Introduction to R

School of Computer Science
University of Windsor

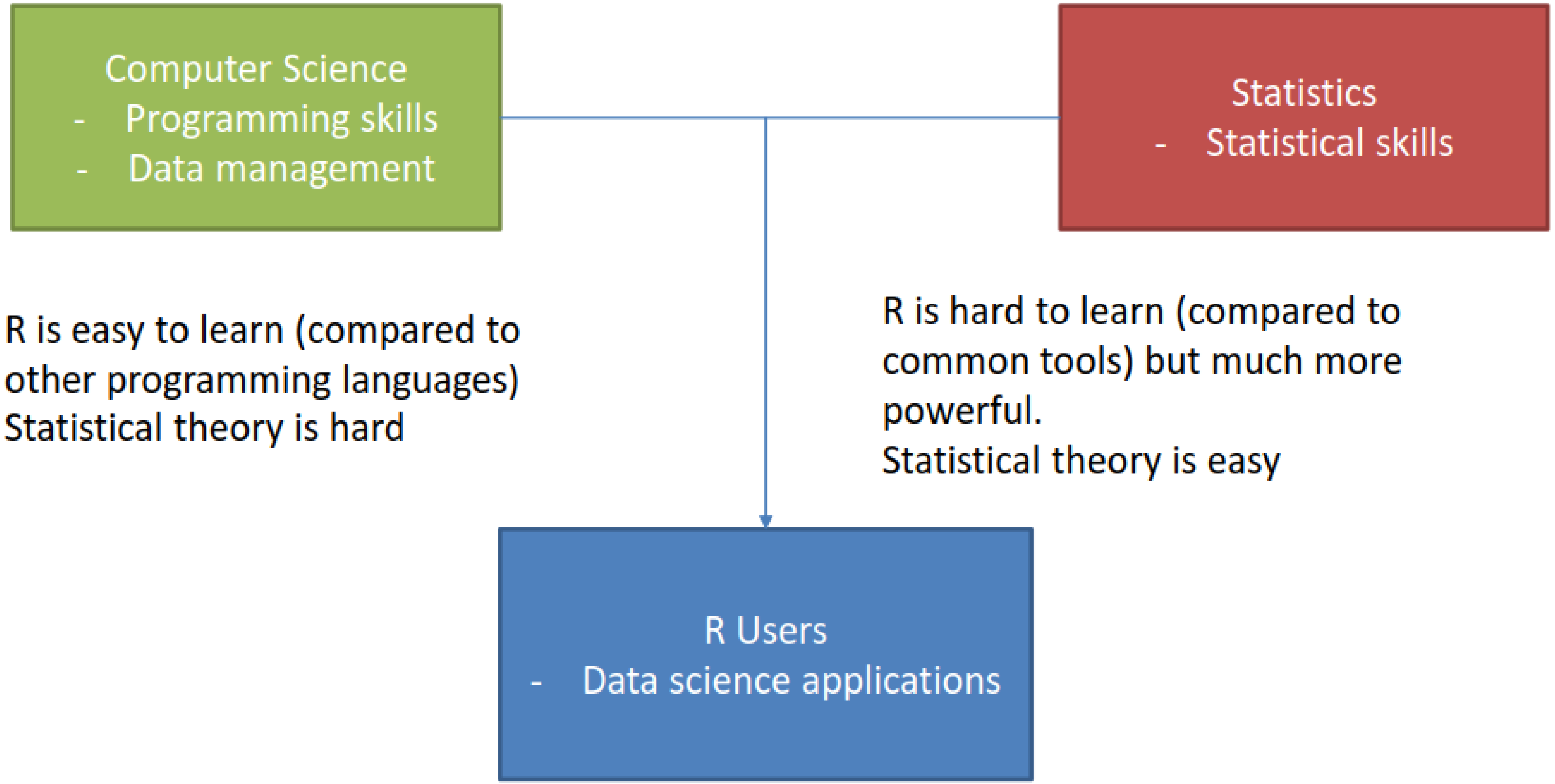
Dr Khan

Lecture Content

- Introduction to R
  - GUI,
  - Data Import & Export
  - Attributes & Data Types,
  - Descriptive Statistics

Introduction to R

- R is a programming language and software framework for statistical analysis and graphics,



Computer Science
- Programming skills
- Data management

Statistics
- Statistical skills

R is easy to learn (compared to other programming languages)
Statistical theory is hard

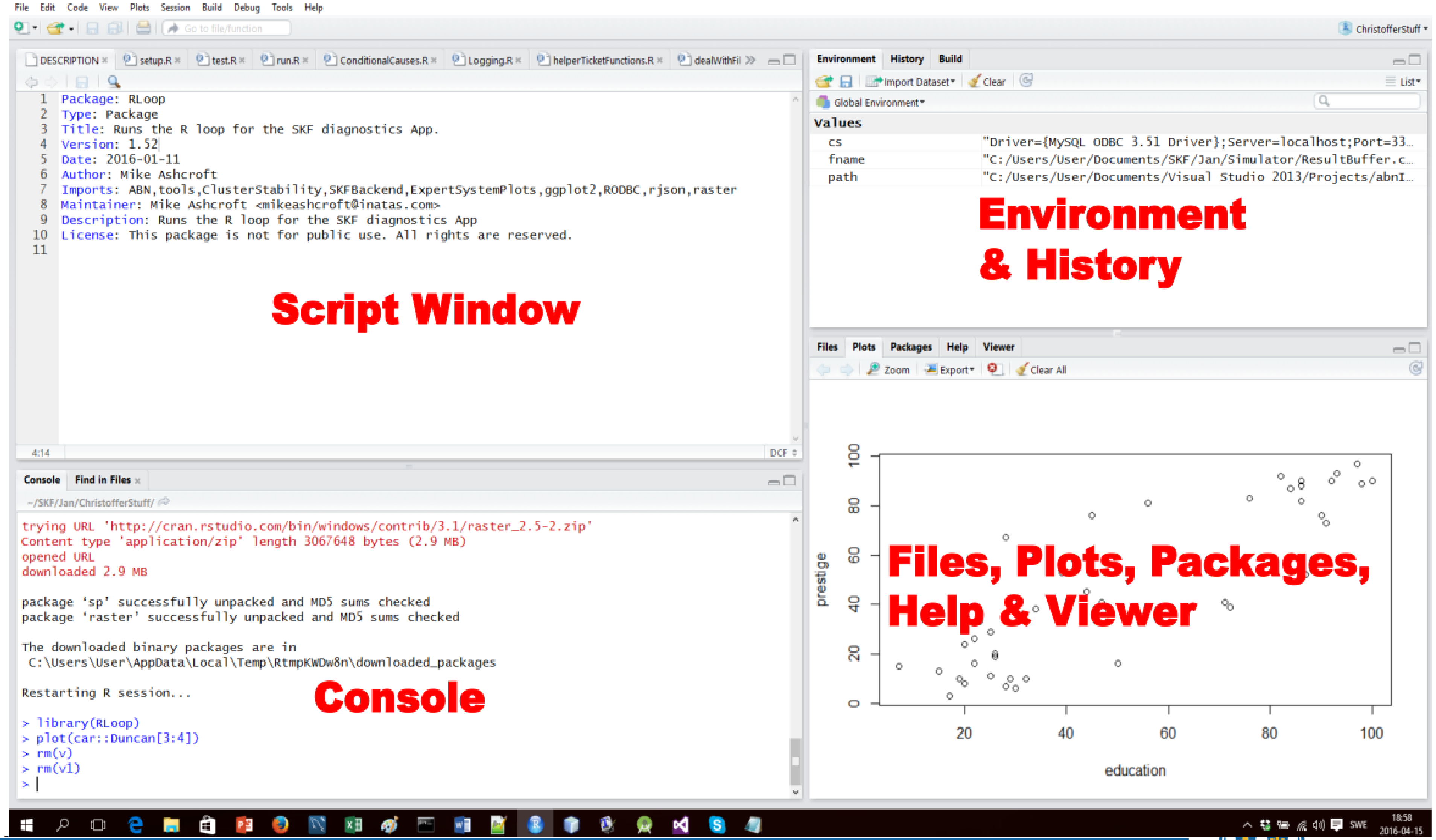
R is hard to learn (compared to common tools) but much more powerful.
Statistical theory is easy

R Users
- Data science applications

Installing R & R Studio

- You should install R & R Studio as follow:
  1. Install R version 3.3.1 from: https://www.r-project.org/ (The R programming Language)
  2. Install Free AGPL Rstudio (GUI to R) https://www.rstudio.com/products/rstudio/download2/
  3. Your computer should access the internet during all R sessions
- The Website contains for R documentation is: https://cran.r-project.org/doc/manuals/r-release/R-intro.html
- https://www.youtube.com/watch?v=cX532N_XLIs

R Studio



```
Package: RLoop
Type: Package
Title: Runs the R loop for the SKF diagnostics App.
Version: 1.52
Date: 2016-01-11
Author: Mike Ashcroft
Imports: ABN,tools,ClusterStability,SKFBackend,ExpertSystemPlots,ggplot2,RODBC,rjson,raster
Maintainer: Mike Ashcroft <mikeashcroft@inatas.com>
Description: Runs the R loop for the SKF diagnostics App
License: This package is not for public use. All rights are reserved.
```

Script Window

Values

```
cs       "Driver={MySQL ODBC 3.51 Driver};Server=localhost;Port=33…
fname    "C:/Users/User/Documents/SKF/Jan/Simulator/ResultBuffer.c…
path     "C:/Users/User/Documents/Visual Studio 2013/Projects/abnI…
```

Environment & History

```
trying URL 'http://cran.rstudio.com/bin/windows/contrib/3.1/raster_2.5-2.zip'
Content type 'application/zip' length 3067648 bytes (2.9 MB)
opened URL
downloaded 2.9 MB

package ‘sp’ successfully unpacked and MD5 sums checked
package ‘raster’ successfully unpacked and MD5 sums checked

The downloaded binary packages are in
 C:\Users\User\AppData\Local\Temp\RtmpKWDw8n\downloaded_packages

Restarting R session...

> library(RLoop)
> plot(car::Duncan[3:4])
> rm(v)
> rm(v1)
> 
```

Console

Files, Plots, Packages, Help & Viewer

IDE

Console

- Where you type commands and receive text output.

Script Window

- Script files are text files used to store scripts of R commands. Multiple can be open at once.
- Source runs an entire file.
- Run runs a highlighted selection.
- Write multiline code, including functions, in a script file and then run them from there.

IDE

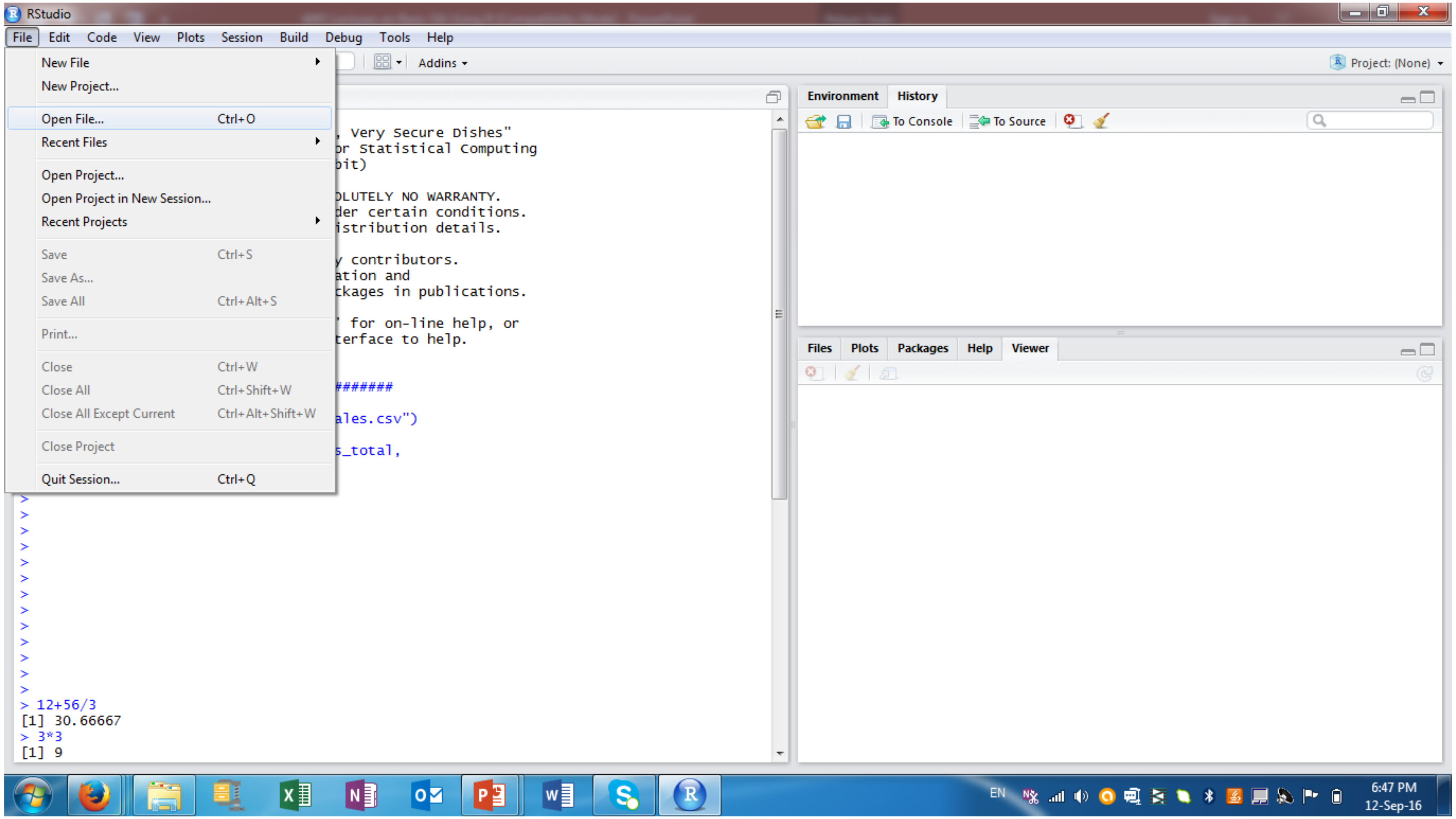
Environment & History

- Environment – Display the objects (including functions) present in the environment.
- Shows you the names of all the data objects (like vectors, matrices, and data frames) that you've defined in your current R session. You can also see information like the number of observations and rows in data objects.
- History – Display commands previously entered into the console.

Files, Plots, Packages, Help & Viewer Window

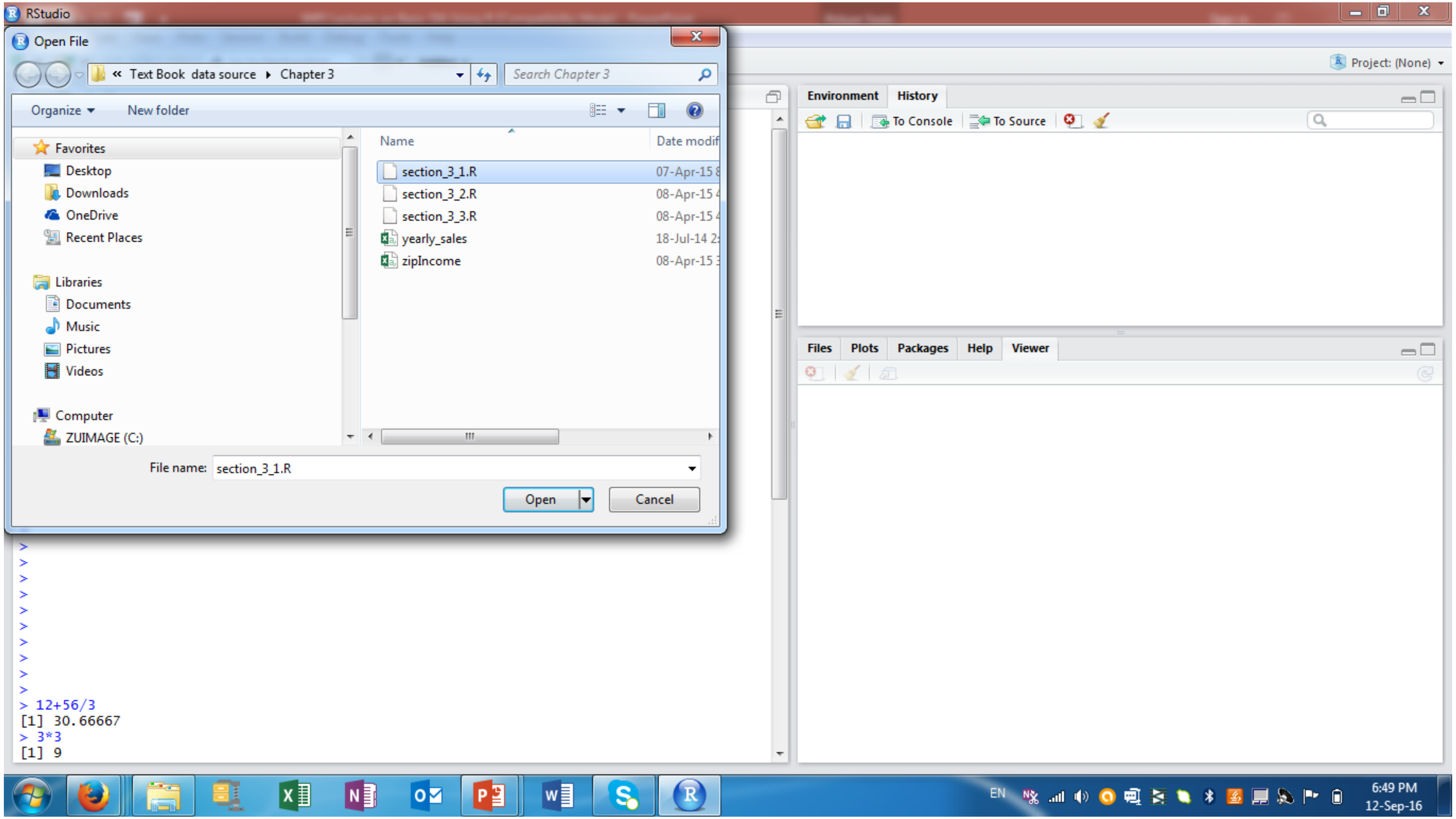
- Files – Navigate your computer's file system. Double clicking a file will open it in the script window.
- Plots – Basic graphic output. Export graphics using the export button.
- Packages – Manage packages.
- Help – Displays help information.
- Viewer – Used to view local web content, web graphics and local web applications. We will not use it.

Open File/Project



```
, very Secure Dishes"
or Statistical Computing
bit)

OLUTELY NO WARRANTY.
der certain conditions.
istribution details.

y contributors.
ation and
ckages in publications.

' for on-line help, or
terface to help.

#######

ales.csv")

s_total,
>
>
>
>
>
>
>
>
>
>
>
>
>
> 12+56/3
[1] 30.66667
> 3*3
[1] 9
```

R code

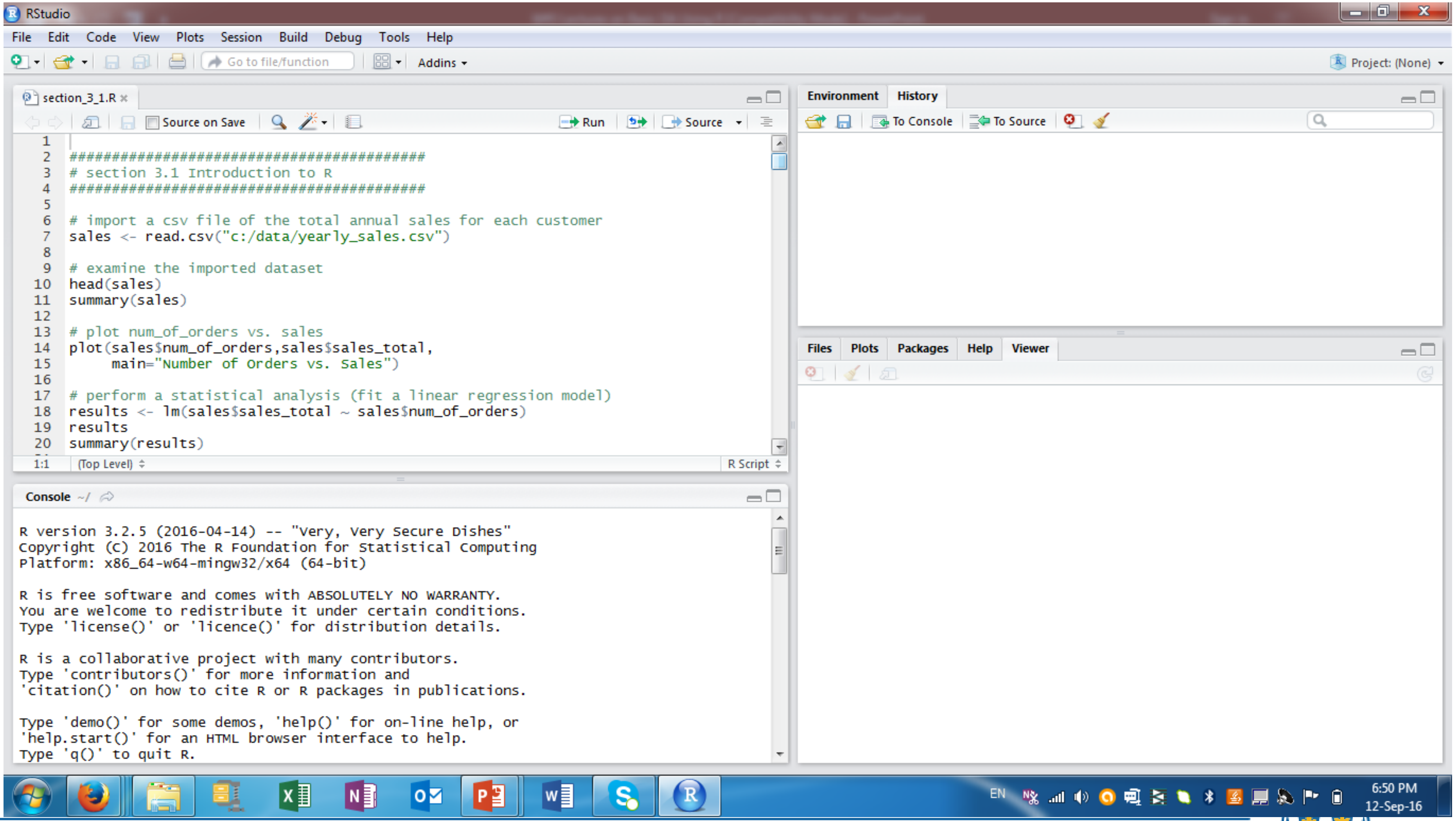


Name	Date modif
section_3_1.R	07-Apr-15 8
section_3_2.R	08-Apr-15 4
section_3_3.R	08-Apr-15 4
yearly_sales	18-Jul-14 2
zipIncome	08-Apr-15 3

File name: section_3_1.R

```
>
>
>
>
>
>
>
>
>
>
> 12+56/3
[1] 30.66667
> 3*3
[1] 9
```

Script Window



```

############################################
# section 3.1 Introduction to R
############################################

# import a csv file of the total annual sales for each customer
sales <- read.csv("c:/data/yearly_sales.csv")

# examine the imported dataset
head(sales)
summary(sales)

# plot num_of_orders vs. sales
plot(sales$num_of_orders,sales$sales_total,
     main="Number of Orders vs. Sales")

# perform a statistical analysis (fit a linear regression model)
results <- lm(sales$sales_total ~ sales$num_of_orders)
results
summary(results)
```

```
R version 3.2.5 (2016-04-14) -- "Very, Very Secure Dishes"
Copyright (C) 2016 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
```

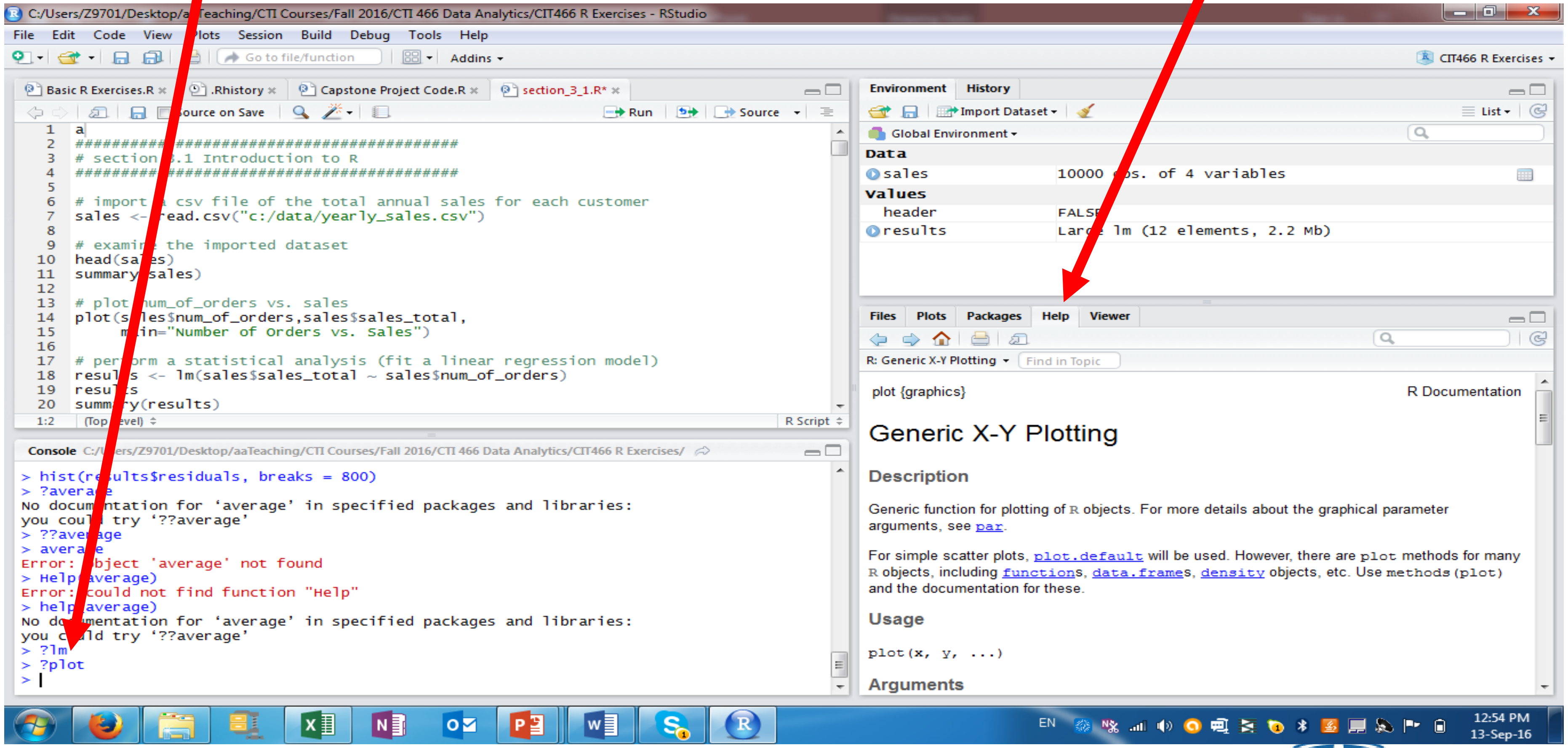
Introduction to R

```
# import a csv file of the total annual sales for each customer
sales <- read.csv("c:/data/yearly_sales.csv")
# examine the imported dataset
head(sales)
summary(sales)
# plot num_of_orders vs. sales
plot(sales$num_of_orders,sales$sales_total, main="Number of Orders vs. Sales")
# Get the working directory
getwd()
# Set the working directory
setwd("D:/Users/Z10596/Desktop/R_files")

# Add a column for the average sales per order
sales$per_order <- sales$sales_total/sales$num_of_orders

# export data as tab delimited without the row names
write.table(sales,"sales_modified.txt", sep="\t", row.names = FALSE)
```

Accessing Help in R Studio

You can either use **help(R function)** or use **? R command/function**

Below **?plot** asks R to explain what Plot means and response in **Help Window**



```
a
##########################################
# section 3.1 Introduction to R
##########################################

# import a csv file of the total annual sales for each customer
sales <- read.csv("c:/data/yearly_sales.csv")

# examine the imported dataset
head(sales)
summary(sales)

# plot num_of_orders vs. sales
plot(sales$num_of_orders,sales$sales_total,
     main="Number of Orders vs. Sales")

# perform a statistical analysis (fit a linear regression model)
results <- lm(sales$sales_total ~ sales$num_of_orders)
results
summary(results)
```

Console C:/Users/Z9701/Desktop/aaTeaching/CTI Courses/Fall 2016/CTI 466 Data Analytics/CIT466 R Exercises/

```
> hist(results$residuals, breaks = 800)
> ?average
No documentation for ‘average’ in specified packages and libraries:
you could try ‘??average’
> ??average
> average
Error: object 'average' not found
> Help(average)
Error: could not find function "Help"
> help(average)
No documentation for ‘average’ in specified packages and libraries:
you could try ‘??average’
> ?lm
> ?plot
> 
```

Data	
sales	10000 obs. of 4 variables
Values	
header	FALSE
results	Large lm (12 elements, 2.2 Mb)

plot {graphics} R Documentation

Generic X-Y Plotting

Description

Generic function for plotting of R objects. For more details about the graphical parameter arguments, see par.

For simple scatter plots, plot.default will be used. However, there are plot methods for many R objects, including functions, data.frames, density objects, etc. Use methods(plot) and the documentation for these.

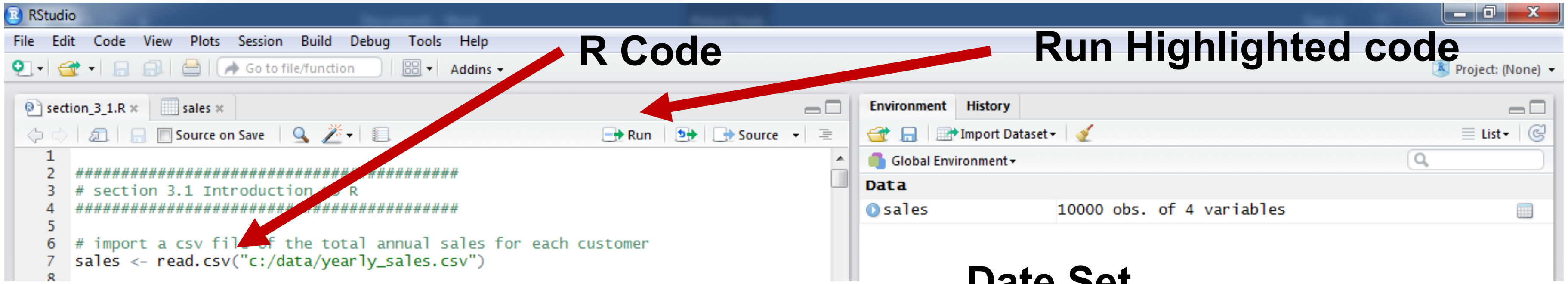
Usage

```
plot(x, y, ...)
```

Arguments

Import CSV Data Set file

sales <- read.csv("c:/data/yearly_sales.csv") means Import *yearly_sales.csv* dataset file and **(<-)** means save it into a file called ***Sales***



R Code

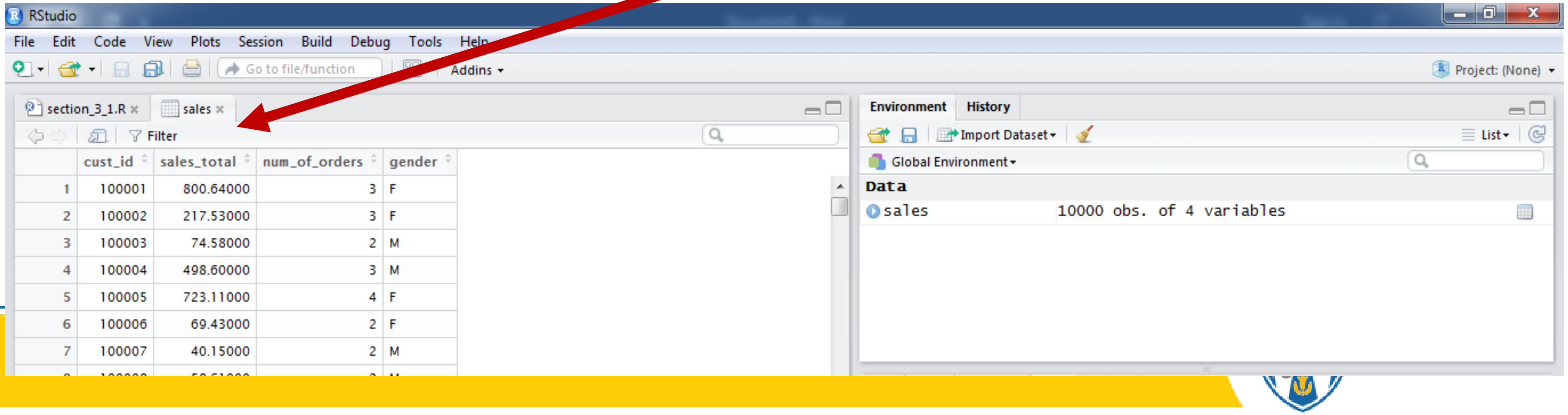
Run Highlighted code

```
##########################################
# section 3.1 Introduction to R
##########################################

# import a csv file of the total annual sales for each customer
sales <- read.csv("c:/data/yearly_sales.csv")
```

```
sales        10000 obs. of 4 variables
```

Date Set

Read-csv imports the *Yearly_sales.csv* file and save it into the file *Sales*

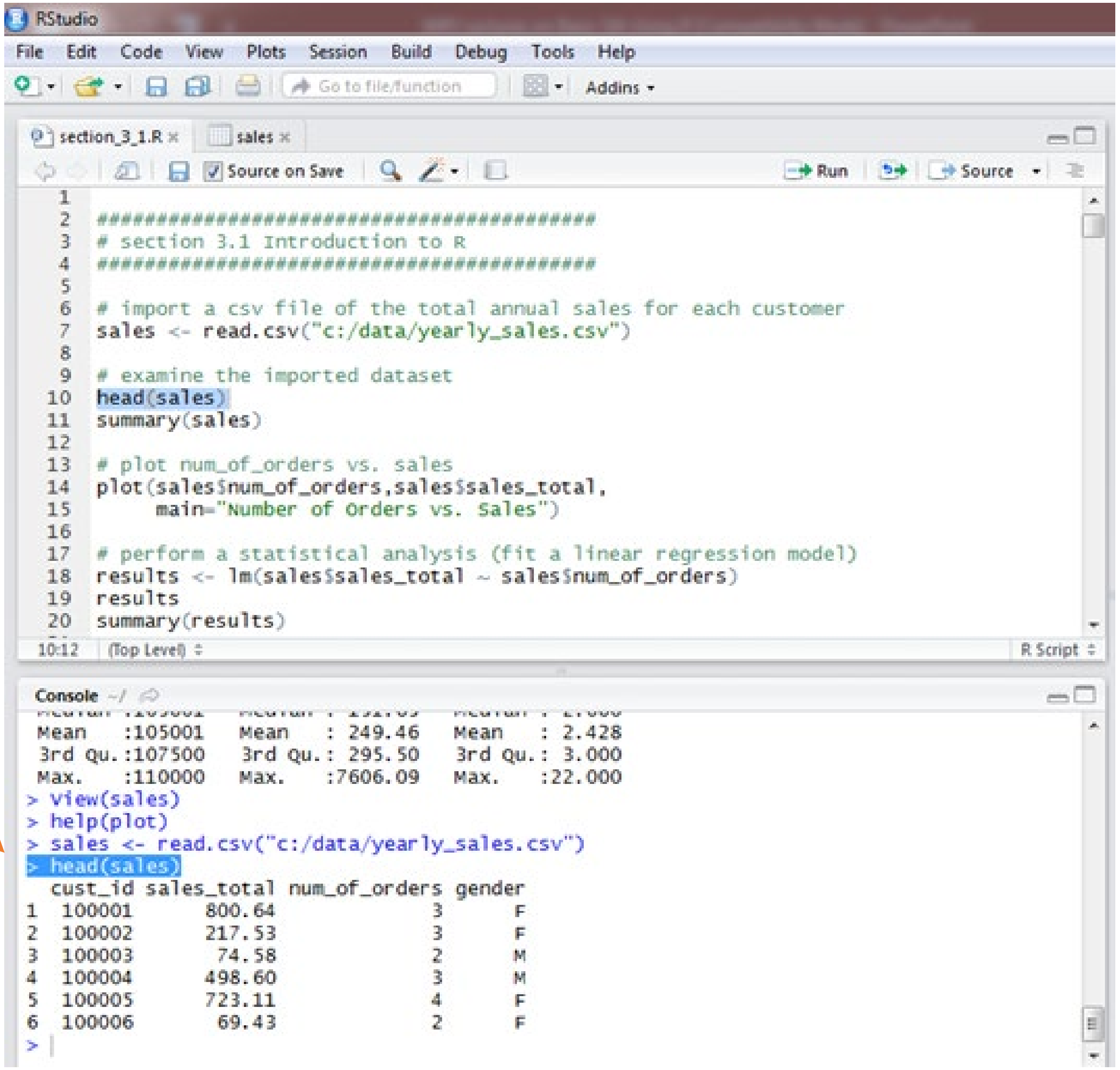


	cust_id	sales_total	num_of_orders	gender
1	100001	800.64000	3	F
2	100002	217.53000	3	F
3	100003	74.58000	2	M
4	100004	498.60000	3	M
5	100005	723.11000	4	F
6	100006	69.43000	2	F
7	100007	40.15000	2	M

```
sales        10000 obs. of 4 variables
```

Head () Function

Head (Sales) *function by default list the six Records of Sales as shown below*



```
############################################
# section 3.1 Introduction to R
############################################

# import a csv file of the total annual sales for each customer
sales <- read.csv("c:/data/yearly_sales.csv")

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plot(sales$num_of_orders,sales$sales_total,
     main="Number of Orders vs. Sales")

# perform a statistical analysis (fit a linear regression model)
results <- lm(sales$sales_total ~ sales$num_of_orders)
results
summary(results)
```
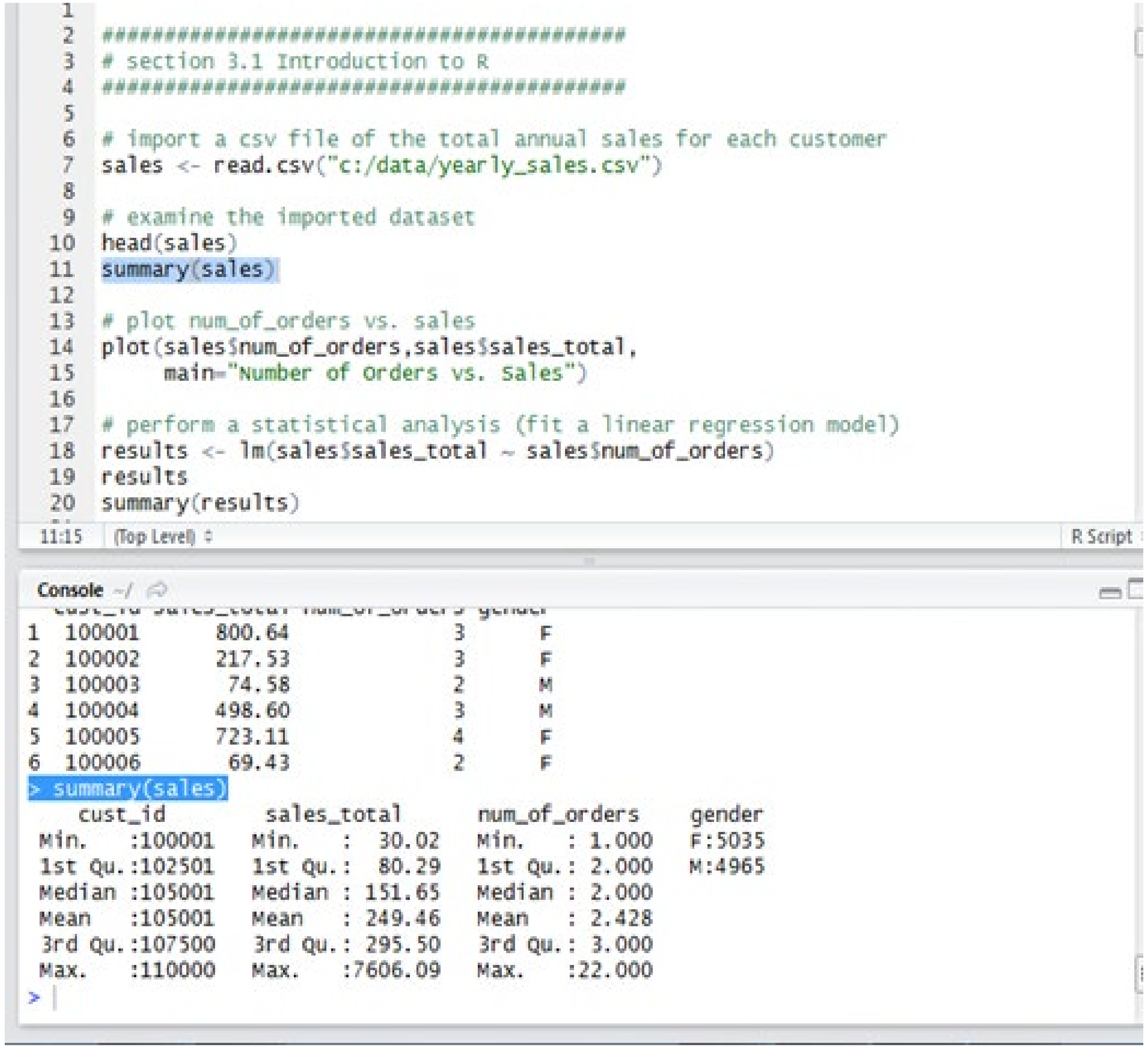

```
 Mean    :105001   Mean    : 249.46   Mean    : 2.428
 3rd Qu.:107500   3rd Qu.: 295.50   3rd Qu.: 3.000
 Max.    :110000   Max.    :7606.09   Max.    :22.000
> View(sales)
> help(plot)
> sales <- read.csv("c:/data/yearly_sales.csv")
> head(sales)
  cust_id sales_total num_of_orders gender
1  100001      800.64             3      F
2  100002      217.53             3      F
3  100003       74.58             2      M
4  100004      498.60             3      M
5  100005      723.11             4      F
6  100006       69.43             2      F
>
```

Summary() Function

- **Summary()** Function provides some descriptive statistics such as Means and Median, etc.



```
##############################################
# section 3.1 Introduction to R
##############################################

# import a csv file of the total annual sales for each customer
sales <- read.csv("c:/data/yearly_sales.csv")

# examine the imported dataset
head(sales)
summary(sales)

# plot num_of_orders vs. sales
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     main="Number of Orders vs. Sales")

# perform a statistical analysis (fit a linear regression model)
results <- lm(sales$sales_total ~ sales$num_of_orders)
results
summary(results)
```
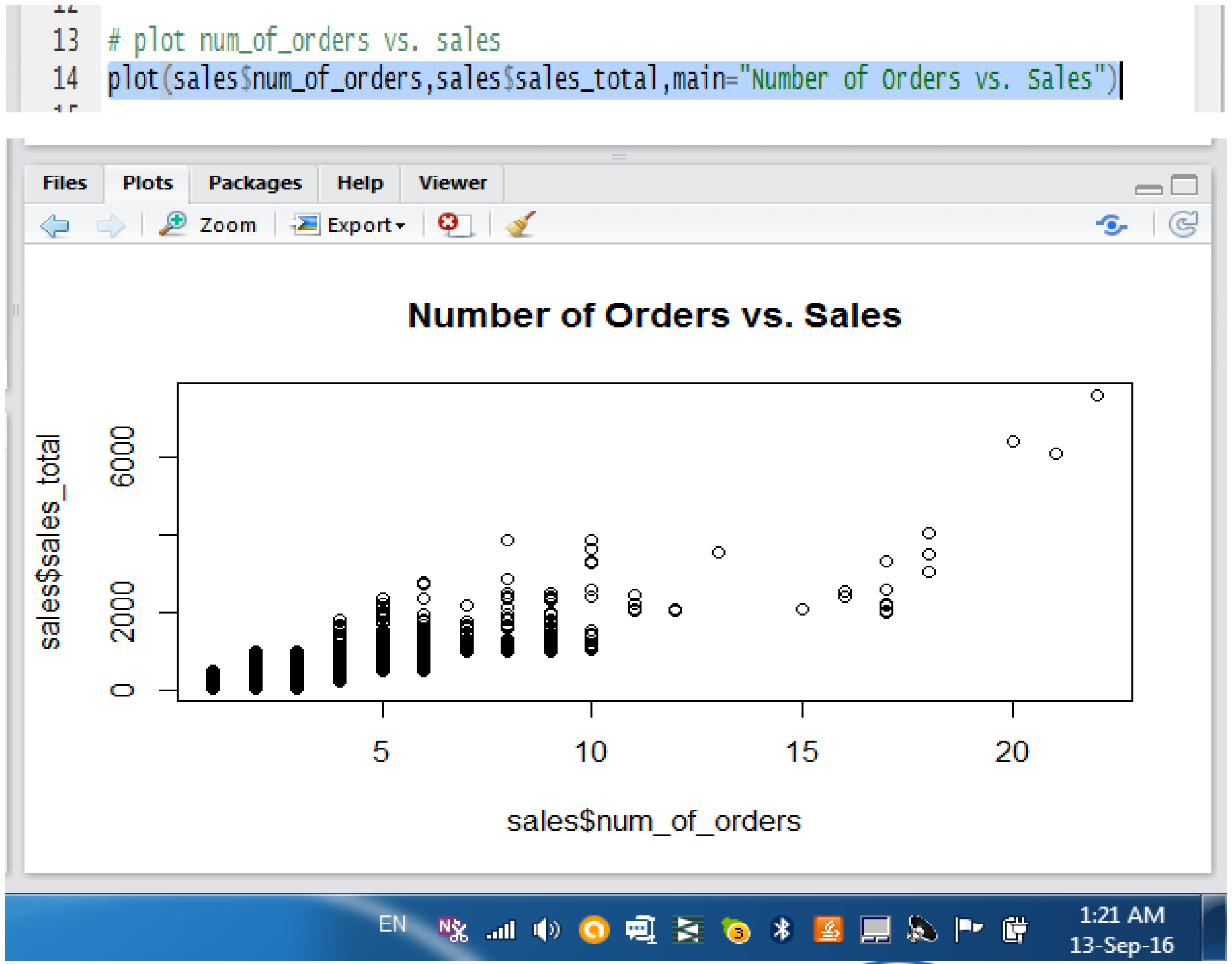

```
  cust_id sales_total num_of_orders gender
1  100001      800.64             3      F
2  100002      217.53             3      F
3  100003       74.58             2      M
4  100004      498.60             3      M
5  100005      723.11             4      F
6  100006       69.43             2      F
> summary(sales)
    cust_id          sales_total      num_of_orders    gender
 Min.   :100001   Min.   :  30.02   Min.   : 1.000   F:5035
 1st Qu.:102501   1st Qu.:  80.29   1st Qu.: 2.000   M:4965
 Median :105001   Median : 151.65   Median : 2.000
 Mean   :105001   Mean   : 249.46   Mean   : 2.428
 3rd Qu.:107500   3rd Qu.: 295.50   3rd Qu.: 3.000
 Max.   :110000   Max.   :7606.09   Max.   :22.000
>
```

Plot () function

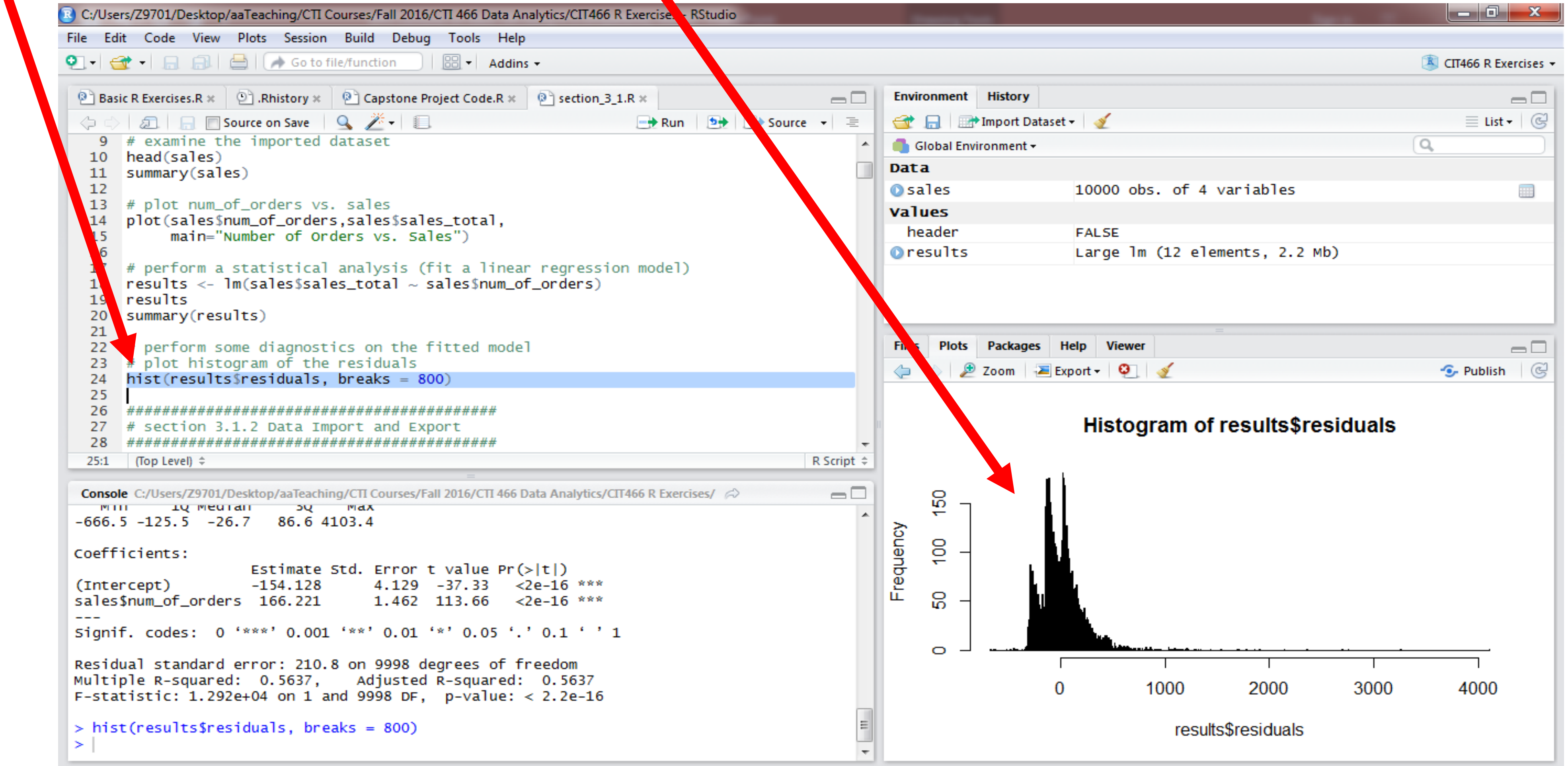
- Plotting a dataset’s content can provide information about the relationships between the various column,
- In this example, Plot() function generate a scatterplot of the number of orders (*Sales$sum_of_orders*) against the annual sales (*Sales$sales_toltal*)
- NB: **$** selects an attribute of a table e.g. *sum_of_orders* attribute of *Sales* Table



```
# plot num_of_orders vs. sales
plot(sales$num_of_orders,sales$sales_total,main="Number of Orders vs. Sales")
```

Performing diagnostic on the model

Hist() function draws histogram of Residual Results to analyze the model. Here we have large residuals



C:/Users/Z9701/Desktop/aaTeaching/CTI Courses/Fall 2016/CTI 466 Data Analytics/CIT466 R Exercises - RStudio
File Edit Code View Plots Session Build Debug Tools Help
Go to file/function
Addins
CIT466 R Exercises
Basic R Exercises.R
.Rhistory
Capstone Project Code.R
section_3_1.R
Source on Save
Run
Source
25:1
(Top Level)
R Script
Console C:/Users/Z9701/Desktop/aaTeaching/CTI Courses/Fall 2016/CTI 466 Data Analytics/CIT466 R Exercises/
Environment
History
Import Dataset
List
Global Environment
Files
Plots
Packages
Help
Viewer
Zoom
Export
Publish

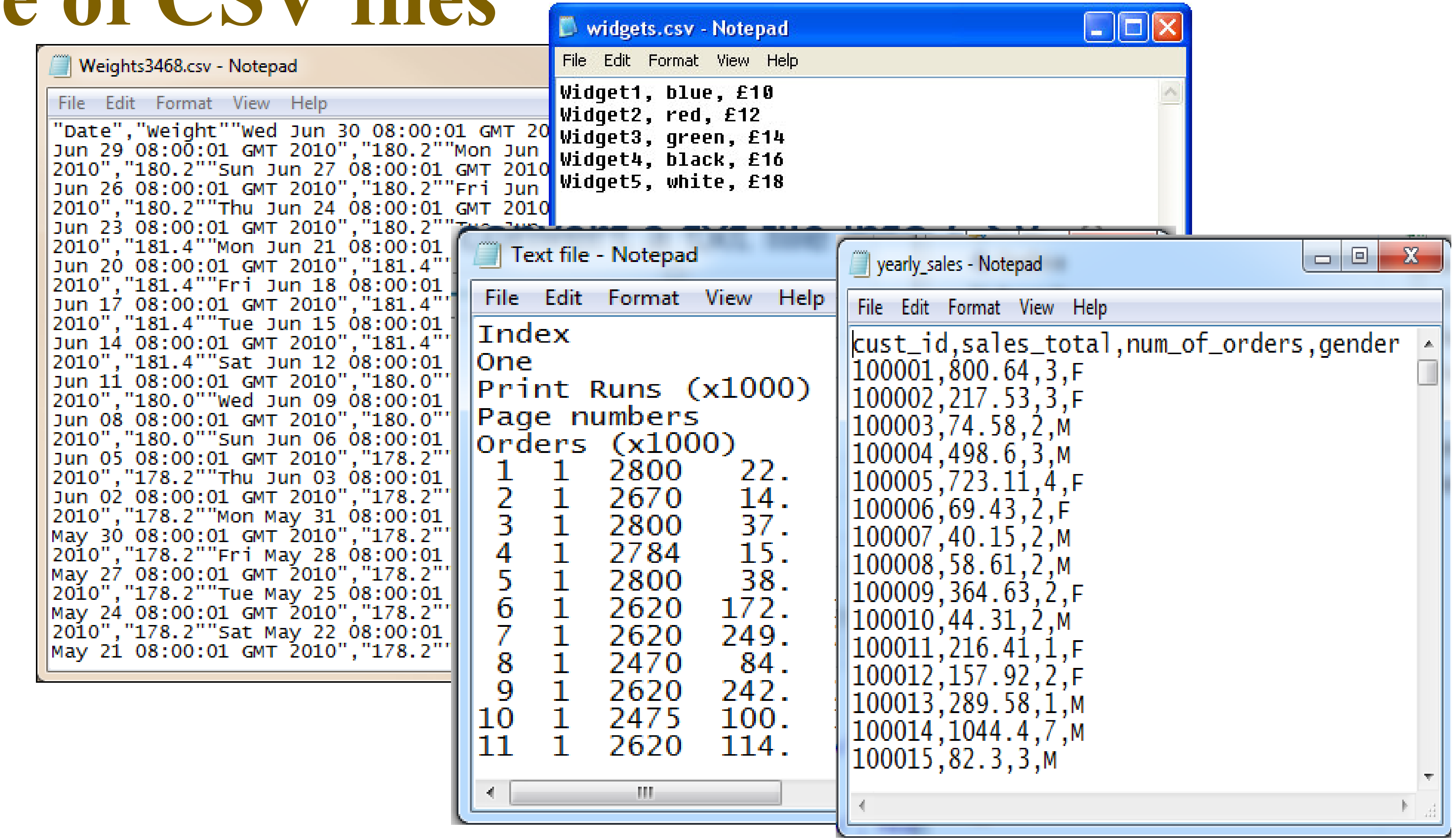
```
# examine the imported dataset
head(sales)
summary(sales)

# plot num_of_orders vs. sales
plot(sales$num_of_orders,sales$sales_total,
     main="Number of Orders vs. Sales")

# perform a statistical analysis (fit a linear regression model)
results <- lm(sales$sales_total ~ sales$num_of_orders)
results
summary(results)

# perform some diagnostics on the fitted model
# plot histogram of the residuals
hist(results$residuals, breaks = 800)

##########################################
# section 3.1.2 Data Import and Export
##########################################
```

```
    Min      1Q  Median      3Q     Max
 -666.5 -125.5   -26.7    86.6  4103.4

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)         -154.128      4.129  -37.33   <2e-16 ***
sales$num_of_orders  166.221      1.462  113.66   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 210.8 on 9998 degrees of freedom
Multiple R-squared:  0.5637,	Adjusted R-squared:  0.5637
F-statistic: 1.292e+04 on 1 and 9998 DF,  p-value: < 2.2e-16

> hist(results$residuals, breaks = 800)
>
```

```
Data
sales       10000 obs. of 4 variables
Values
header      FALSE
results     Large lm (12 elements, 2.2 Mb)
```

Data Import and Export

Example of CSV files


Weights3468.csv - Notepad
File Edit Format View Help
widgets.csv - Notepad
File Edit Format View Help
Text file - Notepad
File Edit Format View Help
yearly_sales - Notepad
File Edit Format View Help

```
"Date","Weight""Wed Jun 30 08:00:01 GMT 20
Jun 29 08:00:01 GMT 2010","180.2""Mon Jun
2010","180.2""Sun Jun 27 08:00:01 GMT 2010
Jun 26 08:00:01 GMT 2010","180.2""Fri Jun
2010","180.2""Thu Jun 24 08:00:01 GMT 2010
Jun 23 08:00:01 GMT 2010","180.2""
2010","181.4""Mon Jun 21 08:00:01
Jun 20 08:00:01 GMT 2010","181.4""
2010","181.4""Fri Jun 18 08:00:01
Jun 17 08:00:01 GMT 2010","181.4""
2010","181.4""Tue Jun 15 08:00:01
Jun 14 08:00:01 GMT 2010","181.4""
2010","181.4""Sat Jun 12 08:00:01
Jun 11 08:00:01 GMT 2010","180.0""
2010","180.0""Wed Jun 09 08:00:01
Jun 08 08:00:01 GMT 2010","180.0""
2010","180.0""Sun Jun 06 08:00:01
Jun 05 08:00:01 GMT 2010","178.2""
2010","178.2""Thu Jun 03 08:00:01
Jun 02 08:00:01 GMT 2010","178.2""
2010","178.2""Mon May 31 08:00:01
May 30 08:00:01 GMT 2010","178.2""
2010","178.2""Fri May 28 08:00:01
May 27 08:00:01 GMT 2010","178.2""
2010","178.2""Tue May 25 08:00:01
May 24 08:00:01 GMT 2010","178.2""
2010","178.2""Sat May 22 08:00:01
May 21 08:00:01 GMT 2010","178.2""
```

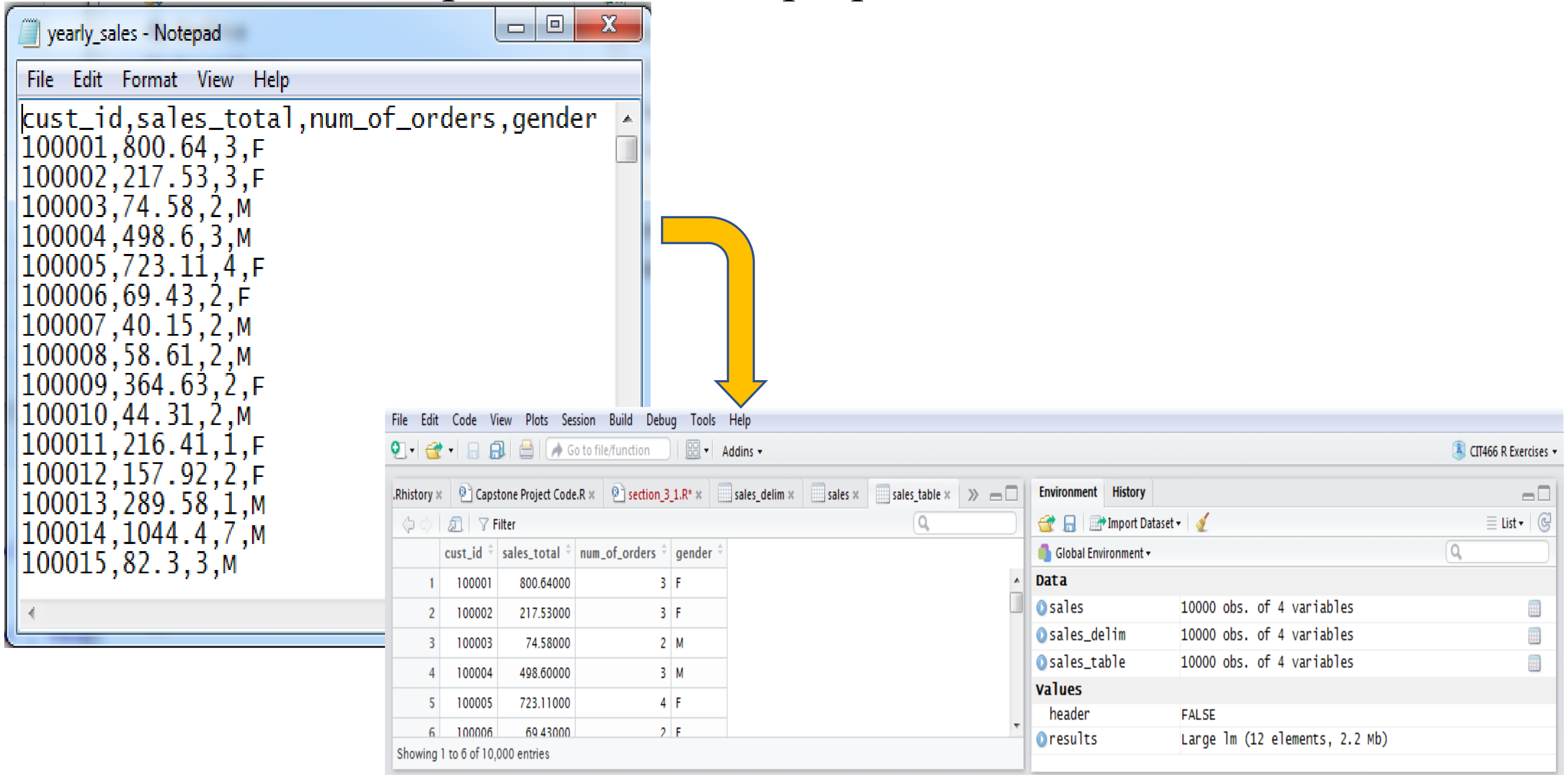
```
Widget1, blue, £10
Widget2, red, £12
Widget3, green, £14
Widget4, black, £16
Widget5, white, £18
```

```
Index
One
Print Runs (x1000)
Page numbers
Orders (x1000)
 1   1   2800    22.
 2   1   2670    14.
 3   1   2800    37.
 4   1   2784    15.
 5   1   2800    38.
 6   1   2620   172.
 7   1   2620   249.
 8   1   2470    84.
 9   1   2620   242.
10   1   2475   100.
11   1   2620   114.
```

```
cust_id,sales_total,num_of_orders,gender
100001,800.64,3,F
100002,217.53,3,F
100003,74.58,2,M
100004,498.6,3,M
100005,723.11,4,F
100006,69.43,2,F
100007,40.15,2,M
100008,58.61,2,M
100009,364.63,2,F
100010,44.31,2,M
100011,216.41,1,F
100012,157.92,2,F
100013,289.58,1,M
100014,1044.4,7,M
100015,82.3,3,M
```

Usage of read.csv function

read.csv() converts Comma Separated Values (CSV) file into formatted Column & Row table and upload into R aeropospace as shown below



```
cust_id,sales_total,num_of_orders,gender
100001,800.64,3,F
100002,217.53,3,F
100003,74.58,2,M
100004,498.6,3,M
100005,723.11,4,F
100006,69.43,2,F
100007,40.15,2,M
100008,58.61,2,M
100009,364.63,2,F
100010,44.31,2,M
100011,216.41,1,F
100012,157.92,2,F
100013,289.58,1,M
100014,1044.4,7,M
100015,82.3,3,M
```

	cust_id	sales_total	num_of_orders	gender
1	100001	800.64000	3	F
2	100002	217.53000	3	F
3	100003	74.58000	2	M
4	100004	498.60000	3	M
5	100005	723.11000	4	F
6	100006	69.43000	2	F

Showing 1 to 6 of 10,000 entries

```
Data
sales         10000 obs. of 4 variables
sales_delim   10000 obs. of 4 variables
sales_table   10000 obs. of 4 variables
Values
header        FALSE
results       Large lm (12 elements, 2.2 Mb)
```

University of Windsor

Data Import and Export

- In the annual Sales example the dataset was imported using *read.csv* as follow: **sales <- read.csv("c:/data/yearly_sales.csv")**
- To simplify multiple files with long path names, the ***setwd()*** function can be used to set the working directory for subsequent import and export as follows:

```
setwd("c:/data/")
sales <- read.csv("yearly_sales.csv")
```

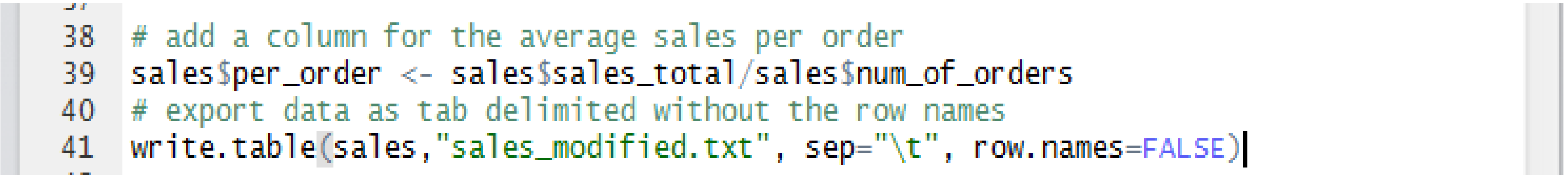
- Other import function include ***read.table()*** and ***read.delim()*** *function are also used* to import CSV files like *yearly_Sales.csv* or other common files such as TXT.
- There are also two additional R functions: ***read.csv2()*** and **read.delim2()**

Main Differences between R Import Functions

Function	Headers	Separators	Decimal Points
read.table()	FALSE	“ ”	“.”
read.csv()	TRUE	“,”	“.”
read.csv2()	TRUE	“;”	“,”
read.delim()	TRUE	“\t”	“.”
read.delim2	TRUE	“\t”	“.”

R Export Functions

- The analogue R functions are ***write.table(), write.csv()*** and ***write.csv2()*** *enable exporting of R data sets to an external file*
- *Example below show making change to Sales file and exporting it*

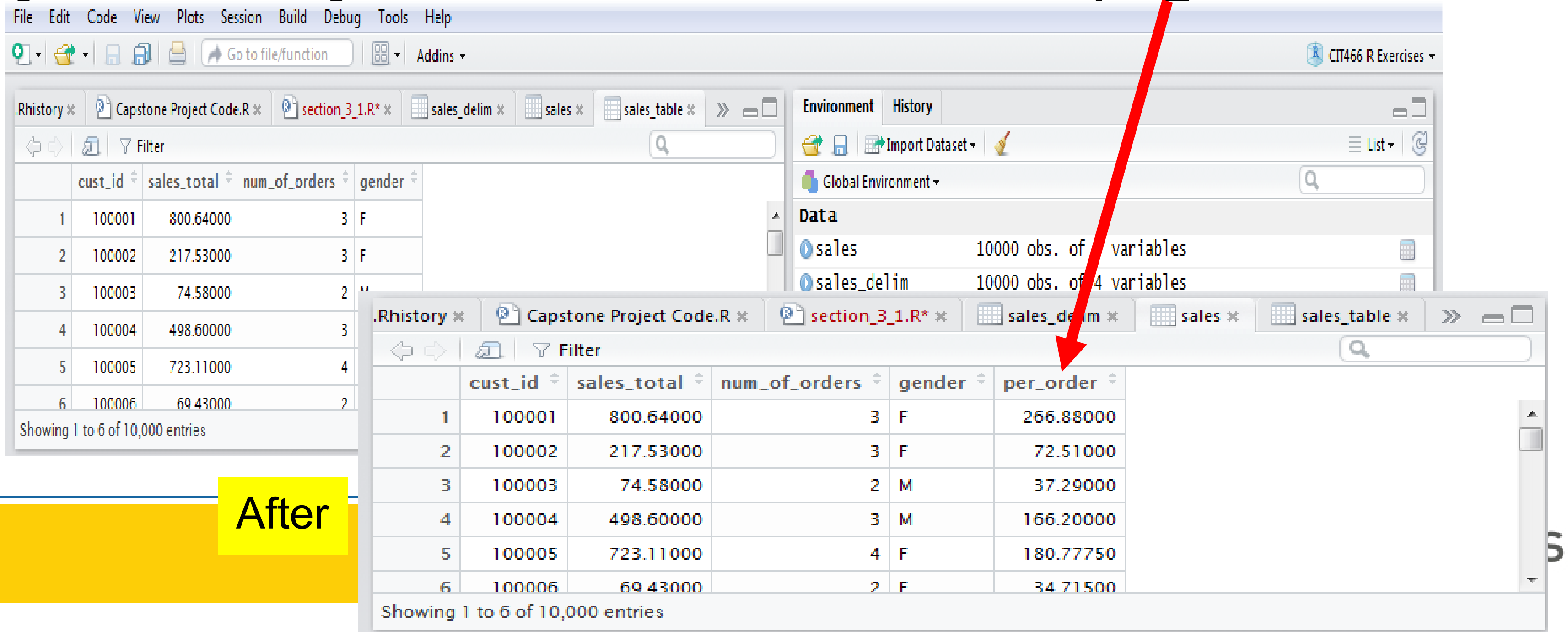


```
# add a column for the average sales per order
sales$per_order <- sales$sales_total/sales$num_of_orders
# export data as tab delimited without the row names
write.table(sales,"sales_modified.txt", sep="\t", row.names=FALSE)
```

This will give the following Sales table with an additional column ***per_order:***

Before

After



Data

sales 10000 obs. of variables

sales_delim 10000 obs. of 4 variables

	cust_id	sales_total	num_of_orders	gender
1	100001	800.64000	3	F
2	100002	217.53000	3	F
3	100003	74.58000	2	
4	100004	498.60000	3	
5	100005	723.11000	4	
6	100006	69.43000	2	

Showing 1 to 6 of 10,000 entries

	cust_id	sales_total	num_of_orders	gender	per_order
1	100001	800.64000	3	F	266.88000
2	100002	217.53000	3	F	72.51000
3	100003	74.58000	2	M	37.29000
4	100004	498.60000	3	M	166.20000
5	100005	723.11000	4	F	180.77750
6	100006	69.43000	2	F	34.71500

Showing 1 to 6 of 10,000 entries

Any Questions