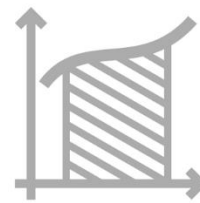


# Statistics



$$\{\sqrt{x}\}^2$$



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# Hypothesis Testing about Paired Means

## Paired Means

### Theory section:

With paired samples, we compare the two population means using a paired t-test.

Our null hypothesis is that the difference between population means ( $\mu_D$ ) is zero.

Our alternative hypothesis is that the difference is not zero, greater than zero, or less than zero, depending on the situation.

The criteria are that the observations are independent from one another, that the variable is approximately normally distributed, and that we don't have outliers in the dataset.

First, we compute the difference for each observation. Next, we calculate the average of the differences  $\bar{D}$  and the standard deviation of the differences  $S_D$ .

We find the standard error of the mean difference,  $SE = \frac{S_D}{\sqrt{n}}$ , and then we use

the t-statistic as follows:  $t_{\bar{D}} = \frac{\bar{D} - \mu_D}{\frac{S_D}{\sqrt{n}}}$ .

The examples in the recordings will also show you how to do a paired t-test using a graphing calculator.

### Example (solution in the recording):

We want to test the claim by Mega market that its prices are lower than at the Star.

We randomly sample 7 products:

Product	Mega	Star
Shampoo	4	5
Detergent	8	10
Cake	14	14
Bread	4	3
Coffee	8	6
Wine	18	20
Cheese	7	9

Test Mega's claim at a 5% level of significance.

**Questions:**

- 1) Is there a difference between the prices of two communication companies Pear and Orange? Prices for landline calls in \$/min to 7 random countries were sampled: Assume that prices are distributed normally. Test at a 5% level of significance whether there is a difference between the average prices of the two companies.

Calls to Country	Pear	Orange
US	1.50	1.40
Canada	2.10	2.00
Netherlands	2.20	1.90
Poland	3.00	3.10
Egypt	3.50	3.20
China	3.20	3.20
Japan	4.20	4.20

- 2) A test prep company claims that on average, it raises scores by more than 30 points. Eight randomly selected customers were tested before and after they studied with this company.

Before	506	470	420	640	670	390	500	590
After	570	540	430	610	680	510	520	580

At a 5% level of significance, what is your conclusion?  
Assume that the test scores follow a normal distribution.

- 3) Five students who finished the Statistics II course were randomly sampled. The following table displays their marks in the Statistics I and Statistics II courses: Assume that the grades follow a normal distribution. What conclusion can be drawn at a 10% level of significance?

Statistics I	Statistics II
74	80
68	84
90	87
75	76
82	100

**Answer Key:**

- 1) No difference.
- 2) Their claim doesn't have statistical evidence.
- 3) We can reject the  $H_0$ .