How to Perform a Paired Samples T-Test on Your TI-84 Calculator

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Understanding the Foundations of the Paired Samples T-Test

The **paired samples t-test**, which is also commonly referred to as the dependent samples t-test, is a sophisticated statistical procedure used to determine whether the **mean** difference between two sets of observations is zero. In a typical research design, this test is applied when the same subjects are measured twice, often before and after a specific intervention, or when individuals are matched into pairs based on specific characteristics. By focusing on the differences within each pair, this test effectively controls for subject-to-subject variability, making it a powerful tool for detecting subtle effects that might otherwise be obscured by individual differences.

When researchers utilize a **TI-84 calculator** to perform this analysis, they are essentially reducing a two-sample problem into a one-sample t-test performed on the differences between the paired values. This mathematical reduction is the cornerstone of the paired analysis, as it shifts the focus from the raw scores of each group to the magnitude and direction of the change experienced by each individual unit. This approach is particularly valuable in clinical trials, educational assessments, and industrial experiments where the goal is to isolate the impact of a single **variable** across a controlled group of participants.

To ensure the validity of the **t-test**, several underlying assumptions must be met. These include the requirement that the differences between the pairs are **independent** of one another and that they follow a **normal distribution**, especially when the sample size is small. Furthermore, the data must be measured at the interval or ratio level. The TI-84 provides a robust environment for these calculations, allowing students and professionals alike to derive meaningful insights from their data without the need for manual computation of complex formulas involving **standard deviation** and **variance**.

Identifying Appropriate Use Cases for Paired Observations

Before proceeding with the technical steps on a **TI-84 calculator**, it is essential to recognize when a paired samples t-test is the correct choice for **data analysis**. The most common scenario is the "pre-test/post-test" design. For example, a medical researcher might measure a patient's blood pressure before administering a new medication and then measure it again after a month of treatment. Because the measurements are taken from the same individual, the two data sets are naturally linked, requiring a paired analysis to account for the inherent correlation between the two time points.

Another frequent application involves matched pairs where subjects are distinct but share critical similarities. In an educational study, students might be paired based on their baseline IQ scores, with one student from each pair assigned to a traditional classroom and the other to an innovative learning environment. By comparing the performance of these matched pairs, researchers can more accurately attribute differences in outcomes to the teaching method rather than the students' innate abilities. This method significantly enhances the **statistical power** of the experiment by minimizing the noise caused by extraneous variables.

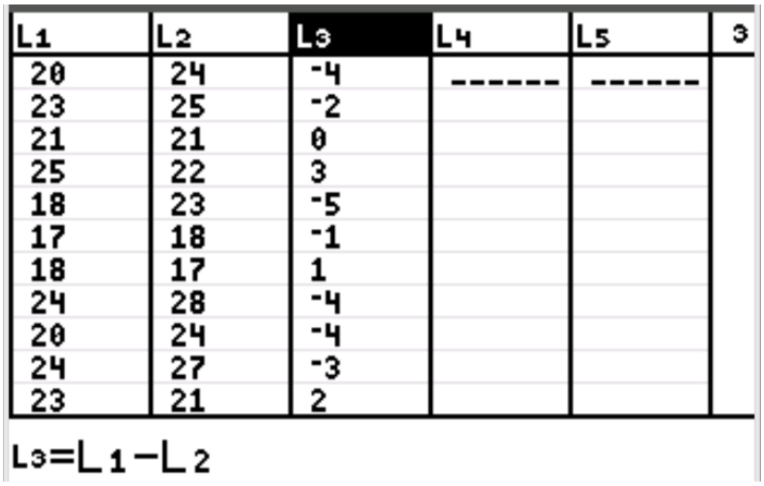
In the context of the example provided in this guide, researchers are evaluating a fuel treatment's effect on vehicle efficiency. By measuring the **miles per gallon (MPG)** of the same 11 cars both with and without the treatment, they eliminate variables such as engine size, car weight, and aerodynamic profile. Each car serves as its own control, which is the hallmark of a high-quality **experiment** designed for a paired t-test. This logical structure ensures that any observed difference in efficiency can be more confidently attributed to the fuel treatment itself.

Step 1: Inputting Data into the TI-84 Lists

The initial phase of conducting a paired samples t-test on a **TI-84 calculator** involves the meticulous entry of raw data. To begin, power on your device and press the **STAT** button, which serves as the gateway to the calculator's statistical suite. From the resulting menu, ensure that **EDIT** is highlighted and press **ENTER**. This action opens the list editor, a spreadsheet-like interface where you can organize your **data set** into columns labeled L1, L2, and beyond.

In this specific tutorial, we will utilize column **L1** to store the control group measurements--specifically, the MPG values for cars without the fuel treatment. Carefully enter each of the 11 values, pressing **ENTER** after each entry to move to the next row. Once L1 is complete, navigate to column **L2** and input the corresponding treatment group measurements, which represent the MPG values for the same cars after receiving the fuel treatment. It is critical that each row across L1 and L2 represents the same car to maintain the integrity of the **paired observations**.

After the primary data sets are entered, we must calculate the differences between them. While this can be done manually, the TI-84 offers a more efficient method. Navigate to the very top of column **L3** so that the label "L3" is highlighted. You will then enter a formula to automate the subtraction. Press **2nd** and then **1** to select L1, press the minus key, and then press **2nd** and **2** to select L2. Upon pressing **ENTER**, the calculator will instantly populate L3 with the differences (L1 minus L2) for every pair in the set. This automated step reduces the risk of human error during the calculation phase.



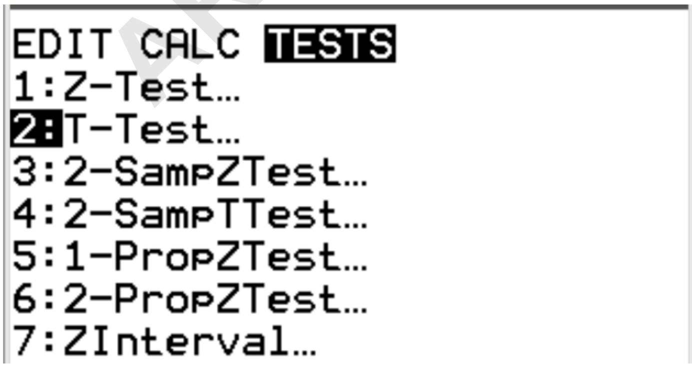
L1	L2	L3	L4	L5	3
20	24	-4	------	------	
23	25	-2			
21	21	0			
25	22	3			
18	23	-5			
17	18	-1			
18	17	1			
24	28	-4			
20	24	-4			
24	27	-3			
23	21	2			

L3=L1−L2

Step 2: Accessing the T-Test Menu and Selection

Once the differences are calculated and stored in list L3, the focus shifts to performing the actual **hypothesis test**. Because a paired samples t-test is mathematically equivalent to a one-sample t-test on the differences, we will use the standard T-Test function on our calculated differences. Press the **STAT** button once more to return to the primary menu, then use the right arrow key to navigate over to the **TESTS** tab. This section contains various **distribution**-based tests used in modern inferential statistics.

Scroll down the list of options until you reach **2:T-Test...** and press **ENTER**. This selection is used when the population standard deviation is unknown and the sample size is relatively small, which fits the parameters of our current experiment. It is important not to confuse this with the "2-SampTTest," as that function is reserved for independent samples where no pairing exists between the two groups. By selecting the one-sample T-Test for our difference column, we are correctly applying the paired test logic.



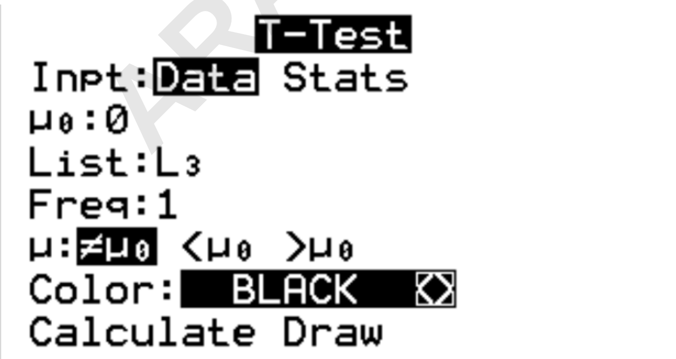
The screen will now present a series of configuration options that define the parameters of your test. Understanding these fields is essential for obtaining accurate results. The calculator asks whether you are providing **Data** or **Stats**. Since we have entered raw values into our lists, you must highlight **Data** and press **ENTER**. This tells the TI-84 to look at the lists we populated in the previous step rather than requiring us to provide pre-calculated values like the sample mean or sample standard deviation.

Configuring Input Parameters and the Null Hypothesis

With the **Data** input mode selected, you must now define the **null hypothesis**. In the field labeled µ**0**, you should enter the value **0**. This represents the assumption that there is no significant difference between the two groups; in other words, the mean of the differences is zero. Press **ENTER** to move to the next field. The calculator then needs to know where the data is located. In the **List** field, specify **L3** by pressing **2nd** and then **3**, as this is the column where we stored our paired differences.

The **Freq** (Frequency) field should generally remain set to **1**. This indicates that each value in your list represents a single observation. If your data were organized in a frequency table, you would point this to a different list, but for most paired t-test applications, a frequency of 1 is standard. After setting the frequency, you will reach the line for the **alternative hypothesis** (µ). This is a critical step that dictates whether you are performing a one-tailed or **two-tailed test**.

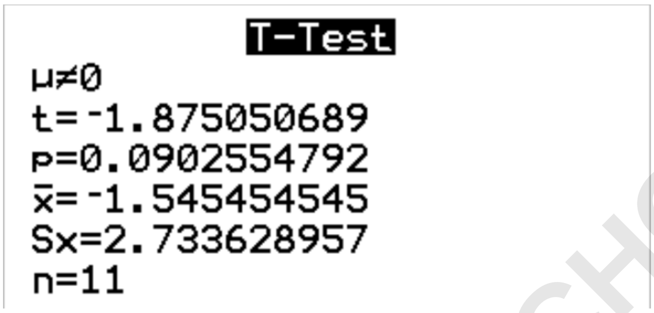
In our MPG study, the researchers are looking for any change in fuel efficiency, regardless of whether it increases or decreases. Therefore, we select the **?** µ**0** option, which signifies a two-tailed test. If the hypothesis specifically suggested that the fuel treatment would only increase MPG, we might choose the **>**µ**0** option for a right-tailed test. However, the two-tailed approach is more conservative and widely used in academic research to detect any significant deviation from the null hypothesis. Highlight **Calculate** and press **ENTER** to generate the results.



Interpreting the Calculator's Statistical Output

Upon selecting **Calculate**, the **TI-84 calculator** will process the data and display a screen filled with various statistical indicators. At the very top, you will see the alternative hypothesis you selected (μ? 0). Immediately following this is the **t-statistic**, which for our example is calculated as **-1.8751**. This value represents how many standard errors the observed mean difference is away from the null hypothesis mean of zero. A larger absolute value for the t-statistic generally indicates a more significant result.

The most important value on this screen for decision-making is the **p-value**, denoted simply as **p**. In our results, the p-value is **0.0903**. This value represents the **probability** of observing a test statistic as extreme as the one calculated, assuming that the null hypothesis is true. In addition to these, the calculator provides the sample mean of the differences (**x?**), which is **-1.5455**, and the sample standard deviation of those differences (**Sx**), which is **2.7336**. The sample size (**n**) is also confirmed as **11**.



To conclude the test, we compare the calculated p-value to our pre-determined **significance level**, often referred to as alpha (α). The standard alpha level in most scientific research is **0.05**. If the p-value is less than or equal to alpha, the results are considered statistically significant, and we reject the null hypothesis. However, if the p-value is greater than alpha, we fail to reject the null hypothesis, concluding that the observed differences may simply be due to random chance rather than the intervention being tested.

Concluding the Fuel Treatment Analysis

In the specific case of our fuel treatment experiment, the **p-value** obtained was **0.0903**. When we compare this to the standard **confidence level** associated with an alpha of 0.05, we find that 0.0903 is significantly larger than 0.05. Consequently, we must fail to reject the **null hypothesis**. This statistical outcome suggests that the average MPG of the cars did not change enough to conclude that the fuel treatment had a definitive impact on performance.

While the mean difference (x? = -1.5455) shows a slight variation, the **statistical significance** is not strong enough to rule out the possibility that this change occurred by chance. It is important to note that failing to reject the null hypothesis is not the same as proving that the fuel treatment does nothing; rather, it means that the current study did not provide sufficient evidence to confirm an effect. Factors such as a small sample size (n=11) or high variability in the data (Sx=2.7336) can contribute to a non-significant result even if a small real-world effect exists.

For researchers, this result might prompt further investigation. They could choose to repeat the **experiment** with a larger number of cars to increase the **degrees of freedom** and enhance the sensitivity of the test. Alternatively, they might look into other variables that could be affecting the results. By using the **TI-84 calculator**, the technical hurdle of calculation is removed, allowing the focus to remain on the critical interpretation of these statistical findings and their practical implications for the automotive industry.

Advanced Tips for Statistical Success on the TI-84

To maximize the accuracy of your **data analysis**, always ensure that your lists are clear of old data before starting a new test. You can quickly clear a list by highlighting the list name (e.g., L1) at the top of the editor and pressing **CLEAR** followed by **ENTER**. Avoid using the "DELETE" key on the list name, as this will remove the column from the display entirely, requiring you to use the "SetUpEditor" command to restore it. Maintaining clean and organized lists is the first step toward error-free computation.

Furthermore, it is often helpful to visualize your data before running a **paired samples t-test**. You can use the **STAT PLOT** feature on your TI-84 to create a histogram or a box plot of the differences in L3. This visual check allows you to identify any **outliers** or significant departures from normality that might violate the assumptions of the t-test. If the data is heavily skewed or contains extreme outliers, the results of your t-test may be unreliable, and a non-parametric alternative might be more appropriate.

Finally, remember that the **degrees of freedom** for a paired t-test are calculated as **n - 1**. In our example with 11 cars, the degrees of freedom would be 10. While the TI-84 handles this calculation internally, understanding the underlying **statistics** helps you better explain your results in a formal report or academic setting. The TI-84 is a powerful ally in the classroom and the field, providing professional-grade statistical capabilities in a portable format that remains the gold standard for educational technology.

Summary of Steps for Future Reference

For those who need a quick refresher on the process, the following **algorithm** summarizes the execution of a paired t-test. First, input your "Before" and "After" data into lists **L1** and **L2**. Second, define list **L3** as the difference between the two (L1 - L2) to isolate the change within each pair. This step is the most critical as it transforms the paired data into a format suitable for a standard t-test analysis on the **TI-84 calculator**.

Next, navigate through the **STAT** and **TESTS** menus to select the **T-Test** function. Set the input to **Data**, the null hypothesis mean (μ0) to **0**, and the data list to **L3**. Ensure your alternative hypothesis matches your research question--typically **?** μ**0** for a general check for change. Finally, calculate the results and focus your attention on the **p-value**. This workflow is highly repeatable and applies to a vast range of scientific and business scenarios.

Input: Enter primary data into L1 and L2; calculate differences in L3.
Navigate: Press **STAT**, go to **TESTS**, and select **2:T-Test**.
Setup: Use **Data** mode, set μ**0: 0**, **List: L3**, and **Freq: 1**.
Execute: Choose your **Alternative Hypothesis** and select **Calculate**.
Interpret: Compare the **p-value** to your **alpha level** (e.g., 0.05).

By following these structured steps, you can confidently perform a **paired samples t-test** and interpret the results with professional precision. Whether you are a student learning the ropes of **inferential statistics** or a researcher analyzing experimental data, the TI-84 provides the tools necessary to reach accurate and scientifically sound conclusions.