4.4 Chi-Square Example

MBC 638

Data Analysis and Decision Making

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Example: Product Feature

vs. Age Group

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Example: Product Feature vs. Age Group

• Use results of survey on preferred product feature (A, B, or C).

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Example: Product Feature vs. Age Group

- Use results of survey on preferred product feature (A, B, or C).
- Determine if you should market your product differently to the younger versus older generation.

Example: Product Feature vs. Age Group

- Use results of survey on preferred product feature (A, B, or C).
- Determine if you should market your product differently to the younger versus older generation.
 - Young: under 30 years old

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Example: Product Feature vs. Age Group

- Use results of survey on preferred product feature (A, B, or C).
- Determine if you should market your product differently to the younger versus older generation.
 - Young: under 30 years old
 - o Old: over 30 years old

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Example: Product Feature vs. Age Group

- Use results of survey on preferred product feature (A, B, or C).
- Determine if you should market your product differently to the younger versus older generation.
 - Young: under 30 years old
 - Old: over 30 years old
- Assume α = 0.05.

Hypothesis statement:

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Steps 1 and 2: Hypothesis and Two-Way Table

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).

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Steps 1 and 2: Hypothesis and Two-Way Table

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- · Two-way table:

Young			
Old			

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a : Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	
Young				
Old				

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	
Young	200	38	20	
Old	157	45	5	
•				

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a : Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	
Young	200	38	20	
Old	157	45	5	

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	
Young	200	38	20	
Old	157	45	5	
•				

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a : Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	
Young	200	38	20	
Old	157	45	5	

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	
Old	157	45	5	
Totals				

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a : Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	
Totals				

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals				

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a : Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357			

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83		

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- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a : Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	

- Hypothesis statement:
 - H_0 : Age and feature preference are independent (no relationship).
 - H_a: Age and feature preference are not independent (relationship).
- Two-way table:

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

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Step 3: Reorganize Table

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Step 3: Reorganize Table

Category
Young A
Young B
Young C
Old A

Old B Old C

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Step 3: Reorganize Table

Category	f(Observed)	
Young A	200	
Young B	38	
Young C	20	
Old A	157	
Old B	45	
Old C	5	

Step 3: Reorganize Table

Category	f(Observed)	
Young A	200	
Young B	38	
Young C	20	
Old A	157	
Old B	45	
Old C	5	

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Step 3: Reorganize Table

Category	f(Observed)	F(Expected)	
Young A	200		
Young B	38		
Young C	20		
Old A	157		
Old B	45		
Old C	5		

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Step 4: Calculate F(Expected)

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

Step 4: Calculate *F***(***Expected***)**

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals	r = row
Young	200	38	20	258	c = column
Old	157	45	5	207	N = total
Totals	357	83	25	465	surveyed

r = rowc = columnN = totalsurveyed

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

Young A =

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c = columnN = totalsurveyed

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals	r = row
Young	200	38	20	258	c = colu
Old	157	45	5	207	N = tota
Totals	357	83	25	465	surveye

Young A =

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

r = row c = column N = totalsurveyed

Young A =

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Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

r = row c = column N = totalsurveyed

Young A =

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Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

r = row c = column N = totalsurveyed

• Young A =
$$\frac{258 \times 357}{465}$$
 = 198.1

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

r = row c = column N = totalsurveyed

• Young A =
$$\frac{258 \times 357}{465}$$
 = 198.1

• Young B =

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Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals
Young	200	38	20	258
Old	157	45	5	207
Totals	357	83	25	465

r = row c = column N = totalsurveyed

• Young A =
$$\frac{258 \times 357}{465}$$
 = 198.1

• Young B =

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals	r = row
Young	200	38	20	258	c = column
Old	157	45	5	207	N = total
Totals	357	83	25	465	surveyed

• Young A =
$$\frac{258 \times 357}{465}$$
 = 198.1

• Young B =

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Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals	r = row
Young	200	38	20	258	c = column
Old	157	45	5	207	N = total
Totals	357	83	25	465	surveyed

• Young A =
$$\frac{258 \times 357}{465}$$
 = 198.1

• Young B =

Step 4: Calculate F(Expected)

$$F(Expected) = \frac{fr \times fc}{N}$$

	Feature A	Feature B	Feature C	Totals	r:
Young	200	38	20	258	c
Old	157	45	5	207	Ν
Totals	357	83	25	465	SI

r = row c = column N = totalsurveyed

• Young A =
$$\frac{258 \times 357}{465}$$
 = 198.1

• Young B =
$$\frac{258 \times 83}{465}$$
 = 46.1

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Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	
Young A	200	198.1	
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	
Young A	200	198.1	
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	
Young A	200	198.1	
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	
Young A	200	198.1	
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

Step 5: Calculate Test Statistic

			$(f-F)^2$
Category	f(Observed)	F(Expected)	\overline{F}
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$

Step 5: Calculate Test Statistic

			$(f-F)^2$
Category	f(Observed)	F(Expected)	\overline{F}
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	
Young C	20	13.9	
Old A	157	158.9	
Old B	45	36.9	
Old C	5	11.1	
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$
 = 3.38

Step 5: Calculate Test Statistic

			$(f-F)^2$
Category	f(Observed)	F(Expected)	$\frac{V}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	1.41
Young C	20	13.9	2.71
Old A	157	158.9	0.02
Old B	45	36.9	1.75
Old C	5	11.1	3.38
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$
 = 3.38

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	1.41
Young C	20	13.9	2.71
Old A	157	158.9	0.02
Old B	45	36.9	1.75
Old C	5	11.1	3.38
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$
 = 3.38

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	1.41
Young C	20	13.9	2.71
Old A	157	158.9	0.02
Old B	45	36.9	1.75
Old C	5	11.1	3.38
Totals	465		

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$
 = 3.38

Step 5: Calculate Test Statistic

Category	f(Observed)	F(Expected)	$\frac{(f-F)^2}{F}$
Young A	200	198.1	0.02
Young B	38	46.1	1.41
Young C	20	13.9	2.71
Old A	157	158.9	0.02
Old B	45	36.9	1.75
Old C	5	11.1	3.38
Totals	465		9.288

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

• Young A =
$$\frac{(200-198.1)^2}{198.1}$$
 = 0.02

• Old C =
$$\frac{(5-11.1)^2}{11.1}$$
 = 3.38

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Step 5: Calculate Test Statistic (cont.)

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Step 5: Calculate Test Statistic (cont.)

• Using your test statistic ($\chi^2 = 9.288$), find p in the distribution table.

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Step 5: Calculate Test Statistic (cont.)

- Using your test statistic ($\chi^2 = 9.288$), find p in the distribution table.
- Remember: If p is low, H_0 must go.

Chi-Square Distribution Table

Table E: Chi-Square (χ^2) Distribution

Degrees	Area to the right of critical value									
of freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
:	:	:	:	:	:	:	:	:	:	
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

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Chi-Square Distribution Table

Table E: Chi-Square (χ^2) Distribution

Degrees of				Area t	o the rig	tht of cri	tical valu	е		
freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
:	:	:	:	:	:	:	:	:	:	:
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

Chi-Square Distribution Table

Table E: Chi-Square (χ^2) Distribution

Degrees of	Area to the right of critical value									
freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.95
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.18
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.75
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.29
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.81
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.80
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.26
:	:	:	:	:	:	:	:	:	:	
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

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Chi-Square Distribution Table

Table E: Chi-Square (χ^2) Distribution

Degrees	Area to the right of critical value										
of freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005	
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879	
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597	
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838	
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860	
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750	
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548	
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278	
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955	
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589	
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188	
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757	
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299	
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819	
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319	
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801	
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267	
÷	:	:	:	:	:	:	:	:	:	:	
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169	

Step 6: Calculate df

Step 6: Calculate df

$$df =$$

Step 6: Calculate df

$$df = (r-1)$$

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Step 6: Calculate df

$$df = (r-1)(c-1)$$

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Step 6: Calculate df

$$df = (r-1)(c-1)$$

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Step 6: Calculate df

$$df = (r-1)(c-1)$$
$$= (2-1)$$

Step 6: Calculate df

$$df = (r-1)(c-1)$$
$$= (2-1)(3-1)$$

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Step 6: Calculate df

$$df = (r-1)(c-1)$$
$$= (2-1)(3-1) = 2$$

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Step 6: Calculate df

$$df = (r-1)(c-1)$$
$$= (2-1)(3-1) = 2$$

• Gives which row to reference in χ^2 distribution table

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Step 6: Calculate df

$$df = (r-1)(c-1)$$
$$= (2-1)(3-1) = 2$$

- Gives which row to reference in χ^2 distribution table
- Gives a sense of how many variables and how much information you have

Step 7: Find *p*-Value

Table E: Chi-Square (χ^2) Distribution

Degrees of	Area to the right of critical value												
freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005			
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879			
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597			
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838			
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860			
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750			
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548			
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278			
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955			
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589			
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188			
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757			
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299			
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819			
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319			
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801			
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267			
÷	:	:	:	:	:	:	:	:	:				
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169			

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Step 7: Find *p*-Value

Table E: Chi-Square (χ^2) Distribution

1	0.051 0.216 0.484 0.831 1.237	0.95 0.004 0.103 0.352 0.711 1.145	0.90 0.016 0.211 0.584 1.064 1.610	0.10 2.706 4.605 6.251 7.779	0.05 3.841 5.991 7.815 9.488	0.025 5.024 7.378 9.348 11.143	0.01 6.635 9.210 11.345 13.277	7.879 10.597 12.838 14.860
20.0100.02030.0720.11540.2070.297	0.051 0.216 0.484 0.831 1.237	0.103 0.352 0.711 1.145	0.211 0.584 1.064	4.605 6.251 7.779	5.991 7.815	7.378 9.348	9.210 11.345	10.597 12.838
3 0.072 0.115 4 0.207 0.297	0.216 0.484 0.831 1.237	0.352 0.711 1.145	0.584 1.064	6.251 7.779	7.815	9.348	11.345	12.838
4 0.207 0.297	0.484 0.831 1.237	0.711 1.145	1.064	7.779				
	0.831 1.237	1.145			9.488	11.143	13 277	14 860
5 0.412 0.554	1.237		1 610					
			1.010	9.236	11.071	12.833	15.086	16.750
6 0.676 0.872		1.635	2.204	10.645	12.592	14.449	16.812	18.548
7 0.989 1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8 1.344 1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9 1.735 2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10 2.156 2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11 2.603 3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12 3.074 3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299
13 3.565 4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14 4.075 4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15 4.601 5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16 5.142 5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
i i i	÷	:	:	:	:	:	:	:
100 67.328 70.065 7	74.222 7	7.929	82.358	118.498	124.342	129.561	135.807	140.169

Step 7: Find *p*-Value

Table E: Chi-Square (χ^2) Distribution

Degrees of	Area to the right of critical value												
freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005			
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879			
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597			
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838			
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860			
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750			
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548			
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278			
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955			
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589			
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188			
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757			
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299			
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819			
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319			
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801			
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267			
÷	:	:	:	:	:	:	:	:	:	:			
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169			

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Step 7: Find *p*-Value

Table E: Chi-Square (χ^2) Distribution

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Degrees of	Area to the right of critical value										
freedom	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005	
1	_	_	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879	
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597	
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838	
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860	
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750	
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548	
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278	
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955	
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589	
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188	
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757	
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299	
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819	
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319	
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801	
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267	
:	:	:	:	:	:	:	:	:	:	:	
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169	

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Conclusion

• If p < a, then reject H_0 .

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Conclusion

- If p < a, then reject H_0 .
 - \circ a = 0.05

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Conclusion

- If p < a, then reject H_0 .
 - \circ $\alpha = 0.05$
 - p = 0.01

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- If p < a, then reject H_0 .
 - \circ a = 0.05
 - p = 0.01
 - o 0.01 < 0.05

Conclusion

- If p < a, then reject H_0 .
 - \circ $\alpha = 0.05$
 - \circ p = 0.01
 - o 0.01 < 0.05
- Reject H₀.

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Conclusion

- If p < a, then reject H_0 .
 - \circ a = 0.05
 - p = 0.01
 - o 0.01 < 0.05
- Reject H_0 .
 - Age and feature preference are not independent.

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- If p < a, then reject H_0 .
 - \circ a = 0.05
 - \circ p = 0.01
 - o 0.01 < 0.05
- Reject H_0 .
 - Age and feature preference are not independent.
 - There is a relationship: depending on age one may value a particular feature more.

- If p < a, then reject H_0 .
 - \circ $\alpha = 0.05$
 - p = 0.01
 - o 0.01 < 0.05
- Reject H₀.
 - Age and feature preference are not independent.
 - There is a relationship: depending on age one may value a particular feature more.
 - Consider separate marketing strategies for younger and older customers.