

How to Perform a Chi-Square Test of Independence on Your TI-84 Calculator

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The Essence of the Chi-Square Test of Independence

The **Chi-Square Test of Independence** is a robust statistical procedure utilized by researchers to ascertain whether a significant relationship exists between two **categorical variables**. Unlike tests that compare means, this analysis focuses on frequencies and distributions within a **contingency table**. By examining the observed counts in various categories, the test evaluates if the distribution of one variable is contingent upon the other. This method is fundamental in fields ranging from sociology to medicine, where understanding the association between non-numeric factors--such as treatment type and recovery status--is paramount for drawing **statistical inference**.

When conducting this test, the primary objective is to determine if the **observed frequencies** collected from a **simple random sample** deviate significantly from what would be expected if the variables were completely independent. If the variables are independent, the probability of an observation falling into a specific category of one variable is unaffected by its category in the second variable. However, if a strong **association** exists, the distribution will shift in a predictable pattern. The **Pearson's Chi-squared test** serves as the mathematical backbone for this calculation, providing a standardized way to measure these discrepancies across different data structures.

Understanding the underlying mechanics of the **Chi-Square Test of Independence** requires a grasp of how **expected values** are derived. For each cell in a data grid, the expected frequency is calculated based on the marginal totals of the rows and columns. This theoretical value represents what the data would look like under the **null hypothesis** of no association. By comparing these theoretical figures to the actual data collected during a survey or experiment, the test quantifies the "goodness of fit" or lack thereof, ultimately yielding a single **test statistic** that encapsulates the total variance between reality and the independence model.

Determining Null and Alternative Hypotheses

Before any data is entered into a **TI-84 Calculator**, it is essential to formally define the **null hypothesis** (H_0) and the **alternative hypothesis** (H_a). In the context of a **Chi-Square Test of Independence**, the null hypothesis consistently posits that there is no relationship between the two variables being studied. It assumes that any observed differences in the **contingency table** are merely the result of **sampling error** or random chance. Establishing this baseline is crucial because the statistical machinery is designed to test how strongly the evidence contradicts this assumption of independence.

Conversely, the **alternative hypothesis** asserts that a significant **association** or dependency exists between the variables. If the resulting data provides a sufficiently small **p-value**, researchers reject the null hypothesis in favor of this alternative. It is important to note that the test is non-

directional; it identifies that a relationship exists but does not inherently specify the nature or "direction" of that relationship. For instance, while it might show that education level and voting preference are linked, it requires further **descriptive statistics** to explain exactly how higher education influences specific voting choices.

The formalization of these hypotheses ensures that the **statistical significance** of the results is interpreted within a rigorous framework. Researchers typically select a **significance level** (commonly denoted as alpha, or α), often set at 0.05, which represents the threshold for rejecting the null hypothesis. By defining these parameters upfront, the analyst maintains objectivity throughout the computational process. The **TI-84 Calculator** simplifies the math, but the conceptual integrity of the test relies entirely on the proper formulation of these two competing claims regarding the **population parameters**.

Utilizing the TI-84 Plus for Statistical Computation

The **TI-84 Calculator**, particularly the **TI-84 Plus** and its successors, has become an indispensable tool in academic and professional settings for performing complex **data analysis**. While the manual calculation of Chi-Square values involves tedious summations of squared differences for every cell in a matrix, the calculator's internal **algorithms** streamline the process, reducing the risk of human error. This efficiency allows students and statisticians to focus more on the interpretation of the **probability distribution** and less on the arithmetic heavy-lifting, making it a staple in **Advanced Placement Statistics** curricula.

One of the standout features of the **TI-84 Calculator** is its specialized **STAT** menu and **matrix editor**. These interfaces allow users to organize raw data into rows and columns that reflect the structure of a real-world **contingency table**. Once the data is nested within these matrices, the calculator can instantaneously compute not only the **chi-square statistic** but also the **expected counts** for each cell, storing them in a separate matrix for further verification. This transparency is vital for confirming that the test's assumptions regarding minimum expected frequencies are met before finalizing any conclusions.

Beyond simple computation, the **TI-84 Calculator** provides a comprehensive output screen that includes the **degrees of freedom** and the corresponding **p-value**. These metrics are the cornerstones of **hypothesis testing**. By automating the integration of the **chi-square distribution** curve, the calculator provides the exact area under the curve that represents the probability of obtaining the observed results under the null hypothesis. This precision is far superior to using traditional printed tables, offering a more nuanced view of the **statistical significance** of the research findings.

Preparing the Contingency Table for Matrix Entry

To successfully execute a **Chi-Square Test of Independence**, the raw data must first be organized into a **contingency table**. This table serves as a cross-tabulation of two categorical variables, where the rows represent the levels of one variable and the columns represent the levels of the other. For example, if researching the link between exercise habits and sleep quality, the rows might be "No Exercise," "Moderate Exercise," and "Frequent Exercise," while the columns could be "Poor Sleep" and "Good Sleep." Each cell in this grid must contain the **frequency count** of individuals who fall into that specific intersection of categories.

It is critical that the data entered into the **TI-84 Calculator** consists of raw counts, not percentages or means. The **chi-squared test** is mathematically dependent on the total **sample size**, and using proportions would invalidate the resulting **test statistic**. Furthermore, practitioners should ensure that the categories are mutually exclusive and exhaustive, meaning every subject in the **random sample** belongs to exactly one cell. Proper preparation of the table ensures that the dimensions of the **matrix**--defined as (number of rows) $\times$ (number of columns)--are correctly identified before the input process begins.

Consider the practical example where we investigate whether **gender** is associated with **political party preference**. We might collect data from 500 voters and categorize them into a 2x3 table. This structure allows the **TI-84 Calculator** to recognize that there are two levels for the first variable (Male and Female) and three levels for the second variable (Republican, Democrat, and Independent). Ensuring the accuracy of these **marginal totals** and cell counts is the most important step in the pre-analysis phase, as even a small data entry error can lead to an incorrect **p-value** and a flawed conclusion.

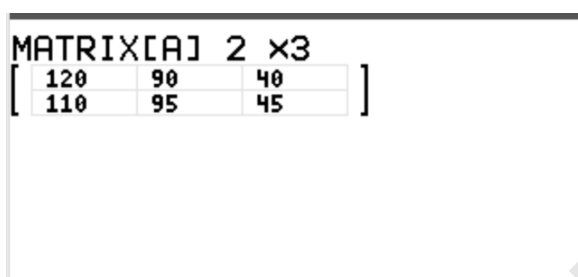
Republican	Democrat	Independent	Total	
Male	120	90	40	250
Female	110	95	45	250
Total	230	185	85	500

Step-by-Step Data Entry into the TI-84 Matrix

The first technical step on the **TI-84 Calculator** involves accessing the **Matrix** menu to input the observed data. To do this, press the **2nd** key followed by the **x²1** button (which serves as the **Matrix** command). Once inside the menu, use the right arrow key to navigate to the **Edit** column. Selecting a matrix, such as , and pressing **Enter** opens the interface where you must define the dimensions. In our specific survey example, you would type **2** for the number of rows, press **Enter**, then type **3** for the number of columns, and press **Enter** again.

After defining the 2x3 structure, the calculator presents a grid where you can enter the **observed frequencies**. Carefully type each value from your **contingency table** into the corresponding cell, pressing **Enter** after each number to move to the next position. It is vital to ignore the "Total" rows and columns from your table; the **TI-84 Calculator** only requires the internal raw data cells to function correctly. Entering the totals by mistake will result in an incorrect calculation of the **degrees of freedom** and an invalid test result.

Once all data points are entered, you should double-check the values against your original records. The **matrix editor** is intuitive, but a single typo can significantly alter the **chi-square statistic**. After confirming the data is accurate, you can exit the matrix screen by pressing **2nd** and then **Mode** (to **Quit**). The data is now securely stored in the calculator's **RAM**, ready to be processed by the statistical testing functions. This structured approach to data entry is the foundation of a successful **quantitative analysis** on a handheld device.



MATRIX[A] 2 x3		
120	90	40
110	95	45

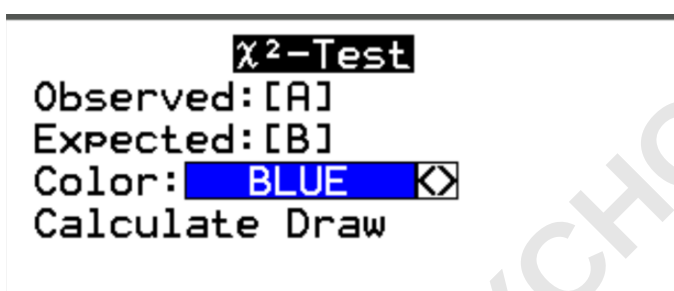
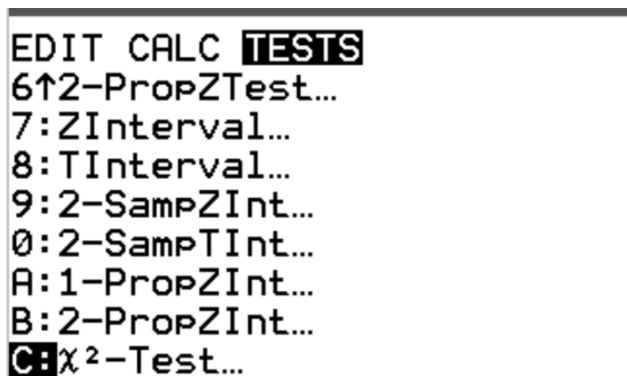
Executing the χ^2 -Test Function

With the data successfully stored in **Matrix**, the next phase is to run the actual **Chi-Square Test**. Press the **stat** button on your **TI-84 Calculator** and use the right arrow key to highlight the **TESTS** menu. This menu contains a vast array of **statistical tests**, including T-tests and Z-tests. Scroll down until you locate the option labeled χ^2 -Test (often item C or D depending on the specific OS version). Press **Enter** to select it. This specific function is designed specifically for the **test of independence** and the **test of homogeneity**.

The calculator will then prompt you for two inputs: **Observed** and **Expected**. For the **Observed** field, ensure that is selected, as this is where you just entered your survey data. For the **Expected** field, you should select an empty matrix, such as . You do not need to manually calculate the expected values; the **TI-84 Calculator** is programmed to compute these automatically during the test execution and will populate **Matrix** with the results. This automated feature is one of the primary reasons the TI-84 is favored for **educational technology**.

Once the matrices are assigned, scroll down to the **Calculate** option and press **Enter**. Alternatively, you could choose **Draw** if you wish to see a visual representation of the **chi-square**

distribution curve with the rejection region shaded. However, for most academic and professional purposes, the **Calculate** option is preferred as it provides the specific numerical values required for a formal report. The calculator then performs the complex **summation** of $(\text{Observed} - \text{Expected})^2 / \text{Expected}$ for every cell in the matrix to arrive at the final results.

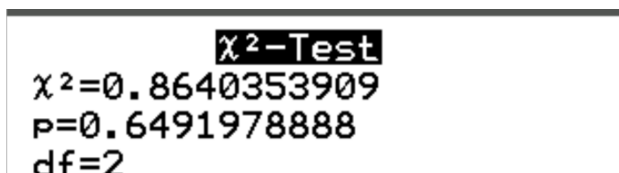


Deciphering the P-Value and Test Statistic

Upon pressing **Calculate**, the **TI-84 Calculator** displays a screen with three vital pieces of information: the χ^2 **test statistic**, the **p-value** (denoted as **p**), and the **degrees of freedom** (df). The test statistic represents the total discrepancy between the observed and expected data. A larger value indicates a greater departure from the **null hypothesis**. However, the test statistic alone is difficult to interpret without context, which is why the **p-value** is the most critical number on the screen for making a final determination.

The **p-value** indicates the probability that the observed **association** (or one even more extreme) could have occurred by sheer chance if the variables were truly independent. In most **statistical analysis**, a threshold or **significance level** of 0.05 is used. If the p-value is less than 0.05, the result is considered "statistically significant," and the null hypothesis is rejected. If the p-value is greater than 0.05, as seen in our example, we fail to reject the null hypothesis, concluding that there is no evidence of a relationship between the variables.

The **degrees of freedom** (df) for a **Chi-Square Test of Independence** are calculated as $(\text{rows} - 1) \times (\text{columns} - 1)$. For a 2x3 table, the df would be $(2-1) \times (3-1) = 2$. This value determines the specific shape of the **chi-square distribution** used to calculate the p-value. Understanding these outputs allows the researcher to move beyond the calculator screen and provide a meaningful **conclusion** regarding the real-world data, ensuring that the results are grounded in **mathematical theory** and proper **logical reasoning**.

A screenshot of a TI-84 calculator screen displaying the results of a Chi-Square Test. The screen shows the title 'χ²-Test' at the top, followed by the test statistic 'χ²=0.8640353909', the p-value 'p=0.6491978888', and the degrees of freedom 'df=2'.

```
χ²-Test
χ²=0.8640353909
p=0.6491978888
df=2
```

Practical Application: Gender and Political Affiliation

In our illustrative case study, we explored the potential **association** between gender and political party preference among a **simple random sample** of 500 voters. The data was meticulously entered into the **TI-84 Calculator**, reflecting 120 Republican males, 90 Democrat males, and 40 Independent males, alongside their female counterparts. By applying the **Chi-Square Test of Independence**, we aimed to see if knowing a person's gender would allow us to predict their political leanings with more accuracy than random guessing. This is a classic example of **bivariate analysis** in **political science**.

The output from the **TI-84 Calculator** revealed a **chi-square test statistic** of **0.8640** and a **p-value** of **0.6492**. Because the p-value is substantially higher than the standard 0.05 **significance level**, we do not have enough evidence to claim that gender and political preference are related. In other words, the variations we saw in the table--such as slightly more male Republicans than female Republicans--are not large enough to be considered **statistically significant**. They are likely just **random fluctuations** that occur whenever you sample a subset of a larger population.

This conclusion is vital for **market research** and campaign strategy. If a **null hypothesis** is not rejected, it suggests that a "one-size-fits-all" approach may be appropriate for both genders, or that other **demographic** factors like age, income, or geography might be more influential drivers of political choice. By using the **TI-84 Calculator** to verify these relationships, analysts can avoid making the mistake of seeing patterns where none truly exist, a phenomenon known as a **Type I error** in **hypothesis testing**.

Validating Assumptions for Accuracy

While the **TI-84 Calculator** makes the execution of a **Chi-Square Test** nearly effortless, the

validity of the results depends on several core **statistical assumptions**. First and foremost, the data must come from a **random sample** to ensure that the findings can be generalized to the broader population. If the sampling method is biased--for instance, if only voters in a specific neighborhood were surveyed--the **test of independence** may produce a result that does not accurately reflect reality, regardless of what the p-value suggests.

Another critical requirement is the **expected cell frequency** condition. For a Chi-Square test to be accurate, most statisticians agree that all expected counts should be at least 1, and at least 80% of the cells should have expected counts of 5 or more. If these conditions are not met, the **chi-square distribution** may not be a good approximation of the actual sampling distribution, leading to unreliable results. Fortunately, the **TI-84 Calculator** allows you to check these values easily by viewing **Matrix** after the test has been run.

Finally, the observations must be **independent** of one another. This means that one subject's response should not influence another's. In our voter survey, this implies that each of the 500 individuals was surveyed separately and that no person was counted twice. When these assumptions are satisfied, the **Chi-Square Test of Independence** becomes a powerful and definitive tool for **data science**. By combining the computational power of the **TI-84 Calculator** with a disciplined approach to **statistical methodology**, researchers can uncover deep insights into the hidden connections within their data.