Using Stata for One-Way Analysis of Variance

We have previously shown how the following one-way ANOVA problem can be solved using SPSS. We will now approach it using Stata. See the related handouts for the underlying theory and formulas.

Problem: A firm wishes to compare four programs for training workers to perform a certain manual task. Twenty new employees are randomly assigned to the training programs, with 5 in each program. At the end of the training period, a test is conducted to see how quickly trainees can perform the task. The number of times the task is performed per minute is recorded for each trainee, with the following results:

Observation	*Program 1*	*Program 2*	*Program 3*	*Program 4*
1	9	10	12	9
2	12	6	14	8
3	14	9	11	11
4	11	9	13	7
5	13	10	11	8
$T_{Aj} = \Sigma y_{ij}$	59	44	61	43
$\hat{\mu}_j = T_{Aj}/N_j$	11.8	8.8	12.2	8.6

Stata Solution. Like SPSS, Stata has `oneway` and `anova` routines, either of which can be used for one-way analysis of variance (`loneway` is also available, and is typically used if you have several hundred categories). `oneway` is quicker than the `anova` command and allows you to perform multiple comparison tests. We'll use `oneway` in this handout and the corresponding two-way ANOVA handout will show how to use the `anova` command.

The basic syntax of the `oneway` command is

`oneway dv iv`

where the iv is a categorical variable, e.g. race, gender, religion, or, in this case, program.

```
. oneway  score program

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups           54.95      3   18.3166667      7.04     0.0031
 Within groups            41.6     16          2.6
------------------------------------------------------------------------
    Total                96.55     19   5.08157895

Bartlett's test for equal variances:  chi2(3) =   0.5685  Prob>chi2 = 0.904
```

This is very similar to SPSS's output. Stata adds Bartlett's test for equal variances. As you'll recall, one of the assumptions of ANOVA is that the variances are the same across groups. The small value for Bartlett's statistic confirms that this assumption is not violated in these data, so the use of ANOVA is ok.

There are some useful optional parameters. To get descriptive statistics, add the `tabulate` parameter, abbreviated `t`.

```
. oneway  score program, t

            |          Summary of score
    program |        Mean   Std. Dev.       Freq.
------------+------------------------------------
          1 |        11.8   1.9235384           5
          2 |         8.8   1.6431677           5
          3 |        12.2   1.3038405           5
          4 |         8.6   1.5165751           5
------------+------------------------------------
      Total |       10.35   2.2542358          20

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups           54.95      3   18.3166667      7.04     0.0031
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Bartlett's test for equal variances:  chi2(3) =   0.5685  Prob>chi2 = 0.904
```

The significant F value of 7.04 tells us that at least one treatment effect differs from zero, i.e. the means are not all equal. However, it does not tell us where the differences are. Bonferroni, Scheffe, and Sidak multiple comparison tests can help to identify these differences. These tests examine the differences between each pair of means. However, just using the .05 level of significance on a pair by pair basis can be misleading: because so many comparisons are being done (J*[J-1]/2 = 6 in this case) the probability is greater than .05 that some differences could be significant just by chance. These tests therefore apply corrections to the reported significance levels that take into account the fact that multiple comparisons are being conducted. You can have `oneway` compute these tests by using the options `bon`, `sch`, and `sid`. Note that these tests tend to be conservative: they reduce the likelihood that you will reject the null when the null is true (i.e. they reduce the likelihood of Type I error.) However, they increase the likelihood of not rejecting the null when the null is false (i.e. they make Type II error more likely.)

As you can see from the printout, the difference between the means of programs 1 and 2 is 3 (11.8 – 8.8). With all three corrections, this difference is not quite significant at the .05 level. On the other hand, the difference between programs 2 and 3 is 3.4, and all three corrections show this difference as significant at the .05 level or better. Basically, the adjustments all agree that there is little difference between the means of 1 and 3, and 2 and 4; there are significant differences between 1 and 4, 2 and 3, and 3 and 4; and the difference between 1 and 2 falls just short of being statistically significant.

```
. oneway  score program, t bon sid sch

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    program |        Mean   Std. Dev.       Freq.
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                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups           54.95      3   18.3166667      7.04     0.0031
 Within groups            41.6     16          2.6
------------------------------------------------------------------------
    Total                96.55     19   5.08157895

Bartlett's test for equal variances:  chi2(3) =   0.5685  Prob>chi2 = 0.904

                        Comparison of score by program
                                (Bonferroni)
Row Mean-|
Col Mean |          1          2          3
---------+---------------------------------
       2 |         -3
         |      0.057
         |
       3 |         .4        3.4
         |      1.000      0.025
         |
       4 |       -3.2        -.2       -3.6
         |      0.038      1.000      0.017

                        Comparison of score by program
                                  (Scheffe)
Row Mean-|
Col Mean |          1          2          3
---------+---------------------------------
       2 |         -3
         |      0.068
         |
       3 |         .4        3.4
         |      0.984      0.034
         |
       4 |       -3.2        -.2       -3.6
         |      0.048      0.998      0.024

                        Comparison of score by program
                                   (Sidak)
Row Mean-|
Col Mean |          1          2          3
---------+---------------------------------
       2 |         -3
         |      0.056
         |
       3 |         .4        3.4
         |      0.999      0.025
         |
       4 |       -3.2        -.2       -3.6
         |      0.038      1.000      0.017
```