Part 2: Exploratory Data Analysis

(a) ggplot2

R

- R’s mission is to enable the best and most thorough exploration of data possible (Chambers 2008).
- It is a dialect of the S language, developed at Bell Laboratories
- ACM noted that S “will forever alter the way people analyze, visualize, and manipulate data”

```r
v <- 1:10
v
```

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

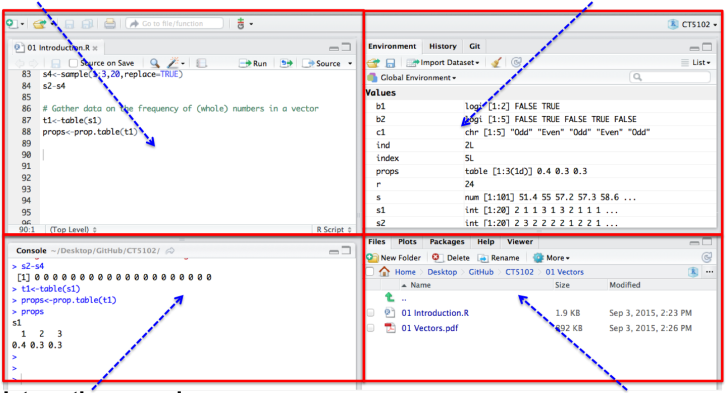
```r
summary(v)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##    1.00    3.25    5.50    5.50    7.75   10.00 
```

R Studio IDE (also available through https://rstudio.cloud)

R Code

Environment/State



```
s4<-sample(1:3,20,replace=TRUE)
s2-s4

# Gather data on the frequency of (whole) numbers in a vector
t1<-table(s1)
props<-prop.table(t1)
```

Values

b1	logi [1:2] FALSE TRUE
b2	logi [1:5] FALSE TRUE FALSE TRUE FALSE
c1	chr [1:5] "Odd" "Even" "Odd" "Even" "Odd"
ind	2L
index	5L
props	table [1:3(1d)] 0.4 0.3 0.3
r	24
s	num [1:101] 51.4 55 57.2 57.3 58.6 ...
s1	int [1:20] 2 1 1 3 1 3 2 1 1 1 ...
s2	int [1:20] 2 3 2 2 2 2 1 2 2 1 ...

```
> s2-s4
 [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
> t1<-table(s1)
> props<-prop.table(t1)
> props
s1
  1   2   3
0.4 0.3 0.3
>
>
>
```

Name	Size	Modified
..		
01 Introduction.R	1.9 KB	Sep 3, 2015, 2:23 PM
01 Vectors.pdf	892 KB	Sep 3, 2015, 2:26 PM

Interactive console

File System

Figure 1: R Studio IDE

R Data Types

	Homogenous	Heterogenous
1d	**Atomic Vector**	List
2d	Matrix	Data Frame/Tibble
nd	Array	

- The basic data structure in R is the Vector
- Vectors come in two flavours:
  - Atomic vectors
  - Lists
- With atomic vectors, all elements have the same type: logical, integer, double (numeric) or character
- **typeof() str()** functions useful

Atomic Vectors - Examples

```r
dbl_var <- c(2.9, 3.1, 4.8)
typeof(dbl_var)
```

```
## [1] "double"
```

```r
int_var <- c(0L, 1L, 2L)
typeof(int_var)
```

```
## [1] "integer"
```

```r
log_var <- c(TRUE, TRUE, FALSE, T, F)
typeof(log_var)
```

```
## [1] "logical"
```

```r
str_var <- c("Dublin", "London", "Edinburgh")
typeof(str_var)
```

```
## [1] "character"
```

str() function useful

```r
str(dbl_var)
```

```
##  num [1:3] 2.9 3.1 4.8
```

```r
str(int_var)
```

```
##  int [1:3] 0 1 2
```

```r
str(log_var)
```

```
##  logi [1:5] TRUE TRUE FALSE TRUE FALSE
```

```r
str(str_var)
```

```
##  chr [1:3] "Dublin" "London" "Edinburgh"
```

Creating Sequences : and seq() function

```r
v1 <- 1:10
v1
```

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

```r
v2 <- 10:20
v2
```

```
##  [1] 10 11 12 13 14 15 16 17 18 19 20
```

```r
v3 <- seq(20, 30, by=1)
v3
```

```
##  [1] 20 21 22 23 24 25 26 27 28 29 30
```

Creating Vectors of fixed size (in advance)

```r
v1 <- vector(mode="numeric", length=20)
v1
```

```
##  [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```r
v2 <- vector(mode="logical", length=5)
v2
```

```
## [1] FALSE FALSE FALSE FALSE FALSE
```

Coercion of atomic vectors

- All elements of an atomic vector MUST be of the same type
- When different type are combined, they will be coerced into the most flexible types

	logical	**integer**	**numeric**	**character**
logical	logical	integer	numeric	character
integer	integer	integer	numeric	character
numeric	numeric	numeric	numeric	character
character	character	character	character	character

Coercion Examples

```r
v1 <- c(10, 20, TRUE)
v1
```

```
## [1] 10 20  1
```

```r
typeof(v1)
```

```
## [1] "double"
```

```r
v2 <- c(10, 20, "True")
v2
```

```
## [1] "10"   "20"   "True"
```

```r
typeof(v2)
```

```
## [1] "character"
```

Challenge 1.1

Determine the tpes for each of the following vectors

```
v1 <- c(1L, T, FALSE)
v2 <- c(1L, T, FALSE, 2)
v3 <- c(T, FALSE, 2, "FALSE")
v4 <- c(2L, "FALSE")
v5 <- c(0L, 1L, 2.11)
```

Subsetting Atomic Vectors

- Subsetting data is a key activity in data science
- R's subsetting operators are powerful and fast
- For atomic vectors, the operator [is used
- In R, the index for a vector starts at 1

```
x <- c( 2.1, 4.2, 3.3, 5.4)
x
```

```
## [1] 2.1 4.2 3.3 5.4
```

```
x[1]
```

```
## [1] 2.1
```

```
x[c(1,4)]
```

```
## [1] 2.1 5.4
```

Subsetting Vectors - (1) Positive Integer

Positive integers return elements at the specified position

```
x <- 1:10
x
```

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

```
x[5]
```

```
## [1] 5
```

```
x[8:10]
```

```
## [1]  8  9 10
```

Subsetting Vectors - (2) Negative Integer

Negative integers omit elements at specified positions

```
x <- 1:10
x
```

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

```
x[-5]
```

```
## [1]  1  2  3  4  6  7  8  9 10
```

```
x[-(8:10)]
```

```
## [1] 1 2 3 4 5 6 7
```

```
x[-(2:10)]
```

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

Subsetting Vectors - (3) Logical Vectors

- Select elements where the corresponding logical value is TRUE.
- This approach supports recycling

```
x <- 1:5
x
```

```
## [1] 1 2 3 4 5
```

```
x[c(F,T,T,T,T)]
```

```
## [1] 2 3 4 5
```

```
x[c(F,T)]
```

```
## [1] 2 4
```

Logical Vectors - Can be formed with logical expressions

```
x <- 1:5
x
```

```
## [1] 1 2 3 4 5
```

```
lx <- x < 2
lx
```

```
## [1]  TRUE FALSE FALSE FALSE FALSE
```

```
x[lx]
```

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

```
x[x>2]
```

```
## [1] 3 4 5
```

Subsetting Vectors - (4) Using character vectors

Return elements with matching names

```
x <- 1:5
names(x) <- c("a","b","c","d","e")
x
```

```
## a b c d e
## 1 2 3 4 5
```

```
x["a"]
```

```
## a
## 1
```

```
x[c("a","e")]
```

```
## a e
## 1 5
```

Challenge 1.2

- Create an R vector of squares of 1 to 10
- Find the minimum
- Find the maximum
- Find the average
- Subset all those values greater than the average

Vectorisation

- A powerful feature of R is that it supports vectorisation
- Functions can operate on every element of a vector, and return the results of each individual operation in a new vector.

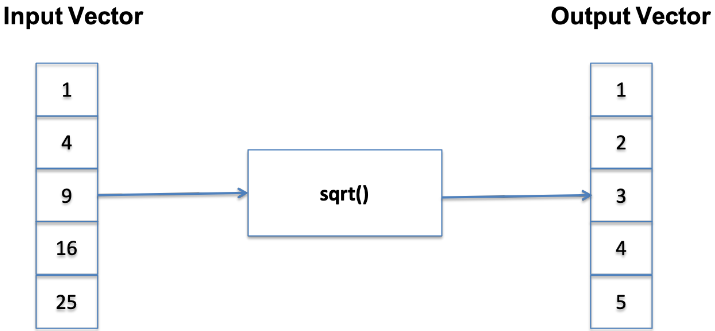
```
x <- c(1,4,9,16,25)
x
```

```
## [1]  1  4  9 16 25
```

```
y <- sqrt(x)
y
```

```
## [1] 1 2 3 4 5
```

Vectorisation



Input Vector

1
4
9
16
25

sqrt()

Output Vector

1
2
3
4
5

Figure 2: Vectorisation in R

Vectorised if/else

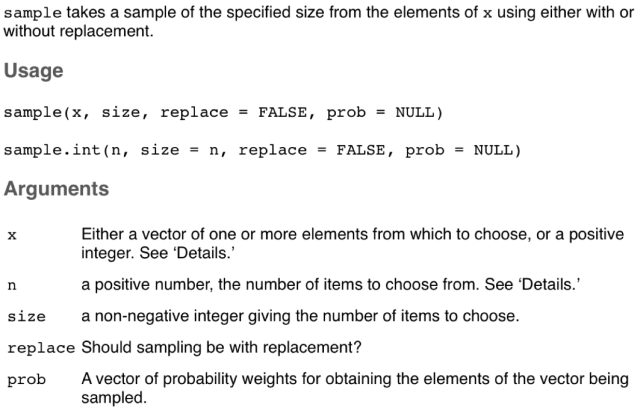
Vectors can also be processed using the vectorized ifelse(b,u,v) function, which accepts a boolean vector b and allocates the element-wise results to be either u or v.

```
v1 <- 1:5

ans <- ifelse(v1 %% 2 == 0, "Even", "Odd")
ans
```

```
## [1] "Odd"  "Even" "Odd"  "Even" "Odd"
```

Sample Function



`sample` takes a sample of the specified size from the elements of `x` using either with or without replacement.

Usage

```
sample(x, size, replace = FALSE, prob = NULL)

sample.int(n, size = n, replace = FALSE, prob = NULL)
```

Arguments

`x` Either a vector of one or more elements from which to choose, or a positive integer. See ‘Details.’

`n` a positive number, the number of items to choose from. See ‘Details.’

`size` a non-negative integer giving the number of items to choose.

`replace` Should sampling be with replacement?

`prob` A vector of probability weights for obtaining the elements of the vector being sampled.

Figure 3: Sample function in Base R

```
s <- sample(c("Y","N"),10,prob=c(.2,.8),repl=T)
s
```

```
##  [1] "N" "N" "Y" "Y" "Y" "N" "N" "Y" "Y" "N"
```

NA Symbol in R (Not available)

- In a project of any size, data is likely to be incomplete due to
  - Missed survey questions
  - Faulty equipment
  - Improperly coded data
- In R, missing data is represented by the symbol NA

```
x <- 1:5
x[3] <- NA
x
```

```
## [1]  1  2 NA  4  5
```

```
sum(x)
```

```
## [1] NA
```

```
sum(x, na.rm=TRUE)
```

```
## [1] 12
```

Testing for NA? Need **is.na()** function

- The function is.na() indicates which elements are missing
- Returns a logical vector, the same size as the input vector

```
x
```

```
## [1]  1  2 NA  4  5
```

```
is.na(x)
```

```
## [1] FALSE FALSE  TRUE FALSE FALSE
```

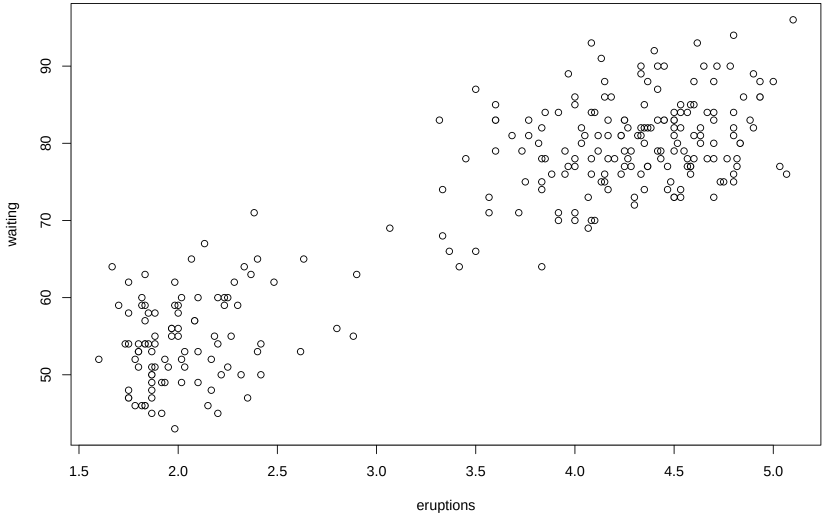
```
which(is.na(x)) # get the location of NA
```

```
## [1] 3
```

```
x[!is.na(x)] # Exclude all NAs from result
```

```
## [1] 1 2 4 5
```

Test Slide with Plot


waiting
eruptions