Two Way ANOVA

Hugo Toledo-Alvarado

Create Dataframe

```
gain<-data.frame(vitI=c("1","1","1","1","1",
                        "1","1","1","1","1",
                        "2","2","2","2","2",
                        "2","2","2","2","2"),
                 vitII=c("1","1","1","1","1",
                         "2","2","2","2","2",
                         "1","1","1","1","1",
                         "2","2","2","2","2"),
                 gain=c(0.585,0.536,0.458,0.486,0.536,
                        0.567,0.545,0.589,0.536,0.549,
                        0.473,0.450,0.869,0.473,0.464,
                        0.684,0.702,0.900,0.698,0.693),
                 stringsAsFactors = TRUE)

print(gain) #See the Data
```

```
##    vitI vitII  gain
## 1     1     1 0.585
## 2     1     1 0.536
## 3     1     1 0.458
## 4     1     1 0.486
## 5     1     1 0.536
## 6     1     2 0.567
## 7     1     2 0.545
## 8     1     2 0.589
## 9     1     2 0.536
## 10    1     2 0.549
## 11    2     1 0.473
## 12    2     1 0.450
## 13    2     1 0.869
## 14    2     1 0.473
## 15    2     1 0.464
## 16    2     2 0.684
## 17    2     2 0.702
## 18    2     2 0.900
## 19    2     2 0.698
## 20    2     2 0.693
```

Two-Way ANOVA test

```
tm<-lm(gain ~ vitI + vitII + vitI*vitII, data = gain) # Fit the linear model
summary(tm)                              # Linear Model Summary
```

```
##
## Call:
## lm(formula = gain ~ vitI + vitII + vitI * vitII, data = gain)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.0958 -0.0541 -0.0273  0.0158  0.3232
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.52020    0.04697  11.075 6.51e-09 ***
## vitI2         0.02560    0.06642   0.385    0.705
## vitII2        0.03700    0.06642   0.557    0.585
## vitI2:vitII2  0.15260    0.09394   1.624    0.124
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.105 on 16 degrees of freedom
## Multiple R-squared:  0.4514, Adjusted R-squared:  0.3485
## F-statistic: 4.388 on 3 and 16 DF,  p-value: 0.01958
```

```
fm<-aov(gain ~ vitI + vitII + vitI*vitII, data = gain) # Fit the ANOVA
summary(fm)                              # ANOVA Table
```

```
##             Df  Sum Sq Mean Sq F value Pr(>F)
## vitI         1 0.05192 0.05192   4.707 0.0454 *
## vitII        1 0.06418 0.06418   5.819 0.0282 *
## vitI:vitII   1 0.02911 0.02911   2.639 0.1238
## Residuals   16 0.17648 0.01103
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#contrast(ref.grid(tm))
```

Least Square Means

```
library(lsmeans)
lsmeans(tm,"vitI")   #LSM for VitI
```

```
##  vitI lsmean         SE df  lower.CL  upper.CL
##  1    0.5387 0.03321178 16 0.4682942 0.6091058
##  2    0.6406 0.03321178 16 0.5701942 0.7110058
##
## Results are averaged over the levels of: vitII
## Confidence level used: 0.95
```

```
lsmeans(tm,"vitII")  #LSM for VitII
```

```
##  vitII lsmean         SE df  lower.CL  upper.CL
##  1     0.5330 0.03321178 16 0.4625942 0.6034058
##  2     0.6463 0.03321178 16 0.5758942 0.7167058
##
## Results are averaged over the levels of: vitI
## Confidence level used: 0.95
```

```
summary(ref.grid(tm))#This is the reference grid of the model
```

```
##  vitI vitII prediction         SE df
##  1    1         0.5202 0.04696855 16
##  2    1         0.5458 0.04696855 16
##  1    2         0.5572 0.04696855 16
##  2    2         0.7354 0.04696855 16
```

```
aggregate(gain$gain, by=list(gain$vitI,gain$vitII), FUN = mean) # Means by group
```

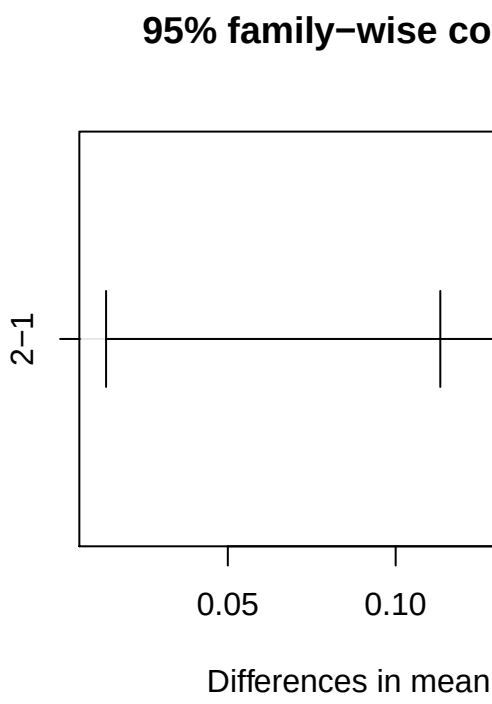
```
##   Group.1 Group.2      x
## 1       1       1 0.5202
## 2       2       1 0.5458
## 3       1       2 0.5572
## 4       2       2 0.7354
```

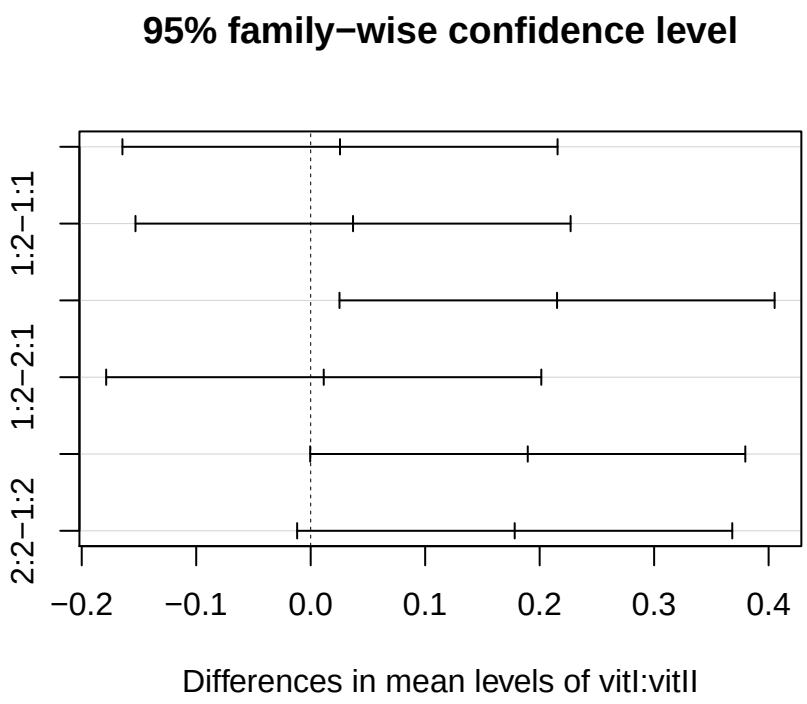
Multiple comparisons

```
TukeyHSD(fm)         # Tukey test for multiple comparisons
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = gain ~ vitI + vitII + vitI * vitII, data = gain)
##
## $vitI
##       diff         lwr       upr     p adj
## 2-1 0.1019 0.002331117 0.2014689 0.0454479
##
## $vitII
##       diff        lwr       upr     p adj
## 2-1 0.1133 0.01373112 0.2128689 0.0282222
##
## $`vitI:vitII`
##           diff           lwr       upr     p adj
## 2:1-1:1 0.0256 -0.1644391365 0.2156391 0.9798534
## 1:2-1:1 0.0370 -0.1530391365 0.2270391 0.9432622
## 2:2-1:1 0.2152  0.0251608635 0.4052391 0.0238280
## 1:2-2:1 0.0114 -0.1786391365 0.2014391 0.9981254
## 2:2-2:1 0.1896 -0.0004391365 0.3796391 0.0506375
## 2:2-1:2 0.1782 -0.0118391365 0.3682391 0.0700704
```

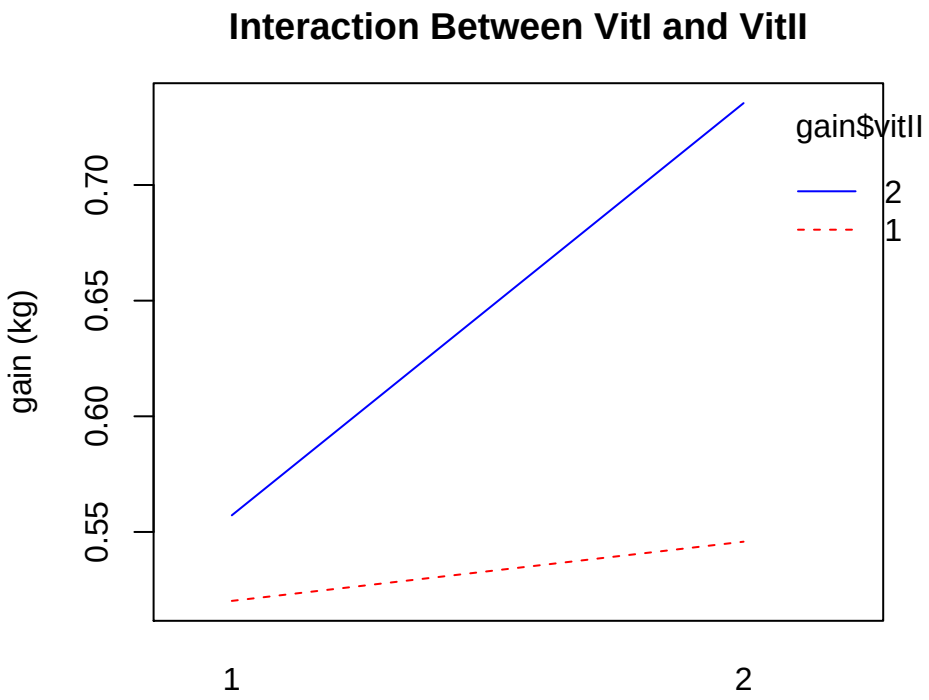
```
plot(TukeyHSD(fm))   # Plot for tukey test
```




95% family−wise confidence level
1:2−1:1
1:2−2:1
2:2−1:2
−0.2
−0.1
0.0
0.1
0.2
0.3
0.4
Differences in mean levels of vitI:vitII

Interaction Plot

```
par(mar=c(3,4,3,2)) # Change parameters for the plot margins
interaction.plot(gain$vitI,gain$vitII,response = gain$gain,
                 col=c("red","blue"),pch = c(16,18),
                 main="Interaction Between VitI and VitII",
                 ylab = "gain (kg)")
```




```
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# NOTE: With the package "HH" you can get an overview of the main factors
#install.packages("HH")
#library(HH)
#interaction2wt(gain$gain ~ gain$vitI + gain$vitII + gain$vitI*gain$vitII)
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
######################################
```