

STAT 425 Project 02

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Preliminary

This section serves to demonstrate that regular R functions handle BIBDs correctly. We begin with the analysis of data in Table 4.22.

```
time <- c(73,74, 71,
          75,67,72,
          73,75,68,
          75, 72,75)
treatment = c(1,1,1,
              2,2,2,
              3,3,3,
              4,4,4) #catalyst
block = c(1,2,4,
          2,3,4,
          1,2,3,
          1,3,4) #batch

df <- data.frame(time, treatment, block)

library(crossdes)

## Warning: package 'crossdes' was built under R version 4.1.2

## Loading required package: AlgDesign

## Loading required package: gtools

(tab <- xtabs(~ treatment + block, data = df))

##           block
## treatment 1 2 3 4
##           1 1 1 0 1
##           2 0 1 1 1
##           3 1 1 1 0
##           4 1 0 1 1

(d <- t(apply(tab, 1, function(x) (1:4)[x != 0])))
```

```
##
## treatment [,1] [,2] [,3]
##          1    1    2    4
##          2    2    3    4
##          3    1    2    3
##          4    1    3    4
```

```
isGYD(d)
```

```
##
## [1] The design is a balanced incomplete block design w.r.t. rows.
```

We have verified this data is a BIBD.

```
one.way <- aov(time~factor(block)+factor(treatment), data=df)
summary(one.way)
```

```
##                Df Sum Sq Mean Sq F value    Pr(>F)
## factor(block)      3  55.00   18.333    28.20 0.00147 **
## factor(treatment)  3  22.75    7.583    11.67 0.01074 *
## Residuals          5   3.25    0.650
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

As the ANOVA table matches Table 4.24, the ‘aov’ function analyzes a BIBD properly, and so we can use it.

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

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

The equation $N = ar = bk$ is satisfied.

The data... along with some data cleaning

```
# load data
eData.raw <- read.csv(file = 'appletaste.csv')
aftertaste <- eData.raw$aftertaste
panelist <- eData.raw$panelist
product <- as.factor(eData.raw$product)
eData <- data.frame(aftertaste,
                    panelist,
                    product)
```

Checking for a balanced design

```
# check balance for panelists
replications(aftertaste ~ panelist, data=eData)
```

```
## panelist
##          3
```

```
# check balance for product
replications(aftertaste ~ product, data=eData)
```

```
## product
##         15
```

```
# let's try a table
table(eData$panelist,eData$product)
```

```
##
##      298 493 649 937
## a    1   1   0   1
## b    1   1   0   1
## c    1   1   0   1
## d    1   1   0   1
## e    1   1   0   1
## f    0   1   1   1
## g    0   1   1   1
## h    0   1   1   1
## i    0   1   1   1
## j    0   1   1   1
## k    1   0   1   1
## l    1   0   1   1
## m    1   0   1   1
## n    1   0   1   1
## o    1   0   1   1
## p    1   1   1   0
## q    1   1   1   0
## r    1   1   1   0
## s    1   1   1   0
## t    1   1   1   0
```

Each of the twenty panelists samples three of the four products. Each product is sampled 15 times. Thus, the design appears to be balanced.

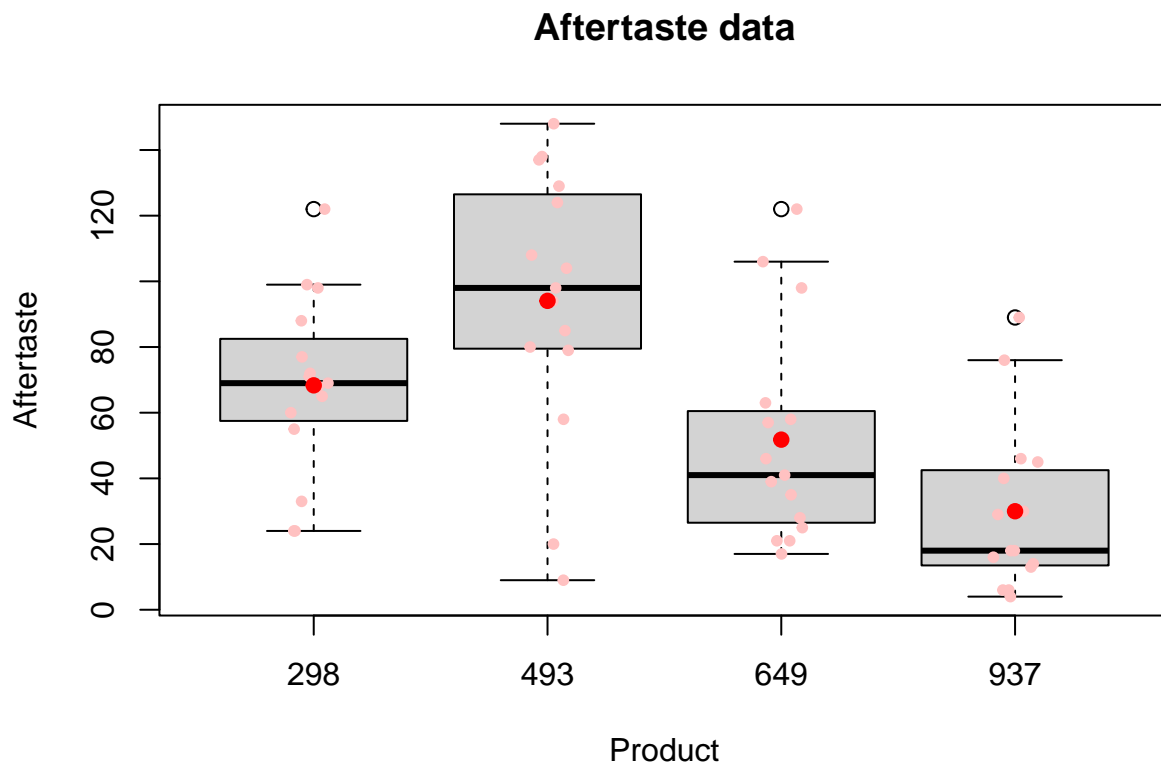
Boxplots

```
boxplot(aftertaste~product,data=eData,
        main="Aftertaste data",
        xlab="Product",
        ylab="Aftertaste")
stripchart(aftertaste ~ product, data=eData,
           vertical = TRUE,
```

```

method = "jitter",
pch = 20,
add = TRUE,
col = "rosybrown1")
means <- tapply(eData$aftertaste, eData$product, mean)
points(means, pch=19, col="red")

```



Product 493 appears to be the sweetest. The rest are relatively more bitter; as regards their differences, that is TBD.

ANOVA

```

appletaste.aov <- aov(aftertaste ~ product + panelist, data=eData)
summary(appletaste.aov)

```

```

##           Df Sum Sq Mean Sq F value    Pr(>F)
## product      3  32892   10964   15.085 1.43e-06 ***
## panelist     19  31582     1662    2.287  0.0153 *
## Residuals    37  26892       727
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

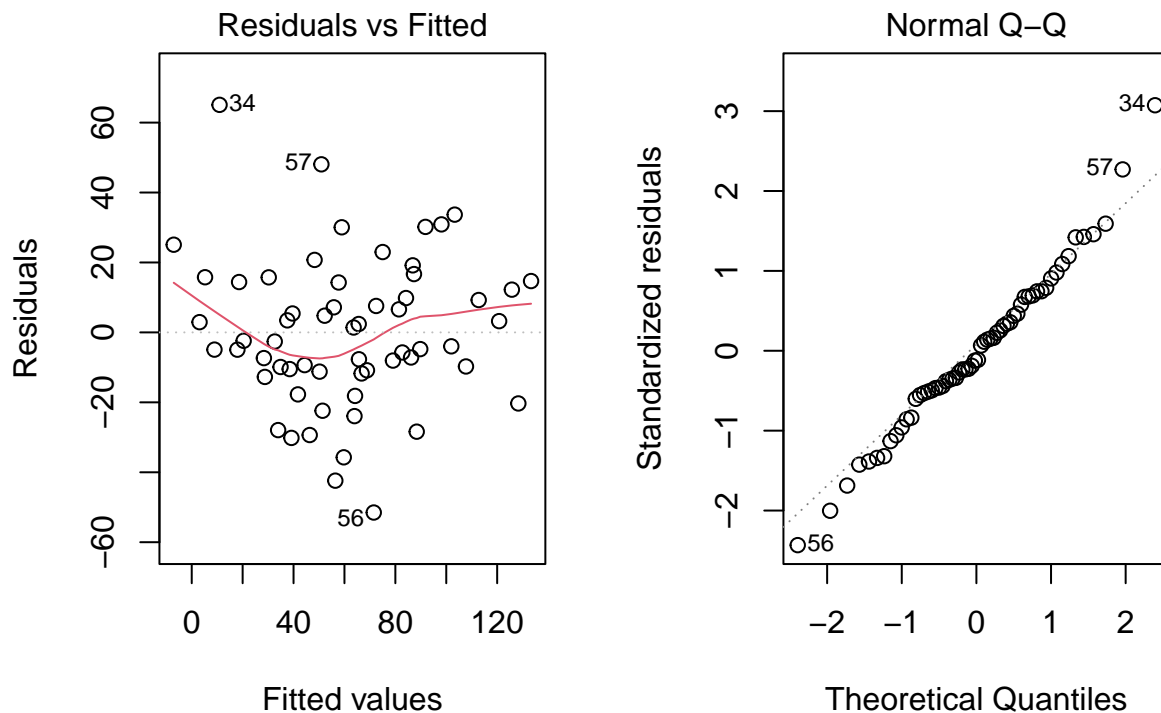
Obviously, the null hypothesis of equality of treatment means, holding a level of $\alpha=0.05$, must be REJECTED. But the treatment, which is the product must follow the block, which is the panelist.

##Below is the correct ANOVA table, and the conclusion that can be drawn is the same

```
appletaste.aov=aov(aftertaste~panelist+product, data=eData)
summary(appletaste.aov)
```

```
##           Df Sum Sq Mean Sq F value    Pr(>F)
## panelist   19  30461    1603    2.206  0.0194 *
## product     3  34014   11338   15.599 1.02e-06 ***
## Residuals   37  26892     727
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

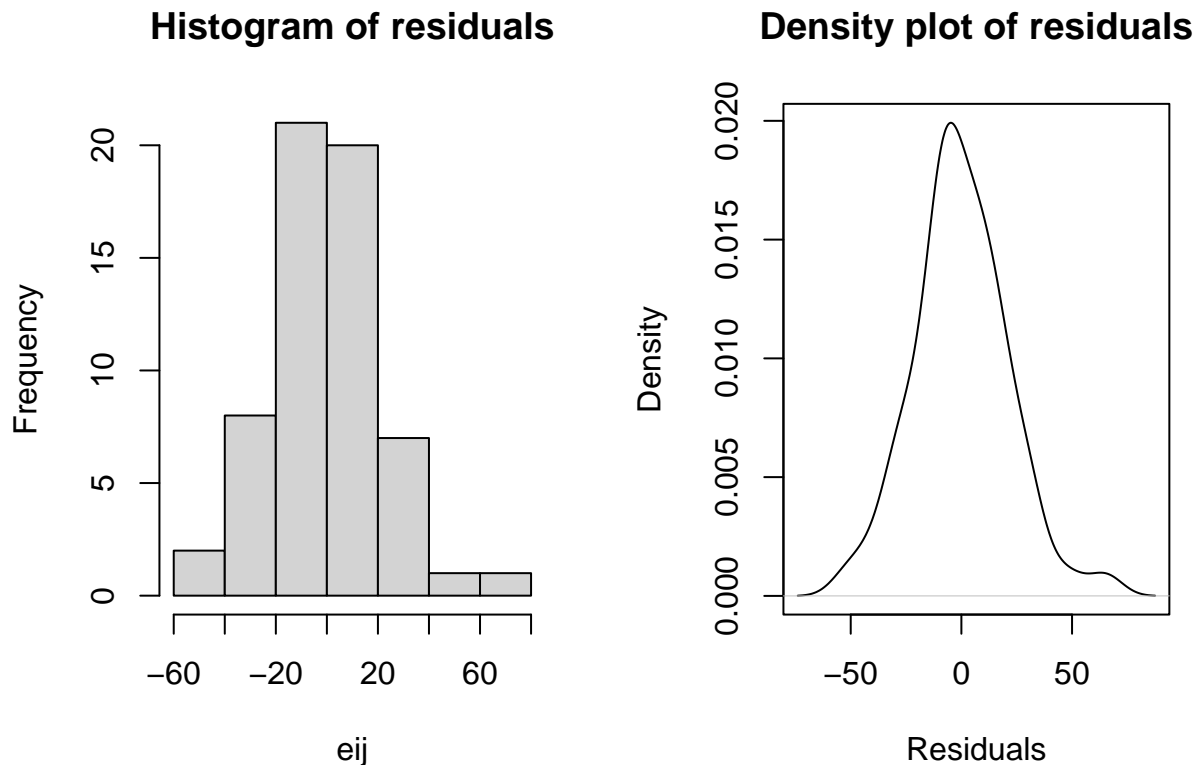
```
par(mfrow=c(1,2))
plot(appletaste.aov,1)
plot(appletaste.aov,2)
```



The Residuals vs Fitted plot: Residuals are randomly distributed with what appears to be constant width, thus, we can conclude the homogeneity of variance (homoscedasticity) requirement is satisfied. Although there is a curve to the red line, we choose to ignore it, as it is quite minor. A Box-Cox transformation may correct this slight deviation.

Normal Q-Q: Theoretical quantities fit the diagonal very well, which intersects the origin. Thus, the normality requirement is satisfied. But, just to be sure, let's check the residuals.

```
par(mfrow=c(1,2))
eij=residuals(appletaste.aov)
hist(eij,main="Histogram of residuals")
plot(density(eij),main="Density plot of residuals",ylab="Density",xlab="Residuals")
```



Beauty. Perfect.

```
shapiro.test(eData$aftertaste)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  eData$aftertaste
## W = 0.94845, p-value = 0.01318
```

```
# bartlett.test(aftertaste ~ product + panelist, data=eData) Fails?
```

```
#LeveneTest(aftertaste~panelist, data=eData)
#LeveneTest(aftertaste~product, data=eData)
```

Idk if this is the correct way but both p-values are above 0.05 so homogeneity of Variance holds

```
#Comparing Treatment means using Fisher LSD
```

```
library(DescTools)
```

```
## Warning: package 'DescTools' was built under R version 4.1.2
```

```
PostHocTest(appletaste.aov, method="lsd")
```

```
##
##   Posthoc multiple comparisons of means : Fisher LSD
##   95% family-wise confidence level
##
## $panelist
##           diff          lwr.ci          upr.ci          pval
## b-a -4.100000e+01 -85.6014369   3.6014369 0.07048 .
## c-a  5.000000e+00 -39.6014369  49.6014369 0.82156
## d-a -2.500000e+01 -69.6014369  19.6014369 0.26338
## e-a -2.633333e+01 -70.9347703  18.2681036 0.23919
## f-a -3.466667e+01 -79.2681036   9.9347703 0.12380
## g-a -6.033333e+01 -104.9347703 -15.7318964 0.00938 **
## h-a -4.300000e+01 -87.6014369   1.6014369 0.05836 .
## i-a -1.200000e+01 -56.6014369  32.6014369 0.58892
## j-a -7.000000e+00 -51.6014369  37.6014369 0.75227
## k-a -7.733333e+01 -121.9347703 -32.7318964 0.00119 **
## l-a -5.933333e+01 -103.9347703 -14.7318964 0.01051 *
## m-a -3.066667e+01 -75.2681036  13.9347703 0.17189
## n-a -4.000000e+01 -84.6014369   4.6014369 0.07730 .
## o-a -6.133333e+01 -105.9347703 -16.7318964 0.00836 **
## p-a -3.233333e+01 -76.9347703  12.2681036 0.15032
## q-a -4.766667e+01 -92.2681036  -3.0652297 0.03687 *
## r-a -3.033333e+01 -74.9347703  14.2681036 0.17648
## s-a -4.500000e+01 -89.6014369  -0.3985631 0.04809 *
## t-a -7.733333e+01 -121.9347703 -32.7318964 0.00119 **
## c-b  4.600000e+01   1.3985631  90.6014369 0.04357 *
## d-b  1.600000e+01 -28.6014369  60.6014369 0.47188
## e-b  1.466667e+01 -29.9347703  59.2681036 0.50936
## f-b  6.333333e+00 -38.2681036  50.9347703 0.77517
## g-b -1.933333e+01 -63.9347703  25.2681036 0.38545
## h-b -2.000000e+00 -46.6014369  42.6014369 0.92810
## i-b  2.900000e+01 -15.6014369  73.6014369 0.19579
## j-b  3.400000e+01 -10.6014369  78.6014369 0.13096
## k-b -3.633333e+01 -80.9347703   8.2681036 0.10729
## l-b -1.833333e+01 -62.9347703  26.2681036 0.41027
## m-b  1.033333e+01 -34.2681036  54.9347703 0.64152
## n-b  1.000000e+00 -43.6014369  45.6014369 0.96401
## o-b -2.033333e+01 -64.9347703  24.2681036 0.36162
## p-b  8.666667e+00 -35.9347703  53.2681036 0.69605
## q-b -6.666667e+00 -51.2681036  37.9347703 0.76369
## r-b  1.066667e+01 -33.9347703  55.2681036 0.63083
## s-b -4.000000e+00 -48.6014369  40.6014369 0.85680
## t-b -3.633333e+01 -80.9347703   8.2681036 0.10729
## d-c -3.000000e+01 -74.6014369  14.6014369 0.18116
## e-c -3.133333e+01 -75.9347703  13.2681036 0.16299
## f-c -3.966667e+01 -84.2681036   4.9347703 0.07970 .
```

```

## g-c -6.533333e+01 -109.9347703 -20.7318964 0.00523 **
## h-c -4.800000e+01 -92.6014369 -3.3985631 0.03565 *
## i-c -1.700000e+01 -61.6014369 27.6014369 0.44485
## j-c -1.200000e+01 -56.6014369 32.6014369 0.58892
## k-c -8.233333e+01 -126.9347703 -37.7318964 0.00062 ***
## l-c -6.433333e+01 -108.9347703 -19.7318964 0.00589 **
## m-c -3.566667e+01 -80.2681036 8.9347703 0.11366
## n-c -4.500000e+01 -89.6014369 -0.3985631 0.04809 *
## o-c -6.633333e+01 -110.9347703 -21.7318964 0.00464 **
## p-c -3.733333e+01 -81.9347703 7.2681036 0.09828 .
## q-c -5.266667e+01 -97.2681036 -8.0652297 0.02192 *
## r-c -3.533333e+01 -79.9347703 9.2681036 0.11696
## s-c -5.000000e+01 -94.6014369 -5.3985631 0.02903 *
## t-c -8.233333e+01 -126.9347703 -37.7318964 0.00062 ***
## e-d -1.333333e+00 -45.9347703 43.2681036 0.95203
## f-d -9.666667e+00 -54.2681036 34.9347703 0.66311
## g-d -3.533333e+01 -79.9347703 9.2681036 0.11696
## h-d -1.800000e+01 -62.6014369 26.6014369 0.41875
## i-d 1.300000e+01 -31.6014369 57.6014369 0.55840
## j-d 1.800000e+01 -26.6014369 62.6014369 0.41875
## k-d -5.233333e+01 -96.9347703 -7.7318964 0.02271 *
## l-d -3.433333e+01 -78.9347703 10.2681036 0.12734
## m-d -5.666667e+00 -50.2681036 38.9347703 0.79827
## n-d -1.500000e+01 -59.6014369 29.6014369 0.49984
## o-d -3.633333e+01 -80.9347703 8.2681036 0.10729
## p-d -7.333333e+00 -51.9347703 37.2681036 0.74091
## q-d -2.266667e+01 -67.2681036 21.9347703 0.30983
## r-d -5.333333e+00 -49.9347703 39.2681036 0.80990
## s-d -2.000000e+01 -64.6014369 24.6014369 0.36945
## t-d -5.233333e+01 -96.9347703 -7.7318964 0.02271 *
## f-e -8.333333e+00 -52.9347703 36.2681036 0.70717
## g-e -3.400000e+01 -78.6014369 10.6014369 0.13096
## h-e -1.666667e+01 -61.2681036 27.9347703 0.45376
## i-e 1.433333e+01 -30.2681036 58.9347703 0.51898
## j-e 1.933333e+01 -25.2681036 63.9347703 0.38545
## k-e -5.100000e+01 -95.6014369 -6.3985631 0.02615 *
## l-e -3.300000e+01 -77.6014369 11.6014369 0.14232
## m-e -4.333333e+00 -48.9347703 40.2681036 0.84502
## n-e -1.366667e+01 -58.2681036 30.9347703 0.53850
## o-e -3.500000e+01 -79.6014369 9.6014369 0.12034
## p-e -6.000000e+00 -50.6014369 38.6014369 0.78670
## q-e -2.133333e+01 -65.9347703 23.2681036 0.33876
## r-e -4.000000e+00 -48.6014369 40.6014369 0.85680
## s-e -1.866667e+01 -63.2681036 25.9347703 0.40189
## t-e -5.100000e+01 -95.6014369 -6.3985631 0.02615 *
## g-f -2.566667e+01 -70.2681036 18.9347703 0.25107
## h-f -8.333333e+00 -52.9347703 36.2681036 0.70717
## i-f 2.266667e+01 -21.9347703 67.2681036 0.30983
## j-f 2.766667e+01 -16.9347703 72.2681036 0.21668
## k-f -4.266667e+01 -87.2681036 1.9347703 0.06025 .
## l-f -2.466667e+01 -69.2681036 19.9347703 0.26969
## m-f 4.000000e+00 -40.6014369 48.6014369 0.85680
## n-f -5.333333e+00 -49.9347703 39.2681036 0.80990
## o-f -2.666667e+01 -71.2681036 17.9347703 0.23341

```



```

## p-f 2.333333e+00 -42.2681036 46.9347703 0.91615
## q-f -1.300000e+01 -57.6014369 31.6014369 0.55840
## r-f 4.333333e+00 -40.2681036 48.9347703 0.84502
## s-f -1.033333e+01 -54.9347703 34.2681036 0.64152
## t-f -4.266667e+01 -87.2681036 1.9347703 0.06025 .
## h-g 1.733333e+01 -27.2681036 61.9347703 0.43604
## i-g 4.833333e+01 3.7318964 92.9347703 0.03446 *
## j-g 5.333333e+01 8.7318964 97.9347703 0.02041 *
## k-g -1.700000e+01 -61.6014369 27.6014369 0.44485
## l-g 1.000000e+00 -43.6014369 45.6014369 0.96401
## m-g 2.966667e+01 -14.9347703 74.2681036 0.18594
## n-g 2.033333e+01 -24.2681036 64.9347703 0.36162
## o-g -1.000000e+00 -45.6014369 43.6014369 0.96401
## p-g 2.800000e+01 -16.6014369 72.6014369 0.21131
## q-g 1.266667e+01 -31.9347703 57.2681036 0.56848
## r-g 3.000000e+01 -14.6014369 74.6014369 0.18116
## s-g 1.533333e+01 -29.2681036 59.9347703 0.49042
## t-g -1.700000e+01 -61.6014369 27.6014369 0.44485
## i-h 3.100000e+01 -13.6014369 75.6014369 0.16739
## j-h 3.600000e+01 -8.6014369 80.6014369 0.11044
## k-h -3.433333e+01 -78.9347703 10.2681036 0.12734
## l-h -1.633333e+01 -60.9347703 28.2681036 0.46277
## m-h 1.233333e+01 -32.2681036 56.9347703 0.57866
## n-h 3.000000e+00 -41.6014369 47.6014369 0.89233
## o-h -1.833333e+01 -62.9347703 26.2681036 0.41027
## p-h 1.066667e+01 -33.9347703 55.2681036 0.63083
## q-h -4.666667e+00 -49.2681036 39.9347703 0.83327
## r-h 1.266667e+01 -31.9347703 57.2681036 0.56848
## s-h -2.000000e+00 -46.6014369 42.6014369 0.92810
## t-h -3.433333e+01 -78.9347703 10.2681036 0.12734
## j-i 5.000000e+00 -39.6014369 49.6014369 0.82156
## k-i -6.533333e+01 -109.9347703 -20.7318964 0.00523 **
## l-i -4.733333e+01 -91.9347703 -2.7318964 0.03813 *
## m-i -1.866667e+01 -63.2681036 25.9347703 0.40189
## n-i -2.800000e+01 -72.6014369 16.6014369 0.21131
## o-i -4.933333e+01 -93.9347703 -4.7318964 0.03110 *
## p-i -2.033333e+01 -64.9347703 24.2681036 0.36162
## q-i -3.566667e+01 -80.2681036 8.9347703 0.11366
## r-i -1.833333e+01 -62.9347703 26.2681036 0.41027
## s-i -3.300000e+01 -77.6014369 11.6014369 0.14232
## t-i -6.533333e+01 -109.9347703 -20.7318964 0.00523 **
## k-j -7.033333e+01 -114.9347703 -25.7318964 0.00286 **
## l-j -5.233333e+01 -96.9347703 -7.7318964 0.02271 *
## m-j -2.366667e+01 -68.2681036 20.9347703 0.28927
## n-j -3.300000e+01 -77.6014369 11.6014369 0.14232
## o-j -5.433333e+01 -98.9347703 -9.7318964 0.01832 *
## p-j -2.533333e+01 -69.9347703 19.2681036 0.25717
## q-j -4.066667e+01 -85.2681036 3.9347703 0.07269 .
## r-j -2.333333e+01 -67.9347703 21.2681036 0.29601
## s-j -3.800000e+01 -82.6014369 6.6014369 0.09264 .
## t-j -7.033333e+01 -114.9347703 -25.7318964 0.00286 **
## l-k 1.800000e+01 -26.6014369 62.6014369 0.41875
## m-k 4.666667e+01 2.0652297 91.2681036 0.04077 *
## n-k 3.733333e+01 -7.2681036 81.9347703 0.09828 .

```

```

## o-k 1.600000e+01 -28.6014369 60.6014369 0.47188
## p-k 4.500000e+01 0.3985631 89.6014369 0.04809 *
## q-k 2.966667e+01 -14.9347703 74.2681036 0.18594
## r-k 4.700000e+01 2.3985631 91.6014369 0.03944 *
## s-k 3.233333e+01 -12.2681036 76.9347703 0.15032
## t-k 2.842171e-14 -44.6014369 44.6014369 1.00000
## m-l 2.866667e+01 -15.9347703 73.2681036 0.20086
## n-l 1.933333e+01 -25.2681036 63.9347703 0.38545
## o-l -2.000000e+00 -46.6014369 42.6014369 0.92810
## p-l 2.700000e+01 -17.6014369 71.6014369 0.22773
## q-l 1.166667e+01 -32.9347703 56.2681036 0.59928
## r-l 2.900000e+01 -15.6014369 73.6014369 0.19579
## s-l 1.433333e+01 -30.2681036 58.9347703 0.51898
## t-l -1.800000e+01 -62.6014369 26.6014369 0.41875
## n-m -9.333333e+00 -53.9347703 35.2681036 0.67402
## o-m -3.066667e+01 -75.2681036 13.9347703 0.17189
## p-m -1.666667e+00 -46.2681036 42.9347703 0.94005
## q-m -1.700000e+01 -61.6014369 27.6014369 0.44485
## r-m 3.333333e-01 -44.2681036 44.9347703 0.98800
## s-m -1.433333e+01 -58.9347703 30.2681036 0.51898
## t-m -4.666667e+01 -91.2681036 -2.0652297 0.04077 *
## o-n -2.133333e+01 -65.9347703 23.2681036 0.33876
## p-n 7.666667e+00 -36.9347703 52.2681036 0.72960
## q-n -7.666667e+00 -52.2681036 36.9347703 0.72960
## r-n 9.666667e+00 -34.9347703 54.2681036 0.66311
## s-n -5.000000e+00 -49.6014369 39.6014369 0.82156
## t-n -3.733333e+01 -81.9347703 7.2681036 0.09828 .
## p-o 2.900000e+01 -15.6014369 73.6014369 0.19579
## q-o 1.366667e+01 -30.9347703 58.2681036 0.53850
## r-o 3.100000e+01 -13.6014369 75.6014369 0.16739
## s-o 1.633333e+01 -28.2681036 60.9347703 0.46277
## t-o -1.600000e+01 -60.6014369 28.6014369 0.47188
## q-p -1.533333e+01 -59.9347703 29.2681036 0.49042
## r-p 2.000000e+00 -42.6014369 46.6014369 0.92810
## s-p -1.266667e+01 -57.2681036 31.9347703 0.56848
## t-p -4.500000e+01 -89.6014369 -0.3985631 0.04809 *
## r-q 1.733333e+01 -27.2681036 61.9347703 0.43604
## s-q 2.666667e+00 -41.9347703 47.2681036 0.90423
## t-q -2.966667e+01 -74.2681036 14.9347703 0.18594
## s-r -1.466667e+01 -59.2681036 29.9347703 0.50936
## t-r -4.700000e+01 -91.6014369 -2.3985631 0.03944 *
## t-s -3.233333e+01 -76.9347703 12.2681036 0.15032
##
## $product
## diff lwr.ci upr.ci pval
## 493-298 18.28889 -1.65748 38.23526 0.0712 .
## 649-298 -11.88889 -31.83526 8.05748 0.2348
## 937-298 -43.37778 -63.32415 -23.43141 8.7e-05 ***
## 649-493 -30.17778 -50.12415 -10.23141 0.0040 **
## 937-493 -61.66667 -81.61304 -41.72030 2.8e-07 ***
## 937-649 -31.48889 -51.43526 -11.54252 0.0028 **
##
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
#Comparing means using Tukey HSD
```

```
PostHocTest(appletaste.aov, method="hsd")
```

```
##
##   Posthoc multiple comparisons of means : Tukey HSD
##   95% family-wise confidence level
##
## $panelist
##      diff      lwr.ci      upr.ci    pval
## b-a -4.100000e+01 -124.83343  42.833427 0.9312
## c-a  5.000000e+00  -78.83343  88.833427 1.0000
## d-a -2.500000e+01 -108.83343  58.833427 0.9997
## e-a -2.633333e+01 -110.16676  57.500094 0.9994
## f-a -3.466667e+01 -118.50009  49.166760 0.9850
## g-a -6.033333e+01 -144.16676  23.500094 0.4312
## h-a -4.300000e+01 -126.83343  40.833427 0.9008
## i-a -1.200000e+01  -95.83343  71.833427 1.0000
## j-a -7.000000e+00  -90.83343  76.833427 1.0000
## k-a -7.733333e+01 -161.16676   6.500094 0.1002
## l-a -5.933333e+01 -143.16676  24.500094 0.4603
## m-a -3.066667e+01 -114.50009  53.166760 0.9960
## n-a -4.000000e+01 -123.83343  43.833427 0.9438
## o-a -6.133333e+01 -145.16676  22.500094 0.4029
## p-a -3.233333e+01 -116.16676  51.500094 0.9928
## q-a -4.766667e+01 -131.50009  36.166760 0.8023
## r-a -3.033333e+01 -114.16676  53.500094 0.9965
## s-a -4.500000e+01 -128.83343  38.833427 0.8631
## t-a -7.733333e+01 -161.16676   6.500094 0.1002
## c-b  4.600000e+01  -37.83343 129.833427 0.8416
## d-b  1.600000e+01  -67.83343  99.833427 1.0000
## e-b  1.466667e+01  -69.16676  98.500094 1.0000
## f-b  6.333333e+00  -77.50009  90.166760 1.0000
## g-b -1.933333e+01 -103.16676  64.500094 1.0000
## h-b -2.000000e+00  -85.83343  81.833427 1.0000
## i-b  2.900000e+01  -54.83343 112.833427 0.9980
## j-b  3.400000e+01  -49.83343 117.833427 0.9877
## k-b -3.633333e+01 -120.16676  47.500094 0.9762
## l-b -1.833333e+01 -102.16676  65.500094 1.0000
## m-b  1.033333e+01  -73.50009  94.166760 1.0000
## n-b  1.000000e+00  -82.83343  84.833427 1.0000
## o-b -2.033333e+01 -104.16676  63.500094 1.0000
## p-b  8.666667e+00  -75.16676  92.500094 1.0000
## q-b -6.666667e+00  -90.50009  77.166760 1.0000
## r-b  1.066667e+01  -73.16676  94.500094 1.0000
## s-b -4.000000e+00  -87.83343  79.833427 1.0000
## t-b -3.633333e+01 -120.16676  47.500094 0.9762
## d-c -3.000000e+01 -113.83343  53.833427 0.9969
## e-c -3.133333e+01 -115.16676  52.500094 0.9949
## f-c -3.966667e+01 -123.50009  44.166760 0.9476
## g-c -6.533333e+01 -149.16676  18.500094 0.2996
## h-c -4.800000e+01 -131.83343  35.833427 0.7939
## i-c -1.700000e+01 -100.83343  66.833427 1.0000
## j-c -1.200000e+01  -95.83343  71.833427 1.0000
```

```

## k-c -8.233333e+01 -166.16676 1.500094 0.0590 .
## l-c -6.433333e+01 -148.16676 19.500094 0.3238
## m-c -3.566667e+01 -119.50009 48.166760 0.9801
## n-c -4.500000e+01 -128.83343 38.833427 0.8631
## o-c -6.633333e+01 -150.16676 17.500094 0.2766
## p-c -3.733333e+01 -121.16676 46.500094 0.9693
## q-c -5.266667e+01 -136.50009 31.166760 0.6630
## r-c -3.533333e+01 -119.16676 48.500094 0.9819
## s-c -5.000000e+01 -133.83343 33.833427 0.7405
## t-c -8.233333e+01 -166.16676 1.500094 0.0590 .
## e-d -1.333333e+00 -85.16676 82.500094 1.0000
## f-d -9.666667e+00 -93.50009 74.166760 1.0000
## g-d -3.533333e+01 -119.16676 48.500094 0.9819
## h-d -1.800000e+01 -101.83343 65.833427 1.0000
## i-d 1.300000e+01 -70.83343 96.833427 1.0000
## j-d 1.800000e+01 -65.83343 101.833427 1.0000
## k-d -5.233333e+01 -136.16676 31.500094 0.6730
## l-d -3.433333e+01 -118.16676 49.500094 0.9864
## m-d -5.666667e+00 -89.50009 78.166760 1.0000
## n-d -1.500000e+01 -98.83343 68.833427 1.0000
## o-d -3.633333e+01 -120.16676 47.500094 0.9762
## p-d -7.333333e+00 -91.16676 76.500094 1.0000
## q-d -2.266667e+01 -106.50009 61.166760 0.9999
## r-d -5.333333e+00 -89.16676 78.500094 1.0000
## s-d -2.000000e+01 -103.83343 63.833427 1.0000
## t-d -5.233333e+01 -136.16676 31.500094 0.6730
## f-e -8.333333e+00 -92.16676 75.500094 1.0000
## g-e -3.400000e+01 -117.83343 49.833427 0.9877
## h-e -1.666667e+01 -100.50009 67.166760 1.0000
## i-e 1.433333e+01 -69.50009 98.166760 1.0000
## j-e 1.933333e+01 -64.50009 103.166760 1.0000
## k-e -5.100000e+01 -134.83343 32.833427 0.7121
## l-e -3.300000e+01 -116.83343 50.833427 0.9910
## m-e -4.333333e+00 -88.16676 79.500094 1.0000
## n-e -1.366667e+01 -97.50009 70.166760 1.0000
## o-e -3.500000e+01 -118.83343 48.833427 0.9835
## p-e -6.000000e+00 -89.83343 77.833427 1.0000
## q-e -2.133333e+01 -105.16676 62.500094 1.0000
## r-e -4.000000e+00 -87.83343 79.833427 1.0000
## s-e -1.866667e+01 -102.50009 65.166760 1.0000
## t-e -5.100000e+01 -134.83343 32.833427 0.7121
## g-f -2.566667e+01 -109.50009 58.166760 0.9996
## h-f -8.333333e+00 -92.16676 75.500094 1.0000
## i-f 2.266667e+01 -61.16676 106.500094 0.9999
## j-f 2.766667e+01 -56.16676 111.500094 0.9989
## k-f -4.266667e+01 -126.50009 41.166760 0.9063
## l-f -2.466667e+01 -108.50009 59.166760 0.9997
## m-f 4.000000e+00 -79.83343 87.833427 1.0000
## n-f -5.333333e+00 -89.16676 78.500094 1.0000
## o-f -2.666667e+01 -110.50009 57.166760 0.9993
## p-f 2.333333e+00 -81.50009 86.166760 1.0000
## q-f -1.300000e+01 -96.83343 70.833427 1.0000
## r-f 4.333333e+00 -79.50009 88.166760 1.0000
## s-f -1.033333e+01 -94.16676 73.500094 1.0000

```

```

## t-f -4.266667e+01 -126.50009 41.166760 0.9063
## h-g 1.733333e+01 -66.50009 101.166760 1.0000
## i-g 4.833333e+01 -35.50009 132.166760 0.7853
## j-g 5.333333e+01 -30.50009 137.166760 0.6428
## k-g -1.700000e+01 -100.83343 66.833427 1.0000
## l-g 1.000000e+00 -82.83343 84.833427 1.0000
## m-g 2.966667e+01 -54.16676 113.500094 0.9973
## n-g 2.033333e+01 -63.50009 104.166760 1.0000
## o-g -1.000000e+00 -84.83343 82.833427 1.0000
## p-g 2.800000e+01 -55.83343 111.833427 0.9987
## q-g 1.266667e+01 -71.16676 96.500094 1.0000
## r-g 3.000000e+01 -53.83343 113.833427 0.9969
## s-g 1.533333e+01 -68.50009 99.166760 1.0000
## t-g -1.700000e+01 -100.83343 66.833427 1.0000
## i-h 3.100000e+01 -52.83343 114.833427 0.9955
## j-h 3.600000e+01 -47.83343 119.833427 0.9782
## k-h -3.433333e+01 -118.16676 49.500094 0.9864
## l-h -1.633333e+01 -100.16676 67.500094 1.0000
## m-h 1.233333e+01 -71.50009 96.166760 1.0000
## n-h 3.000000e+00 -80.83343 86.833427 1.0000
## o-h -1.833333e+01 -102.16676 65.500094 1.0000
## p-h 1.066667e+01 -73.16676 94.500094 1.0000
## q-h -4.666667e+00 -88.50009 79.166760 1.0000
## r-h 1.266667e+01 -71.16676 96.500094 1.0000
## s-h -2.000000e+00 -85.83343 81.833427 1.0000
## t-h -3.433333e+01 -118.16676 49.500094 0.9864
## j-i 5.000000e+00 -78.83343 88.833427 1.0000
## k-i -6.533333e+01 -149.16676 18.500094 0.2996
## l-i -4.733333e+01 -131.16676 36.500094 0.8105
## m-i -1.866667e+01 -102.50009 65.166760 1.0000
## n-i -2.800000e+01 -111.83343 55.833427 0.9987
## o-i -4.933333e+01 -133.16676 34.500094 0.7588
## p-i -2.033333e+01 -104.16676 63.500094 1.0000
## q-i -3.566667e+01 -119.50009 48.166760 0.9801
## r-i -1.833333e+01 -102.16676 65.500094 1.0000
## s-i -3.300000e+01 -116.83343 50.833427 0.9910
## t-i -6.533333e+01 -149.16676 18.500094 0.2996
## k-j -7.033333e+01 -154.16676 13.500094 0.1965
## l-j -5.233333e+01 -136.16676 31.500094 0.6730
## m-j -2.366667e+01 -107.50009 60.166760 0.9999
## n-j -3.300000e+01 -116.83343 50.833427 0.9910
## o-j -5.433333e+01 -138.16676 29.500094 0.6123
## p-j -2.533333e+01 -109.16676 58.500094 0.9996
## q-j -4.066667e+01 -124.50009 43.166760 0.9356
## r-j -2.333333e+01 -107.16676 60.500094 0.9999
## s-j -3.800000e+01 -121.83343 45.833427 0.9639
## t-j -7.033333e+01 -154.16676 13.500094 0.1965
## l-k 1.800000e+01 -65.83343 101.833427 1.0000
## m-k 4.666667e+01 -37.16676 130.500094 0.8264
## n-k 3.733333e+01 -46.50009 121.166760 0.9693
## o-k 1.600000e+01 -67.83343 99.833427 1.0000
## p-k 4.500000e+01 -38.83343 128.833427 0.8631
## q-k 2.966667e+01 -54.16676 113.500094 0.9973
## r-k 4.700000e+01 -36.83343 130.833427 0.8185

```

```

## s-k 3.233333e+01 -51.50009 116.166760 0.9928
## t-k 2.842171e-14 -83.83343 83.833427 1.0000
## m-l 2.866667e+01 -55.16676 112.500094 0.9982
## n-l 1.933333e+01 -64.50009 103.166760 1.0000
## o-l -2.000000e+00 -85.83343 81.833427 1.0000
## p-l 2.700000e+01 -56.83343 110.833427 0.9992
## q-l 1.166667e+01 -72.16676 95.500094 1.0000
## r-l 2.900000e+01 -54.83343 112.833427 0.9980
## s-l 1.433333e+01 -69.50009 98.166760 1.0000
## t-l -1.800000e+01 -101.83343 65.833427 1.0000
## n-m -9.333333e+00 -93.16676 74.500094 1.0000
## o-m -3.066667e+01 -114.50009 53.166760 0.9960
## p-m -1.666667e+00 -85.50009 82.166760 1.0000
## q-m -1.700000e+01 -100.83343 66.833427 1.0000
## r-m 3.333333e-01 -83.50009 84.166760 1.0000
## s-m -1.433333e+01 -98.16676 69.500094 1.0000
## t-m -4.666667e+01 -130.50009 37.166760 0.8264
## o-n -2.133333e+01 -105.16676 62.500094 1.0000
## p-n 7.666667e+00 -76.16676 91.500094 1.0000
## q-n -7.666667e+00 -91.50009 76.166760 1.0000
## r-n 9.666667e+00 -74.16676 93.500094 1.0000
## s-n -5.000000e+00 -88.83343 78.833427 1.0000
## t-n -3.733333e+01 -121.16676 46.500094 0.9693
## p-o 2.900000e+01 -54.83343 112.833427 0.9980
## q-o 1.366667e+01 -70.16676 97.500094 1.0000
## r-o 3.100000e+01 -52.83343 114.833427 0.9955
## s-o 1.633333e+01 -67.50009 100.166760 1.0000
## t-o -1.600000e+01 -99.83343 67.833427 1.0000
## q-p -1.533333e+01 -99.16676 68.500094 1.0000
## r-p 2.000000e+00 -81.83343 85.833427 1.0000
## s-p -1.266667e+01 -96.50009 71.166760 1.0000
## t-p -4.500000e+01 -128.83343 38.833427 0.8631
## r-q 1.733333e+01 -66.50009 101.166760 1.0000
## s-q 2.666667e+00 -81.16676 86.500094 1.0000
## t-q -2.966667e+01 -113.50009 54.166760 0.9973
## s-r -1.466667e+01 -98.50009 69.166760 1.0000
## t-r -4.700000e+01 -130.83343 36.833427 0.8185
## t-s -3.233333e+01 -116.16676 51.500094 0.9928
##
## $product
##      diff      lwr.ci      upr.ci      pval
## 493-298 18.28889 -8.189782 44.767560 0.26354
## 649-298 -11.88889 -38.367560 14.589782 0.62596
## 937-298 -43.37778 -69.856449 -16.899107 0.00048 ***
## 649-493 -30.17778 -56.656449 -3.699107 0.02020 *
## 937-493 -61.66667 -88.145337 -35.187996 1.6e-06 ***
## 937-649 -31.48889 -57.967560 -5.010218 0.01438 *
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```