Lab activity: multiple comparisons

Researchers conduct an expt to compare mean body temp for n=45 subjects randomized to one of 9 different blood pressure medications, labelled a, b ... g.

Ten hourly body temperature measurements were made from 8:00 am onward after administration of the drug at 6:00 am. The average of these measurements for each subject, along with SAS code to read them into a dataset, appears in the file “bp.sas”. Data are taken from “An intro. to stat. methods and data analysis,” by Ott and Longnecker.

1. Specify a one-factor ANOVA model for body temperatures with MEDICATION as the experimental factor of interest.

2. Specify the null hypothesis that all medications are equivalent.

3. Use PROC GLM to obtain the F-ratio and p-value corresponding to a test of the hypothesis in part b)

4. How many degrees of freedom are there for assessing error within each treatment group?

5. How many treatment groups are there?

6. What are the degrees of freedom associated with $MSE$?

7. Add the following statement within PROC GLM

   $$\text{MEANS medication/TUKEY BON SCHEFFE ;}$$

   Using your textbook, or appropriate software like excel, SAS or R, find the appropriate critical values you would need to carry out simultaneous inference for all pairwise comparisons using $experimentwise error rate \alpha = 0.05$: 

   $$t(0.025/36,36) = ?$$
   $$F(0.05, 8, 36) = 2.21 \text{ (for Scheffé)}$$
   $$q(0.05, 9, 36) = ?$$

8. Match the multiple comparison procedure with the appropriate critical value.

9. Inspect the output to find these same critical values.

10. Which of these three multiple comparison procedure is most powerful if you are only interested in all pairwise comparisons in this setting?
11. Some of the output from these three options has been condensed into the file “bp.txt”. Medications \(a\) and \(e\) differ significantly using Tukey or Bonferroni, but not using Scheffé. (We didn’t cover the how-to of Scheffé, but take a moment to glance at the output for comparison w/ Bonferroni and Tukey.) Name two other differences in simultaneous inference from the three procedures.

(a) \(a\) and \(e\) differ significantly using Tukey or Bonferroni, but not Scheffé

(b)

(c)

12. Try adding the CLDIFF option to get simultaneous confidence intervals in addition to the multiple tests you’ve carried out:

```sas
MEANS medication/TUKEY BON SCHEFFE CLDIFF;
```

13. What would happen if you carried out the multiple comparisons with experimentwise error rate \(\alpha = 0.10\)? Would you find more or fewer significant differences among your \(k = 36\) comparisons? Try it and see using

```sas
MEANS medication/TUKEY BON SCHEFFE CLDIFF ALPHA=0.10;
```

The analysis so far does not report any \(p\)-values for pairwise comparisons. If you want a matrix of \(p\)-values from all the tests, where the \(i,j\) entry corresponds to a pairwise comparison of the mean for level \(i\) with that for level \(j\) of the factor, use the code below:

```sas
LSMEANS medication/PDIFF ADJ=TUKEY;
LSMEANS medication/PDIFF ADJ=BON;
LSMEANS medication/PDIFF ADJ=SCHEFFE;
```

Report the multiplicity-adjusted \(p\)-value for a test of \(\mu_a = \mu_e\) using each of the three multiple comparison procedures.

(a) \(p = 0.0083\) (Tukey)

(b)

(c)

(Note the agreement with our earlier analysis based on confidence intervals.)

14. Dunnett’s procedure can be used to make the \(t-1\) comparisons of each non-control treatment with a control treatment. Pretend that medication \(a\) is the control and make only the \(9-1 = 8\) comparisons using the DUNNETT option of PROC MEANS. Make the comparisons while controlling the experimentwise error rate at \(\alpha = 0.05\). All of the necessary code can be found in “bp-dunnett.sas”.

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