

Learn How to Interpret Two-Sample T-Tests in Excel: A Step-by-Step Guide

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November 1, 2025

RECOMMENDED CITATION

Mohammed looti (2025). *Learn How to Interpret Two-Sample T-Tests in Excel: A Step-by-Step Guide*. PSYCHOLOGICAL STATISTICS. Retrieved from <https://statistics.arabpsychology.com/?p=7912>

The **t-test** is a fundamental inferential statistical tool employed to determine if there is a statistically significant difference between the **means** of two independent data sets, or **populations**. Specifically, the two-sample t-test assesses the likelihood that any observed difference between the sample means occurred purely by chance. Understanding how to execute and, crucially, how to interpret the output of this test is essential for effective data analysis in various fields, ranging from biology to finance.

This comprehensive tutorial is designed to walk you through the process of performing a two-sample t-test assuming equal **variances** using **Microsoft Excel**, and then provides a detailed, line-by-line guide on interpreting the resultant statistical output. We focus on the scenario where we must assume that the underlying population variances are equivalent (homoscedasticity), which dictates the specific t-test variant chosen in Excel's analysis toolkit.

Step 1: Structuring and Preparing the Sample Data

Before running any statistical analysis, properly structuring the input data in Excel is paramount. For this example, let us consider a common research question: A biologist intends to investigate whether two distinct species of plants (Species A and Species B) exhibit a statistically significant difference in their average height. This constitutes a two-sample hypothesis test where the **null hypothesis** (H_0) states that the population means are equal.

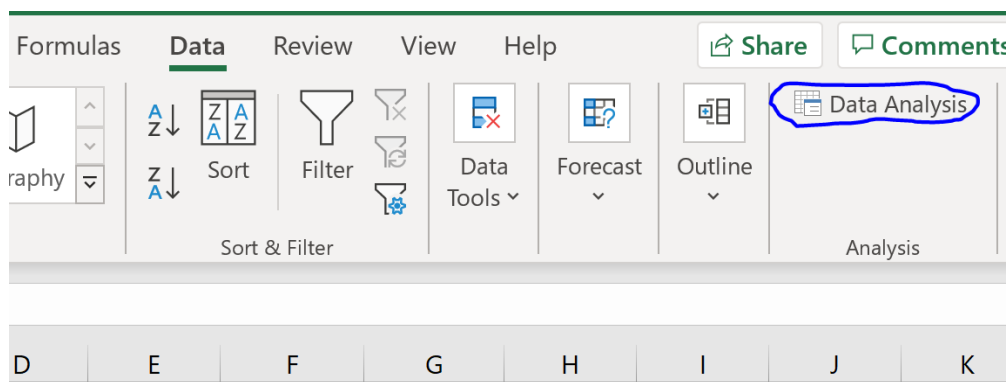
To gather evidence, the biologist utilizes a **simple random sample** methodology, collecting height measurements from 20 plants for each species. It is crucial that these samples are independent--meaning the selection of one group does not influence the selection of the other. In Excel, this data must be organized into two distinct columns, as shown below, to be correctly processed by the Data Analysis ToolPak.

	A	B	C	D	E	F
1	Species 1 Height	Species 2 Height				
2	14	15				
3	15	17				
4	15	14				
5	16	17				
6	13	14				
7	8	8				
8	14	12				
9	17	19				
10	16	19				
11	14	14				
12	19	17				
13	20	22				
14	21	24				
15	15	16				
16	15	13				
17	16	16				
18	16	13				
19	13	18				
20	14	15				
21	12	13				
22						
23						
24						
25						

Note that both Sample 1 (Species A) and Sample 2 (Species B) contain 20 **observations**. This balanced design simplifies the calculation of the pooled variance, though the t-test can accommodate unequal sample sizes (unbalanced designs) as well, provided the assumption of equal variance is still met.

Step 2: Executing the Two-Sample t-Test in Excel

To initiate the analysis, navigate to the **Data** tab located on the main ribbon in Microsoft Excel. Within this tab, locate and click the **Data Analysis** button, which launches the statistical calculation suite known as the **Analysis ToolPak**. If this option is not visible, you must first enable the [Data Analysis ToolPak add-in](#), which is typically found under Excel Options or Add-ins settings.



Upon selecting Data Analysis, a dialog box will appear presenting numerous statistical tests. For this specific scenario, where we assume the populations have similar spread, select the option titled **t-Test: Two-Sample Assuming Equal Variances**. This choice is based on the prerequisite assumption of homoscedasticity. Click **OK** to proceed to the input configuration window.

In the configuration window, you must accurately define the input ranges and parameters. The **Variable 1 Range** should correspond to the data for Species A (Sample 1), and the **Variable 2 Range** should correspond to Species B (Sample 2). The **Hypothesized Mean Difference** is typically set to 0, aligning with the [null hypothesis](#) that there is no difference between the population means. Ensure the Alpha level (significance level) is set correctly, usually at 0.05 (5%).

The image shows an Excel spreadsheet with two columns of data: 'Species 1 Height' (Column A) and 'Species 2 Height' (Column B). The data ranges from row 2 to row 21. A t-Test dialog box is open, titled 't-Test: Two-Sample Assuming Equal Variances'. The dialog box has the following settings:

- Input:**
 - Variable 1 Range: \$A\$2:\$A\$21
 - Variable 2 Range: \$B\$2:\$B\$21
 - Hypothesized Mean Difference: 0
 - ☐ Labels
 - Alpha: 0.05
- Output options:**
 - ☒ Output Range: \$D\$2
 - ☐ New Worksheet Ply:
 - ☐ New Workbook

The dialog box has buttons for OK, Cancel, and Help.

	A	B
1	Species 1 Height	Species 2 Height
2	14	15
3	15	17
4	15	14
5	16	17
6	13	14
7	8	8
8	14	12
9	17	19
10	16	19
11	14	14
12	19	17
13	20	22
14	21	24
15	15	16
16	15	13
17	16	16
18	16	13
19	13	18
20	14	15
21	12	13
22		
23		
24		

After clicking **OK**, Excel generates a detailed results table, which contains all the necessary statistics required to draw a conclusion about the plant heights. The next step involves dissecting this output to determine if the differences observed are statistically significant.

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	A	B	C	D	E	F
1	Species 1 Height	Species 2 Height				
2	14	15		t-Test: Two-Sample Assuming Equal Variances		
3	15	17				
4	15	14			Variable 1	Variable 2
5	16	17		Mean	15.15	15.8
6	13	14		Variance	8.134211	12.905263
7	8	8		Observations	20	20
8	14	12		Pooled Variance	10.51974	
9	17	19		Hypothesized Mean Difference	0	
10	16	19		df	38	
11	14	14		t Stat	-0.63374	
12	19	17		P(T<=t) one-tail	0.265024	
13	20	22		t Critical one-tail	1.685954	
14	21	24		P(T<=t) two-tail	0.530047	
15	15	16		t Critical two-tail	2.024394	
16	15	13				
17	16	16				
18	16	13				
19	13	18				
20	14	15				
21	12	13				
22						
23						
24						

Step 3: Comprehensive Interpretation of the t-Test Output

Interpreting the output table provided by Excel is the most critical phase of the hypothesis test. Each line item provides specific calculated metrics that collectively guide the decision regarding the [null hypothesis](#). We will now examine the definition and significance of each statistic presented in the results table.

Statistical Summary of Samples

The initial section of the output summarizes the descriptive statistics calculated directly from your input data, providing context for the subsequent inferential statistics:

Mean: This represents the arithmetic average of the measurements for each independent sample.

Sample 1 Mean (Species A): **15.15**

Sample 2 Mean (Species B): **15.8**

The observed sample means show that Species B is slightly taller on average. The t-test aims to determine if this 0.65 unit difference is large enough, relative to the data variability, to be considered non-random.

Variance: The **variance** measures the spread or dispersion of the data points around the mean for each sample. Since we selected the "Assuming Equal Variances" option, Excel utilizes a weighted average of these two [variance](#) values to estimate the common population variance.

Sample 1 [Variance](#): **8.13**

Sample 2 [Variance](#): **12.9**

Observations: This simply confirms the count of data points used in the calculation for each group, denoted by n1 and n2. In this balanced test, both counts are 20.

Sample 1 Observations (n1): **20**

Sample 2 Observations (n2): **20**

Key Calculated Metrics and Test Statistics

This section provides the calculated intermediate values necessary for the final hypothesis decision, standardizing the observed difference relative to the expected error:

Pooled Variance: Since we assume the underlying population variances are equal, the **Pooled Variance** (s^2_p) represents the best combined estimate of that common variance based on the two sample variances. This value is essential as it is used in the denominator of the t-statistic formula to account for the variability inherent in the data. The calculation is a weighted average based on the [degrees of freedom](#) of each sample:

$$s^2_p = ((n_1-1)s^2_1 + (n_2-1)s^2_2) / (n_1+n_2-2)$$

Applying the observed values:

$$s^2_p = ((20-1)8.13 + (20-1)12.9) / (20+20-2)$$

The resulting Pooled Variance is: **10.51974**.

Hypothesized Mean Difference: This is the value specified in the input dialogue, which corresponds to the assumed difference between the two population means under the [null hypothesis](#). For a standard test of equality (testing if $\mu_1 = \mu_2$), this value is always **0**.

df (Degrees of Freedom): The [degrees of freedom](#) (df) define the specific shape of the t-distribution curve used to calculate the critical values and p-values. For a two-sample t-test assuming equal variances, the degrees of freedom are calculated by summing the sample sizes and subtracting the number of samples (which is 2):

$$df = n_1 + n_2 - 2$$

$$df = 20 + 20 - 2$$

The calculated df is: **38**.

t Stat (Test Statistic): The calculated **t Stat** is the core metric of the test. It measures how many standard errors the difference between the observed sample means is from the hypothesized mean difference (0). A larger absolute value of t suggests a greater difference between the groups relative to the variability within the samples. The formula used is:

$$t = (x_1 - x_2) / \sqrt{s_p^2(1/n_1 + 1/n_2)}$$

Plugging in our sample statistics:

$$t = (15.15 - 15.8) / \sqrt{10.51974(1/20 + 1/20)}$$

The calculated t Stat is: **-0.63374**. The negative sign simply indicates that the mean of Sample 1 is less than the mean of Sample 2.

Final Decision Metrics: P-Value and Critical Value

The final lines of the Excel output provide the necessary values to make a conclusive decision about the [null hypothesis](#) based on the chosen significance level (Alpha = 0.05).

P(T<=t) two-tail: This is the [p-value](#) for the two-tailed test. The **p-value** represents the probability of observing a test statistic as extreme as, or more extreme than, the calculated **t Stat** (-0.63374), assuming the null hypothesis is true. This value is derived from the t-distribution table using the calculated t Stat and 38 [degrees of freedom](#).

The calculated **p-value** is **0.530047**. The decision rule states that if the p-value is less than the significance level ($\alpha = 0.05$), we reject H0. Since 0.530047 is significantly larger than 0.05, we **fail to reject the null hypothesis**. Consequently, we lack sufficient statistical evidence to claim that the mean heights of the two plant species are actually different.

t Critical two-tail: The **critical value** is the threshold t-statistic associated with the 95% confidence level ($\alpha = 0.05$) and 38 [degrees of freedom](#). If the absolute value of the calculated **t Stat** falls outside the range defined by the critical values (i.e., $|t \text{ Stat}| > |t \text{ Critical}|$), we reject the null hypothesis.

In this analysis, the critical value turns out to be **2.024394**. Since the absolute value of our test statistic, $|-0.63374|$, is less than 2.024394, the t Stat falls within the acceptance region. Therefore, using the critical value method, we also **fail to reject the null hypothesis**. Both methods--the p-value method and the critical value method--will always lead to the same statistical conclusion.

Conclusion and Further Learning

The ability to correctly interpret the output of a two-sample [t-test](#) in Excel is a vital skill for anyone dealing with comparative data analysis. By understanding the meaning of the **t Stat**, [degrees of freedom](#), and the resulting **p-value**, researchers can confidently determine whether observed differences between groups are statistically meaningful or merely the result of sampling fluctuation.

Important Note on Tail Selection: Researchers performing a directional test (e.g., Hypothesis: Species A is taller than Species B) must utilize the values provided for **P(T≤t) one-tail** and **t Critical one-tail** instead of the two-tailed metrics, as a one-tailed test focuses statistical power entirely on detecting a difference in a single specified direction.

For those seeking to expand their knowledge of hypothesis testing, the following resources offer step-by-step guidance on other types of t-tests and statistical procedures available within Excel: