

Title: Chi-Square Analysis and M&M's

Purpose:

- to practice using chi-square analysis
- to compare the observed and expected color ratios of M&M's candies

Null Hypothesis:

If the Mars Co. M &M sorters are doing their job correctly, then there should be *no* difference in M&M color ratios between actual store-bought bags and what the Mars Co. claims are the actual ratios.

Materials: bags of M&M's

Procedure:

1. Obtain bags of M&M's
2. Determine the expected number of M&M's (<http://us.mms.com/us/about/products/>)
  - a. Record in Data Table A
3. Determine the actual number of M&M's of each color
  - a. Record in Data Table A
4. Calculate the Chi-Square value.
  - a. Show your calculations!
5. Determine degrees of freedom (number of classes - 1)
6. Use the 0.05 probability level as the critical value.
  - a. If the calculated chi-square value is less than the 0.05 value, we *accept* the NULL hypothesis.
  - b. If the value is greater than the value, we *reject* the NULL hypothesis.
7. Repeat using a different type of M&M's. Record in Data Table B
8. Share your data with classmates

Data Table A: Expected and Observed Color Ratios for M&Ms (type = \_\_\_\_\_)

Expected* (percent)						
Red	Brown	Blue	Yellow	Green	Orange	
**Observed (number/percent)						
/	/	/	/	/	/	/

Data Table B: Expected and Observed Color Ratios for M&Ms (type = \_\_\_\_\_)

Expected* (percent)						
Red	Brown	Blue	Yellow	Green	Orange	
**Observed (number/percent)						
/	/	/	/	/	/	/

\*Source = <http://us.mms.com/us/about/products/>

$$** \frac{\# \text{ M \& M's of one color}}{\text{total \# M \& M's}} \times 100$$

$$\chi^2 = \frac{(\text{Observed Value} - \text{Expected Value})^2}{\text{Expected Value}}$$

Data Table C: $\chi^2$ Calculations Individual Data					M&M's Type _____
	A	B	C	D	E
	Obs	Exp	(Obs - Exp)	(Obs - Exp) <sup>2</sup>	$\frac{(\text{Obs} - \text{Exp})^2}{\text{Exp}}$
Red					
Brown					
Blue					
Yellow					
Green					
Orange					
$\chi^2$					
Degrees of Freedom					
Accept or reject null hypothesis?					*

Data Table D: $\chi^2$ Calculations Individual Data					M&M's Type _____
	A	B	C	D	E
	Obs	Exp	(Obs - Exp)	(Obs - Exp) <sup>2</sup>	$\frac{(\text{Obs} - \text{Exp})^2}{\text{Exp}}$
Red					
Brown					
Blue					
Yellow					
Green					
Orange					
$\chi^2$					
Degrees of Freedom					
Accept or reject null hypothesis?					*

$\chi^2$  tutorial <http://www.ndsu.nodak.edu/instruct/mcclean/plsc431/mendel/mendel4.htm>

**Discussion and Analysis:**

Are the Mars Co M&M sorters doing a good job? Explain!

Conclusion: The null hypothesis, that the M&M sorters are doing a good job, is (*accepted, rejected*) for (type of M&Ms).  
You will have a conclusion for each type of M&M examined!

Reflection: personal statement

Degrees of Freedom	Probability				
	0.9	0.5	0.1	0.05	0.01
1	0.02	0.46	2.71	3.84	6.64
2	0.21	1.39	4.61	5.99	9.21
3	0.58	2.37	6.25	7.82	11.35
4	1.06	3.36	7.78	9.49	13.28
5	1.61	4.35	9.24	11.07	15.09

\* If the  $\chi^2$  is smaller than the critical value for the indicated degrees of freedom, then we *accept* the null hypothesis that the variation in color percentages is due to chance (random) variation.

If the  $\chi^2$  is larger than the critical value for the indicated degrees of freedom (# classes-1), then we *reject* the null hypothesis and conclude that the sorters are doing a *statistically significant* poor job.  
The test does NOT indicate reasons for a poor job!

Extra Data Tables

Data Table \_\_\_: Expected and Observed Color Ratios for M&Ms (type = \_\_\_\_\_)

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/	/	/	/	/	/	/

Data Table \_\_\_: Expected and Observed Color Ratios for M&Ms (type = \_\_\_\_\_)

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**Observed (number/percent)						
/	/	/	/	/	/	/



Data Table ___: $\chi^2$ Calculations Individual Data				M&M's Type _____	
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	Obs	Exp	(Obs - Exp)	(Obs - Exp) <sup>2</sup>	$\frac{(\text{Obs} - \text{Exp})^2}{\text{Exp}}$
Red					
Brown					
Blue					
Yellow					
Green					
Orange					
$\chi^2$					
Degrees of Freedom					
Accept or reject null hypothesis?					*

Data Table ___: $\chi^2$ Calculations Individual Data				M&M's Type _____	
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$\chi^2$					
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Accept or reject null hypothesis?					*

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Accept or reject null hypothesis?					*