Complete Randomized Block Design: ANOVA

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Create Dataframe

```
pigs<-data.frame(trt=c("T1","T1","T1","T1","T1",
                       "T2","T2","T2","T2","T2",
                       "T3","T3","T3","T3","T3"),
                 litter=c("1","2","3","4","5",
                          "1","2","3","4","5",
                          "1","2","3","4","5"),
                 y=c(7.86,8.00,7.93,7.62,7.81,
                     7.76,7.73,7.74,7.43,7.44,
                     7.46,7.68,7.51,7.21,7.42),
                 stringsAsFactors = TRUE)
print(pigs) #See the Data
```

```
##    trt litter    y
## 1   T1      1 7.86
## 2   T1      2 8.00
## 3   T1      3 7.93
## 4   T1      4 7.62
## 5   T1      5 7.81
## 6   T2      1 7.76
## 7   T2      2 7.73
## 8   T2      3 7.74
## 9   T2      4 7.43
## 10  T2      5 7.44
## 11  T3      1 7.46
## 12  T3      2 7.68
## 13  T3      3 7.51
## 14  T3      4 7.21
## 15  T3      5 7.42
```

ANOVA test

```
tm<-lm(y ~  trt + litter, data = pigs) # Fit the linear model
summary(tm)                            # Linear Model Summary
```

```
##
## Call:
## lm(formula = y ~ trt + litter, data = pigs)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.09667 -0.03500 -0.00400  0.04033  0.08667
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  7.89733    0.04564 173.040 1.39e-15 ***
## trtT2       -0.22400    0.04225  -5.301 0.000727 ***
## trtT3       -0.38800    0.04225  -9.183 1.60e-05 ***
## litter2      0.11000    0.05455   2.017 0.078477 .
## litter3      0.03333    0.05455   0.611 0.558109
## litter4     -0.27333    0.05455  -5.011 0.001039 **
## litter5     -0.13667    0.05455  -2.505 0.036632 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.06681 on 8 degrees of freedom
## Multiple R-squared:  0.9484, Adjusted R-squared:  0.9097
## F-statistic: 24.51 on 6 and 8 DF,  p-value: 9.763e-05
```

```
fm<-aov(y ~ trt + litter, data = pigs) # Fit the ANOVA
summary(fm)                            # ANOVA Table SS I
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## trt          2 0.3794 0.18968   42.50 5.48e-05 ***
## litter       4 0.2771 0.06928   15.52 0.000771 ***
## Residuals    8 0.0357 0.00446
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

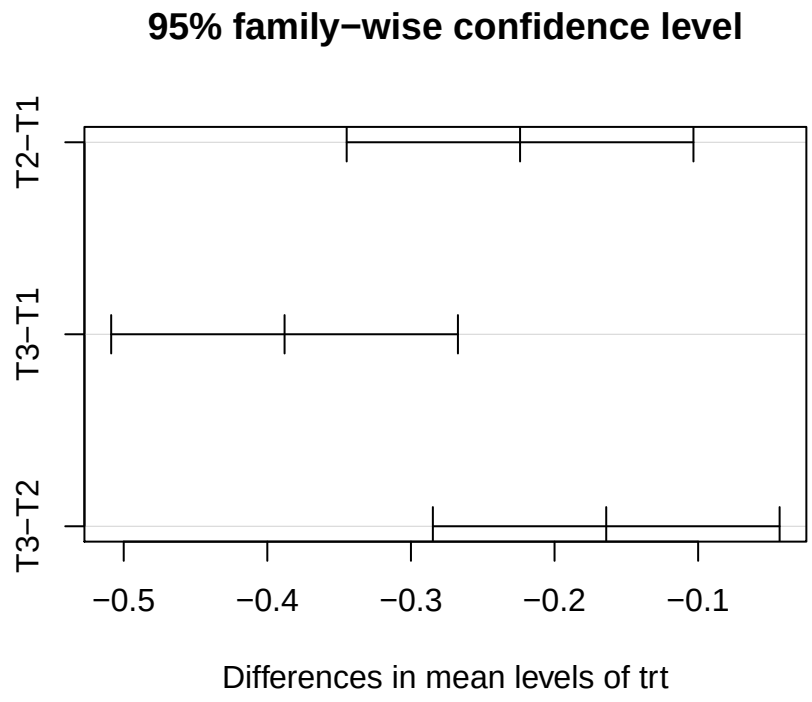
```
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
#NOTE: Compare two Models
# tm1<-lm(y ~  litter, data = pigs)
# anova(tm,tm1)
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

Multiple comparisons

```
TukeyHSD(fm,"trt")          # Tukey test for multiple comparisons
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = y ~ trt + litter, data = pigs)
##
## $trt
##         diff        lwr         upr     p adj
## T2-T1 -0.224 -0.3447362 -0.10326382 0.0018520
## T3-T1 -0.388 -0.5087362 -0.26726382 0.0000418
## T3-T2 -0.164 -0.2847362 -0.04326382 0.0115281
```

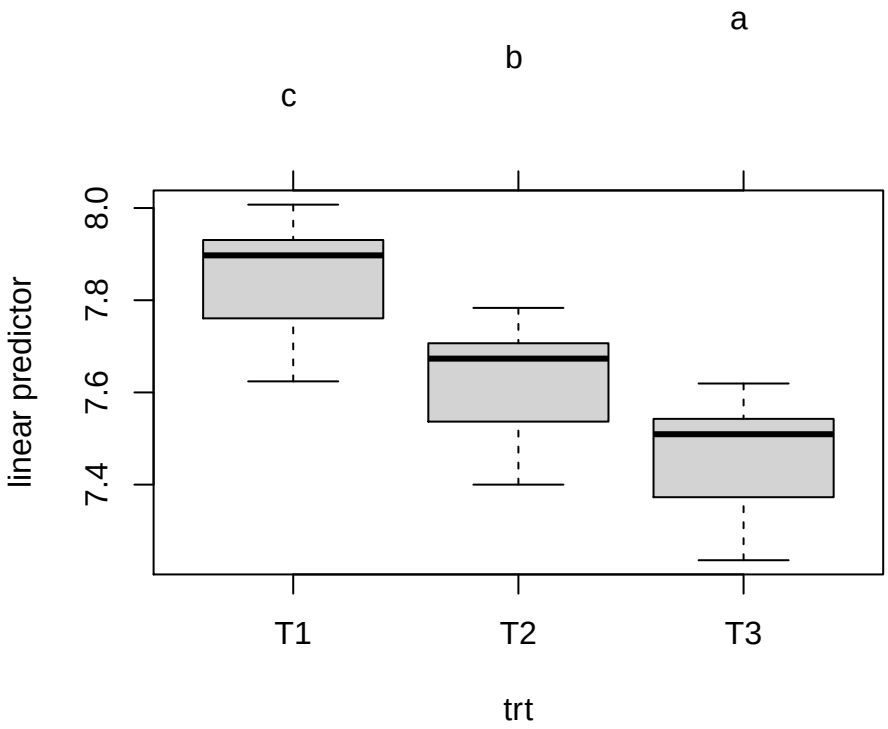
```
plot(TukeyHSD(fm,"trt"))    # Plot for tukey test
```




```
aggregate(pigs$y, by=list(pigs$trt), FUN = mean) # Means by group
```

```
##   Group.1     x
## 1      T1 7.844
## 2      T2 7.620
## 3      T3 7.456
```

```r
#install.packages("multcomp")
library(multcomp)
par(mar=c(4,4,6,2)) # Change parameters for the plot margins
tuk <- glht(fm, linfct=mcp(trt="Tukey")) # Fit the general Linear Hypotheses
plot(cld(tuk, level=0.05),col="lightgrey") # Plot the mean differences
```




```r
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# NOTE: to obtain type II and III SS use car package.
# This defines a new function, Anova(),
# which can calculate type II and III SS directly.
#library(car)
# Type II
# Anova(lm(y ~ trt + litter, data=pigs), type=2)
# Type III:
# Anova(lm(y ~ trt + litter, data=pigs, contrasts = c("contr.sum", "contr.poly")), type=3)
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```