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MSIS 545

12. This is the example study on discriminating people with physical disabilities. The data is sample test conducted on 70 students who were randomly assigned with videotapes which differed with the applicant with a different handicap (same male actors were videotaped for all the videos). In one tape, the applicant was on wheelchair, second on crutches, third with impairment, forth with one leg amputated and final tape appeared with no handicap. Each student got fourteen tapes which are to be viewed and rated. Each subject rated the qualifications of the applicant on 0 to 10 scale. The study was to determine whether all the subjects evaluate the applicant qualifications symmetrically or if the differ according to the candidate's handicap. If they differ, which handicaps give different evaluations.

Let's head on to the data and see the big picture

```
> table(case0601$Handicap)


   Amputee   Crutches    Hearing       None Wheelchair

        14         14         14         14         14
```

As said, each applicant was given 14 tapes, making 70 for 5 sets of handicaps to be evaluated. Let's get to know the summary of the data to see if any transformations are to be applied on the data

```
> summary(case0601)

     Score              Handicap

 Min.   :1.400   Amputee   :14

 1st Qu.:3.700   Crutches  :14

 Median :5.050   Hearing   :14

 Mean   :4.929   None      :14

 3rd Qu.:6.100   Wheelchair:14

 Max.   :8.500
```

From the above, the minimum and maximum of score field is good to scale and no transfromations are required to be imposed on the data.

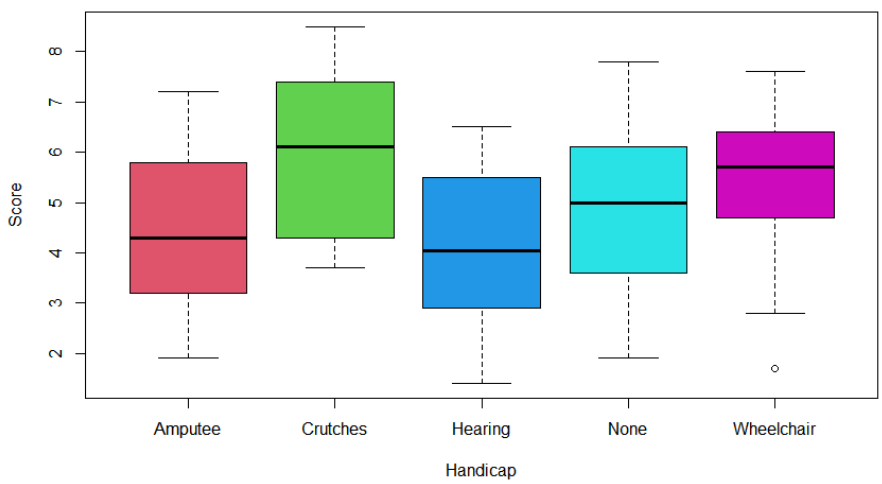
Let's get into the summary statistics to find more on the mean and medians

```
> tapply(case0601$Score, case0601$Handicap, summary)

$Amputee

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

  1.900   3.300   4.300   4.429   5.725   7.200
```

```
$Crutches
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  3.700   4.500   6.100   5.921   7.150   8.500
$Hearing
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.400   3.025   4.050   4.050   5.300   6.500
$None
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.900   3.725   5.000   4.900   6.050   7.800
$Wheelchair
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.700   4.725   5.700   5.343   6.350   7.600
```

The above say that no clear difference can be identified on means and medians. The spread is also good on all the handicap groups. Let's have a boxplot on the above summary statistics to have a pictorial view

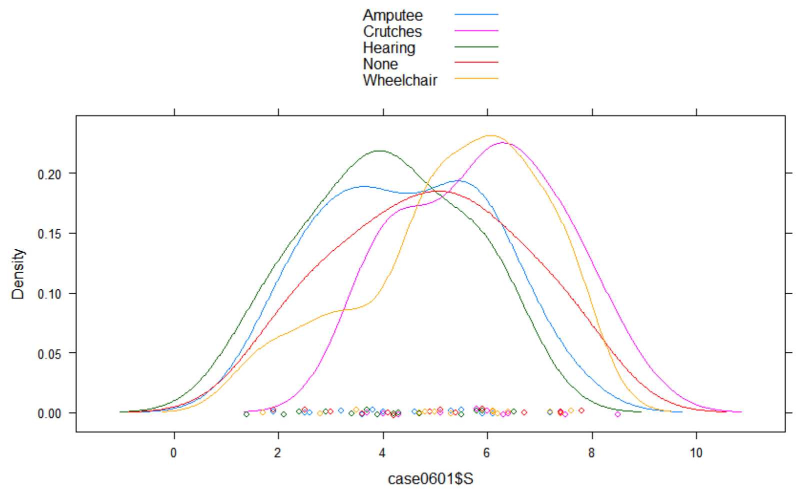
```
> boxplot(Score ~ Handicap, data = case0601, col = 2:7)
```



The boxplot shows that hearing and amputee handicap groups are almost similar with very close mean, median and quartiles though the spread is a bit different. By the boxplot, it can be said that no real difference can be taken out but let's look into further analysis of this data.

```
> densityplot(case0601$S, groups = case0601$Handicap, auto.key = TRUE)
```

The above command gives the density plot of the data groups through which we can find if any one graph is different from another or if there are any similarities



The above plot has a significance. All the groups in the plot follow more or less similar pattern though no one is similar to other but the "None" group follows a perfect normal distribution curve.

Let's categorize the groups "Amputee", "Crutches", and "Wheelchair" to be handicaps of pertaining to mobility and "Hearing" affecting communication and impose linear combination on these categories to test if there any difference in the average of the means. Below is the command to find the linear models for the whole data

```
> sh.lm <- lm(Score ~ Handicap, data = case0601)
```

Which gives the below estimates

```
> sh.lm

Call:

lm(formula = Score ~ Handicap, data = case0601)

Coefficients:

       (Intercept)     HandicapCrutches      HandicapHearing
HandicapNone   HandicapWheelchair

            4.4286                1.4929              -0.3786
0.4714                0.9143
```

As said before, let's find the fit contrast between the three mobility groups with communication (Hearing) group and below is the command for this

The linear combination combines the mobility handicaps and contrast them with the communication handicap to test their equivalence. `1` is used for the coefficient of the communication handicap and `-1/3` for the coefficient of the three mobility handicaps. The resulting linear combination is shown below, indicating that the average of the means is not equal for both groups

```
> fit.contrast(sh.lm, "Handicap", coef = c(-1/3, -1/3, 1, 0 , -1/3),
conf.int = .95)

Estimate Std. Error

Handicap    c=(    -0.333333333333333    -0.333333333333333    1    0    -
0.333333333333333 ) -1.180952  0.5039353

t value   Pr(>|t|)

Handicap    c=(    -0.333333333333333    -0.333333333333333    1    0    -
0.333333333333333 ) -2.34346 0.02217534

lower CI  upper CI

Handicap    c=(    -0.333333333333333    -0.333333333333333    1    0    -
0.333333333333333 ) -2.187381 -0.174524

attr(,"class")

[1] "fit_contrast"
```

The above results show that both the groups are different with average of mean of the communication (hearing) group less than average of mean of the mobility group (p value 0.022) with a confidence interval of -2.19 as lower limit and -0.74 as upper limit

---

15.

This problem is based on the article which reported results of a planned experiment comparing five different teaching methods. Nine students were allocated to each of five subjects, totaling to 45 students in random and an hour examination was run to these students after completing the experimental course. The data consists of the summary of these scores on 10-minute retention test, given 6 weeks later.

The data summary consists of the 5 different teaching methods on which 9 in each group of students were tested, its average score and standard deviation. The summary statistics show that out of all five teaching method groups, programmed text with lectures group stood least with average of 26.20 and standard deviation of 4.66 while computer instruction teaching method stood on top with average of 31.10 and standard deviation of 4.91. However, the averages of lecture and discussion group and computer instruction with lectures group are similar to 30.20 with standard deviation being closer to 3.82 and 3.53 respectively. And the remaining one group Programmed text has a mean of 28.80 with high standard deviation of 5.26.

a. Let’s compute the pooled estimate of the standard deviation from these summary statistics

The pooled estimate of variance is a weighted average of sample variances in which each sample variance receives the weight of its degree of freedom, calculated by the formula

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 + \cdots + (n_I - 1)s_I^2}{(n_1 - 1) + (n_2 - 1) + \cdots + (n_I - 1)}.$$

Where n_I is the sample size of each group. Since here all the sample sizes are equal, the best single estimate of standard deviation is the square root of the averages of variance

$S_p^2 = (s_1^2 + s_2^2 + s_3^2 + s_4^2 + s_5^2)/5 = (3.82^2 + 5.26^2 + 4.66^2 + 4.91^2 + 3.53^2)/5$

Pooled standard deviation, S_p = sqrt((14.59 + 27.67 + 21.72 + 24.11 + 12.46)/5) = Sqrt(20.11) = 4.48

b. This is to determine the set of coefficients to contrast the methods using programmed text with those that do not use programmed text

The groups that use programmed text teaching methods are groups 2 and 3 with teaching methods as programmed text, R and programmed text with lectures R+L and remaining lecture and discussion , L+D, computer instruction, C, and computer instruction with lectures, C+L are the ones which do not use programmed text.

While fitting contrast between programmed text and non-programmed text teaching methods, the coefficients used are as follows

L+D	R	R+L	C	C+L	
-1/3	1/2	1/2	-1/3	-1/3 or	
1/3	-1/2	-1/2	1/3	1/3	depending on the evaluations to be made

c. Let's compute 95% confidence interval for the above taken coefficient contrasts

Confidence interval construction for the linear combination in Teaching methods study					
Teaching methods					
	Lecture and discussion	Programmed text	Programmed text with lectures	Computer instruction	Computer instruction with lectures
n	9	9	9	9	9
Average	30.2	28.80	26.20	31.10	30.20
C	- 1/3	1/2	1/2	- 1/3	- 1/3

Estimating the linear combination, $$g = C_1\overline{Y}_1 + C_2\overline{Y}_2 + \cdots + C_I\overline{Y}_I$$

g = ((y2 + y3)/2) – ((y1 + y4 + y5)/3)

= ((28.80 + 26.20)/2) – ((30.20 + 31.10 + 30.20)/3)

= 27.50 – 30.50 = -3.00

Therefore, the estimated linear combination is -3.00

The standard error of the estimate is determined by,

$$\mathrm{SE}(g) = s_p\sqrt{\frac{C_1^2}{n_1} + \frac{C_2^2}{n_2} + \cdots + \frac{C_I^2}{n_I}}$$

$$SE(g) = 4.48 * \text{Sqrt}[(1/9)\{(-1/3)^2 + (1/2)^2 + (1/2)^2 + (-1/3)^2 + (-1/3)^2\}]$$

$$= 4.48 * \text{sqrt}[(1/9) * (5/6)]$$

$$= 1.36$$

Constructing 95% confidence interval, degree of freedom = n – groups = 45 – 5 = 40

The two tailed critical values for t_0 (.975) = ± 2.021

95% confidence interval = g ± t_0 * SE(g) = -3.00 + 2.021 * 1.36 & -3.00 - 2.021 * 1.36

= (-0.25 & 5.75)

Therapy Problem.

The therapy data was loaded into RStudio by below command and choosing the downloaded "therapy.csv" file

```
therapy <- read.csv(file.choose(), stringsAsFactors = TRUE)
```

before getting into the data statistics, the data consists of three fields – Treat, Prewt and Postwt. The Treat consisted of three groups – Control group, CBT (Cognitive Behavioural treatment) and FT (Family Treatment) group. Prewt and postwt are the fields where the weights of 72 young anorexic girls is recorded pre and post therapy sessions. These 72 young girls with anorexia are divided into three groups. The control group received no treatment while some girls received CBT and few girls received family treatment. Let's see how many girls are in each group

```
> table(therapy$Treat)

 CBT Cont   FT

  29   26   17
```

From above, control group has prewt and postwt of 26 anorexic girls and 29 received CBT and 26 received family treatment. Let's see the summary of the data to see if there is any need of log or any other transformations

```
> summary(therapy)

  Treat         Prewt           Postwt

 CBT :29   Min.   :70.00   Min.   : 71.30

 Cont:26   1st Qu.:79.60   1st Qu.: 79.33

 FT  :17   Median :82.30   Median : 84.05

           Mean   :82.41   Mean   : 85.17

           3rd Qu.:86.00   3rd Qu.: 91.55

           Max.   :94.90   Max.   :103.60
```

The minimum and maximum values of prewt and postwt fields are not widely spread and so no transformations are required.

Let's see what are the group wise summary statistics in prewt and postwt

```
> tapply(therapy$Prewt,therapy$Treat, summary)

$CBT

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

  70.00   80.40   82.60   82.69   85.00   94.90

$Cont

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

  70.50   77.72   80.65   81.56   85.88   91.80

$FT

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

  73.40   80.50   83.30   83.23   86.00   94.20
```

The above prewt summary statistics are a bit closely related where the control group stands with least mean and median while family treatment group stands with high mean and median. Let's see if there is any relation in these statistics with postwt field

> tapply(therapy$Postwt,therapy$Treat, summary)

```
$CBT

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

   71.3    81.9    83.9    85.7    90.9   103.6

$Cont

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

  73.00   77.58   80.70   81.11   84.67   89.60

$FT

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

  75.20   90.70   92.50   90.49   95.20  101.60
```

The postwt summary statistics also give similar results as prewt where the control group stood with least mean and median while Family treatment group with high mean and median.

It is said that in this study the main focus is not on pre and post weights but in the gains. Let's calculate the gain or loss in the weights by the below command in R

```
> gainwt <- therapy$Postwt - therapy$Prewt
```

The gainwt variable stores all the gain or loss weights. Let's see how many girls have lost or gain the weights by below commands

```
> table(gainwt>0, gainwt<0)
        FALSE TRUE
  FALSE     1   29
  TRUE     42    0
> table(gainwt == 0)
FALSE  TRUE
   71     1
```

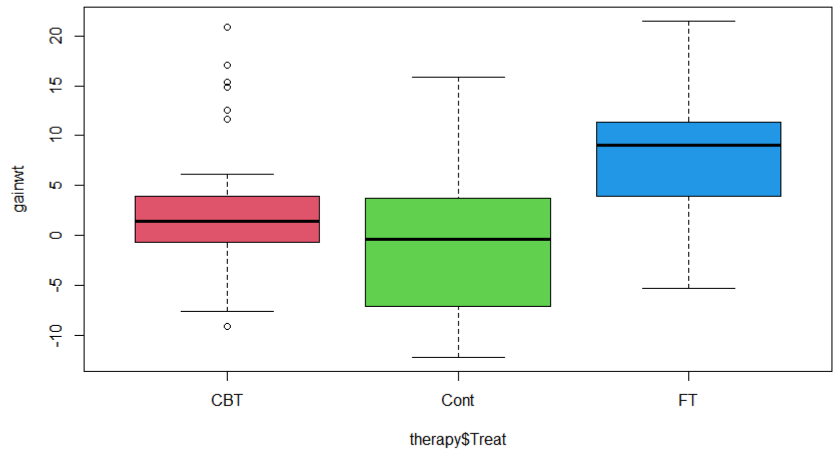
The above says that there are 42 girls who have gained weight after the treatment while 29 have negative weights or lost the weight after the treatment and 1 has neither gained nor lost weight

The following gives the summary statistics of gainwt with respect to treatment field

```
> tapply(gainwt,therapy$Treat, summary)
$CBT
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 -9.100  -0.700   1.400   3.007   3.900  20.900

$Cont
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 -12.20   -7.00   -0.35   -0.45    3.60   15.90

$FT
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 -5.300   3.900   9.000   7.265  11.400  21.500
```

Lets make a boxplot on this data

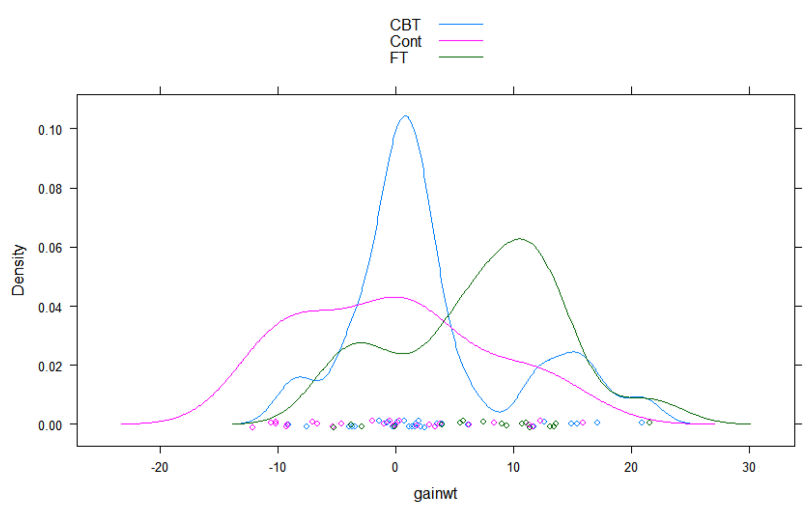
```
> boxplot(gainwt ~ therapy$Treat, col = 2:4)
```



By the boxplot we can say that there are many outliers in the positive end of CBT group and FT group is more different to CBT and control group. The boxplot clearly shows that the girls who have received family treatment have gained more weight than the other.

The below command gives the density plot for the data

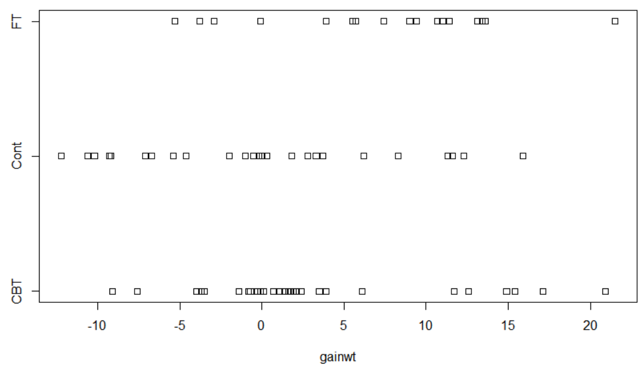
```
> densityplot(gainwt, groups = therapy$Treat, auto.key = TRUE)
```



The density plot shows that the control group has equal spread of gainwt data density while the CBT has highest density while family treatment has much of its portion on the positive side of gainwt.

Let's have a look at the strip chart

```
> stripchart(gainwt ~ therapy$Treat, jitter = T)
```



The above strip chart also gives same spread of data as of density plot.

Let’s conduct t-test on the data to see whether the pre and post therapy weight change is different from other.

```
> t.test(gainwt, mu = 0)

      One Sample t-test

data:  gainwt
t = 2.9376, df = 71, p-value = 0.004458
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
 0.8878354 4.6399424
sample estimates:
mean of x
 2.763889
```

The output shows that the average weight change is positive. The change is statisitically significant with a p value of 0.0044.

The below code for analysis of variance is done to analyze the difference in the effectiveness of the three therapies in girls

```
> gw.aov <- aov(gainwt ~ therapy$T)
> gw.aov
Call:
   aov(formula = gainwt ~ therapy$T)
```

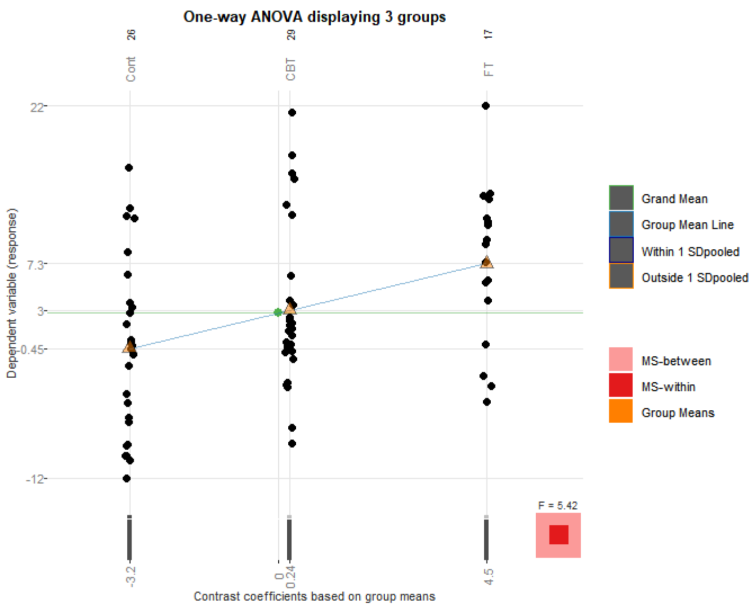
```
Terms:
                therapy$T Residuals
Sum of Squares    614.644  3910.742
Deg. of Freedom         2        69

Residual standard error: 7.528441
Estimated effects may be unbalanced
```

Below is the code for pictorial result of grounded ANOVA, to dig deeper into the results

```
> granovagg.1w(gainwt, group = therapy$Treat)
By-group summary statistics for your input data (ordered by group means)
  group  group.mean  trimmed.mean  contrast  variance  standard.deviation
group.size
2  Cont      -0.45         -1.16    -3.21    63.82                7.99
26
1   CBT       3.01          1.80     0.24    53.41                7.31
29
3    FT       7.26          7.91     4.50    51.23                7.16
17
Below is a linear model summary of your input data
Call:
lm(formula = score ~ group, data = owp$data)
Residuals:
    Min      1Q  Median      3Q     Max
-12.565  -4.543  -1.007   3.846  17.893
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    3.007      1.398   2.151   0.0350 *
groupCont     -3.457      2.033  -1.700   0.0936 .
groupFT        4.258      2.300   1.852   0.0684 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 7.528 on 69 degrees of freedom
Multiple R-squared:  0.1358,     Adjusted R-squared:  0.1108
F-statistic: 5.422 on 2 and 69 DF,  p-value: 0.006499
```

The above results show that there is strong evidence that at least one of the groups are statistically different form others with p value0.0065.



The above plot shows the depiction of the results where the contrast difference of grouped mean and trimmed mean for group CBT is just above the grand mean and for FT group is much above the grand mean while for control group is very much below the grand mean.

The below code is to find if there is any difference in the groups by ANOVA by drawing linear models

```
> gw.lm <- lm(gainwt ~ therapy$Treat)
> gw.lm
Call:
lm(formula = gainwt ~ therapy$Treat)
Coefficients:
      (Intercept)  therapy$TreatCont    therapy$TreatFT
            3.007             -3.457              4.258
> summary(gw.lm)
Call:
lm(formula = gainwt ~ therapy$Treat)
Residuals:
```

```
    Min       1Q  Median       3Q      Max
-12.565  -4.543  -1.007   3.846  17.893

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)          3.007      1.398   2.151   0.0350 *
therapy$TreatCont   -3.457      2.033  -1.700   0.0936 .
therapy$TreatFT      4.258      2.300   1.852   0.0684 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.528 on 69 degrees of freedom
Multiple R-squared:  0.1358,     Adjusted R-squared:  0.1108
F-statistic: 5.422 on 2 and 69 DF,  p-value: 0.006499
```

The above result show that the each of control and FT groups differ significantly from CBT group. Lets take a look at anova model

```
> anova(gw.lm)
Analysis of Variance Table

Response: gainwt
              Df Sum Sq Mean Sq F value   Pr(>F)
therapy$Treat  2  614.6 307.322  5.4223 0.006499 **
Residuals     69 3910.7  56.677
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

All the models give the same result that at least one group is different from the other (with respect to the gainwt) with convincing strong evidence p value = 0.0065

To have a deeper group wise analysis of the difference, Let's take a look at the DTK commands

```
> gw.dtk <- DTK.test(gainwt, therapy$Treat)
> gw.dtk
[[1]]
```

```
[1] 0.05

[[2]]
              Diff  Lower CI  Upper CI
Cont-CBT -3.456897 -8.605223  1.691430
FT-CBT    4.257809 -1.215117  9.730735
FT-Cont   7.714706  1.774911 13.654501


> DTK.plot(gw.dtk)
> TK.test(gainwt, therapy$Treat)
  Tukey multiple comparisons of means
    95% family-wise confidence level
Fit: aov(formula = x ~ f)
$f
              diff       lwr       upr     p adj
Cont-CBT -3.456897 -8.327276  1.413483 0.2124428
FT-CBT    4.257809 -1.250554  9.766173 0.1607461
FT-Cont   7.714706  2.090124 13.339288 0.0045127
```

The above results show that FT – Cont group differ significantly with significant evidence of p value 0.004 with the confidence interval of 1.77 and 13.65 where as the remaining FT-CBT and cont-CBT have a quite opposite result compared to FT-Cont, as discussed in the ANOVA results.