Stat 145

Chapter 10
THE CHI-SQUARE TEST

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WHEN IS THE CHI-SQUARE TEST USED?

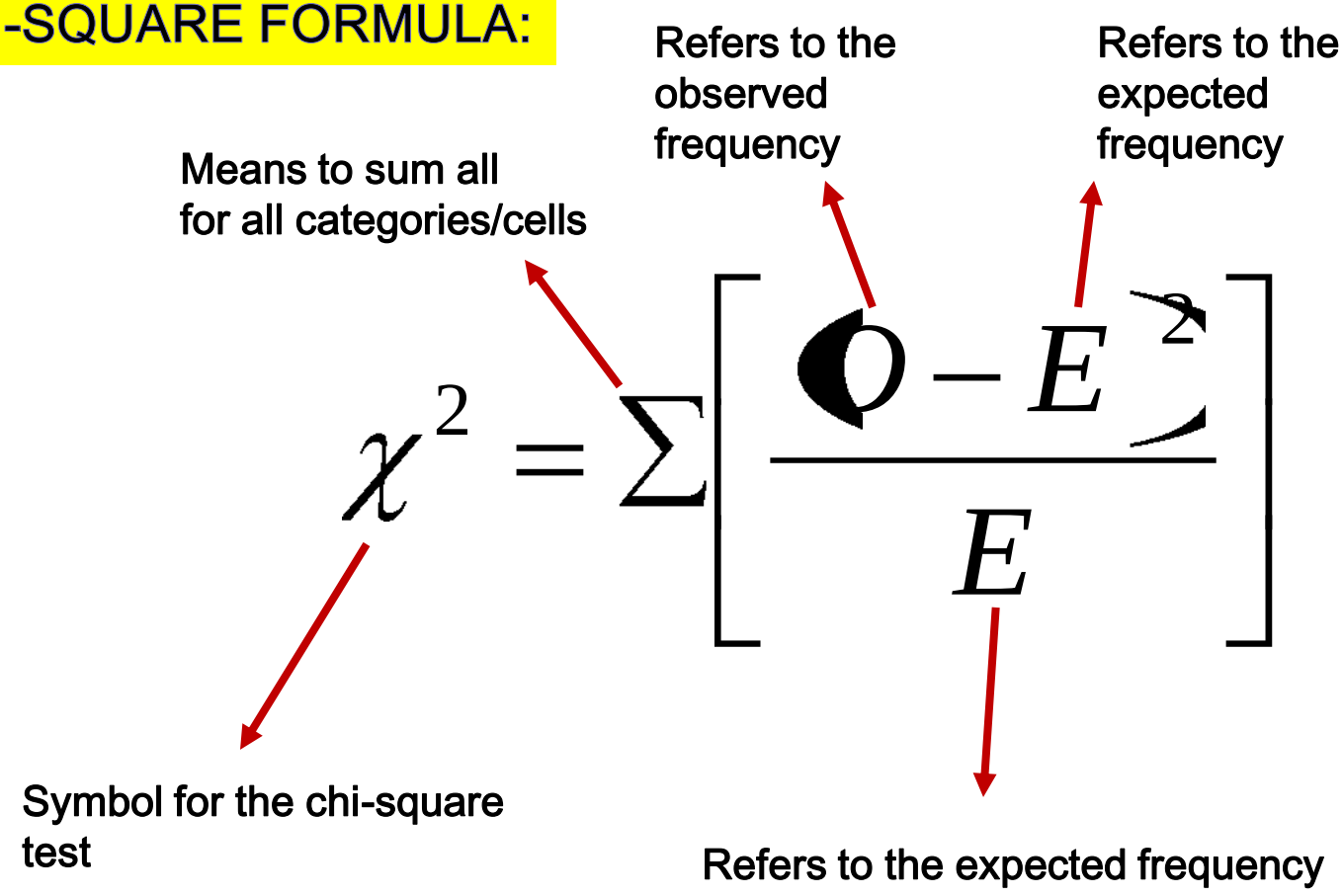
1. When data represent frequency or percentage in each category (i.e., Nominal scale data)

2. Subjects in each category are independent from each other

3. There are at least 5 observations (i.e., scores) per category

Chapter 10
THE CHI-SQUARE TEST

CHI-SQUARE FORMULA:



NOTE: This formula is used for both one-way and two-way chi-square tests

Chapter 10

THE ONE-WAY CHI-SQUARE TEST

WHEN IS THE ONE-WAY CHI-SQUARE TEST USED?

1. When there is only one independent variable
   - With two or more levels (or categories)
2. When the data are nominal scale
3. The null hypothesis is rejected when the obtained chi-square value is equal to or greater than the critical chi-square value
4. The degrees of freedom for the one-way chi-square test is the number of categories minus one or
   - $df = r - 1$, where r is the number of categories

EXAMPLE : Grade Distribution

An instructor makes out his final grades for 200 students in his introductory statistics class. He is curious to see if his grade distribution resembles the "normal curve" and notes from the college catalog that in a normal distribution of grades 45% of them would be C's, 24% of them would be B's, 24% D's, 3.5% of them would be A's, and 3.5% F's. The instructor compared the frequency of grades given in his class to the normal curve. The frequency of each grade is given on the following slide.

EXAMPLE : Grade Distribution

1. Null Hypothesis:
   - The grade distribution used by the instructor will be the same as the distribution described in the college catalog. Any observed differences between the frequencies of grades given by the instructor versus what is recommended in the college catalog is assumed to be solely due to random error.

Chapter 10
THE ONE-WAY CHI-SQUARE TEST

EXAMPLE : Grade Distribution

1. The 'Observed Frequency' column represents the frequency of grades given by the instructor
2. The 'Expected %' column represents the percentage of grades to be given for each category
3. The 'Expected Frequency' column is the expected frequency of grades suggested by the college catalog

	Observed Frequency	Expected %	Expected Frequency
	15	3.5%	7
	53	24.0%	48
	87	45.0%	90
	33	24.0%	48
	12	3.5%	7
Total:	200		200

Chapter 10
THE ONE-WAY CHI-SQUARE TEST

EXAMPLE : Grade Distribution

1. The observed values and expected values must be in the same unit of measurement - either percentage or frequency

2. The expected percentage will be converted to frequency by multiplying each expected percentage (expressed as a proportion) by the total number of observations

	Observed Frequency	Expected %	Expected Frequency
	15	3.5%	7
	53	24.0%	48
	87	45.0%	90
	33	24.0%	48
	12	3.5%	7
Total:	200		200

EXAMPLE : Grade Distribution

1. For example, the expected percentage of ‘A’s to be given is 3.5%
   - The expected frequency was obtained by multiplying .035 by 200
   - This gave an expected frequency of 7

	Observed Frequency	Expected %	Expected Frequency
	15	3.5%	7
	53	24.0%	48
	87	45.0%	90
	33	24.0%	48
	12	3.5%	7
Total:	200		200

EXAMPLE : Grade Distribution

1. Once both the observed and expected frequencies are in the same unit of measurement, it is important to check that both columns have the same totals
   - Notice that both have the same total of 200
   - This is a check to ensure that the expected frequency calculations were done correctly

	Observed Frequency	Expected %	Expected Frequency
	15	3.5%	7
	53	24.0%	48
	87	45.0%	90
	33	24.0%	48
	12	3.5%	7
Total:	200		200

Chapter 10
THE ONE-WAY CHI-SQUARE TEST

	Observed Frequency		Expected Frequency
	15		7
	53		48
	87		90
	33		48
	12		7
Total:	200		200

EXAMPLE : Calculating the obtained chi-square value

$$\chi^2_{obt} = \sum\left[\frac{(5-7)^2}{7} + \frac{(53-48)^2}{48} + \frac{(87-90)^2}{90} + \frac{(33-48)^2}{48} + \frac{(12-7)^2}{7}\right]$$

Chi-square Obtained

$\chi^2_{obt} = 18.02$

$df = 5 - 1 = 4$

Critical Chi-square from table

$\chi^2_{.05} = 9.488$

EXAMPLE : Grade Distribution

1. Statistical Conclusion:
   - "Since X^2 (4) = 18.02, p < .05; Reject the null hypothesis"
2. If this problem is done in Excel, we can obtain the exact p – value and re-write the statistical conclusion like this:
   - "Since X^2 (4) = 18.02, p = .001; Reject the null hypothesis"
3. Interpretation:

"It appears that the instructor's grade distribution is significantly different from the distribution suggested by the college's catalog (p = .05). The instructor gave more than twice as many A's than is suggested by the college catalog. This observed difference in frequencies is not solely due to random error, but suggests that the instructor assigns grades in a slightly different distribution."

Chapter 10

THE TWO-WAY CHI-SQUARE TEST

WHEN IS THE TWO-WAY CHI-SQUARE TEST USED?

1. When there are two independent variables
   - Each IV has two or more levels (or categories)
2. When the data are nominal scale
3. The null hypothesis is rejected when the obtained chi-square value is equal to or greater than the critical chi-square value
4. The degrees of freedom for the two-way chi-square test is:
   - $df = (r - 1)(c - 1)$
   - where r is the number of rows for IV #1 and
   - c is the number of columns for IV #2

Chapter 10

THE TWO-WAY CHI-SQUARE TEST

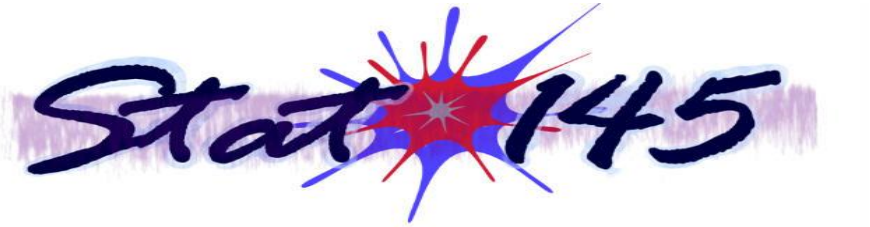
WHAT IS THE TWO-WAY CHI-SQUARE TESTING?

1. When there are two independent variables, the chi-square test determines if group membership on the first IV is *contingent* on group membership on the second IV
   - Gender (males vs females) and Type of vehicle owned (Trucks vs cars)
   - Political Party Affiliation (republican vs democrat) and Position on death penalty (For or against)
2. If the chi-square test is significant (p = .05) for the Gender and Type of Vehicle owned example, an interpretation would be that type of vehicle owned is contingent on gender (i.e., males own more trucks than females)

WHAT IS THE TWO-WAY CHI-SQUARE TESTING?

3. If the chi-square test is significant (p = .05) for the Political Party Affiliation and Position on Death Penalty example, an interpretation would be that being for or against the death penalty is contingent on political party affiliation (i.e., Republicans are more likely for the death penalty)

4. When the chi-square test is non-significant, it suggests that membership on the first IV is not contingent on membership on the second IV



That’s it for chapter 10!