# Independent Samples t tests in SPSS (Practical)

The development of this E-Book has been supported by the British Academy.

## Independent Samples t test practical

In this practical we are going to investigate how to perform an independent samples t-test. This test is used when we have an interval or ratio level variable measured for two separate, or independent, groups of cases and we want to test if the mean of this dependent variable is different in the two groups. The test assumes that the dependent variable is normally distributed in both groups. To run a single test in SPSS requires that your dataset has one column containing the dependent variable to be tested and another column of the same length containing an indicator for which group the case belongs to.

The example provided here explores the question of whether there are gender differences in the PISA measure of achievement in science. The variable SCISCORE is the dependent variable (individuals' test scores) and the group indicator is provided by the GENDER variable (with categories Male and Female).

In this case the groups are identified by specific group codes although it is possible to also use a second continuous variable for groups and specify ranges of this variable that correspond to groups.

Here we are considering the variable, **SCISCORE**.

As a first step we should generally test for the normality of the variable **SCISCORE** in each of the two groups that are indicated by **GENDER**. We first test for normality in each group.

- Select **Descriptive Statistics** from the **Analyze** menu.
- Select **Explore** from the **Descriptive Statistics** sub-menu.
- Click on the **Reset** button.
- Copy the **Science test score[SCISCORE]** variables into the **Dependent List:** box.
- Copy the **Student gender[GENDER]** variable into the **Factor List:** box.
- Click on the **Plots...** button.
- On the screen that appears select the **Histogram** tick box.
- Unselect the **Stem and leaf** button.
- Select the **Normality plots with tests** button.
- Click on the **Continue** button.
- Click on the **OK** button.

We will first look at a histogram of the **SCISCORE** variable, for the group defined by **GENDER** = **Male**. This can be found in amongst the set of output objects and looks as follows:
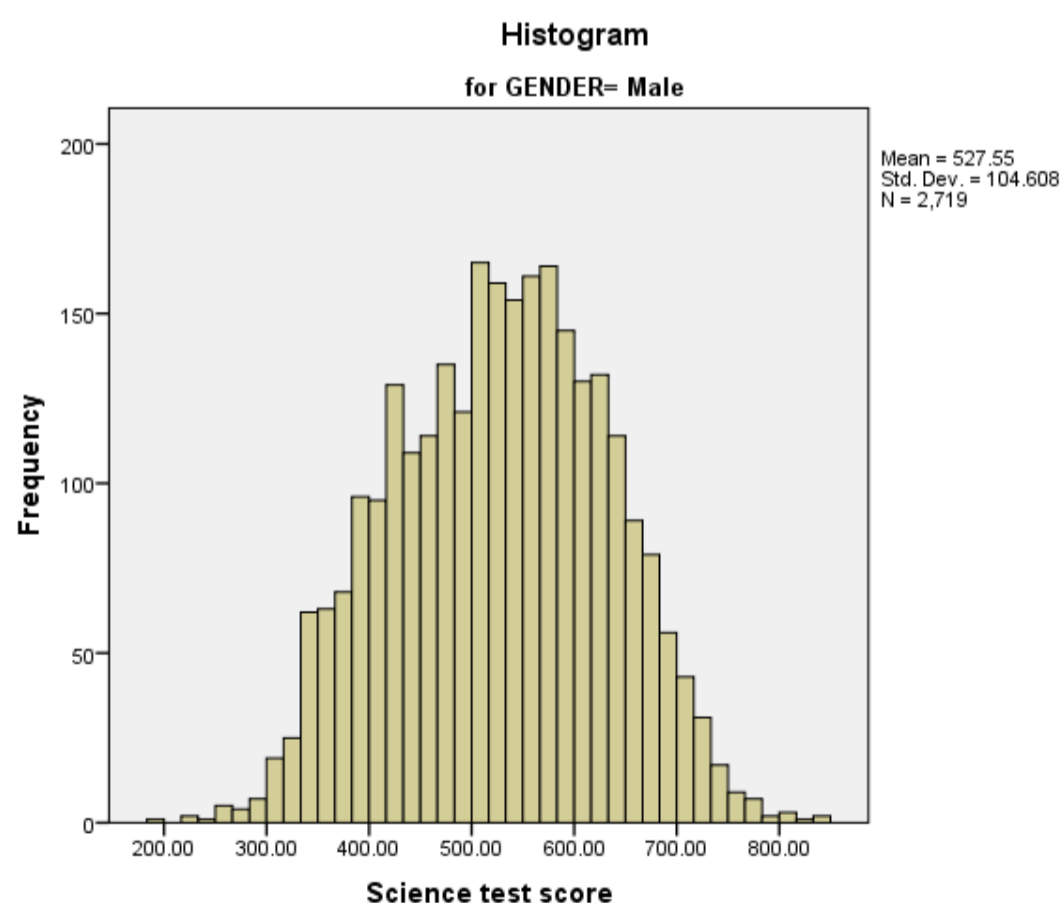


Histogram for GENDER= Male

Mean = 527.55
Std. Dev. = 104.608
N = 2,719

Ideally for a normal distribution this histogram should look symmetric around the mean of the distribution, in this case 527.5540. This distribution appears to be reasonably symmetric.

Next we will look at a histogram of the **SCISCORE** variable, for the group defined by **GENDER** = **Female**. This can be found in amongst the set of output objects and looks as follows:
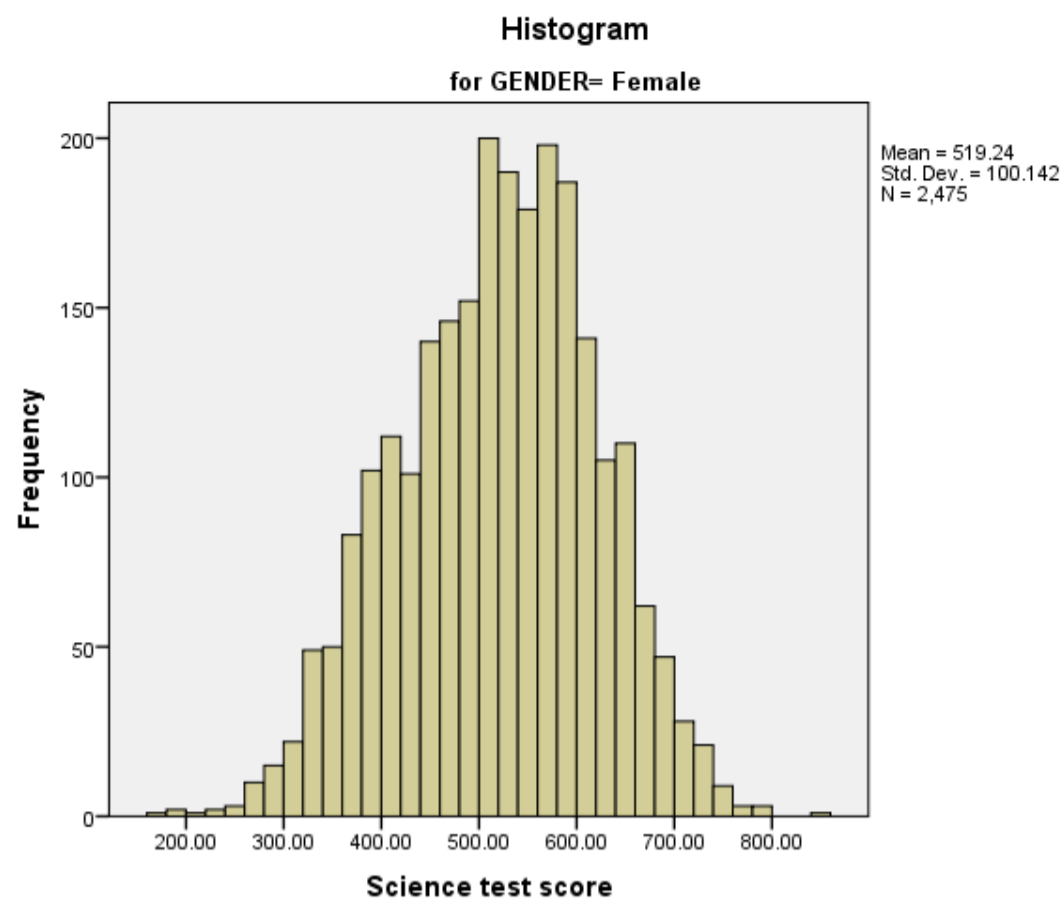
**Histogram**

**for GENDER= Female**

Mean = 519.24
Std. Dev. = 100.142
N = 2,475

Ideally for a normal distribution this histogram should look symmetric around the mean of the distribution, in this case 519.2443. This distribution appears to be negatively skewed.

We will next look at a statistical test to see if this backs up our visual impressions from the histogram.

The Kolmogorov-Smirnov test is used to test the null hypothesis that a set of data comes from a Normal distribution. The Kolmogorov Smirnov test produces test statistics that are used (along with a degrees of freedom parameter) to test for normality.

**Tests of Normality**

| | Student gender | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Science test score | Female | .029 | 2475 | .000 | .996 | 2475 | .000 |
| | Male | .029 | 2719 | .000 | .995 | 2719 | .000 |

a. Lilliefors Significance Correction

For the group **GENDER = Male**: This has degrees of freedom which equals the number of data points, namely 2719.

The p-value provided by SPSS (quoted under Sig. for Kolmogorov-Smirnov) is .000 (reported as p < .001). We therefore have significant evidence to reject the null hypothesis that the variable follows a normal distribution.

For the group **GENDER = Female**: This has degrees of freedom which equals the number of data points, namely 2475.

The p-value provided by SPSS (quoted under Sig. for Kolmogorov-Smirnov) is .000 (reported as p < .001). We therefore have significant evidence to reject the null hypothesis that the variable follows a normal distribution.

Although these statistics tell the researcher whether the distribution followed by a variable is statistically significantly different from a normal distribution one should take care in not overinterpreting such findings. Significance will be strongly affected by the number of observations and so only a small discrepancy from normality will be deemed significant for very large sample sizes whilst very large discrepancies will be required to reject the null hypothesis for small sample sizes.

SPSS also supplies QQ plots to assist in looking at normality but for brevity we do not show them here.
If both groups can be assumed to follow normal distributions then a first descriptive step before performing the t test is to look at an error bar plot to see if the intervals of the two groups overlap.

To do this do the following in SPSS:

- Select **Error Bar** from the **Legacy Dialogs** submenu of the **Graphs** menu.
- Select **Simple** and **Summaries for groups of cases** as for the boxplot and click on the **Define** button.
- Transfer the Science test score[SCISCORE] variable to the **Variable** box.
- Transfer the **Student gender[GENDER]** variable to the **Category Axis** box.
- Click on the **OK** button.

The output will look as follow:
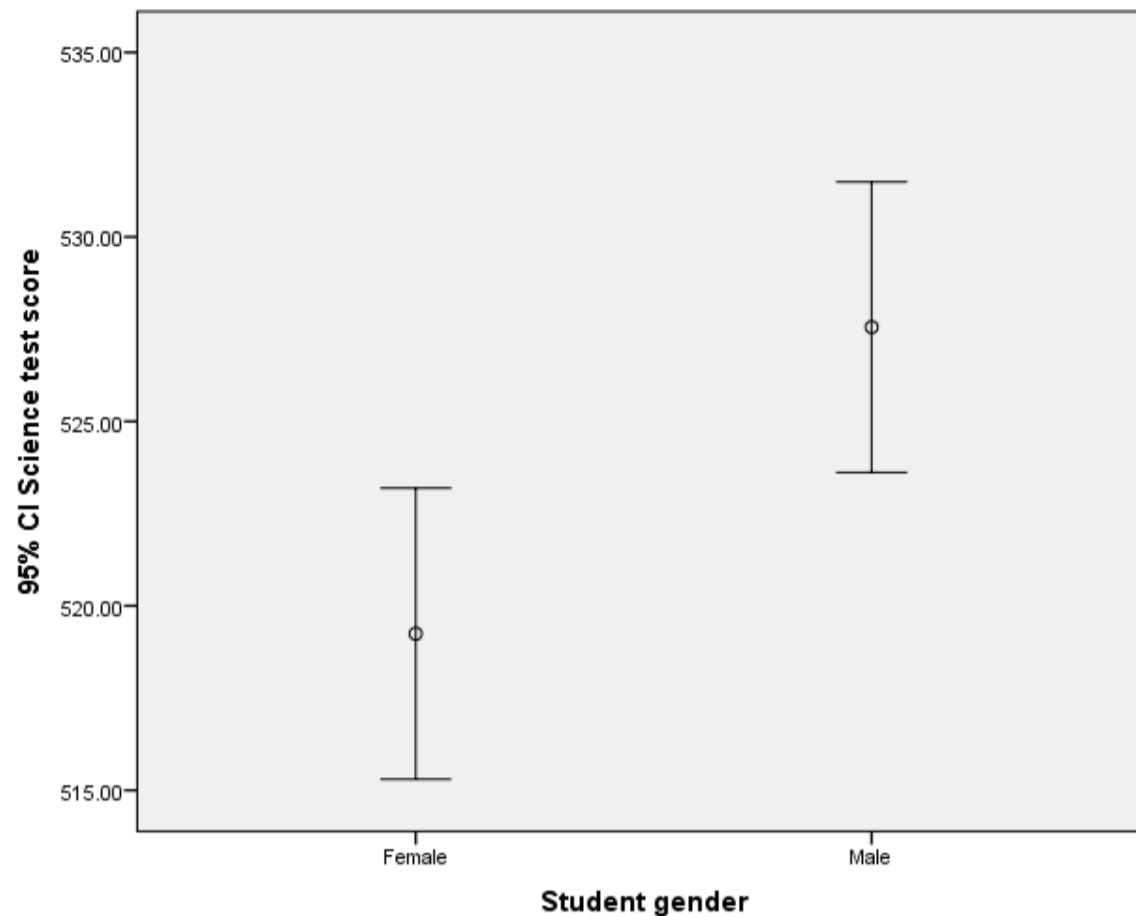
Here we see that the mean of **SCISCORE** in the group **GENDER** = **Male** is higher than the mean for **GENDER** = **Female**. The bars do not overlap so we will expect the t test to return a significant result.

We will now do the t test itself.

Below you will see instructions on how to perform the t test in SPSS. If you follow the instructions you will see the two tabular outputs that are embedded in the explanations below.

- Select **Compare Means** from the **Analyze** menu.
- Select **Independent-Sample T Test...** from the **Compare Means** sub-menu.
- Click on the **reset** button.
- Copy the **Science test score[SCISCORE]** variable into the **Test Variable(s):** box.
- Copy the **Student gender[GENDER]** variable into the **Grouping Variable:** box.
- Click on the **Define Groups...** button.
- Click on the **Use specified values** button.
- Type **2** into the **Group 1** box.
- Type **1** into the **Group 2** box.
- Click on the **Continue** button.
- Click on the **OK** button.

The first SPSS output table contains summary statistics for all the variables considered split by group and can be seen below:

**Group Statistics**

|  | Student gender | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Science test score | Male | 2719 | 527.5540 | 104.60755 | 2.00613 |
|  | Female | 2475 | 519.2443 | 100.14185 | 2.01293 |

The summary statistics table contains 5 columns and 1 row for each group. After the first column which contains the name of each dependent variable and group categories we next see the number of valid observations in each group, i.e. cases with a valid value of **SCISCORE**. Here for the group indexed by **GENDER = Male**, we have 2719 observations and for **GENDER = Female**, there are 2475 observations. Next we see that the mean of the variable **SCISCORE** for the group with **GENDER = Male** is 527.5540 whilst for the group with **GENDER = Female** it is 519.2443. Hence, as we saw from the error bar chart the group with **GENDER = Male** has the bigger mean and the test will now establish if this difference is statistically significant.

In the next column we see the standard deviations for **SCISCORE** variable in the two groups. As we will see in the next table there are two versions of the independent samples t-test depending on whether the variability (and therefore the standard deviations) of the dependent variable in the two groups can be assumed equal or not. In this case the standard deviation of **SCISCORE** when **GENDER = Male** is 104.60755 whilst for **GENDER = Female** it is 100.14185. So there is slightly more variability among **GENDER = Male** than **GENDER = Female**. But is the difference big enough to violate the assumption of equal variances? In the final column are the standard errors of the means for each group. Whilst the standard deviations measure the variability in the data the standard errors of the means measures how confident we are in the estimates of the means. As we collect more data the standard error of the mean gets smaller as we get more confident in the mean estimate and in fact the formula for the standard error of the mean = standard deviation / square root of N. In this case the standard error of the mean for **SCISCORE** when **GENDER = Male** is 2.00613 whilst for **GENDER = Female** it is 2.01293.

The second SPSS output table contains details of the test itself and can be seen below:

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Science test score | Equal variances assumed | 8.483 | .004 | 2.918 | 5192 | .004 | 8.30970 | 2.84773 | 2.72695 | 13.89246 |
| | Equal variances not assumed | | | 2.924 | 5178.827 | .003 | 8.30970 | 2.84190 | 2.73837 | 13.88104 |

The above table in fact captures two tests.

The first test is known as Levene's test and tests the assumption that the variability in the two groups is equal and if this is not the case then a slightly different t-test is performed. The two rows of numbers in the right of the table correspond to the two different versions of the test. We decide which one to report depending on the p-value (labelled Sig in SPSS) of Levene's test. The null hypothesis of Levene's test is that the variances (and SDs) in the two groups are equal in the population. When this is true, the Levene's test statistic follows a standard statistical distribution called an F distribution. Higher values of the F-statistic are associated with a lower likelihood that the sample did indeed come from a population in which the null hypothesis is true. In this case the F statistic has value 8.483 and SPSS calculates the corresponding p value for this statistic which is .004. This p value being less than 0.05 gives us enough evidence to reject the null hypothesis and to assume that the two groups have different variances. This leads us to using the bottom row of numbers to the right in the table.

So if we now look at the bottom row of numbers we will start with the column headed Mean Difference. Here we see the value 8.30970. If you look back at the summary statistics table this value is calculated by subtracting one mean from the other. Here it is positive because earlier we defined Group 1 as corresponding to the group with **GENDER =Male** (with a higher mean) and Group 2 as corresponding to the group with **GENDER =Female** (with a lower mean). The SPSS t-test calculates the mean differences as [Mean of Group 1] - [Mean of Group 2]. If we reversed the definition of the groups in the initial dialog box, in this case the mean difference would have been negative -8.3097. Next to the mean difference is the standard error of the difference. This here has the value 2.84190 and is calculated via a formula from the standard errors of the means of each group and their respective sample sizes. You will notice that this value is slightly different from the value in the row above for results with Equal variances assumed, which results from the adjustment made for unequal variances. Working back to the start of the row, the column entitled t is the statistic used in the t test and t like F is a standard statistical distribution. The t statistic is calculated simply by dividing the mean difference by its standard error so 8.30970 / 2.84190 = 2.924. Next to t is a column labelled df which stands for degrees of freedom and is a parameter used to choose the correct t distribution for the sampling distribution of the statistic. When we can assume equal variances then the degrees of freedom equal two less than the number of observations (N - 2, here 5192) as we have used 2 degrees of freedom in estimating 2 means. If we cannot assume equal variances then the value is lower as seen here (5178.827).

The column labelled "Sig (2-tailed)" contains a test of the null hypothesis that the means of the **SCISCORE** variable in the two groups are the same. By default, the two-tailed test reported uses a non-directional alternative hypothesis. It gives the probability that the data in the sample came from a population in which the group means are truly equal, when either a positive or a negative difference between sample group means is evidence against that null hypothesis. To conduct a one-tailed test, in which the alternative hypothesis specifies a particular direction to the difference, we would simply halve the p-value provided by SPSS.

We can reject the null if there is sufficient evidence that the mean of Group 1 is either higher or lower than the mean of Group 2. SPSS looks up the t statistic in the appropriate table gives the associated p value associated with the calculated t-statistic and degrees of freedom. In this case SPSS reports it as p = .003. Here we see that the p value is less than 0.05 and therefore we can reject the null hypothesis that the two groups have the same means. Finally we can see the 95% confidence interval for the difference which runs from 2.73837 to 13.88104. Another way to decide whether we can reject the null hypothesis is to check whether this interval contains the value 0. Here we see it does not, a finding that would lead us to reject the null hypothesis.

In conclusion, we could report this to a reader as follows: Mean test scores were higher among **GENDER = Male** (N=2719, M=527.5540, SD=104.60755) than **GENDER = Female** (N=2475, M=519.2443, SD=100.14185). Levene's test rejected the null hypothesis of equal variances between the two groups (F=8.483, p < .001) so an adjusted version of the independent samples t-test that relaxes this assumption was chosen. The difference in means (difference = 8.30970) was statistically significant, t(5178.827) = 2.924, p=.003.

According to the PISA test, boys in England were significantly better at science than girls at the age of 15.