

Math formulas with Greek symbols can look intimidating. But the idea is simple, and we'll walk through what everything here means.

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

2

#### What is it used for?



To answer the question: Is the distribution of frequencies in the dataset meaningful?



In other words, does the data match our expectations?



In still other words, do we accept or reject the null hypothesis?

**Example:** Out of 300 dinosaurs,



220 eat everything



55 eat only meat



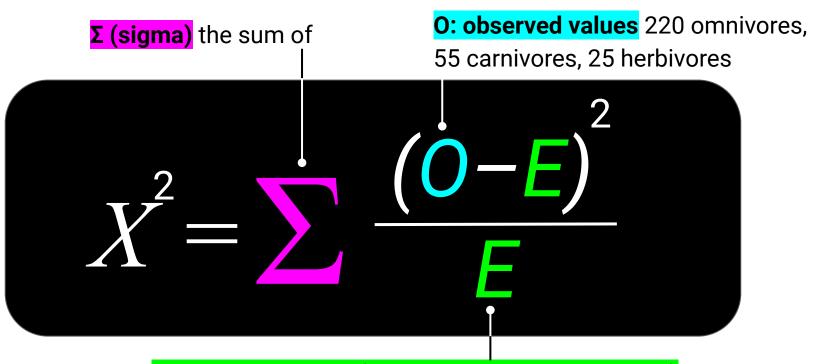
25 eat only plants

#### **Null hypothesis:**

No statistical significance exists in the distribution of omnivores, carnivores, and herbivores. That is, this data can be explained by random distribution.



The chi-squared test can help us accept or reject the null hypothesis.



E: expected values (in randomly distributed data)

100 omnivores, 100 carnivores, 100 herbivores

$$\chi^2 = (220-100)2/100 + (55-100)2/100 + (25-100)2/100$$

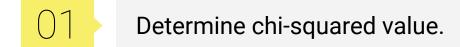
$$= 144 + 20.25 + 56.25$$

**= 220.5** 

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

6

Steps for using the chi-squared test formula:







Determine critical value.

Make a decision.

## **Degree of Freedom**

To determine the degree of freedom (df), take the number of rows and subtract 1:

> Omnivores: 220 Carnivores: 55 Herbivores: 25

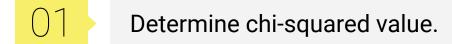
There are three rows, so the degree of freedom is

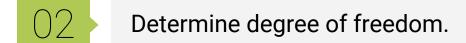
3 - 1 = 2

The degree of freedom is the number of figures required to fill out the table (like Sudoku).

If we have two of the numbers, we can figure out the value of the third.

Steps for using the chi-squared test formula:



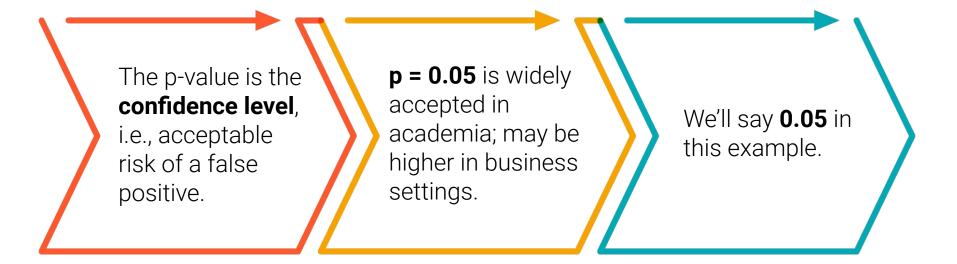




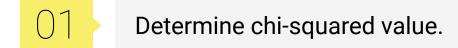


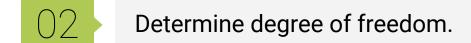
Make a decision.

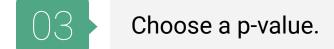
### P-value



Steps for using the chi-squared test formula:









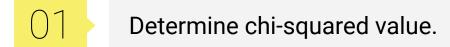
05 Make a decision.

### **Critical Value**

The critical value is found by consulting a table:

df	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	11.070	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

Steps for using the chi-squared test formula:



- Determine degree of freedom.
- Choose a p-value.
- 04 Determine critical value.
- 05 Make a decision.

#### Make a Decision



## Using the Chi-Squared Test In Python

01

Import the **scipy.stats** module.

```
# The statistical module used to run chi square test import scipy.stats as stats
```

02

Determine the **critical value**.

```
# The degree of freedom is 3-1 = 2
# With a p-value of 0.05, the confidence level is 1.00-0.05 = 0.95.
critical_value = stats.chi2.ppf(q = 0.95, df = 2)
```

```
# The critical value critical_value
```

5.99146454710798

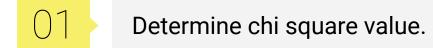
03

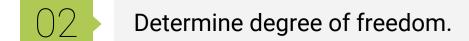
Run the **chi-squared test.** 

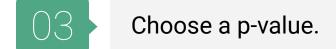
```
# Run the chi square test with stats.chisquare()
stats.chisquare(df['observed'], df['expected'])
```

Power divergenceResult(statistic=220.5, pvalue=1.3153258948574585e-48)

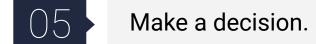
Steps for using the chi-squared test formula:











#### A few more considerations:



The chi-squared test is used to test categorical variables; it can't be used on continuous data.



The categories must be mutually exclusive.



We have covered using the chi-squared test formula to test goodness of fit.



It can also be used to test independence. (Feel free to explore this on your own.)