

# **Week-2: Introduction to Data & Visualization**

**NM2207: Computational Media Literacy**

**Narayani Vedam, Ph.D.**

**Department of Communications and New Media**



**NUS**  
National University  
of Singapore

Faculty of Arts  
& Social Sciences

# This week

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# I. Introduction to data

# What constitutes a data-set?

```
# Load R packages for data science
library(tidyverse)
# Data in starwars data-set
starwars
```

```
## # A tibble: 87 × 14
##   name      height  mass hair_color skin_color eye_color birth_year sex   gender
##   <chr>     <int> <dbl> <chr>       <chr>       <chr>        <dbl> <chr> <chr>
## 1 Luke Sk...    172     77 blond      fair        blue          19  male  mascul...
## 2 C-3PO       167     75 <NA>       gold        yellow        112 none  mascul...
## 3 R2-D2        96      32 <NA>      white, bl... red           33  none  mascul...
## 4 Darth V...    202    136 none      white        yellow        41.9 male  mascul...
## 5 Leia Or...    150      49 brown      light       brown          19 female femin...
## 6 Owen La...    178    120 brown, gr... light       blue           52  male  mascul...
## 7 Beru Wh...    165      75 brown      light       blue           47 female femin...
## 8 R5-D4        97      32 <NA>      white, red red           NA  none  mascul...
## 9 Biggs D...    183      84 black      light       brown          24  male  mascul...
## 10 Obi-Wan...   182      77 auburn, w... fair        blue-gray        57  male  mascul...
## # i 77 more rows
## # i 5 more variables: homeworld <chr>, species <chr>, films <list>,
## #   vehicles <list>, starships <list>
```

# Luke Skywalker

```
height = 172 cm      name = "Luke Skywalker"  
  
weight = 77 kg       hair_color = "blond"  
  
eye_color = "blue"    birth_year = 19 BBY  
  
skin_color = "fair"   films = c("The Empire Strikes Back",  
                                "Revenge of the Sith",  
                                "Return of the Jedi",  
                                "A New Hope",  
                                "The Force Awakens")  
  
species = "Human"  
  
sex = "male"  
  
gender = "masculine"  
  
homeworld = "Tatooine" vehicles = c("Snowspeeder",  
                                         "Imperial Speeder Bike")  
  
starships = c("X-wing",  
              "Imperial shuttle")
```



Source: <https://datasciencebox.org/>

# Overview of the data-set

```
# Salient features of the data-set
?starwars
```

starwars {dplyr}

R Documentation

## Starwars characters

### Description

The original data, from SWAPI, the Star Wars API, <https://swapi.dev/>, has been revised to reflect additional research into gender and sex determinations of characters.

### Usage

starwars

### Format

A tibble with 87 rows and 14 variables:

name

Name of the character

height

Height (cm)

mass

Weight (kg)

hair\_color,skin\_color,eye\_color

Hair, skin, and eye colors

birth\_year

Year born (BBY = Before Battle of Yavin)

sex

The biological sex of the character, namely male, female, hermaphroditic, or none (as in the case for Droids).

gender

The gender role or gender identity of the character as determined by their personality or the way they were programmed (as in the case for Droids).

# Dissecting the data-set: a glimpse

```
# Catch a glimpse starwars data-set
glimpse(starwars)
```

```
## Rows: 87
## Columns: 14
## $ name      <chr> "Luke Skywalker", "C-3PO", "R2-D2", "Darth Vader", "Leia Or...
## $ height     <int> 172, 167, 96, 202, 150, 178, 165, 97, 183, 182, 188, 180, 2...
## $ mass       <dbl> 77.0, 75.0, 32.0, 136.0, 49.0, 120.0, 75.0, 32.0, 84.0, 77...
## $ hair_color  <chr> "blond", NA, NA, "none", "brown", "brown, grey", "brown", N...
## $ skin_color  <chr> "fair", "gold", "white, blue", "white", "light", "light", ...
## $ eye_color   <chr> "blue", "yellow", "red", "yellow", "brown", "blue", "blue", ...
## $ birth_year  <dbl> 19.0, 112.0, 33.0, 41.9, 19.0, 52.0, 47.0, NA, 24.0, 57.0, ...
## $ sex         <chr> "male", "none", "none", "male", "female", "male", "female", ...
## $ gender      <chr> "masculine", "masculine", "masculine", "masculine", "femini...
## $ homeworld   <chr> "Tatooine", "Tatooine", "Naboo", "Tatooine", "Alderaan", "T...
## $ species     <chr> "Human", "Droid", "Droid", "Human", "Human", "Human", "Huma...
## $ films        <list> <"The Empire Strikes Back", "Revenge of the Sith", "Return...
## $ vehicles    <list> <"Snowspeeder", "Imperial Speeder Bike">, <>, <>, <>, "Imp...
## $ starships   <list> <"X-wing", "Imperial shuttle">, <>, <>, "TIE Advanced x1", ...
```

# Dissecting the data-set: columns

Each **column** is a variable

Notice the *type* of each variable **in the previous slide**. They are,

1. `chr` (**character** for text-based entries)
2. `int` (**integer** for whole numbers)
3. `dbl` (**double** for decimal numbers)
4. `list` (**list** for entries of more than one type `chr`, `int`, `dbl`)

# Dissecting the data-set: column of type integer

Let us look at the entries of one of the columns of type `int`

```
# Access column "height"  
starwars$height
```

```
## [1] 172 167 96 202 150 178 165 97 183 182 188 180 228 180 173 175 170 180 66  
## [20] 170 183 200 190 177 175 180 150 NA 88 160 193 191 170 196 224 206 183 137  
## [39] 112 183 163 175 180 178 94 122 163 188 198 196 171 184 188 264 188 196 185  
## [58] 157 183 183 170 166 165 193 191 183 168 198 229 213 167 79 96 193 191 178  
## [77] 216 234 188 178 206 NA NA NA NA 165
```

# Dissecting the data-set: column of type double

Let us look at the entries of one of the columns of type `dbl`

```
# Access column "mass"
starwars$mass
```

## [1]	77.0	75.0	32.0	136.0	49.0	120.0	75.0	32.0	84.0	77.0
## [11]	84.0	NA	112.0	80.0	74.0	1358.0	77.0	110.0	17.0	75.0
## [21]	78.2	140.0	113.0	79.0	79.0	83.0	NA	NA	20.0	68.0
## [31]	89.0	90.0	NA	66.0	82.0	NA	NA	NA	40.0	NA
## [41]	NA	80.0	NA	55.0	45.0	NA	65.0	84.0	82.0	87.0
## [51]	NA	50.0	NA	NA	80.0	NA	85.0	NA	NA	80.0
## [61]	56.2	50.0	NA	80.0	NA	79.0	55.0	102.0	88.0	NA
## [71]	NA	15.0	NA	48.0	NA	57.0	159.0	136.0	79.0	48.0
## [81]	80.0	NA	NA	NA	NA	NA	45.0			

# Dissecting the data-set: column of type character

Let us look at entries of one of the columns of type `chr`

```
# Access column "gender"  
starwars$gender
```

```
## [1] "masculine" "masculine" "masculine" "masculine" "feminine" "masculine"  
## [7] "feminine" "masculine" "masculine" "masculine" "masculine" "masculine"  
## [13] "masculine" "masculine" "masculine" "masculine" "masculine" "masculine"  
## [19] "masculine" "masculine" "masculine" "masculine" "masculine" "masculine"  
## [25] "masculine" "masculine" "feminine" "masculine" "masculine" "masculine"  
## [31] "masculine" "masculine" "masculine" "masculine" "masculine" "masculine"  
## [37] NA "masculine" "masculine" NA "feminine" "masculine"  
## [43] "masculine" "feminine" "masculine" "masculine" "masculine" "masculine"  
## [49] "masculine" "masculine" "masculine" "feminine" "masculine" "masculine"  
## [55] "masculine" "masculine" "masculine" "feminine" "masculine" "masculine"  
## [61] "feminine" "feminine" "feminine" "masculine" "masculine" "masculine"  
## [67] "feminine" "masculine" "masculine" "feminine" "feminine" "masculine"  
## [73] "feminine" "masculine" "masculine" "feminine" "masculine" "masculine"  
## [79] "masculine" NA "masculine" "masculine" "feminine" "masculine"  
## [85] "masculine" NA "feminine"
```

# Dissecting the data-set: column of type list

Let us look at entries of one of the columns of type `list`

```
# Access column "films"  
starwars$films[1:3]
```

```
## [[1]]  
## [1] "The Empire Strikes Back" "Revenge of the Sith"  
## [3] "Return of the Jedi"      "A New Hope"  
## [5] "The Force Awakens"  
  
##  
## [[2]]  
## [1] "The Empire Strikes Back" "Attack of the Clones"  
## [3] "The Phantom Menace"      "Revenge of the Sith"  
## [5] "Return of the Jedi"      "A New Hope"  
  
##  
## [[3]]  
## [1] "The Empire Strikes Back" "Attack of the Clones"  
## [3] "The Phantom Menace"      "Revenge of the Sith"  
## [5] "Return of the Jedi"      "A New Hope"  
## [7] "The Force Awakens"
```

# Dissecting the data-set: rows

Each **row** is an observation

```
# Rows of interest
filter_rows <- c("Luke Skywalker", "R2-D2", "Darth Vader")
# Extract row corresponding to Luke Skywalker
starwars %>% filter(name %in% filter_rows)
```

```
## # A tibble: 3 × 14
##   name      height  mass hair_color skin_color eye_color birth_year sex gender
##   <chr>     <int> <dbl> <chr>       <chr>       <chr>       <dbl> <chr> <chr>
## 1 Luke Skywalker 172     77 blond       fair        blue         19 male   mascul...
## 2 R2-D2          96      32 <NA>        white, bl... red          33 none   mascul...
## 3 Darth Vader    202    136 none        white        yellow       41.9 male   mascul...
## # i 5 more variables: homeworld <chr>, species <chr>, films <list>,
## #   vehicles <list>, starships <list>
```

# Dissecting the data-set: rows with selected variables

*Filter* some rows and **select** some of their attributes

```
# Rows of interest
filter_rows <- c("Luke Skywalker", "R2-D2")
# Extract row corresponding to Luke Skywalker
starwars %>% filter(name %in% filter_rows) %>% select(name, height, mass, homeworld, films)
```

```
## # A tibble: 2 × 5
##   name           height   mass homeworld films
##   <chr>        <int> <dbl> <chr>     <list>
## 1 Luke Skywalker    172     77 Tatooine   <chr [5]>
## 2 R2-D2            96      32 Naboo     <chr [7]>
```

**Notice** how the entries of the column, films, do not show up!



# Dissecting the data-set: rows with selected variables (continued)

Select attributes of type `list`

```
# Rows of interest
filter_rows <- c("Luke Skywalker", "R2-D2")
# Extract rows in 'rows'
starwars %>% filter(name %in% filter_rows) %>% pull(films)
```

```
## [[1]]
## [1] "The Empire Strikes Back" "Revenge of the Sith"
## [3] "Return of the Jedi"       "A New Hope"
## [5] "The Force Awakens"
##
## [[2]]
## [1] "The Empire Strikes Back" "Attack of the Clones"
## [3] "The Phantom Menace"      "Revenge of the Sith"
## [5] "Return of the Jedi"       "A New Hope"
## [7] "The Force Awakens"
```

# Dissecting the data-set: basic properties

```
# Number of rows in the data-set  
nrow(starwars)
```

```
## [1] 87
```

```
# Number of columns in the data-set  
ncol(starwars)
```

```
## [1] 14
```

```
# Number of rows and columns in the data-set  
dim(starwars)
```

```
## [1] 87 14
```

## II. Exploratory Data Analyses (EDA)

# What is EDA?

- It is a systematic and iterative approach to explore data, and includes,
  - A hypothesis
  - Visualization, transformation or modelling data for answers
  - Substantiation or refinement of the hypothesis
- We will focus on **exploring** -- wrangling, manipulating, transforming --- and **visualizing** data

# Need for EDA

1. Are the attributes of the starwars characters related?

- For instance, mass and height of the characters

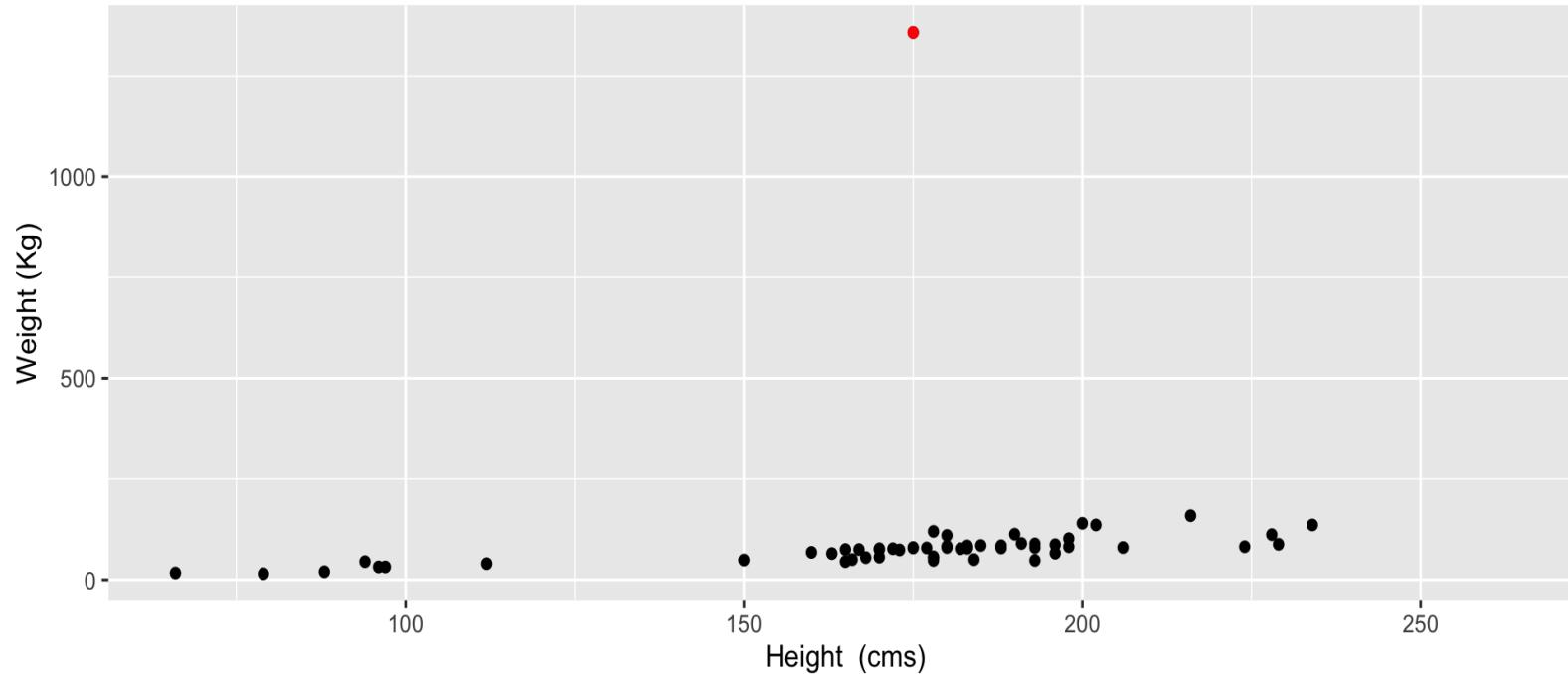
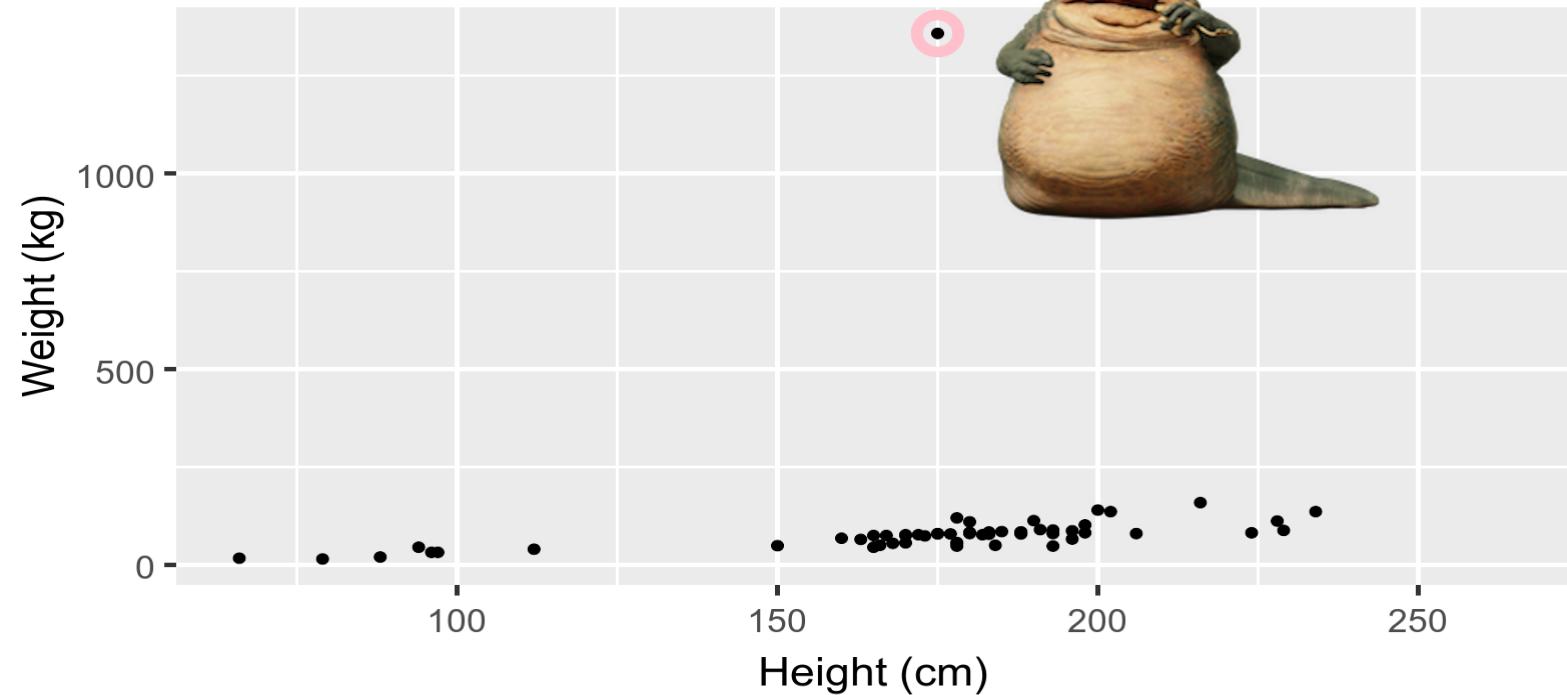


Figure: Relationship between weight and height

# Jabba!

Mass vs. height of Starwars characters



Source: <https://datasciencebox.org/>

# Data visualization

"A picture is worth a thousand words" - Frederick R. Bernard

1. Is just a visual representation of data
2. Entails creation and study of such representations
3. Among the many  packages that are available for visualization, we will use `ggplot2` and `shiny`

# Need for visualization: Anscombe's quartet

1. Consider a data-set, the **Anscombe's quartet**
2. It has four sets of data indicated by *I*, *II*, *III* and *IV*
3. Each set of data has 11 points,  $(x, y)$

```
# Invoke the library
library(Tmisc)
# Filter data-set I in quartet
quartet %>% filter(set=="I")
```

```
##   set  x     y
## 1   I 10 8.04
## 2   I  8 6.95
## 3   I 13 7.58
## 4   I  9 8.81
## 5   I 11 8.33
## 6   I 14 9.96
## 7   I  6 7.24
## 8   I  4 4.26
## 9   I 12 10.84
## 10  I  7 4.92
```

```
# Invoke the library
library(Tmisc)
# Filter data-set II in quartet
quartet %>% filter(set=="II")
```

```
##   set  x     y
## 1   II 10 9.14
## 2   II  8 8.14
## 3   II 13 8.74
## 4   II  9 8.77
## 5   II 11 9.26
## 6   II 14 8.10
## 7   II  6 6.13
## 8   II  4 3.10
## 9   II 12 9.13
## 10  II  7 7.26
```

# Need for visualization: Anscombe's quartet

1. Consider a data-set, the **Anscombe's quartet**
2. It has four sets of data indicated by *I*, *II*, *III* and *IV*
3. Each set of data has 11 points,  $(x, y)$

```
# Invoke the library
library(Tmisc)
# Filter data-set III in quartet
quartet %>% filter(set=="III")
```

```
##   set  x     y
## 1 III 10 7.46
## 2 III  8 6.77
## 3 III 13 12.74
## 4 III  9 7.11
## 5 III 11 7.81
## 6 III 14 8.84
## 7 III  6 6.08
## 8 III  4 5.39
## 9 III 12 8.15
## 10 III  7 6.43
```

```
# Invoke the library
library(Tmisc)
# Filter data-set IV in quartet
quartet %>% filter(set=="IV")
```

```
##   set  x     y
## 1 IV  8 6.58
## 2 IV  8 5.76
## 3 IV  8 7.71
## 4 IV  8 8.84
## 5 IV  8 8.47
## 6 IV  8 7.04
## 7 IV  8 5.25
## 8 IV 19 12.50
## 9 IV  8 5.56
## 10 IV  8 7.01
```

# Anscombe's quartet: features (continued)

- And look at some statistics,
  - Mean of `x` in each set, `mean_x`
  - Mean of `y` in each set, `mean_y`
  - Standard deviation of `x` in each set, `sd_x`
  - Standard deviation of `y` in each set, `sd_y`
  - Correlation between `x` and `y`, `r`

```
# Obtain the needed statistics
grouped_quartet %>%
  summarise(
    mean_x = mean(x),
    mean_y = mean(y),
    sd_x = sd(x),
    sd_y = sd(y),
    r = cor(x, y)
  )
```

```
## # A tibble: 4 × 6
##   set   mean_x  mean_y   sd_x   sd_y     r
##   <fct>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
## 1 I        9     7.50   3.32   2.03  0.816
## 2 II       9     7.50   3.32   2.03  0.816
## 3 III      9     7.5    3.32   2.03  0.816
## 4 IV       9     7.50   3.32   2.03  0.817
```

# Anscombe's quartet: features (continued)

Will the **distributions** of the four sets of data points be identical too? Let us find out!

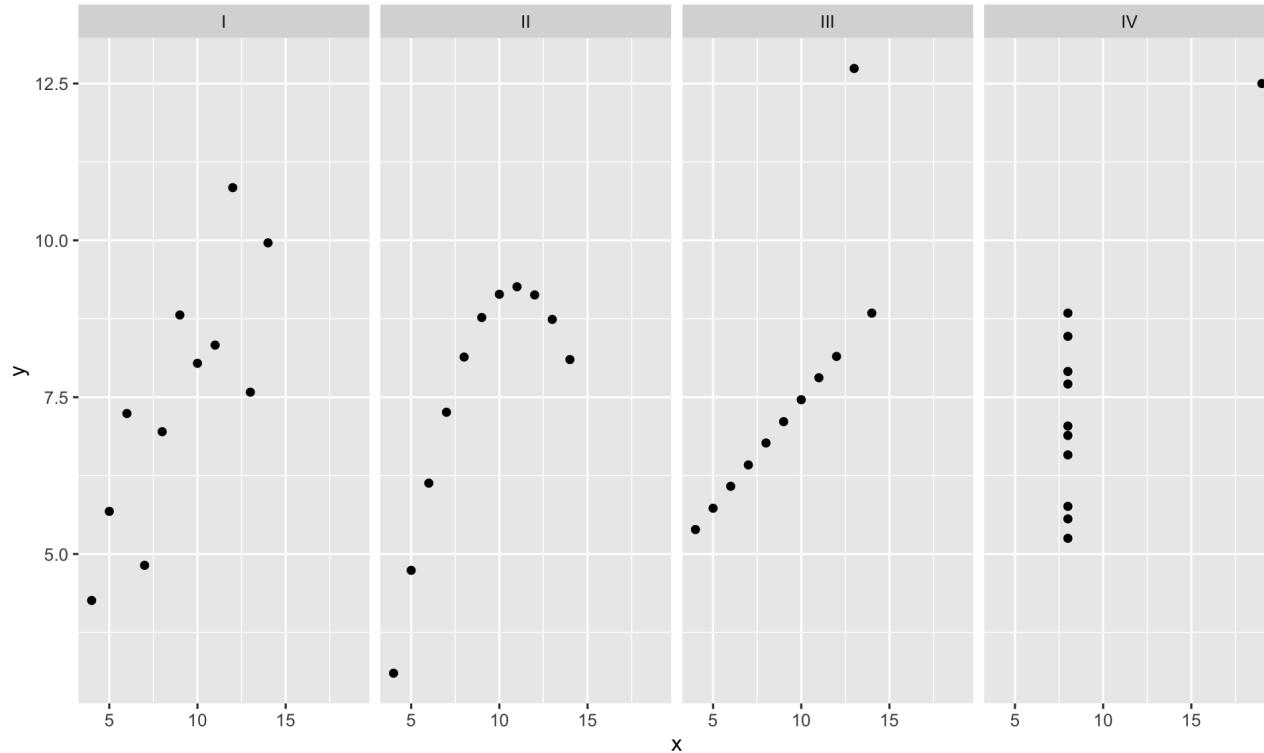


Figure: Data in each of the four data sets



### III. **ggplot2**

# Data visualization with `ggplot2`

- It is the `tidyverse` library's visualization package
- `gg` in `ggplot` stands for Grammar of Graphics
- Enables us to describe different components of a graphic



Figure: Different layers of ggplot

# Let us construct our first plot: Mass versus Height

- The main function is `ggplot()`
- We will work with `starwars` data-set

```
# Plot the data
ggplot(data=starwars) # <-- Look here!
```

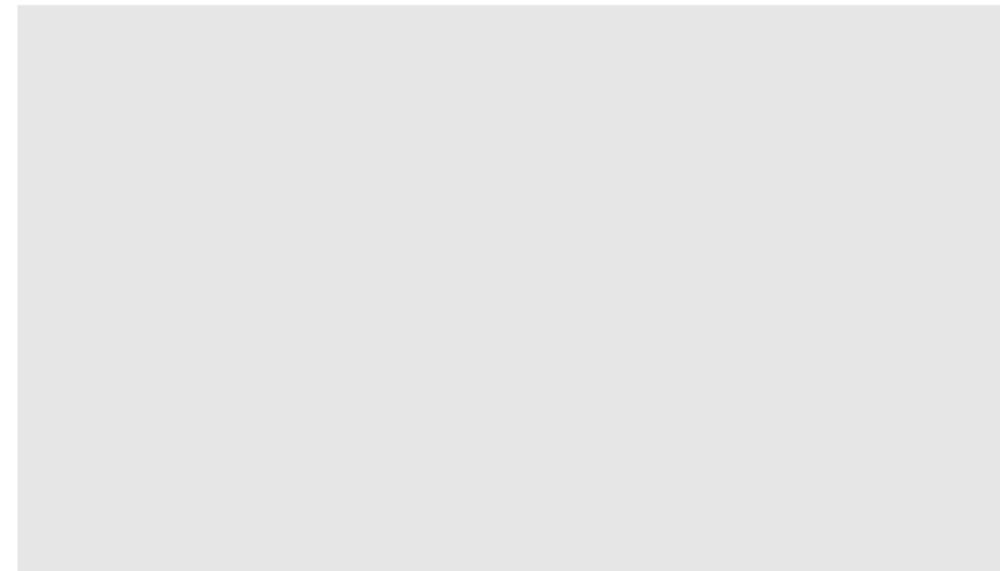


Figure: Constructing Mass versus Height plot

# Mass versus Height: independent variable (IV)

- The **independent variable** (along x-axis) is the variable/column -- `height`

```
# Plot height along x-axis
ggplot(data=starwars) +
  aes(x=height) # <-- Look here!
```

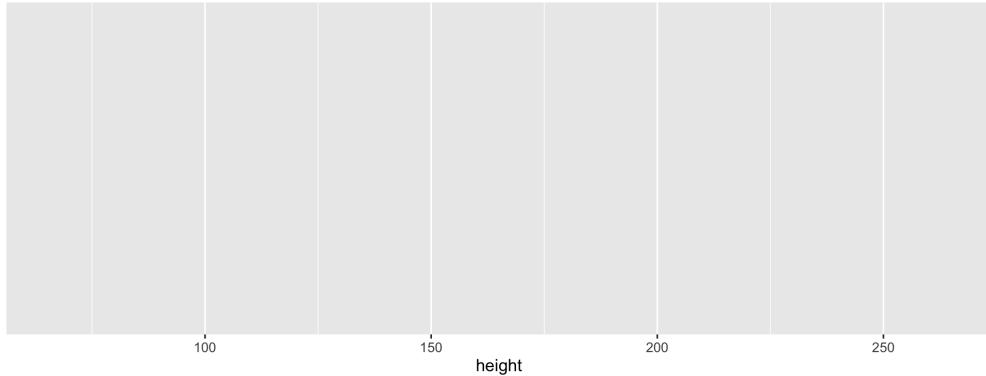


Figure: Adding independent variable

# Mass versus Height: dependent variable (DV)

- Similarly, the **dependent variable** (along y-axis) is the variable/column -- `mass`

```
# Plot mass along y-axis
ggplot(data=starwars) +
  aes(x=height,y=mass) # <-- Look here!
```

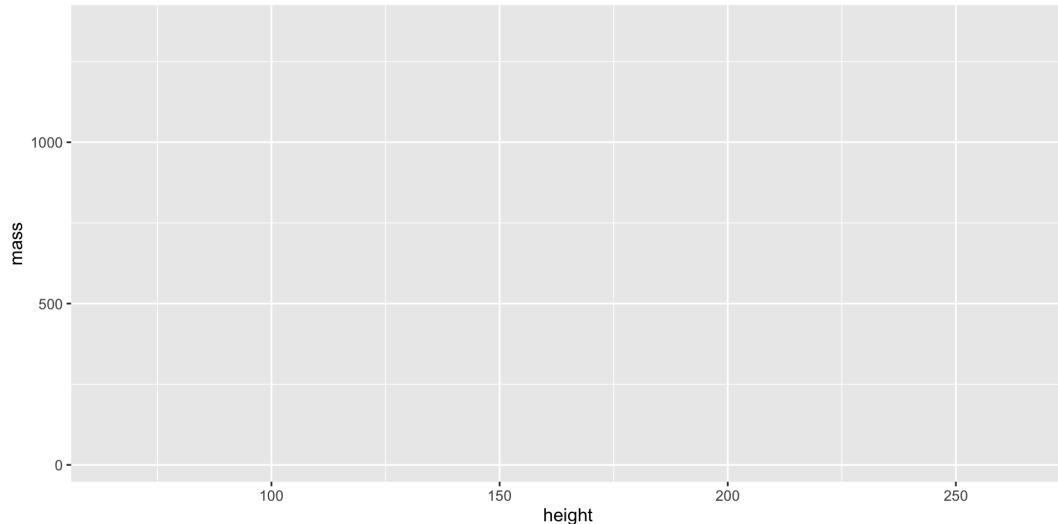


Figure: Adding dependent variable

# Mass versus Height: visualize data as dots

- Let us choose to visualize the data as **points** (dots)

```
ggplot(data=starwars) + aes(x=height,y=mass) +  
  geom_point() # <-- Look here!
```

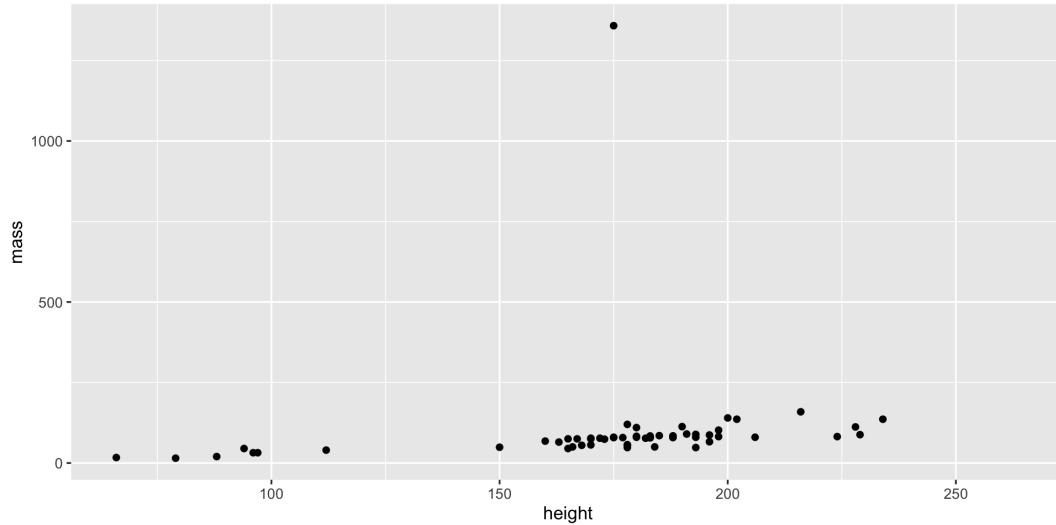


Figure: Visualizing data as points

# Mass versus Height: re-write axes labels

- Let us rewrite **labels** for the **axes** -- `x` and `y`

```
ggplot(data=starwars) + aes(x=height,y=mass) + geom_point() +  
  labs(x="Height (cm)",y="Weight (Kg)") # <-- Look here!
```

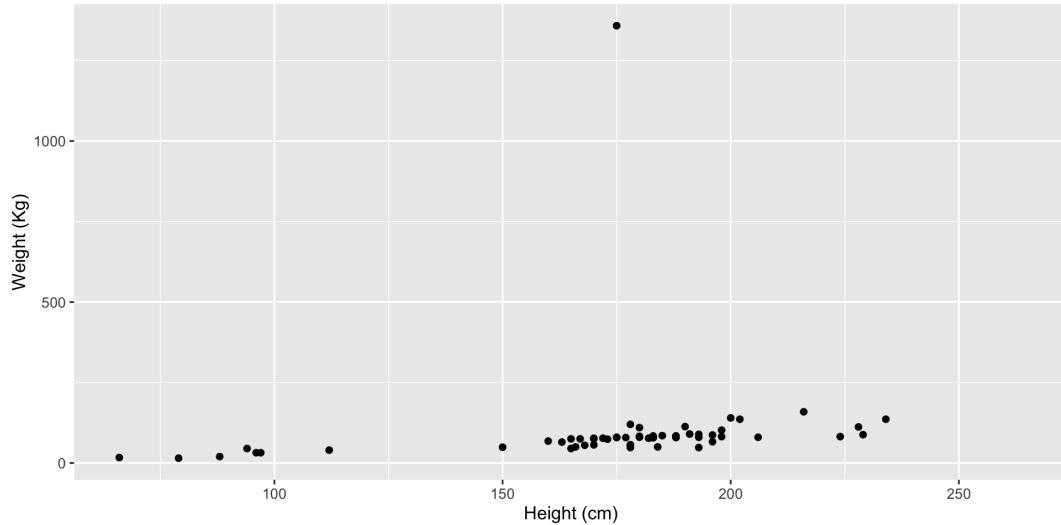


Figure: Inserting labels

# Mass versus Height: add title

- Let us insert a **title** for the plot

```
ggplot(data=starwars,mapping=aes(x=height,y=mass)) +  
  geom_point() +  
  labs(x="Height (cm)",y="Weight (Kg)",  
       title="Mass versus Height")# <-- Look here!
```

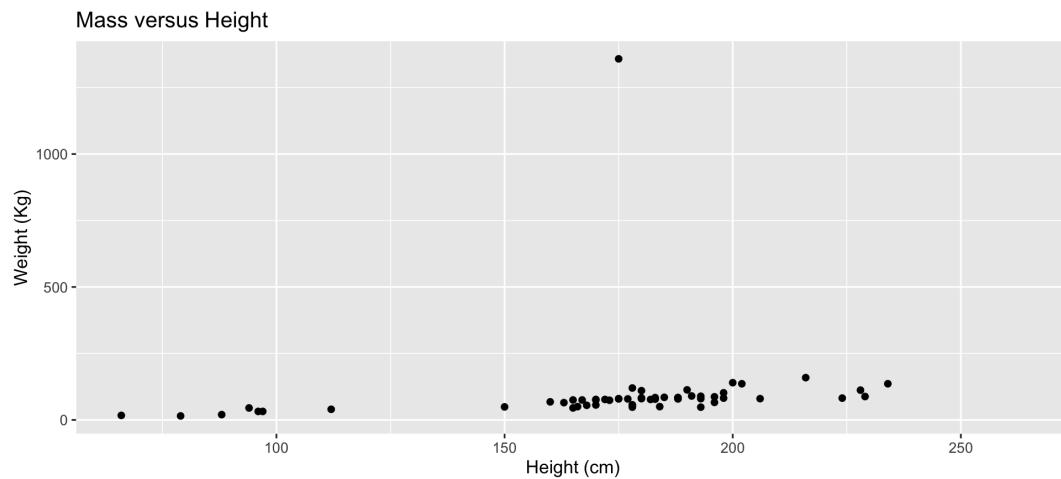


Figure: Inserting title

# Mass versus Height: add caption

- Let us insert a **caption** for the plot

```
ggplot(data=starwars,mapping=aes(x=height,y=mass)) +  
  geom_point() +  
  labs(x="Height (cm)",y="Weight (Kg)",  
       title="Mass versus Height",  
       caption="Source: tidyverse/ starwars dataset") # <-- Look here!
```

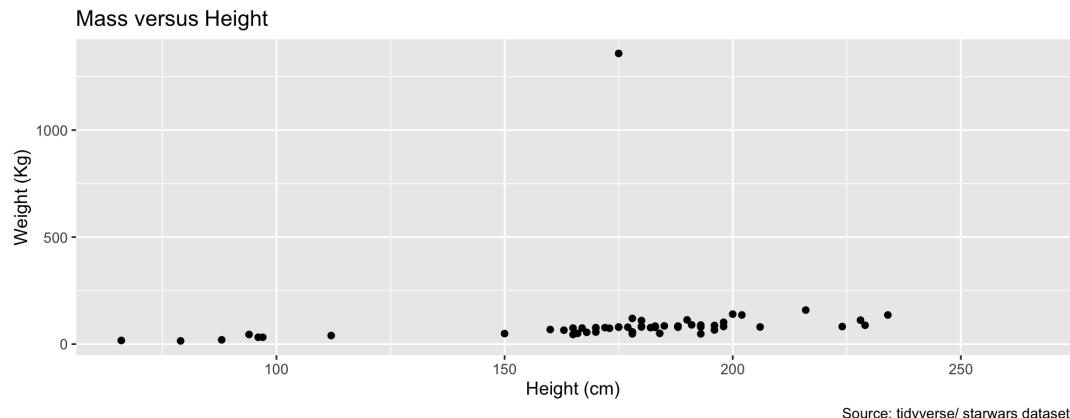


Figure: Inserting caption

# Mass versus Height: complete code

```
ggplot(starwars) +  
  aes(x=height,y=mass) +  
  geom_point() +  
  labs(x="Height (cm)",  
       y="Weight (Kg)",  
       title="Mass versus Height",  
       caption="Source: tidyverse/ starwars dataset")
```

# Mass versus Height: tadaa!

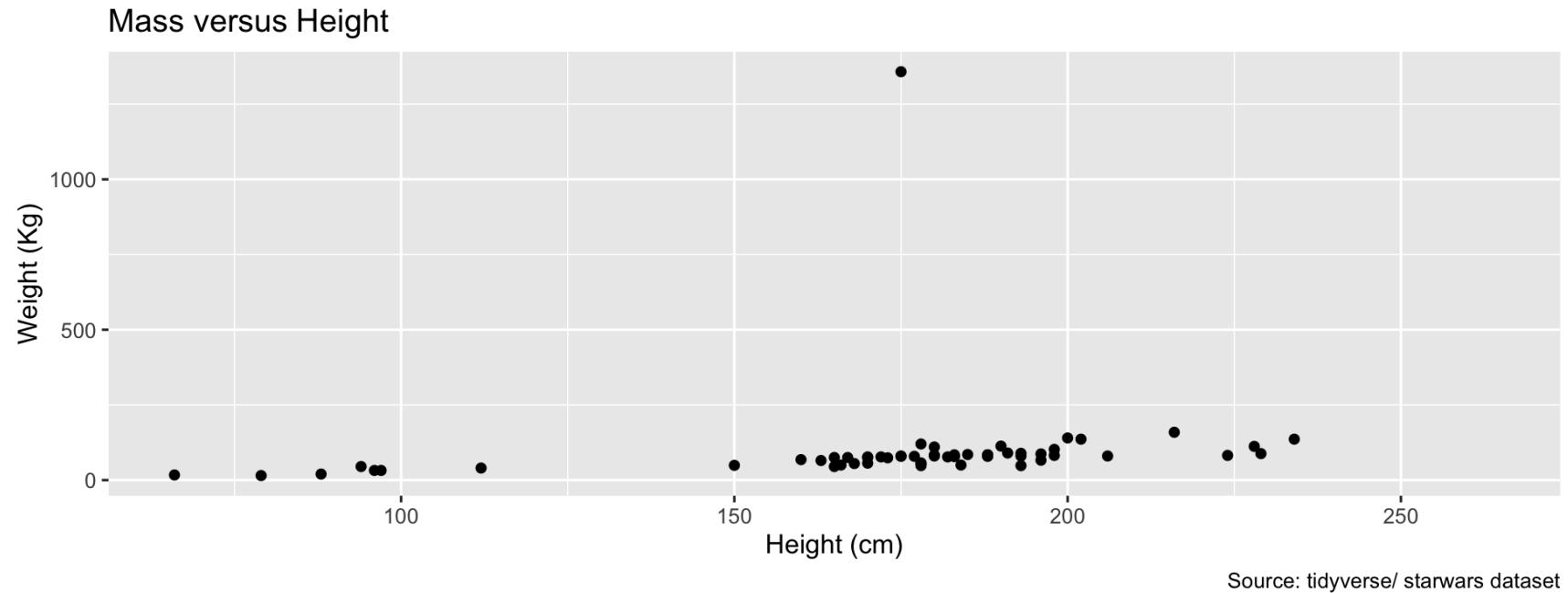


Figure: Final Mass versus Height plot



## IV. Shiny

# Shiny: introduction

1. `Shiny` is an  package that facilitates interactive web apps [more here](#). Using which, apps
  - a. can be hosted on a webpage
  - b. embedded in a dashboard, or
  - c. embedded in an R Markdown document
2. We shall explore some examples in the subsequent slides

# Shiny: example

- The package has eleven built-in examples to demonstrate how `shiny` works
- To explore the first example, run the code below

```
# Install package
install.packages("shiny")

# Invoke the package
library(shiny)

# Run an example from the library
runExample("01_hello")
```

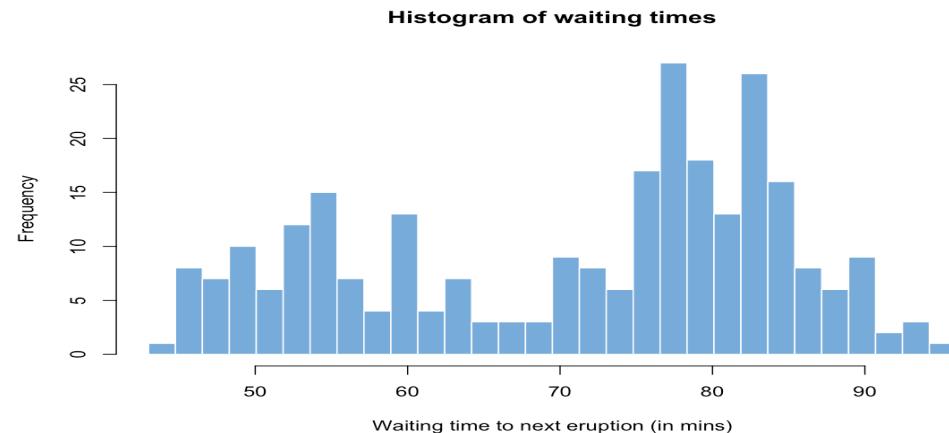
- You could try to list all the examples using `runExample()`
- If you haven't been using `?` operator before every function you use, start doing so
- It reveals a lot of information about the function
- If you tried the code, move on to the next slide for the output

# Example

Shiny dashboard with example - "01\_hello"

## Hello Shiny!

Number of bins:



This small Shiny application demonstrates Shiny's automatic UI updates.

Move the *Number of bins* slider and notice how the `renderPlot` expression is automatically re-evaluated when its dependant, `input$bins`, changes, causing a histogram with a new number of bins to be rendered.

app.R

 show with app

```
library(shiny)

# Define UI for app that draws a histogram ----
ui <- fluidPage(
  # App title ----
  titlePanel("Hello Shiny!")
```

# Shiny: comprehensive example

```
# Install package
install.packages("shiny")

# Invoke the package
library(shiny)

# Run an example from the library
runExample("06_tabssets")
```

Head to the next slide for the output!

# Comprehensive example

Shiny dashboard with example - "06\_tabssets"

## Tabssets

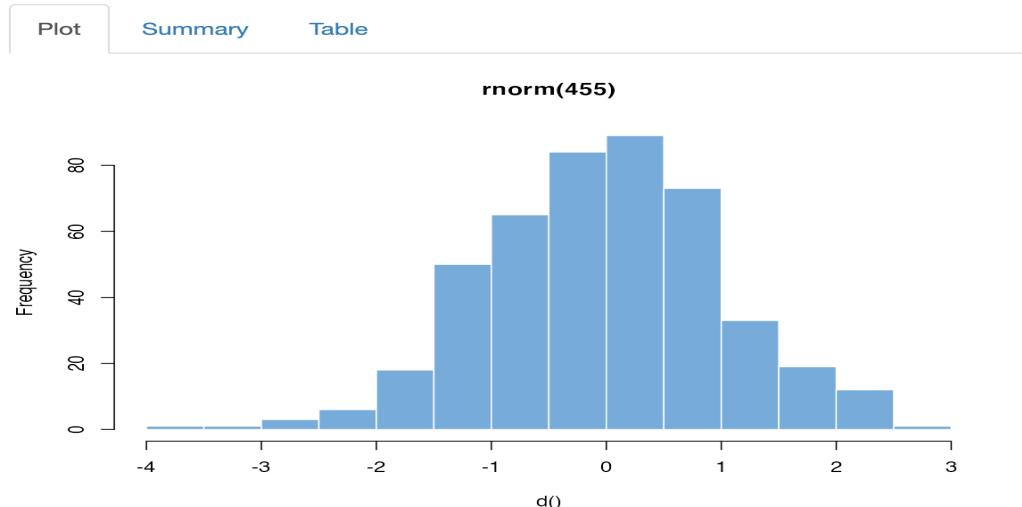
**Distribution type:**

- Normal
- Uniform
- Log-normal
- Exponential

**Number of observations:**

1      455      1,000

1 101 201 301 401 501 601 701 801 901 1,000



This example demonstrates the `tabsetPanel` and `tabPanel` widgets.

Notice that outputs that are not visible are not re-evaluated until they become visible.

Try this:

1. Scroll to the bottom of the server

app.R

**library(shiny)**

```
# Define UI for random distribution app ----
ui <- fluidPage(
```

[show with app](#)

# More examples

To try more examples, just replace the example name in the code snippet from the list

1. 01\_hello

2. 02\_text

3. 03\_reactivity

4. 04\_mpg

5. 05\_sliders

6. 06\_tabssets

7. 07\_widgets

8. 08\_html

9. 09\_upload

10. 10\_download

11. 11\_timer

```
# Install package
install.packages("shiny")

# Invoke the package
library(shiny)

# Run an example from the library
runExample("insert_example_name_here")
```

# Commands and operators revisited

1. `? - operator to learn more about an R command`
2. `$ - operator to extract a specific part of data`
3. `%>% - pipe operator that passes the output of one function as an input to another`
4. `%in%` - operator to check if an element belongs to a data-set
5. `library(package_name) - to load an add-on package`
6. `glimpe(dataset_name) - get a glimpse of your data`
7. `filter(row_attributes) - subset rows using column values`
8. `select(col_names) - subset columns using their names or types`
9. `pull(column_name) - extracts a single column`
10. `nrow/ncol/dim(dataset_name) - number of rows/columns/dimension of a data-set`

# Thanks!

Slides created via the  packages:

xaringan  
gadenbuie/xaringanthemer.



Faculty of Arts  
& Social Sciences