TareaANOVA.Rmd

F. A. BarriosInstituto de Neurobiología, UNAM

2020-10-24

Outline

1

23

Chapter 8 Daniel

Solution of some examples and exercises from Daniel's book, the ANOVA chapter.

Including Code and comments

As part of the Homework we include R code in the document, and the R code will be included too.

1. Example 8.2.1

Game meats, including those from white-tailed deer and eastern gray squirrels, are used as food by families, hunters and other individuals for health, cultural, or personal reasons. A study by D Holben assessed the selenium content of the meat from free-roaming white-tailed deer (venison) and gray squirrel (squirrel) obtained from a low selenium region of the United States. These selenium content values were also compared to those of beef produced whithin and outside the same region. We want to know if the selenium levels are different in the four meat groups.

```
setwd("~/Dropbox/Fdo/ClaseStats/RegressionClass/RegressionR_code")
# Example Chap 8, One-Way ANOVA
Exa8_2=read.csv(file="DataOther/EXA_C08_S02_01.csv", header=TRUE)
summary(Exa8_2)
```

```
      VEN             SQU             RRB             NRB        
 Min.   : 8.70   Min.   : 4.55   Min.   : 9.69   Min.   :  4.45  
 1st Qu.:21.37   1st Qu.:32.00   1st Qu.:22.35   1st Qu.: 46.34  
 Median :26.30   Median :40.23   Median :28.94   Median : 66.36  
 Mean   :25.88   Mean   :43.25   Mean   :29.08   Mean   : 62.05  
 3rd Qu.:31.43   3rd Qu.:55.32   3rd Qu.:34.91   3rd Qu.: 75.79  
 Max.   :45.08   Max.   :87.50   Max.   :56.61   Max.   :139.09  
 NA's   :11      NA's   :23                      NA's   :34      
```

```
boxplot(Exa8_2)
Exa8_2.dat = stack(Exa8_2)
names(Exa8_2.dat)
```

```
[1] "values" "ind"
```

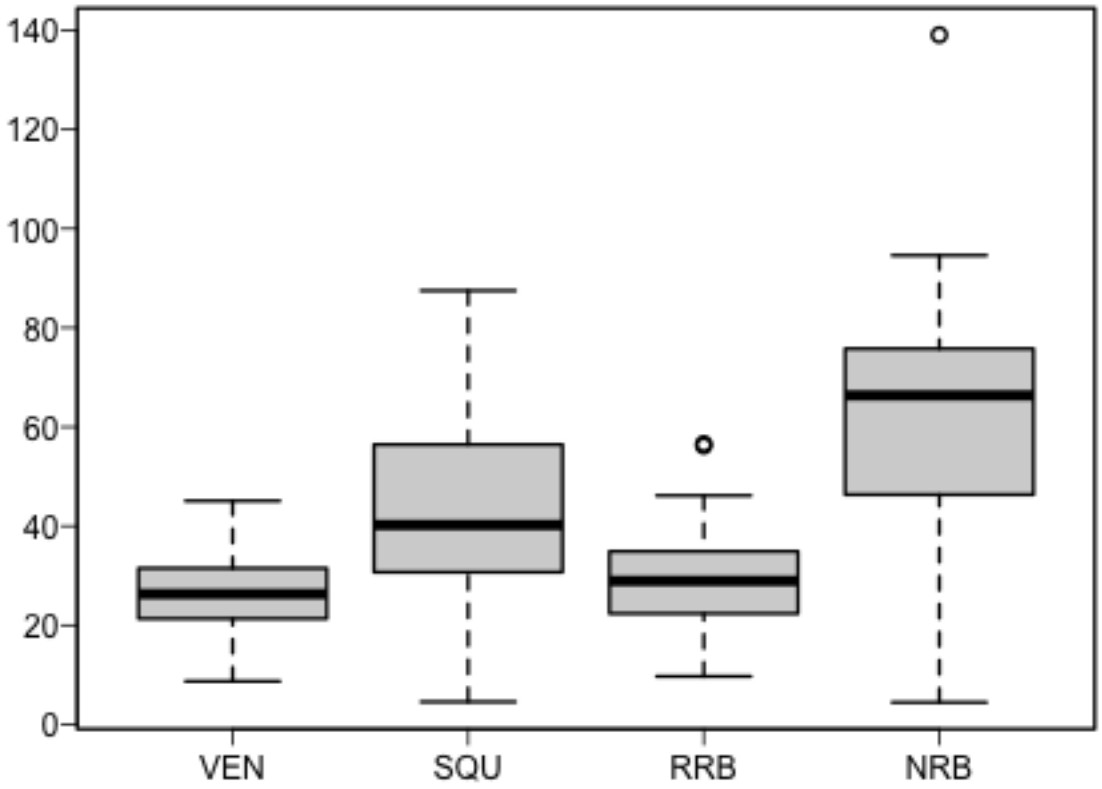
```r
Exa8_2.aov=aov(values~ind, data=Exa8_2.dat)
summary(Exa8_2.aov)
```

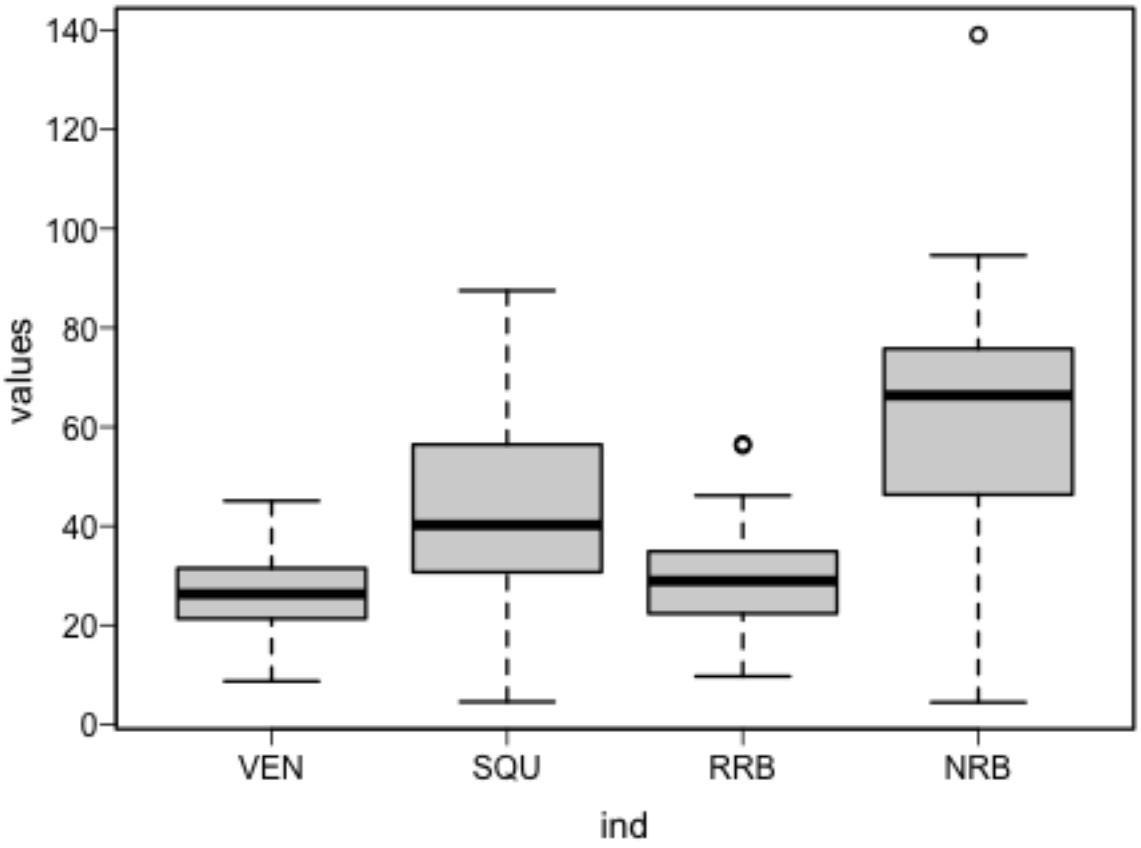
```
             Df Sum Sq Mean Sq F value   Pr(>F)
ind           3  21262    7087      27 7.68e-14 ***
Residuals   140  36747     262
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
68 observations deleted due to missingness
```

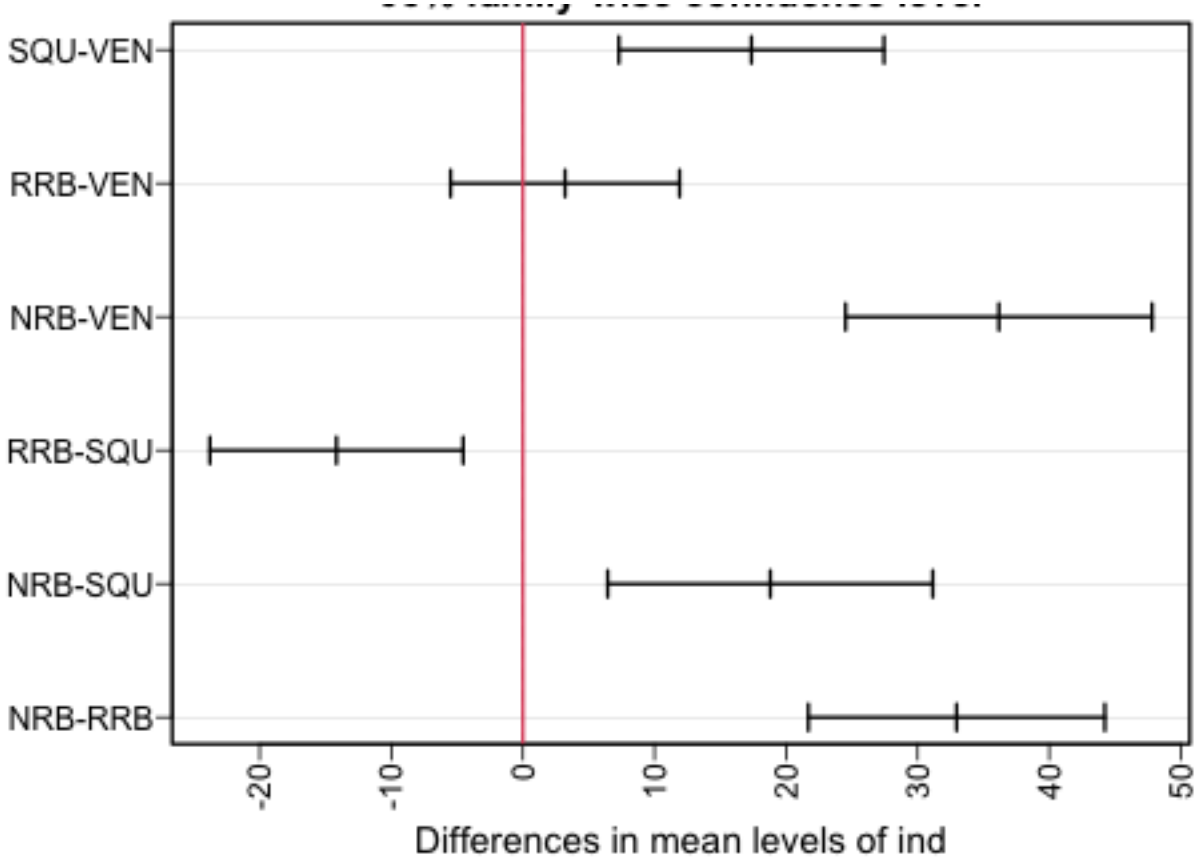
```r
# # # # # # # # # # # # # # # # # #
plot(values~ind, data=Exa8_2.dat)
TukeyHSD(Exa8_2.aov, ordered=TRUE)
```

```
  Tukey multiple comparisons of means
    95% family-wise confidence level
    factor levels have been ordered

Fit: aov(formula = values ~ ind, data = Exa8_2.dat)

$ind
             diff       lwr      upr     p adj
RRB-VEN  3.207543 -5.495016 11.91010 0.7732308
SQU-VEN 17.370190  7.300208 27.44017 0.0000881
NRB-VEN 36.170840 24.523916 47.81776 0.0000000
SQU-RRB 14.162648  4.537925 23.78737 0.0011105
NRB-RRB 32.963297 21.699125 44.22747 0.0000000
NRB-SQU 18.800649  6.449472 31.15183 0.0006857
```

```r
plot(TukeyHSD(Exa8_2.aov), las=2)
abline(v=0, col=2)
```

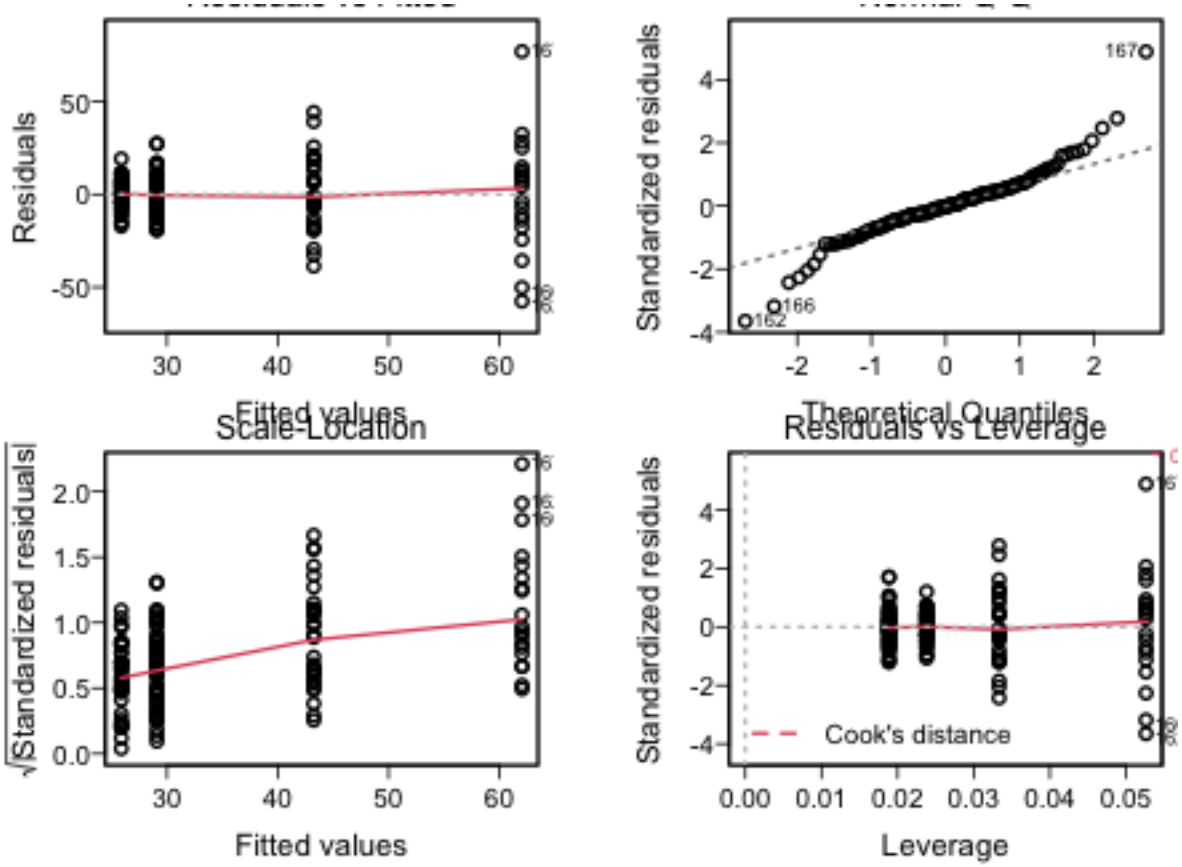

140
120
100
80
60
40
20
0
VEN
SQU
RRB
NRB


140
120
100
80
60
40
20
0
values
VEN
SQU
RRB
NRB
ind



Including Plots

Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot. You can also plot on different quadrants, for example:



2. Example 8.3.1

A physical therapist wishe to compare three methods for patients to use a certain prosthetic device. He felt that the rate of learing would be different for patients of different ages and wished to design an experiment in which the ifluence of age could be taken into account. Data. Three patients in each of the five age groups were selected to partipate in the experiment, and one patient in each age group was randomly assigned to each of the teaching methods. The methods of instruction constitute our three treatments, and the five gorups are the blocks. (The section 2 of the ANOVA chapter in Daniel's book is for a two-way ANOVA. The data for this example is not loadable from a data file provided by the site of the book. Nevertheless, we will make a table copying the data directly, which is not large, form the text.

```
# Build a table, index by index since
# Two-Way ANOVA EXAMPLE 8.3.1 has NO-data file
# Therefore we make the example table.
#
Age=factor(rep(c(1,2,3,4,5), 3))
Age
```

```
 [1] 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
Levels: 1 2 3 4 5
```

```
Method=factor(rep(1:3,c(5,5,5)))
Method
```

```
 [1] 1 1 1 1 1 2 2 2 2 2 3 3 3 3 3
Levels: 1 2 3
```

```r
levels(Method)=letters[1:3]
Method
```

```
 [1] a a a a a b b b b b c c c c c
Levels: a b c
```

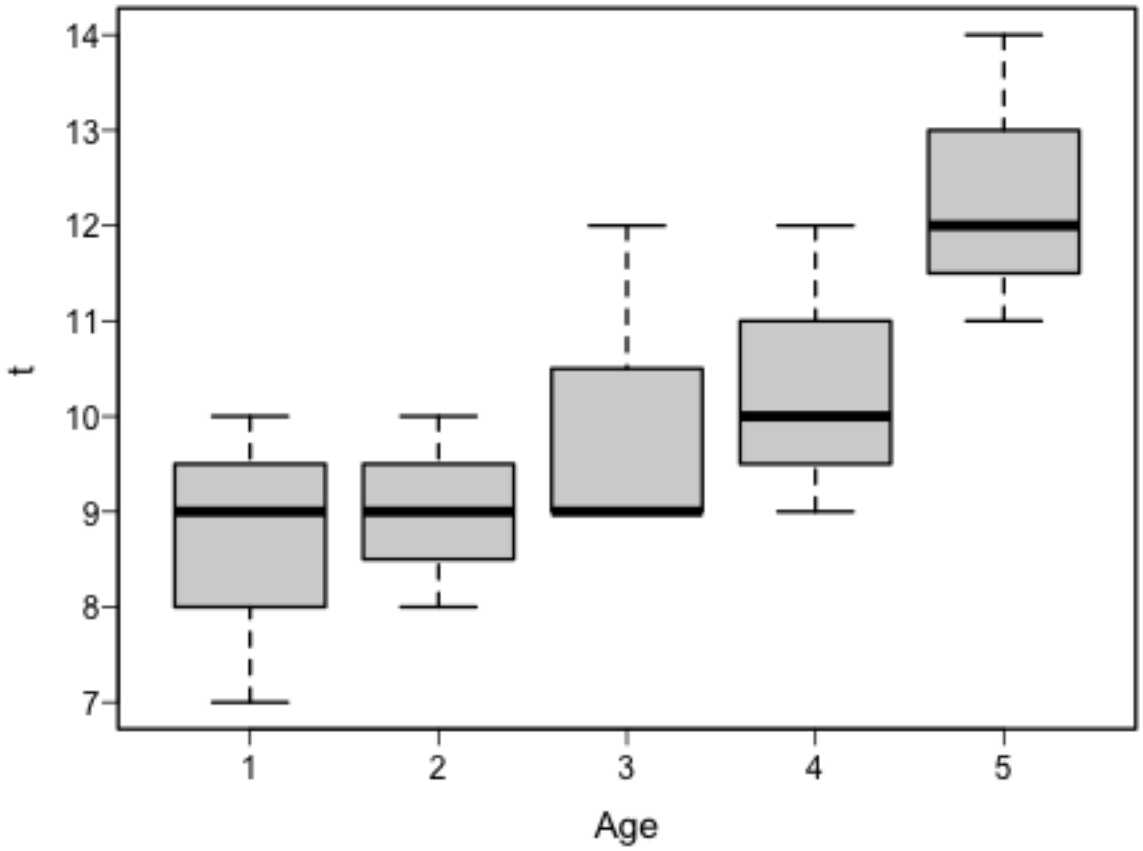
```r
t = c(7,8,9,10,11,9,9,9,9,12,10,10,12,12,14)
#
plot(t ~ Age + Method)
# now the ANOVA model
t_aov = aov(t ~ Method + Age)
summary(t_aov)
```

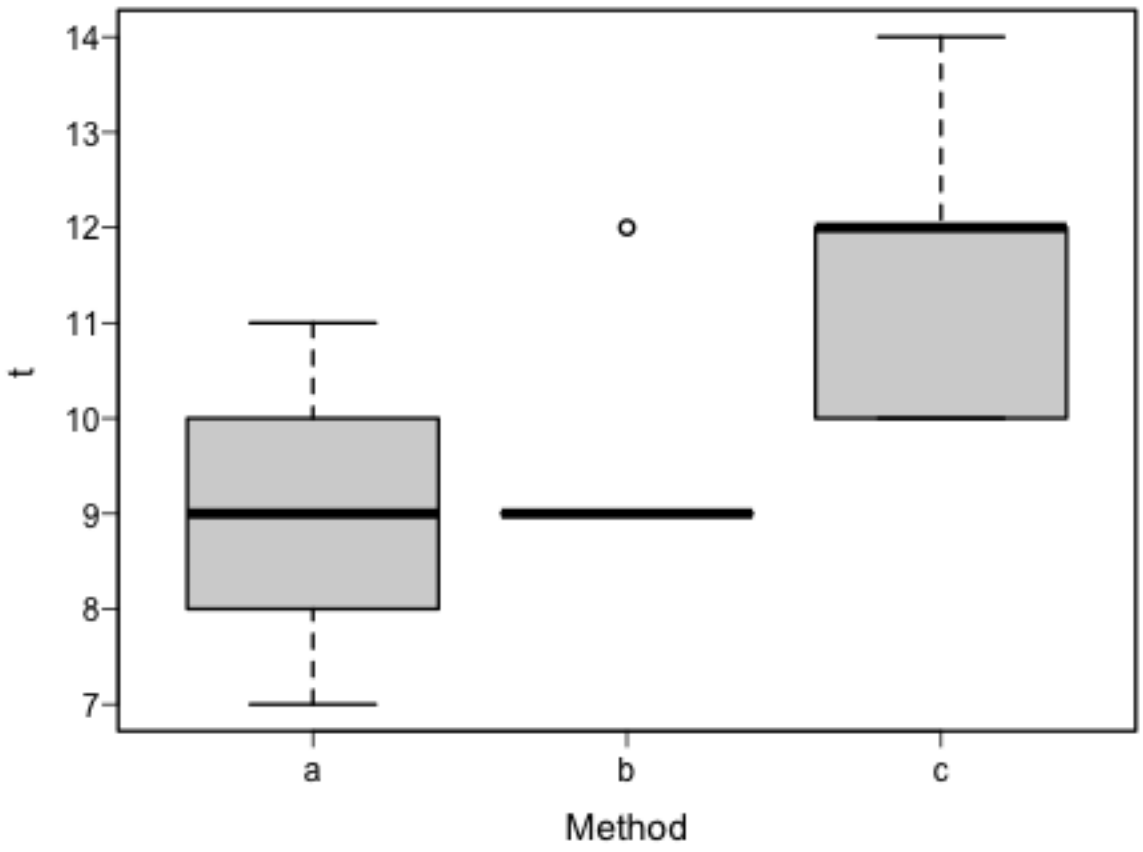
```
            Df Sum Sq Mean Sq F value   Pr(>F)
Method       2 18.533   9.267   21.39 0.000617 ***
Age          4 24.933   6.233   14.38 0.001002 **
Residuals    8  3.467   0.433
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

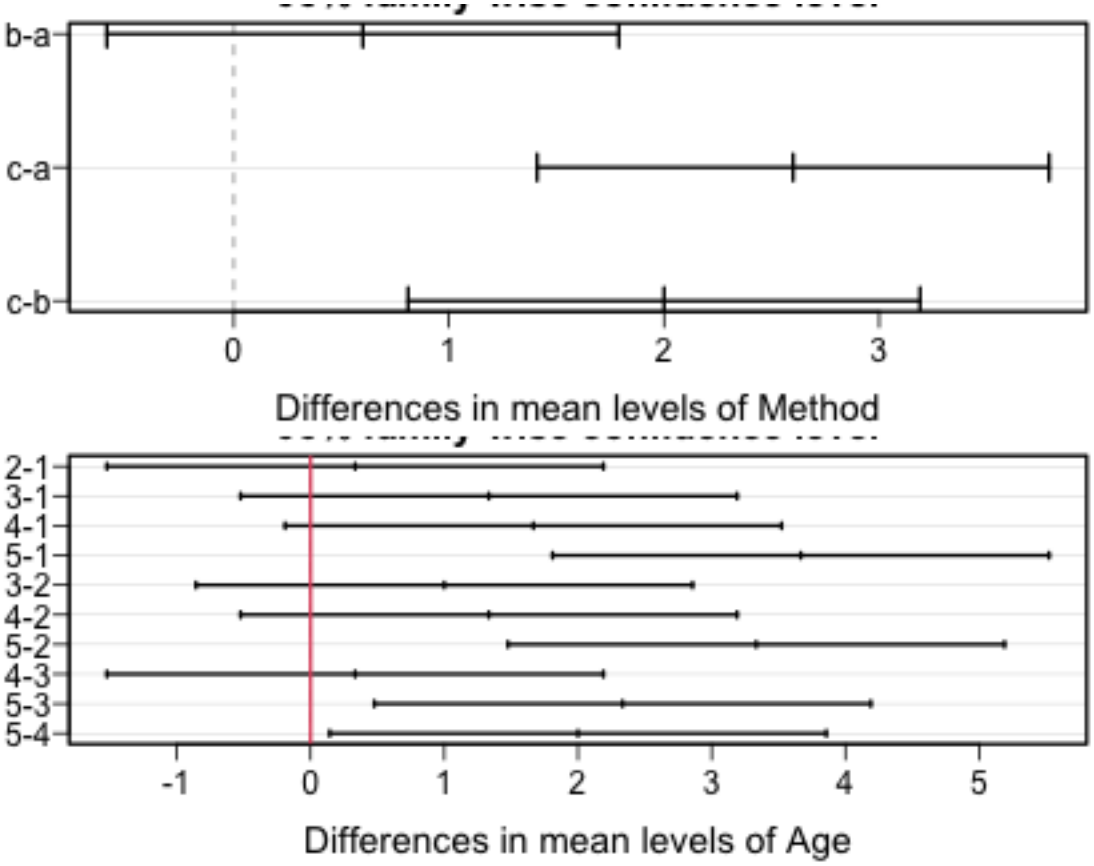
```r
layout(matrix(c(1,2), nrow=2, ncol=1, byrow=TRUE))
TukeyHSD(t_aov)
```

```
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = t ~ Method + Age)

$Method
    diff        lwr      upr     p adj
b-a  0.6 -0.5896489 1.789649 0.3666717
c-a  2.6  1.4103511 3.789649 0.0006358
c-b  2.0  0.8103511 3.189649 0.0034083

$Age
         diff        lwr      upr     p adj
2-1 0.3333333 -1.5235390 2.190206 0.9676094
3-1 1.3333333 -0.5235390 3.190206 0.1877558
4-1 1.6666667 -0.1902056 3.523539 0.0810838
5-1 3.6666667  1.8097944 5.523539 0.0009146
3-2 1.0000000 -0.8568723 2.856872 0.4057524
4-2 1.3333333 -0.5235390 3.190206 0.1877558
5-2 3.3333333  1.4764610 5.190206 0.0017351
4-3 0.3333333 -1.5235390 2.190206 0.9676094
5-3 2.3333333  0.4764610 4.190206 0.0154324
5-4 2.0000000  0.1431277 3.856872 0.0348816
```

```r
plot(TukeyHSD(t_aov))
abline(v=0, col=2)
```


14
13
12
11
10
9
8
7
t
1
2
3
4
5
Age

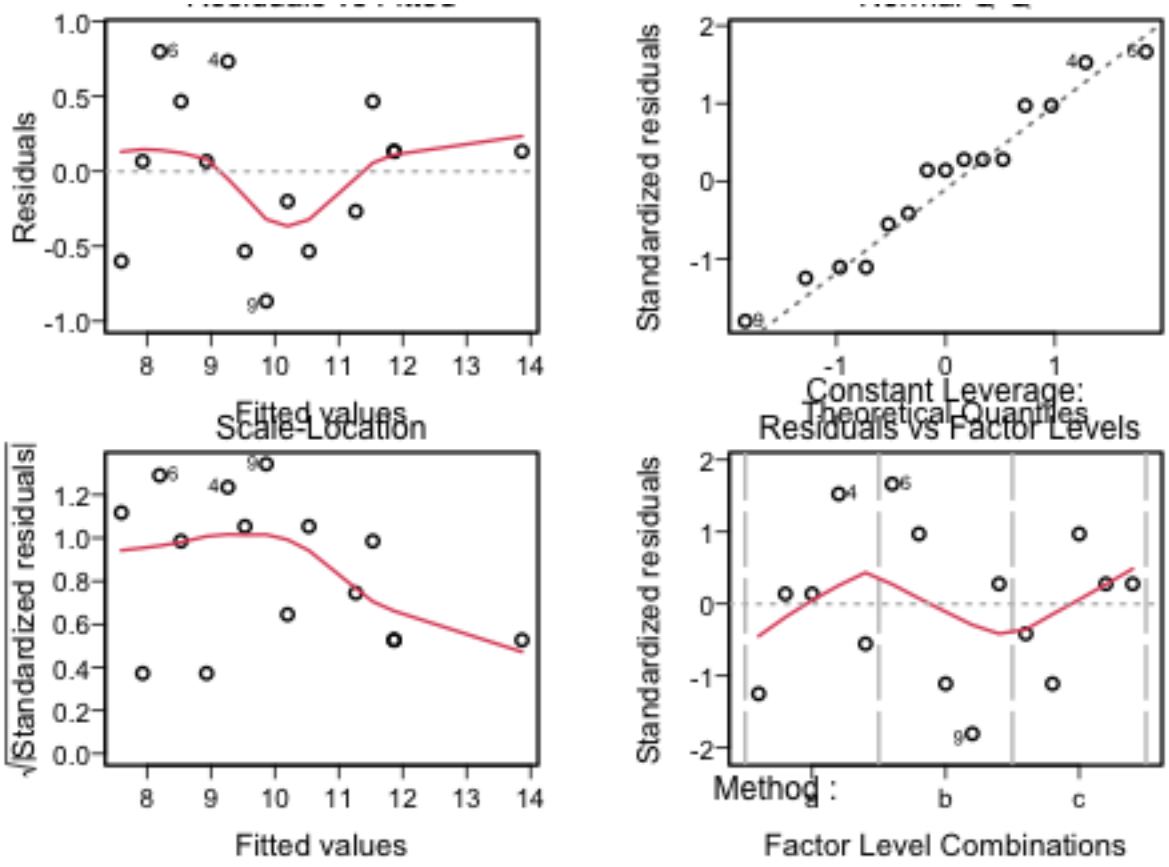

14
13
12
11
10
9
8
7
t
a
b
c
Method



Plotting

Layout instruction divides the graphical screen in four sections, square diff and QQ-plot graphs.

```
layout(matrix(c(1, 2, 3, 4), nrow=2, ncol=2, byrow=TRUE))
plot(t_aov)
```



3. Example 8.4.1

Licciardone et al. examined subjects with chronic, nonspecific low back pain. In this study, 18 of the subjects completed a survey questionnaire assessing physical functioning at baseline, and after 1, 3, and 6 months. The file has data for these subjects which received a sham treatment thet appeared to be genuine osteopathic manipulations. Higher values indicate better physical functioning. Higher values indicate better physical functioning. The goal of the experiment was to determine if subjects would report improvement over time even though the treatment they received would provide minimal improvement. We wish to know if there is a difference in the mean survey values among the four points in time.

```
setwd("~/Dropbox/Fdo/ClaseStats/RegressionClass/RegressionR_code")
# Example 8.4.1 ANOVA Single factor repeated measures
#
Exa4.1=read.csv(file="DataOther/EXA_C08_S04_01mod.csv", header=TRUE)
names(Exa4.1)
```

```
[1] "Assessment" "Time"       "Subject"
```

```
# FUNC we want to estimate if depends on SUBJ with
# repeated measurements for SUBJ.
# factor is used to force the numbers as factors !
# And were grouped in time to measure effect
# model FUNC ~ factor(TIME) + factor(SUBJ)
# layout(matrix(c(1,2), nrow=2, ncol=1, byrow=TRUE))
plot(Assessment ~ factor(Time) + factor(Subject), data=Exa4.1)
Exa4.1.aov = aov(Assessment ~ factor(Time) + factor(Subject), data=Exa4.1)
```

```r
summary(Exa4.1.aov)
```

```
                Df Sum Sq Mean Sq F value   Pr(>F)
factor(Time)     3   2396   798.6   5.501  0.00237 **
factor(Subject) 17  20238  1190.4   8.200 2.18e-09 ***
Residuals       51   7404   145.2
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
TukeyHSD(Exa4.1.aov)
```

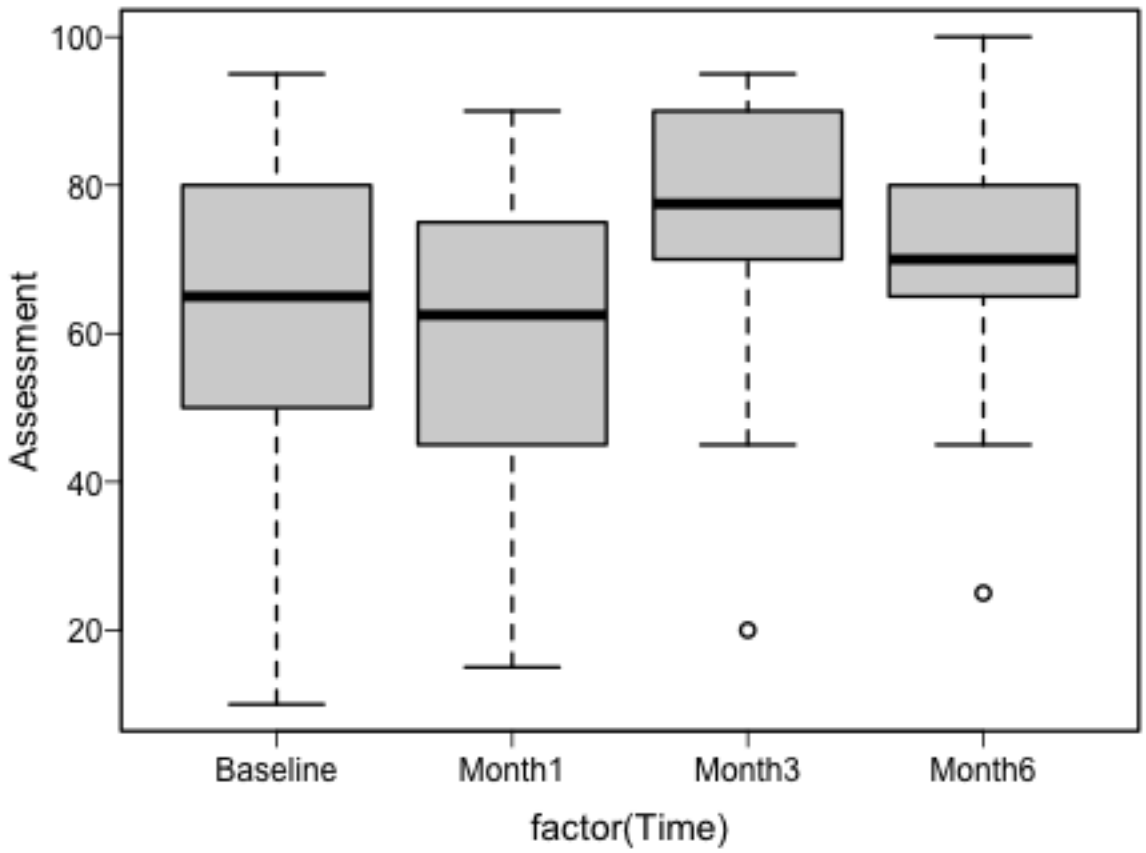
```
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Assessment ~ factor(Time) + factor(Subject), data = Exa4.1)

$`factor(Time)`
                     diff         lwr       upr     p adj
Month1-Baseline -2.500000 -13.1666579  8.166658 0.9244135
Month3-Baseline 11.666667   1.0000088 22.333325 0.0269476
Month6-Baseline  8.055556  -2.6111023 18.722213 0.1993649
Month3-Month1   14.166667   3.5000088 24.833325 0.0048300
Month6-Month1   10.555556  -0.1111023 21.222213 0.0534057
Month6-Month3   -3.611111 -14.2777690  7.055547 0.8053159

$`factor(Subject)`
               diff           lwr          upr     p adj
2-1    1.000000e+01  -21.28918619  41.28918619 0.9991367
3-1   -3.000000e+01  -61.28918619   1.28918619 0.0737815
4-1   -2.500000e+01  -56.28918619   6.28918619 0.2705596
5-1   -8.750000e+00  -40.03918619  22.53918619 0.9998418
6-1   -1.250000e+01  -43.78918619  18.78918619 0.9894152
7-1   -2.500000e+00  -33.78918619  28.78918619 1.0000000
8-1   -1.625000e+01  -47.53918619  15.03918619 0.8957133
9-1   -1.000000e+01  -41.28918619  21.28918619 0.9991367
10-1  -3.375000e+01  -65.03918619  -2.46081381 0.0226473
11-1  -7.500000e+00  -38.78918619  23.78918619 0.9999807
12-1  -2.625000e+01  -57.53918619   5.03918619 0.2025154
13-1  -1.875000e+01  -50.03918619  12.53918619 0.7439419
14-1  -1.000000e+01  -41.28918619  21.28918619 0.9991367
15-1  -1.500000e+01  -46.28918619  16.28918619 0.9435248
16-1  -6.125000e+01  -92.53918619 -29.96081381 0.0000004
17-1  -4.500000e+01  -76.28918619 -13.71081381 0.0003441
18-1  -2.500000e+00  -33.78918619  28.78918619 1.0000000
3-2   -4.000000e+01  -71.28918619  -8.71081381 0.0024187
4-2   -3.500000e+01  -66.28918619  -3.71081381 0.0148202
5-2   -1.875000e+01  -50.03918619  12.53918619 0.7439419
6-2   -2.250000e+01  -53.78918619   8.78918619 0.4446866
7-2   -1.250000e+01  -43.78918619  18.78918619 0.9894152
8-2   -2.625000e+01  -57.53918619   5.03918619 0.2025154
9-2   -2.000000e+01  -51.28918619  11.28918619 0.6471493
10-2  -4.375000e+01  -75.03918619 -12.46081381 0.0005658
11-2  -1.750000e+01  -48.78918619  13.78918619 0.8285097
12-2  -3.625000e+01  -67.53918619  -4.96081381 0.0095745
```

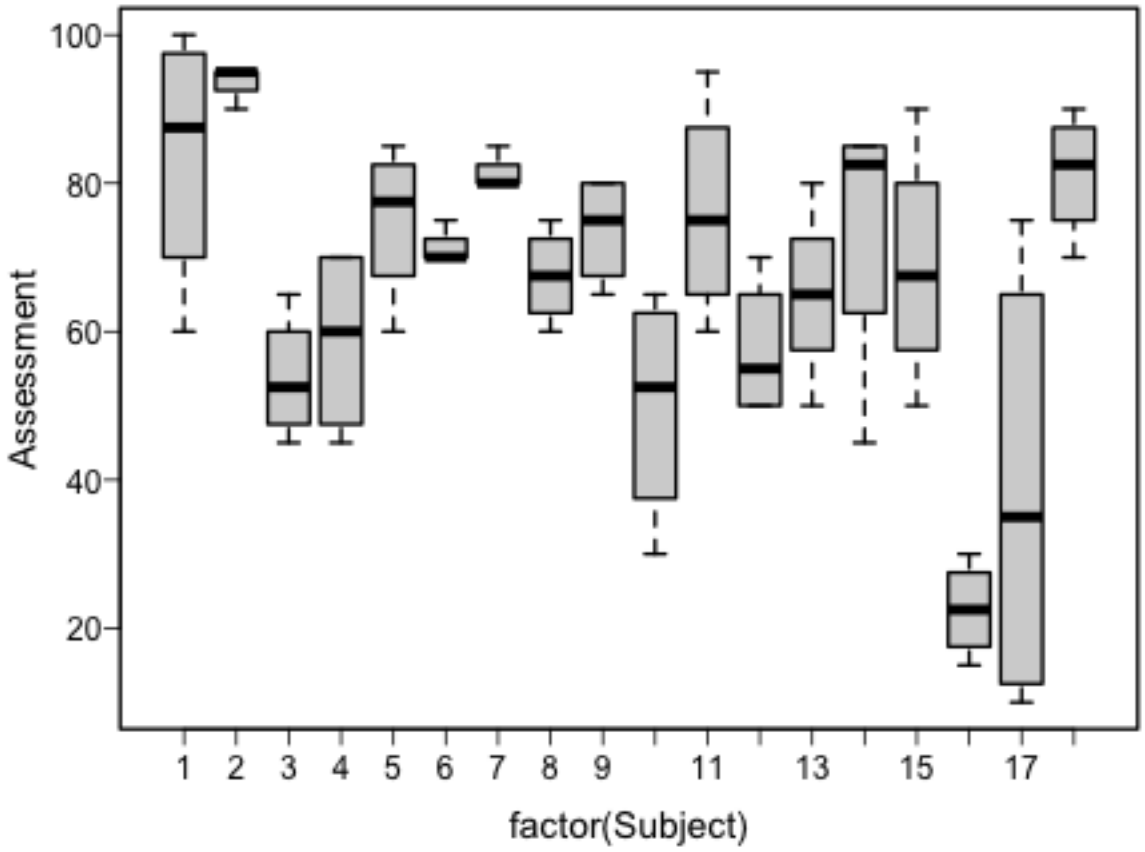
13-2	-2.875000e+01	-60.03918619	2.53918619	0.1055443
14-2	-2.000000e+01	-51.28918619	11.28918619	0.6471493
15-2	-2.500000e+01	-56.28918619	6.28918619	0.2705596
16-2	-7.125000e+01	-102.53918619	-39.96081381	0.0000000
17-2	-5.500000e+01	-86.28918619	-23.71081381	0.0000056
18-2	-1.250000e+01	-43.78918619	18.78918619	0.9894152
4-3	5.000000e+00	-26.28918619	36.28918619	1.0000000
5-3	2.125000e+01	-10.03918619	52.53918619	0.5450485
6-3	1.750000e+01	-13.78918619	48.78918619	0.8285097
7-3	2.750000e+01	-3.78918619	58.78918619	0.1478727
8-3	1.375000e+01	-17.53918619	45.03918619	0.9733998
9-3	2.000000e+01	-11.28918619	51.28918619	0.6471493
10-3	-3.750000e+00	-35.03918619	27.53918619	1.0000000
11-3	2.250000e+01	-8.78918619	53.78918619	0.4446866
12-3	3.750000e+00	-27.53918619	35.03918619	1.0000000
13-3	1.125000e+01	-20.03918619	42.53918619	0.9965698
14-3	2.000000e+01	-11.28918619	51.28918619	0.6471493
15-3	1.500000e+01	-16.28918619	46.28918619	0.9435248
16-3	-3.125000e+01	-62.53918619	0.03918619	0.0506089
17-3	-1.500000e+01	-46.28918619	16.28918619	0.9435248
18-3	2.750000e+01	-3.78918619	58.78918619	0.1478727
5-4	1.625000e+01	-15.03918619	47.53918619	0.8957133
6-4	1.250000e+01	-18.78918619	43.78918619	0.9894152
7-4	2.250000e+01	-8.78918619	53.78918619	0.4446866
8-4	8.750000e+00	-22.53918619	40.03918619	0.9998418
9-4	1.500000e+01	-16.28918619	46.28918619	0.9435248
10-4	-8.750000e+00	-40.03918619	22.53918619	0.9998418
11-4	1.750000e+01	-13.78918619	48.78918619	0.8285097
12-4	-1.250000e+00	-32.53918619	30.03918619	1.0000000
13-4	6.250000e+00	-25.03918619	37.53918619	0.9999986
14-4	1.500000e+01	-16.28918619	46.28918619	0.9435248
15-4	1.000000e+01	-21.28918619	41.28918619	0.9991367
16-4	-3.625000e+01	-67.53918619	-4.96081381	0.0095745
17-4	-2.000000e+01	-51.28918619	11.28918619	0.6471493
18-4	2.250000e+01	-8.78918619	53.78918619	0.4446866
6-5	-3.750000e+00	-35.03918619	27.53918619	1.0000000
7-5	6.250000e+00	-25.03918619	37.53918619	0.9999986
8-5	-7.500000e+00	-38.78918619	23.78918619	0.9999807
9-5	-1.250000e+00	-32.53918619	30.03918619	1.0000000
10-5	-2.500000e+01	-56.28918619	6.28918619	0.2705596
11-5	1.250000e+00	-30.03918619	32.53918619	1.0000000
12-5	-1.750000e+01	-48.78918619	13.78918619	0.8285097
13-5	-1.000000e+01	-41.28918619	21.28918619	0.9991367
14-5	-1.250000e+00	-32.53918619	30.03918619	1.0000000
15-5	-6.250000e+00	-37.53918619	25.03918619	0.9999986
16-5	-5.250000e+01	-83.78918619	-21.21081381	0.0000159
17-5	-3.625000e+01	-67.53918619	-4.96081381	0.0095745
18-5	6.250000e+00	-25.03918619	37.53918619	0.9999986
7-6	1.000000e+01	-21.28918619	41.28918619	0.9991367
8-6	-3.750000e+00	-35.03918619	27.53918619	1.0000000
9-6	2.500000e+00	-28.78918619	33.78918619	1.0000000
10-6	-2.125000e+01	-52.53918619	10.03918619	0.5450485
11-6	5.000000e+00	-26.28918619	36.28918619	1.0000000
12-6	-1.375000e+01	-45.03918619	17.53918619	0.9733998

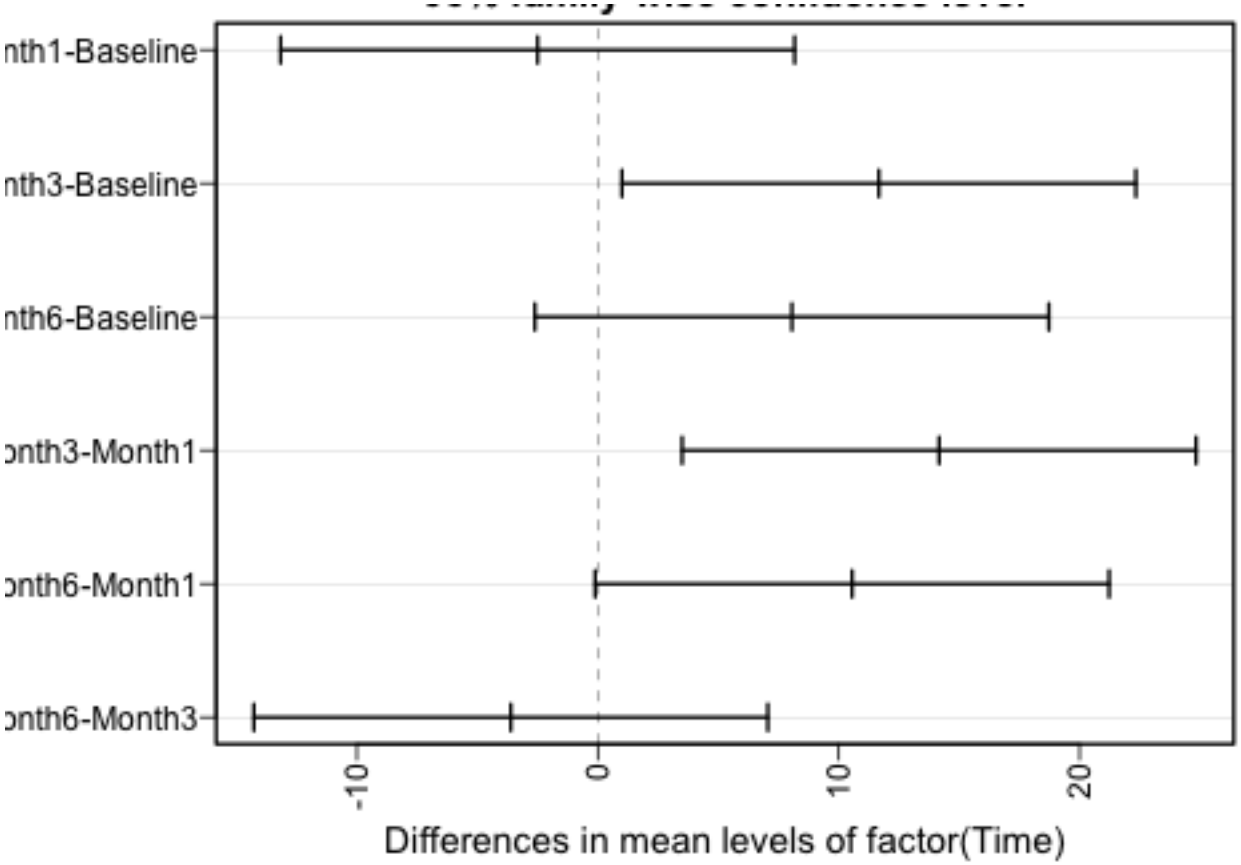
13-6	-6.250000e+00	-37.53918619	25.03918619	0.9999986
14-6	2.500000e+00	-28.78918619	33.78918619	1.0000000
15-6	-2.500000e+00	-33.78918619	28.78918619	1.0000000
16-6	-4.875000e+01	-80.03918619	-17.46081381	0.0000751
17-6	-3.250000e+01	-63.78918619	-1.21081381	0.0341209
18-6	1.000000e+01	-21.28918619	41.28918619	0.9991367
8-7	-1.375000e+01	-45.03918619	17.53918619	0.9733998
9-7	-7.500000e+00	-38.78918619	23.78918619	0.9999807
10-7	-3.125000e+01	-62.53918619	0.03918619	0.0506089
11-7	-5.000000e+00	-36.28918619	26.28918619	1.0000000
12-7	-2.375000e+01	-55.03918619	7.53918619	0.3518949
13-7	-1.625000e+01	-47.53918619	15.03918619	0.8957133
14-7	-7.500000e+00	-38.78918619	23.78918619	0.9999807
15-7	-1.250000e+01	-43.78918619	18.78918619	0.9894152
16-7	-5.875000e+01	-90.03918619	-27.46081381	0.0000011
17-7	-4.250000e+01	-73.78918619	-11.21081381	0.0009248
18-7	1.421085e-14	-31.28918619	31.28918619	1.0000000
9-8	6.250000e+00	-25.03918619	37.53918619	0.9999986
10-8	-1.750000e+01	-48.78918619	13.78918619	0.8285097
11-8	8.750000e+00	-22.53918619	40.03918619	0.9998418
12-8	-1.000000e+01	-41.28918619	21.28918619	0.9991367
13-8	-2.500000e+00	-33.78918619	28.78918619	1.0000000
14-8	6.250000e+00	-25.03918619	37.53918619	0.9999986
15-8	1.250000e+00	-30.03918619	32.53918619	1.0000000
16-8	-4.500000e+01	-76.28918619	-13.71081381	0.0003441
17-8	-2.875000e+01	-60.03918619	2.53918619	0.1055443
18-8	1.375000e+01	-17.53918619	45.03918619	0.9733998
10-9	-2.375000e+01	-55.03918619	7.53918619	0.3518949
11-9	2.500000e+00	-28.78918619	33.78918619	1.0000000
12-9	-1.625000e+01	-47.53918619	15.03918619	0.8957133
13-9	-8.750000e+00	-40.03918619	22.53918619	0.9998418
14-9	1.421085e-14	-31.28918619	31.28918619	1.0000000
15-9	-5.000000e+00	-36.28918619	26.28918619	1.0000000
16-9	-5.125000e+01	-82.53918619	-19.96081381	0.0000267
17-9	-3.500000e+01	-66.28918619	-3.71081381	0.0148202
18-9	7.500000e+00	-23.78918619	38.78918619	0.9999807
11-10	2.625000e+01	-5.03918619	57.53918619	0.2025154
12-10	7.500000e+00	-23.78918619	38.78918619	0.9999807
13-10	1.500000e+01	-16.28918619	46.28918619	0.9435248
14-10	2.375000e+01	-7.53918619	55.03918619	0.3518949
15-10	1.875000e+01	-12.53918619	50.03918619	0.7439419
16-10	-2.750000e+01	-58.78918619	3.78918619	0.1478727
17-10	-1.125000e+01	-42.53918619	20.03918619	0.9965698
18-10	3.125000e+01	-0.03918619	62.53918619	0.0506089
12-11	-1.875000e+01	-50.03918619	12.53918619	0.7439419
13-11	-1.125000e+01	-42.53918619	20.03918619	0.9965698
14-11	-2.500000e+00	-33.78918619	28.78918619	1.0000000
15-11	-7.500000e+00	-38.78918619	23.78918619	0.9999807
16-11	-5.375000e+01	-85.03918619	-22.46081381	0.0000094
17-11	-3.750000e+01	-68.78918619	-6.21081381	0.0061141
18-11	5.000000e+00	-26.28918619	36.28918619	1.0000000
13-12	7.500000e+00	-23.78918619	38.78918619	0.9999807
14-12	1.625000e+01	-15.03918619	47.53918619	0.8957133
15-12	1.125000e+01	-20.03918619	42.53918619	0.9965698

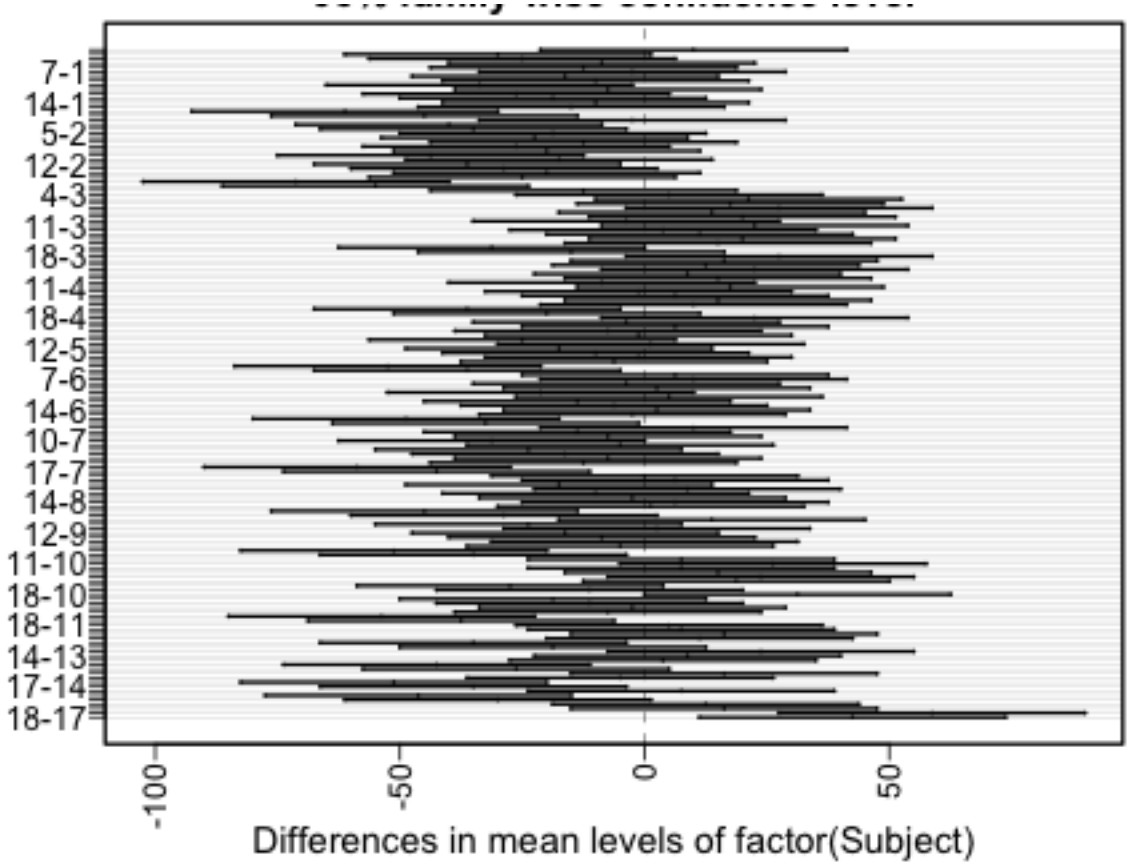
```
16-12 -3.500000e+01  -66.28918619  -3.71081381 0.0148202
17-12 -1.875000e+01  -50.03918619  12.53918619 0.7439419
18-12  2.375000e+01   -7.53918619  55.03918619 0.3518949
14-13  8.750000e+00  -22.53918619  40.03918619 0.9998418
15-13  3.750000e+00  -27.53918619  35.03918619 1.0000000
16-13 -4.250000e+01  -73.78918619 -11.21081381 0.0009248
17-13 -2.625000e+01  -57.53918619   5.03918619 0.2025154
18-13  1.625000e+01  -15.03918619  47.53918619 0.8957133
15-14 -5.000000e+00  -36.28918619  26.28918619 1.0000000
16-14 -5.125000e+01  -82.53918619 -19.96081381 0.0000267
17-14 -3.500000e+01  -66.28918619  -3.71081381 0.0148202
18-14  7.500000e+00  -23.78918619  38.78918619 0.9999807
16-15 -4.625000e+01  -77.53918619 -14.96081381 0.0002081
17-15 -3.000000e+01  -61.28918619   1.28918619 0.0737815
18-15  1.250000e+01  -18.78918619  43.78918619 0.9894152
17-16  1.625000e+01  -15.03918619  47.53918619 0.8957133
18-16  5.875000e+01   27.46081381  90.03918619 0.0000011
18-17  4.250000e+01   11.21081381  73.78918619 0.0009248
```

```
plot(TukeyHSD(Exa4.1.aov), las=2)
```

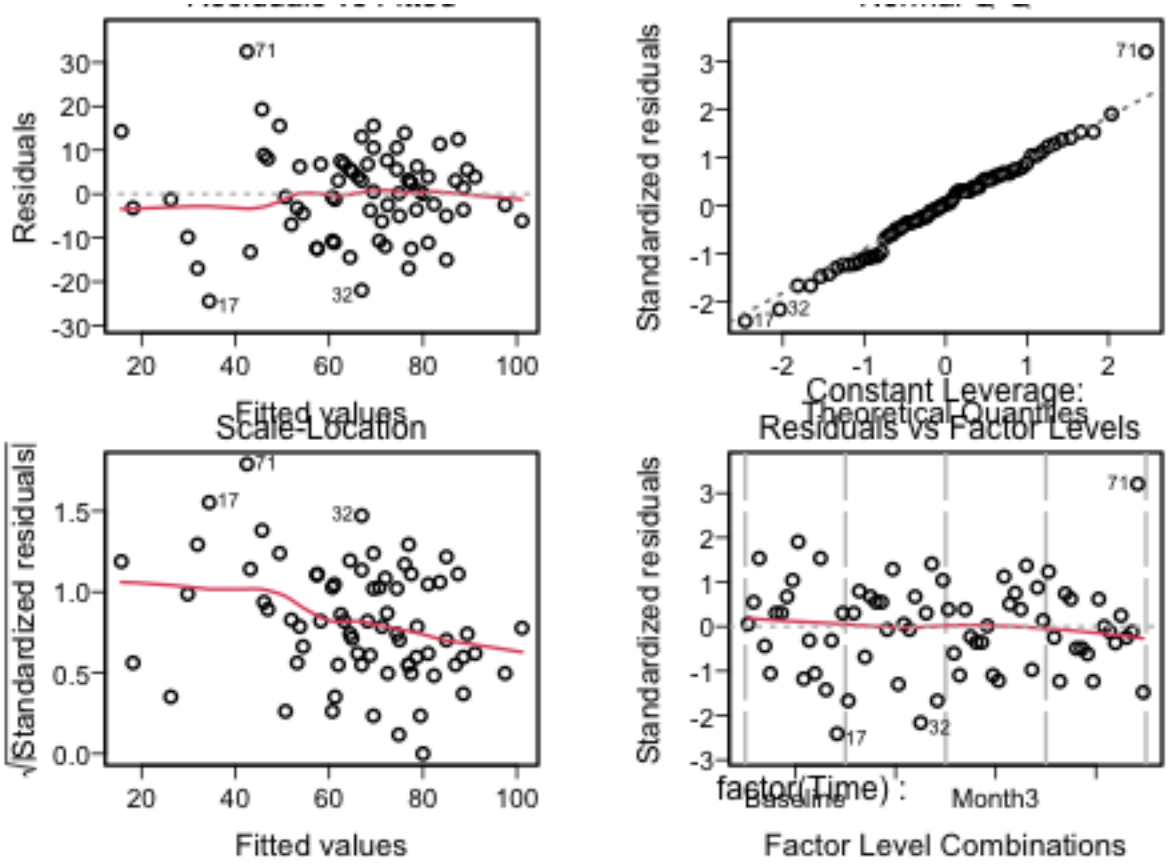



100
80
60
40
20
Assessment
1
2
3
4
5
6
7
8
9
11
13
15
17
factor(Subject)


nth1-Baseline
nth3-Baseline
nth6-Baseline
onth3-Month1
onth6-Month1
onth6-Month3
-10
0
10
20
Differences in mean levels of factor(Time)




```
layout(matrix(c(1,2,3,4), nrow=2, ncol=2, byrow=TRUE))
plot(Exa4.1.aov)
```


Residuals
Fitted values
Standardized residuals
Theoretical Quantiles
Scale-Location
√|Standardized residuals|
Fitted values
Residuals vs Factor Levels
Standardized residuals
factor(Time) :
Baseline
Month3
Factor Level Combinations

“‘