PSYCH 710
Practice Questions

September 30, 2022

Initialize R

Initialize R by entering the following commands at the prompt. Type the commands exactly as shown.

```r
options(contrasts=c("contr.sum","contr.poly") )
```

The `options` command sets up R to use sum-to-zero coding for factors, and polynomial coding for ordered factors. The `load` command loads the data variables that you need to answer the following questions.

1. Verbal IQ scores were obtained from 30 children. The data are stored in the variable `iq.dat`, which was placed into R with the `load` command above. Use the data in `iq.dat` to answer the following questions.

   (a) Use a \( t \) test to evaluate the null hypothesis that the data were sampled from a population with a mean of 100. Make sure answer includes the values of \( t \) value, \( p \), and the degrees of freedom, and a clear description of the null and alternative hypotheses being evaluated.

   (b) Cohen’s \( d \) is a common measure of effect size. What, exactly, does Cohen’s \( d \) represent? Why is a measure like Cohen’s \( d \) a useful complement to \( p \) values?

   (c) Calculate Cohen’s \( d \) for the analysis performed to answer question (a).

   (d) The IQ test was designed so that, in a population of typically-developed children, the mean score is 100 and the standard deviation is 15 (\( \mu = 100, \sigma = 15 \)). Use an equivalence test to evaluate the hypothesis that our sample was selected from a population with a normal mean, with the assumption that a mean is considered normal if it is within the bounds 100 \( \pm \sigma \), or 100 \( \pm 7.5 \). State the null and alternative hypotheses for the equivalence test, and your conclusion regarding that null hypothesis.

2. A perceptual learning experiment measured visual sensitivity in a group of 40 young adults before and after practice in visual detection tasks. The data are contained in the data frame `paired.df`: visual sensitivity measures taken before and after practice are stored in the variables `t1` and `t2`. Use a \( t \) test to see if the two measures differ significantly. State the null (H0) and alternative (H1) hypotheses, as well as your conclusion about H0.

   (a) Does your \( t \) test mean that we can conclude that mean sensitivity was equal before and after practice (i.e., that the effect of practice on sensitivity was zero)? Explain your answer.

   (b) Assume that the smallest change in visual sensitivity that is of interest to us is \( \pm 5 \). In other words, if the difference \( \mu_D = \mu_{t2} - \mu_{t1} \) is between \( \pm 5 \), then we would say that sensitivity before and after practice was equivalent. Use the TOST procedure to evaluate the claim that sensitivity before and after practice was equivalent. Use the Type I error rate (alpha) of 0.05 for the TOST equivalence test.
3. An experiment was conducted to assess the effects of four treatments on a dependent variable, \( y \). The experiment measured \( y \) on 32 subjects assigned randomly to the four treatments \((n = 8 \text{ per treatment})\), and the data are stored in the data frame \( \text{aov.df} \). Use \( \text{aov.df} \) to answer the following questions.

(a) Calculate the mean and standard deviation of \( y \) for each treatment group.
(b) Conduct an analysis of variance to evaluate the effect of treatment on \( y \). Record the results of your ANOVA (i.e., write the ANOVA table).
(c) Explain the null and alternative hypotheses that are evaluated by your ANOVA.
(d) Our ANOVA makes assumptions about the distribution of the errors: specifically, that the errors are distributed normally and have constant variance across groups. Use statistical (i.e., not graphical) methods to evaluate these assumptions.
(e) Evaluate the pairwise differences between all group means.
(f) Explain what is meant by Type I errors and how they relate to your analysis of pairwise differences.
(g) What does eta-squared \( (\eta^2) \) represent? Calculate \( \eta^2 \) for treatment.

4. The results of an ANOVA are shown below. Refer to the ANOVA table when answering the next 5 questions.

<table>
<thead>
<tr>
<th>Analysis of Variance Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response: ( y )</td>
</tr>
<tr>
<td>Df</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>group</td>
</tr>
<tr>
<td>Residuals</td>
</tr>
</tbody>
</table>

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(a) When the null hypothesis is true, what do the values \( MS_{\text{group}} \) and \( MS_{\text{residuals}} \) represent?
(b) The sums-of-squares for group is 102. In the context of nested linear models that were used to construct this table, what does this value represent?
(c) Based on this ANOVA, what is the probability that the null hypothesis is true? Explain.
(d) The degrees of freedom for group is 3, which equals the number of groups minus 1. The degrees of freedom for group also corresponds to a particular difference between two nested linear models that are used to construct the ANOVA table. What is this difference?
(e) Use the information in the table to calculate a measure of effect size or association strength for group.

5. Use \( \text{aov.df} \) to answer the following questions.

(a) Evaluate a linear comparison between the mean of treatment 1 and the mean of the other three treatments. Assume that your comparison is planned.
(b) Assume that you decided to perform the previous contrast after looking at the data. How would your statistical test change? Perform that statistical test.
(c) List a set of weights that could be used to evaluate a linear contrast that is orthogonal to the contrast tested in the previous two questions. Describe the null hypothesis that is evaluated by your contrast weights.
6. An experiment measured detection thresholds for spots of different sizes. The point of the experiment was to test a theory’s prediction that detection threshold would decline as the spot increased from small to medium, but then would level off or actually increase as spot size increased from medium to large. The experiment measured detection thresholds for spots at six, equally-spaced diameters ranging from small (condition d1) to large (condition d16). There were 6 subjects per condition. The data are stored in the data frame spot.dat which consists of the factor diameter and the numeric variable threshold

(a) Use ANOVA to evaluate the effect of diameter on threshold.
(b) Does the omnibus $F$ test support or refute the main prediction? Explain.
(c) Evaluate the linear and non-linear trends of threshold across diameter.
(d) Calculate effect size and association strength for the quadratic trend.
(e) Is the trend analysis a more appropriate way of evaluating the main hypothesis about the effect of spot diameter? Explain.