Math 3080 § 1.	**Fruit Fly Example:**	Name: Example
Treibergs	**One factor Randomized Block ANOVA**	Jan. 27, 2014

Today's example was motivated from W. Rosenkrantz, *Probability and Statistics for Science, Engineering and Finance*, Chapman & Hall / CRC, Boca Raton FL, 2009. It is an example of a randomized block fixed effects model.

The interaction plot shows that the means of different blocks are almost vertical translates of each other, showing that the linear model is appropriate. The ANOVA table shows that both effect are very significantly different. The simultaneous confidence intervals show that all of the treatments differ significantly at the $\alpha = .05$ level. The plot of residuals vs. fitted values shows that the variances are fairly uniform. The QQ-normal plot of the standardized residuals follows the 45° line nicely albeit a bit "S" shaped, indicating that there is little evidence that normality assumption is violated.

Note that without blocking, the same data would not have rejected $\mathcal{H}_{A0}$: that all A means are equal. In the one factor test, the variability of the blocks swamped the variability of the treatments.

Data Set Used in this Analysis :

```
# Math 3080       Fruit Fly Data              Jan.26, 2014
# Treibergs
#
# From J. L. Gill, Design and Analysis of Experiments in the Animal and
# Medical Sciences, vol. 2, Iowa State University Press, Ames IA, 1978.
# Quoted by W. Rosenkrantz, Probability and Statistics for Science,
# Engineering and Finance, Chapman & Hall / CRC, Boca Raton FL, 2009.
# Experiment measured mortality rates (in percent) for four genetic strains
# (B) of fruit fly subject to three different dosages of insecticide (A).
# The strain is the blocking variable. Are the mortality rates for the
# fruit fly influenced by the dosage level?
#
Treatment  block1  block2  block3  block4
1  66  55  43  32
2  71  57  44  37
3  79  63  51  44
```

R Session:

```
R version 2.14.0 (2011-10-31)
Copyright (C) 2011 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: i386-apple-darwin9.8.0/i386 (32-bit)

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  Natural language support but running in an English locale

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```
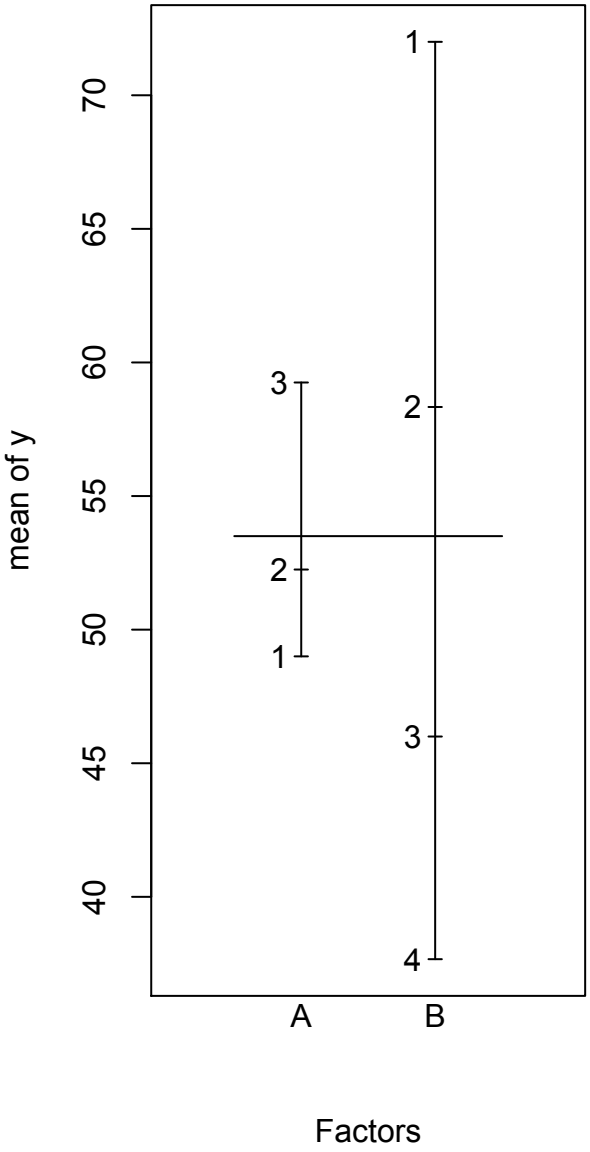
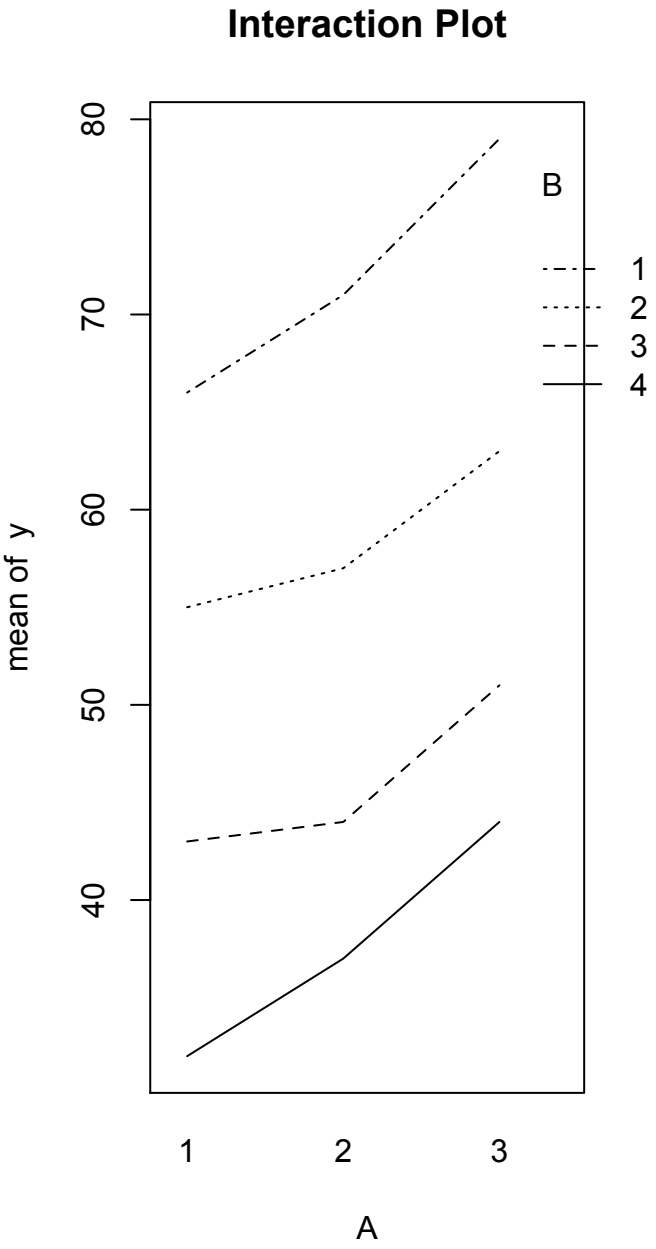
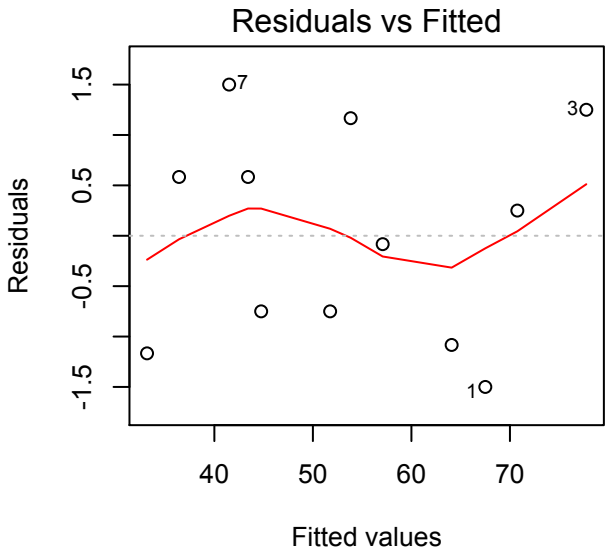

```
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

[R.app GUI 1.42 (5933) i386-apple-darwin9.8.0]

[Workspace restored from /home/1004/ma/treibergs/.RData]
[History restored from /home/1004/ma/treibergs/.Rhistory]

> tt=read.table("M3082DataFruitFly.txt",header=T)
> tt
  Treatment block1 block2 block3 block4
1         1     66     55     43     32
2         2     71     57     44     37
3         3     79     63     51     44
> attach(tt)
> y=c(block1,block2,block3,block4); y
 [1] 66 71 79 55 57 63 43 44 51 32 37 44

> A=factor(rep(Treatment,times=4));A
 [1] 1 2 3 1 2 3 1 2 3 1 2 3
Levels: 1 2 3

> B=factor(rep(1:4,each=3)); B
 [1] 1 1 1 2 2 2 3 3 3 4 4 4
Levels: 1 2 3 4

> ######################## RUN ANOVA ############################
> a1=aov(y~A+B); summary(a1)
            Df Sum Sq Mean Sq F value   Pr(>F)
A            2  219.5   109.7   55.65 0.000134 ***
B            3 2017.7   672.6  341.01 4.33e-07 ***
Residuals    6   11.8     2.0
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

> ##################### TABLES OF EFFECTS AND MEANS #############
> model.tables(a1)
Tables of effects

 A
A
    1     2     3
-4.50 -1.25  5.75

 B
B
      1       2       3       4
 18.500   4.833  -7.500 -15.833
```

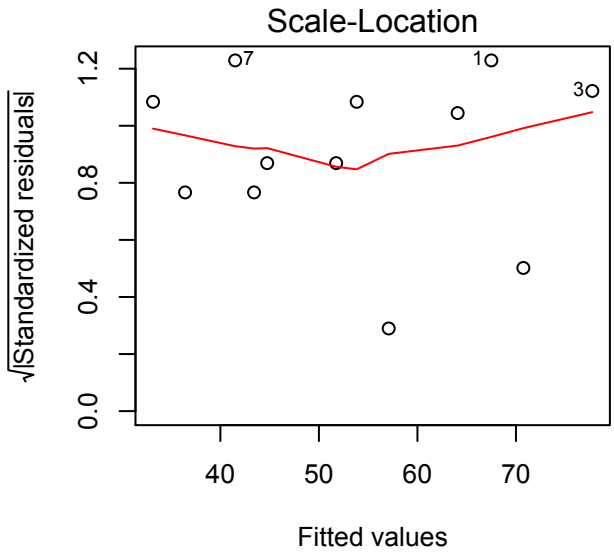
```
> model.tables(a1,"means")
Tables of means
Grand mean

53.5

 A
A
    1     2     3
49.00 52.25 59.25

 B
B
    1     2     3     4
72.00 58.33 46.00 37.67

>
> ##### PLOTS MEANS PER FACTOR AND INTERACTION ##################
> layout(matrix(1:2,ncol=2))
>  plot.design(y~A+B)
> interaction.plot(A,B,y,main="Interaction Plot")
>
> ########## EASY PLOT OF STANDARD DIAGNOSTICS ##################
> layout(matrix(1:4,ncol=2))
> plot(a1)
> ########## SHAPIRO-WILK TEST FOR NORMALITY ####################
> shapiro.test(rstandard(a1))

Shapiro-Wilk normality test

data:  rstandard(a1)
W = 0.9309, p-value = 0.3893

> ######## TUKEY'S SIMULTANEOUS CI'S ON DIFFERENCES OF MEANS ####
> t2=TukeyHSD(a1,which="A",ordered=T)
> layout(1)
> plot(t2)
> print(t2)
  Tukey multiple comparisons of means
    95% family-wise confidence level
    factor levels have been ordered

Fit: aov(formula = y ~ A + B)

$A
     diff       lwr       upr     p adj
2-1  3.25 0.2031075  6.296892 0.0389591
3-1 10.25 7.2031075 13.296892 0.0001192
3-2  7.00 3.9531075 10.046892 0.0009949
```

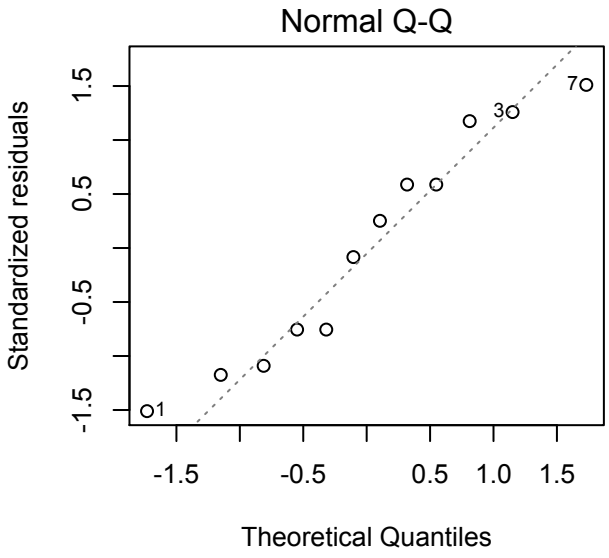
```
> ############## FOR CONTRAST, DO EXPERIMENT WITHOUT BLOCKING ####
> ###### NOTE THAT  DF  OF  MSE  INCREASES FROM  6  TO  9  ######
> ############## BUT THE MAIN EFFECT IS NO LONGER REJECTED #######
> a2=aov(y~A); summary(a2)
            Df Sum Sq Mean Sq F value Pr(>F)
A            2  219.5   109.8   0.487   0.63
Residuals    9 2029.5   225.5
>
```

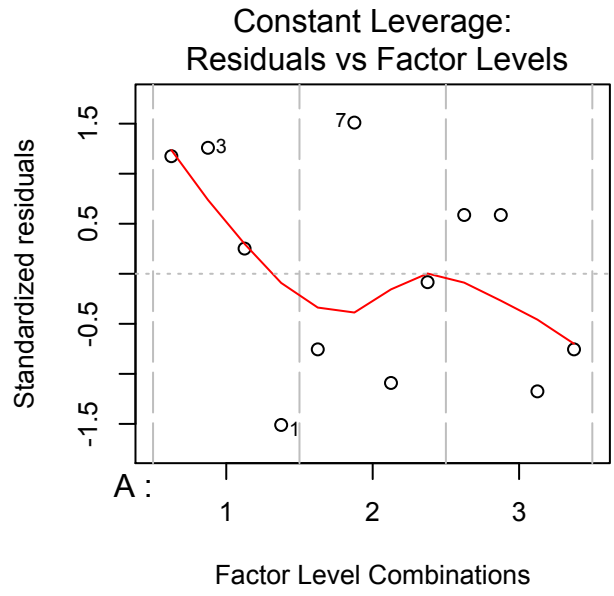

mean of y
40
45
50
55
60
65
70
1
2
3
4
3
2
1
A
B
Factors

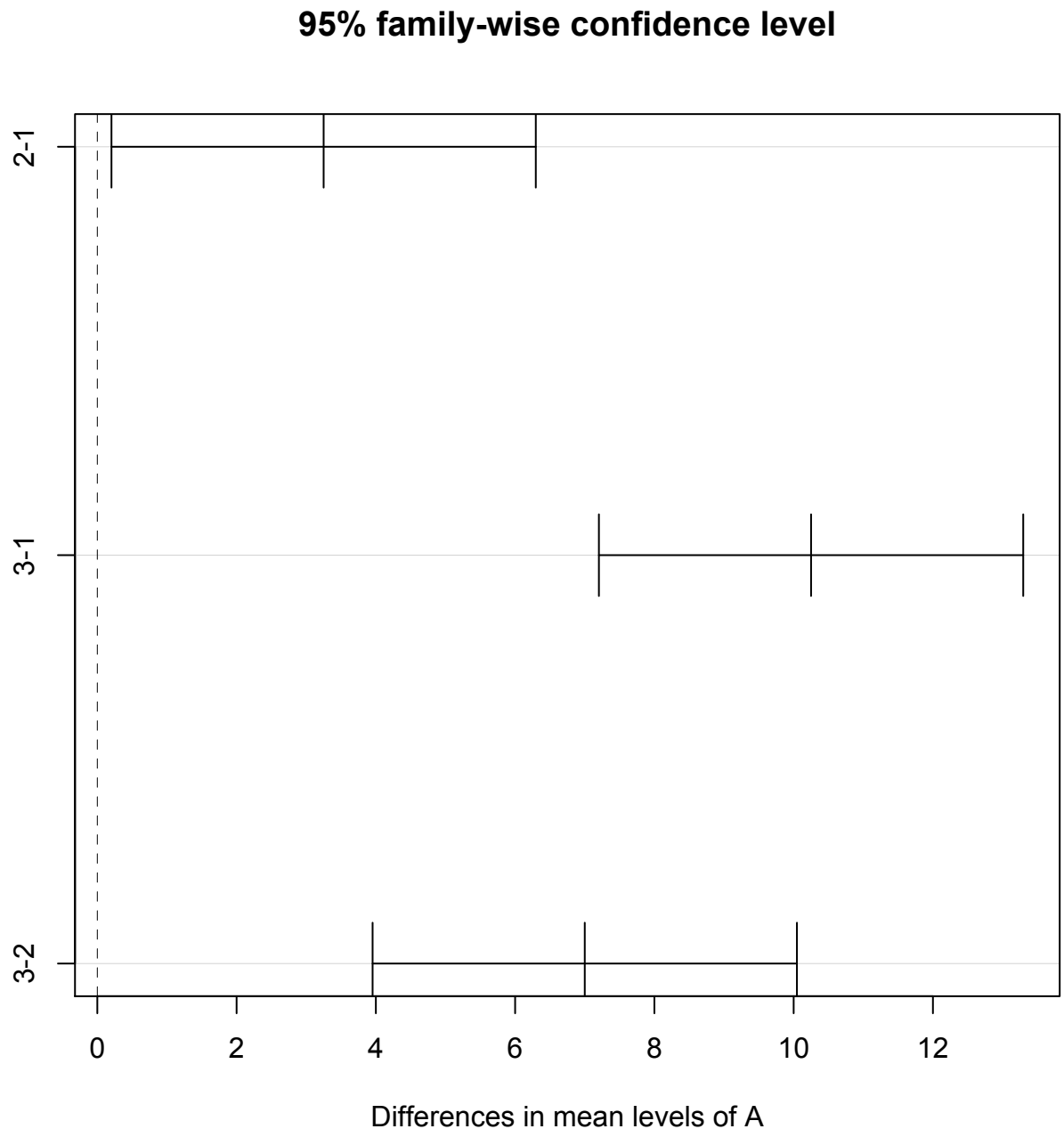

Interaction Plot
mean of y
40
50
60
70
80
B
1
2
3
4
1
2
3
A


Residuals vs Fitted
Residuals
Fitted values
7
3
1
40
50
60
70
1.5
0.5
-0.5
-1.5


Scale-Location
√|Standardized residuals|
Fitted values
7
1
3
40
50
60
70
1.2
0.8
0.4
0.0


Normal Q-Q
Standardized residuals
Theoretical Quantiles
7
3
1
-1.5
-0.5
0.5
1.0
1.5


Constant Leverage:
Residuals vs Factor Levels
Standardized residuals
Factor Level Combinations
A :
7
3
1
1
2
3
1.5
0.5
-0.5
-1.5


95% family-wise confidence level
2-1
3-1
3-2
0
2
4
6
8
10
12
Differences in mean levels of A