1. You have a theory which states, in part, that television public service announcements increase viewers' dedication to public service. Therefore, following IRB approval, you collect data from 5 respondents you choose at random passing a street corner in College Park on number of hours weekly individuals devote to public service (y) and number of hours of television viewing (X). As is seemingly always the case with this course, you lose some data, and are left with only –

\[ M \text{ and } s \text{ of Number of weekly public service hours: } 3 \text{ and } 1.58114 \]

and, the five values for \( e \): 0 -1 0 1 0

(1) State the model under investigation:

\[ y = \beta_0 + \beta_1 X + e \]

(2) State \( H_0 \), both formally (in terms of population parameters), and in words:

\[ H_0 : \beta_1 = 0 \]

\( X \) does not explain \( y \) in the population: The regression coefficient \( \beta_1 \) is equal to zero in the population. Any difference of this \( \beta_1 \) parameter from zero in the sample is due to chance or random factors.

(3) State \( H_1 \), both formally (in terms of population parameters), and in words:

\[ H_1 : \beta_1 \neq 0 \]

\( X \) does explain \( y \) in the population: The regression coefficient \( \beta_1 \) is different from zero in the population.

► \( H_1 \) could also be directional, with justification.

(4) Select an error rate, state the critical value for your test statistic based on this error rate, and briefly defend your choice of this error rate:

\[ \alpha = .05 \quad F(1, 3) = 10.13 \]

No information is offered that would suggest we disregard 'convention' for the test of the slope coefficient, and there is nothing about the statistical model that would suggest that some other approach to control of the error rate would be appropriate in this case.

(5) Based on the information presented above, write out a complete raw score Source Table:

\[
\begin{align*}
SS_{Total} &= s_y^2 \cdot df_{Total} = (1.58114)^2 (4) = 10 \\
SS_{Residual} &= \sum (y_i - \hat{y}_i)^2 = \sum e_i^2 = (0)^2 + (-1)^2 + (0)^2 + (1)^2 + (0)^2 = 2
\end{align*}
\]
$$SS_{Regression} = SS_{Total} - SS_{Residual} = 10 - 2 = 8$$
(6) What can and can't you conclude at this point:

- At this point we can reject the null hypothesis and say that $\beta_1$, the regression coefficient of interest (the slope), is significantly different from zero and so $X$ does explain/predict $y$ in the population. The regression analysis tells us that there is a significant relationship between television public service announcements and viewer’s dedication to public service. However:
  - We cannot conclude that we have support for our theory because the theory had a directional component and we do not know whether the predictor variable is positively or negatively associated with the criterion variable.
  - We would want to examine/plot our data to determine the extent to which the observed data might not meet the assumptions of the statistical model (for example, linearity).

(7) Do you see any methodological problems or limitations to your study:

The current study has several methodological problems and limitations:

- The sample size is very small
- It was a sample of convenience, rather than a random sample from a defined population
  - The place of “sampling” severely limits the ability to generalize the results
  - Using only location for sampling leads to an inability to generalize results, because you don’t know the population from which the sample was drawn
- The measures of number of hours weekly individuals devote to public service ($y$) and number of hours of television viewing ($X$) are self-report
- The study purports to examine the relationship between television public service announcements and public service, yet measures number of hours of television viewing, which may not be a good measure of exposure to public service announcements, given Tivo, VCRs, etc...
2. You have a theory which states, in part, that attachment (A) is a function of three factors: Mother's warmth and caring (W), father's degree of involvement in childrearing (I), and child's temperament (T). Therefore, you have collected data from 50 subjects regarding these four variables. All variables were measured on seven-point Likert-type scales, with higher scores indicating 'more' of the given construct.

You lose data yet again, and so have only the following information available to you:

\[ SS_{TOTAL} = 192 \]

\[ R^2_{A\cdot WIT} = .86 \]

\[ R^2_{A\cdot IT} = .36 \quad R^2_{A\cdot WT} = .85 \quad R^2_{A\cdot WI} = .78 \]

\[ R^2_{A\cdot T} = .00 \quad R^2_{A\cdot I} = .33 \quad R^2_{A\cdot W} = .78 \]

Raw score regression equation for the full model:  
\[ A = .03 + .96W - .09I + .30T + e \]

(1) State the model under investigation:

\[ y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + e \]

(2) State \( H_0 \), both formally (in terms of population parameters), and in words:

\( X_i \) do not predict\( y \) in the population. Any differences of the set of \( b_i \) from the set of 0, in the sample are due to chance or random factors:

\[ H_0 : \beta_j = 0 \quad \text{for all } j \]

\[ H_0 : y = \beta_0 + e \]

\( X_i \) do not explain\( y \) in the population. Any differences of the set of \( b_i \) from the set of zero, in the sample are due to chance or random factors.

(3) State \( H_1 \), both formally (in terms of population parameters), and in words:

\[ H_0 : \beta_j \neq 0 \quad \text{for some } j \]

The \( X_i \) do explain\( y \) in the population. The set of \( b_i \) differ from the set of 0, in the population.

\[ \text{Note that no statement is being made about any individual } \beta_j. \]
(4) Select an error rate, state the critical value(s) for your test statistic(s) based on this error rate(s), and briefly defend your choice of this error rate(s):

\[ \alpha = 0.05 \text{ for test of Regression} \]

\[ F(3, 46) \approx 2.81 \]

No information is offered that would suggest we disregard 'convention' for the test of the slope coefficient, and there is nothing about the statistical model that would suggest that some other approach to control of the error rate would be appropriate in this case.

\[ \alpha = 0.017 = 0.05/3 \text{ for test of each partial regression coefficient} \]

\[ F(1, 46) \approx 6.17 \]

Some method to control the cumulative error rate associated with the multiplicity problem is necessary. In this case, Bonferroni's method would be appropriate, although other methods could prove more powerful, and should be considered with 'real' data. The choice of a 'protected t' approach or of Scheffé's method would need justification.

- The critical value for \( F(3, 46) \) appeared only in the CCW&A tables, while the critical value for \( F(1, 46) \) at \( \alpha = 0.017 \) did not appear in the tables in either textbook. Any reasonable interpolation or 'guesstimate' would be acceptable, given a brief explanation of the values' derivation.

- The test of each partial regression coefficient would only be conducted if the test of regression was significant.

(5) Based on the information presented above, write out a complete Source Table (including SS for W, I, and T):

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>165.12</td>
<td>3</td>
<td>55.04</td>
<td>94.9</td>
<td>0.86</td>
</tr>
<tr>
<td>Total</td>
<td>192</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>R²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>sr²W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>sr²I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>sr²T</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mothers Warmth |    96 |    1 |  96 |  165.52
Fathers Involvement | 1.92 |    1 |  1.92 |  3.31
Childs Temperament | 15.36 |    1 |  15.36 |  26.48
Residual | 26.88 |  46 |  0.58 |
Total | 192 |  49 |

(6) Draw the inferences you are able at this point in your analyses:

- At this point we can reject the null hypothesis and say that the regression coefficients, as a set, are significantly different from the set of 0 coefficients and that the set of the $X_i$ – or some subset of the $X_i$ – do predict|explain $y$ in the population.
- Moreover, the model accounts for a large percentage of the variance in the criterion variable.
- We can very tentatively say what the model is that gave rise to the data: The model with only X1 and X3. HOWEVER, if we examine the $R^2$ for the model with W and I, it explains almost as much variance as the model with W and T, suggesting that we should examine this model also, because there is the possibility of model indeterminacy.
- Moreover, we would want to examine the correlation among the predictors and the partial regression coefficients to determine if there was the possibility of suppression.
- Finally, we would want to plot|examine our data to determine if we met the assumptions of the model.
3. You have conducted a multiple regression analysis predicting $y$ from the four predictors $X_1$, $X_2$, $X_3$, and $X_4$. Assume that you have conducted the appropriate tests of significance for the $b$ weights for the model including all four predictors, and have found that $X_1$ and $X_2$ significantly contribute to prediction, while $X_3$ and $X_4$ do not.

(1) At this point, what are the possible models that might have given rise to the data?

The 'likeliest' model is:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + e$$

The 'next-best' competitors would be:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + e$$

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_4X_4 + e$$

However, the model

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + e$$

cannot be rejected.

(2) Describe a strategy that you would follow that would allow you to decide which of these possible models is the one(s) that gave rise to the data:

At this point there is no basis to reject any model without further testing! To do so requires a series of model comparisons, that even with a simple model like this one is fairly complex (and a stretch for what we’ve covered in class). First, one might want to test the joint contribution of $X_3$ and $X_4$ above $X_1$ and $X_2$, that is, compare this model:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + e$$

to this model:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + e$$

Failure to find a significant result would suggest that $X_3$ and $X_4$ are not jointly needed in the equation. Then, one could test including either $X_3$ or $X_4$ to the equation with only $X_1$ and $X_2$, that is compare this model:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + e$$

and this model

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_4X_4 + e$$

to this model:
\[ y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + e \]

Failure to find a significant result in both cases would suggest that neither \( X_3 \) nor \( X_4 \) is not needed in the equation, and suggest that we need a model that includes only \( X_1 \) and \( X_2 \), while finding that one but not the other is needed in the equation would then suggest we need a model including only the three predictors in question.

You would want to look further with ‘real’ data, but that’s all we’d want to do for now ...
4. You have a theory which states, in part, that the nucleus accumbens plays a central role in the anticipation of the reward. Therefore, you assigned 4 subjects each to one of four conditions: (1) No reward; (2) $10 reward; (3) $20 reward; or, (4) $50 reward. The dependent measure was amount of activity in the nucleus accumbens as measured by functional MRI, with higher scores indicating increasing activity.

The following summary data result from your investigation:

<table>
<thead>
<tr>
<th>Condition</th>
<th>M</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Reward</td>
<td>1</td>
<td>1.414</td>
</tr>
<tr>
<td>$10 Reward</td>
<td>4</td>
<td>2.263</td>
</tr>
<tr>
<td>$20 Reward</td>
<td>7</td>
<td>2.121</td>
</tr>
<tr>
<td>$50 Reward</td>
<td>8</td>
<td>1.273</td>
</tr>
</tbody>
</table>

(1) Assuming a fixed-effects model, state \( H_0 \) and \( H_1 \), both formally (in two different ways, using two different sets of population parameters), and in words for the model:

\[
\begin{align*}
H_0 &: \mu_1 = \mu_2 = \mu_3 = \mu_4 \\
H_1 &: \text{not } H_0
\end{align*}
\]

The means do not differ in the population.
Any sample differences are due to chance or random factors.

\[
H_0 : \alpha_j = 0 \quad \text{for all } j
\]

The differences among the means are 0 in the population; any sample differences are due to chance or random factors:

\[
H_1 : \text{not } H_0
\]

Differences among the means are not zero in the population due to the effects of treatment.
There exists one or more parametric functions of (linear contrasts among) the means that is different from zero in the population.

(2) Assuming a random-effects model, state \( H_0 \) and \( H_1 \) formally (in terms of population parameters):

The variance of the means does not differ from zero in the population; any sample difference is due to chance or random factors.

\[
H_0 : \sigma^2_{\alpha_j} = 0
\]
The variance of the means differs from zero in the population.

\[ H_1 : \sigma_{\mu_j}^2 > 0 \]

(3) Select an error rate, state the critical value for your test statistic based on this error rate, and briefly defend your choice of this error rate:

\[ \alpha = 0.05 \]

No information is offered that would suggest we disregard 'convention' for the test of the mean differences, and there is nothing about the statistical model that would suggest that some other approach to control of the error rate would be appropriate in this case.

The table shows that for this error rate the critical F value is

\[ F(3, 12) = 3.49 \]

(4) Calculate the two Mean Squares necessary to conduct an F test:

\[
MS_{\text{Between}} = ns_M^2 = n \frac{\sum (\bar{y}_j - \bar{y})^2}{a - 1} = 4 \left( \frac{(1 - 5)^2 + (4 - 5)^2 + (7 - 5)^2 + (8 - 5)^2}{4 - 1} \right) = 40
\]

\[
MS_{\text{Within}} = s^2 = \frac{\sum (n_j - 1)(s_j^2)}{N - a} = \frac{(4 - 1)(1.414)^2 + (4 - 1)(2.263)^2 + (4 - 1)(2.121)^2 + (4 - 1)(1.273)^2}{16 - 4} = 3.311
\]

(5) Determine the necessary degrees of freedom:

\[ df_{\text{Between}} = a - 1 = 3 \]

Where \( a \) is the number of groups

\[ df_{\text{Total}} = N - 1 = 15 \]

Where \( N \) is the total number of participants

\[ df_{\text{Within}} = df_{\text{Total}} - df_{\text{Between}} = 15 - 3 = 12 \]

\[ (df_{\text{Within}} = N - a = 16 - 4 = 12) \]

(6) Calculate F:
(7) **Draw the inferences you are able at this point in your analyses:**

We can reject the null hypothesis since our obtained $F = 12.08$ exceeds our critical $F = 3.49$. Thus, we can either say that the treatment effects are different from zero if we are using a random effects model or that the differences among the group means differ from zero if we are using a fixed effects model. It appears that there is a relationship between the nucleus accumbens and the anticipation of award, but any further conclusions would need to be based on (a) whether we said our effect was fixed or random; and, (b) if fixed, comparisons among the means would be necessary.

$$F = \frac{MS_{\text{Between}}}{MS_{\text{Within}}} = \frac{40}{3.311} = 12.08$$
1. A colleague approaches you with some data regarding the potential effects of a new drug on recovery from memory loss. She has performed bi-lateral lesions in the hippocampi of 4 rats. These rats are then assigned, in order, to all four possible dosage conditions: 0 mg, 10 mg, 20mg, and then 30mg. The dependent variable is the number of correct trials out of 10 possible trials on a maze task in which all rats reached the criterion of 8 out of 10 correct trials prior to the lesion. Based on what she knows about the drug, she has hypothesized a linear trend in the data.

The only data she brings with her to your office is the means for the various conditions:

<table>
<thead>
<tr>
<th>Dosage</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>0mg</td>
<td>3</td>
</tr>
<tr>
<td>10mg</td>
<td>3</td>
</tr>
<tr>
<td>20mg</td>
<td>5</td>
</tr>
<tr>
<td>30mg</td>
<td>7</td>
</tr>
</tbody>
</table>

After some prodding on your part, she remembers that $SS_{RESIDUAL} = 4.5$.

You decide to try to help her, so you:

(1) **State the model under investigation:**

$$y = \mu + \psi_{Linear} + \psi_{Deviations} + \pi + \epsilon$$

(2) **State $H_0$, both formally (in terms of population parameters), and in words:**

$$H_0 : \psi_{(Linearity: -3 -1 1 3)} = 0$$

*There is no linear trend {OR: slope} associated with the treatment means in the population. Any difference of linearity {OR: slope) from zero in the sample is due to chance or random factors.*

(3) **State $H_1$, both formally (in terms of population parameters), and in words:**

$$H_1 : \psi_{(Linearity: -3 -1 1 3)} \neq 0$$

*There is a linear trend associated with the treatment means in the population.*

(4) **Select an error rate(s), state the critical value(s) for your test statistic(s) based on this error rate(s), and briefly defend your choice of this error rate(s):**

$$\alpha = .05 \text{ for Linearity} \quad F(1, 9) = 4.75$$
$$\alpha = .15 \mid .20 \mid .25 \text{ for Deviations} \quad F(2, 9) = 2.36 \mid 1.93 \mid 1.62$$

*No information is offered that would suggest we disregard 'convention’ for the test of Linearity. And, in order to support a conclusion of Linearity ‘only’, the test of Deviations should be conducted at a liberal error rate (typically, .15, or .20, or .25).*
Spring 2007 Exam 2

(5) Conduct your test(s) of significance:

\[ SS_{(\text{Linear})} = \frac{(\sum cj \bar{y}_j)^2}{\sum \frac{c_j^2}{n_j}} = \frac{[(-3)(3)+(-1)(3)+(1)(5)+(3)(7)]^2}{5} = \frac{196}{5} = 39.2 \]

\[ df_{\text{Linear}} = 1 \]

\[ \bar{y}_\text{..} = (3 + 3 + 5 + 7)/4 = 4.5 \]

\[ SS_{\text{Between}} = n_j \frac{\Sigma (\bar{y}_j - \bar{y}_\text{..})^2}{\sum n_j} = 4[(3-4.5)^2 + (3-4.5)^2 + (5-4.5)^2 + (7-4.5)^2] = 4(11) = 44 \]

\[ SS_{\text{Deviations}} = SS_{\text{Between}} - SS_{\text{Linear}} = 44 - 39.2 = 4.8 \]

\[ df_{\text{deviations}} = 2 \]

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>( \eta^2 )</th>
<th>partial ( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>44</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>39.2</td>
<td>1</td>
<td>39.2</td>
<td>78.4</td>
<td>.90</td>
<td></td>
</tr>
<tr>
<td>Deviations</td>
<td>4.8</td>
<td>2</td>
<td>2.4</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>4.5</td>
<td>9</td>
<td>.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- A Source Table was not requested, so is not required – and a complete Source Table could not be constructed based on the information supplied.

(6) Draw your inference(s) regarding the hypothesis your colleague has offered:

Linearity: at \( \alpha = .05 \), obtained \( F(1, 9) = 78.4 > \text{critical } F(1, 9) = 5.12. \)

\[ \therefore \text{Reject } H_0. \text{ A linear trend exists in the population.} \]

Deviations from Linearity: at \( \alpha = .15 | .20 | .25 \), obtained \( F(2, 9) = 4.8 > \text{critical } F(2, 9) = 2.36 | 1.93 | 1.62 \)

\[ \therefore \text{Reject } H_0. \text{ A linear trend is not sufficient to describe the relationship in the population.} \]

Therefore, the dose-response relationship between drug dose and memory functioning in the population is not entirely linear. However, because \( SS_{\text{linear}} = 39.2 \) and the \( SS_{\text{between}} = 44 \), whatever is going on in the data seems to be predominantly linear (39.2/44 = .89; so, 89% of the systematic variance is explained by a simple straight-line functional relationship). Examination of the means suggests that a 10mg dose is not effective; and the largest mean was 7, which was less than the success criterion of 8 out of 10 established prior to hippocampal ablation (which may – or may not – be the best performance one could obtain). Your conclusion should be that
the effective range of dosages has probably not been studied, and that the experiment should be repeated with a dose of at least 40mg also included.

► NOTE there is the potential for an order effect, as all rats were exposed to the same order of doses.
2. Another colleague approaches you with a seeming quandary. (You’ve just got to get better colleagues …) He has an output from SAS fitting what he thought was an RB-5 model. However, he is unable to make any sense out of it, because it has a lot of dots where he thinks there should be important information. Take his output, below, and write out what you consider a complete source table in this case.

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Effect of Interest</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>PI Subject Effect</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

Number of Observations Read 20
Number of Observations Used 20

Dependent Variable: Y

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>125.2</td>
<td>6.5894737</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>Error</td>
<td>0</td>
<td>0.000</td>
<td>.</td>
<td></td>
<td>.</td>
</tr>
<tr>
<td>Corrected Total</td>
<td>19</td>
<td>125.200</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>83.2</td>
<td>20.8</td>
<td>11.37</td>
<td>.66</td>
</tr>
<tr>
<td>PI</td>
<td>3</td>
<td>20.0</td>
<td>6.67</td>
<td>3.64</td>
<td></td>
</tr>
<tr>
<td>A*PI</td>
<td>12</td>
<td>22.0</td>
<td>1.83</td>
<td></td>
<td>.</td>
</tr>
</tbody>
</table>

Source SS df MS F $\eta^2$ partial $\eta^2$

<table>
<thead>
<tr>
<th>A</th>
<th>83.2 4 20.8 11.37 .66 .80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within (PI+A*PI)</td>
<td>42 15 2.8</td>
</tr>
<tr>
<td>PI = Subjects</td>
<td>20 3 6.67 3.64</td>
</tr>
<tr>
<td>A*PI = Residual</td>
<td>22 12 1.83</td>
</tr>
<tr>
<td>Total</td>
<td>125.2 19</td>
</tr>
</tbody>
</table>

$F_{effect} = \frac{MS_{effect}}{MS_{Residual}}$ \hspace{1cm} \text{where effect is A or PI, respectively}$

$\eta^2 = \frac{SS_{effect}}{SS_{Total}}$ \hspace{2cm} \text{partial} \ \eta^2 = \frac{SS_{effect}}{SS_{effect} + SS_{Residual}}$
3a. You have conducted a one-way ANOVA for four groups using effect coding in a regression program. Group 1 was coded 1 on X1; Group 2 was coded 1 on X2; and, Group 3 was coded 1 on X3. The cell means are: $M_1 = 2$; $M_2 = 4$; $M_3 = 5$; and, $M_4 = 1$. Write out the unstandardized regression equation that would result from this analysis.

\[ y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + e \]

\[ b_0 = (2 + 4 + 5 + 1)/4 = 3 \]

\[ b_1 = M_1 - b_0 = 2 - 3 = -1 \]

\[ b_2 = M_2 - b_0 = 4 - 3 = 1 \]

\[ b_3 = M_3 - b_0 = 5 - 3 = 2 \]

\[ y = 3 - X_1 + X_2 + 2X_3 + e \]

3b. You have conducted a one-way ANOVA for three groups using dummy coding in a regression program. Group 2 was coded 1 on X1; and, Group 3 was coded 1 on X2. The resulting regression equation was: $y = 4 + 0 \times X_1 + 4 \times X_2$. What are the cell means?

\[ y = M_1 + (M_2 - M_1)X_1 + (M_3 - M_1)X_2 + e \]

\[ M_1 = 4 \]

\[ M_2 - M_1 = M_2 - 4 = 0 \Rightarrow M_2 = 4 \]

\[ M_3 - M_1 = M_3 - 4 = 4 \Rightarrow M_3 = 8 \]

3c. You have a one-way ANOVA design that you wish to analyze by multiple regression methods. You have three treatment groups, Groups 1, 2, and 3, respectively, and two control groups, Group 4 and 5. You wish to test: 1) whether treatment is better than no treatment; 2) whether the control groups are different from each other; 3) whether treatments 1 and 2 are better than treatment 3; and, 4) whether treatments 1 and 2 differ. Write out one set of codes that might be used to test these hypotheses.

<table>
<thead>
<tr>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TX versus all C</td>
<td>C1 versus C2</td>
<td>TX1 &amp; TX2 versus TX3</td>
<td>TX1 versus TX2</td>
</tr>
<tr>
<td>TX1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TX2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TX3</td>
<td>1</td>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>C1</td>
<td>-1.5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>C2</td>
<td>-1.5</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

► The actual values can differ by constant(s) of proportionality and still receive full credit as long as they follow the appropriate guidelines for selecting contrast coefficients.
4. You have a theory which states, in part, that consumer satisfaction with a purchase is a function of the frequency of use of the item. Thus, your effect of interest (A effect) is the average frequency of use of an item, which may be either: 1) once a month or less; 2) between once a week and once a month; or, 3) more than once a week. Past research has suggested that there are two 'extraneous' factors that influence satisfaction with a purchase. The first is cost of the item (B effect), which may be: 1) either low cost (less than $10); 2) average cost (about $25); or, 3) high cost (over $100). The second is the repair record of the item (C effect), which may be either: 1) less than average; 2) average; or, 3) above average number of repairs.

You randomly sample 2 subjects in each of the combinations of the treatment effects you have determined to include in your study, as shown below. One year following their purchase, you ask their satisfaction with the item purchased on a Likert-type scale, where higher scores indicate greater satisfaction.

<table>
<thead>
<tr>
<th>Cell Means</th>
<th>A_1</th>
<th>A_2</th>
<th>A_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>B_1</td>
<td>B_2</td>
<td>B_3</td>
<td></td>
</tr>
<tr>
<td>C_1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>B_1</td>
<td>B_2</td>
<td>B_3</td>
<td></td>
</tr>
<tr>
<td>C_2</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>B_1</td>
<td>B_2</td>
<td>B_3</td>
<td></td>
</tr>
<tr>
<td>C_3</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

SS_{BETWEEN} = 68
SS_{TOTAL} = 86

(1) State the model under investigation, and briefly defend your choice of random and/or fixed effects in your model:

\[ \gamma_{i(jkl)} = \mu + \alpha_j + \beta_k + \gamma_i + \epsilon_{jkl} \]

The effects in the model are fixed because we have chose specific levels of each factor based on previous research and theory and will be selecting combinations of the levels of each of these factors for data collection based on the specific levels of each effect.

(2) State \( H_0 \), both formally (in terms of population parameters), and in words for the effect of interest in the model you have chosen;

\[ H_0 : \alpha_j = 0 \text{ for all } j \]

Differences among the means of the treatment effect A does not differ from zero in the population. Any sample differences among the means for the A effect are due to chance or random factors.

(3) State \( H_1 \), both formally (in terms of population parameters), and in words for the effect of interest in the model you have chosen;

\[ H_1 : \text{not } H_0 \]

Differences among the means are not zero in the population due to the effects of treatment A.
There exists one or more parametric functions of (linear contrasts among) the A effect means that is different from zero in the population.
There is an effect of treatment.

► NOTE that you cannot say that the means are different in the population. ANOVA tests only whether some parametric function of (that is, linear contrast among) the means is different from zero – not that the means themselves are actually different from one another.

► Similar null and alternative hypotheses should be stated for the nuisance variables B and C. However, our basic assumption in this design is that, in fact, the alternative hypothesis is true for each of these two factors, and, as such, there will be significance associated with B and C; otherwise, we would not have included B and C as ‘control’ or ‘nuisance’ factors in this study and its design.

(4) Select an error rate(s), state the critical value(s) for your test statistic(s) based on this error rate(s), and briefly defend your choice of this error rate(s);

\[ \alpha = .05 \text{ for } A, B, \text{ and } C \]
\[ F(2, 9) = 4.26 \]
\[ \alpha = .15 \mid .20 \mid .25 \text{ for Residual } \]
\[ F(2, 9) = 2.36 \mid 1.93 \mid 1.62 \]

No information is offered that would suggest we disregard ‘convention’ for the test of A. And, because A is the only theoretical effect of interest, it is not necessary to adjust the error rate for A just because we test for significant B and C effects – which we already ‘know’ are going to be significant.
And, in order to discount the possibility of an interaction effect, the test of Residual should be conducted at a liberal error rate (typically, .15, or .20, or .25).

(5) Based on the information presented below, write out what you consider a complete Source Table:

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>( \eta^2 )</th>
<th>partial ( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>68</td>
<td>8</td>
<td>8.5</td>
<td>4.25</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>48</td>
<td>2</td>
<td>24</td>
<td>12</td>
<td>.56</td>
<td>.73</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>.05</td>
<td>.18</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>.14</td>
<td>.4</td>
</tr>
<tr>
<td>Residual</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>.04</td>
<td>.18</td>
</tr>
<tr>
<td>Within</td>
<td>18</td>
<td>9</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ SS_{Between} = 68 \]
\[ SS_{Total} = 86 \]
\[ SS_{Within} = SS_{Total} - SS_{Between} = 86 - 68 = 18 \]
\[ df_{Between} = a - 1 = 9 - 1 = 8 \]
\[ df_{Total} = N - 1 = 18 - 1 = 17 \]
\[ df_{Within} = df_{Total} - df_{Between} = 17 - 8 = 9 \]
\[ \bar{y}_{\cdot} = \frac{2 + 2 + 2 + 4 + 5 + 3 + 8 + 4 + 6}{9} = 4 \]

\[ \bar{y}_{A_i} = \frac{(2 + 2 + 2)}{3} = 2 \]
\[ \bar{y}_{A_2} = \frac{(4 + 5 + 3)}{3} = 4 \]
\[ \bar{y}_{A_3} = \frac{(8 + 4 + 6)}{3} = 6 \]

\[ SS_A = n \cdot \Sigma (\bar{y}_{j.} - \bar{y}_{\cdot})^2 = 6[(2 - 4)^2 + (4 - 4)^2 + (6 - 4)^2] = 6(8) = 48 \]

\[ \bar{y}_{B_i} = \frac{(2 + 4 + 8)}{3} = 4.67 \]
\[ \bar{y}_{B_2} = \frac{(2 + 5 + 4)}{3} = 3.67 \]
\[ \bar{y}_{B_3} = \frac{(2 + 3 + 6)}{3} = 3.67 \]

\[ SS_B = n \cdot \Sigma (\bar{y}_{k.} - \bar{y}_{\cdot})^2 = 6[(4.67 - 4)^2 + (3.67 - 4)^2 + (3.67 - 4)^2] = 6(.67) = 4 \]

\[ \bar{y}_{C_i} = \frac{(2 + 3 + 4)}{3} = 3 \]
\[ \bar{y}_{C_2} = \frac{(2 + 4 + 6)}{3} = 4 \]
\[ \bar{y}_{C_3} = \frac{(2 + 5 + 8)}{3} = 5 \]

\[ SS_C = n \cdot \Sigma (\bar{y}_{..} - \bar{y}_{\cdot})^2 = 6[(3 - 4)^2 + (4 - 4)^2 + (5 - 4)^2] = 6(2) = 12 \]

\[ \eta^2 = \frac{SS_{\text{effect}}}{SS_{\text{Total}}} \quad \text{partial } \eta^2 = \frac{SS_{\text{effect}}}{SS_{\text{effect}} + SS_{\text{within}}} \]

(6) State what conclusions you are able to draw from the source table you have presented:

A: at \( \alpha = .05 \), obtained \( F(2, 9) = 12 > \text{critical } F(2, 9) = 4.26 \).

\[ \therefore \text{Reject } H_0. \text{ There is a treatment effect in the population.} \]

B: at \( \alpha = .05 \), obtained \( F(2, 9) = 1 < \text{critical } F(2, 9) = 4.26 \).

\[ \therefore \text{Fail to Reject } H_0. \text{ Results do not support the existence of a } B \text{ effect in the population.} \]
C: at $\alpha = .05$, obtained $F(2, 9) = 3 < \text{critical } F(2, 9) = 4.26$.

$\therefore$ Fail to Reject $H_0$. Results do not support the existence of a C effect in the population.

Residual: at $\alpha = .15 \mid .20 \mid .25$, obtained $F(2, 9) = 1 < \text{critical } F(2,9) = 2.36 \mid 1.93 \mid 1.62$

$\therefore$ Fail to Reject $H_0$. Results do not support the possibility of some interaction among A, B, and/or C in the population.

Therefore, despite the fact that our Residual effect isn’t significant, we probably shouldn’t have used a Latin Squares design, because the failure of nuisance effects B and C to be significant cost us power.
Psychology 602: Design of Experiments

There are four questions on the following four pages. Each question is worth 50 points, for a total possible score of 200. Determination of points awarded will be entirely by magnitude estimation on the part of your teaching assistant.

You may seek aid from any and all books and notes. However, you are not allowed to speak with anyone at any time regarding the test itself other than your instructor and class TAs, until the exam has ended. If you do have questions, please ask.

You may use a calculator or other adding device. However, you may not use any device that will calculate any statistics.

You do not need to report $p$ in your Source Table other than to say it is something like: less than; greater than; or non-significant, as appropriate.

Place all answers in the space below each question, and on the back of the following page, as necessary.

You may also wish to use loose-leaf paper for scratch work. Do not attach such loose-leaf paper to the test. All credit will be determined solely from what you write on the front and back of each page.

Please place your UID in the upper-right-hand corner of each page. Do not place your name anywhere on this test.

At the conclusion of the test, please recycle this instruction sheet. Then, make sure the questions are still paper-clipped together, and in order from first to last, consecutively.
1. You have conducted a study in which you examined the effects of PC screen illumination and font size on reading ability. Subjects were assigned at random to one of the nine possible treatment conditions. The two treatment factors were completely crossed with each other. The first treatment factor (A) had three levels of illumination: low, medium, or high contrast screen lighting. The second treatment factor (B) had three levels of type size: 10-point font, 12-point font, or 14-point font.

The nine cell means are:

\[
egin{align*}
AB_{11} &= 1 & AB_{12} &= 2 & AB_{13} &= 3 & AB_{21} &= 3 & AB_{22} &= 4 & AB_{23} &= 5 & AB_{31} &= 5 & AB_{32} &= 6 & AB_{33} &= 7
\end{align*}
\]

(1) State the model under investigation, and briefly defend your choice of random and/or fixed effects in your model;

\[
Y_{(ijk)} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{ijk}
\]

Fixed effects model. The study would most likely be replicated using the same levels.

(2) State \( H_0 \), both formally (in terms of population parameters), and in words for the model you have chosen; and

(3) State \( H_1 \), both formally (in terms of population parameters), and in words for the model you have chosen;

\( H_0: \alpha_j = 0 \) for all \( j \)

\( H_1: \alpha_j \neq 0 \) for some \( j \)

\( H_0: \beta_k = 0 \) for all \( k \)

\( H_1: \beta_k \neq 0 \) for some \( k \)

\( H_0: \alpha\beta_{jk} = 0 \) for all \( j, k \)

\( H_1: \alpha\beta_{jk} \neq 0 \) for some \( j, k \)

\( H_0: \) The effect of treatment A does not differ from zero in the population.

Any differences from zero in the sample are due to chance or random factors.

\( H_1: \) The effects of treatment A are different from zero in the population.

\( H_0: \) The effect of treatment B does not differ from zero in the population.

Any differences from zero in the sample are due to chance or random factors.

\( H_1: \) The effects of treatment B are different from zero in the population.

\( H_0: \) The AB interaction effect does not differ from zero in the population.

Any differences from zero in the sample are due to chance or random factors.

\( H_1: \) The AB interaction effect is different from zero in the population.

► NOTE see the Homework #7 key for another way to state these hypotheses, particularly the interaction hypothesis.

(4) Determine the analysis of variance parameter estimates \( \mu, \alpha_j, \beta_k \), and \( (\alpha\beta)_{jk} \) from the nine cell means above; and,

\[
\begin{align*}
\mu &= 4 \\
\alpha_1 &= -2 & \alpha\beta_{11} &= 0 & \alpha\beta_{31} &= 0 \\
\alpha_2 &= 0 & \alpha\beta_{12} &= 0 & \alpha\beta_{32} &= 0
\end{align*}
\]
\[ \alpha_3 = 2 \quad \alpha_{13} = 0 \quad \alpha_{33} = 0 \]
\[ \beta_1 = -1 \quad \alpha_{21} = 0 \]
\[ \beta_2 = 0 \quad \alpha_{22} = 0 \]
\[ \beta_1 = 1 \quad \alpha_{23} = 0 \]

► NOTE that the class overheads, pages 309-312, explain the derivation of these estimates.

(5) What one definitive conclusion can you draw from an examination of your parameter estimates, for which you do not need the results of any inferential test?

*Because all of the \( \alpha \beta \) parameter estimates are identically 0, there is the strong suggestion that there is no interaction effect in the population.*
2. You have a theory which states, in part, that problem-solving ability is impacted by the environment within which a creature is raised. You decide to investigate this possible phenomenon in rats. Therefore, 15 rats are assigned at random to one of five cages, three to a cage. There are two possible environments, either 'normal' or 'enriched', with 2 cages assigned to the normal environment, and 3 cages to the enriched environment. [It was thought that only two cages were necessary to adequately assessment behavior in the 'normal' condition.] Rats are raised together in their cages for the first year of their lives, at which time they are tested on a discrimination task. The dependent variable is the number of successes in the discrimination task.

Normal Environment Means: First Cage = 9 Second Cage = 11
Enriched Environment Means: First Cage = 16 Second Cage = 14 Third Cage = 15

e values, arranged from smallest to largest:
-2 -2 -1 -1 -1 0 0 0 0 1 1 1 2 2

(1) State the model under investigation, and briefly defend your choice of random and/or fixed effects in your model;

\[
Y_{ij} = \mu + \alpha_j + \beta_{kj} + \varepsilon_{ij}
\]

Mixed effects model. In any replication, the effect A would most likely use the same levels. However, the effect B(A) is simply a ‘nuisance’ factor, and cages can be seen as arbitrary instantiations of the infinity of cages that could be created in future replications.

(2) State H₀, both formally (in terms of population parameters), and in words for the model you have chosen; and
(3) State H₁, both formally (in terms of population parameters), and in words for the model you have chosen;

H₀: \( \alpha_j = 0 \) for all \( j \)
H₁: \( \alpha_j \neq 0 \) for some \( j \)

H₀: The effect of treatment A does not differ from zero in the population. Any differences from zero in the sample are due to chance or random factors. H₁: The effects of treatment A are different from zero in the population.

H₀: \( \sigma_{\beta}^2 = 0 \)
H₁: \( \sigma_{\beta}^2 > 0 \)

H₀: The variance of treatment B(A) does not differ from zero in the population. Any difference of the variance of the effect of B(A) from zero in the sample is due to chance or random factors. H₁: The variance of treatment B(A) is greater than zero in the population.

(4) Select an error rate(s), state the critical value for your test statistic based on your error rate(s), and briefly defend your choice of error rate(s);

\[ \alpha = .05 \quad \text{or} \quad \alpha = .05 / 2 = .025 \]

► NOTE that two effects, A and B(A), will be tested in the model. However, it is possible to argue that B(A) is not of theoretical or practical interest.
A: at $\alpha = .05/.025$, critical $F(1, 3) = 10.13/17.44$.
B(A): at $\alpha = .05/.025$, critical $F(3, 10) = 3.71/4.83$.

► NOTE that A is tested against B(A), while B(A) is tested against within.

(5) Based on the information presented below, write out what you consider a complete Source Table:

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>$\eta^2$</th>
<th>partial $\eta^2$</th>
<th>$\rho$</th>
<th>partial $\rho$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>102</td>
<td>4</td>
<td>25.5</td>
<td>22.5</td>
<td>.73</td>
<td>.88</td>
<td>.18</td>
<td>.21</td>
</tr>
<tr>
<td>A</td>
<td>90</td>
<td>1</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B(A)</td>
<td>12</td>
<td>3</td>
<td>4</td>
<td>1.82</td>
<td>.18</td>
<td>.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>22</td>
<td>10</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>124</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SS$_A = 6(10-13)^2 + 9(15-13)^2 = 90$
SS$_{B(A)} = 3[(9-10)^2 + (11-10)^2 + (16-15)^2 + (14-15)^2 + (15-15)^2] = 12$
SS$_{Between} = SS_A + SS_{B(A)} = 102$
SS$_{Within} = (-2)^2 + (-2)^2 + (-1)^2 + (-1)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2 + (1)^2 + (1)^2 + (1)^2 + (2)^2 + (2)^2 = 22$
SS$_{Total} = SS_{Between} + SS_{Within} = 124$

(6) State the conclusions you are able to draw from the Source Table you have presented; and,

- We can reject the null hypothesis for A at either choice of $\alpha$
- The A effect is explaining a large amount of the variance
- We cannot reject the null hypothesis for B(A) at either choice of $\alpha$
  - This failure to reject the null hypothesis for B(A) works in our favor, because the small MS associated with B(A) increases power for the test of A

(7) Are there any aspect(s) of the design that threaten the validity of your conclusions in (6)?

- There is an unequal number of participants in the different A levels (6 in A1 and 9 in A2)
- Number of rats in each condition is fairly small
- Rats are randomized to cages, and then cages are randomized to conditions – it may be more appropriate to approach this analysis as a group-randomized trial
3. You have a theory which states that aggression is a result, in part, of implicit social norms that condone such behavior. Therefore, you select 8 subjects at random from a population of adult males, and assign 4 to the experimental condition, and 4 to the control condition, again at random. All subjects then come to your lab to watch 2 hours of television each night for two months. In the first month, they all watch Discovery Channel documentaries. At the end of the month, each subject is frustrated in their attempt to attain a goal, and their hostile behavior is measured. In the second month, the experimental subjects watch professional hockey games, while the control condition continues to watch documentaries. At the end of the second month, the hostile behavior of all subjects following frustration is again measured.

Following the collection of data, you suffered a fire in your lab that ruined almost all materials. In an earlier misunderstanding of your design, you had conducted two separate randomized blocks analyses – one for the experimental condition, and another for the control condition. You have the source tables for those two analyses. You also know the means for all four conditions, and that $S_{Stotal}$ for the analysis including all 8 subjects is 95.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>Source</th>
<th>df</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$</td>
<td>1</td>
<td>0</td>
<td>$B$</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>SUBJECT</td>
<td>3</td>
<td>8</td>
<td>SUBJECT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SUBJECT*B</td>
<td>3</td>
<td>8</td>
<td>SUBJECT*B</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Error</td>
<td>0</td>
<td>0</td>
<td>Error</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>16</td>
<td>Total</td>
<td>7</td>
<td>54</td>
</tr>
</tbody>
</table>

Control Means: Baseline Assessment = 4 Follow-up Assessment = 4
Experimental Means: Baseline Assessment = 4 Follow-up Assessment = 9

(1) State the model under investigation, and briefly defend your choice of random and/or fixed effects in your model:

$$\bar{Y}_{ij(k)} = \mu + \alpha_j + \Pi_{i(j)} + \beta_k + (\alpha\beta)_{jk} + (\beta\Pi)_{k(ij)} + \epsilon_{ij(k)}$$

Mixed effects model. The study would probably be replicated using the same levels of both A and B, so in this sense, the design can be seen as involving only fixed effects. However, $\pi$ and $\beta\pi$ are included in the model, and both of these effects must be considered random – unless some compelling argument can be made for the subjects effecting being fixed.

(2) State $H_0$, both formally (in terms of population parameters), and in words for the model you have chosen; and

(3) State $H_1$, both formally (in terms of population parameters), and in words for the model you have chosen;

► NOTE that the statement of hypotheses would be exactly the same as in question (1)!

► NOTE that it is possible to state a hypothesis for $\pi$ as well, but, as in the RB-a design, some rationale would need to be offered for making such a statement.

(4) Select an error rate(s), state the critical value(s) for your test statistic(s) based on your error rate(s), and briefly defend your choice of error rate(s);

► NOTE that three effects, A, B, and AB, will be tested in the model. If experimentwise control of the error rate is desire, then $\alpha = .05/3 = .0167$. However, an argument could be made that a familywise approach to significance testing would be appropriate, or that the goal of significance testing is to determine the model that gave rise to the data, and so $\alpha = .05$ would be permissible.
at $\alpha = .05, .0167$, critical $F(1, 6) = 5.99|10.81$.

► NOTE that A would be tested against Subjects(A), while B and AB would be tested against Residual. $df_{\text{ERROR}}$ in both instances would be 6.

(5) Based on the information presented below, write out what you consider a complete Source Table;

<table>
<thead>
<tr>
<th>Source</th>
<th>$SS$</th>
<th>$df$</th>
<th>$MS$</th>
<th>$F$</th>
<th>$\eta^2$</th>
<th>$\eta^2_{\text{partial}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>75</td>
<td>3</td>
<td>25</td>
<td></td>
<td>.79</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>25</td>
<td>1</td>
<td>25</td>
<td>25/1.5</td>
<td>16.67</td>
<td>.74</td>
</tr>
<tr>
<td>B</td>
<td>25</td>
<td>1</td>
<td>25</td>
<td>25/1.83</td>
<td>13.66</td>
<td>.41</td>
</tr>
<tr>
<td>AB</td>
<td>25</td>
<td>1</td>
<td>25</td>
<td>25/1.83</td>
<td>13.66</td>
<td>.41</td>
</tr>
<tr>
<td>Within</td>
<td>20</td>
<td>12</td>
<td>1.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects(A)</td>
<td>9</td>
<td>6</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>11</td>
<td>6</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$SS_{\text{Total}} = 95$

$SS_{\text{within}} = SS_{\text{Subject(RB1)}} + SS_{\text{Subject*B(RB1)}} + SS_{\text{Subject(RB2)}} + SS_{\text{Subject*B(RB2)}} = 8 + 8 + 1 + 3 = 20$

$SS_{\text{Subjects}} = SS_{\text{Subject(RB1)}} + SS_{\text{Subject(RB2)}} = 8 + 1 = 9$

$SS_{\text{Residual}} = SS_{\text{Subject*B(RB1)}} + SS_{\text{Subject*B(RB2)}} = 8 + 3 = 11$

$SS_{\text{Between}} = SS_{\text{Total}} - SS_{\text{within}} = 95 - 20 = 75$

$SS_A = 8[(4-5.25)^2+(6.5-5.25)^2] = 25$

$SS_B = 8[(4-5.25)^2+(6.5-5.25)^2] = 25$

$SS_{AB} = SS_{\text{Between}} - SS_A - SS_B = 75 - 25 - 25 = 25$

► NOTE that the calculations for $\eta^2$ can be found in the class notes on page 396.

(6) State what conclusions you are able to draw from the Source Table you have presented;
• The effects A, B, and AB are significant regardless of the choice of $\alpha$

(7) Are there any aspect(s) of the design that threaten the validity of your conclusions in (6)?
• Only males were selected and the theory is not specific to males
• The manipulation of social norms is viewing aggression or not viewing aggression and that may or may not be a good operationalization of social acceptance of aggression, and hockey is a pretty specific manipulation
4. I have argued throughout the semester for a model comparisons approach to understanding the results of inferential tests, with which we were more or less comfortable until we encountered the analysis of covariance model that included a test for homogeneity of regression. In an attempt to evaluate this model, we found ourselves facing a seeming multitude of effects, namely: \( Z \) \( Z|A \) \( Z|A,Z \) \( A \) \( A|Z \) \( A|Z,ZA \) \( ZA|A,Z \)

(a) There are seven possible models that can be compared to evaluate these effects. Please write of the seven equations that correspond to the seven models, numbering each one.

Now for each effect (that is: \( Z \) \( Z|A \) \( Z|A,Z \) \( A \) \( A|Z \) \( A|Z,ZA \) \( ZA|A,Z \)) indicate which two models are being compared, using the numbers you have used to indicate your models [that is, say something like: “\( Z \) compares model (1) to model (2)”].

- \( Z \) compares model 2 to model 1
- \( A \) compares model 3 to model 1
- \( Z|A \) compares model 4 to model 3
- \( A|Z \) compares model 4 to model 2
- \( Z|A,ZA \) compares model 7 to model 6
- \( A|Z,ZA \) compares model 7 to model 5
- \( ZA|A,Z \) compares model 7 to model 4

▷ NOTE that the error term in all instances should be derived from model 7.