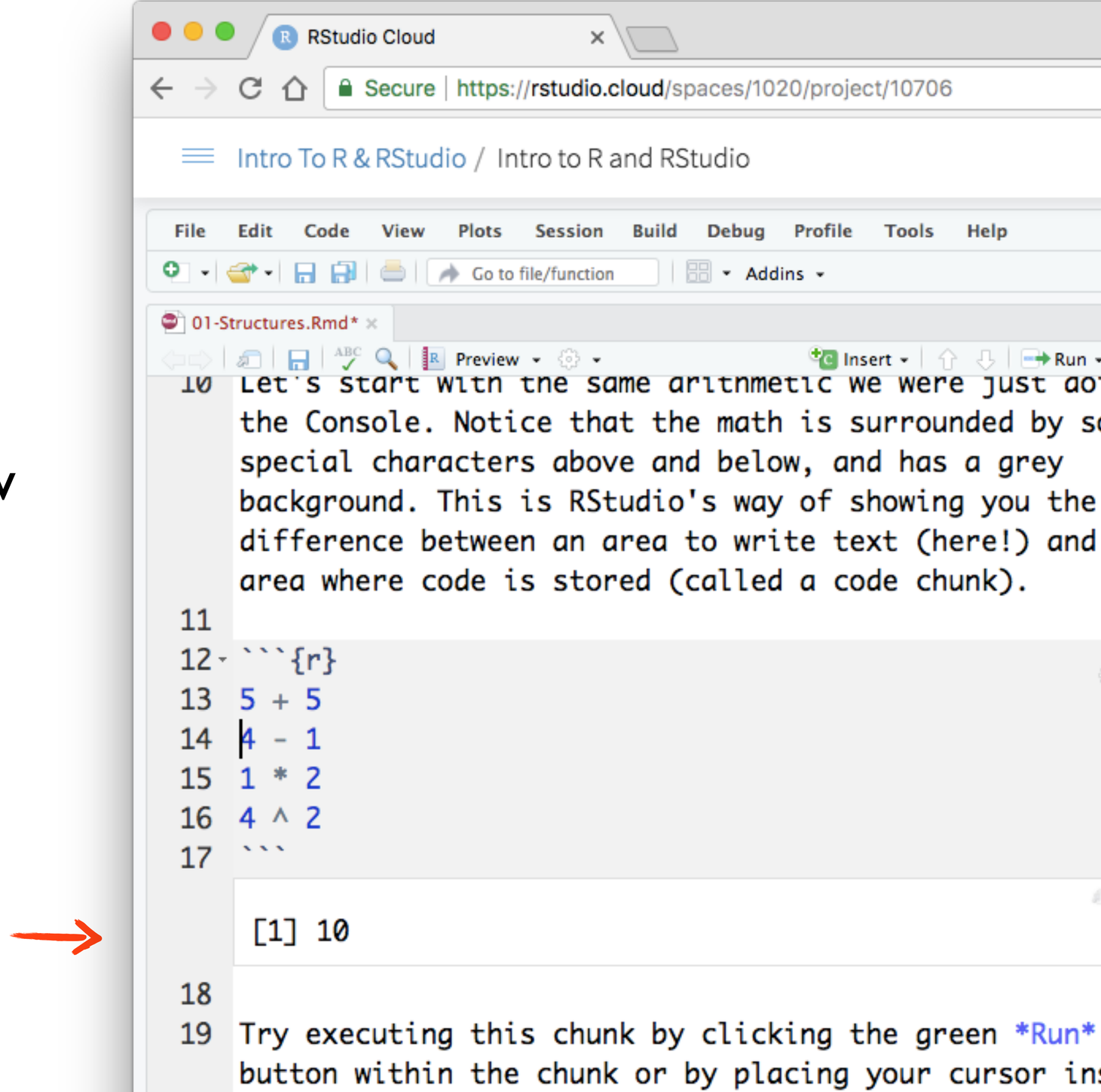
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 3.4.2
01-Structures.Rmd
Preview
Insert
Run
1 ---
2 title: "R Notebook"
3 output: html_notebook
4 editor_options:
5 chunk_output_type: inline
6 ---
7
8 # Arithmetic and algebra
9
10 Let's start with the same arithmetic we were just doing in the Console. Notice that the math is surrounded by some special characters above and below, and has a grey background. This is RStudio's way of showing you the difference between an area to write text (here!) and an area where code is stored (called a code chunk).
11
12 ```{r}
13 5 + 5
14 4 - 1
15 1 * 2
R Notebook
1:1
R Notebook
R Markdown
Console
Environment History Connections
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
New Folder
Upload
Delete
Rename
More
Home
Day1
code
Name
Size
Modified
..
01-Structures.Rmd 1.3 KB Jan 27, 2018, 5:19 PM
02-Syntax.Rmd 869 B Jan 27, 2018, 5:20 PM
03-Programming.Rmd 869 B Jan 27, 2018, 5:20 PM



Notice that the Console has automatically minimized itself, to give you room to work in your notebook. From here out, we'll be working almost exclusively in notebooks, but all the code we write would work in the Console as well.

Do what the text instructs, and run a line of the code. Notice how results display immediately below the chunk, just like they did in the Console.



Let's start with the same arithmetic we were just doing in the Console. Notice that the math is surrounded by some special characters above and below, and has a grey background. This is RStudio's way of showing you the difference between an area to write text (here!) and an area where code is stored (called a code chunk).

```{r}
5 + 5
4 - 1
1 * 2
4 ^ 2
```

```
[1] 10
```

Try executing this chunk by clicking the green *Run* button within the chunk or by placing your cursor inside it and pressing *Cmd+Shift+Enter*

Global Environment

Files | Plots | Packages | Help

New Folder | Delete

Home > Dropbox > Intro_to

Name

..
.Rhistory
04-Syntax.nb.html
04-Syntax.Rmd
03-DataTypes.nb.html
03-DataTypes.Rmd
02-Visualization.Rmd
01-Intro.Rmd
solutions

Let's start with the same arithmetic we were just doing in the Console. Notice that the math is surrounded by some special characters above and below, and has a grey background. This is RStudio's way of showing you the difference between an area to write text (here!) and an area where code is stored (called a code chunk).

```{r}
5 + 5
4 - 1
1 * 2
4 ^ 2
```

You can also run just one line of code, by placing your cursor on the line and hitting Command Enter

```
[1] 10
```

Output for the one line you've run

Try executing this chunk by clicking the green *Run* button within the chunk or by placing your cursor inside it and pressing *Cmd+Shift+Enter*

Global Environment

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Name

..

.Rhistory

04-Syntax.nb.html

04-Syntax.Rmd

03-DataTypes.nb.html

03-DataTypes.Rmd

02-Visualization.Rmd

01-Intro.Rmd

solutions

R objects

You can save information as an R object with the greater than sign followed by a minus, e.g, an arrow: <-

```
the_answer <- 42
```

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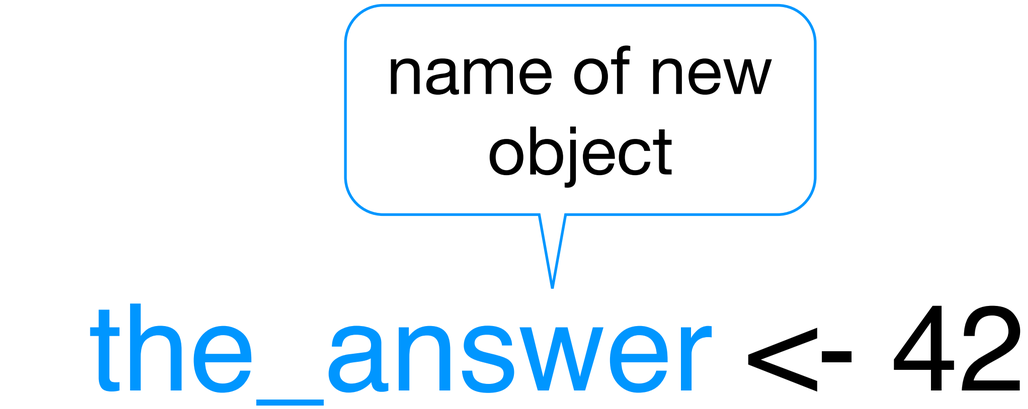

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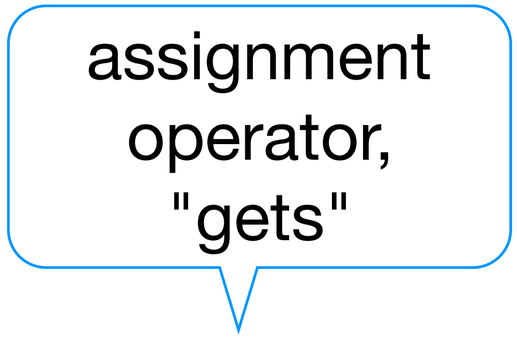


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the_answer <- 42
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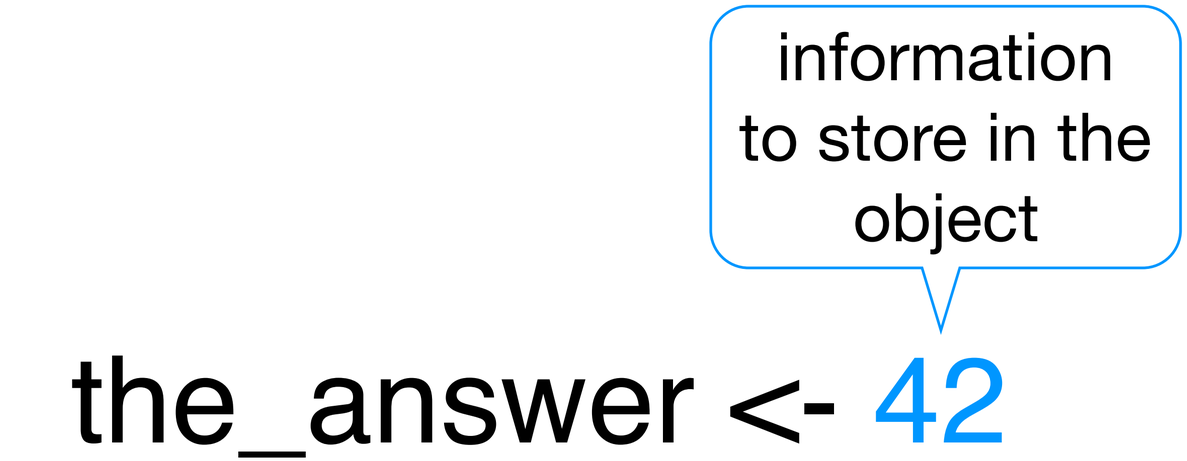
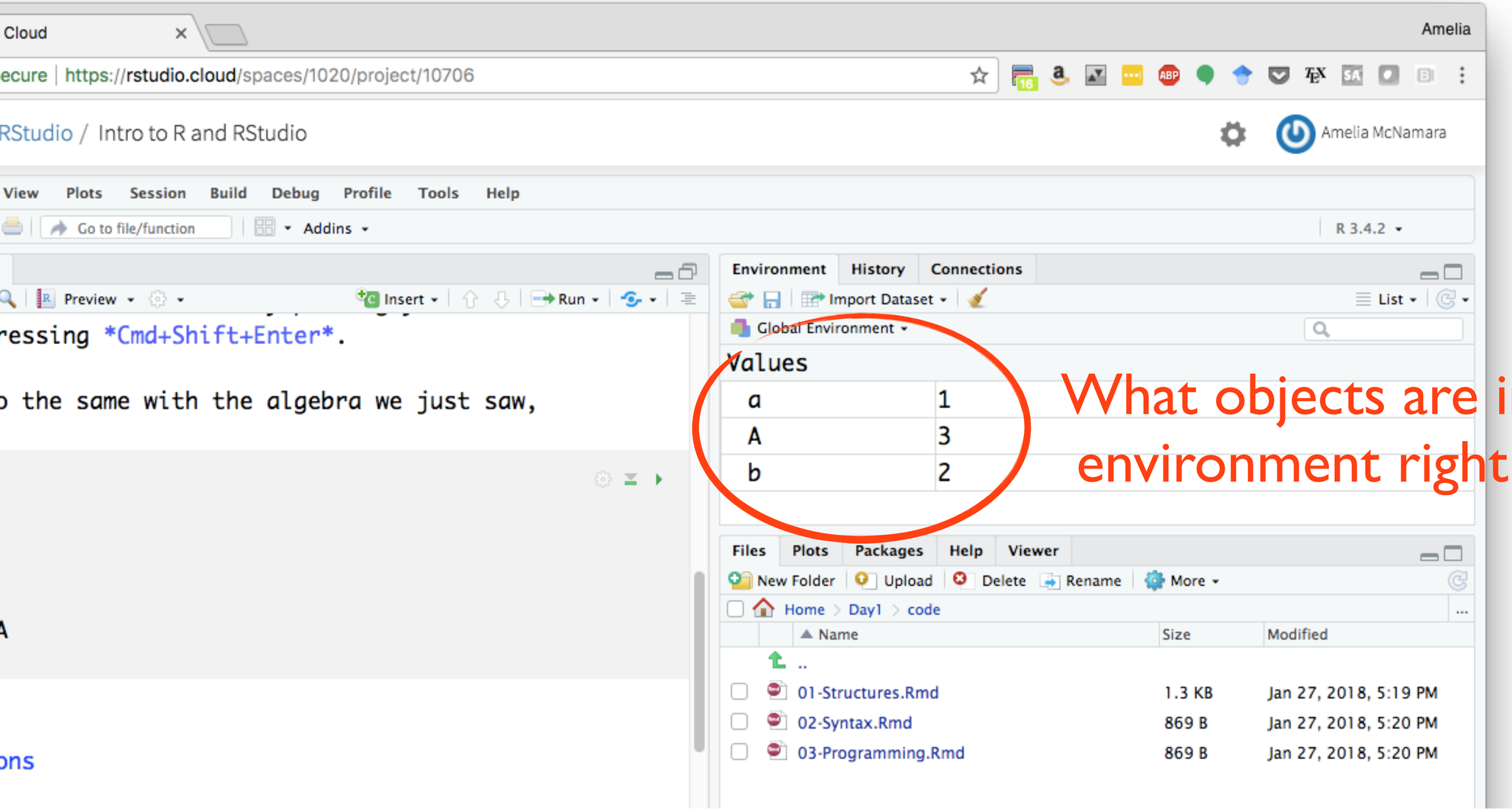
You can save information as an R object with the greater than sign followed by a minus, e.g, an arrow: <-



When you create an R object, you'll see it appear in your environment pane



What objects are in your environment right now?

Common R workflow

Save output of one function as an R object to use in a second function.

```
more_pi <- round(3.1415) + 1
more_pi
# 4

factorial(more_pi)
# 24
```

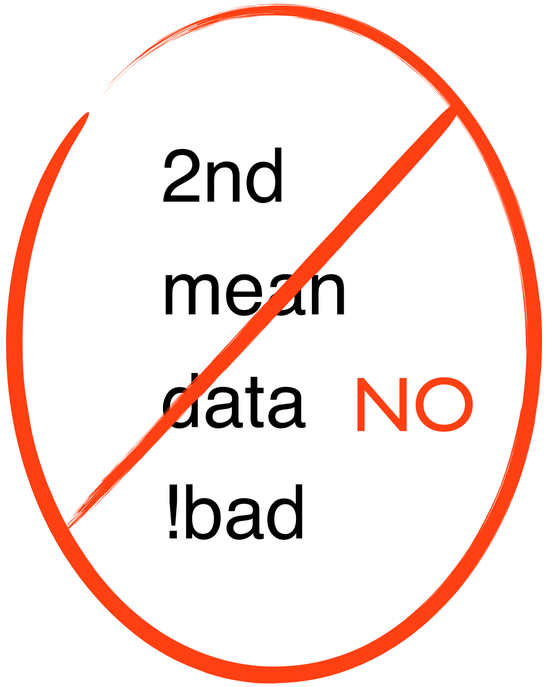
Object names

Object names cannot begin with numbers

They cannot contain spaces

It is wise to avoid names already in use

Informative names are better than generic ones



a
b
FOO
my_var
.day
eh

CDC_data
finalModel
more_pi
withoutOver64
yeah!

Capitalization matters

R will treat each of these as a different object

cdc_data	CDC_data
finalmodel	finalModel
sum	SUM

rm

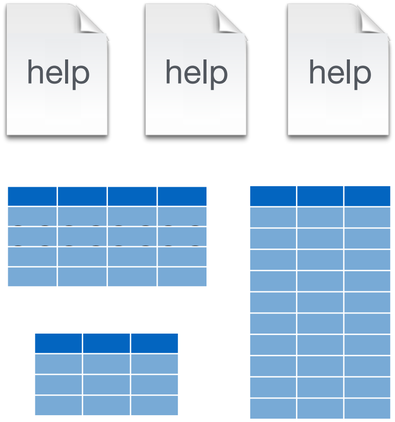
You can remove an object from your environment with rm

```
more_pi
# 4

rm(more_pi)
more_pi
# Error: object ‘more_pi' not found
```

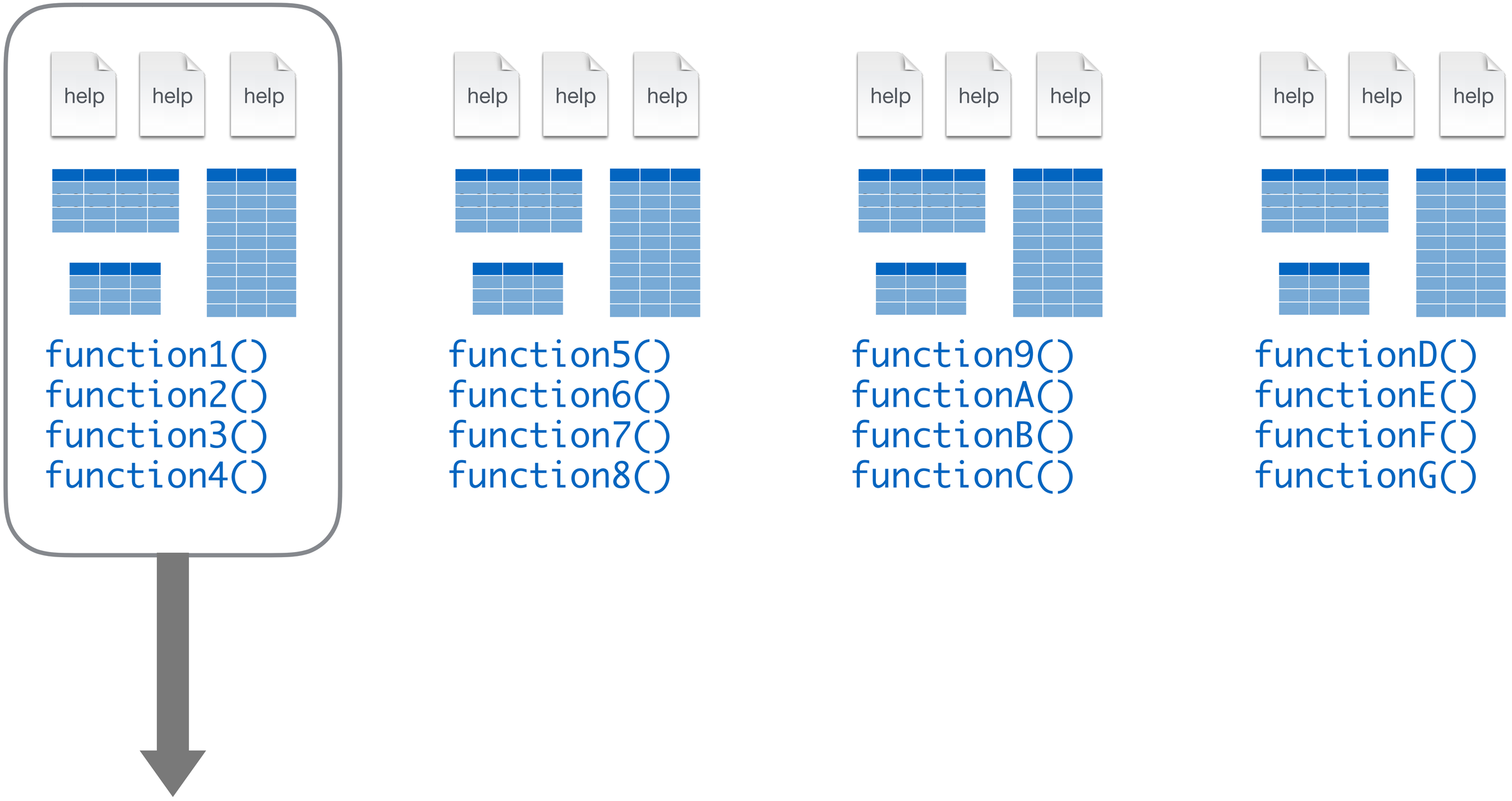
This can be useful if you overwrite an object that comes with R

```
pi
# 3.141593

pi <- 1
pi
# 1

rm(pi)
pi
# 3.141593
```

R packages




```
function1()
function2()
function3()
function4()
```


help
help
help
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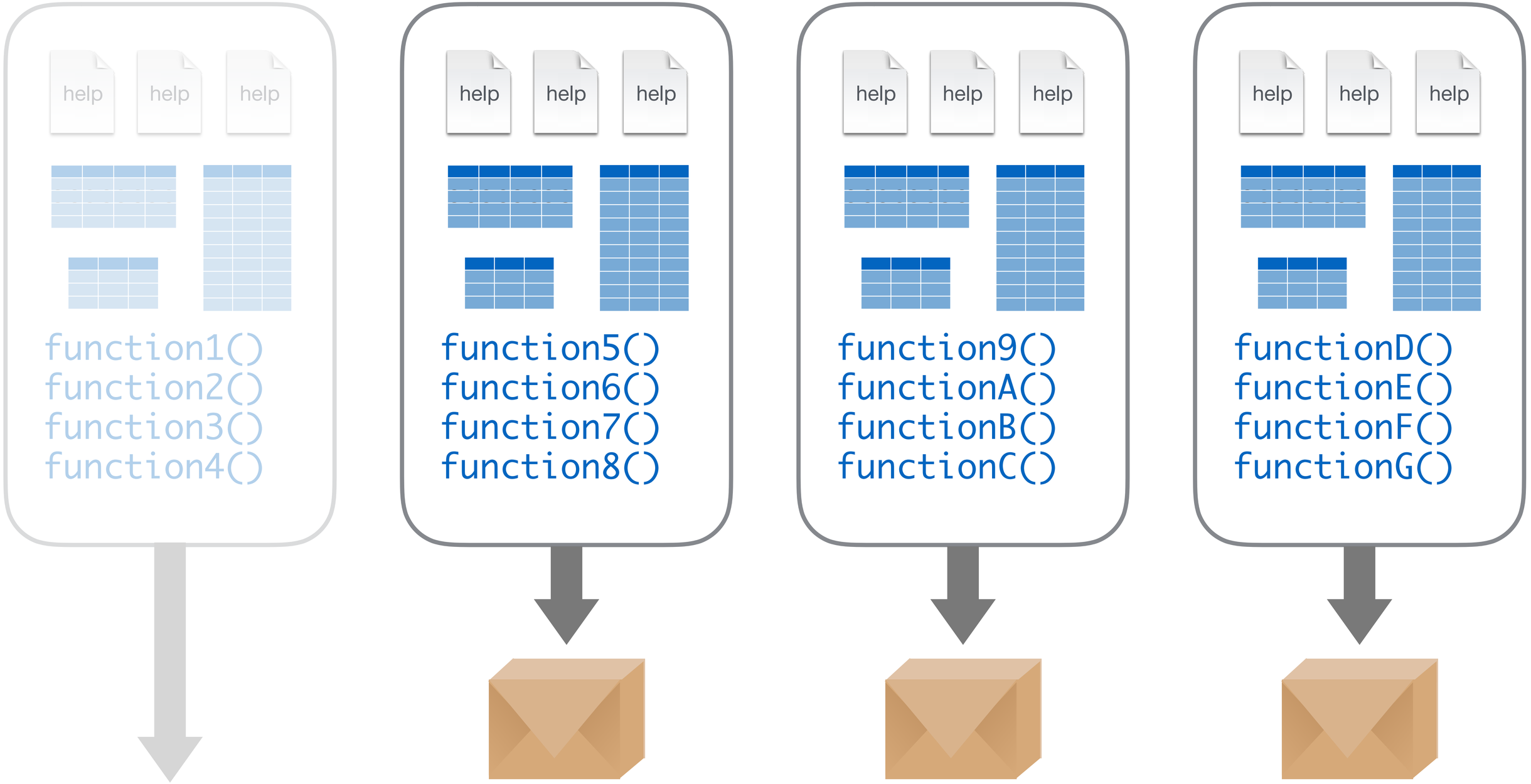
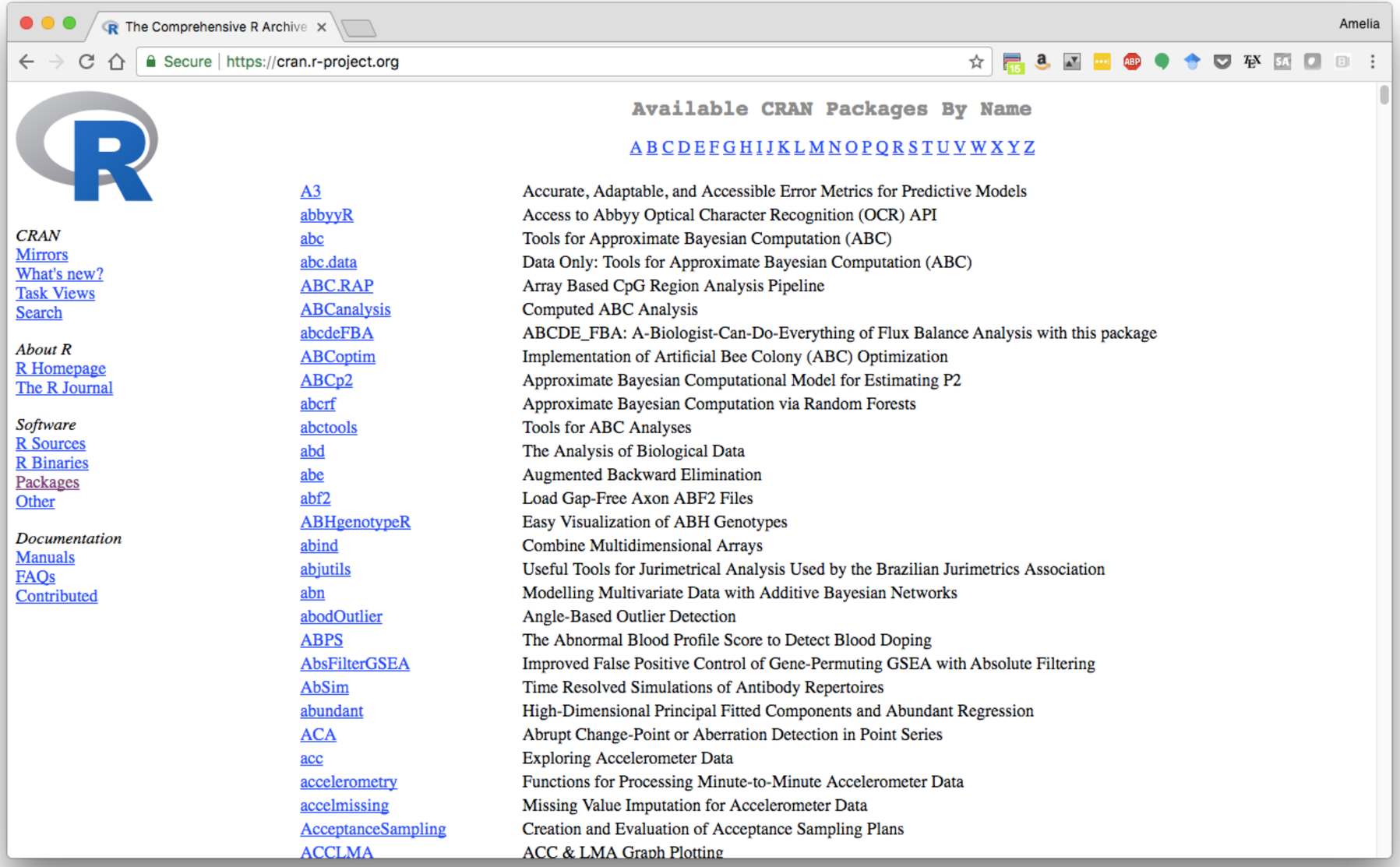
help
help
help
help
help
function1()
function2()
function3()
function4()
function5()
function6()
function7()
function8()
function9()
functionA()
functionB()
functionC()
functionD()
functionE()
functionF()
functionG()
Base R



Base R

R Packages


The Comprehensive R Archive
Amelia
Secure | https://cran.r-project.org
Available CRAN Packages By Name
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
CRAN
Mirrors
What's new?
Task Views
Search
About R
R Homepage
The R Journal
Software
R Sources
R Binaries
Packages
Other
Documentation
Manuals
FAQs
Contributed
A3 Accurate, Adaptable, and Accessible Error Metrics for Predictive Models
abbyyR Access to Abbyy Optical Character Recognition (OCR) API
abc Tools for Approximate Bayesian Computation (ABC)
abc.data Data Only: Tools for Approximate Bayesian Computation (ABC)
ABC.RAP Array Based CpG Region Analysis Pipeline
ABCanalysis Computed ABC Analysis
abcdeFBA ABCDE_FBA: A-Biologist-Can-Do-Everything of Flux Balance Analysis with this package
ABCoptim Implementation of Artificial Bee Colony (ABC) Optimization
ABCp2 Approximate Bayesian Computational Model for Estimating P2
abcrf Approximate Bayesian Computation via Random Forests
abctools Tools for ABC Analyses
abd The Analysis of Biological Data
abe Augmented Backward Elimination
abf2 Load Gap-Free Axon ABF2 Files
ABHgenotypeR Easy Visualization of ABH Genotypes
abind Combine Multidimensional Arrays
abjutils Useful Tools for Jurimetrical Analysis Used by the Brazilian Jurimetrics Association
abn Modelling Multivariate Data with Additive Bayesian Networks
abodOutlier Angle-Based Outlier Detection
ABPS The Abnormal Blood Profile Score to Detect Blood Doping
AbsFilterGSEA Improved False Positive Control of Gene-Permuting GSEA with Absolute Filtering
AbSim Time Resolved Simulations of Antibody Repertoires
abundant High-Dimensional Principal Fitted Components and Abundant Regression
ACA Abrupt Change-Point or Aberration Detection in Point Series
acc Exploring Accelerometer Data
accelerometry Functions for Processing Minute-to-Minute Accelerometer Data
accelmissing Missing Value Imputation for Accelerometer Data
AcceptanceSampling Creation and Evaluation of Acceptance Sampling Plans
ACCLMA ACC & LMA Graph Plotting

Using packages

1.

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

Downloads files to computer

1 x per computer

2.

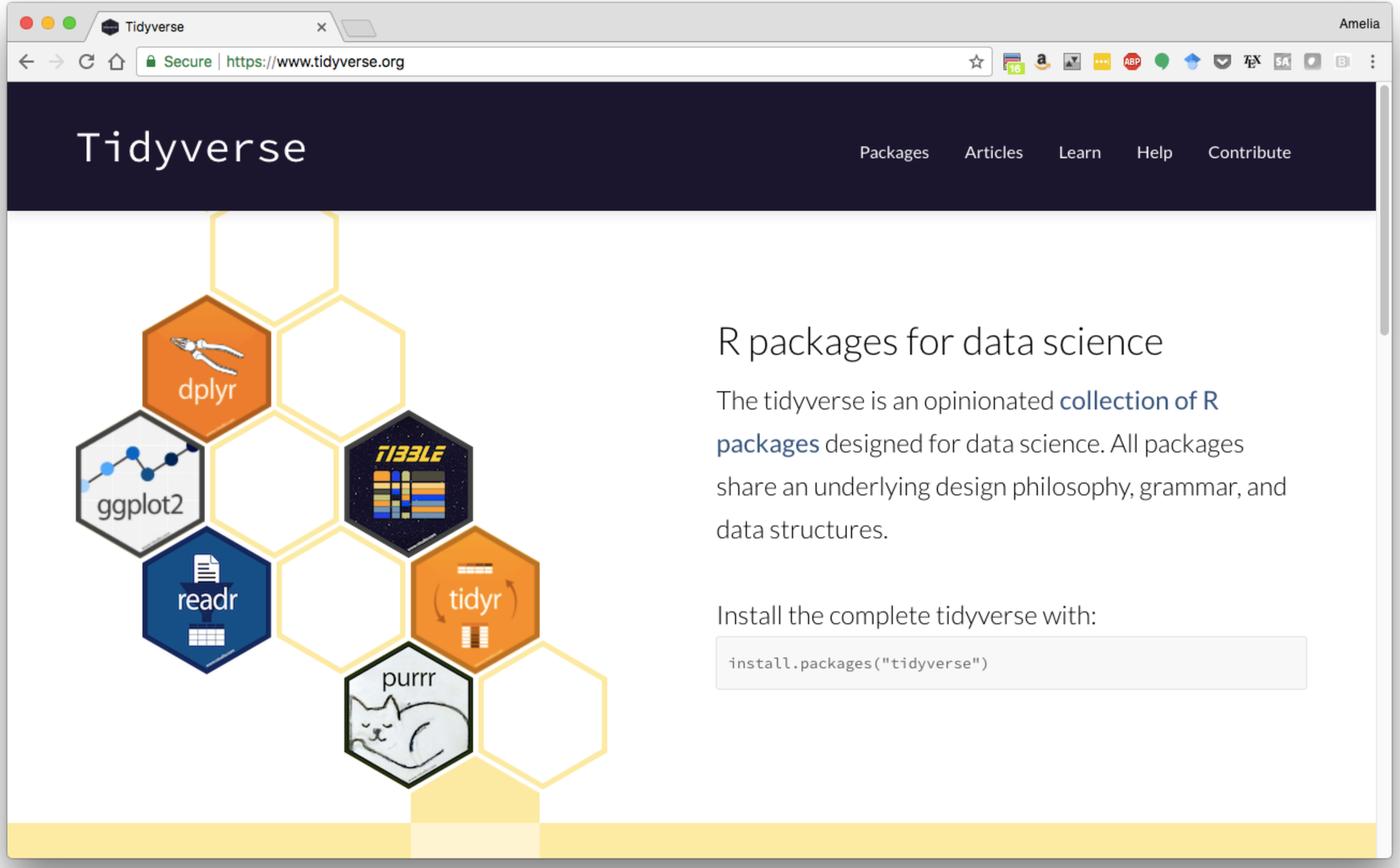
```
library(ggplot2)
```

Loads package

1 x per R Session

I've done this for you

The tidyverse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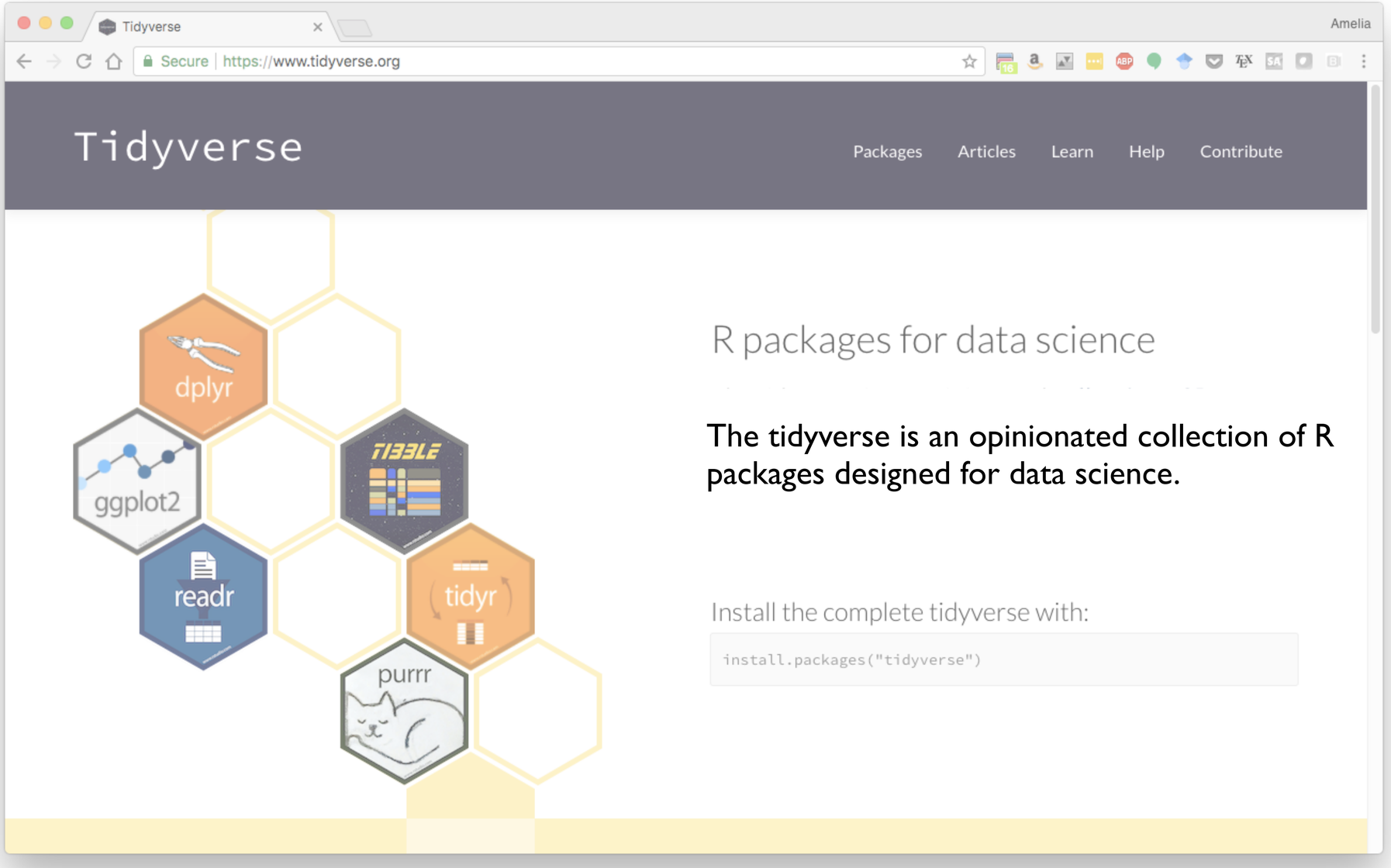
readr
tidyr
purrr
R packages for data science
The tidyverse is an opinionated collection of R packages designed for data science. All packages share an underlying design philosophy, grammar, and data structures.
Install the complete tidyverse with:
install.packages("tidyverse")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R packages for data science
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R Syntax Comparison : : **CHEAT SHEET**

Dollar sign syntax

`goal(data$x, data$y)`

SUMMARY STATISTICS:

one continuous variable:
```
mean(mtcars$mpg)
```

one categorical variable:
```
table(mtcars$cyl)
```

two categorical variables:
```
table(mtcars$cyl, mtcars$am)
```

one continuous, one categorical:
```
mean(mtcars$mpg[mtcars$cyl==4])
mean(mtcars$mpg[mtcars$cyl==6])
mean(mtcars$mpg[mtcars$cyl==8])
```

PLOTTING:

one continuous variable:
```
hist(mtcars$disp)

boxplot(mtcars$disp)
```

one categorical variable:
```
barplot(table(mtcars$cyl))
```

two continuous variables:
```
plot(mtcars$disp, mtcars$mpg)
```

two categorical variables:
```
mosaicplot(table(mtcars$am, mtcars$cyl))
```

one continuous, one categorical:
```
histogram(mtcars$disp[mtcars$cyl==4])
histogram(mtcars$disp[mtcars$cyl==6])
histogram(mtcars$disp[mtcars$cyl==8])

boxplot(mtcars$disp[mtcars$cyl==4])
boxplot(mtcars$disp[mtcars$cyl==6])
boxplot(mtcars$disp[mtcars$cyl==8])
```

WRANGLING:

subsetting:
```
mtcars[mtcars$mpg>30, ]
```

making a new variable:
```
mtcars$efficient[mtcars$mpg>30] <- TRUE
mtcars$efficient[mtcars$mpg<30] <- FALSE
```

Formula syntax

`goal(y~x|z, data=data, group=w)`

SUMMARY STATISTICS:

one continuous variable:
```
mosaic::mean(~mpg, data=mtcars)
```

one categorical variable:
```
mosaic::tally(~cyl, data=mtcars)
```

two categorical variables:
```
mosaic::tally(cyl~am, data=mtcars)
```

one continuous, one categorical:
```
mosaic::mean(mpg~cyl, data=mtcars)
```

tilde

PLOTTING:

one continuous variable:
```
lattice::histogram(~disp, data=mtcars)

lattice::bwplot(~disp, data=mtcars)
```

one categorical variable:
```
mosaic::bargraph(~cyl, data=mtcars)
```

two continuous variables:
```
lattice::xyplot(mpg~disp, data=mtcars)
```

two categorical variables:
```
mosaic::bargraph(~am, data=mtcars, group=cyl)
```

one continuous, one categorical:
```
lattice::histogram(~disp|cyl, data=mtcars)

lattice::bwplot(cyl~disp, data=mtcars)
```

The variety of R syntaxes give you many ways to "say" the same thing

read **across** the cheatsheet to see how different syntaxes approach the same problem

Tidyverse syntax

`data %>% goal(x)`

SUMMARY STATISTICS:

one continuous variable:
```
mtcars %>% dplyr::summarize(mean(mpg))
```

one categorical variable:
```
mtcars %>% dplyr::group_by(cyl) %>%
dplyr::summarize(n())
```

the pipe

two categorical variables:
```
mtcars %>% dplyr::group_by(cyl, am) %>%
dplyr::summarize(n())
```

one continuous, one categorical:
```
mtcars %>%  dplyr::group_by(cyl) %>%
   dplyr::summarize(mean(mpg))
```

PLOTTING:

one continuous variable:
```
ggplot2::qplot(x=mpg, data=mtcars, geom = "histogram")

ggplot2::qplot(y=disp, x=1, data=mtcars, geom="boxplot")
```

one categorical variable:
```
ggplot2::qplot(x=cyl, data=mtcars, geom="bar")
```

two continuous variables:
```
ggplot2::qplot(x=disp, y=mpg, data=mtcars, geom="point")
```

two categorical variables:
```
ggplot2::qplot(x=factor(cyl), data=mtcars, geom="bar") +
       facet_grid(.~am)
```

one continuous, one categorical:
```
ggplot2::qplot(x=disp, data=mtcars, geom = "histogram") +
       facet_grid(.~cyl)

ggplot2::qplot(y=disp, x=factor(cyl), data=mtcars,
              geom="boxplot")
```

WRANGLING:

subsetting:
```
mtcars %>% dplyr::filter(mpg>30)
```

making a new variable:
```
mtcars <- mtcars %>%
dplyr::mutate(efficient = if_else(mpg>30,  TRUE, FALSE))
```