Use the background information and the analytical results on the ***R Handout Results #1*** to answer the following questions. Make sure to answer each question as thoroughly as possible and by citing supporting evidence where appropriate (you may want to label output on the handout).

a) Assess all assumptions on the original scale. State whether you will interpret results on the original or transformed scale (you should examine, but you do not need to describe, the tests of assumptions on the transformed scale).

b) What type(s) of effects are **and** are not evident in these results?

c) For the effect(s) that you identified in (b), which group means are **and** are not statistically different? For group means that differ, specifically state which group means are larger or smaller and by how much (on the original scale, if possible).

d) Modify one of the graphics to illustrate your results from question (c) (*make sure to explicitly identify which graph(s) you marked*).

e) Were the author's research hypotheses supported by the data? Be specific.

Biometry Quiz #2 R Handout Results #1

Sanz (2001) examined the nesting behavior and nesting success for male and female Pied Flycatchers (*Ficedula hypoleuca*). He hypothesized that males would be more involved in nesting activities as the level of brood demand increased and as the "attractiveness" of the male decreased.

The author manipulated brood demand by removing two eggs from randomly selected nests and placing those eggs into other randomly selected nests. Still other nests were not manipulated. This created three levels for the "clutch-size manipulation" factor (`csm`) – reduced (two eggs removed), enlarged (two eggs added), and control (no eggs removed or added).

The author manipulated the "attractiveness" of the male by reducing the size of the white patch on the forehead. The forehead patch was reduced in size on randomly selected males by clipping approximately two-thirds of the white feathers. Thus, the experiment consisted of two levels of the "forehead manipulation" factor (`fh`) – "unmanipulated" (more attractive) and "reduced" (less attractive).

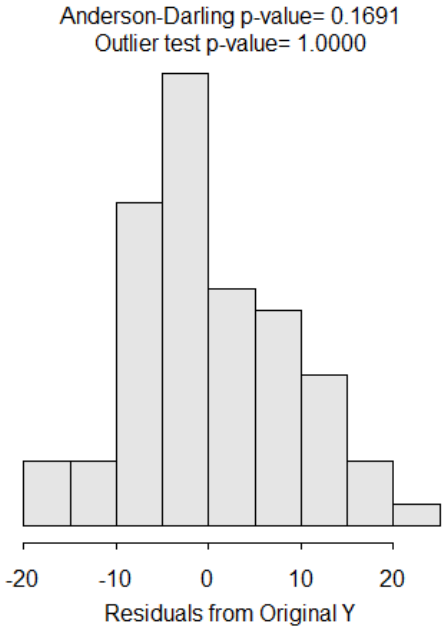
In one aspect of the experiment, Sanz recorded the feeding rate (`mfr`; number of times the male fed the hatchlings per hour) of the male flycatchers on the 13th day post-hatch. The author tested his hypotheses by examining the data for clutch-size manipulation, forehead manipulation, and the interaction between these two factors on feeding rates.

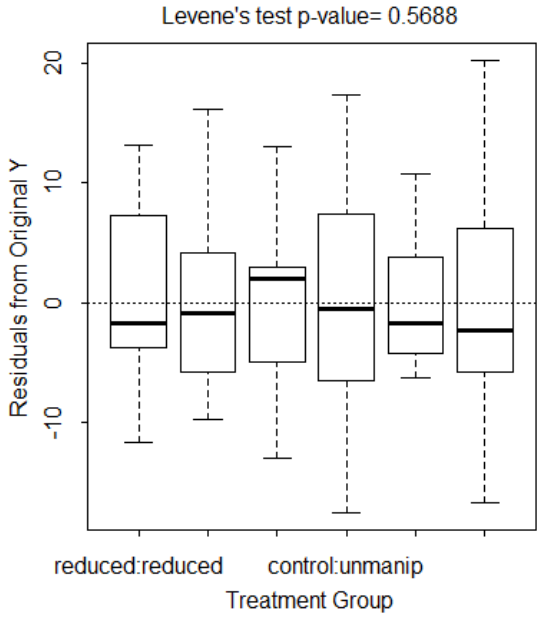
```
> pfc <- read.table("PiedFlycatcher1.txt",head=TRUE)

> pfc$csm <- factor(pfc$csm,levels=c("reduced","control","enlarged"))
> pfc$comb <- pfc$csm:pfc$fh
> pfc$logmfr <- log(pfc$mfr)
```

```
> str(pfc)
  'data.frame': 74 obs. of  5 variables:
   $ csm   : Factor w/ 3 levels "reduced","control",..: 2 2 2 2 2 2 2 2 ...
   $ fh    : Factor w/ 2 levels "reduced","unmanip": 2 2 2 2 2 2 2 2 2 ...
   $ mfr   : int  1 13 11 3 24 12 26 36 17 19 ...
   $ comb  : Factor w/ 6 levels "reduced:reduced",..: 4 4 4 4 4 4 4 4 4 ...
   $ logmfr: num  0 2.56 2.4 1.1 3.18 ...
```

> aov1 <- lm(mfr~csm*fh,data=pfc)

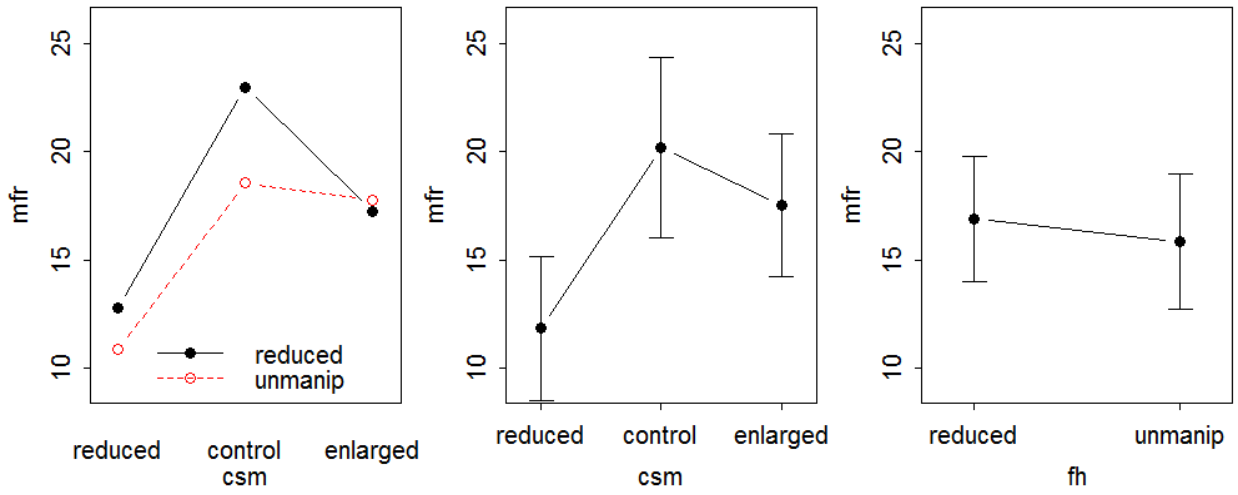
```
> transChooser(aov1)
```



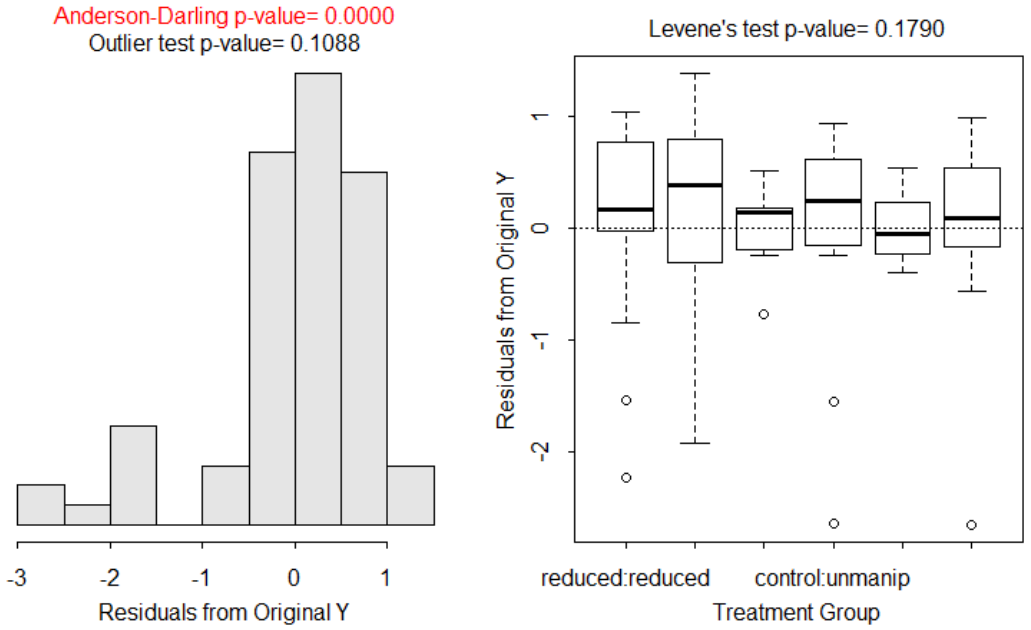



```
> anova(aov1)
            Df Sum Sq Mean Sq F value   Pr(>F)
csm          2  896.1  448.04  5.9343 0.004212
fh           1   55.3   55.26  0.7319 0.395276
csm:fh       2   70.5   35.24  0.4667 0.629034
Residuals 68 5134.0   75.50

> mc1 <- glht(aov1,mcp(csm="Tukey"))
> summary(mc1)
                         Estimate Std. Error t value Pr(>|t|)
control - reduced == 0     10.231      3.905   2.620   0.0286
enlarged - reduced == 0     4.481      3.478   1.288   0.4058
enlarged - control == 0    -5.750      3.966  -1.450   0.3207

> confint(mc1)
                         Estimate lwr      upr
control - reduced == 0   10.2308   0.8817  19.5798
enlarged - reduced == 0   4.4808  -3.8480  12.8096
enlarged - control == 0  -5.7500 -15.2463   3.7463
```

```
> aov1c <- lm(mfr~comb,data=pfc)
> mc1c <- glht(aov1c,mcp(comb="Tukey"))

> summary(mc1c)
                                          Estimate Std. Error t value Pr(>|t|)
reduced:unmanip - reduced:reduced == 0     -1.9231     3.4081  -0.564   0.9929
control:reduced - reduced:reduced == 0     10.2308     3.9045   2.620   0.1056
control:unmanip - reduced:reduced == 0      5.8022     3.3467   1.734   0.5133
enlarged:reduced - reduced:reduced == 0     4.4808     3.4784   1.288   0.7893
enlarged:unmanip - reduced:reduced == 0     5.0165     3.3467   1.499   0.6647
control:reduced - reduced:unmanip == 0     12.1538     3.9045   3.113   0.0307
control:unmanip - reduced:unmanip == 0      7.7253     3.3467   2.308   0.2039
enlarged:reduced - reduced:unmanip == 0     6.4038     3.4784   1.841   0.4455
enlarged:unmanip - reduced:unmanip == 0     6.9396     3.3467   2.074   0.3119
control:unmanip - control:reduced == 0     -4.4286     3.8510  -1.150   0.8577
enlarged:reduced - control:reduced == 0    -5.7500     3.9660  -1.450   0.6953
enlarged:unmanip - control:reduced == 0    -5.2143     3.8510  -1.354   0.7525
enlarged:reduced - control:unmanip == 0    -1.3214     3.4183  -0.387   0.9988
enlarged:unmanip - control:unmanip == 0    -0.7857     3.2842  -0.239   0.9999
enlarged:unmanip - enlarged:reduced == 0    0.5357     3.4183   0.157   1.0000

> confint(mc1c)
                                          Estimate lwr      upr
reduced:unmanip - reduced:reduced == 0     -1.9231 -11.9068   8.0606
control:reduced - reduced:reduced == 0     10.2308  -1.2070  21.6685
control:unmanip - reduced:reduced == 0      5.8022  -4.0016  15.6060
enlarged:reduced - reduced:reduced == 0     4.4808  -5.7088  14.6703
enlarged:unmanip - reduced:reduced == 0     5.0165  -4.7873  14.8203
control:reduced - reduced:unmanip == 0     12.1538   0.7161  23.5916
control:unmanip - reduced:unmanip == 0      7.7253  -2.0785  17.5291
enlarged:reduced - reduced:unmanip == 0     6.4038  -3.7857  16.5934
enlarged:unmanip - reduced:unmanip == 0     6.9396  -2.8642  16.7434
control:unmanip - control:reduced == 0     -4.4286 -15.7097   6.8525
enlarged:reduced - control:reduced == 0    -5.7500 -17.3679   5.8679
enlarged:unmanip - control:reduced == 0    -5.2143 -16.4954   6.0668
enlarged:reduced - control:unmanip == 0    -1.3214 -11.3348   8.6919
enlarged:unmanip - control:unmanip == 0    -0.7857 -10.4063   8.8348
enlarged:unmanip - enlarged:reduced == 0    0.5357  -9.4777  10.5491

> fitPlot(aov1,legend="bottomright",ylim=c(9,26),main="",interval=FALSE)
> fitPlot(aov1,which="csm",ylim=c(9,26),main="")
> fitPlot(aov1,which="fh",ylim=c(9,26),main="")
```




```
> ############################################################
> aov2 <- lm(logmfr~csm*fh,data=pfc)
> transChooser(aov2)
```



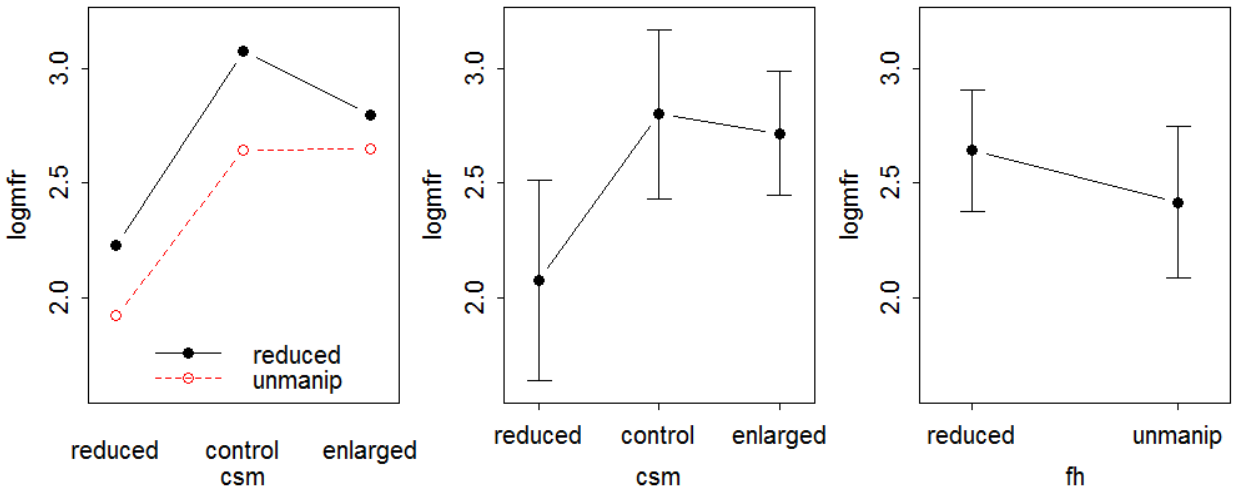

```
> anova(aov2)
           Df Sum Sq Mean Sq F value   Pr(>F)
csm         2  7.907  3.9537  5.0287 0.009188
fh          1  1.491  1.4915  1.8971 0.172926
csm:fh      2  0.231  0.1153  0.1467 0.863828
Residuals  68 53.462  0.7862

> mc2 <- glht(aov2,mcp(csm="Tukey"))
> summary(mc2)
                       Estimate Std. Error t value Pr(>|t|)
control - reduced == 0   0.8488     0.3984   2.130   0.0909
```

```
  enlarged - reduced == 0   0.5699     0.3550   1.605   0.2496
  enlarged - control == 0  -0.2789     0.4047  -0.689   0.7701
```

```
> confint(mc2)
                          Estimate lwr     upr
  control - reduced == 0   0.8488  -0.1056  1.8031
  enlarged - reduced == 0  0.5699  -0.2803  1.4201
  enlarged - control == 0 -0.2789  -1.2483  0.6905
```

```
> aov2c <- lm(logmfr~comb,data=pfc)
> mc2c <- glht(aov2c,mcp(comb="Tukey"))
```

```
> summary(mc2c)
                                          Estimate Std. Error t value Pr(>|t|)
  reduced:unmanip-reduced:reduced == 0   -0.308021   0.347787  -0.886   0.9483
  control:reduced-reduced:reduced == 0    0.848763   0.398440   2.130   0.2831
  control:unmanip-reduced:reduced == 0    0.415207   0.341520   1.216   0.8267
  enlarged:reduced-reduced:reduced == 0   0.569860   0.354958   1.605   0.5963
  enlarged:unmanip-reduced:reduced == 0   0.418257   0.341520   1.225   0.8223
  control:reduced-reduced:unmanip == 0    1.156784   0.398440   2.903   0.0535
  control:unmanip-reduced:unmanip == 0    0.723228   0.341520   2.118   0.2893
  enlarged:reduced-reduced:unmanip == 0   0.877882   0.354958   2.473   0.1458
  enlarged:unmanip-reduced:unmanip == 0   0.726279   0.341520   2.127   0.2850
  control:unmanip-control:reduced == 0   -0.433556   0.392981  -1.103   0.8776
  enlarged:reduced-control:reduced == 0  -0.278903   0.404715  -0.689   0.9825
  enlarged:unmanip-control:reduced == 0  -0.430505   0.392981  -1.095   0.8808
  enlarged:reduced-control:unmanip == 0   0.154654   0.348820   0.443   0.9977
  enlarged:unmanip-control:unmanip == 0   0.003051   0.335136   0.009   1.0000
  enlarged:unmanip-enlarged:reduced == 0 -0.151603   0.348820  -0.435   0.9979

> confint(mc2c)
                                           Estimate  lwr       upr
  reduced:unmanip - reduced:reduced == 0   -0.308021 -1.326942  0.710899
  control:reduced - reduced:reduced == 0    0.848763 -0.318558  2.016083
  control:unmanip - reduced:reduced == 0    0.415207 -0.585354  1.415767
  enlarged:reduced - reduced:reduced == 0   0.569860 -0.470072  1.609792
  enlarged:unmanip - reduced:reduced == 0   0.418257 -0.582303  1.418818
  control:reduced - reduced:unmanip == 0    1.156784 -0.010536  2.324105
  control:unmanip - reduced:unmanip == 0    0.723228 -0.277332  1.723788
  enlarged:reduced - reduced:unmanip == 0   0.877882 -0.162050  1.917813
  enlarged:unmanip - reduced:unmanip == 0   0.726279 -0.274282  1.726839
  control:unmanip - control:reduced == 0   -0.433556 -1.584885  0.717773
  enlarged:reduced - control:reduced == 0  -0.278903 -1.464607  0.906802
  enlarged:unmanip - control:reduced == 0  -0.430505 -1.581834  0.720823
  enlarged:reduced - control:unmanip == 0   0.154654 -0.867295  1.176602
  enlarged:unmanip - control:unmanip == 0   0.003051 -0.978806  0.984907
  enlarged:unmanip - enlarged:reduced == 0 -0.151603 -1.173552  0.870346

> fitPlot(aov2,legend="bottomright",ylim=c(1.6,3.2),main="",interval=FALSE)
> fitPlot(aov2,which="csm",ylim=c(1.6,3.2),main="")
> fitPlot(aov2,which="fh",ylim=c(1.6,3.2),main="")
```


logmfr
2.0
2.5
3.0
reduced
unmanip
reduced
control
enlarged
csm
logmfr
2.0
2.5
3.0
reduced
control
enlarged
csm
logmfr
2.0
2.5
3.0
reduced
unmanip
fh