t-tests

What is a *t*-test?

A *t*-test is a statistical test used to compare the means of groups to determine whether any observed difference is likely to be real or due to chance.

There are three main types of *t*-tests, depending on the data and research question.

t-test	Used when	Example
Independent samples	Comparing two different groups that are unrelated	Treatment vs control
Paired samples	Same participants measured twice	Pre-test vs post-test
One-sample	Comparing a sample mean to a known or expected value	Class average vs national benchmark

When you run a *t*-test, several key outputs help you to interpret the results:

- ***p*-value**: shows whether the difference between means is statistically significant (usually $p < 0.05$).
- **Confidence interval (CI)**: gives a range of plausible values for the true difference between means; if it includes 0, the difference may not be significant.
- **Effect size (Cohen's *d*)**: shows the size of the difference in practical terms (small, medium, or large effect).

Together, these outputs help you decide not only whether a difference exists, but also how meaningful that difference is.

p-value

The *p*-value shows whether a difference between groups is likely to be real or just due to random chance. The *p*-value does not tell you how big or important the effect is, only whether it is likely to exist.

A result is considered statistically significant if:

- $p < 0.05$ → statistically significant difference
- $p \geq 0.05$ → not statistically significant

Confidence interval (CI)

The confidence interval shows a range of values where the true difference is likely to fall (usually 95%).

- If the CI includes 0, the difference may not be statistically significant.
- If the CI does not include 0, the difference is likely significant.

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Effect size (Cohen's *d*)

Effect size shows how big the difference is in practical terms. A result can be statistically significant but still have a small effect size.

Cohen's d value	Effect size
~0.2	Small
~0.5	Medium
~0.8+	Large

How to report a *t*-test (template)

Independent samples example

- A *t*-test showed that Group A scored significantly higher than Group B
  $t(df)$ = __, p = __, Cohen's d = __, 95% CI [__, __]

Paired samples example

- Scores increased significantly from pre-test to post-test
  $t(df)$ = __, p = __, Cohen's d = __, 95% CI [__, __]

One-sample example

- The sample mean was significantly different from the test value of 75
  $t(df)$ = __, p = __, Cohen's d = __, 95% CI [__, __]

Degrees of freedom (*df*) represent the number of independent observations that can vary when calculating a *t*-test, and are used to determine the critical value needed to assess statistical significance. For a *t*-test, the calculation of degrees of freedom (*df*) depends on the type of *t*-test.

Independent-samples *t*-test

- $df = n_1 + n_2 - 2$
  where n_1 and n_2 are the sample sizes of the two groups.

Paired-samples *t*-test

- $df = n - 1$
  where n is the number of paired observations.

One-sample *t*-test

- $df = n - 1$
  where n is the sample size.

Related helpsheets

- Correlations
- Correlation vs Cause-effect

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