SAS: k Between Groups ANOVA & Post Hoc Tests

Application: To compare means of a quantitative variable obtained from 2 or more independent groups.

Research Hypothesis: The researcher hypothesized that Coop stores would have the most fish on display, Chain stores would display the least, and Private pet stores would display an intermediate amount.

H0: for this analysis: The three different types of pet shops have the mean number of fish displayed.

PROC FORMAT;
  VALUE chainf;
  1 = "chain store"
  2 = "privately owned"
  3 = "coop store";
RUN;

LIBNAME stats "C:\stats";
PROC ANOVA DATA=stats.sasplay1;
  FORMAT chain chainf. ;
  CLASS chain;
  MODEL fishnum = chain;
  MEANS chain ;
  MEANS chain / LSD ;
  MEANS chain / TUKEY ;
RUN;

The ANOVA Procedure

Level of CHAIN       N  -------FISHNUM-------  Std Dev
        chain store  5  17.4000000   5.02991054
        coop store  4  35.5000000   4.79583152
       privately owned  3  19.3333333   4.04145188

The GLM Procedure

Dependent Variable: FISHNUM number of fish at store

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>812.0500000</td>
<td>406.025000</td>
<td>18.01</td>
<td>0.0007</td>
</tr>
<tr>
<td>Error</td>
<td>9</td>
<td>202.8666668</td>
<td>22.540741</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>11</td>
<td>1014.9166668</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The p-value of .0007 means that there is about a .07% chance that this result is a Type I error.

Remember, even if the printout shows it, never report p = .0000, because that would suggest there is no possibility of a Type 1 error. Instead, report "p < .0001"
The ANOVA Procedure
*t Tests (LSD) for FISHNUM

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha 0.05
Error Degrees of Freedom 3
Error Mean Square 22.54074
Critical Value of t 2.26216

Comparisons significant at the 0.05 level are indicated by ***.

<table>
<thead>
<tr>
<th>CHAIN Comparison</th>
<th>Difference Between Means</th>
<th>95% Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>coop store vs. privately owned</td>
<td>16.167</td>
<td>7.964 24.370 ***</td>
</tr>
<tr>
<td>coop store vs. chain store</td>
<td>18.100</td>
<td>10.895 25.305 ***</td>
</tr>
<tr>
<td>privately owned vs. coop store</td>
<td>-16.167</td>
<td>-24.370 -7.964 ***</td>
</tr>
<tr>
<td>privately owned vs. chain store</td>
<td>1.933</td>
<td>5.310 9.777</td>
</tr>
<tr>
<td>chain store vs. coop store</td>
<td>-18.100</td>
<td>-25.305 -10.895 ***</td>
</tr>
<tr>
<td>chain store vs. privately owned</td>
<td>-1.933</td>
<td>-9.777 5.910</td>
</tr>
</tbody>
</table>

Notice that each pairwise comparison is presented twice!

Be sure you get the direction of each significant mean difference right!!

The ANOVA Procedure
*Tukey's Studentized Range (HSD) Test for FISHNUM

NOTE: This test controls the Type I experimentwise error rate.

Alpha 0.05
Error Degrees of Freedom 3
Error Mean Square 22.54074
Critical Value of Studentized Range 3.94845

Comparisons significant at the 0.05 level are indicated by ***.

<table>
<thead>
<tr>
<th>CHAIN Comparison</th>
<th>Difference Between Means</th>
<th>Simultaneous 95% Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>coop store vs. privately owned</td>
<td>16.167</td>
<td>6.043 26.291 ***</td>
</tr>
<tr>
<td>coop store vs. chain store</td>
<td>18.100</td>
<td>9.208 26.992 ***</td>
</tr>
<tr>
<td>privately owned vs. coop store</td>
<td>-16.167</td>
<td>-26.291 -6.043 ***</td>
</tr>
<tr>
<td>privately owned vs. chain store</td>
<td>1.933</td>
<td>-7.747 11.614</td>
</tr>
<tr>
<td>chain store vs. coop store</td>
<td>-18.100</td>
<td>-26.992 -9.208 ***</td>
</tr>
<tr>
<td>chain store vs. privately owned</td>
<td>-1.933</td>
<td>-11.614 7.747</td>
</tr>
</tbody>
</table>

Notice that each pairwise comparison is presented twice!

Be sure you get the direction of each significant mean difference right!!

Usually, but not always, results from LSD & HSD analyses agree. When they don't the source of the disagreement is usually that the study is "underpowered" for the HSD. A sample size providing adequate power to reject H0: using the more sensitive LSD may not provide adequate power to reject H0: using the more conservative LSD. This most likely to happen when the sample size is selected based on p<.05, and then the HSD is applied.
Post Hoc “Computators”

SPSS does not provide post hoc analyses for all ANOVA models (e.g., WG designs). Also, there may be occasions when you want to compare means from a study that didn’t post analyses, or did them differently than you would have preferred. One additional advantage of using these is that you can provide your readers with the LSD or HSD values that were the basis of your post hoc tests.

http://psych.unl.edu/psychrs/statpage/escomp.exe  http://psych.unl.edu/psychrs/statpage/computator_131a.xls

The two Computators will produce slightly different results, and those results might be slightly different from the SPSS results, because they all use slightly different t-table values and Student’s t-table values. The specific table (with the applied sample size rounding) can be seen for the xls version if you extend the right side of the spreadsheet.

Applying these LSD/HSD values to the pairwise comparisons…  Chain = 17.40  Private = 19.33  Coop = 35.50
Pair   Chain v Private  Chain v Coop  Private v Coop
Mean Difference  1.93 <  18.10 <  16.17 <
LSD Result  =  <  <
HSD Result  =  <  <

RH: The researcher hypothesized that Coop stores would have the most fish on display, Chain stores would display the least, and Private pet stores would display an intermediate amount.

RH: support?  Not supported  Supported  Supported  Partial Support

Reporting the Results

The number of fish displayed at each type of store is summarized in Table/Figure 1. There were significant mean differences in the number of fish displayed among the three types of stores, F(2,9) = 18.01, Mse = 22.54, p <.05. Pairwise comparisons using LSD (with a minimum mean difference = 7.59) revealed that, consistent with the research hypothesis, Coop stores displayed more fish than either Private or Chain stores. However, contrary to the research hypothesis, there was no difference between the average number of fish displayed by Chain and Private pet stores.