

UNDERSTANDING *t* -TESTS



A HOW-TO GUIDE





Understanding t -Tests: A How To Guide

t -tests offer an opportunity to compare two groups on scores such as differences between boys and girls or between children in different school grades. A t -test is a type of inferential statistic, that is, an analysis that goes beyond just describing the numbers provided by data from a sample but seeks to draw conclusions about these numbers among populations. To do this, the t -test analyzes the difference between the two means (a.k.a. two averages) derived from the different group scores. t -tests tell the researcher if the difference between two means is larger than would be expected by chance (i.e. *statistically significant*). In this guide we will go through two common types of t -test:

- (1) **Dependent samples t -test** (also called **repeated measures t -test** or **paired-samples t -test**)
- (2) **Independent samples t -tests.**

Each of these analyses are discussed in detail below:

Dependent Samples t -Test – As described above, t -tests are used when we want to compare two groups of scores and their means. Sometimes, however, the participants in one group are somehow meaningfully related to the participants in the other group. One common example of such a relation is in a pre-test post-test research design. Because participants at the pre-test are the same participants at the post-test, the scores between pre- and post-test are meaningfully related. In other words, the scores between pre- and post-test are dependent on each other. Other forms of dependency may also exist such as scores between parents and their children or between dating couples. For simplicity we present an example based on the pre-test post-test research design, but as a critical consumer of research it is important to be able to identify situations where scores from two groups are likely to be related.

As you might have guessed, when researchers compare two means that are dependent on each other, a dependent samples t -test is often used. An example of when you might see or use a dependent samples t -test would be for an intervention aimed at improving instruction quality in youth programs. In such a design, instruction quality would initially be measured to obtain pre-test scores. Next, the intervention would be administered followed by a second measurement of instruction quality (post-test). In order to determine if there was an increase in instruction quality as a result of the intervention, the researchers would use a dependent samples t -test that accounts for the meaningful relation between participants at the pre-test and post-test (i.e. they are the same people).



The results of the dependent samples t -test will tell you if the difference between the means of the two groups (e.g. pre-test and post-test) are statistically significant, that is, whether this difference is larger than would be expected by chance. In the case of the youth program intervention, if the dependent samples t -test was significant and the mean for instructor quality was higher at the post-test than at the pre-test, we might conclude that the intervention had a real, positive, effect on instructor quality.

Independent Samples t -Test – Unlike the dependent samples t -tests, the independent samples t -test is used to compare two groups whose means **are not** dependent on one another. In other words, when the participants in each group are independent from each other and actually comprise two separate groups of individuals, who do not have any linkages to particular members of the other group (in contrast to dependent samples). A common example of independent groups might be comparisons between males and females who do not have relationships between particular males and females (versus if the males and females were linked through romantic relationships). In this example the factor that differentiates the two groups, gender, does not indicate that the scores from one group (males) will be dependent on scores from the other group (females) and they are thus considered independent samples.

As another example, imagine you collected information about instruction quality in youth programs from two separate sets of youth programs: programs that received the instructor quality intervention and those that did not. Because the participants in each group comprise separate, independent samples, the scores from each group are not dependent on each other. Thus, to compare the means between these two groups an independent samples t -test would be used.

Results of an independent samples t -test indicate whether the difference between two means (e.g., means of programs receiving intervention and means of programs not receiving intervention) are larger than expected by chance. Using the example above, if the instructors who received the intervention had higher mean quality scores compared to a group that did not receive the intervention, there would be evidence that the intervention increased the quality of instruction.

Understanding the t -Test in Research Articles

It is important to be able to understand the meaning of a t -test in the context of a research article. Below is an example of how a dependent-samples t -test might be reported:

One hundred youth program instructors were recruited from throughout the United States to participate in an intervention designed to improve instruction quality. After collecting a pre-test measure of instruction quality, all instructors were given an intervention designed to enhance the quality of their instruction. Following the administration of the intervention, instruction quality was assessed a second time with a post-test. Results indicate that instruction quality increased from pre-test ($M = 2.37$, $SD = 1.02$) to post-test ($M = 4.56$, $SD = 1.10$). The increase in instruction quality was statistically significant ($t[99] = 1.96$, $p < .05$).



From this example, several pieces of information can be derived.

1. **The research design.** The researchers are using a pre-test, post-test design. The means derived from each group (who are actually the same people) are dependent on each other. It is important to understand the research design so you can assess if the researcher is using the appropriate statistical test for analysis.

2. **The means and standard deviations.** In the above example, the pre-test mean was 2.37 while the post-test mean was 4.56. Similarly, the pre-test standard deviation was 1.02 while at post-test it was 1.10. This information tells you that there was a general increase in instruction quality between pre-test and post-test. The similar values of the standard deviations indicate that the distribution of scores around the means are similar for the pre-test and post-test (see the How-To Guide on *Statistical Language* for more information on the mean and standard deviation)

3. **The t -test.** The t -test provides information about the results of the comparisons between the two means. Perhaps the most important element of reporting the t -test is its significance level. The significance level tells you if the difference observed between the means was greater than would be expected by chance (typically $p < .05$; see the How-To Guide on *Statistical Language* for more information on p -values and significance testing). Other information provided when reporting a t -test includes the degrees of freedom (99) and the t -value (1.96). For a dependent samples t -test the degrees of freedom will always be $N - 1$. For an independent samples t -test the degrees of freedom will always be $N - 2$. The meaning of the t -value itself is beyond the scope of the current tutorial, however, it should be noted that t -tests with degrees of freedom in excess of 100 will always be significant if the value meets or exceeds 1.96. This is a useful tip in understanding the necessary critical value of a t -test for it to reach statistical significance.

Summary

In this How-To Guide we have described the basics of a t -test. Having reviewed this guide we hope that the information provided has offered an overview of the t -test. In addition, we hope that the information provided has clarified the differences between an independent and dependent t -test. Additional How-To Guides are also available that cover topics such as *Statistical Language*, *Correlation*, *Regression*, and *Analysis of Variance*. Readers are encouraged to use this site to gain additional statistical knowledge to become more critical consumers of scientific research.



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