Paired t-Test

Dependent Samples t-Test

Paired t-Test

The paired t-Test tests the difference between Mean in pairs of measurements to a Mean of zero

The Paired t-test compares the differences between pairs of ***measurements taken from the same test subjects*** at different times or under different conditions

Paired t-Test

Paired *t*-test			
	Before Training	After Training	Difference $n = 5$
K. Albert	74	78	+4
P. Jacobs	76	83	+7
T. Smith	73	81	+8
R. Wang	81	84	+3
D. Young	78	86	+8

Paired t-Test

$$\text{Paired } t\text{-test: } \frac{\bar{d} - 0}{s_d / \sqrt{n}}$$

Paired t-Test

$\bar{d}$ **is the Mean of the differences in the two values comprising each pair**

Paired t-Test

Degree of freedom

$n - 1$

(*n* is the number of pairs)

Paired t-Test

- There are two sets of measurements taken – **before and after**

- The test treats it as one Sample which consists of the differences calculated between the two measurements taken from each individual test subject

Paired t-Test

Conditions for use

- Check for normality of the measurements after the experiment takes place (difference between means)

- The most common use for the Paired t-test is for a “before and after” analysis

Paired t-Test

EXAMPLE

Does a training program make a Statistically Significant difference in the production output of individual workers?

Paired t-Test

The 2-Sample t-test would not work as well for answering that question.

There are any number of **Factors** which can affect worker production output. Experience is one. If one Sample has workers with more experience than the other Sample, then that could give us misleading results.

But if we measure the same workers before and after training, we can eliminate other Factors, like experience, so that we can focus on only one Factor – **the training**

Paired t-Test

Before

After

Paired t-Test

Compared to the 2-Samples t-test the Paired t-test does a much better job of **Blocking** out the **effect of other Factors (Experimental Design)**

Paired t-Test

Null Hypothesis

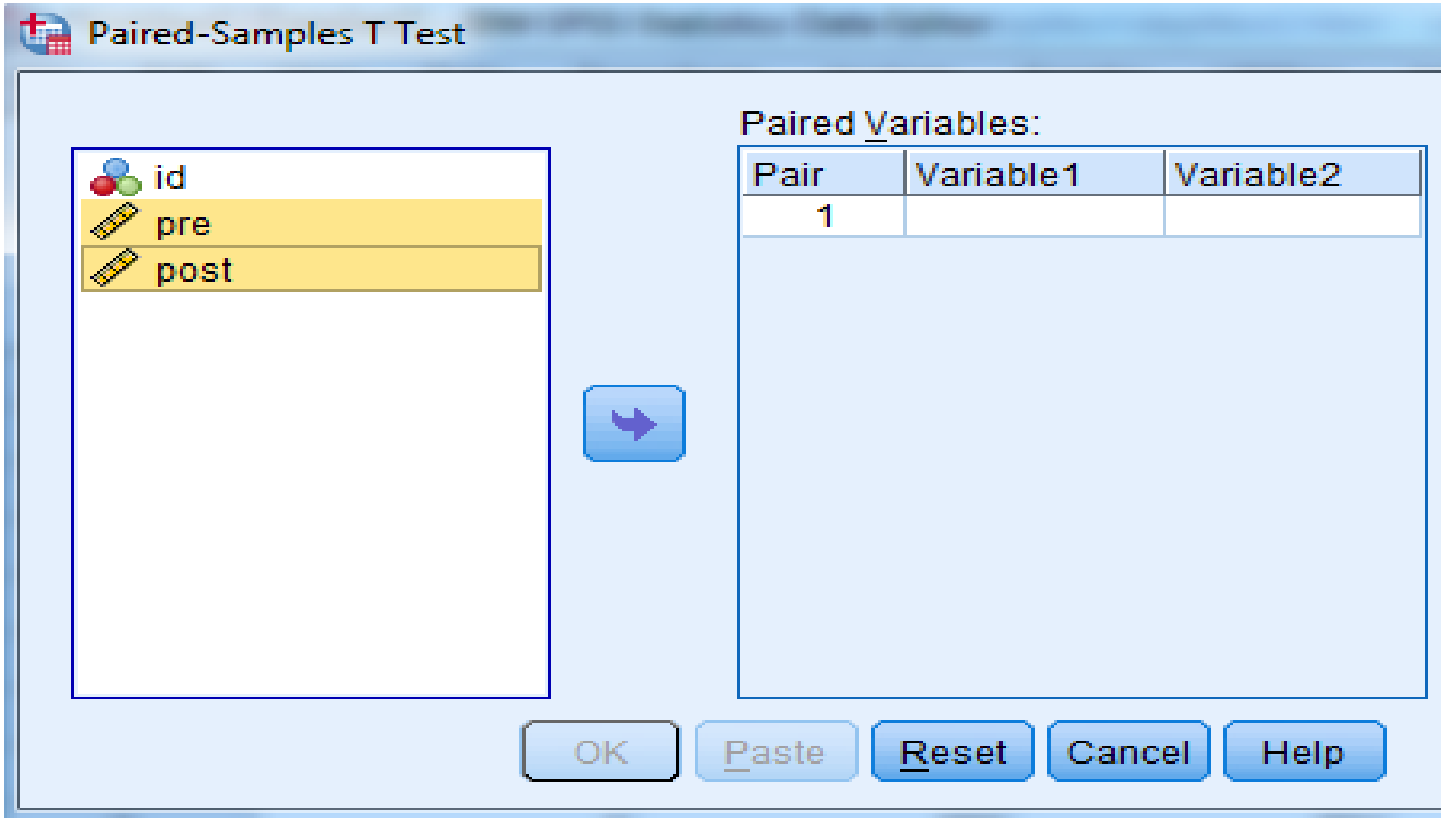
The experiment (training) has had **No** (Statistically Significant) **effect**

Paired t-Test

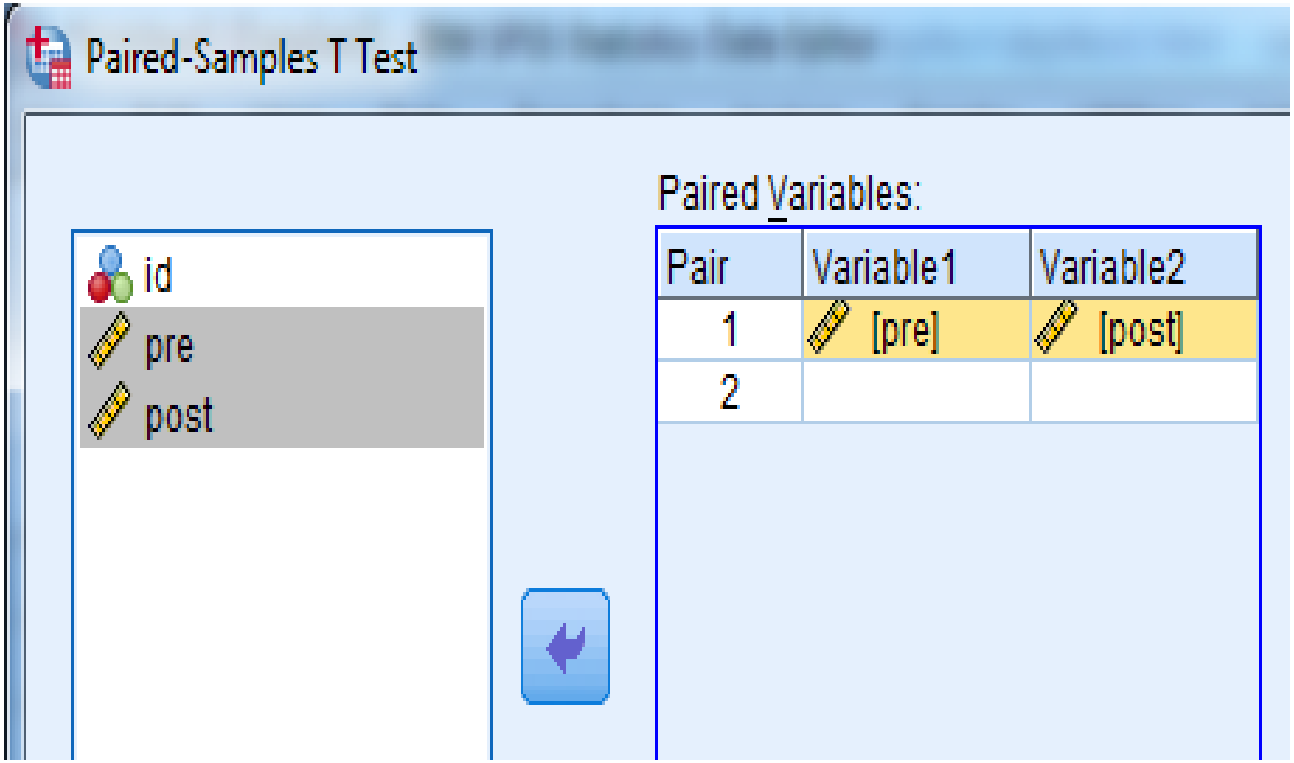
H0= Mean difference between the two paired measurements is zero

HA= Mean difference between the two paired measurements is not equal to zero

Paired t-Test



Paired t-Test



Paired t-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pre	1073.00	20	165.119	36.922
	post	1088.80	20	164.560	36.797

Paired t-Test

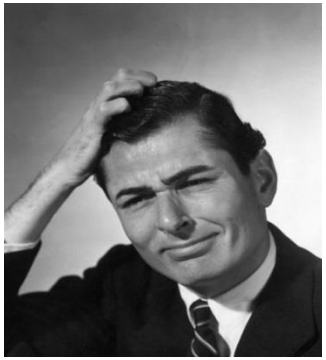
Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pre - post	-15.800	2.648	.592	-17.039	-14.561	-26.687	19	.000

Paired t-Test

Does the Biostatistics course add to the students' knowledge in statistics??

Paired t-Test



Student	Before mark	After mark	Diff
1	18	22	4
2	21	25	4
3	16	17	1
4	22	24	2
5	19	16	-3
6	24	29	5
7	17	20	3
8	21	23	2
9	23	19	-4
10	18	20	2
11	14	15	1
12	16	15	-1
13	16	18	2
14	19	26	7
15	18	18	0
16	20	24	4
17	12	18	6
18	22	25	3
19	15	19	4
20	17	16	-1

Paired t-Test

- H0: There is no difference in mean pre- and post-marks

- HA: There is a difference in mean pre- and post-marks

Paired t-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Mark after	20.45	20	4.058	.907
	Mark before	18.40	20	3.152	.705

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Mark after - Mark before	**2.050**	2.837	.634	.722	3.378	3.231	19	**.004**

p-value

Paired t-Test

Conclusion:

There is strong evidence ($t = 3.23$, $p = 0.004$) that the teaching intervention improves marks

Paired t-Test

In an experiment to compare **anxiety levels** induced between looking at real spiders and pictures of spiders, the following data was collected from 12 people with a fear of spiders (arachnophobia)

Paired t-Test

	Anxiety score		
Participant	Picture	Real	Diff
1	30	40	10
2	35	35	0
3	45	50	5
4	40	55	15
5	50	65	15
6	35	55	20
7	55	50	-5
8	25	35	10
9	30	30	0
10	45	50	5
11	40	60	20
12	50	39	11

Paired t-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Anxiety score when looking at a spider picture	40.00	12	9.293	2.683
	Anxiety score when looking at a real spider	47.00	12	11.029	3.184

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	Std. Error Mean	95% CI of the Difference Lower	95% CI of the Difference Upper			
Pair 1	Anxiety score when looking at a spider picture - Anxiety score when looking at a real spider	-7.000	9.807	2.831	-13.231	-.769	-2.473	11	.031

Paired t-Test

There is evidence to suggest that participants experienced statistically significantly greater anxiety ($p = 0.031$) when exposed to real spiders (mean = 47.0 units, SD = 9.3) than to pictures of spiders (mean = 40.0 units, SD = 11.0).`The 95% confidence interval for the difference is (-13.2,-0.77)

Test for Normality

To test for normality of the quantitative variable:

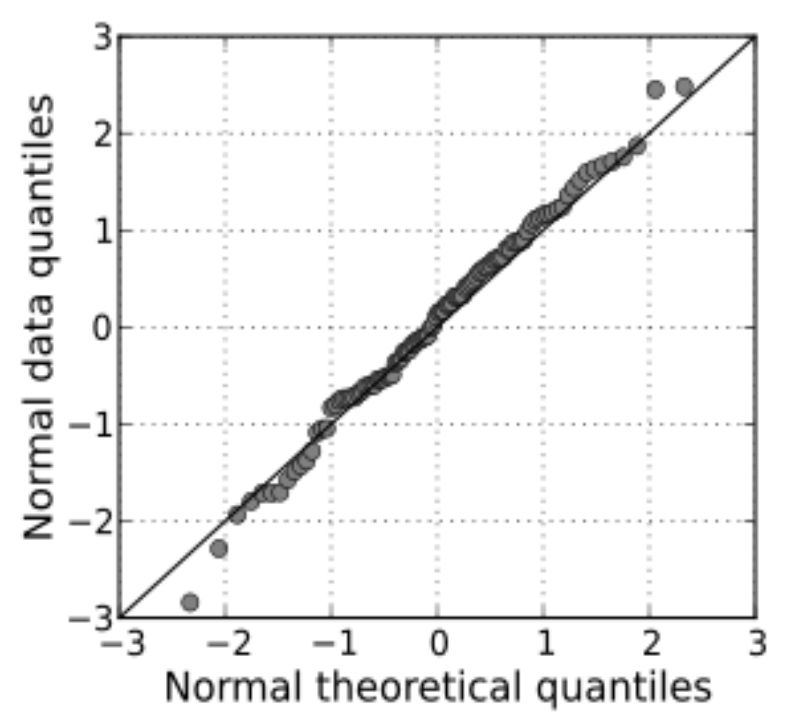
1- Q-Q Plot

2- Kolmogorov-Smirnov Test

3- Shapiro-Wilk Test

Test for Normality

Q-Q Plot

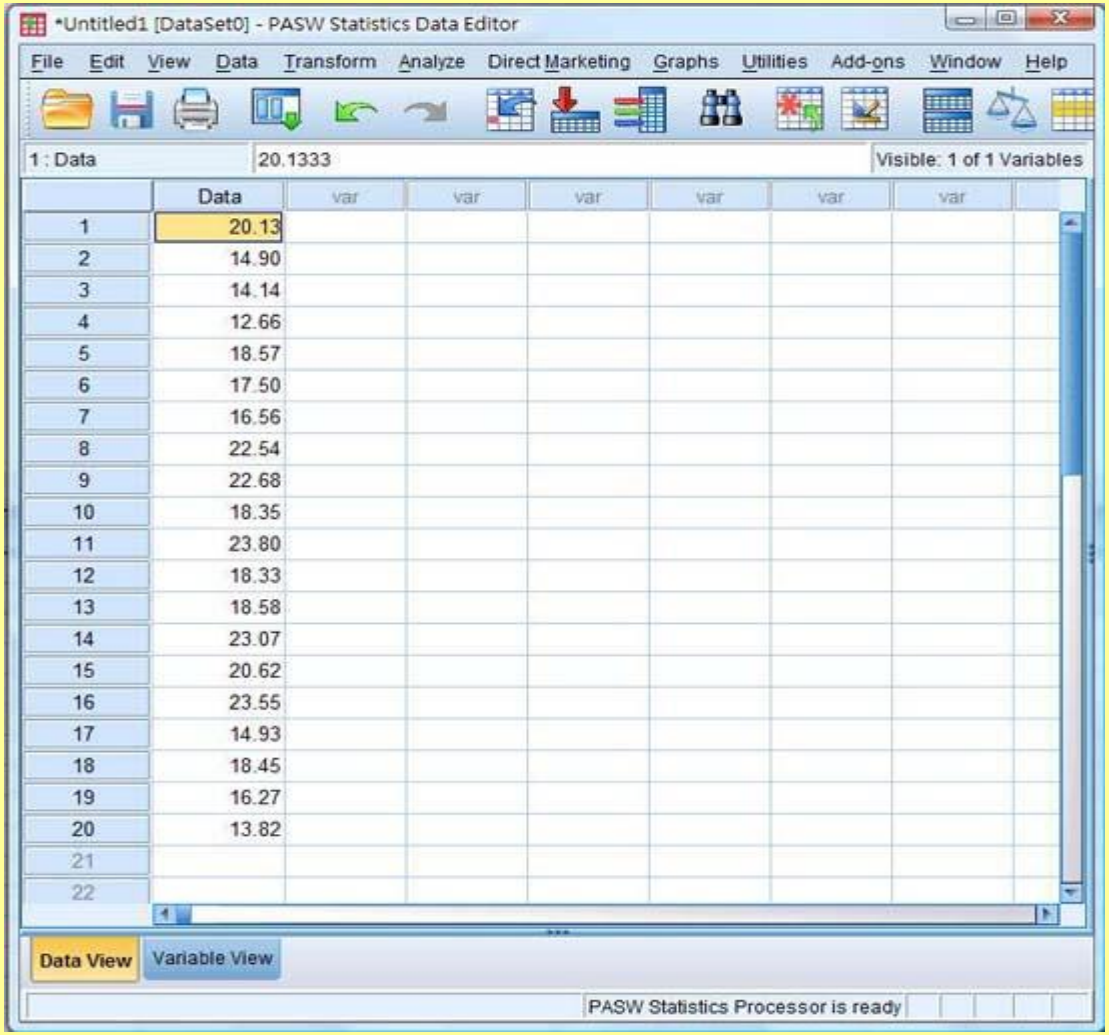


Test for Normality

Null Hypothesis for Kolmogorov-Smirnov Test & Shapiro-Wilk Test

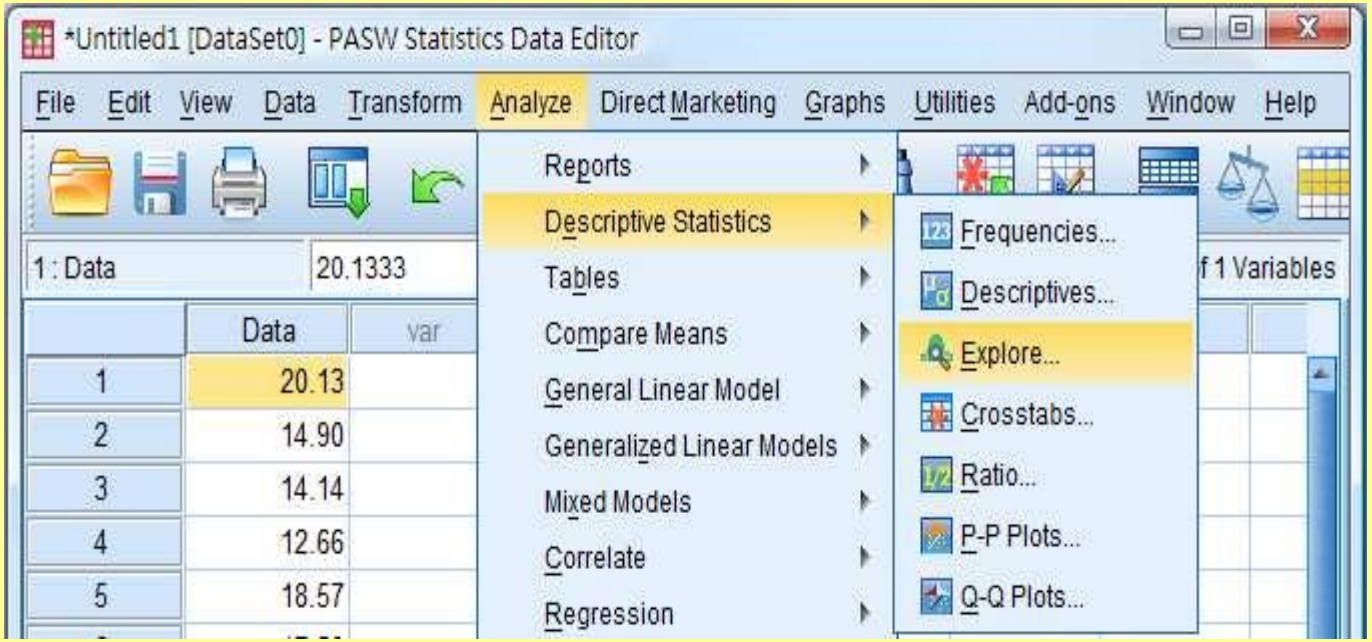
The DATA is normally distributed

Test for Normality

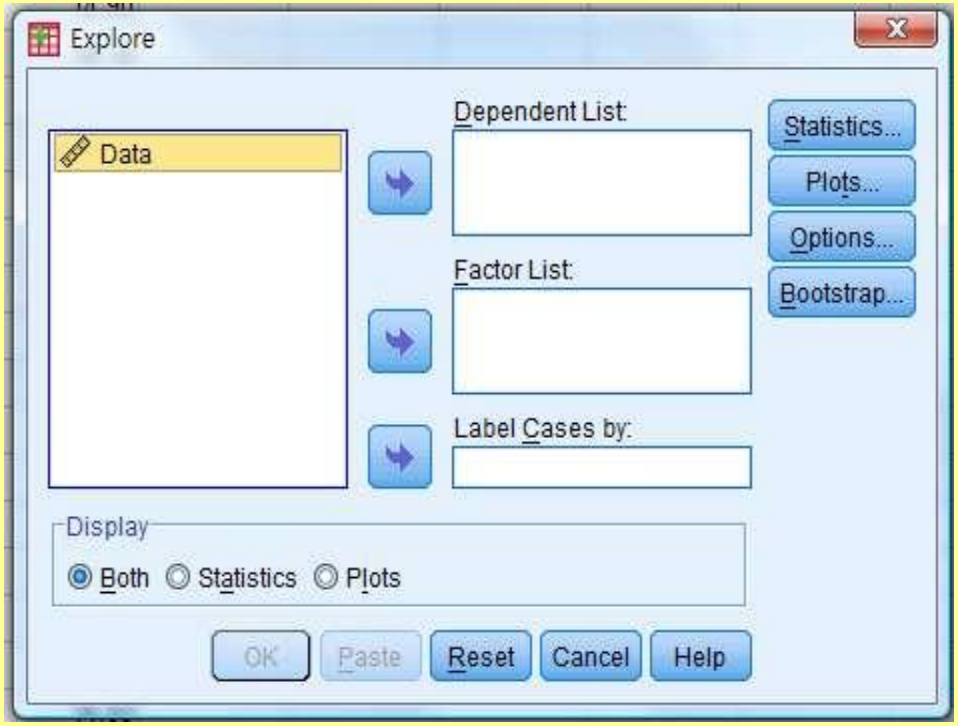


Test for Normality

Select "Analyze -> Descriptive Statistics -> Explore

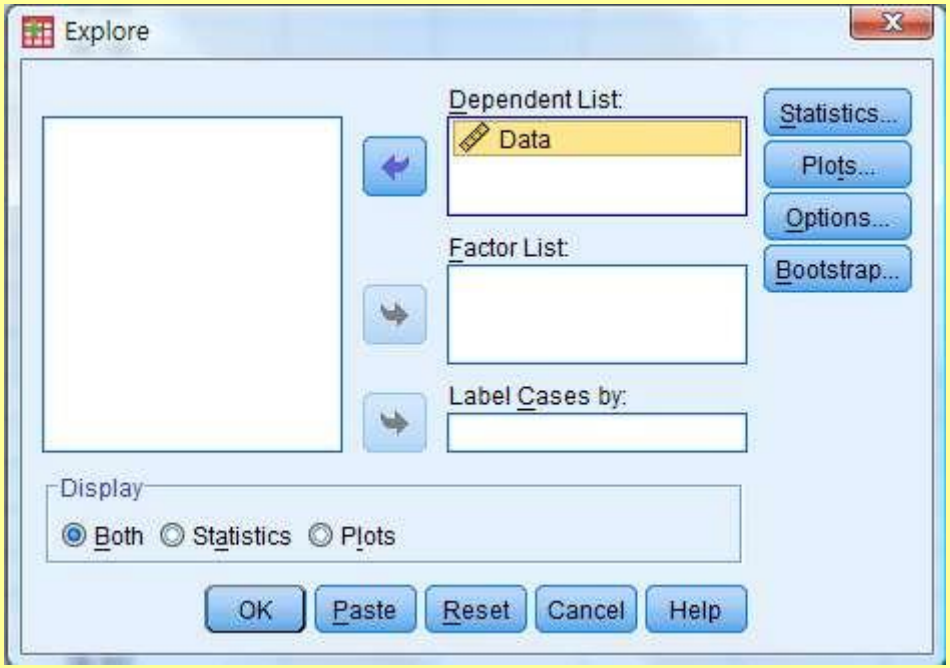


Test for Normality

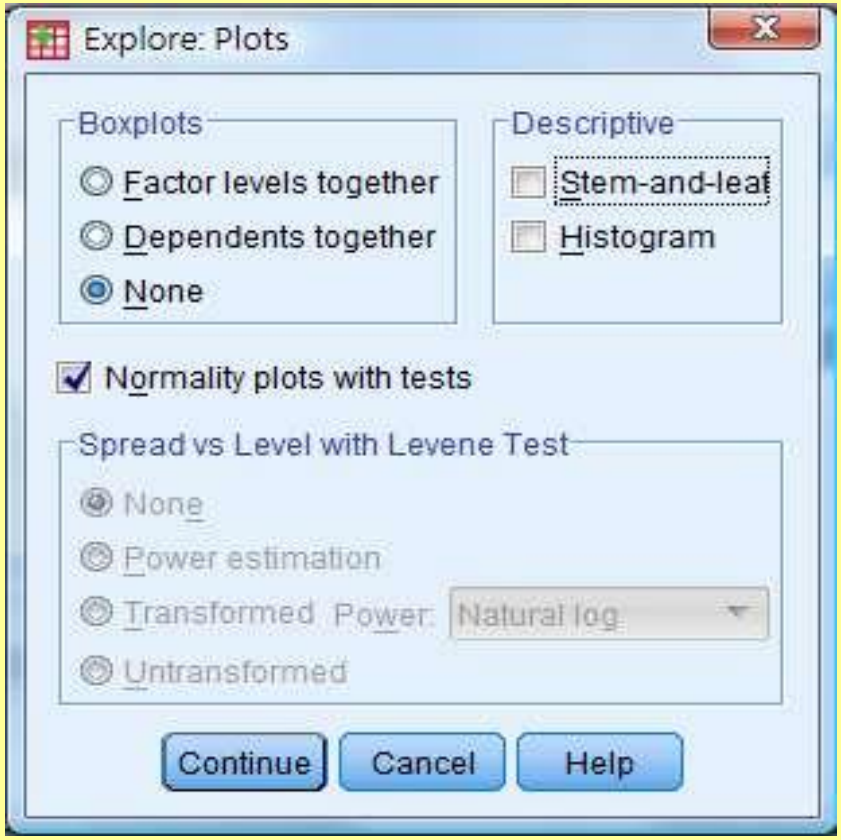


Test for Normality

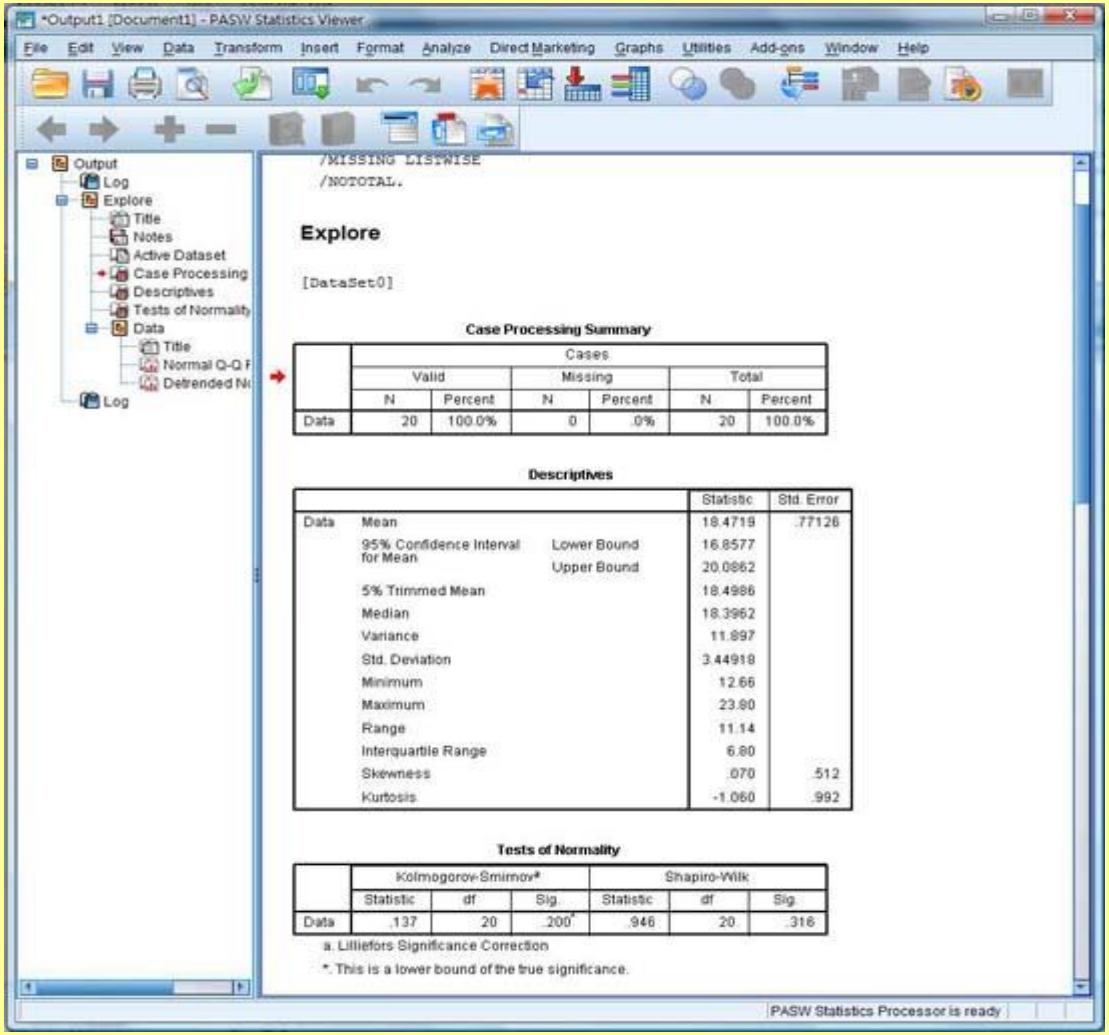
From the list on the left, select the variable "Data" to the "Dependent List"



Test for Normality



Test for Normality



Test for Normality

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Data	20	100.0%	0	.0%	20	100.0%

Descriptives

			Statistic	Std. Error
Data	Mean		18.4719	.77126
	95% Confidence Interval for Mean	Lower Bound	16.8577	
		Upper Bound	20.0862	
	5% Trimmed Mean		18.4986	
	Median		18.3962	
	Variance		11.897	
	Std. Deviation		3.44918	
	Minimum		12.66	
	Maximum		23.80	
	Range		11.14	
	Interquartile Range		6.80	
	Skewness		.070	.512
	Kurtosis		-1.060	.992

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Data	.137	20	.200*	.946	20	.316

a. Lilliefors Significance Correction

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