**Fisher’s Least Significant Difference: a Multiple Comparison Procedure**

If the null hypothesis in an ANOVA is rejected, then you may conclude that not all the population means are equal. However, ANOVA by itself cannot tell you *which* of the means are different. It could be only one group that has a different mean with the rest being equal, or two groups, or all of the groups could have different means. ANOVA is silent in that respect.

Consider the case where there are four groups in an ANOVA analysis, so the null and alternative hypotheses are:

If the null is rejected, then the question becomes: which mean is not equal to the others? Are they all different, or is only one or two different from the others? This is where *multiple comparison procedures* come in. Multiple comparison procedures are only used after ANOVA confirms a difference, to find out which groups have a different mean from the others.

Multiple comparison procedures test pairs of means, and you have to run one test per pair. Mathematically, we need to ask: is Notice how those questions look like alternative hypotheses in a two tailed test? Well, that is exactly what they are used for in multiple comparisons.

Fisher’s Least Significant Difference (Fisher’s LSD) procedure is commonly used for multiple comparisons. Fisher’s LSD is a special type of two-tailed t test.

There are three different methods to use Fisher’s LSD: a traditional t test; a modified t test; and, a confidence interval. All three methods will come to the same conclusion, because they are all different ways of using the same information. All three ways are presented in this handout and in 13.3 in the book, but in this class only **METHOD 2** will be used on the homework and on exams.

***Method 1*: *Fisher’s LSD as a series of traditional t tests:***

1. Take any two groups from the ANOVA (here they are labeled and just to differentiate them). Set an significance level.
2. The hypotheses are:

1. The test statistic is:

and the degrees of freedom are from the ANOVA

1. The rejection rules are:

NOTE: the df here are the same df from the in the ANOVA

1. If the null hypothesis is rejected, then the two group means are different. If the null hypothesis is not rejected, then there is no evidence that are different.
2. Conduct one test for each possible pair of means from the ANOVA

***Method 2: Fisher’s LSD as a series of modified t tests: (This is the one we will use in this course)***

Take any two groups from the ANOVA (here they are labeled and just to differentiate them). Set an significance level.

1. The hypotheses are:

1. The test statistic is:

1. The Least Significant Difference is:

and the rejection rule is:

1. If the null hypothesis is rejected, then the two group means are different. If the null hypothesis is not rejected, then there is no evidence that are different.
2. Conduct one test for each possible pair of means from the ANOVA. Note that this method is very efficient to use for multiple comparisons in balanced designs (i.e. those in which the groups are all the same size). In balanced designs, you only have to compute the LSD once because it will be the same no matter which two groups you are testing. Then you can compute the difference between each pair of means and compare the absolute value of each difference to the LSD to see whether to reject the null. In unbalanced designs (i.e. those in which the groups are not all the same size), you will have to compute the LSD individually for each test.

***Method 3: Fisher’s LSD as a series of confidence intervals:***

Take any two groups from the ANOVA (here they are labeled and just to differentiate them). Set an α significance level.

1. The hypotheses are:

1. Calculate a confidence interval for the difference between using the following equation:

1. The rejection rule is:

1. If the null hypothesis is rejected, then the two group means are different.
2. Conduct one test for each possible unique pair of means from the ANOVA

*Example.* We are going to use Fisher’s LSD to test the groups from the Grocery Store Ad example on Ch 13: Handout #4.

*Part 1.* Using Method 2, perform a Fisher’s LSD procedure to test whether the population mean produce spending for the group that received Ad A is different than Ad B. Use an significance level. If you can confirm a difference between the means, which group spent more on average?

*Example, part 2:* Using Method 2, perform a Fisher’s LSD procedure to test whether the population mean produce spending for the group that received Ad A is different than Ad C. Use an significance level. If you can confirm a difference between the means, which group spent more on average?

*Example, part 3:* Using Method 2, perform a Fisher’s LSD procedure to test whether the population mean produce spending for the group that received Ad B is different than Ad C. Use an significance level. If you can confirm a difference between the means, which group spent more on average?