

# BIOS 545 Week 1 Lecture 1

Department of Biostatistics and Bioinformatics

Steve Pittard [wsp@emory.edu](mailto:wsp@emory.edu)

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# Why R ?

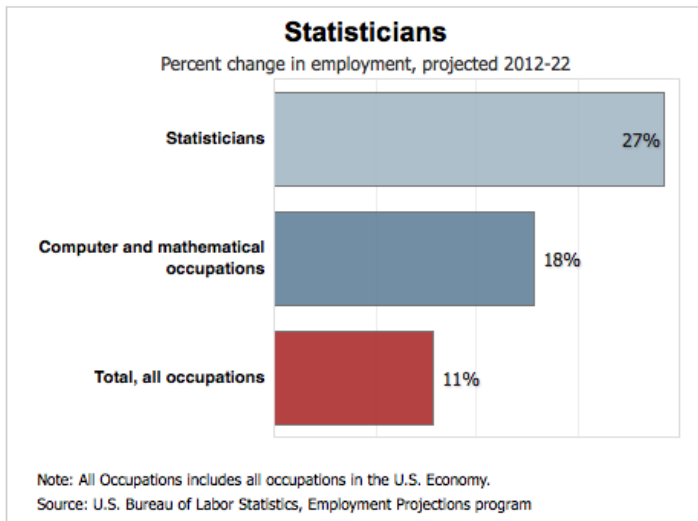
## Occupational Outlook Handbook 2014

Employment of computer and information research scientists is projected to grow 18 percent from 2012 to 2022, faster than the average for all occupations. Employment of statisticians is projected to grow 27 percent from 2012 to 2022, much faster than the average for all occupations.

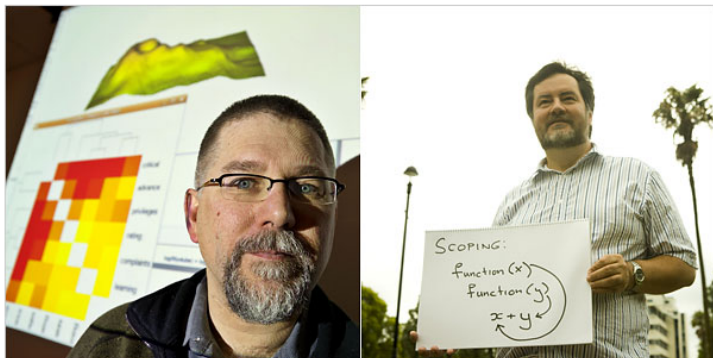
Rapid growth in data collection by businesses may lead to an increased need for data mining services. Information research scientists are likely to enjoy excellent job prospects.

Graduates with a master's degree in statistics and a strong background in a related discipline, such as finance, biology, engineering, or computer science, are projected have the best prospects of finding jobs in their field of study.

# Why R ?



## Data Analysts Captivated by R's Power



Left, Stuart Isett for The New York Times; right, Kieran Scott for The New York Times

R first appeared in 1996, when the statistics professors Robert Gentleman, left, and Ross Ihaka released the code as a free software package.

By **ASHLEE VANCE**

Published: January 6, 2009

<http://tinyurl.com/cxa774n>

# Who Uses R ?

| Company                     | How R is Used                                |
|-----------------------------|--|
| Bank of America             | Modeling and visualization                   |
| Facebook                    | User analysis and interaction                |
| FDA                         | Used in parallel with SAS                    |
| Ford Motor Company          | Decision support                             |
| Google                      | Calculate ROI on advertising                 |
| John Deere                  | Time series modeling and geospatial analysis |
| National Weather Service    | Visualization for flood forecasting          |
| New York Times Newspaper    | Data visualization                           |
| Nordstrom                   | Recommendation systems                       |
| Orbitz Travel               | Search result optimization                   |
| Twitter                     | User experience analysis                     |
| Trulia Real Estate          | Housing cost predictions                     |
| OK Cupid Online Dating      | Trend analysis                               |
| Lloyd's of London Insurance | Investment recommendation                    |

<http://www.revolutionanalytics.com/companies-using-r>

# Why R ?

- R is an interactive framework for data and statistical analysis that also happens to have a builtin programming language.
- Compare this to languages such as Python, Perl, and Java that have data analysis addons
- Which language to use ? Use them all if necessary but if data analysis is a large part of the work then R is the “go to” language
- R can reference or call code written in C, C++, Perl, Python, Java, and FORTRAN.
- Most of the effort in using R relates to shaping data for analysis and understanding the available functions and packages.
- To be a good *programmer* in R one must first be a knowledgeable *user* of R.

# Why R ?

## Differences between R and other statistical packages

“When talking about user friendliness of computer software I like to the analogy of cars vs. busses. Using this analogy programs like SPSS are busses, easy to use for the standard things, but very frustrating if you want to do something that is not already preprogrammed.”

“R is a 4-wheel drive SUV with a bike on the back, a kayak on the top, good walking and running shoes in the passenger seat, and a mountain climbing and spelunking gear in the back.”

“R can take you anywhere you want to go if you take the time to learn how to use the equipment, but that is going to take longer than learning where the bus stops are in SPSS.”

Greg Snow, R-help (May 2006)

# Why R ?

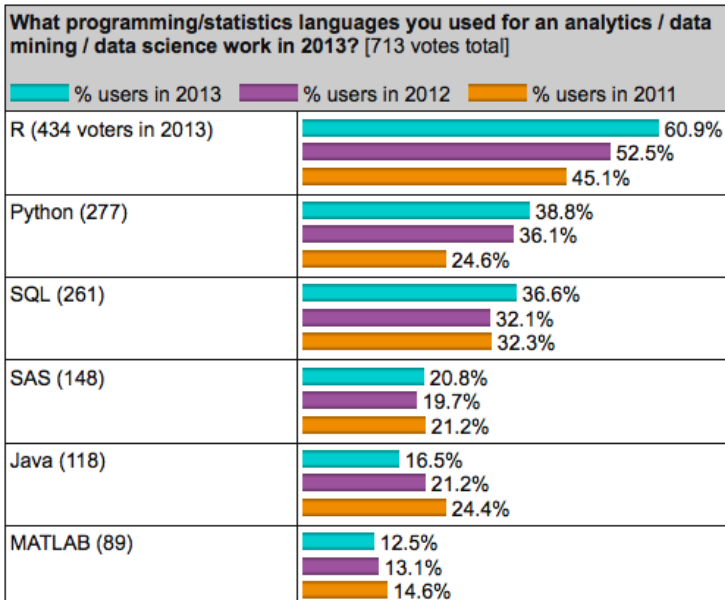
## Cool things about R

- Vast capabilities with a wide range of statistical and graphics techniques
- Written primarily by statisticians
- Free of cost
- Collaborative development with over 6,092 user contributed packages
- Excellent community support with mailing lists, blogs, and tutorials
- Excellent “google” support
- Wildly popular in Academia and increasingly so in the business world

[www.slideshare.net/izahn/rintro](http://www.slideshare.net/izahn/rintro)



# R vs Other Languages - kdnuggets.com



# Obtaining R

- Go to <http://cran.revolutionanalytics.com/>
- Click on your platform which will be either Windows or Apple OSX
- You will be redirected to another page which has a download link near the top
- Click it to download and begin installation. Wait till it is finished
- Go to <http://www.rstudio.com/products/rstudio/download/> to download the RStudio GUI
- Double click the installer to initiate the installation of RStudio
- Once finished start up Rstudio

# Base Packages

It is important to note that R comes with a base set of packages as part of every installation.

```
> getOption("defaultPackages")
[1] "datasets" "utils"      "grDevices" "graphics" "stats"      "methods"

> search()
[1] ".GlobalEnv"      "package:stats"    "package:graphics" "package:grDevices"
[5] "package:utils"    "package:datasets" "package:methods"   "Autoloads"
[9] "package:base"

> library(help="stats")
```

# Base Packages

```
> library(help="stats")
```

Description:

```
Package:      stats
Version:      3.1.2
Priority:      base
Title:        The R Stats Package
Author:       R Core Team and contributors worldwide
Maintainer:   R Core Team <R-core@r-project.org>
Description:  R statistical functions
License:      Part of R 3.1.2
Built:        R 3.1.2; x86_64-apple-darwin13.4.0; 2014-10-31 20:19:14 UTC; unix
```

Index:

|                              |   |
|------------------------------|---|
| <code>.checkMFClasses</code> | Functions to Check the Type of Variables passed to Model Frames |
| <code>AIC</code>             | Akaike's An Information Criterion                               |
| <code>ARMAacf</code>         | Compute Theoretical ACF for an ARMA Process                     |
| <code>ARMAtoMA</code>        | Convert ARMA Process to Infinite MA Process                     |
| <code>Beta</code>            | The Beta Distribution   |
| <code>Binomial</code>        | The Binomial Distribution                                       |
| <code>Box.test</code>        | Box-Pierce and Ljung-Box Tests                                  |
| <code>C</code>               | Sets Contrasts for a Factor                                     |

# Base Packages

Many packages come with example data that is helpful when attempting to understand how various functions work. To see what data sets are available in a given package, do something like:

```
> search()
[1] ".GlobalEnv" "package:lattice" "package:stats" "package:graphics"
[5] "package:grDevices" "package:utils" "package:datasets" "package:methods"
[9] "Autoloads" "package:base"

> data(package="stats") # Find data included in package "stats"
```

Data sets in package "datasets":

|                        |   |
|------------------------|---|
| AirPassengers          | Monthly Airline Passenger Numbers 1949-1960 |
| BJsales                | Sales Data with Leading Indicator           |
| BJsales.lead (BJsales) | Sales Data with Leading Indicator           |
| BOD                    | Biochemical Oxygen Demand                   |
| CO2                    | Carbon Dioxide Uptake in Grass Plants       |
| DNase                  | Elisa assay of DNase                        |
| EuStockMarkets         | Daily Closing Prices of Major European      |
| ..                     |   |

# CRAN Packages

- One of the most powerful aspects of R is the ability to install user-contributed addon packages available in CRAN, (Comprehensive R Archive Network).
- As of December 2014 there are over 6,000 packages available.
- To obtain information on the wide variety of packages then visit the following URL to see some of the areas covered.  
`cran.cnr.berkeley.edu`
- Also go to the “Task Views” You can also see packages grouped by domain at <http://cran.r-project.org/web/views/>

# CRAN Packages

Here are some of the areas covered. There are many more of course

## CRAN Task Views

|  |   |
|--|---|
| <a href="#">Bayesian</a>                 | Bayesian Inference  |
| <a href="#">ChemPhys</a>                 | Chemometrics and Computational Physics                                |
| <a href="#">ClinicalTrials</a>           | Clinical Trial Design, Monitoring, and Analysis                       |
| <a href="#">Cluster</a>                  | Cluster Analysis & Finite Mixture Models                              |
| <a href="#">DifferentialEquations</a>    | Differential Equations  |
| <a href="#">Distributions</a>            | Probability Distributions   |
| <a href="#">Econometrics</a>             | Computational Econometrics  |
| <a href="#">Environmetrics</a>           | Analysis of Ecological and Environmental Data                         |
| <a href="#">ExperimentalDesign</a>       | Design of Experiments (DoE) & Analysis of Experimental Data           |
| <a href="#">Finance</a>                  | Empirical Finance   |
| <a href="#">Genetics</a>                 | Statistical Genetics  |
| <a href="#">Graphics</a>                 | Graphic Displays & Dynamic Graphics & Graphic Devices & Visualization |
| <a href="#">HighPerformanceComputing</a> | High-Performance and Parallel Computing with R                        |
| <a href="#">MachineLearning</a>          | Machine Learning & Statistical Learning                               |
| <a href="#">MedicalImaging</a>           | Medical Image Analysis  |

# CRAN Packages

If you are using RStudio there are menu items that can simplify the process of identifying and installing packages. However, you can also do this from the command prompt. Let's say you want to install the “actuar” package from CRAN.

```
> install.packages("actuar",dependencies=TRUE)
```

```
trying URL 'http://mirrors.nics.utk.edu/cran/bin/macosx/contrib/2.15/
actuar_1.1-5.tgz'
Content type 'application/x-gzip' length 1837121 bytes (1.8 Mb)
opened URL
```

```
=====
```

```
downloaded 1.8 Mb
```

```
> library(actuar) # Brings the package into the workspace
```



# CRAN Packages

When we use the **library** command to load the contents of the **actuar** package it will show up when we execute the **search()** function. Check it out.

```
> library(actuar) # Brings the package into the workspace
```

```
> search()
```

```
[1] ".GlobalEnv" "package:actuar" "package:lattice" "package:stats"  
[5] "package:graphics" "package:grDevices" "package:utils"  
[8] "package:datasets" "package:methods" "Autoloads" "package:base"
```

# CRAN Packages

On occasion you will need to install a package from a specific repository such as `omegahat.org` or `R-forge`. RStudio has menu items that can help with this but you can also do it from the command line.

```
> install.packages("GeoIP", repos = "http://www.omegahat.org/R")
```

Sometimes you download packages written by colleagues and you have to install them from your local hard drive. Again, RStudio can help but you could also do something like:

```
$ R CMD INSTALL GeoIP.tar.gz
```

# Finding Documentation

There are lots of free books on the web as well as blogs and Youtube channels for learning R

| Resource               | URL   |
|------------------------|---|
| The R Inferno          | <a href="http://www.burns-stat.com/documents/books/the-r-inferno/">http://www.burns-stat.com/documents/books/the-r-inferno/</a>   |
| R Programming Wiki     | <a href="http://en.wikibooks.org/wiki/R_Programming">http://en.wikibooks.org/wiki/R_Programming</a>                               |
| Intro to Stats Using R | <a href="http://ipsur.org">http://ipsur.org</a>   |
| Stats with R           | <a href="http://zoonek2.free.fr/UNIX/48_R/all.html">http://zoonek2.free.fr/UNIX/48_R/all.html</a>                                 |
| Lattice Graphics       | <a href="http://lmdvr.r-forge.r-project.org">http://lmdvr.r-forge.r-project.org</a>   |
| Contributed R Info     | <a href="http://cran.r-project.org/other-docs.html">http://cran.r-project.org/other-docs.html</a>                                 |
| simpleR Intro Stats    | <a href="http://cran.r-project.org/doc/contrib/Verzani-SimpleR.pdf">http://cran.r-project.org/doc/contrib/Verzani-SimpleR.pdf</a> |
| DIY Intro to R         | <a href="http://www.unt.edu/rss/class/Jon/R_SC/">http://www.unt.edu/rss/class/Jon/R_SC/</a>                                       |
| R Bloggers             | <a href="http://www.r-bloggers.com/">http://www.r-bloggers.com/</a>   |
| R Journal              | <a href="http://journal.r-project.org/">http://journal.r-project.org/</a>   |
| R Tutorial             | <a href="http://www.r-tutor.com/r-introduction">http://www.r-tutor.com/r-introduction</a>   |
| Google Style Guide     | <a href="https://github.com/hadley/devtools/wiki/Style">https://github.com/hadley/devtools/wiki/Style</a>                         |
| Applied Epi Using R    | <a href="http://www.medepi.net/docs/EpidemiologyUsingR.pdf">http://www.medepi.net/docs/EpidemiologyUsingR.pdf</a>                 |
| Rolling your Rs        | <a href="http://rollingyours.wordpress.com">http://rollingyours.wordpress.com</a>   |

# Finding Documentation

There are some good books you can buy although for this class they aren't required.

| Book   | Author                      |
|--|-----------------------------|
| R Cookbook   | Paul Teetor                 |
| R in a Nutshell  | Joseph Adler                |
| The Art of Programming                                 | Norman Matloff              |
| Data Manipulation with R                               | Phil Spector                |
| ggplot2: Elegant Graphics for Data Analyses            | Hadley Wickham              |
| Intro to Scientific Programming and Simulation Using R | Jones, Maillardet, Robinson |
| Introductory Statistics with R                         | Peter Dalgaard              |
| The R Book   | Michael J. Crawley          |
| Discovering Statistics Using R                         | Andy Field                  |

# Mailing Lists

- Here are some mailing lists that accept questions relative to R and BioConductor.
- Moderators and participants in these lists take questions seriously, sometimes too seriously,
- Please don't ask a question without first searching through the archives to see if your question has already been answered. Chances are it has.

| Mailing Lists   | URL   |
|-----------------|---|
| R-Help          | <a href="http://stat.ethz.ch/mailman/listinfo/r-help">http://stat.ethz.ch/mailman/listinfo/r-help</a> |
| Cross Validated | <a href="http://stats.stackexchange.com">http://stats.stackexchange.com</a>                           |
| Stack Overflow  | <a href="http://stackoverflow.com/questions/tagged">http://stackoverflow.com/questions/tagged</a>     |

# Getting Help

R has a number of ways to get help. Rstudio has a Help menu item. Other ways include the following:

```
> help.start()           # Launches a web browser with search capability

> help(function_name)    # Get help on "function_name"

> ?function_name         # Equivalent to the above

> args(function_name)    # See what arguments the function accepts

> example(function_name) # See an example of the function

> example(mean)
```

```
mean> x <- c(0:10, 50)
mean> xm <- mean(x)
mean> c(xm, mean(x, trim = 0.10))
[1] 8.75 5.50
```

# Getting Help

R has a number of ways to get help. Rstudio has a Help menu item. Other ways include the following:

```
# Find all functions and data having to do with time series
```

```
> help.search("time series")
```

```
> ?? "time series"      # Equivalent to the above
```

Help files with alias or concept or title matching "time series" using fuzzy matching:

|                                 |   |
|---------------------------------|---|
| <code>boot::tsboot</code>       | Bootstrapping of Time Series                                |
| <code>datasets::austres</code>  | Quarterly Time Series of the Number of Australian Residents |
| <code>datasets::beavers</code>  | Body Temperature Series of Two Beavers                      |
| <code>ggplot2::economics</code> | US economic time series.                                    |
| <code>lattice::xyplot.ts</code> | Time series plotting methods                                |
| <code>MASS::beav1</code>        | Body Temperature Series of Beaver 1                         |
| <code>MASS::beav2</code>        | Body Temperature Series of Beaver 2                         |
| <code>stats::StructTS</code>    | Fit Structural Time Series                                  |
| <code>stats::ar</code>          | Fit Autoregressive Models to Time Series                    |
| <code>stats::ar.ols</code>      | Fit Autoregressive Models to Time Series by OLS             |
| <code>..</code>                 |   |

# Things to Know !

- Everything in R is an object
- The great thing about R is that there are many different ways to do something
- The bad thing about R is that there are many different ways to do something
- Everything that happens in R is a function call
- Supports procedural programming with functions and object oriented programming
- R is based on a “read-eval-print” loop
- Interpreted language



# Walkthrough

```
url <- "http://steviepie42.bitbucket.org/YOUTUBE.DIR/table_7_3.csv"
```

```
engine <- read.table(url, sep = ",", header=TRUE)
engine <- engine[,-1]
```

```
head(engine) # 3 engine pollutants
```

```
      hc co nox
1 0.50 5.01 1.28
2 0.65 14.67 0.72
3 0.46 8.60 1.17
4 0.41 4.42 1.31
5 0.41 4.95 1.16
```

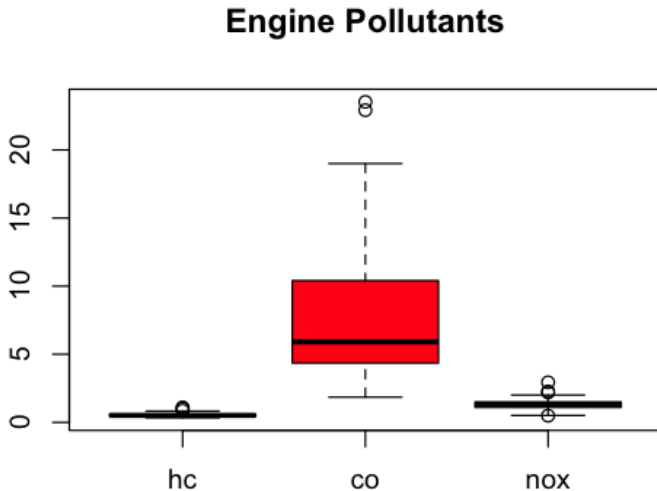
```
summary(engine)
```

| hc            | co            | nox          |
|---------------|---------------|--------------|
| Min. :0.340   | Min. : 1.85   | Min. :0.49   |
| 1st Qu.:0.438 | 1st Qu.: 4.39 | 1st Qu.:1.11 |
| Median :0.510 | Median : 5.91 | Median :1.31 |
| Mean :0.550   | Mean : 7.88   | Mean :1.34   |
| 3rd Qu.:0.602 | 3rd Qu.:10.02 | 3rd Qu.:1.50 |
| Max. :1.100   | Max. :23.53   | Max. :2.94   |

```
http://www.cyclismo.org/tutorial/R/hwI.html
```

# Walkthrough

```
boxplot(engine,col="red",main="Engine Pollutants")
```



# Walkthrough

```
par(mfrow=c(1,3))
```

```
boxplot(engine$co,main="Carbon Monoxide")
```

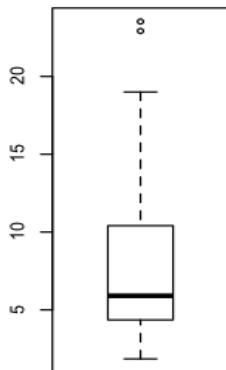
```
hist(engine$co)
```

```
qqnorm(engine$co,main="Carbon Monoxide")
```

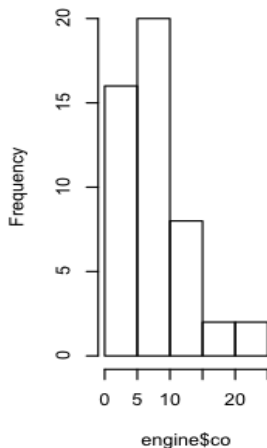
```
qqline(engine$co)
```

# Walkthrough

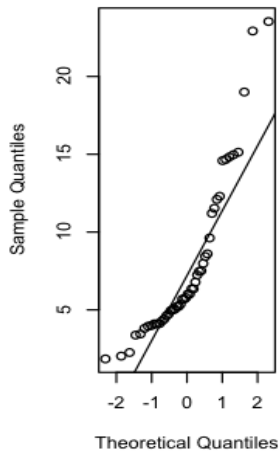
**Carbon Monoxide**



**Histogram of engine\$co**



**Carbon Monoxide**



# Walkthrough

# The null hypothesis is that the data is normal

```
shapiro.test(engine$co)
```

Shapiro-Wilk normality test

```
data: engine$co
```

```
W = 0.8357, p-value = 9.289e-06
```

# Take the log of the CO

```
log.engine <- log(engine$co)
```

```
shapiro.test(log.engine)
```

Shapiro-Wilk normality test

```
data: log.engine
```

```
W = 0.9693, p-value = 0.2379
```

# Walkthrough

```
par(mfrow=c(2,2))

log.engine <- log(engine$co)

boxplot(log.engine,main="Carbon Monoxide")

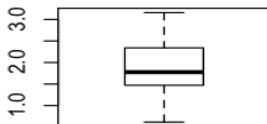
hist(log.engine,main="Carbon Monoxide")

qqnorm(log.engine,main="QQ Plot for the Log of the
      Carbon Monoxide")

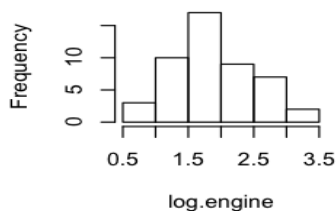
qqline(log.engine)
```

# Walkthrough

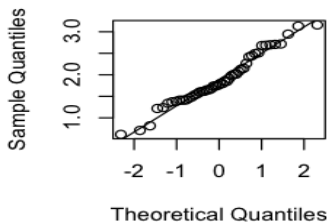
**Carbon Monoxide**



**Carbon Monoxide**



**QQ Plot for the Log of the Carbon Monox**



# Walkthrough

```
# Let's build a confidence interval
```

```
my.mean <- mean(log.engine)
my.sd <- sd(log.engine)
n <- length(log.engine)
```

```
# Get standard error
se <- my.sd/sqrt(n)
```

```
error <- se*qt(0.975,df=n-1)
```

```
left <- my.mean - error
```

```
right <- my.mean + error
```

```
c(left,right)
[1] 1.709925 2.057431
```

```
c(exp(left),exp(right))
[1] 5.528548 7.825840
```



# Walkthrough

```
# Test H0: mu = 5.4
# HA:mu != 5.4

lNull <- log(5.4) - error

rNull <- log(5.4) + error

c(lNull,rNull)
[1] 1.512646 1.860152

my.mean
[1] 1.883678
```

So the mean is outside the range thus we reject the null. There is a low probability that we would have obtained our sample mean if the true mean really was 5.4

# Walkthrough

We could have calculated a p-value by hand

```
p.val <- 2*(1-pt((my.mean-log(5.4))/se,df=n-1))
```

```
p.val  
[1] 0.02692539
```

# But its easier to call a procedure to do it all !!!!

```
t.test(log.engine,mu = log(5.4),alternative = "two.sided")
```

One Sample t-test

data: log.engine

t = 2.2841, df = 47, p-value = 0.02693

alternative hypothesis: true mean is not equal to 1.686399

95 percent confidence interval:

1.709925 2.057431

sample estimates:

mean of x

1.883678

# First R Session

```
?mean                # Get help on the mean function

example(kmeans)      # Run an example of kmeans (if it exists)

pi                    # Some popular quantities are built-in to R
[1] 3.141593

sqrt(2) # Basic arithmetic
[1] 1.414214

print(pi) # Print the comments of the pi variable
[1] 3.141593

X <- 3; Y <- 4 # Semicolon lets you enter 2 commands on the same line

Z <- sqrt(X^2 + Y^2) # Variables contain information

# List all variables in the "environment"

ls()
[1] "X" "Y" "Z"
```

|  |  |   |
|--|--|---|
| <code>log(10)</code><br>[1] 2.302585       | <code>ceiling(6.8)</code><br>[1] 7                       | <code>2+3</code><br>[1] 5                         |
| <code>log10(100)</code><br>[1] 2           | <code>round(6.889,2)</code><br>[1] 6.89                  | <code>3/2</code><br>[1] 1.5                       |
| <code>sin(pi/2)</code><br>[1] 1            | <code>3/0</code><br>[1] Inf                              | <code>2^3</code><br>[1] 8                         |
| <code>cos(pi/2)</code><br>[1] 6.123234e-17 | <code>0/0</code><br>[1] NaN                              | <code>(56-14)/6 - 4*7*10/(5^2-5)</code><br>[1] -7 |
| <code>1.3e6</code><br>[1] 1300000          | <code>is.finite(3)</code><br>[1] TRUE                    | <code>abs(2-4)</code><br>[1] 2                    |
| <code>9 %% 2</code><br>[1] 1               | <code>x &lt;- c(1:8,NA)</code><br>[1] 1 2 3 4 5 6 7 8 NA |   |
| <code>floor(5.7)</code><br>[1] 5           | <code>mean(x)</code><br>NA                               |   |

# Common Operators

## # RELATIONAL OPERATORS

|                          |    |                                    |
|--------------------------|----|------------------------------------|
| Equal to                 | == | if (myvar == "test") {print("EQ")} |
|                          | == | if (mynum == 3) {print("EQ")}      |
| Not equal to             | != | if (myvar != "test") {print("NE")} |
| Less than or equal to    | <= | if (number <= 5) {print("LTE")}    |
| Less than                | <  | if (number < 10) {print("LT")}     |
| Greater than or equal to | >= | if (number >= 10) {print("GTE")}   |
| Greater than             | >  | if (number > 12) {print("GT")}     |

## # BOOLEAN OPERATORS

|     |   |   |
|-----|---|---|
| And | & | if ((myvar == "test") & (num <= 10) ) {<br>print("Equal and less than")<br>}    |
| Not | ! | if (!complete.cases(myvec)) {<br>print("Non complete cases")<br>}               |
| Or  |   | if ((num > 3)   (num < -3)) {<br>print("Only one of these has to be true")<br>} |

# More Examples

Here are some popular math formulas rewritten in R. Note that the variables must first exist in order for the formula to do an actual computation.

```
# a^2 + b^2 = c^2                                # Pythagorean Theorem

a <- 2; b <- 4

c <- sqrt(a^2 + b^2)                             # To solve the PT for c

a <- 2; b <- 4; c <- 1

(-b + sqrt(b^2-4*a*c)) / (2*a)                  # First case quadratic formula solution

(-b - sqrt(b^2 - 4*a*c)) / (2*a)               # Second case quadratic formula solution
r <- 4; h <- 6; b <- 3

circumference <- 2*pi*r                        # circumference of a circle

area <- (b*h)/2 # Area of a triangle
```

## More Examples

You can create expressions that can be evaluated later. The variables they reference don't have to exist. They are placeholders.

```
area <- expression( (b*h)/2 )
```

```
# Solve where b =3 and h = 4
```

```
b <- 3
```

```
h <- 4
```

```
eval(area)
```

```
[1] 6
```

# Expressions

```
r1 <- expression((-b + sqrt(b^2 - 4*a*c)) / (2*a))  
r2 <- expression((-b - sqrt(b^2 - 4*a*c)) / (2*a))  
# Solve for  $ax^2 + bx + c$  where  $a = 1$ ,  $b=6$ , and  $c=8$ 
```

```
a = 1 ; b=6 ; c=8  
eval(r1)
```

```
[1] -2
```

```
eval(r2)
```

```
[1] -4
```

```
a*eval(r1)^2 + b*eval(r1) + c
```

```
[1] 0
```

```
a*eval(r2)^2 + b*eval(r2) + c
```

```
[1] 0
```



# Expressions

We can create functions which are “grown up ” expressions.

```
my.quad <- function(a,b,c) {  
  r1 <- (-b + sqrt(b^2 - 4*a*c)) / (2*a)  
  r2 <- (-b - sqrt(b^2 - 4*a*c)) / (2*a)  
  my.roots = c(r1,r2)  
  return(my.roots)  
}  
# Solve for  $ax^2 + bx + c$  where  $a = 1$ ,  $b=6$ , and  $c=8$   
  
my.quad(1,6,8)  
  
[1] -2 -4
```

# Startup

- You can use the Preferences menu item in RStudio to specify your default home directory
- When R starts it looks for a file called `.Rprofile` within your home directory
- You can influence the R environment by setting a number of “startup” variables therein
- Use your favorite editor to create/edit this file in your default folder
- You can change many of these variables or options during an R session but if you want them to be permanent then you will need to edit the `.Rprofile` file

# Startup .Rprofile

```
# Things you might want to change

options(editor="notepad")
cd = setwd
pwd = getwd
lss = dir

# R interactive prompt
setwd("/Users/fender/steve.test") # Set's my default directory for me.
options(prompt="> ")
options(continue="+ ")

# General options
options(digits=3)
options(width = 130)
options(graphics.record=TRUE)
.First <- function(){                # You can load functions
  library(Hmisc)
  cat("\nWelcome at", date(), "\n")
}
.Last <- function(){
  cat("\nGoodbye at ", date(), "\n")
}
```

# Workspace - Being Organized

Being organized helps ! Knowing how to find stuff quickly is essential. Create a master folder that will contain your work in this class.

You can create subfolders according to your projects. Note that some people do this on a DropBox folder to insure that all work is backed up.

```
$ ls RProjects
RProjects
  Data_Files
  Genomes
    1000_Genomes
    Centenarians
  HIV
    Replicates
  Hepatitis
    Hep_A
    Hep_B
```

# Workspace - Navigating Directories

There are a number of functions that allow you to “move” around in your folder structure. These are important to know because sometimes you will need to write code that needs to refer to specific folders and files during execution.

```
getwd()  
[1] "/Users/fender/TEST.DIR"
```

```
setwd("/Users/fender")  
getwd()  
[1] "/Users/fender"
```

```
setwd("/Users/fender/TEST.DIR")  
getwd()  
[1] "/Users/fender/TEST.DIR"
```

```
dir()  
[1] "coolpkg" "coolpkg_1.0.tar.gz" "coolpkg.pdf" "coolpkg.Rcheck"  
"g.Rd" "stuff.R"
```

# Workspace - Listing Files

R also has some functions that list files in a folder. You can do this visually within R Studio although sometimes you will need to use these commands to open and read in files as part of a program.

```
myfiles <- list.files()
```

```
str(myfiles)
```

```
chr [1:29] "001.csv" "002.csv" "003.csv" "004.csv" "005.csv" "006.csv" ...
```

```
myfiles[1:5]
```

```
[1] "001.csv" "002.csv" "003.csv" "004.csv" "005.csv"
```

# You could write a for-loop to process each and every file

```
for (ii in 1:length(myfiles)) {
```

```
  file <- myfiles[ii]
```

```
  # Do something
```

```
}
```

# Workspace - ls()

R creates an environment for each session you initiate. This is very useful because it accumulates all your variables and objects while you experiment with data.

Over time your environment will accumulate lots of variables. In general this is good because you don't lose anything. The **ls()** function can show you what objects you currently have in your environment.

```
ls()
[1] "access_log"           "cntr"
[3] "ii"                   "init"
[5] "mpg"                  "mtcars"
[7] "mymean"               "myrle"
[9] "mystr"                "nhanes1"
[11] "retvec"              "retvectr"
[13] "SacramentocrimeJanuary2006" "Sacramentorealestatetransactions"
[15] "SalesJan2009"
```

# Workspace - rm()

You can remove one or more objects using the **rm()** function

```
ls()
[1] "access_log"          "cntr"
[3] "ii"                  "init"
[5] "mpg"                  "mtcars"
[7] "mymean"               "myrle"
[9] "mystr"                "nhanes1"
[11] "retvec"              "retvectr"
[13] "SacramentocrimeJanuary2006" "Sacramentorealestatetransactions"
[15] "SalesJan2009"
```

```
rm(access_log)    # Removes the object named "access_log"
```

```
access_log        # Now R can't find it
Error: object 'access_log' not found
```

```
rm(mystr,retvec,init)    # Remove more than one object at once
```



## Workspace - .Rdata

When you quit R you will be asked if you wish to save your current environment to disk. If you type “y” then all objects, (and their values), will be written to a file called **.Rdata**

This is useful because when you restart R in the same folder it will read **.Rdata** which contains all previously saved information.

```
> q()
Save workspace image? [y/n/c]: y
Goodbye at Mon Oct 1 14:26:47 2012

fenders-macbook:TEST.DIR fender$ ls .Rdata
.Rdata
```

The **.Rdata** file is a “binary” file, (its contents are unintelligible to the eye), that contains all the R objects and values in between sessions. This file could be shared with others if you wanted.

## Workspace - save()

You can also save one or more objects to a file using the **save()** function. The inverse of the **save()** function is the **load()** function.

```
my.lm <- lm(mpg ~ wt,mtcars)
```

```
ls(my.lm)
```

```
[1] "assign" "call" "coefficients" "df.residual" "effects" "fitted.values"  
[7] "model" "qr" "rank" "residuals" "terms" "xlevels"
```

```
save(my.lm,file="/Users/myhome/mylmresults")
```

```
# You can come back later and load this file
```

```
mylmstuff <- load("/Users/myhome/mylmresults")
```

# Variables

As in most programming languages, it is customary to store or hold the results of an operation in a variable name.

In R such results are assigned with the symbols "<-" or "=". Variable names are case sensitive.

```
A <- 2.5      # The "<-" is the preferred method of assignment
```

```
A = 2.5      # This is equivalent to the above although using the "=" is  
              # discouraged except in setting function arguments.
```

```
A  
[1] 2.5
```

```
mynewvar <- A + 3
```

```
MYNEWVAR <- A + 3      # Two different variables
```

# Variables

- R has several one-letter reserved words: c, q, s, t, C, D, F, I, T
- Variables cannot begin with the period characters “.”
- Variable names are case sensitive, so “myvar” is different from “Myvar”
- Variable names cannot begin with numbers or symbols (%, \$, \_)
- Variable names cannot contain spaces in the name (“my var”)

# Variables

## GOOD

mean.height  
smoker  
non.smoker  
temp.var  
patient\_id  
Eye.Color  
State.Population  
disease.state  
White\_Cell\_Count  
jobTitle

## BAD

.mean.height  
\_myvariable  
\_Mean.height  
1variable  
1\_variable  
%some.var  
some.var  
"some var"  
\$myvar

# Reading and Writing Files

R has a number of builtin example data frames. One common way to import data is via “.csv” files. Before we consider reading a .csv file let's first create one.

```
head(mtcars)
```

|                | mpg  | cyl | disp | hp  | drat | wt    | qsec  | vs | am | gear | carb |
|----------------|------|-----|------|-----|------|-------|-------|----|----|------|------|
| Mazda RX4      | 21.0 | 6   | 160  | 110 | 3.90 | 2.620 | 16.46 | 0  | 1  | 4    | 4    |
| Mazda RX4 Wag  | 21.0 | 6   | 160  | 110 | 3.90 | 2.875 | 17.02 | 0  | 1  | 4    | 4    |
| Datsun 710     | 22.8 | 4   | 108  | 93  | 3.85 | 2.320 | 18.61 | 1  | 1  | 4    | 1    |
| Hornet 4 Drive | 21.4 | 6   | 258  | 110 | 3.08 | 3.215 | 19.44 | 1  | 0  | 3    | 1    |

```
write.table(mtcars,file="mtcars.csv",  
            row.names=TRUE,           # Row names get saved  
            col.names=TRUE,          # Header gets saved  
            sep=",")                 # Field separator is ,
```

```
$ head mtcars.csv
```

```
"mpg","cyl","disp","hp","drat","wt","qsec","vs","am","gear","carb"  
"Mazda RX4",21,6,160,110,3.9,2.62,16.46,0,1,4,4  
"Mazda RX4 Wag",21,6,160,110,3.9,2.875,17.02,0,1,4,4
```

# Reading and Writing Files

The first line of `mtcars.csv` describes the column names. Each subsequent row represents an observation with each field being separated by a “,”.  
Let's read it in:

```
mycars <- read.table("mtcars.csv",header=TRUE,sep=",")
```

```
head(mycars)
```

|                   | mpg  | cyl | disp | hp  | drat | wt    | qsec  | vs | am | gear | carb |
|-------------------|------|-----|------|-----|------|-------|-------|----|----|------|------|
| Mazda RX4         | 21.0 | 6   | 160  | 110 | 3.90 | 2.620 | 16.46 | 0  | 1  | 4    | 4    |
| Mazda RX4 Wag     | 21.0 | 6   | 160  | 110 | 3.90 | 2.875 | 17.02 | 0  | 1  | 4    | 4    |
| Datsun 710        | 22.8 | 4   | 108  | 93  | 3.85 | 2.320 | 18.61 | 1  | 1  | 4    | 1    |
| Hornet 4 Drive    | 21.4 | 6   | 258  | 110 | 3.08 | 3.215 | 19.44 | 1  | 0  | 3    | 1    |
| Hornet Sportabout | 18.7 | 8   | 360  | 175 | 3.15 | 3.440 | 17.02 | 0  | 0  | 3    | 2    |
| Valiant           | 18.1 | 6   | 225  | 105 | 2.76 | 3.460 | 20.22 | 1  | 0  | 3    | 1    |

# Reading Tabular Data from the Internet

You already know that you can read CSV files directly a URL. But you can also read data directly from a table from a website.

Take a look at this example. Let's say we want to get the data in the first table from here:<http://msenux.redwoods.edu/math/R/regression.php>

## *Scatterplots*

The data set in the table that follows is taken from measured the heights of 161 children in Kalama, a village recorded each month, with the study lasting several years follows.

| Mean Height versus Age |                               |
|------------------------|-------------------------------|
| Age in Months          | Average Height in Centimeters |
| 18                     | 76.1                          |
| 19                     | 77                            |
| 20                     | 78.1                          |
| 21                     | 78.2                          |
| 22                     | 78.8                          |
| 23                     | 79.7                          |



# Reading Tabular Data from the Internet

```
library(XML)
url <- "http://msenux.redwoods.edu/math/R/regression.php"
my.table <- readHTMLTable(url,which=1,skip=1)
```

```
head(my.table,5)
```

|   | Age in Months | Average Height in Centimeters |
|---|---------------|-------------------------------|
| 1 | 18            | 76.1                          |
| 2 | 19            | 77                            |
| 3 | 20            | 78.1                          |
| 4 | 21            | 78.2                          |
| 5 | 22            | 78.8                          |

```
names(my.table) <- c("Age","Height")
```

```
head(my.table,5)
```

|   | Age | Height |
|---|-----|--------|
| 3 | 18  | 76.1   |
| 4 | 19  | 77     |
| 5 | 20  | 78.1   |
| 6 | 21  | 78.2   |
| 7 | 22  | 78.8   |

## Reading Excel Files

It is possible to read an Excel spreadsheet although the best thing to do is to first save the spreadsheet into a .csv file and then import it into R using **read.table()** function. However, you can read the spreadsheet directly from a file using the add on **RODBC** package.

```
library(RODBC)
```

```
channel <- odbcConnectExcel("examp.xls")
```

```
## list the spreadsheets
```

```
sqlTables(channel)
```

```
TABLE_CAT TABLE_SCHEM TABLE_NAME TABLE_TYPE REMARKS
1 C:\\bdr NA Sheet1$ SYSTEM TABLE NA
2 C:\\bdr NA Sheet2$ SYSTEM TABLE NA
3 C:\\bdr NA Sheet3$ SYSTEM TABLE NA
4 C:\\bdr NA Sheet1$Print_Area TABLE NA
```

```
## retrieve the contents of sheet 1, by either of
```

```
sh1 <- sqlFetch(channel, "Sheet1")
```

```
sh1 <- sqlQuery(channel, "select * from [Sheet1$]")
```

# Reading Files from Other Packages

It is possible to read data sets from other statistical packages although I think the best way is to first export data to CSV files and then into R. But here are the available functions.

| Function(s) | Purpose   |
|-------------|---|
| read.epinfo | Read saved objects from EpiInfo                                       |
| read.xport  | Read saved objects in SAS export format                               |
| read.spss   | Read saved objects from SPSS written using the save or export command |
| read.systat | Read saved objects from SYSTAT rectangular (mtype=1) data only        |
| read.dta    | Read saved objects from STATA (versions 5-9)                          |
| read.mtp    | Read Minitab Portable Worksheet Files                                 |
| read.octave | Read saved objects from GNU octave                                    |
| read.dbf    | Read or write saved objects from DBF files (FoxPro, dBase,etc)        |

# Reading Files from Other Packages

R can process XML files which is a format that underlies many websites that distribute interesting data. As an example we can use R and XML to “geocode” cities.

Google Maps API Web Services  191

Introduction

Directions API

Distance Matrix API

Elevation API

**Geocoding API**

Time Zone API

Blog

Forum

FAQ

## The Google Geocoding API

[What is Geocoding?](#)

[Audience](#)

[Usage Limits](#)

[Geocoding Requests](#)

[Geocoding Responses](#)

[JSON Output Formats](#)

[XML Output Formats](#)

[Status Codes](#)

[Results](#)

[Address Component Types](#)

[Reverse Geocoding](#)

[Viewport Biasing](#)

[Region Biasing](#)

[Component Filtering](#)

<https://developers.google.com/maps/documentation/geocoding/>

# Reading XML

```
- <GeocodeResponse>
  <status>OK</status>
  - <result>
    <type>locality</type>
    <type>political</type>
    <formatted_address>Atlanta, GA, USA</formatted_address>
  - <address_component>
    <long_name>Atlanta</long_name>
    <short_name>Atlanta</short_name>
    <type>locality</type>
    <type>political</type>
  </address_component>
  - <address_component>
    <long_name>Fulton</long_name>
    <short_name>Fulton</short_name>
    <type>administrative_area_level_2</type>
    <type>political</type>
  </address_component>
```

# Reading XML

As an example we'll get the latitude and longitude corresponding to the city of Atlanta, Georgia

```
library(RCurl)
library(XML)

my.url <- "http://maps.googleapis.com/maps/api/geocode/xml?
address <- Atlanta,GA&sensor=false"
txt <- getURL(my.url)
hold <- xmlTreeParse(txt,useInternalNodes=TRUE)

hold
<?xml version="1.0" encoding="UTF-8"?>
<GeocodeResponse>
<status>OK</status>
<result>
<type>locality</type>

place <- getNodeSet(hold,"//GeocodeResponse/result[1]/geometry/location[1]/*")
as.numeric(sapply(place,xmlValue))
[1] 33.74900 -84.38798
```