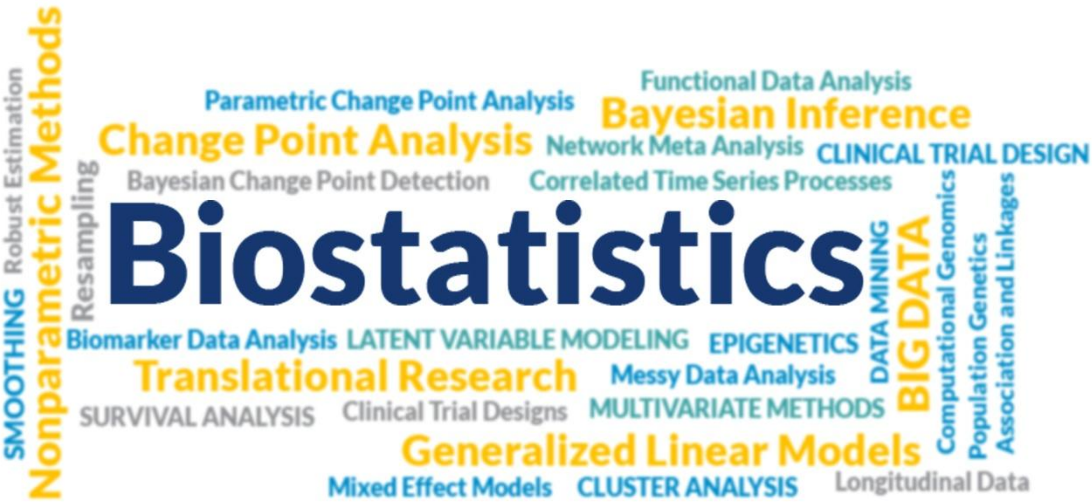


◉ Sheet ◯ Slides

Number

12

Done by:

Ola Al-juenidi

corrected by:

Abdullah AlZibdeh

Doctor

Mahmoud Al-Hussami

First, we will finish the last lecture done by: Mariam Hassouneh

Slide 6: slides 11 – 17 are covered (and copied as they are)

Record#12: 35.45min- 48.18min

When running t test and ANOVA (Parametric Techniques used with continuous data):

1- We compare: Mean differences between groups

- We assume:

1. Random sampling

2. The groups are homogeneous

3. Distribution is normal

4. Samples are large enough to represent population (>30)

5. DV (dependent variable) Data: represented on an **interval or ratio** scale.

- How to measure Degree of Freedom (*df*)??

a. For one group, regardless of Variables (1 variable, two variables, three variables, 1-way ANOVA "dependent within the group or repeated measure ") , *df* = n-1 , n stands for sample size . CAN YOU SEE here how we included number of values?! When it comes to continuous data, we care about values!
b. For 2 groups: *df* = n-2, where n stands for sum of sample sizes, in other words it's like $(n_1-1) + (n_2-1)$.
c. For 3 groups and more =: n – X, n stands for sum of sample sizes, X for number of samples.

– When determining HOW to calculate degree of freedom, first you'll have to look at the sample size; then whether data is continuous (use one of formulas above) or not (other formulas will be applied); then if continuous, regardless of way of analysis **immediately** look to number of groups. Don't let the doctor fool you in the exam, Forget anything related to variables, just focus on how many groups you have, 1 group then *df* = n-1 , 2 groups then *df* = n-2 and so on.

- When the assumptions are violated by the following:

1. Subjects were not randomly sampled

2. DV Data is: Ordinal (ranked) or nominal (categorized: types of car, levels of education, learning styles).

3. The scores are greatly skewed or we have no knowledge of the distribution.

We use tests that are equivalent to t test and ANOVA --> Non-Parametric Tests!

One of them

Chi- square

- The first type of NON-Parametric techniques (remember it is used with Nominal data) that is used to study associations between variables.

- Features of Chi- square test:

1. Must be a random sample from population
2. Data must be in raw frequencies
3. Variables must be independent
4. A sufficiently large sample size is required (at least 20): And to be taken later on in details, expected frequency (data) for each cell must be at least 5.
5. Actual count data (not percentages)
6. Observations must be independent (each participant has an independent answer from the others).
7. Does not prove causality: In Chi- square, causality has **no place to fit in**; no cause-effect is to be proven; only associations and percentages!

BARRY IN MIND: If you're willing to know what effect A has on B , **don't study it on nominal level of data**!!!

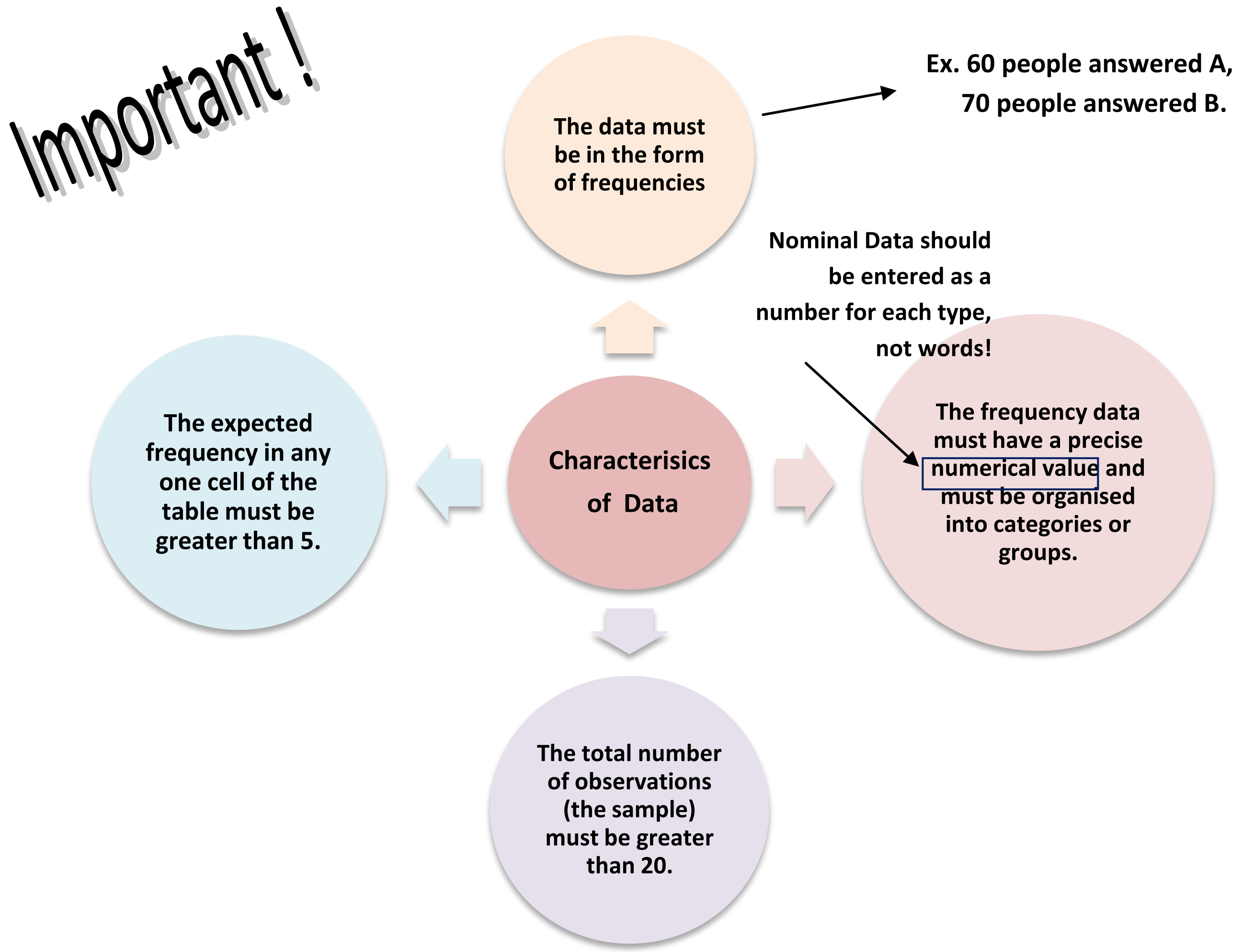
- Chi- Square Degree of freedom (*df*) formula :(column – 1) × (Row – 1) in a Table called Contingency table جدول الاحتمالات (YES, NO table; 2*2 Table).

- WHY does the formula look like this?? Remember that Chi- square is used exclusively with nominal data, which depend mainly on percentages more than individual values, that's why we care about Cells more than what's in them!

**** Summary: Different Scales, Different Measures of Association.**

Scale of Both Variables	Measures of Association
Nominal Scale	Pearson Chi-Square: $\chi 2$
Ordinal Scale	Spearman's rho
Interval or Ratio Scale	Pearson r

- The chi- square test can **only be used** on data that has the following characteristics:



Chi-Square Formula:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where:

χ2 = The value of chi square

O = The observed value (observed frequency)

E = The expected value (expected frequency)

Σ (O – E)2 = all the values of (O – E) squared then added together

What is the degree of freedom??
***df* =(Column – 1) × (Row – 1)**
= (3-1) * (2-1) = 2

A contingency table in Slide 32 for clarification:

	Favor	Neutral	Oppose	f_{row}
Democrat	10	10	30	50
Republican	15	15	10	40
f_{column}	25	25	40	n= 90

A study in the USA that shows opinions of parties in gunshot prevention policy.

** All of these are OBSERVED frequencies.

- Some calculations: For expected Frequency of democrats favoring out of:

1. Favoring opinions = (10*25)/ 90 = 2.78
2. All opinions (frequency we want to be at least 5) = (50*25)/90 = 13.9

The cell is point of meeting for 2 Totals; totals are used in expected frequency calculations to show the frequency of a cell out of all cells. Here for example frequency of democrats who favor out of the whole sample.

Lecture12 Record #13

Slide #6 (14-56)

Review

If the dependent variable is continuous and normally distributed, and the independent is categorical (more than 1 group):
→ we use parametric inferential statistics

If the dependent variable is continuous, and the independent is nominal:
→ we use t-test (it doesn't study associations, it studies effects)

If the data is nominal or ordinal, or continuous but skewed (negatively or positively)
→ we use nonparametric statistics (chi-square)

Chi-square tests hypotheses by giving percentages (frequencies) but not causality (only percentages). It is one of the weakest types of inferential analysis. Usually researchers don't like to use it because the results we get using this test can NOT be worked on or generalized. Consequently, there must be several researches done in the same field for us to be able to conclude something useful from chi-square.

To calculate chi-square:

- Must be a random sample from population
- Variables must be independent
- The data must be in the form of frequencies (numbers not words)
- The frequency data must have a precise numerical value and must be organized into categories or groups:
  Nominal and ordinal data are considered qualitative data. To use chi-square we convert it to numbers to see the frequencies or the median.
- We must know the raw frequencies and the expected frequencies.
- All the cells in the tables must not have a value less than 5.
- The total number of observations in the sample must at least be 20.

Then we use the formula discussed previously in this sheet to find the calculated value of chi-square. We use this test to study associations between nominal data (not causality).

Types of chi-square tests:

1. **Chi Square Test of Goodness of Fit:**
   - To study associations between the <u>dependent</u> variables (1 group, 2 variables)
   - Ex: test Jordanian people's preference of junk food (yes/no questions) before 5 years, then you administer the same questionnaire to the same group now.
   - Purpose:
     - To determine whether an observed frequency distribution departs significantly from a hypothesized frequency distribution.
     - This test is sometimes called a One-sample Chi Square Test.
   - Hypotheses:
     The null hypothesis is that the two variables are independent. This will be true if the observed counts in the sample are similar to the expected counts.
     - H0: X follows the hypothesized distribution
     - H1: X deviates from the hypothesized distribution

2. **Chi Square Test of Independence:**
   - Difference between 2 groups
   - Purpose:
     - To determine if two variables of interest independent (not related) or are related (dependent)?
     - When the variables are independent, we are saying that knowledge of one gives us no information about the other variable. When they are dependent, we are saying that knowledge of one variable is helpful in predicting the value of the other variable.
   - Some examples where one might use the chi-squared test of independence are:
     - Is level of education related to level of income?
     - Is the level of price related to the level of quality in production?
   - Hypotheses:
     The null hypothesis is that the two variables are independent. This will be true if the observed counts in the sample are similar to the expected counts.
     - H0: X and Y are independent
     - H1: X and Y are dependent

In SPSS we find them in different places:

-click analyze → descriptive statistics → independence chi square

-nonparametric tests → chi square goodness of fit

2:10-10:45
Slides covered 14-19

Steps in Test of Hypothesis:

1. **Determine the appropriate test** (from the table in slide10)
   - Chi Square is used when both variables are measured on a nominal scale.
   - It can be applied to interval or ratio data that have been categorized into a small number of groups.
   - It assumes that the observations are randomly sampled from the population.
   - All observations are independent (an individual can appear only once in a table and there are no overlapping categories).
   - It does not make any assumptions about the shape of the distribution nor about the homogeneity of variances.

2. **Establish the level of significance: α**
   - α is a predetermined value
   - The convention
     - α = .05
     - α = .01
     - α = .001
   - When using SPSS we get an actual p value (probability). EX: it gives 0.007. If you cut it off to 0.05 you can report the p value as is if you didn't decide at the beginning. But if you decided that the p value must be less than 0.01, then you must write p value must be ≤ 0.01 in the body of the manuscript. For the meaning of p value, suppose that the chosen α value= 0.05, and the resultant p value= 0.04, then this means that the possibility (p value) of getting the results by chance (not by the manipulation; but by the extraneous variables) is less than stated (α value), so the null hypothesis is rejected.

3. **Formulate the statistical (null) hypothesis** (Whether There is an Association or Not):
   The null hypothesis states that there is no relationship between the variables

- Ho : The two variables are independent
- Ha : The two variables are associated

4. **Calculate the test statistics:**
   - Contrasts observed frequencies in each cell of a contingency table with expected frequencies:
     - The expected frequencies represent the number of cases that would be found in each cell if the null hypothesis were true (i.e. the nominal variables are unrelated).
     - Expected frequency of two unrelated events is product of the row and column frequency divided by number of cases.

       Fe= Fr Fc / N

$$\text{Expected frequency} = \frac{\text{row total} \times \text{column total}}{\text{Grand total}}$$

$$\chi^2 = \sum \left[\frac{(F_o - F_e)^2}{F_e} \right]$$

Where:

F_o: observed frequency

F_e: expected frequency

5. **Determine the degree of freedom**

$$df = (R-1)*(C-1)$$

Number of levels in row variables

Number of levels in column variables

   - In **t-test** it is different. According to the number of groups:
     - 1 group: df = n-1
     - 2 groups: df = n-2
     - 3 groups: df = n-3

6. **Compare computed test statistic against a tabled/critical value**
   - The computed value of the Pearson chi- square statistic is compared with the critical value to determine if the computed value is improbable

- The critical tabled values are based on sampling distributions of the Pearson chi-square statistic
- If calculated χ^2 is greater than χ^2 table value, reject Ho

Degree Of Freedom

The power and the value of α

	$P(X \leq x)$							
	0.010	0.025	0.050	0.100	0.900	0.950	0.975	0.990
r	$\chi^2_{0.99}(r)$	$\chi^2_{0.975}(r)$	$\chi^2_{0.95}(r)$	$\chi^2_{0.90}(r)$	$\chi^2_{0.10}(r)$	$\chi^2_{0.05}(r)$	$\chi^2_{0.025}(r)$	$\chi^2_{0.01}(r)$
1	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635
2	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210
3	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.34
4	0.297	0.484	0.711	1.064	7.779	9.488	11.14	13.28
5	0.554	0.831	1.145	1.610	9.236	11.07	12.83	15.09
6	0.872	1.237	1.635	2.204	10.64	12.59	14.45	16.81
7	1.239	1.690	2.167	2.833	12.02	14.07	16.01	18.48
8	1.646	2.180	2.733	3.490	13.36	15.51	17.54	20.09
9	2.088	2.700	3.325	4.168	14.68	16.92	19.02	21.67
10	2.558	3.247	3.940	4.865	15.99	18.31	20.48	23.21

According to the table, you match the α value and the power with the degree of freedom. The value you get is the critical χ^2.

**If the calculated χ^2 value is greater than the critical value → reject the null hypothesis

**If the calculated χ^2 value is equal or less than the critical value → accept the null hypothesis

*Which is stronger, small or large effect size?

- Small effect size gives you larger sample size compared to large effect size.

In the value of α, we are looking at the type1 error. If you put α to be 0.05 but when the calculated p value turned to be 0.04, you reject the null hypothesis. If the *P*-value is less than (or equal to) α, then the null hypothesis is rejected in favor of the alternative hypothesis. And, if the *P*-value is greater than α, then the null hypothesis is not rejected.

Decision and Interpretation

*If the probability of the test statistic is less than or equal to the probability of the alpha error rate, we reject the null hypothesis and conclude that our data supports the research hypothesis. We conclude that there is a relationship between the variables.

*If the probability of the test statistic is greater than the probability of the alpha error rate, we fail to reject the null hypothesis. We conclude that there is no relationship between the variables, i.e. they are independent.

10:45-21:20
Slides covered 19-30

Example

- Suppose a researcher is interested in voting preferences on gun control issues.
- A questionnaire was developed and sent to a random sample of 90 voters.
- The researcher also collects information about the political party membership of the sample of 90 respondents (50 democrats and 40 republicans).

Bivariate Frequency Table or Contingency Table

	Favor	Neutral	Oppose	f_{row}
Democrat	**10**	**10**	**30**	**50**
Republican	**15**	**15**	**10**	**40**
F_{column}	**25**	**25**	**40**	**n = 90**

1. **Determine Appropriate Test:**
   - Party Membership (2 levels) and Nominal : democrat or republican
   - Voting Preference (3 levels) and Nominal : favor, neutral, or oppose
     2 different groups → chi square test of independence

2. **Establish Level of Significance:** Alpha of .05

3. **Determine The Hypothesis:**

- Ho: There is no difference between democrats & republicans in their opinion on gun control issue.
- Ha: There is an association between responses to the gun control survey and the party membership in the population.

4. **Calculating Test Statistics**

Using the equation:

$$\text{Expected frequency} = \frac{\text{row total x column total}}{\text{Grand total}}$$

We calculate f_e for each observed value as follows:

	Favor	Neutral	Oppose	f_{row}
Democrat	**F_o=10** F_e= 13.9	**F_o=10** F_e= 13.9	**F_o=30** F_e= 22.2	**50**
Republican	**F_o=15** F_e=11.1	**F_o=15** F_e=11.1	**F_o=10** F_e=17.8	**40**
F_{column}	**25**	**25**	**40**	**n = 90**

Let's take the first observation as an example:

Row total = 50   Column total = 25   Grand total (n) = 90

F_e= 50 * 25/90 = 13.9

Now we calculate the value of χ^2 from the following equation: $\chi^2 = \sum\left[\frac{(F_o - F_e)^2}{F_e}\right]$

$$\chi^2 = \frac{(10-13.89)^2}{13.89} + \frac{(10-13.89)^2}{13.89} + \frac{(30-22.2)^2}{22.2} +$$

$$\frac{(15-11.11)^2}{11.11} + \frac{(15-11.11)^2}{11.11} + \frac{(10-17.8)^2}{17.8} \quad =11.03$$

5. **Determine Degrees of Freedom:** df = (R-1)*(C-1)= (2-1)*(3-1) = 2

6. **Compare computed test statistic against a tabled/critical value:**

- $\alpha = 0.05$
- df = 2
- Critical tabled value = 5.991 (look at the table in the next page)
- Test statistic, 11.03, exceeds critical value; <u>null hypothesis is rejected</u> → Democrats & Republicans <u>differ</u> significantly in their opinions on gun control issues
- ***Remember***: Chi square doesn't prove causality

	$P(X \le x)$							
	0.010	0.025	0.050	0.100	0.900	0.950	0.975	0.990
r	$\chi^2_{0.99}(r)$	$\chi^2_{0.975}(r)$	$\chi^2_{0.95}(r)$	$\chi^2_{0.90}(r)$	$\chi^2_{0.10}(r)$	$\chi^2_{0.05}(r)$	$\chi^2_{0.025}(r)$	$\chi^2_{0.01}(r)$
1	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635
2	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210
3	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.34
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5	0.554	0.831	1.145	1.610	9.236	11.07	12.83	15.09
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7	1.239	1.690	2.167	2.833	12.02	14.07	16.01	18.48
8	1.646	2.180	2.733	3.490	13.36	15.51	17.54	20.09
9	2.088	2.700	3.325	4.168	14.68	16.92	19.02	21.67
10	2.558	3.247	3.940	4.865	15.99	18.31	20.48	23.21

When df=2

$\chi^2_{\alpha=0.05}=5.991$

SPSS Output: 2 different groups (democrat, republican) →chi square test of independence

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.025[a]	2	.004
Likelihood Ratio	11.365	2	.003
Linear-by-Linear Association	8.722	1	.003
N of Valid Cases	90		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.11.

Pearson chi-square = 11.025; df = 2

→P value (see the table; P value= assumption sygnificance) = 0.004 (the assumption is significant)

P value is less than 0.05 (α); so you reject the null hypothesis

End of example

Pearson Chi-Square provides information about the existence of relationship between 2 nominal variables, but not about the magnitude of the relationship.

We said that chi-square doesn't measure the strength of associations; it only tells us if there is an association or not. To calculate the strength of the association we either use **phi coefficient** or **Cramer's V**.

Phi Coefficient

- Phi coefficient is the measure of the strength of the association
- Used when the table is smaller or equal to 2X2 (contains 2 cells or less)

$$\phi = \sqrt{\frac{\chi^2}{N}}$$

χ^2: value of chi-square
N: sample size
Φ is between 0 and 1(we deal with it like the correlations/r)

21:20-31:25
Slides covered 30-46

Cramer's V

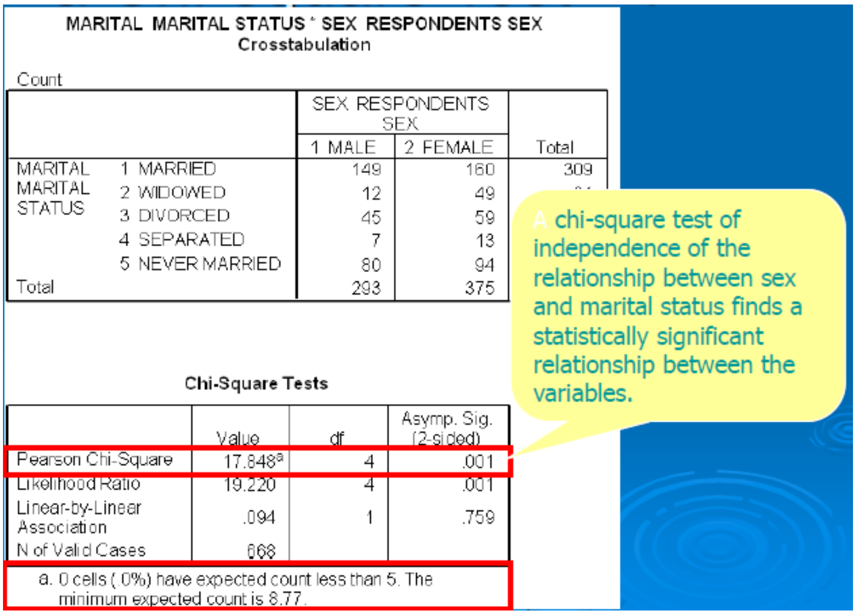
- When the table is larger than 2by 2, a different index must be used to measure the strength of the relationship between the variables. One such index is Cramer's V.
- If Cramer's V is large, it means that there is a tendency for particular categories of the first variable to be associated with particular categories of the second variable.

$$V = \sqrt{\frac{\chi^2}{n(k-1)}}$$

χ^2: value of chi-square
n: number of cases
k: smallest number of rows or columns
V is between 0 and 1(we deal with it like the correlations/r)

Interpreting Cell Differences in a Chi-square Test

Looking at the picture, notice that chi-square value = 17.848 and p value =0.001. Here we reject the null hypothesis.



MARITAL MARITAL STATUS * SEX RESPONDENTS SEX Crosstabulation

Count

		SEX RESPONDENTS SEX		
		1 MALE	2 FEMALE	Total
MARITAL MARITAL STATUS	1 MARRIED	149	160	309
	2 WIDOWED	12	49	
	3 DIVORCED	45	59	
	4 SEPARATED	7	13	
	5 NEVER MARRIED	80	94	
Total		293	375	

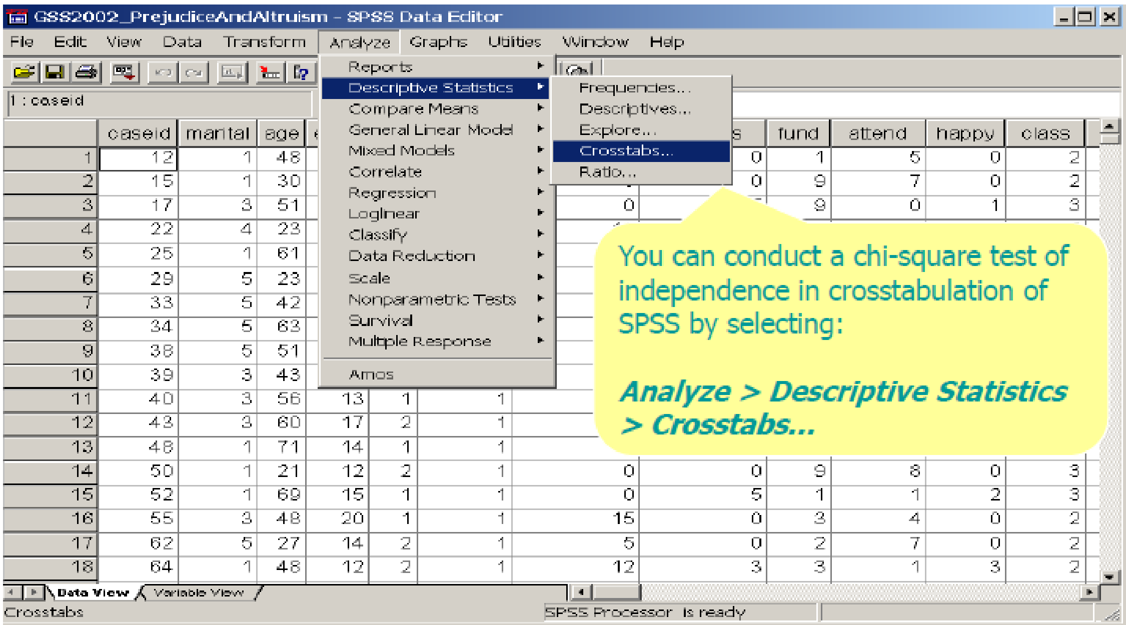
Chi-Square Tests

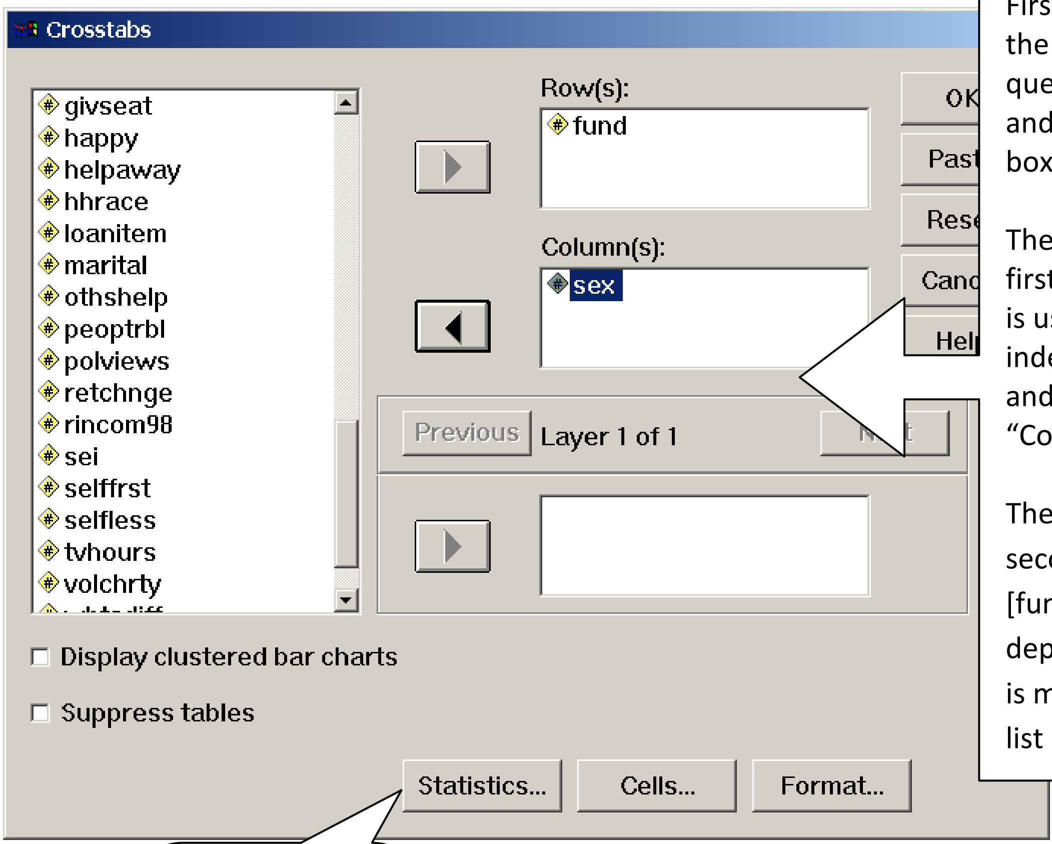
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.848[a]	4	.001
Likelihood Ratio	19.220	4	.001
Linear-by-Linear Association	.094	1	.759
N of Valid Cases	668		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.77.

SPSS analysis:

- **Chi-Square Test of Independence: post hoc test in SPSS**



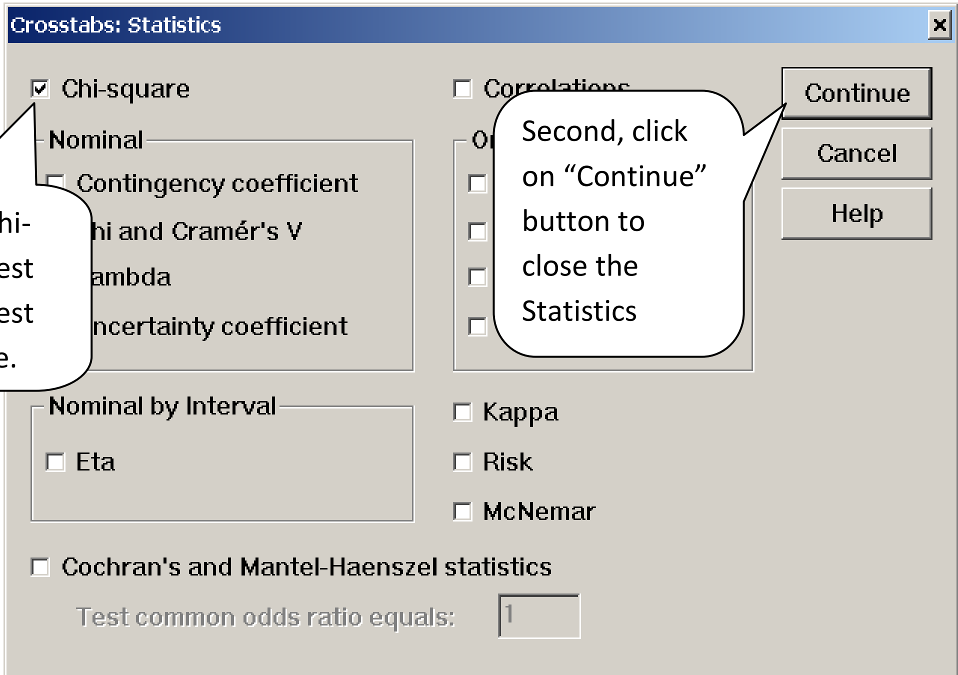


First, select and move the variables for the question to “Row(s):” and “Column(s):” list boxes.

The variable mentioned first in the problem, sex, is used as the independent variable and is moved to the “Column(s):” list box.

The variable mentioned second in the problem, [fund], is used as the dependent variable and is moved to the “Row(s)” list box.

Second, click on “Statistics...” button to request the test statistic.



First, click on “Chi-square” to request the chi-square test of independence.

Second, click on “Continue” button to close the Statistics

HOW FUNDAMENTALIST IS R CURRENTLY * RESPONDENTS SEX Crosstabulation

			RESPONDENTS SEX		
			1 MALE	2 FEMALE	Total
HOW FUNDAMENTALIST IS R CURRENTLY	1 FUNDAMENTALIST	Count	75	99	174
		Expected Count	74.9	99.1	174.0
		Residual	.1	-.1	
		Std. Residual	.0	.0	
	2 MODERATE	Count	107	161	268
		Expected Count	115.4	152.6	268.0
		Residual	-8.4	8.4	
		Std. Residual	-.8	.7	
	3 LIBERAL	Count	79	85	164
		Expected Count	70.6	93.4	164.0
		Residual	8.4	-8.4	
		Std. Residual	1.0	-.9	
Total		Count	261	345	606
		Expected Count	261.0	345.0	606.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.821[a]	2	.244
Likelihood Ratio	2.815	2	.245
Linear-by-Linear Association	.832	1	.362
N of Valid Cases	606		

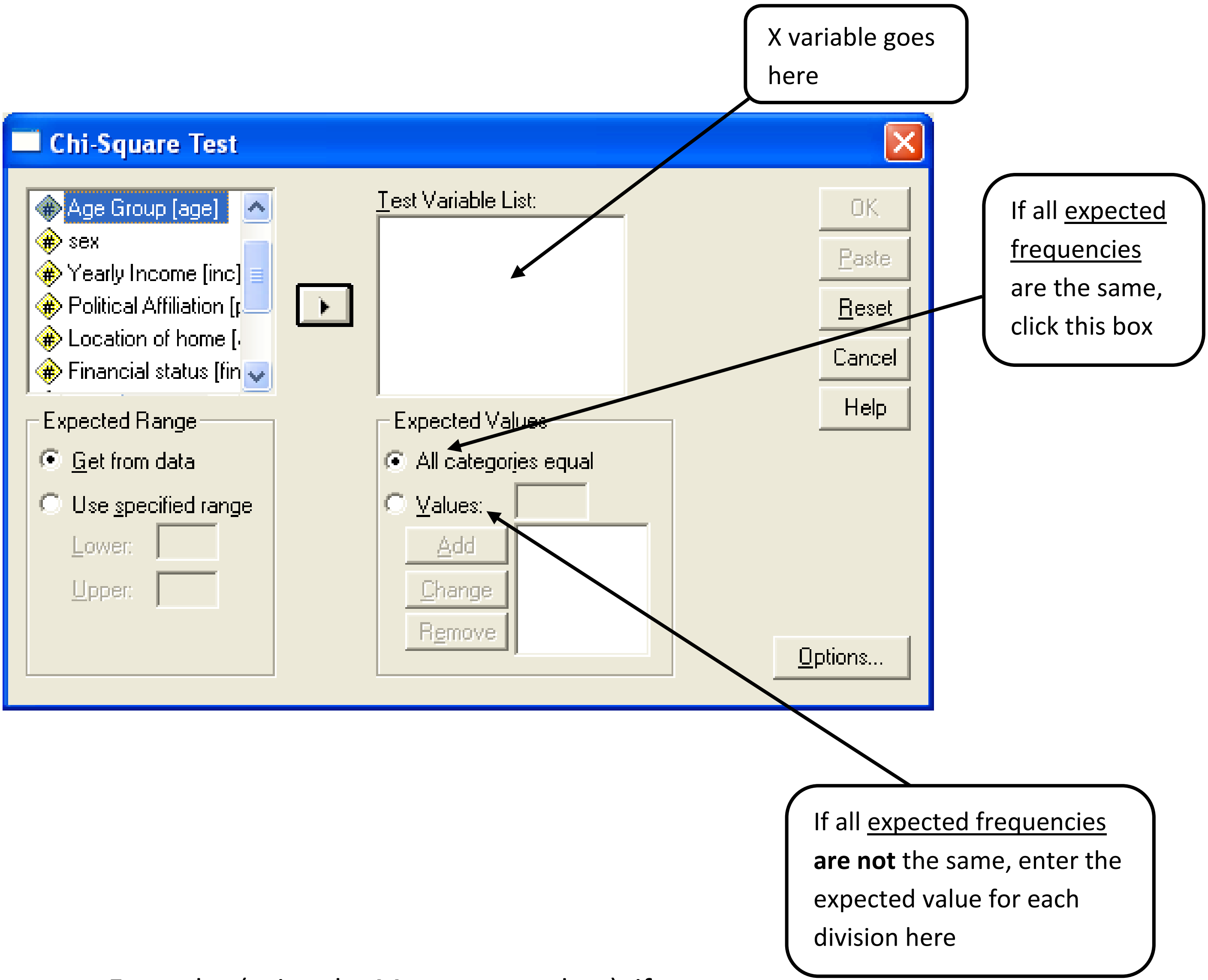
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 70.63.

In the table Chi-Square Tests result, SPSS also tells us that "0 cells have expected count less than 5 and the minimum expected count is 70.63".
The sample size requirement for the chi-square test of independence is satisfied.

According to the picture above:
The probability of the chi-square test statistic (chi-square=2.
821) was p=0.244, it is greater than the alpha level of significance of 0.05. The null hypothesis that differences in "degree of religious fundamentalism" are independent of differences in "sex" is <u>not rejected.</u>
The research hypothesis that differences in "degree of religious fundamentalism" are related to differences in "sex" is not supported by this analysis.
Thus, the answer for this question is False. We do not interpret cell differences unless the chi-square test statistic supports the research hypothesis.

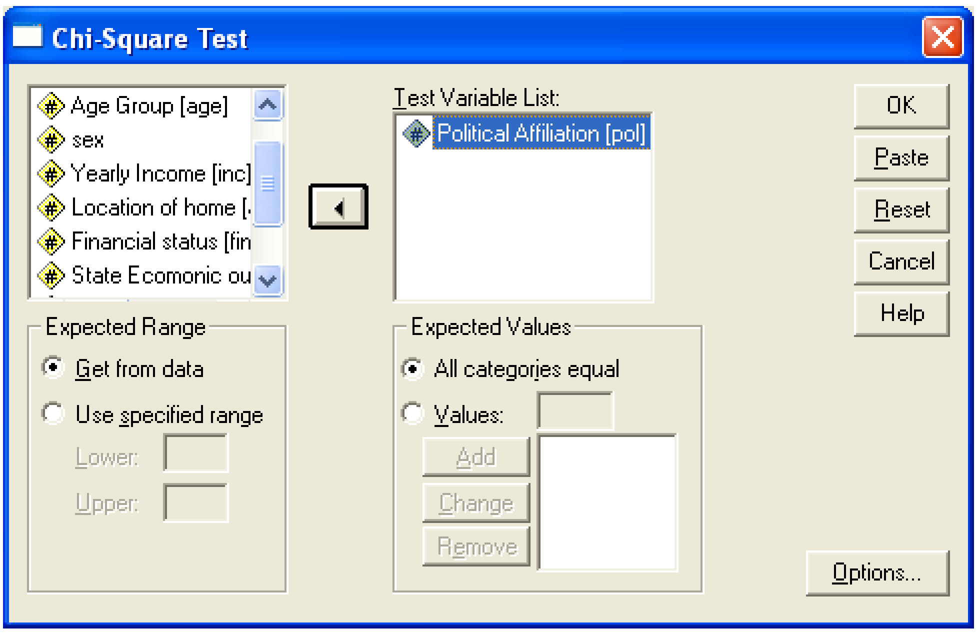
- **Chi Square Test of Goodness of Fit**

Click Analyze→ Nonparametric Tests→ Chi Square→ determine the α value→ calculate

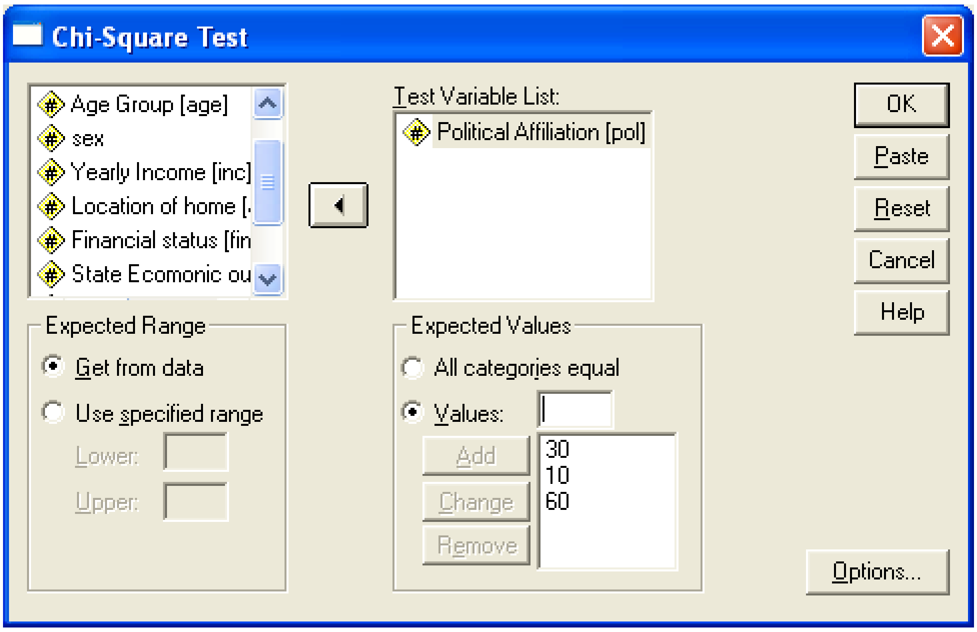


Examples (using the Montana.sav data), if

- All expected frequencies are the same:



- All expected frequencies are not the same:



31:25-40:25
Slides covered 46-56

The End