

STATISTICS 500 – Fall 2009

Homework 4 - handed out Friday, September 18, 2009

DUE DATE:

- on campus Friday, 25 Sept 2009, in lecture (11 am)
 or by e-mail to Chuanlong, dclong@iastate.edu, no later than noon.
- off campus Monday, 28 Sept 2009, by 4 pm to Nicole Rembert, email: rembeall@iastate.edu or
 FAX: 515-294-4040 (please include cover page with Stat 500 / Nicole Rembert).

- The following is based on an experiment comparing diet plans for dogs. Individual dogs are randomly assigned to a diet plan. At the end of one month the investigators measure blood urea concentration, in mg/dL. They use ANOVA to analyze the data. A portion of the ANOVA table is provided below.

Source	d.f.	SS	MS
Treatment	3		
Error	20	441.35	
Total		2714.15	

Note: This problem requires hand calculation throughout.

- Fill in the rest of the ANOVA table from the information provided.
 - How many diet plans are being compared?
 - Assume all groups have the same sample size. How many observations in each treatment group?
 - Test H_0 : all means are equal. Report the F statistic, p-value, and state a reasonable conclusion.
- For each of the following studies, indicate whether the specified factor(s) should be considered fixed or random and explain your choice (1 sentence).
 - A study of student achievement in Los Angeles High Schools. 10 high schools are randomly chosen from the list of high schools in LA. (I don't know the actual number, but there must be 100+ high schools in the LA school district). 40 seniors are randomly chosen from each school and given an achievement test. The aim is to estimate the average achievement score for the school district. Schools should be treated as (Fixed? Random?).
 - A second study of student achievement in LA. You are a principal at high school A. You want to know if your school has higher achievement than any other school. You get permission to survey 9 additional schools. Again, the achievement test is given to 40 students per school. The aim is to estimate the 9 differences between school A and each of the other 9 schools. Schools should be treated as ??.
 - A third study of student achievement in LA. You are an educational researcher. You have developed two new curricula and want to assess their effectiveness. You randomly choose 10 high schools in LA. Then, 3 schools are randomly assigned to Curriculum A, 3 are randomly assigned to Curriculum B, and 4 continue with the traditional curriculum. You want to estimate the differences between curricula. You also want to estimate the variability among schools using the same curriculum. Schools should be treated as ???. Curriculum should be treated as ???.
 - The following data come from a study of industrial bottle filling machines. The data are in bottle.txt. The values are the actual amount of liquid put into a bottle. This is called the "fill". These filling machines are supposed to fill bottles to an average of 32.1 ounces. The goal of this study is to see whether any machine under or over fills, or whether all six machines have the same mean. I suggest you use the computer. You may assume that the usual assumptions (independence, equal variance, normality) hold.

- (a) Plot the data in a way that shows both the variability among machines and the variability among observations within a machine. Some possible examples of such a plot are a side-by-side boxplots or a dot plot (Y = observation, X = machine). Does it seem reasonable that all machines have the same mean fill? (no test required here).
- (b) Test the hypothesis that all six machines have the same mean fill. Report your test statistic and p-value. Provide a one (or perhaps two) sentence conclusion.
- (c) Assume that all six machines have the same variance and test whether the mean fill for machine 1 equals 32.1 oz.
- (d) Estimate a 95% confidence interval for the mean difference between machines 5 and 6. Again, assume all six machines have the same variance.
- (e) This part is an exercise to demonstrate the model comparison approach to calculating SS. You don't know how SAS computes the SS for the F test of equal means (although we'll talk about it later when it matters). I want you to demonstrate numerically the equivalence of the model comparison approach and 'the SAS numbers'. We'll use the computer to compute what I called SS_1 and SS_2 . For any model, these are given by SAS proc glm in the 'Error' row. What I called df_1 and df_2 are given by the Error df. Other software might call these 'Residual' or 'Within'. For the bottle data, use the model comparison approach to calculate the F statistic that compares:

model 1: $Y_{ij} = \mu + \epsilon_{ij}$ proc glm; model y = ; run;

model 2: $Y_{ij} = \mu_i + \epsilon_{ij}$ proc glm; class group; model y = group; run;

Is this the same F statistic that you got in part 3b? I.e. that you get from the computer's test of H_0 : all means are equal.

- (f) After you discuss your results with the plant managers, they tell you they are not surprised. Machines 1 and 2 were purchased new 5 years ago. Machines 3 and 4 were purchased reconditioned 5 years ago. Machines 5 and 6 were purchased new last year. This suggests two interesting contrasts:
 - a) purchased new (machines 1, 2, 5 and 6) or reconditioned (3 and 4)
 - b) purchased new 5 years ago (machines 1 and 2) or last year (5 and 6).

For each comparison, report your estimate of the contrast, its s.e., and the p-value for a test of contrast = 0.

Note: use the error variance (variability among bottles) to calculate the se. If you think carefully about this problem, you may realize that it would be better to use the variability between machines of the same condition. I agree, but we haven't talked about how to do this. We'll do that at the end of the semester.

- (g) Are the two contrasts (a and b, above) uncorrelated? There are 20 bottles measured for each machine.
- (h) Are there any other interesting difference among the machines? In other words, if you partition the variation among machines into an "interesting" part (contrasts a and b) and "everything else". Is the "everything else" part significant? Report your test statistic and p-value.

4. Treatments and contrasts — An experiment looked at the effect of diet on longevity of mice. The investigators wanted to see if restricting caloric intake would increase life expectancy. Female mice were randomly assigned to one of six treatment groups. The data are in **dietlong.txt** on the class web site. The six treatments are:

NP - no diet restriction, mice can eat as much as they want.

N/N85 - normal feeding before and after weaning with 85 kcal/wk after weaning, a typical recommended mice diet.

N/R50 - normal feeding before weaning, restricted to 50 kcal/wk after weaning

lopro - N/R50 diet (normal, then restricted to 50 kcal/wk after weaning) with low protein content

R/R50 - restricted to 50 kcal/wk before and after weaning

N/R40 - normal feeding before weaning, severely restricted diet with 40 kcal/wk after weaning.

The response is the lifetime of the mouse, measured in months.

- (a) Test whether all diets have the same mean longevity.
- (b) If you are interested in all pairwise differences between treatments, what multiple comparisons procedure (if any) is appropriate? Then, identify which pairs of diets differ significantly using the appropriate m.c.p.
- (c) In this problem, examining all pairwise comparisons is not very reasonable because some comparisons do not make much sense. Based on the treatments, the investigators are primarily interested in the contrasts given in the following table.

Contrast	NP	N/N85	N/R50	lopro	R/R50	N/R40
# mice	49	57	71	56	56	60
0	0	0	1	0	0	-1
1	1	0	-0.25	-0.25	-0.25	-0.25
2	0	0	1	0	-1	0
3	0	0	1	-1	0	0
4	0	1	-0.5	-0.5	0	0
5	1	-1	0	0	0	0

For contrasts 1 through 5, describe in words the quantity being estimated. As an example of what I want, contrast 0 could be described as “the effect of reducing calories even further, from 50 kcal/wk to 40 kcal/wk after weaning”. Notice the first part of my answer: I want more than just “the difference between N/R50 and N/R40”.

- (d) Assume (for a moment) that each treatment has the same sample size. (I.e. ignore the sample sizes given above). You may assume all treatments have 60 mice. Are contrasts 1 and 2 orthogonal? Are contrasts 3 and 4 orthogonal?
- (e) The real sample sizes are in the table above. Are contrasts 1 and 2 orthogonal? Are contrasts 3 and 4 orthogonal?
- (f) For each of the five contrasts in the table, estimate the contrast and test H_0 : contrast = 0.