INTRODUCTION TO

R

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Senior Data Scientist
Wednesday, June 28, 2023

About me

- Ph.D. in Psychology from University of Denver (2018)
- Galvanize data science bootcamp (2018)
- Instructor @ Woz-U data science bootcamp (2021)
- NIH contractor with ODSS as a Data Science Training Specialist (2022)
- Senior Data Scientist at Daybreak LLC contracting with FDA (2023)
- Started programming in Python in 2011
- Experience with Python, R, MATLAB, SPSS, SQL, AFNI, SPM
- Neuroimaging data (fMRI), skin conductance, eye-tracking, experiment design and more
- Support free and open-source software (FOSS) like R and Python to create reproducible analysis and workflows

Overview

- What is R
- R platforms
  - R
  - Posit/R Studio
  - Posit Cloud/R Studio Cloud
- R file types

1. Basic R commands
2. R packages and built-in datasets
3. Data manipulation
4. Data visualization
5. Data import and export
6. Data analysis

Each of the 6 lessons has a separate notebook.
We will **not** be able to cover all of them today.
All notebooks remain in the repository for future reference and self-review.

Tips and Tricks

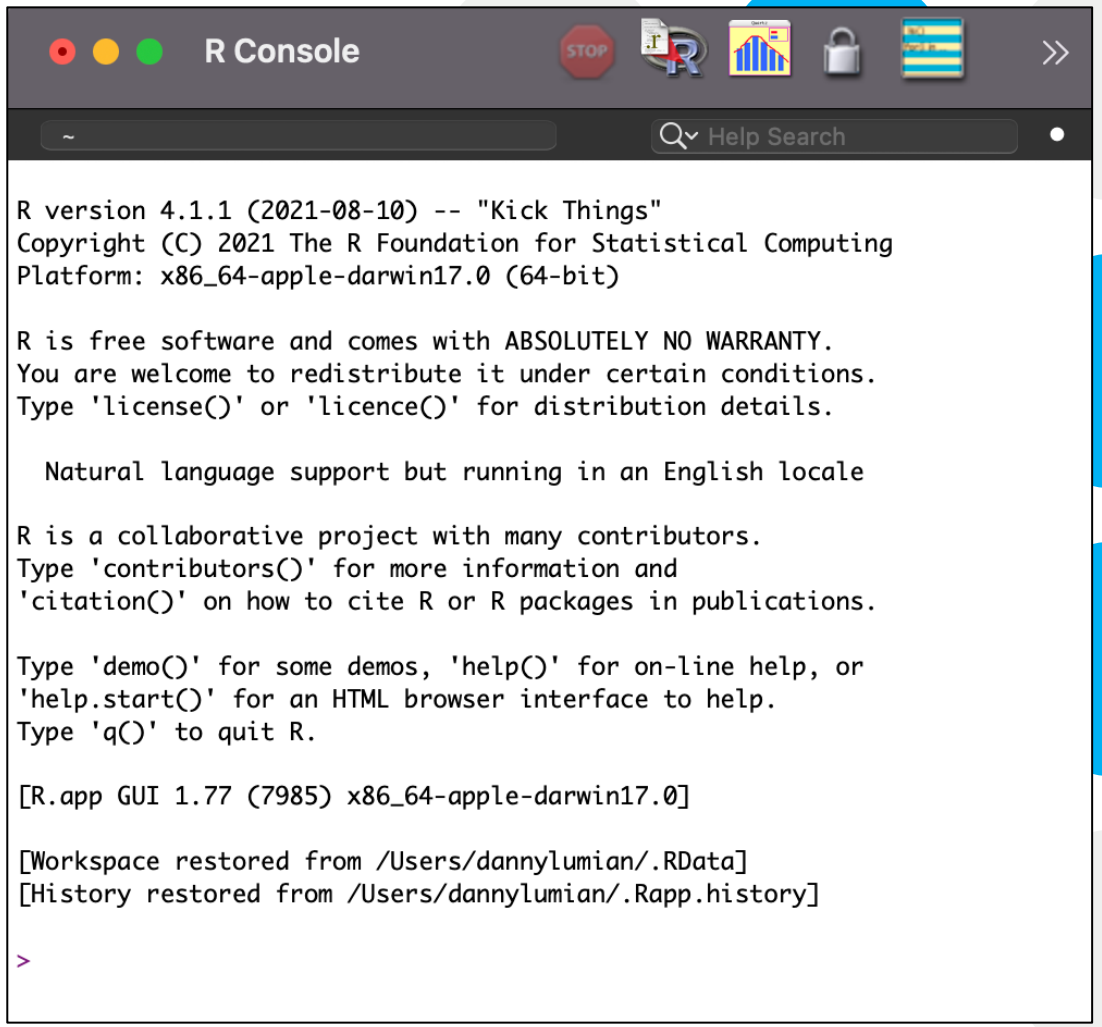
- R programming has much in common with other programming languages such as Python
  - Each has unique packages but often similar functionality
  - Packages are essential to getting the most out of your effort
- Documentation-Check it and write it!
- Error messages are designed to help with debugging
- There are MANY helpful resources available
  - Improve your skills
  - Solve issues (StackOverflow)

Tech Stack/Programming Ecosystem

- R allows for many common data operations, however, to be a complete programmer often requires additional skillsets
- Below are common skillsets that enhance your ability to do your work as a researcher, developer or data scientist
  - Version Control: GitHub, GitLab
  - Database: SQL
  - Environments: Allows others to replicate and use your scripts
  - Remote compute and cloud services: Vital skill when data is too large for your personal workstation
  - Dashboards: R Shiny, Tableau

What is R?

- An open-source programming language and software environment that can:
  - Manipulate data
  - Visualize data
  - Perform statistics
- Free and relatively easy to run in any environment (Unix, Windows, & MacOS)
- Recently changed to Posit
- https://www.r-project.org/

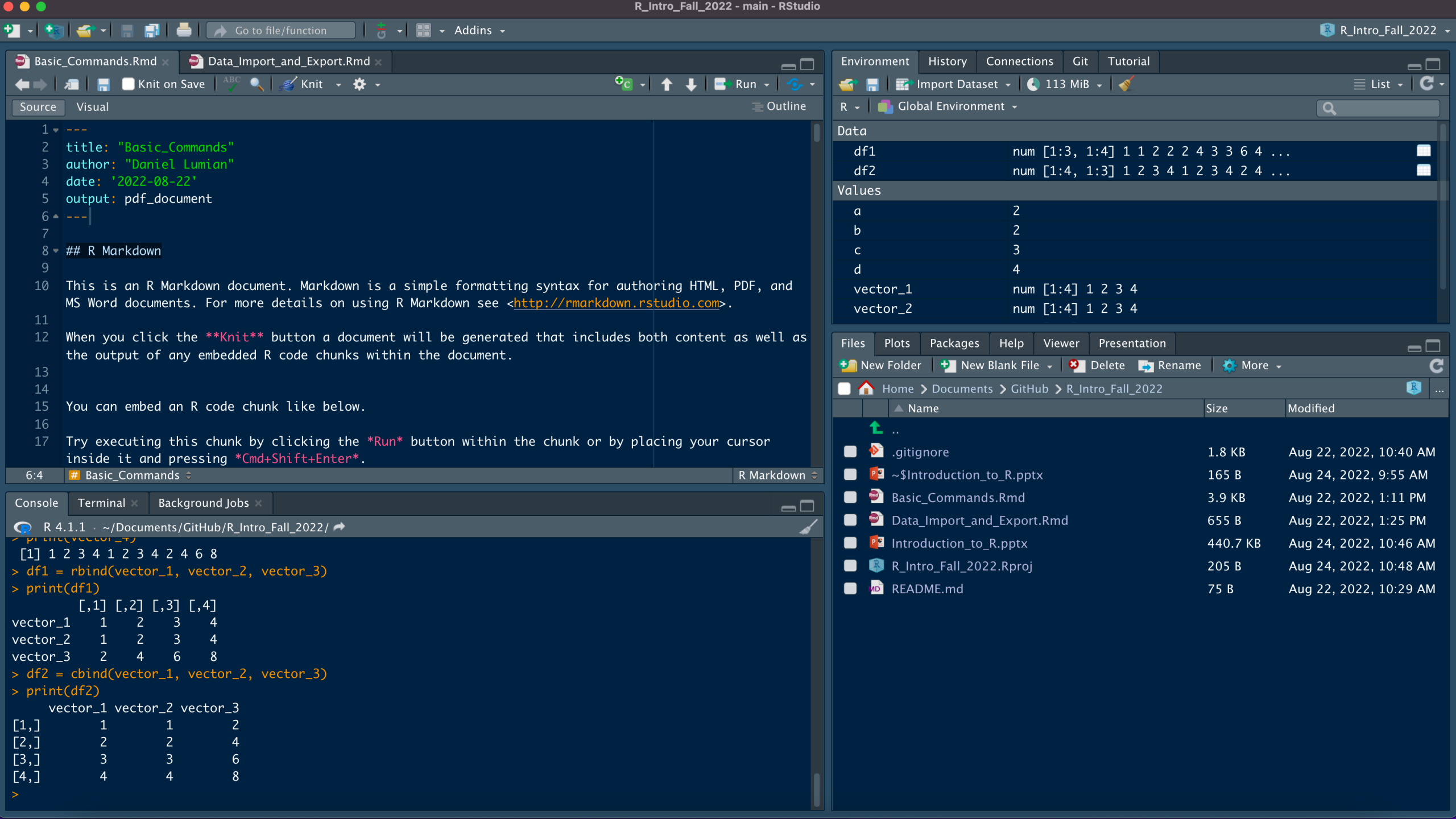


Why R?

- With FOSS, it is easy to get analysis tools, share and collaborate on work with few barriers to access
  - Compared with MATLAB, which requires licensing
- Use of programming language is typically required for big data
  - Excel can not handle millions of datapoints
- R is currently considered the standard for bioinformatics and biostatistics with many packages for advanced visualization and analysis
  - Bioconductor
  - Tidyverse

What is R Studio?

- An integrated development environment (IDE) for R
- Software that includes R, R console, file explorer, graphics viewer, code notebook and more!
- One stop shop for coding in R
- https://posit.co/


R_Intro_Fall_2022 - main - RStudio
Go to file/function
Addins
R_Intro_Fall_2022
Basic_Commands.Rmd
Data_Import_and_Export.Rmd
Knit on Save
Knit
Run
Source
Visual
Outline
1 ---
2 title: "Basic_Commands"
3 author: "Daniel Lumian"
4 date: '2022-08-22'
5 output: pdf_document
6 ---
7
8 ## R Markdown
9
10 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>.
11
12 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.
13
14
15 You can embed an R code chunk like below.
16
17 Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Cmd+Shift+Enter*.
6:4
Basic_Commands
R Markdown
Console
Terminal
Background Jobs
R 4.1.1 · ~/Documents/GitHub/R_Intro_Fall_2022/
[1] 1 2 3 4 1 2 3 4 2 4 6 8
> df1 = rbind(vector_1, vector_2, vector_3)
> print(df1)
[,1] [,2] [,3] [,4]
vector_1 1 2 3 4
vector_2 1 2 3 4
vector_3 2 4 6 8
> df2 = cbind(vector_1, vector_2, vector_3)
> print(df2)
vector_1 vector_2 vector_3
[1,] 1 1 2
[2,] 2 2 4
[3,] 3 3 6
[4,] 4 4 8
>
Environment
History
Connections
Git
Tutorial
Import Dataset
113 MiB
List
R
Global Environment
Data
df1 num [1:3, 1:4] 1 1 2 2 2 4 3 3 6 4 ...
df2 num [1:4, 1:3] 1 2 3 4 1 2 3 4 2 4 ...
Values
a 2
b 2
c 3
d 4
vector_1 num [1:4] 1 2 3 4
vector_2 num [1:4] 1 2 3 4
Files
Plots
Packages
Help
Viewer
Presentation
New Folder
New Blank File
Delete
Rename
More
Home > Documents > GitHub > R_Intro_Fall_2022
Name
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.gitignore 1.8 KB Aug 22, 2022, 10:40 AM
~$Introduction_to_R.pptx 165 B Aug 24, 2022, 9:55 AM
Basic_Commands.Rmd 3.9 KB Aug 22, 2022, 1:11 PM
Data_Import_and_Export.Rmd 655 B Aug 22, 2022, 1:25 PM
Introduction_to_R.pptx 440.7 KB Aug 24, 2022, 10:46 AM
R_Intro_Fall_2022.Rproj 205 B Aug 24, 2022, 10:48 AM
README.md 75 B Aug 22, 2022, 10:29 AM

What is Posit Cloud?

- Cloud based version of R Studio
- No need to download software
- Can share projects easily for analysis and teaching
- Allows for pre-installation of required packages
- https://posit.cloud/
- Recommended platform if you have not used R/R Studio before
    - Not recommended for larger projects due to limitation on resources

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function | Addins | R 4.2.1

Basic_Commands.Rmd

Knit | Run | Source | Visual | Outline

Package rmarkdown required but is not installed. Install Don't Show Again

```
1  ---
2  title: "Basic_Commands"
3  author: "Daniel Lumian"
4  date: '2022-08-22'
5  output: pdf_document
6  ---
7
8  ## R Markdown
9
10 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>.
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15 You can embed an R code chunk like below.
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17 Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing
   *Cmd+Shift+Enter*.
```

1:1 Basic_Commands R Markdown

Console Terminal Background Jobs

R 4.2.1 · /cloud/project/

```
R version 4.2.1 (2022-06-23) -- "Funny-Looking Kid"
Copyright (C) 2022 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (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.

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.
```

Environment History Connections Git Tutorial

Import Dataset | 135 MiB | List

R | Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

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

Cloud > project

Name	Size	Modified
..		
.gitignore	1.8 KB	Aug 25, 2022, 8:33 AM
.Rhistory	0 B	Aug 25, 2022, 8:33 AM
Basic_Commands.Rmd	3.9 KB	Aug 25, 2022, 8:33 AM
Data_Import_and_Export.Rmd	655 B	Aug 25, 2022, 8:33 AM
Introduction_to_R.pptx	1.3 MB	Aug 25, 2022, 8:33 AM
R_Intro_Fall_2022.Rproj	205 B	Aug 25, 2022, 8:33 AM
README.md	75 B	Aug 25, 2022, 8:33 AM

R File Types

R Script File

- Basic file for saving code
- Can add comments using `#` symbol
    - Documenting code with comments is a best practice
- Useful for testing code snippets and work that will not be shared
- Sections can be selected and run

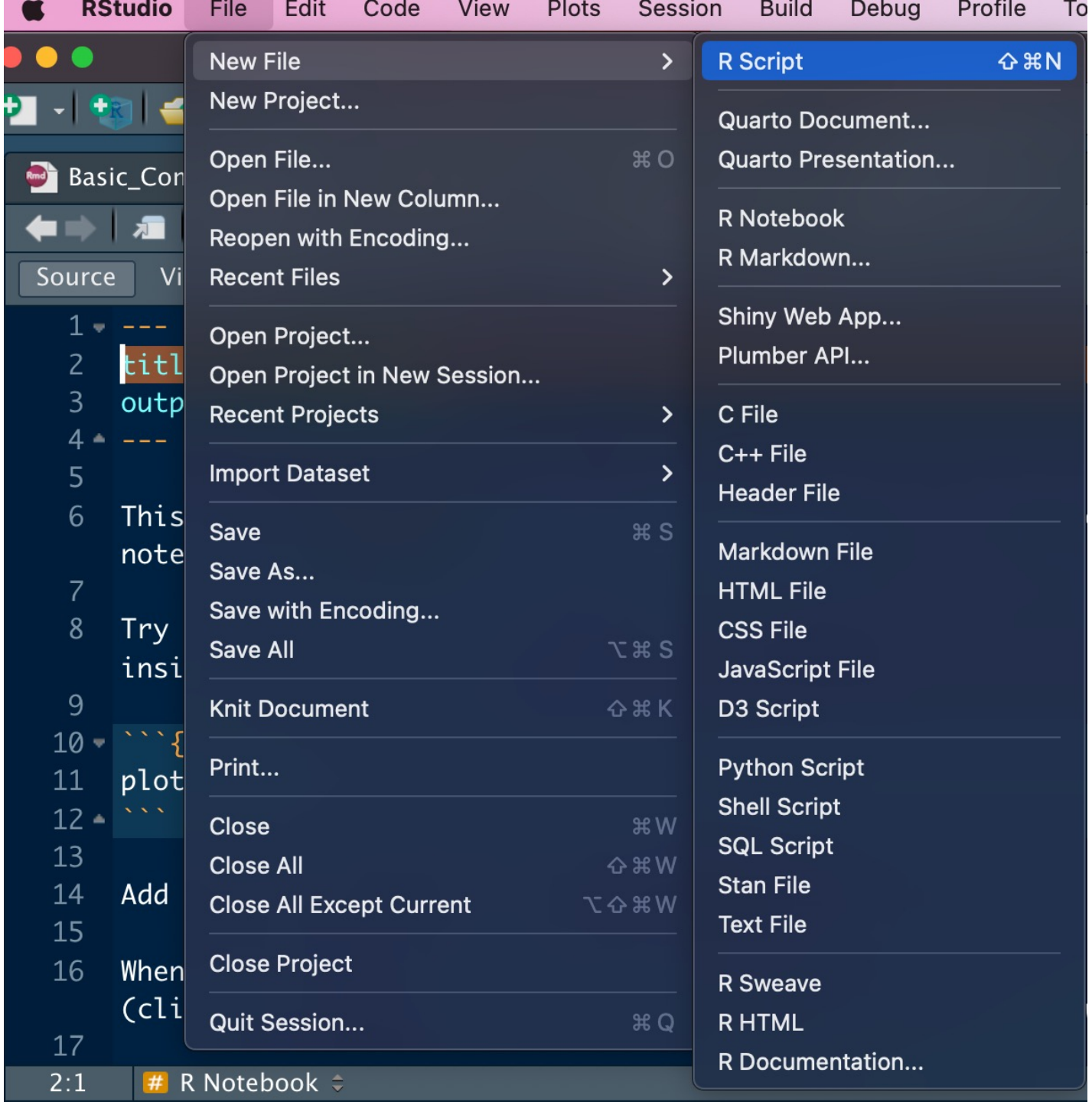
R Markdown and Notebook

- More advanced files that allow inclusion of markdown and style elements for documentation
- Code lives in chunks within the file
- Better for sharing and publishing code
- Notebooks allow a preview feature, while Markdown files are knit

---

https://stackoverflow.com/questions/43820483/difference-between-r-markdown-and-r-notebook

- Open a new file
  - Select File from the top panel
  - Select New File from the dropdown
  - Select appropriate file type
    - R script
    - R Notebook
    - R Markdown
- Open an existing file
  - Select File from the top panel
  - Select Open File
  - Select the file you wish to open
- Save a file
  - Select File from the top panel
  - Select Save or Save as
  - Specify the save location

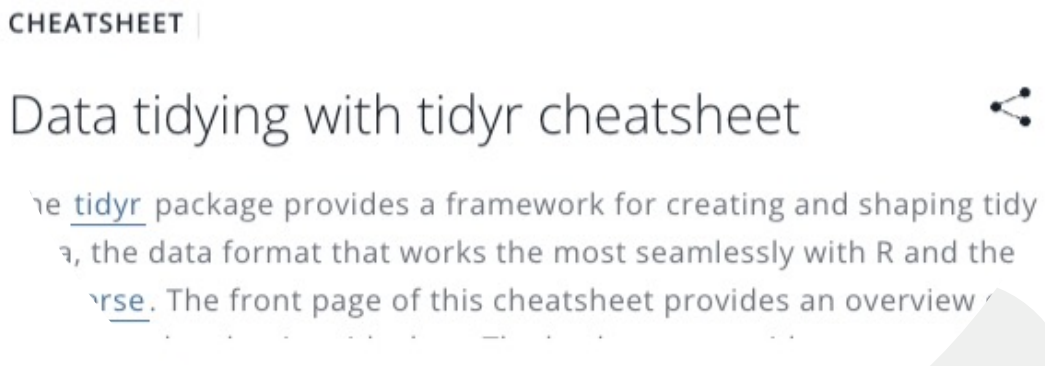


R and R Studio Cheat Sheets

Cheat Sheets

There are many capabilities, packages and tools available in R which can not be covered in a single session

This resource has helpful guides to some of the most popular packages and common uses of these packages



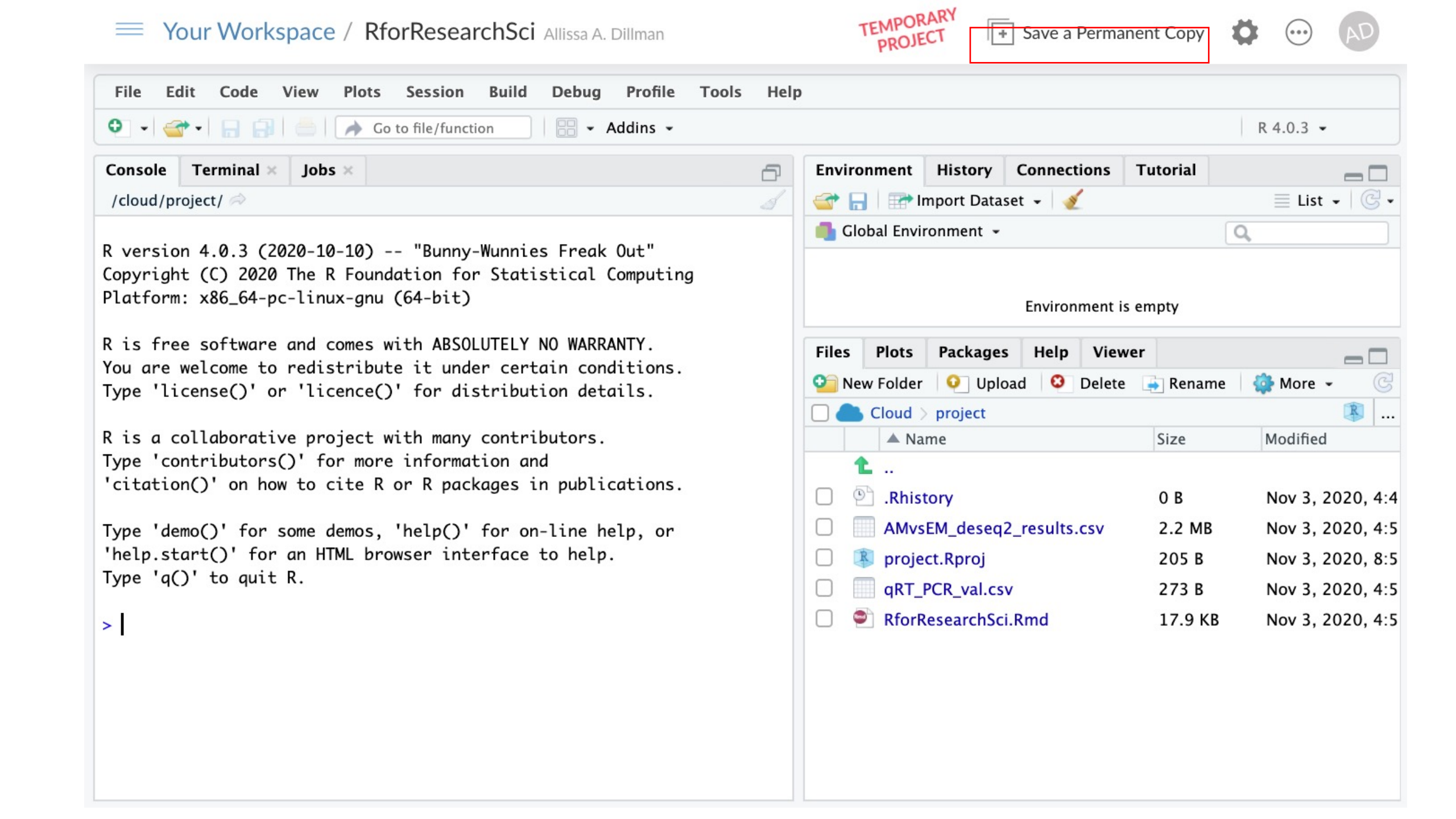
Let’s get started!

R Studio Cloud

- Log in or sign up for Posit Cloud
  - Go to: https://posit.cloud/
- Open the following project
  - https://posit.cloud/content/6136578
  - Click on Save a permanent copy
- Click on the new file icon
- Select R script

Local R Studio

- Clone GitHub repo
  - https://github.com/dlumian/NIH-R-Introduction
- Navigate to repo directory
  - Open NIH-R-Introduction.Rproj file with RStudio
- Click on the new file icon
- Select R script


Your Workspace / RforResearchSci Allissa A. Dillman
TEMPORARY PROJECT
Save a Permanent Copy
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File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.3
Console Terminal Jobs
/cloud/project/
R version 4.0.3 (2020-10-10) -- "Bunny-Wunnies Freak Out"
Copyright (C) 2020 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (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.
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.
>
Environment History Connections Tutorial
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
New Folder
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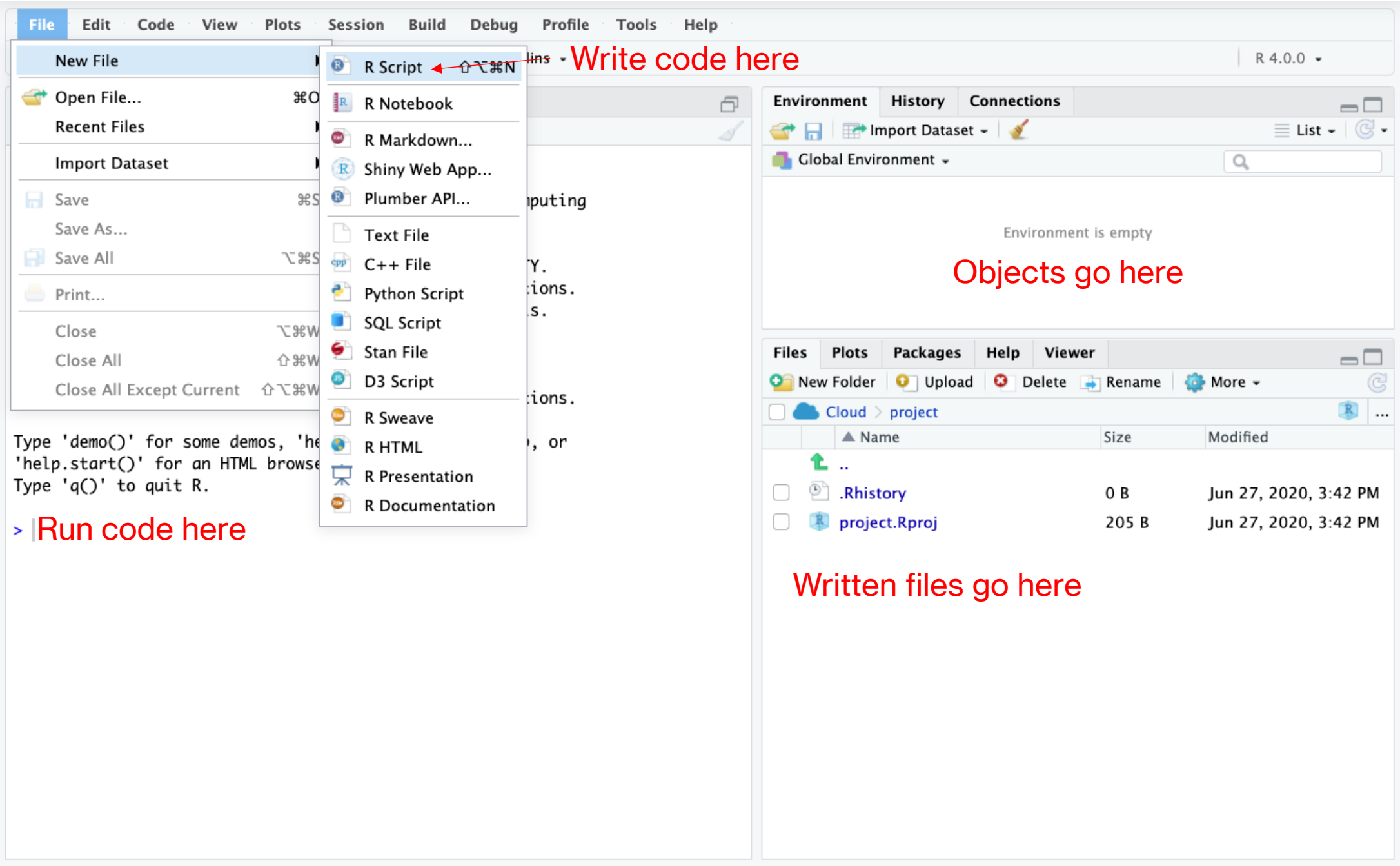
.Rhistory 0 B Nov 3, 2020, 4:4
AMvsEM_deseq2_results.csv 2.2 MB Nov 3, 2020, 4:5
project.Rproj 205 B Nov 3, 2020, 8:5
qRT_PCR_val.csv 273 B Nov 3, 2020, 4:5
RforResearchSci.Rmd 17.9 KB Nov 3, 2020, 4:5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Profile
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Help
New File
Open File...
Recent Files
Import Dataset
Save
Save As...
Save All
Print...
Close
Close All
Close All Except Current
R Script
R Notebook
R Markdown...
Shiny Web App...
Plumber API...
Text File
C++ File
Python Script
SQL Script
Stan File
D3 Script
R Sweave
R HTML
R Presentation
R Documentation
Write code here
R 4.0.0
Type 'demo()' for some demos, 'he
'help.start()' for an HTML browse
Type 'q()' to quit R.
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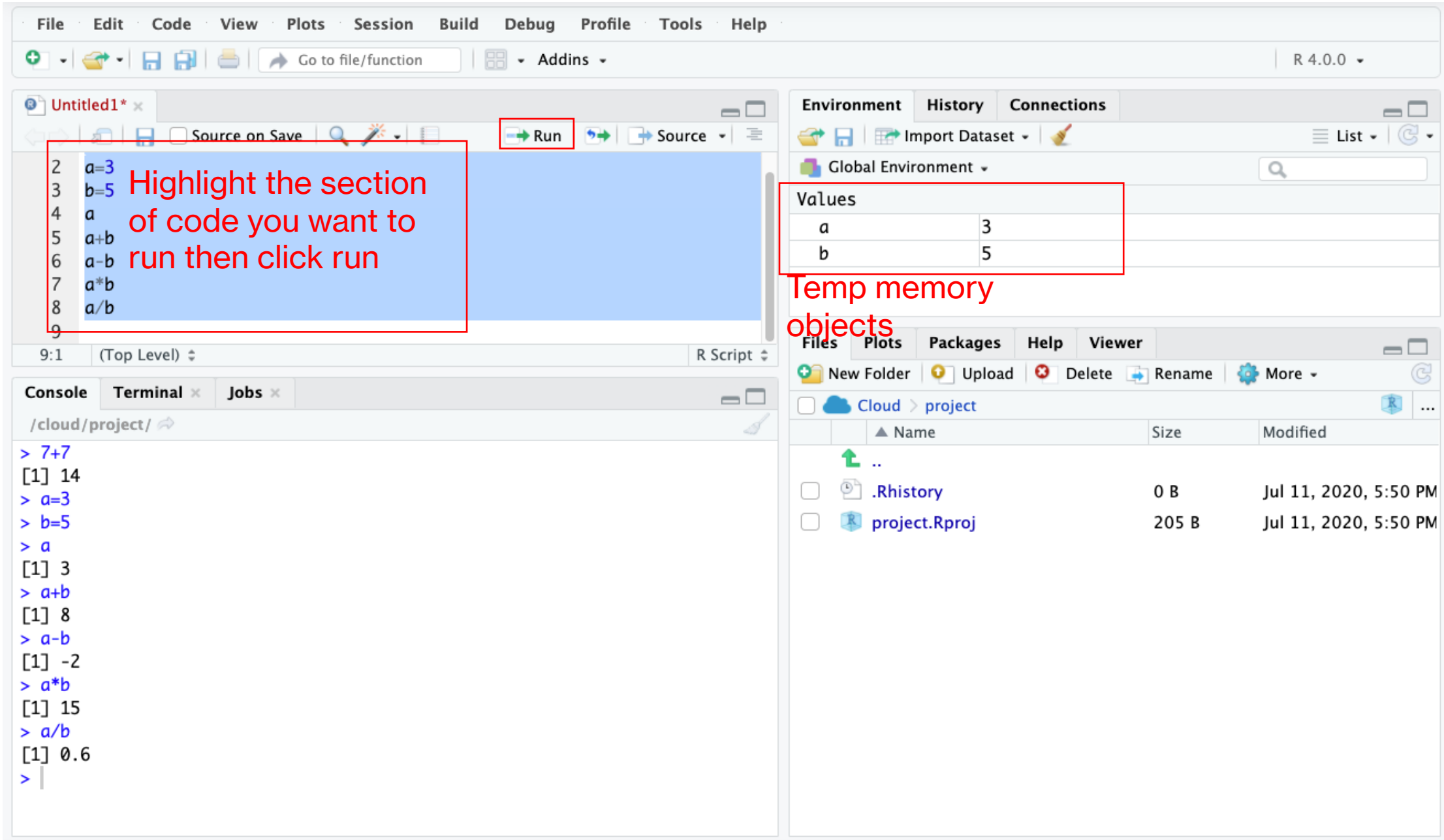
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
Untitled1*
Source on Save
Run
Source
a=3
b=5
a
a+b
a-b
a*b
a/b
Highlight the section of code you want to run then click run
9:1
(Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
> 7+7
[1] 14
> a=3
> b=5
> a
[1] 3
> a+b
[1] 8
> a-b
[1] -2
> a*b
[1] 15
> a/b
[1] 0.6
>
Environment
History
Connections
Import Dataset
List
Global Environment
Values
a 3
b 5
Temp memory objects
Files
Plots
Packages
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.Rhistory 0 B Jul 11, 2020, 5:50 PM
project.Rproj 205 B Jul 11, 2020, 5:50 PM

Basic R Arithmetic Operations

- Basic addition: **7 + 7**
- Assign variables:
  - **a=3**
  - **b=5**
- See contents of a variable:
  - Typing "**a**" returns "**3**"
  - Typing "**b**" returns "**5**"

Run operations on variables:

a+b

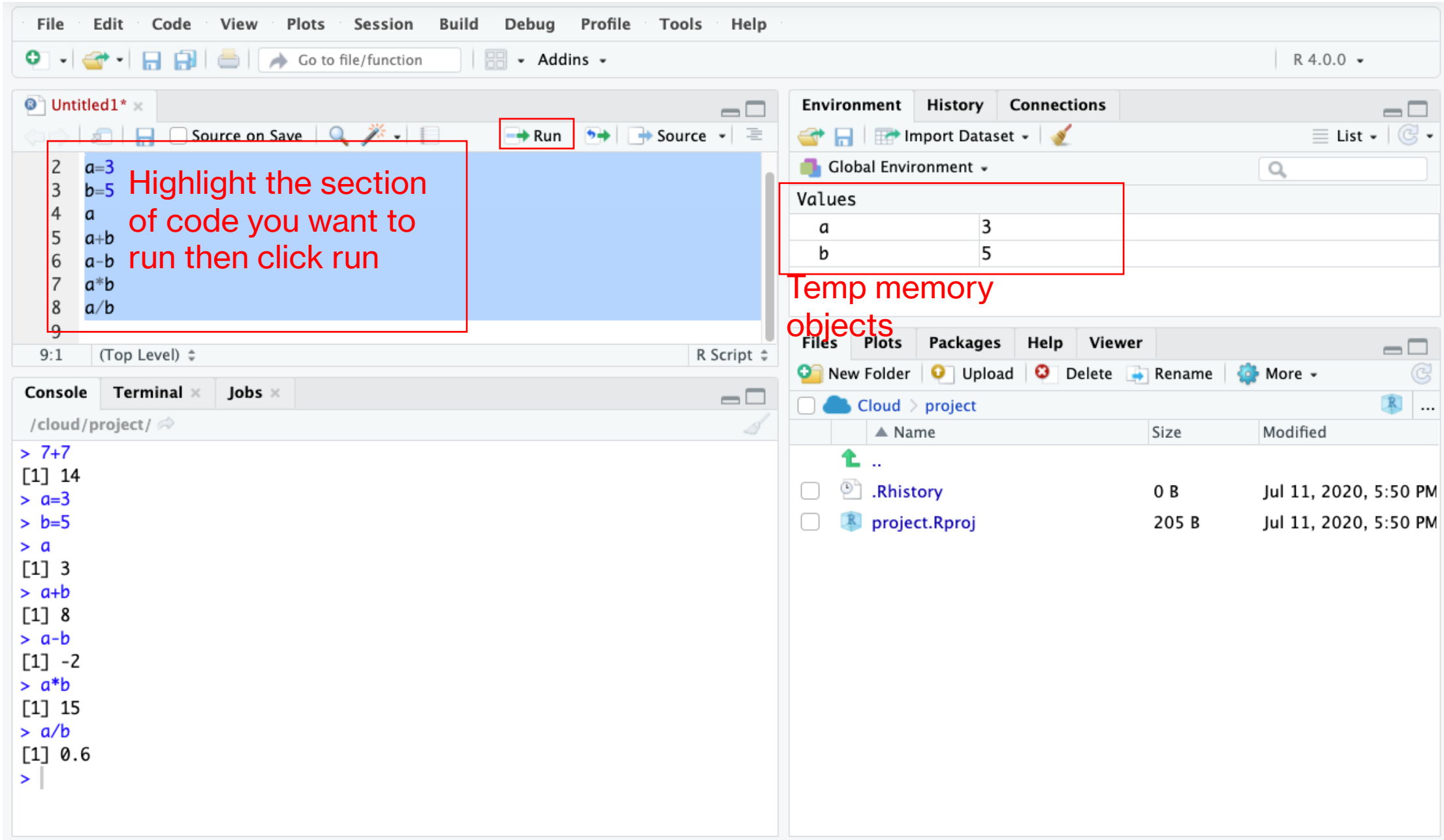
a-b

a*b

a/b

Two ways to run these operations:

- Enter each line in the console and push enter
- Enter all lines into the script, select which lines to run and push run


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
Untitled1*
Source on Save
Run
Source
a=3
b=5
a
a+b
a-b
a*b
a/b
Highlight the section of code you want to run then click run
9:1
(Top Level)
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/cloud/project/
> 7+7
[1] 14
> a=3
> b=5
> a
[1] 3
> a+b
[1] 8
> a-b
[1] -2
> a*b
[1] 15
> a/b
[1] 0.6
>
Environment
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Connections
Import Dataset
List
Global Environment
Values
a 3
b 5
Temp memory objects
Files
Plots
Packages
Help
Viewer
New Folder
Upload
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Rename
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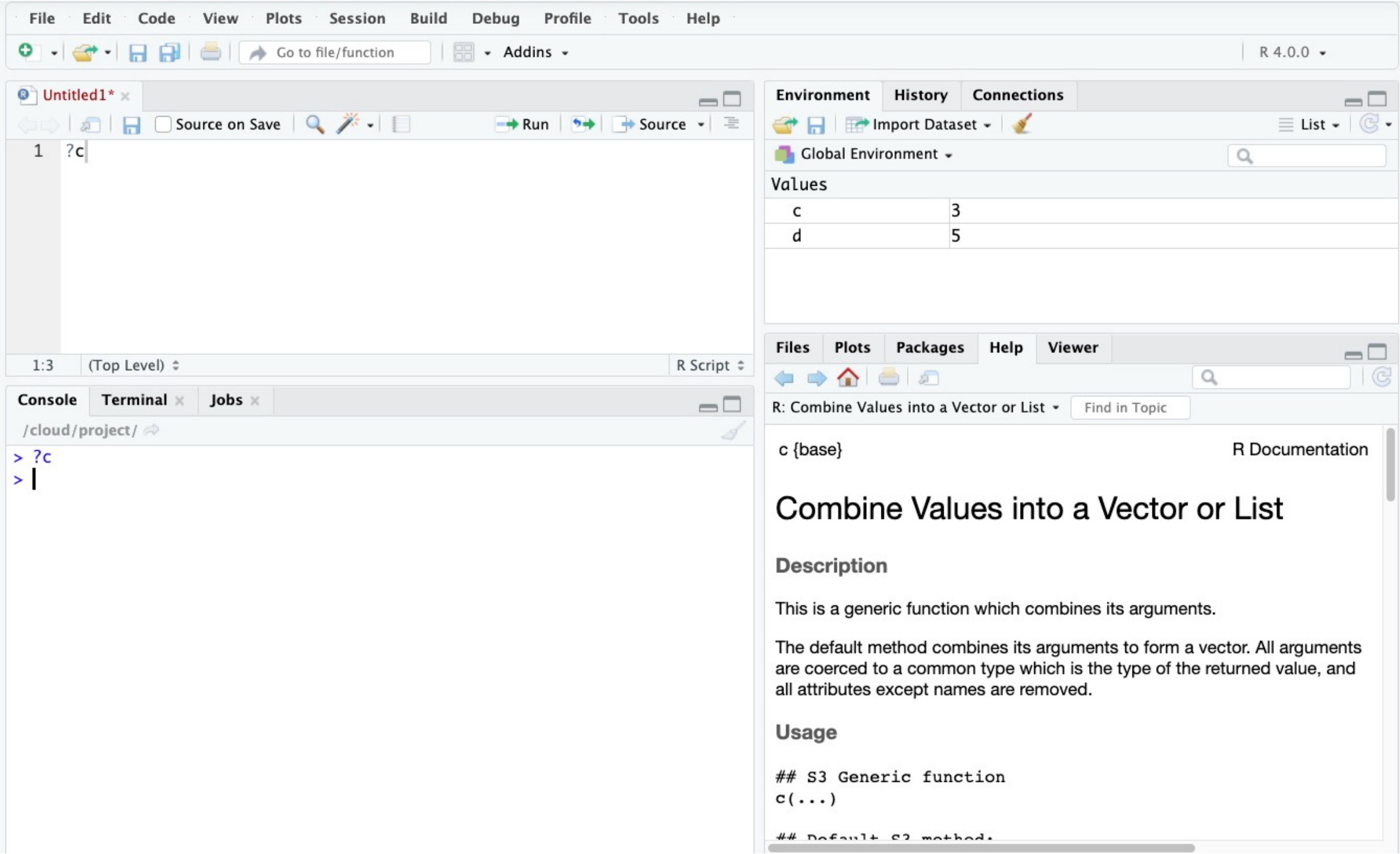
Cloud
project
Name
Size
Modified
..
.Rhistory 0 B Jul 11, 2020, 5:50 PM
project.Rproj 205 B Jul 11, 2020, 5:50 PM

Vectors and Functions

- Vectors are a data structure in R
  - must be same data type
  - list of characters
  - list of numbers
- Use the ”c” function to combine items
  - c(5,6,7,8) creates a vector
- c stands for combine
- Putting a `?` before a command or object will retrieve the help for that object
- Type: `?c`


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
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R 4.0.0
Untitled1*
Source on Save
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1 ?c
1:3
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R Script
Console
Terminal
Jobs
/cloud/project/
> ?c
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Environment
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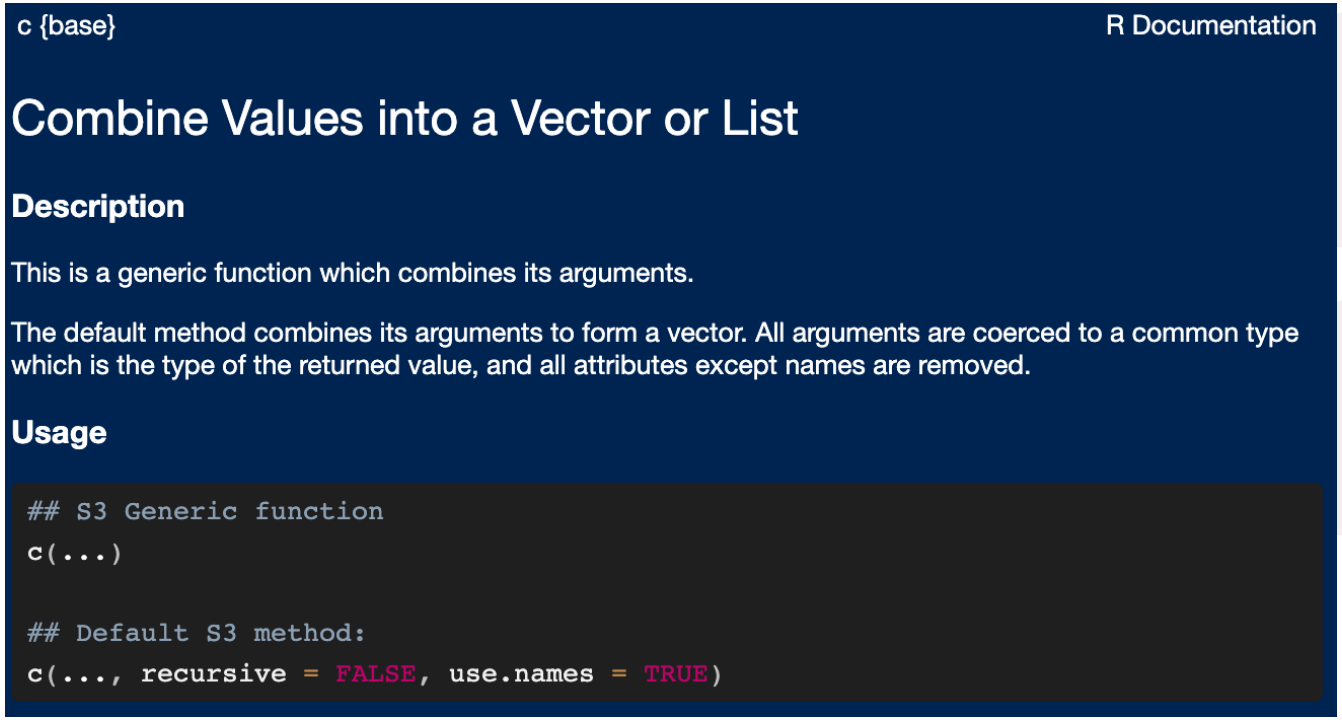
Connections
Import Dataset
List
Global Environment
Values
c 3
d 5
Files
Plots
Packages
Help
Viewer
R: Combine Values into a Vector or List
Find in Topic
c {base}
R Documentation
Combine Values into a Vector or List
Description
This is a generic function which combines its arguments.
The default method combines its arguments to form a vector. All arguments are coerced to a common type which is the type of the returned value, and all attributes except names are removed.
Usage
S3 Generic function
c(...)

Help Details

- Typing “?” then the command name will give you help on the command name
- Typically, examples you can try may be available at the bottom of the help information



c {base} R Documentation

Combine Values into a Vector or List

Description

This is a generic function which combines its arguments.

The default method combines its arguments to form a vector. All arguments are coerced to a common type which is the type of the returned value, and all attributes except names are removed.

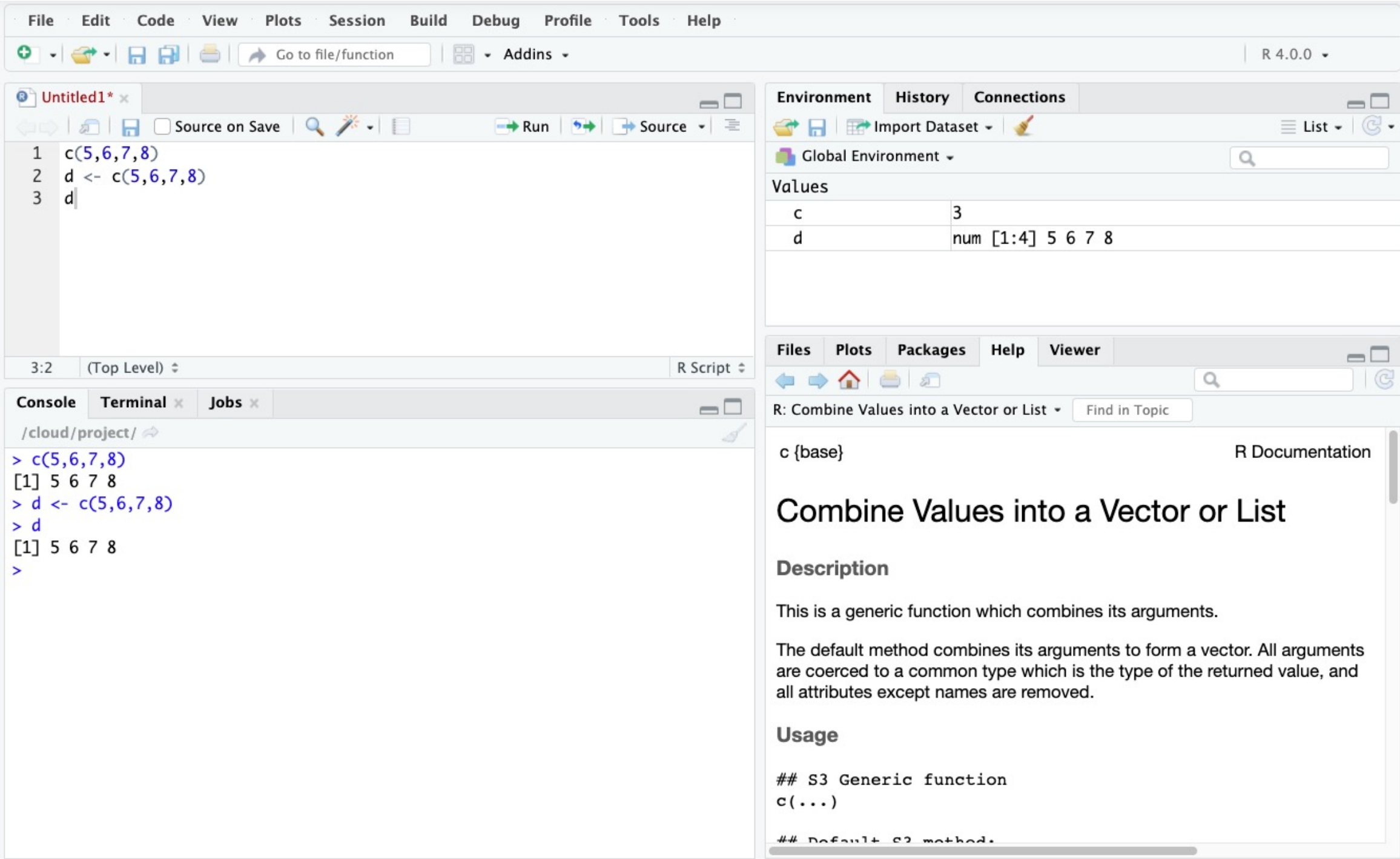
Usage

```
## S3 Generic function
c(...)

## Default S3 method:
c(..., recursive = FALSE, use.names = TRUE)
```

Create an object

- Running c(5,6,7,8) will only return the output to console
- To store objects in R memory assign a variable name
  - This allows for reuse of the variable
- Type "d <-" in front of c(5,6,7,8) : d <- c(5,6,7,8)
- This creates an R object called “d” that is a vector of 5,6,7,8
- Keyboard shortcut for <-
  - -PC: Alt and - at the same time
  - -Mac: option and - at the same time


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
Untitled1*
Source on Save
Run
Source
1 c(5,6,7,8)
2 d <- c(5,6,7,8)
3 d
3:2
(Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
> c(5,6,7,8)
[1] 5 6 7 8
> d <- c(5,6,7,8)
> d
[1] 5 6 7 8
>
Environment
History
Connections
Import Dataset
List
Global Environment
Values
c 3
d num [1:4] 5 6 7 8
Files
Plots
Packages
Help
Viewer
R: Combine Values into a Vector or List
Find in Topic
c {base}
R Documentation
Combine Values into a Vector or List
Description
This is a generic function which combines its arguments.
The default method combines its arguments to form a vector. All arguments are coerced to a common type which is the type of the returned value, and all attributes except names are removed.
Usage
S3 Generic function
c(...)

Make more vectors

- e <- c(11,12,13,15)
- f <- c(1,2,3,4)
- g <- c(1,2,3,15)

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function | Addins | R 4.0.0

Untitled1*

Source on Save | Run | Source

```
1  e <- c(11,12,13,15)
2  f <- c(1,2,3,4)
3  g <- c(1,2,3,15)
4  e
5  f
6  g
7
```

7:1 (Top Level) R Script

Console Terminal Jobs

/cloud/project/

```
> e <- c(11,12,13,15)
> f <- c(1,2,3,4)
> g <- c(1,2,3,15)
> e
[1] 11 12 13 15
> f
[1] 1 2 3 4
> g
[1]  1  2  3 15
>
```

Environment History Connections

Import Dataset | List

Global Environment

Values

c	3
d	num [1:4] 5 6 7 8
e	num [1:4] 11 12 13 15
f	num [1:4] 1 2 3 4
g	num [1:4] 1 2 3 15

Files Plots Packages Help Viewer

standard devia

R: Search Results | Find in Topic

Search Results

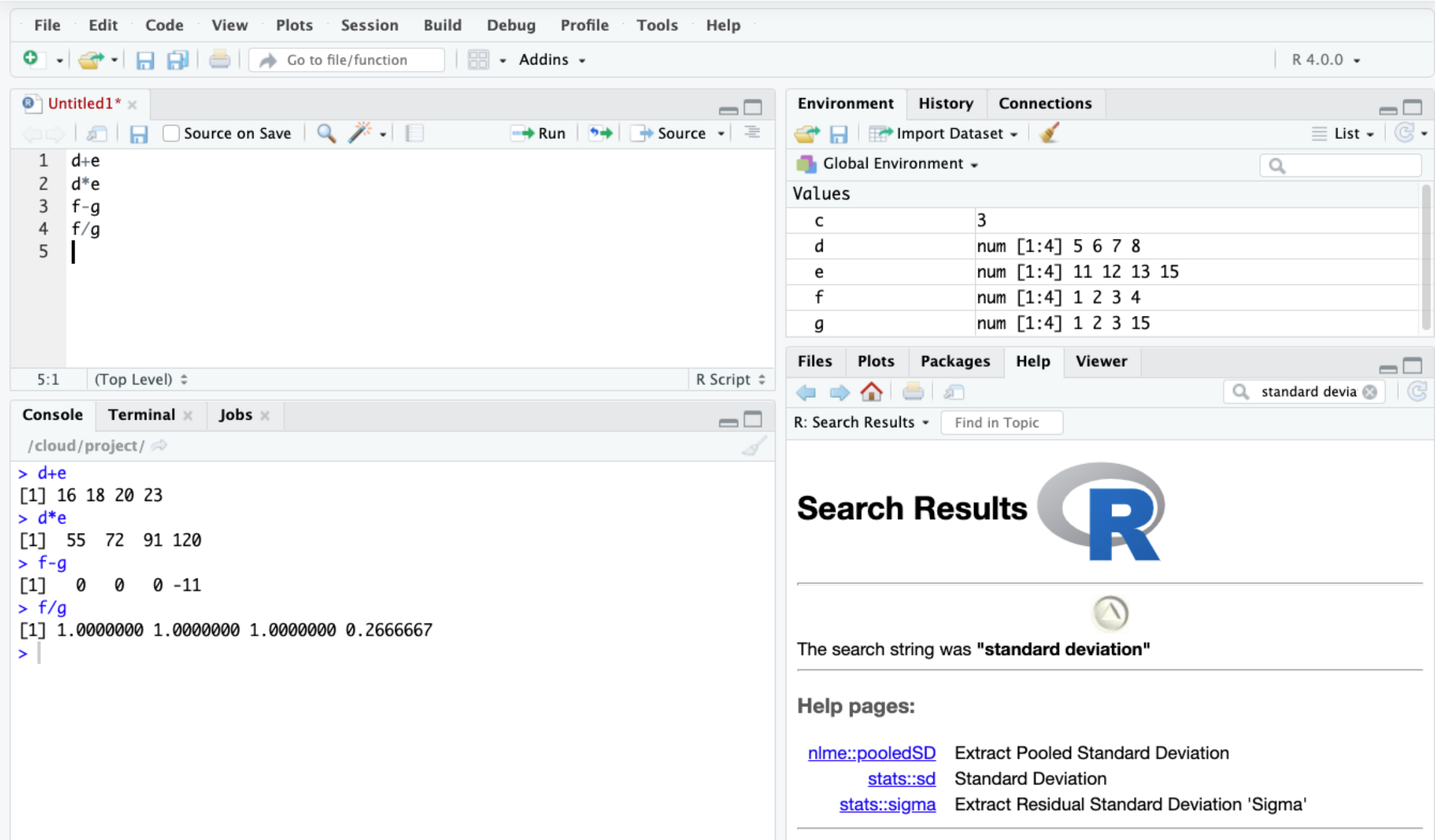
The search string was **"standard deviation"**

Help pages:

nlme::pooledSD	Extract Pooled Standard Deviation
stats::sd	Standard Deviation
stats::sigma	Extract Residual Standard Deviation 'Sigma'

Perform Vector Calculations

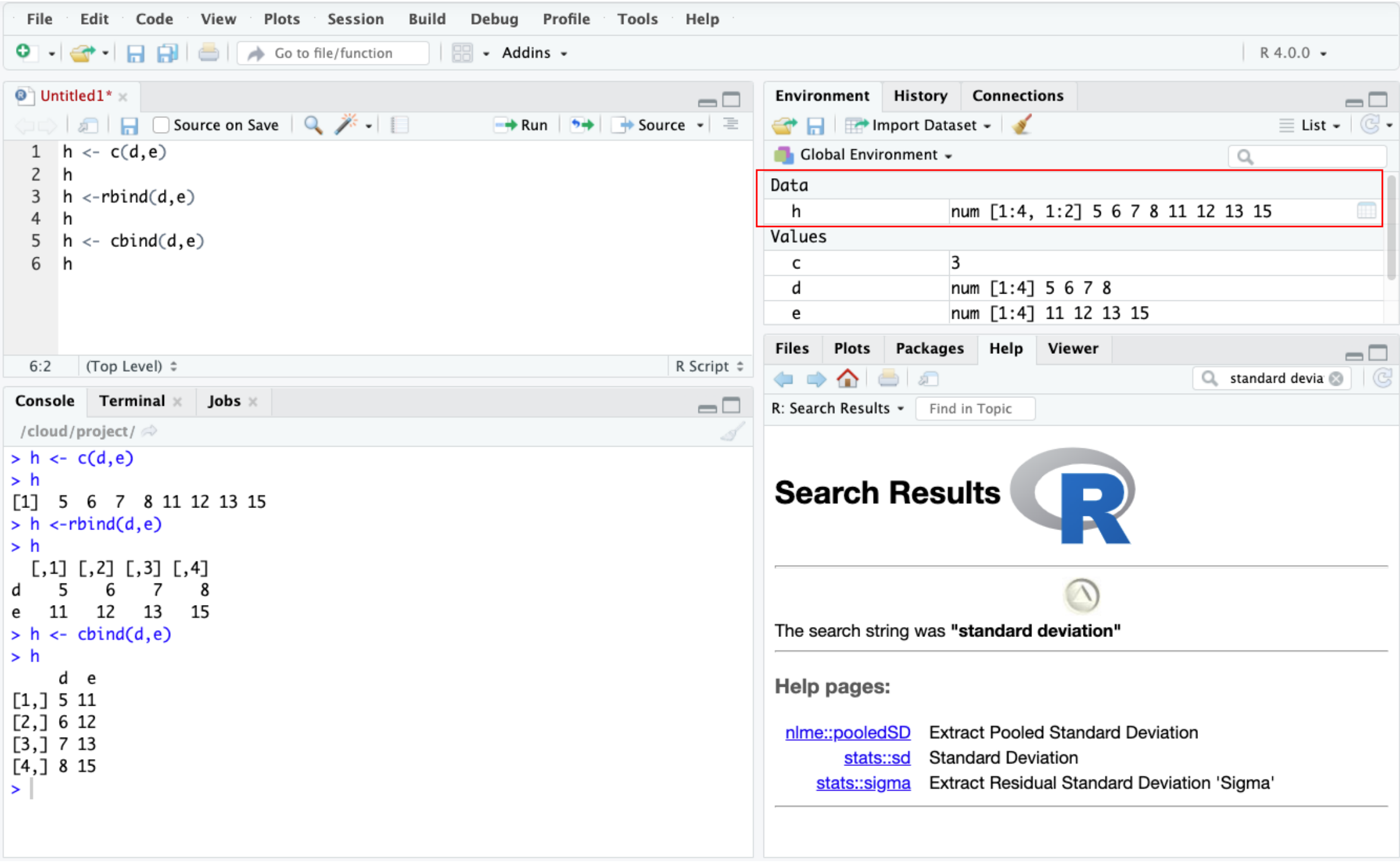
- d+e
- d*e
- f-g
- f/g


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
Untitled1*
Source on Save
Run
Source
1 d+e
2 d*e
3 f-g
4 f/g
5
5:1
(Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
> d+e
[1] 16 18 20 23
> d*e
[1] 55 72 91 120
> f-g
[1] 0 0 0 -11
> f/g
[1] 1.0000000 1.0000000 1.0000000 0.2666667
>
Environment
History
Connections
Import Dataset
List
Global Environment
Values
c 3
d num [1:4] 5 6 7 8
e num [1:4] 11 12 13 15
f num [1:4] 1 2 3 4
g num [1:4] 1 2 3 15
Files
Plots
Packages
Help
Viewer
standard devia
R: Search Results
Find in Topic
Search Results
The search string was "standard deviation"
Help pages:
nlme::pooledSD Extract Pooled Standard Deviation
stats::sd Standard Deviation
stats::sigma Extract Residual Standard Deviation 'Sigma'

Combine Vectors

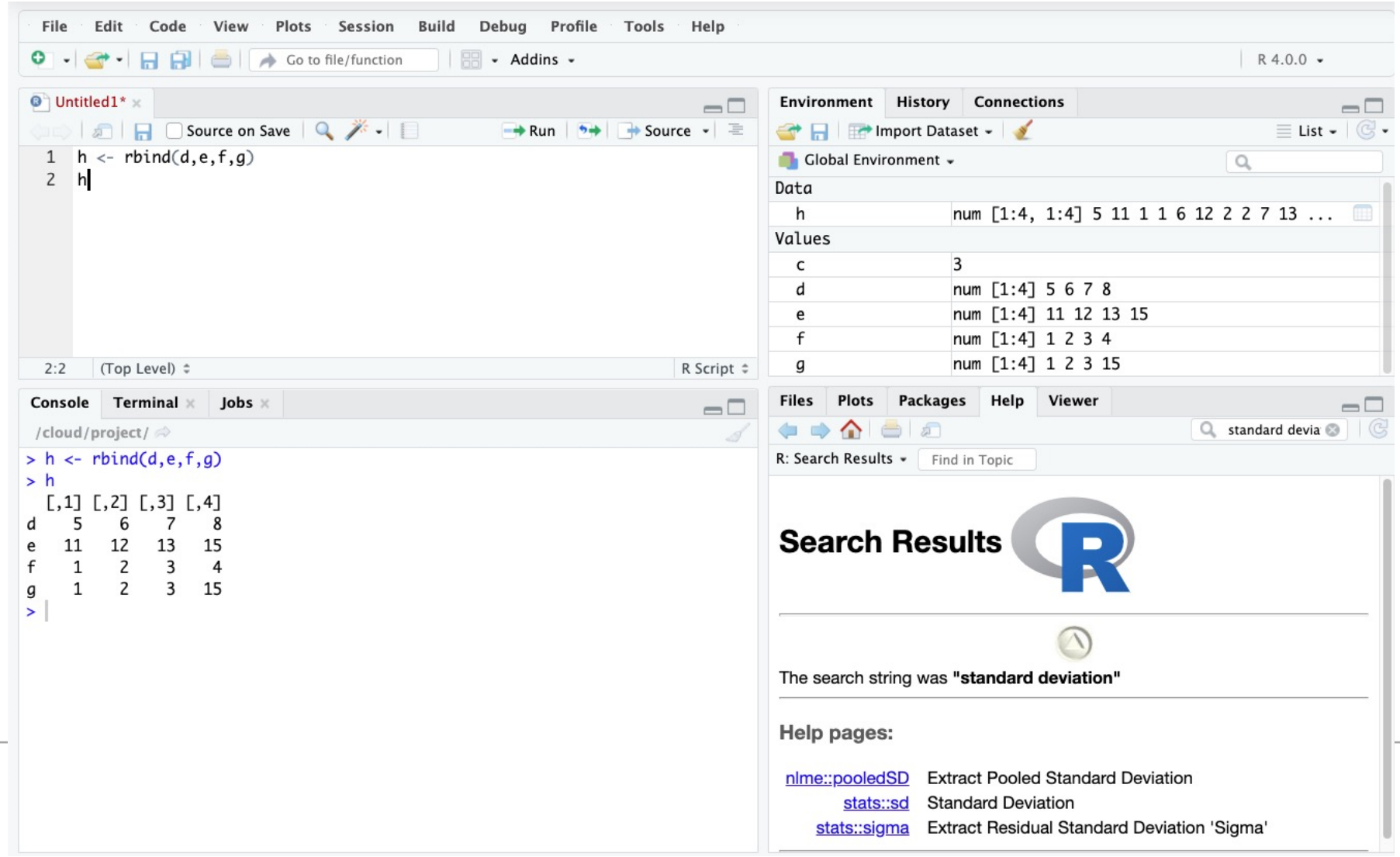
- h <-c(d,e)
- h <-rbind(d,e)
- h <-cbind(d,e)

- Not sure how c will combine vectors?
  - Run the example and see!
- Not sure what rbind and cbind do?
  - Check their help documentation!


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
Untitled1*
Source on Save
Run
Source
1 h <- c(d,e)
2 h
3 h <-rbind(d,e)
4 h
5 h <- cbind(d,e)
6 h
6:2
(Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
> h <- c(d,e)
> h
[1] 5 6 7 8 11 12 13 15
> h <-rbind(d,e)
> h
[,1] [,2] [,3] [,4]
d 5 6 7 8
e 11 12 13 15
> h <- cbind(d,e)
> h
d e
[1,] 5 11
[2,] 6 12
[3,] 7 13
[4,] 8 15
>
Environment
History
Connections
Import Dataset
List
Global Environment
Data
h
num [1:4, 1:2] 5 6 7 8 11 12 13 15
Values
c
3
d
num [1:4] 5 6 7 8
e
num [1:4] 11 12 13 15
Files
Plots
Packages
Help
Viewer
standard devia
R: Search Results
Find in Topic
Search Results
The search string was "standard deviation"
Help pages:
nlme::pooledSD Extract Pooled Standard Deviation
stats::sd Standard Deviation
stats::sigma Extract Residual Standard Deviation 'Sigma'

Let's Make a Data Table!

h <- rbind(d,e,f,g)



Colnames and Rownames

- Independent of the data
- Makes it easier to work with data later
  - ?colnames
  - ?rownames
- Type the following:
  - colnames(h) <- c("Col1","Col2","Col3","Col4")
  - rownames(h) <- c("Row1","Row2","Row3","Row4")

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function | Addins | R 4.0.0

Untitled1*

Source on Save | Run | Source

```
1  h
2  colnames(h) <- c("Col1","Col2","Col3","Col4")
3  h
4  rownames(h) <- c("Row1","Row2","Row3","Row4")
5  h
6
```

6:1 (Top Level) R Script

Console Terminal Jobs

/cloud/project/

```
  [,1] [,2] [,3] [,4]
d    5    6    7    8
e   11   12   13   15
f    1    2    3    4
g    1    2    3   15
> colnames(h) <- c("Col1","Col2","Col3","Col4")
> h
  Col1 Col2 Col3 Col4
d    5    6    7    8
e   11   12   13   15
f    1    2    3    4
g    1    2    3   15
> rownames(h) <- c("Row1","Row2","Row3","Row4")
> h
     Col1 Col2 Col3 Col4
Row1    5    6    7    8
Row2   11   12   13   15
Row3    1    2    3    4
Row4    1    2    3   15
>
```

Environment History Connections

Import Dataset | List

Global Environment

Data	
h	num [1:4, 1:4] 5 11 1 1 6 12 2 2 7 13 ...
Values	
c	3
d	num [1:4] 5 6 7 8
e	num [1:4] 11 12 13 15
f	num [1:4] 1 2 3 4
g	num [1:4] 1 2 3 15

Files Plots Packages Help Viewer

standard devia

R: Search Results | Find in Topic

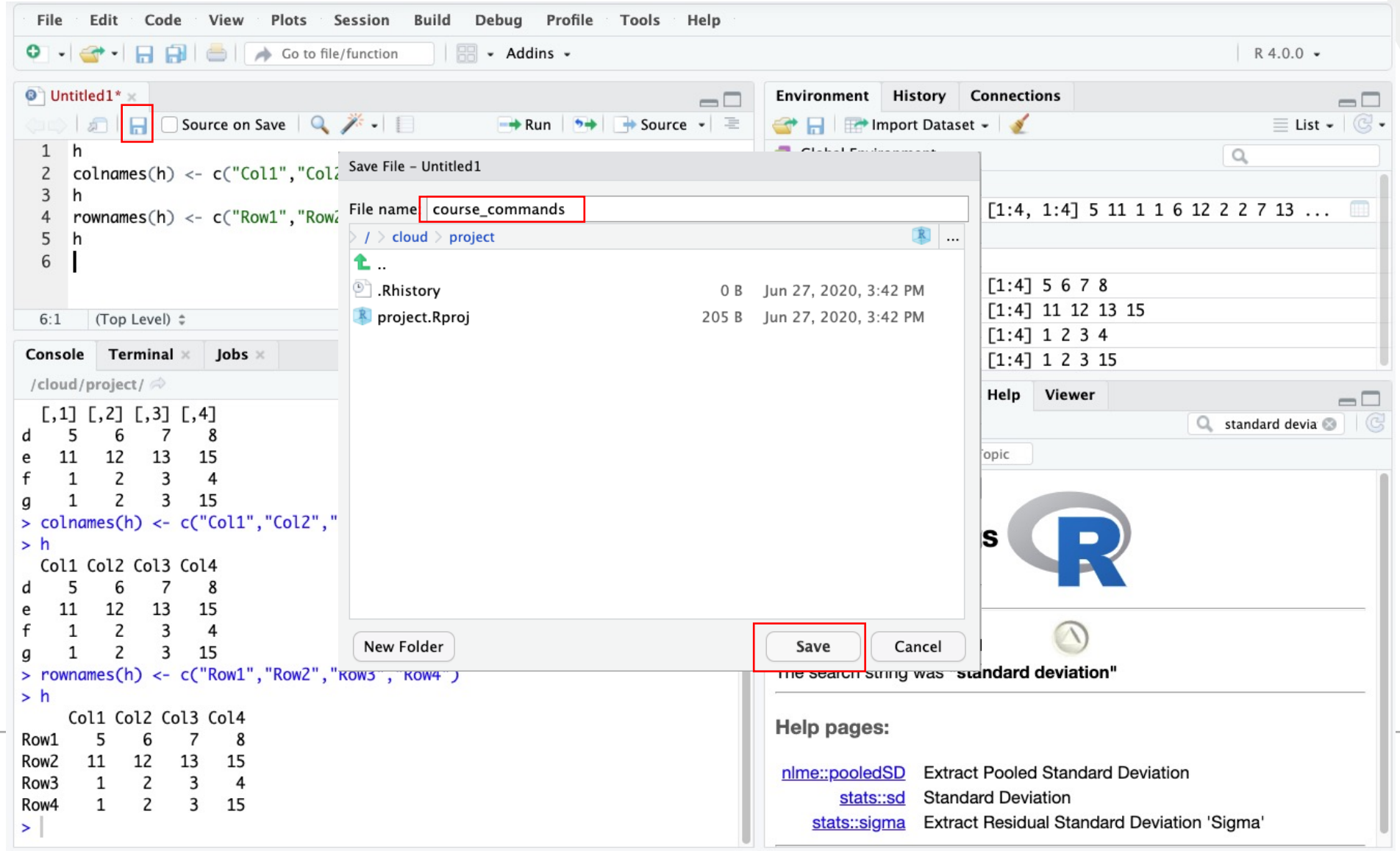
Search Results

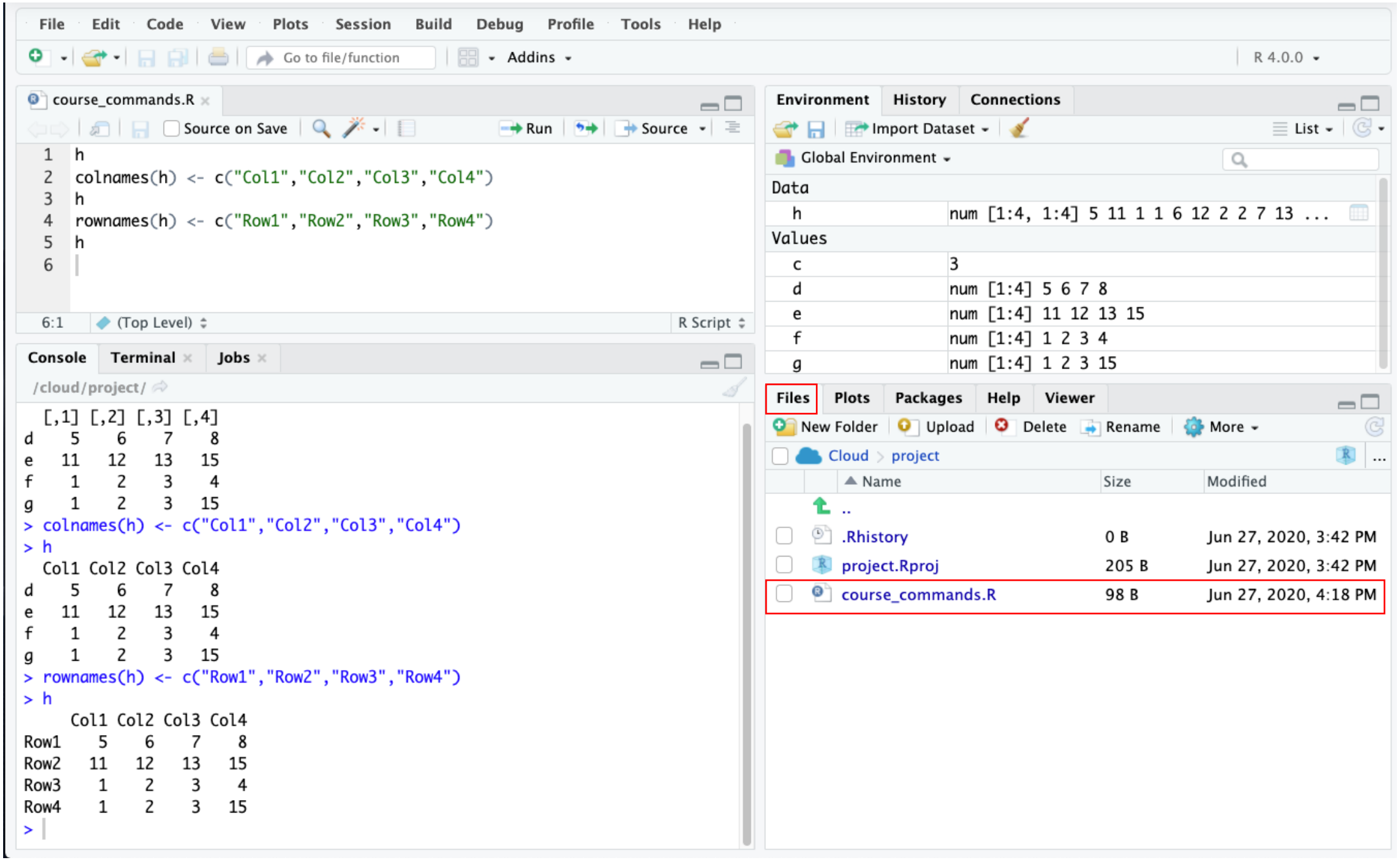
The search string was **"standard deviation"**

Help pages:

nlme::pooledSD	Extract Pooled Standard Deviation
stats::sd	Standard Deviation
stats::sigma	Extract Residual Standard Deviation 'Sigma'

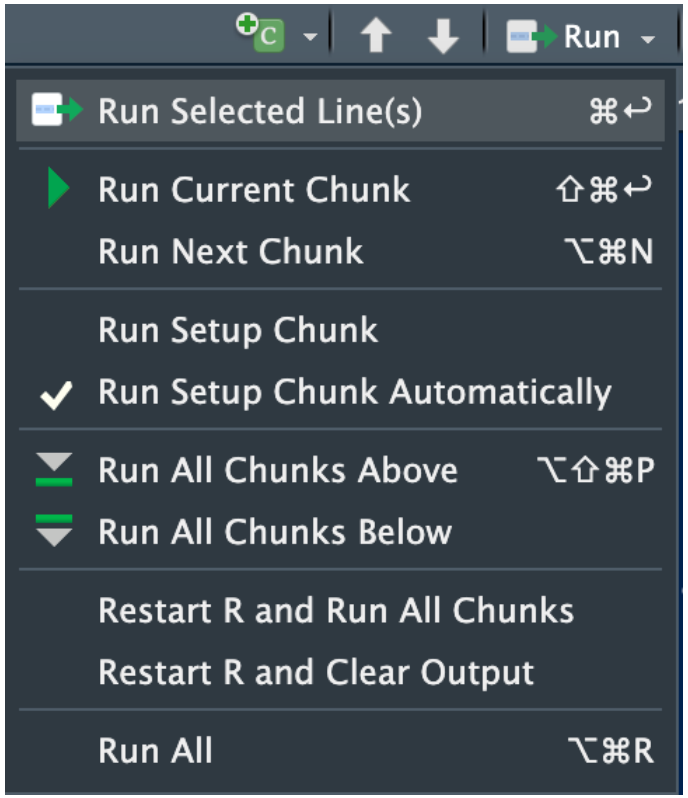
Save your amazing work!

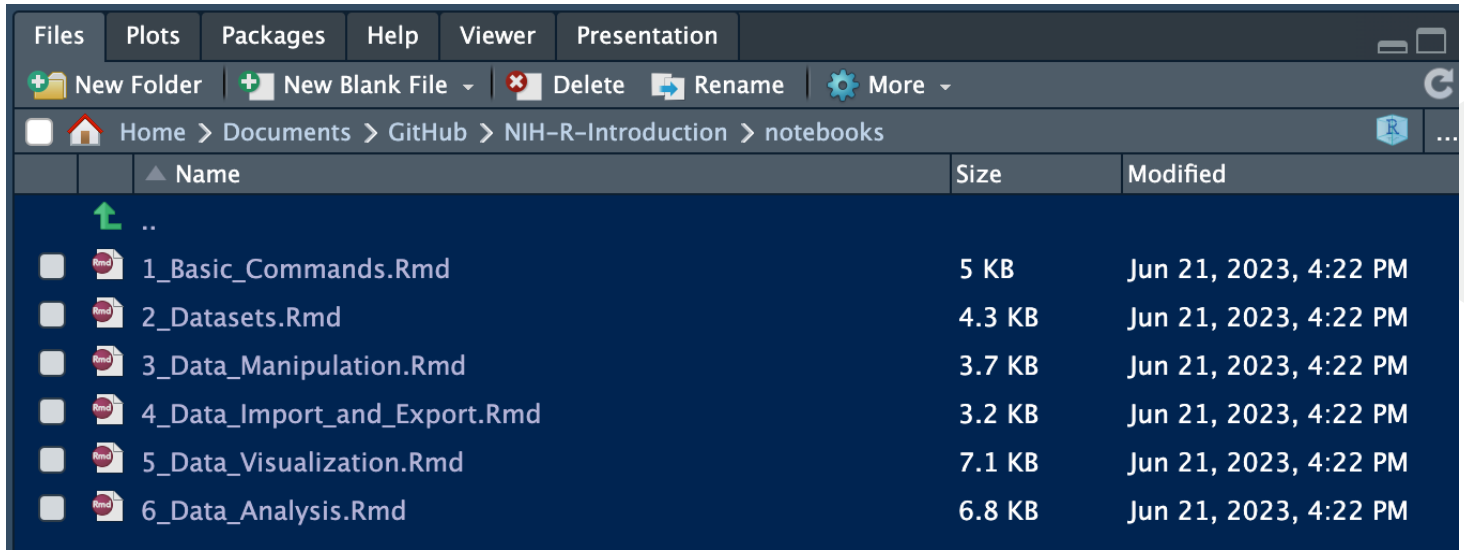



File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
course_commands.R
Source on Save
Run
Source
1 h
2 colnames(h) <- c("Col1","Col2","Col3","Col4")
3 h
4 rownames(h) <- c("Row1","Row2","Row3","Row4")
5 h
6
6:1
(Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
[,1] [,2] [,3] [,4]
d 5 6 7 8
e 11 12 13 15
f 1 2 3 4
g 1 2 3 15
> colnames(h) <- c("Col1","Col2","Col3","Col4")
> h
Col1 Col2 Col3 Col4
d 5 6 7 8
e 11 12 13 15
f 1 2 3 4
g 1 2 3 15
> rownames(h) <- c("Row1","Row2","Row3","Row4")
> h
Col1 Col2 Col3 Col4
Row1 5 6 7 8
Row2 11 12 13 15
Row3 1 2 3 4
Row4 1 2 3 15
>
Environment
History
Connections
Import Dataset
List
Global Environment
Data
h num [1:4, 1:4] 5 11 1 1 6 12 2 2 7 13 ...
Values
c 3
d num [1:4] 5 6 7 8
e num [1:4] 11 12 13 15
f num [1:4] 1 2 3 4
g num [1:4] 1 2 3 15
Files
Plots
Packages
Help
Viewer
New Folder
Upload
Delete
Rename
More
Cloud
project
Name
Size
Modified
..
.Rhistory 0 B Jun 27, 2020, 3:42 PM
project.Rproj 205 B Jun 27, 2020, 3:42 PM
course_commands.R 98 B Jun 27, 2020, 4:18 PM

Activity 1: 1_Basic_Commands.Rmd

- We just learned about creating R scripts to manipulate basic data (vectors, data frames)
- Run 1_Basic_Command.Rmd notebook to reinforce your skills and learn about running R Markdown
- Please let me know if you run into any issues or have any questions





Questions?

- Recap
  - Accessed R via R Studio or R Studio Cloud
  - Created a script
  - Done basic math operations
  - Created and used vectors
  - Done vector math
  - Created a data frame with named rows and cols
  - Ran a markdown notebook reinforcing these concepts
- Up next:
  - R Built-In Datasets

Datasets

- In the previous section, we created datasets by inputting and combining vectors
- It is more common to import existing data
- R has functionality to import many kinds of data
  - Tabular data like csv, excel and text delimited files
  - Outputs from other analysis packages (e.g., SPSS, Stata)
  - Images and other complex data formats
  - Specific packages for importing bioinformatics data

Built-in Datasets

- Datasets can be imported to or exported from R,
- R and some packages also include built-in datasets
- Built-in datasets are helpful for learning about data wrangling and testing functionality
  - Do not require complex imports
  - Often have example analysis and results for comparison

New Operations

- data(): shows available datasets
- summary(df): summary data for all cols in dataframe
- $: df$column will return the column specified for that dataframe
- Basic plots: hist, boxplot and scatterplot

Activity 2:

Built-in Datasets

- Open 2_Datasets.Rmd file
- This file explores working with built-in datasets and base R plotting
- We will work with the Iris dataset from Base R

Data Manipulation

USE BASE R FUNCTIONS

USE THE TIDYVERSE COLLECTION OF PACKAGES

SPECIFICALLY DESIGNED FOR DATA SCIENCE

What is a package?

A collection of R functions, complied code and data

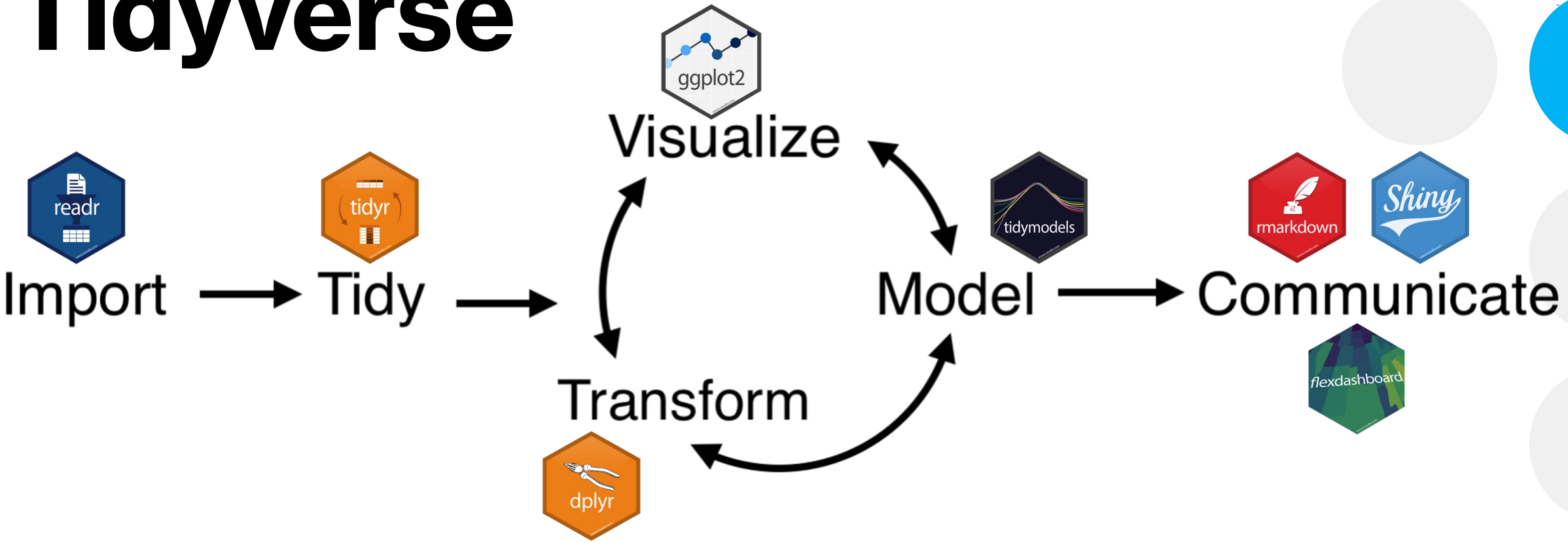
Saved in a directory called “library”

Can be turned on and off

Made by different people so commands may clash

Would be very slow to load everything every time, so load only what you need

Tidyverse

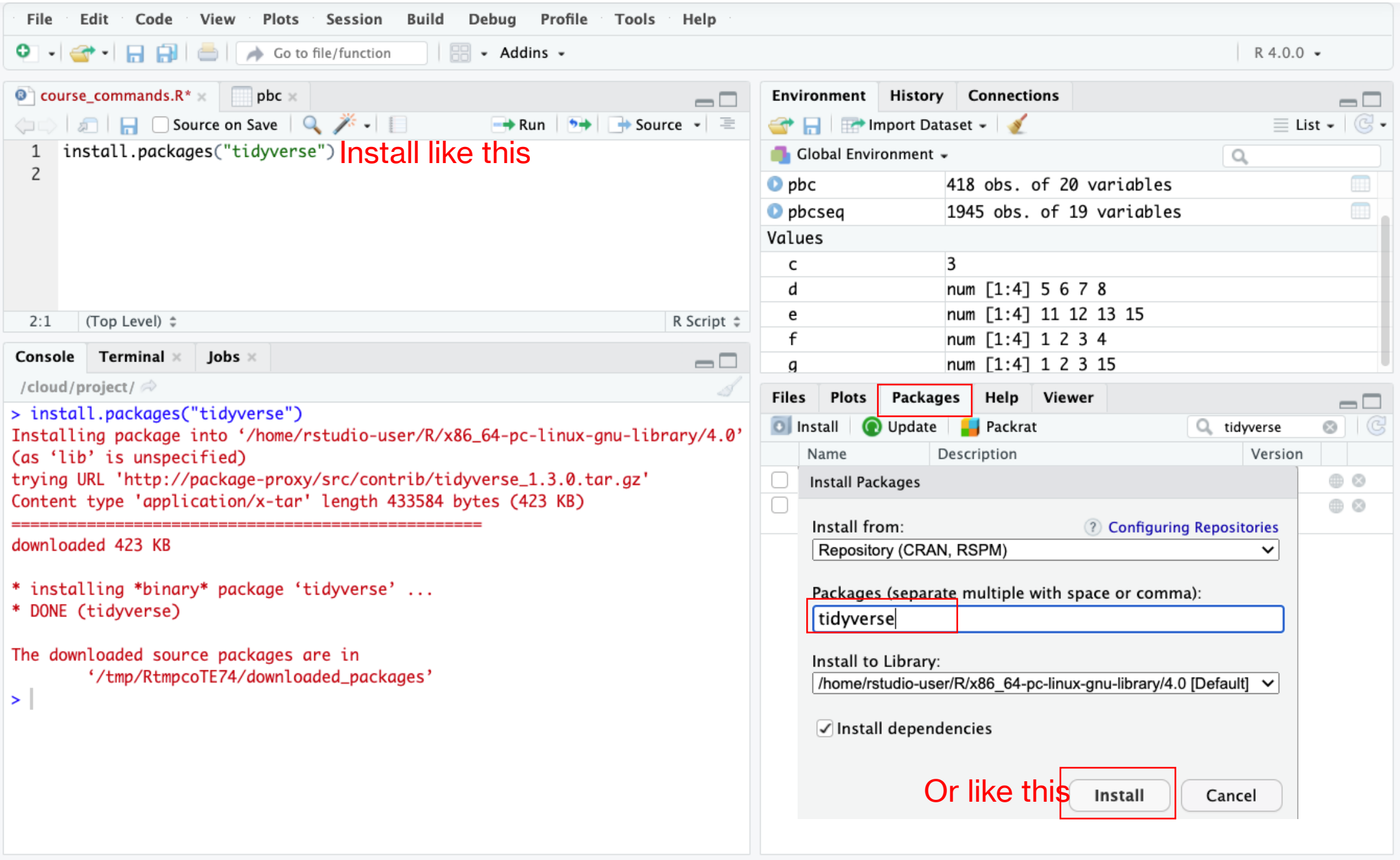


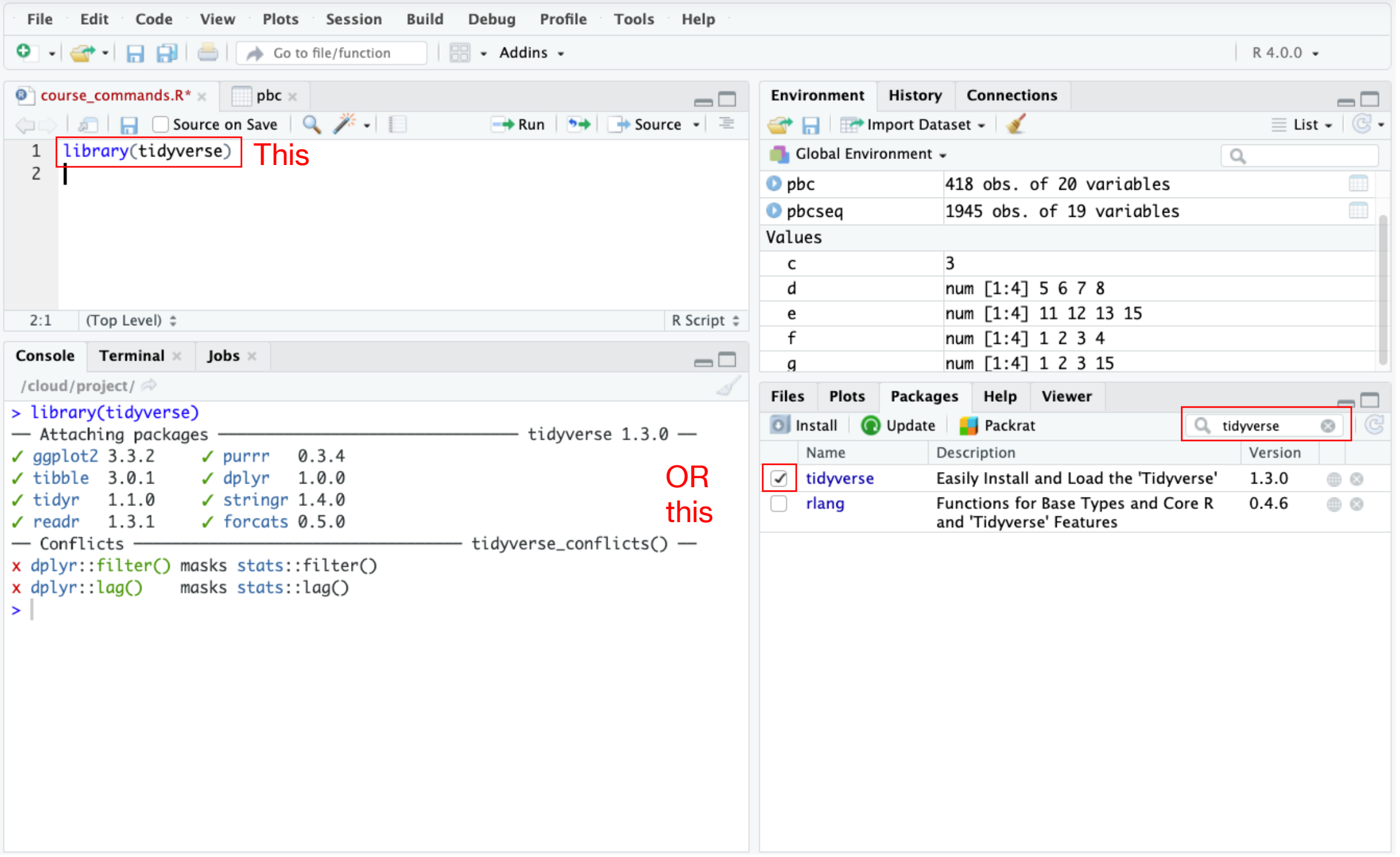
First time install:

```
install.packages("tidyverse")
```

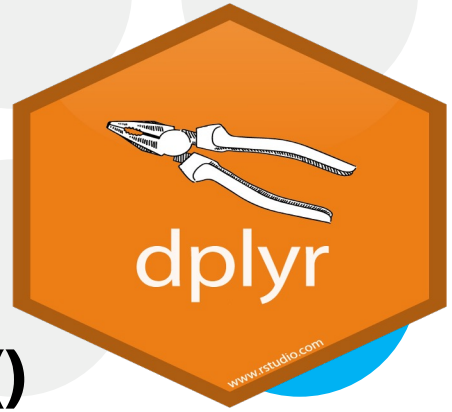
Turn on package:

```
library(tidyverse)
```


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
course_commands.R*
pbc
Source on Save
Run
Source
1 install.packages("tidyverse")
2
Install like this
2:1 (Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
> install.packages("tidyverse")
Installing package into '/home/rstudio-user/R/x86_64-pc-linux-gnu-library/4.0'
(as 'lib' is unspecified)
trying URL 'http://package-proxy/src/contrib/tidyverse_1.3.0.tar.gz'
Content type 'application/x-tar' length 433584 bytes (423 KB)
==
downloaded 423 KB
* installing *binary* package 'tidyverse' ...
* DONE (tidyverse)
The downloaded source packages are in
'/tmp/RtmpcoTE74/downloaded_packages'
>
Environment
History
Connections
Import Dataset
List
Global Environment
pbc 418 obs. of 20 variables
pbcseq 1945 obs. of 19 variables
Values
c 3
d num [1:4] 5 6 7 8
e num [1:4] 11 12 13 15
f num [1:4] 1 2 3 4
g num [1:4] 1 2 3 15
Files
Plots
Packages
Help
Viewer
Install
Update
Packrat
tidyverse
Name
Description
Version
Install Packages
Install from:
Configuring Repositories
Repository (CRAN, RSPM)
Packages (separate multiple with space or comma):
tidyverse
Install to Library:
/home/rstudio-user/R/x86_64-pc-linux-gnu-library/4.0 [Default]
Install dependencies
Or like this
Install
Cancel


File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
R 4.0.0
course_commands.R*
pbc
Source on Save
Run
Source
1 library(tidyverse)
2
This
2:1 (Top Level)
R Script
Console
Terminal
Jobs
/cloud/project/
> library(tidyverse)
── Attaching packages ──────────────────────────────────── tidyverse 1.3.0 ──
✓ ggplot2 3.3.2 ✓ purrr 0.3.4
✓ tibble 3.0.1 ✓ dplyr 1.0.0
✓ tidyr 1.1.0 ✓ stringr 1.4.0
✓ readr 1.3.1 ✓ forcats 0.5.0
── Conflicts ─────────────────────────────────────── tidyverse_conflicts() ──
x dplyr::filter() masks stats::filter()
x dplyr::lag() masks stats::lag()
>
OR
this
Environment
History
Connections
Import Dataset
List
Global Environment
pbc 418 obs. of 20 variables
pbcseq 1945 obs. of 19 variables
Values
c 3
d num [1:4] 5 6 7 8
e num [1:4] 11 12 13 15
f num [1:4] 1 2 3 4
g num [1:4] 1 2 3 15
Files
Plots
Packages
Help
Viewer
Install
Update
Packrat
tidyverse
Name
Description
Version
tidyverse
Easily Install and Load the 'Tidyverse'
1.3.0
rlang
Functions for Base Types and Core R and 'Tidyverse' Features
0.4.6

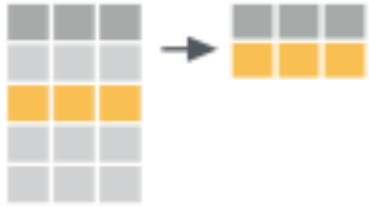
dplyr: Transform your data



arrange()

select()

filter()



mutate()

summarize()

group_by()

Basic structure:
functionName(data, specifics)
Example:
arrange(iris, Sepal.Length)

Pipes!

Keyboard Shortcut:

PC:Ctrl+Shift+M

Mac:Cmd+Shift+M

Pipes allow for sequential operations to be done on the same dataset

- Output from one step is used as input to the next step
- Avoids having to store all intermediate steps

Basic way to chain actions

- group_by_species <- group_by(iris, Species)
- iris_sep_len <-summarize(group_by_species, mean = mean(Sepal.Length))
- View(iris_sep_len)

Pipe sequence (%>%)

- iris_sep_len <- iris %>% group_by(Species) %>% summarize(new_col = mean(Sepal.Length))
- View(iris_sep_len)

	Species	new_col
1	setosa	5.006
2	versicolor	5.936
3	virginica	6.588

Activity 3:
Data Manipulation

- 3_Data_Manipulation.Rmd will explore the following data manipulations using the Tidyverse library:
  - Arrange
  - Select
  - Filter
  - Mutate
  - Summarize
  - GroupBy

Questions?

- Activity 3 used the Tidyverse packages to explore data manipulation techniques
- Process used the built-in Iris dataset
- Final result was a grouped by aggregation

Concluding Remarks

- This introduction to R introduced the basics of R, built-in datasets and package imports
- Importing and using packages often prevents you from having to “reinvent the wheel”’
- Statistical programming is greatly enhanced when combined with version control and data sharing techniques
- Don’t be afraid of errors and be sure to explore the available resources for your work

This concludes the Intro to R

Thank you for your attention and participation!

Additional Materials

The following slides provide an overview of activities 4-6. Feel free to explore this topics on your own and use the code to learn more about R!

- Activity 4: Data Import and export
- Activity 5: Data Visualizations
- Activity 6: Basic Data Analysis

Data Import and Export

- Data comes in many formats
- There are a variety of tools for importing and exporting data
- R can handle data in csv, tab-delimited, excel formats, images and more

Save a table as a file

- write.table(iris_mutate,"../data/iris_mutate.txt",row.names=F,sep="\t")
- write.table is the command
- iris_mutate is the data to be written
- "../data/iris_mutate.txt" is the file path to write to
  - .. means go up a directory
  - Then go into the data directory and name the file iris_mutate.txt
- row.names=F (False, do not write row names)
- Sep = "\t" for tab delimited data

Read Data From Website

- read_csv() and read_tsv() are special cases of the more general read_delim(). They're useful for reading the most common types of flat file data, comma separated values and tab separated values, respectively.

- File can be a url where data is stored
- Run `?read_tsv` for more help information

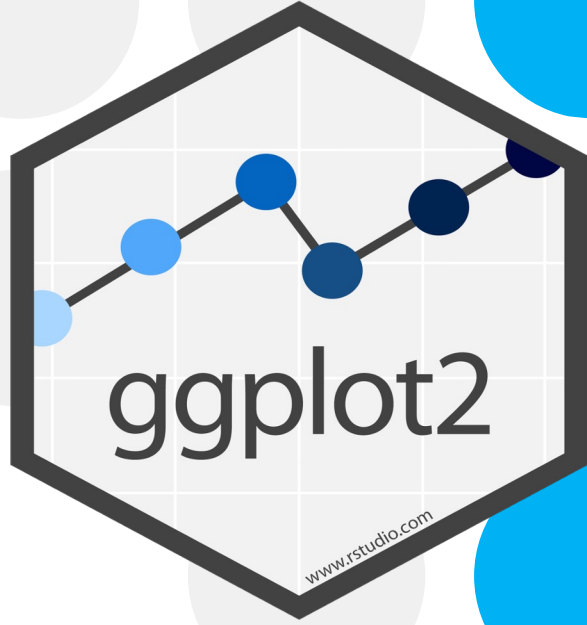
Activity 4:
Data Import and Export

- 4_Data_Import_and_Export.Rmd will explore the following:
- Save data as tab delimited text
- Save data as a csv file
- Load both tab delimited and csv files
- Load data from a url

Visualizations for Today

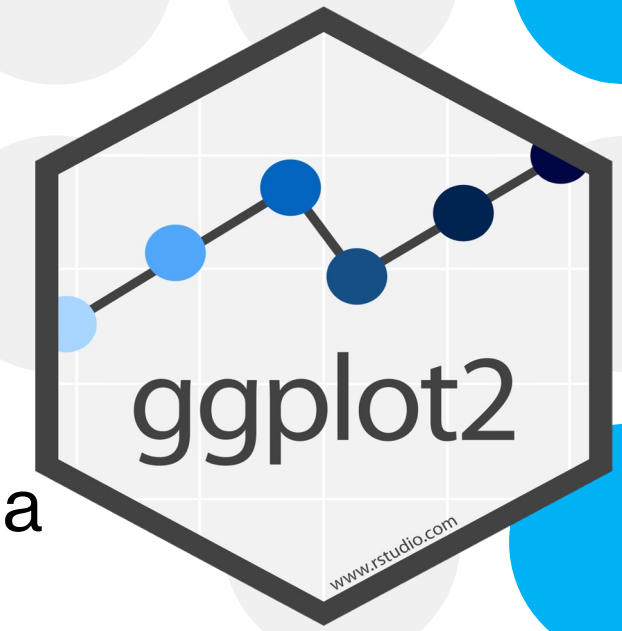
- Pie chart
- Bar plot
- Histogram
- Density Plot
- Scatter plot
- Box Plot
- Heat Map
- Faceted plots (multiple plots in the same figure)

ggplot2: Visualize Data



- Part of Tidyverse
- Easy out of box formatting
- Handles complex data quickly
- Default options are aesthetically pleasing
- Layering system = add complexity as you go
- Automatic scaling generally works well
- Great documentation and support

ggplot2: Visualize Data



What you need:

1. A data object
2. Aesthetic mappings (aes): how variables in the data are assigned to visual properties
    - x- and y-direction
    - shapes, colors, lines
3. A geometry object (geom): the type of plot

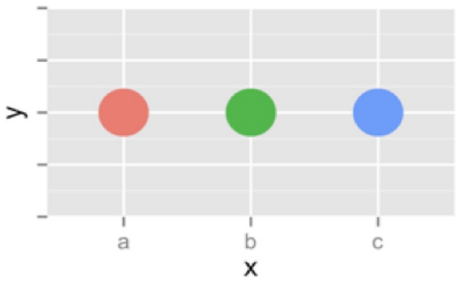
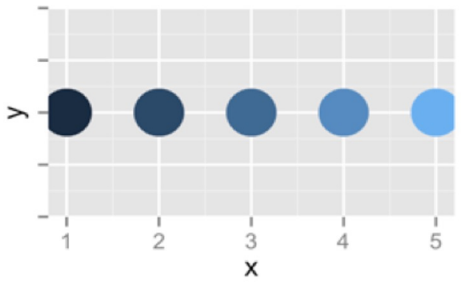
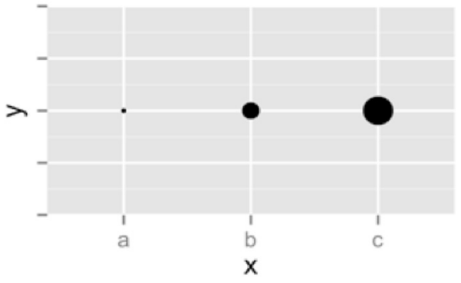
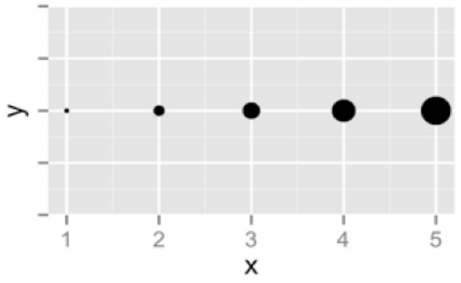
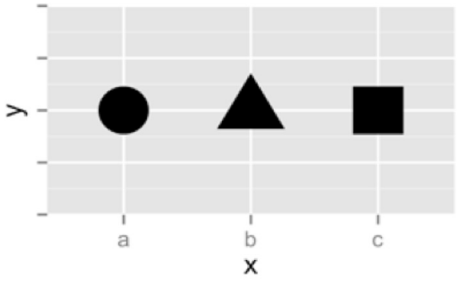
Basic structure:

```
ggplot(data, aes(x=variable)) + geom_type()
```

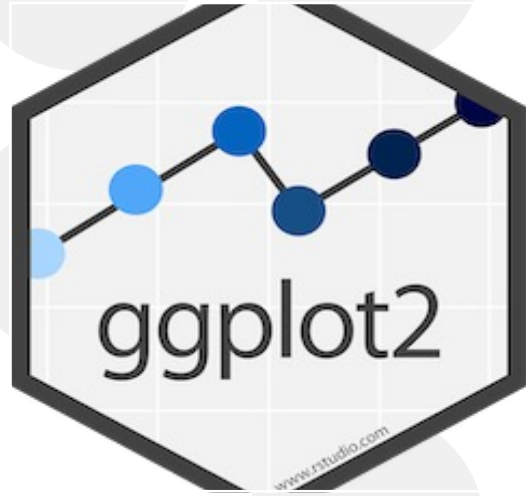
Example:

```
ggplot(iris, aes(x=Sepal.Length)) + geom_bar()
```

Aesthetic mapping options

	Discrete	Continuous
Color		
Size		
Shape		

ggplot2: Faceting



- Divide a plot into subplots based on one or more discrete variable
- Can be used with a variety of plot types
- There are a couple of facet flavors

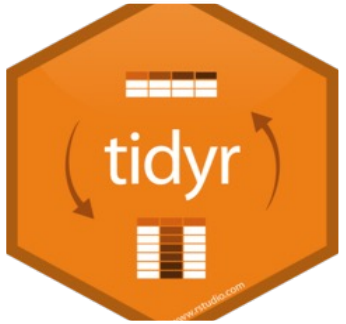
t + facet_grid(cols = vars(fl))
facet into columns based on fl

t + facet_grid(rows = vars(year))
facet into rows based on year

t + facet_grid(rows = vars(year), cols = vars(fl))
facet into both rows and columns

t + facet_wrap(vars(fl))
wrap facets into a rectangular layout

tidr: gather



- Transform data from wide to long format
- Typically, each variable is in its own column and each observation/case is its own row (wide format)
- **gather(**data, key, value**)**
- Moves column names into a **key** column, gathering the column values into a single **value** column (long format)

country	1999	2000
A	0.7K	2K
B	37K	80K
C	212K	213K

→

country	year	cases
A	1999	0.7K
B	1999	37K
C	1999	212K
A	2000	2K
B	2000	80K
C	2000	213K

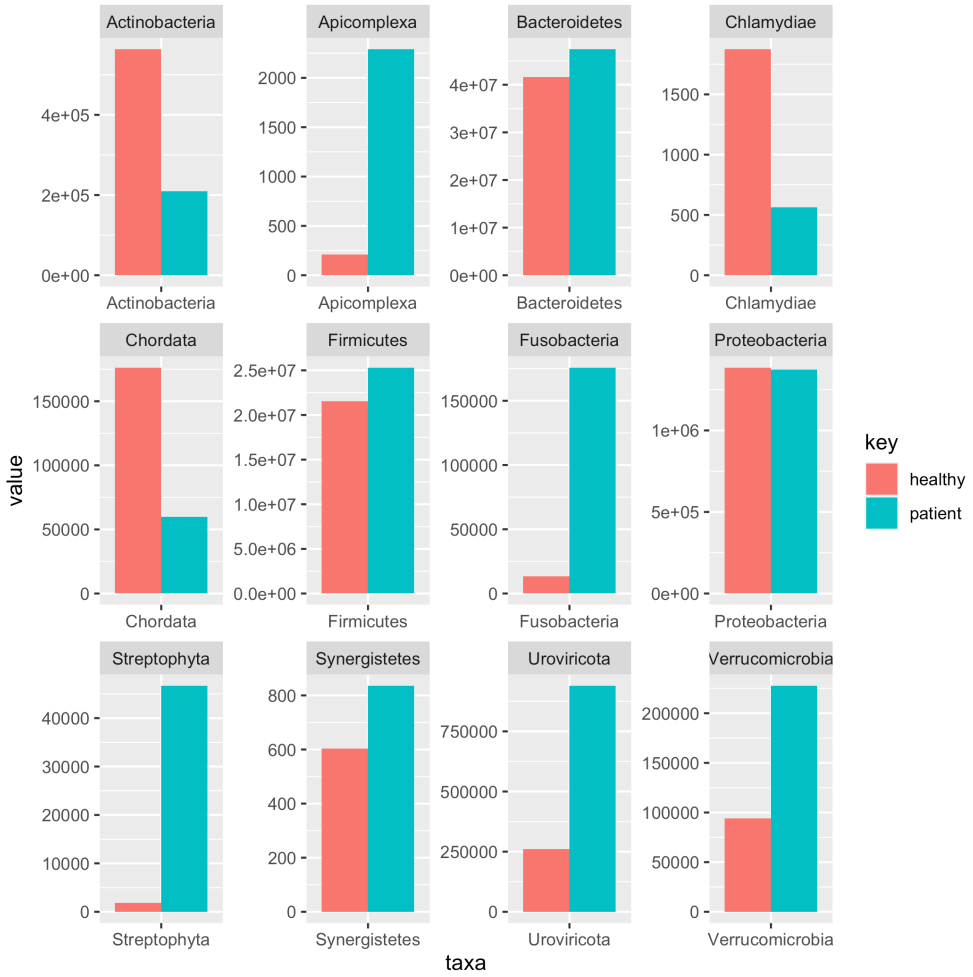
key value

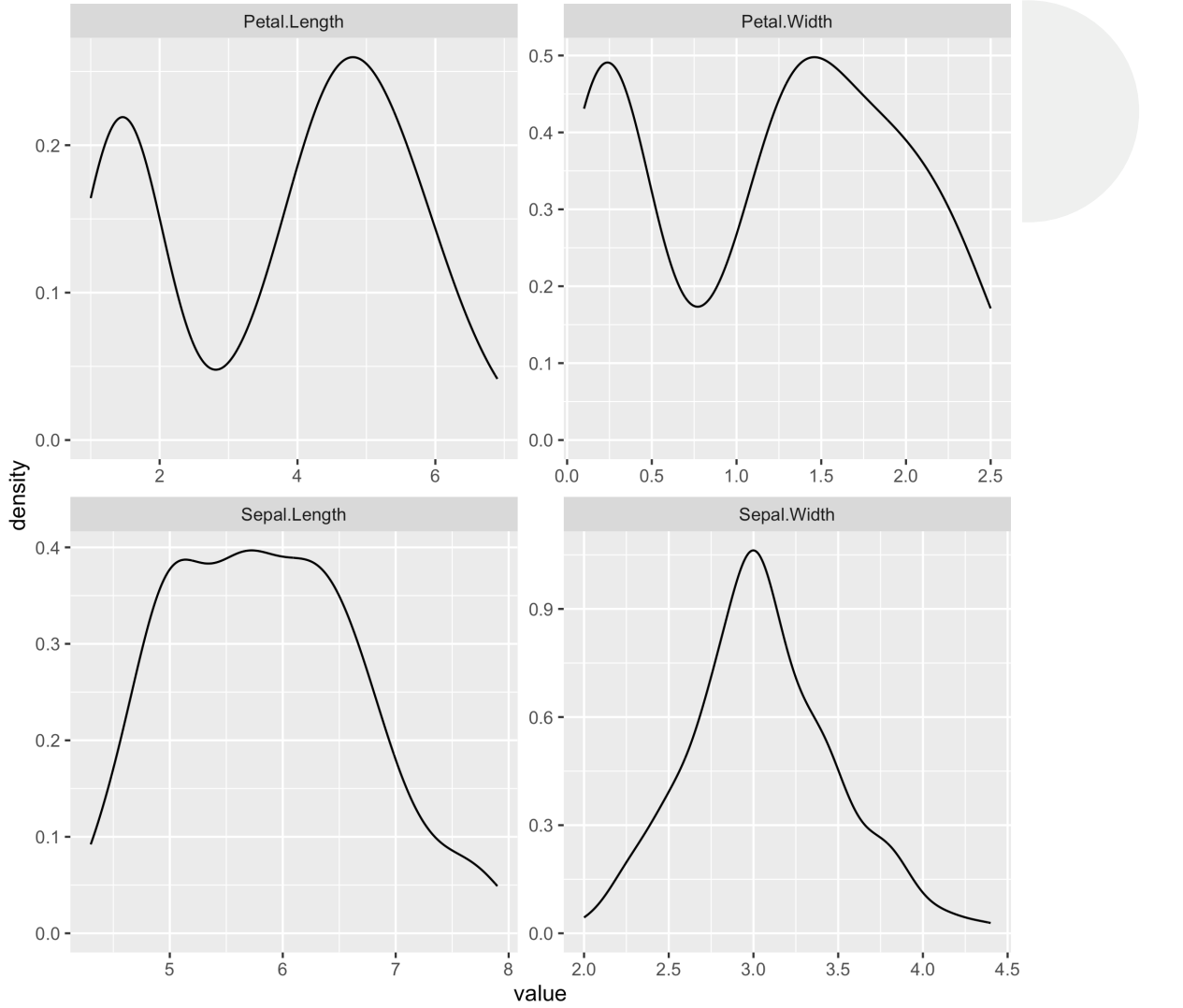
Activity 5:
Data Visualization

- 5_Data_Visualization.Rmd explores plotting of various data types

- Explore plotting and data visualizations

Questions on Basic Visualizations?





Data Analysis in R

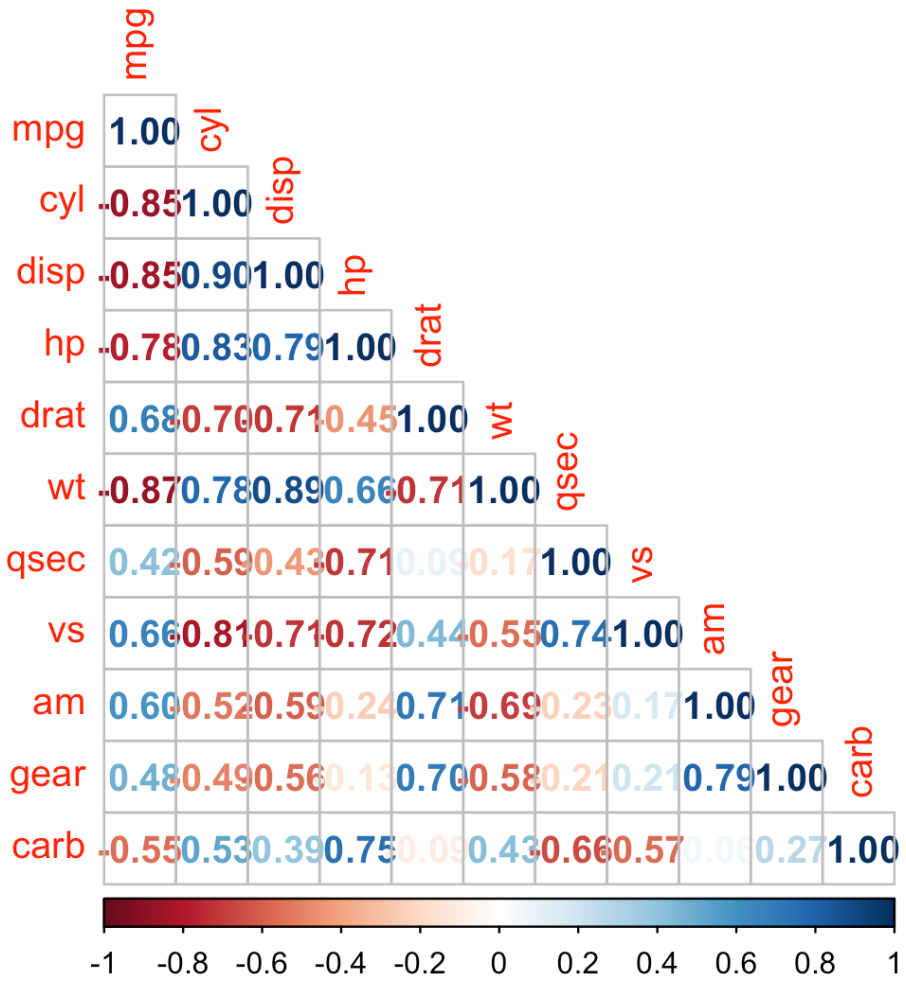
- Correlations
  - Pearson
- t-tests
  - Single sample
  - Independent
  - Paired

Correlation

- Measure of how well two variables hang together
- Range from -1 to 1
- 1 is a perfect positive correlation
- -1 is an inverse correlation

Correlation Matrix

- Diagonal is all 1's
  - Each variable is a perfect correlation with itself
- Positive and negative correlations are color coded
  - Blue is positive
  - Red is negative
- Strength is shown in darker colors



Correlation Test

Cor.test

P-value shows significance

Correlation coefficient is shown at bottom

```r
cor.test(mtcars$mpg, mtcars$hp)
```

```
        Pearson's product-moment correlation

data:  mtcars$mpg and mtcars$hp
t = -6.7424, df = 30, p-value = 1.788e-07
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.8852686 -0.5860994
sample estimates:
       cor
-0.7761684
```

t-tests

- Single sample
  - Compares a sample to a known value (mu)
- Independent
  - Compares two samples which are not related
- Paired
  - Compares two samples which are related

One Sample t-test

- Compares a vector of data against a know value (mu)
- p-value indicates significance
- Mean of vector is shown at bottom

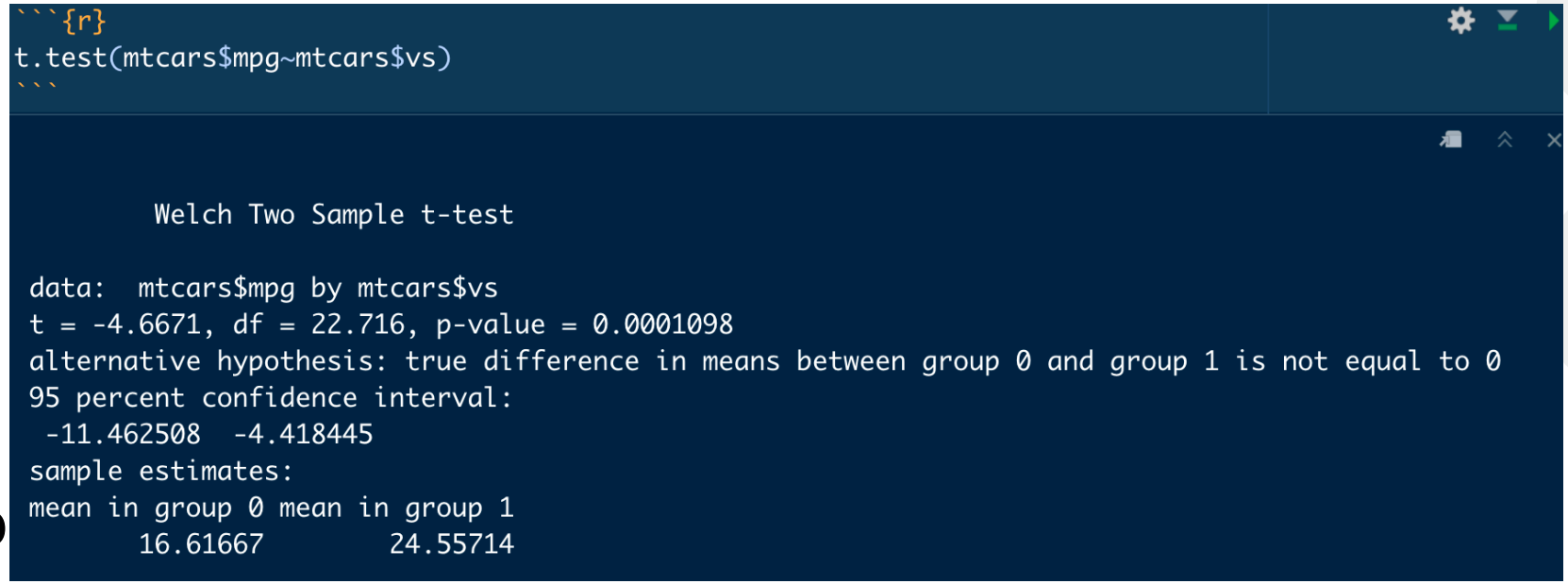
```{r}
t.test(mtcars$wt, mu=3)
```

```
        One Sample t-test

data:  mtcars$wt
t = 1.256, df = 31, p-value = 0.2185
alternative hypothesis: true mean is not equal to 3
95 percent confidence interval:
 2.864478 3.570022
sample estimates:
mean of x
  3.21725
```

Two Sample Independent t-test

- Compares two vectors of numeric data
- Determines if means are different
- p-value indicates significance
- Means of each group displayed at bottom



Paired-Samples t-test

- Compares two related samples
- p-value indicates significance
- Average of the differences is shown at the bottom

```r
t.test(ChickWeightWide$weight.0, ChickWeightWide$weight.2, paired = TRUE)
```

```
        Paired t-test

data:  ChickWeightWide$weight.0 and ChickWeightWide$weight.2
t = -17.409, df = 44, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -9.496402 -7.525820
sample estimates:
mean of the differences
              -8.511111
```

Activity 6:
Data Analysis in R

- 6_Data_Analysis.Rmd explores two basic analysis techniques
  - Correlations
  - t-tests

- MANY more analysis tools exist, this is only an introduction to the basics