How to perform a Paired Samples t-test on a TI-84 Calculator?

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The Paired Samples t-test is a fundamental statistical procedure used extensively in research across various fields, including biology, finance, and engineering. This test is specifically designed to compare the means of two related samples, where each observation in the first sample is naturally paired or matched with an observation in the second sample. This pairing is crucial as it accounts for variability between individual subjects, leading to a more powerful statistical analysis compared to the standard Independent Samples t-test.

Understanding how to execute this test efficiently is essential for any statistical practitioner. While statistical software packages are powerful, the TI-84 Calculator remains a primary tool for students and professionals requiring quick, reliable calculations in a non-computer environment. The process, however, differs slightly from performing a standard one-sample or two-sample t-test, requiring an initial data transformation step to calculate the differences between the pairs before the test can be run successfully.

This comprehensive guide details the precise steps needed to perform a Paired Samples t-test using the statistical capabilities built into the TI-84 Calculator. By following these instructions meticulously, you will be able to input your paired data, execute the T-Test function on the differences, and accurately interpret the resulting t-statistic and p-value to draw meaningful conclusions about your research hypothesis.

A Paired Samples t-test, also known as a dependent samples t-test, is employed whenever the data collection involves measurements taken on the same subjects under two different conditions or when using matched pairs. This design inherently controls for inter-subject variability, making the analysis particularly sensitive to detecting systematic differences caused by the treatment or intervention being studied. The core principle of the paired t-test is transforming the two related variables into a single variable representing the difference scores, and then performing a one-sample t-test on those differences against a hypothesized mean difference (typically zero).

The reason we utilize this specialized approach on the TI-84 Calculator is because the calculator does not have a dedicated "Paired T-Test" option. Instead, we must manually create the difference variable, which allows us to leverage the existing one-sample T-Test function. This technique simplifies the computation process immensely, provided the initial data entry and calculation of differences are executed correctly, ensuring that the subsequent statistical output accurately reflects the hypothesis test.

Before proceeding, it is crucial to ensure your data meets the assumptions of the paired t-test, primarily that the paired differences are approximately normally distributed (especially for smaller sample sizes) and that the observations within each pair are dependent, while the pairs themselves are independent. Once these conditions are verified, the process of inputting the data and running the test on the TI-84 Calculator is straightforward and highly efficient.

Illustrative Example: Fuel Treatment Efficacy Study

To demonstrate the mechanics of the paired t-test on the TI-84, consider a practical research scenario. A team of researchers is investigating whether a newly developed fuel treatment significantly alters the average miles per gallon (mpg) of a specific vehicle model. To isolate the effect of the treatment from other potential confounding variables, they design an experiment using 11 identical cars. They measure the mpg for each car under standard conditions (without the treatment) and then measure the mpg again for the exact same 11 cars after applying the fuel treatment. This setup constitutes a classic paired sample design.

In this context, the measurements are dependent because the "before" and "after" mpg readings belong to the same vehicle. If the fuel treatment has no effect, we would expect the mean difference in mpg (Untreated MPG minus Treated MPG) to be zero. Therefore, the null hypothesis (**H0**) states that there is no difference in average mpg (µd = 0), and the alternative hypothesis (**Ha**) states that there is a significant difference (µd ? 0), indicating a two-tailed test.

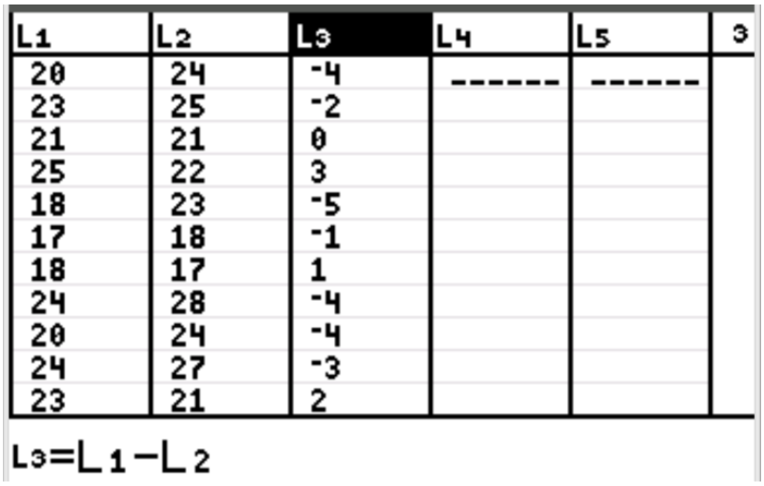
The goal is to determine if the observed mean difference is statistically significant enough to reject the null hypothesis at a standard significance level (e.g., $\alpha = 0.05$). The following steps will detail how to use the raw data collected from these 11 cars to execute the Paired Samples t-test using the functions available on the TI-84 Calculator.

Step 1: Inputting Data and Calculating Paired Differences

The initial and most critical step is accurately inputting the raw data into the statistical lists of the TI-84 Calculator. Begin by pressing the **Stat** key, navigating to the **EDIT** menu, and selecting option 1: **Edit...**. This opens the list editor screen, where we will organize our data. We will designate list L1 for the control group (Untreated MPG) and list L2 for the treatment group (Treated MPG), ensuring that the corresponding values for the same car are placed on the same row.

Once L1 and L2 are populated, we must compute the difference scores, which will be stored in a third list, L3. Navigate to the very top of the list editor screen and highlight the list name **L3**. Crucially, do not enter the differences manually; instead, use the formula definition feature of the calculator. Press **2nd** followed by **1** to input L1, then press the minus sign (**-**), and finally press **2nd** followed by **2** to input L2. The formula displayed at the bottom should read **L3 = L1 - L2**.

After pressing **Enter**, the calculator will automatically populate every cell in column L3 with the difference between the corresponding values in L1 and L2. This new list, L3, contains the single variable (the differences) upon which we will perform the one-sample T-Test. This transformation correctly sets up the problem for the calculator's built-in functions, treating the paired test as a test against a mean difference of zero.



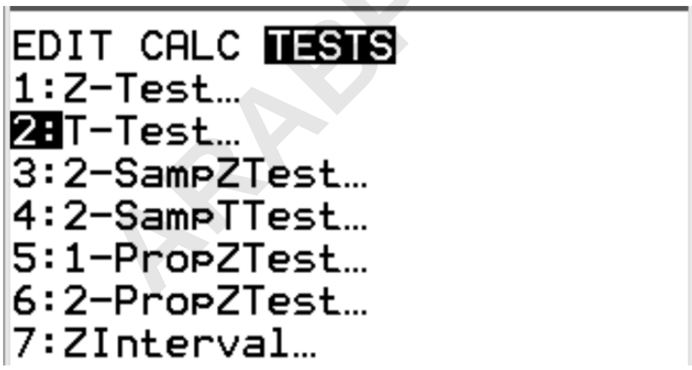
L1	L2	L3	L4	L5
20	24	-4	------	------
23	25	-2		
21	21	0		
25	22	3		
18	23	-5		
17	18	-1		
18	17	1		
24	28	-4		
20	24	-4		
24	27	-3		
23	21	2		

L3=L1−L2

Step 2: Executing the One-Sample T-Test on the Differences

With the difference scores stored in L3, the next step is to initiate the statistical test. Press the **Stat** key again, but this time, scroll over to the **TESTS** menu. Scroll down and select option **2:T-Test...** and press **ENTER**. Although this is called the T-Test (typically associated with a one-sample test), by applying it to the difference scores in L3, it effectively functions as the Paired Samples t-test.

The calculator will now prompt you to define several parameters required for the test calculation. It is essential to configure these settings correctly to match the intended hypothesis. The structure of the test relies entirely on the list L3 we generated in the previous step; any mistakes here will invalidate the output and lead to erroneous conclusions regarding the fuel treatment efficacy.



Step 3: Configuring the T-Test Parameters on the TI-84

The T-Test setup screen requires careful specification of the test parameters:

Inpt: You must select **Data** here, as we are working with raw data stored in a list (L3), rather than pre-calculated summary statistics (such as the mean and standard deviation of the differences).

Highlight **Data** and press **ENTER**.

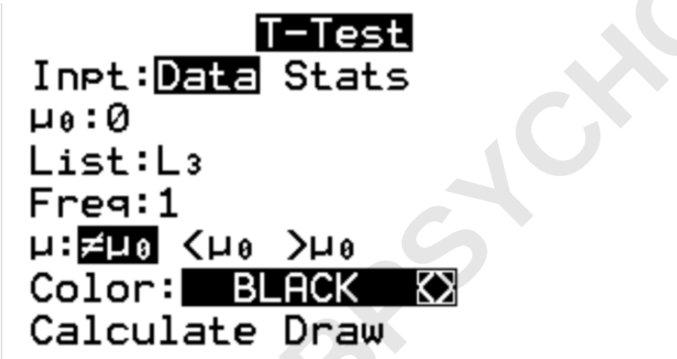
µ**0:** This represents the hypothesized mean difference under the null hypothesis. For a standard paired test, we hypothesize that the true mean difference (µd) is zero, meaning the treatment had no effect. Therefore, type **0** and press **ENTER**.

List: This specifies which list contains the values for the test. Since we calculated the difference scores in L3, we must ensure L3 is selected. To input L3, press **2nd** followed by **3**. Press **ENTER**.

Freq: This field specifies the frequency of each data point. Since each difference score represents a single paired observation, leave this set to the default value, **1**.

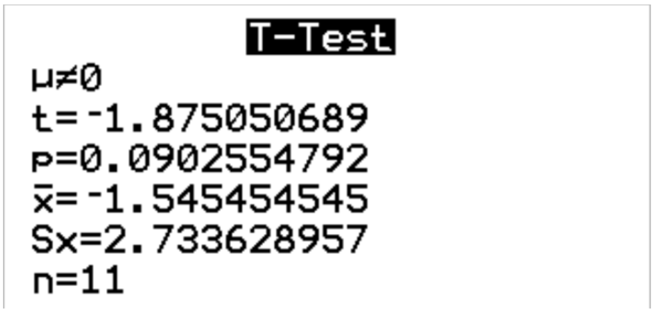
µ**:** This selection defines the alternative hypothesis (**Ha**). Since the research question seeks to know if the treatment leads to any change (either positive or negative), we choose the two-tailed option: **?** µ**0**. Highlight this option and press **ENTER**. This indicates that our alternative hypothesis is µ? 0. If the researchers were specifically testing if the treatment *increased* mpg, they would select >µ0 (right-tailed); if they tested for a *decrease*, they would select <µ0 (left-tailed).

Finally, navigate down to **Calculate** and press **ENTER** to initiate the statistical calculations. The TI-84 Calculator will process the data in L3 and display the comprehensive test results on the output screen.



Step 4: Interpreting the Paired T-Test Results

The output screen provides all necessary metrics to make a decision regarding the research hypothesis. The results generated correspond to a one-sample t-test conducted on the difference scores in L3, effectively completing our paired analysis.



The key values displayed on the output screen are interpreted as follows:

µ**? 0**: This restates the alternative hypothesis that the true mean difference is not equal to zero.
t=-1.8751: This is the calculated test statistic, known as the t-statistic. This value measures how many standard deviation units the observed sample mean difference (**x?**) is away from the hypothesized mean difference (µ0=0).
p=0.0903: This is the p-value associated with the calculated t-statistic and the degrees of freedom (n-1 = 10). The p-value represents the probability of observing a sample mean difference as extreme as -1.5455, assuming the null hypothesis is true.
x=-1.5455: This is the sample mean difference of the L1 - L2 calculation. Since L1 was Untreated and L2 was Treated, a negative mean difference suggests that the treated group (L2) generally had higher mpg values than the untreated group (L1).
sx=2.7336: This is the sample standard deviation of the differences (L3), measuring the variability or spread of the difference scores around the mean difference.
n=11: This confirms the sample size, which is the number of paired observations used in the test.

Drawing the Final Conclusion

The final step in any hypothesis test is comparing the calculated p-value to the predetermined significance level (α), typically set at 0.05. The decision rule is straightforward: if the p-value is less than or equal to α, we reject the null hypothesis; otherwise, we fail to reject it.

In this example, the calculated p-value is 0.0903. Comparing this to the standard significance level of α = 0.05, we observe that 0.0903 > 0.05. Because the probability of observing this result under the assumption of no effect is relatively high (9.03%), we do not have sufficient statistical evidence to conclude that the mean difference is significantly non-zero.

Therefore, based on the Paired Samples t-test conducted on the TI-84 Calculator, we fail to reject the null hypothesis. The conclusion is that there is insufficient statistical evidence, at the 5% significance level, to claim that the new fuel treatment causes a significant change in the average mpg of the vehicles tested. While the sample mean difference (x? = -1.5455) suggests a small potential increase in mpg, this difference is not statistically significant given the variability observed in the data.