NONPARAMETRIC TESTS: RANK SUM TEST, SIGN TEST, KRUSKAL-WALLIS AND FRIEDMAN TESTS
BI 311: Homework 10

Introduction:

Between chi-square tests and the parametric tests we practiced in earlier homework, you are on your way to having a great set of statistical tools for data analysis. Chi-square tests are good for nominal data that can be expressed in terms of a count or frequency. Parametric tests are very powerful tests for continuous data on an ordinal, interval or ratio scale. However, parametric tests assume the data fit a normal distribution. Sometimes you can transform the data to fit a normal distribution but sometimes you can't. Non-parametric tests may have less power (less ability to detect a statistical difference when one exists- type I errors), but they make no assumption about the underlying distribution of the data. Therefore, non-parametric tests allow you to analyze data that cannot be transformed to fit a normal curve.

Over the next few homework exercises we will practice different types of non-parametric analyses. We will start with non-parametric equivalents to the t-test and ANOVA.

Skills:

1. Practice using Rank Sum Test.
2. Practice using Sign Test.
3. Practice using Kruskal-Wallis Test.
4. Practice using Friedman Test.

Materials:

1. Access to EXCEL
2. EXCEL file named *Homework 10*

EXERCISE 1- USING RANK SUM TEST TO TEST FOR DIFFERENCES BETWEEN TWO POPULATIONS

Background:

Recall from homework 6 that you performed a t-test when you wanted to test for differences in home range size between male versus female scrub lizards. You may also remember that the home range data was not normally distributed and you had to transform the data by taking the log. Alternatively, you can use the Rank Sum Test to test for differences between two populations.

The Rank Sum Test is fully explained with examples starting on page 68 of Ambrose et al (2007). The primary use is in testing for differences between two populations. The main limitation is that the data from the two populations must be independent of each other… in other words, the result for one data point in one population cannot depend on (or is not influenced by) a corresponding data point from the other population.

Laboratory Procedure:

1. Read the example problems in pages 68-71 of Ambrose et al (2007). Complete the example for vitamin C on page 70 for your homework. I've copied the data into an EXCEL spreadsheet named *Homework 10*, on the sheet named *Vitamin C*.
2. On the sheet named *scrub lizard home range* of the *Homework 10* EXCEL file you will find the same data you used for homework 6. Instead of taking the log to transform the non-normal data and then using a t-test, this time test for a significant difference between female and male home range size using the Rank Sum Test.

EXERCISE 2- USING SIGN TEST TO TEST FOR DIFFERENCES BETWEEN TWO RELATED POPULATIONS

Background:

Sometimes neither a Rank Sum Test nor a t-test is appropriate to test for differences between two populations. When data from one population is not independent of data from the other population, you can use a Sign Test. This commonly occurs when you have experimental subjects that are measured twice to form the basis of the two populations. For example, imagine a group of human test subjects that you wish to use to measure the effectiveness of a drug. To control for variation between individuals, you could first test each individual before the drug treatment and then compare the result with a test of the same individuals after drug treatment. The same individual acts as a control (before treatment) and as a treatment (after treatment). But because each individual is being measured twice, those two measurements are not independent of each other.

The Sign Test is explained on pages 78-80 of Ambrose et al (2007). Read the examples to fully understand the utility of this test.

Laboratory Procedure:

1. Read the example problems in pages 78-80 of Ambrose et al (2007). Complete the example for the knee-jerk reflex on page 79 for your homework. I've copied the data to the sheet named *Knee-Jerk Reflex* on the *Homework 10* EXCEL file
2. On the worksheet labeled *HomeRange BeforeAfter Fire* of the *Homework 10* EXCEL file you will find before/after data for homr range sizes of scrub lizards. For 30 male scrub lizards, we were able to measure their home range size before a controlled burn of their scrub patch and after a controlled burn. Remember that lizards prefer open sandy areas and scrub habitat is very pyrogenic. We hypothesized that male scrub lizards should increase their home range size in response to fire cleaning out the undergrowth. Use the Sign Rank test to evaluate our hypothesis.

EXERCISE 3- USING KRUSKAL-WALLIS TO TEST FOR DIFFERENCES BETWEEN MORE THAN TWO POPULATIONS

Background:

Although ANOVA is very powerful, sometimes data cannot be transformed to meet parametric assumptions. Alternatively, you can use the Kruskal-Wallis Test to test for differences between more than two populations. The Kruskal-Wallis test can be used anytime a single factor ANOVA is appropriate.

The Kruskal-Wallis Test is fully explained with examples starting on page 63 of Ambrose et al (2007). The primary use is in testing for differences between more than two populations. The main limitation is that the data from the populations must be independent of each other… in other words, the result for one data point in one population cannot depend on (or is not influenced by) a corresponding data point from the other population.

Laboratory Procedure:

1. Read the example problems in pages 63-67 of Ambrose et al (2007). Complete the example for first grade teachers on page 66 for your homework. Note: to help with the calculations, I've entered the farm example in table 3 (worksheet labeled *Farm Example*) of the *Homework 10* EXCEL file. I've entered the data in a continuous format on the left side of the worksheet. By sorting the first two columns based on weight, I was able to quickly rank all the weights. Then, by sorting the first three columns by farm and then by ranks, I could quickly copy and paste the weights and results into the calculation table. I already have formulas entered on the calculation table which automatically calculate my test statistic. You can use this table as a template for calculating the test statistic for your teacher example or you can do it by hand. Either way, I've entered the raw data for teachers on the sheet named *Teachers* of the *Homework 10* file. One further note: although the Kruskal-Wallis can test for significant differences between 3 or more groups, it can't tell you which groups are different. By calculating the means and standard errors of each population, you can determine which groups are the same (overlapping error bars) and which groups are different (non-overlapping error bars).
2. Recall from homework 6 that you performed ANOVA when you wanted to test for differences in survivorship between hatchling, juvenile and adult scrub lizards. Imagine if the survival data was non-normal and could not be corrected with a transformation. You can use a Kruskal-Wallis Test to test for differences in survival. To practice, on the worksheet labeled *scrub lizard survival* of the *Homework 10* EXCEL file you will find the same data you used for homework 6. Test for a significant difference between hatchling, juvenile and adult survival using the Kruskal-Wallis Test.

EXERCISE 4- USING THE FRIEDMAN TEST TO TEST FOR DIFFERENCES BETWEEN THREE OR MORE RELATED POPULATIONS

Background:

Sometimes neither an ANOVA nor a Kruskal-Wallis test is appropriate for testing for differences between 3 or more groups. When data from one population is not independent of data from the other populations, you can use a Friedman test. This commonly occurs when you have experimental subjects that are measured more than twice to form the basis of the three or more populations. For example, imagine a group of human test subjects used measure the effectiveness of a drug. To control for variation between individuals, you could first test each individual before the drug treatment and then compare the result with a test of the same individuals after drug treatment. The same individual acts as a control (before treatment) and as a treatment (after treatment). But because each individual is being measured twice, those two measurements are not independent of each other. Imagine now that we want to extend the experiment to a 3^{rd} or 4^{th} drug using the same test subjects. We have the same problem that the test subject is being used across all treatments and thus, is not independent. In this case, the same test subject is being repeatedly measured across all treatment groups. Note for future reference that there is a parametric equivalent of the Friedman Test called the Repeated Measures ANOVA but, as with all parametric tests, it is restricted to normally distributed data.

The Friedman Test is fully explained on pages 58-62 of Ambrose et al (2007). Read the examples to fully understand the utility of this test. Note that in the examples in Ambrose et al (2007), one with mice and one with corn, it is not individuals that are being used repeatedly across test groups but rather close, genetic relatives. The same problem of independence exists because the subjects are not randomly assigned to treatments but are assigned to the same treatment as their relative.

Laboratory Procedure:

1. Read the example problems in pages 58-62 of Ambrose et al (2007). Complete the corn example on page 61 for your homework. Note: to help with the calculations, I've entered data and formulas for the mouse example on the worksheet labeled *smoking mice* of the *Homework 10* EXCEL file and I've entered the data for the corn example on the spreadsheet named *corn*. You can use the template formulas in the mouse example to calculate your statistics for the corn example or you can do it by hand.
2. On the worksheet labeled *scrub lizard egg survival* of the *Homework 10* EXCEL file you will find data on the effects of soil moisture levels on egg survival. We noticed that smaller scrub patches were closer to the water table than larger scrub patches and hypothesized that soil moisture might explain why recruitment is lower in small patches versus large patches. We hypothesized that egg survival would be higher in drier soils. Use the Friedman Test to test our hypothesis for your homework.

HOMEWORK SUBMISSION

1. For your homework, create a WORD file named *Homework 10* and report your answers for the following questions:

a. Exercise 1: Is vitamin C effective for treating colds?
b. Exercise 1: Is there a significant difference between male and female home range sizes?
c. Exercise 1: What was your calculated Z statistic for the test of home range differences?
d. Exercise 2: Does the tensed versus relaxed condition of muscles significantly affect the knee-jerk reflex?
e. Exercise 2: Does fire have a significant effect on male scrub lizard home range size?
f. Exercise 2: If fire does have an effect, is it positive or negative (i.e. are home ranges larger or smaller after fire)?
g. Exercise 3: Is there a significant difference between teachers?
h. Exercise 3: Does the Kruskal-Wallis test indicate a significant difference in survival for scrub lizard age classes?
i. Exercise 3: What was your calculated H statistic for the survival test?
j. Exercise 4: Is there a significant difference between fertilizer treatments for corn growth?
k. Exercise 4: Does soil moisture have an effect on the proportion of eggs surviving for scrub lizards?
l. Exercise 4: What was your calculated Chi-square statistic for the egg survival test?