

LESSON 5: TEST 02: *t*-Test (Part I)

Now, let's move to a bit more complicated matters and see how to compare two groups under two different conditions, which is a common scenario in the field of TEFL. For that we will need to run a *t*-test.

Researchers often aim to analyze differences among groups, particularly in experimental research where manipulating variables allows causal inferences. The simplest form of experimentation involves a **single independent variable** manipulated in two ways, measured against a single outcome. Frequently, this manipulation involves an experimental condition and a control group. For instance, consider scenarios like comparing teaching methods, assessing vocabulary training techniques, or evaluating learning app outcomes in TEFL research. In these scenarios, researchers manipulate variables (like teaching methods or learning tools) and analyze their impact on outcomes. The aim is to **discern significant differences** between different approaches to language learning and teaching.

Here, I will elaborate on each of these scenarios for a better understanding.

1. Comparing the Effectiveness of Two Teaching Methods:

Scenario: In a TEFL program, an educator is exploring the efficacy of two different teaching methods for enhancing speaking skills among intermediate-level students. The methods include a traditional lecture-based approach and an interactive conversational learning approach. The educator designs two groups, one taught using the lecture-based method and the other with the conversational method, and administers speaking assessments before and after the teaching period.

Research Question: Is there a significant difference in the improvement of speaking skills between students taught through the lecture-based approach and those taught through the conversational approach in the TEFL program?

2. Assessing the Impact of Vocabulary Training Techniques:

Scenario: A researcher in TEFL settings is investigating the effectiveness of two vocabulary training techniques – flashcards and mnemonic devices – on enhancing vocabulary retention among beginner-level language learners. Participants are randomly assigned to either the flashcards group or the mnemonic devices group and undergo a vocabulary test before and after the training period.

Research Question: Is there a significant difference in the post-training vocabulary scores between language learners using flashcards and those using mnemonic devices in the TEFL program?

3. Comparing the Learning Outcomes of Language Apps:

Scenario: In a language institute, researchers are interested in comparing the language proficiency outcomes of students using two different language learning apps over a semester. Students are divided into two groups, one using App A and the other using App B, and their language proficiency is assessed at the beginning and end of the semester.

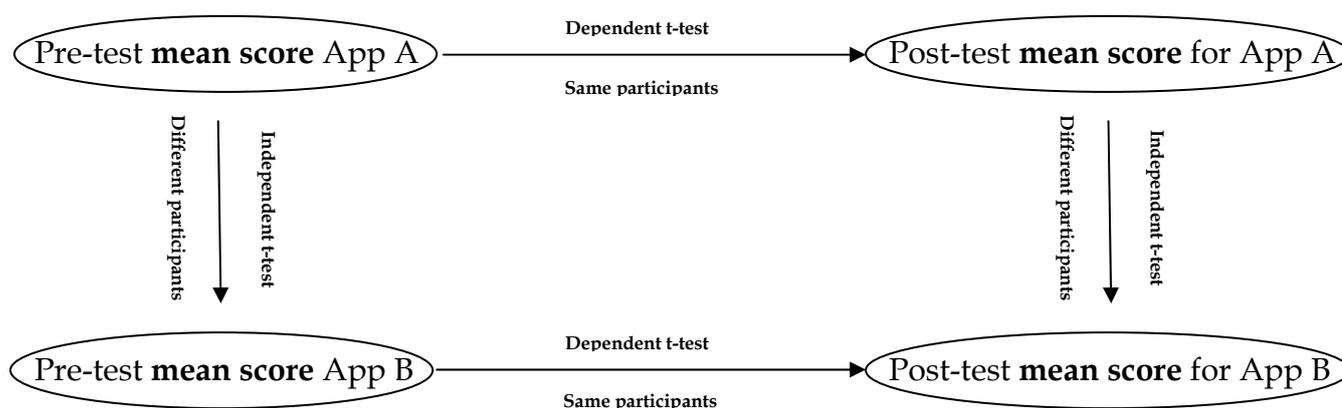
Research Question: Is there a significant difference in language proficiency gains between students using App A and those using App B in the TEFL program?

These scenarios illustrate how t-tests can be applied in TEFL research to compare the effectiveness of teaching methods, training techniques, or learning tools to discern any significant differences between different approaches in language learning and teaching.

Types of *t*-tests:

There are two types: the **Independent-samples t-test**, used when different participants are assigned to distinct conditions, and the **Dependent or Paired-samples t-test**, applied when the same participants are involved in both conditions of the experiment. These tests are fundamental in determining if there are statistically significant differences between experimental conditions in TEFL research.

Note that in the field of TEFL, you might be required to run both the dependent and the independent *t*-tests within the same experimental research. HOW? Let's elaborate more on the 3rd scenario above about the two Apps using the figure below:



Rationale for the *t*-test :

The rationale behind both types of t-tests revolves around **hypothesis testing**. When collecting two sets of data and calculating their **means**, these means might slightly or significantly differ. If these samples originate from the same population, we anticipate their means to be roughly similar. Under the null hypothesis – assuming no effect of the experimental manipulation – we expect close similarity in sample means. By comparing the observed difference between sample means with the expected difference, we can infer two possibilities:

- No effect exists, and the sample means represent atypical fluctuations within the population.
- The samples belong to different populations, showing a genuine difference between them, thereby questioning the null hypothesis.

But what is the mean score?

A mean score, commonly termed the arithmetic average, is computed by summing all values within a set of numbers and dividing the total by the count of values. Often regarded as a measure of central tendency, the mean represents the typical or most representative value within a dataset.

Assumptions of the *t*-test:

Both the independent t-test and the dependent (paired-samples) t-test are parametric tests based on the normal distribution and, therefore, they assume:

- 1- data are from normally distributed populations.
- 2- data are measured at least at the interval level.

Because it is used to test different groups of people, the independent test also assumes:

- 3- variance in these populations are roughly equal (homogeneity of variance)
- 4- scores are independent (because they come from different people)

Testing for Normality using SPSS Statistics

Assessing data normality is crucial for many statistical tests that rely on this assumption. There are two main approaches to determine normality: **graphical** and **numerical**. Graphical methods involve assessing plots or graphs, offering subjective judgment, while numerical tests offer an objective assessment but might lack sensitivity with small sample sizes or become too sensitive with larger ones. Individuals with less experience in graphical interpretation may prefer relying on numerical methods for assessing normality. In SPSS Statistics, comprehensive step-by-step guides are available for testing normality and handling situations where data violates the normality assumption, including transformations to achieve normality.

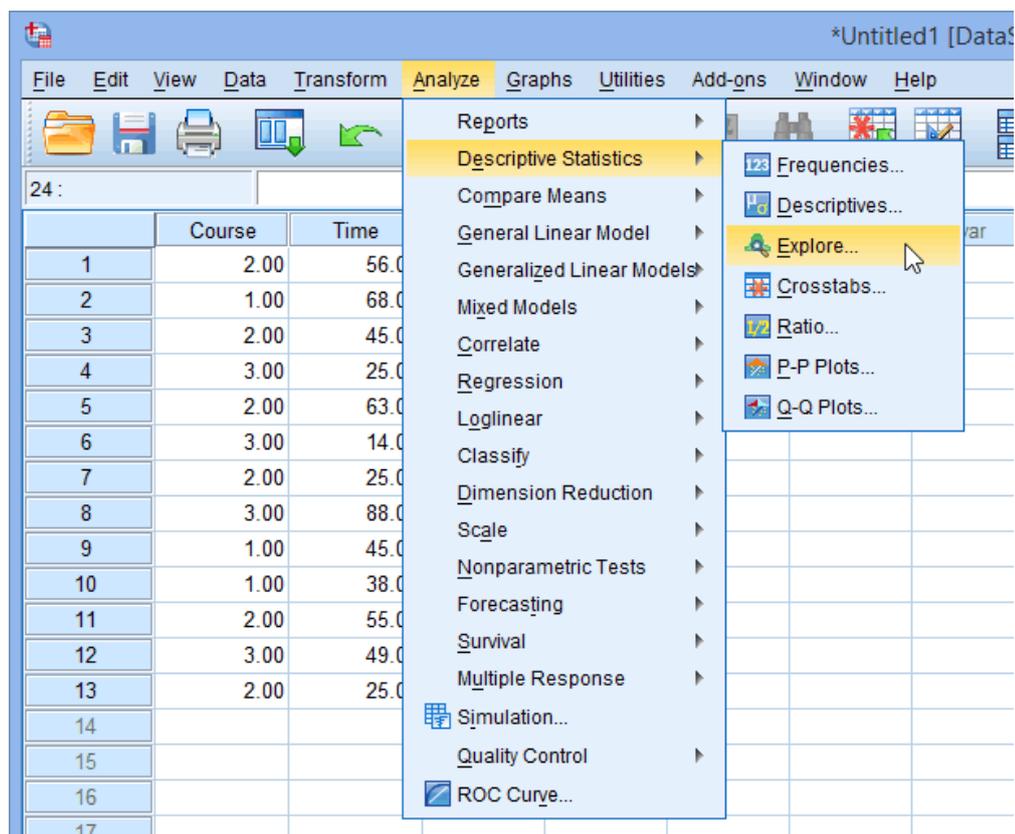
Methods of assessing normality

SPSS Statistics offers the Explore... command to test procedures related to normality. When evaluating normality within one group or multiple groups in a dataset, Explore... command can be used. For instance, determining if participants' **height** data is normally distributed can be accomplished using Explore... If the dataset is split by categorical variables like gender (male and female), the Explore... command helps test the normality of height within each group separately. However, when dealing with multiple categorical independent variables, Explore... command alone might not suffice, necessitating the use of the Split File... command.

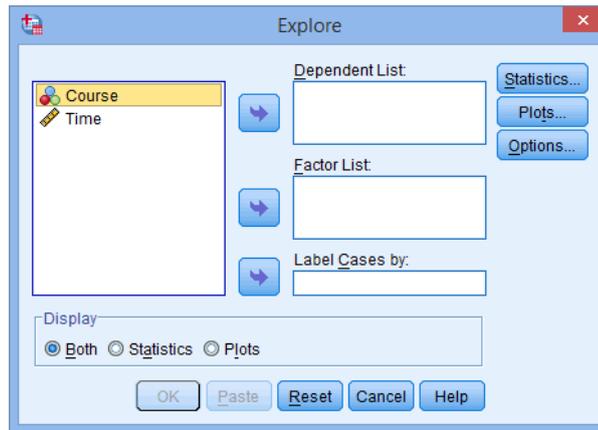
Procedure for none or one grouping variable

In this section we will use the example of the duration of a given course (let's say speaking course). Time would stand as the dataset we are interested in determining the normality (or otherwise). The categorical variables that may split our dataset would be the course level (beginner, intermediate, and advanced)

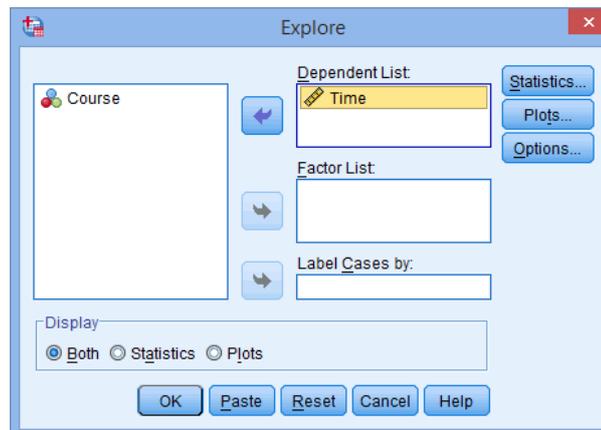
1. Click **Analyze > Descriptive Statistics > Explore...** on the top menu, as shown below:



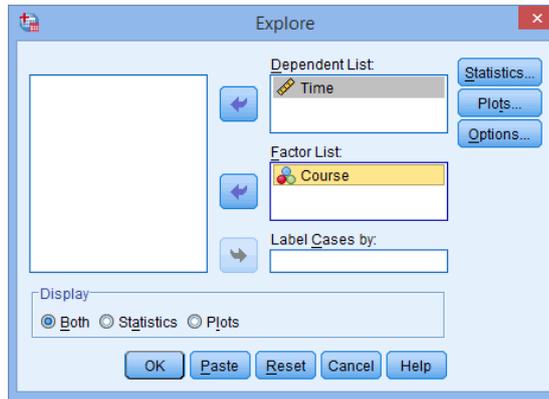
2. You will be presented with the **Explore** dialogue box, as shown below:



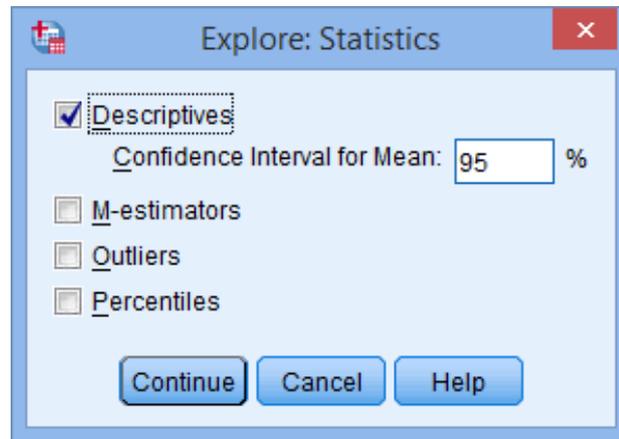
3. Transfer the variable that needs to be tested for normality into the **Dependent List:** box by either drag-and-dropping or using the  button. In this example, we transfer the **Time** variable into the **Dependent List:** box. You will then be presented with the following screen:



4. [Optional] If you need to establish if your variable is normally distributed for each level of your independent variable, you need to add your independent variable to the **Factor List:** box by either drag-and-dropping or using the  button. In this example, we transfer the **Course** variable into the **Factor List:** box. You will be presented with the following screen:

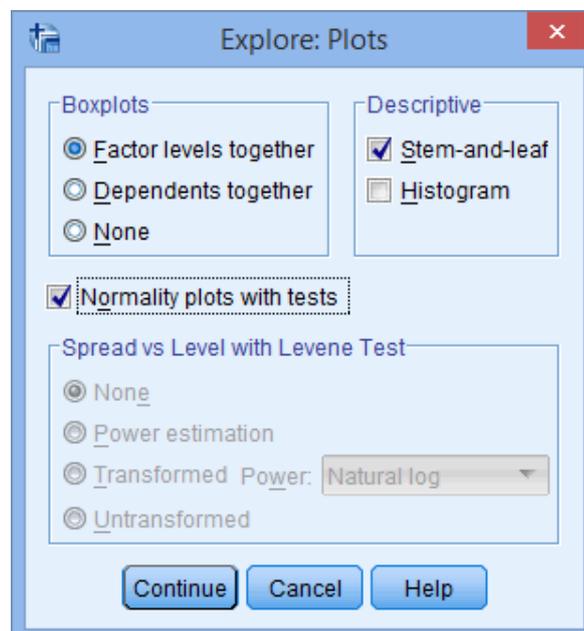


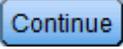
Click on the **Statistics...** button. You will be presented with the **Explore: Statistics** dialogue box, as shown below:



Leave the above options unchanged and click on the **Continue** button.

5. Click on the **Plots...** button. Change the options so that you are presented with the following screen:



6. Click on the  button.

7. Click on the  button.

Output

SPSS Statistics outputs many table and graphs with this procedure. One of the reasons for this is that the **Explore...** command is not used solely for the testing of normality, but in describing data in many different ways. When testing for normality, we are mainly interested in the **Tests of Normality** table and the **Normal Q-Q Plots**, our numerical and graphical methods to test for the normality of data, respectively.

Kolmogorov-Smirnov and Shapiro-Wilk Test of Normality

Course		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Time	Beginner	.177	10	.200 [*]	.964	10	.827
	Intermediate	.166	10	.200 [*]	.969	10	.882
	Advanced	.151	10	.200 [*]	.965	10	.837

a. Lilliefors Significance Correction

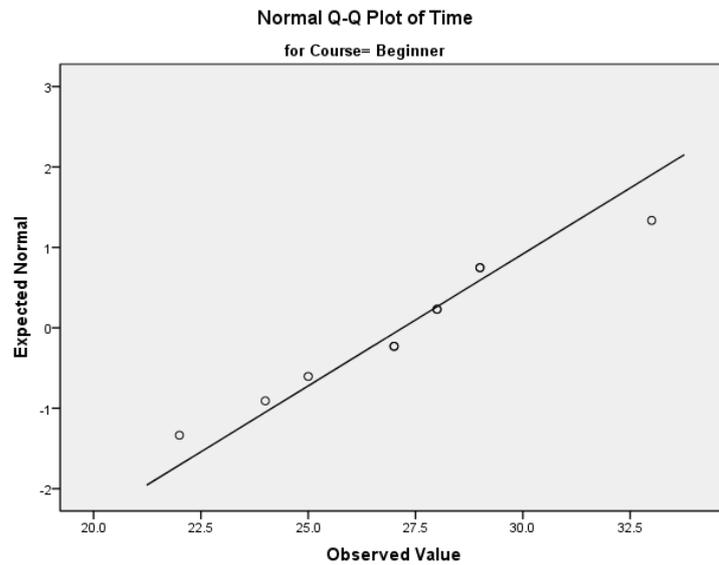
*. This is a lower bound of the true significance.

The above table presents the results from two well-known tests of normality, namely the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test. **The Shapiro-Wilk Test** is more appropriate for small sample sizes (< 50 samples), but can also handle sample sizes as large as 2000. For this reason, we will use the Shapiro-Wilk test as our numerical means of assessing normality.

We can see from the above table that for the "Beginner", "Intermediate" and "Advanced" Course Group the dependent variable, "Time", was normally distributed. **How do we know this?** If the **Sig.** value of the Shapiro-Wilk Test is **greater than 0.05**, the data is **normal**. If it is below 0.05, the data significantly deviate from a normal distribution.

Normal Q-Q Plot

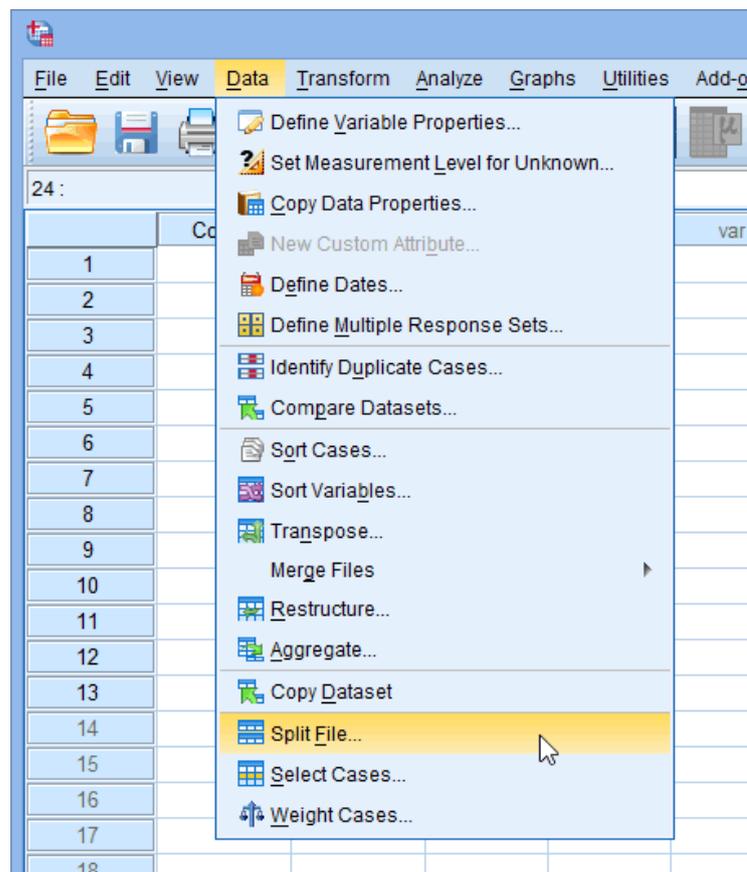
In order to determine normality graphically, we can use the output of a normal Q-Q Plot. If the data are normally distributed, **the data points will be close to the diagonal line**. If the data points stray from the line in an obvious non-linear fashion, the data are not normally distributed. As we can see from the normal Q-Q plot below, the data is normally distributed. If you are at all unsure of being able to correctly interpret the graph, rely on the numerical methods instead because it can take a fair bit of experience to correctly judge the normality of data based on plots.



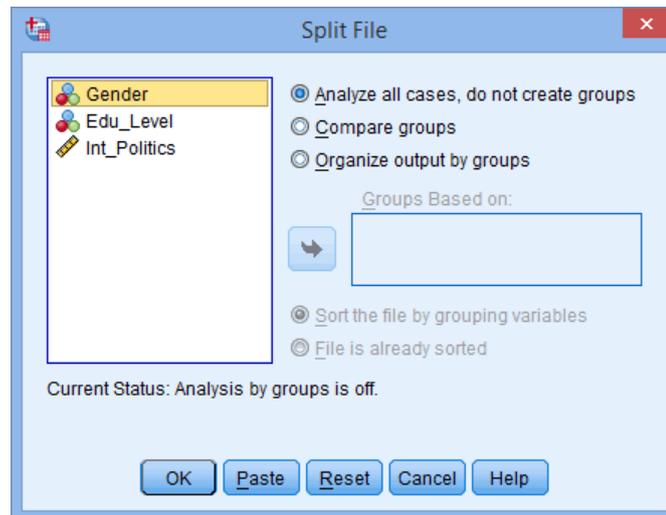
Procedure when there are two or more independent variables

The **Explore...** command on its own cannot separate the dependent variable into groups based on not one but two or more independent variables. However, we can perform this by using the **Split File...** command.

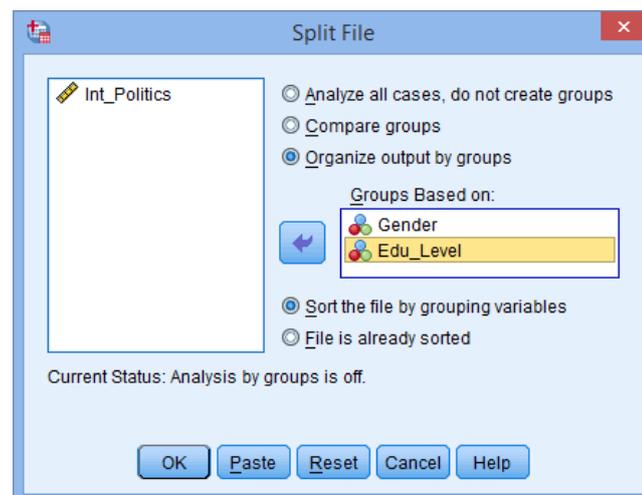
1. Click **Data > Split File...** on the top menu as shown below:

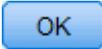


2. You will be presented with the **Split File** dialogue box, as shown below:



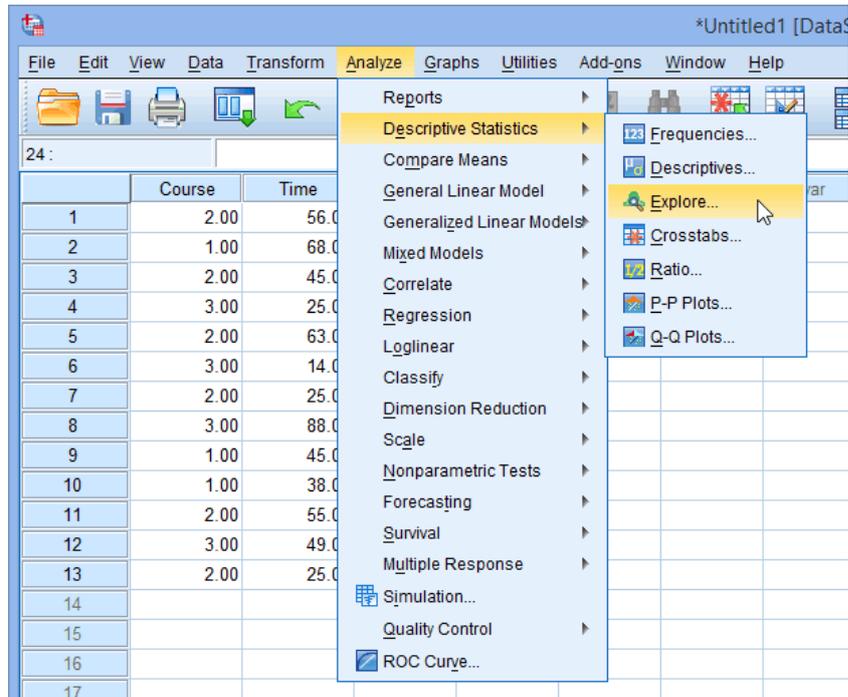
3. Click the option, Organize output by groups. Transfer the independent variables you wish to categorize the dependent variable on into the Groups Based on: box. In this example, we want to know whether interest in politics (Int_Politics) is normally distributed when grouped/categorized by Gender AND Edu_Level (education level). You will be presented with the following screen:



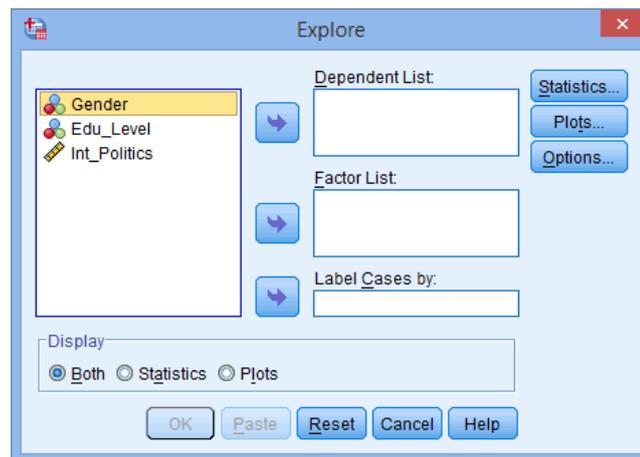
4. Click on the  button.

Note: Your file is now split and the output from any tests will be organized into the groups you have selected.

1. Click Analyze > Descriptive Statistics > Explore... on the top menu as shown below:

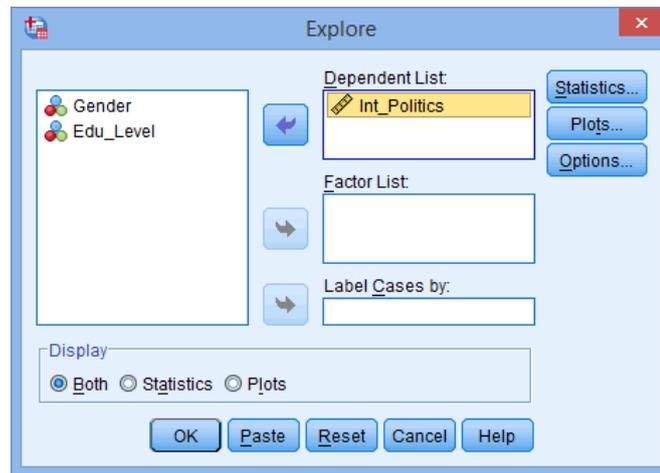


2. You will be presented with the **Explore** dialogue box, as shown below:



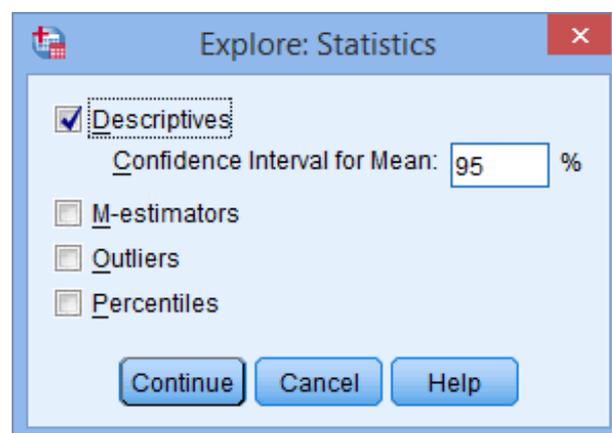
3. Leave the above options unchanged and click on the **Continue** button.

4. Transfer the variable that needs to be tested for normality into the Dependent List: box by either drag-and-dropping or using the  button. In this example, we transfer the **Int_Politics** variable into the Dependent List: box. You will then be presented with the following screen:

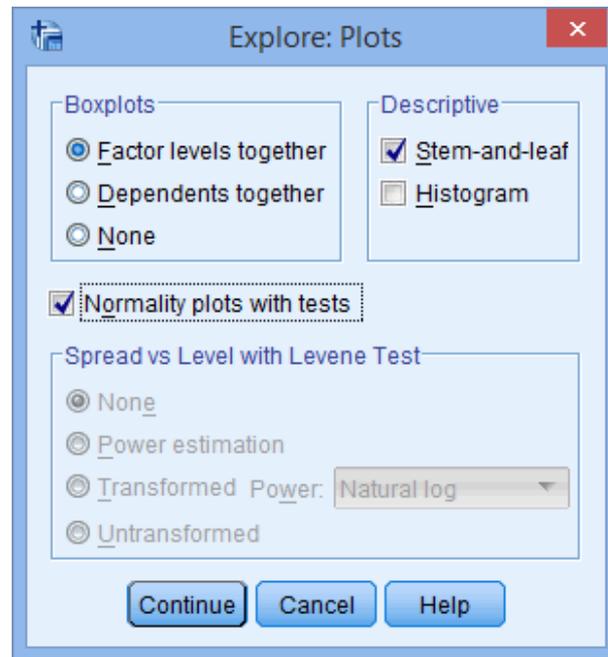


Note: There is no need to transfer the independent variables *Gender* and *Edu_Level* into the Factor List: box because this has been accomplished with the **Split File...** command. We cannot simply transfer these two independent variables into the Factor List: box because this will not achieve the desired result. It will first analyse *Int_Politics* for normality with respect to *Gender* and then with respect to *Edu_Level*. It does NOT analyse *Int_Politics* for normality by grouping individuals into both *Gender* and *Edu_Level* AT THE SAME TIME.

5. Click on the **Statistics...** button. You will be presented with the **Explore: Statistics** dialogue box, as shown below:



6. Leave the above options unchanged and click on the **Continue** button.
7. Click on the **Plots...** button. Change the options so that you are presented with the following screen:



8. Click on the **Continue** button.

Click on the **OK** button.