Chapter 15: Chi-Square and Other Nonparametric Tests

100,000 lemmings can't be wrong. ~ unknown author

Learning Objectives

Upon completion of this chapter, students should know

- How to define and to differentiate between parametric and nonparametric statistics.
- When to use, how to compute, and how to interpret the Chi-Square.
- When to use, how to compute, and how to interpret the Mann-Whitney *U* Test.
- When to use, how to compute, and how to interpret the Wilcoxon *T* Test.
- When to use, how to compute, and how to interpret the Kruskal-Wallis Test.

Key Terms

Chi-square (c^2) is a statistical technique for nominal data that compares the observed frequencies in different categories with the frequencies expected from a theory or hypothesis. The test requires that the observations must be independent, randomly sampled, nominal data, and that there are not less than 5 expected frequencies in a cell.

Parametric statistics are those that are stated in terms of and make assumptions about population parameters (the characteristic elements of a population under study, such as the population mean and standard deviation). For example, the hypothesis for the *t* test and the analysis of variance are stated terms of the population mean and it is assumed that the variances of the populations being compared are equal and the scores are normally distributed.

Nonparametric statistics do not compare population parameters and they make fewer assumptions than parametric statistics. The major advantage of most nonparametric statistics is that they work well with data that are ranked or skewed, as well as with small samples. The disadvantage is that, on average, they are less powerful.

Mann-Whitney *U* is a nonparametric test used to analyze two independent samples. It is the nonparametric counterpart of the independent groups *t* test.

Wilcoxon *T* is a nonparametric test used to determine if there is a significant difference between two correlated samples. The major requirements of the test are (1) that the sample be correlated and (2) it must be possible to rank the differences between the samples. It is the nonparametric counterpart of the correlated samples *t* test.

Sign the ranks is a process whereby each rank is assigned to a category based on the arithmetic sign of the difference score for that rank. If the difference score is negative, the rank is assigned to the minus category; if the difference is positive the rank is assigned to the plus category.

Kruskal-Wallis test is the nonparametric test used to analyze studies with more than two independent samples. It is the nonparametric counterpart of the one-way analysis of variance.

Lecture and Demonstration Ideas

Nonparametric tests are used when data do not fit the assumptions of parametric tests. Students may have the mistaken idea that these are not worthy tests or data are not as valuable. This is not the case. One of the major issues relating to the use of nonparametric tests is power. They simply are not as powerful as parametric tests. Thus, the likelihood of rejecting the null hypothesis is less when these tests are used.

Review the parametric tests (see Transparencies 15-1 to 15-3) with students and point out that in some areas of psychology, such as comparative psychology, nonparametric tests are used most of the time.

Guest Speaker. Invite a comparative psychologist to share their research with your class. Ask the guest speaker to explain why he/she uses nonparametric procedures and the credibility of the findings. Students enjoy this experience.

Chi-Square. Use the data presented on Transparency 15-4 to demonstrate computation of the chi-square statistic. The research question asks men and women if they would prefer to give up morning coffee, cable television, or the newspaper to keep the Internet hookup. It was predicted men and women would differ in their responses. Results of the analysis (see Transparency 15-5) indicated there were no differences between men and women.

Instructional Video. *Against All Odds: Inside Statistics***.** Program Twenty-Four, "Inference for Two-Way Tables" reviews the chi-square test and its uses. These videos are produced by the Consortium for Mathematics and Its Applications and Chedd-Angier (1989) and available through Annenberg/CPB.

Additional Assignments

Using Nonparametric Tests. Ask students to visit the websites below and read the research and statistical tests used to analyze data. Have students write a one-paper reaction paper about nonparametric statistics and these research studies.

1. Kruskal Wallis Test. Hey, J. Internet study – Blurry graphics and the words used to describe them. http://lifesci.rutgers.edu/~heylab/wordexp/results.htm

2. Chi-Square and Smoker Behavior. (Pezzullo, J. at Georgetown University). http://192.190.202.200/sobol/survey5/chi.htm

Transparency 15-1.

Parametric versus Nonparametric
What's the difference?

Parametric statistics are those that are stated in terms of and make assumptions about population parameters.

Nonparametric statistics do not compare population parameters and they make fewer assumptions.

- Disadvantage of nonparametric tests: Less Powerful

Transparency 15-2.

Parametric Tests and Nonparametric Counterpart

Parametric	Nonparametric
Independent Samples *t* Test	Mann-Whitney U
Correlated *t* Test	Wilcoxon *T* Test
One-Way Analysis of Variance	Kruskal-Wallis Test

Transparency 15-3.

Chi-Square

Compares the observed frequencies in different categories with the expected frequencies from the hypothesis

Assumptions:

1. **Sample is randomly selected from the population.**
2. **All observations are independent.**
3. **Limited to nominal data.**
4. **Must have expected frequencies of 5 or more.**

Transparency 15-4.

Chi-Square Example

Do men or women differ in what they are willing to give up in order to keep the Internet hookup?

	Morning Coffee	Cable TV	Newspaper	Total
Men	87	73	66	226
Women	113	77	84	274
Total	200	150	150	500

Transparency 15-5.

Chi-Square Solution

	Morning Coffee	Cable TV	Newspaper	Total
Men	f_o = 87 f_e = 90.4	f_o = 73 f_e = 67.80	f_o = 66 f_e = 67.80	226
Women	f_o = 113 f_e = 109.60	f_o = 77 f_e = 82.20	f_o = 84 f_e = 82.20	274
Total	200	150	150	500

= .1279 + .3988 + .0478 + .1055 + .329 + .0394 = 1.048

Computed c^2 = 1.048.

degrees of freedom = k - 1 = 2

Critical Value c^2 (2, .05) = 5.991

Fail to reject the null hypothesis. There were no differences between men and women in their willingness to give up morning coffee, cable television, or the newspaper to keep the Internet.