STAT 516 - Spring 2004 - Homework 4 Solutions

Pg. 279: #1 False. If for two samples the conclusions from an ANOVA and t test disagree, you ~~should trust the t-test~~ made a mistake! (see bottom of page 230 and top of 231... they must be the same)

Pg. 279: #2 True. Since F=MSB/MSW, if MSW is smaller, the F is larger and we would reject more often.

Pg. 279: #12

Source	df	SS
Between Factors	2	810
Within (error)	8	720

False: The null hypothesis is that all ~~four~~ three means are equal.

False: F=MSB/MSW=(810/2)/(720/8)=405/90=4.5 (1.125 is SSB/SSW)

False: The critical value for F for 5% significance is ~~6.60~~ 4.46. (Table A.4A on page 627)

True: It can be rejected at 5% significance because the observed 4.5 is greater than the critical value of 4.46.

True: The null hypothesis cannot be rejected at 1% significance because the observed 4.5 is less than the critical value of 8.65.

False: There are ~~10~~ 11 observations in the experiment. (total df = 8+2 = sample size minus 1)

2a) Write down the equation of the one-way ANOVA model that is described by this set-up. Be sure to clearly identify each parameter and the sample sizes.

Following page 233, the section called "The Linear Model for Several Populations" we could writte

$y_{ij} = \mu_i + \varepsilon_{ij}$ where the y_{ij} and ε_{ij} are the observed scores and errors respectively for the *j*th observer for face *i*. μ_i is the average dominance score for that facial expression. The *i* faces are 1=Angry, 2=Disgusted, 3=Fearful, 4=Happy, 5=Sad, 6=Neutral; and, *j* goes from 0 to 6 (six observers for each face).

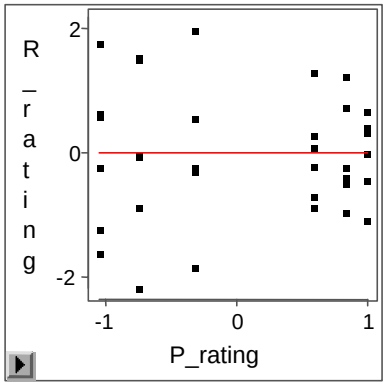
Using the section on page 233 called "The Analysis of Variance Model" we would have split the μ_i into an overall average and treatment effects (τ_i).

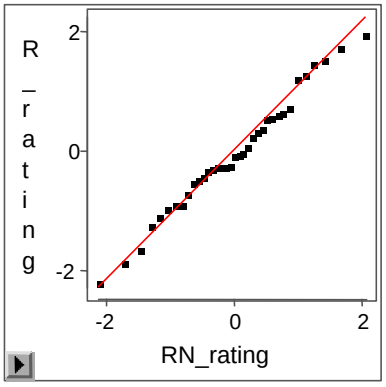
```
DATA faces;
INPUT emotion $ rating @@;
CARDS;
Angry 2.10 Angry  0.64 Angry 0.47 Angry 0.37 Angry 1.62 Angry -0.08
Disg  0.40 Disg   0.73 Disg -0.07 Disg -0.25 Disg  0.89 Disg   1.93
Fear  0.82 Fear  -2.93 Fear -0.74 Fear  0.79 Fear -0.77 Fear  -1.60
Happy 1.71 Happy -0.04 Happy 1.04 Happy 1.44 Happy 1.37 Happy  0.59
Sad   0.74 Sad   -1.26 Sad  -2.27 Sad  -0.39 Sad  -2.65 Sad   -0.44
Neut  1.69 Neut  -0.60 Neut -0.55 Neut  0.27 Neut -0.57 Neut  -2.16
;

PROC INSIGHT:
OPEN faces;
FIT rating=emotion;
RUN;

PROC GLM DATA=faces ORDER=DATA;
CLASS emotion;
MODEL rating=emotion;
MEANS emotion / HOVTEST=BF;
RUN;
```

b) Check that the assumptions for performing a one-way ANOVA hold, including using Levene's test.





Brown and Forsythe's Test for Homogeneity of rating Variance
ANOVA of Absolute Deviations from Group Medians

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
emotion	5	1.6184	0.3237	0.67	0.6477
Error	30	14.4467	0.4816		

1) Since the students were randomly divided into the six groups, the errors are independent.
2) The means of the errors are always 0 in a one-way ANOVA (or could look at residual vs. predicted plot)
3) The errors appear to be normally distributed as the q-q plot is very close to a straight line.
4) It is not clear from the residual versus predicted plot if the variance of the errors is constant, but with a p-value of 0.6477 in the modified Levene's test we accept that the variances of the errors are equal.

c) What hypothesis is being tested by the F-statistic in the ANOVA table? State your conclusion at the α=0.05 level.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Stat	Pr > F
Model	5	23.0852	4.6170	3.96	0.0071
Error	30	34.9870	1.1662		
C Total	35	58.0722			

H_0: $\mu_{Angry}=\mu_{Disgusted}=\mu_{Fearful}=\mu_{Happy}=\mu_{Sad}=\mu_{Neutral}$
H_A: At least one is different

At α=0.05 we reject H_0 because the p-value of 0.0071 is less than α.

d) Use the Holm procedure with an experiment-wise (family-wise) α_T=0.05 level to test all of the pair-wise differences, and make a display showing the ranking in which the different facial expressions reflect dominance.

```
PROC MULTTEST DATA=faces ORDER=DATA HOLM;
CLASS emotion;
CONTRAST 'Ang vs Dsg'  1 -1  0  0  0  0;
CONTRAST 'Ang vs Fer'  1  0 -1  0  0  0;
CONTRAST 'Ang vs Hap'  1  0  0 -1  0  0;
CONTRAST 'Ang vs Sad'  1  0  0  0 -1  0;
CONTRAST 'Ang vs Neu'  1  0  0  0  0 -1;
CONTRAST 'Dsg vs Fer'  0  1 -1  0  0  0;
CONTRAST 'Dsg vs Hap'  0  1  0 -1  0  0;
CONTRAST 'Dsg vs Sad'  0  1  0  0 -1  0;
CONTRAST 'Dsg vs Neu'  0  1  0  0  0 -1;
CONTRAST 'Fer vs Hap'  0  0  1 -1  0  0;
CONTRAST 'Fer vs Sad'  0  0  1  0 -1  0;
CONTRAST 'Fer vs Neu'  0  0  1  0  0 -1;
CONTRAST 'Hap vs Sad'  0  0  0  1 -1  0;
CONTRAST 'Hap vs Neu'  0  0  0  1  0 -1;
CONTRAST 'Sad vs Neu'  0  0  0  0  1 -1;
TEST mean(rating);
RUN;
```

Variable	emotion	NumObs	Mean	Standard Deviation
rating	Angry	6	0.8533	0.8294
rating	Disg	6	0.6050	0.7850
rating	Fear	6	-0.7383	1.4360
rating	Happy	6	1.0183	0.6456
rating	Sad	6	-1.0450	1.2731
rating	Neut	6	-0.3200	1.2623

p-Values

Variable	Contrast	Raw	Stepdown Bonferroni
rating	Ang vs Dsg	0.6932	1.0000
rating	Ang vs Fer	0.0160	0.1761
rating	Ang vs Hap	0.7931	1.0000
rating	Ang vs Sad	0.0048	0.0674
rating	Ang vs Neu	0.0696	0.5567
rating	Dsg vs Fer	0.0394	0.3935
rating	Dsg vs Hap	0.5124	1.0000
rating	Dsg vs Sad	0.0128	0.1540
rating	Dsg vs Neu	0.1484	1.0000
rating	Fer vs Hap	0.0085	0.1103
rating	Fer vs Sad	0.6264	1.0000
rating	Fer vs Neu	0.5074	1.0000
rating	Hap vs Sad	0.0024	0.0366
rating	Hap vs Neu	0.0400	0.3935
rating	Sad vs Neu	0.2541	1.0000

Happy	**1.0183**	**A**	
Angry	**0.8533**	**A**	**B**
Disg	**0.6050**	**A**	**B**
Neut	**-0.3200**	**A**	**B**
Fear	**-0.7383**	**A**	**B**
Sad	**-1.0450**		**B**

We can only tell that happy and sad are different... and that’s all.

e) Use a contrast to make a 95% confidence interval for the difference in dominance between the average of the two strong negative emotions (Angry and Disgusted) and the positive emotion (Happy).

```
PROC GLM DATA=faces ORDER=DATA;
CLASS emotion;
MODEL rating=emotion;
ESTIMATE 'strongneg vs pos'  emotion  1  1  0  -2 0 0 / divisor=2;
RUN;
```

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	23.08522222	4.61704444	3.96	0.0071
Er36ror	**30**	34.98700000	1.16623333		
Corrected Total	35	58.07222222			

Parameter	Estimate	Standard Error	t Value	Pr > |t|
strongneg vs pos	**-0.28916667**	**0.53996142**	-0.54	0.5962

So, we get the 95% confidence interval for $(\mu_{angry}+\mu_{disgusted})/2 - \mu_{happy}$ is

$$\hat{L} \pm t_{0.025,df=30}\hat{\sigma}_{\hat{L}} = -0.28917 \pm 2.0423(0.53996) = -0.28917 \pm 1.10276 = (-1.39, 0.81)$$

where a negative number means that the positive emotion is more dominant, and a positive number means the negative emotions are more dominant.