An Introduction to R-Programming

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NOT a biostatistician or R expert just simply an R user

Some slides were adapted from lectures by
Angie Mae Rodday MSc, PhD at Tufts University

What is R?

- Open source programming language and software environment for statistical computing and graphics
- R is an implementation of the S programming language
- S was created by John Chambers while at Bell Labs
- R was created by Ross Ihaka and Robert Gentleman
- R is named partly after the first names of the first two R authors and partly as a play on the name of S

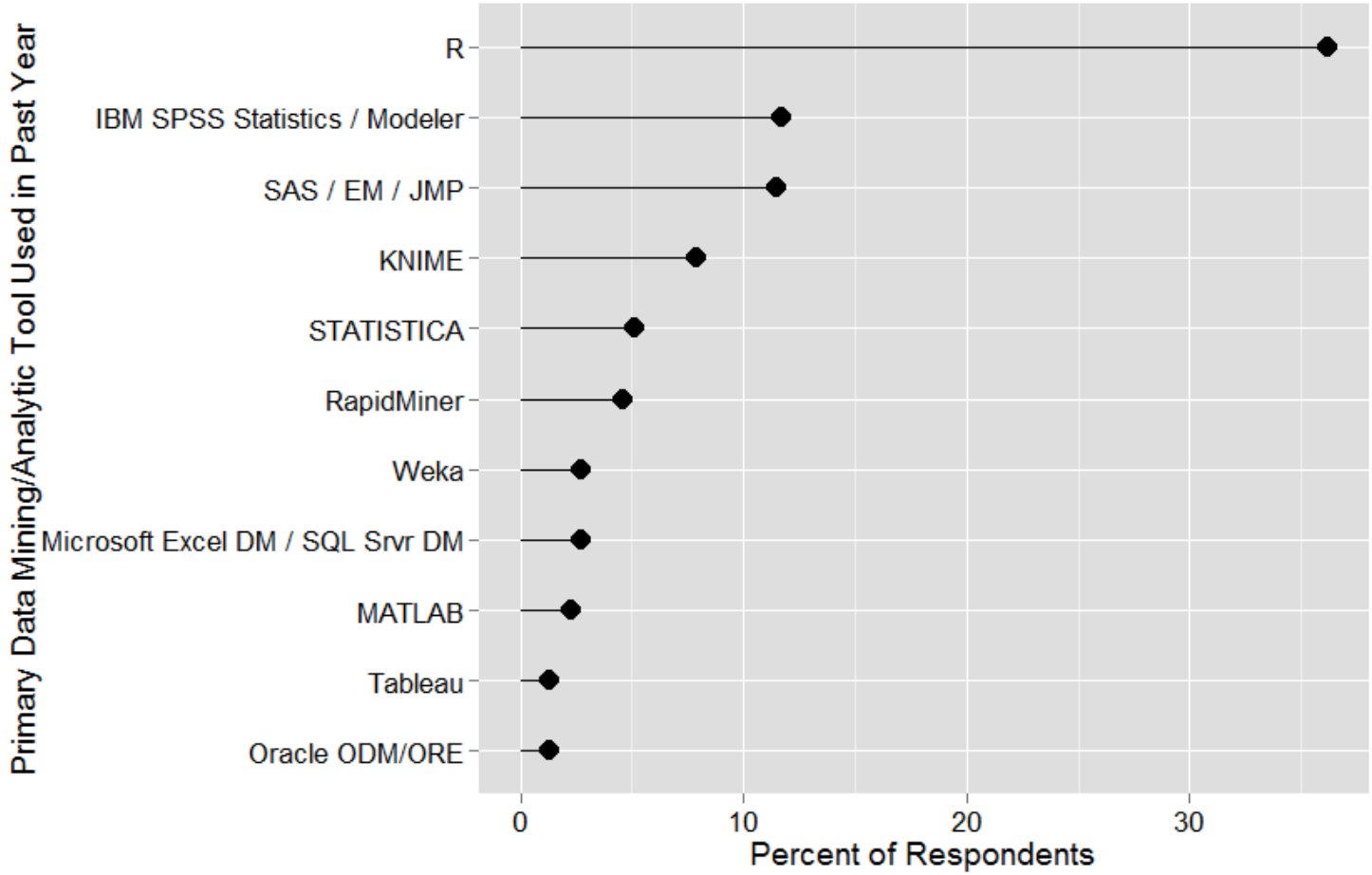
Why Use R?

- FREE and Open Source
- Strong user Community
- Highly extensible, flexible
- Implementation of high end statistical methods
- Flexible graphics and intelligent defaults
- Runs on Windows, Mac OS, and Linux/UNIX platforms

Then, why is not everyone using R???

- Difficult, but NOT FOR YOU ☺
- Command- (not menu-) driven.
- No commercial support, means you need to look for solutions your self, which can be very frustrating
- Easy to make mistakes and not know
- Data prep and cleaning can be messier and more mistake prone in R vs. SPSS or SAS

Survey Asking Researched their Primary Data Analysis Tool?



https://r4stats.wordpress.com/articles/popularity/

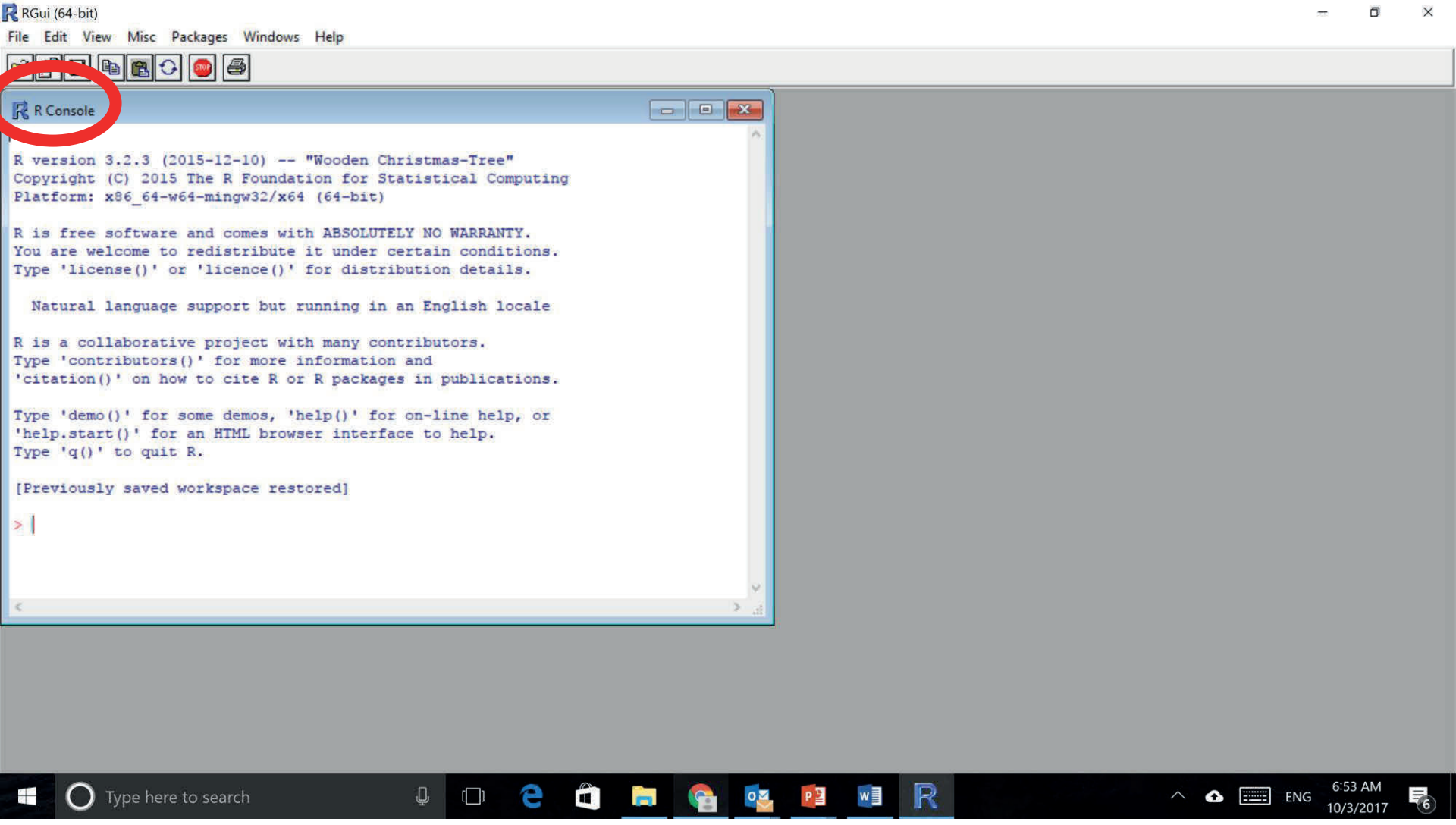
Let us start learning R

Learning R… Piece of cake

Downloading R

- https://cran.r-project.org/

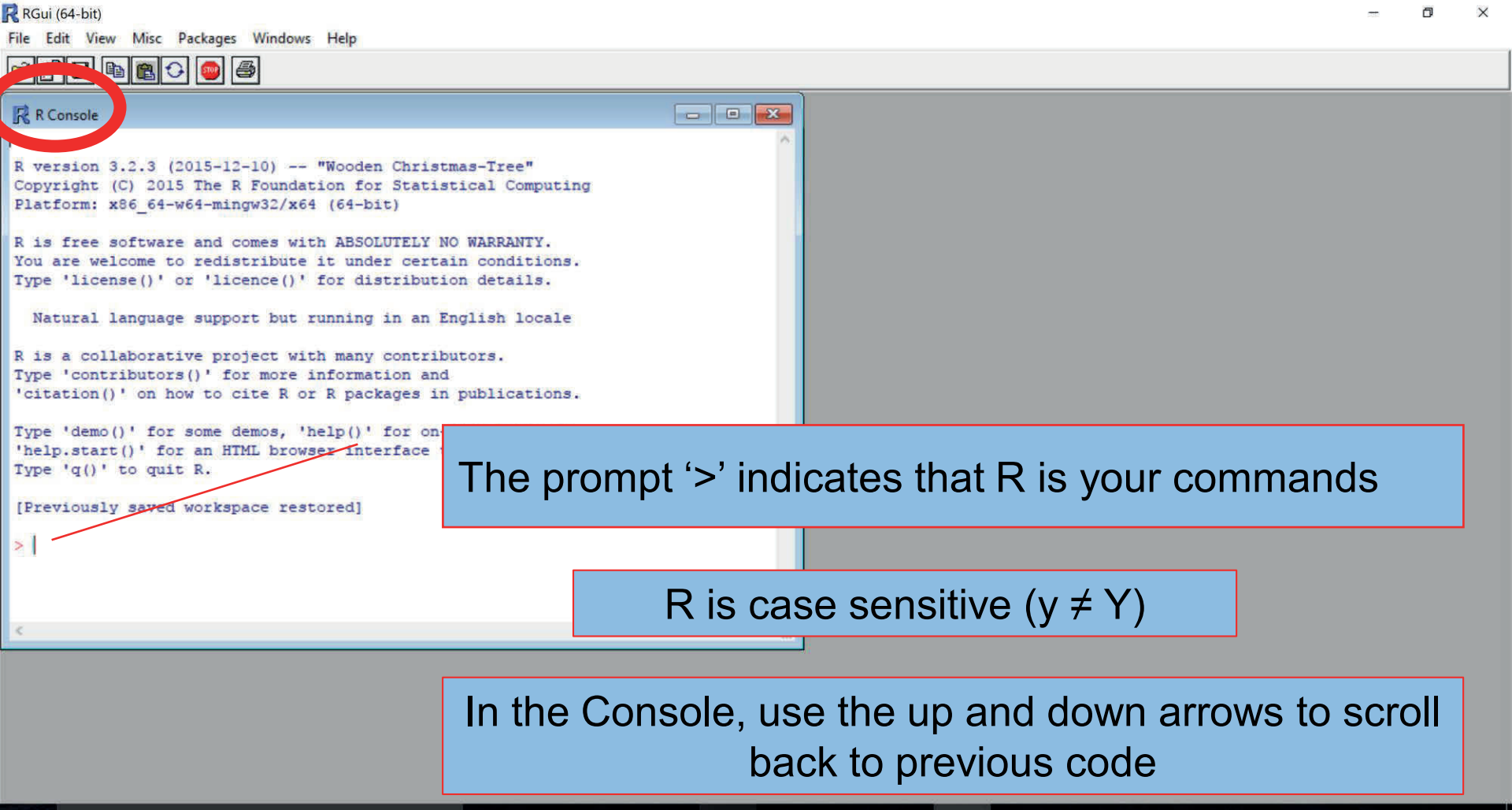
The R Environment- R Command Window



The R Environment- R Command Window

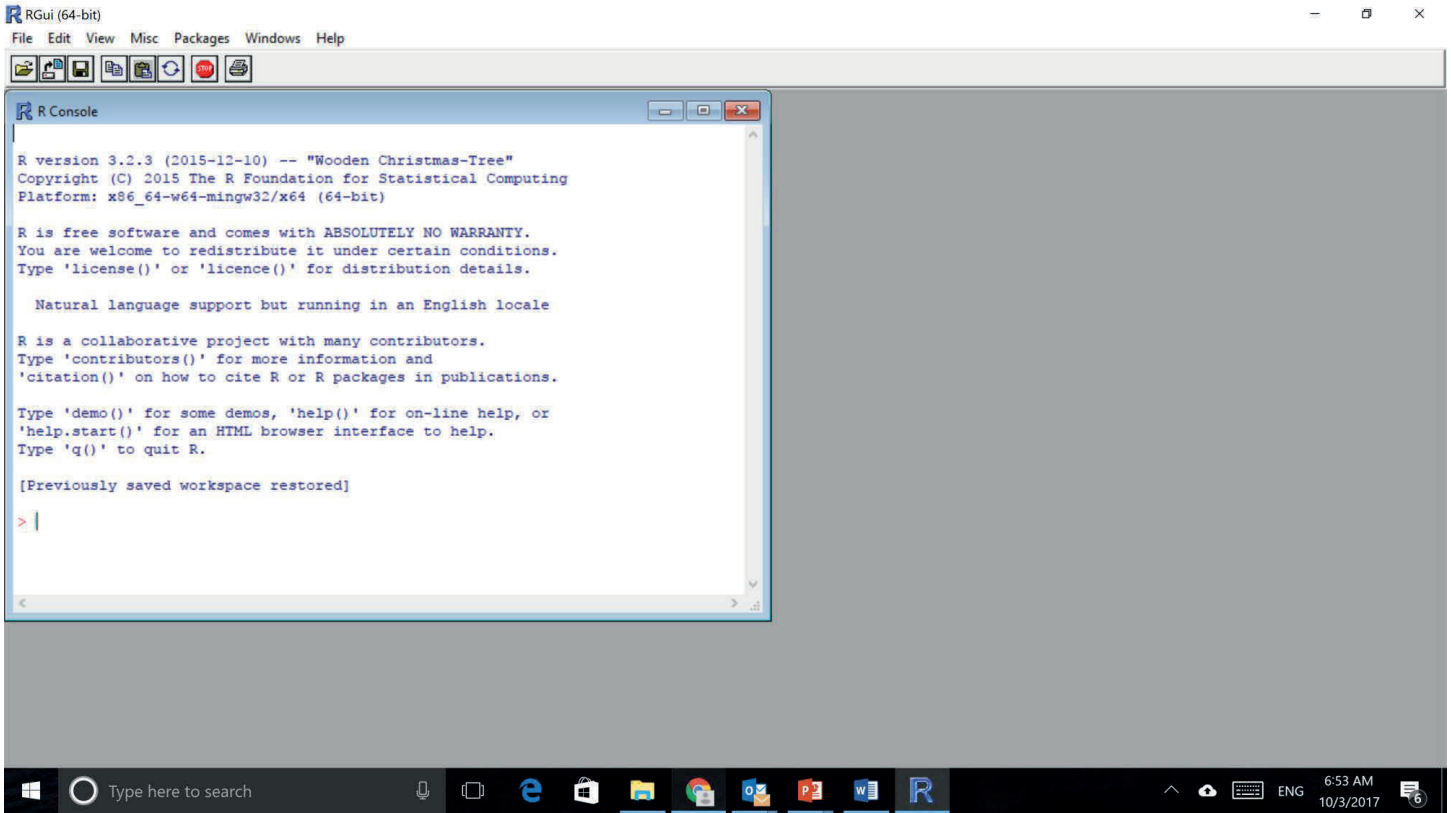
- R command window (**console**) or Graphical User Interface (GUI)
- Used for entering commands, data manipulations, analyses, graphing
- Output: results of analyses, queries, etc. are written here
- Toggle through previous commands by using the up and down arrow keys

The R Environment- R Command Window



The R Environment- R Workspace

- Current working environment
- Comprised primarily of variables, datasets, functions



R as Calculator

- 2+2
- 2*2
- 2*100/2
- 2^10
- 2*5^2
- X<-2*5^2
- X

In R **<-** indicates that you making an assignment. This will come up often, particularly with data manipulation

Operations in R

Comparison operators	Purpose	Example
==	Equal	1==1 returns TRUE
!=	Not equal	1!=1 returns FALSE
< >	Great/less than	1<1 returns FALSE
>= <=	Greater/less than or equal	1<=1 returns TRUE
Logical operators		
&	And—must meet both condition	1==1 & 1<1 returns FALSE
| (above backslash key)	Or—only needs to meet 1 condition	1==1 | 1<1 returns TRUE

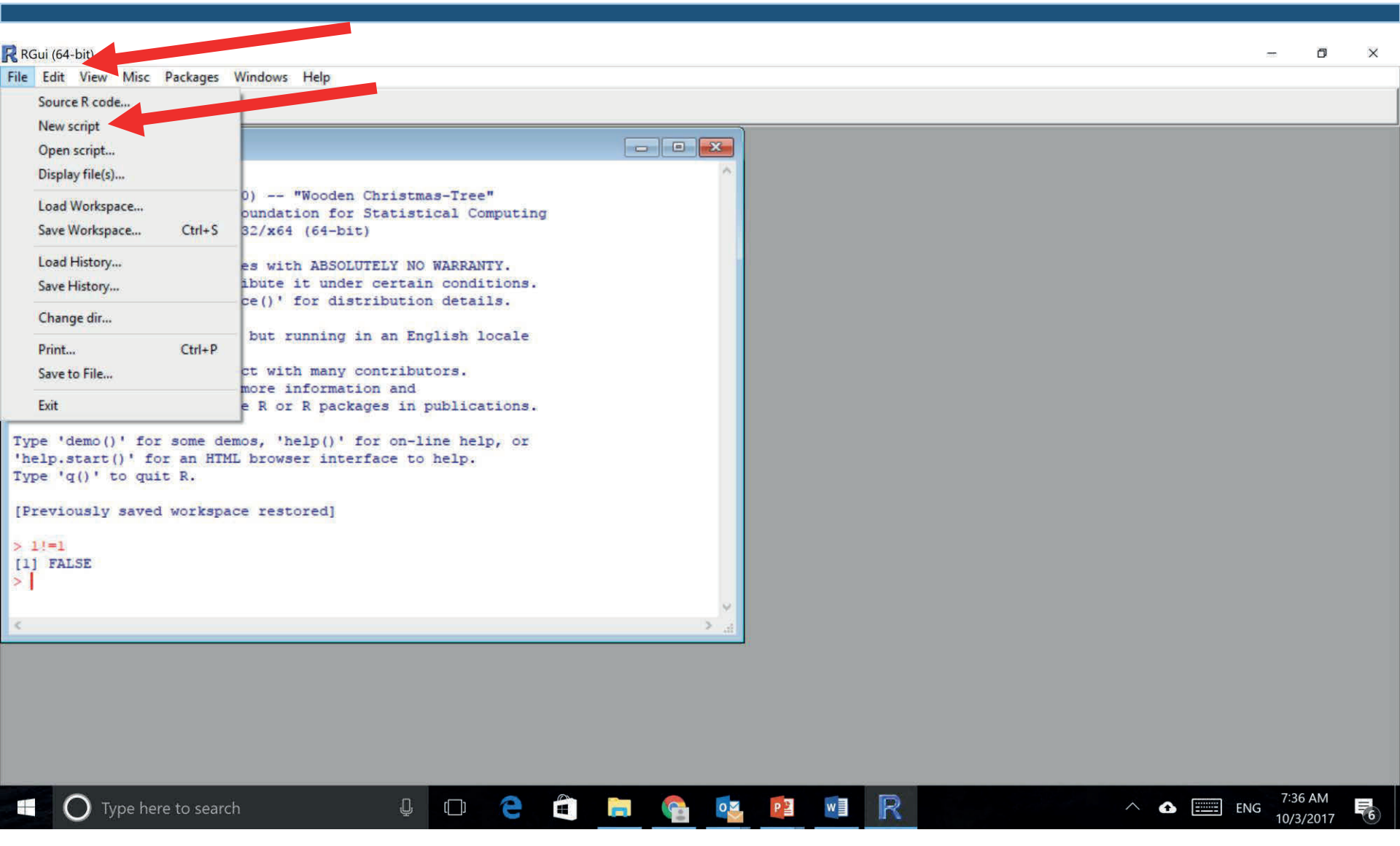
The R Environment- R Script

- A text file containing commands that you would enter on the command line of R
- To place a comment in a R script, use a hash mark (#) at the beginning of the line

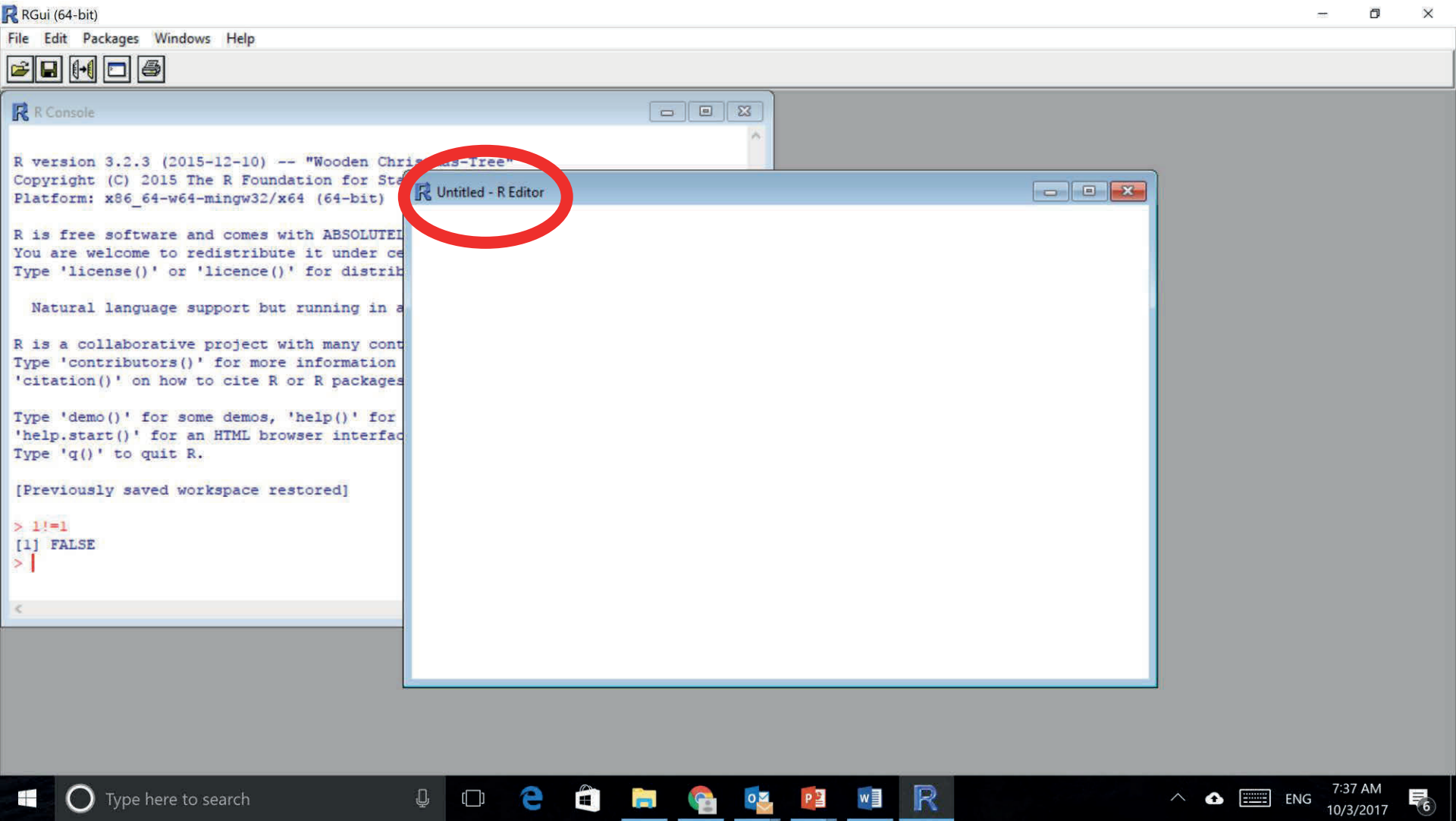
The R Environment- R Script

- In the R console, you can create a new script (from the file menu → “New Script”) and write all of your R code there
- This allows you to save your code (but not output) for later
- To place a comment in a R script, use a hash mark (#) at the beginning of the line

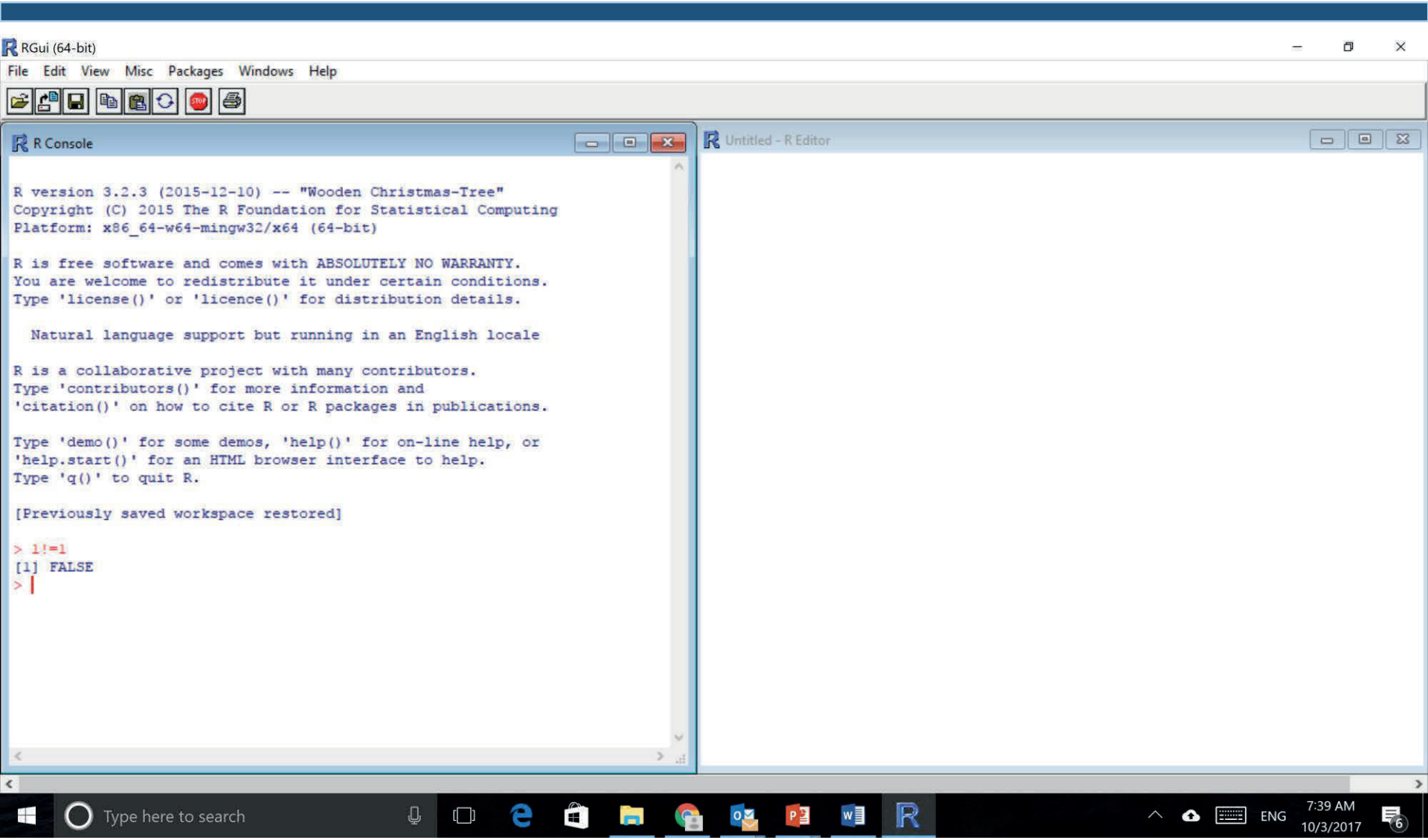
The R Environment- R Script



The R Environment- R Script



The R Environment- R Script



The R Environment- R Script

- When working from your script, you can highlight sections of code and press “F5” to automatically get the code to run in the R console
- When saving your script, type the extension “.R” after the file name so that your computer recognizes that it is an R file (e.g., Hadeel.R)
- You can then open previously saved scripts to re-run or modify your code

Saving Output (Results)

- Saving output using R's menu options can be annoying
- One option is to copy and paste (into a Word document) the output that you need while working
- Problem with waiting until the end:
  - You end up copying a bunch of code and output you may not need (e.g., you'll be copying all your errors)
  - At some point, the R console window fills up and you can't access your earlier work
- When copying and pasting your R output, you can change the font to "Courier New" and the output will line up and look pretty

Objects in R

- Everything that you work within R is an object
- Types of objects include vectors, matrices, and data frames
- To see which objects are available in the “workspace” (i.e., R memory) use the command ls() or objects()
- You can remove objects with the rm()function
- The class() function tells you the type of object

Objects in R- **Vectors**

- An ordered collection of numerical, categorical, complex or logical objects
- vec1<-1:10
- vec1
- [1] 1 2 3 4 5 6 7 8 9 10
- class(vec1)
- [1] "integer"

This is putting numbers 1 through 10 into a vector called, “vec1”

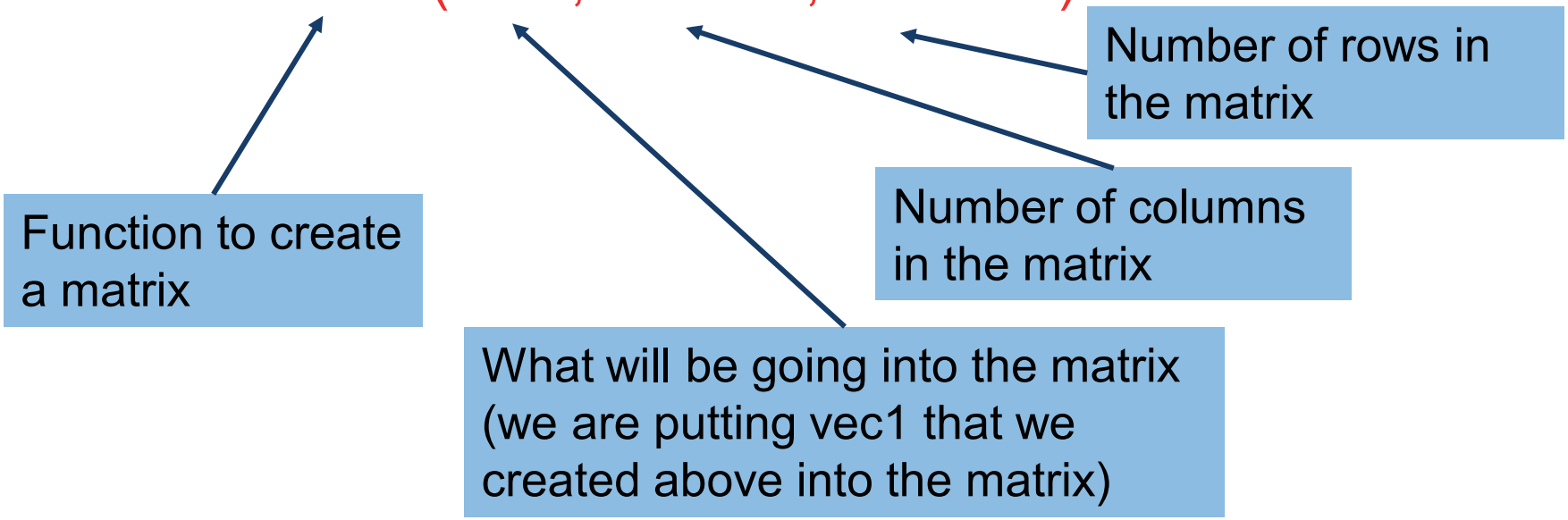
Objects in R- **Vectors**

- vec2<-LETTERS[1:10]
- vec2
- [1] "A" "B" "C" "D" "E" "F" "G" "H" "I" "J“
- class(vec2)
- [1] "character"

This is putting letters A (1st letter) through J (10th letter) into a vector called, “vec2”

Objects in R- **Matrix**

- A matrix is a *multidimensional collection of data entries* of the same type
- Matrices have two dimensions: rows and columns
- mat1 <- matrix(vec1, ncol = 2, nrow = 5)



Objects in R- **Matrix**

- mat1 <- matrix(vec1, ncol = 2, nrow = 5)

	[,1]	[,2]
[1,]	1	6
[2,]	2	7
[3,]	3	8
[4,]	4	9
[5,]	5	10

- class(mat1)
- [1] "matrix"

Objects in R- **Matrix**

- To find the dimensions (i.e., number of rows and columns) of the matrix:
- dim(mat1)
- [1] 5 2
- Print the data in the first row of the matrix:
- mat1[1,]
- [1] 1 6

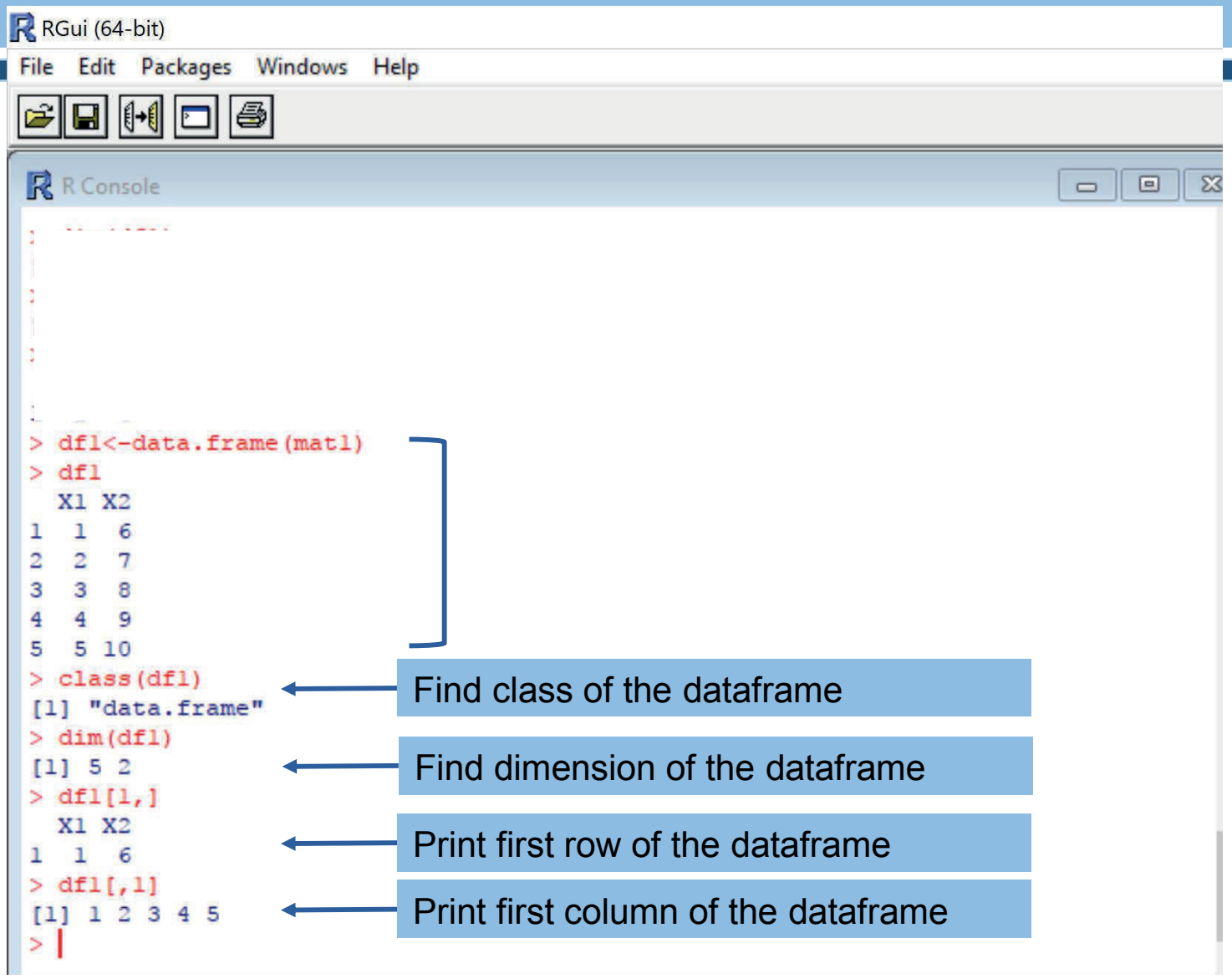
Objects in R- **Data Frame**

- A data.frame may be regarded as a matrix with columns that can be different modes (e.g., numeric, character)
- It is displayed in matrix form, by rows and columns
- It's like an excel spreadsheet
- This is primarily what we will be using when analyzing our data in R

Objects in R- **Data Frame**

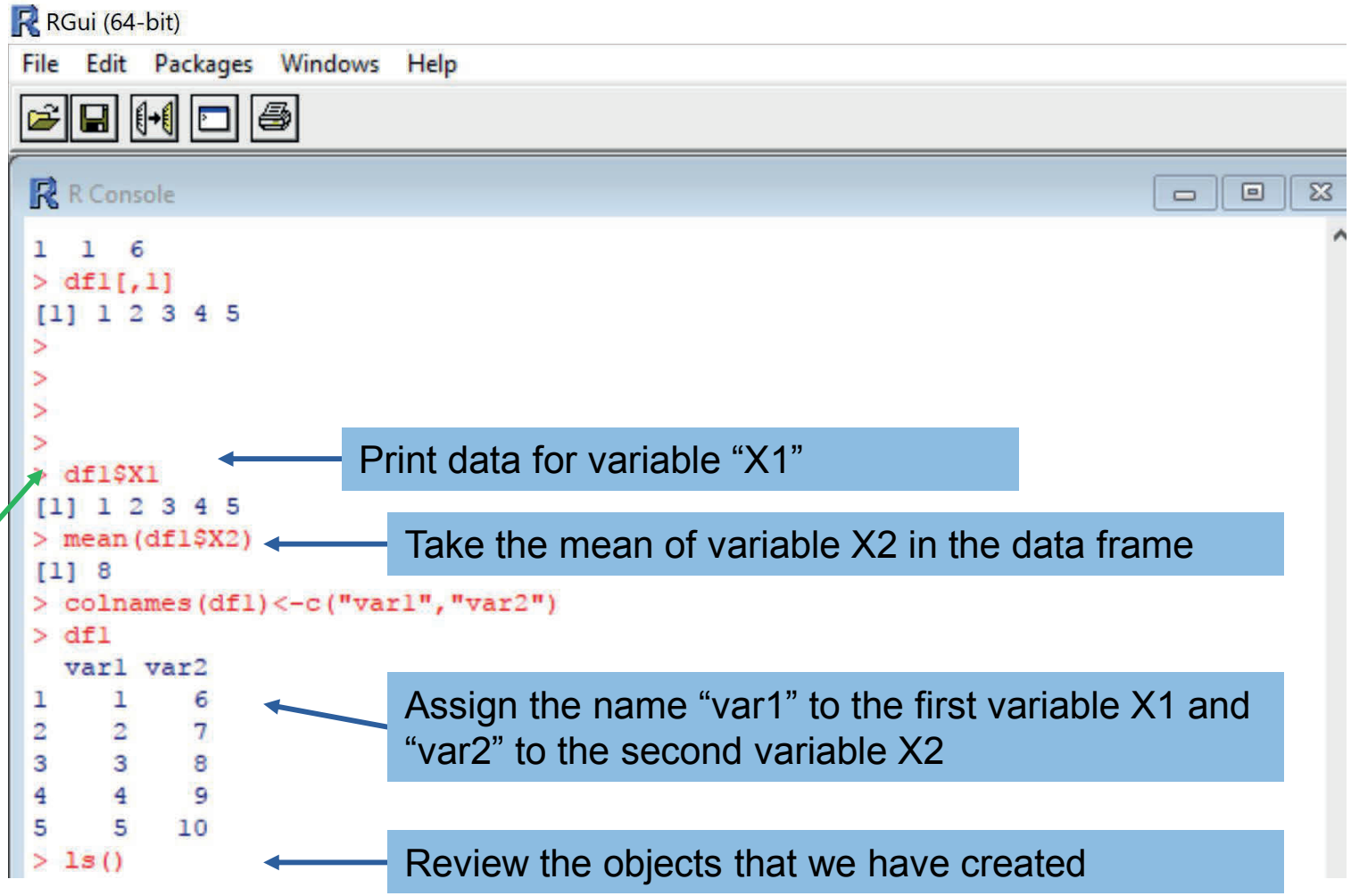
- Creates a data frame from the matrix we had previously made:
- df1<-data.frame(mat1)
- df1

Objects in R- **Data Frame**



Objects in R- Let's Play a little with the **Data Frame**

When referring to a variable within a data frame, you must use the **$ sign**



R Help

- R help is web-based—each function has its own page
- On the bottom of each page, R gives us an example of each function
- ?ls
- help(ls)
- ?colnames
- ?c

R Packages

- R is built around packages
- R consist of a core (that already includes a number of packages) and contributed packages programmed by user around the world
- Contributed packages add new functions that are not available in the core (e.g., genomic analyses)
- In computer terms, packages are ZIP-files that contain all that is needed for using the new functions

Downloading R Packages

- Two main functions when installing and loading packages:

1. install.packages()

   - With nothing in parentheses: list all packages available to install

   - With the name of package in parentheses: install that package. The package will live permanently on your hard drive, you don't need to install again (unless you download a newer R version)

   - After entering this command, you will select a CRAN Mirror (a server from where package will be downloaded)

Downloading R Packages

- Two main functions when installing and loading packages:

2. library()

   - With nothing in the parentheses, this will list all packages that are currently loaded

   - Each time you open R, you must load the installed packages you would like to use by running the library command with the package name listed in the parentheses

Example Downloading Package

- The Introductory Statistics with R book comes with a package that contains many example datasets that we will be using
- Install and load the package called “ISwR”
- install.packages("ISwR")
- library(ISwR)

Built-in Datasets

- By default, R is also pre-loaded with a small set of datasets and each package often comes with example datasets
- Several commands are helpful when exploring these built-in datasets:
- data(): Lists available datasets
- help(NAME OF DATASET): Brief description of dataset
- NAME OF DATASET: Prints the entire dataset—be careful!

Built-in Dataset Example

- Look at the dataset “energy” from the ISwR package
- help(energy)
- energy

Now that we understand some basic R functions.. How can I work with my dataset???

Reading Data into R

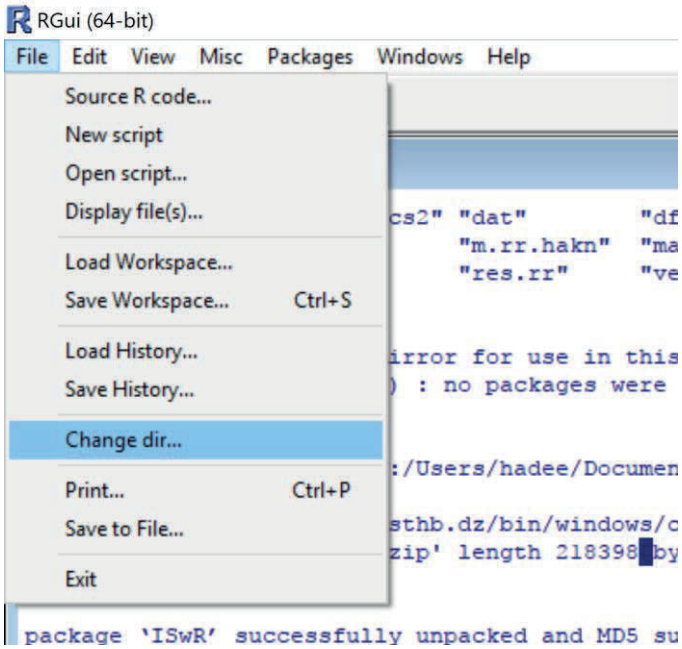
- Reading data into R using the function **read.csv.**
- Reads in data that are in the comma delimited format
- Excel spreadsheet containing data example: “fev1.csv”
- The dataset contains variables on subject number (variable name=subject), forced expiratory volume (variable name=fev1), and gender (variable name=gender)

How to know if my dataset is in CSV format?

- If your data are in excel, you can save into a comma-delimited format
- Use “saving as” and selecting “CSV (Comma Delimited)”

Now how will R now where the dataset is?

- Tell R the location of the data you will be reading in
- First know the working directory by using getwd() command
- To change working directory



Now you can read your Dataset

- In the flash memory handed please save the file fev1.csv in your working directory (eg. Documents)
- Read the file:
- fev<-read.csv("fev1.csv", header=TRUE)

fev is the name of the object that contains our data.
“fev1.csv” is the name of the csv file we created.
header=TRUE indicates that the first row of data are variable names.

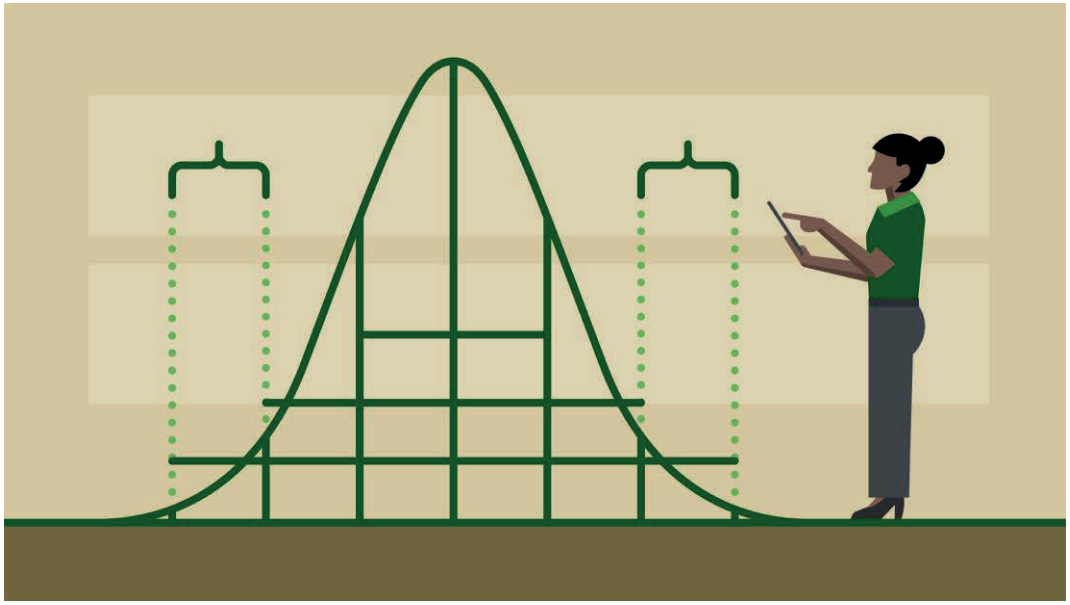
Attributes of Datasets and Variables

Function	Purpose
For datasets	
dim	Gives dimensions of data (#rows, #columns)
names	Lists the variable names of data
head	Lists first 6 rows of data
tail	Lists last 6 rows of data
class	Lists class of the object (e.g., data frame)
View	Displays data like a spreadsheet
For variables	
is.numeric	Returns TRUE or FALSE if variable is numeric
is.character	Returns TRUE or FALSE if variable is character
is.factor	Returns TRUE or FALSE if variable is factor

Exercise Exploring “fev” Dataset

- What are the dimensions of the dataset?
- Print the dataset
- What class is the dataset?
- What are the variable names of the dataset?
- Look at the first few and last rows of the data
- Print the variable fev1
- What type of variable is fev1? What about gender?

Now let us actually run some statistics in R



Descriptive Statistics in R

- Has functions for all common statistics
- summary() gives lowest, mean, median, first, third quartiles, highest for numeric variables
- table() gives tabulation of categorical variables
- Many other functions to summarize data

Summarizing Data in R

- We will be summarizing the FEV dataset using:
  - Means, SD, ranges, quartiles, histograms, boxplots, proportions and frequencies

Functions to Describe Variables

Function	Purpose
Continuous variables	
mean(data$var)	Mean
sd(data$var)	Standard deviation
summary(data$var)	Min, max, q1, q3, median, mean
min(data$var)	Minimum
max(data$var)	Maximum
range(data$var)	Min & Max
median(data$var)	Median
hist(data$var)	Histogram
boxplot(data$var)	Boxplot
Categorical/Binary variables	
table(data$var)	Gives frequency of different level of the variable
prob.table(table(data$var))	Gives proportion of different level of the variable

Exercise Summarizing Data in “fev” Dataset

- What is the mean, SD, median, min, and max of fev1?
- Use two different plots to look at the distribution of fev1. Is it normally distributed?
- What is the frequency of each gender? What is the proportion of each gender?
- How does the proportion of gender 1 compare to the proportion of gender 2?
- What does the histogram of gender look like?

Statistical Modeling in R

- So many modeling functions: e.g. lm, glm, aov, ts
- Numerous libraries and packages: survival, coxph, nls, …
- Distinction between factors and regressors
  - Factors: categorical, regressors: continuous
- Must specify factors unless they are obvious to R

Statistical Modeling in R

- Specify your model like this:
  - y ~ xi+ci (VERY simplified)
  - y = outcome variable, xi = main explanatory variables, ci = covariates, + = add terms

Example for Linear Regression

- Read new dataset
- lbwt<-read.csv("lbwt.csv", header=TRUE)

Example: Linear Regression with Continuous Predictor

First we usually test correlations

- Scatterplot: plot(lbwt$headcirc~lbwt$gestage) #simple plot

  - plot(lbwt$headcirc~lbwt$gestage, col="red", xlab="Gest. Age (weeks)", ylab="Head Circumfference (cm)", main="Scatterplot")

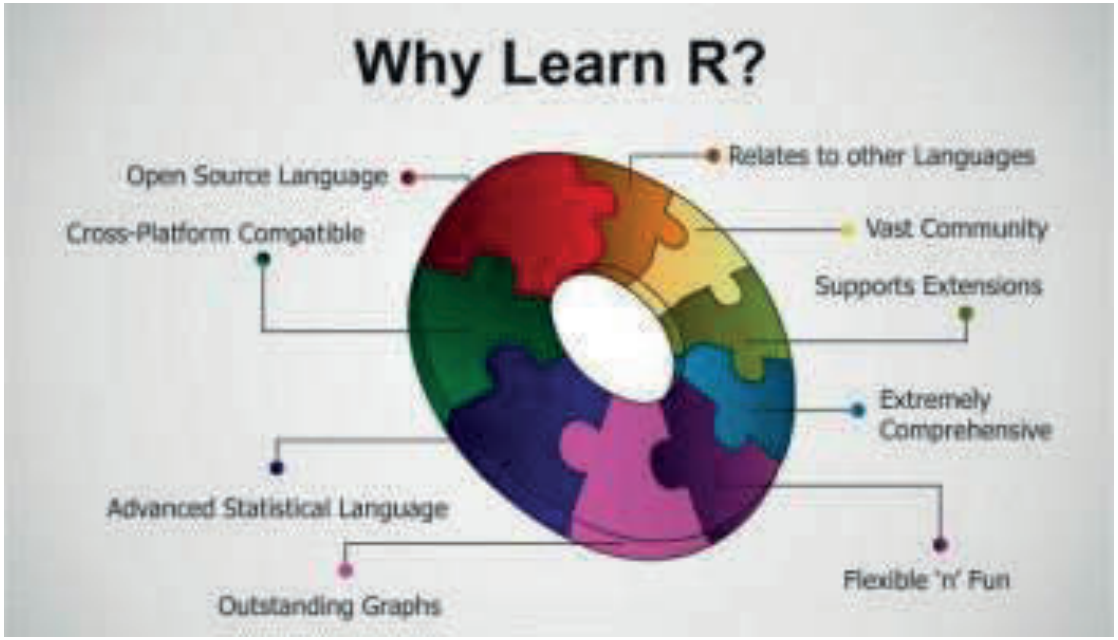
- Pearson correlation: cor.test(lbwt$headcirc,lbwt$gestage)

Example: Linear Regression with Continuous Predictor

Then we run the linear regression model:

- lm1<-lm(headcirc~gestage, data=lbwt)
- summary(lm1)
- plot(lbwt$headcirc~lbwt$gestage, col="red", xlab="Gest. Age (weeks)", ylab="Head Circumfference (cm)", main="Scatterplot", xlim=c(0,35), ylim=c(0,35))
- abline(lm1)
- abline(a=3.19, b=0.78)

How to Learn More About R?



R Resources

- R home page: http://www.r-project.org
- R discussion group:
  http://www.stat.math.ethz.ch/mailman/listinfo/r-help
- Search Google for R and Statistics

Tutorials

- http://www.statmethods.net/stats/
- http://scc.stat.ucla.edu/mini-courses
- http://www.ats.ucla.edu/stat/R/

Top 10 Great Books About R

- http://www.datasciencecentral.com/profiles/blogs/10-great-books-about-r-1

Thank you