UJI BEDA

(t Test for Independent & Paired Groups)

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2022

The independent *t* test is used for testing the difference between the means of two independent groups. It is particularly useful when the research question requires the comparison of variables (measured at least at the *ordinal* level) obtained from two independent samples.

“Do males and females differ in performance on a standardized achievement test?”

“What is the effect of drug versus no drug on rats’ maze learning behavior?”

“Does the recidivism rate of juvenile offenders who are provided with father fgures differ from those without father fgures?”

Checklist of Requirements

In any one analysis, there must be:

• Only one independent (grouping) variable (IV)
(e.g., subject's gender)
• Only two levels for that IV (e.g., male, female)
• Only one dependent variable (DV)

Assumptions

- **Independence**—The two groups are independent of one another.
- **Normality**—The dependent variable is normally distributed.
- **Homogeneity of variance**—That is, the distribution of the dependent variable for one of the groups being compared has the same variance as the distribution for the other group being compared.

Example

A researcher wants to investigate whether frst-year male and female students at a university differ in their memory abilities. Ten male students and 10 female students were randomly selected from the frst-year enrolment roll to serve as subjects.

All 20 subjects were read 30 unrelated words and were then asked to recall as many of the words as possible. The numbers of words correctly recalled by each subject were recorded.

Males	Females
s1 16	s1 24
s2 14	s2 23
s3 18	s3 26
s4 25	s4 17
s5 17	s5 18
s6 14	s6 20
s7 19	s7 23
s8 21	s8 26
s9 16	s9 24
s10 17	s10 20

Data Entry Format

Variables	Column	Code
Gender	1	1 = male, 2 = female
Words	2	Number of words correctly recalled

Independence

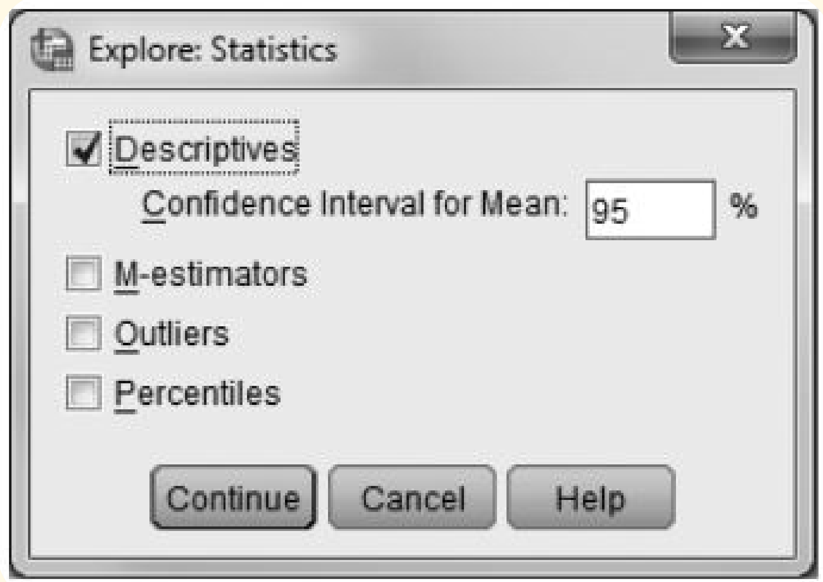
During data collection, ensure that the observations in one group are independent of the observations of the other group.

Normality

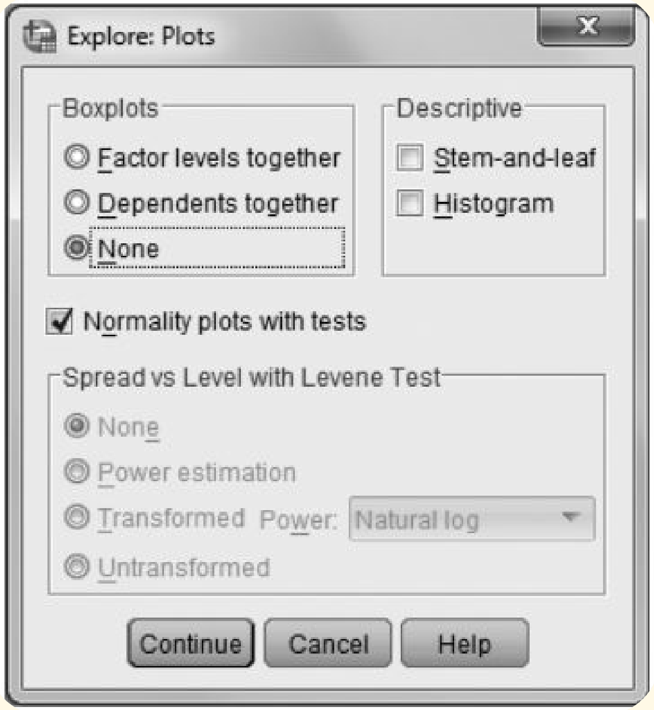
From the menu bar, click **Analyze**, then **Descriptive Statistics**, and then **Explore…** . The following **Explore** window will open.

Transfer the **WORDS** variable to the **Dependent List:** feld by clicking this variable (highlight) and then clicking

Click to open the **Explore: Statistics** window. Check the **Descriptives** feld and click to return to the **Explore** window



In the **Explore** window click to open the **Explore: Plots**



window. Check the **Normality plots with tests** feld. Click to return to the **Explore** window.

SPSS Output

Explore Analysis (Selected) Output

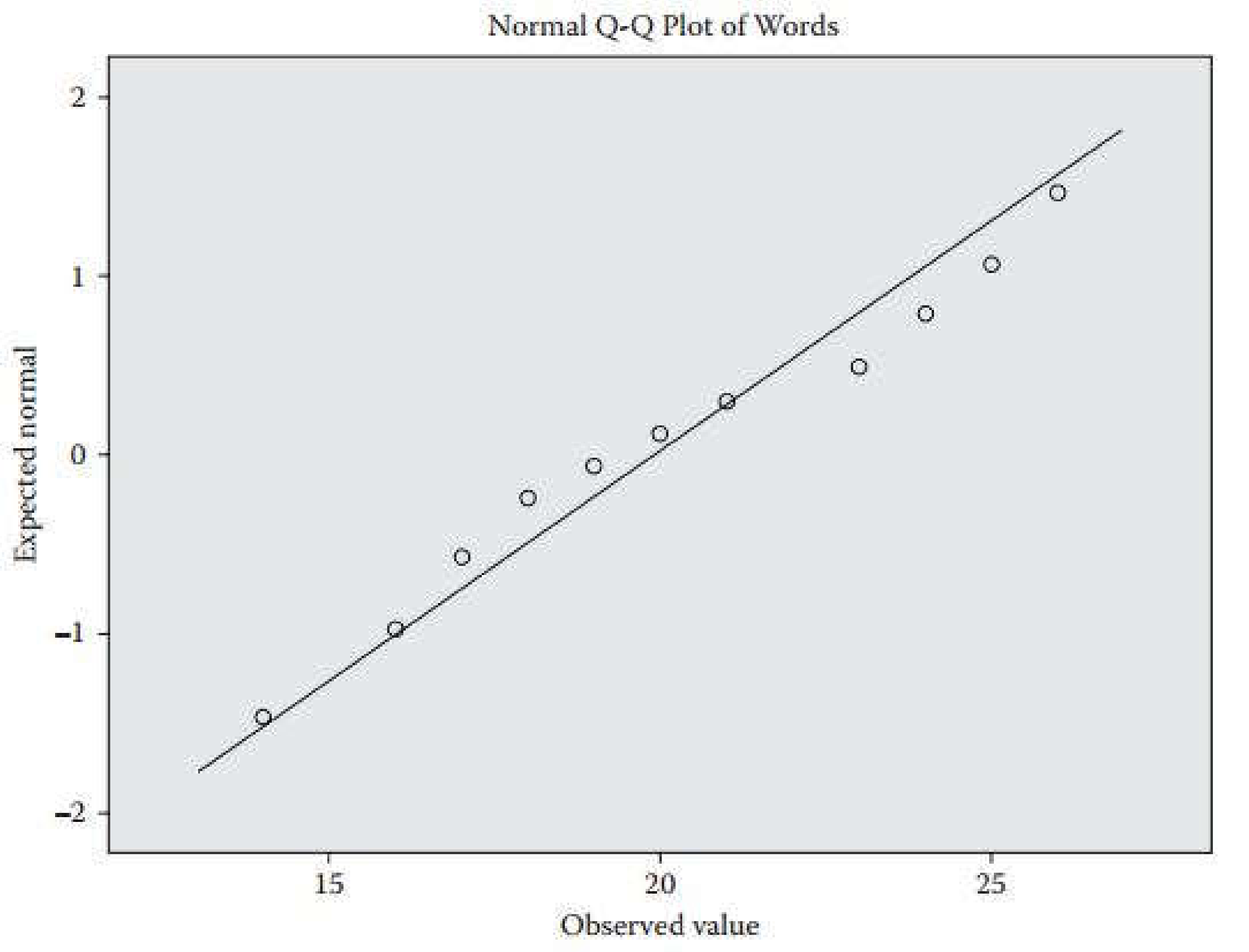
Descriptives

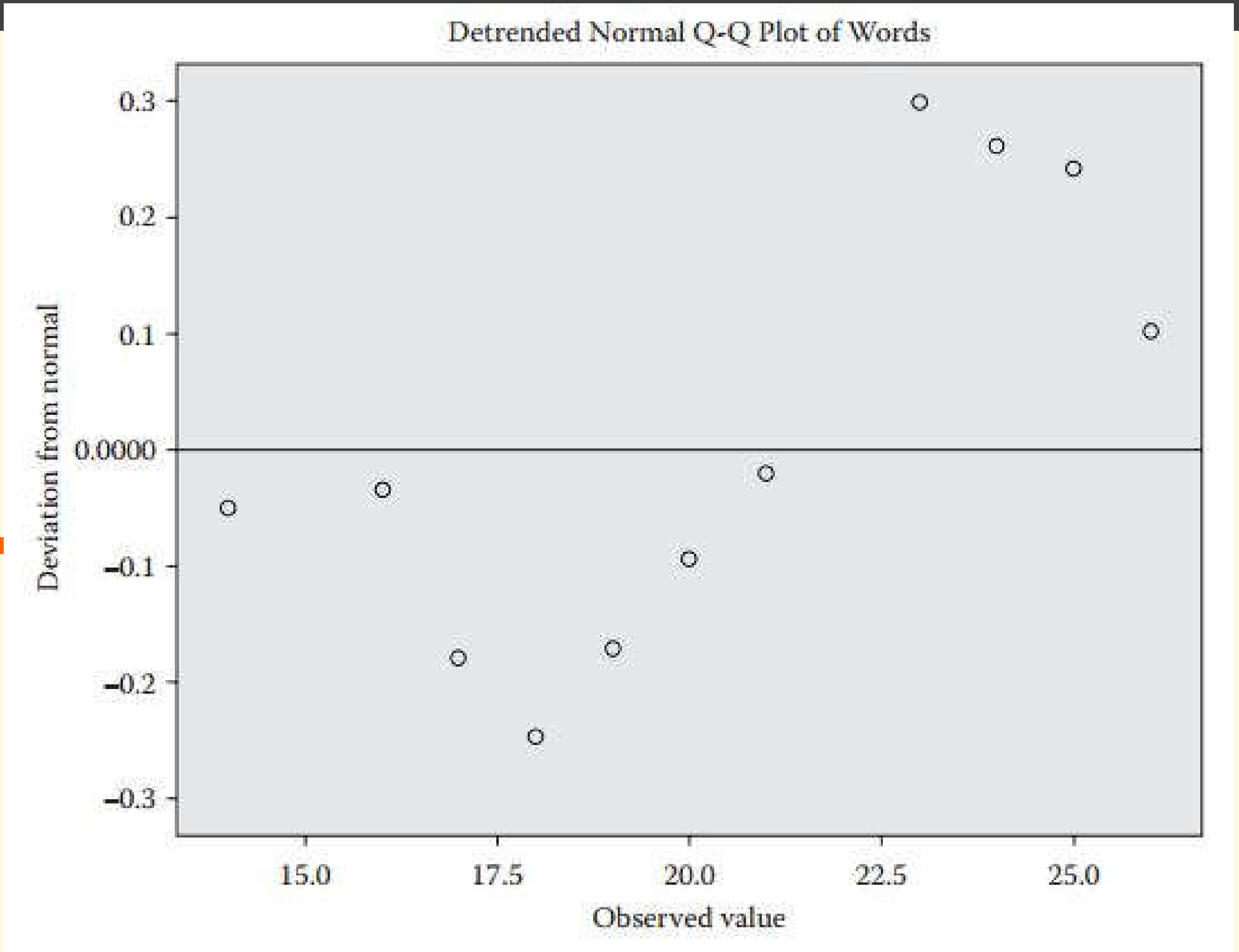
			Statistic	Std. Error
Words	Mean		19.9000	0.87027
	95% Confidence Interval for Mean	Lower Bound	18.0785	
		Upper Bound	21.7215	
	5% Trimmed Mean		19.8889	
	Median		19.5000	
	Variance		15.147	
	Std. Deviation		3.89196	
	Minimum		14.00	
	Maximum		26.00	
	Range		12.00	
	Interquartile Range		6.75	
	Skewness		0.167	0.512
	Kurtosis		−1.234	0.992

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	Sig.	Statistic	*df*	Sig.
Words	0.137	20	0.200*	0.936	20	0.201

[a] Lilliefors significance correction.
* This is a lower bound of the true significance.


Normal Q-Q Plot of Words
Expected normal
Observed value
2
1
0
–1
–2
15
20
25


Detrended Normal Q-Q Plot of Words
0.3
0.2
0.1
0.0000
-0.1
-0.2
-0.3
Deviation from normal
15.0
17.5
20.0
22.5
25.0
Observed value

Interpretation

The Kolmogorov-Smirnov statistic and the Shapiro-Wilk statistic are tests for normality, and if their signifcance levels are greater than 0.05, then normality is assumed. The Shapiro-Wilk statistic is calculated when the sample size is small (<50).

For both the Kolmogorov-Smirnov and the Shapiro-Wilk tests, the computed signifcance levels are >0.05 (0.200 and 0.201, respectively). Therefore, normality can be assumed.

Another diagnostic test for normality is a visual check of the **Normal Q–Q Plot** that compares the cumulative distribution of the observed values with the expected values derived from the normal distribution.

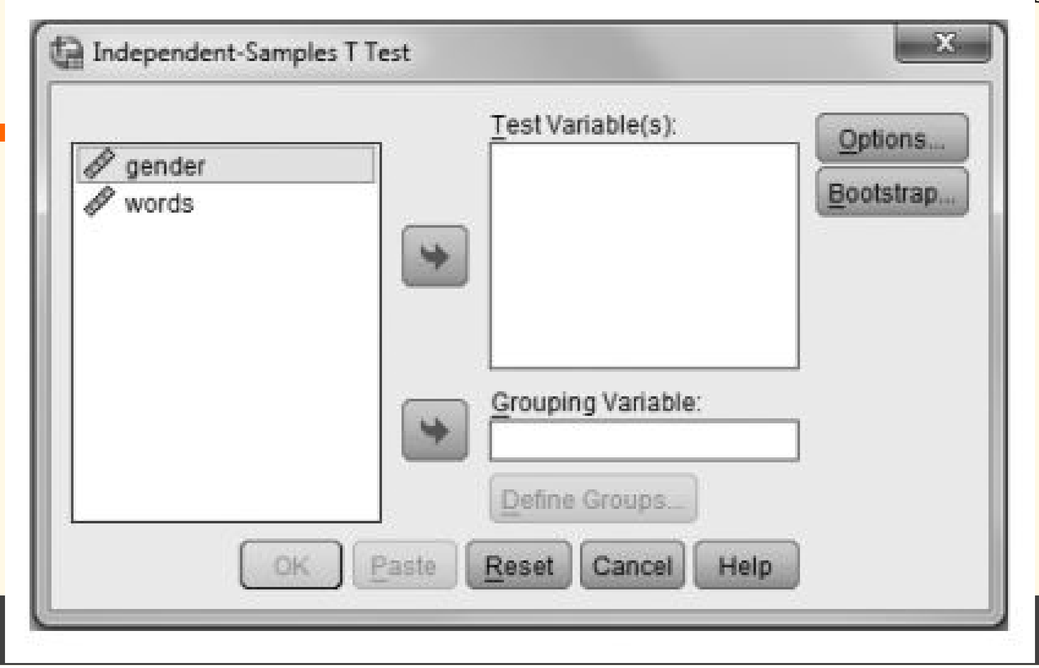
The normal distribution forms a straight diagonal line, and if a variable's distribution is normal, the data distribution will fall more or less on the diagonal. Inspection of the normal Q–Q plot shows very little departure from normality for the **WORDS** variable.

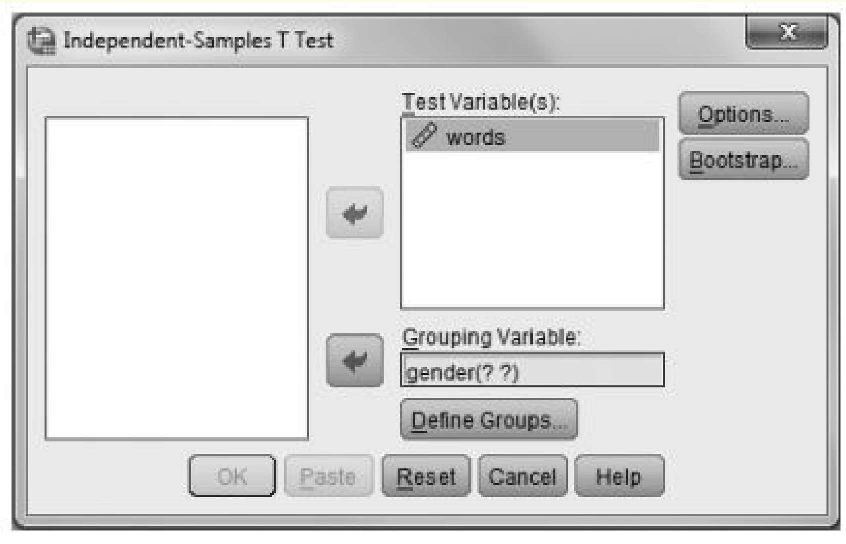
The **Detrended Normal Q–Q Plot** offers another visual check for normality. It shows the differences between the observed and expected values of a normal distribution, and plots the deviations of the scores from a straight line. If the distribution is normal, the scores should cluster around a horizontal line through zero with no pattern. The fgure shows little deviation from normality

Homogeneity of Variance

The homogeneity assumption is checked in SPSS by Levene's test

From the menu bar, click **Analyze**, then **Compare Means**, and then **Independent-Samples T Test**. The following window will open.

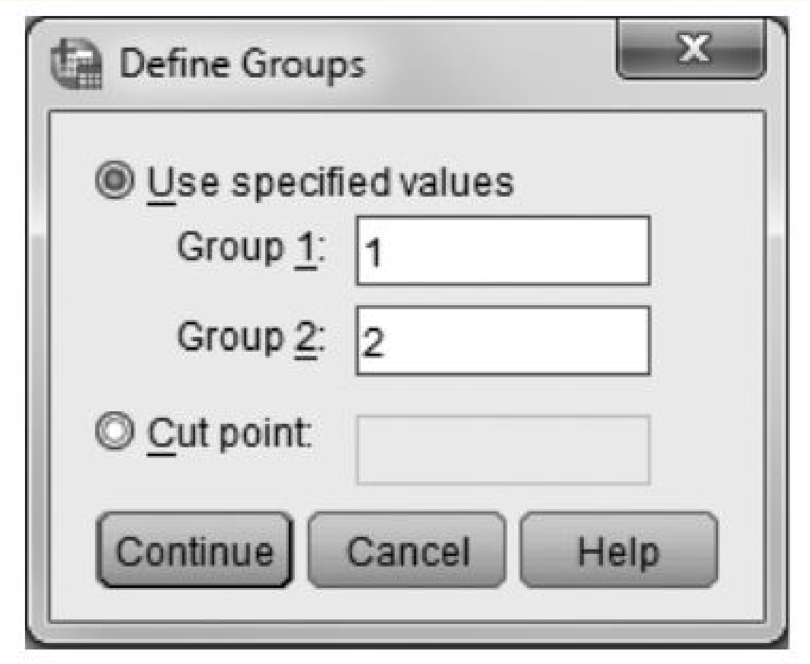




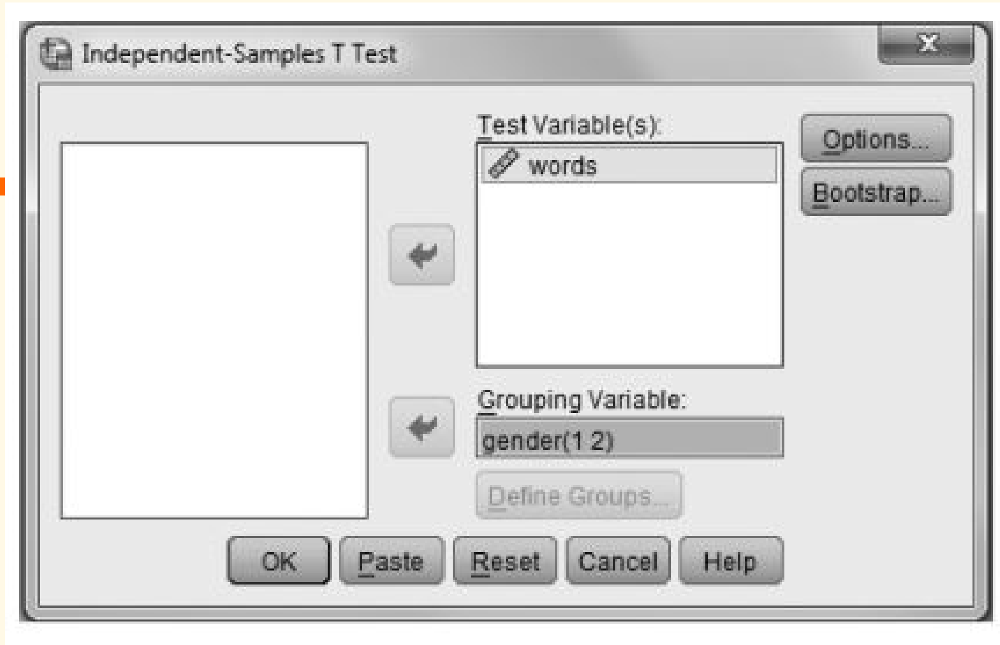
Since **GENDER** is the grouping (independent) variable, transfer it to the **Grouping Variable:** feld by clicking (highlight) the variable and then clicking .

As **WORDS** is the test (dependent) variable, transfer it to the **Test Variable(s):** feld by clicking (highlight) the variable and then clicking

Click to defne the range for the grouping variable **GENDER** (coded 1 = male, 2 = female). When the following **Defne Groups** window opens, type **1** in the **Group 1:** feld and **2** in the **Group 2:** feld, and then click .



When the following **Independent-Samples** ***t*** **Test** window opens, run the *t* test analysis by clicking Ok.



SPSS Output

Independent *t* Test Output

Group Statistics

	Gender	*N*	Mean	Std. Deviation	Std. Error Mean
WORDS	MALE	10	17.7000	3.3350	1.0546
	FEMALE	10	22.1000	3.1780	1.0050

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
WORDS	Equal variances assumed	.087	.772	−3.020	18	.007	−4.4000	1.4568	−7.4606	−1.3394
	Equal variances not assumed			−3.020	17.958	.007	−4.4000	1.4568	−7.4611	−1.3389

Results and Interpretation

The assumption of **homogeneity of variance** is tested by **Levene's test for equality of variances**, which tests the hypothesis that the two population variances are equal. In this example, the Levene statistic is $F = 0.087$ and the corresponding level of signifcance is large (i.e., $p > 0.05$)

Thus, the assumption of homogeneity of variance has not been violated, and the **equal variances assumed** *t* test statistic can be used for evaluating the null hypothesis of equality of means. If the signifcance level of the Levene statistic is small (i.e., $p < 0.05$), the assumption that the population variances are equal is rejected and the **equal variances not assumed** *t* test statistic should be used.

There is a signifcant difference between the male and female samples in the number of words correctly recalled, $t(df = 18) = -3.02$, $p < 0.01$. The mean values indicate that females correctly recalled signifcantly more words (M = 22.10) than males (M = 17.70)

The confdence interval information shows that the null hypothesis value (i.e., zero) does not fall within this interval (Lower = -7.4606, Upper = -1.3394). Therefore, the null hypothesis of equality of means can be rejected.

Paired-Samples t Test

The paired-samples *t* test is used in **repeated measures** or **correlated groups** design, in which each subject is tested twice on the same variable. A common experiment of this type involves the *before and after* design.

The test can also be used for the **matched group** design in which pairs of subjects that are matched on one or more characteristics (e.g., IQ, grades, and so forth) serve in the two conditions. As the subjects in the groups are matched and not independently assigned, this design is also referred to as a **correlated groups** design

Checklist of Requirements

- In any one analysis, there must be only two sets of data.
- The two sets of data must be obtained from (1) the same subjects, or (2) from two matched groups of subjects.

Assumption

The sampling distribution of the means should be normal.

Example

A researcher designed an experiment to test the effect of drug X on eating behavior. The amount of food eaten by a group of rats in a one-week period, prior to ingesting drug X, was recorded. The rats were then given drug X, and the amount of food eaten in a one-week period was again recorded. The following amounts of food in grams were eaten during the "before" and "after" conditions.

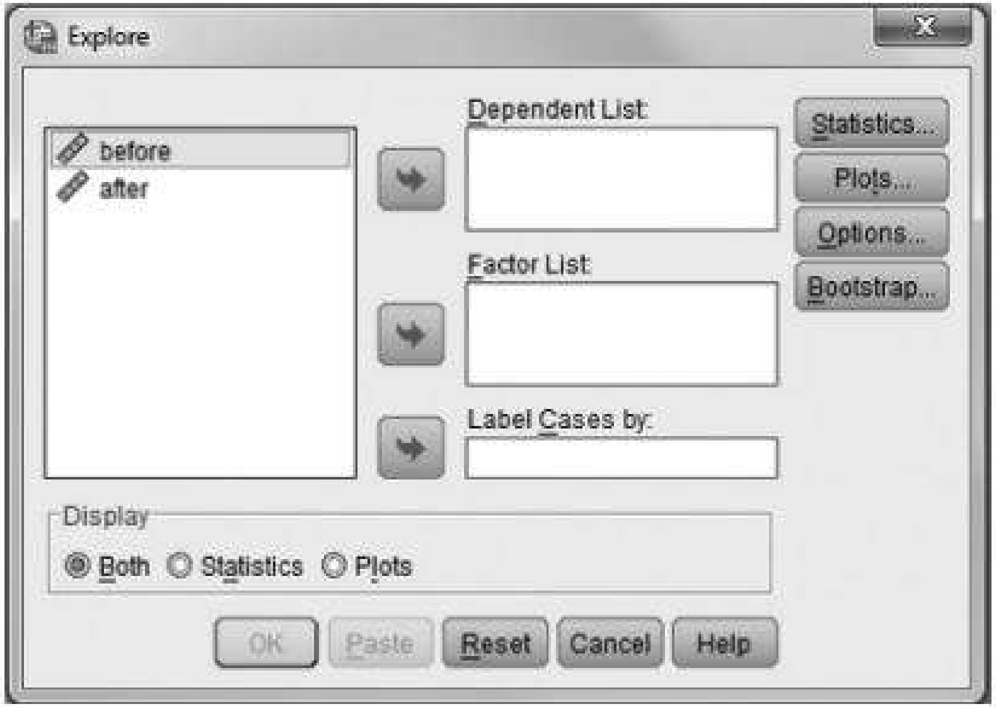
	Food Eaten	
	Before Ingesting Drug X	After Ingesting Drug X
s1	100	60
s2	180	80
s3	160	110
s4	220	140
s5	140	100
s6	250	200
s7	170	100
s8	220	180
s9	120	140
s10	210	130

Data Entry Format

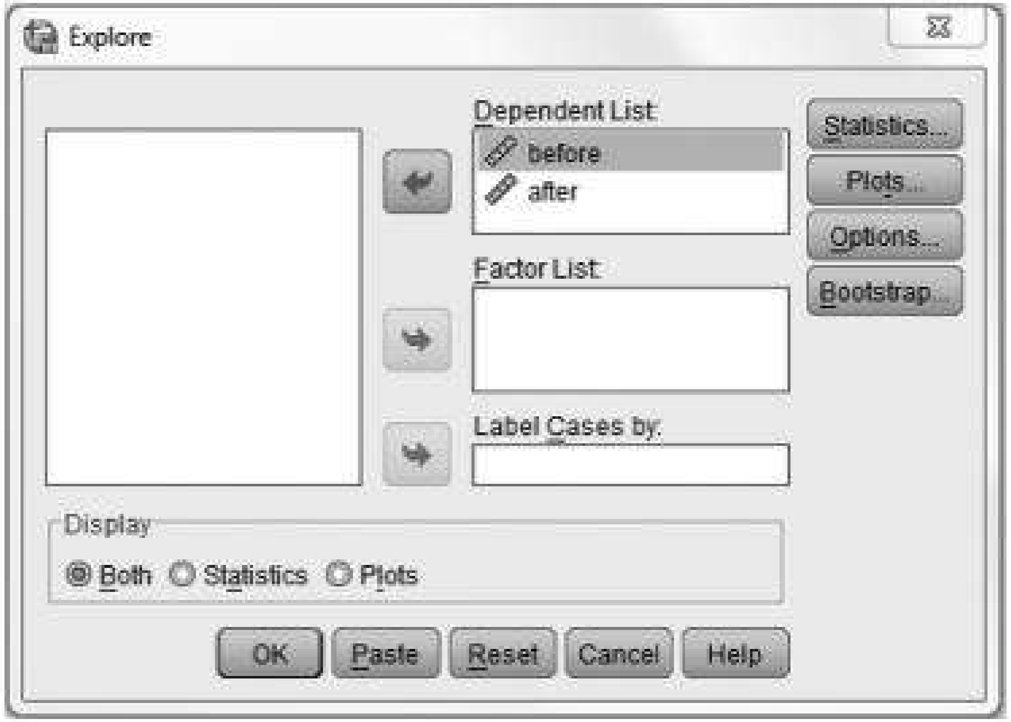
Variables	Column	Code
• BEFORE	• 1	• Food eaten in grams
• AFTER	• 2	• Food eaten in grams

Testing Assumption

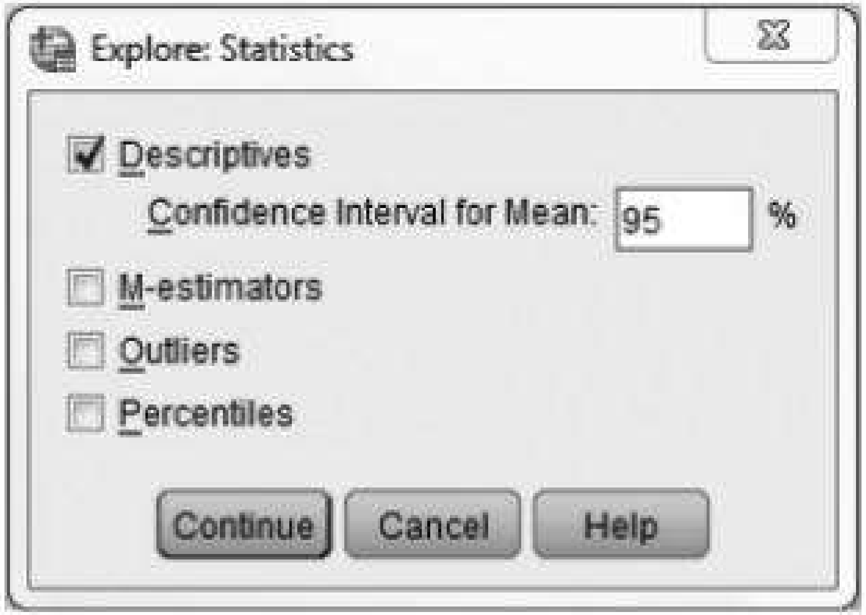
1. From the menu bar, click **Analyze**, then **Descriptive Statistics**, and then **Explore….** The following **Explore** window will open.



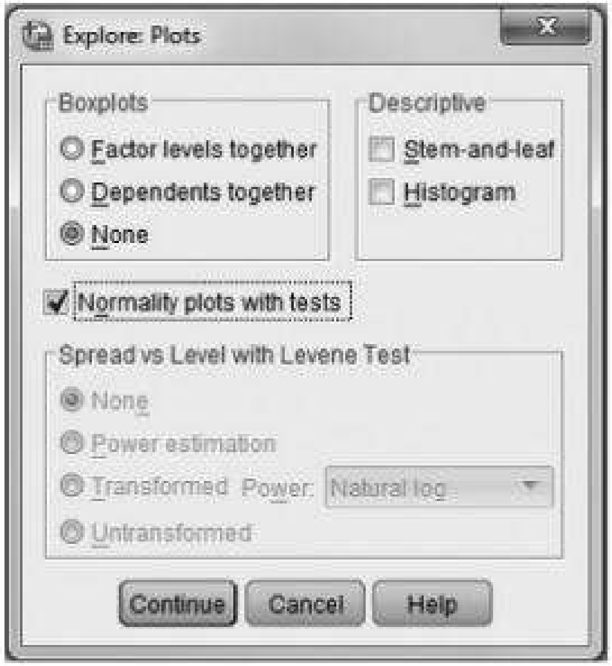
2. Transfer the **BEFORE** and **AFTER** variables to the **Dependent List:** field by clicking these variables (highlight) and then clicking [arrow button].



3. Click [Statistics...] to open the **Explore: Statistics** window. Check the **Descriptives** field and click [Continue] to return to the **Explore** window.

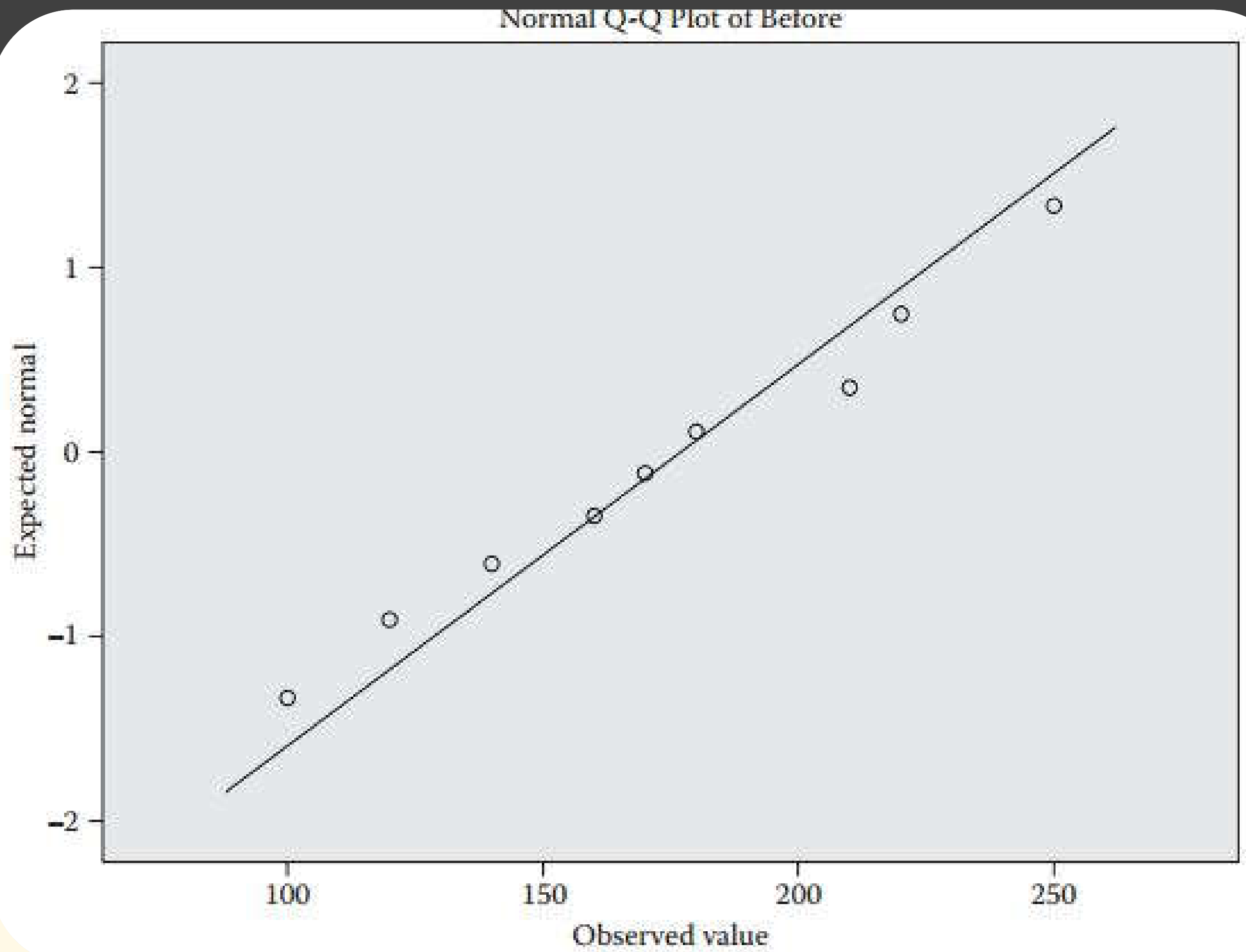


4. In the **Explore** window click Plots... to open the **Explore: Plots** window. Check the **Normality plots with tests** field.

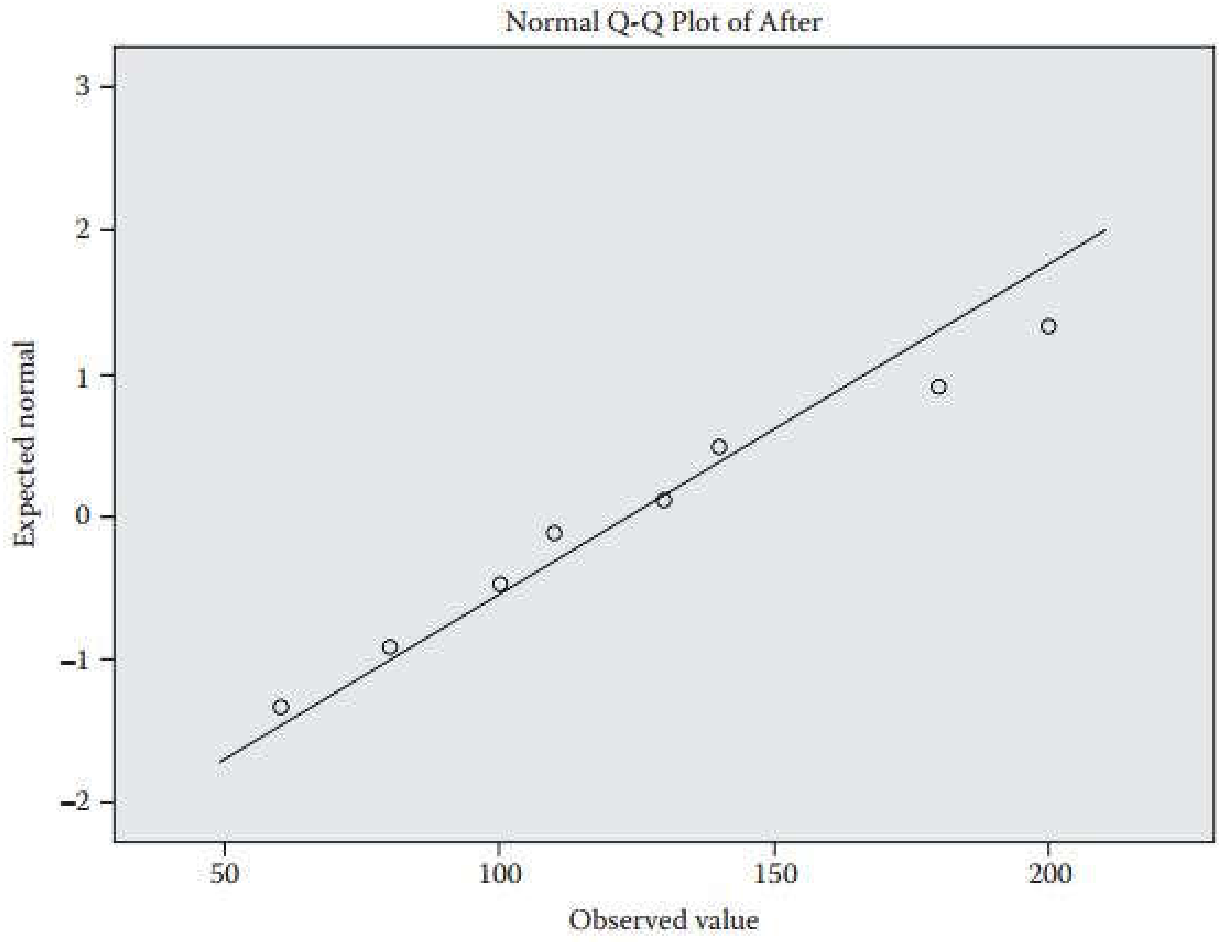


Click Plots... to return to the **Explore** window.

SPSS Output



Normal Q-Q Plot of Before
Expected normal
2
1
0
−1
−2
100
150
200
250
Observed value


Normal Q-Q Plot of After
Expected normal
3
2
1
0
−1
−2
50
100
150
200
Observed value

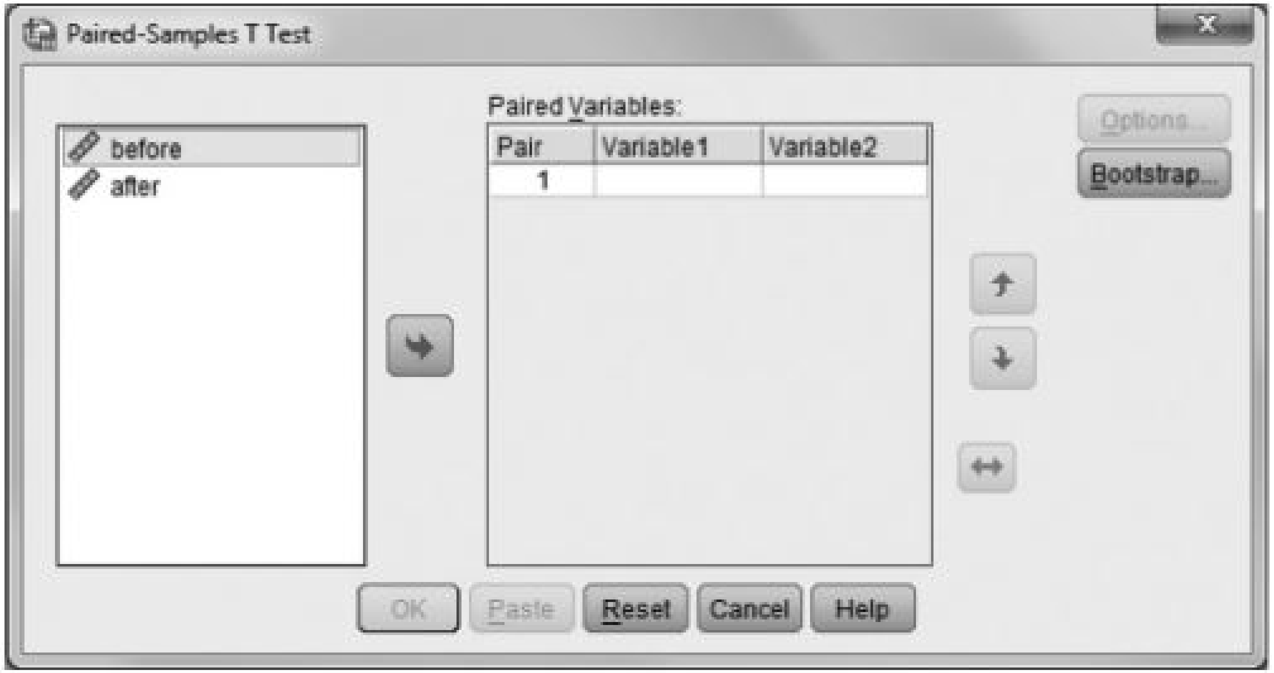
Another diagnostic test for normality is a visual check of the **Normal Q–Q Plot** that compares the cumulative distribution of the observed values with the expected values derived from the normal distribution. The normal distribution forms a straight diagonal line, and if a variable's distribution is normal, the data distribution will fall more or less on the diagonal.

Inspection of the normal Q–Q plots shows very little departure from normality for both the **BEFORE** and **AFTER** variables.

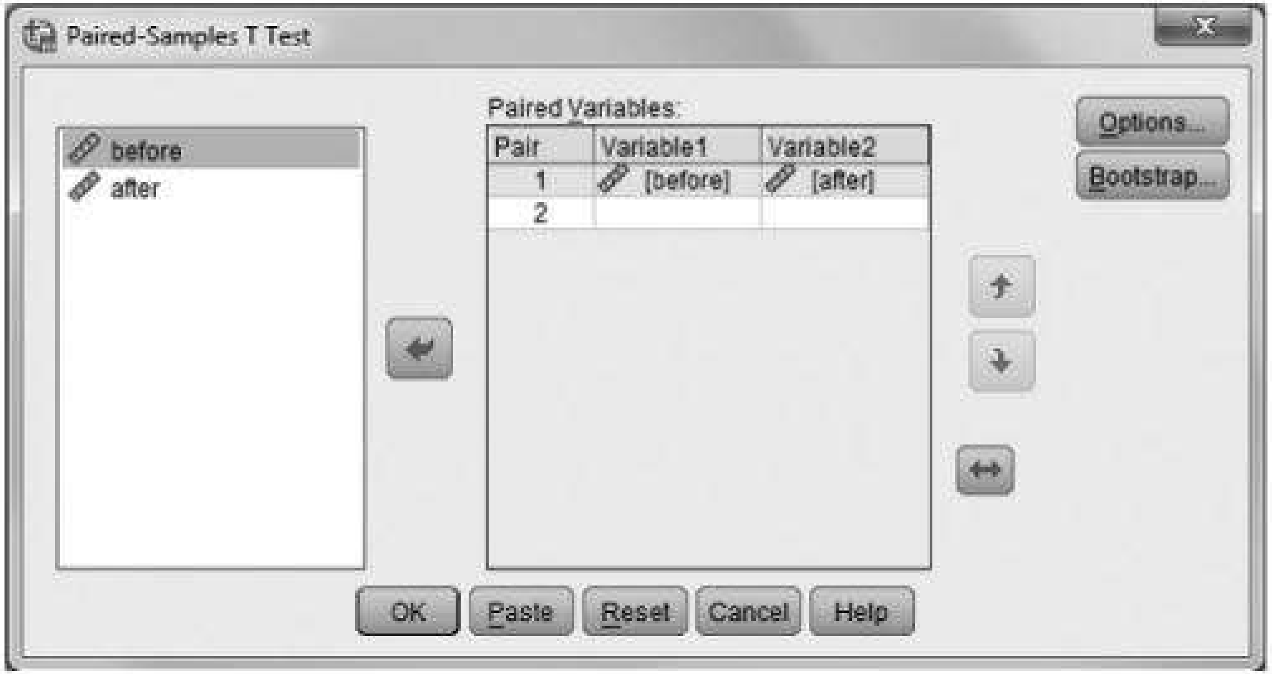
Similarly, a visual check of the **Detrended Normal Q–Q Plot**, which plots the deviations of the scores from a straight line, shows little deviation from normality for both the **BEFORE** and **AFTER** variables.

Windows Method: Paired-Samples t Test

From the menu bar, click **Analyze**, then **Compare Means**, and then **Paired-Samples *t* Test.** The following window will open.



2. Transfer both the **BEFORE** and **AFTER** variables to the **Paired Variables:** field by clicking (highlight) these two variables, and then clicking [arrow button]. Click [OK] to run the *t* Test analysis. See Table 5.2 for the results.



SPSS Output

Paired-Samples *t* Test Output

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	177.0000	10	48.31609	15.27889
	After	124.0000	10	43.25634	13.67886

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Before and After	10	0.745	0.013

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	*t*	*df*	Sig. (2-tailed)
Pair 1	before - after	53.00000	33.01515	10.44031	29.38239	76.61761	5.076	9	.001

Results and Interpretation

The result from the analysis indicates that there is a signifcant difference in the amount of food eaten before and after drug X was ingested, $t(df = 9) = 5.08$, $p < .01$ (see **Paired Samples Test** table).

The mean values indicate that signifcantly less food was consumed after ingestion of drug X ($M = 124.00$) than before ($M = 177.00$)

Thank You!

Any Questions?