Statistical Tests

Chi-square Test

Load the data

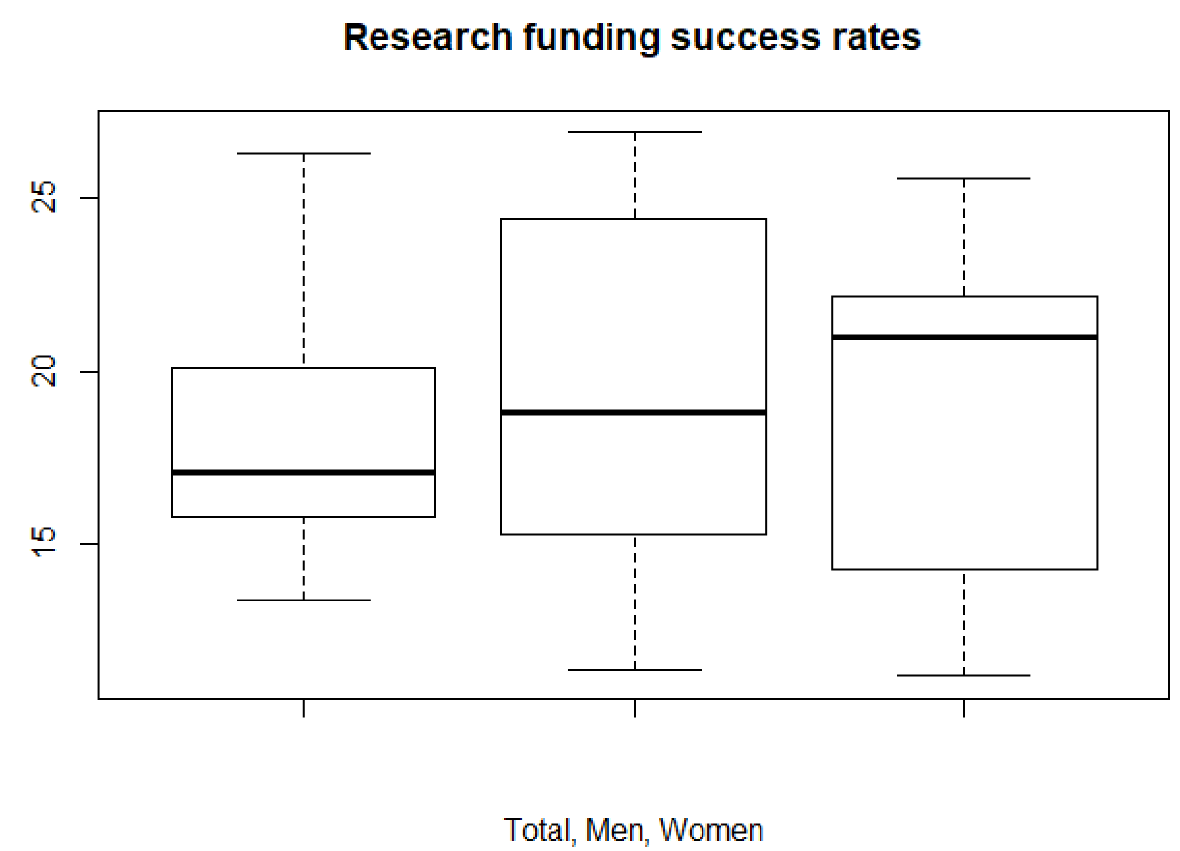
```
load("rdas/research_funding_rates.rda")
```

```
research_funding_rates
```

```
##            discipline applications_total applications_men
## 1   Chemical sciences                122               83
## 2   Physical sciences                174              135
## 3             Physics                 76               67
## 4          Humanities                396              230
## 5  Technical sciences                251              189
## 6   Interdisciplinary                183              105
## 7 Earth/life sciences                282              156
## 8     Social sciences                834              425
## 9    Medical sciences                505              245
##   applications_women awards_total awards_men awards_women
## 1                 39           32         22           10
## 2                 39           35         26            9
## 3                  9           20         18            2
## 4                166           65         33           32
## 5                 62           43         30           13
## 6                 78           29         12           17
## 7                126           56         38           18
## 8                409          112         65           47
## 9                260           75         46           29
##   success_rates_total success_rates_men success_rates_women
## 1                26.2              26.5                25.6
## 2                20.1              19.3                23.1
## 3                26.3              26.9                22.2
## 4                16.4              14.3                19.3
## 5                17.1              15.9                21.0
## 6                15.8              11.4                21.8
## 7                19.9              24.4                14.3
## 8                13.4              15.3                11.5
## 9                14.9              18.8                11.2
```

Plot research funding success rates: Total, Men, Women

```
boxplot(research_funding_rates$success_rates_total,research_funding_rates$success_rat
    research_funding_rates$success_rates_women, xlab=c("Total, Men, Women"),
    main ="Research funding success rates")
```




```
summary(research_funding_rates)
```

```
##                 discipline applications_total applications_men
##  Chemical sciences  :1    Min.   : 76.0      Min.   : 67.0
##  Earth/life sciences:1    1st Qu.:174.0      1st Qu.:105.0
##  Humanities         :1    Median :251.0      Median :156.0
##  Interdisciplinary  :1    Mean   :313.7      Mean   :181.7
##  Medical sciences   :1    3rd Qu.:396.0      3rd Qu.:230.0
##  Physical sciences  :1    Max.   :834.0      Max.   :425.0
##  (Other)            :3
##  applications_women  awards_total      awards_men      awards_women
##  Min.   :  9        Min.   : 20.00   Min.   :12.00   Min.   : 2.00
##  1st Qu.: 39        1st Qu.: 32.00   1st Qu.:22.00   1st Qu.:10.00
##  Median : 78        Median : 43.00   Median :30.00   Median :17.00
##  Mean   :132        Mean   : 51.89   Mean   :32.22   Mean   :19.67
```

```
## Mean :152 Mean : 91.89 Mean :32.22 Mean :19.67
## 3rd Qu.:166 3rd Qu.: 65.00 3rd Qu.:38.00 3rd Qu.:29.00
## Max. :409 Max. :112.00 Max. :65.00 Max. :47.00
##
## success_rates_total success_rates_men success_rates_women
## Min. :13.4 Min. :11.4 Min. :11.20
## 1st Qu.:15.8 1st Qu.:15.3 1st Qu.:14.30
## Median :17.1 Median :18.8 Median :21.00
## Mean :18.9 Mean :19.2 Mean :18.89
## 3rd Qu.:20.1 3rd Qu.:24.4 3rd Qu.:22.20
## Max. :26.3 Max. :26.9 Max. :25.60
##
```

Compute the totals that were successful and the totals that were not as follows:

```
totals <- research_funding_rates %>% select(-discipline) %>% summarize_all(funs(sum)
  summarize(yes_men = awards_men, no_men = applications_men - awards_men, yes_women =
            no_women = applications_women - awards_women)
totals
```

```
##   yes_men no_men yes_women no_women
## 1     290   1345       177     1011
```

Larger percent of men than women received awards

```
totals %>% summarize(percent_men = yes_men/(yes_men+no_men),
                     percent_women = yes_women/(yes_women+no_women))
```

```
##   percent_men percent_women
## 1     0.17737     0.1489899
```

Percent funding when randomly assigned

```
funding_rate <- totals %>%  summarize(percent_total =
                    (yes_men + yes_women)/(yes_men + no_men +yes_women + no_women)) %
funding_rate
```

```
## [1] 0.1654269
```

Chi-square test is to compare any signficant difference between the groups with the help of a two-by-two table

Create the two-by-two Observed data table:

```
Observed_data <- data.frame(awarded = c("no", "yes"),
                            men = c(totals$no_men, totals$yes_men),
                            women = c(totals$no_women, totals$yes_women))
Observed_data
```

```
##   awarded  men women
## 1      no 1345  1011
## 2     yes  290   177
```

Have a look at the two-by-two expected data table:

```
Expected_data <- data.frame(awarded = c("no", "yes"),
              men = (totals$no_men + totals$yes_men) * c(1 - funding_rate, funding_rat
              women = (totals$no_women + totals$yes_women)*c(1 - funding_rate, funding
Expected_data
```

```
##   awarded       men    women
## 1      no 1364.5271 991.4729
## 2     yes  270.4729 196.5271
```

The idea is to compare the observed to expected.

```
chisq_test <- Observed_data %>% select(-awarded) %>% chisq.test()
chisq_test
```

```
## 
##  Pearson's Chi-squared test with Yates' continuity correction
## 
## data:  .
## X-squared = 3.8111, df = 1, p-value = 0.05091
```

```
qchisq(0.95,df=1)
```

```
## [1] 3.841459
```

H0 is There is no difference beween the groups

H1 is there is difference between the groups

Pvalue is >0.05 at 95% significance level. So Ho cannot be rejected.

The Chisquare value of 3.8111 wont cross the critical value at 95% signifcance level for df=1 is 3.841459, so H0 cannot be rejected

Conclusion is that there is no difference between the groups

Odds Ratio

```
odds_men <- (Observed_data$men[2] / sum(Observed_data$men)) / (Observed_data$men[1] /
odds_women <- (Observed_data$women[2] / sum(Observed_data$women)) / (Observed_data$wo
odds_ratio <- odds_men / odds_women
odds_ratio
```

```
## [1] 1.231554
```

Larger sample size will give lesser p-value but odds ratio remains same.

Confidence interval for Odds Ratio

```
log_or <- log( odds_men / odds_women )
se <- Observed_data %>%  select(-awarded) %>% summarize(se = sqrt(sum(1/men) + sum(1/
ci <- log_or + c(-1,1) * qnorm(0.975) * se
ci
```

```
## [1] 0.004303265 0.412250970
```

Fisher's Test

Similar to chisquare test used when sample size is very small <5

Fisher's test with lady tasing tea for milk poured before or after tea was poured.

```
tab <- matrix(c(3,1,1,3),2,2)
rownames(tab)<-c("Poured Before","Poured After")
colnames(tab)<-c("Guessed before","Guessed after")
tab
```

```
##               Guessed before Guessed after
## Poured Before              3             1
## Poured After               1             3
```

Idea is test actual to guess really works or was it just random happening

```
fisher.test(tab)
```

```
##
##  Fisher's Exact Test for Count Data
##
## data:  tab
## p-value = 0.4857
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##    0.2117329 621.9337505
## sample estimates:
## odds ratio
##   6.408309
```

```
fisher.test(tab, alternative="greater")
```

```
##
##  Fisher's Exact Test for Count Data
##
## data:  tab
## p-value = 0.2429
## alternative hypothesis: true odds ratio is greater than 1
## 95 percent confidence interval:
##  0.3135693       Inf
## sample estimates:
## odds ratio
##   6.408309
```

H0 is that there is no difference

H1 is that there is difference between groups

p-value is >0.05 so H0 cannot be rejected. It cannot be said with statistical sig that the lady can actucally guess.

When sample size increase p-vlaue gets reduced but odd ratio remains same.

McNemar Test

McNemar test for paired data

```
x<-matrix(c(21,9,2,12),2,2)
mcnemar.test(x)
```

```
##
##  McNemar's Chi-squared test with continuity correction
##
## data:  x
## McNemar's chi-squared = 3.2727, df = 1, p-value = 0.07044
```

```
mcnemar.test(x,correct=FALSE)
```

```
##
##  McNemar's Chi-squared test
##
## data:  x
## McNemar's chi-squared = 4.4545, df = 1, p-value = 0.03481
```

The argument correct = FALSE is a logical indicating whether to apply continuity correction when computing the test statistic.

```
mcnemar.exact(x)
```

```
##
##  Exact McNemar test (with central confidence intervals)
##
```

```
## data:  x
## b = 2, c = 9, p-value = 0.06543
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##  0.02336464 1.07363844
## sample estimates:
## odds ratio
##  0.2222222
```