Week 6 Preparation for Chi-Square Analysis
(Replaces previously sent document "One Variable Chi-Square Test and Chi-Square Test for Independence")

The Chi-Square Test for Independence or Chi-Square Test of Association

What is the relationship between the gender of the students and the assignment of a Pass or No Pass test grade (data from chapter 6, Kirkpatrick & Feeney)? The following is called a Crosstabs table, using the observed frequencies from the *recoded* data (Pass = score 70 or above):

	Pass	No Pass	Row Totals
Males	12	3	15
Females	13	2	15
Column Totals	25	5	30

Chi-Square compares *expected frequencies* with *observed frequencies. Expected frequencies* are those that would occur most often if the null hypothesis were true. We *estimate* the expected frequencies from our sample using the Column and Row totals (otherwise known as "marginal totals"). Each of the four cells (male, pass; male not pass; female pass; and female not pass) will each have an expected frequency.

SPSS does all the calculating, but for instructional purposes here's how it's done:

Calculating the Chi-Square by hand:

$$X^2 = \Sigma \left[\frac{(O-E)^2}{E} \right]$$

Σ = Summation sign, read "the sum of…"
O = Observed frequencies
E = Expected frequencies

Expected frequencies are calculated with the marginal totals….see Weinbach and Grinnell book, p. 195 on how to compute these manually.

	O (observed)	E (Expected)	O – E	$(O - E)^2$	$(O - E)^2 / E$
Males and Pass	12	12.5	12 – 12.5 = -.5	$(-.5)^2$= .25	.25 / 12.5 = .02
Male and No Pass	3	2.5	3 – 2.5 = .5	$(.5)^2$= .25	.25 / 2.5 = .10
Females and Pass	13	12.5	13 – 12.5 = .5	$(.5)^2$= .25	.25 / 12.5 = .02
Females and No Pass	2	2.5	2 – 2.5 = -.5	$(-.5)^2$= .25	.25 / 2.5 = .10
					X^2= .24

You now want to know if there is a statistically significant difference in the distribution of passes and

no passes earned between male and female students. Another way of saying this: is there a relationship between gender and passing the test?

Determine your hypotheses—one- or two-tailed?

1. H$_o$ (Null hypothesis): There is no relationship between gender and P/NP

2. H$_A$ (Alternative or research hypothesis): There is a relationship between gender and P/NP

        *** What would Step 2 be if you had a one-tailed hypothesis?

Choose Statistical Test

SPSS:
Click on **Analyze**, **Descriptive Statistics**, and **Crosstabs**... In the Crosstabs window, move your "gender" variable into the row(s) portion and your Pass/Not Pass variable into the column(s) section. Generally, in the Crosstabs Window, you would place the independent variable in the row box and the dependent variable in the column box. Click on the **Statistics** option and choose Chi Square. Click on the **Cells** option and under "Counts" check observed and expected. Then click Continue, and then OK (or Paste to see your syntax).

Review SPSS Output
The first table in the output is a Case Processing Summary report. This allows you to check to see all cases were included, and if there were any missing data.

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
gender * Pass or fail	30	100.0%	0	.0%	30	100.0%

The next table shows crosstabulation frequencies, showing the frequencies of the variables gender and the variable passfail (Pass or Not pass).

gender * Pass or fail Crosstabulation

			Pass	Not pass	Total
			Pass or fail
Gender	Male	Count	12	3	15
		Expected Count	12.5	2.5	15.0
	Female	Count	13	2	15
		Expected Count	12.5	2.5	15.0
	Total	Count	25	5	30
		Expected Count	25.0	5.0	30.0

You can also command SPSS to give you a more complicated table, showing row and column percentages and "marginal" totals for both rows and columns, as shown below. This is harder to read, but for reporting purposes it's handy to have percentages.

Gender * Pass or fail Crosstabulation

			Pass	Not pass	Total
			Pass or fail
Gender	Male	Count	12	3	15
		Expected Count	12.5	2.5	15.0
		% within gender	80.0%	20.0%	100.0%
		% within Pass or fail	48.0%	60.0%	50.0%
		% of Total	40.0%	10.0%	50.0%
	Female	Count	13	2	15
		Expected Count	12.5	2.5	15.0
		% within gender	86.7%	13.3%	100.0%
		% within Pass or fail	52.0%	40.0%	50.0%
		% of Total	43.3%	6.7%	50.0%
	Total	Count	25	5	30
		Expected Count	25.0	5.0	30.0
		% within gender	83.3%	16.7%	100.0%
		% within Pass or fail	100.0%	100.0%	100.0%
		% of Total	83.3%	16.7%	100.0%

This last output table shows our Chi-Square statistic ("Pearson Chi-Square"), the p value and some alternative statistics.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.240[b]	1	.624		
Continuity Correction[a]	.000	1	1.000		
Likelihood Ratio	.241	1	.623		
Fisher's Exact Test				1.000	.500
Linear-by-Linear Association	.232	1	.630		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.50.

First, the alternative statistics (column 1). The Pearson Chi-Square uses the formula shown above on page 1. "Continuity Correction" is supposed to provide improved results for small samples (like ours), but it is rarely used. The "Likelihood ratio" is used for data that are loglinear in nature, which we can ignore. "Fisher's Exact Text" is often used as an alternative to the Pearson X^2 when one or more cells contain less than 5 observations (as is true in our case—note that there are only 3 male not pass observations and only 2 female not pass observations. **Pearson Chi-Square results when one or more cells contain less than 5 observations cannot be trusted**, hence the warning below the table.) I usually check both statistics. For learning purposes, we'll stick with the Pearson Chi-Square. The "Linear-by-Linear Association" statistic is used when the variables are ordinal, but many simply use the Pearson for those as well.

Column 2 shows the Chi Square values for each alternative test. The main one of interest is the Pearson Chi-Square value of .240. (Compare this with the by-hand calculation on p. 1). This number cannot be interpreted by itself; we need to know the p value associated with it.

Column 2 shows "Degree of freedom" which is a value used by SPSS to determine how the chi-square statistic is distributed. **Degrees of freedom are calculated (manually and by SPSS) as:** df = (R-1) x (C-1) where R = number of rows (subcategories of the independent variable), and C = number of columns (subcategories of the dependent variable). The more degrees of freedom (tables with more cells), the larger the Chi Square values that are needed to achieve statistical significance. (See Table 10.5, p. 198 in Weinbach & Grinnell.) We need the *df* for reporting purposes (see below).

Column 3 shows the p value, here labeled "Asymptotic Sig." Asymptotic is a mathematical term meaning a distribution in which a variable approaches infinity. Both tails of a normal curve do not end, and so here SPSS uses the term to describe a two-tailed statistic. The term itself is not important.

In this example, the p value is .623, definitely <u>not</u> significant. The Null Hypothesis cannot be rejected. Either there really is no relationship between gender and passing the test in the population, or any trend of a relationship is mainly due to sampling error. Knowing how few observations we have of not passing (only five out of 30), this makes sense.

Explanation/interpretation of results and conclusion

This findings do not provide evidence that gender matters in performance on examinations in this sample. Limitations: given the small sample size and that two Chi-Square cells contain less than five observations, further research should be conducted with a larger sample to test the hypothesis that there is a relationship between gender a test performance.

Reporting Chi-Square:

In the narrative Results section (if not in a tabular form), the proper APA format for reporting Chi-Square results is as follows:

"From these results, there is no relationship between gender and passing the test ..., $X^2 = 0.24$, $df = 1$, $p = .623$."

(Typically though, in reporting this type of non-statistical finding, there would be no need to report these numbers in the narrative. You would <u>definitely</u> report them for significant findings.)

ON YOUR OWN: Do the Chapter 17 example in Kirkpatrick and Feeney.