Power and 1-way ANOVAS

**Major concepts to know this week:**
- Effect size, and its relation to sample size
- Power, and factors that affect it
- Rule for conducting one-way ANOVA versus t-test (and reasons for the choice)
- Hypothesis change in one-way ANOVA
- Between group variance (and reasons for it to be large or small)
- Within group variance (and reasons for it to be large or small)
- Reason why $F > 1$ implies greater chance of significance.
- When to conduct a follow-up test
- How to interpret different follow-up test results, and how to test for homogeneity of variance

1. How should you change the $\alpha$-level (not the p-value) of your statistical test to improve the power of the test?

2. If you wanted to maximize power, what should you do with standard deviations within samples and sample sizes?

3. You have two samples that are significantly different from each other, but you want to also assess the true meaningfulness of this significant difference. The first sample mean is 42, and the second is 40. The sample size in both cases is 6. The SD of the first sample is 2, and the SD of the second sample is 0. Is this a meaningful difference?

4. If you increase the sample size in the above question, would you expect the effect size to change?

5. Say you have 3 groups of size 10. You run a 1-way ANOVA to test for differences among the groups on their shoe sizes. What are the between groups, within groups, and total df?

6. You are running two experiments, each of which comprises three groups (A, B, & C). In the first experiment, you expect A to be better than B and C. In the second, you expect A to be different from B and C, but you don’t know the direction of the difference. How does this difference in hypothesis play out in the ANOVA? Does it make a difference?

7. I used the data file on the web titled “our data”, and ran one-way ANOVAs analyzing the association of beer preference with number of breakfasts eaten per week and units of alcohol consumed per week. Using the output on the next page, summarize the findings for each dependent variable, including comments about homogeneity of variance.
A. Output part one – Descriptive Stats and ANOVA results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>95% Confidence Interval for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfasts eaten per wk</td>
<td>25</td>
<td>5.936</td>
<td>2.221</td>
<td>0.418</td>
<td>3.987</td>
<td>8.059</td>
<td>0.00</td>
</tr>
<tr>
<td>Dinner drink</td>
<td>27</td>
<td>4.231</td>
<td>2.162</td>
<td>0.397</td>
<td>2.462</td>
<td>6.040</td>
<td>0.00</td>
</tr>
<tr>
<td>Light</td>
<td>37</td>
<td>3.963</td>
<td>2.427</td>
<td>0.419</td>
<td>2.509</td>
<td>5.430</td>
<td>0.00</td>
</tr>
<tr>
<td>Regular</td>
<td>21</td>
<td>3.963</td>
<td>2.427</td>
<td>0.419</td>
<td>2.509</td>
<td>5.430</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>4.719</td>
<td>2.332</td>
<td>0.406</td>
<td>3.905</td>
<td>5.533</td>
<td>0.00</td>
</tr>
<tr>
<td>Units of Alcohol per wk</td>
<td>25</td>
<td>6.866</td>
<td>1.777</td>
<td>0.427</td>
<td>5.473</td>
<td>8.259</td>
<td>0.00</td>
</tr>
<tr>
<td>Dinner drink</td>
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<td>6.701</td>
<td>1.907</td>
<td>0.397</td>
<td>4.902</td>
<td>8.433</td>
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<tr>
<td>Light</td>
<td>21</td>
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<td>1.777</td>
<td>0.427</td>
<td>5.473</td>
<td>8.259</td>
<td>0.00</td>
</tr>
<tr>
<td>Regular</td>
<td>21</td>
<td>6.866</td>
<td>1.777</td>
<td>0.427</td>
<td>5.473</td>
<td>8.259</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>7.087</td>
<td>1.950</td>
<td>0.405</td>
<td>6.146</td>
<td>8.030</td>
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</table>

Test of Homogeneity of Variances

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfasts eaten per wk</td>
<td>2</td>
<td>111</td>
<td>0.00</td>
</tr>
<tr>
<td>Units of Alcohol per wk</td>
<td>2</td>
<td>111</td>
<td>0.00</td>
</tr>
</tbody>
</table>

ANOVA

<table>
<thead>
<tr>
<th></th>
<th>Source of Variation</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfasts eaten per wk</td>
<td>Between Groups</td>
<td>2</td>
<td>14.846</td>
<td>3.116</td>
<td>0.048</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>111</td>
<td>4.893</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>113</td>
<td>553.916</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units of Alcohol per wk</td>
<td>Between Groups</td>
<td>2</td>
<td>1988.512</td>
<td>17.635</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>111</td>
<td>63.293</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>113</td>
<td>9111.801</td>
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<td></td>
</tr>
</tbody>
</table>

B. Output part 2 – follow-up tests

Multiple Comparisons

<table>
<thead>
<tr>
<th></th>
<th>(A) Beer Preference</th>
<th>(B) Beer Preference</th>
<th>Mean Difference (A-B)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfasts eaten per wk</td>
<td>Don't drink beer</td>
<td>Light</td>
<td>8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-3.6745</td>
</tr>
<tr>
<td></td>
<td>Regular</td>
<td>Light</td>
<td>-1.6592</td>
<td>.81427</td>
<td>.351</td>
<td>2.0883</td>
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<tr>
<td></td>
<td>Light</td>
<td>Don't drink beer</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-2.0312</td>
</tr>
<tr>
<td></td>
<td>Regular</td>
<td>Don't drink beer</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-2.0312</td>
</tr>
<tr>
<td></td>
<td>Regular</td>
<td>Light</td>
<td>-7.5688</td>
<td>.54856</td>
<td>.345</td>
<td>-3.5311</td>
</tr>
<tr>
<td></td>
<td>Light</td>
<td>Don't drink beer</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-2.0312</td>
</tr>
<tr>
<td></td>
<td>Regular</td>
<td>Don't drink beer</td>
<td>-10.8166*</td>
<td>2.31554</td>
<td>.001</td>
<td>-15.1460</td>
</tr>
<tr>
<td></td>
<td>Regular</td>
<td>Don't drink beer</td>
<td>-10.8166*</td>
<td>2.31554</td>
<td>.001</td>
<td>-15.1460</td>
</tr>
<tr>
<td></td>
<td>Regular</td>
<td>Light</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
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<td>Don't drink beer</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-2.0312</td>
</tr>
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<td>Regular</td>
<td>Light</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-2.0312</td>
</tr>
<tr>
<td>Units of Alcohol per wk</td>
<td>Don't drink beer</td>
<td>Light</td>
<td>-10.8166*</td>
<td>2.31554</td>
<td>.001</td>
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<td>2.31554</td>
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<td>-10.8166*</td>
<td>2.31554</td>
<td>.001</td>
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<td>Light</td>
<td>-8.2836</td>
<td>.50625</td>
<td>.255</td>
<td>-2.0312</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

Homogeneous Subsets

<table>
<thead>
<tr>
<th></th>
<th>Breakfasts eaten per wk</th>
<th>Units of Alcohol per wk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tukey HSD</td>
<td>Tukey HSD</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Subset for alpha = 0.05</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>21</td>
<td>3.9048</td>
</tr>
<tr>
<td>Light</td>
<td>67</td>
<td>4.6716</td>
</tr>
<tr>
<td>Don't drink beer</td>
<td>26</td>
<td>5.5000</td>
</tr>
<tr>
<td>Sig.</td>
<td>372</td>
<td>319</td>
</tr>
<tr>
<td></td>
<td>Tukey HSD</td>
<td>Tukey HSD</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Subset for alpha = 0.05</td>
</tr>
<tr>
<td></td>
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<td>2</td>
</tr>
<tr>
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<td>2</td>
<td></td>
</tr>
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</table>

Means for groups in homogeneous subsets are displayed.