YIMING LI, 15 MAR 2017

THE BEGINNER'S GUIDE TO R

WARNING: COMPLETELY FOR BEGINNERS!

IN TODAY'S GUIDE...

1. What is R? Why R?
2. Installation and "Hello World!" in R
3. R data types – vectors, matrices and data frames
4. R operators and managing a data frame
5. I/O and basic graphs in R
6. Pop quiz

* A set of materials used in this workshop could be download via: http://web.hku.hk/~liym1018/projects.html#RWorkshop

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(From Wikipedia)

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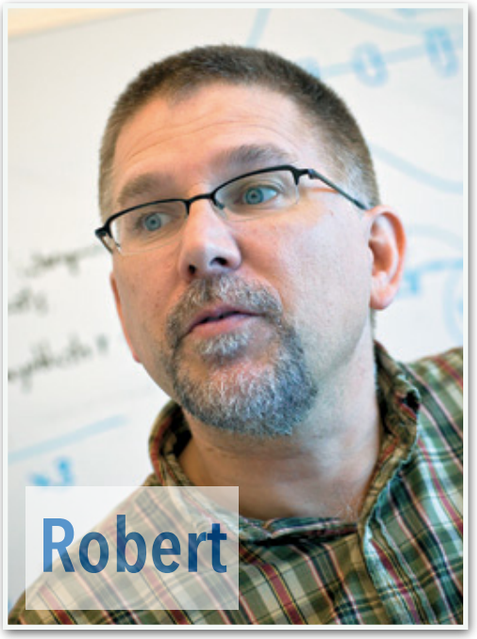

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  - Structural equation modelling

    Many packages available — `sem`, `lavaan`, `OpenMX`

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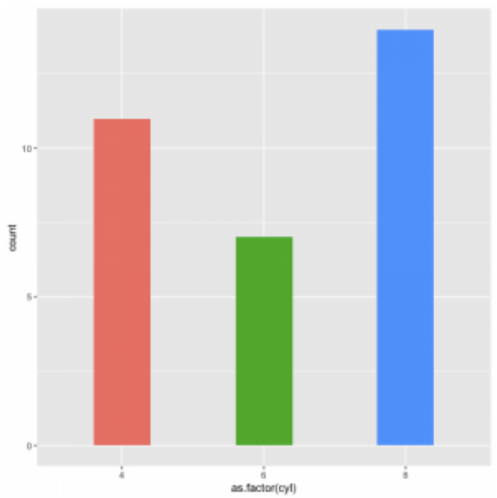

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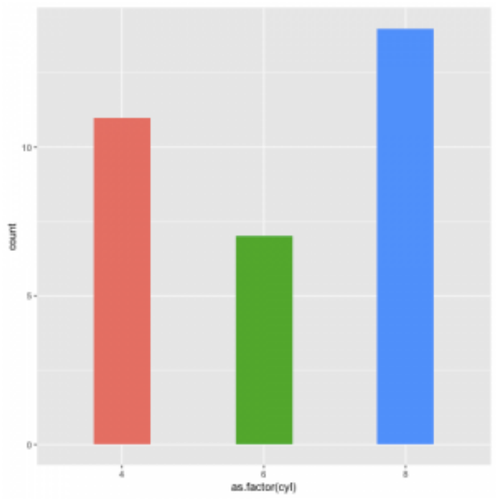

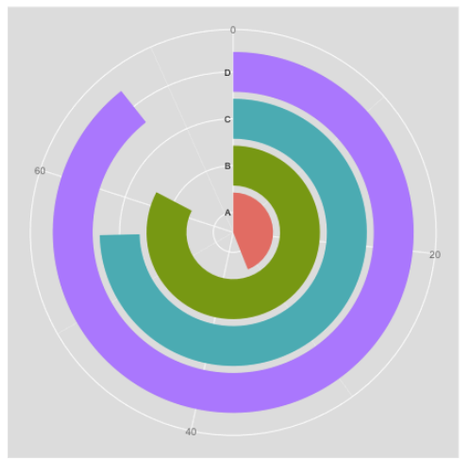

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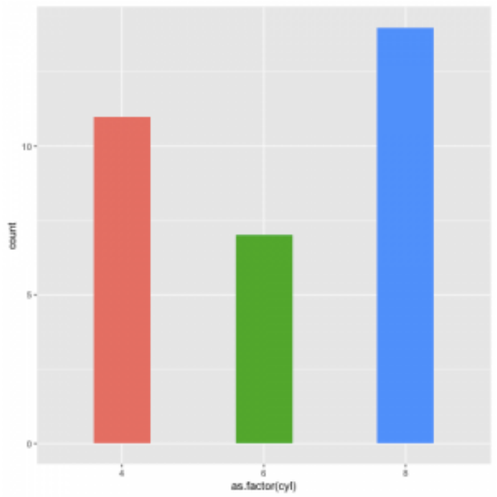

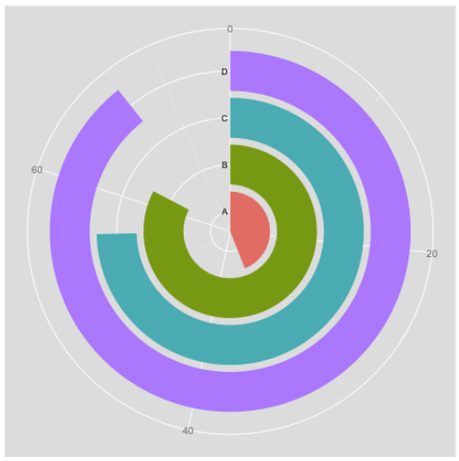

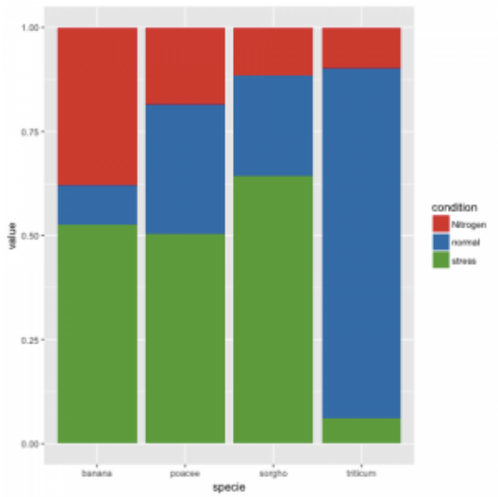

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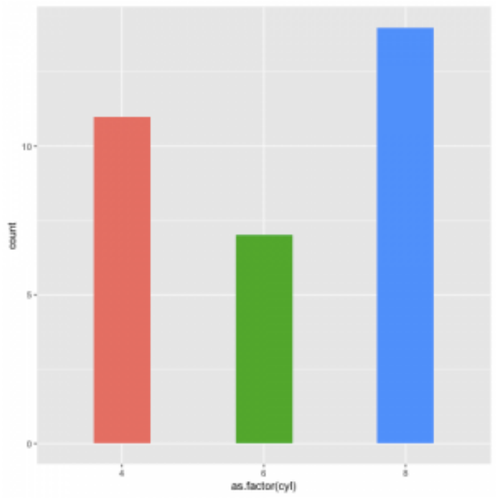

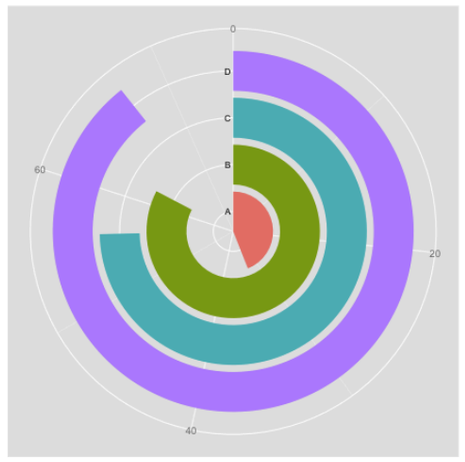

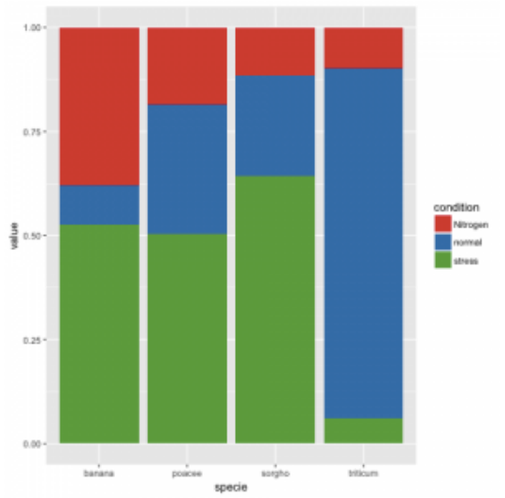

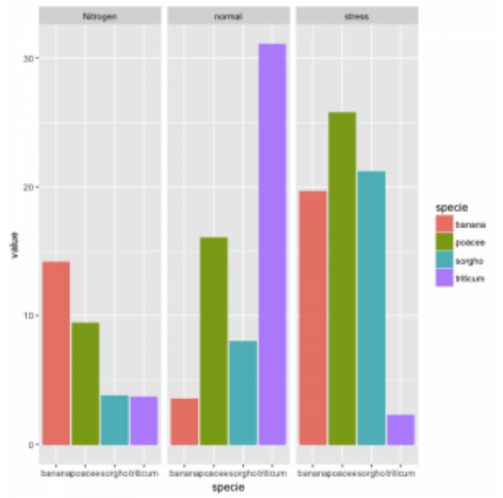

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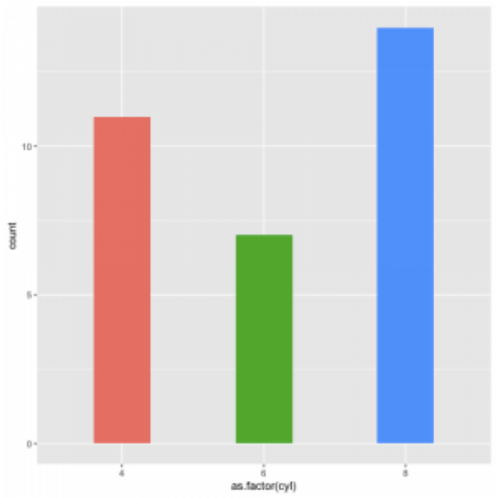

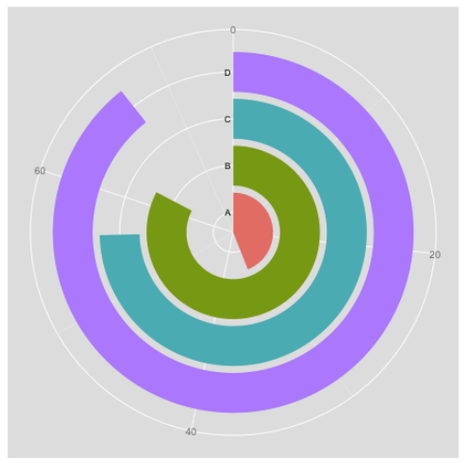

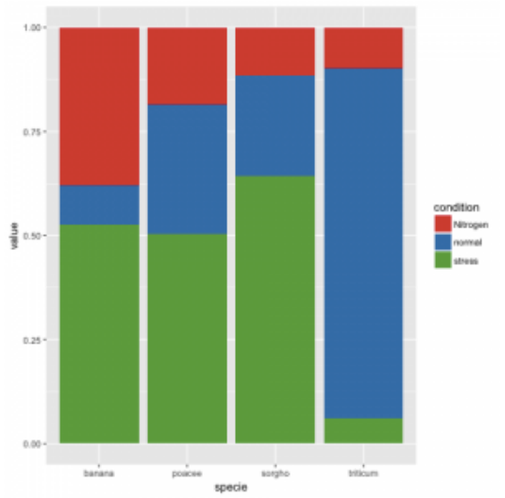

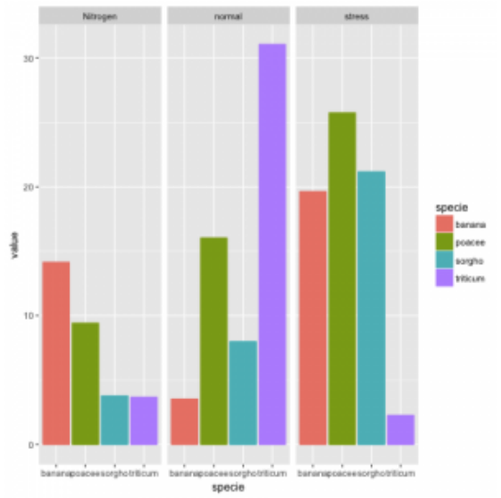

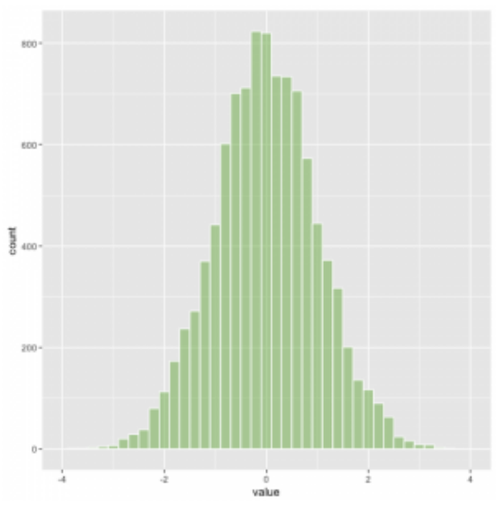

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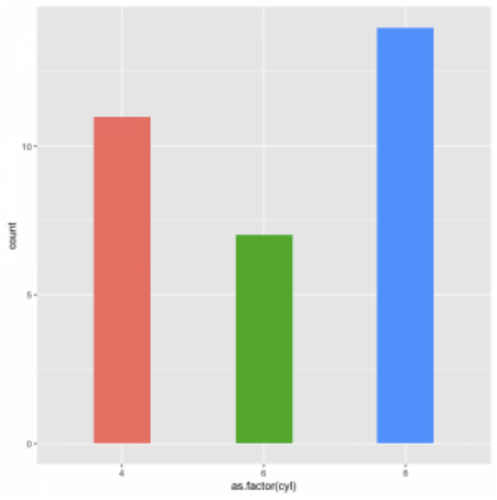

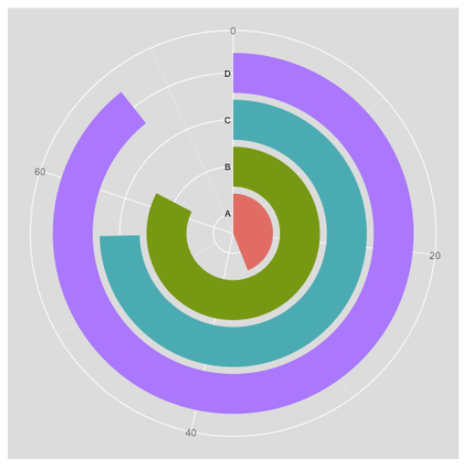

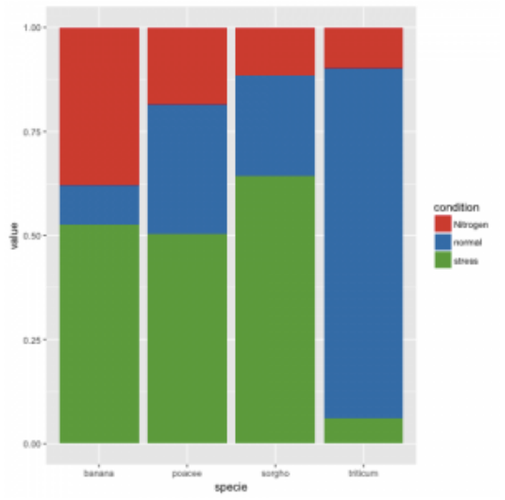

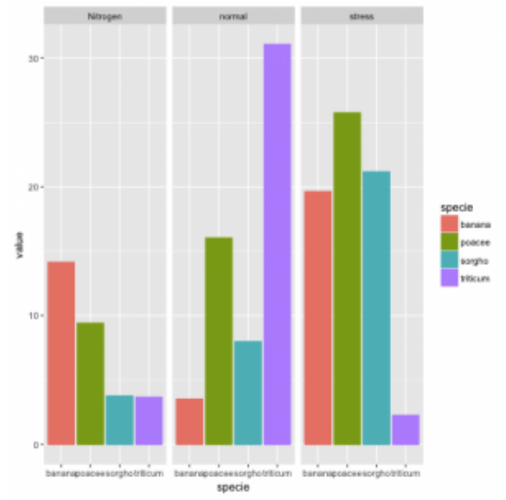

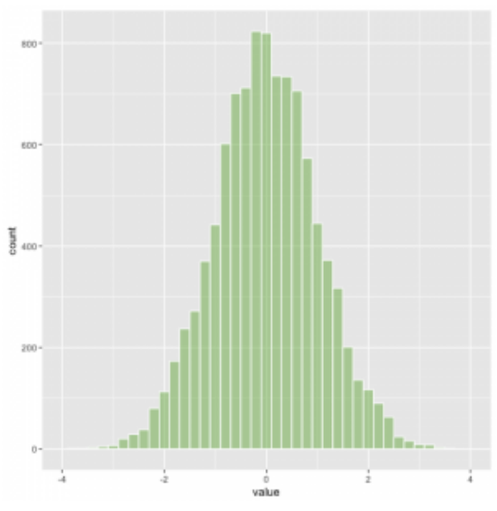

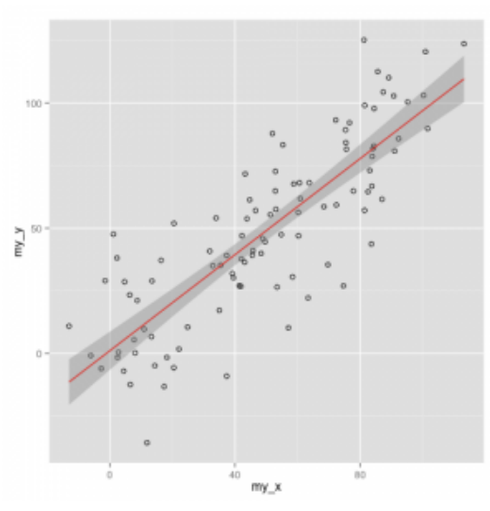

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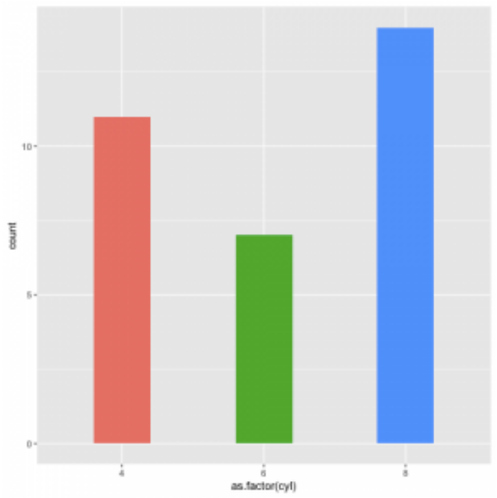

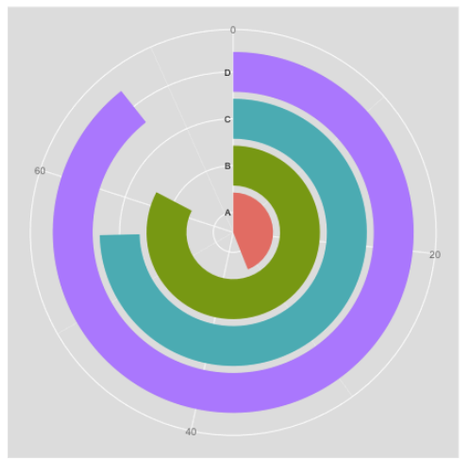

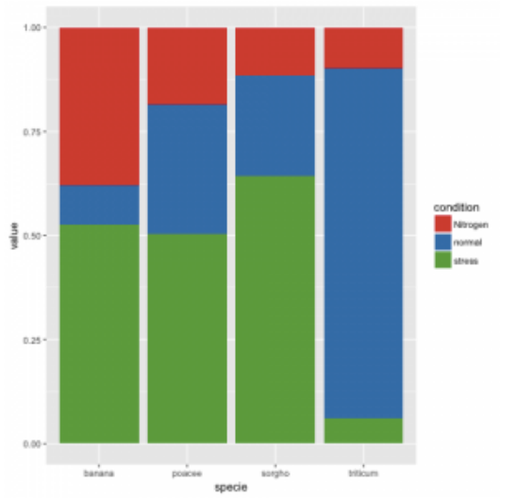

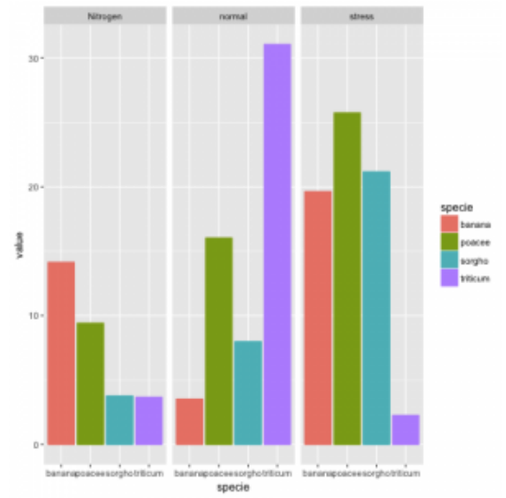

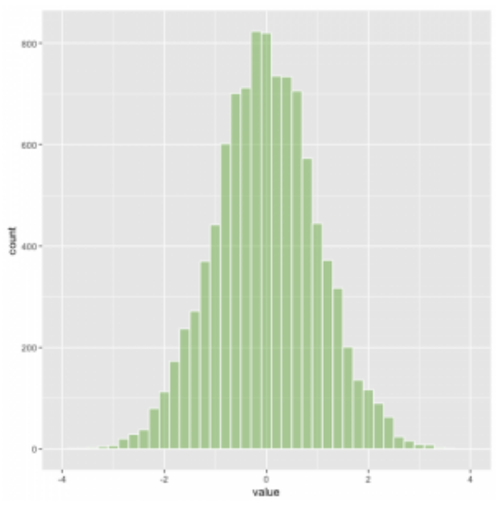

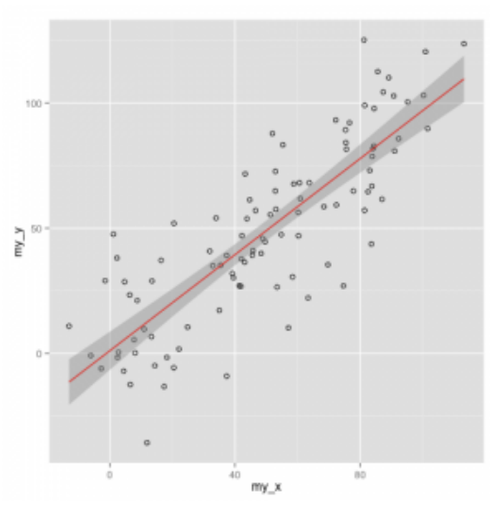

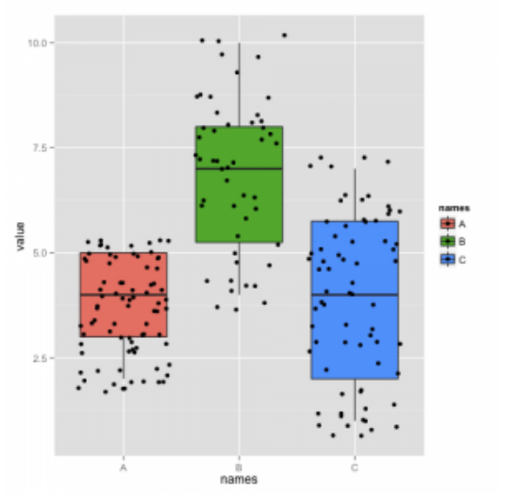

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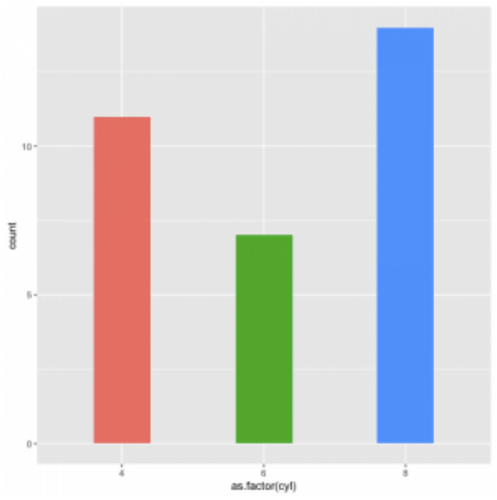

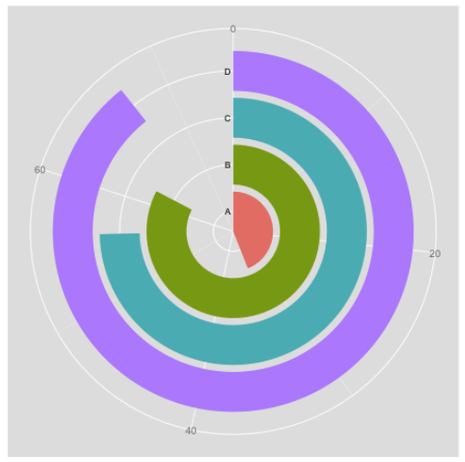

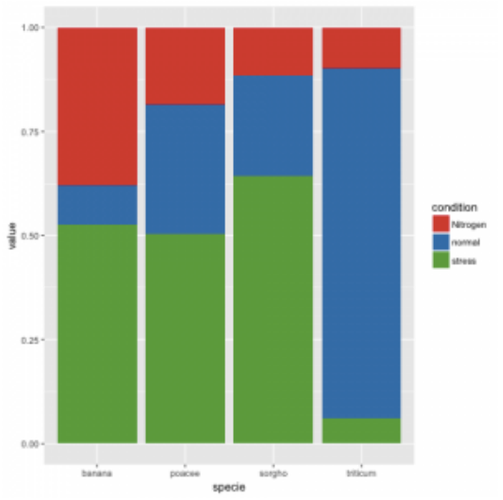

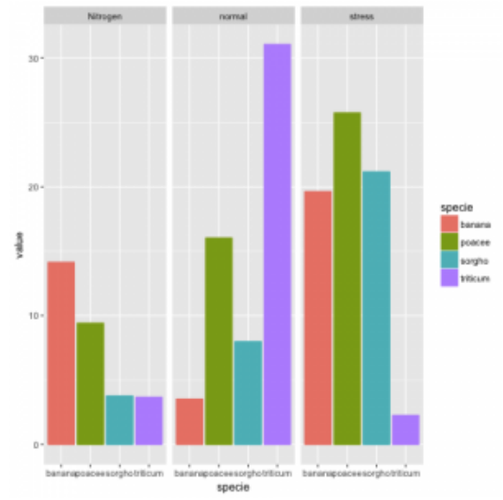

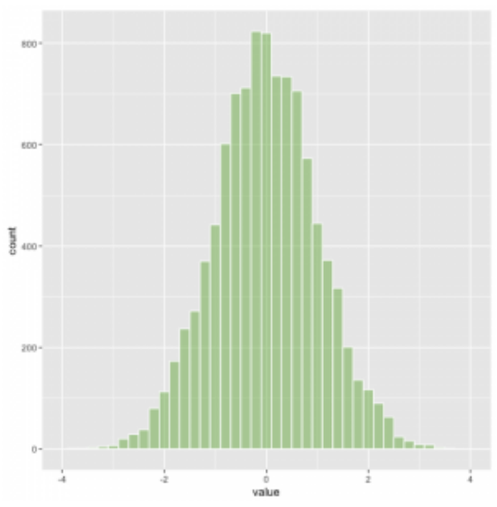

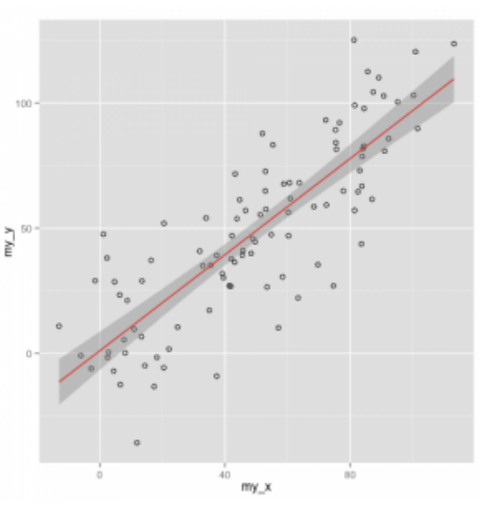

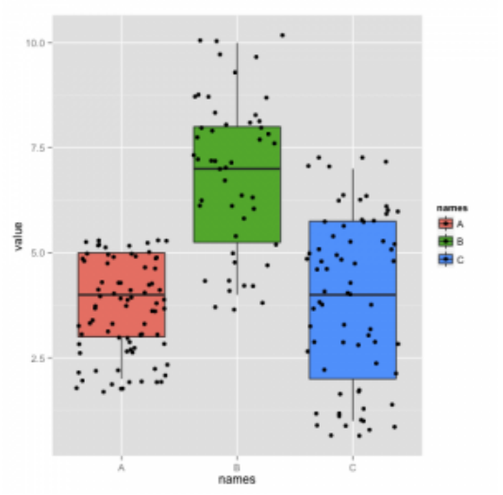

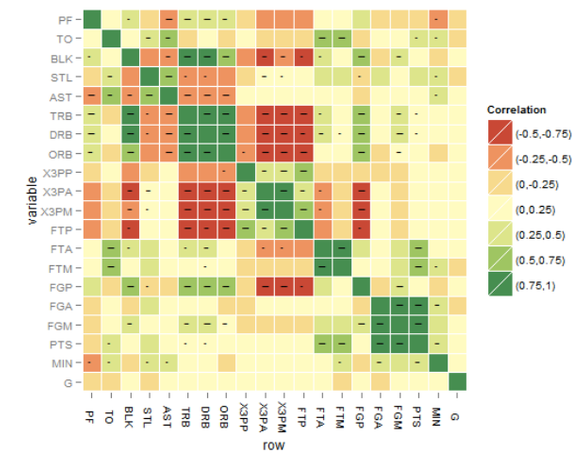

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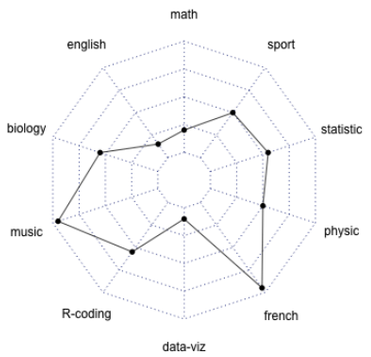

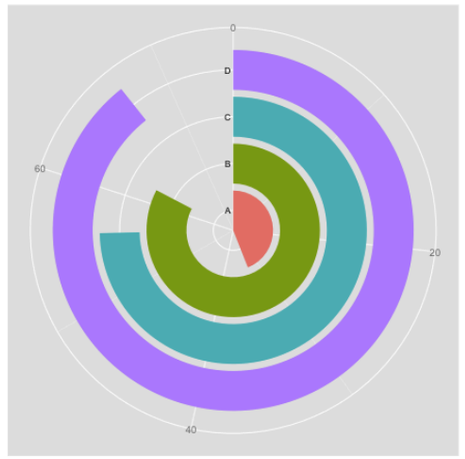

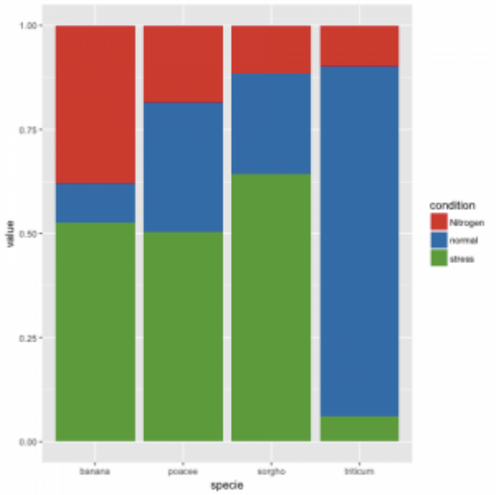

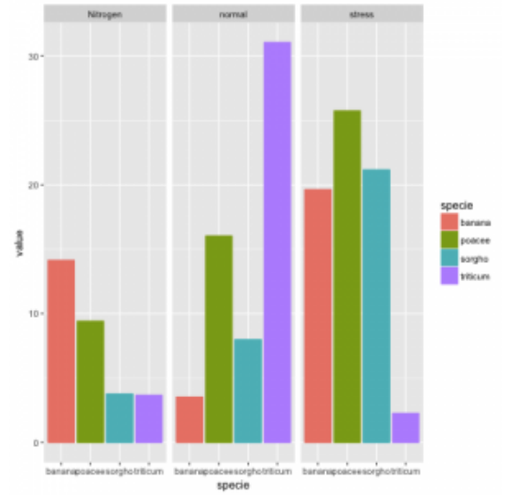

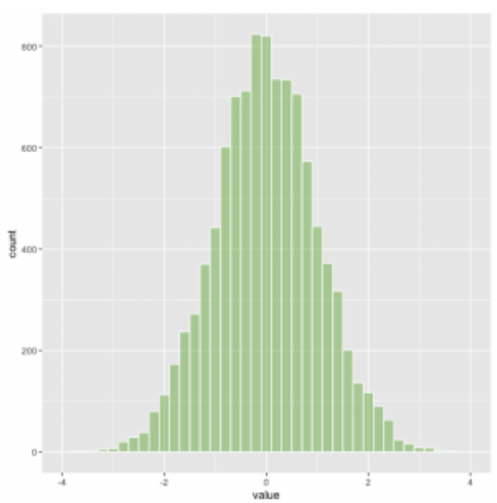

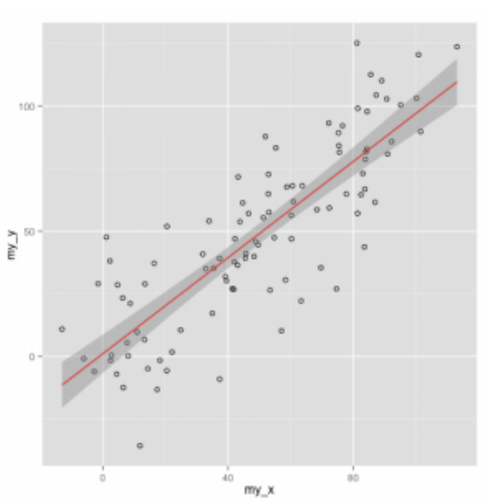

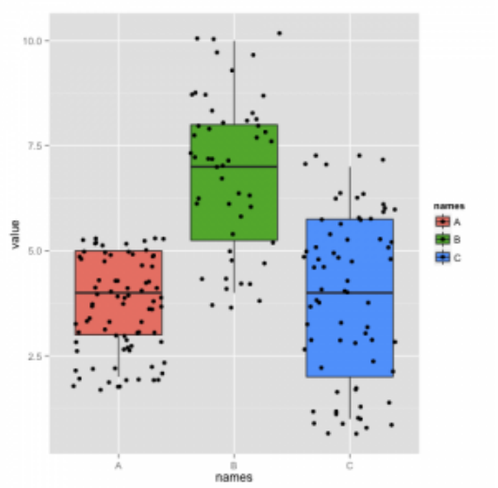

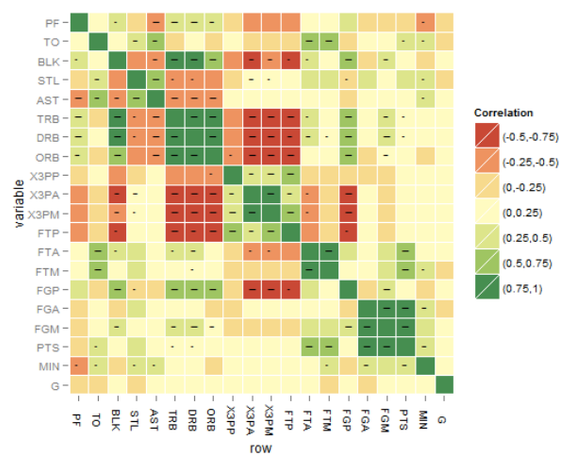

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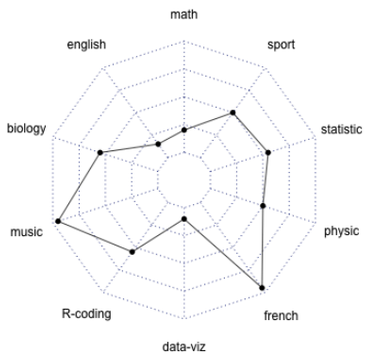
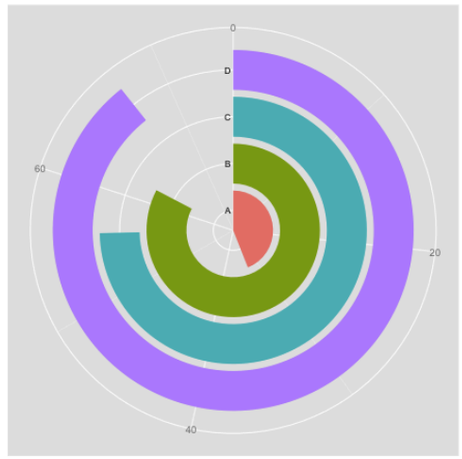
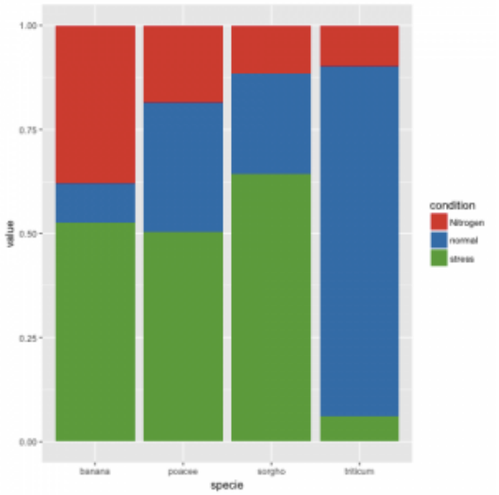
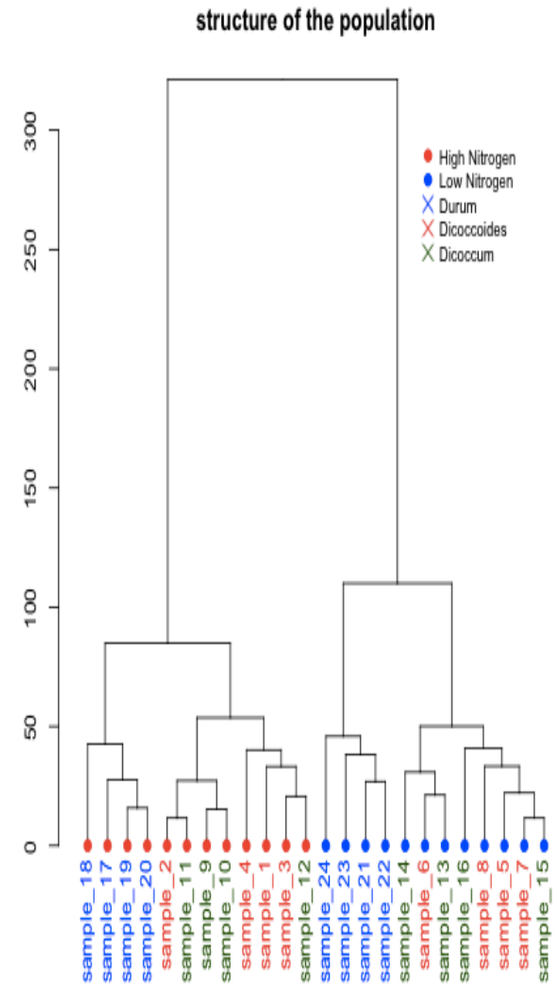
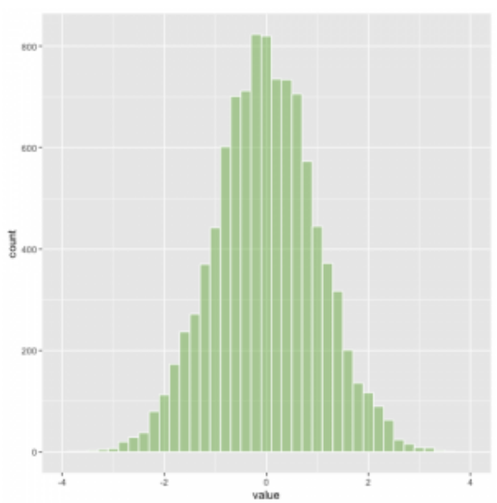
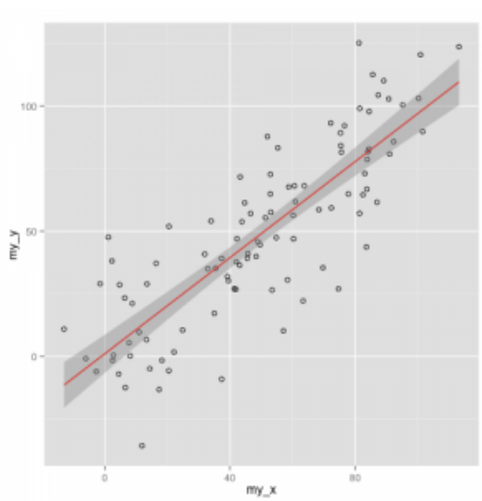


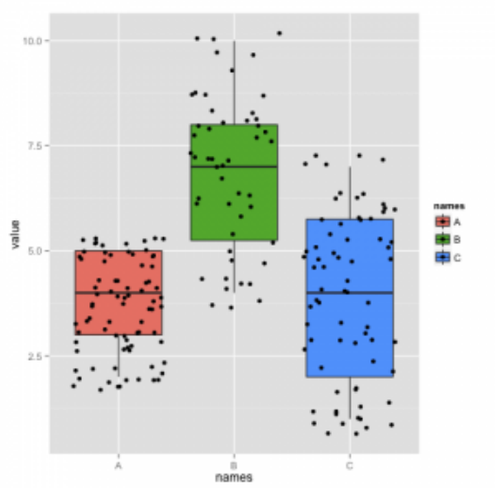






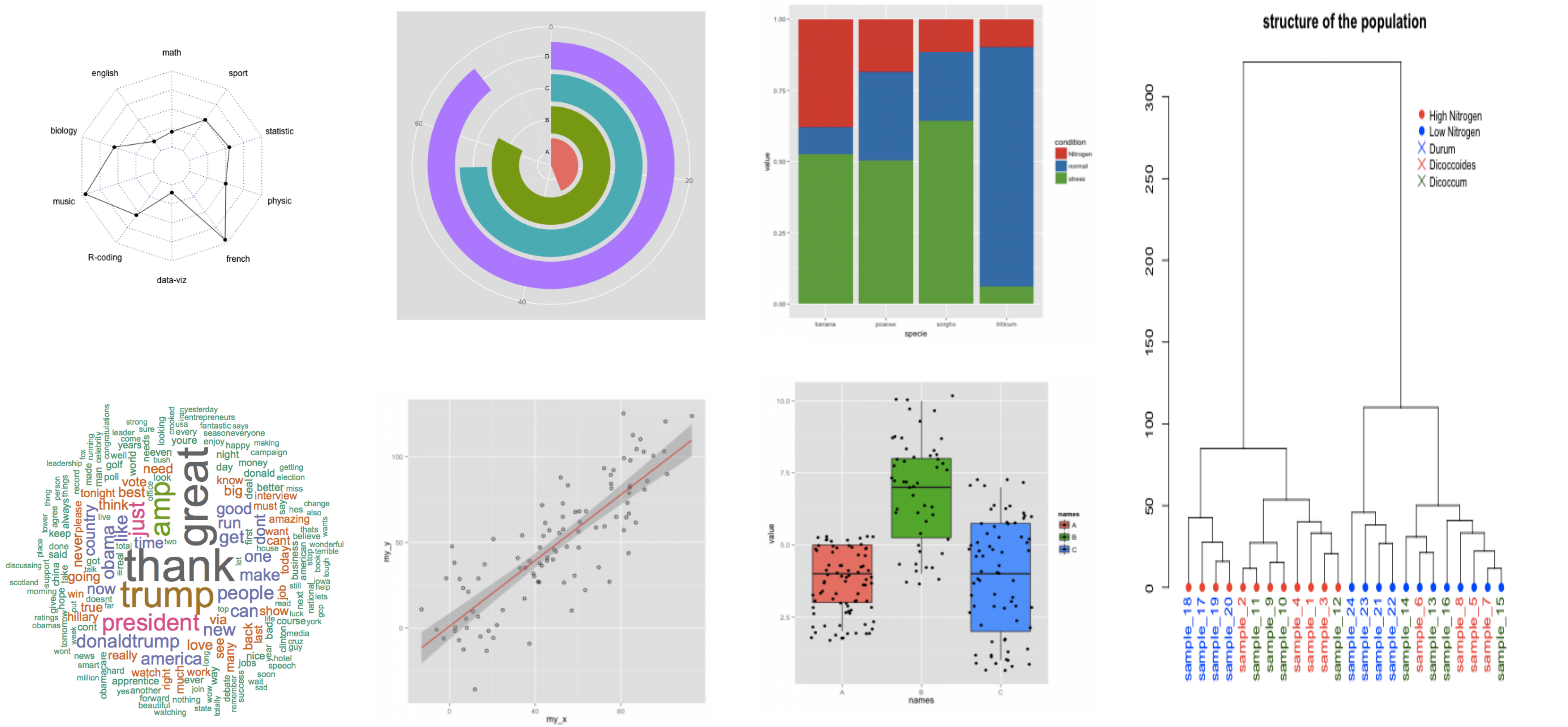






Why R ?

- **R** is **statistical**.
- Use R for **data visualisation**.



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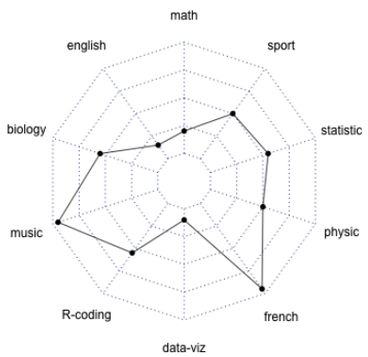

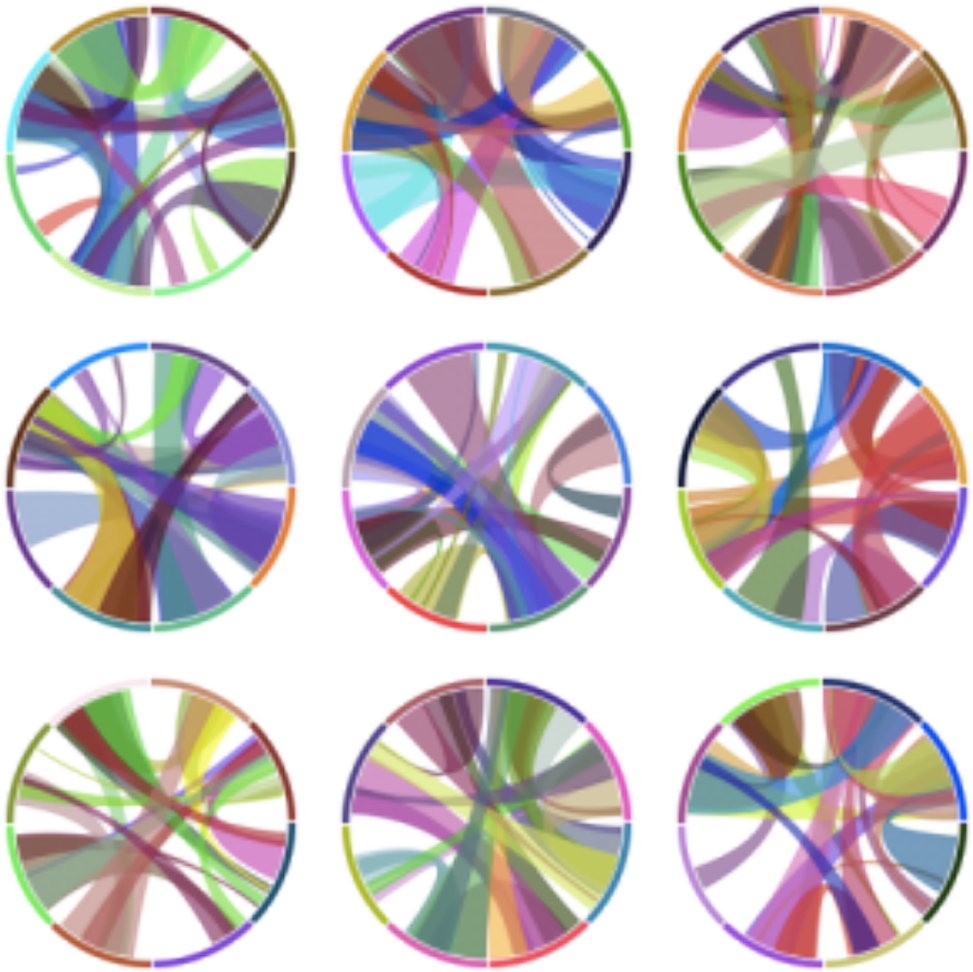

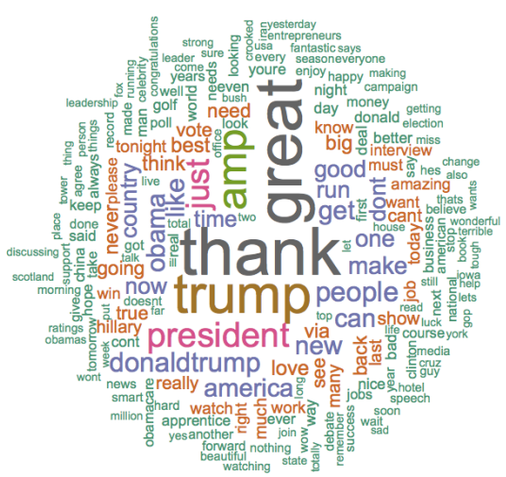

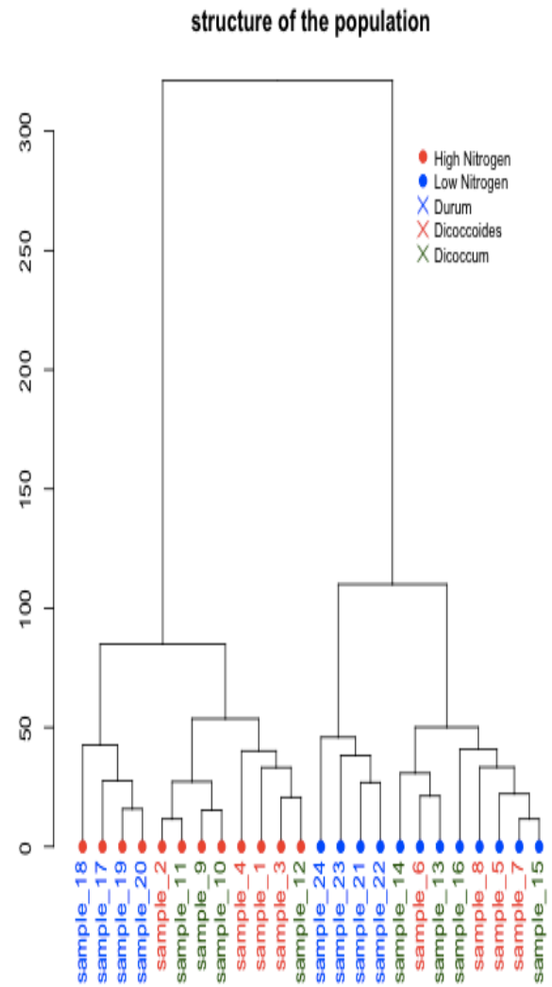

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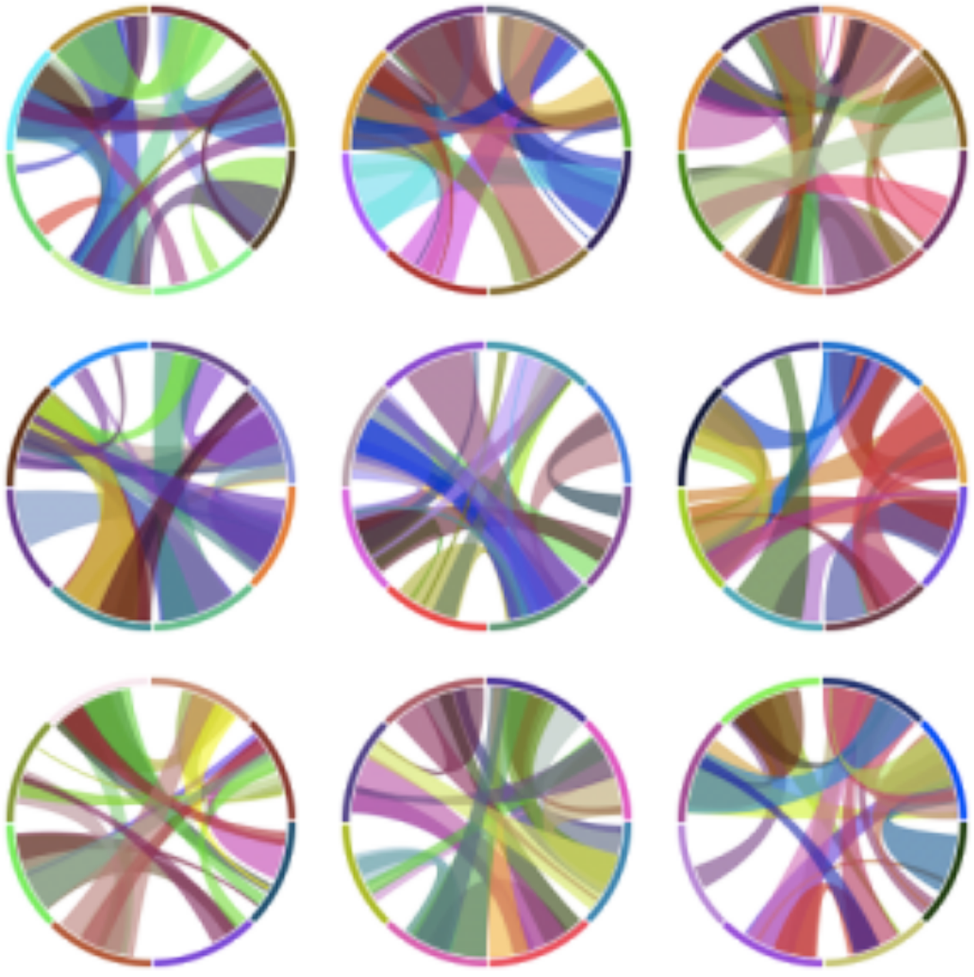

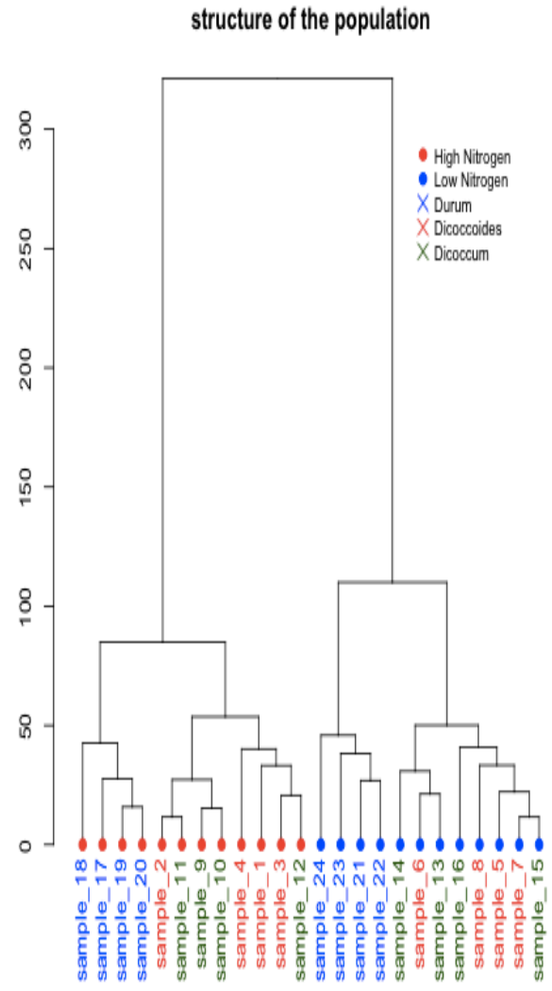

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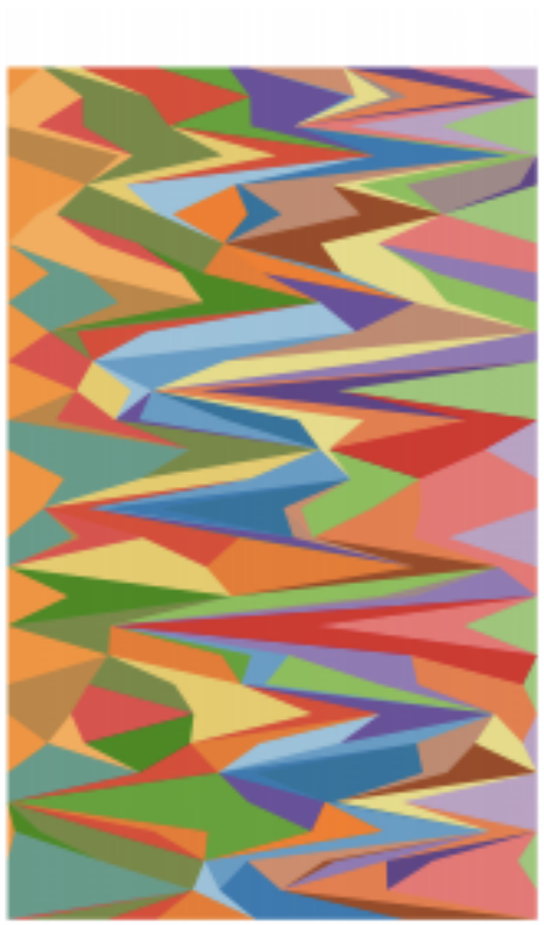

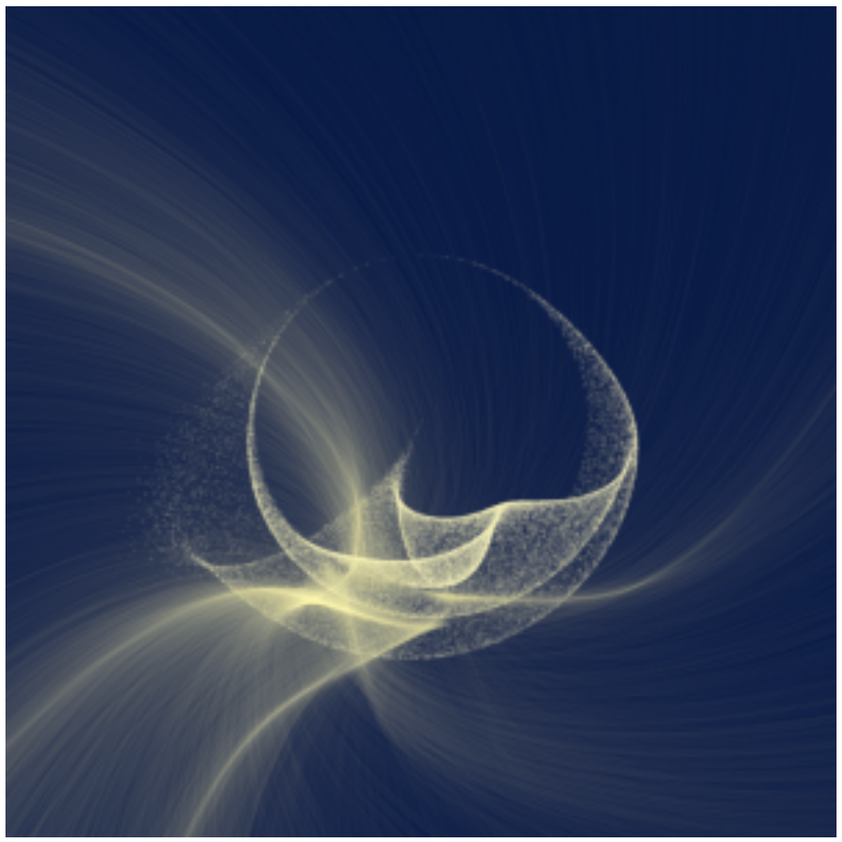

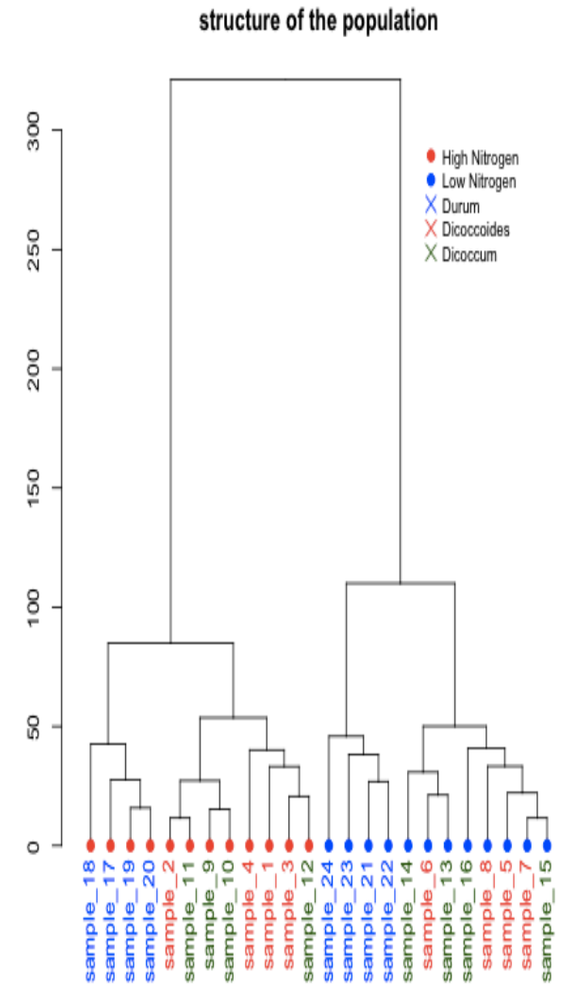

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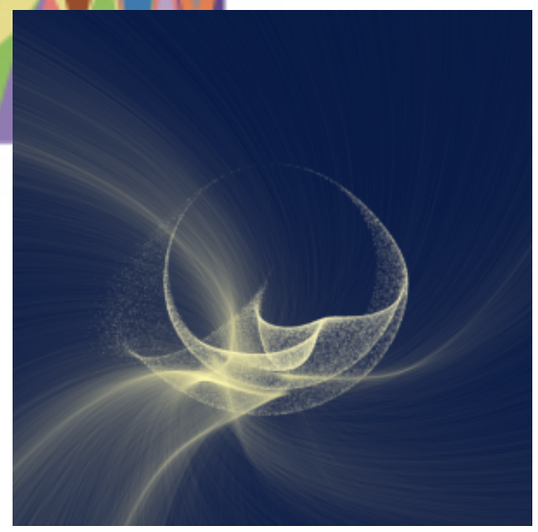
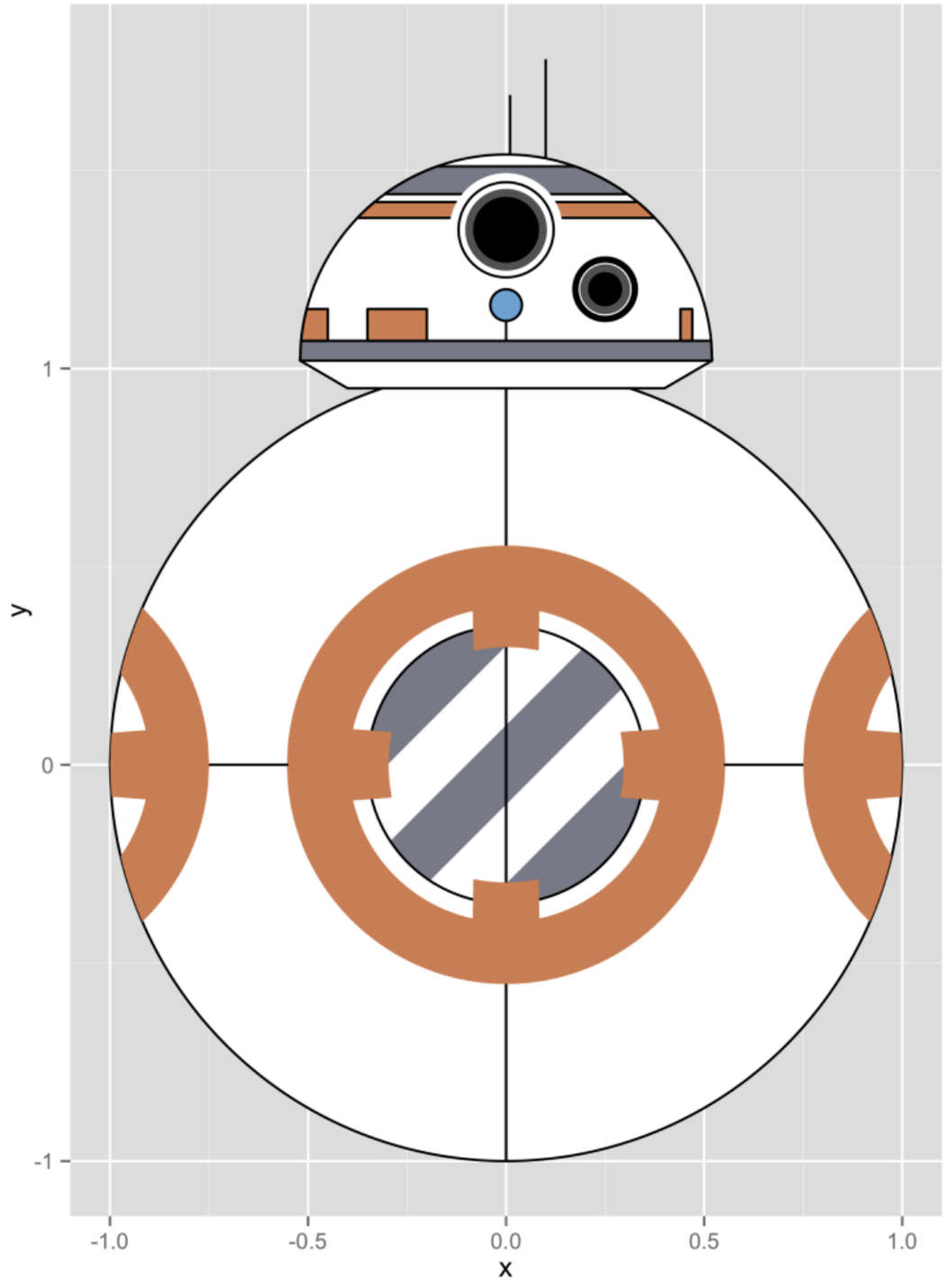


* “Droid”. https://goo.gl/kYXRRw



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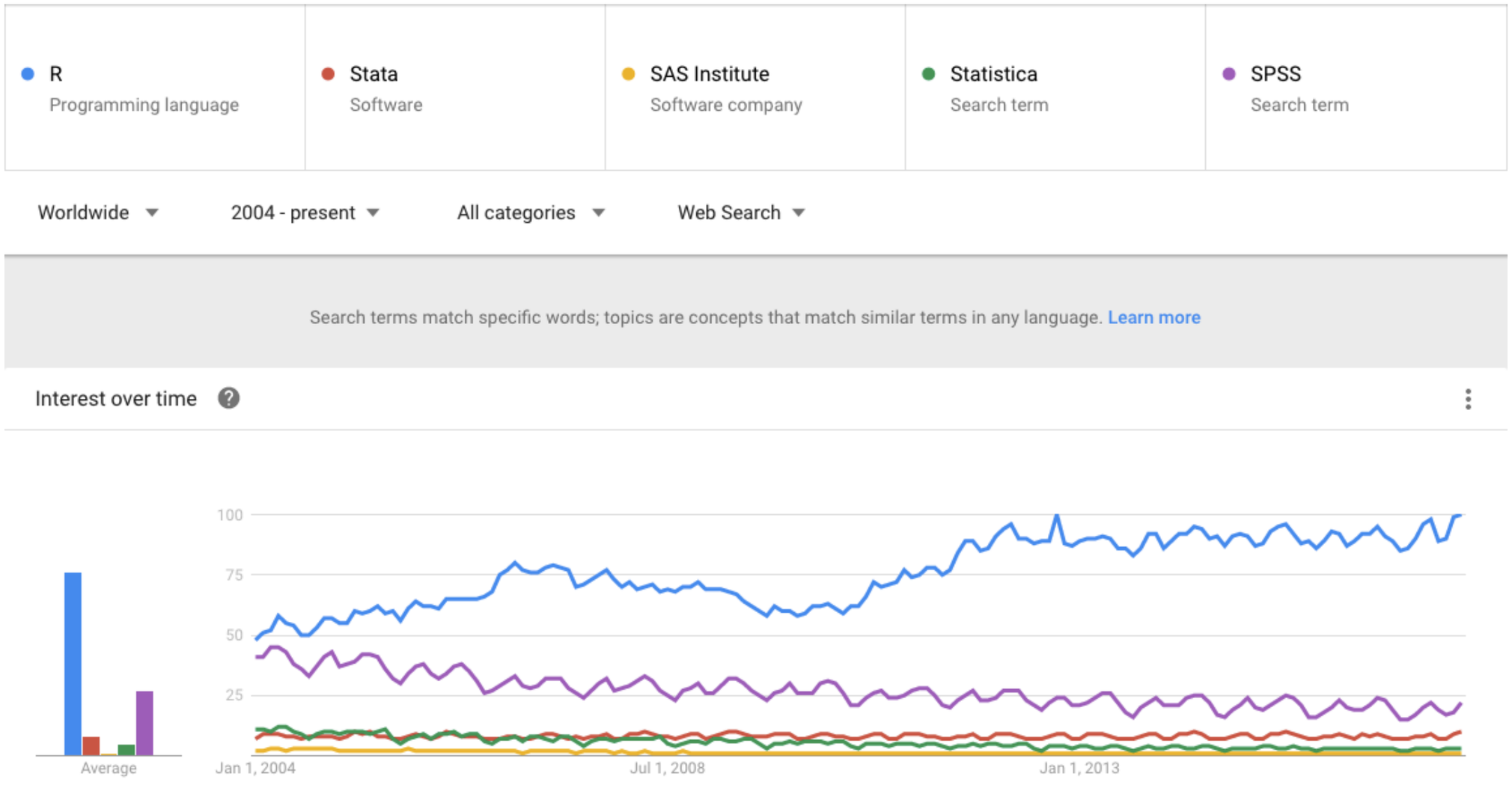

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☑More developers — many packages available.

- Ranging from *Rcpp* to *ggplot2* to *Bioconductor*!

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Installing 

- The **Comprehensive R Archive Network** (CRAN) is your friend!
- **Linux**: I assume you could find your own way…
  - RedHat-based: `sudo yum install` (or `sudo dnf install`)
  - Debian-based: `sudo apt-get install`
  - Slackware-based: ~~You are on your own~~ https://slackbuilds.org/repository/13.37/academic/R/
- **Windows**: https://cran.r-project.org/bin/windows/base/
- **Mac OS X**: https://cran.r-project.org/bin/macosx/

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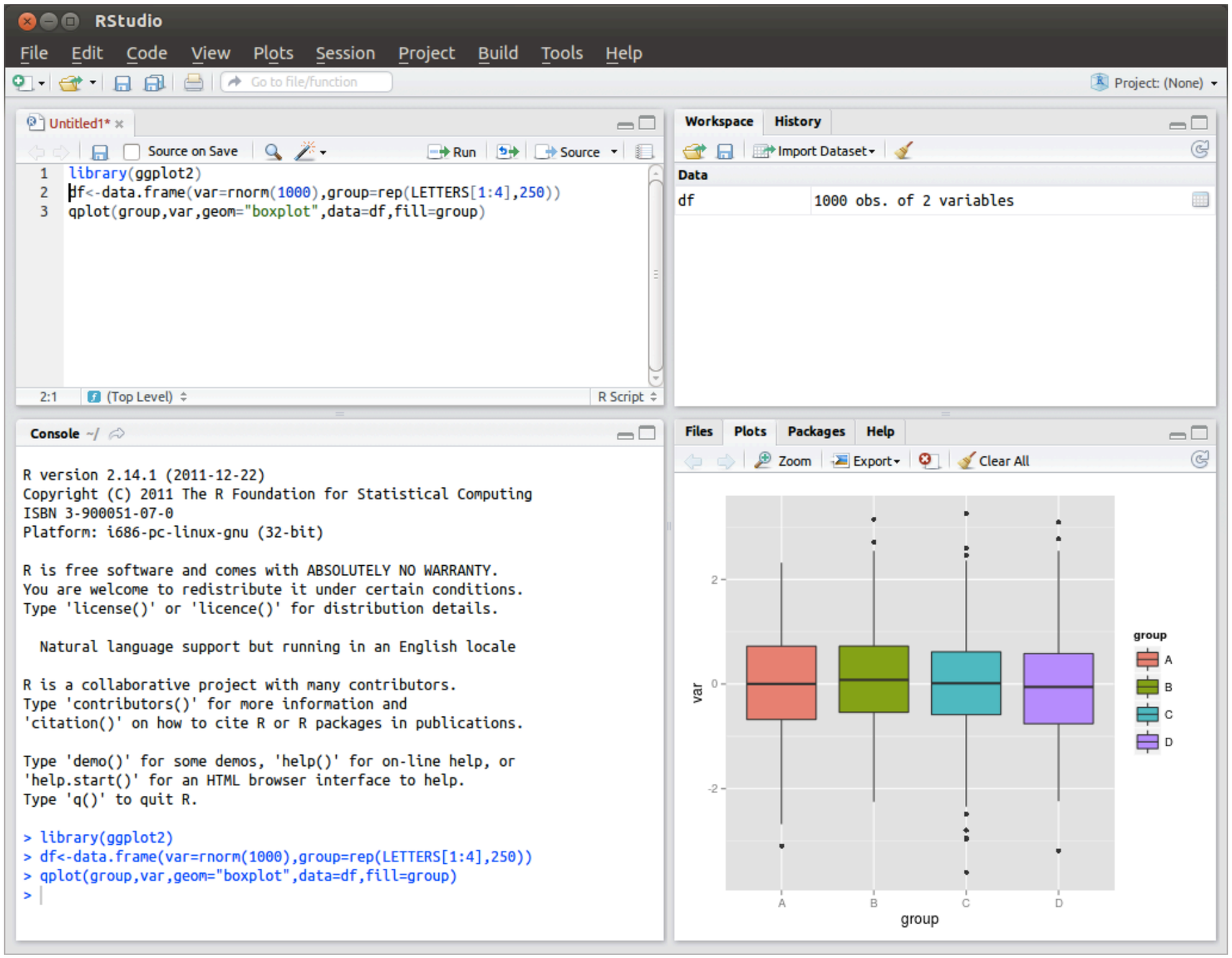

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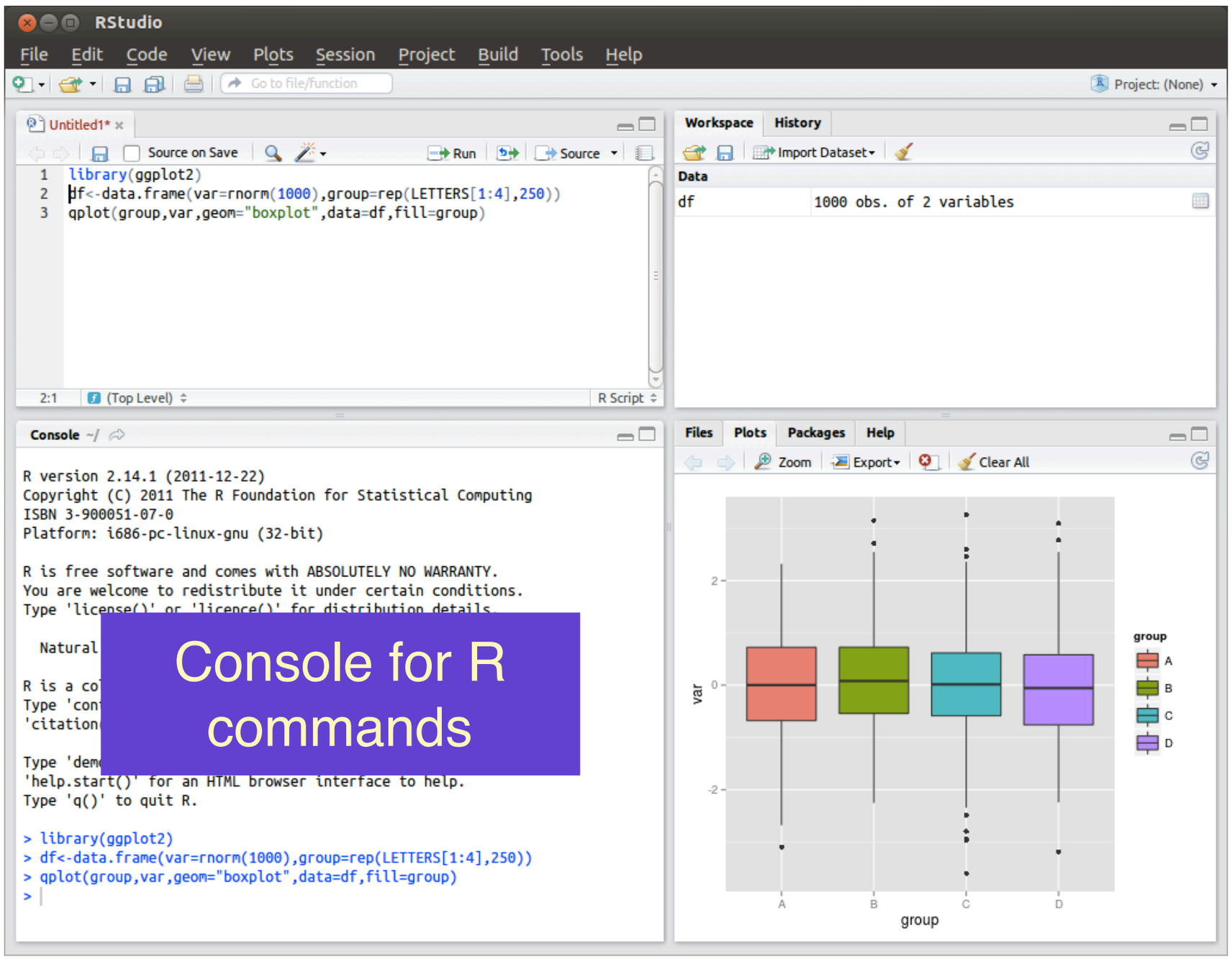

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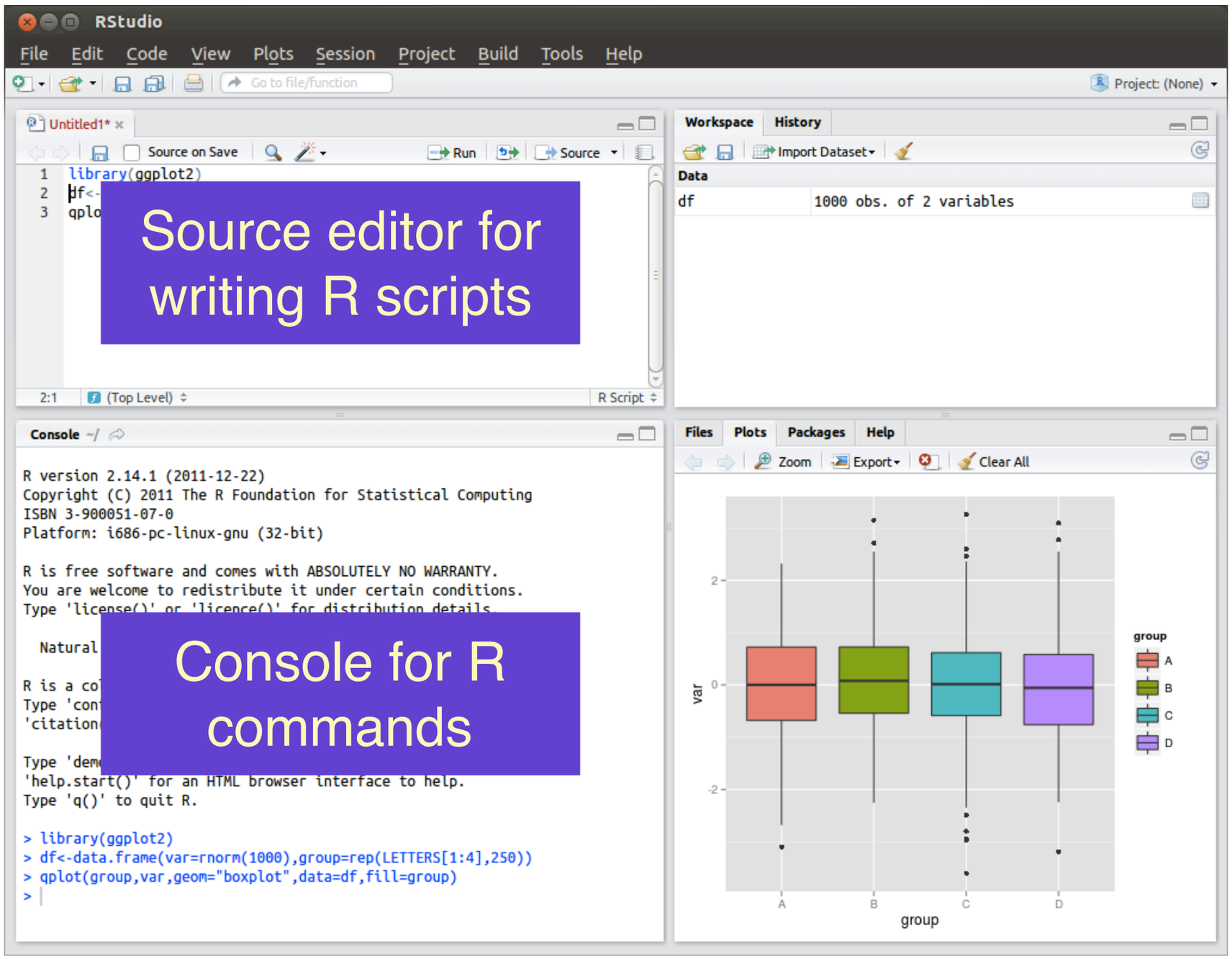

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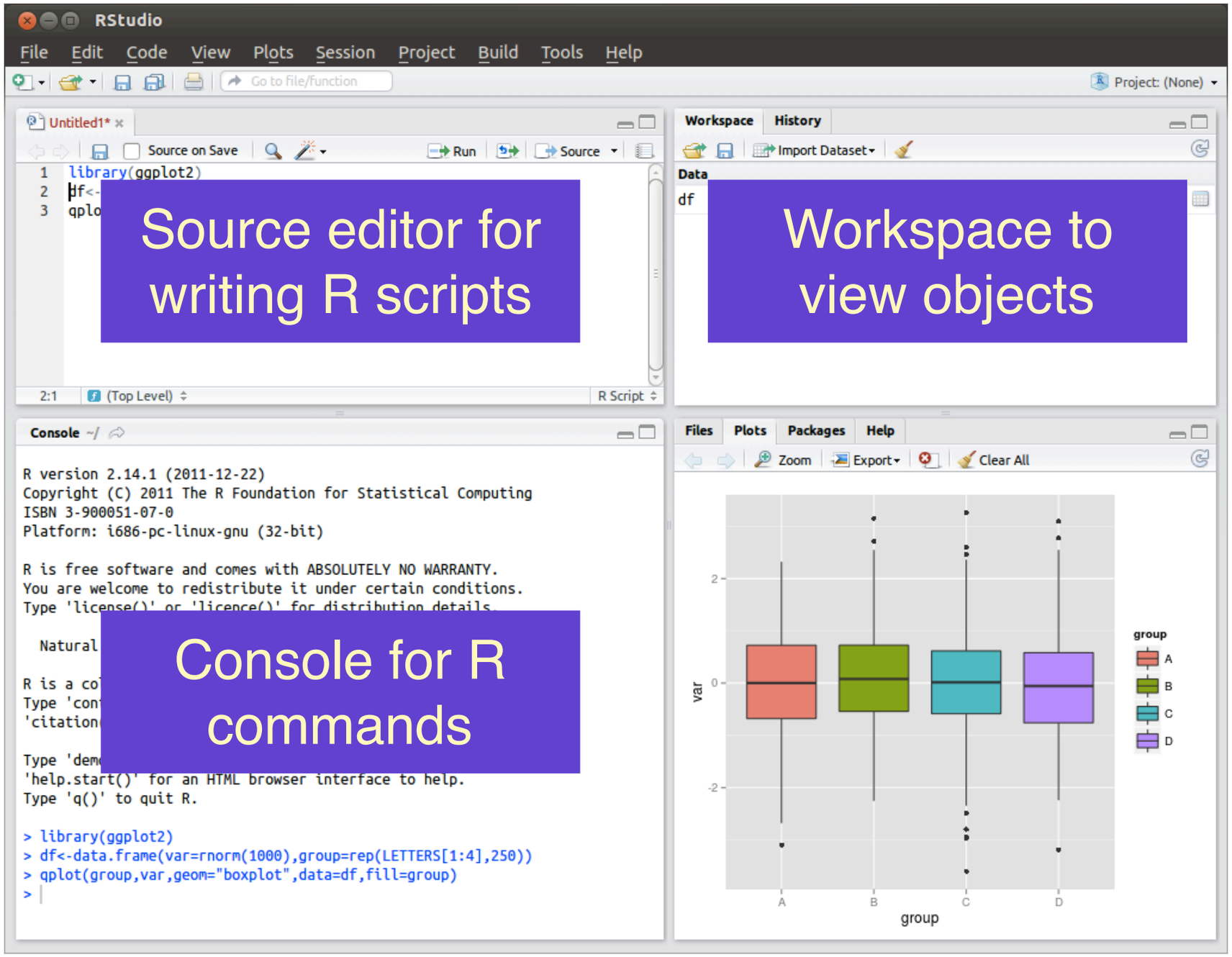

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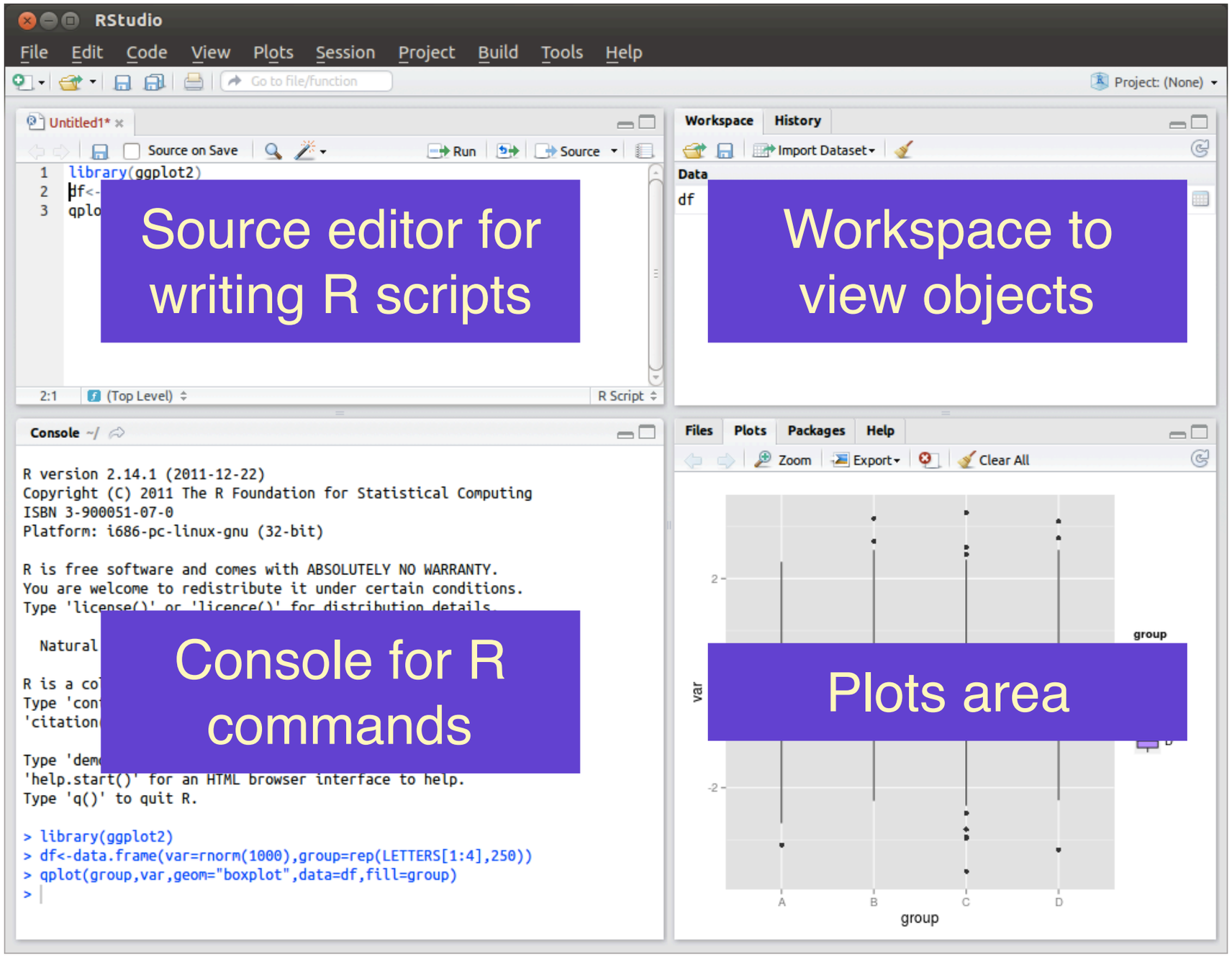

Running R

```
[y_li@aerodynamik ~]$ R

R version 3.3.2 (2016-10-31) -- "Sincere Pumpkin Patch"
Copyright (C) 2016 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin13.4.0 (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.

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[1] "Hello World!"
>
```

- Hit “Enter”
- R evaluates the expression and prints to screen the output

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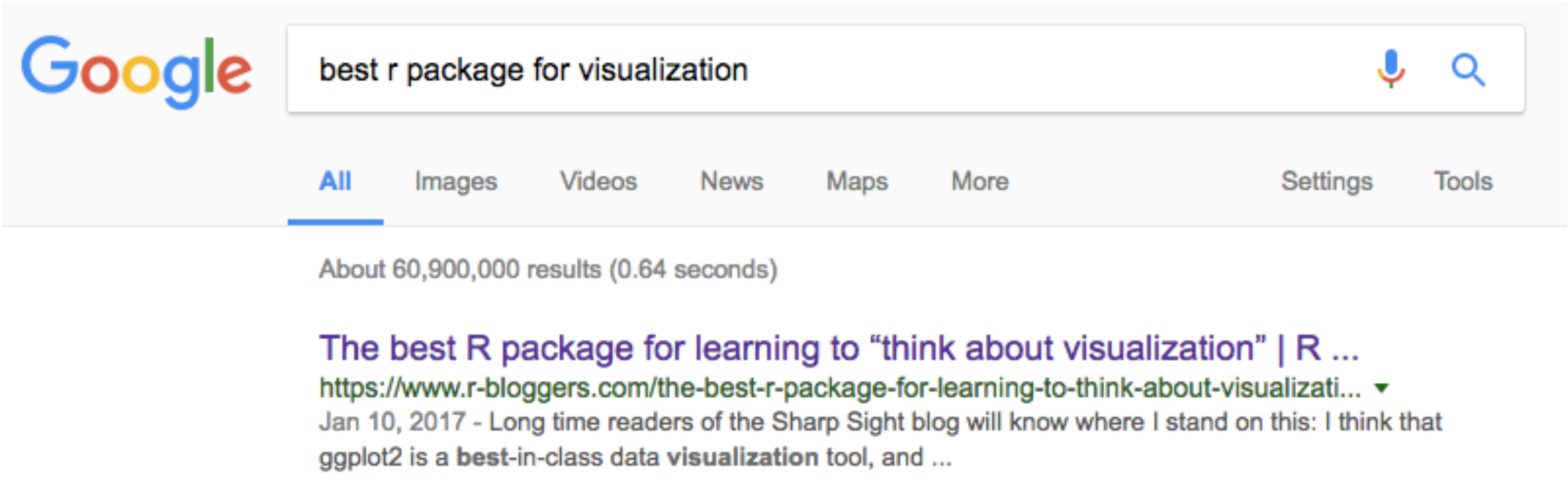

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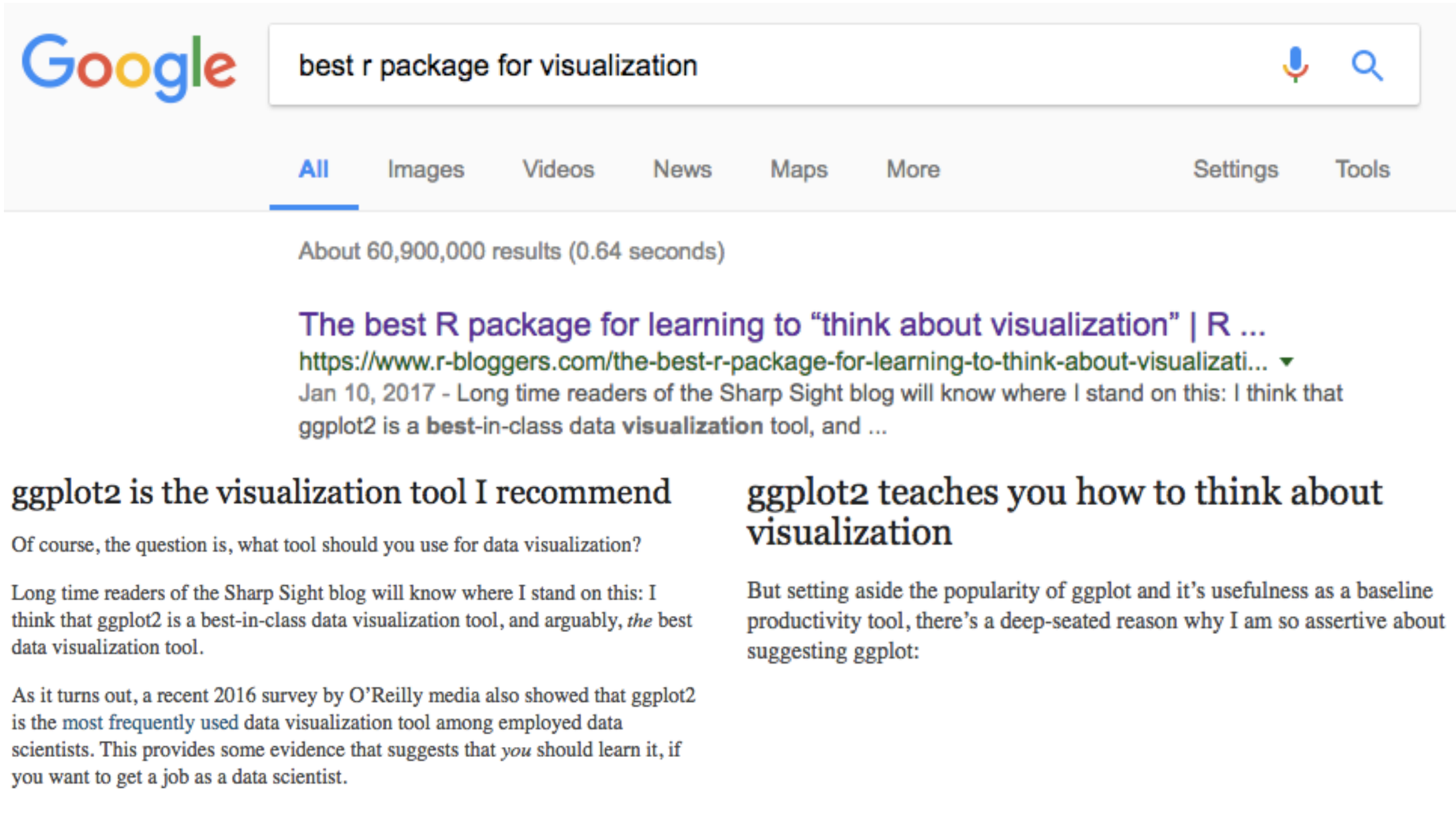

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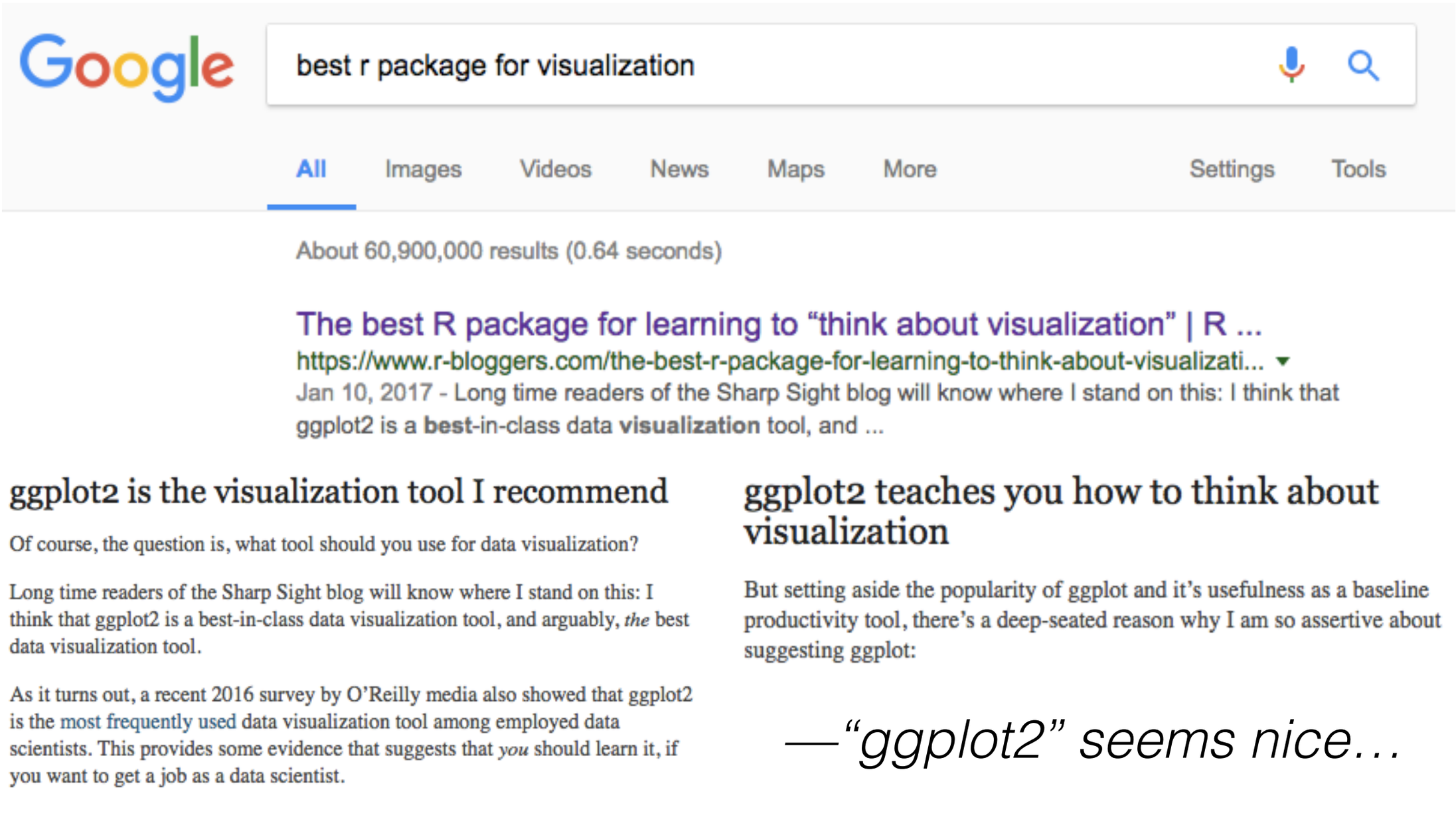

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5. **Read its manual and enjoy.**

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R data types

- R has a wide variety of data types including —
  - **Scalars**
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- By "**vector**" we usually mean atomic vectors. An **atomic vector** is a linear vector of a **single** primitive type.
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Assignment operator ("=" is also okay)
Here we are assigning a value to the vector named "a".

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`c()` is actually a function in R, which **concatenates**, or **combines**.

```
> c(c(1, 2), c(3))
[1] 1 2 3
```

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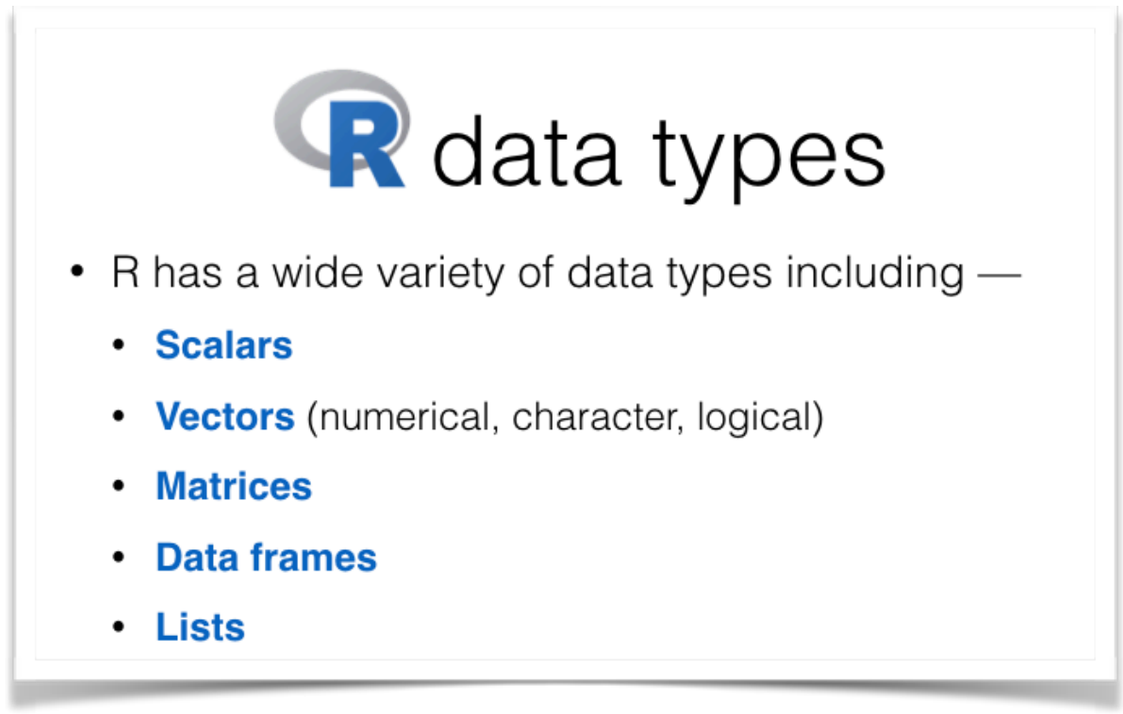

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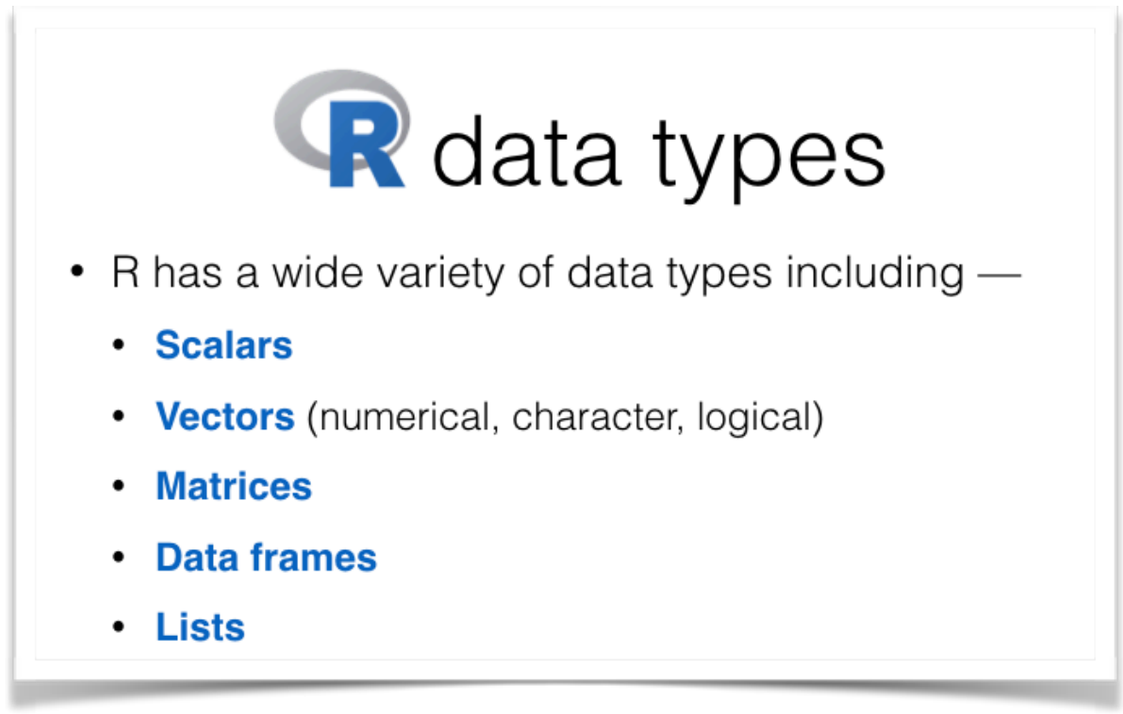
  - `a[10]` returns `NA`
- A **scalar** is just a vector of length 1.



Vectors

- By "**vector**" we usually mean atomic vectors. An **atomic vector** is a linear vector of a **single** primitive type.
- Examples

```
a <- c(1,2,5,3,6,-2,4) # Numeric vector

b <- c("one","two","three") # Character vector

c <- c(TRUE,TRUE,TRUE,FALSE,TRUE,FALSE) # Logical vector
```

- All **indexing** in R is **base-one**.
  - `a[1]` returns `1`
  - `c[3]` returns `TRUE`
  - `b[0]` returns `character(0)`
  - `a[10]` returns `NA`
- A **scalar** is just a vector of length 1.

How about categorical variables?

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
  - The values are internally **stored as integers**.
  - Each integer corresponds to a **level**, which is a **character string**.

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
  - The values are internally **stored as integers**.
  - Each integer corresponds to a **level**, which is a **character string**.
- Unordered factor

```
> mons <- c(“March”,”April”,”January”,”November",”January",”September",
“October",“September”,”November”,"August","January","November",
“November",”February",“May”,“August",”July",”December","August",
"August","September","November","February", "April")

> mons2 <- factor(mons) # Convert to unordered factor
```

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
  - The values are internally **stored as integers**.
  - Each integer corresponds to a **level**, which is a **character string**.
- Unordered factor

```
> mons <- c(“March”,”April”,”January”,”November",”January",”September",
“October",“September”,”November”,"August","January","November",
“November",”February",“May”,“August",”July",”December","August",
"August","September","November","February", "April")

> mons2 <- factor(mons) # Convert to unordered factor
```

The part after # is interpreted as comments

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
  - The values are internally **stored as integers**.
  - Each integer corresponds to a **level**, which is a **character string**.
- Unordered factor

```
> mons <- c(“March”,”April”,”January”,”November",”January",”September",
“October",“September”,”November”,"August","January","November",
“November",”February",“May”,“August",”July",”December","August",
"August","September","November","February", "April")

> mons2 <- factor(mons) # Convert to unordered factor

> table(mons2) # Build contingency table

mons2
    April     August   December   February    January       July
        2          4          1          2          3          1
    March        May   November    October  September
        1          1          5          1          3
```

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
  - The values are internally **stored as integers**.
  - Each integer corresponds to a **level**, which is a **character string**.
- Ordered factor

```
> mons3 <- factor(mons,levels=c("January","February","March","April",
"May","June","July","August","September","October","November",
"December"),ordered=TRUE) # Convert to ordered factor
```

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
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  - Each integer corresponds to a **level**, which is a **character string**.
- Ordered factor

```
> mons3 <- factor(mons,levels=c("January","February","March","April",
"May","June","July","August","September","October","November",
"December"),ordered=TRUE) # Convert to ordered factor

> mons3[1] < mons3[2] # Now we could do comparison
```

Factors

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"May","June","July","August","September","October","November",
"December"),ordered=TRUE) # Convert to ordered factor

> mons3[1] < mons3[2] # Now we could do comparison

[1] TRUE
```

```
> mons <- c("March","April"
```

Factors

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```
> mons3 <- factor(mons,levels=c("January","February","March","April",
"May","June","July","August","September","October","November",
"December"),ordered=TRUE) # Convert to ordered factor
> mons3[1] < mons3[2] # Now we could do comparison
[1] TRUE
> table(mons3) # Build contingency table
mons
  January  February     March     April       May      June
        3         2         1         2         1         0
     July    August September   October  November  December
        1         4         3         1         5         1
```

```
> mons <- c("March","April"
```

Factors

- A **factor vector** is a special storage class used for **qualitative** data.
  - The values are internally **stored as integers**.
  - Each integer corresponds to a **level**, which is a **character string**.
- Ordered factor: Another example

```
> fert <- c(10,20,20,50,10,20,10,50,20)
> fert <- factor(fert,levels=c(10,20,50),ordered=TRUE)
> fert
[1] 10 20 20 50 10 20 10 50 20
Levels: 10 < 20 < 50
```

Factors

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> fert <- factor(fert,levels=c(10,20,50),ordered=TRUE)
> fert
[1] 10 20 20 50 10 20 10 50 20
Levels: 10 < 20 < 50
> levels(fert)
[1] "10" "20" "50"
```

Factors

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```
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> fert <- factor(fert,levels=c(10,20,50),ordered=TRUE)
> fert
[1] 10 20 20 50 10 20 10 50 20
Levels: 10 < 20 < 50
> levels(fert)
[1] "10" "20" "50"
> mean(as.numeric(levels(fert)[fert]))
# Calculate the mean of the original numeric values of the fert variable
[1] 23.33333
```

Factors

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> levels(fert)
[1] "10" "20" "50"
> mean(as.numeric(levels(fert)[fert]))
# Calculate the mean of the original numeric values of the fert variable
[1] 23.33333
```

Factor levels of `fert`

Factors

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- Ordered factor: Another example

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> fert <- c(10,20,20,50,10,20,10,50,20)
> fert <- factor(fert,levels=c(10,20,50),ordered=TRUE)
> fert
[1] 10 20 20 50 10 20 10 50 20
Levels: 10 < 20 < 50
> levels(fert)
[1] "10" "20" "50"
> mean(as.numeric(levels(fert)[fert]))
# Calculate the mean of the original numeric values of the fert variable
[1] 23.33333
```

When you use a factor as an index, R silently converts it to an integer vector

Factors

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# Calculate the mean of the original numeric values of the fert variable
[1] 23.33333
```

```
[1] "10" "20" "20" "50" "10" "20" "10" "50" "20"
```

Factors

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> fert
[1] 10 20 20 50 10 20 10 50 20
Levels: 10 < 20 < 50
> levels(fert)
[1] "10" "20" "50"
> mean(as.numeric(levels(fert)[fert]))
# Calculate the mean of the original numeric values of the fert variable
[1] 23.33333
```

```
[1] 10 20 20 50 10 20 10 50 20
```

Factors

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> fert <- factor(fert,levels=c(10,20,50),ordered=TRUE)
> fert
[1] 10 20 20 50 10 20 10 50 20
Levels: 10 < 20 < 50
> levels(fert)
[1] "10" "20" "50"
> mean(as.numeric(levels(fert)[fert]))
# Calculate the mean of the original numeric values of the fert variable
[1] 23.33333
```

Take the average of —

```
[1] 10 20 20 50 10 20 10 50 20
```

R data types

- R has a wide variety of data types including —
  - **Scalars**
  - **Vectors** (numerical, character, logical)
  - **Matrices**
  - **Data frames**
  - **Lists**
- We could use `class(objectName)` to find out which type an R object is.

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

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+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

```
> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                   # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

Matrices

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```
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+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

`A[2,3]`

Element at position (2,3)

Matrices

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- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

A["row2", "col3"]

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

`A["row2", "col3"]`

Refer by row name and column name

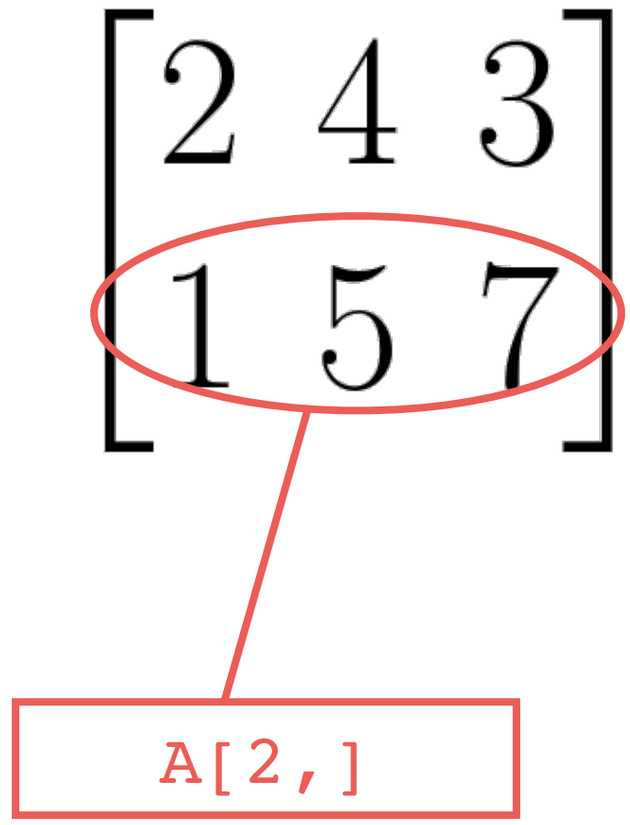
Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```



Matrices

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- Example

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+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

`A[2,]`

Get the 2nd row

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

A[,3]

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows

> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                  # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

`A[,3]`

Get the 3rd column

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

```
> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                   # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

`A[ ,c(1,3)]`

?

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

```
> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                    # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

```
A[ ,c(1,3)]
```

$$\begin{bmatrix} 2 & 3 \\ 1 & 7 \end{bmatrix}$$

Matrices

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- Example

```
> A <- matrix(
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+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

```
> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                    # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

```
A[ ,c(1,3)]
```

$$\begin{bmatrix} 2 & 3 \\ 1 & 7 \end{bmatrix}$$

Get sub-matrix

Matrices

- A **matrix** is a collection of data elements arranged in a **two-dimensional rectangular** layout. The data elements must be of the **same basic type**.
- Example

```
> A <- matrix(
+   c(2, 4, 3, 1, 5, 7), # The data elements
+   nrow=2,              # Number of rows
+   ncol=3,              # Number of columns
+   byrow = TRUE)        # Fill matrix by rows
```

$$\begin{bmatrix} 2 & 4 & 3 \\ 1 & 5 & 7 \end{bmatrix}$$

```
> dimnames(A) <- list(
+   c("row1", "row2"),          # Row names
+   c("col1", "col2", "col3")) # Column names

> A                    # Print A
     col1 col2 col3
row1    2    4    3
row2    1    5    7
```

`t(A)`
Transpose of A

$$\begin{bmatrix} 2 & 1 \\ 4 & 5 \\ 3 & 7 \end{bmatrix}$$

R data types

- R has a wide variety of data types including —
  - **Scalars**
  - **Vectors** (numerical, character, logical)
  - **Matrices**
  - **Data frames**
  - **Lists**
- We could use `class(objectName)` to find out which type an R object is.

Data frames

- A **data frame** is used for storing data tables. It is a list of **vectors of equal length**. Different columns can have **different classes** (numeric, character, factor, etc.).
- Example

```
> d <- c(1,2,3,4)

> e <- c("red", "white", "red", NA)

> f <- c(TRUE,TRUE,TRUE,FALSE)

> mydata <- data.frame(d,e,f) # A data frame

> colnames(mydata) <- c("ID","Color","Passed") # Column names (header)

> mydata

  ID Color Passed

1  1   red   TRUE

2  2 white   TRUE

3  3   red   TRUE

4  4  <NA>  FALSE
```

Data frames

- A **data frame** is used for storing data tables. It is a list of **vectors of equal length**. Different columns can have **different classes** (numeric, character, factor, etc.).
- Example

```
> mydata[1,2]
```

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

Data frames

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- Example

```
> mydata[1,2]
[1] red
Levels: red white
```

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

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- Example

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> mydata[1,2]
[1] red
Levels: red white
```

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

To avoid character vectors being converted to strings, add the option **`stringsAsFactors = FALSE`** when creating a data frame

Data frames

- A **data frame** is used for storing data tables. It is a list of **vectors of equal length**. Different columns can have **different classes** (numeric, character, factor, etc.).
- Example

```
> mydata[1,2]
[1] red
Levels: red white
> nrow(mydata) # Number of rows
[1] 4
> ncol(mydata) # Number of columns
[1] 3
> dim(mydata) # Dimensions
[1] 4 3
```

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

Data frames

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- Example

```
> str(mydata) # Get a summary of the data frame

'data.frame': 4 obs. of  3 variables:

$ ID    : num  1 2 3 4

$ Color : Factor w/ 2 levels "red","white": 1 2 1 NA

$ Passed: logi  TRUE TRUE TRUE FALSE
```

```
> mydata

  ID Color Passed

1  1   red   TRUE

2  2 white   TRUE

3  3   red   TRUE

4  4  <NA>  FALSE
```

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> str(mydata) # Get a summary of the data frame

'data.frame': 4 obs. of  3 variables:
 $ ID    : num  1 2 3 4
 $ Color : Factor w/ 2 levels "red","white": 1 2 1 NA
 $ Passed: logi  TRUE TRUE TRUE FALSE
> head(mydata) # Show first several rows
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

Data frames

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```
> str(mydata) # Get a summary of the data frame

'data.frame': 4 obs. of  3 variables:
 $ ID    : num  1 2 3 4
 $ Color : Factor w/ 2 levels "red","white": 1 2 1 NA
 $ Passed: logi  TRUE TRUE TRUE FALSE
> head(mydata) # Show first several rows
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

- **`head()`** by default returns the first 6 rows (or all the rows if nrow <= 6)
- To show the first **i** rows, use **`head(mydata, n = i)`**

WARNING: COMPLETELY FOR BEGINNERS!

IN TODAY'S GUIDE...

1. What is R? Why R?
2. Installation and "Hello World!" in R
3. R data types – vectors, matrices and data frames
4. R operators and managing a data frame
5. I/O and basic graphs in R
6. Pop quiz

operators

- Arithmetic operators

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division

R operators

- Arithmetic operators

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division
^ or **	Exponentiation

R operators

- Arithmetic operators

Operator	Description
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/	Division
^ or **	Exponentiation
x %% y	x mod y (5 %% 2 is 1)

R operators

- Arithmetic operators

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division
^ or **	Exponentiation
x %% y	x mod y (5 %% 2 is 1)
x %/% y	Integer division (5 %/% 2 is 2)

Special values in 

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- **`NA`**: Not available (missing); a logical constant

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  - Different from the string **`"NA"`**!

Special values in 

- **`NA`**: Not available (missing); a logical constant
  - Check via **`is.na(x)`**
  - Different from the string **`"NA"`**!
- **`NaN`**: Not a number

```
> 0 / 0

[1] NaN
```

Special values in 

- **`NA`**: Not available (missing); a logical constant
  - Check via **`is.na(x)`**
  - Different from the string **`"NA"`**!
- **`NaN`**: Not a number

```
> 0 / 0
[1] NaN
```

- **`Inf`** (**`-Inf`**): Infinity

```
> 12 / 0
[1] Inf
```

Special values in 

- **`NA`**: Not available (missing); a logical constant
  - Check via **`is.na(x)`**
  - Different from the string **`"NA"`**!
- **`NaN`**: Not a number

```
> 0 / 0
[1] NaN
```

- **`Inf`** (**`-Inf`**): Infinity

```
> 12 / 0
[1] Inf
```

- **`NULL`**: The null object; undefined and of length 0

R operators

- Logical operators

Operator	Description
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to

R operators

- Logical operators

Operator	Description
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>=	Greater than or equal to
==	Exactly equal to

R operators

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R operators

- Logical operators

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<=	Less than or equal to
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>=	Greater than or equal to
==	Exactly equal to
!=	Not equal to
!x	Not x

R operators

- Logical operators

Operator	Description
<	Less than
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>=	Greater than or equal to
==	Exactly equal to
!=	Not equal to
!x	Not x
x | y; x || y	x OR y (| is vectorized)

R operators

- Logical operators

Operator	Description
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to
==	Exactly equal to
!=	Not equal to
!x	Not x
x | y; x || y	x OR y (| is vectorized)
x & y; x && y	x AND y (& is vectorized)

R operators

- Logical operators

Operator	Description
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to
==	Exactly equal to
!=	Not equal to
!x	Not x
x | y; x || y	x OR y (| is vectorized)
x & y; x && y	x AND y (& is vectorized)
isTRUE(x)	Test if x is TRUE

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
  6. !
  7. & and &&
  8. | and ||
  9. <-
  10. =
- **Associativity**: Left to right, except for exponentiation and assignment
- **Parentheses** override order

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
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Examples

operator rules

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  2. %% and %/%
  3. * and /
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  5. <, >, <=, >= and !=
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  8. | and ||
  9. <-
  10. =
- **Associativity**: Left to right, except for exponentiation and assignment
- **Parentheses** override order

Examples

```
> 4 + 20 / 17 %/% 3
[1]   ?
```

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
  6. !
  7. & and &&
  8. | and ||
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  10. =
- **Associativity**: Left to right, except for exponentiation and assignment
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Examples

```
> 4 + 20 / 17 %/% 3
[1] 8
```

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
  6. !
  7. & and &&
  8. | and ||
  9. <-
  10. =

Examples

```
> 4 + 20 / 17 %/% 3
[1] 8
```

```
> !FALSE | TRUE & FALSE
[1]   ?
```

- **Associativity**: Left to right, except for exponentiation and assignment
- **Parentheses** override order

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
  6. !
  7. & and &&
  8. | and ||
  9. <-
  10. =
- **Associativity**: Left to right, except for exponentiation and assignment
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Examples

```
> 4 + 20 / 17 %/% 3
[1] 8
```

```
> !FALSE | TRUE & FALSE
[1] TRUE
```

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
  6. !
  7. & and &&
  8. | and ||
  9. <-
  10. =

Examples

```
> 4 + 20 / 17 %/% 3
[1] 8
```

```
> !FALSE | TRUE & FALSE
[1] TRUE
```

```
> (!FALSE | TRUE) & FALSE
[1]    ?
```

- **Associativity**: Left to right, except for exponentiation and assignment
- **Parentheses** override order

operator rules

- **Operator precedence**
  1. ^
  2. %% and %/%
  3. * and /
  4. + and -
  5. <, >, <=, >= and !=
  6. !
  7. & and &&
  8. | and ||
  9. <-
  10. =

Examples

```
> 4 + 20 / 17 %/% 3
[1] 8
```

```
> !FALSE | TRUE & FALSE
[1] TRUE
```

```
> (!FALSE | TRUE) & FALSE
[1] FALSE
```

- **Associativity**: Left to right, except for exponentiation and assignment
- **Parentheses** override order

Working with data frames:

Subsetting / Sampling

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

Working with data frames:

Subsetting / Sampling

```
> mydata[4,] # Select 4th row

  ID Color Passed

4  4  <NA>  FALSE
```

```
  > mydata

    ID Color Passed

  1  1   red   TRUE

  2  2 white   TRUE

  3  3   red   TRUE

  4  4  <NA>  FALSE
```

Working with data frames:

Subsetting / Sampling

```
> mydata[4,] # Select 4th row

  ID Color Passed

4  4  <NA>  FALSE
```

```
> mydata[,c(2:3)]

> # Select the 2nd and 3rd columns

  Color Passed

1   red   TRUE

2 white   TRUE

3   red   TRUE

4  <NA>  FALSE
```

```
> mydata

  ID Color Passed

1  1   red   TRUE

2  2 white   TRUE

3  3   red   TRUE

4  4  <NA>  FALSE
```

Working with data frames:

Subsetting / Sampling

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

```
> mydata[4,] # Select 4th row
  ID Color Passed
4  4  <NA>  FALSE
```

```
> mydata[,c(2:3)]
> # Select the 2nd and 3rd columns
  Color Passed
1   red   TRUE
2 white   TRUE
3   red   TRUE
4  <NA>  FALSE
```

```
> mydata$ID
> # Select the column named “ID”
[1] 1 2 3 4
```

Working with data frames:

Subsetting / Sampling

```
> mydata
  ID Color Passed
1  1   red    TRUE
2  2 white    TRUE
3  3   red    TRUE
4  4  <NA>   FALSE
```

```
> mydata[4,] # Select 4th row
  ID Color Passed
4  4  <NA>   FALSE
```

```
> mydata[,c(2:3)]
> # Select the 2nd and 3rd columns
  Color Passed
1   red    TRUE
2 white    TRUE
3   red    TRUE
4  <NA>   FALSE
```

```
> mydata$ID
> # Select the column named “ID”
[1] 1 2 3 4
```

```
> mydata[which(mydata$Passed & mydata$ID > 2), ]
> # Select observation(s) by value
  ID Color Passed
3  3   red    TRUE
```

Working with data frames:

Subsetting / Sampling

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

```
> mydata[4,] # Select 4th row
  ID Color Passed
4  4  <NA>  FALSE
```

```
> mydata[,c(2:3)]
> # Select the 2nd and 3rd columns
  Color Passed
1   red   TRUE
2 white   TRUE
3   red   TRUE
4  <NA>  FALSE
```

```
> mydata$ID
> # Select the column named "ID"
[1] 1 2 3 4
```

```
> set.seed(42) # Set random seed
> mydata[sample(1:nrow(mydata),2,replace=FALSE),]
> # Randomly sample 2 rows
  ID Color Passed
4  4  <NA>  FALSE
3  3   red   TRUE
```

```
> mydata[which(mydata$Passed & mydata$ID > 2), ]
> # Select observation(s) by value
  ID Color Passed
3  3   red   TRUE
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed
1  1   red   TRUE
2  2 white   TRUE
3  3   red   TRUE
4  4  <NA>  FALSE
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight
1  1   red   TRUE     65
2  2 white   TRUE     70
3  3   red   TRUE     75
4  4  <NA>  FALSE     80
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight
1  1   red   TRUE     65
2  2 white   TRUE     70
3  3   red   TRUE     75
4  4  <NA>  FALSE     80
```

```
> # Adding a new variable called weight

> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

```
> # Adding a new variable called height

> mydata$height <- rep(170, 4)
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight height
1  1   red   TRUE     65    170
2  2 white   TRUE     70    170
3  3   red   TRUE     75    170
4  4  <NA>  FALSE     80    170
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

```
> # Adding a new variable called height
> mydata$height <- rep(170, 4)
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight height
1  1   red   TRUE     65    170
2  2 white   TRUE     70    170
3  3   red   TRUE     75    170
4  4  <NA>  FALSE     80    170
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

```
> # Adding a new variable called height
> mydata$height <- rep(170, 4)
```

```
> # Adding a new variable calculated based on weight and height
> mydata$bmi <- mydata$weight / (mydata$height/100)^2
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight height      bmi
1  1   red   TRUE     65    170 22.49135
2  2 white   TRUE     70    170 24.22145
3  3   red   TRUE     75    170 25.95156
4  4  <NA>  FALSE     80    170 27.68166
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

```
> # Adding a new variable called height
> mydata$height <- rep(170, 4)
```

```
> # Adding a new variable calculated based on weight and height
> mydata$bmi <- mydata$weight / (mydata$height/100)^2
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight height      bmi
1  1   red   TRUE     65    170 22.49135
2  2 white   TRUE     70    170 24.22145
3  3   red   TRUE     75    170 25.95156
4  4  <NA>  FALSE     80    170 27.68166
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

```
> # Adding a new variable called height
> mydata$height <- rep(170, 4)
```

```
> # Adding a new variable calculated based on weight and height
> mydata$bmi <- mydata$weight / (mydata$height/100)^2
```

```
> # Adding a new logical variable based on bmi
> mydata$overwt <- mydata$bmi >= 25
```

Working with data frames:

Adding variables

```
> mydata
  ID Color Passed weight height      bmi overwt
1  1   red   TRUE     65    170 22.49135  FALSE
2  2 white   TRUE     70    170 24.22145  FALSE
3  3   red   TRUE     75    170 25.95156   TRUE
4  4  <NA>  FALSE     80    170 27.68166   TRUE
```

```
> # Adding a new variable called weight
> mydata$weight <- seq(from = 65, to = 80, by = 5)
```

```
> # Adding a new variable called height
> mydata$height <- rep(170, 4)
```

```
> # Adding a new variable calculated based on weight and height
> mydata$bmi <- mydata$weight / (mydata$height/100)^2
```

```
> # Adding a new logical variable based on bmi
> mydata$overwt <- mydata$bmi >= 25
```

Working with data frames:

Dropping variables

```
> mydata

  ID Color Passed weight height      bmi overwt
1  1   red   TRUE     65    170 22.49135  FALSE
2  2 white   TRUE     70    170 24.22145  FALSE
3  3   red   TRUE     75    170 25.95156   TRUE
4  4  <NA>  FALSE     80    170 27.68166   TRUE
```

Working with data frames:

Dropping variables

```
> mydata

  ID Color Passed weight height      bmi overwt
1  1   red   TRUE     65    170 22.49135  FALSE
2  2 white   TRUE     70    170 24.22145  FALSE
3  3   red   TRUE     75    170 25.95156   TRUE
4  4  <NA>  FALSE     80    170 27.68166   TRUE
```

```
> # Exclude variables ID, Color

> myvars <- colnames(mydata) %in% c("ID", "Color")

> newdata <- mydata[!myvars]

> newdata

  Passed weight height      bmi overwt
1   TRUE     65    170 22.49135  FALSE
2   TRUE     70    170 24.22145  FALSE
3   TRUE     75    170 25.95156   TRUE
4  FALSE     80    170 27.68166   TRUE
```

Working with data frames:

Dropping variables

```
> mydata
  ID Color Passed weight height      bmi overwt
1  1   red   TRUE     65    170 22.49135  FALSE
2  2 white   TRUE     70    170 24.22145  FALSE
3  3   red   TRUE     75    170 25.95156   TRUE
4  4  <NA>  FALSE     80    170 27.68166   TRUE
```

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> # Exclude variables ID, Color

> myvars <- colnames(mydata) %in% c("ID", "Color")

> newdata <- mydata[!myvars]

> newdata
  Passed weight height      bmi overwt
1   TRUE     65    170 22.49135  FALSE
2   TRUE     70    170 24.22145  FALSE
3   TRUE     75    170 25.95156   TRUE
4  FALSE     80    170 27.68166   TRUE
```

```
> # Exclude 1st and 3rd variables

> newdata2 <- mydata[c(-1,-3)]

> newdata2
  Color weight height      bmi overwt
1   red     65    170 22.49135  FALSE
2 white     70    170 24.22145  FALSE
3   red     75    170 25.95156   TRUE
4  <NA>     80    170 27.68166   TRUE
```

Working with data frames:

Dropping variables

```
> mydata
  ID Color Passed weight height      bmi overwt
1  1   red   TRUE     65    170 22.49135  FALSE
2  2 white   TRUE     70    170 24.22145  FALSE
3  3   red   TRUE     75    170 25.95156   TRUE
4  4  <NA>  FALSE     80    170 27.68166   TRUE
```

```
> # Exclude variables ID, Color

> myvars <- colnames(mydata) %in% c("ID", "Color")

> newdata <- mydata[!myvars]

> newdata
  Passed weight height      bmi overwt
1   TRUE     65    170 22.49135  FALSE
2   TRUE     70    170 24.22145  FALSE
3   TRUE     75    170 25.95156   TRUE
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```

```
> # Exclude 1st and 3rd variables

> newdata2 <- mydata[c(-1,-3)]

> newdata2
  Color weight height      bmi overwt
1   red     65    170 22.49135  FALSE
2 white     70    170 24.22145  FALSE
3   red     75    170 25.95156   TRUE
4  <NA>     80    170 27.68166   TRUE
```

```
> # Delete variable Color

> mydata$Color <- NULL
```

Working with data frames:

Dropping variables

```
> mydata
  ID Passed weight height      bmi overwt
1  1   TRUE     65    170 22.49135  FALSE
2  2   TRUE     70    170 24.22145  FALSE
3  3   TRUE     75    170 25.95156   TRUE
4  4  FALSE     80    170 27.68166   TRUE
```

```
> # Exclude variables ID, Color
> myvars <- colnames(mydata) %in% c("ID", "Color")
> newdata <- mydata[!myvars]
> newdata
  Passed weight height      bmi overwt
1   TRUE     65    170 22.49135  FALSE
2   TRUE     70    170 24.22145  FALSE
3   TRUE     75    170 25.95156   TRUE
4  FALSE     80    170 27.68166   TRUE
```

```
> # Delete variable Color
> mydata$Color <- NULL
```

WARNING
This would directly delete from the data frame mydata!

```
> # Exclude 1st and 3rd variables
> newdata2 <- mydata[c(-1,-3)]
> newdata2
  Color weight height      bmi overwt
1   red     65    170 22.49135  FALSE
2 white     70    170 24.22145  FALSE
3   red     75    170 25.95156   TRUE
<NA>      80    170 27.68166   TRUE
```

Working with data frames:

Sorting by variables

```
> mydata
  ID Passed weight height      bmi overwt
1  1   TRUE     65    170 22.49135  FALSE
2  2   TRUE     70    170 24.22145  FALSE
3  3   TRUE     75    170 25.95156   TRUE
4  4  FALSE     80    170 27.68166   TRUE
```

- To sort a data frame in R, use the **`order( )`** function.
  - By default, sorting is ascending.
  - Prepend the sorting variable by a minus sign to indicate descending order.

Working with data frames:

Sorting by variables

```
> mydata
  ID Passed weight height      bmi overwt
1  1   TRUE     65    170 22.49135  FALSE
2  2   TRUE     70    170 24.22145  FALSE
3  3   TRUE     75    170 25.95156   TRUE
4  4  FALSE     80    170 27.68166   TRUE
```

```
> # Sort by descending weight and ascending height
> sortedData <- mydata[order(-mydata$weight, mydata$height),]
```

Working with data frames:

Sorting by variables

```
> mydata
  ID Passed weight height      bmi overwt
1  1   TRUE     65    170 22.49135  FALSE
2  2   TRUE     70    170 24.22145  FALSE
3  3   TRUE     75    170 25.95156   TRUE
4  4  FALSE     80    170 27.68166   TRUE
```

```
> # Sort by descending weight and ascending height
> sortedData <- mydata[order(-mydata$weight, mydata$height),]
```

```
> sortedData
  ID Passed weight height      bmi overwt
4  4  FALSE     80    170 27.68166   TRUE
3  3   TRUE     75    170 25.95156   TRUE
2  2   TRUE     70    170 24.22145  FALSE
1  1   TRUE     65    170 22.49135  FALSE
```

WARNING: COMPLETELY FOR BEGINNERS!

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5. I/O and basic graphs in R
6. Pop quiz

Exporting data from R

- **write.table()**: print data frame to text file

```
# First row contains variable names; do not print row names

# Delimiter is tab (“\t”)

# Do not double quote character / factor variables

write.table(mydata, file = “datFile.txt”, sep = “\t”, quote =
FALSE, row.names = FALSE, col.names = TRUE)
```

Exporting data from R

- **`write.table()`**: print data frame to text file

```
# First row contains variable names; do not print row names

# Delimiter is tab (“\t”)

# Do not double quote character / factor variables

write.table(mydata, file = “datFile.txt”, sep = “\t”, quote =
FALSE, row.names = FALSE, col.names = TRUE)
```

- **`save()`**: Write R objects to an external file

```
save(file = “savedData.RData”, list = ls())
```

Exporting data from R

- **write.table()**: print data frame to text file

```
# First row contains variable names; do not print row names

# Delimiter is tab (“\t”)

# Do not double quote character / factor variables

write.table(mydata, file = “datFile.txt”, sep = “\t”, quote =
FALSE, row.names = FALSE, col.names = TRUE)
```

- **save()**: Write R objects to an external file

```
save(file = “savedData.RData”, list = ls())
```

- Other functions for exporting data

Exporting data from 

- **write.table()**: print data frame to text file

```
# First row contains variable names; do not print row names

# Delimiter is tab (“\t”)

# Do not double quote character / factor variables

write.table(mydata, file = “datFile.txt”, sep = “\t”, quote =
FALSE, row.names = FALSE, col.names = TRUE)
```

- **save()**: Write R objects to an external file

```
save(file = “savedData.RData”, list = ls())
```

- Other functions for exporting data
  - **write.csv()**

Exporting data from R

- **`write.table()`**: print data frame to text file

```
# First row contains variable names; do not print row names

# Delimiter is tab (“\t”)

# Do not double quote character / factor variables

write.table(mydata, file = “datFile.txt”, sep = “\t”, quote =
FALSE, row.names = FALSE, col.names = TRUE)
```

- **`save()`**: Write R objects to an external file

```
save(file = “savedData.RData”, list = ls())
```

- Other functions for exporting data
  - **`write.csv()`**
  - **`write.xlsx()`** in the **`xlsx`** package

Exporting data from R

- **`write.table()`**: print data frame to text file

```
# First row contains variable names; do not print row names

# Delimiter is tab (“\t”)

# Do not double quote character / factor variables

write.table(mydata, file = “datFile.txt”, sep = “\t”, quote =
FALSE, row.names = FALSE, col.names = TRUE)
```

- **`save()`**: Write R objects to an external file

```
save(file = “savedData.RData”, list = ls())
```

- Other functions for exporting data
  - **`write.csv()`**
  - **`write.xlsx()`** in the **`xlsx`** package
  - ***`?<function_name>`*** and read their manual

Importing data into R

- **`read.table()`**: read a text file in table format and create a data frame from it

```
# First row contains variable names

# Delimiter is tab ("\t")

read.table(file = "datFile.txt", sep = "\t", header = TRUE)
```

- **`load()`**: Reload datasets written with the function "save"

```
load("savedData.RData")
```

- Other functions for importing data
  - **`read.csv()`**
  - **`read.xlsx()`** in the **`xlsx`** package
  - **`?<function_name>`** and read their manual

Practical: Simple visualisation in R

- There are actually a lot of built-in data sets in R.
  - Type `library(help = “datasets")` to see what are they…

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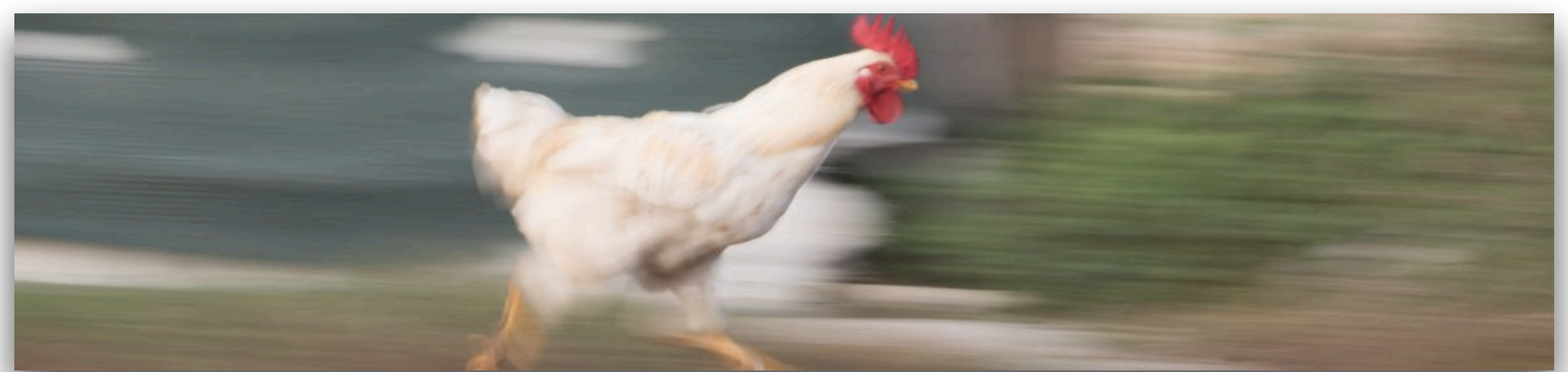
- Since by Chinese zodiac this year is year of the rooster, we would try to deal with the **`ChickWeight`** data set.



Practical: Like Regular Chickens

- The data set is already available for use when we start R.
- First few lines of **`str(ChickWeight)`** —

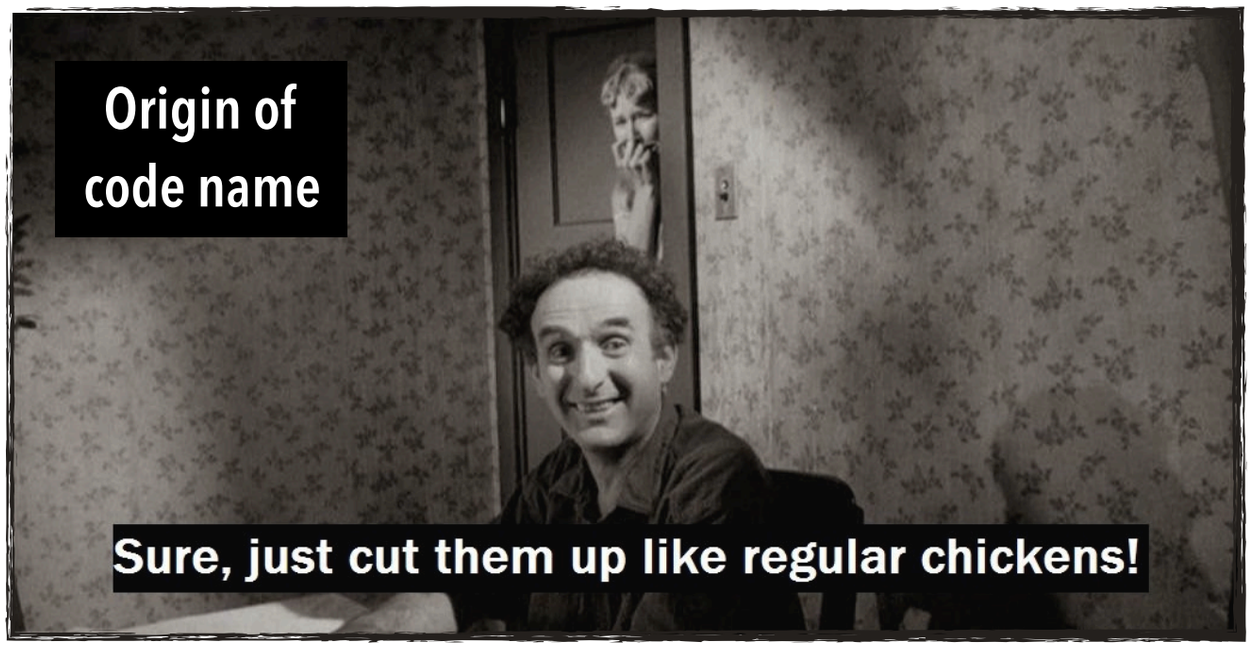
```
Classes ‘nfnGroupedData’, ‘nfGroupedData’, ‘groupedData’ and
'data.frame':  578 obs. of  4 variables:

 $ weight: num  42 51 59 64 76 93 106 125 149 171 ...

 $ Time  : num  0 2 4 6 8 10 12 14 16 18 ...

 $ Chick : Ord.factor w/ 50 levels "18"<"16"<"15"<..: 15 15 15 15 15
15 15 15 15 15 ...

 $ Diet  : Factor w/ 4 levels "1","2","3","4": 1 1 1 1 1 1 1 1 1 1 ...
```



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- ***Explore by data visualisation!***

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Practical: Like Regular Chickens

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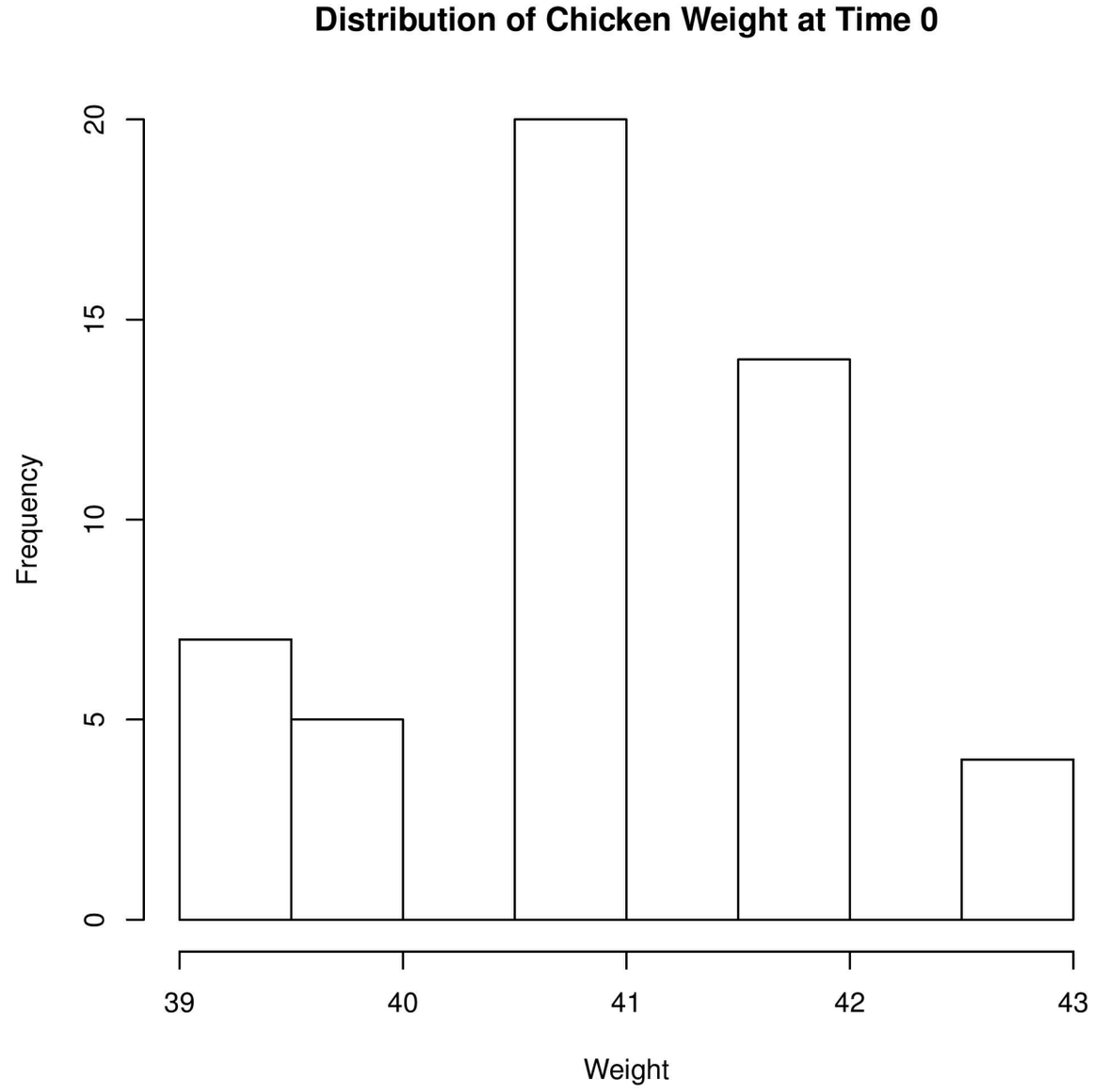
```
hist(ChickWeight$weight[
ChickWeight$Time == 0],
main = "Distribution of
Chicken Weight at Time
0", xlab = "Weight")
```



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Practical: Like Regular Chickens

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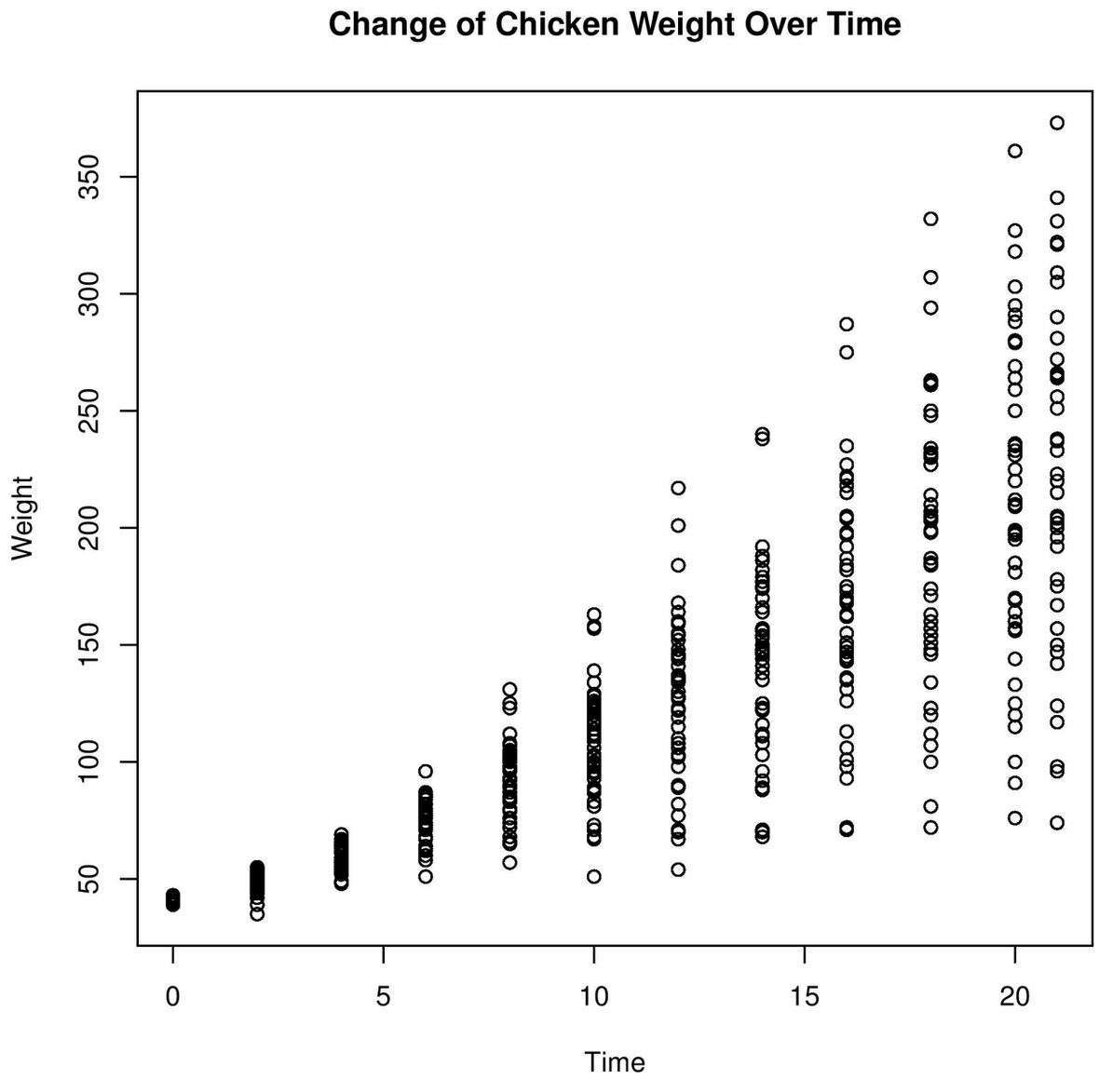
- Draw a scatterplot!

```
plot(ChickWeight$Time,
ChickWeight$weight, main
= "Change of Chicken
Weight Over Time", xlab =
"Time", ylab = "Weight")
```



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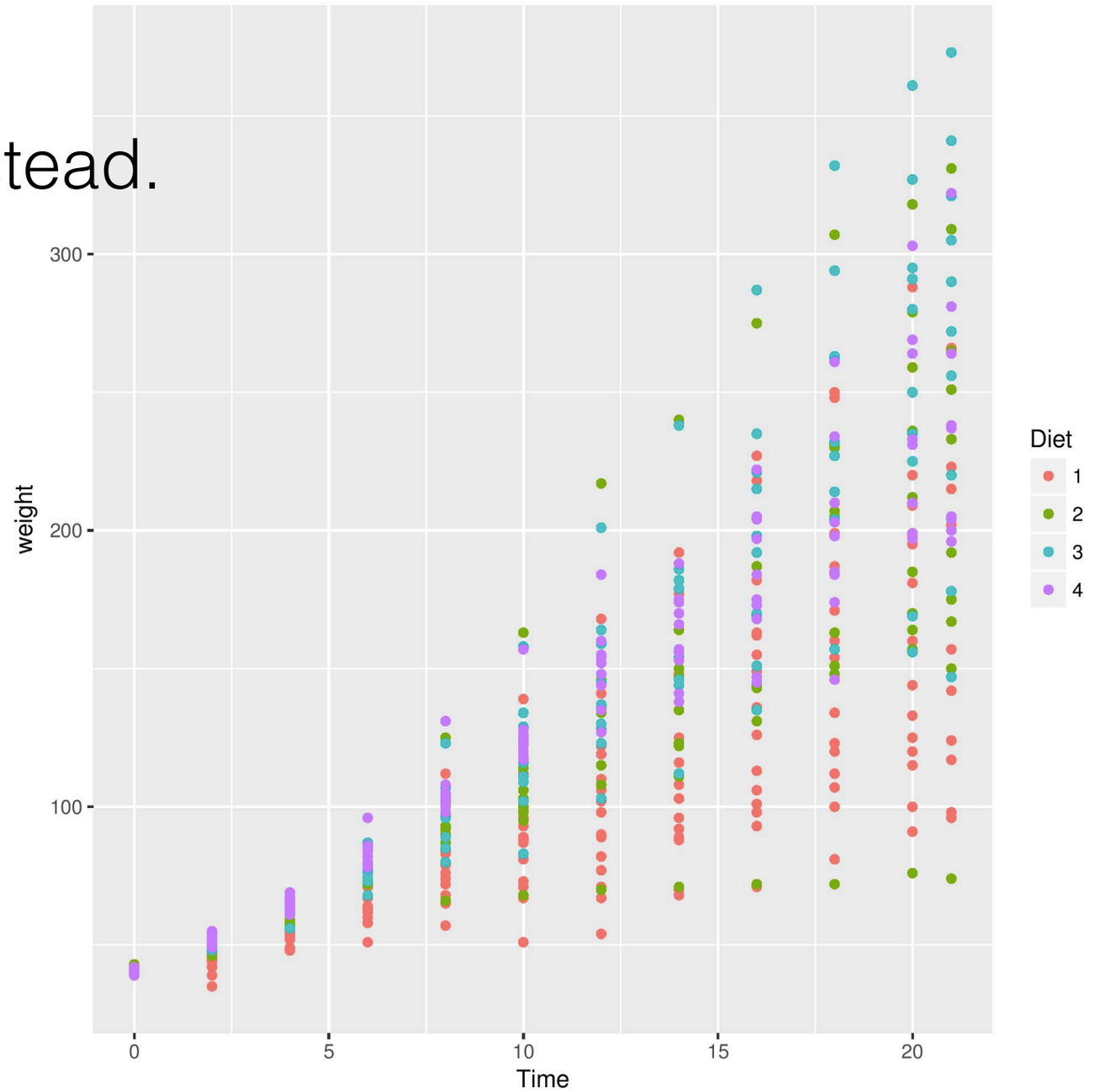
```
> library("ggplot2")
> qplot(Time, weight,
data = ChickWeight,
colour = Diet)
```



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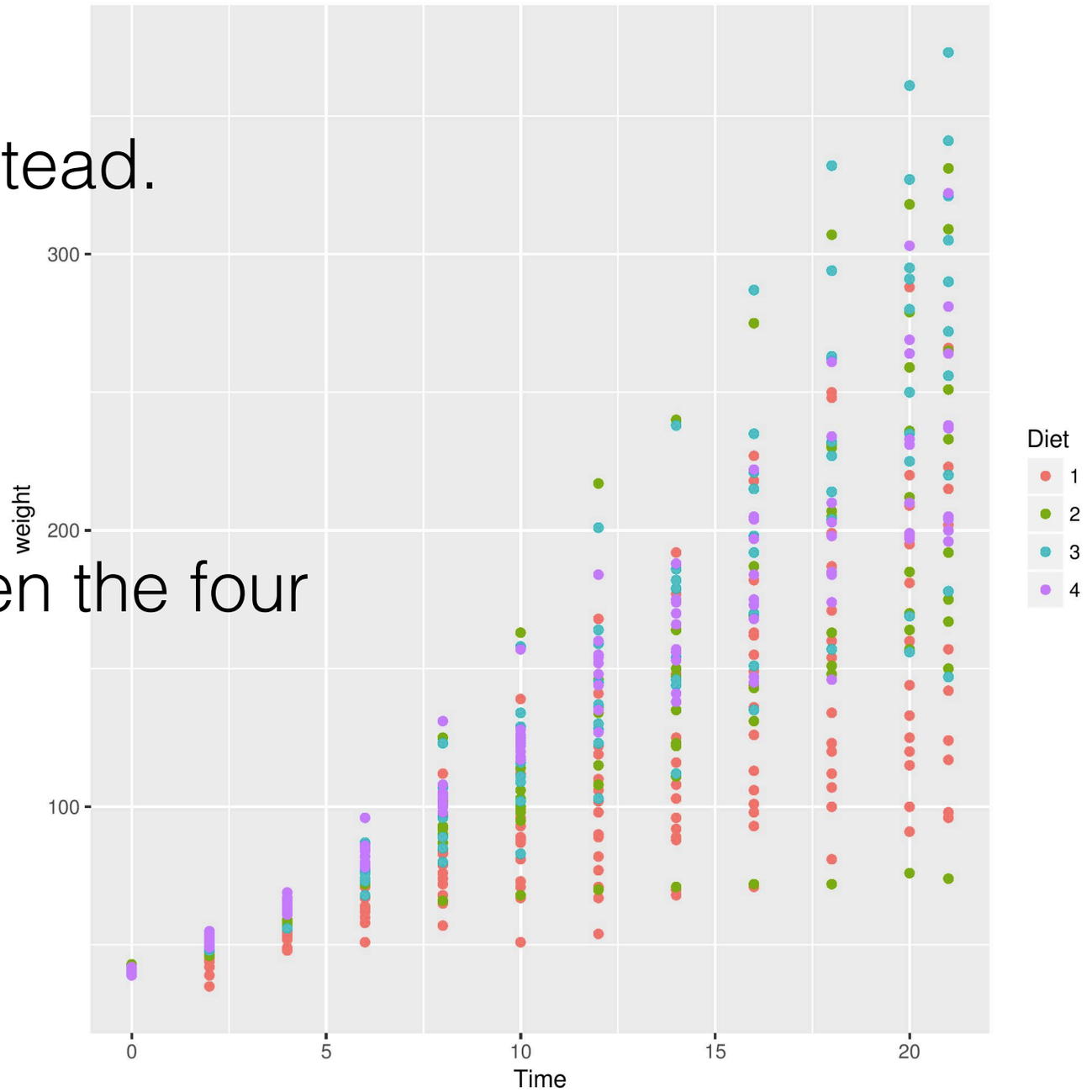
- It is hard to distinguish between the four diet groups.



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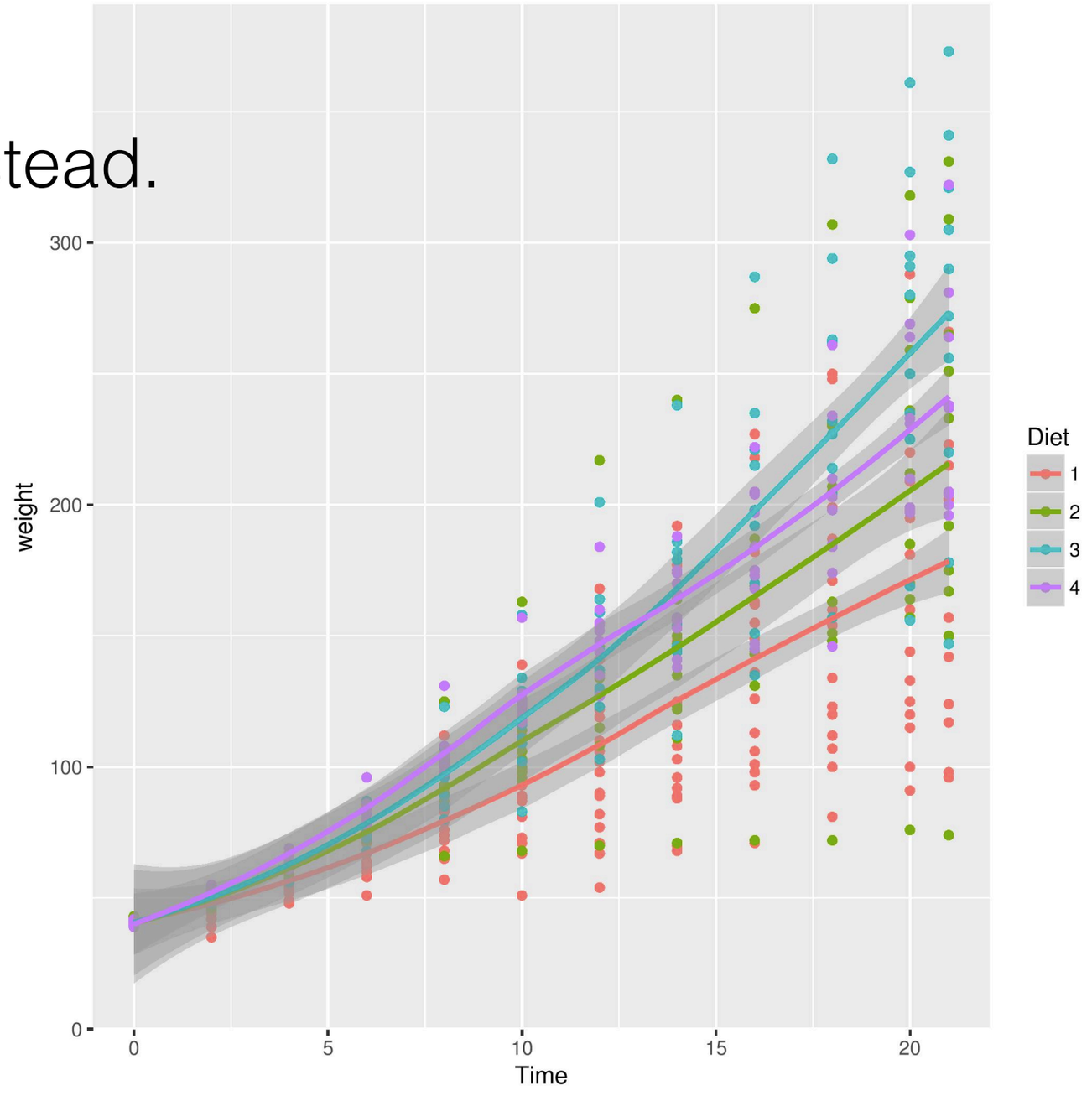
> qplot(Time, weight,
data = ChickWeight,
colour = Diet, geom =
c("point", "smooth"))
```



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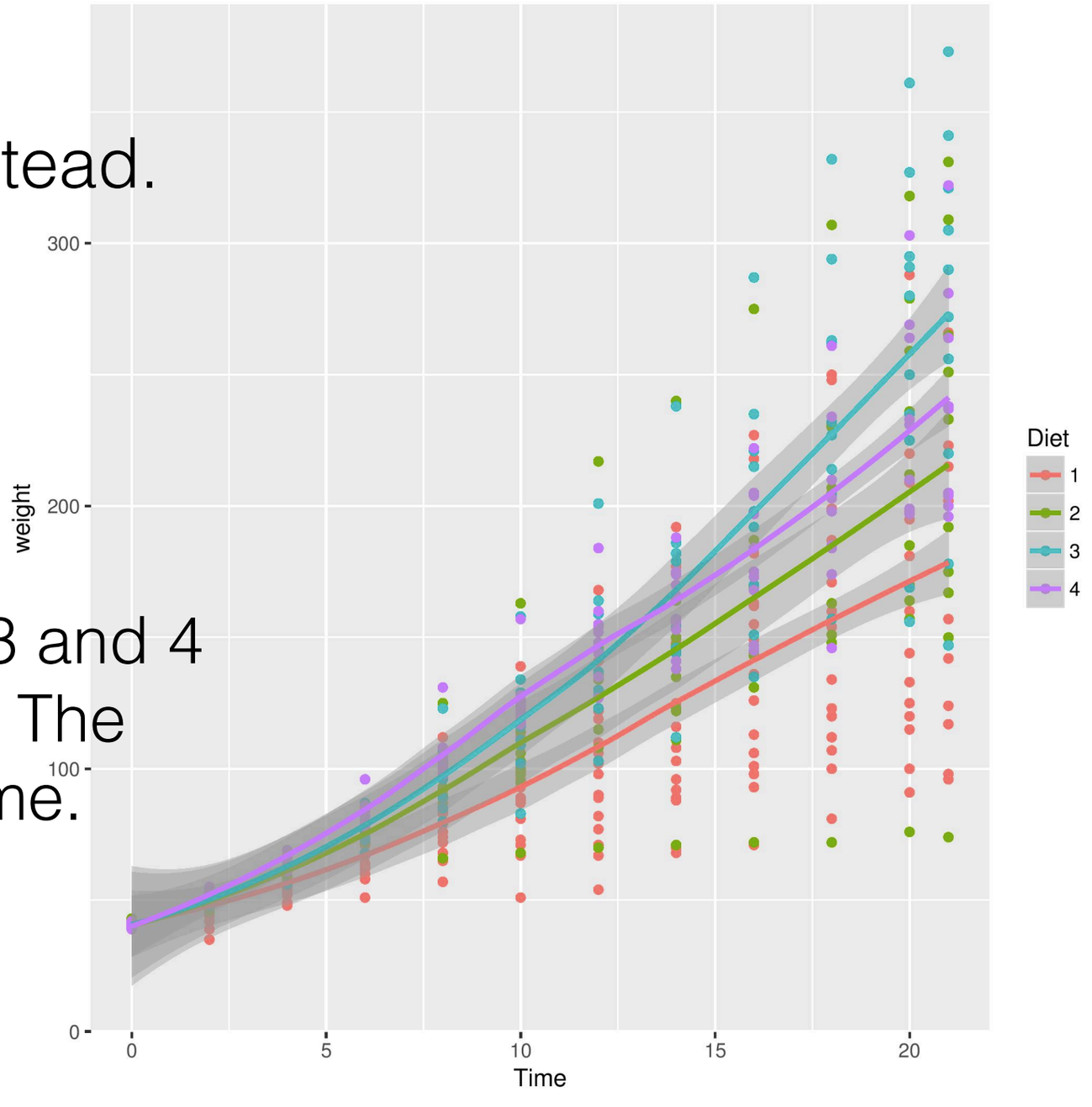
- It seems that on average, diets 3 and 4 result in heavier chicken weight. The difference grows greater over time.



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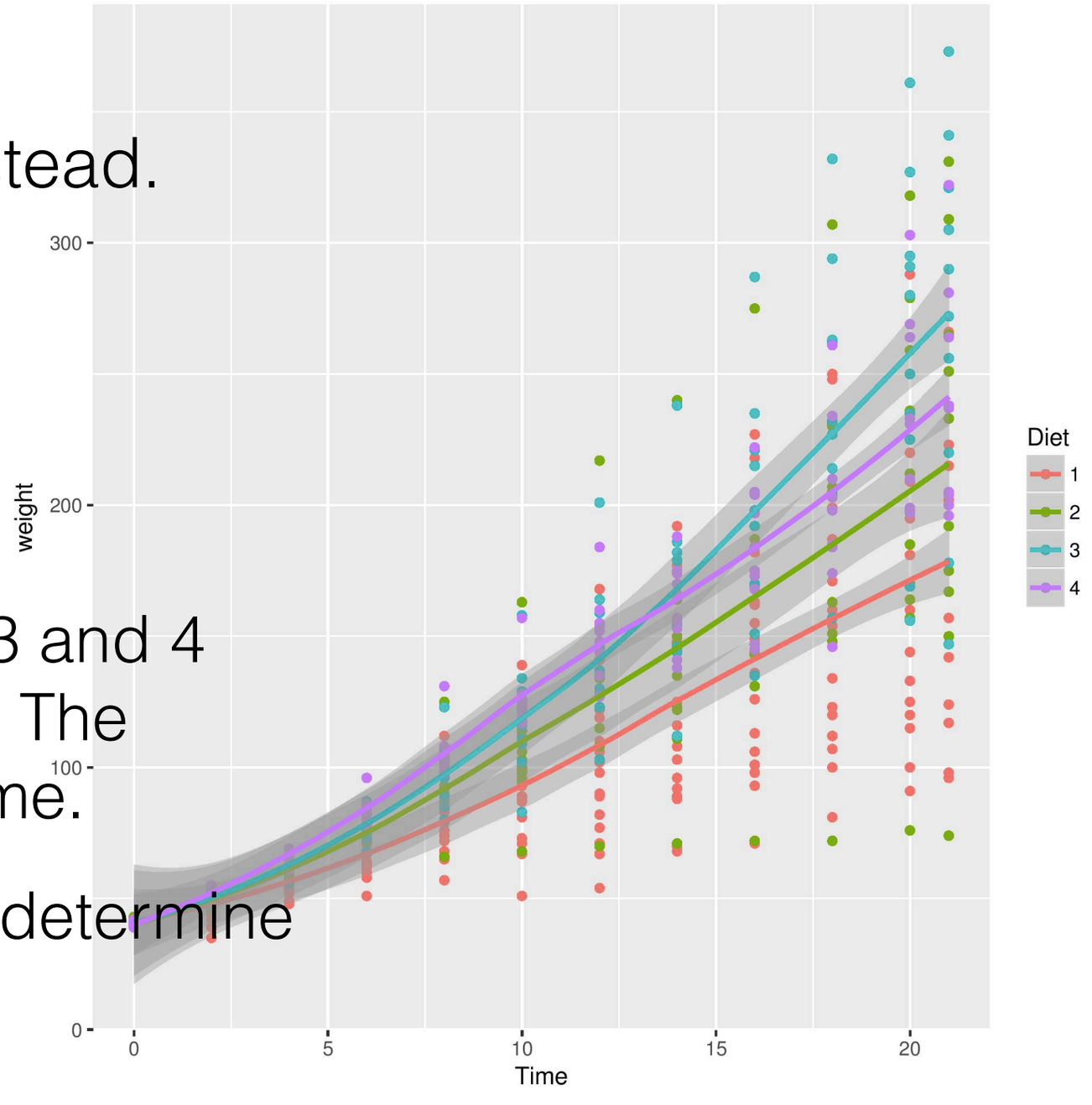


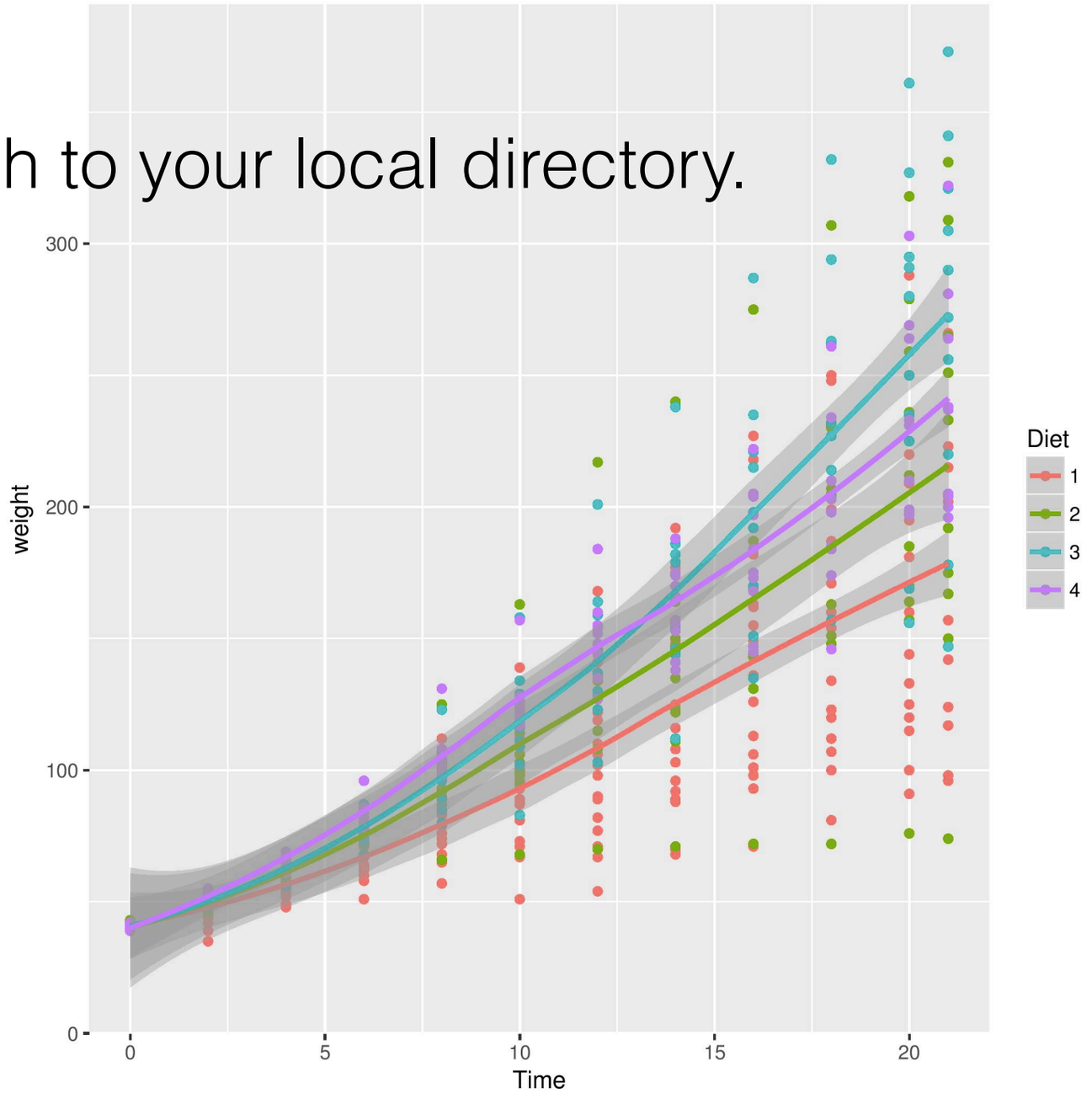
- It seems that on average, diets 3 and 4 result in heavier chicken weight. The difference grows greater over time.
- Statistical analysis is needed to determine whether this is truly significant.

Practical: Like Regular Chickens

- Questions we could ask —
  - Is there a **difference** in the average chicken weights when they have different diets?
- You could also save your graph to your local directory.

```
> library(“ggplot2”)
> pdf(“LRCvis.pdf”)
> qplot(Time, weight, data
= ChickWeight, colour =
Diet, geom = c("point",
“smooth"))
> dev.off()
```

- Your plot would then be saved as ./LRCvis.pdf.



WARNING: COMPLETELY FOR BEGINNERS!

IN TODAY'S GUIDE...

1. What is R? Why R?
2. Installation and "Hello World!" in R
3. R data types – vectors, matrices and data frames
4. R operators and managing a data frame
5. I/O and basic graphs in R
6. Pop quiz

References

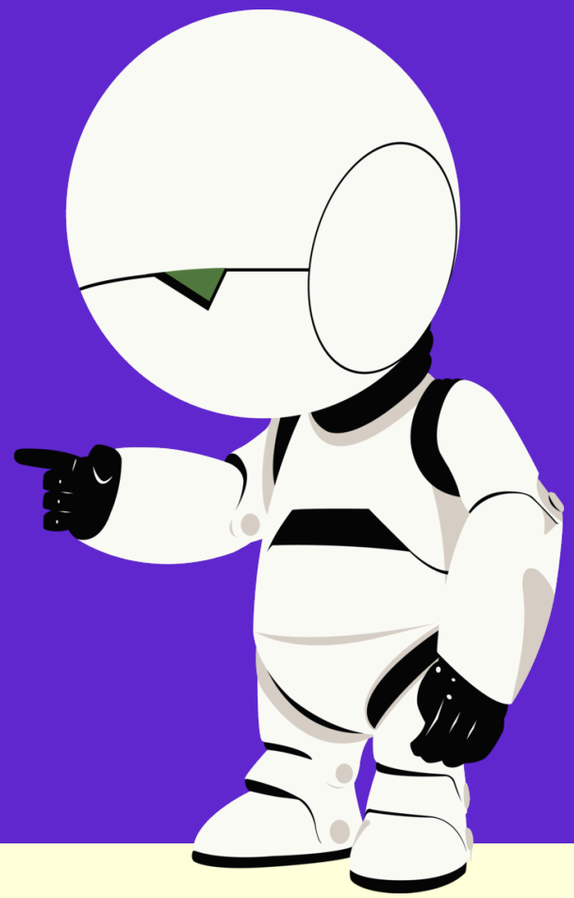
- Many ideas were generated when visiting the following websites / materials.
- Also some of the used code snippets were modified based on the demo codes there.
  - The R manual.
  - UC Berkeley STAT133 lecture notes.
  - http://stackoverflow.com/
  - http://www.statmethods.net/
  - http://arrgh.tim-smith.us/
  - http://www.r-tutor.com/r-introduction/matrix

Image sources

- R logo. https://www.r-project.org/logo/Rlogo.png
- Hitchhiker's thumb. http://i1.kym-cdn.com/entries/icons/facebook/000/018/991/HitchHikersGuideBlackSS.jpg
- Don't panic. http://geekifyinc.com/wp-content/uploads/2014/04/IMG_0333-1280.jpg
- Ross Ihaka. http://www.stats.org.nz/Newsletter69/images/Ross_Pickering_Medal.jpg
- Robert Gentleman. https://www.fredhutch.org/en/news/center-news/2009/05/Gentlemen-presents-lecture/_jcr_content/articletext/textimage/image.img.jpg/1322528033362.jpg
- Richard Stallman (left). https://upload.wikimedia.org/wikipedia/commons/f/f3/Richard_Stallman_by_Anders_Brenna_01.jpg
- Richard Stallman (right). http://i1-news.softpedia-static.com/images/news2/Richard-Stallman-Says-He-Created-GNU-Which-Is-Called-Often-Linux-482416-2.jpg
- GNU logo. https://www.gnu.org/graphics/empowered-by-gnu.svg
- Copyleft. https://upload.wikimedia.org/wikipedia/commons/thumb/8/8b/Copyleft.svg/1024px-Copyleft.svg.png
- Statistics clipart. http://images.clipartpanda.com/statistics-clipart-statistics.png
- All ggplot2 sample graphs from: http://www.r-graph-gallery.com/portfolio/ggplot2-package/
- Google trends graph of statistical software. Screenshot of https://goo.gl/jyOViq
- RStudio screenshot. http://1.bp.blogspot.com/-BCAWGBV9ze4/USjitphaQoI/AAAAAAAAMzI/-hlfvxFfbVg/s1600/Screenshot+from+2013-02-23+09%3A38%3A38.png
- Running rooster. https://notadinnerblog.files.wordpress.com/2016/09/cropped-avian_influenza_running_chicken.jpg
- "Sure, just cut them up like regular chickens". Screenshot from *Eraserhead* by David Lynch. http://www.funnyjunk.com/Just+cut+them+up+like+regular+chickens/hdgifs/5674895#1486a9_5674451
- Marvin. http://pre04.deviantart.net/cd13/th/pre/f/2014/342/c/8/marvin_the_paranoid_android_by_wheelmaker42-d896526.png

THANK YOU.

ANY QUESTIONS?



YIMING LI, 15 MAR 2017