Data Analysis in R

Orientation to R Studio

Michael E DeWitt Jr

2018-09-06 (updated: 2018-11-02)

Our mission

- Introduce R as a programming language and `<<data science>>` environment
- Introduce R Studio as an IDE
- Get you working on your use cases quickly

A little bit about R

- R started with S… 1976-05-05 at Bell Labs

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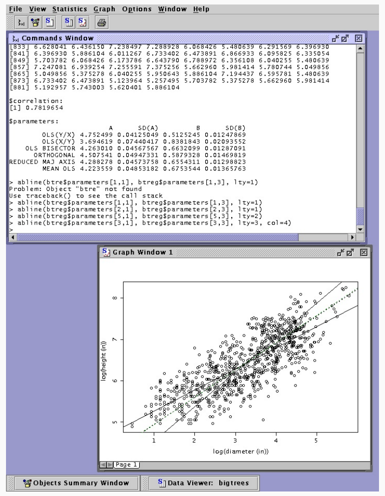
- Developed out of the statistics department
- Non-standard methods were needed
- Solution: Develop programming language and environment designed explicitly for **interactive** data analysis using the best available computation methods and flexible enough to meet new use cases!

If you can do something well, then have someone pay you for it



```
[833] 6.628041 6.436150 7.238497 7.288928 6.068426 5.480639 6.291569 6.396930
[841] 6.396930 5.886104 6.011267 6.733402 6.473891 6.866933 6.095825 6.335054
[849] 5.703782 6.068426 6.173786 6.643790 6.788972 6.356108 6.040255 5.480639
[857] 7.247081 6.939254 7.255591 7.375256 5.662960 5.981414 5.780744 5.049856
[865] 5.049856 5.375278 6.040255 5.950643 5.886104 7.194437 6.595781 5.480639
[873] 6.733402 6.473891 5.123964 5.257495 5.703782 5.375278 5.662960 5.981414
[881] 5.192957 5.743003 5.620401 5.886104

$correlation:
[1] 0.7819654

$parameters:
                        A      SD(A)         B      SD(B)
        OLS(Y/X) 4.752499 0.04125049 0.5125245 0.01247869
        OLS(X/Y) 3.694619 0.07440417 0.8381843 0.02093552
    OLS BISECTOR 4.263010 0.04567567 0.6632099 0.01287091
      ORTHOGONAL 4.507541 0.04947331 0.5879328 0.01469819
REDUCED MAJ AXIS 4.288278 0.04573758 0.6554311 0.01298823
        MEAN OLS 4.223559 0.04853182 0.6753544 0.01365763

> abline(btre$parameters[1,1], btreg$parameters[1,3], lty=1)
Problem: Object "btre" not found
Use traceback() to see the call stack
> abline(btreg$parameters[1,1], btreg$parameters[1,3], lty=1)
> abline(btreg$parameters[2,1], btreg$parameters[2,3], lty=1)
> abline(btreg$parameters[5,1], btreg$parameters[5,3], lty=2)
> abline(btreg$parameters[3,1], btreg$parameters[3,3], lty=3, col=4)
>
```

S was then sold to the open market as S

Later distributed as S-Plus

Bought by TIBCO

After S, R?

- Ross Ihaka and Robert Gentleman met at University of Auckland while Dr. Gentleman on sabbatical

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- Solution: Develop an **open source** implementation of S!

After S, R?

- Ross Ihaka and Robert Gentleman met at University of Auckland while Dr. Gentleman on sabbatical
- Common Problem: `$A$, $-plus, $TATA, $P$$`
- Solution: Develop an **open source** implementation of S!
- Allow for new methods to be adopted and shared through **packages** [*]

[*] Packages are ways of collecting, documenting and sharing R (or other language) scripts that have been pre-written. They can be installed and then run as new functions extending base-R

CRAN Established

- Comprehensive R Archive Network Established cran

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- R-Core established to review and approve packages for inclusion on CRAN

Why chose R?

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- It has been extended into webpage generation, documentation, dashboards, etc

Why not R?

Why not R?

- Syntax is *not* consistent between packages

```r
# From randomForest
rf_1 <- randomForest(x, y, mtry = 12, ntree = 2000, importance = TRUE)

# From ranger
rf_2 <- ranger(
  y ~ .,
  data = dat,
  mtry = 12,
  num.trees = 2000,
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)
```

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- R **can** be slower than some other languages
- Performs calculations *in-memory* (e.g. data < RAM)

R Studio

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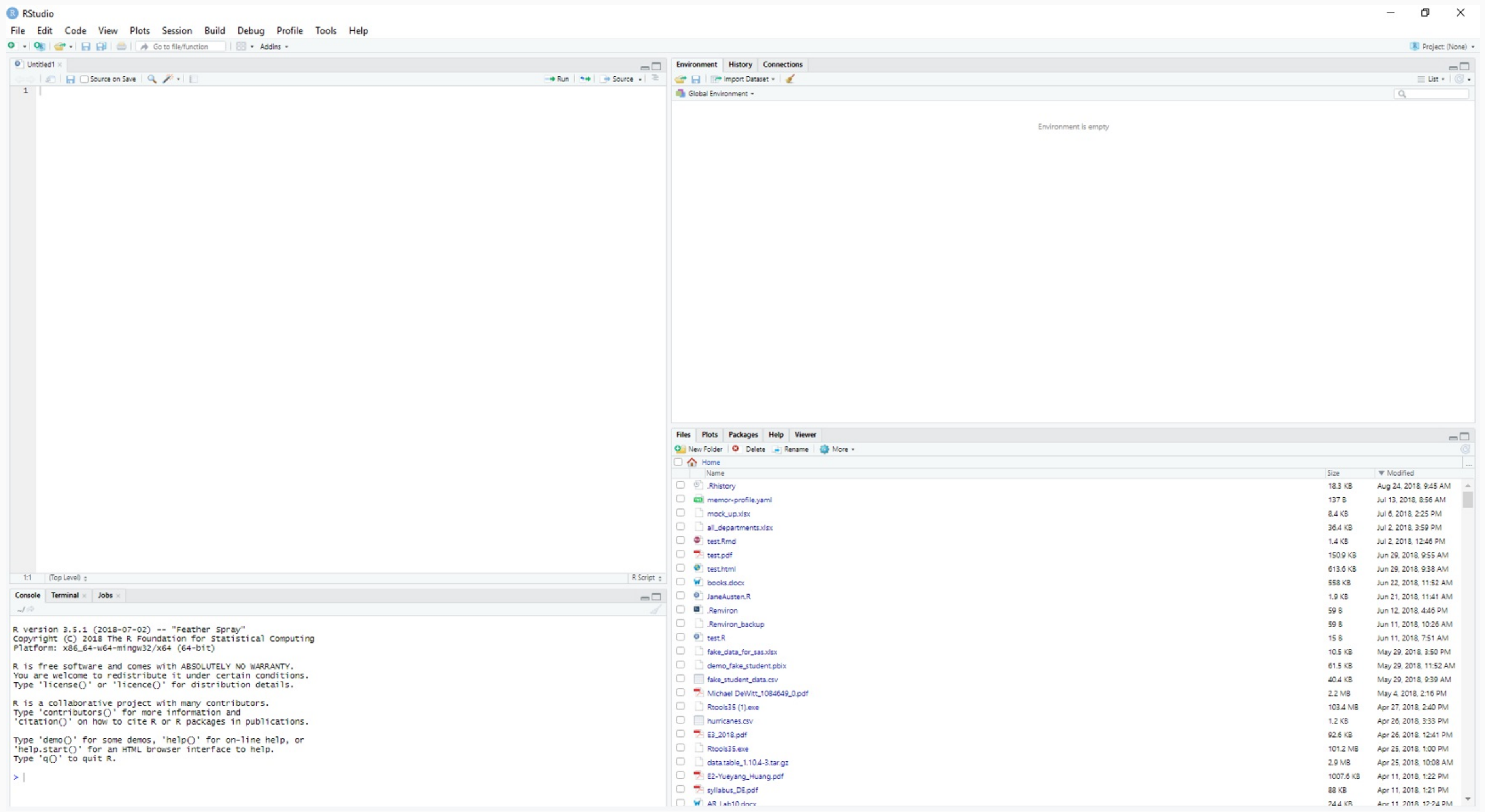
- IDE is an Integrated Development Environment
- Syntax highlighting, auto-complete, visual exploration, integration with version control systems and more!

So Let's Explore it

Press CTRL + SHIFT + N or CMD + SHIFT + N to create a new script



```
R version 3.5.1 (2018-07-02) -- "Feather Spray"
Copyright (C) 2018 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.

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'citation()' on how to cite R or R packages in publications.

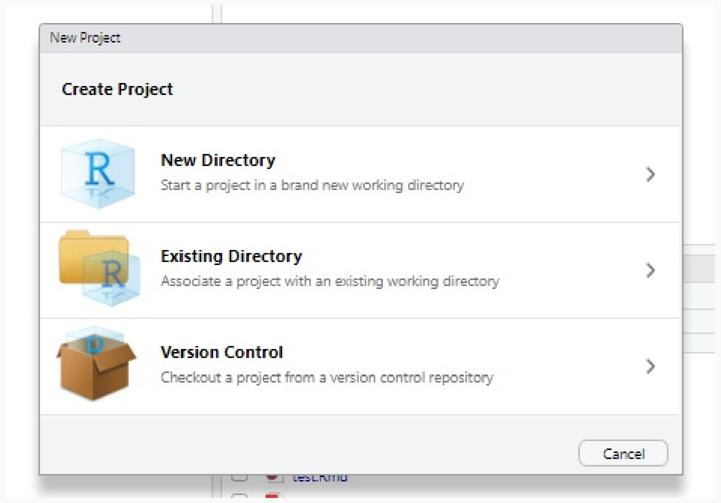
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> |
```

Name	Size	Modified
.Rhistory	18.3 KB	Aug 24, 2018, 9:45 AM
memor-profile.yaml	137 B	Jul 13, 2018, 8:56 AM
mock_up.xlsx	8.4 KB	Jul 6, 2018, 2:25 PM
all_departments.xlsx	36.4 KB	Jul 2, 2018, 3:59 PM
test.Rmd	1.4 KB	Jul 2, 2018, 12:46 PM
test.pdf	150.9 KB	Jun 29, 2018, 9:55 AM
test.html	613.6 KB	Jun 29, 2018, 9:38 AM
books.docx	558 KB	Jun 22, 2018, 11:52 AM
JaneAusten.R	1.9 KB	Jun 21, 2018, 11:41 AM
.Renviron	59 B	Jun 12, 2018, 4:46 PM
.Renviron_backup	59 B	Jun 11, 2018, 10:26 AM
test.R	15 B	Jun 11, 2018, 7:51 AM
fake_data_for_sas.xlsx	10.5 KB	May 29, 2018, 3:50 PM
demo_fake_student.pbix	61.5 KB	May 29, 2018, 11:52 AM
fake_student_data.csv	40.4 KB	May 29, 2018, 9:39 AM
Michael DeWitt_1084649_0.pdf	2.2 MB	May 4, 2018, 2:16 PM
Rtools35 (1).exe	103.4 MB	Apr 27, 2018, 2:40 PM
hurricanes.csv	1.2 KB	Apr 26, 2018, 3:33 PM
E3_2018.pdf	92.6 KB	Apr 26, 2018, 12:41 PM
Rtools35.exe	101.2 MB	Apr 25, 2018, 1:00 PM
data.table_1.10.4-3.tar.gz	2.9 MB	Apr 25, 2018, 10:08 AM
E2-Yueyang_Huang.pdf	1007.6 KB	Apr 11, 2018, 1:22 PM
syllabus_DE.pdf	88 KB	Apr 11, 2018, 1:21 PM
AR_Lab10.docx	24.4 KB	Apr 11, 2018, 12:24 PM

Start a new project

We want to start a new project


New Project

Create Project

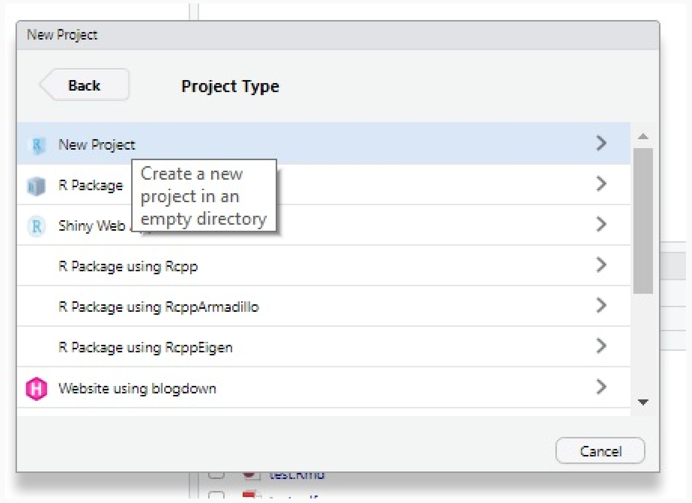
New Directory
Start a project in a brand new working directory

Existing Directory
Associate a project with an existing working directory

Version Control
Checkout a project from a version control repository

Put the project in a new directory (typically the default)

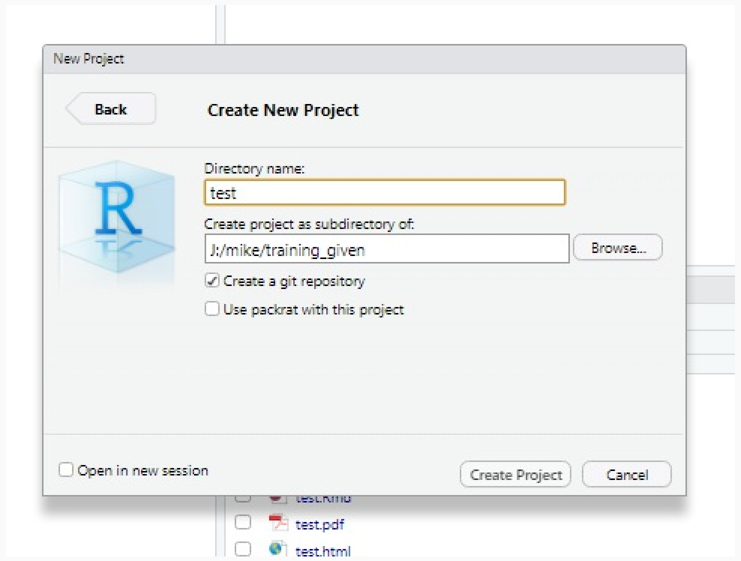
Create a new project



We would like a new project (other items are for more advanced topics)

Name it

Name the new project and place it in whatever directory works for you



Directory name: test

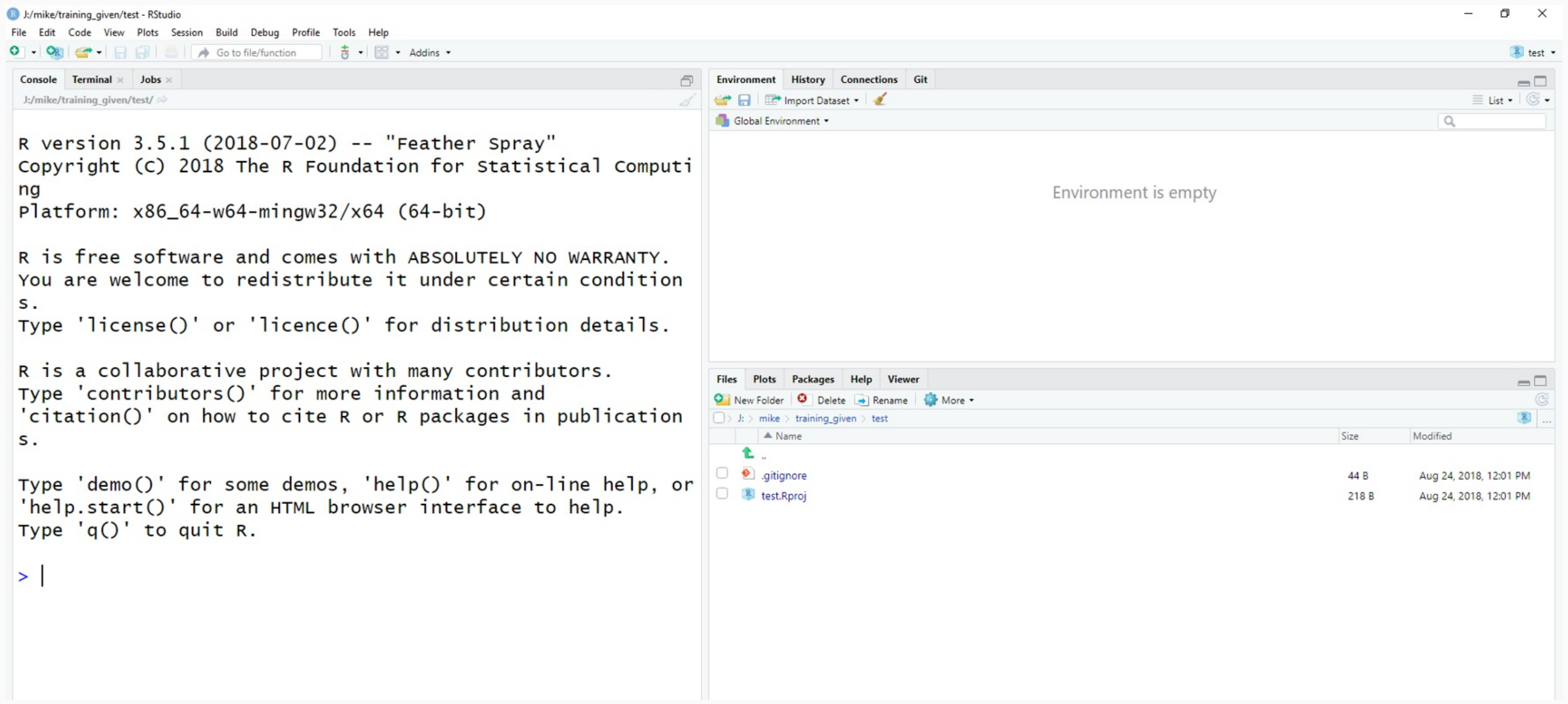
Create project as subdirectory of: J:/mike/training_given

[✓] Create a git repository

[ ] Use packrat with this project

Ta Da!

This should be your starting point for each new project



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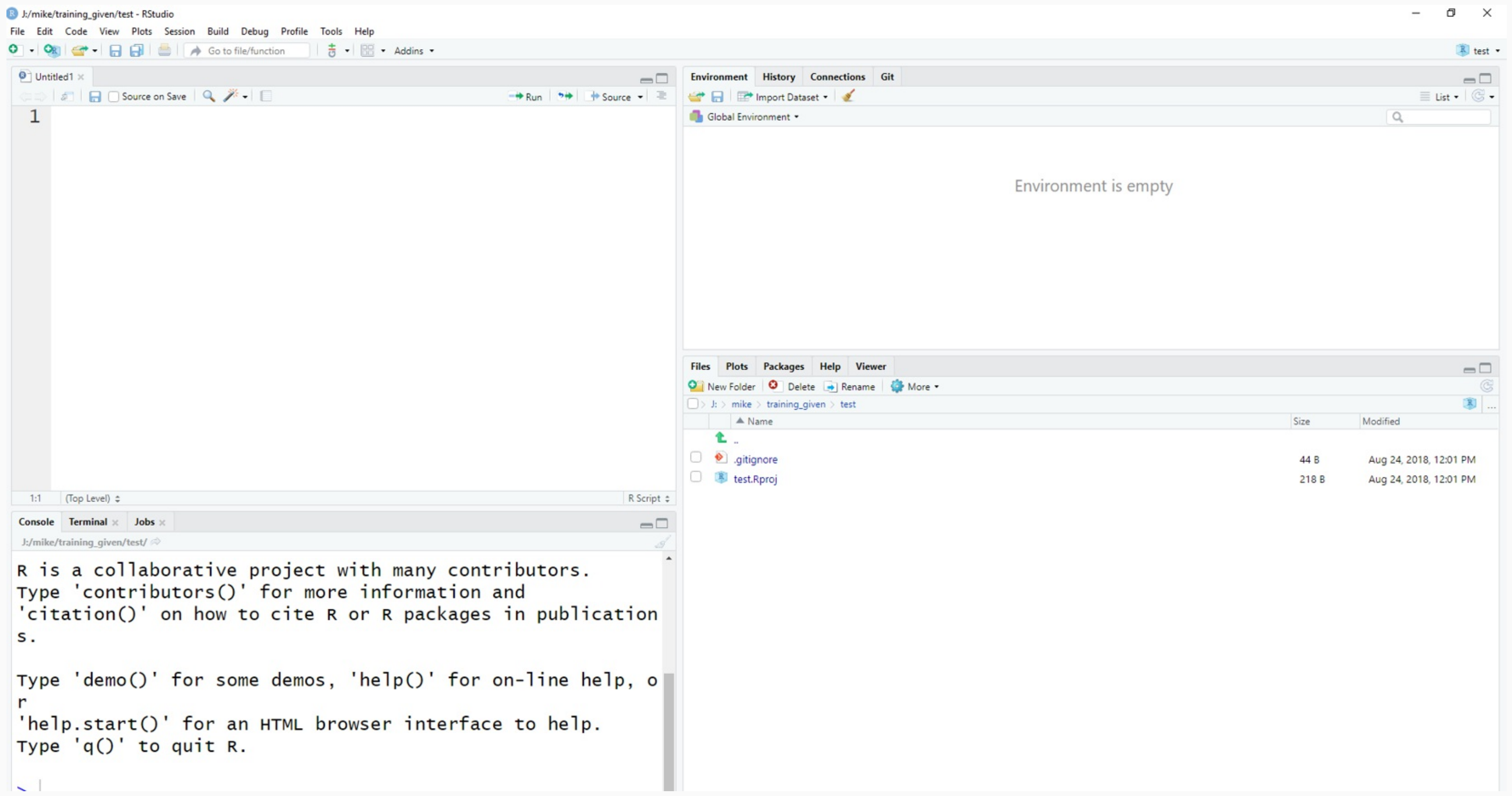
```

J:/mike/training_given/test - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
test
Console Terminal Jobs
J:/mike/training_given/test/
Environment History Connections Git
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
New Folder Delete Rename More
J: mike training_given test
Name Size Modified
..
.gitignore 44 B Aug 24, 2018, 12:01 PM
test.Rproj 218 B Aug 24, 2018, 12:01 PM

Now open a new scripting pane

`CRTL+N` or `CMD+N` to open a new script


J:/mike/training_given/test - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
test
Untitled1
Source on Save
Run
Source
Environment History Connections Git
Import Dataset
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Files Plots Packages Help Viewer
New Folder Delete Rename More
J: mike training_given test
Name Size Modified
1:1 (Top Level) R Script
Console Terminal Jobs
J:/mike/training_given/test/

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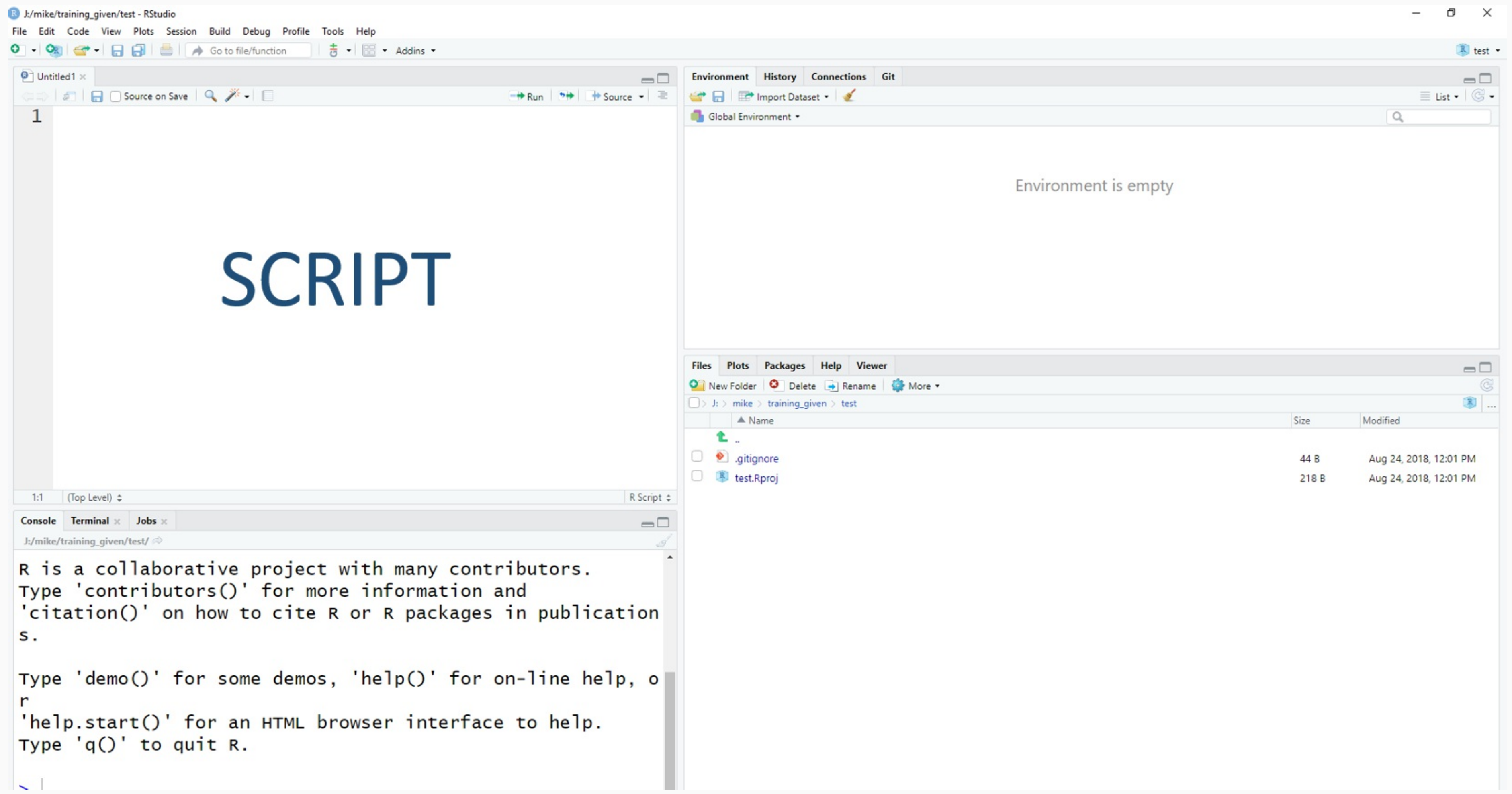
Scripting Pane



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Scripting Pane (Where the magic happens)

Generally you want to write all of your code here in either:

- Rmarkdown document (.Rmd)
- R script (.R)

This way you can save your code and submit it to R!

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(And save a copy to run again later)

Scripting Pane (Where the magic happens)

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- Rmarkdown document (.Rmd)
- R script (.R)

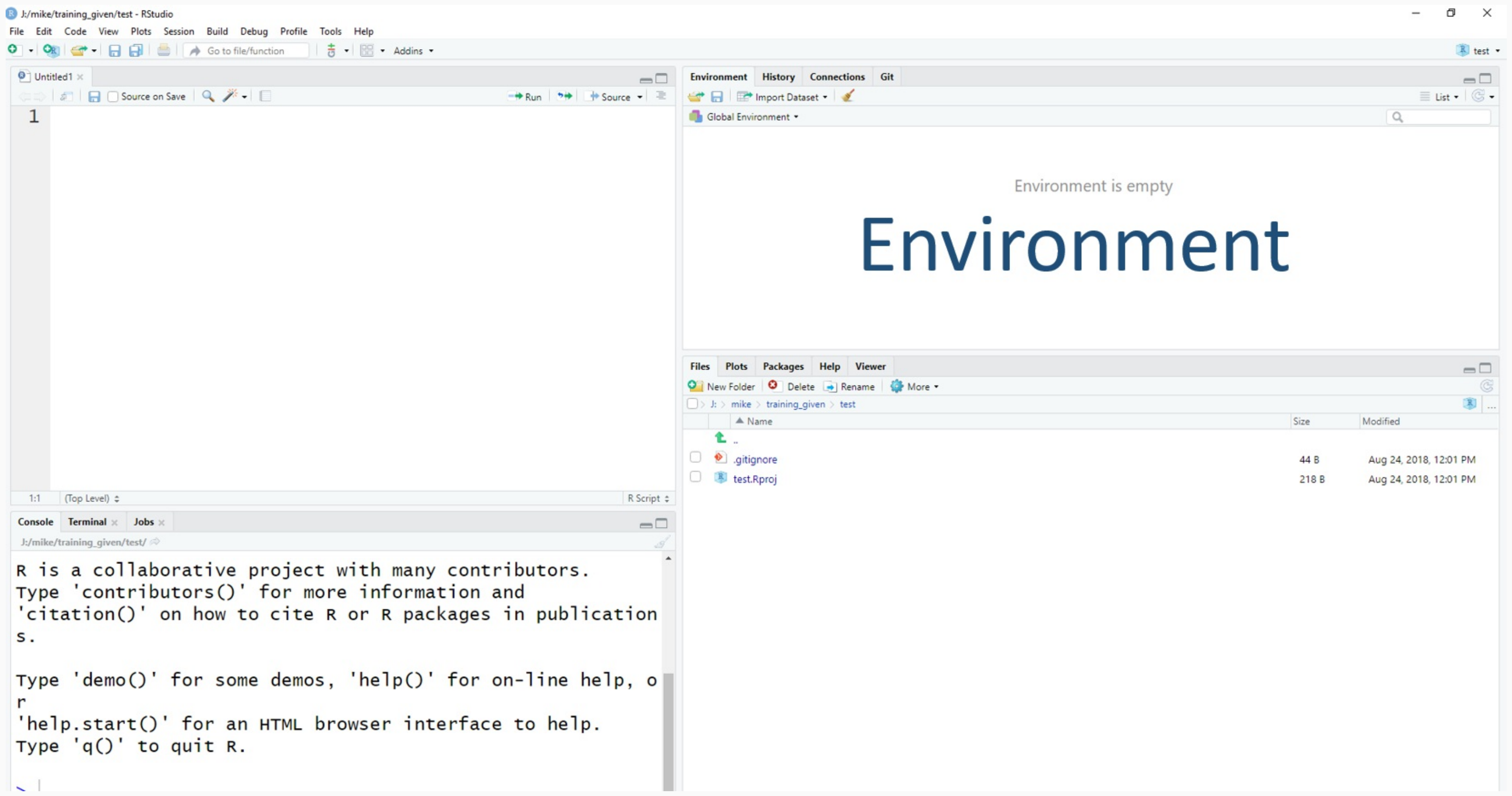
This way you can save your code and submit it to R!

(And save a copy to run again later)

You can send the script to R using the `CRTL + ENTER`/ `CMD + ENTER` Shortcut

Environment Pane

This is where you will find objects that are `in-memory` or available to call


J:/mike/training_given/test - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
test
Untitled1
Source on Save
Run
Source
Environment History Connections Git
Import Dataset
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Global Environment
Environment is empty
Environment
Files Plots Packages Help Viewer
New Folder Delete Rename More
J: mike training_given test
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.gitignore 44 B Aug 24, 2018, 12:01 PM
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1:1 (Top Level) R Script
Console Terminal Jobs
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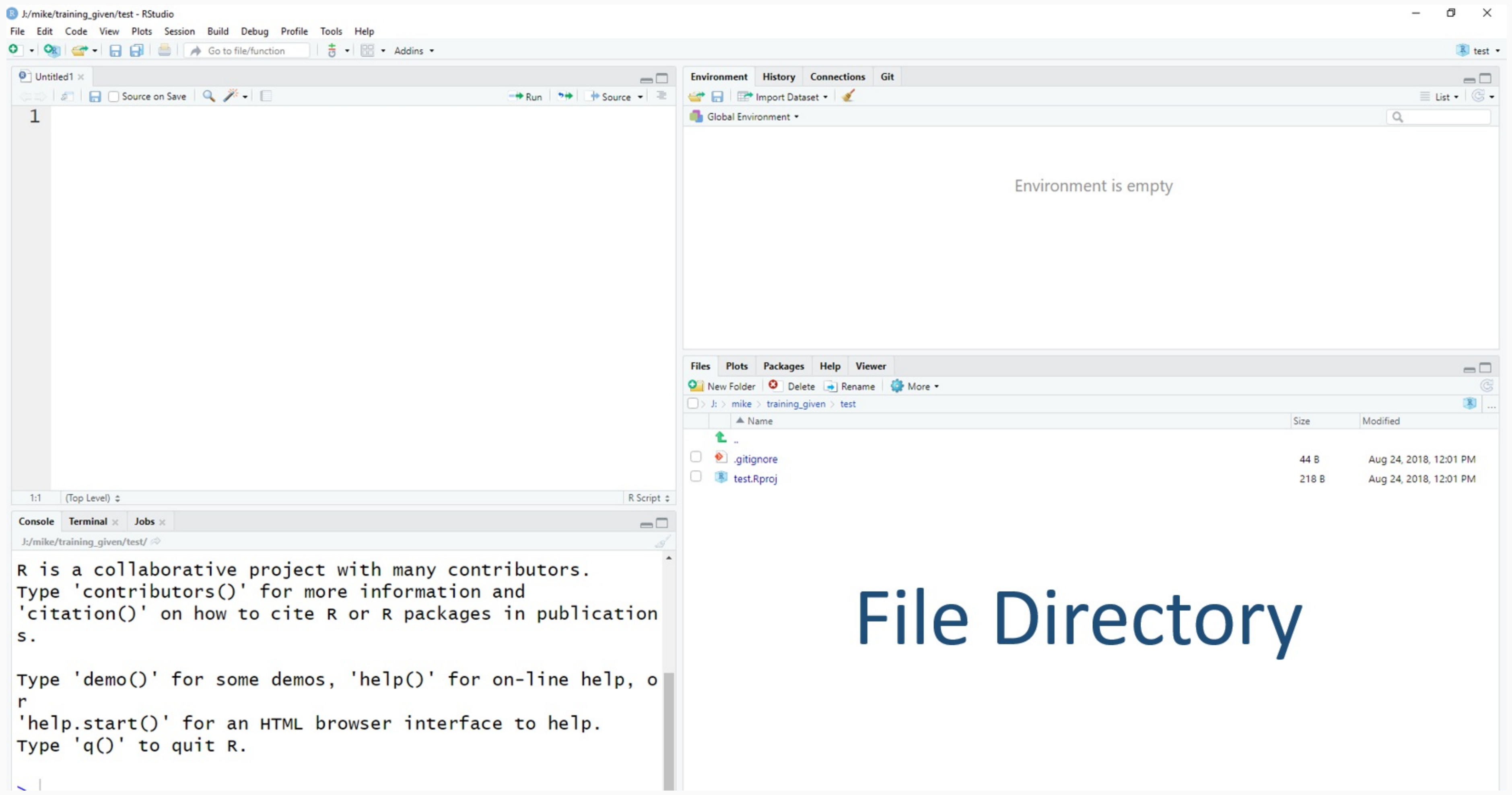
File Directory Pane


J:/mike/training_given/test - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
test
Untitled1
Source on Save
Run
Source
1:1
(Top Level)
R Script
Console
Terminal
Jobs
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Delete
Rename
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File Directory

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Name	Size	Modified
..		
.gitignore	44 B	Aug 24, 2018, 12:01 PM
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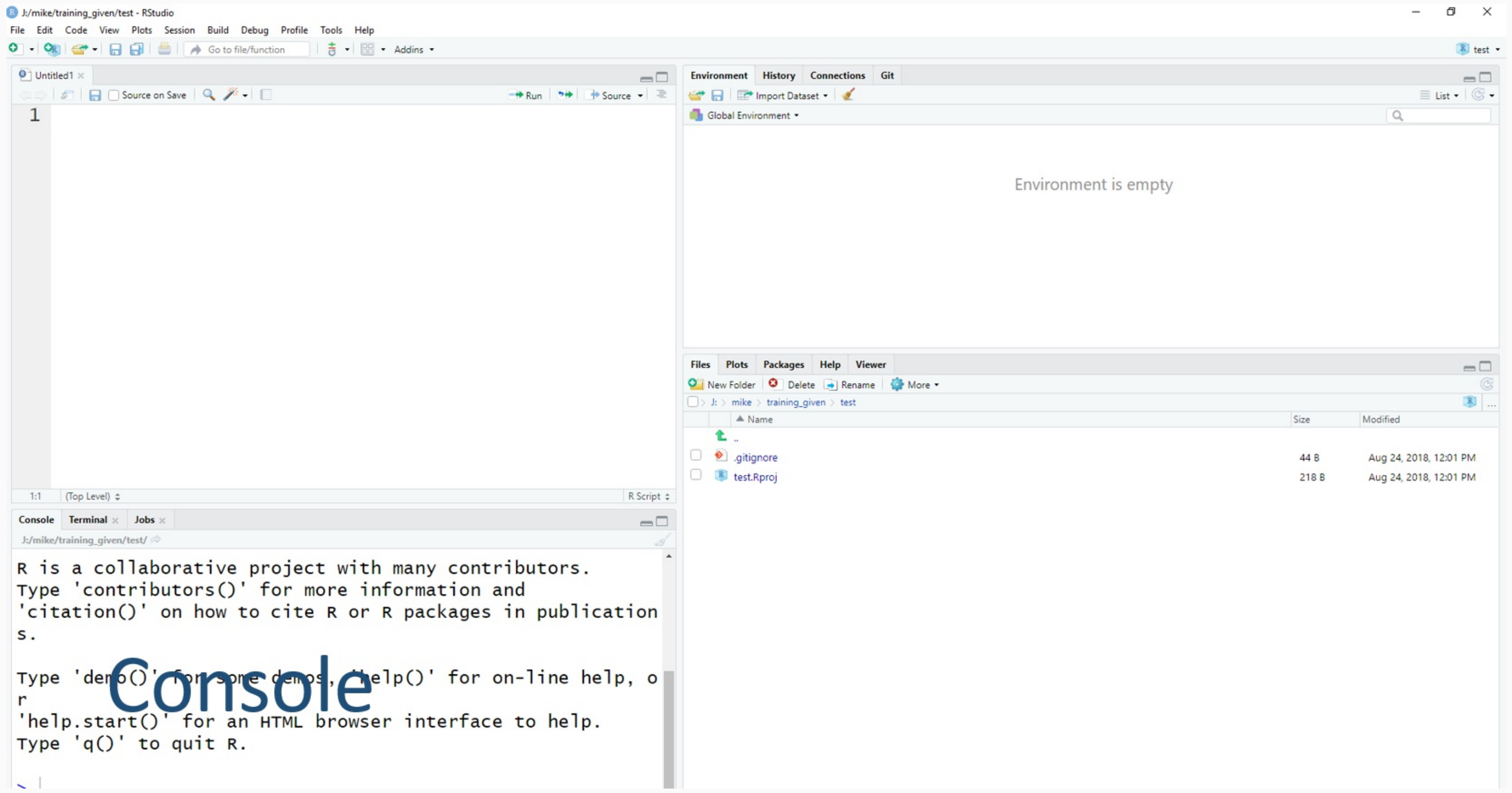
Console Pane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Console

The console is the heart of R and the best calculator in the world

```r
4+6
```

```
## [1] 10
```

If you type directly the output will be printed, but *not* saved

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4+6
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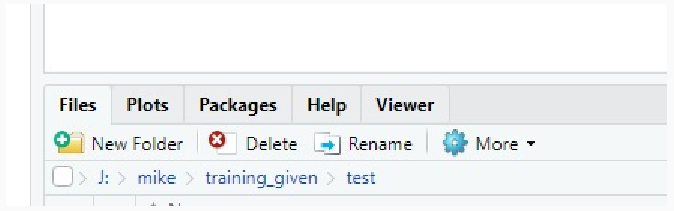
If you type directly the output will be printed, but *not* saved

To save you need to use the assignment operator `<-` to store the object in memory

```
my_output <- 4+6
my_output
```

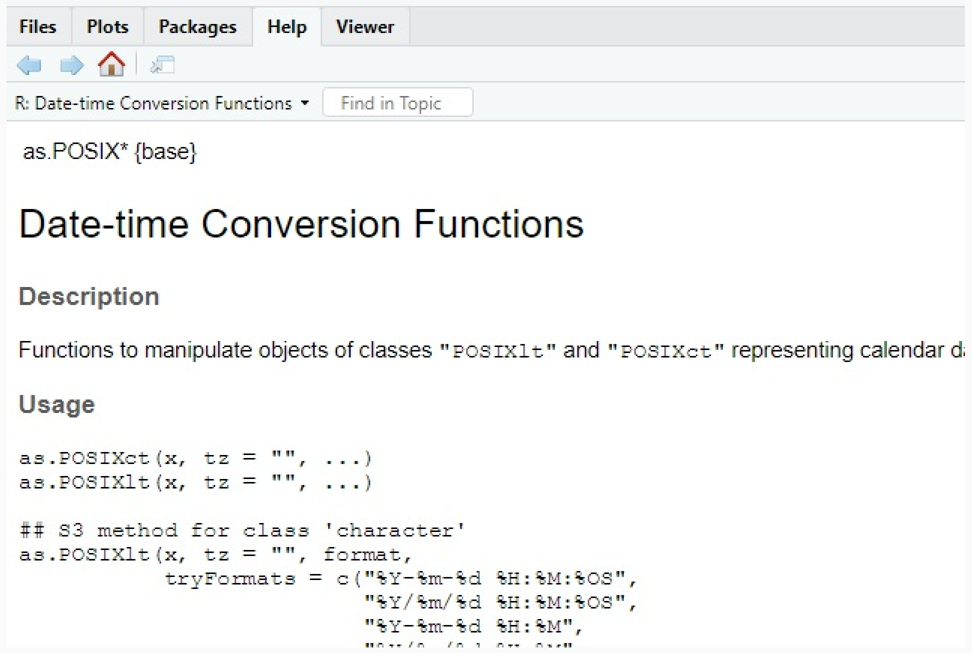
```
## [1] 10
```

Additional Tabs



Additional tabs contain other objects include files, plots, packages, and viewer

Help!



as.POSIX* {base}

Date-time Conversion Functions

Description

Functions to manipulate objects of classes "POSIXlt" and "POSIXct" representing calendar d

Usage

```
as.POSIXct(x, tz = "", ...)
as.POSIXlt(x, tz = "", ...)

## S3 method for class 'character'
as.POSIXlt(x, tz = "", format,
           tryFormats = c("%Y-%m-%d %H:%M:%OS",
                          "%Y/%m/%d %H:%M:%OS",
                          "%Y-%m-%d %H:%M",
```

A handy feature is the searchable help pane where you can get information on functions

Additional Help

You can also use the console to help you *find help*

To call the help file for a particular function:

```
??lm
```

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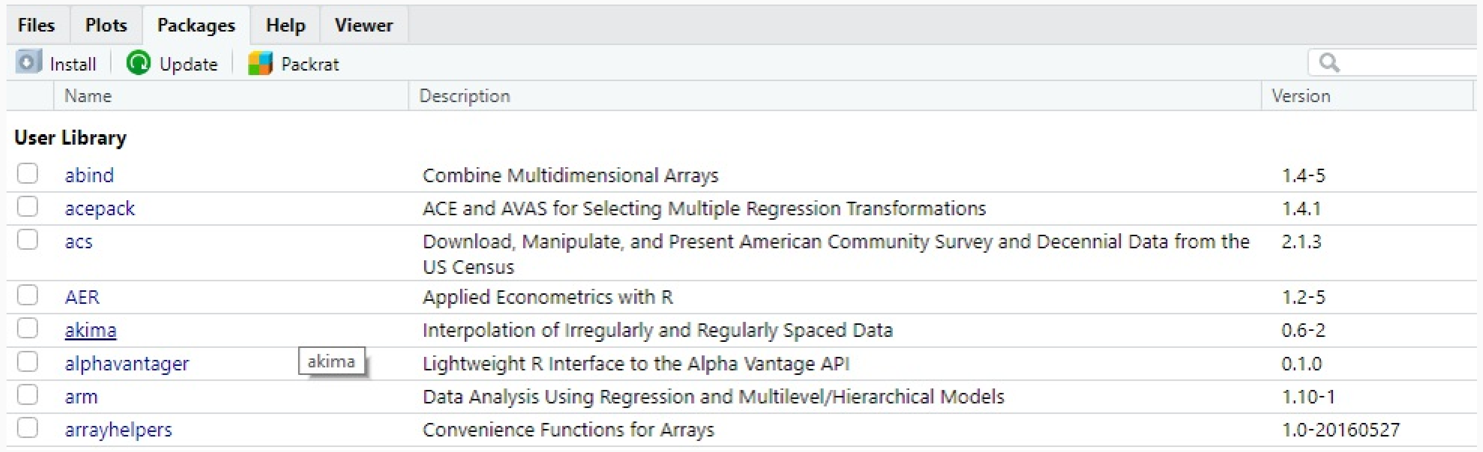
For a function that you can't quite remember...

```
apropos("glm")
```

```
## [1] "glm"           "glm.control"   "glm.fit"       "predict.glm"
## [5] "residuals.glm" "summary.glm"
```

Package Viewer

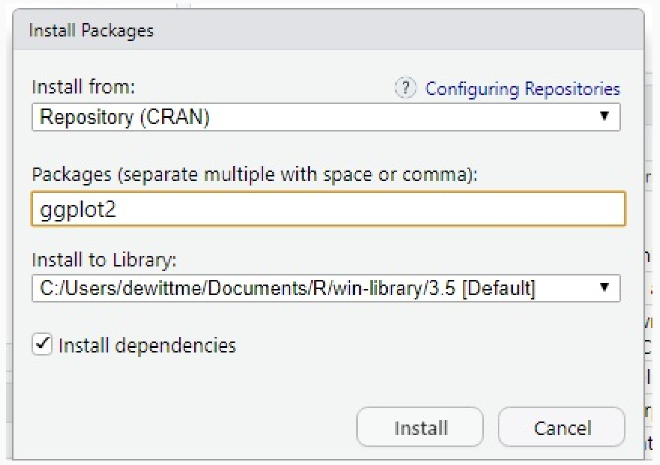


User Library

Name	Description	Version
abind	Combine Multidimensional Arrays	1.4-5
acepack	ACE and AVAS for Selecting Multiple Regression Transformations	1.4.1
acs	Download, Manipulate, and Present American Community Survey and Decennial Data from the US Census	2.1.3
AER	Applied Econometrics with R	1.2-5
akima	Interpolation of Irregularly and Regularly Spaced Data	0.6-2
alphavantager	Lightweight R Interface to the Alpha Vantage API	0.1.0
arm	Data Analysis Using Regression and Multilevel/Hierarchical Models	1.10-1
arrayhelpers	Convenience Functions for Arrays	1.0-20160527

The package viewer allows you to see your install packages (with links to the function descriptions)

Package Install


Install Packages

Install from: Repository (CRAN)

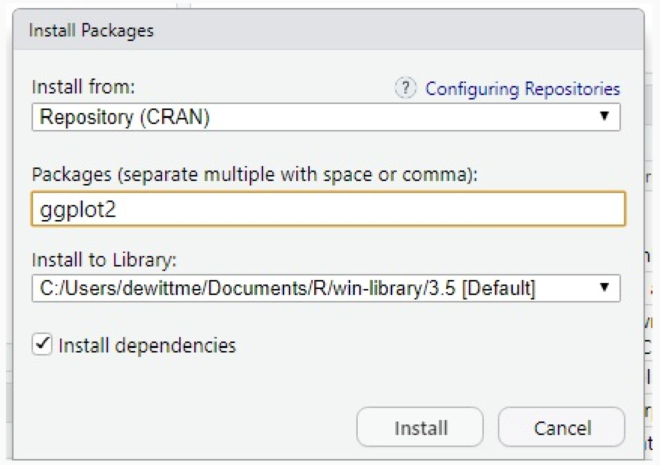
Packages (separate multiple with space or comma): ggplot2

Install to Library: C:/Users/dewittme/Documents/R/win-library/3.5 [Default]

☑ Install dependencies

You can install packages from `cran` using the package install feature

Package Install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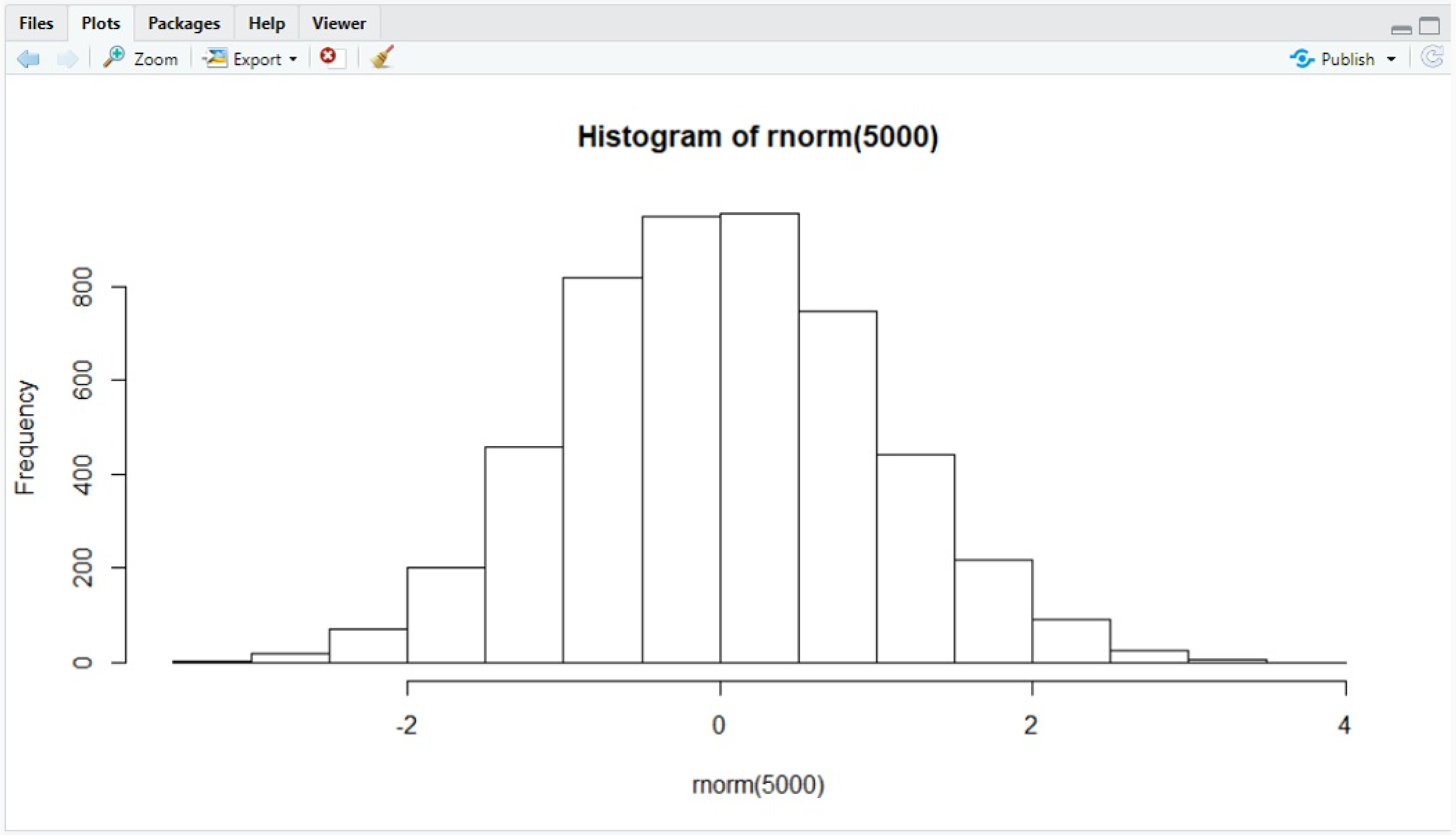
Install to Library: C:/Users/dewittme/Documents/R/win-library/3.5 [Default]

[✓] Install dependencies

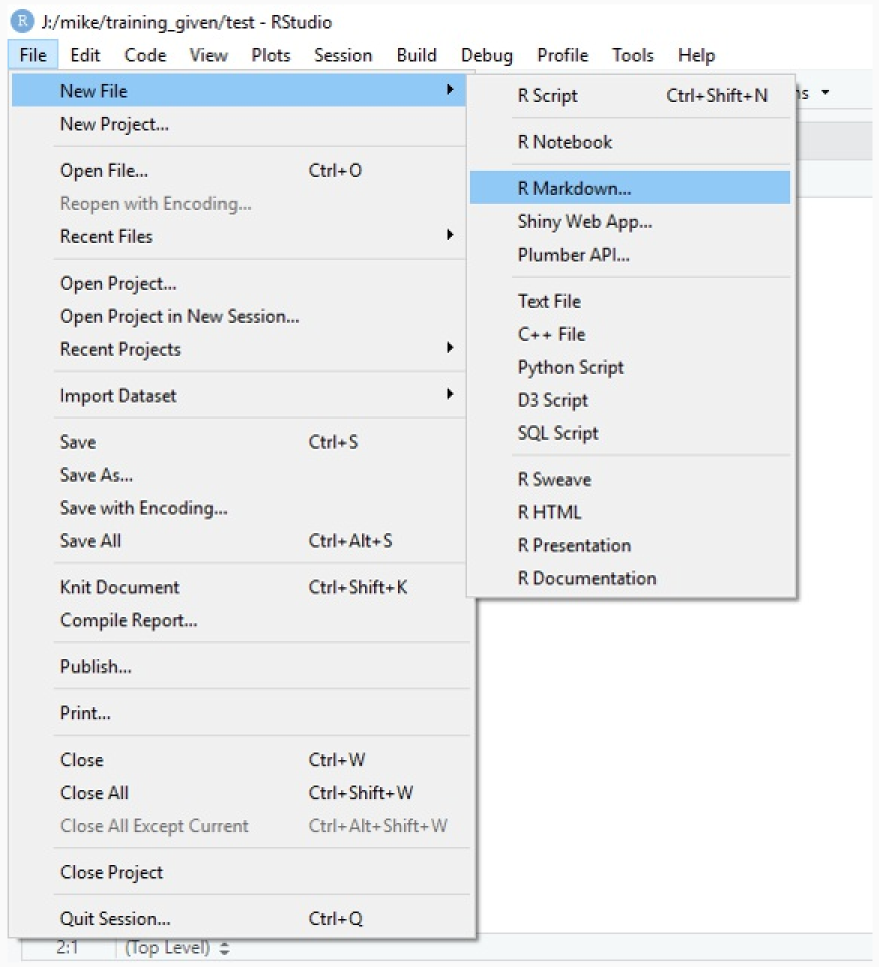
You can install packages from `cran` using the package install feature

Later we will install packages from other sources like github

Plots

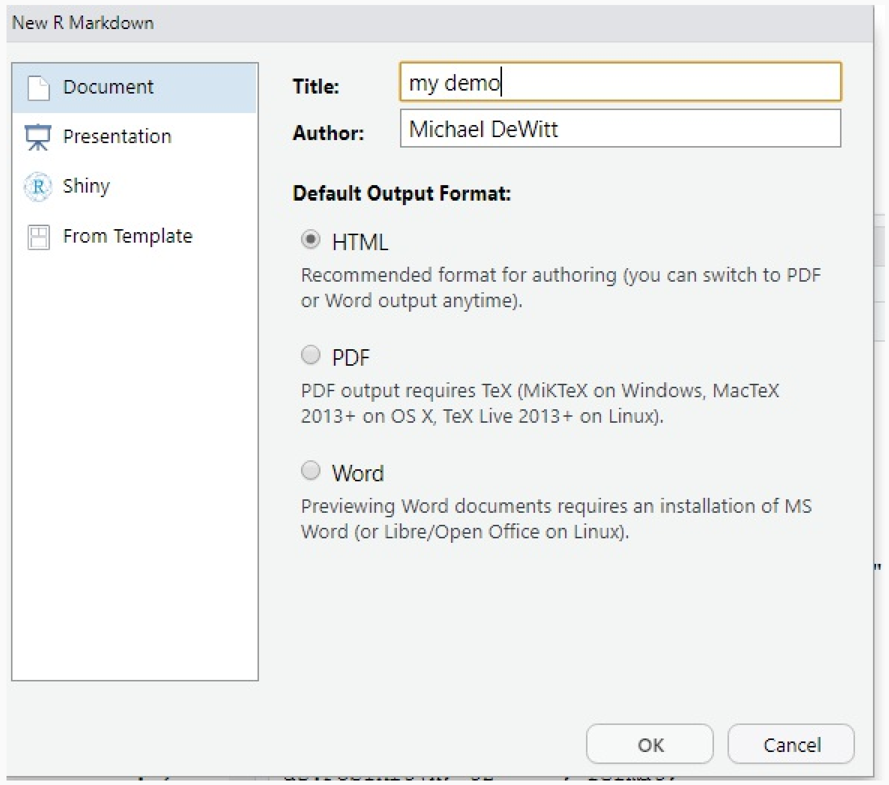

Files
Plots
Packages
Help
Viewer
Zoom
Export
Publish
Histogram of rnorm(5000)
Frequency
0
200
400
600
800
-2
0
2
4
rnorm(5000)

Creating a new file



New Rmarkdown

Markdown documents are a way to weave text and code into the same documents



Title: my demo

Author: Michael DeWitt

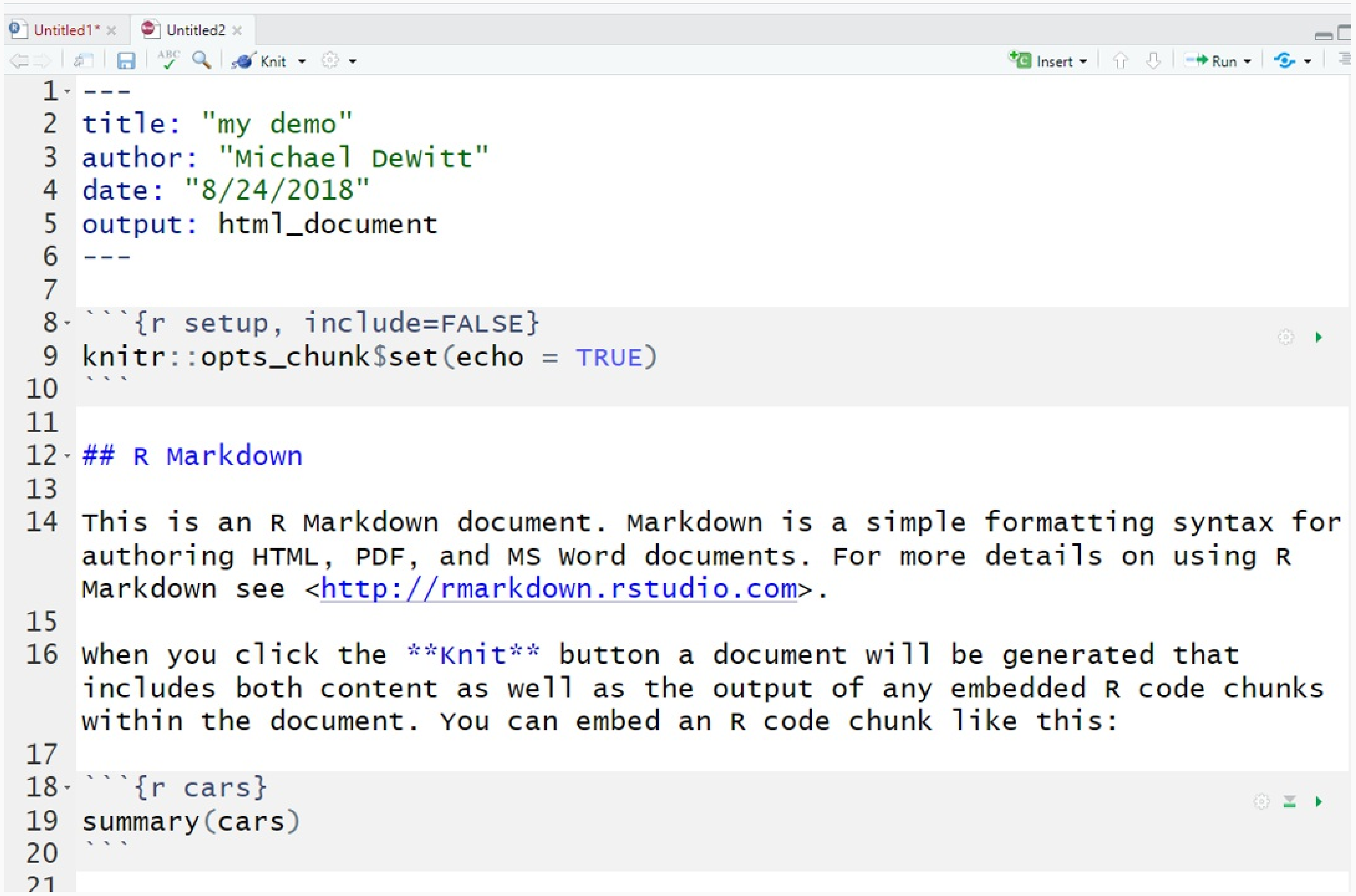
Default Output Format:

[✓ HTML]
Recommended format for authoring (you can switch to PDF or Word output anytime).

PDF
PDF output requires TeX (MiKTeX on Windows, MacTeX 2013+ on OS X, TeX Live 2013+ on Linux).

Word
Previewing Word documents requires an installation of MS Word (or Libre/Open Office on Linux).

Rmarkdown Example File



~~~
---
title: "my demo"
author: "Michael DeWitt"
date: "8/24/2018"
output: html_document
---

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

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:

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

Parts of an Rmarkdown Document - YAML Header

The YAML header block is separated by three _ symbols

```
---
title: "Untitled"
author: "Michael DeWitt"
date: "9/5/2018"
output: html_document
---
```

Parts of an Rmarkdown Document - YAML Header

The YAML header block is separated by three _ symbols

```
---
title: "Untitled"
author: "Michael DeWitt"
date: "9/5/2018"
output: html_document
---
```

Specifies to `pandoc` how to convert the document and into what format to render the document

- html_output = html
- pdf_output = pdf
- word_output = Microsoft Word

Parts of an Rmarkdown Document - Code Chunks

Code chunks can be inserted with `CTRL + ALT + I` or `CMD + ALT + I`

```
fit <- lm(mpg ~ disp + wt, data = mtcars)
```

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fit <- lm(mpg ~ disp + wt, data = mtcars)
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Here you can type R code, and determine if the output will be printed in the document

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```
fit <- lm(mpg ~ disp + wt, data = mtcars)
```

Here you can type R code, and determine if the output will be printed in the document

You can run each code chunk by pressing the green arrow in the chunk

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```
fit <- lm(mpg ~ disp + wt, data = mtcars)
```

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You can run each code chunk by pressing the green arrow in the chunk

Or running the code line by line

Parts of an Rmarkdown Document - Plain Text

The rest of the Rmarkdown is plain text

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This is where you can write down ideas, your opinions, your findings

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You can use this for both exploration (think lab notebook) and final documents

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Rmarkdown also provides ways to add some additional formatting

Rmarkdown Markup

Formatting

`#` # Header 1

`##` ## Header 2

`*italics*` or `_italics_` for *italics*

`**bold**` or `__bold__` for **bold**

`-` or `*` for bullets

- Bullet 1
- Bullet 2
  - Bullet 2a

`1` for numbered lists

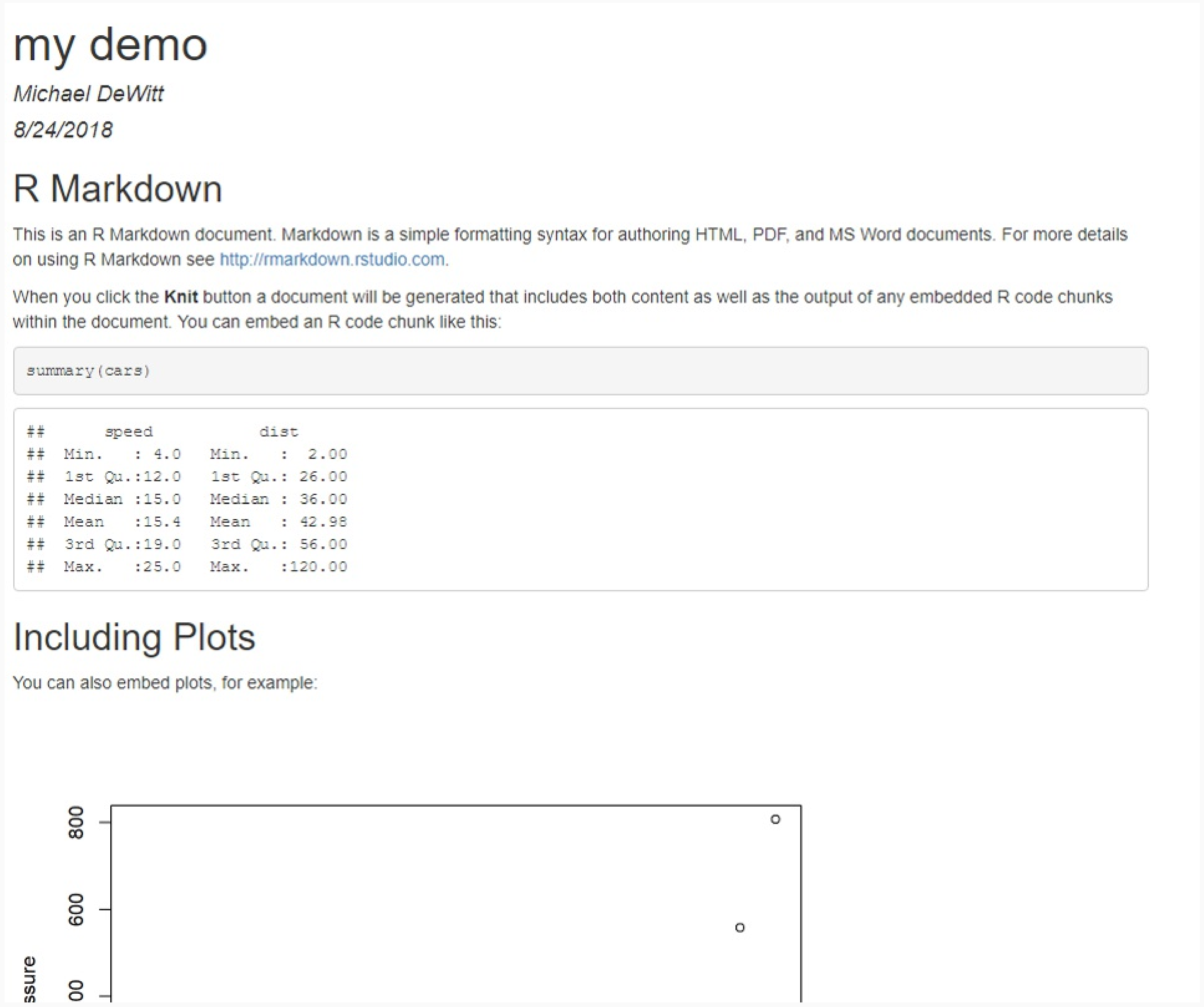
1 Item 1
2 Item 2

`$\int_{a}^bx^2dx$` for \(\LaTeX\) e.g. \(\int_{a}^bx^2dx\)

Knit it!

Rmarkdown to html!

Check out the gallery at https://rmarkdown.rstudio.com/gallery.html



my demo

Michael DeWitt

8/24/2018

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```
summary(cars)
```

```
##      speed           dist       
##  Min.   : 4.0   Min.   :  2.00  
##  1st Qu.:12.0   1st Qu.: 26.00  
##  Median :15.0   Median : 36.00  
##  Mean   :15.4   Mean   : 42.98  
##  3rd Qu.:19.0   3rd Qu.: 56.00  
##  Max.   :25.0   Max.   :120.00  
```

Including Plots

You can also embed plots, for example:

Some final words about the course

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The emphasis is on *application* and not on *theory*

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I will teach using the `tidyverse` paradigm

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I will teach using the `tidyverse` paradigm

We will learn data structures as we go along (not a programming class)

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We will learn data structures as we go along (not a programming class)

My way isn't always the best way (always alternatives)