ST553 HW3

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April 22, 2019

Question 1

We have 5 total treatments, which means that at most we can have 4 orthogonal contrasts. Our treatments are:

- A, B which corresponds to flipped classroom setups
- C, D which correspond to online classrooms
- E which is for conventional lecture style classrooms

This treatment design lends itself to many interesting investigations. A possible orthogonal contrast configuration is:

μ_A	μ_B	μ_C	μ_D	μ_E
1/2	-1/2	0	0	0
0	0	1/2	-1/2	0
1/4	1/4	-1/4	-1/4	0
-1/4	-1/4	-1/4	-1/4	1

All of these treatments are orthogonal to one another. The first contrast tests if the flipped classroom treatment means are different from one another. The second contrast likewise tests if the online treatment means are different from each other. The third contrasts tests the means of the flipped classroom treatments and the online classroom treatments. Finally, the fourth contrast tests if the flipped and online classroom treatments are different from the traditional lecture style treatment.

Question 2

Here we are given a hypothetical experiment setup where the number of groups g = 7 and sample size n = 21.

a.

The Bonferroni and Scheffe procedures have different methods of producing simultaneous confidence intervals. The Bonferroni method consists of calculating margin of error using a critical t-statistic with a left tail probability of $1 - \frac{\epsilon}{k}$ where ϵ is our predetermined strong familywise error rate and k is our number of hypothesis tests.

The Scheffe method meanwhile calculates margin of error using $\sqrt{(g-1)F_{1-\epsilon,g-1,\nu}}$ where ν is the degrees of freedom from the MSE.

Our Scheffe margin of error can be calculated in R using `qf()`

```
## [1] 4.133565
```

All we need to do now is find the appropriate k such that our t-statistic in Bonferroni is larger than this value.

```
##     k tstatistic
## 50 50   4.140454
## 51 51   4.150615
## 52 52   4.160582
## 53 53   4.170364
## 54 54   4.179968
## 55 55   4.189399
```

From the table above, the Bonferroni t-statistic becomes larger than our Scheffe F-statistic when k is larger than 50.

b.

Now we are interested in pairwise comparisons using Tukey and Dunnett's procedures. In total we have 21 possible pairwise comparisons.

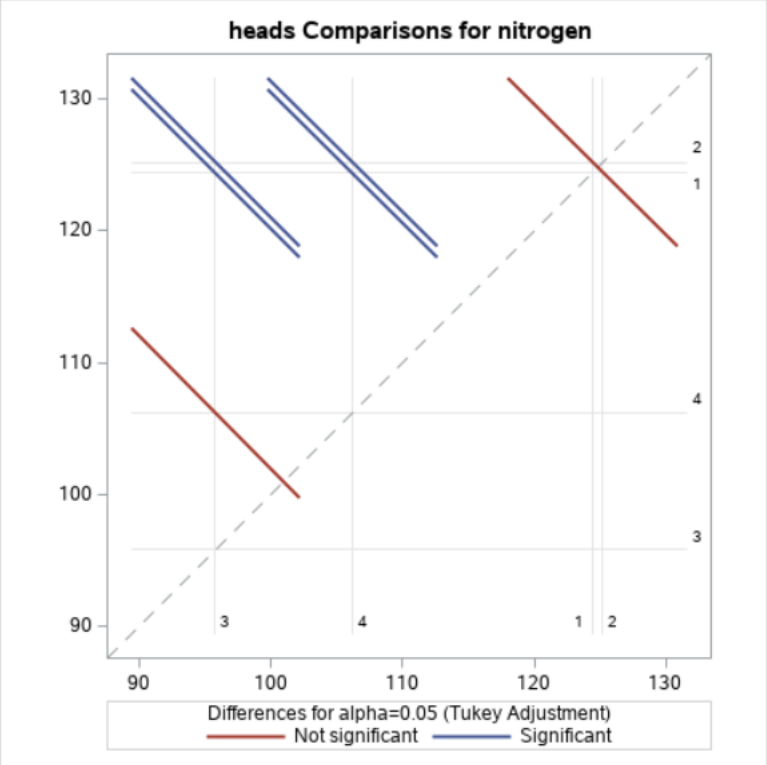
Tukey's honestly significant differences procedure looks at possible comparisons, so in our case, it would look at all 21 possible pairs of means.

Dunnett's procedure looks at pairwise comparisons of all the treatments *against a single other treatment*, for example, a control group. Since we have 7 groups, assuming that one group is our group of interest, we will have six total comparisons.

Question 3

a.

We can do Tukey's Honestly Significant differences for this problem.



Since 0 is contained inside the intervals for the difference between bloodmeal and cottonseed and the difference between ammonium nitrate and urea, these treatment pairs are not significantly different from each other. All the other pairwise differences are significantly different from each other.

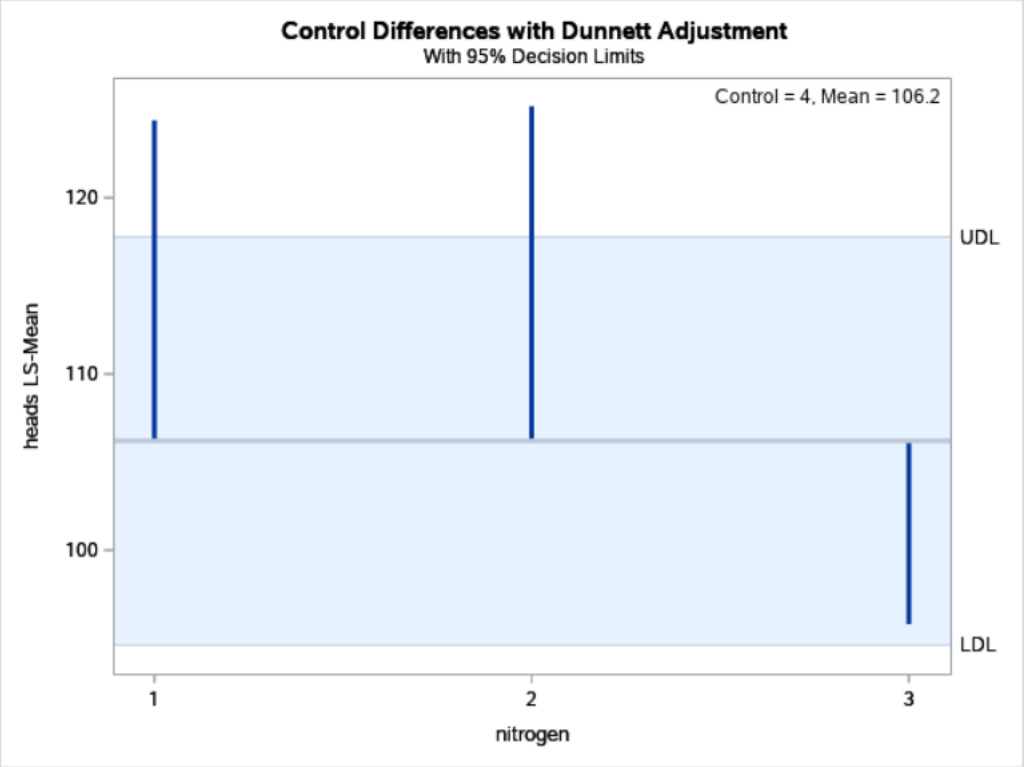
In an underline diagram, we would have something like:

1	2	3	4
A	A		
		B	B

Where the treatments are the columns and treatments which share letters *are not* different from one another.

b.

We can use Dunnett's procedure for this with urea as our control.



Blood meal and cottonseed treatments are significantly different from urea while ammonium nitrate is not.

c.

We can do Multiple Comparisons with the Best (MCB) for this problem. The gist of the output is below:

Effect	nitrogen	Estimate	StdErr	cllo	clhi	rval	sval
nitrogen	1	124.40	3.1615	-10.7575	9.1575	0.68179	.
nitrogen	2	125.20	3.1615	-9.1575	10.7575	.	0.68179
nitrogen	3	95.8000	3.1615	-39.3575	0.0000	0.00001	.
nitrogen	4	106.20	3.1615	-28.9575	0.0000	0.00084	.

The columns **cllo** and **clhi** define the confidence interval for the difference between each estimate and the "best" treatment, which going off of our point estimates is treatment 2, the cottonseed meal. We can see that treatments 1 and 2 have 0 contained inside of their confidence interval while 3 and 4 do not, meaning that treatments 3 and 4 are significantly different from the best treatment while treatment 1 is not.

d.

	p-Values	
Test	Raw	Bonferroni
1	0.8602	1.0000
2	0.0335	0.0670

After using `PROC MULTTEST` with Bonferroni corrections, we see that there is no evidence that there is a difference between blood meal and cottonseed and weak evidence that there is a difference between ammonium nitrate and urea.

e.

Parameter	Estimate	Standard Error	t Value	Pr > |t|
ammonium vs others	22.8000000	3.65057073	6.25	<.0001

The estimate for this contrast is 22.8, meaning that on average ammonium nitrate produces 22.8 less heads of lettuce than blood meal, cottonseed, and urea.