Introduction to data analysis in R

Basic statistics in R

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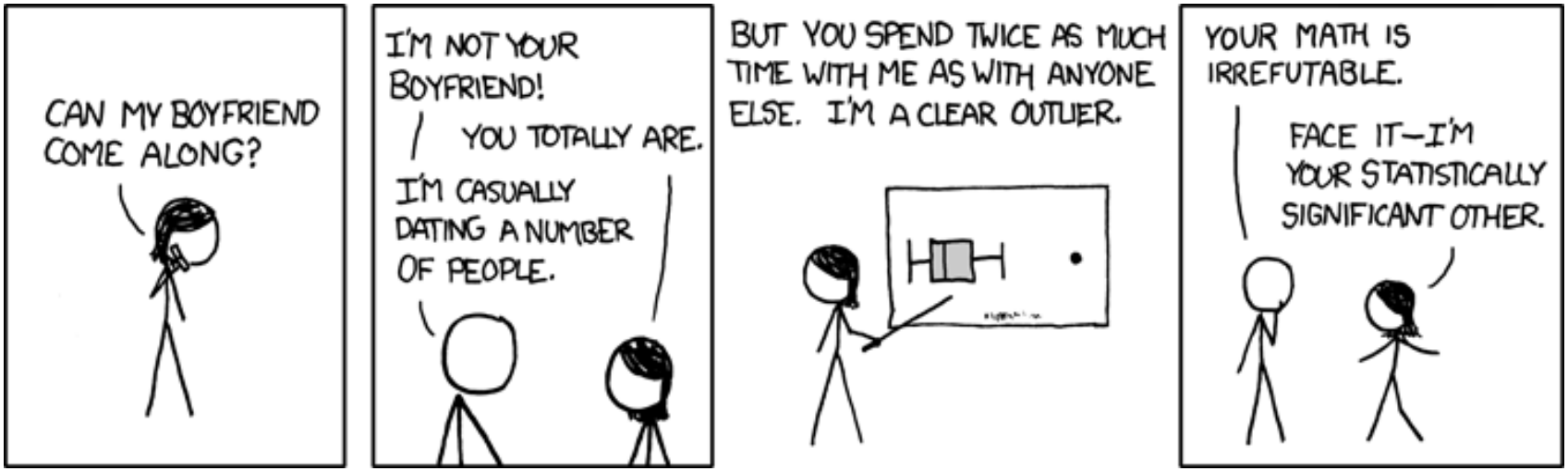


https://xkcd.com/539/

What is statistics?

Statistics is the practice concerned with collecting and analyzing data.

We will only be looking at a few basic ideas in statistics that are common in every data analysis. Namely

- Summarizing data
- Applying statistical tests
- Plotting data

Creating a toy dataset

The code below creates three variables and collects them in a data.frame. You can think of this object (d) as encoding an experiment. In the following sense

- V1: the sample ID
- V2: measurements
- V3: a grouping variable

```
# create a data.frame
set.seed(1234)
d <- data.frame(
    V1 = 1:30,
    V2 = rnorm(30, mean = 1, sd = 1),
    V3 = rep(c('A', 'B'), each = 15)
)
```

Inspecting the dataset

The function summary displays information about each column in the data.frame depending on its type.

```
# summarize the columns
summary(d)
```

```
##        V1                 V2          V3
##  Min.   : 1.00   Min.   :-1.3457   A:15
##  1st Qu.: 8.25   1st Qu.: 0.1232   B:15
##  Median :15.50   Median : 0.4992
##  Mean   :15.50   Mean   : 0.7036
##  3rd Qu.:22.75   3rd Qu.: 1.2416
##  Max.   :30.00   Max.   : 3.4158
```

God spiked the 'B'ees

The code below introduces some bias (increase by 1) in the measurements of group 'B'.

```
# add 2 to V2 if, V3 == 'B'
d$V2 <- ifelse(d$V3 == 'B',
               d$V2 + 1,
               d$V2)
```

We will use summary statistics to explore and retrieve this bias.

Summary statistics

Summarizing data is a sensible starting point when dealing with many data points.

Two useful summary statistics are the average and variance.

- *Averages* are single numbers that describe the center of a list of numbers.
- *Variance* is a measure of dispersion.

Averages

There is more than one way to define an average.

1. Mean: the sum divided by the length
2. Median: the value separating the upper and lower halves
3. Mode: the value that appears most often

There are functions in R that correspond to these statistics.

```
# calculate the mean of V2
mean(d$V2)

## [1] 1.203575

# calculate the median of V2
median(d$V2)

## [1] 1.220129
```

Variance

Variance is a measure of how far a set of numbers is spread out from their average value.

Here is the code to calculate the variance and the standard deviation.

```
# calculate the variance of V2
var(d$V2)

## [1] 1.11628

# calculate the standard deviation of V2
sd(d$V2)

## [1] 1.056542
```

Did god spike the 'B'ees?

Now we can calculate the difference we introduced in the measurements of group 'B'.

```
# calculate the mean of the groups
A <- mean(d$V2[d$V3 == 'A'])
B <- mean(d$V2[d$V3 == 'B'])

# calculate the difference
B - A

## [1] 1.081744
```

Plots

There are many ways to visualize any given set of data.

The basic graphs are

- Points
- Bars
- Lines

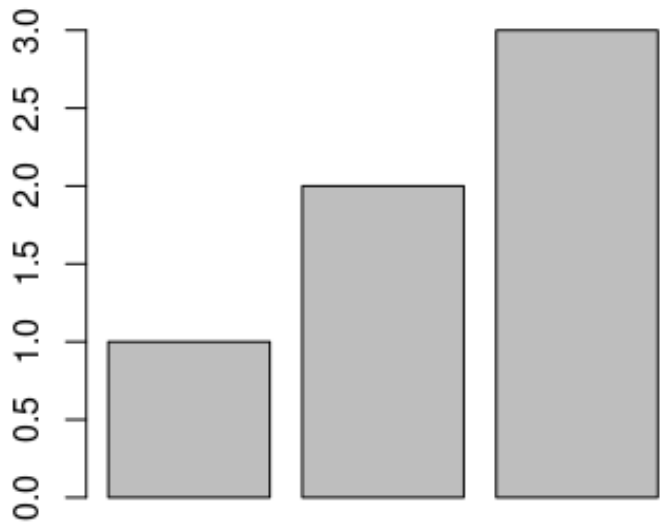
Used in the right way and context these can be very illuminating.

Once your data is large enough, graphs like these will be the only way to explore the data and the relationships between the variables.

Bar plot

The function barplot creates a bar graph. The only required argument is called height, the rest is optional.

```
# plot 1 to 3
barplot(1:3)
```

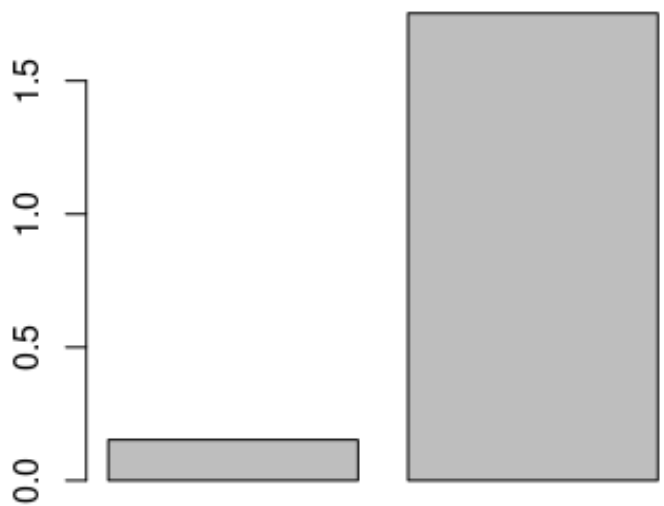


Bar plot

Here are the mean values for each group.

```
# calculate and plot the group means
m <- c(mean(d$V2[d$V3 == 'A']),
       mean(d$V2[d$V3 == 'B']))

barplot(m)
```



Bar plot (Pretty)

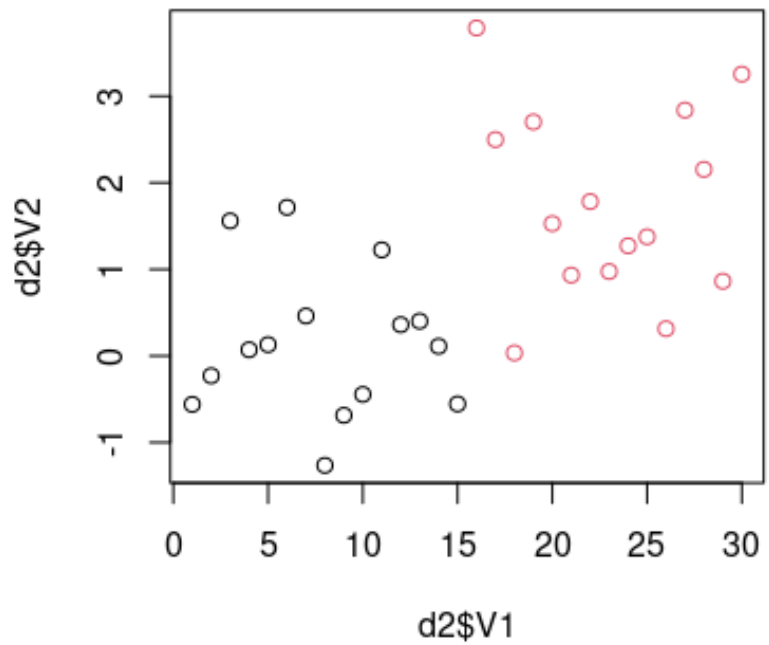
The code below shows some embellishment to the previous graph.

```
# modify the graph
barplot(m, xlab = 'Group', ylab = 'Measurement',
ylim = c(0, 2))
axis(side = 1, at = c(.7, 1.9), labels = c('A', 'B'))
```

Point plot (or scatter plot)

This code plots V1 on the x-axis and V2 on the y-axis and colors the points by V3.

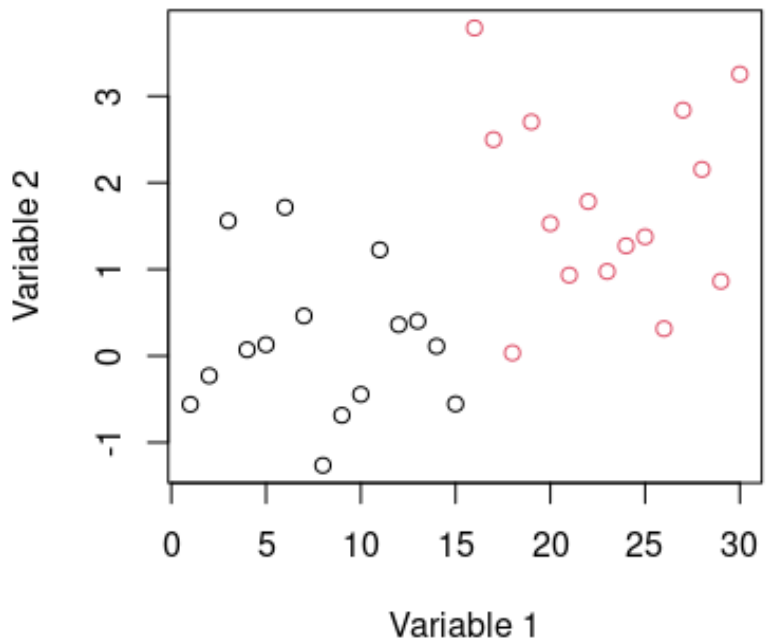
```
# plot all three variables
# as factor is necessary to force A and B to colors
plot(x = d$V1, y = d$V2, col = as.factor(d$V3))
```



Point plot (Pretty)

The code below shows some embellishment to the previous graph.

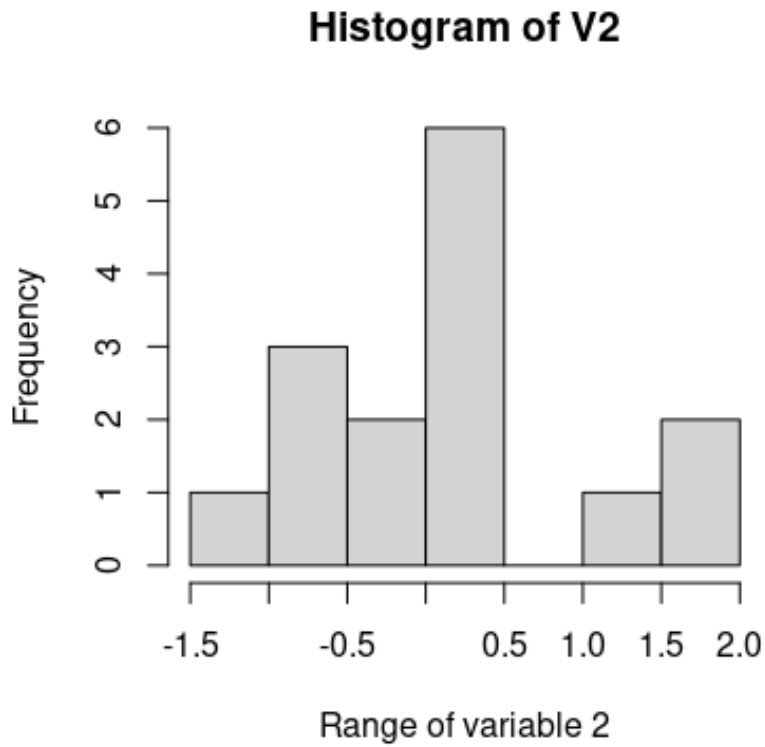
```
# plot all three variables
# as factor is necessary to force A and B to colors
plot(x = d$V1, y = d$V2, col = as.factor(d$V3),
     xlab = 'Variable 1', ylab = 'Variable 2')
```



Histogram plot

A *histograms* counts the frequency of data points within specified ranges. In other words, it divides the data into ranges called bins and counts how many occur in each bin.

```
# draw a histogram
hist(d$V2, xlab = 'Range of variable 2')
```



Tests

Looking at the mean, variance, and the plots we made, you can easily see the difference between the group means.

Is this difference statistically significant?

One way to answer this kind of question is to use statistical tests.

Choosing which test to use, indeed whether you should use tests at all or whether significance means anything is not discussed here.

Tests

This code compares the means of groups A and B using a *t*-test.

```
# apply t.test
t.test(d$V2[d$V3 == 'B'], d$V2[d$V3 == 'A'])

##
##  Welch Two Sample t-test
##
## data:  d$V2[d$V3 == "B"] and d$V2[d$V3 == "A"]
## t = 3.2271, df = 27.974, p-value = 0.003181
## alternative hypothesis: true difference in means is not
## 95 percent confidence interval:
##  0.3950823 1.7684055
## sample estimates:
## mean of x mean of y
##  1.744447  0.662703
```

Summary

What you've learned

- Summary statistics
- Plots
- Tests

What's next

- Practice (Link)
- Homework (Link)
- Module 3: Quantifying mRNA using the pcr package (Link)