Statistical tests

One sample Wilcoxon Test

Wilcoxon's rank sum test (also known as the unpaired Wilcoxon rank sum test or the Mann-Whitney U test) It is the test for ordinal or continuous data. In contrast to Student's t-test, does not require the data to be normally distributed. This test too can be used for paired or unpaired data.

Dataset shows different method for identifying protiens and the accuracy.

```
load("rdas/protStruct.rda")
head(protStruct)
```

```
##     Protein Method Correct
## 1 Ubiquitin  CFAVG   0.467
## 2 Ubiquitin    GOR   0.645
## 3 Ubiquitin    PHD   0.868
## 4   DeoxyHb  CFAVG   0.472
## 5   DeoxyHb    GOR   0.844
## 6   DeoxyHb    PHD   0.879
```

```
str(protStruct)
```

```
## 'data.frame':    12 obs. of  3 variables:
##  $ Protein: Factor w/ 4 levels "DeoxyHb","Prealbumin",..: 4 4 4 1 1 1 3 3 3 2 ...
##  $ Method : Factor w/ 3 levels "CFAVG","GOR",..: 1 2 3 1 2 3 1 2 3 1 ...
##  $ Correct: num  0.467 0.645 0.868 0.472 0.844 0.879 0.405 0.604 0.787 0.449 ...
```

Test against a specific hypothesis, mean =0.5

```
wilcox.test(protStruct$Correct,mu=0.5)
```

```
##
##  Wilcoxon signed rank test
```

```
##
## data:  protStruct$Correct
## V = 68, p-value = 0.021
## alternative hypothesis: true location is not equal to 0.5
```

The results of this test concur with the results of the t-test that the central measure (mean or median) of the data differs significantly from 0.5.

Two sample Wilcoxon Rank Sum Tests

Load the data

Dataset includes info on effectivesness of 2 painkillers as rated by patients

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

```
##         Drug Score Rank
## 1  Oxycodone     1  1.0
## 2  Oxycodone     2  2.5
## 3  Oxycodone     2  2.5
## 4  Oxycodone     3  4.0
## 5  Oxycodone     4  6.0
## 6  Oxycodone     4  6.0
## 7  Oxycodone     5  9.0
## 8  Oxycodone     5  9.0
## 9  Oxycodone     6 13.0
## 10 Oxycodone     6 13.0
## 11 Oxycodone     8 21.5
## 12 Oxycodone     8 21.5
## 13 Ibuprofen     4  6.0
## 14 Ibuprofen     5  9.0
## 15 Ibuprofen     6 13.0
## 16 Ibuprofen     6 13.0
## 17 Ibuprofen     6 13.0
## 18 Ibuprofen     7 17.5
## 19 Ibuprofen     7 17.5
## 20 Ibuprofen     7 17.5
## 21 Ibuprofen     7 17.5
## 22 Ibuprofen     8 21.5
## 23 Ibuprofen     8 21.5
## 24 Ibuprofen     9 24.0
```

```
group_by(medrank, Drug) %>%
  summarise(
    count = n(),
    medi_score = median(Score, na.rm = TRUE),
    IQR_score = IQR(Score, na.rm = TRUE),
    medi_rank = median(Rank, na.rm = TRUE),
    IQR_rank = IQR(Rank, na.rm = TRUE)
  )
```

```
## # A tibble: 2 x 6
##   Drug      count medi_score IQR_score medi_rank IQR_rank
##   <fct>     <int>      <dbl>     <dbl>     <dbl>    <dbl>
## 1 Ibuprofen    12        7        1.25      17.5     5.5
## 2 Oxycodone    12        4.5      3.25       7.5     9.38
```

```
oxycodone_rank <- medrank$Rank[medrank$Drug=="Oxycodone"]
ibuprofen_rank <- medrank$Rank[medrank$Drug=="Ibuprofen"]
```

Test the 2 drugs

```
relation <- wilcox.test(oxycodone_rank, ibuprofen_rank)
```

```
## Warning in wilcox.test.default(oxycodone_rank, ibuprofen_rank): cannot
## compute exact p-value with ties
```

```
relation
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  oxycodone_rank and ibuprofen_rank
## W = 31, p-value = 0.0181
## alternative hypothesis: true location shift is not equal to 0
```

No difference between the median of 2 groups

Unpaired Wilcoxon Rank Sum Tests

Load the data

```
load("rdas/my_data.rda")
head(my_data)
```

```
##   group weight
## 1 Woman   38.9
## 2 Woman   61.2
## 3 Woman   73.3
## 4 Woman   21.8
## 5 Woman   63.4
## 6 Woman   64.6
```

```
group_by(my_data, group) %>%
  summarise(
    count = n(),
    median = median(weight, na.rm = TRUE),
    IQR = IQR(weight, na.rm = TRUE)
  )
```

```
## # A tibble: 2 x 4
##   group count median   IQR
##   <fct> <int>  <dbl> <dbl>
## 1 Man       9   67.3  10.9
## 2 Woman     9   48.8  15
```

```
ggboxplot(my_data, x = "group", y = "weight",
          color = "group", palette = c("#00AFBB", "#E7B800"),
          ylab = "Weight", xlab = "Groups")
```

Compute two-samples Wilcoxon test - Method 1

```
women_weight <- my_data$weight[my_data$group=="Woman"]
men_weight <- my_data$weight[my_data$group=="Man"]
res <- wilcox.test(women_weight, men_weight)
```

```
## Warning in wilcox.test.default(women_weight, men_weight): cannot compute
## exact p-value with ties
```

```
res
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  women_weight and men_weight
## W = 15, p-value = 0.02712
## alternative hypothesis: true location shift is not equal to 0
```

Compute two-samples Wilcoxon test - Method 2

```
res <- wilcox.test(weight ~ group, data = my_data,
                   exact = FALSE)
res
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  weight by group
## W = 66, p-value = 0.02712
## alternative hypothesis: true location shift is not equal to 0
```

To test whether the median men's weight is less than the median women's weight:

```
wilcox.test(weight ~ group, data = my_data,
            exact = FALSE, alternative = "less")
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  weight by group
```

```
## W = 66, p-value = 0.9892
## alternative hypothesis: true location shift is less than 0
```

To test whether the median men's weight is greater than the median women's weight

```
wilcox.test(weight ~ group, data = my_data,
            exact = FALSE, alternative = "greater")
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  weight by group
## W = 66, p-value = 0.01356
## alternative hypothesis: true location shift is greater than 0
```

Pairwise Wilcoxon Rank Sum Tests

Load the data

```
attach(airquality)
head(airquality)
```

```
##   Ozone Solar.R Wind Temp Month Day
## 1    41     190  7.4   67     5   1
## 2    36     118  8.0   72     5   2
## 3    12     149 12.6   74     5   3
## 4    18     313 11.5   62     5   4
## 5    NA      NA 14.3   56     5   5
## 6    28      NA 14.9   66     5   6
```

```
Month <- factor(Month, labels = month.abb[5:9])
```

```
pairwise.wilcox.test(Ozone, Month)
```

```
## 
##  Pairwise comparisons using Wilcoxon rank sum test 
## 
## data:  Ozone and Month 
## 
##     May    Jun    Jul    Aug   
## Jun 0.5775 -      -      -     
## Jul 0.0003 0.0848 -      -     
## Aug 0.0011 0.1295 1.0000 -     
## Sep 0.4744 1.0000 0.0060 0.0227
## 
## P value adjustment method: holm
```

These give warnings because of ties

```
pairwise.wilcox.test(Ozone, Month, p.adj = "bonf")
```

```
## 
##  Pairwise comparisons using Wilcoxon rank sum test 
## 
## data:  Ozone and Month 
## 
```

```
##     May    Jun    Jul    Aug
## Jun 1.0000 -      -      -
## Jul 0.0003 0.1414 -      -
## Aug 0.0012 0.2591 1.0000 -
## Sep 1.0000 1.0000 0.0074 0.0325
##
## P value adjustment method: bonferroni
```

```
detach()
```

Krusal Wallis Test

Load the data

Dataset is about the reaction time taken after intake of 3 different drinks

```
load("rdas/reactionR.rda")
str(reactionR)
```

```
## 'data.frame':    30 obs. of  3 variables:
##  $ ReactionTime: num  0.37 0.38 0.61 0.78 0.83 0.86 0.9 0.95 0.98 1.11 ...
##  $ Drink       : Factor w/ 3 levels "Alcohol","Coffee",..: 3 3 3 3 3 3 3 3 2 2 ...
##  $ Rank        : num  1 2 3 4 5 6 7 8 9 10 ...
```

Medians

```
tapply(reactionR$ReactionTime, reactionR$Drink, median)
```

```
## Alcohol  Coffee   Water
##   2.250   1.445   0.845
```

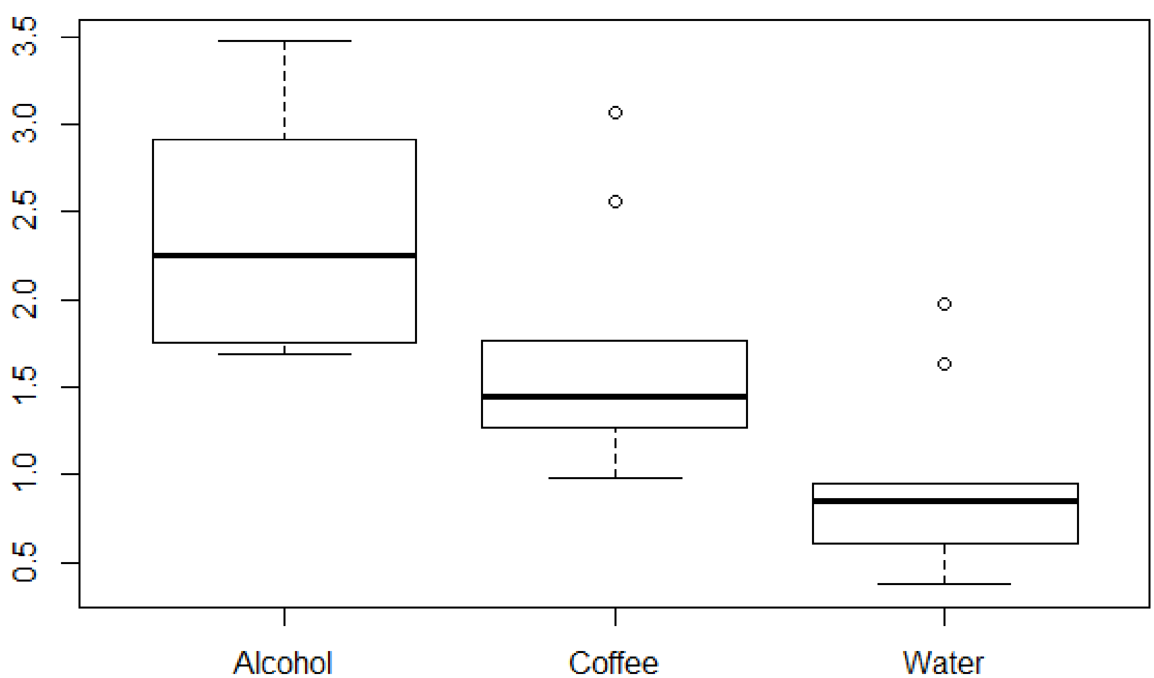
Summary

```
Water_summary<-summary(reactionR$ReactionTime[reactionR$Drink=='Water'])
Coffee_summary<-summary(reactionR$ReactionTime[reactionR$Drink=='Coffee'])
Alcohol_summary<-summary(reactionR$ReactionTime[reactionR$Drink=='Alcohol'])
```

```
compare1<-cbind(Water_summary,Coffee_summary,Alcohol_summary)
round(compare1,2)
```

```
##         Water_summary Coffee_summary Alcohol_summary
## Min.             0.37           0.98            1.69
## 1st Qu.          0.65           1.28            1.77
## Median           0.84           1.44            2.25
## Mean             0.93           1.64            2.38
## 3rd Qu.          0.94           1.68            2.85
## Max.             1.97           3.07            3.47
```

```
boxplot(reactionR$ReactionTime~reactionR$Drink)
```




```
kruskal.test(reactionR$ReactionTime~reactionR$Drink)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  reactionR$ReactionTime by reactionR$Drink
```

```
## Kruskal-Wallis chi-squared = 16.322, df = 2, p-value = 0.0002856
```

The simplest adjustment is the Bonferroni adjustment p.adj='bonferroni' which multiplies each Wilcoxon signed rank p-value by the total number of Wilcoxon tests being carried out (here it is 3) while the exact=F stands for the asymptotic test which allows tied ranks.

Look for which drinks are

```
pairwise.wilcox.test(reactionR$ReactionTime,reactionR$Drink,p.adj='bonferroni',exact=
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test
##
## data:  reactionR$ReactionTime and reactionR$Drink
##
##        Alcohol Coffee
## Coffee 0.042   -
## Water  0.002   0.027
##
## P value adjustment method: bonferroni
```

Friedman Test

Load the data

```
load("rdas/Data.rda")
str(Data)
```

```
## 'data.frame':    40 obs. of  3 variables:
##  $ Instructor: Factor w/ 5 levels "'Bob Belcher'",..: 1 1 1 1 1 1 1 1 3 3 ...
##  $ Rater     : Factor w/ 8 levels "a","b","c","d",..: 1 2 3 4 5 6 7 8 1 2 ...
##  $ Likert    : int  4 5 4 6 6 6 10 6 8 6 ...
```

```
Data$Likert.f <- as.factor(Data$Likert)
XT <- xtabs( ~ Instructor + Likert.f,
             data = Data)
XT
```

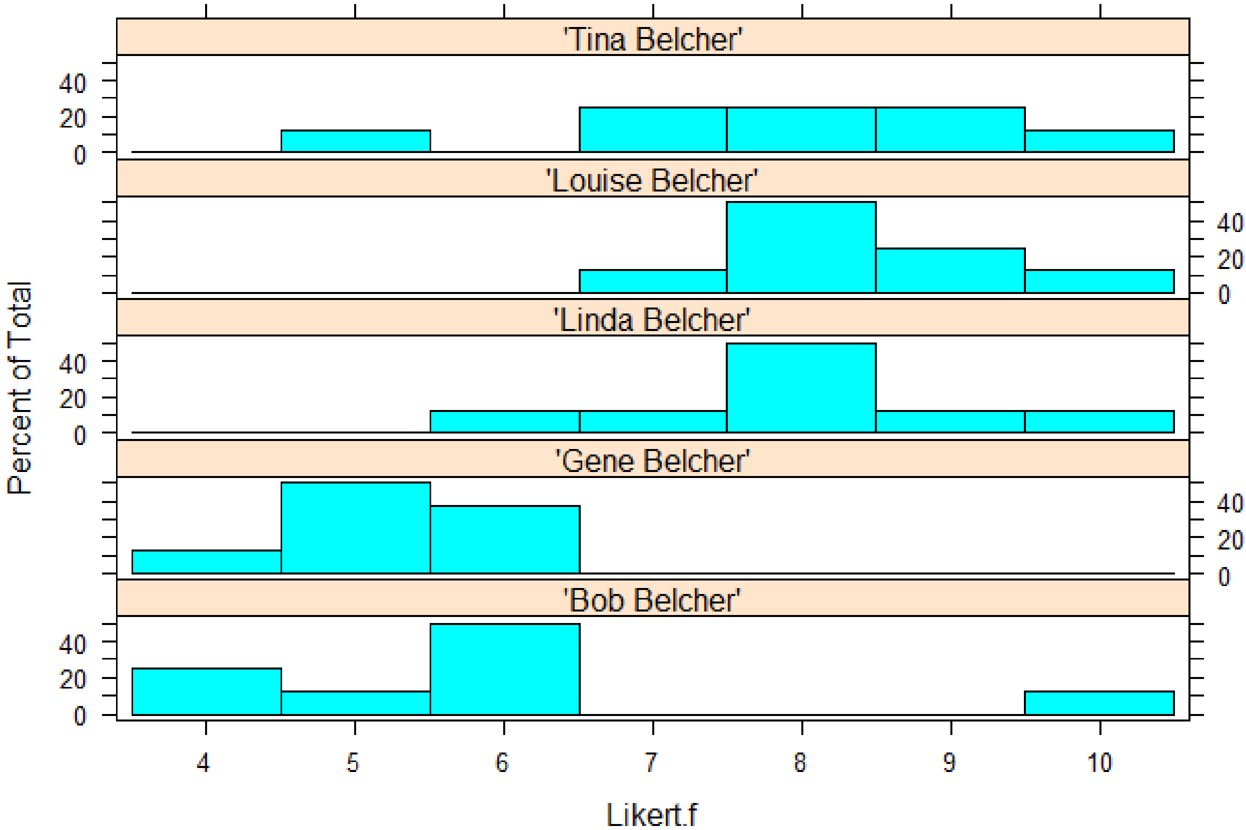
```
##                    Likert.f
## Instructor          4 5 6 7 8 9 10
##   'Bob Belcher'     2 1 4 0 0 0  1
##   'Gene Belcher'    1 4 3 0 0 0  0
##   'Linda Belcher'   0 0 1 1 4 1  1
##   'Louise Belcher'  0 0 0 1 4 2  1
##   'Tina Belcher'    0 1 0 2 2 2  1
```

As proportions

```
prop.table(XT,
           margin = 1)
```

```
##                    Likert.f
## Instructor              4     5     6     7     8     9    10
##   'Bob Belcher'     0.250 0.125 0.500 0.000 0.000 0.000 0.125
##   'Gene Belcher'    0.125 0.500 0.375 0.000 0.000 0.000 0.000
##   'Linda Belcher'   0.000 0.000 0.125 0.125 0.500 0.125 0.125
##   'Louise Belcher'  0.000 0.000 0.000 0.125 0.500 0.250 0.125
##   'Tina Belcher'    0.000 0.125 0.000 0.250 0.250 0.250 0.125
```

```
histogram(~ Likert.f | Instructor,
          data=Data,
          layout=c(1,5)      #  columns and rows of individual plots
)
```




```
friedman.test(Likert ~ Instructor | Rater,
              data = Data)
```

```
##
##  Friedman rank sum test
##
## data:  Likert and Instructor and Rater
## Friedman chi-squared = 23.139, df = 4, p-value = 0.0001188
```

Also done as

```
friedman.test(Data$Likert, Data$Instructor, Data$Rater)
```

```
##
##  Friedman rank sum test
##
## data:  Data$Likert, Data$Instructor and Data$Rater
## Friedman chi-squared = 23.139, df = 4, p-value = 0.0001188
```

```
Ratertable <- xtabs(Likert ~ Instructor + Rater,
                    data = Data)
```

Can do rowmeans of ratertable to see the difference in mean ratings,the diff is tested statistically by friedmantest

Conover test

```
PT = posthoc.friedman.conover.test(y      = Data$Likert,
                                   groups = Data$Instructor,
                                   blocks = Data$Rater,
                                   p.adjust.method="fdr")
PT
```

```
##
##  Pairwise comparisons using Conover's test for a two-way
##                    balanced complete block design
##
## data:  Data$Likert , Data$Instructor and Data$Rater
##
##                  'Bob Belcher' 'Gene Belcher' 'Linda Belcher'
## 'Gene Belcher'   0.17328       -              -
## 'Linda Belcher'  2.8e-05       1.2e-06        -
## 'Louise Belcher' 1.9e-06       1.1e-07        0.27303
## 'Tina Belcher'   0.00037       8.8e-06        0.31821
##                  'Louise Belcher'
## 'Gene Belcher'   -
## 'Linda Belcher'  -
## 'Louise Belcher' -
## 'Tina Belcher'   0.05154
##
## P value adjustment method: fdr
```