Assignment 2 - ANOVA - Blocking

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Questions

1. What assumption must we test to include a variable as a blocking factor?
   - Kurtosis, Skewness, Normality, Independence of Observation, Variance test, and Additivity
   - Blocking technique should also help us reduce the Error
2. Recognize the IV, DV, block and create a table for the following research statement.
   - Independent Variable: Motor Skill Test (condition)
   - Dependent Variable: Performance Score (Performance_score)
   - Blocking Variable: Age Group (Age)

Specification Table

Variable	#Levels
Motor Skill Test	3
Age(Block)	3

	Test1	Test2	Test3
Age_60-69			
Age_70_79			
Age_80+			

ANOVA

Hypothesis

H_0: Performance Scores of all elderly people are equal
H_A: Performance Scores of all elderly people may not be equal

Assumptions

- From the density plot, there seems to have 2 spikes which may affect our results
- We fail to reject the null hypothesis on kurtosis test

- We fail to reject the null hypothesis from skewness test
- We fail to reject the null hypothesis in normality test
- We fail to reject the null hypothesis for variance test
- The largest to smallest ratio of variance is less than 3. Which is not enough evidence to reject the null hypothesis
- Model1 –> Condition*Age, is not a significant factor
- Model2 –> Condition, is a significant factor
- Model3 –> Age, is a significant factor
- Model4 –> Condition+Age, is cannot be a blocker, it's a significant factor
- Condition1 –> n = 28, Mean = 32.0714286, SD = 4.2854497
- Condition2 –> n = 30, Mean = 27.8666667, SD = 4.5768031
- Condition3 –> n = 31, Mean = 23.0645161, SD = 4.5529147

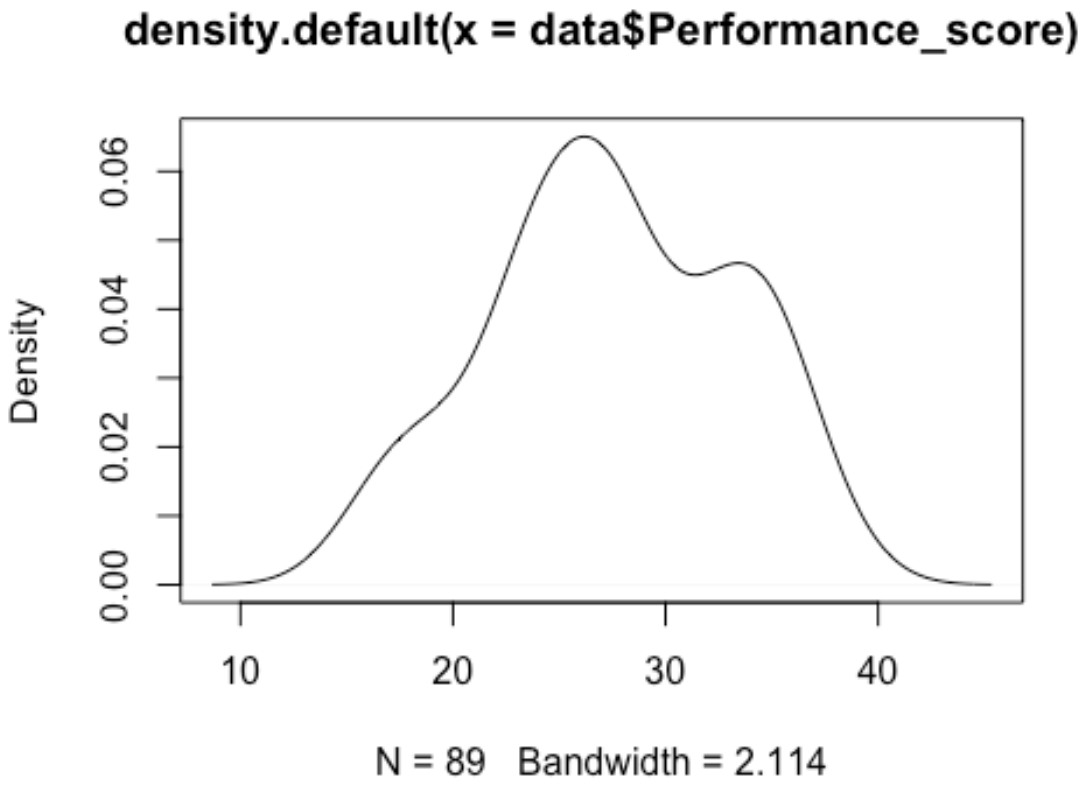
Summary

Observations from the study were analyzed by conducting a one-way analysis of variance using R version 4.0.5. First, all assumptions are met and no adjustments were made. Conditions has a significant effect on ($F(2,86)$, p-value < 0.05).
A Tukey test was performed and there was a significant difference in Task 1 and 2, also Task 2 and 3, and Task 1 and 3 (all p-values < 0.001). Cohen's D effect are too large.

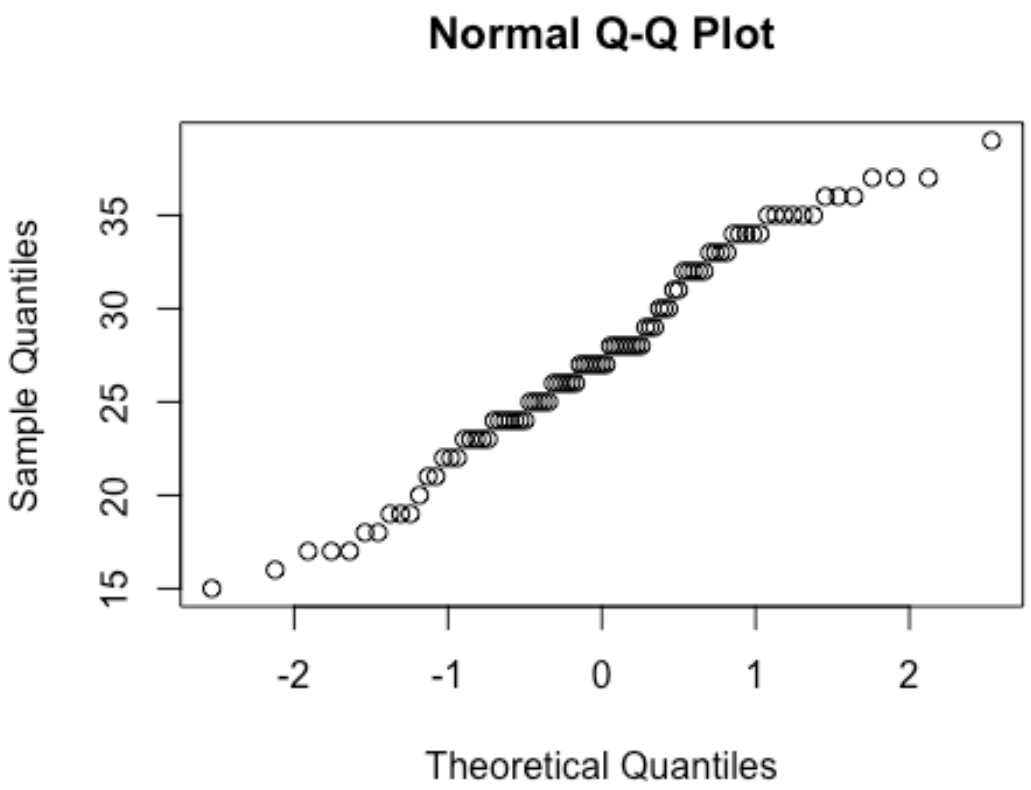
```
library(readxl)
library(moments)
library(pgirmess)
library(pastecs)
library(compute.es)

data <- read_excel("Lab3.xlsx")
summary(data)

# Denisty Plot
plot(density(data$Performance_score))
```




```
qqnorm(data$Performance_score)
```

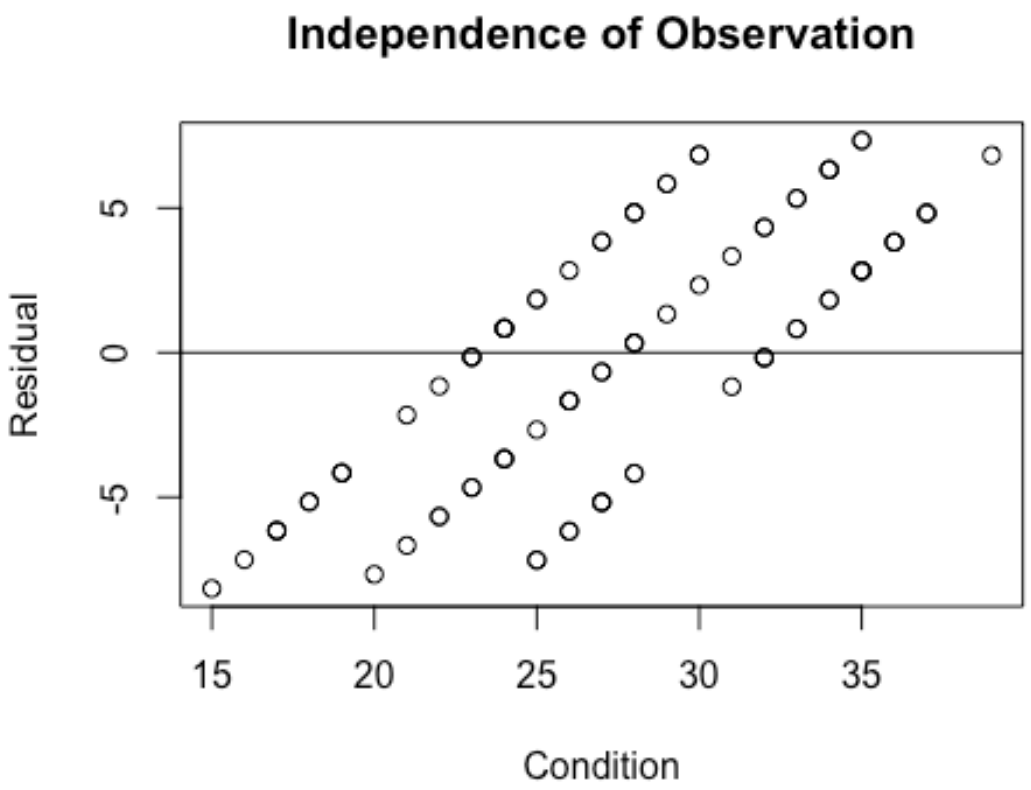



```
# Kurtosis Test
anscombe.test(data$Performance_score)

# Skewness Test
agostino.test(data$Performance_score)

# Normality Test
shapiro.test(data$Performance_score)

#Residual Plot
perf.lm = lm(Performance_score ~ Condition, data = data)
perf.res = resid(perf.lm)
plot(data$Performance_score, perf.res, ylab = "Residual", xlab = "Condition",
main = "Independence of Observation")
abline(0, 0)
```




```r
# Variance Test
bartlett.test(data$Performance_score, data$Condition)
tapply(data$Performance_score, data$Condition, var)

# ANOVA with Blocking
model1 = aov(Performance_score ~ factor(Condition)*factor(Age), data = data)
summary(model1)
model2 = aov(Performance_score ~ factor(Condition), data = data)
summary(model2)
model3 = aov(Performance_score ~ factor(Age), data = data)
summary(model3)
model4 = aov(Performance_score ~ factor(Condition)+factor(Age), data = data)
summary(model4)

anova(model1, model2)

#Pairwise t test
pairwise.t.test(data$Performance_score, data$Condition, paired = FALSE, p.adj
ust.method = "bonferroni")

#Tukey's test
TukeyHSD(model1)
```

```
by(data$Performance_score, data$Condition, stat.desc)
mes(27.8666667, 32.0714286, 4.5768031, 4.2854497, 30, 28)
mes(23.0645161, 27.8666667, 4.5529147, 4.5768031, 31, 30)
mes(23.0645161, 32.0714286, 4.5529147, 4.2854497, 31, 28)
```

```
##       Age    Performance_score   Condition
##  Min.   :1   Min.   :15.00     Min.   :1.000
##  1st Qu.:1   1st Qu.:24.00     1st Qu.:1.000
##  Median :2   Median :27.00     Median :2.000
##  Mean   :2   Mean   :27.52     Mean   :2.034
##  3rd Qu.:3   3rd Qu.:32.00     3rd Qu.:3.000
##  Max.   :3   Max.   :39.00     Max.   :3.000
##
##  Anscombe-Glynn kurtosis test
##
## data:  data$Performance_score
## kurt = 2.2365, z = -2.0554, p-value = 0.03984
## alternative hypothesis: kurtosis is not equal to 3
##
##
##  D'Agostino skewness test
##
## data:  data$Performance_score
## skew = -0.11171, z = -0.45976, p-value = 0.6457
## alternative hypothesis: data have a skewness
##
##
##  Shapiro-Wilk normality test
##
## data:  data$Performance_score
## W = 0.9755, p-value = 0.09018
##
##
##  Bartlett test of homogeneity of variances
##
## data:  data$Performance_score and data$Condition
## Bartlett's K-squared = 0.14381, df = 2, p-value = 0.9306
##
##       1        2        3
## 18.36508 20.94713 20.72903
##                               Df Sum Sq Mean Sq F value Pr(>F)
## factor(Condition)              2 1199.0   599.5 313.667 <2e-16 ***
## factor(Age)                    2 1549.6   774.8 405.389 <2e-16 ***
## factor(Condition):factor(Age)  4   22.6     5.7   2.961 0.0246 *
## Residuals                     80  152.9     1.9
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##                   Df Sum Sq Mean Sq F value  Pr(>F)
## factor(Condition)  2   1199   599.5   29.89 1.4e-10 ***
## Residuals         86   1725    20.1
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##             Df Sum Sq Mean Sq F value   Pr(>F)
## factor(Age)  2   1550   774.9   48.48 7.97e-15 ***
## Residuals   86   1374    16.0
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##                   Df Sum Sq Mean Sq F value Pr(>F)
## factor(Condition)  2 1199.0   599.5   286.9 <2e-16 ***
## factor(Age)        2 1549.6   774.8   370.8 <2e-16 ***
## Residuals         84  175.5     2.1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## Analysis of Variance Table
##
## Model 1: Performance_score ~ factor(Condition) * factor(Age)
## Model 2: Performance_score ~ factor(Condition)
##   Res.Df     RSS Df Sum of Sq     F    Pr(>F)
## 1     80  152.91
## 2     86 1725.19 -6   -1572.3 137.1 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Pairwise comparisons using t tests with pooled SD
##
## data:  data$Performance_score and data$Condition
##
##   1      2
## 2 0.0017 -
## 3 6e-11  0.0002
##
## P value adjustment method: bonferroni
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Performance_score ~ factor(Condition) * factor(Age), da
ta = data)
##
## $`factor(Condition)`
##          diff       lwr       upr p adj
## 2-1 -4.204762 -5.072310 -3.337214     0
## 3-1 -9.006912 -9.867679 -8.146146     0
## 3-2 -4.802151 -5.647707 -3.956594     0
##
## $`factor(Age)`
##           diff        lwr       upr p adj
## 2-1  -4.516166  -5.369099 -3.663233     0
## 3-1 -10.310345 -11.177377 -9.443313     0
## 3-2  -5.794179  -6.647112 -4.941246     0
##
```

```
## $`factor(Condition):factor(Age)`
##                   diff        lwr         upr     p adj
## 2:1-1:1 -2.922222e+00  -4.947474  -0.8969700 0.0005097
## 3:1-1:1 -8.022222e+00 -10.047474  -5.9969700 0.0000000
## 1:2-1:1 -2.922222e+00  -4.947474  -0.8969700 0.0005097
## 2:2-1:1 -8.722222e+00 -10.747474  -6.6969700 0.0000000
## 3:2-1:1 -1.276768e+01 -14.748843 -10.7865103 0.0000000
## 1:3-1:1 -9.666667e+00 -11.744532  -7.5888017 0.0000000
## 2:3-1:1 -1.342222e+01 -15.447474 -11.3969700 0.0000000
## 3:3-1:1 -1.872222e+01 -20.747474 -16.6969700 0.0000000
## 3:1-2:1 -5.100000e+00  -7.071236  -3.1287642 0.0000000
## 1:2-2:1  1.421085e-14  -1.971236   1.9712358 1.0000000
## 2:2-2:1 -5.800000e+00  -7.771236  -3.8287642 0.0000000
## 3:2-2:1 -9.845455e+00 -11.771369  -7.9195406 0.0000000
## 1:3-2:1 -6.744444e+00  -8.769697  -4.7191922 0.0000000
## 2:3-2:1 -1.050000e+01 -12.471236  -8.5287642 0.0000000
## 3:3-2:1 -1.580000e+01 -17.771236 -13.8287642 0.0000000
## 1:2-3:1  5.100000e+00   3.128764   7.0712358 0.0000000
## 2:2-3:1 -7.000000e-01  -2.671236   1.2712358 0.9674422
## 3:2-3:1 -4.745455e+00  -6.671369  -2.8195406 0.0000000
## 1:3-3:1 -1.644444e+00  -3.669697   0.3808078 0.2078478
## 2:3-3:1 -5.400000e+00  -7.371236  -3.4287642 0.0000000
## 3:3-3:1 -1.070000e+01 -12.671236  -8.7287642 0.0000000
## 2:2-1:2 -5.800000e+00  -7.771236  -3.8287642 0.0000000
## 3:2-1:2 -9.845455e+00 -11.771369  -7.9195406 0.0000000
## 1:3-1:2 -6.744444e+00  -8.769697  -4.7191922 0.0000000
## 2:3-1:2 -1.050000e+01 -12.471236  -8.5287642 0.0000000
## 3:3-1:2 -1.580000e+01 -17.771236 -13.8287642 0.0000000
## 3:2-2:2 -4.045455e+00  -5.971369  -2.1195406 0.0000001
## 1:3-2:2 -9.444444e-01  -2.969697   1.0808078 0.8583631
## 2:3-2:2 -4.700000e+00  -6.671236  -2.7287642 0.0000000
## 3:3-2:2 -1.000000e+01 -11.971236  -8.0287642 0.0000000
## 1:3-3:2  3.101010e+00   1.119844   5.0821766 0.0001161
## 2:3-3:2 -6.545455e-01  -2.580459   1.2713685 0.9750171
## 3:3-3:2 -5.954545e+00  -7.880459  -4.0286315 0.0000000
## 2:3-1:3 -3.755556e+00  -5.780808  -1.7303033 0.0000028
## 3:3-1:3 -9.055556e+00 -11.080808  -7.0303033 0.0000000
## 3:3-2:3 -5.300000e+00  -7.271236  -3.3287642 0.0000000
##
## data$Condition: 1
##      nbr.val     nbr.null       nbr.na          min          max        ra
nge
##   28.0000000    0.0000000    0.0000000   25.0000000   39.0000000   14.0000
000
##          sum       median         mean      SE.mean CI.mean.0.95
var
##  898.0000000   33.0000000   32.0714286    0.8098739    1.6617239   18.3650
794
##      std.dev     coef.var
##    4.2854497    0.1336220
```

```
## ------------------------------------------------------------
## data$Condition: 2
##      nbr.val     nbr.null       nbr.na          min          max        ra
nge
##   30.0000000    0.0000000    0.0000000   20.0000000   35.0000000   15.0000
000
##          sum       median         mean      SE.mean CI.mean.0.95
var
##  836.0000000   27.5000000   27.8666667    0.8356061    1.7090064   20.9471
264
##      std.dev     coef.var
##    4.5768031    0.1642393
## ------------------------------------------------------------
## data$Condition: 3
##      nbr.val     nbr.null       nbr.na          min          max        ra
nge
##   31.0000000    0.0000000    0.0000000   15.0000000   30.0000000   15.0000
000
##          sum       median         mean      SE.mean CI.mean.0.95
var
##  715.0000000   24.0000000   23.0645161    0.8177276    1.6700226   20.7290
323
##      std.dev     coef.var
##    4.5529147    0.1973991
## Mean Differences ES:
##
##  d [ 95 %CI] = -0.95 [ -1.49 , -0.4 ]
##   var(d) = 0.08
##   p-value(d) = 0
##   U3(d) = 17.17 %
##   CLES(d) = 25.15 %
##   Cliff's Delta = -0.5
##
##  g [ 95 %CI] = -0.93 [ -1.47 , -0.4 ]
##   var(g) = 0.07
##   p-value(g) = 0
##   U3(g) = 17.5 %
##   CLES(g) = 25.44 %
##
##  Correlation ES:
##
##  r [ 95 %CI] = -0.43 [ -0.62 , -0.2 ]
##   var(r) = 0.01
##   p-value(r) = 0
##
##  z [ 95 %CI] = -0.46 [ -0.73 , -0.2 ]
##   var(z) = 0.02
##   p-value(z) = 0
##
##  Odds Ratio ES:
```

```
##
##  OR [ 95 %CI] = 0.18 [ 0.07 , 0.48 ]
##   p-value(OR) = 0
##
##  Log OR [ 95 %CI] = -1.72 [ -2.7 , -0.73 ]
##   var(lOR) = 0.25
##   p-value(Log OR) = 0
##
##  Other:
##
##  NNT = -6.13
##  Total N = 58Mean Differences ES:
##
##  d [ 95 %CI] = -1.05 [ -1.59 , -0.52 ]
##   var(d) = 0.07
##   p-value(d) = 0
##   U3(d) = 14.64 %
##   CLES(d) = 22.85 %
##   Cliff's Delta = -0.54
##
##  g [ 95 %CI] = -1.04 [ -1.57 , -0.51 ]
##   var(g) = 0.07
##   p-value(g) = 0
##   U3(g) = 14.95 %
##   CLES(g) = 23.14 %
##
##  Correlation ES:
##
##  r [ 95 %CI] = -0.47 [ -0.65 , -0.25 ]
##   var(r) = 0.01
##   p-value(r) = 0
##
##  z [ 95 %CI] = -0.51 [ -0.77 , -0.25 ]
##   var(z) = 0.02
##   p-value(z) = 0
##
##  Odds Ratio ES:
##
##  OR [ 95 %CI] = 0.15 [ 0.06 , 0.39 ]
##   p-value(OR) = 0
##
##  Log OR [ 95 %CI] = -1.91 [ -2.88 , -0.94 ]
##   var(lOR) = 0.25
##   p-value(Log OR) = 0
##
##  Other:
##
##  NNT = -5.85
##  Total N = 61Mean Differences ES:
##
```

```
##  d [ 95 %CI] = -2.03 [ -2.66 , -1.4 ]
##   var(d) = 0.1
##   p-value(d) = 0
##   U3(d) = 2.1 %
##   CLES(d) = 7.52 %
##   Cliff's Delta = -0.85
##
##  g [ 95 %CI] = -2.01 [ -2.63 , -1.39 ]
##   var(g) = 0.1
##   p-value(g) = 0
##   U3(g) = 2.24 %
##   CLES(g) = 7.79 %
##
##  Correlation ES:
##
##  r [ 95 %CI] = -0.72 [ -0.82 , -0.57 ]
##   var(r) = 0
##   p-value(r) = 0
##
##  z [ 95 %CI] = -0.9 [ -1.17 , -0.64 ]
##   var(z) = 0.02
##   p-value(z) = 0
##
##  Odds Ratio ES:
##
##  OR [ 95 %CI] = 0.02 [ 0.01 , 0.08 ]
##   p-value(OR) = 0
##
##  Log OR [ 95 %CI] = -3.69 [ -4.83 , -2.55 ]
##   var(lOR) = 0.34
##   p-value(Log OR) = 0
##
##  Other:
##
##  NNT = -5.05
##  Total N = 59
```