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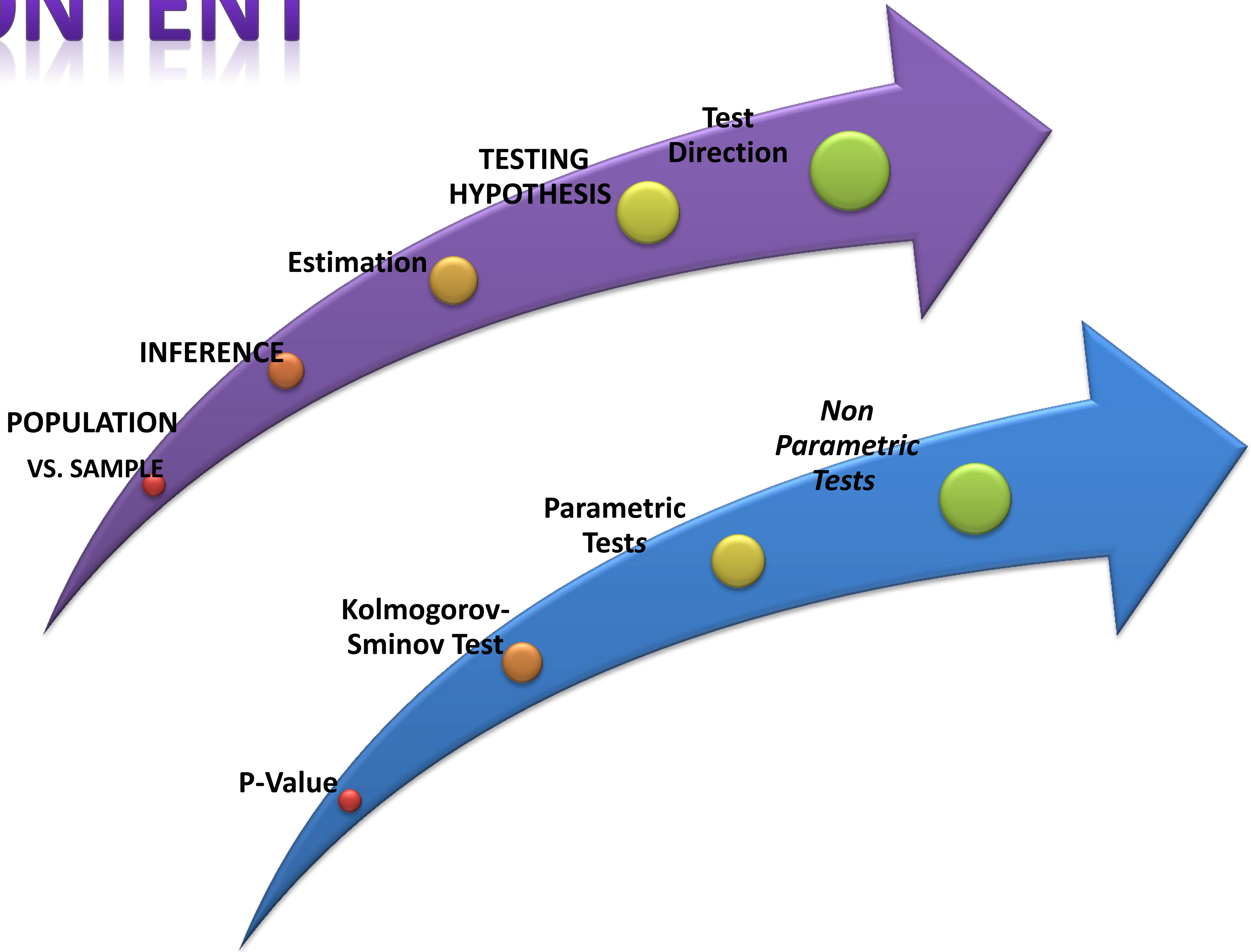
TUESDAY 2th AUG 2016

# Workshop
# on
# Statistical Data Analysis

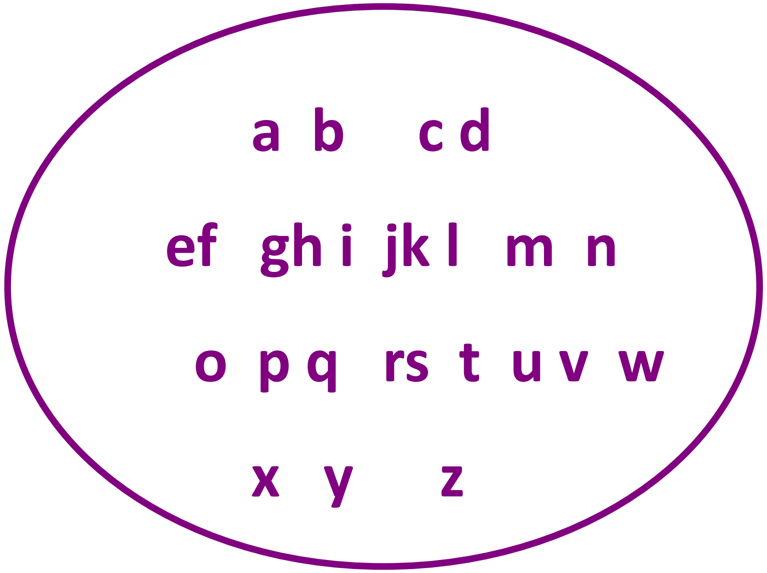
***Parametric & Non Parametric Test Using SPSS***

# CONTENT


POPULATION
VS. SAMPLE
INFERENCE
Estimation
TESTING
HYPOTHESIS
Test
Direction
P-Value
Kolmogorov-
Sminov Test
Parametric
Tests
*Non*
*Parametric*
*Tests*

# POPULATION VS. SAMPLE

## Population

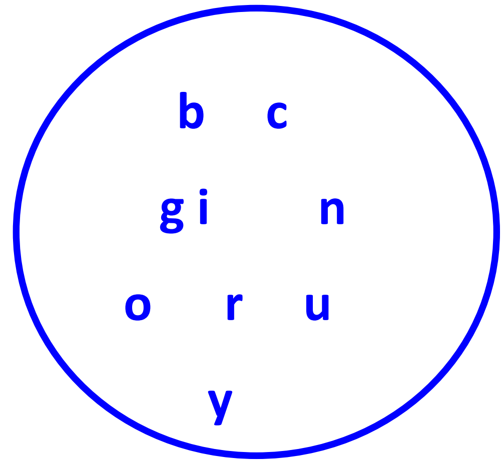



Measures used to describe a population are called

**parameters**

**Unknown**

## Sample



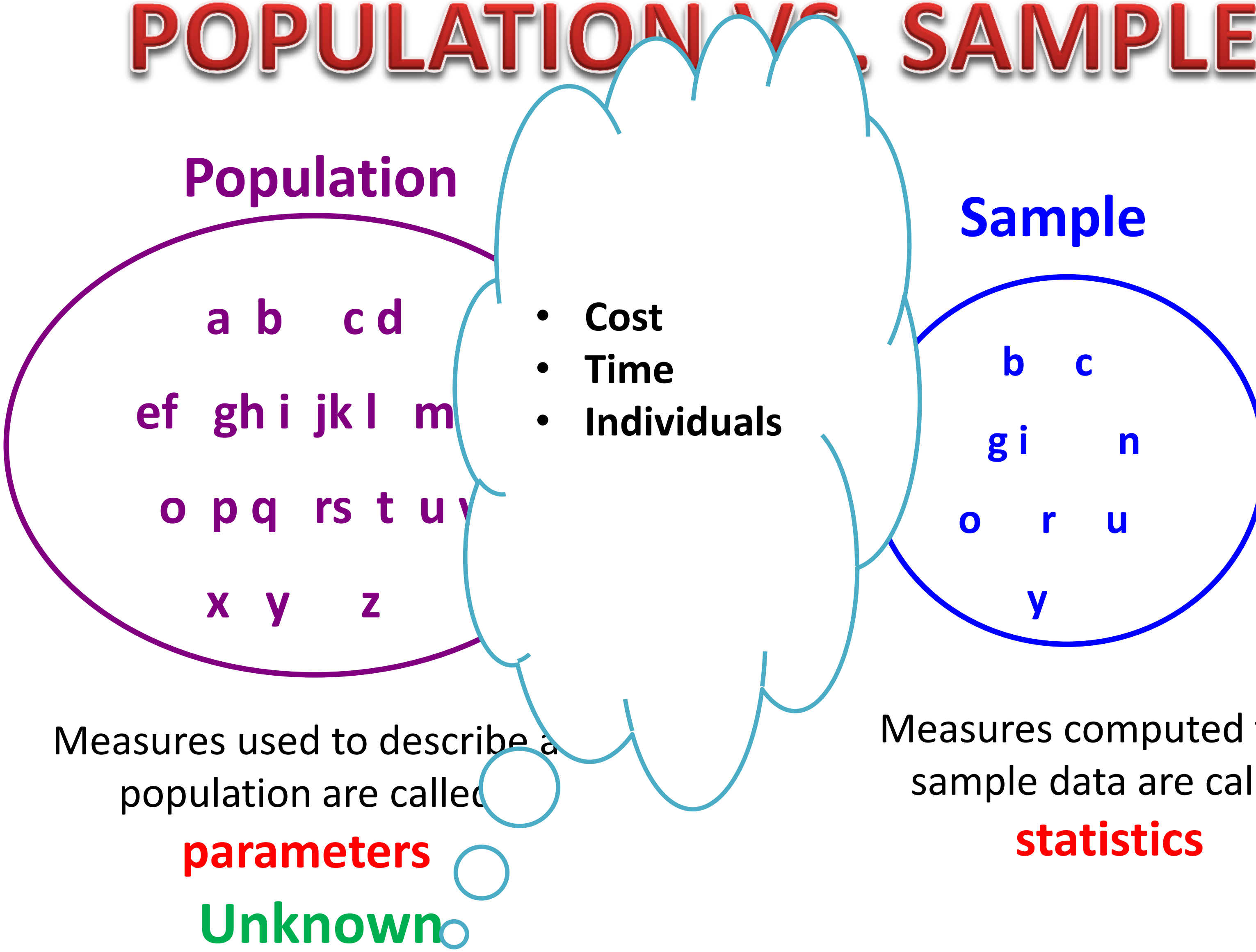

Measures computed from sample data are called

**statistics**

# POPULATION VS. SAMPLE

## Population

## Sample

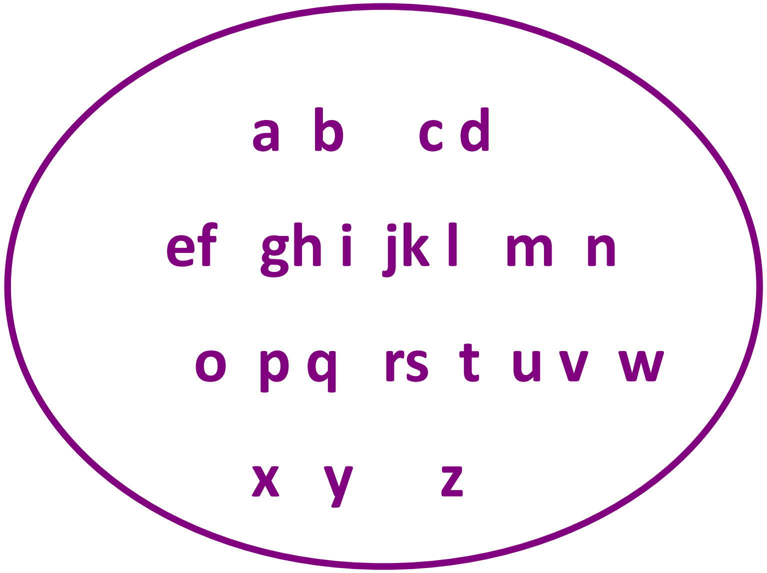



Measures used to describe a population are called
**parameters**
**Unknown**

Measures computed from sample data are called
**statistics**

# POPULATION VS. SAMPLE

## Population

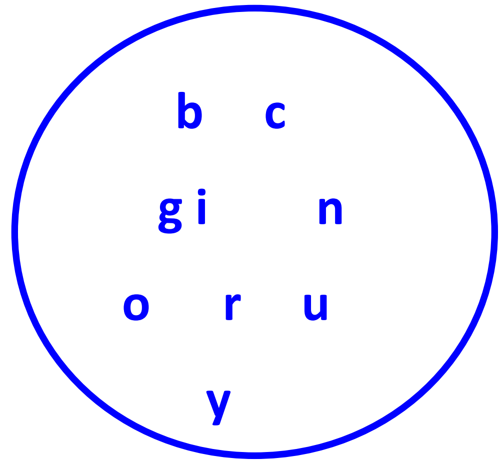



Measures used to describe a population are called

**parameters**

**Unknown**

## Sample




Measures computed from sample data are called

**statistics**

**Known**

# POPULATION VS SAMPLE

## Population

a b c d

ef gh i jk l m

o p q rs t u v

x y z

Measures used to describe a population are called

**parameters**

**Unknown**

## Less

- Cost
- Time
- Individuals

## Sample

b c

g i n

o r u

y

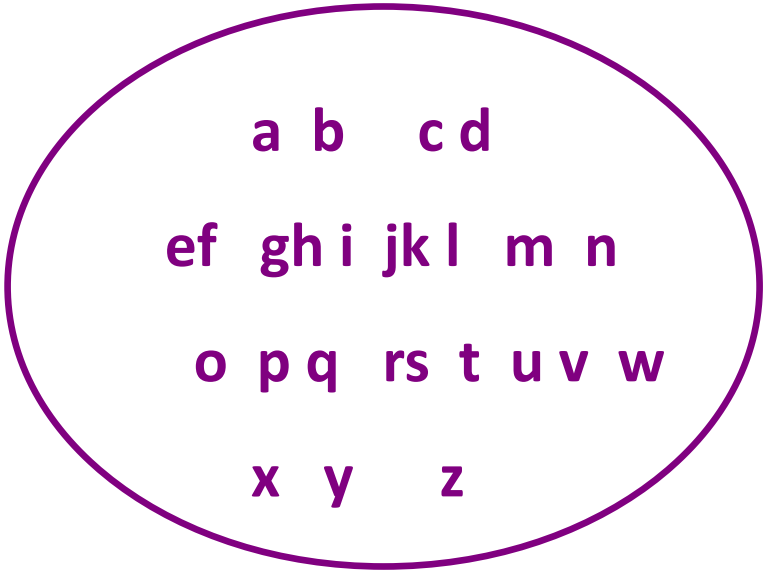
Measures computed from mple data are called

**statistics**

**Known**

# POPULATION VS. SAMPLE

## Population

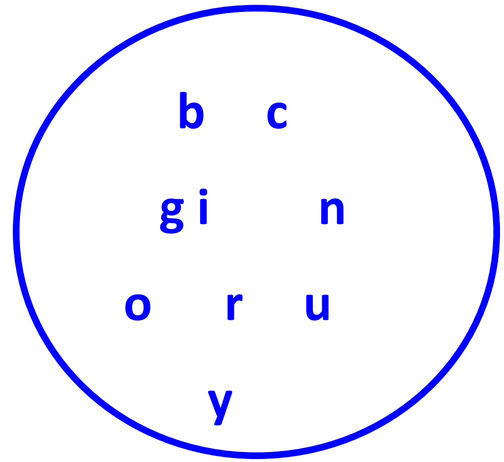



Measures used to describe a population are called

**parameters**

**Unknown**

## Sample



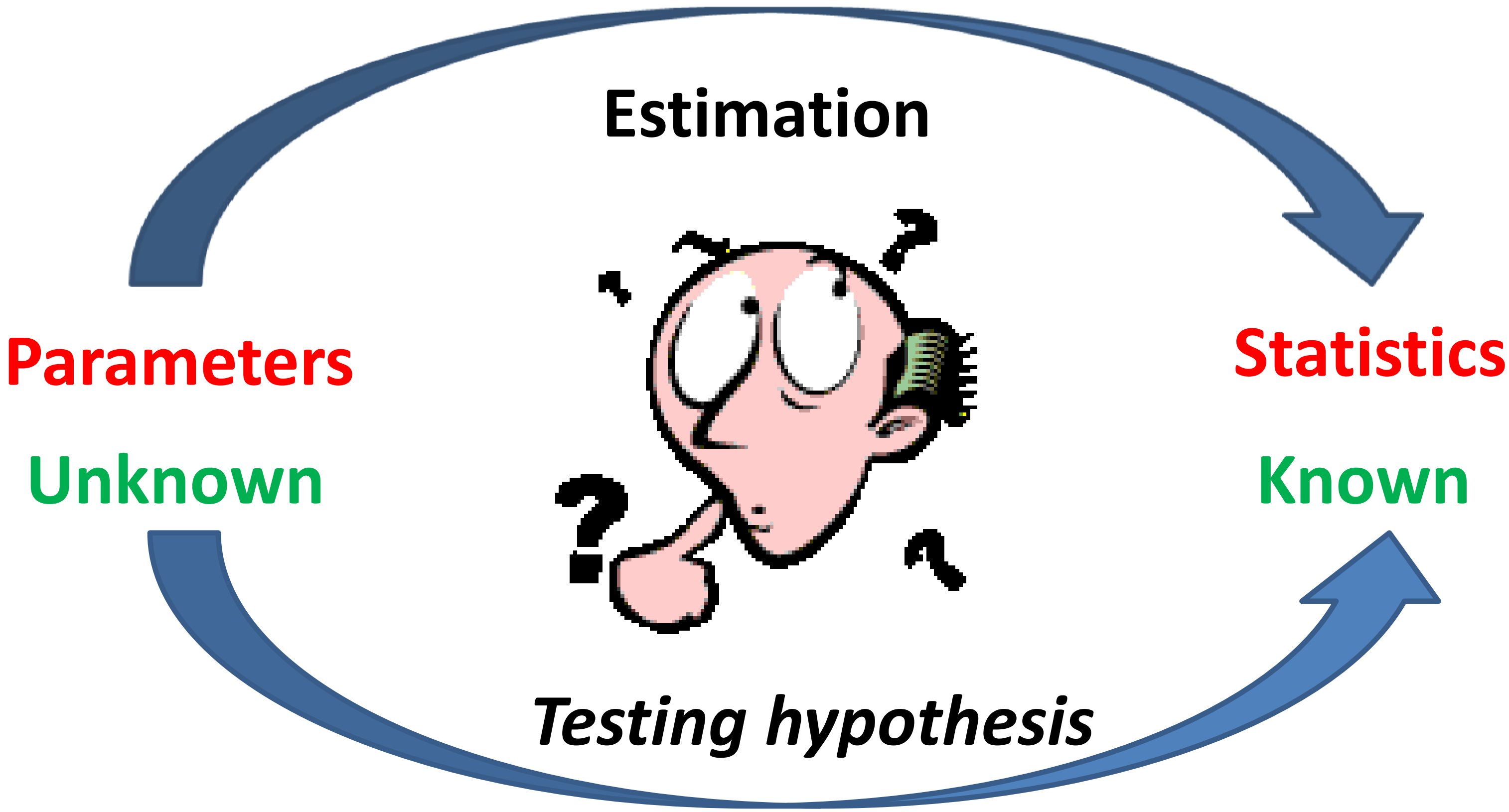

Measures computed from sample data are called

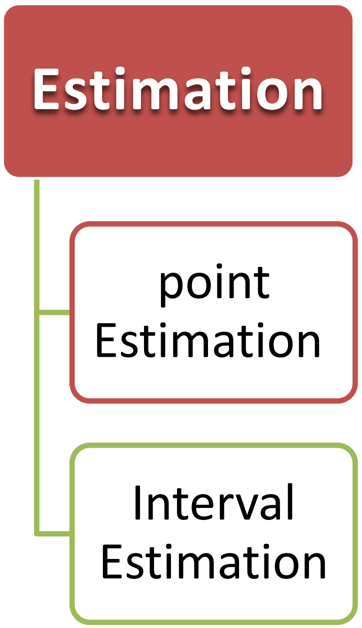
**statistics**

**Inference** →

**Known**

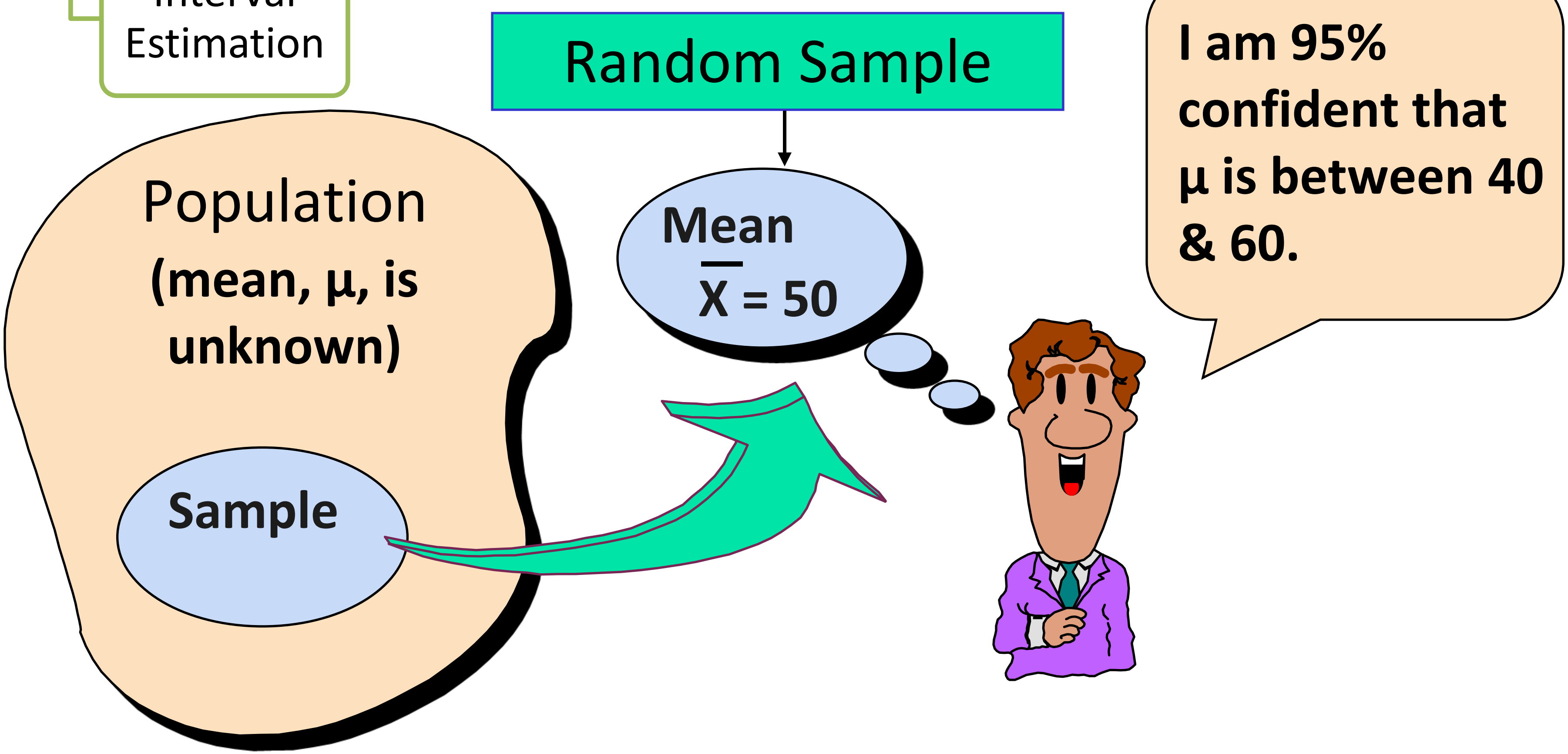
# INFERENCE


Estimation
Parameters
Unknown
Statistics
Known
Testing hypothesis




# ESTIMATION

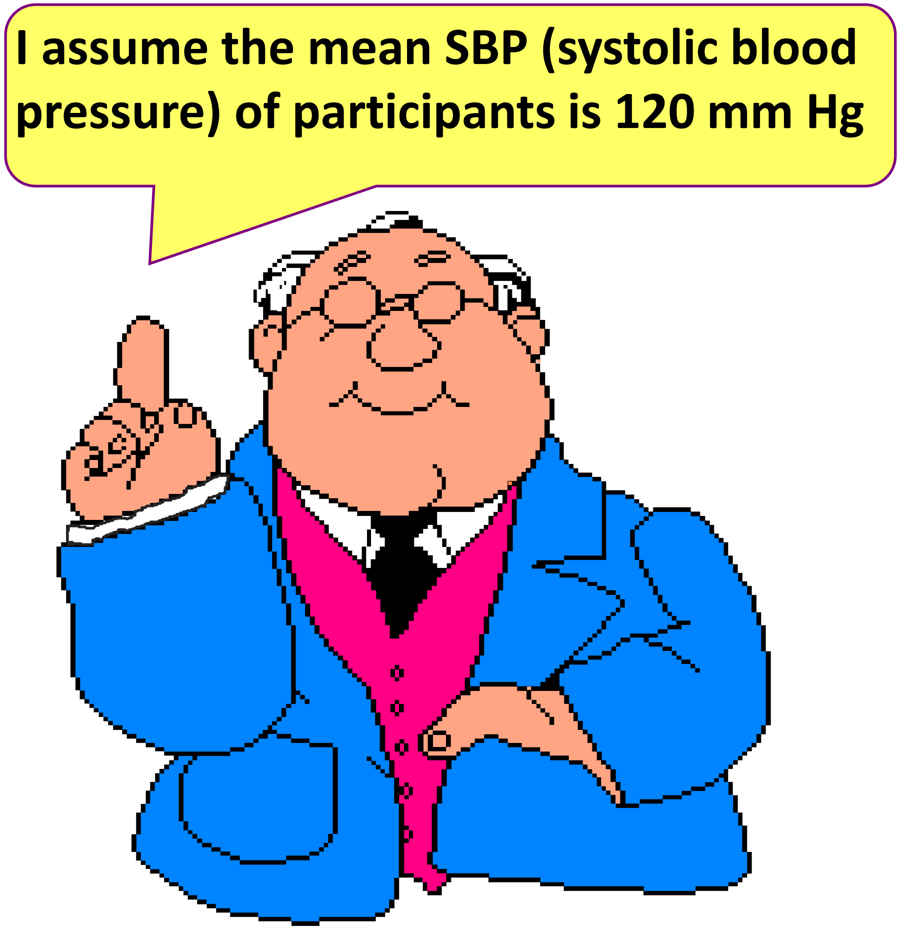
- A point estimate is a single number.
- a confidence interval provides additional information about variability



# TESTING HYPOTHESIS

**A statistical method that uses sample data to evaluate a hypothesis about a population parameter. It is intended to help researchers differentiate between real and random patterns in the data.**

**An assumption about the population parameter.**

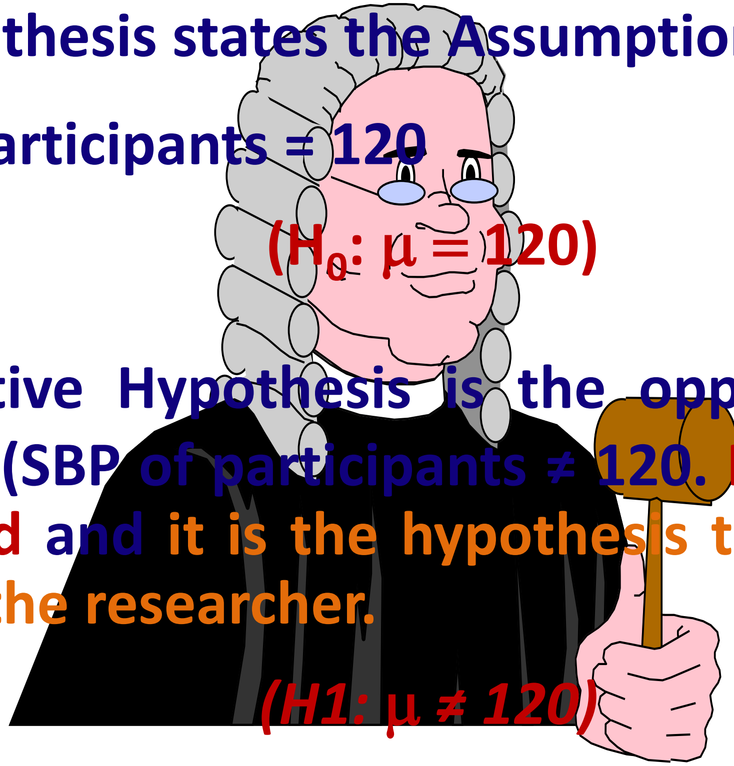


# Null & Alternative Hypotheses

***$H_0$*** **Null Hypothesis states the Assumption to be tested.**

**E.g. SBP of participants = 120**

**($H_0$: $\mu = 120$)**



***H1*** **Alternative Hypothesis is the opposite of the null hypothesis (SBP of participants ≠ 120. It may or may not be accepted and it is the hypothesis that is believed to be true by the researcher.**

***(H1: $\mu \neq 120$)***

# Null Hypothesis: $H_0$

- **Must contain condition of equality**

  $=$, $\geq$, or $\leq$

- **Test the Null Hypothesis directly**

  **Reject $H_0$ or fail to reject $H_0$**

# Alternative Hypothesis: $H_1$

- Must be true if $H_0$ is false

$\neq$, <, >

- 'opposite' of Null

**Example:**

$H_0 : \mu = 30$ versus $H_1 : \mu > 30$

# Type I & II Error

| | | REALITY<br>NULL HYPOTHESIS<br>TRUE | REALITY<br>NULL HYPOTHESIS<br>FALSE |
|---|---|---|---|
| STUDY FINDINGS | TRUE |  | Type II error (β) 'False negative' |
| STUDY FINDINGS | FALSE | Type I error (α) 'False positive' |  |

# TWO-TAILED, LEFT-TAILED, RIGHT-TAILED TESTS

# Left-tailed Test

$$H_0: \mu \geq 200$$

$$H_1: \mu < 200$$

# Left-tailed Test

$$H_0: \mu \geq 200$$

$$H_1: \mu < 200$$

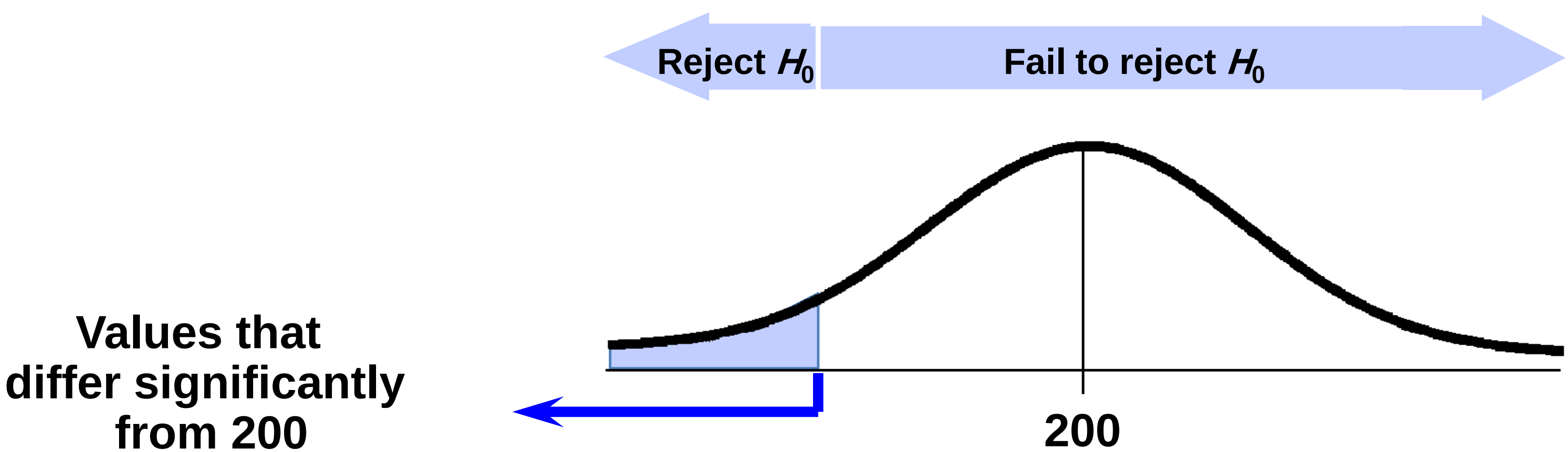
**Points Left**

# Left-tailed Test

$H_0$: $\mu \geq 200$

$H_1$: $\mu < 200$

**Points Left**



# Right-tailed Test

$H_0$: $\mu \leq 200$

$H_1$: $\mu > 200$

# Right-tailed Test

$H_0$: $\mu \leq 200$

$H_1$: $\mu > 200$

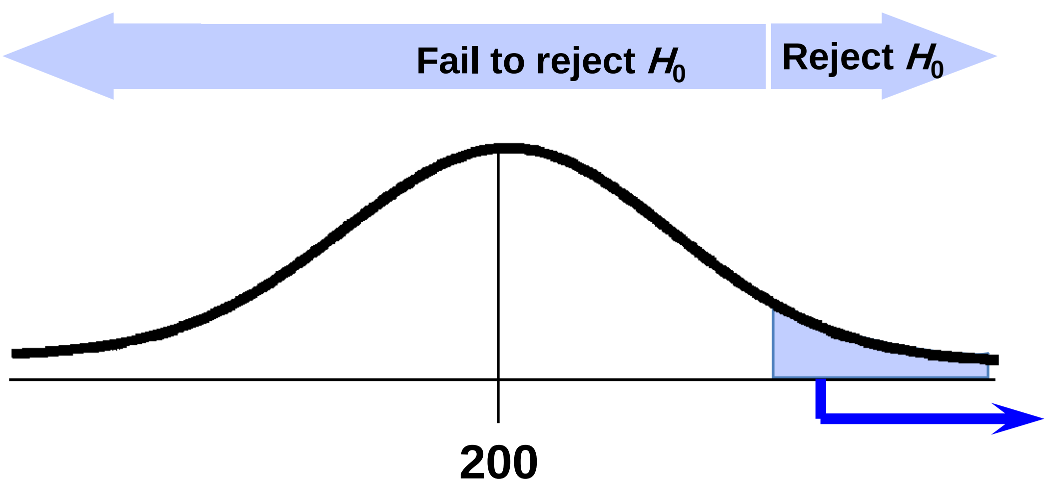
**Points Right**

# Right-tailed Test

$H_0$: $\mu \leq 200$

$H_1$: $\mu > 200$

**Points Right**




**Values that differ significantly from 200**

# Two-tailed Test

$H_0$: μ = 200

$H_1$: μ ≠ 200

# Two-tailed Test

$H_0$: μ = 200
$H_1$: μ ≠ 200

α is divided equally between the two tails of the critical region

# Two-tailed Test

$H_0$: μ = 200
$H_1$: μ ≠ 200

α is divided equally between the two tails of the critical region

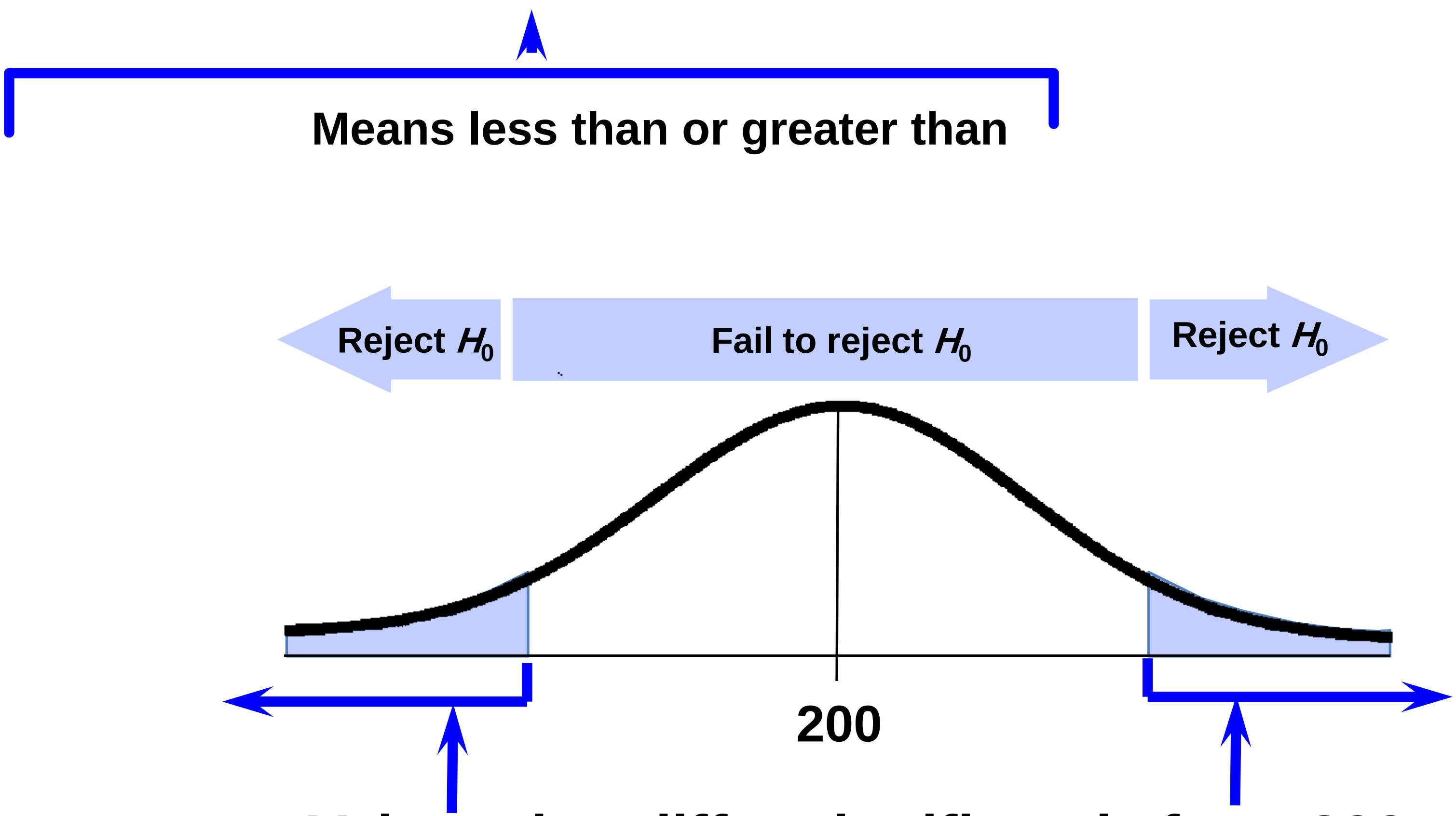
Means less than or greater than

# Two-tailed Test

$H_0$: $\mu = 200$

$H_1$: $\mu \neq 200$

$\alpha$ is divided equally between the two tails of the critical region




**Values that differ significantly from 200**

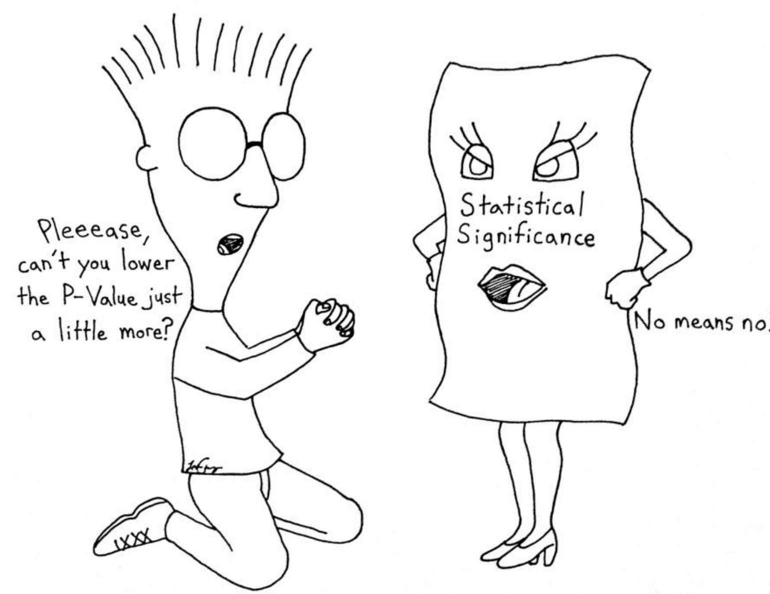
## *Most of us understand only one thing about p-value*

If p-value is < 0.05, reject the null hypothesis

If p-value is > 0.05, do not reject the null hypothesis

**P- Value**

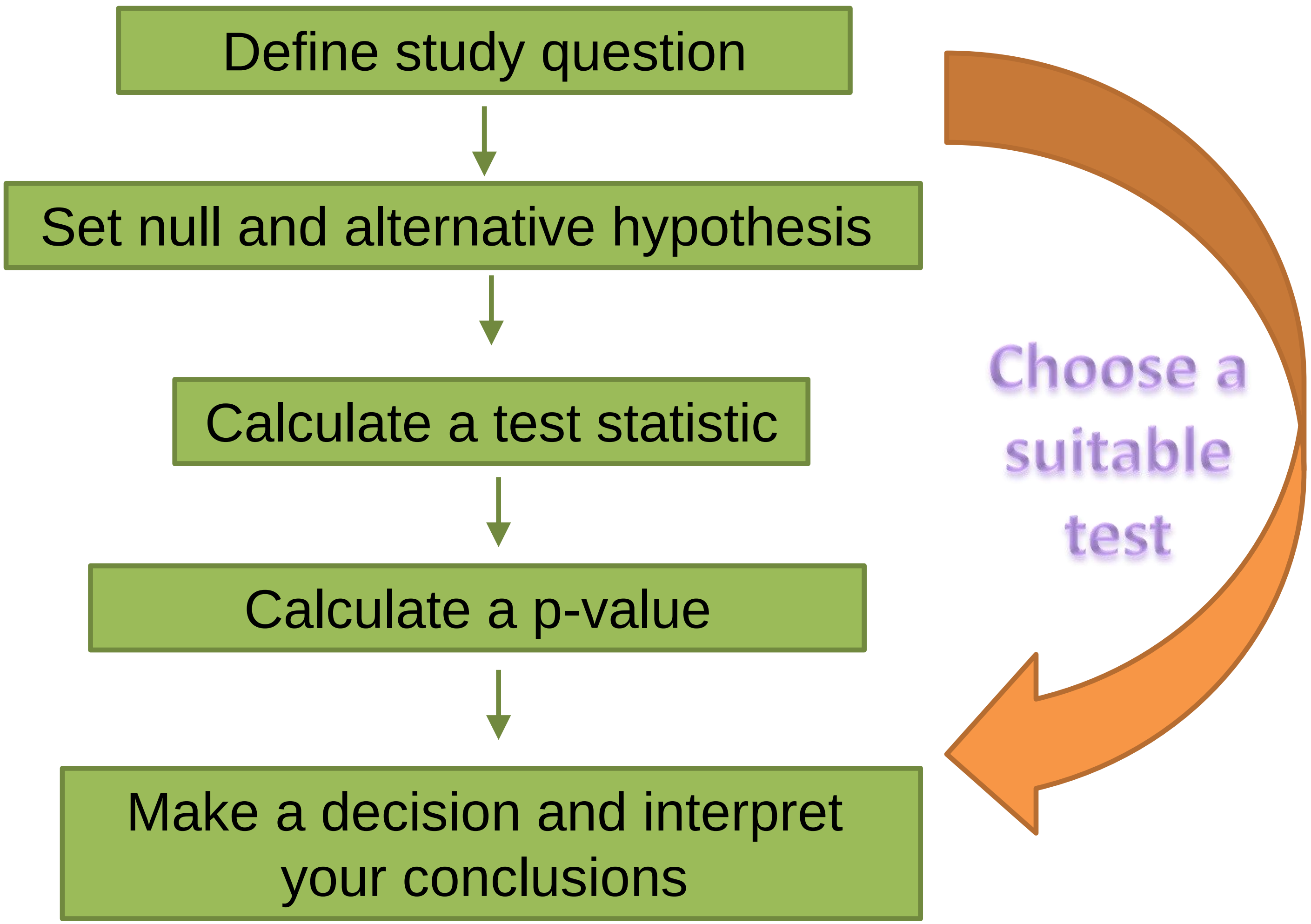
But what really is this p-value?
Many of us don't even **try** to understand that, because in our heads, we imagine the concept to be something like the red-eyed (p) monster above!



# p-Value Approach to Testing

- Convert Sample Statistic (e.g., $\bar{X}$ ) to Test Statistic (e.g., Z statistic )
- Obtain the p-value from a table or computer
- Compare the p-value with $\alpha$
  - If p-value $< \alpha$ , reject $H_0$
  - If p-value $\geq \alpha$ , do not reject $H_0$

# Steps to undertaking a Hypothesis test

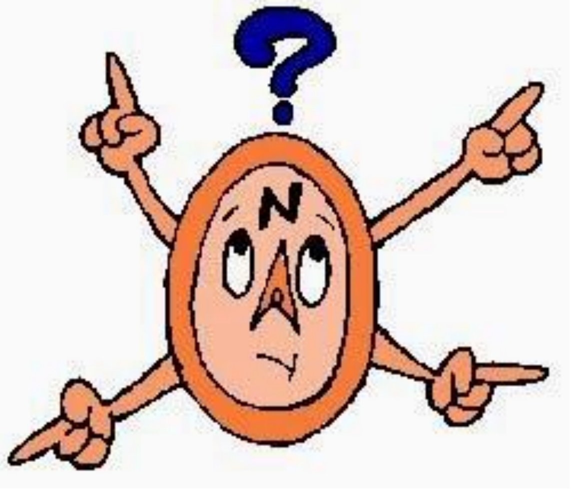


Non-Parametric Test

Parametric Test

# Kolmogorov-Sminov Test

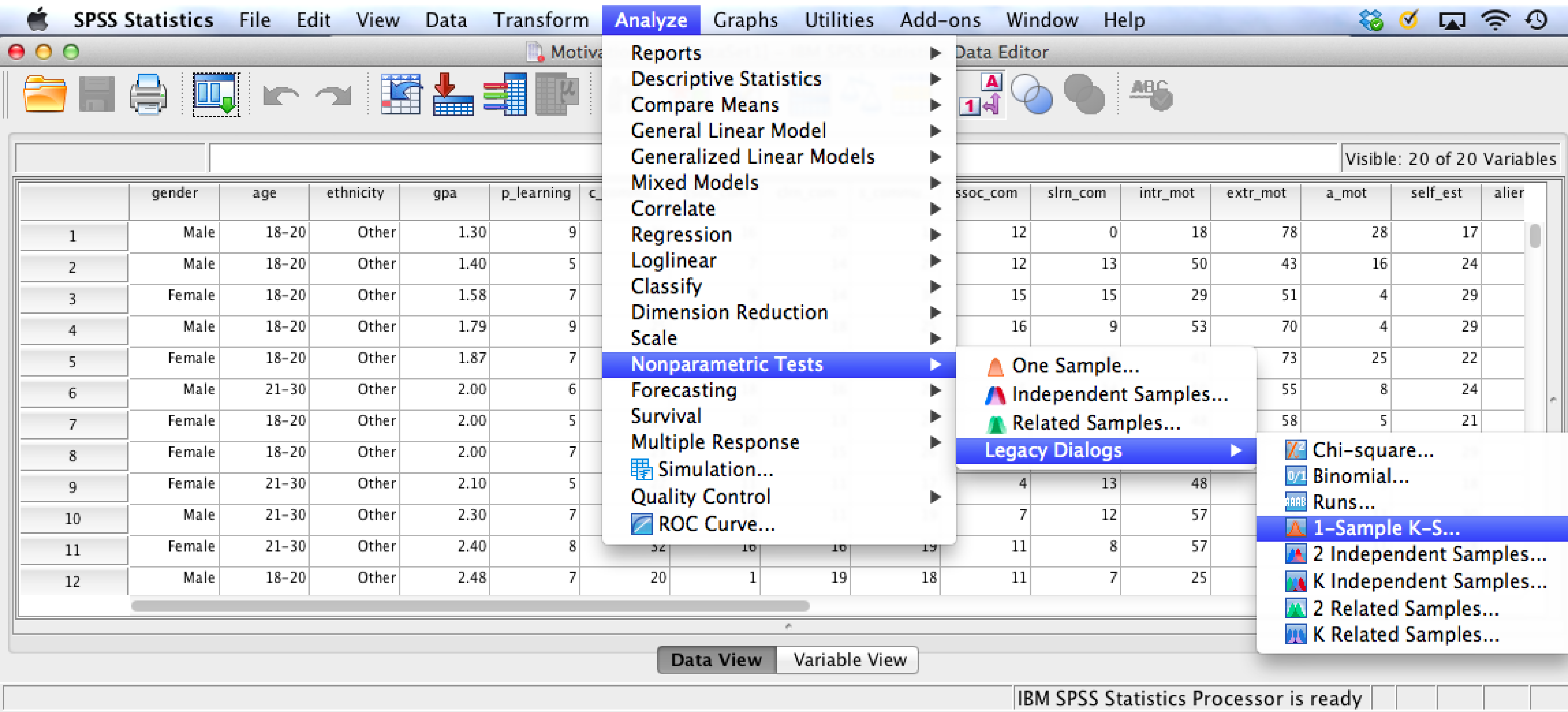
- The Kolmogorov-Smirnov test (also known as the K-S test or one-sample Kolmogorov-Smirnov test) is a nonparametric procedure that determines whether a sample of data comes from a specific distribution, i.e., normal, uniform, Poisson, or exponential distribution.



File available at
http://www.watertreepress.com/stats

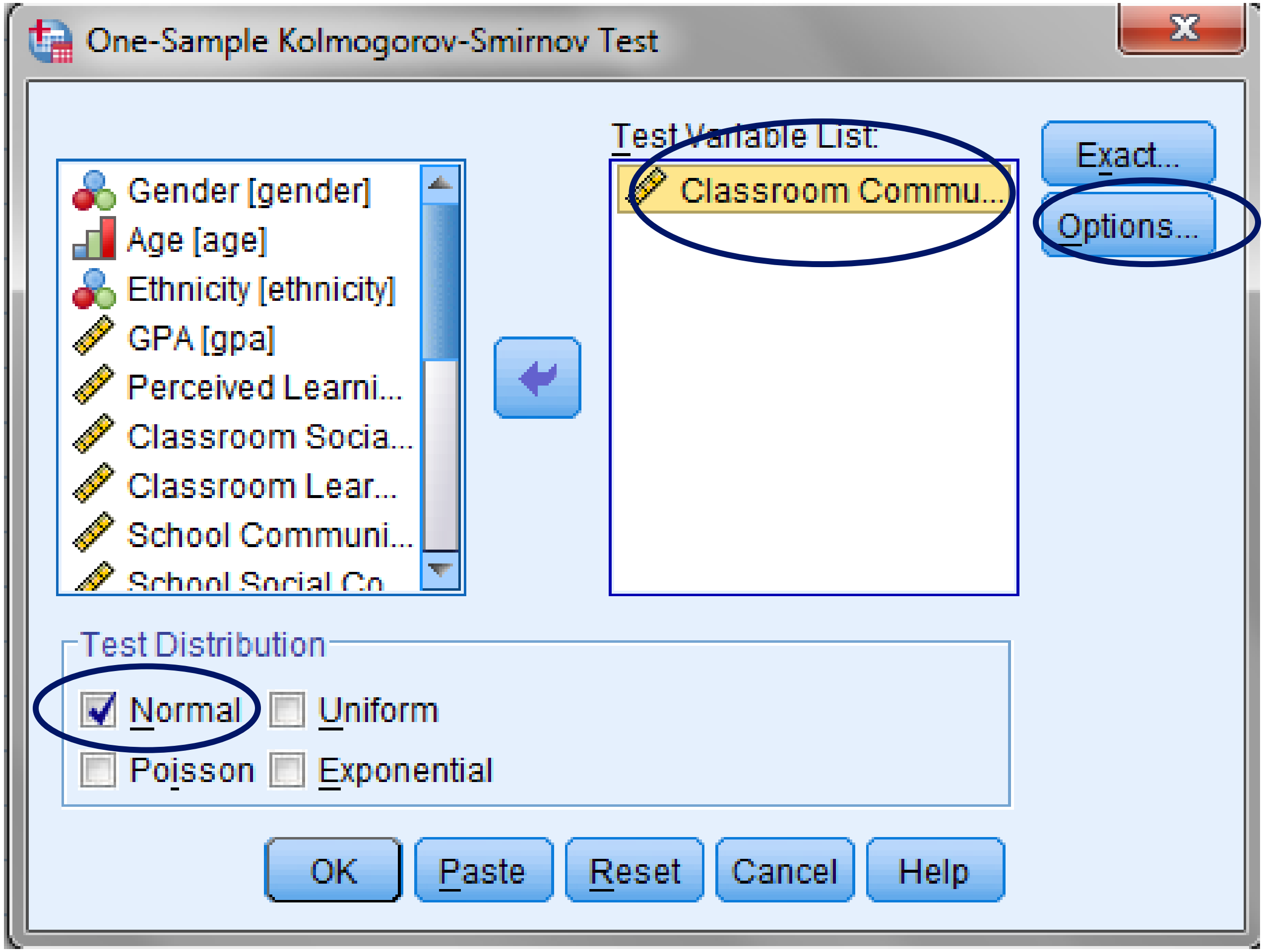
Open the dataset *Motivation.sav*.

| | gender | age | ethnicity | gpa | p_learning | c_community | csoc_com | clrn_com | s_community | ssoc_com |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 1.30 | 9 | 36 | 16 | 20 | 12 | 12 |
| 2 | 2 | 2 | 2 | 1.40 | 5 | 21 | 7 | 14 | 25 | 12 |
| 3 | 1 | 2 | 2 | 1.58 | 7 | 23 | 9 | 14 | 30 | 15 |
| 4 | 2 | 2 | 2 | 1.79 | 9 | 25 | 7 | 18 | 25 | 16 |
| 5 | 1 | 2 | 2 | 1.87 | 7 | 22 | 5 | 17 | 28 | 12 |
| 6 | 2 | 3 | 2 | 2.00 | 6 | 34 | 18 | 16 | 29 | 15 |
| 7 | 1 | 2 | 2 | 2.00 | 5 | 23 | 10 | 13 | 28 | 15 |
| 8 | 1 | 2 | 2 | 2.00 | 7 | 23 | 8 | 15 | 26 | 11 |
| 9 | 1 | 3 | 2 | 2.10 | 5 | 22 | 11 | 11 | 17 | 4 |
| 10 | 2 | 3 | 2 | 2.30 | 7 | 25 | 14 | 11 | 19 | 7 |
| 11 | 1 | 3 | 2 | 2.40 | 8 | 32 | 16 | 16 | 19 | 11 |
| 12 | 2 | 2 | 2 | 2.48 | 7 | 20 | 1 | 19 | 18 | 11 |
| 13 | 1 | 4 | 2 | 2.50 | 7 | 24 | 10 | 14 | 16 | 10 |
| 14 | 1 | 2 | 2 | 2.50 | 6 | 22 | 5 | 17 | 40 | 20 |
| 15 | 1 | 3 | 4 | 2.50 | 5 | 28 | 15 | 13 | 25 | 12 |
| 16 | 1 | 2 | 2 | 2.50 | 5 | 25 | 14 | 11 | 30 | 15 |
| 17 | 1 | 3 | 2 | 2.55 | 7 | 22 | 11 | 11 | 15 | 5 |
| 18 | 1 | 2 | 2 | 2.60 | 6 | 23 | 10 | 13 | 31 | 15 |
| 19 | 1 | 3 | 2 | 2.60 | 9 | 33 | 14 | 19 | 32 | 13 |
| 20 | 2 | 3 | 2 | 2.60 | 7 | 34 | 18 | 16 | 25 | 15 |
| 21 | 1 | 3 | 2 | 2.62 | 2 | 19 | 15 | 4 | 39 | 19 |
| 22 | 1 | 3 | 4 | 2.65 | 5 | 38 | 19 | 19 | 40 | 20 |
| 23 | 1 | 2 | 2 | 2.70 | 6 | 27 | 9 | 18 | 30 | 16 |
| 24 | 1 | 2 | 2 | 2.70 | 7 | 19 | 8 | 11 | 28 | 15 |




**Follow the menu as indicated to conduct the K-S test using Legacy Dialogs. Alternatively, one can run the test using the One-Sample option under the Nonparametric Tests menu or the Explore option in the Descriptive Statistics menu.**

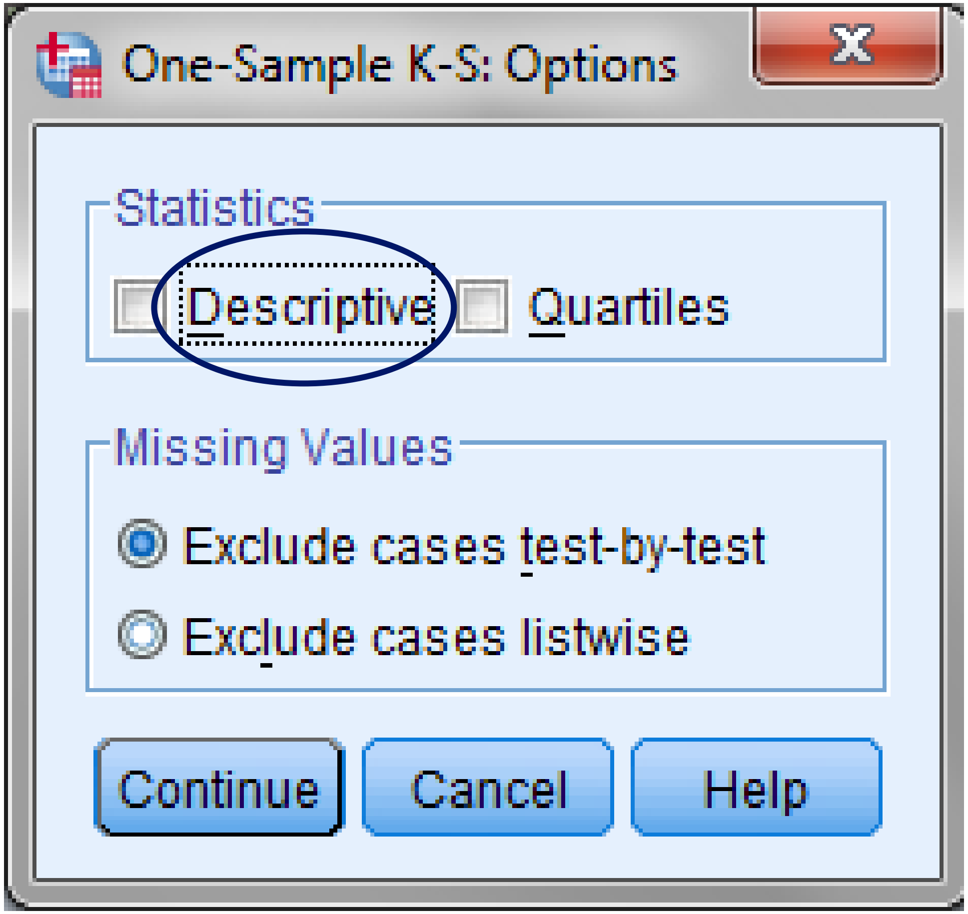
**Note: *N* = 169 in the active dataset; if *N* < 50, the Shapiro-Wilk test should be used to evaluate normality.**




In this example, we will test the following null hypothesis:

***$H_o$*: There is no difference between the distribution of sense of classroom community data and a normal distribution.**

Move *Classroom Community* to the **Test Variable List:** box. Check Normal as the Test Distribution. Click Options.




**Check Descriptive to generate descriptive statistics output. Click Continue and then OK to run the test.**

# SPSS Output

## NPar Tests

```
[DataSet1] C:\Users\dell\Downloads\Motivation.sav
```

**Descriptive Statistics**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Classroom Community | 169 | 28.84 | 6.242 | 15 | 40 |

**The above SPSS output displays descriptive statistics.**

# SPSS Output

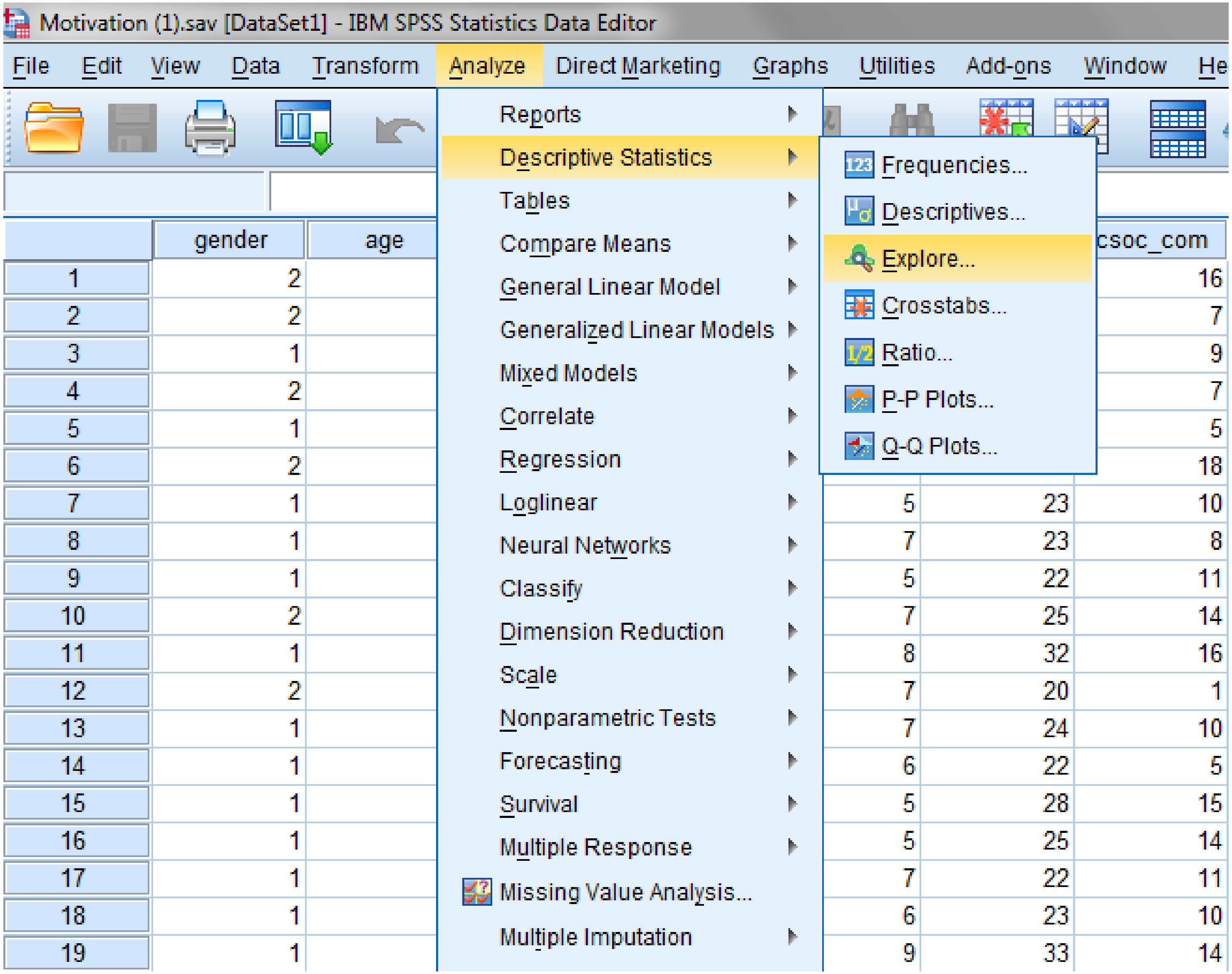
**One-Sample Kolmogorov-Smirnov Test**

| | | Classroom Community |
|---|---|---|
| N | | 169 |
| Normal Parameters[a,b] | Mean | 28.84 |
| | Std. Deviation | 6.242 |
| Most Extreme Differences | Absolute | .089 |
| | Positive | .089 |
| | Negative | -.073 |
| Kolmogorov-Smirnov Z | | 1.153 |
| Asymp. Sig. (2-tailed) | | .002 |

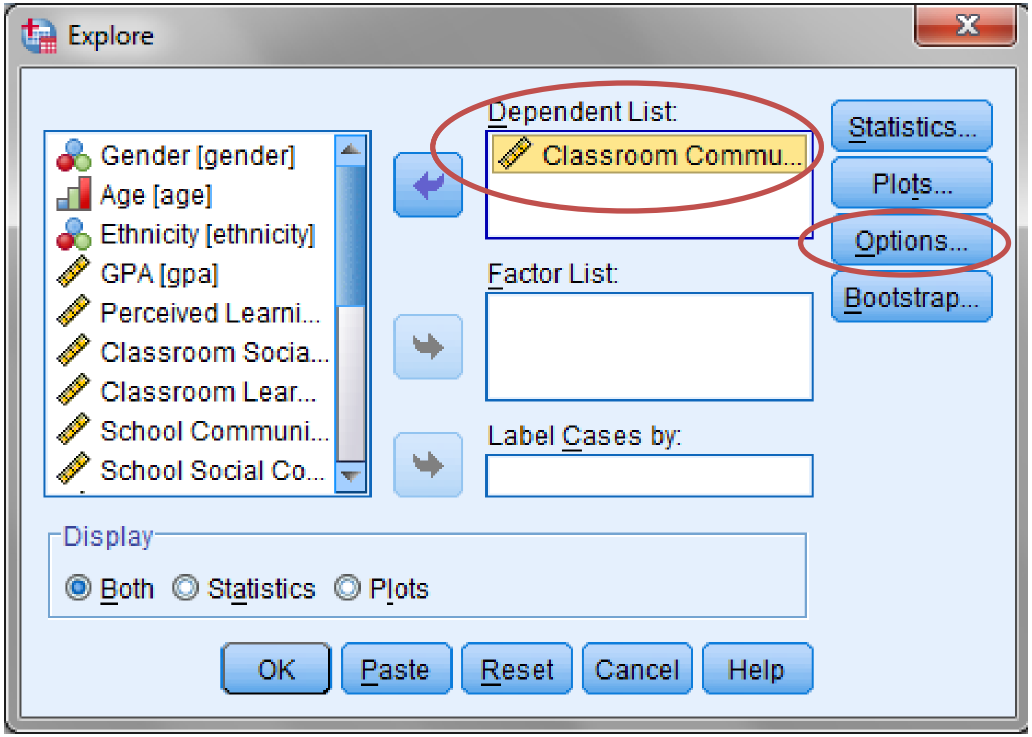
a. Test distribution is Normal.

b. Calculated from data.

**The above SPSS output shows a significant relationship *p-Value* = .002, since the asymptotic significance level <= .05 (the assumed à priori significance level).**

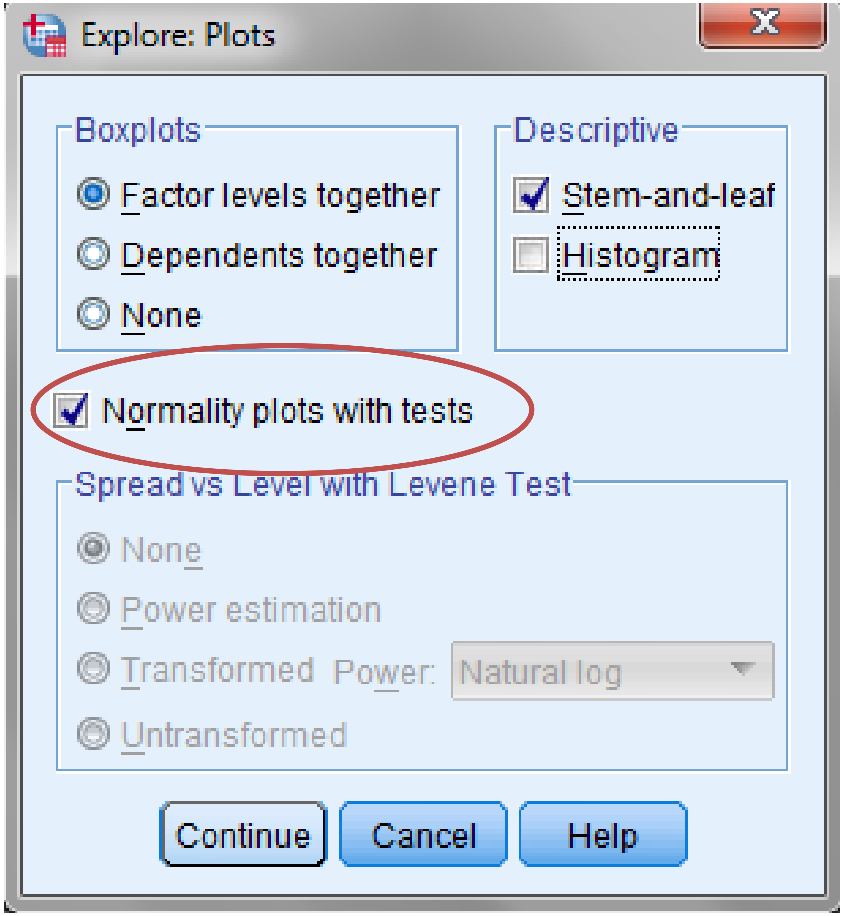



**Follow the menu as indicated to conduct the K-S test using the Explore option in the Descriptive Statistics menu.**




**Move Classroom Community to the Dependent List: box. Click Plots.**

**Note: optionally, you can also select one or more factor variables, e.g., gender, whose values will define groups of cases. Output will provide results disaggregated by the categories within each factor, e.g., K-S test results will be provided for male and female distributions of classroom community.**




**Select Normality plots with tests. Check Histogram, if desired. Click Continue and then OK to run the procedure.**

# SPSS Output

**Descriptives**

| | | | Statistic | Std. Error |
|---|---|---|---|---|
| Classroom Community | Mean | | 28.84 | .480 |
| | 95% Confidence Interval for Mean | Lower Bound | 27.89 | |
| | | Upper Bound | 29.79 | |
| | 5% Trimmed Mean | | 28.82 | |
| | Median | | 29.00 | |
| | Variance | | 38.956 | |
| | Std. Deviation | | 6.242 | |
| | Minimum | | 15 | |
| | Maximum | | 40 | |
| | Range | | 25 | |
| | Interquartile Range | | 11 | |
| | Skewness | | .073 | .187 |
| | Kurtosis | | -1.044 | .371 |

Output includes descriptive. Kurtosis statistics are of special interest. The standard coefficient of kurtosis = $-1.044/.371 = -2.81$, indicating a pronounced platykurtic distribution that suggests a non-normality since the coefficient $< -2.00$.

# SPSS Output

**Tests of Normality**

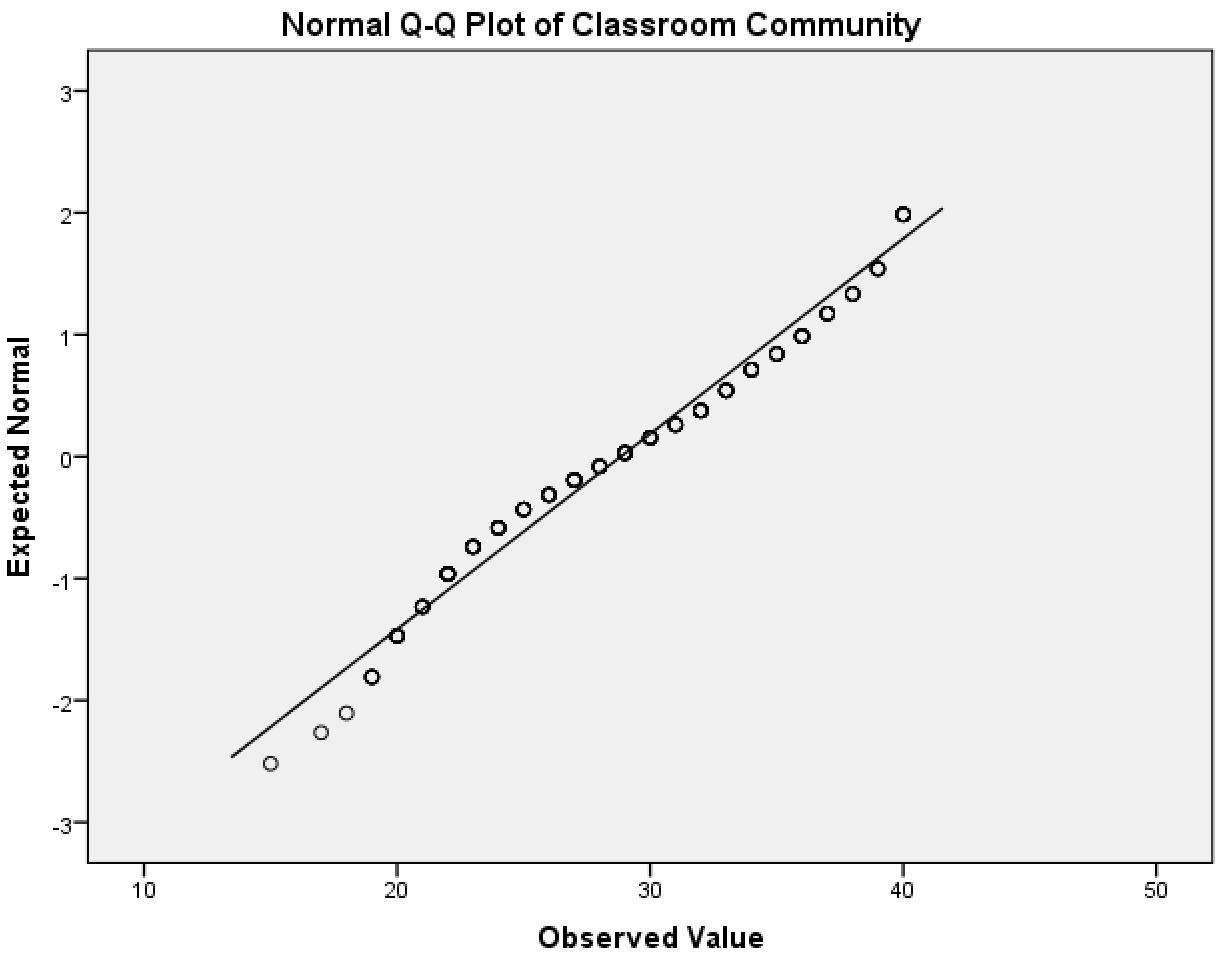
| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Classroom Community | .089 | 169 | .002 | .966 | 169 | .000 |

a. Lilliefors Significance Correction

**The relevant part of the output is the above table on tests of normality. The results, as expected, are the same as the results obtained using the Legacy Dialogs procedure (i.e., the results are statistically significant since $p < .05$.)**

**Note: Shapiro-Wilk test results should be ignored in this example since $N > 50$.**

# SPSS Output

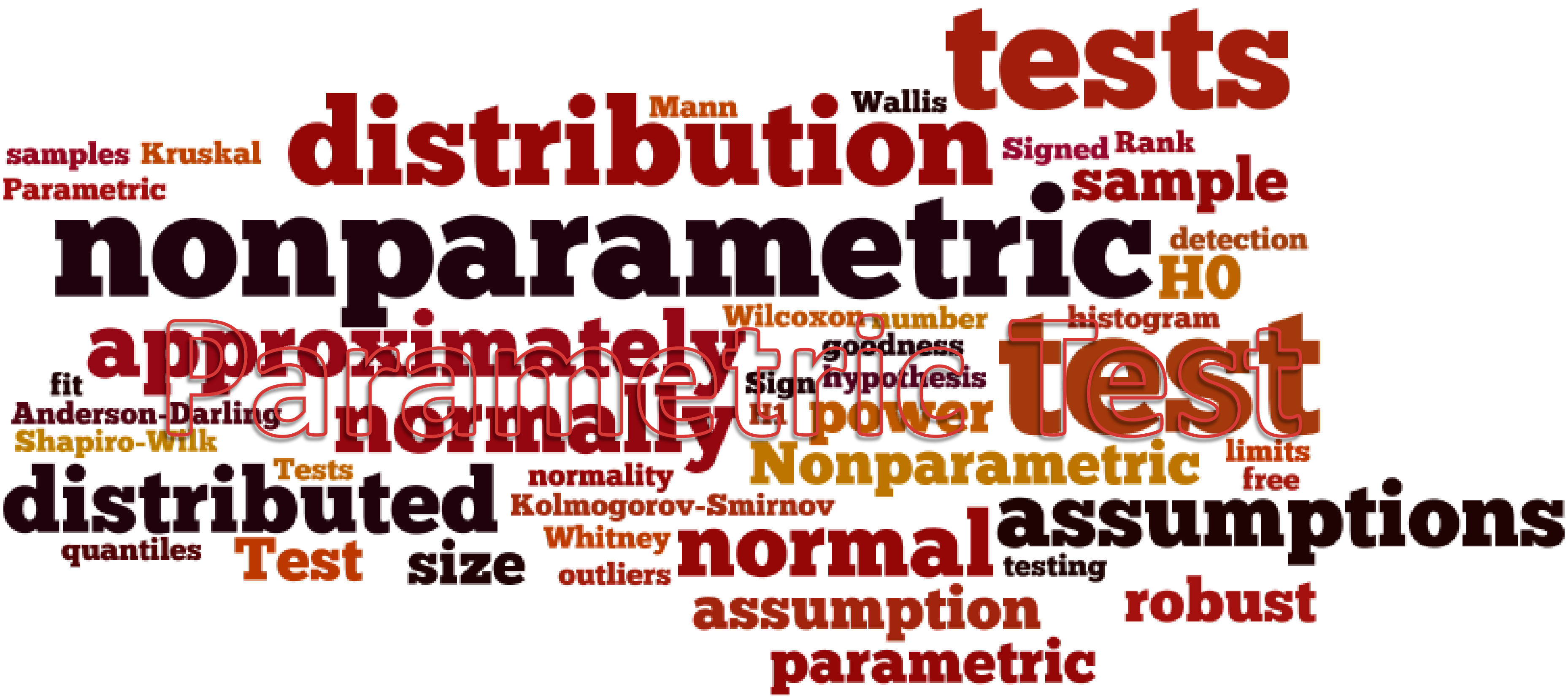



SPSS output includes other relevant material to assist in evaluating normality, such as this Q-Q plot, which supports the conclusion of a non-normal distribution.

# Kolmogorov-Smirnov Test Results Summary

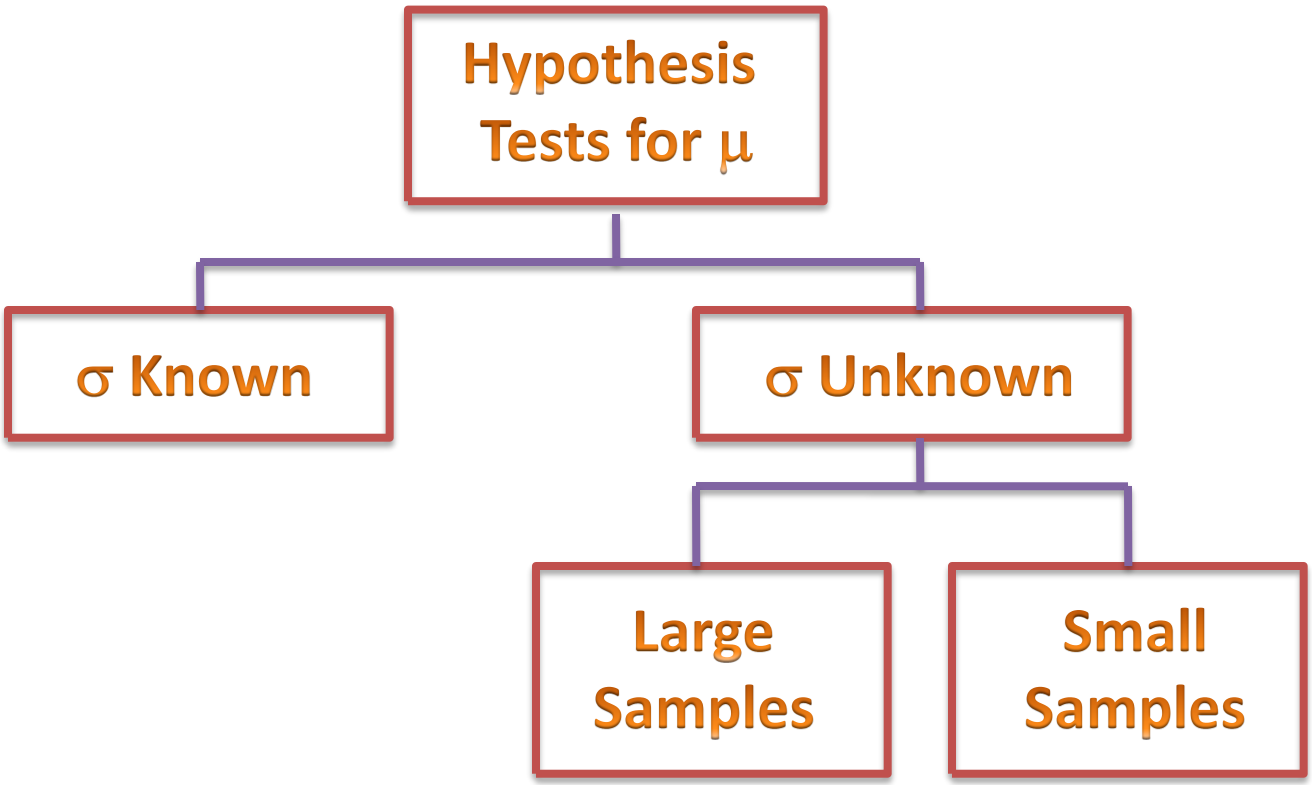
- $H_0$: There is no difference between the distribution of sense of classroom community data and a normal distribution. Test results are significant, $p$ = .002, providing evidence to reject the null hypothesis. Consequently, it is concluded that classroom community scores are not normally distributed.

# Parametric Test

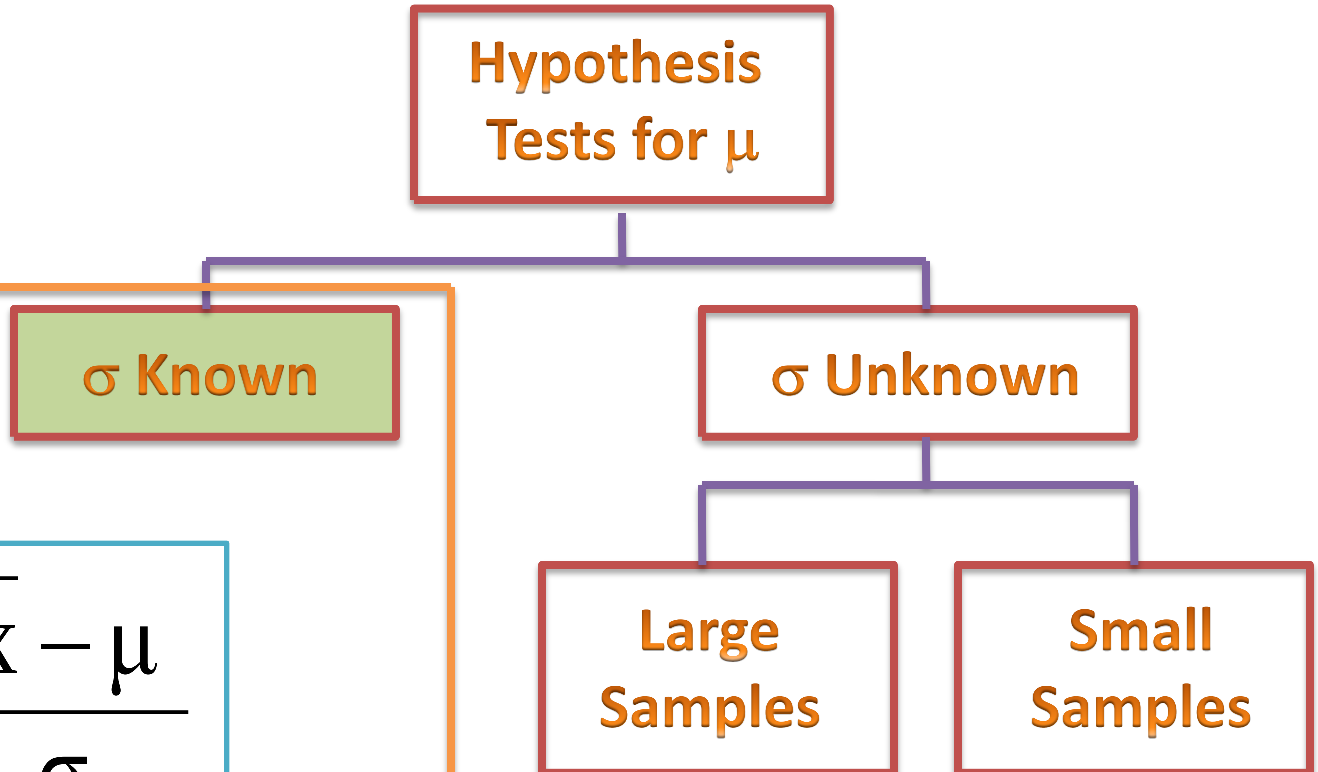


# One sample Test of Hypothesis

- Convert sample statistic ( $\bar{x}$ ) to a test statistic ( $Z$ *or* $t$ statistic ).



# One sample Test of Hypothesis




**The test statistic is:**

$$z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$$

# One sample Test  of Hypothesis

Hypothesis Tests for μ

σ Known

σ Unknown

Large Samples

Small Samples

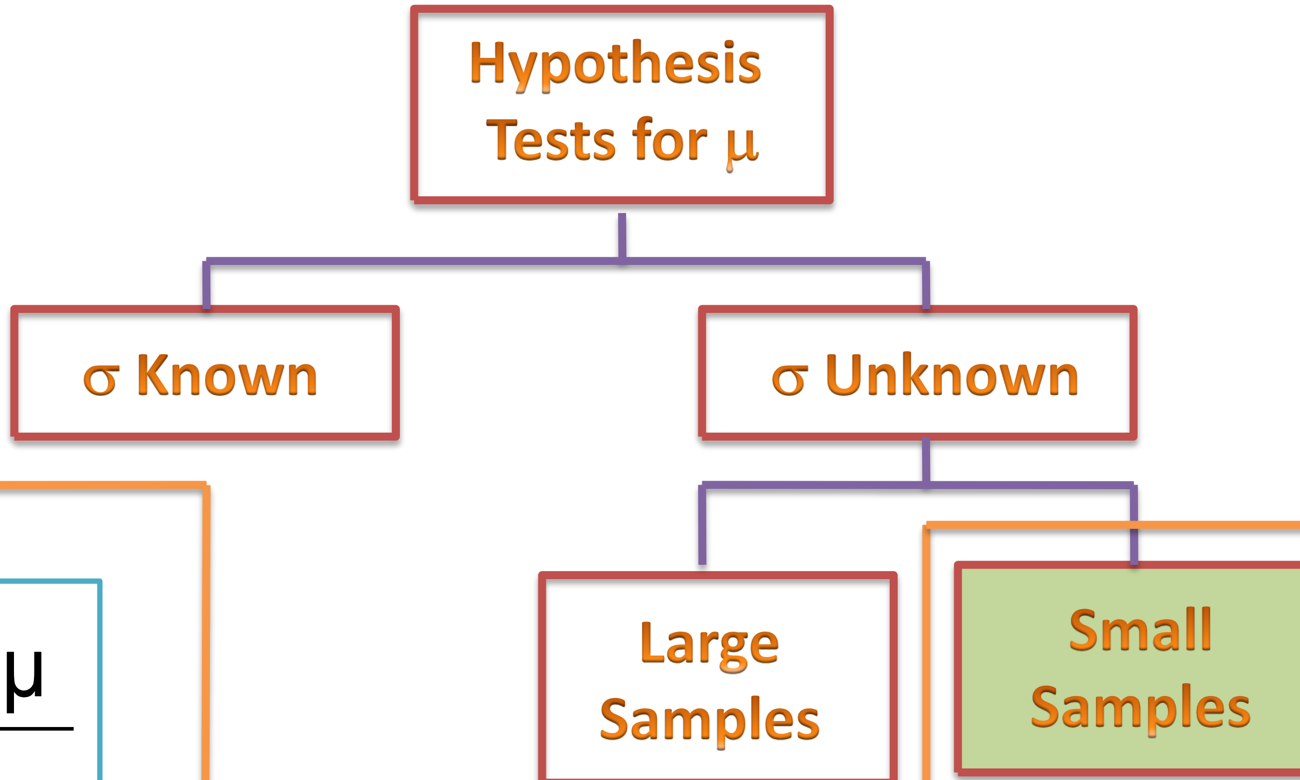
**The test statistic is:**

$$t_{n-1} = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$$

But is sometimes approximated using a z:

$$z = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$$

# One sample Test of Hypothesis




The test statistic is:

$$t_{n-1} = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$$

**(The population must be approximately normal)**

# Uses of the One-Sample *T*-Test

- **Test the hypothesis that there is no difference between the sample mean (*M*) and a given population mean (μ).**
- **Establish an estimate (i.e., a confidence interval) for the population mean.**

# Uses of the One-Sample *T*-Test

File available at http://www.watertreepress.com/stats

Open the dataset *Motivation.sav*.

| | gender | age | ethnicity | gpa | p_learning | c_community | csoc_com | clrn_com | s_community | ssoc_com |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 1.30 | 9 | 36 | 16 | 20 | 12 | 12 |
| 2 | 2 | 2 | 2 | 1.40 | 5 | 21 | 7 | 14 | 25 | 12 |
| 3 | 1 | 2 | 2 | 1.58 | 7 | 23 | 9 | 14 | 30 | 15 |
| 4 | 2 | 2 | 2 | 1.79 | 9 | 25 | 7 | 18 | 25 | 16 |
| 5 | 1 | 2 | 2 | 1.87 | 7 | 22 | 5 | 17 | 28 | 12 |
| 6 | 2 | 3 | 2 | 2.00 | 6 | 34 | 18 | 16 | 29 | 15 |
| 7 | 1 | 2 | 2 | 2.00 | 5 | 23 | 10 | 13 | 28 | 15 |
| 8 | 1 | 2 | 2 | 2.00 | 7 | 23 | 8 | 15 | 26 | 11 |
| 9 | 1 | 3 | 2 | 2.10 | 5 | 22 | 11 | 11 | 17 | 4 |
| 10 | 2 | 3 | 2 | 2.30 | 7 | 25 | 14 | 11 | 19 | 7 |
| 11 | 1 | 3 | 2 | 2.40 | 8 | 32 | 16 | 16 | 19 | 11 |
| 12 | 2 | 2 | 2 | 2.48 | 7 | 20 | 1 | 19 | 18 | 11 |
| 13 | 1 | 4 | 2 | 2.50 | 7 | 24 | 10 | 14 | 16 | 10 |
| 14 | 1 | 2 | 2 | 2.50 | 6 | 22 | 5 | 17 | 40 | 20 |
| 15 | 1 | 3 | 4 | 2.50 | 5 | 28 | 15 | 13 | 25 | 12 |
| 16 | 1 | 2 | 2 | 2.50 | 5 | 25 | 14 | 11 | 30 | 15 |
| 17 | 1 | 3 | 2 | 2.55 | 7 | 22 | 11 | 11 | 15 | 5 |
| 18 | 1 | 2 | 2 | 2.60 | 6 | 23 | 10 | 13 | 31 | 15 |
| 19 | 1 | 3 | 2 | 2.60 | 9 | 33 | 14 | 19 | 32 | 13 |
| 20 | 2 | 3 | 2 | 2.60 | 7 | 34 | 18 | 16 | 25 | 15 |
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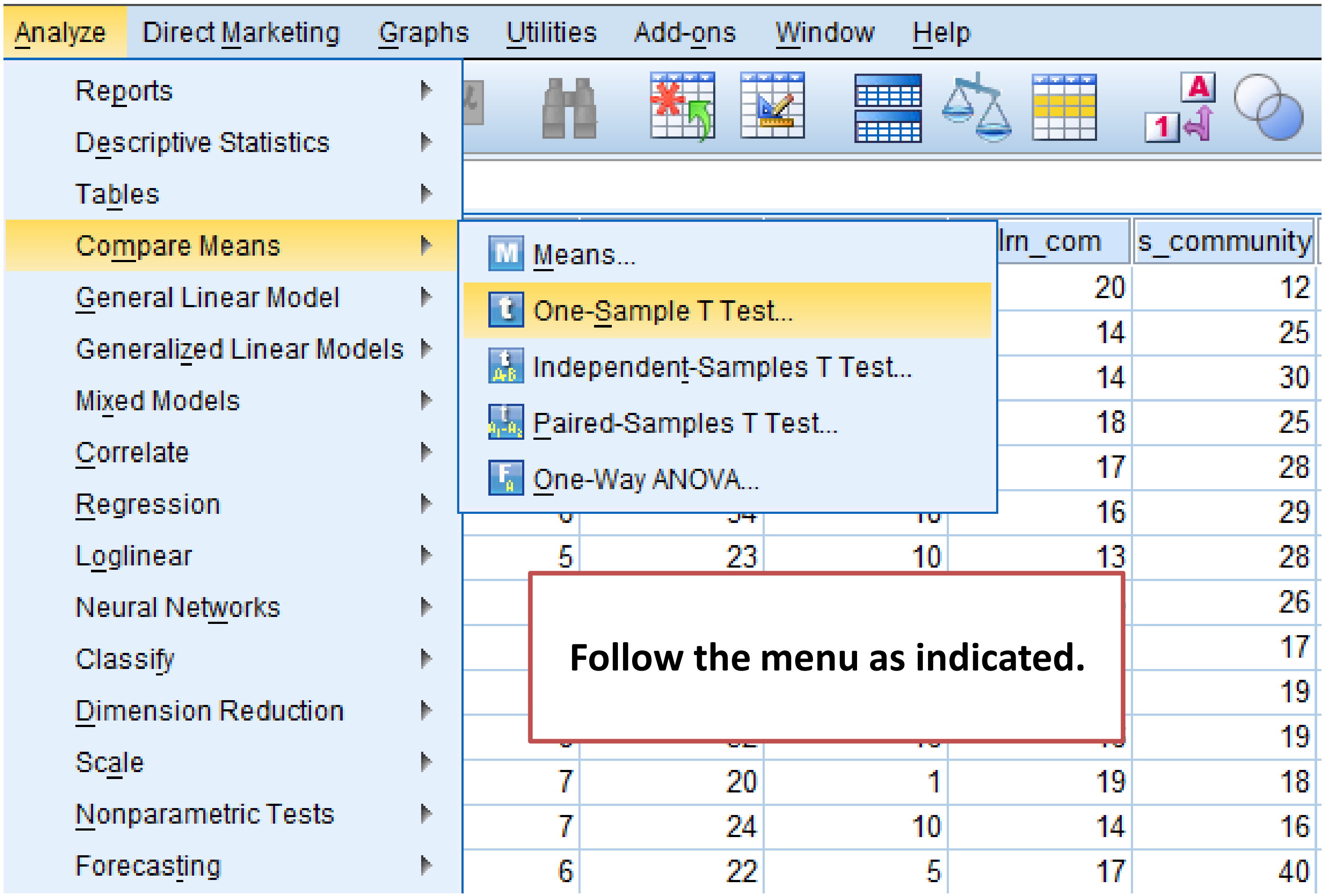
# One sample Test of Hypothesis



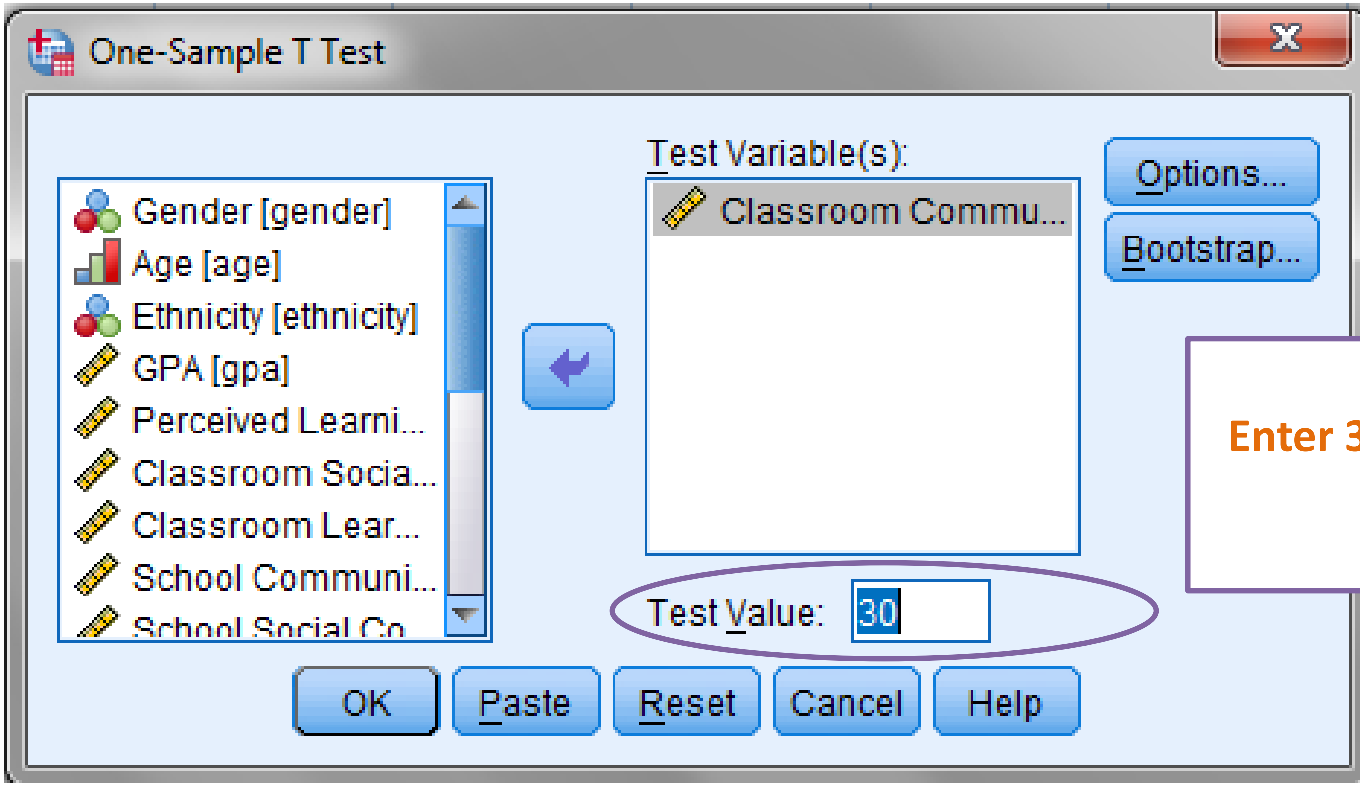

**Follow the menu as indicated.**

# One sample Test of Hypothesis

In this example, we will test the following null hypothesis:

**$H_o$: There is no difference between the sample mean for the variable *Classroom Community* and $\mu = 30$.**

**Select and move the *Classroom Community* variable to the Test Variable(s) box.**




**Enter 30 as the Test Value and click OK.**

# One sample Test of Hypothesis

## T-Test

```
[DataSet1] C:\Users\dell\Downloads\Motivation.sav
```

**One-Sample Statistics**

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Classroom Community | 169 | 28.84 | 6.242 | .480 |

**One-Sample Test**

| | Test Value = 30 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
| | | | | | Lower | Upper |
| Classroom Community | -2.416 | 168 | .017 | -1.160 | -2.11 | -.21 |

**Using a two-tailed level of significance of $\alpha$ = .05, we reject the null hypothesis (i.e., .017 <= .05) and conclude there is a difference between the sample mean and a population mean of 30.**

# One sample Test of Hypothesis

**One-Sample Test**

| | Test Value = 30 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
| | | | | | Lower | Upper |
| Classroom Community | -2.416 | 168 | .017 | -1.160 | -2.11 | -.21 |

**We are 95% confident that the true population mean is within the interval 27.89 and 29.79 (i.e., 30-2.11 and 30-.21); that is, $CI_{95}$ = (27.89, 29.79) for the 95% confidence interval.**

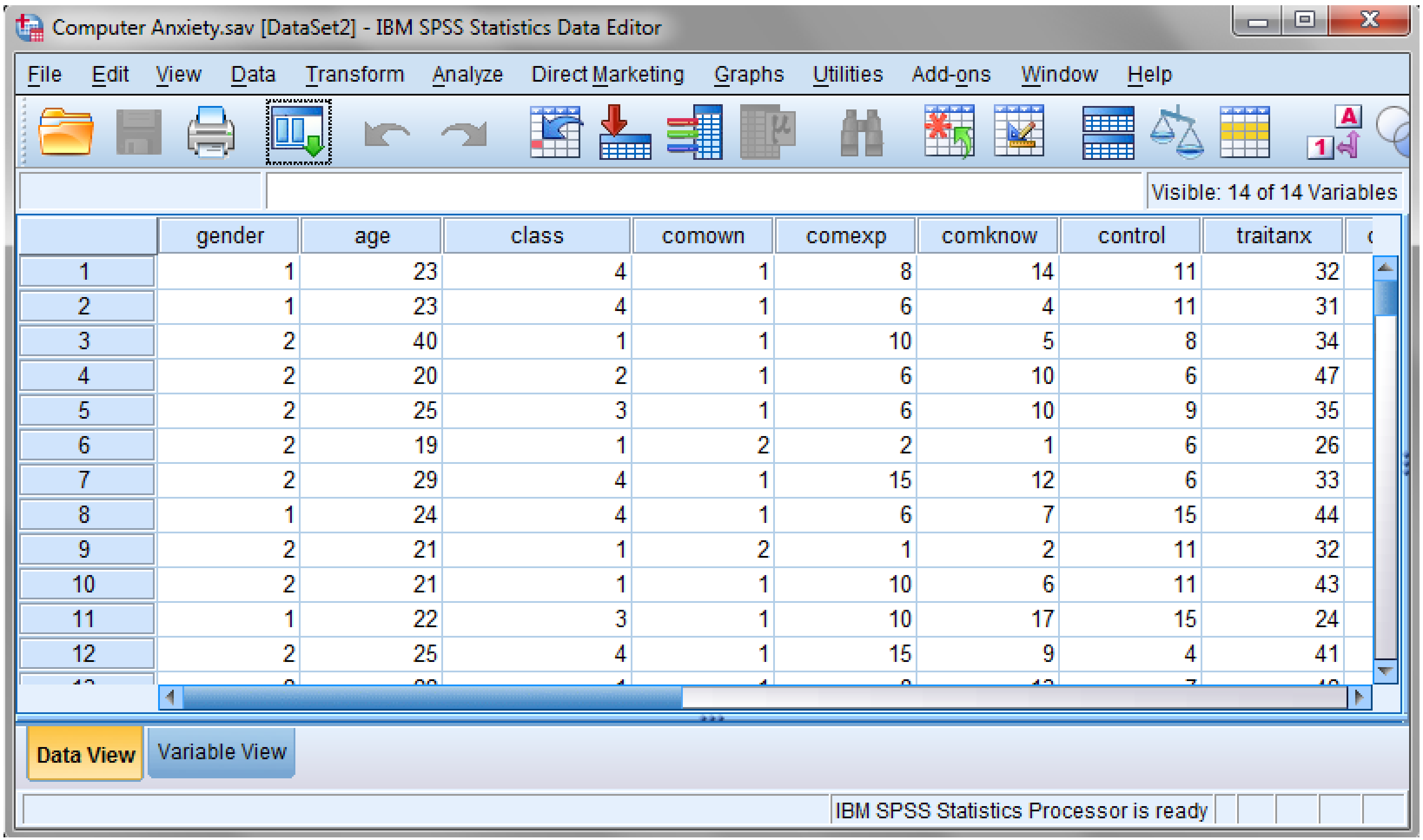
# Uses of the Independent-Samples T-Test

- Test the hypothesis that there is no difference between the population means ($\mu$) of two independent groups.
- Establish an estimate (i.e., a confidence interval) for the difference between the two population means.

# Uses of the Independent-Samples T-Test

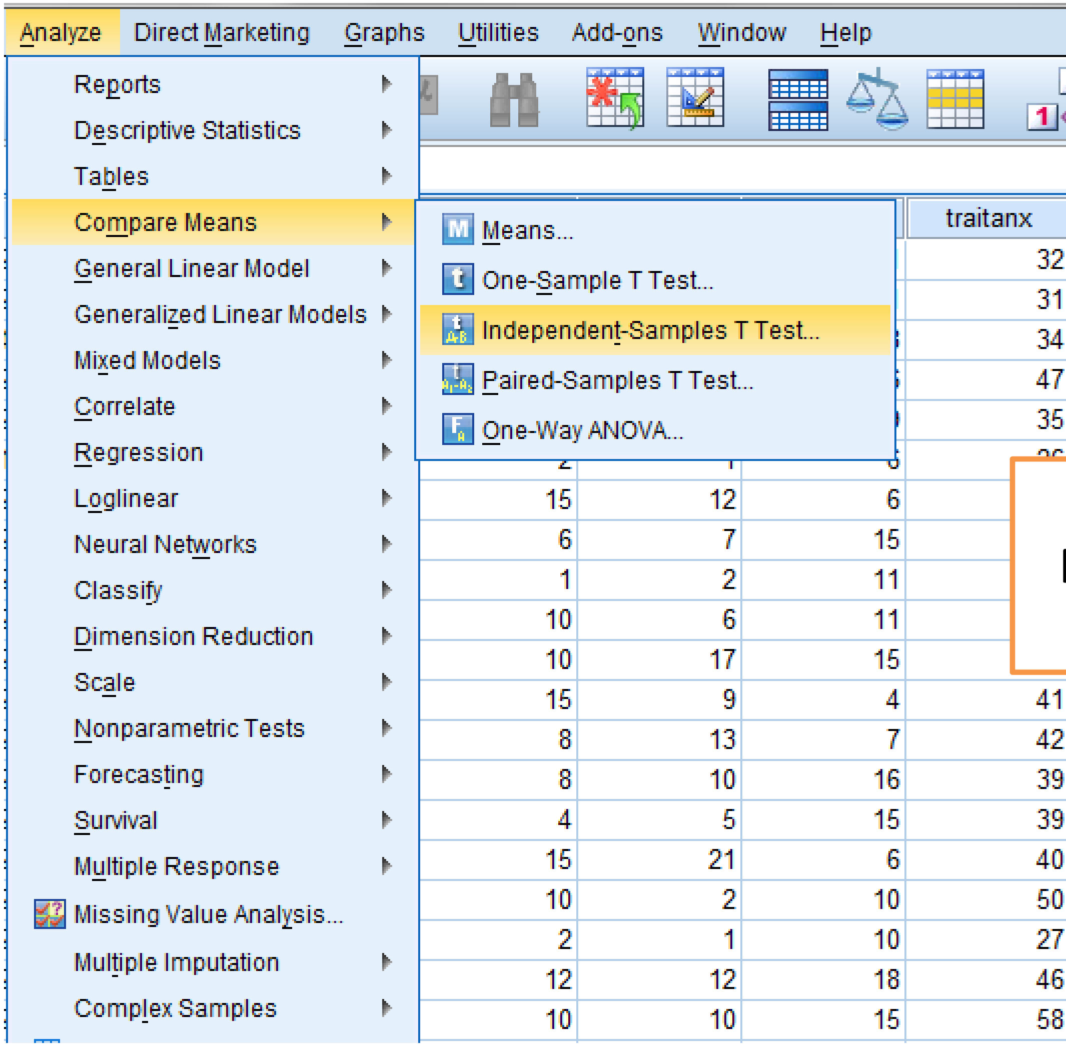
File available at http://www.watertreepress.com/stats

Open the dataset *Computer Anxiety.sav*.




| | gender | age | class | comown | comexp | comknow | control | traitanx |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 23 | 4 | 1 | 8 | 14 | 11 | 32 |
| 2 | 1 | 23 | 4 | 1 | 6 | 4 | 11 | 31 |
| 3 | 2 | 40 | 1 | 1 | 10 | 5 | 8 | 34 |
| 4 | 2 | 20 | 2 | 1 | 6 | 10 | 6 | 47 |
| 5 | 2 | 25 | 3 | 1 | 6 | 10 | 9 | 35 |
| 6 | 2 | 19 | 1 | 2 | 2 | 1 | 6 | 26 |
| 7 | 2 | 29 | 4 | 1 | 15 | 12 | 6 | 33 |
| 8 | 1 | 24 | 4 | 1 | 6 | 7 | 15 | 44 |
| 9 | 2 | 21 | 1 | 2 | 1 | 2 | 11 | 32 |
| 10 | 2 | 21 | 1 | 1 | 10 | 6 | 11 | 43 |
| 11 | 1 | 22 | 3 | 1 | 10 | 17 | 15 | 24 |
| 12 | 2 | 25 | 4 | 1 | 15 | 9 | 4 | 41 |

# Uses of the Independent-Samples T-Test



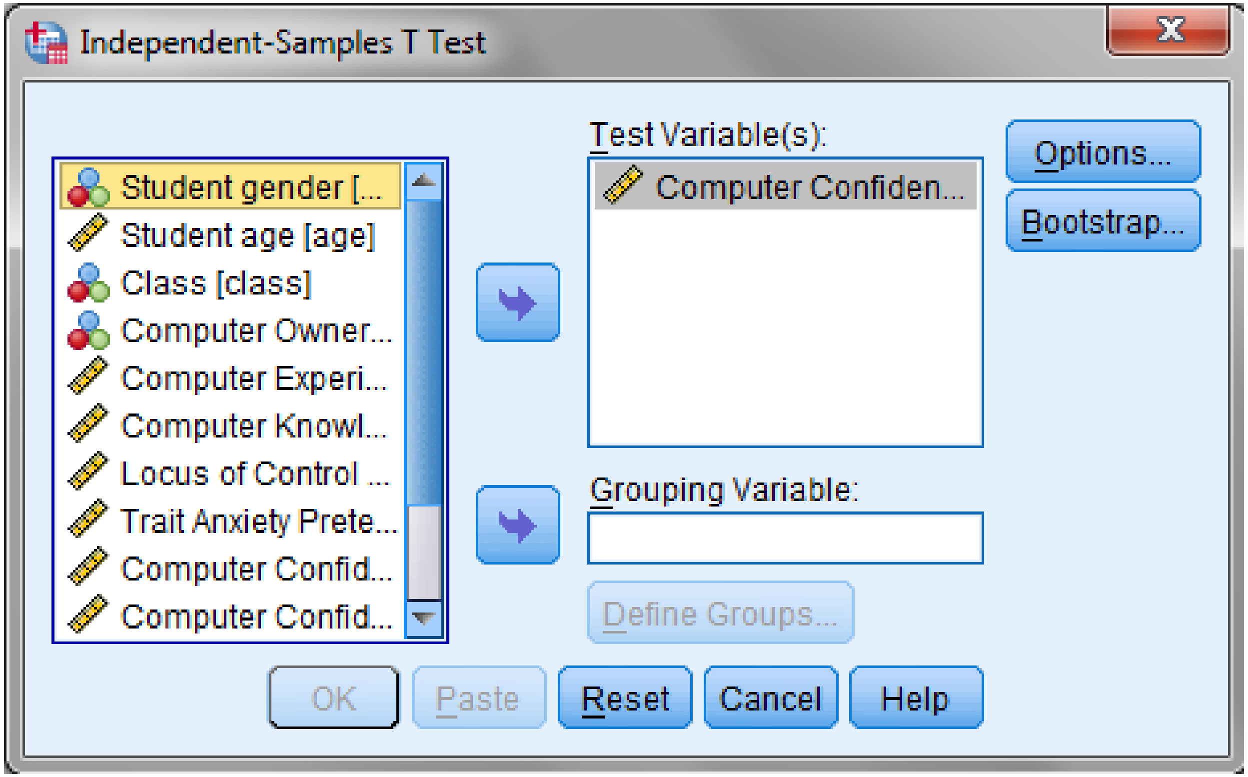

**Follow the menu as indicated.**

# Uses of the Independent-Samples T-Test

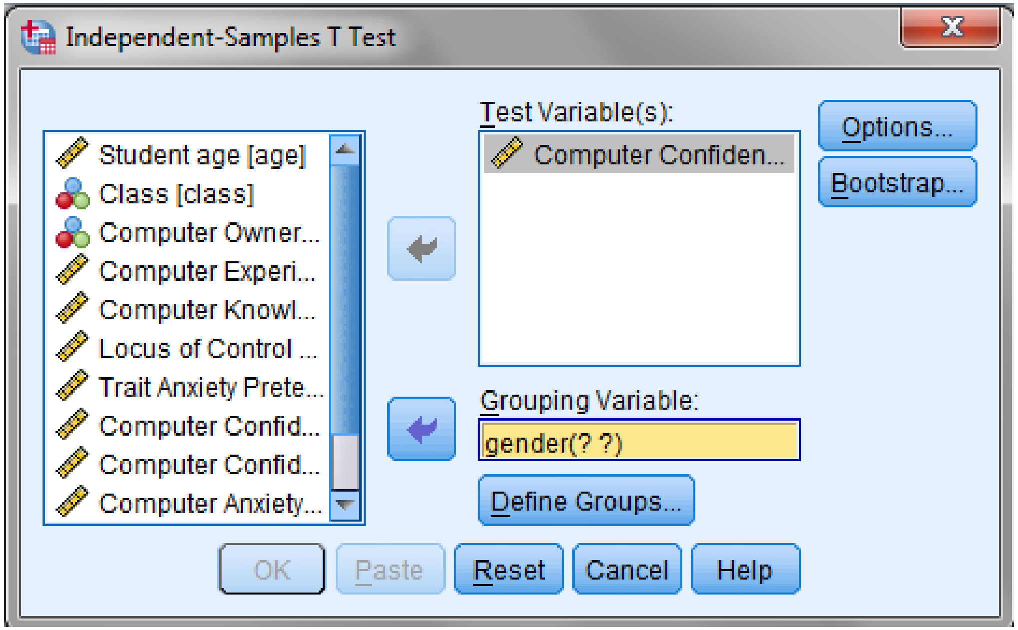
**In this example, we will test the following null hypothesis:**

**$H_o$: There is no difference in mean computer confidence posttest between male (group 1) and female (group 2) University students (i.e., $\mu_1 = \mu_2$).**

**Select and move the *Computer Confidence Posttest [comconf2]* variable to the Test Variable(s) box.**

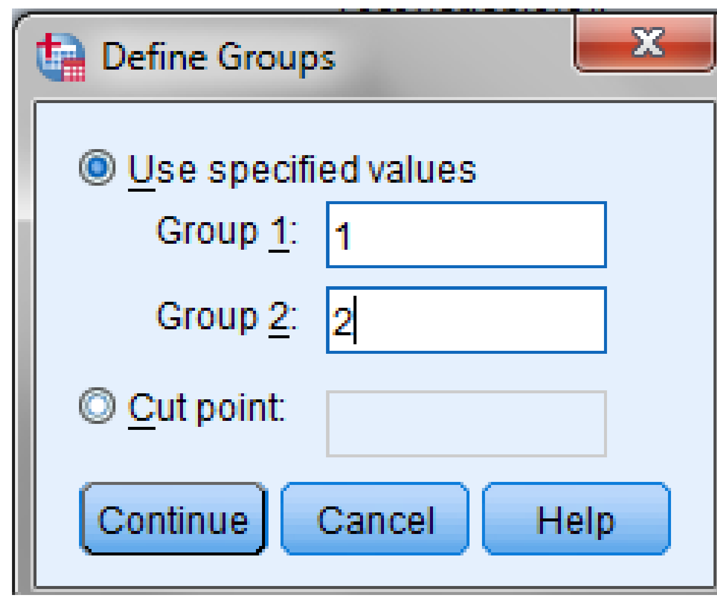


# Uses of the Independent-Samples T-Test




**Select and move the *gender* variable to the Grouping Variable box; click Define Groups.**

**For Group 1 and 2 boxes, enter the *gender* variable values 1 and 2, respectively; click Continue.**



# Uses of the Independent-Samples T-Test

**SPSS performs two *t*-tests: one assuming equal variances between the two groups and one not assuming equal variances. To determine which *t*-test to use, we must perform an intermediate hypothesis test.**

## T-Test

C:\Users\dell\Downloads\Computer Anxiety.sav

**Group Statistics**

| | Student gender | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Computer Confidence Posttest | Male | 22 | 31.77 | 4.740 | 1.011 |
| | Female | 64 | 32.78 | 5.559 | .695 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Computer Confidence Posttest | Equal variances assumed | .146 | .704 | -.760 | 84 | .449 | -1.009 | 1.326 | -3.646 | 1.629 |
| | Equal variances not assumed | | | -.822 | 42.392 | .416 | -1.009 | 1.226 | -3.483 | 1.466 |

# Uses of the Independent-Samples T-Test

**We need to test the following null hypothesis using the Levene's Test: $H_o: \sigma_1^2 = \sigma_2^2$; that is, the variance in group 1 (males) is equal to the variance in group 2 (females).**

**For $\alpha = .05$, we see that the significance value of .704 is greater than $\alpha$; therefore, we fail to reject the above $H_o$ and can assume equal variances.**

**Thus, we will use the *t*-test in the top line of the output table.**

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Computer Confidence Posttest | Equal variances assumed | .146 | .704 | -.760 | 84 | .449 | -1.009 | 1.326 | -3.646 | 1.629 |
| | Equal variances not assumed | | | -.822 | 42.392 | .416 | -1.009 | 1.226 | -3.483 | 1.466 |

# Uses of the Independent-Samples T-Test

For the independent-samples *t*-test we are testing the null hypothesis $H_o$: $\mu_1 = \mu_2$ in which the subscripts 1 and 2 correspond to groups 1 and 2, respectively (i.e., the null hypothesis is that the mean of the variable *Computer Confidence Posttest* is the same for both group populations). We will choose $\alpha = .05$ for a two-tailed test (i.e., we are interested if either group mean is larger than the other). Note that the significance value of $.449 > \alpha$; therefore, we fail to reject $H_o$ and conclude that there is no difference between the two groups for the population mean of the variable *Computer Confidence Posttest*.

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference Lower | Upper |
| Computer Confidence Posttest | Equal variances assumed | .146 | .704 | -.760 | 84 | .449 | -1.009 | 1.326 | -3.646 | 1.629 |
| | Equal variances not assumed | | | -.822 | 42.392 | .416 | -1.009 | 1.226 | -3.483 | 1.466 |

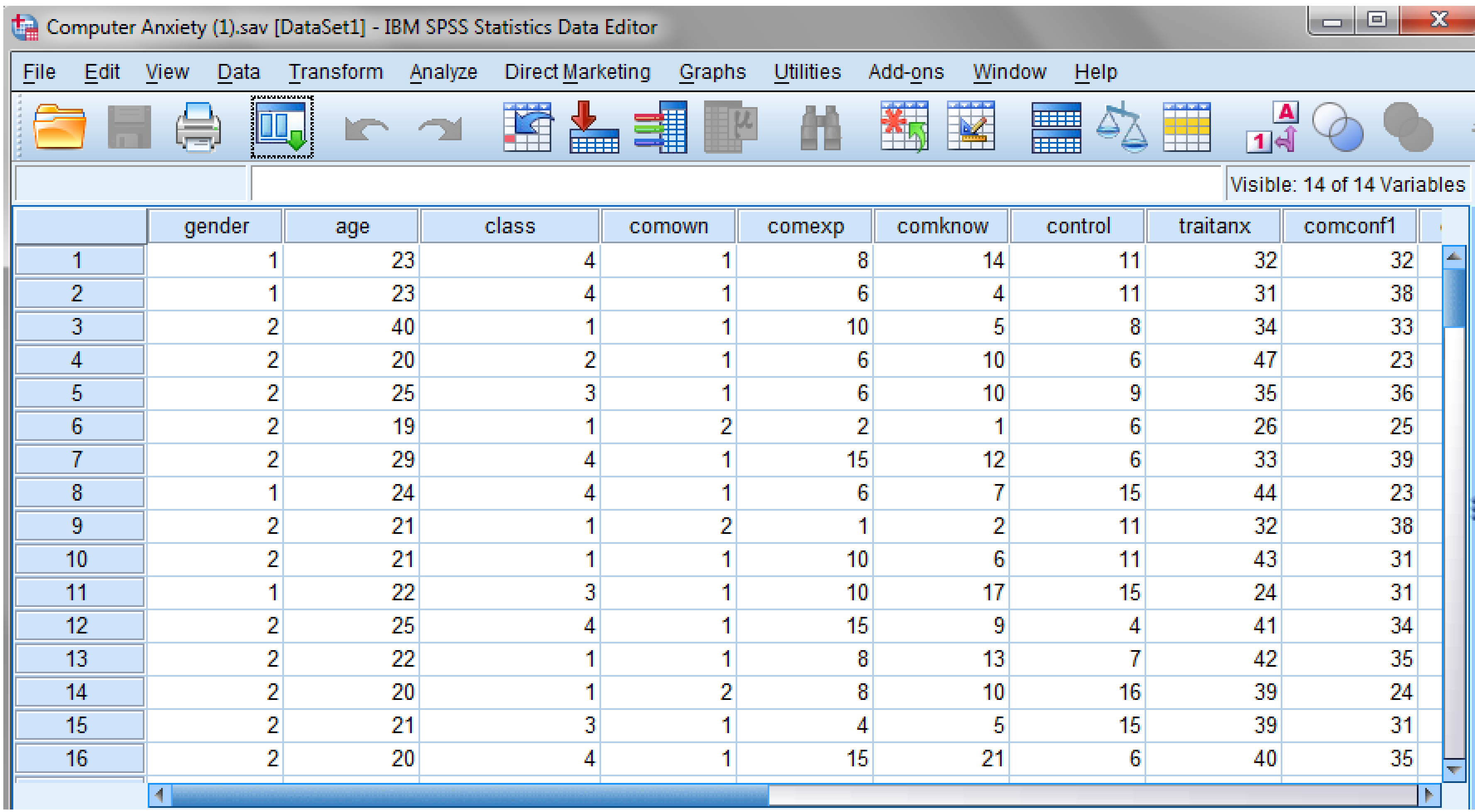
# Uses of the Dependent-Samples T-Test

- Test the hypothesis that there is no difference between the population means ($\mu$) of two dependent groups (i.e., two repeated measures for the same sample).
- Establish an estimate (i.e., a confidence interval) for the difference between the two population means.

# Uses of the Dependent-Samples T-Test

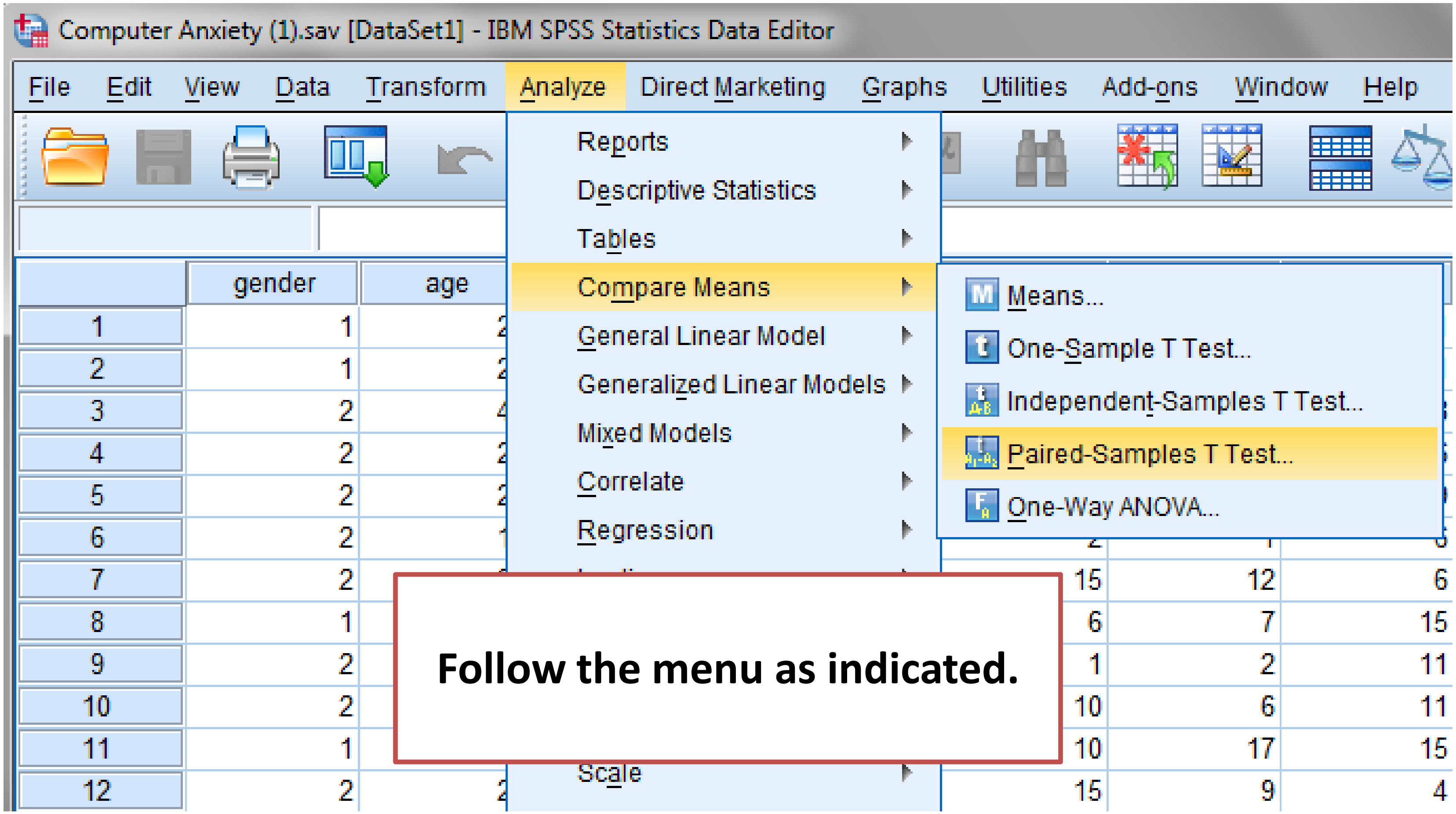
File available at http://www.watertreepress.com/stats

Open the dataset *Computer Anxiety.sav*.




| | gender | age | class | comown | comexp | comknow | control | traitanx | comconf1 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 23 | 4 | 1 | 8 | 14 | 11 | 32 | 32 |
| 2 | 1 | 23 | 4 | 1 | 6 | 4 | 11 | 31 | 38 |
| 3 | 2 | 40 | 1 | 1 | 10 | 5 | 8 | 34 | 33 |
| 4 | 2 | 20 | 2 | 1 | 6 | 10 | 6 | 47 | 23 |
| 5 | 2 | 25 | 3 | 1 | 6 | 10 | 9 | 35 | 36 |
| 6 | 2 | 19 | 1 | 2 | 2 | 1 | 6 | 26 | 25 |
| 7 | 2 | 29 | 4 | 1 | 15 | 12 | 6 | 33 | 39 |
| 8 | 1 | 24 | 4 | 1 | 6 | 7 | 15 | 44 | 23 |
| 9 | 2 | 21 | 1 | 2 | 1 | 2 | 11 | 32 | 38 |
| 10 | 2 | 21 | 1 | 1 | 10 | 6 | 11 | 43 | 31 |
| 11 | 1 | 22 | 3 | 1 | 10 | 17 | 15 | 24 | 31 |
| 12 | 2 | 25 | 4 | 1 | 15 | 9 | 4 | 41 | 34 |
| 13 | 2 | 22 | 1 | 1 | 8 | 13 | 7 | 42 | 35 |
| 14 | 2 | 20 | 1 | 2 | 8 | 10 | 16 | 39 | 24 |
| 15 | 2 | 21 | 3 | 1 | 4 | 5 | 15 | 39 | 31 |
| 16 | 2 | 20 | 4 | 1 | 15 | 21 | 6 | 40 | 35 |

# Uses of the Dependent-Samples T-Test

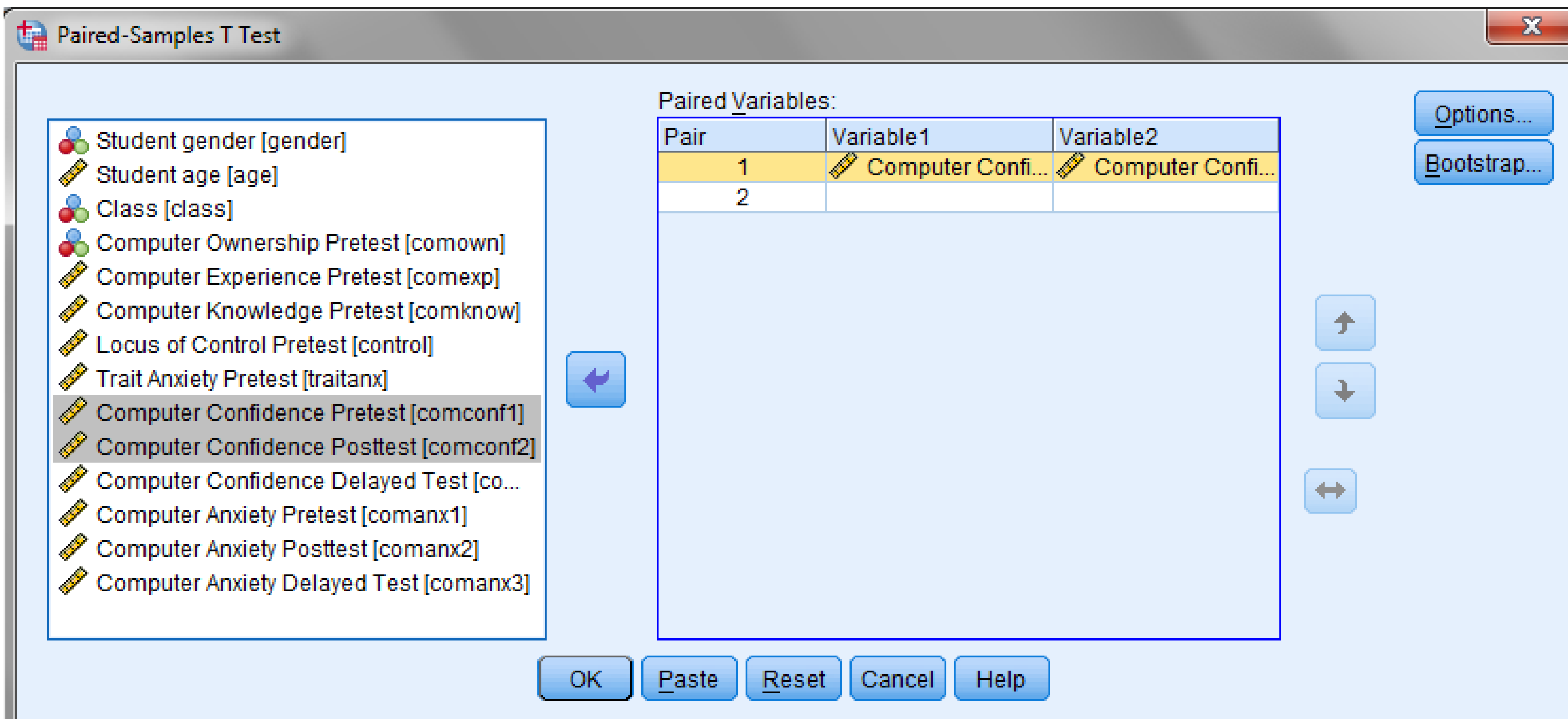


# Uses of the Dependent-Samples T-Test

**In this example, we will test the following null hypothesis:**

**$H_o$: There is no difference in computer confidence pretest and posttest among university students (i.e., $\mu_1 = \mu_2$).**

**Select and move *Computer Confidence Pretest [comconf1]* to Variable 1 and *Computer Confidence Posttest [comconf2]* to Variable 2 in the Paired Variables box; click OK.**



# Uses of the Dependent-Samples T-Test

## T-Test

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Computer Confidence Pretest | 31.09 | 86 | 5.800 | .625 |
| | Computer Confidence Posttest | 32.52 | 86 | 5.353 | .577 |

**Paired Samples Correlations**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Computer Confidence Pretest & Computer Confidence Posttest | 86 | .694 | .000 |

**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 | Computer Confidence Pretest - Computer Confidence Posttest | -1.430 | 4.383 | .473 | -2.370 | -.490 | -3.026 | 85 | .003 |

# Uses of the Dependent-Samples T-Test

For the dependent-samples *t*-test we are testing the null hypothesis

$H_o$: $\mu_1 = \mu_2$ in which the subscripts 1 and 2 correspond to the pretest and posttest, respectively (i.e., the null hypothesis is that the mean is the same for both the pretested and posttested populations).

We will choose $\alpha = .05$ for a two-tailed test (i.e., we are interested if either mean is larger than the other). Note that the significance value of $.003 < \alpha$; therefore, we reject $H_o$ and conclude that there is a statistically significant difference between the pretest and posttest population means.

**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 | Computer Confidence Pretest - Computer Confidence Posttest | -1.430 | 4.383 | .473 | -2.370 | -.490 | -3.026 | 85 | .003 |

# Uses of the Dependent-Samples T-Test

$CI_{95}$ of the difference is (-2.37, -.49). This indicates that we are 95% confident that the difference in the population means is in the range -2.37 to -.49.

**Note that the difference is calculated by variable 1 - variable 2 as defined in the "Paired Variables"; that is, we are 95% confident that $-2.37 <= \mu_1 - \mu_2 <= -.49$ (i.e., posttest > pretest by .49 to 2.37).**

**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 | Computer Confidence Pretest - Computer Confidence Posttest | -1.430 | 4.383 | .473 | -2.370 | -.490 | -3.026 | 85 | .003 |

# Uses of the Between Subjects Analysis Of Variance (ANOVA)

- **The One Way Analysis of Variance (ANOVA) is a parametric procedure that tests the hypothesis that there is no difference between the population means (μ) of three or more independent groups on a single factor.**
  - **The independent *t*-test is used to compare the means of two independent groups on a single factor.**
- **It also tests the hypotheses that there are no differences between the population means (μ) of two or more independent groups on multiple factors (i.e., a factorial ANOVA) and that there are no interaction effects between factors.**

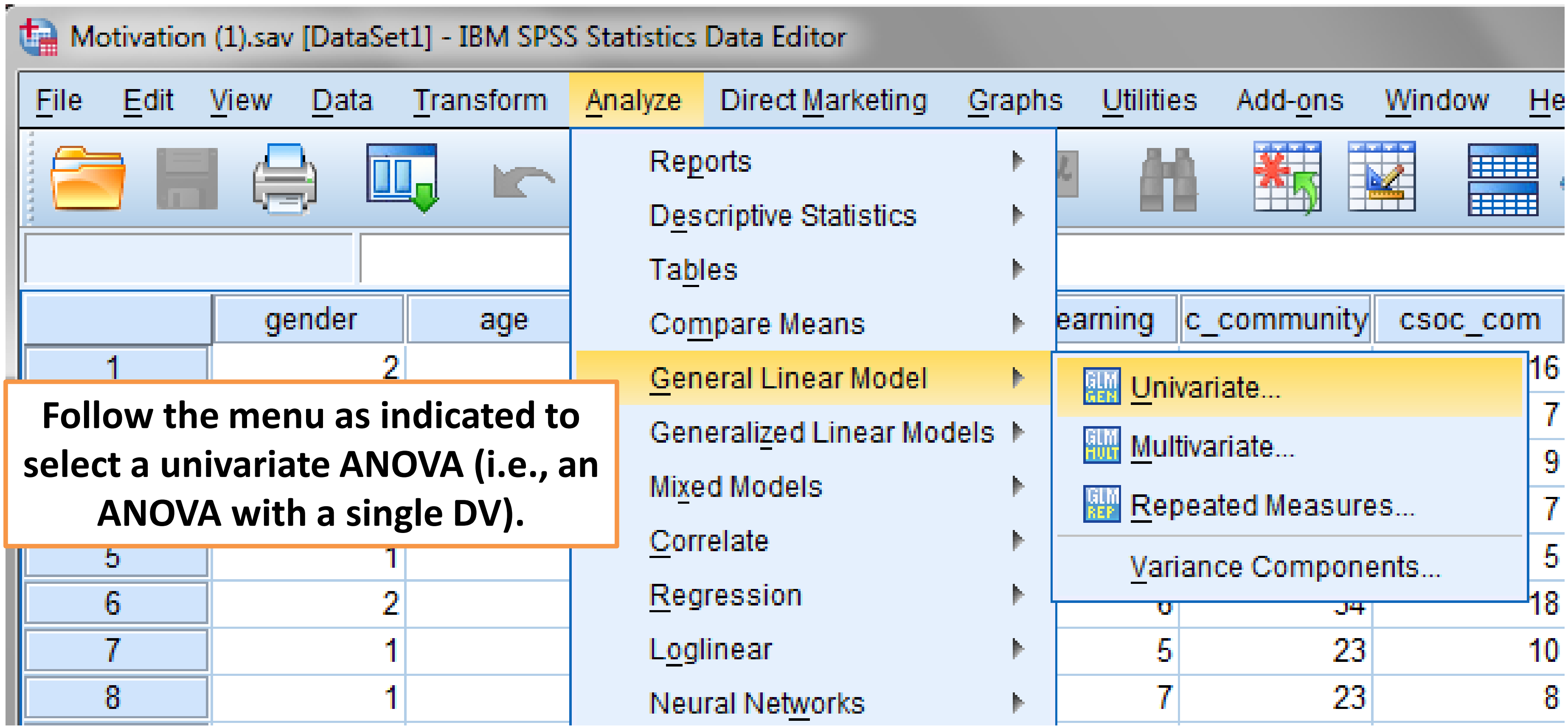
# Uses of the Between Subjects Analysis of Variance

File available at http://www.watertreepress.com/stats

Open the dataset *Motivation.sav*.

| | gender | age | ethnicity | gpa | p_learning | c_community | csoc_com | clrn_com | s_community | ssoc_ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 1.30 | 9 | 36 | 16 | 20 | 12 | |
| 2 | 2 | 2 | 2 | 1.40 | 5 | 21 | 7 | 14 | 25 | |
| 3 | 1 | 2 | 2 | 1.58 | 7 | 23 | 9 | 14 | 30 | |
| 4 | 2 | 2 | 2 | 1.79 | 9 | 25 | 7 | 18 | 25 | |
| 5 | 1 | 2 | 2 | 1.87 | 7 | 22 | 5 | 17 | 28 | |
| 6 | 2 | 3 | 2 | 2.00 | 6 | 34 | 18 | 16 | 29 | |
| 7 | 1 | 2 | 2 | 2.00 | 5 | 23 | 10 | 13 | 28 | |
| 8 | 1 | 2 | 2 | 2.00 | 7 | 23 | 8 | 15 | 26 | |
| 9 | 1 | 3 | 2 | 2.10 | 5 | 22 | 11 | 11 | 17 | |
| 10 | 2 | 3 | 2 | 2.30 | 7 | 25 | 14 | 11 | 19 | |
| 11 | 1 | 3 | 2 | 2.40 | 8 | 32 | 16 | 16 | 19 | |
| 12 | 2 | 2 | 2 | 2.48 | 7 | 20 | 1 | 19 | 18 | |
| 13 | 1 | 4 | 2 | 2.50 | 7 | 24 | 10 | 14 | 16 | |
| 14 | 1 | 2 | 2 | 2.50 | 6 | 22 | 5 | 17 | 40 | |
| 15 | 1 | 3 | 4 | 2.50 | 5 | 28 | 15 | 13 | 25 | |
| 16 | 1 | 2 | 2 | 2.50 | 5 | 25 | 14 | 11 | 30 | |

# Uses of the Between Subjects Analysis of Variance




Follow the menu as indicated to select a univariate ANOVA (i.e., an ANOVA with a single DV).

# Uses of the Between Subjects Analysis of Variance

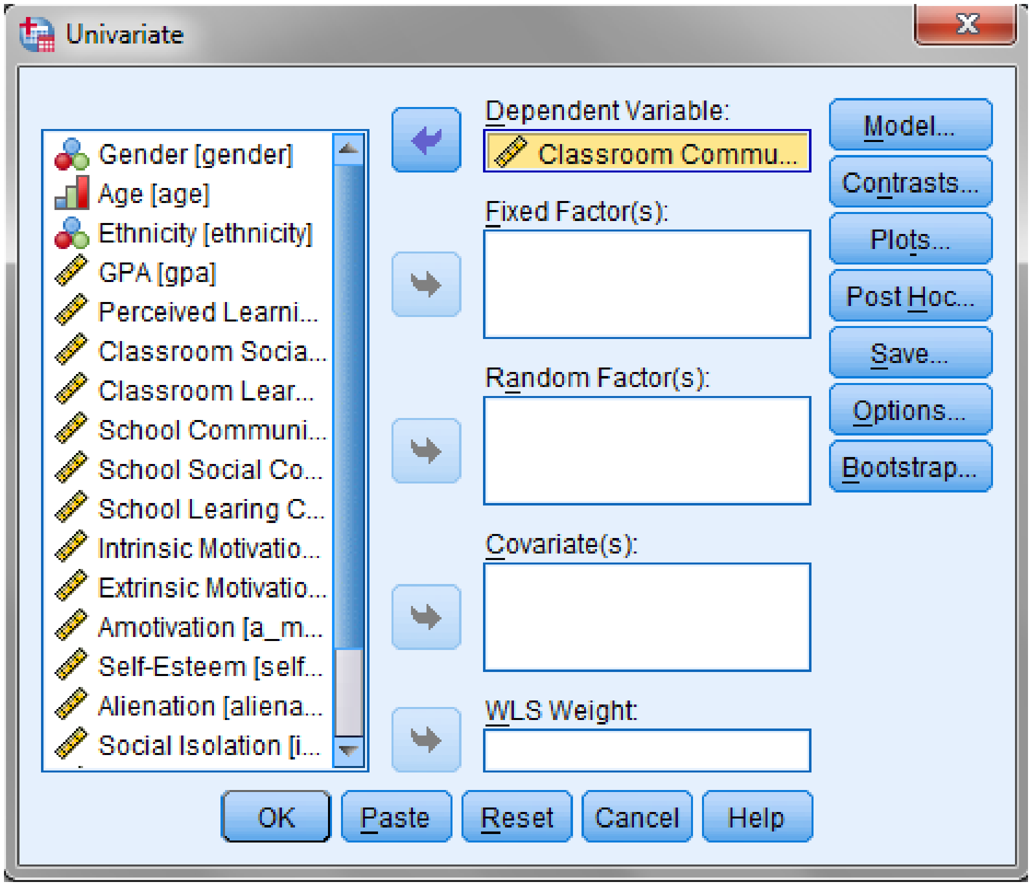
**Select and move the Classroom Community variable to the Dependent Variable: box.**
**In this example, we will conduct a two-way factorial ANOVA (i.e., two factors) and test the following three null hypotheses:**

**$H_{01}$: There is no difference in sense of classroom community between graduate students based on gender (male, female).**

**$H_{02}$: There is no difference in sense of classroom community between graduate students based on age (18-20, 21-30, 31-40, 41-50, over 50).**

**$H_{03}$: The difference in sense of classroom community between students based on gender remains constant regardless of age.**

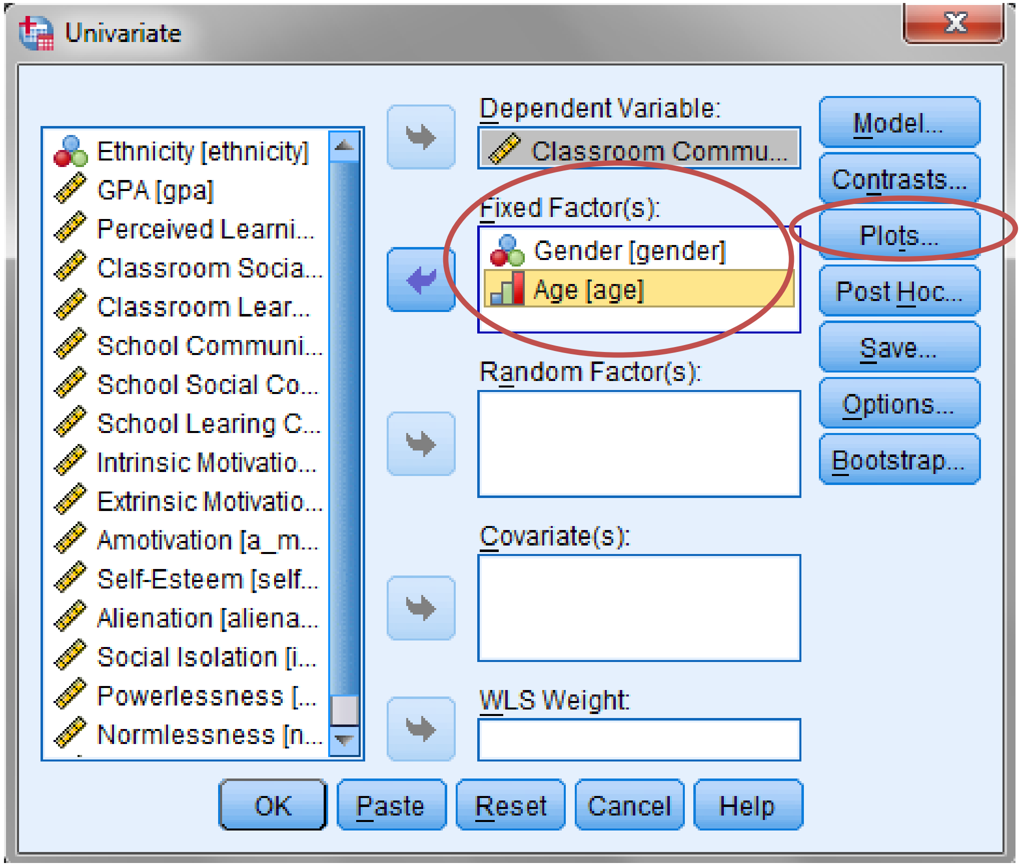
**Since there are two between subjects factors (IVs), this is a two-way between subjects ANOVA.**



# Uses of the Between Subjects Analysis of Variance

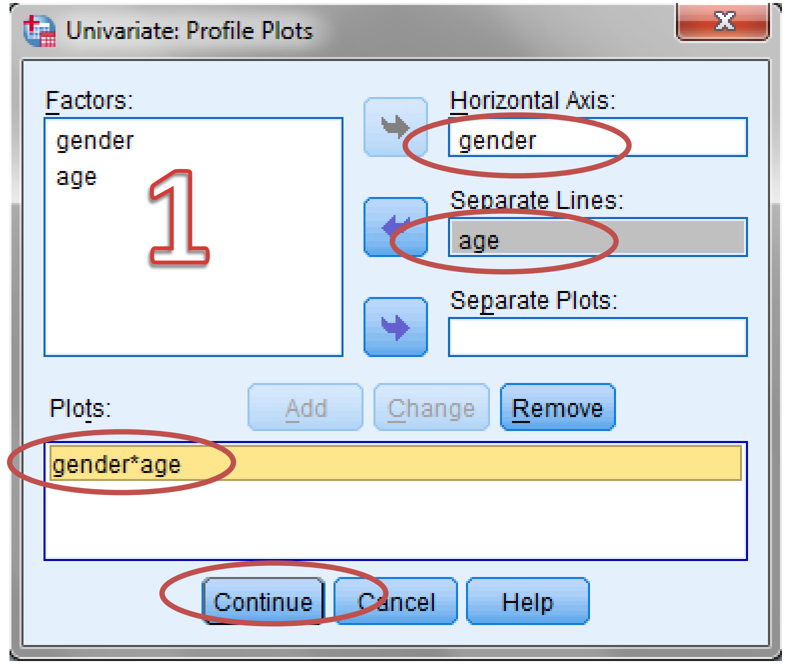
**Select and move the Gender and Age *variables* to the Fixed Factor(s): box; click Plots to display the Profile Plots dialog.**

**Note: A fixed factor has only the levels used in the analysis (e.g., gender and age). A random factor has many possible levels and only a subset of levels are used in the analysis.**

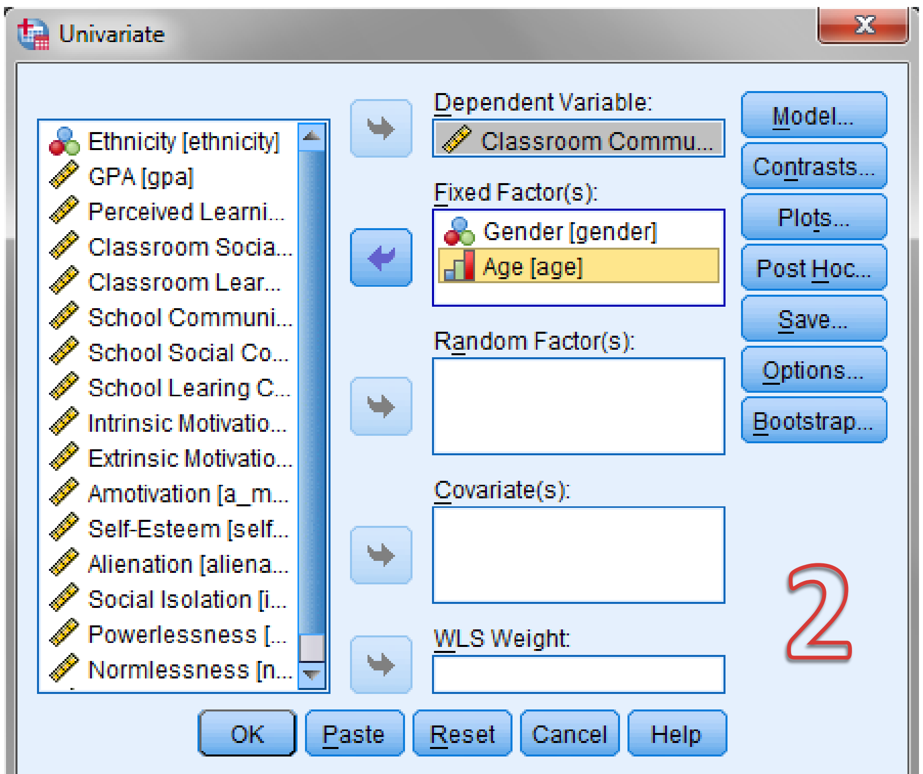


# Uses of the Between Subjects Analysis of Variance

**Move gender to the Horizontal Axis: box and age to the Separate Lines: box. Click Add.**

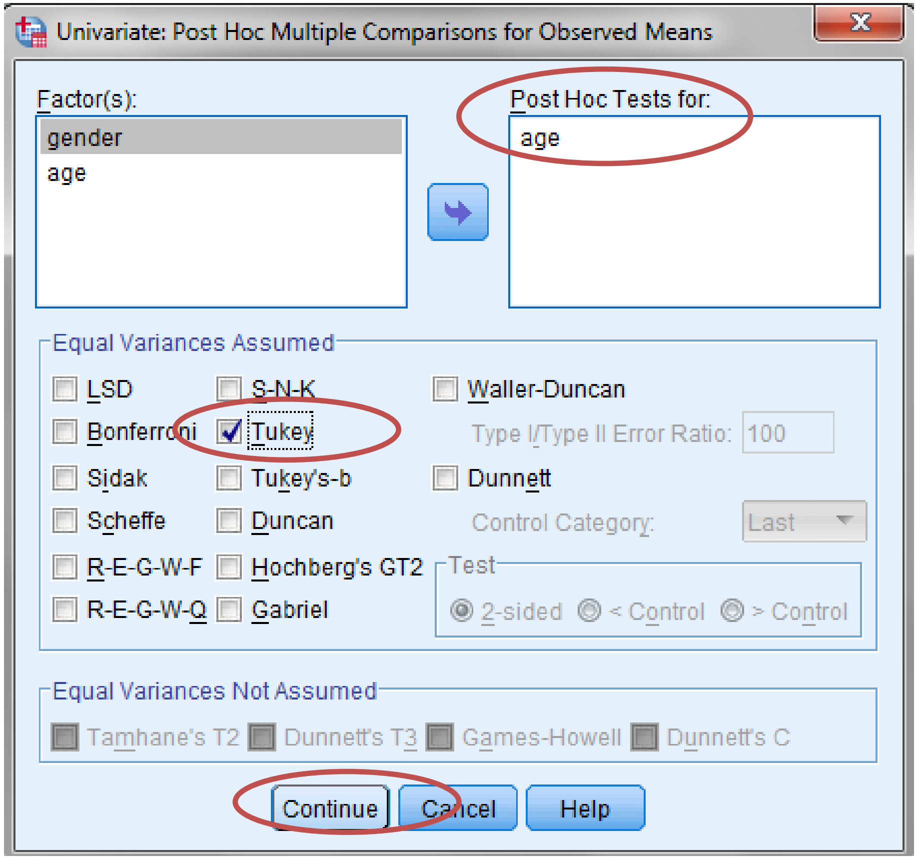



**The gender*age profile plot will be included in the SPSS output. Click Continue.**




**Click Post Hoc… to display the Post Hoc Multiple Comparisons for Observed Means dialog.**

# Uses of the Between Subjects Analysis of Variance



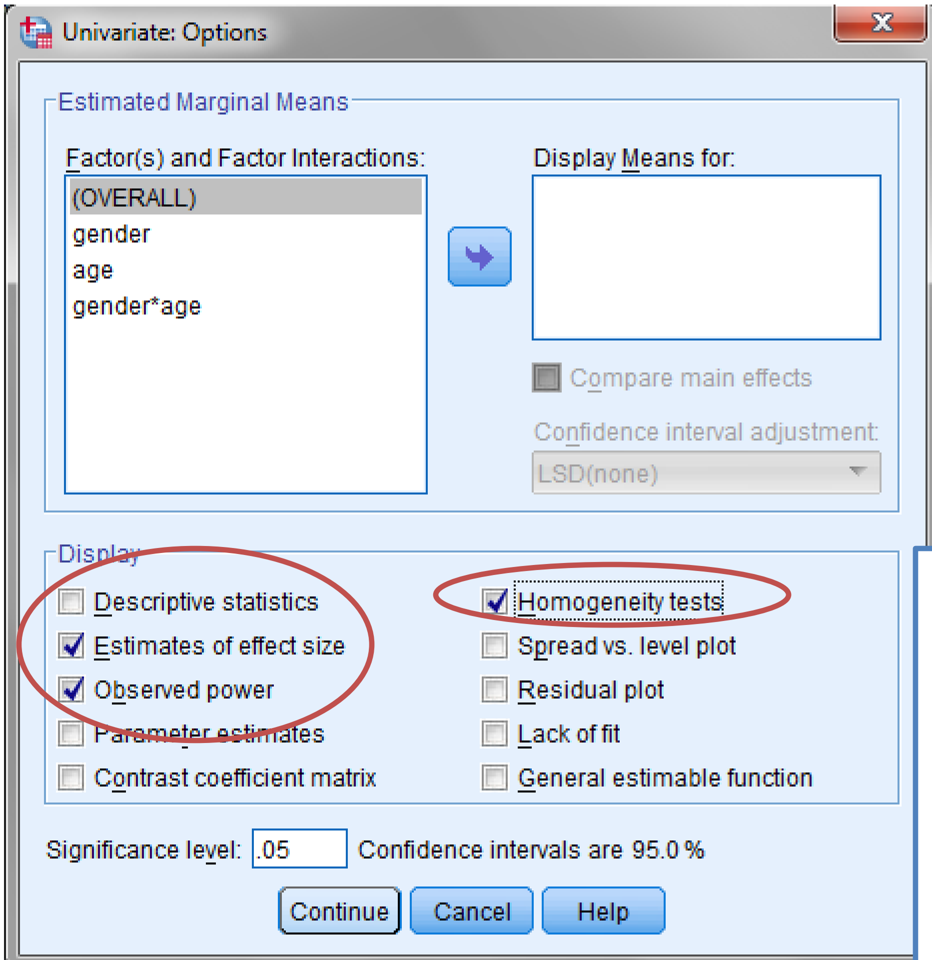

**Move age to the Post Hoc Tests for: box. If the age factor is significant, post hoc tests will be required to determine group differences since there are six age categories. If the gender factor is significant, post hoc tests are not required because gender has only two categories.**

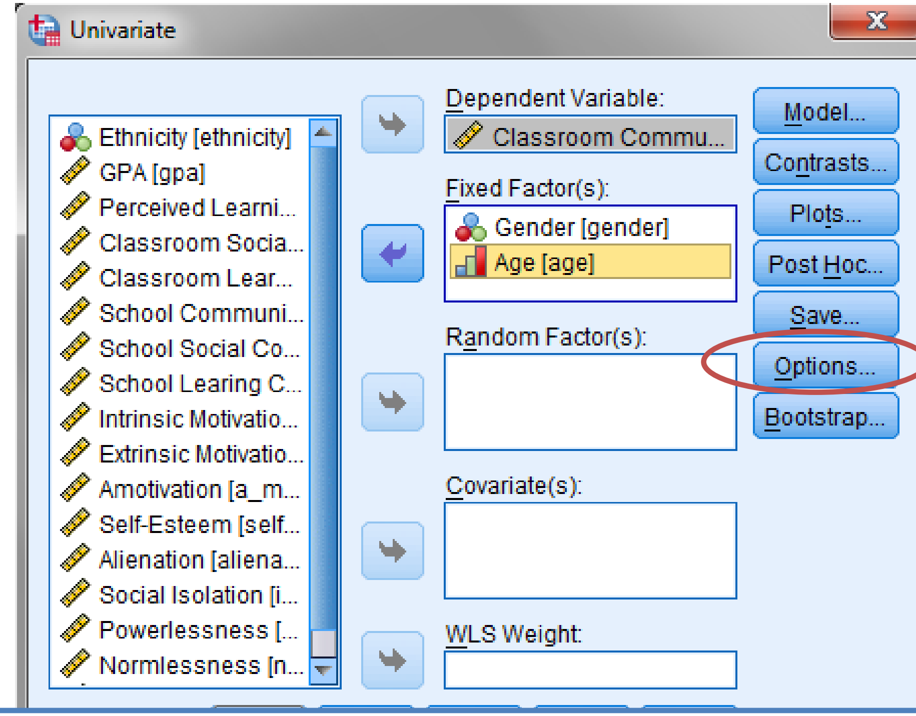
**Assume equal variances is tenable and select an appropriate post hoc test. In this example Tukey is selected because it is neither very conservative (like Scheffe) or very liberal (like LSD). If output shows equal variances is not tenable (i.e., if Levene's test is significant), the post hoc procedure will need to be conducted again with an appropriate equal variances not assumed post hoc test**

**Click Continue.**

# Uses of the Between Subjects Analysis of Variance

**Click Options to display the Options dialog.**




**Select Descriptive statistics, Estimates of effect size, Observed power, and Homogeneity tests. Observed power will display the statistical power of each tested effect. Estimates of effect size will display partial eta squared for each effect and the overall ANOVA. Homogeneity tests will produce Levene's test of equality of error variances.**

**Click Continue then click OK to run the ANOVA.**

# Uses of the Between Subjects Analysis of Variance

Also provided is a descriptive statistics table.

**Descriptive Statistics**

Dependent Variable: Classroom Community

| Gender | Age | Mean | Std. Deviation | N |
|---|---|---|---|---|
| Female | 18-20 | 24.21 | 4.049 | 19 |
| | 21-30 | 27.32 | 5.562 | 60 |
| | 31-40 | 30.86 | 6.152 | 44 |
| | 41-50 | 32.69 | 5.582 | 16 |
| | Over 50 | 34.60 | 5.459 | 5 |
| | Total | 28.84 | 6.181 | 144 |
| Male | 18-20 | 26.40 | 6.656 | 5 |
| | 21-30 | 26.33 | 6.088 | 6 |
| | 31-40 | 29.00 | 6.568 | 8 |
| | 41-50 | 34.67 | 4.726 | 3 |
| | Over 50 | 37.00 | 2.828 | 2 |
| | Total | 29.17 | 6.651 | 24 |
| Total | 18-20 | 24.67 | 4.622 | 24 |
| | 21-30 | 27.23 | 5.569 | 66 |
| | 31-40 | 30.58 | 6.188 | 52 |
| | 41-50 | 33.00 | 5.385 | 19 |
| | Over 50 | 35.29 | 4.751 | 7 |
| | Total | 28.89 | 6.231 | 168 |

**Between-Subjects Factors**

| | | Value Label | N |
|---|---|---|---|
| Gender | 1 | Female | 144 |
| | 2 | Male | 24 |
| Age | 2 | 18-20 | 24 |
| | 3 | 21-30 | 66 |
| | 4 | 31-40 | 52 |
| | 5 | 41-50 | 19 |
| | 6 | Over 50 | 7 |

SPSS output includes a table listing each between subjects factor that displays each category, value label, and sample size.

# Uses of the Between Subjects Analysis of Variance

**Levene's Test of Equality of Error Variances[a]**

Dependent Variable: Classroom Community

| F | df1 | df2 | Sig. |
|---|---|---|---|
| .824 | 9 | 158 | .595 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + gender + age + gender * age

**SPSS output includes the results of Levene's test, which shows that the assumption of equal variances is tenable since $p > .05$.**

# Uses of the Between Subjects Analysis of Variance

**Tests of Between-Subjects Effects**

Dependent Variable: Classroom Community

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 1431.691[a] | 9 | 159.077 | 4.976 | .000 | .221 | 44.783 | .999 |
| Intercept | 54691.919 | 1 | 54691.919 | 1710.760 | .000 | .915 | 1710.760 | 1.000 |
| gender | 8.247 | 1 | 8.247 | .258 | .612 | .002 | .258 | .080 |
| age | 827.787 | 4 | 206.947 | 6.473 | .000 | .141 | 25.893 | .990 |
| gender * age | 65.846 | 4 | 16.461 | .515 | .725 | .013 | 2.060 | .171 |
| Error | 5051.161 | 158 | 31.969 | | | | | |
| Total | 146671.000 | 168 | | | | | | |
| Corrected Total | 6482.851 | 167 | | | | | | |

a. R Squared = .221 (Adjusted R Squared = .176)

b. Computed using alpha = .05

**Tests of between subjects effects show that the overall ANOVA and the age main effect are significant, *p* < .001. However, the gender main effect, *p* = .61, and the gender * age interaction effect, *p* = .73, are not significant**

# Uses of the Between Subjects Analysis of Variance

**Multiple Comparisons**

Dependent Variable: Classroom Community

Tukey HSD

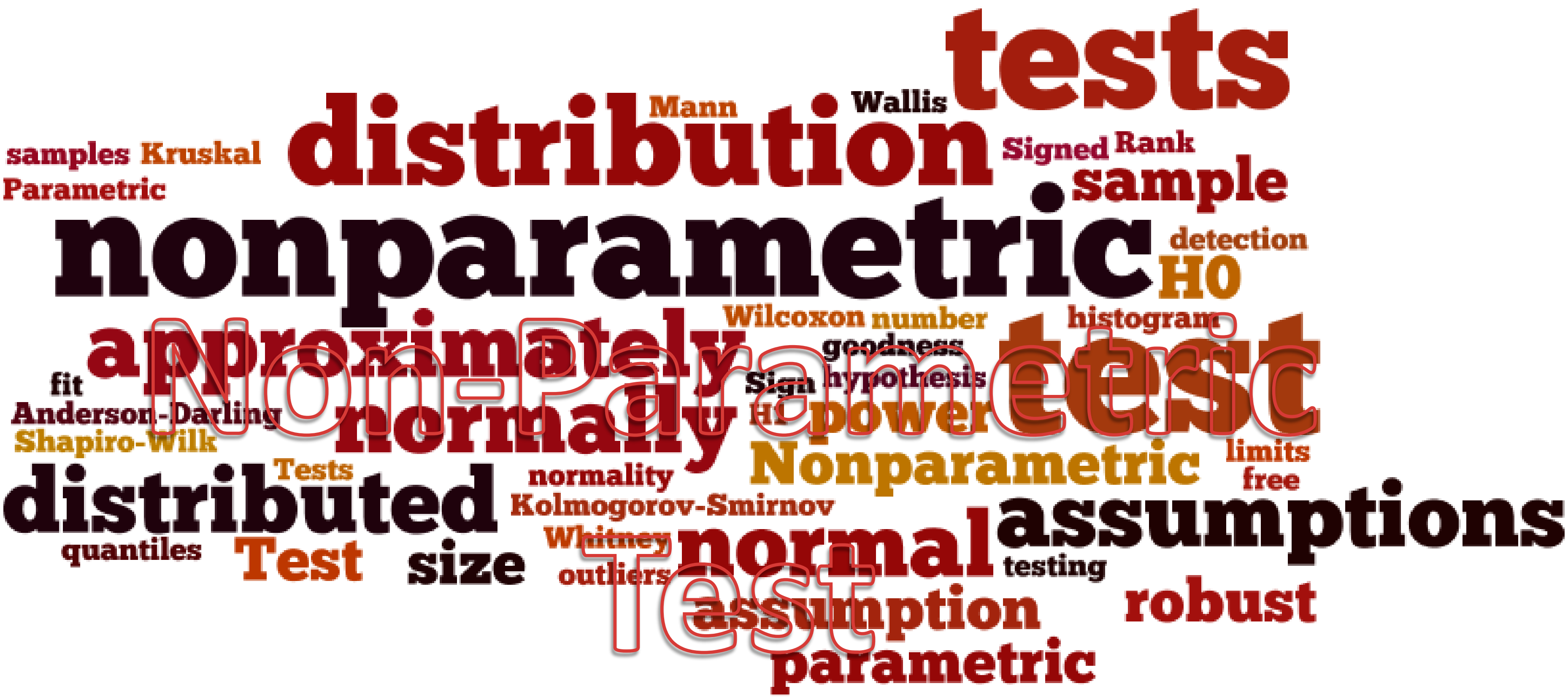
| (I) Age | (J) Age | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| 18-20 | 21-30 | -2.56 | 1.348 | .322 | -6.28 | 1.16 |
| | 31-40 | -5.91* | 1.395 | .000 | -9.76 | -2.06 |
| | 41-50 | -8.33* | 1.736 | .000 | -13.12 | -3.54 |
| | Over 50 | -10.62* | 2.429 | .000 | -17.32 | -3.92 |
| 21-30 | 18-20 | 2.56 | 1.348 | .322 | -1.16 | 6.28 |
| | 31-40 | -3.35* | 1.048 | .014 | -6.24 | -.46 |
| | 41-50 | -5.77* | 1.472 | .001 | -9.83 | -1.71 |
| | Over 50 | -8.06* | 2.248 | .004 | -14.26 | -1.86 |
| 31-40 | 18-20 | 5.91* | 1.395 | .000 | 2.06 | 9.76 |
| | 21-30 | 3.35* | 1.048 | .014 | .46 | 6.24 |
| | 41-50 | -2.42 | 1.516 | .500 | -6.61 | 1.76 |
| | Over 50 | -4.71 | 2.276 | .239 | -10.99 | 1.57 |
| 41-50 | 18-20 | 8.33* | 1.736 | .000 | 3.54 | 13.12 |
| | 21-30 | 5.77* | 1.472 | .001 | 1.71 | 9.83 |
| | 31-40 | 2.42 | 1.516 | .500 | -1.76 | 6.61 |
| | Over 50 | -2.29 | 2.500 | .891 | -9.18 | 4.61 |
| Over 50 | 18-20 | 10.62* | 2.429 | .000 | 3.92 | 17.32 |
| | 21-30 | 8.06* | 2.248 | .004 | 1.86 | 14.26 |
| | 31-40 | 4.71 | 2.276 | .239 | -1.57 | 10.99 |
| | 41-50 | 2.29 | 2.500 | .891 | -4.61 | 9.18 |

Based on observed means.
The error term is Mean Square(Error) = 31.969.

*. The mean difference is significant at the .05 level.

**Tukey Honestly Significant Difference (HSD) post hoc multiple comparison tests are also displayed. These results show that significant differences exist between the following age categories:**
**18-20 and 31-40**
**18-20 and 41-50**
**18-20 and Over 50**
**21-30 and 31-40**
**21-30 and 41-50**
**21-30 and Over 50**

# Non-Parametric Test



# Uses of the Mann-Whitney U Test

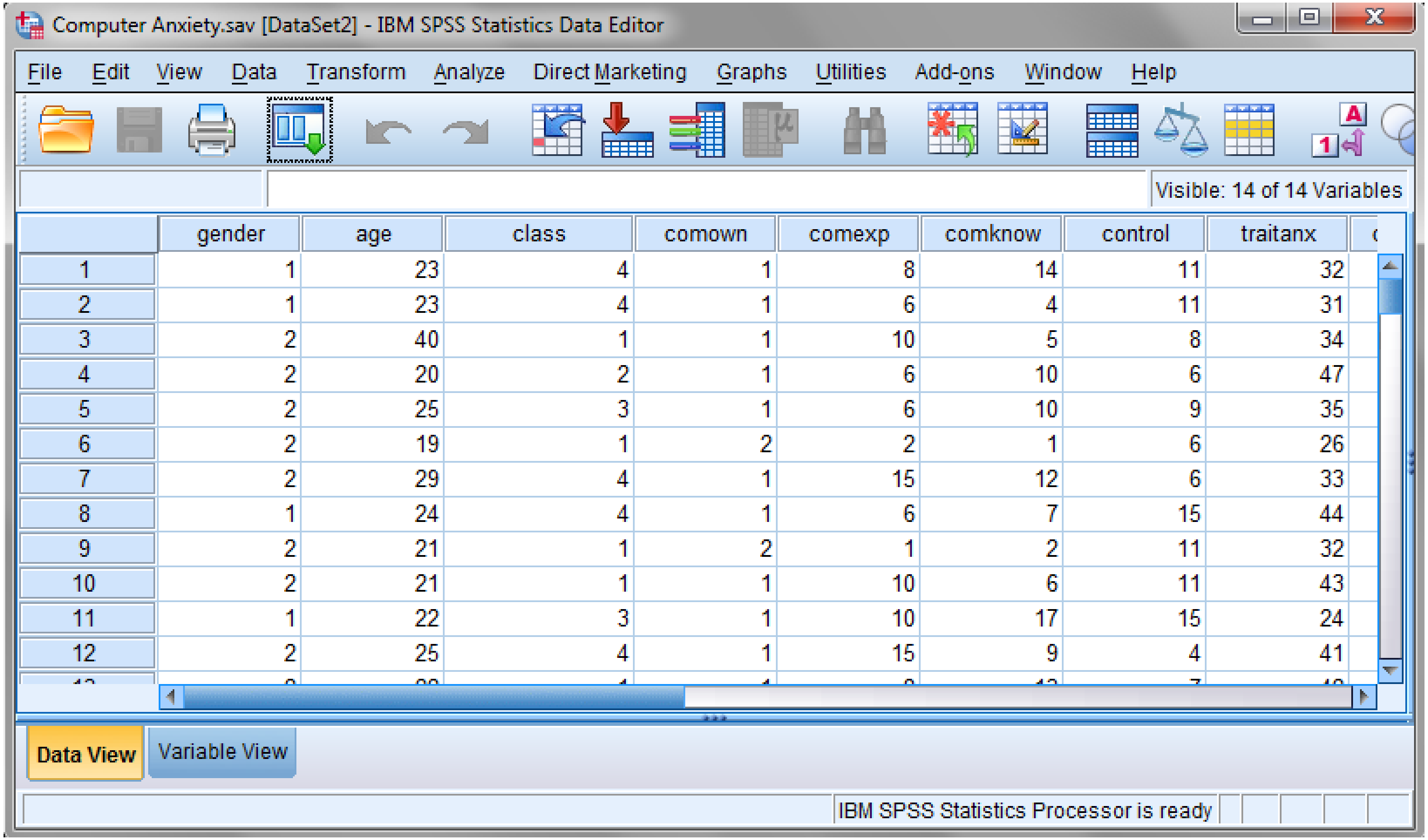


- **The Mann-Whitney *U* test is a nonparametric procedure that determines if ranked scores (i.e., ordinal data) in two independent groups differ. It is also used to analyze interval or ratio scale variables that are not normally distributed.**
- **This test is equivalent to the Kruskal-Wallis *H* test when only two independent groups are compared.**
- **This test is useful when when the normality assumption of the independent *t*-test is not tenable.**

# Uses of the Mann-Whitney U Test

File available at http://www.watertreepress.com/stats

Open the dataset *Computer Anxiety.sav*.

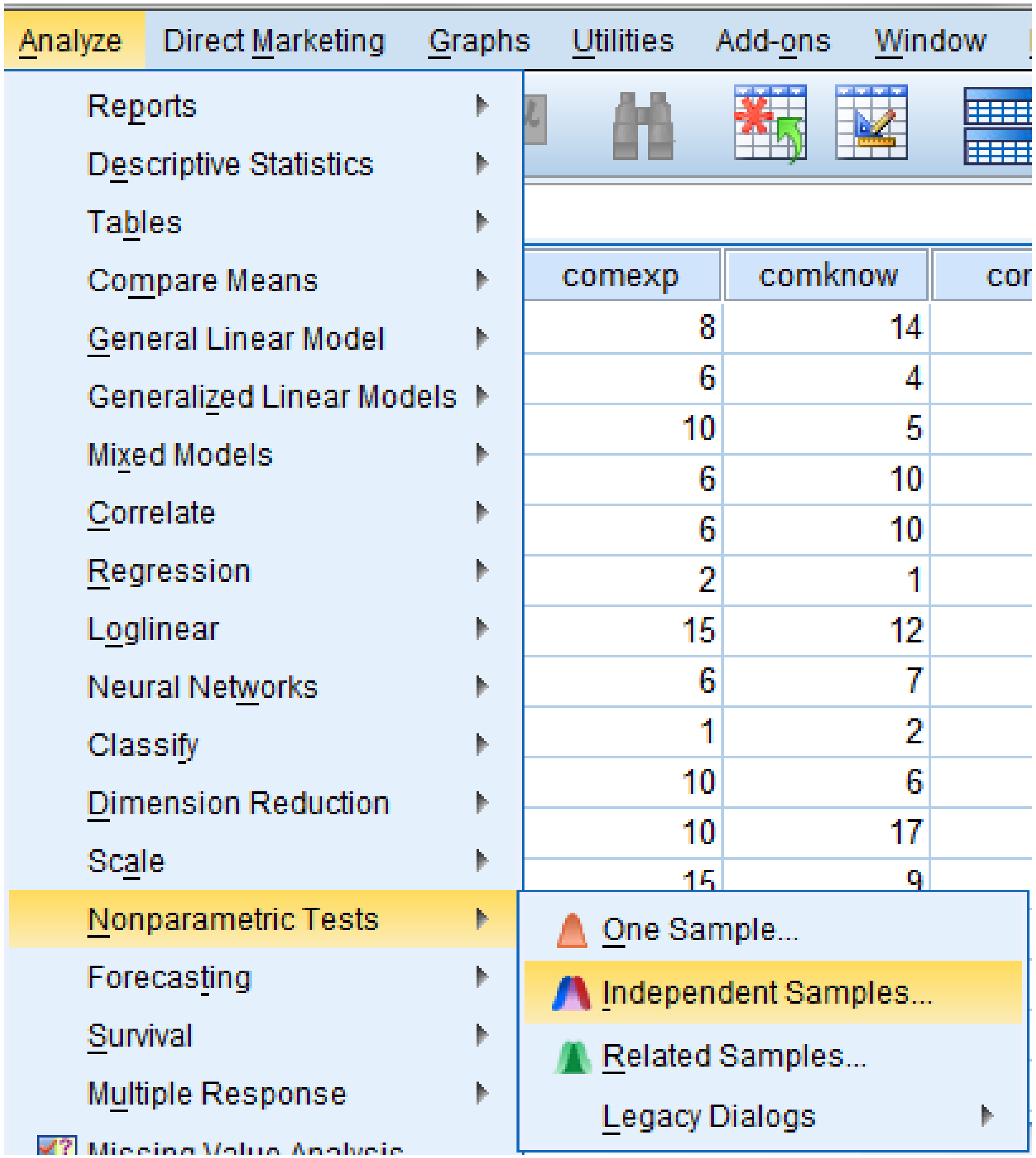



| | gender | age | class | comown | comexp | comknow | control | traitanx |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 23 | 4 | 1 | 8 | 14 | 11 | 32 |
| 2 | 1 | 23 | 4 | 1 | 6 | 4 | 11 | 31 |
| 3 | 2 | 40 | 1 | 1 | 10 | 5 | 8 | 34 |
| 4 | 2 | 20 | 2 | 1 | 6 | 10 | 6 | 47 |
| 5 | 2 | 25 | 3 | 1 | 6 | 10 | 9 | 35 |
| 6 | 2 | 19 | 1 | 2 | 2 | 1 | 6 | 26 |
| 7 | 2 | 29 | 4 | 1 | 15 | 12 | 6 | 33 |
| 8 | 1 | 24 | 4 | 1 | 6 | 7 | 15 | 44 |
| 9 | 2 | 21 | 1 | 2 | 1 | 2 | 11 | 32 |
| 10 | 2 | 21 | 1 | 1 | 10 | 6 | 11 | 43 |
| 11 | 1 | 22 | 3 | 1 | 10 | 17 | 15 | 24 |
| 12 | 2 | 25 | 4 | 1 | 15 | 9 | 4 | 41 |

Independent-Samples T-Test

# Uses of the Mann-Whitney U Test

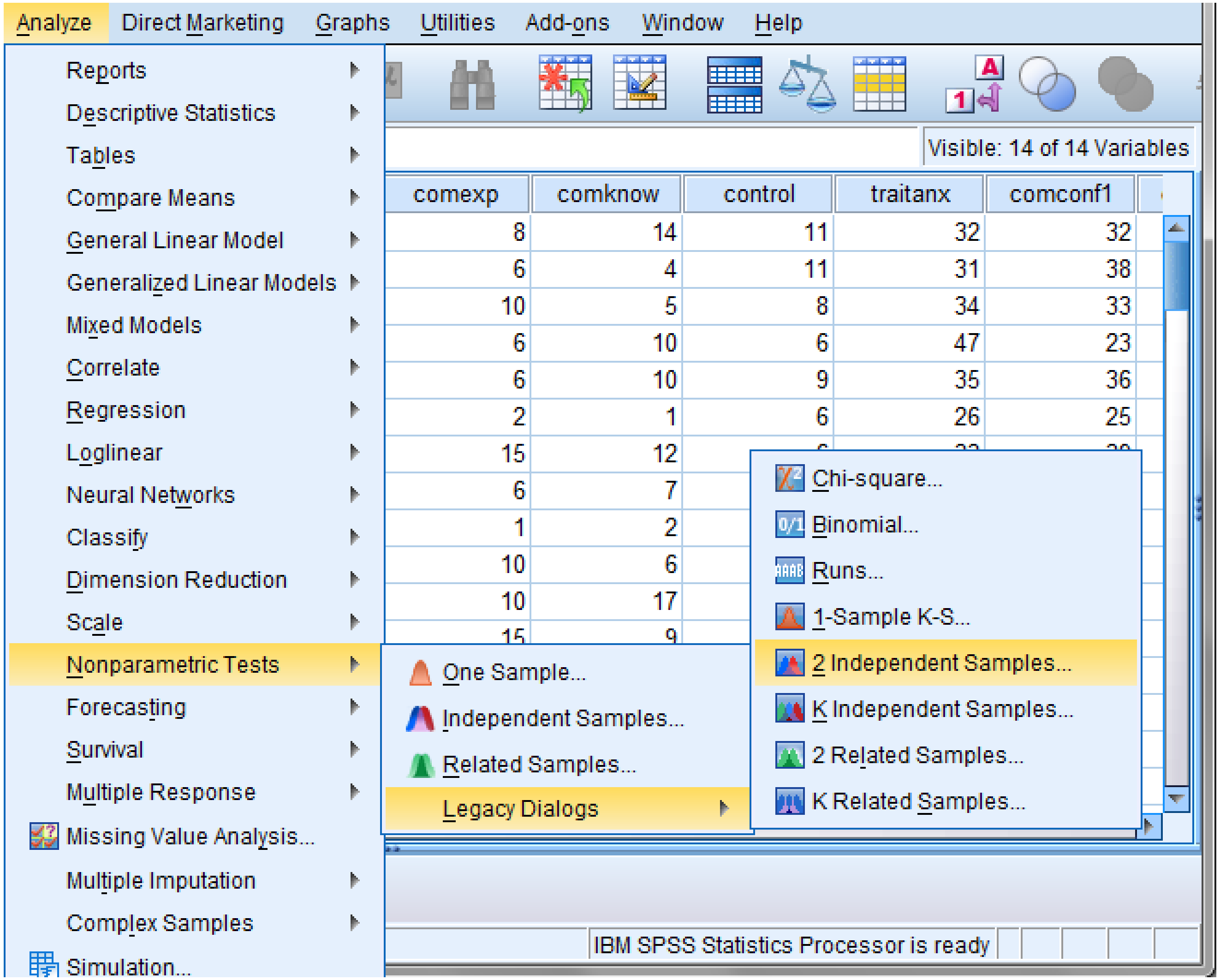
Independent-Samples T-Test




**Follow the menu as indicated. Alternatively, one can use the Legacy Dialogs as shown on the following slides.**

# Uses of the Mann-Whitney U Test

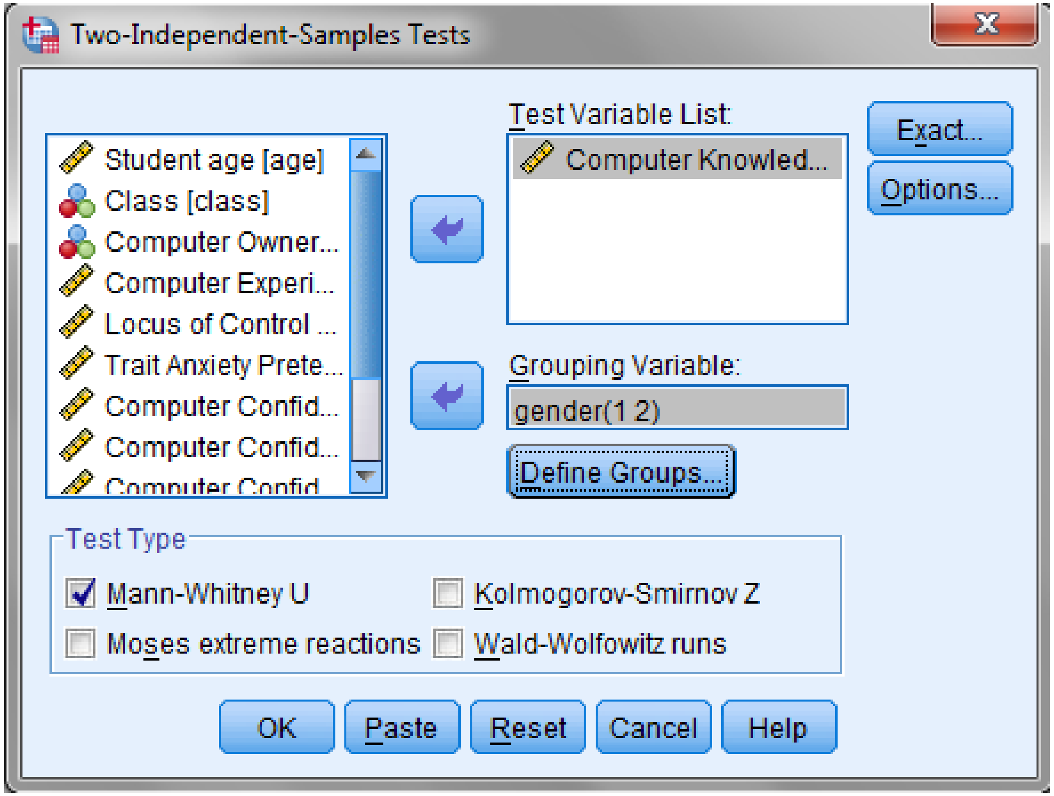
Independent-Samples T-Test

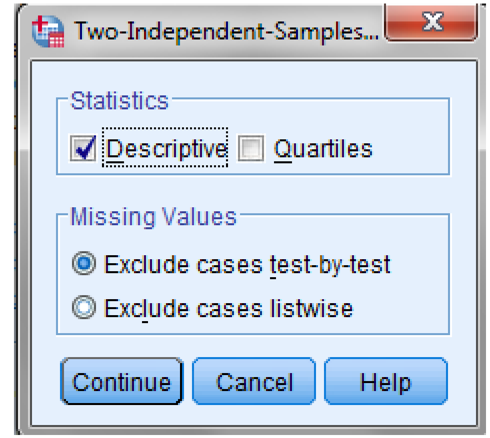



Follow the menu as indicated to use Legacy Dialogs. Alternatively, one can run the test using the Independent Samples option under the Nonparametric Tests menu.

# Uses of the Mann-Whitney U Test

Independent-Samples T-Test




**Check Descriptive to generate descriptive statistics; click Continue then OK.**

**In this example, we will test the following null hypothesis:**
**$H_o$: There is no difference in how the ranks of computer knowledge pretest are dispersed between male and female university students.**
**Select and move *Computer Knowledge Pretest* to the Test Variable List:. Check Mann-Whitney *U* as the Test Type. Click Options...**

# Uses of the Mann-Whitney U Test



## NPar Tests

**Descriptive Statistics**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Computer Knowledge Pretest | 92 | 9.14 | 5.909 | 0 | 21 |
| Student gender | 92 | 1.74 | .442 | 1 | 2 |

## Mann-Whitney Test

**Ranks**

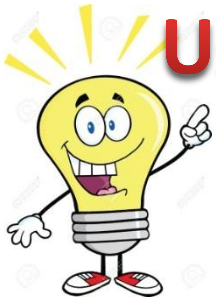
| | Student gender | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Computer Knowledge Pretest | Male | 24 | 52.50 | 1260.00 |
| | Female | 68 | 44.38 | 3018.00 |
| | Total | 92 | | |

**Test Statistics[a]**

| | Computer Knowledge Pretest |
|---|---|
| Mann-Whitney U | 672.000 |
| Wilcoxon W | 3018.000 |
| Z | -1.283 |
| Asymp. Sig. (2-tailed) | .199 |

a. Grouping Variable: Student gender

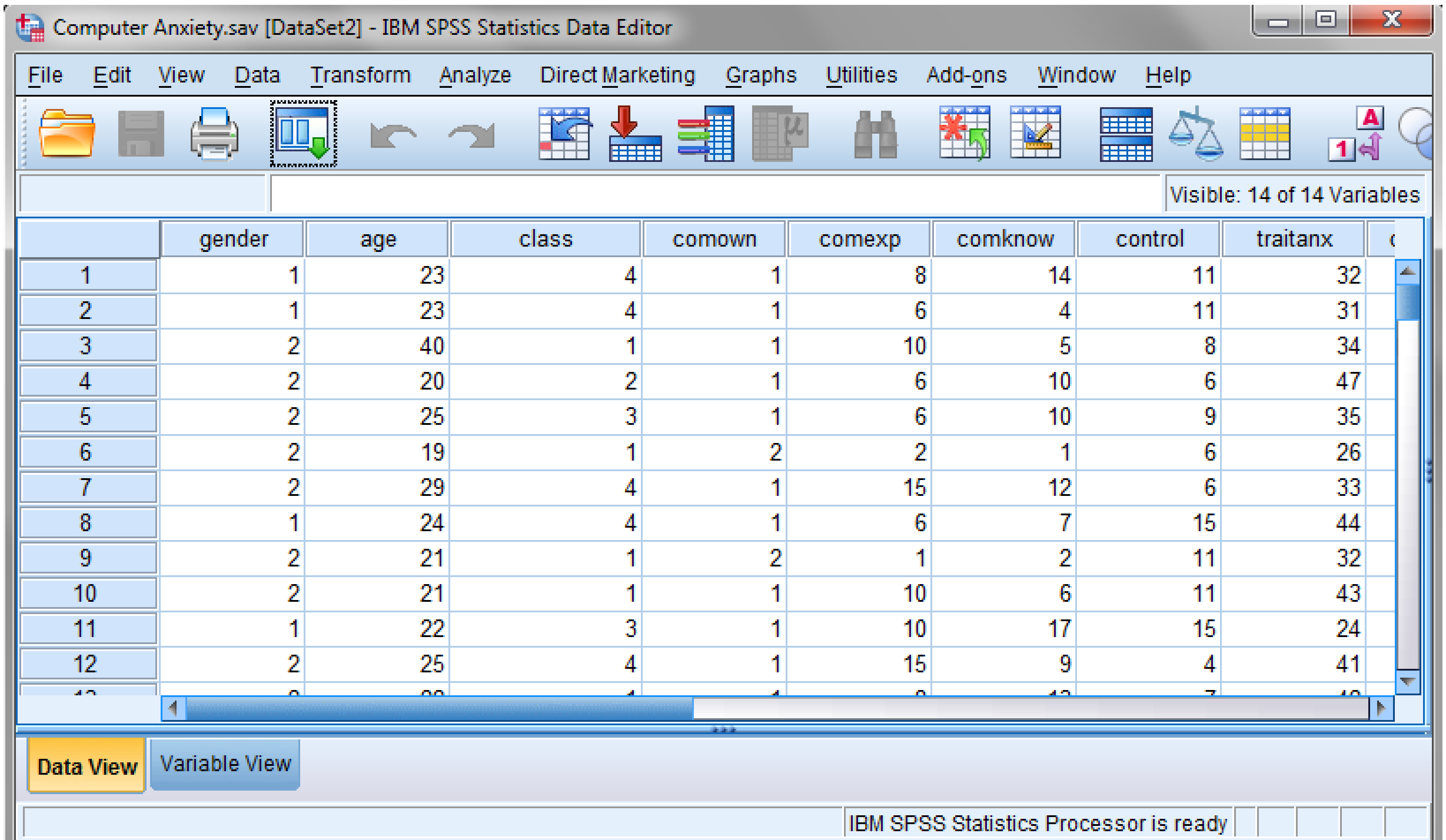
**SPSS output includes descriptive statistics to include a summary of ranks. SPSS output also displays test statistics that show an insignificant difference, *p* = .20, between males and females since the asymptotic significance level >= .05 (the assumed *à priori* significance level).**



# Uses of the Wilcoxon Matched-Pair Signed Ranks Test

File available at http://www.watertreepress.com/stats

Open the dataset *Computer Anxiety.sav*.




| | gender | age | class | comown | comexp | comknow | control | traitanx |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 23 | 4 | 1 | 8 | 14 | 11 | 32 |
| 2 | 1 | 23 | 4 | 1 | 6 | 4 | 11 | 31 |
| 3 | 2 | 40 | 1 | 1 | 10 | 5 | 8 | 34 |
| 4 | 2 | 20 | 2 | 1 | 6 | 10 | 6 | 47 |
| 5 | 2 | 25 | 3 | 1 | 6 | 10 | 9 | 35 |
| 6 | 2 | 19 | 1 | 2 | 2 | 1 | 6 | 26 |
| 7 | 2 | 29 | 4 | 1 | 15 | 12 | 6 | 33 |
| 8 | 1 | 24 | 4 | 1 | 6 | 7 | 15 | 44 |
| 9 | 2 | 21 | 1 | 2 | 1 | 2 | 11 | 32 |
| 10 | 2 | 21 | 1 | 1 | 10 | 6 | 11 | 43 |
| 11 | 1 | 22 | 3 | 1 | 10 | 17 | 15 | 24 |
| 12 | 2 | 25 | 4 | 1 | 15 | 9 | 4 | 41 |

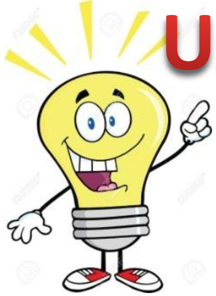
# Uses of the Wilcoxon Matched-Pair Signed Ranks Test



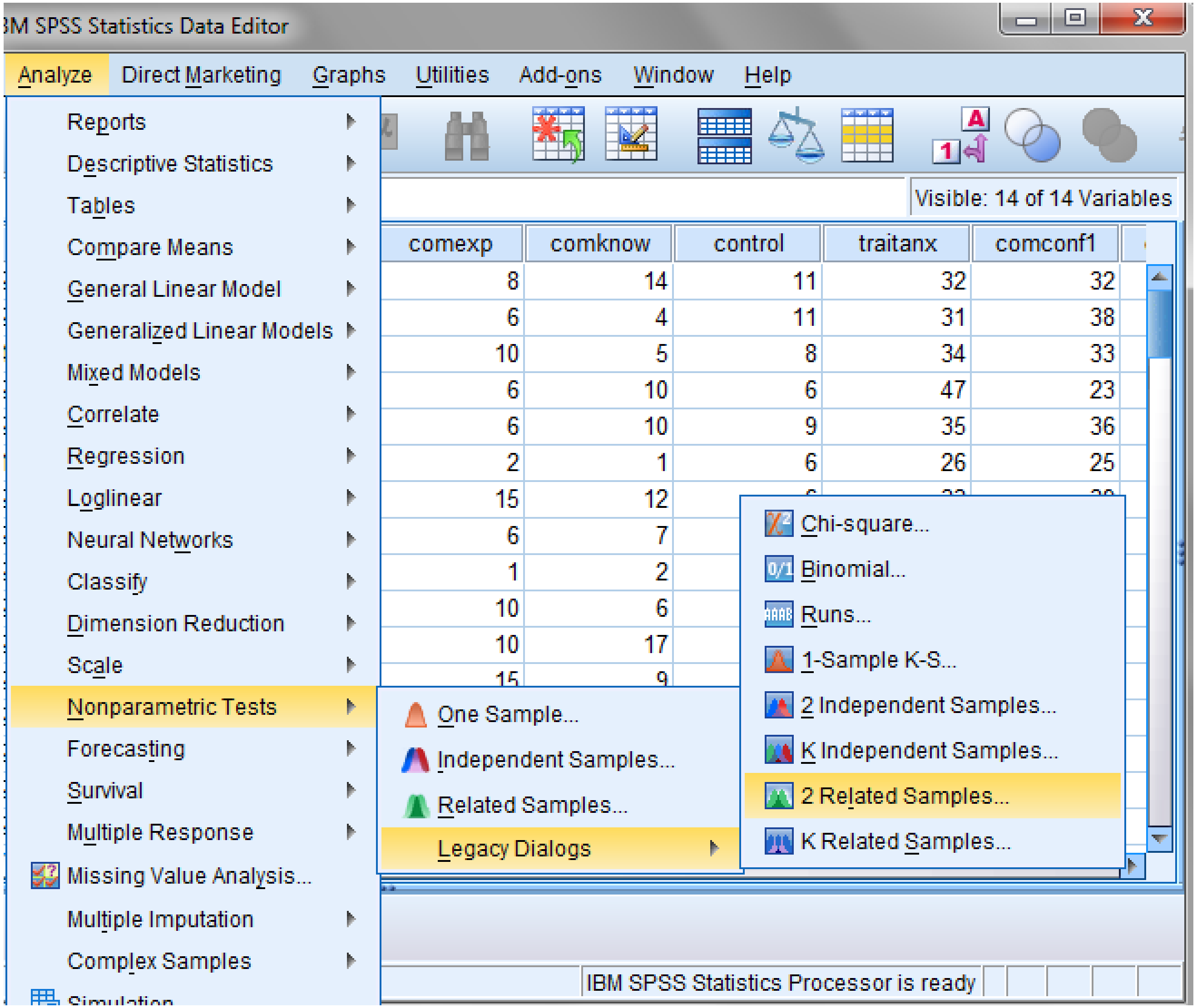
- **The Wilcoxon matched-pair signed ranks test (also called the Wilcoxon matched pairs test or the Wilcoxon signed ranks test) is a nonparametric procedure that compares differences between data pairs of data from two dependent samples.**
- **It is similar to the related samples sign test except that this test factors in the size as well as the sign of the paired differences.**
- **This procedure involves ranking all nonzero difference scores disregarding sign, reattaching the sign to the rank, and then evaluating the mean of the positive and the mean of the negative ranks. Consequently, the Wilcoxon matched-pair signed ranks test is more powerful than the related sample sign test and is the preferred test.**

# Uses of the Wilcoxon Matched-Pair Signed Ranks Test

Uses of the Dependent-Samples T-Test

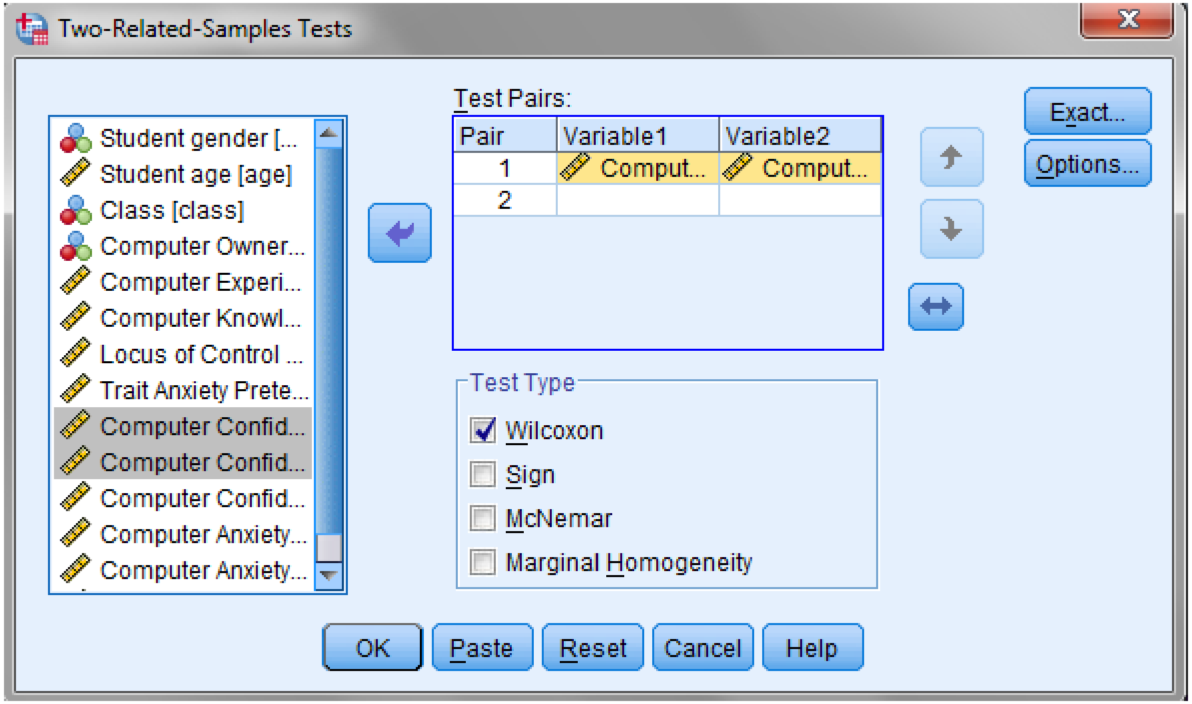


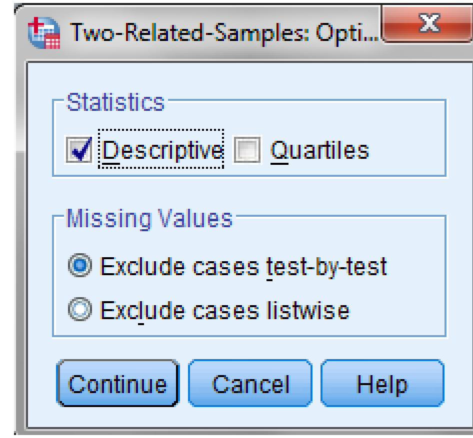
**Follow the menu as indicated to conduct the Wilcoxon test using Legacy Dialogs. Alternatively, one can run the test using the Related Samples option under the Nonparametric Tests menu.**



# Uses of the Wilcoxon Matched-Pair Signed Ranks Test

Uses of the Dependent-Samples T-Test




**Check Descriptive to generate descriptive statistics output. Click Continue and then OK to run the test.**

**In this example, we will test the following null hypothesis:**
***H*$_o$: There is no difference in ranks between computer anxiety pretest and computer anxiety posttest among university students.**

**Move *Computer Anxiety Pretest* and *Computer Anxiety Posttest* to the Test Pairs: box. Check Wilcoxon as the Test Type. Click Options.**

# Uses of the Wilcoxon Matched-Pair Signed Ranks Test



**Descriptive Statistics**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Computer Anxiety Pretest | 92 | 53.49 | 15.120 | 22 | 87 |
| Computer Anxiety Posttest | 86 | 46.84 | 11.045 | 23 | 75 |

The above SPSS output displays descriptive statistics.

## Wilcoxon Signed Ranks Test

**Ranks**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Computer Anxiety Posttest - Computer Anxiety Pretest | Negative Ranks | 60[a] | 49.20 | 2952.00 |
| | Positive Ranks | 23[b] | 23.22 | 534.00 |
| | Ties | 3[c] | | |
| | Total | 86 | | |

a. Computer Anxiety Posttest < Computer Anxiety Pretest

b. Computer Anxiety Posttest > Computer Anxiety Pretest

c. Computer Anxiety Posttest = Computer Anxiety Pretest

The above SPSS output displays ranks statistics. It shows the mean of the ranks of the difference scores in which posttest computer anxiety decreased is 49.20 and the mean of the ranks of the difference scores in which posttest computer anxiety increased is 23.22.

# Uses of the Wilcoxon Matched-Pair Signed Ranks Test



**Test Statistics[a]**

| | Computer Anxiety Posttest - Computer Anxiety Pretest |
|---|---|
| Z | -5.492[b] |
| Asymp. Sig. (2-tailed) | .000 |

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

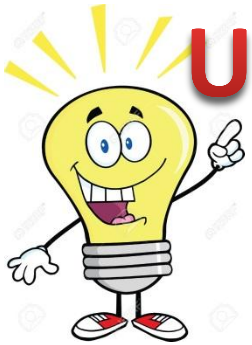
**The above SPSS output shows that the test is significant using the *z*-approximation since the significance level <= .05 (the assumed *à priori* significance level).**

**Note: report the *p*-value as *p* < .001. SPSS truncates values; the SPSS output does not mean that the *p*-value is zero.**

# Uses of the Kruskal-Wallis test



**The Kruskal-Wallis test is a non-parametric procedure that tests the hypothesis that there is no difference between the population medians (M) of three or more independent groups on a single factor.**



# Uses of the Kruskal-Wallis test

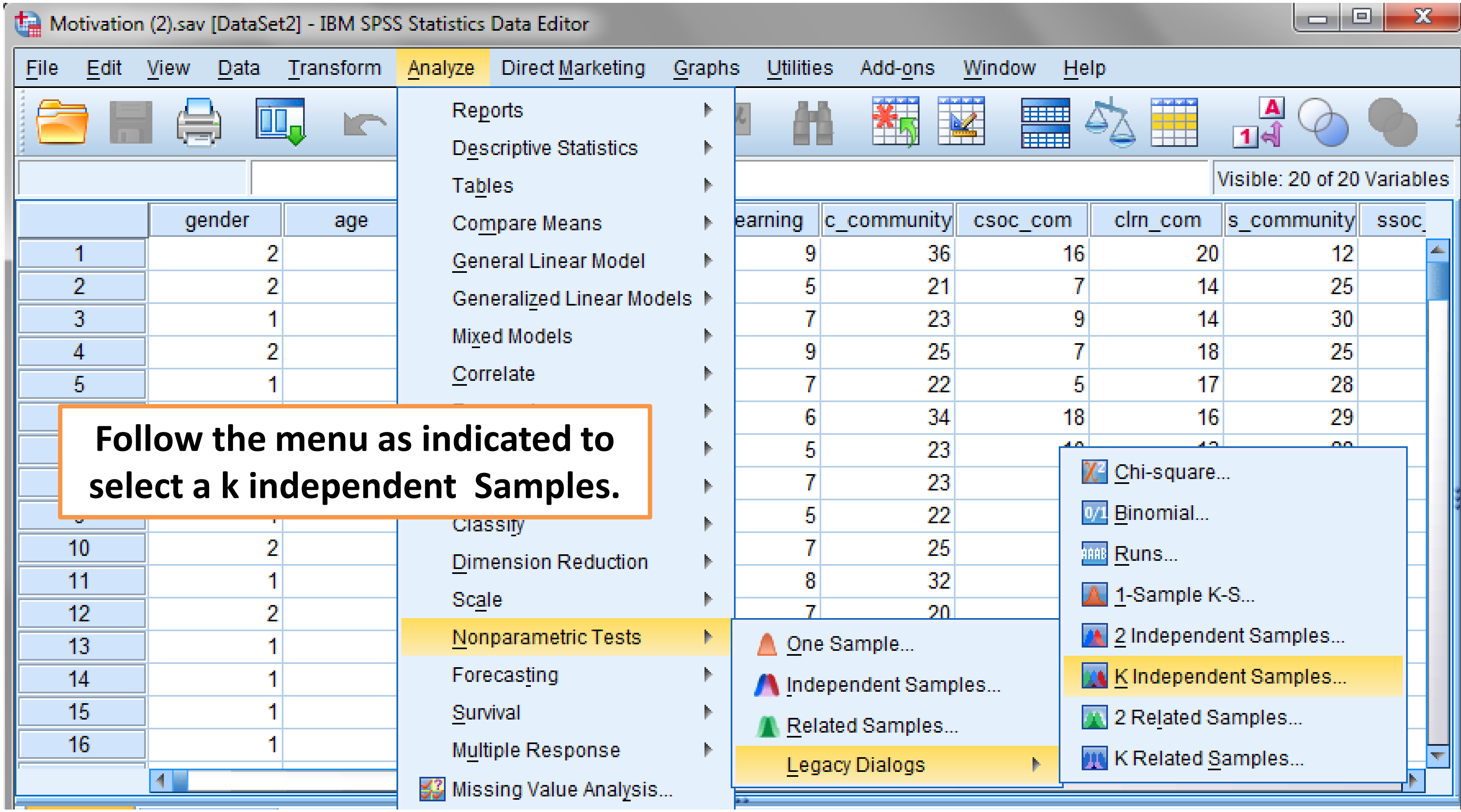
**File available at [http://www.watertreepress.com/stats](http://www.watertreepress.com/stats)**

**Open the dataset *Motivation.sav*.**

| | gender | age | ethnicity | gpa | p_learning | c_community | csoc_com | clrn_com | s_community | ssoc_ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 1.30 | 9 | 36 | 16 | 20 | 12 | |
| 2 | 2 | 2 | 2 | 1.40 | 5 | 21 | 7 | 14 | 25 | |
| 3 | 1 | 2 | 2 | 1.58 | 7 | 23 | 9 | 14 | 30 | |
| 4 | 2 | 2 | 2 | 1.79 | 9 | 25 | 7 | 18 | 25 | |
| 5 | 1 | 2 | 2 | 1.87 | 7 | 22 | 5 | 17 | 28 | |
| 6 | 2 | 3 | 2 | 2.00 | 6 | 34 | 18 | 16 | 29 | |
| 7 | 1 | 2 | 2 | 2.00 | 5 | 23 | 10 | 13 | 28 | |
| 8 | 1 | 2 | 2 | 2.00 | 7 | 23 | 8 | 15 | 26 | |
| 9 | 1 | 3 | 2 | 2.10 | 5 | 22 | 11 | 11 | 17 | |
| 10 | 2 | 3 | 2 | 2.30 | 7 | 25 | 14 | 11 | 19 | |
| 11 | 1 | 3 | 2 | 2.40 | 8 | 32 | 16 | 16 | 19 | |
| 12 | 2 | 2 | 2 | 2.48 | 7 | 20 | 1 | 19 | 18 | |
| 13 | 1 | 4 | 2 | 2.50 | 7 | 24 | 10 | 14 | 16 | |
| 14 | 1 | 2 | 2 | 2.50 | 6 | 22 | 5 | 17 | 40 | |
| 15 | 1 | 3 | 4 | 2.50 | 5 | 28 | 15 | 13 | 25 | |
| 16 | 1 | 2 | 2 | 2.50 | 5 | 25 | 14 | 11 | 30 | |

# Uses of the Kruskal-Wallis test

Analysis Of Variance (ANOVA)

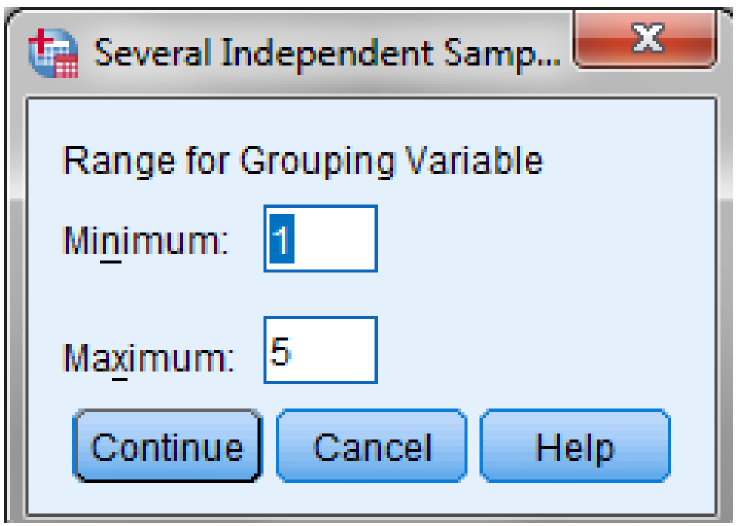


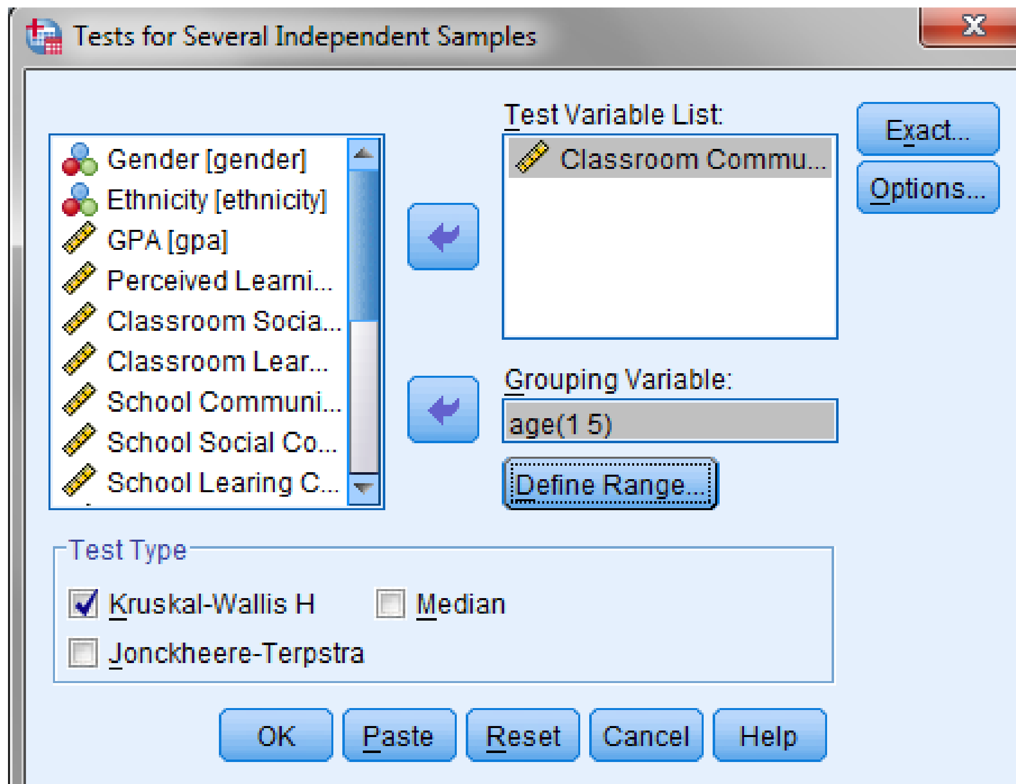
# Uses of the Kruskal-Wallis test

**Select and move the Classroom Community variable to Test Variable List : box.**
**In this example, null hypotheses is:**

***$H_0$*: There is no difference in sense of classroom community between graduate students based on age (18-20, 21-30, 31-40, 41-50, over 50).**

.



# Uses of the Kruskal-Wallis test

## Kruskal-Wallis Test

**Ranks**

| | Age | N | Mean Rank |
|---|---|---|---|
| Classroom Community | 18-20 | 24 | 50.83 |
| | 21-30 | 66 | 71.00 |
| | 31-40 | 52 | 95.45 |
| | 41-50 | 19 | 114.29 |
| | Total | 161 | |

**Test Statistics[a,b]**

| | Classroom Community |
|---|---|
| Chi-Square | 27.842 |
| df | 3 |
| Asymp. Sig. | .000 |

a. Kruskal Wallis Test

b. Grouping Variable: Age

Classroom Community levels were significantly affected by which Age statistics was different in, Chi-Square = 27.84, $p = 0.000$.


THANK
YOU