

INTRODUCTION TO R

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Senior Data Scientist



Topics Covered

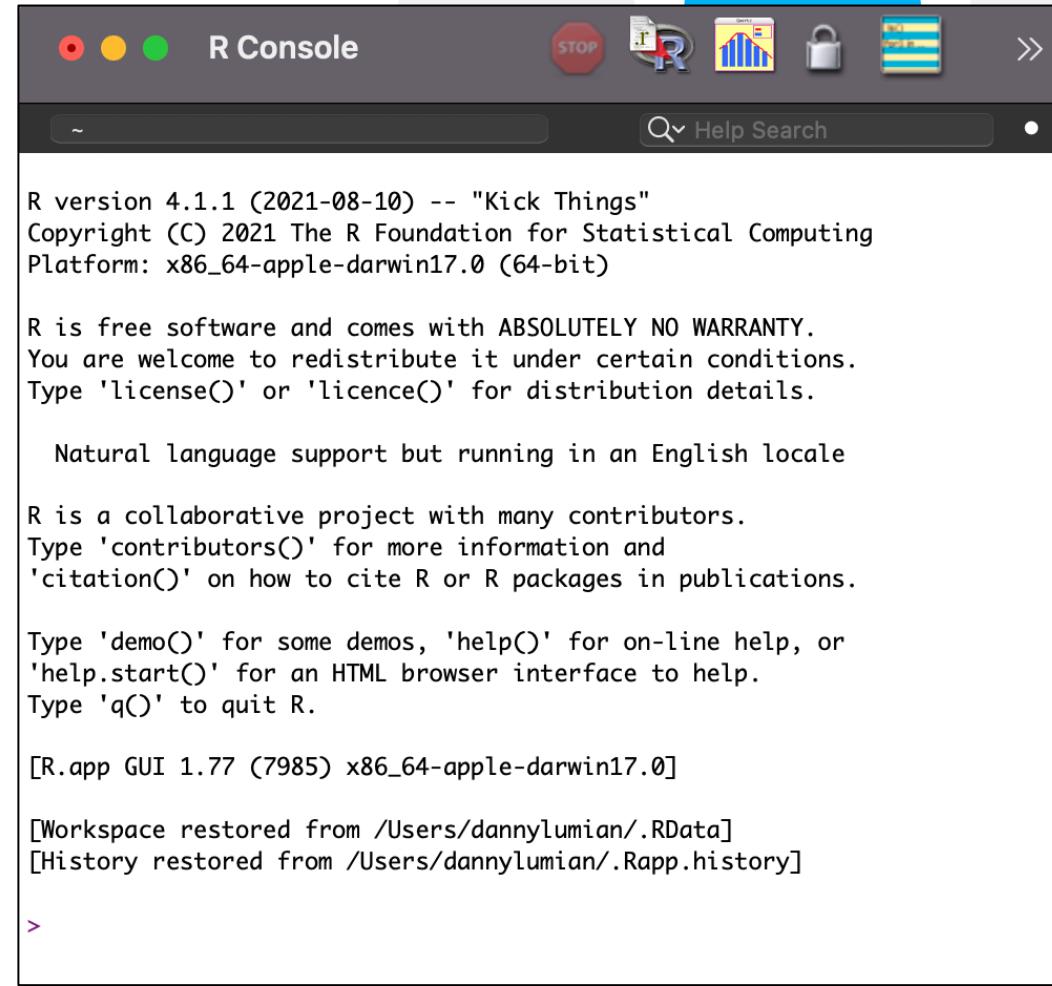
- R platforms
 - R
 - Posit/R Studio
 - Posit Cloud/R Studio Cloud
- R file types
 - R script
 - R markdown
 - R notebook
- Basic R commands
- R packages and built-in datasets
- Data manipulation
- Data visualization
- Data import and export
- Data analysis



What is R?



- A programming language and open-source software environment that can
 - Manipulate data
 - Visualize data
 - Perform statistics
- Free and relatively easy to run in any environment
- <https://www.r-project.org/>



A screenshot of the R Console interface. The title bar says "R Console". The main area displays the R startup message:

```
R version 4.1.1 (2021-08-10) -- "Kick Things"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin17.0 (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.

Natural language support but running in an English locale

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.

[R.app GUI 1.77 (7985) x86_64-apple-darwin17.0]

[Workspace restored from /Users/dannylumian/.RData]
[History restored from /Users/dannylumian/.Rapp.history]

>
```

What is R Studio?

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

R_Intro_Fall_2022 - main - RStudio

Basic_Commands.Rmd Data_Import_and_Export.Rmd

Source Visual

```
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 You can embed an R code chunk like below.  
15  
16 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/  
> print(vector_1)  
[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

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	Size	Modified
..		
.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/Posit
- No need to download software
- Can share projects easily for analysis and teaching
- <https://posit.cloud/>

File Edit Code View Plots Session Build Debug Profile Tools Help

    Go to file/function  Addins

R 4.2.1

 Basic_Commands.Rmd



⚠ 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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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 You can embed an R code chunk like below.  

15  

16 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.Rmd

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.  

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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.
```

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
 ..			
<input type="checkbox"/>  .gitignore	1.8 KB	Aug 25, 2022, 8:33 AM	
<input type="checkbox"/>  .Rhistory	0 B	Aug 25, 2022, 8:33 AM	
<input type="checkbox"/>  Basic_Commands.Rmd	3.9 KB	Aug 25, 2022, 8:33 AM	
<input type="checkbox"/>  Data_Import_and_Export.Rmd	655 B	Aug 25, 2022, 8:33 AM	
<input type="checkbox"/>  Introduction_to_R.pptx	1.3 MB	Aug 25, 2022, 8:33 AM	
<input type="checkbox"/>  R_Intro_Fall_2022.Rproj	205 B	Aug 25, 2022, 8:33 AM	
<input type="checkbox"/>  README.md	75 B	Aug 25, 2022, 8:33 AM	

R File Types

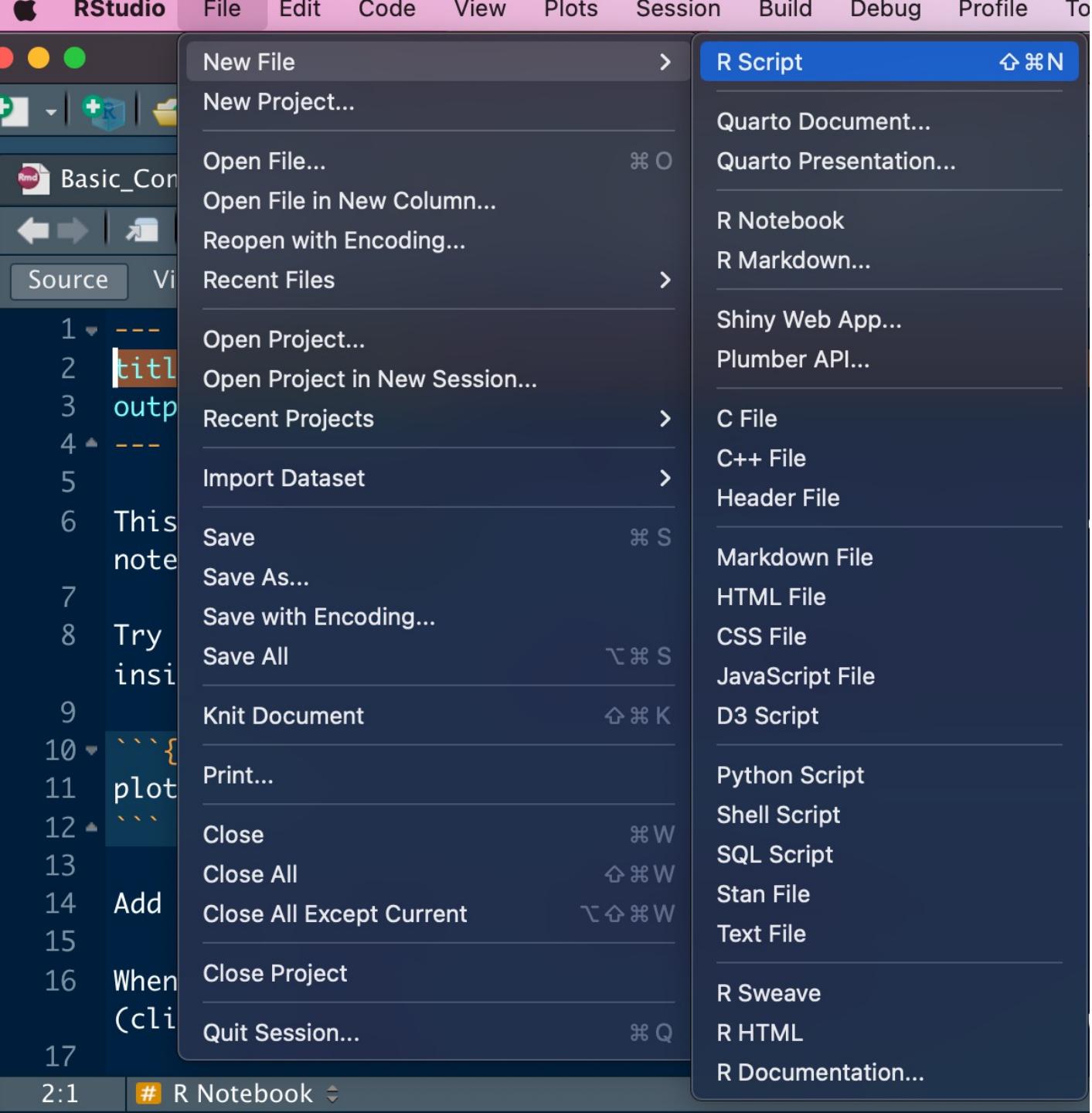
R Script File

- Basic file for saving code
- Can add comments using `#` symbol
- 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

- To 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
- To open an existing file, select File from the top panel
- Select Open File...
- To save a file, select File from the top panel
- Select Save or Save as... and specify the save location



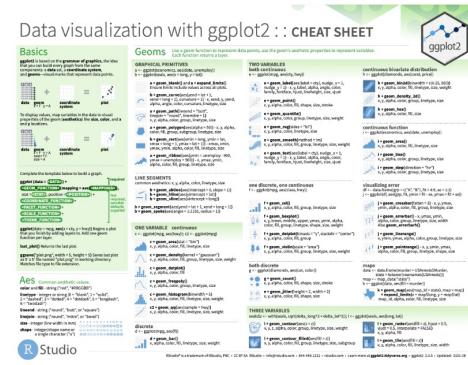
R Studio Cheat sheets:

<https://www.rstudio.com/resources/cheatsheets/>

Data visualization with ggplot2 cheatsheet

The `ggplot2` package lets you make beautiful and customizable plots of your data. It implements the grammar of graphics, an easy to use system for building plots. Updated August 2021.

[DOWNLOAD](#)

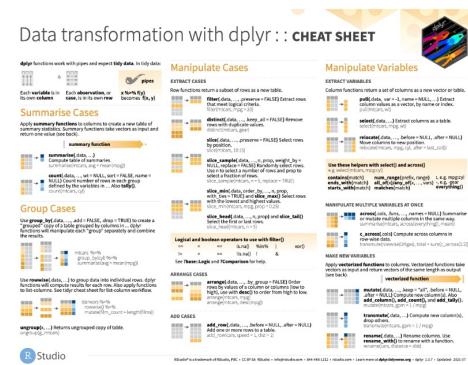


Data transformation with dplyr cheatsheet

The `dplyr` package provides a grammar for manipulating tables in R. This cheatsheet will guide you through the grammar, reminding you how to select, filter, arrange, mutate, summarise, group, and join data frames and tibbles.

Updated July 2021.

[DOWNLOAD](#)



Let's get started!

- You may need to log in to your RStudio cloud account first
 - Go to: <https://posit.cloud/>
 - Click log in
 - <https://posit.cloud/content/5313201>
 - First click on Save a permanent copy
 - https://github.com/dlumian/R_Intro_Winter_2023
 - Click on the new file icon
 - Select R script
-

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.

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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 | Global Environment

List | C

Environment is empty

Files Plots Packages Help Viewer

New Folder Upload Delete Rename More

Cloud > project

	Name	Size	Modified
	..		
<input type="checkbox"/>	.Rhistory	0 B	Nov 3, 2020, 4:4
<input type="checkbox"/>	AMvsEM_deseq2_results.csv	2.2 MB	Nov 3, 2020, 4:5
<input type="checkbox"/>	project.Rproj	205 B	Nov 3, 2020, 8:5
<input type="checkbox"/>	qRT_PCR_val.csv	273 B	Nov 3, 2020, 4:5
<input type="checkbox"/>	RforResearchSci.Rmd	17.9 KB	Nov 3, 2020, 4:5

The screenshot shows the RStudio interface with several red annotations:

- A red arrow points to the "R Script" option in the "File" menu, which is highlighted.
- The main workspace area has a red annotation "Write code here" with a red arrow pointing to the top-left corner.
- The Environment pane has a red annotation "Objects go here" with a red arrow pointing to its title bar.
- The Files pane has a red annotation "Written files go here" with a red arrow pointing to its title bar.

File Edit Code View Plots Session Build Debug Profile Tools Help

New File

Open File... Recent Files Import Dataset Save Save As... Save All Print... Close Close All Close All Except Current

Type 'demo()' for some demos, 'help.start()' for an HTML browser. Type 'q()' to quit R.

> |Run code here

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

Environment History Connections

Import Dataset Global Environment

Environment is empty

Objects go here

Files Plots Packages Help Viewer

New Folder Upload Delete Rename More

Cloud > project

	Name	Size	Modified
<input type="checkbox"/>	..		
<input type="checkbox"/>	.Rhistory	0 B	Jun 27, 2020, 3:42 PM
<input type="checkbox"/>	project.Rproj	205 B	Jun 27, 2020, 3:42 PM

Written files go here

R is like a calculator

- Enter the following

7+7

a=3

b=5

- If I type a it will print out the contents of a which is 3

a+b

a-b

a*b

a/b

The screenshot shows the RStudio interface with several panels:

- Code Editor:** An R script named "Untitled1" is open. A red box highlights the section of code from line 2 to line 8, which contains:

```
2 a=3  
3 b=5  
4 a  
5 a+b  
6 a-b  
7 a*b  
8 a/b
```
- Toolbar:** The "Run" button is highlighted with a red box.
- Environment Panel:** Shows the "Global Environment" with two objects:

Values
a 3
b 5

A red box highlights this table.
- Console Panel:** Displays the output of the executed code:

```
> 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  
>
```
- File Explorer:** Shows a project structure in the cloud:

Name	Size	Modified
..	0 B	Jul 11, 2020, 5:50 PM
.Rhistory	0 B	Jul 11, 2020, 5:50 PM
project.Rproj	205 B	Jul 11, 2020, 5:50 PM

Red annotations provide instructions:

- "Highlight the section of code you want to run then click run"
- "Temp memory objects"

Make a Vector

- Vectors are a data structure in R
 - -list of characters
 - -list of numbers
 - -must be same data type
 - Use the `c()` command to enter a bunch of numbers together
 - `c` stands for combine
 - Don't know how to use it?
 - Type: `?c`
 - Putting a `?` before a command or object will retrieve the help for that object
-

Untitled1*

Source on Save Run Source

1 ?c

1:3 (Top Level) R Script

Console Terminal Jobs

/cloud/project/

> ?c

>

Environment History Connections

Import Dataset

Global Environment

Values

c	3
d	5

Files Plots Packages Help Viewer

← → Home

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(...)
```

```
## Default S3 method:
```

Typing ?

- 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
- Now let's use the `c()` command
- `c(5,6,7,8)`
- This just prints the output to the screen

Create an object

- We can create an object for R to keep in its temporary memory
- We will assign a name to the vector we used before
- Type "d <- " in front of `c(5,6,7,8)` : `d <- c(5,6,7,8)`
- We created 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

R 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)

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

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(...)
```

```
## Default S3 method:
```

Make more vectors

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

Untitled1*

```
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

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



R: Search Results



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

Untitled1* Go to file/function Addins R 4.0.0

1 d+e
2 d*e
3 f-g
4 f/g
5 |

Source on Save Run Source

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 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

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)`
-

Untitled1*

```
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 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

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)`

The screenshot shows the RStudio interface with the following components:

- Code Editor:** An untitled R script with the following code:

```
1 h <- rbind(d,e,f,g)
2 h
```
- Environment View:** Shows the global environment with variables d, e, f, g, and h. The variable h is a numeric matrix of size 4x4 with values: 5, 11, 1, 1; 6, 12, 2, 2; 7, 13, 15, ...
- Console View:** Displays the output of the R code:

```
> h <- rbind(d,e,f,g)
> h
     [,1] [,2] [,3] [,4]
d      5     6     7     8
e     11    12    13    15
f      1     2     3     4
g      1     2     3    15
>
```
- Search Results View:** A search results page for "standard deviation". It shows the R logo and a message: "The search string was 'standard deviation'". It also lists help pages for `nlme:::pooledSD`, `stats::sd`, and `stats::sigma`.

Column and Row Names

- 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")`

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 Global Environment

Data

h	num [1:4, 1:4] 5 11 1 1 6 12 2 2 7 13 ...
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

Values

Files Plots Packages Help Viewer

standard devia

R: Search Results Find in Topic

Search Results

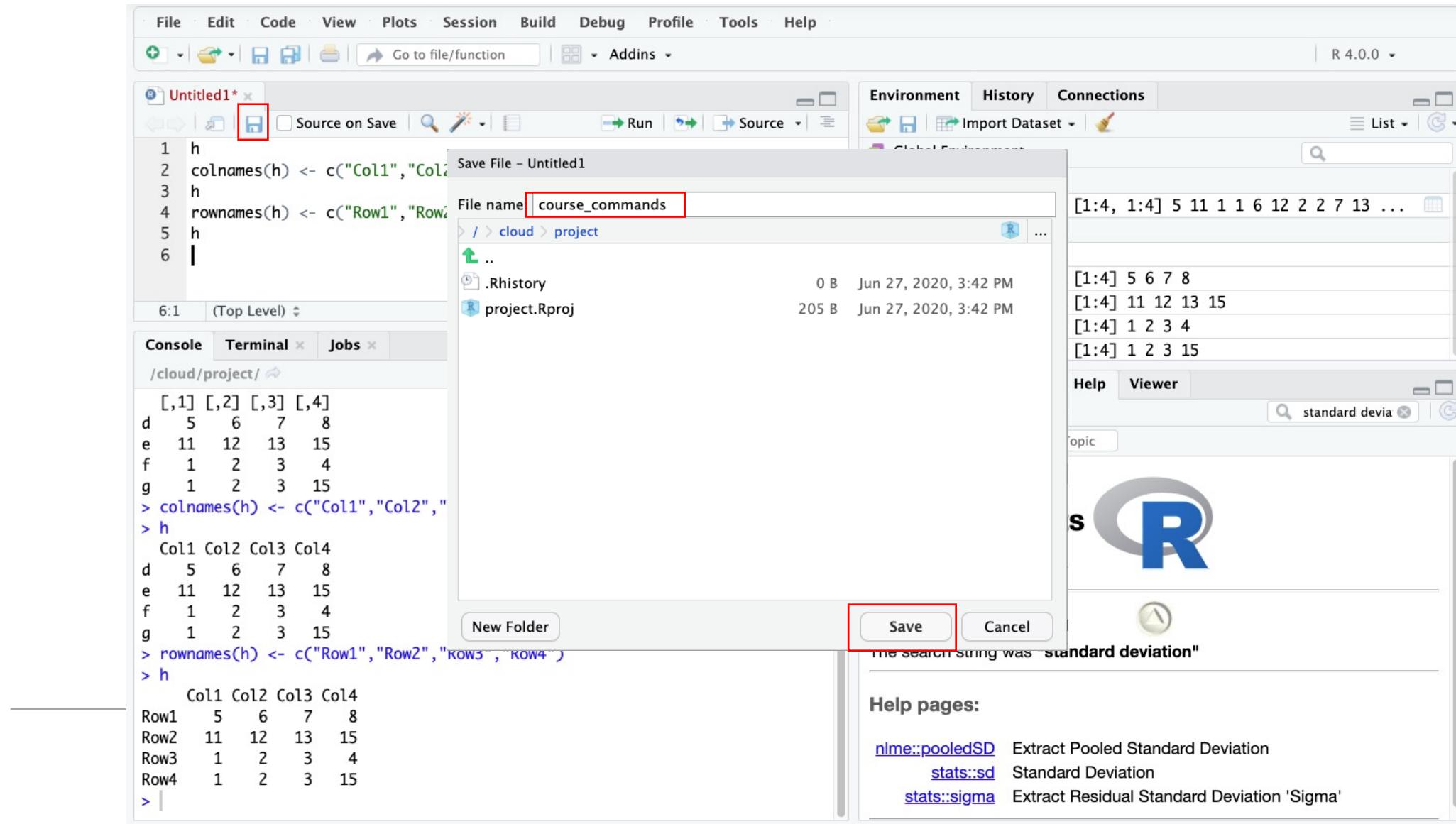


The search string was "standard deviation"

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

course_commands.R | Go to file/function | Addins | R 4.0.0

course_commands.R x

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 Global Environment

Data

h	num [1:4, 1:4]	5 11 1 1 6 12 2 2 7 13 ...
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

Values

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 practiced creating a R script to manipulate basic data.
 - Try running the 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?

- So far, we have:
 - 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
 - Run a markdown notebook reinforcing these concepts
 - Up next:
 - R Built-In Datasets
-

Built-in Datasets

- Datasets can be imported to or exported from R, however base R and some packages include built-in datasets
 - Built-in datasets are helpful for learning about data wrangling and testing functionality
 - Since they do not require complex import, they are ideal for many situations
-

Activity 2:

Built-in Datasets

- Click on the `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



WE COULD USE BASE R



OR 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

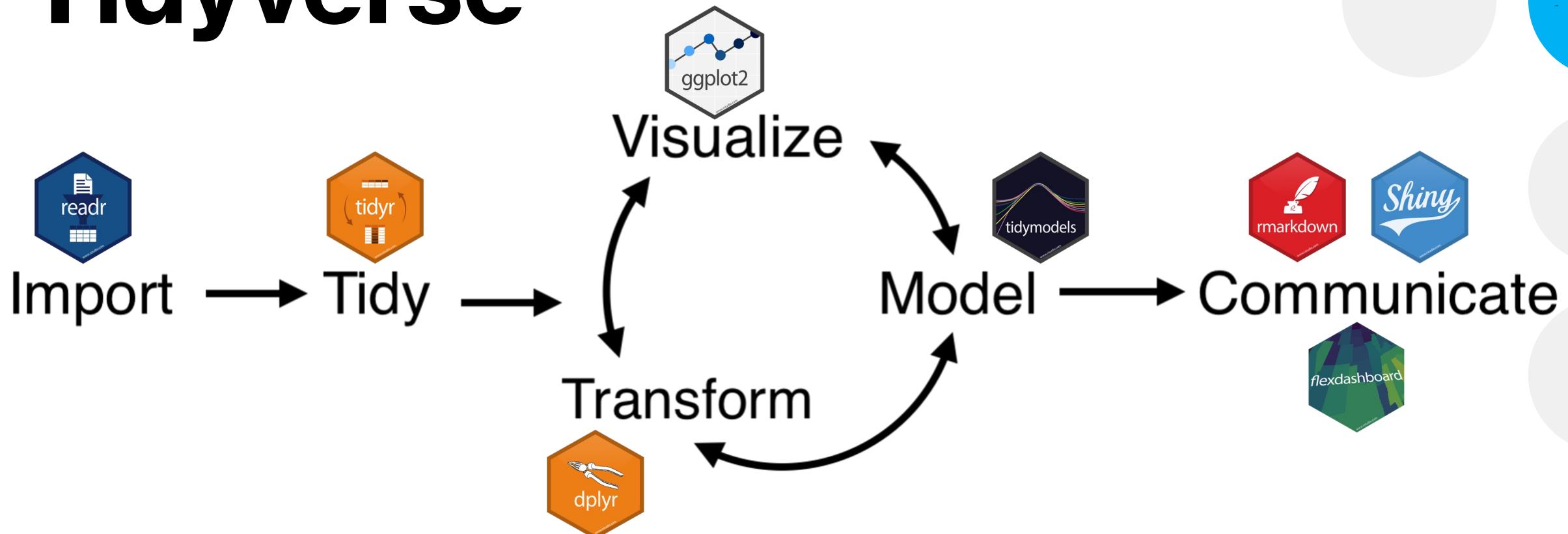


Made by different people commands may clash



Would also be very slow to load everything every time

Tidyverse



First time install:
`install.packages("tidyverse")`

Turn on package set: `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") **Install like this**

2

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

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

The screenshot shows the RStudio interface with three main panels:

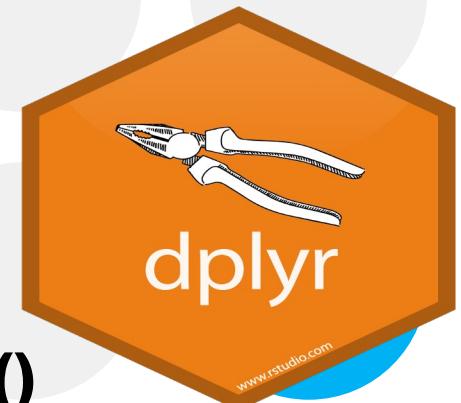
- Code Editor (Left Panel):** Displays the file `course_commands.R*`. The first line contains `library(tidyverse)`, which is highlighted with a red box. To the right of the code, the word "This" is written in red.
- Environment (Top Right Panel):** Shows the global environment with objects `pbc` and `pbcseq`. Below that, it lists variables `c`, `d`, `e`, `f`, and `g`, each with its corresponding value and type.
- Packages (Bottom Right Panel):** Shows the `Packrat` interface. The search bar at the top contains "tidyverse". A red box highlights the checkbox next to `tidyverse`, which is checked. The table below lists the package details:

Name	Description	Version
<input checked="" type="checkbox"/> tidyverse	Easily Install and Load the 'Tidyverse'	1.3.0
<input type="checkbox"/> rlang	Functions for Base Types and Core R and 'Tidyverse' Features	0.4.6

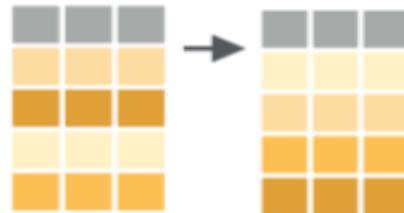
Centered between the Code Editor and the Packages panel is the text "OR this" in red.

```
library(tidyverse)
#> 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()
#>
```

dplyr: Transform your data



arrange()



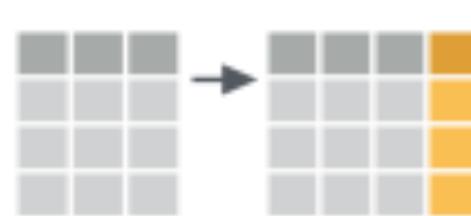
select()



filter()



mutate()



summarize()



group_by()



Basic structure:
`dplyr function(data, specifics)`
Example:
`arrange(iris, Sepal.Length)`

Pipes!

Let's say I want to know the average sepal length for each species. I could:

- `group_by_species <- group_by(iris, Sepal.Length)`
- `Avg_sep_len_species <- summarize(group_by_species, mean = mean(Sepal.Length))`

Or use a pipe! `%>%`!

- This allows sequential operations to be done on the same dataset:
- `iris_sep_len <- iris %>% group_by(species) %>% summarize(new_col = mean(Sepal.Length))`
- `View(iris_sep_len)`

Keyboard Shortcut:

PC:Ctrl+Shift+M

Mac:Cmd+Shift+M

Untitled1 × iris_sep_len ×

Species new_col

	Species	new_col
1	setosa	5.006
2	versicolor	5.936
3	virginica	6.588

Showing 1 to 3 of 3 entries, 2 total columns

Console Terminal × Background Jobs ×

R 4.2.2 · ~/Documents/GitHub/R_Intro_Winter_2023/ ↵

```
> library(tidyverse)
> iris_sep_len = iris %>% group_by(Species) %>% summarize(new_col=mean(Sepal.Length))
> view(iris_sep_len)
> |
```

Activity 3:

Data Manipulation

- Using the pre-made R Notebook 3_Data_Manipulation.Rmd we will explore the following data manipulations:
 - Arrange
 - Select
 - Filter
 - Mutate
 - Summarize
 - GroupBy

Questions?

- What data manipulation options are available?
 - Which operation would you use to create a new column of data?
 - Which two options are available for arranging data?
 - What symbol is used to join multiple commands?
-

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 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:

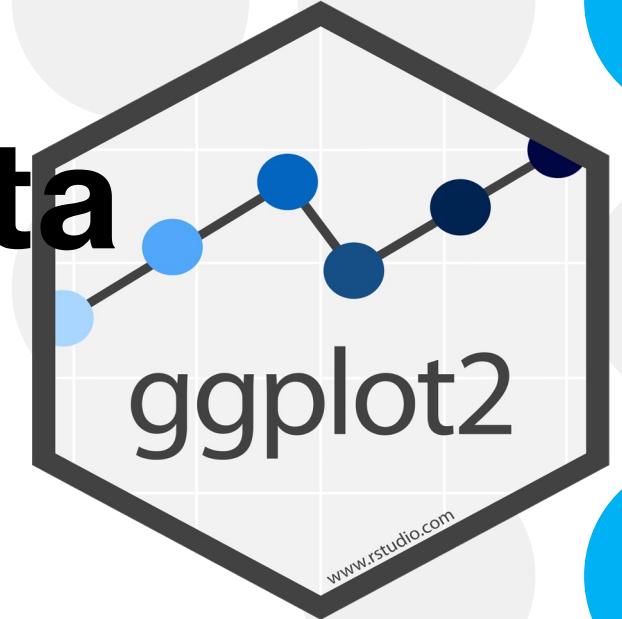
Data Import and Export

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

Visualizations for Today

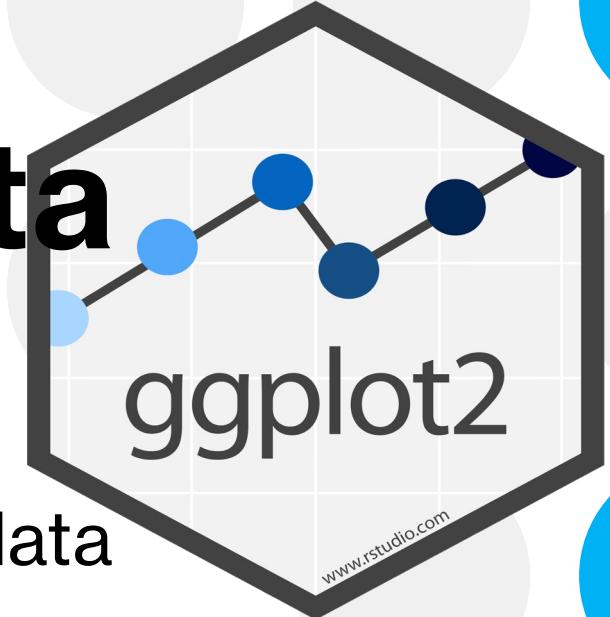
- Pie chart
 - Bar plot
 - Histogram
 - Density Plot
 - Scatter plot
 - Box Plot
 - Heat Map
 - Faceted plots (multiple plots in the same figure)
-

ggplot2: Visualize your data



- 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 your 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:

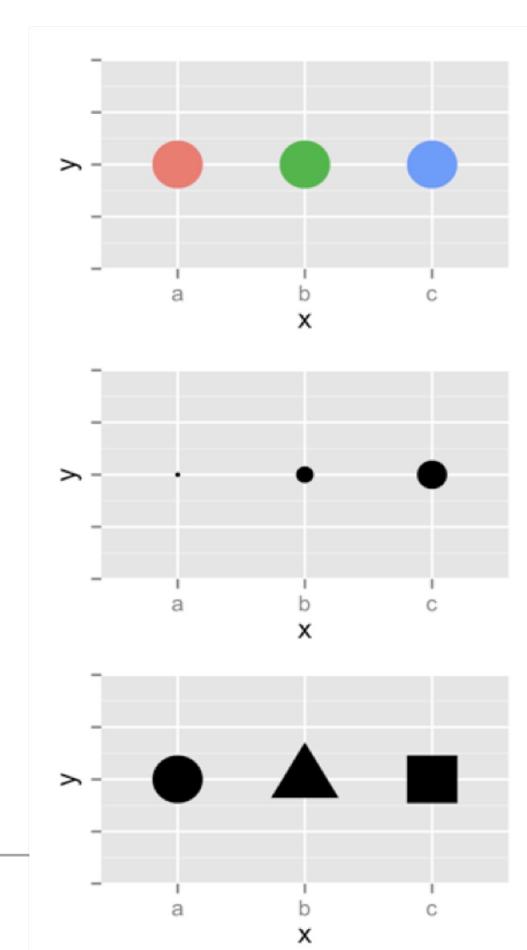
```
ggplot(data, aes(x=variable)) + geom_type()
```

Example:

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

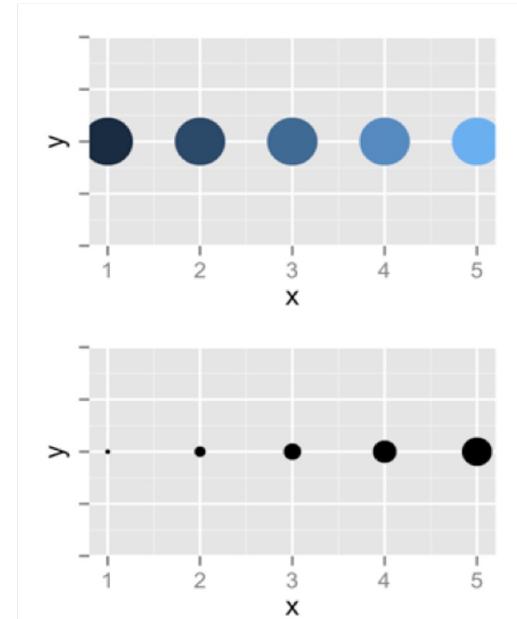
Aesthetic mapping options

Color



Size

Continuous

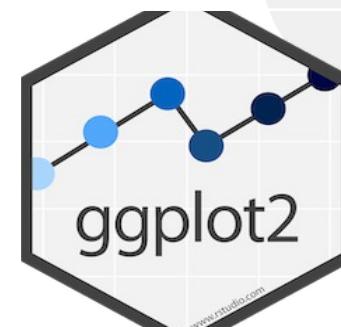


Shape

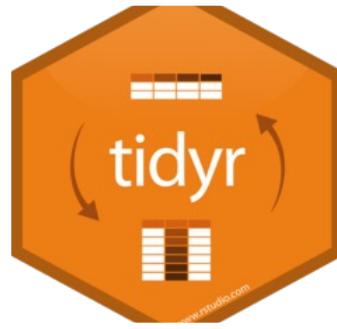


ggplot2:Faceting

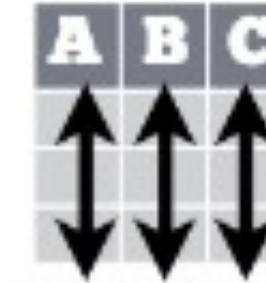
- Divide a plot into subplots based on one or more discrete variable
- Can be used with a variety of plot types
- There are a couple of facet flavors
 -  **`t + facet_grid(cols = vars(f1))`**
facet into columns based on f1
 -  **`t + facet_grid(rows = vars(year))`**
facet into rows based on year
 -  **`t + facet_grid(rows = vars(year), cols = vars(f1))`**
facet into both rows and columns
 -  **`t + facet_wrap(vars(f1))`**
wrap facets into a rectangular layout



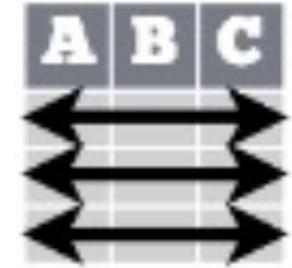
tidr:gather



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



&



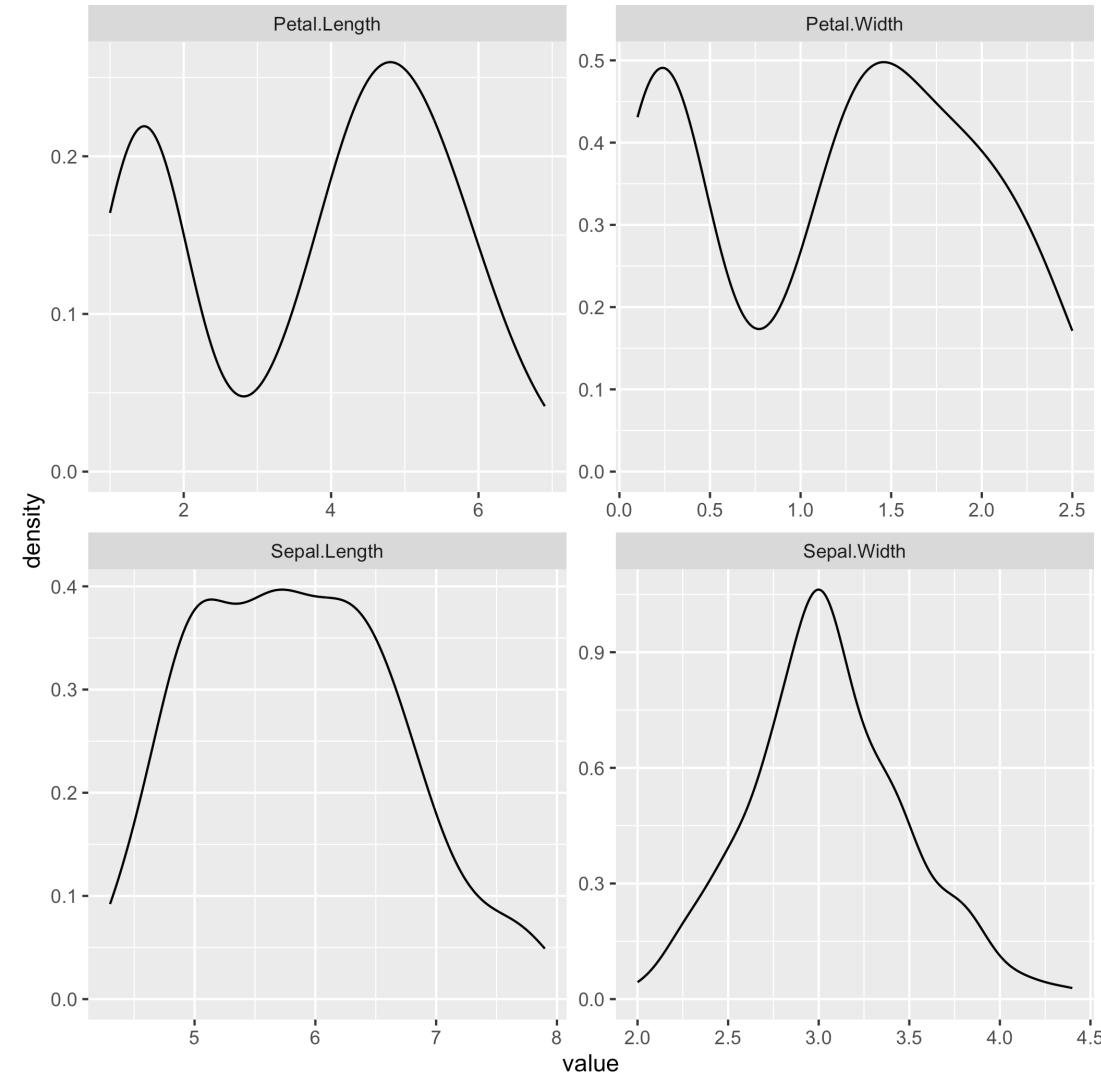
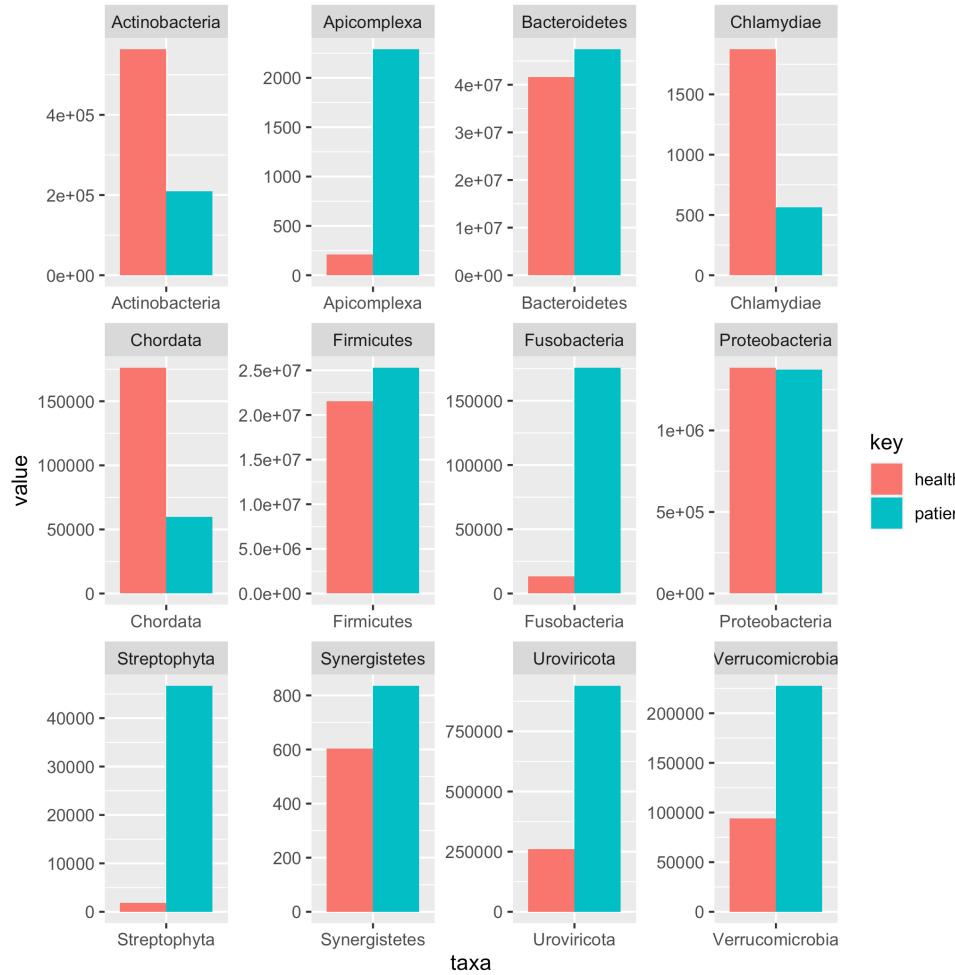
country	1999	2000
A	0.7K	2K
B	37K	80K
C	212K	213K



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

key value

Questions on Basic Visualizations



Activity 5:

Data Visualization

- Open the notebook 5_Data_Visualization.Rmd
- Explore plotting and data visualizations

Data Analysis in R

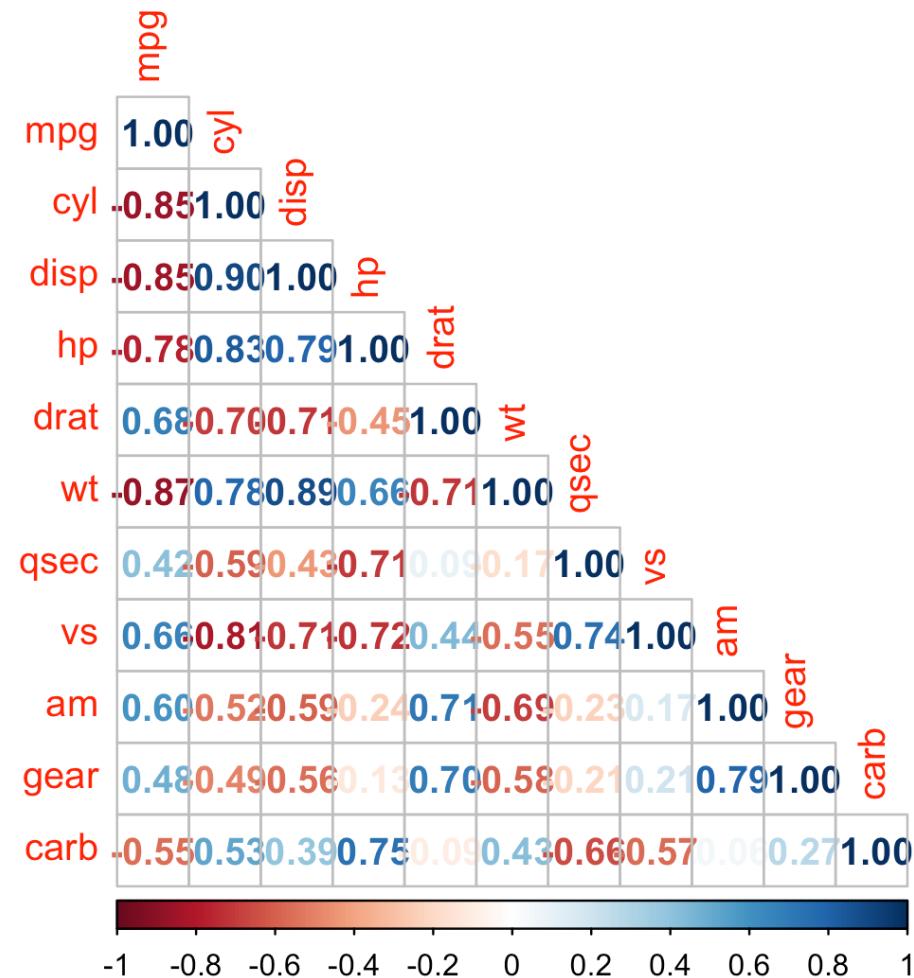
- Correlations
 - Pearson
- t-tests
 - Single sample
 - Independent
 - Paired

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
- Positive and negative correlations are color coded
- 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 (μ)
 - 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

```
```{r}
t.test(mtcars$mpg~mtcars$vs)
```

Welch Two Sample t-test

data: mtcars$mpg by mtcars$vs
t = -4.6671, df = 22.716, p-value = 0.0001098
alternative hypothesis: true difference in means between group 0 and group 1 is not equal to 0
95 percent confidence interval:
-11.462508 -4.418445
sample estimates:
mean in group 0 mean in group 1
16.61667      24.55714
```

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

- Open the notebook Data_Analysis.Rmd
- Basic analysis techniques in R
 - Correlations
 - t-tests

**This
concludes
the Intro to R**

Thank you for your attention and participation!
