


Online

Search online for a 't-test calculator'. E.g. open *graphpad.com* & *mathportal.org* or similar. Enter data for population (group) 1 and population (group) 2. If the P value is ≤ 0.05 , they are significantly different! Maintain default values/assumptions: two sample t-test, two-tailed test, unpaired t-test, independent groups, groups have equal variance, 0.05 significant level.

Excel

Enter the data into two separate columns on Excel spreadsheet. Click on an empty cell. Select  (input box appears). Search and select **T.TEST** and input data from your two columns as Array1 & Array 2. Use the same default values/assumptions as listed above. If an output box appears, find P(T<=t) two tail. Otherwise Excel will simply put the P value in the empty cell you clicked on earlier in the spreadsheet.

Hand calculation

The formula is:
$$t_{calc} = \frac{\bar{x}_1 - \bar{x}_2}{SE_{\bar{x}_1 - \bar{x}_2}}$$

Diagram illustrating the formula components:

- numerator**: Difference between the means (Group 1 mean – Group 2 mean)
- denominator**: Standard error of the difference (Square root of: $\frac{[(s_1^2 \times df_1) + (s_2^2 \times df_2)] / [df_1 + df_2] + \leftarrow \text{that again}}{n_1 + n_2}$)

Calculating the numerator – the difference between the means - is the easy part. Calculating the answer to the denominator is not so easy. This is also called - the standard error (SE) of the difference. Although the formula appears complex, you are just simply working out the spread of both data sets.

Numerator: If the numerator is a large number, then the difference between the means is also large. If there is a large difference between the means, then without even looking at the denominator yet, you could (make the mistake to) assume that the *difference* between the two means may indeed be significant.

Denominator: However, if the denominator is also a large number, then when you divide the numerator by the denominator, as per the formula, the answer (t_{calc}) is small. This means the two sets of data *overlap* somewhat because they are both really spread apart. In which case, the two population (group) means are *not* significantly different after all.

The hand calculation method uses t_{calc} (sometimes called 't Stat' or just 't') instead of a P value. t_{calc} is then compared to another value called t_{crit} that can be found on a table called a '**Student's t-distribution table**' (Table 1) using the df & $\alpha=0.05$. If t_{calc} is a small number, smaller than t_{crit} , there is *no* significant difference between the two population (group) means (too much overlap). If t_{calc} is, however, equal to or greater than t_{crit} , there *is* a significant difference. For example, using the data from the previous page, t_{calc} was 13.2582 (congratulations if you got it!) which is greater than t_{crit} that according to Table 1 is 2.45. Thus, a significant difference does indeed exist between these two means.

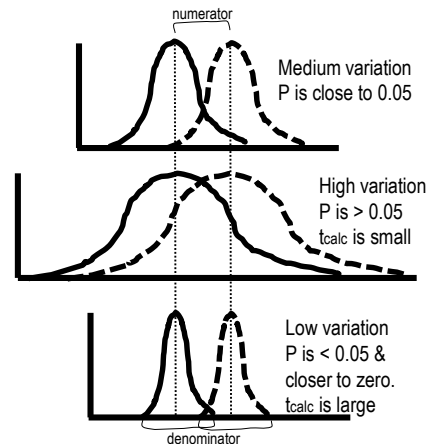


Figure 1: Even though the numerator (difference between the means) is the same for all three examples above, the denominator determines the amount of overlap (variation) between both data sets. Only when the overlap is minimal will a significant difference be able to be identified.

Table 1: Student's t-distribution

df	$\alpha = 0.1$	$\alpha = 0.05$	$\alpha = 0.01$	$\alpha = 0.001$
1	6.31	12.71	63.66	636.58
2	2.92	4.80	9.92	31.80
3	2.35	3.18	5.84	12.92
4	2.13	2.78	4.60	8.61
5	2.02	2.57	4.03	6.87
6	1.94	2.45	3.71	5.96
8	1.89	2.36	3.50	5.41
8	1.86	2.31	3.36	5.04
9	1.83	2.26	3.25	4.78