Statistical Applications in Engineering (IENG385/MANE385)

SPSS Lab Tutorial

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Sample t-test

T-test purpose

- Z test requires that you know σ from pop
- Use a t-test when you don't know the population standard deviation.
- One sample t-test:
  - Compare a sample mean to a population with a known mean but an unknown variance
  - Use Sy (sample std dev) to estimate σ (pop std dev)

T formula

$$T_{observation} = \frac{\bar{Y} - \mu}{\frac{s}{\sqrt{n}}}$$

- Procedure:
  - Compute t obtained from sample data
  - Determine cutoff point (not a z, but now a critical t) based on α
  - Reject the null hypothesis if your observed t value falls in critical region <u>(|t observed| > |t critical|)</u>

T distribution

- Can't use unit normal table to find critical value – must use t table to find critical t
  - Based on degrees of freedom (df): # scores free to vary in t obtained
  - Start w/sample size N, but lose 1 df due to having to estimate pop std dev
  - Df = N-1
  - Find t critical based on df and alpha level you choose

(cont.)

- To use the t table, decide what alpha level to use & whether you have a 1- or 2-tailed test → gives column
- Then find your row using df.
- For $\alpha = .05$, 2 tailed, df=40, t critical = 2.021
  - Means there is only a 5% chance of finding a $t>=2.021$ if null hyp is true, so we should reject Ho if t obtained > 2.021

Note

- Note that only positive values given in t table, so…
- If 1-tailed test,
  - Use + t critical value for upper-tail test (1.813)
  - Use – t critical value for lower-tail test (you have to remember to switch the sign, – 1.813)
- If 2-tailed test,
  - Use + and – signs to get 2 t critical values, one for each tail (1.813 and –1.813)

Example

- Is EMT response time under the new system (ybar =28 min) <u>less than</u> old system (μ = 30 min)? Sy = 3.78 and N=10
  - Ha: new < old ($\mu < 30$)
  - Ho: no difference ($\mu = 30$)
  - Use .05 signif., 1-tailed test (see Ha)
  - <u>T obtained</u> = (28-30) / (3.78 / sqrt10) = (28-30) / 1.20 = <u>- 1.67</u>

(cont.)

- Cutoff score for .05, 1–tail, 9 df = 1.833
  - Remember, we're interested in lower tail (less response time), so critical t is –1.833
- T obtained is not in critical region (not > | –1.833 |), so fail to reject null
- No difference in response time now compared to old system

1-sample t test in SPSS

- Use menus for:

  Analyze → Compare Means → One sample t

  Gives pop-up menu…need 2 things:

  - select variable to be tested/compared to population mean
  - Notice "test value" window at bottom. Enter the population/comparison mean here (use μ given to you)
  - Hit OK, get output and find sample mean, observed t, df, "sig value" (p value)
  - Won't get t critical, but SPSS does the comparison for you…(if sig value < α, reject null)

Example

To test whether the average weight of student population is different from 140 lb. A random sample of 22 students' weights from student population. use the following data.

(Alfa=0.05)

135	119	106	135	180	108	128	160	143	175	170
205	195	185	182	150	175	190	180	195	220	235

Manual Solution

$H_0 : \mu = 140$
$H_1 : \mu \neq 140$

n=22
Mean= $\frac{\sum x}{n} = \frac{3671}{22}$ = 166.86
Std Deviation= $\delta = \frac{\sum (x - \bar{x})^2}{n}$ = 35.178
Std Error Mean = $\frac{\delta}{n}$ = 7.49

$T_{\text{observation}} = \frac{\bar{Y} - \mu}{\frac{s}{\sqrt{n}}} = \frac{166.86 - 140}{\frac{35.178}{\sqrt{22}}}$ = 3.58
T critical=1.721
df=22-1=21
Alfa= 0.05

$T_{\text{observation}} > T_{\text{critical}}$
3.58>1.721 Reject

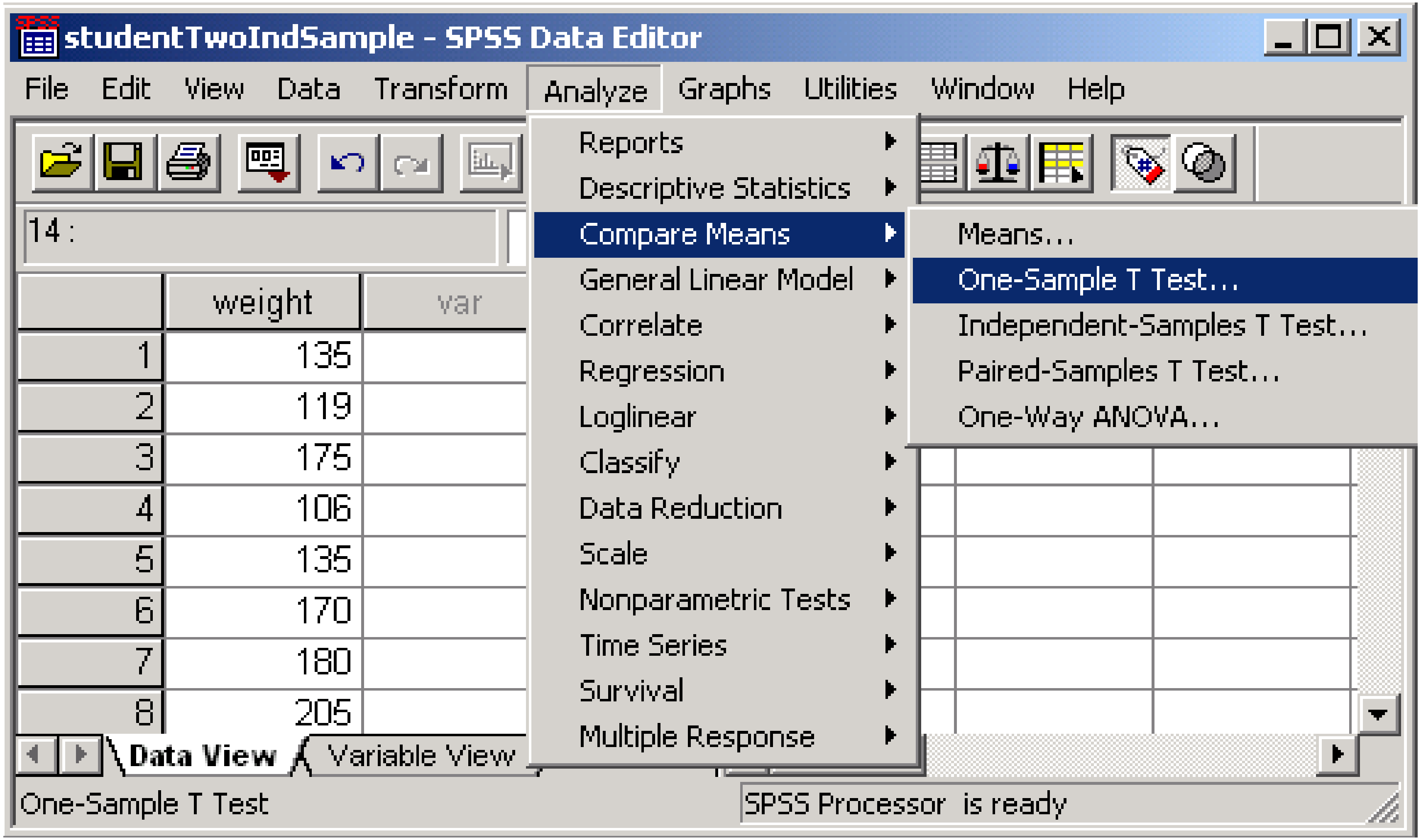
One Sample T test

Click through the menu selections:

Analyze →Compare Means → One Sample T Test.

as in the following picture, and the One-Sample T Test dialog box will appear on the screen.

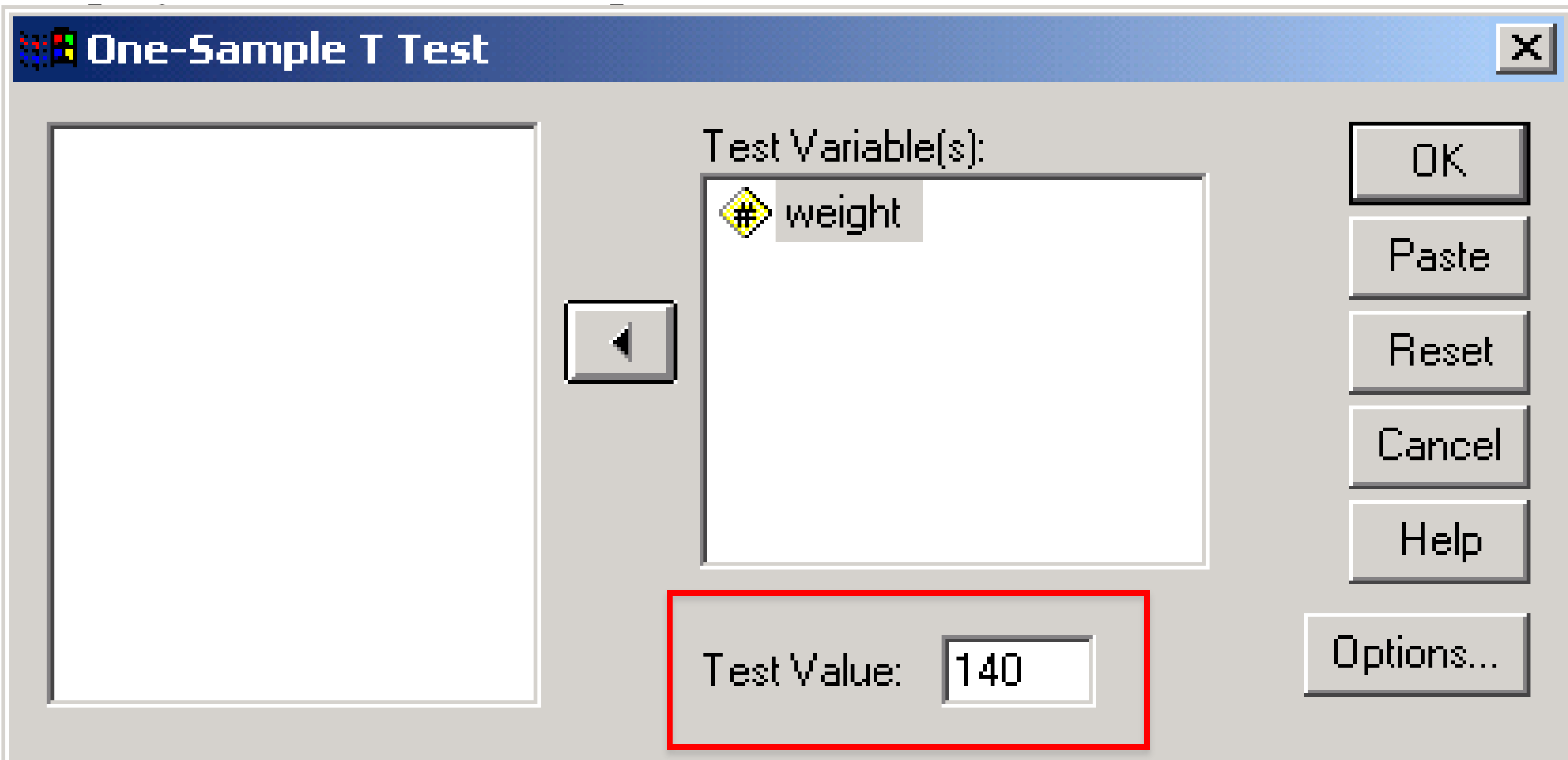
One Sample T test



One Sample T test

Select the variable “weight” to be analyzed into the Test Variable box, and enter the Test Value which the average value to be tested with (the mean value specified in the null hypothesis, that is 140 in this example). Click Continue and click OK for performing the test and estimation. The results will be displayed in the SPSS Output window.

One Sample T test



One Sample T test

Interpret SPSS Output: The statistics for the test are in the following table. The one sample t-test statistic is 3.582 and the p-value from this statistic is .002 and that is less than 0.05 (the level of significance usually used for the test) Such a p-value indicates that the average weight of the sampled population is statistically significantly different from 140 lb. The 95% confidence interval estimate for the difference between the population mean weight and 140 lb is (11.27, 42.46).

One-Sample Test

	Test Value = 140					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
WEIGHT	3.582	21	.002	26.86	11.27	42.46

Independent T Test

- The independent-samples t-test (or independent t-test, for short) compares the means between two unrelated groups on the same continuous, dependent variable.

- You could use an independent t-test to understand whether first year graduate salaries differed based on gender (i.e., your dependent variable would be "first year graduate salaries" and your independent variable would be "gender", which has two groups: "male" and "female"). Alternately, you could use an independent t-test to understand whether there is a difference in test anxiety based on educational level (i.e., your dependent variable would be "test anxiety" and your independent variable would be "educational level", which has two groups: "undergraduates" and "postgraduates").

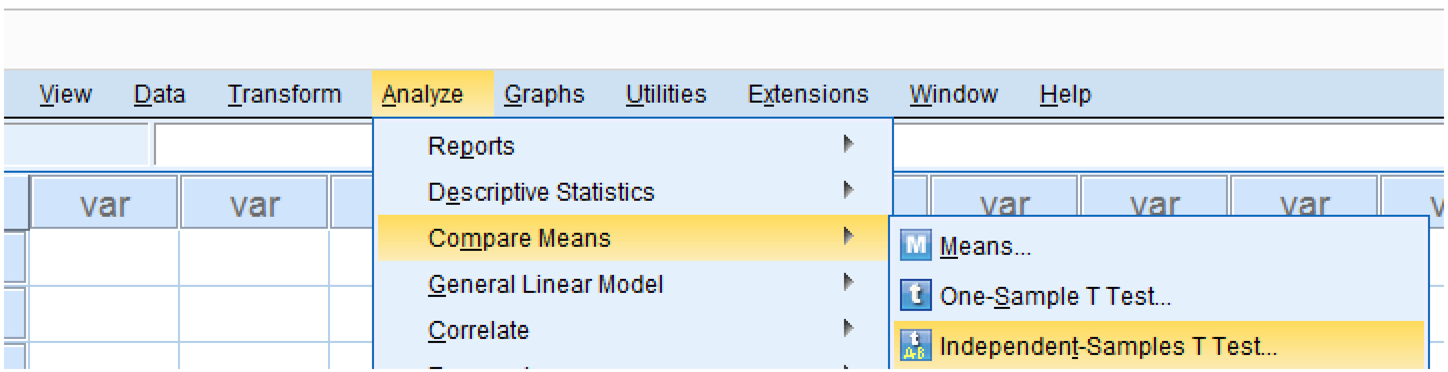
Independent T Test Example

- A scientist wants to know if children from divorced parents score differently on some psychological tests than children from non divorced parents.

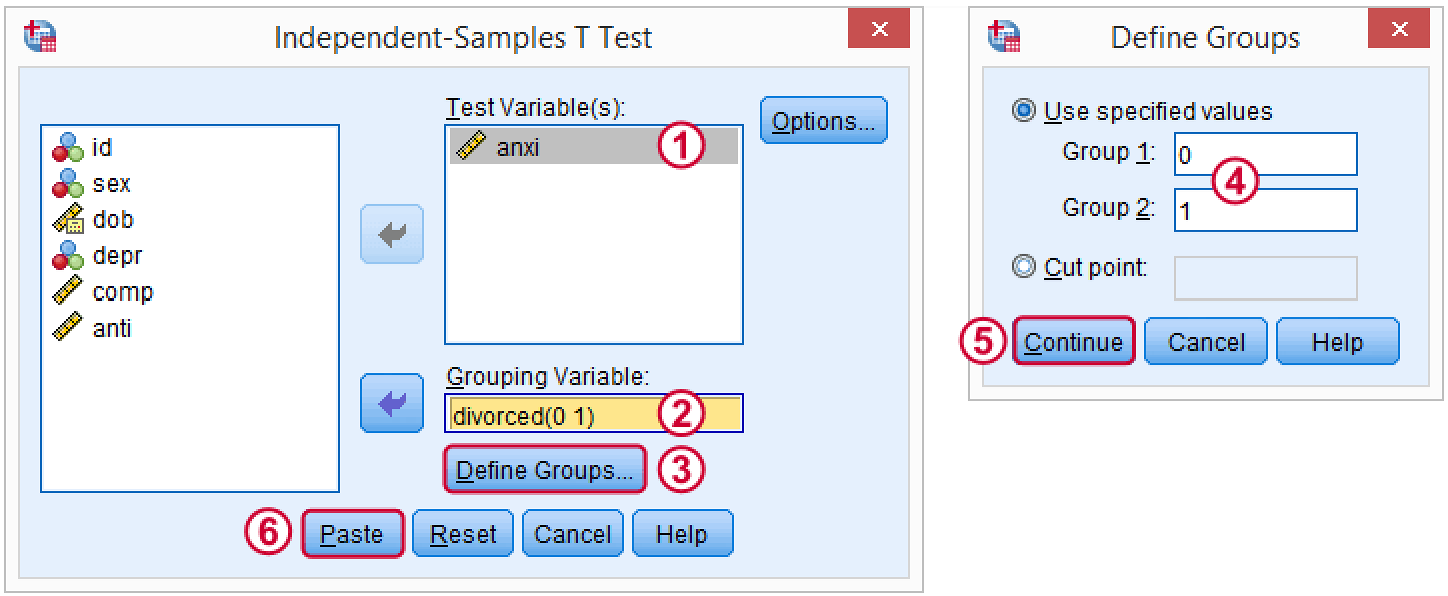
ID No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gender	1	0	1	1	0	1	0	0	1	0	1	0	1	1	0
Divorced	0	0	1	0	1	1	0	1	0	1	1	0	0	1	0
Anxiety	21	22	16	18	19	20	21	17	23	21	22	18	20	19	21

Independent T Test Example

- We are going back to the Analyze menu. Click Analyze, click Compare means and then Click Independent Samples T Test.



Independent T Test Example



- We'll first test anxi and make sure we understand the output.

SPSS Output for an Independent Samples T Test

Group Statistics

	Divorced	N	Mean	Std. Deviation	Std. Error Mean
Anxciety	divorced	8	20.50	1.773	.627
	not divorced	7	19.14	2.116	.800

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
Anxciety	Equal variances assumed	.143	.712	1.353	13	.199	1.357	1.003	-.810	3.525
	Equal variances not assumed			1.336	11.815	.207	1.357	1.016	-.860	3.575

Paired-Samples t Test

Example

In a study conducted in the Forestry and Wildlife Department at Virginia Tech, J. A. Wesson examined the influence of the drug succinylcholine on the circulation levels of androgens in the blood. Blood samples were taken from wild, free-ranging deer immediately after they had received an intramuscular injection of succinylcholine administered using darts and a capture gun. A second blood sample was obtained from each deer 30 minutes after the first sample, after which the deer was released. The levels of androgens at time of capture and 30 minutes later, measured in Nano grams per milliliter (ng/mL), for 15 deer are given in the table. Assuming that the populations of androgen levels at time of injection and 30 minutes later are normally distributed, test at the 0.05 level of significance whether the androgen concentrations are altered after 30 minutes.

Data of Example

Deer	Androgen (ng/mL) At Time of Injection	Androgen (ng/mL) 30 Minutes after Injection	d_i
1	2.76	7.02	4.26
2	5.18	3.10	−2.08
3	2.68	5.44	2.76
4	3.05	3.99	0.94
5	4.10	5.21	1.11
6	7.05	10.26	3.21
7	6.60	13.91	7.31
8	4.79	18.53	13.74
9	7.39	7.91	0.52
10	7.30	4.85	−2.45
11	11.78	11.10	−0.68
12	3.90	3.74	−0.16
13	26.00	94.03	68.03
14	67.48	94.03	26.55
15	17.04	41.70	24.66

Manual Solution

1. H_0: $\mu_1 = \mu_2$ or $\mu_D = \mu_1 - \mu_2 = 0$.

2. H_1: $\mu_1 \neq \mu_2$ or $\mu_D = \mu_1 - \mu_2 \neq 0$.

3. $\alpha = 0.05$.

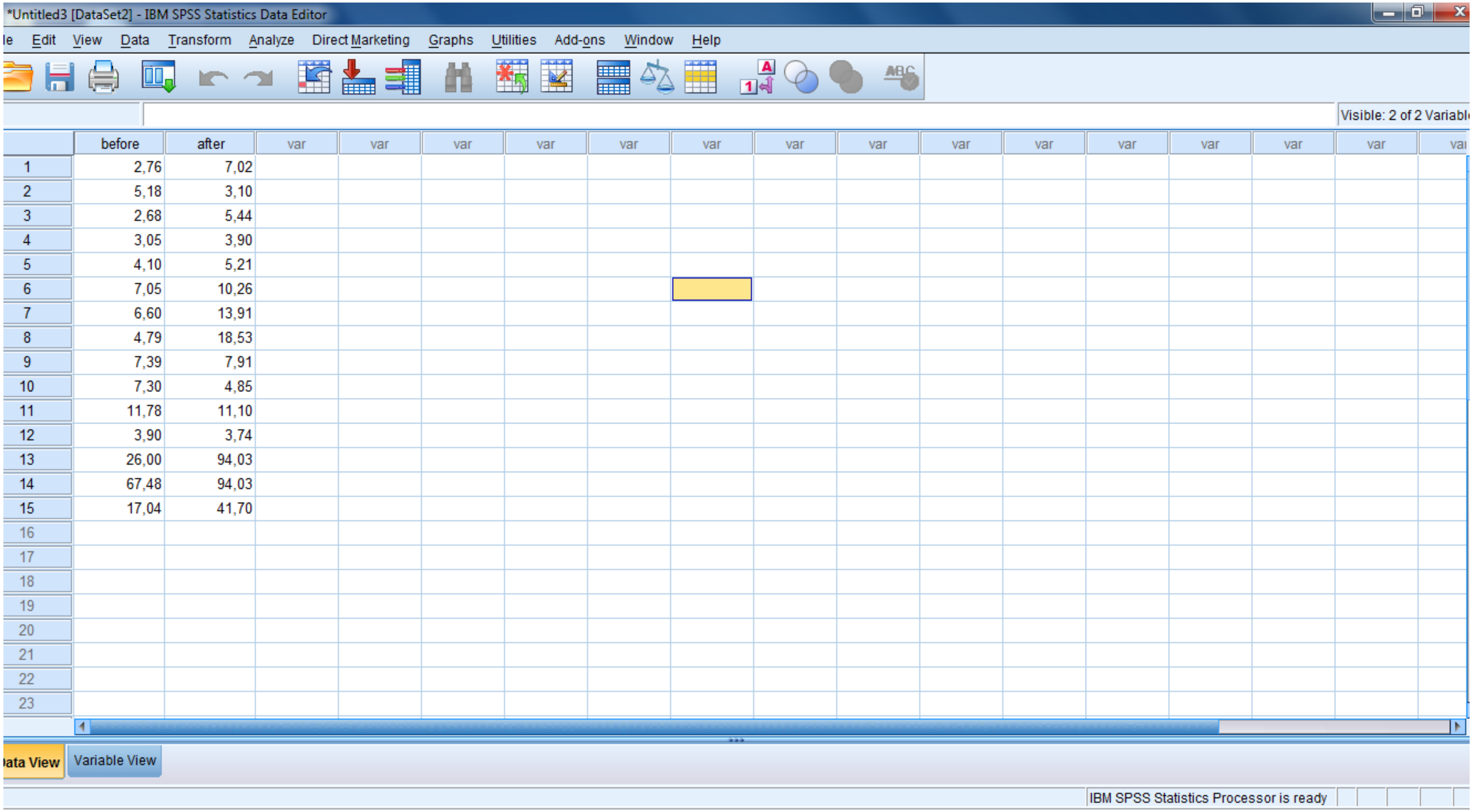
4. Critical region: $t < -2.145$ and $t > 2.145$, where $t = \frac{\bar{d} - d_0}{\frac{s_d}{\sqrt{n}}}$ with $\nu = 14$.

5. Computations: $\bar{d} = 9.848$ and $s_d = 18.474$.

Therefore, $t = \frac{9.848 - 0}{\frac{18.474}{\sqrt{15}}} = 2.06$

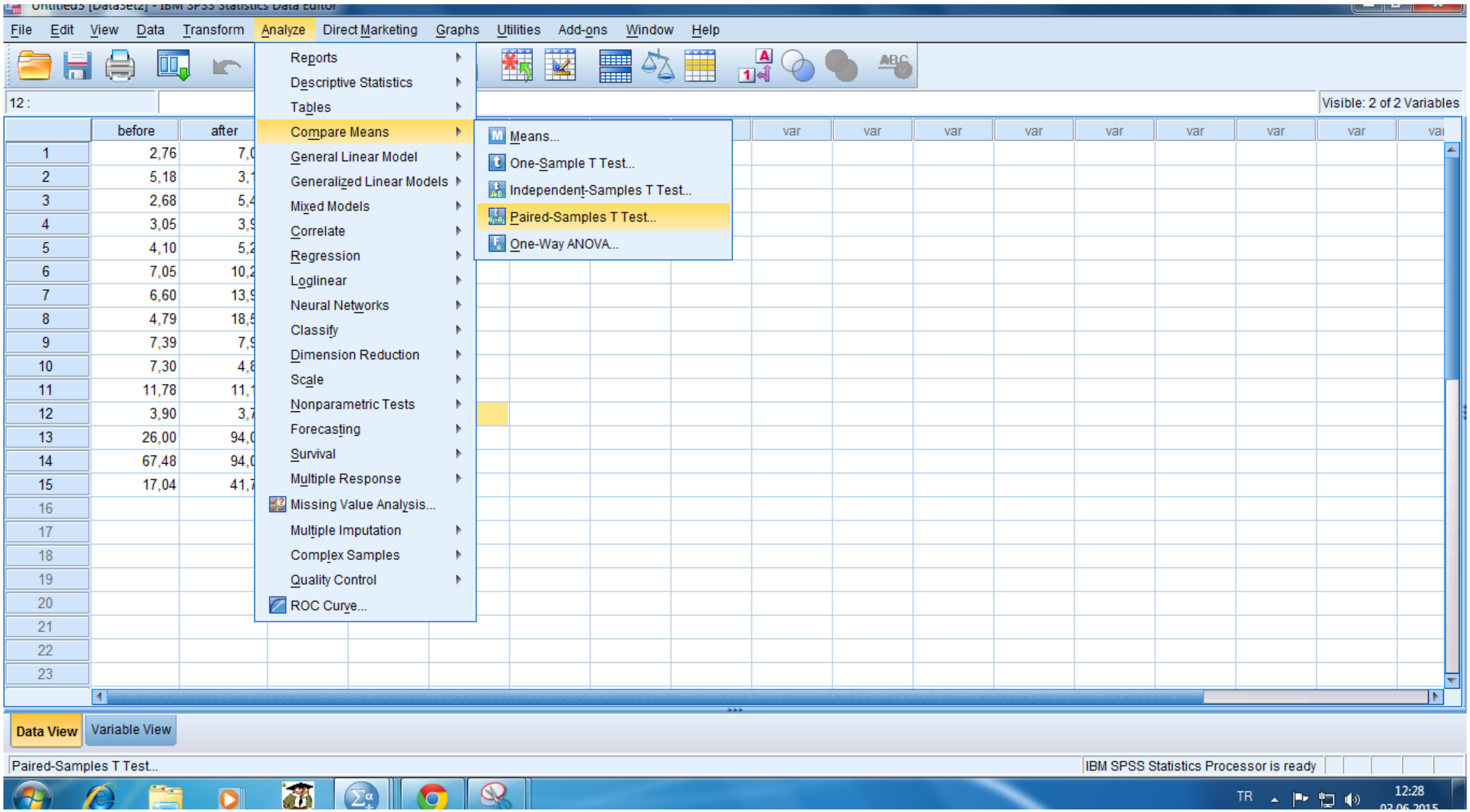
6. Though the t-statistic is not significant at the 0.05 level, from Table A.4, $P = P(|T| > 2.06) \approx 0.06$. As a result, there is some evidence that there is a difference in mean circulating levels of androgen.

Input Data

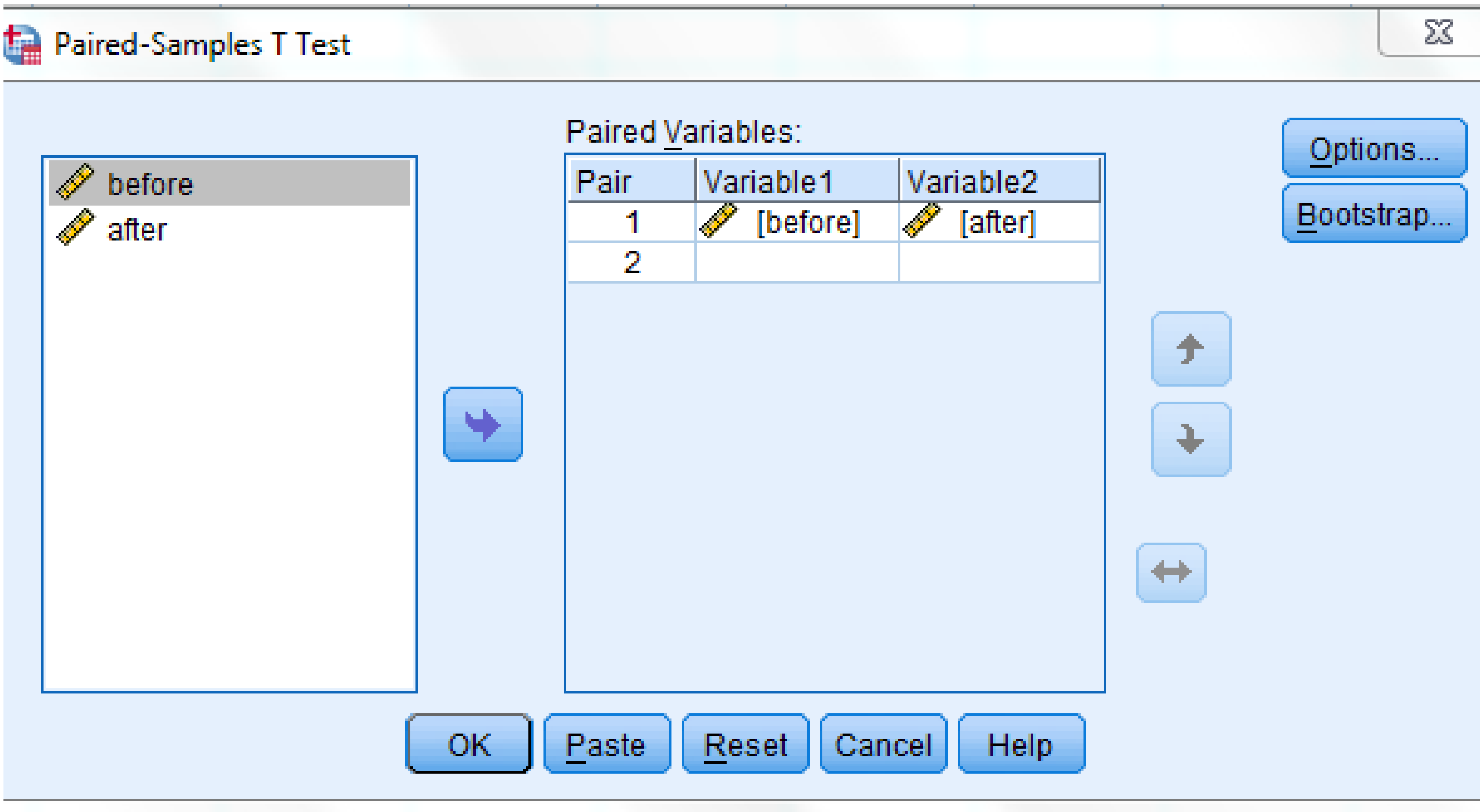


	before	after
1	2,76	7,02
2	5,18	3,10
3	2,68	5,44
4	3,05	3,90
5	4,10	5,21
6	7,05	10,26
7	6,60	13,91
8	4,79	18,53
9	7,39	7,91
10	7,30	4,85
11	11,78	11,10
12	3,90	3,74
13	26,00	94,03
14	67,48	94,03
15	17,04	41,70

Paired Sample T test



Paired Sample T test



Result

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	before	11,8067	15	16,63641	4,29550
	after	21,6487	15	30,92438	7,98464

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	before & after	15	,867	,000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	before - after	-9,84200	18,47674	4,77067	-20,07408	,39008	-2,063	14	,058

Example

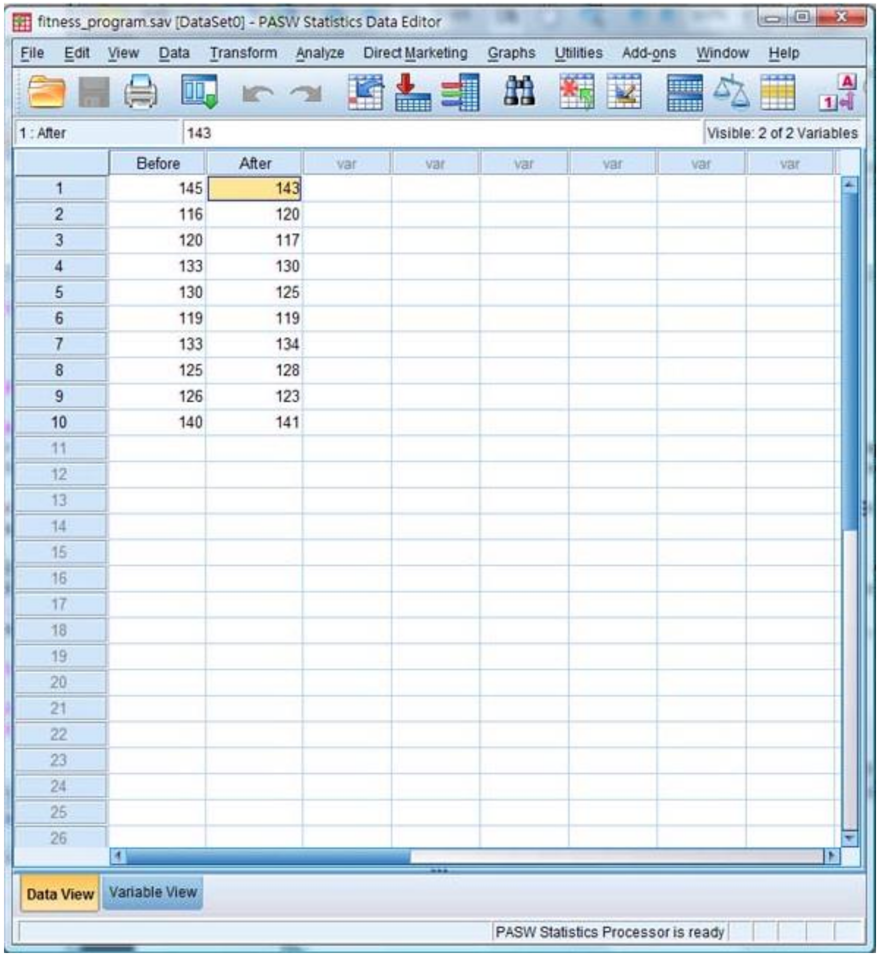
A new fitness program is devised for obese people. Each participant's weight was measured before and after the program to see if the fitness program is effective in reducing their weights.

In this example, our null hypothesis is that the program is not effective, i.e., there is no difference between the weight measured before and after the program. The alternative hypothesis is that the program is effective and the weight measured after is less than the weight measured before the program.

In the data, the first column is the weight measured before the program and the second column is the weight after.

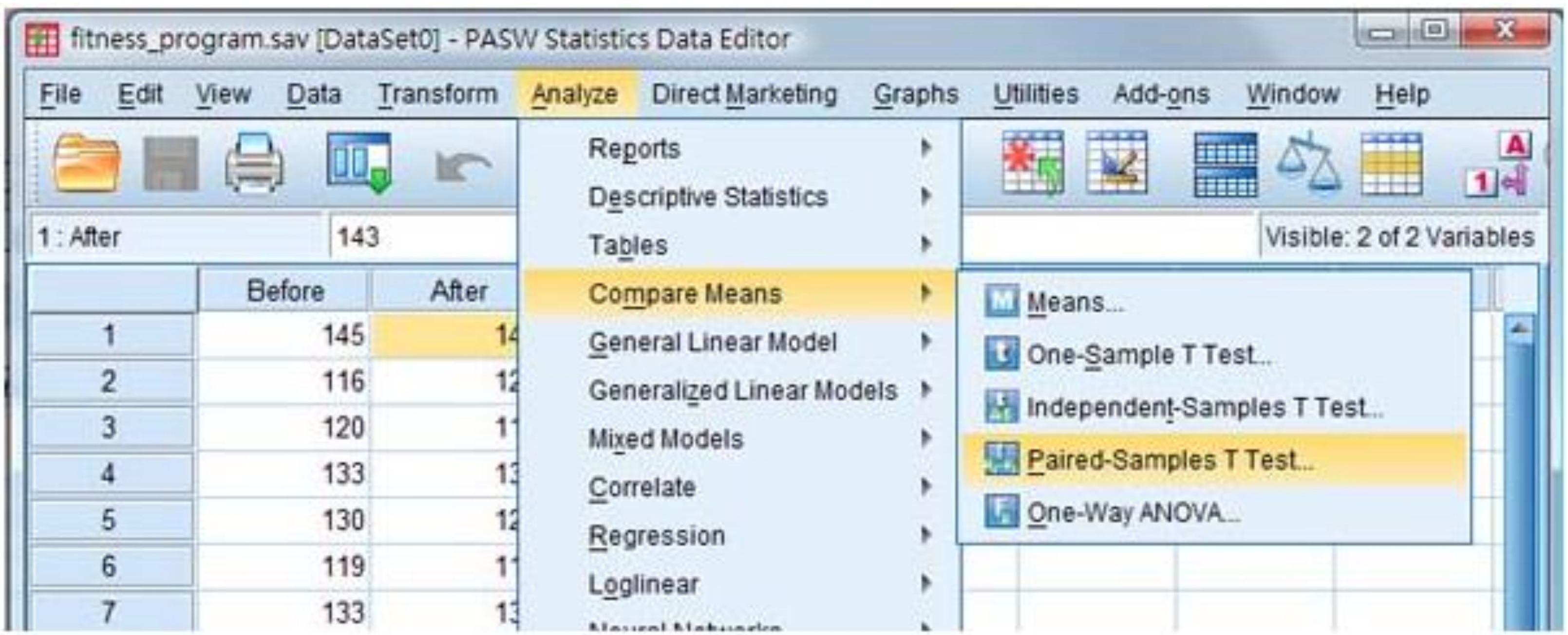
Before	145	116	120	133	130	119	133	125	126	140
After	143	120	117	130	125	119	134	128	123	141

Input Data


fitness_program.sav [DataSet0] - PASW Statistics Data Editor
File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help
1 : After
143
Visible: 2 of 2 Variables
Before After var var var var var var
1 145 143
2 116 120
3 120 117
4 133 130
5 130 125
6 119 119
7 133 134
8 125 128
9 126 123
10 140 141
Data View
Variable View
PASW Statistics Processor is ready

Paired Sample T Test

Select "Analyze -> Compare Means -> Paired-Samples T Test".



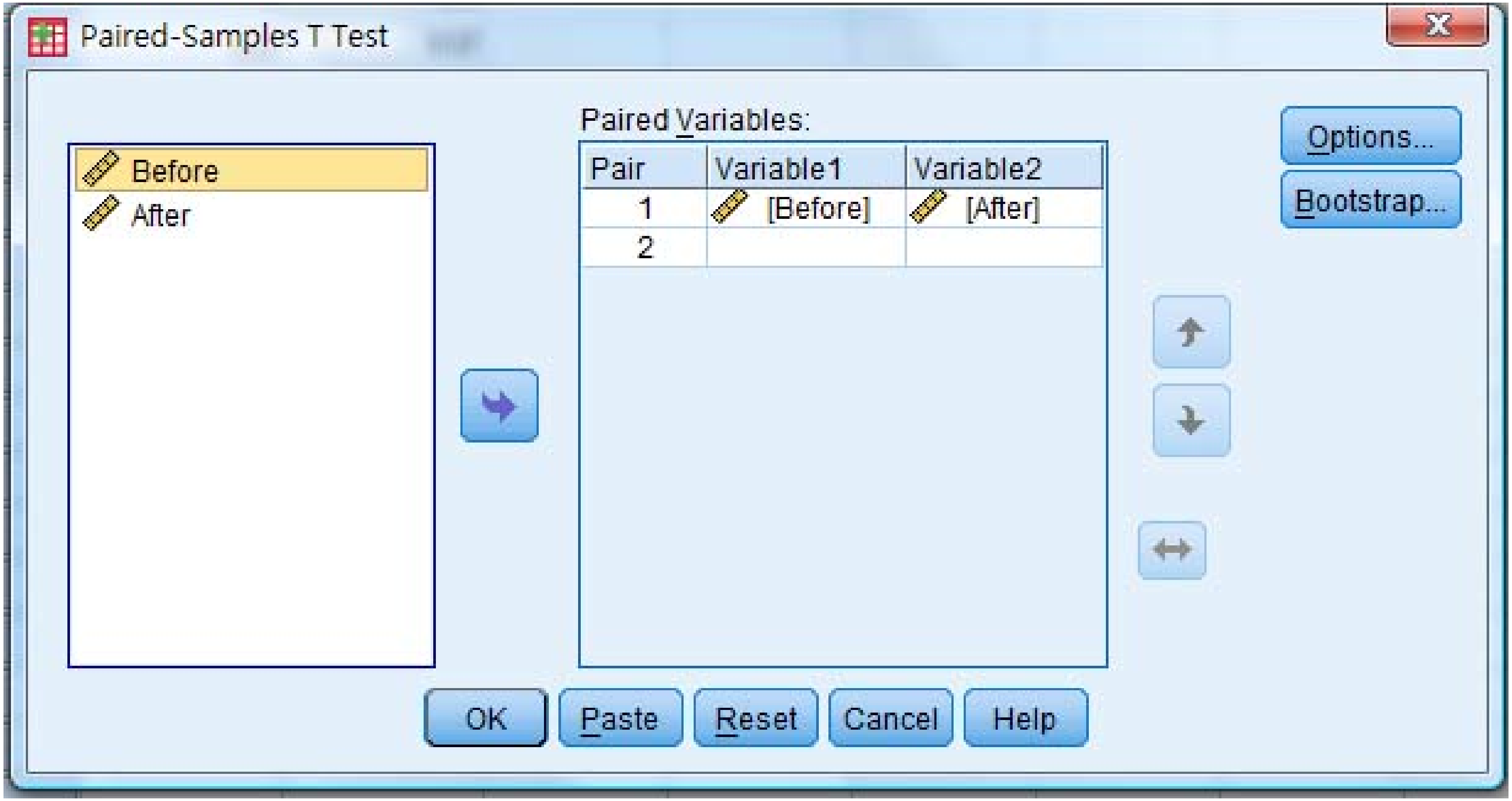
Paired Sample T Test

A new window pops out. Drag the variable "Before" and "After" from the list on the left to the pair 1 variable 1 and variable 2 respectively, as shown next slide.

Click on Option to change the confidence interval level.

Then click "OK".

Paired Sample T Test



Paired Sample T Test

The results now pop out in the "Output" window.

Since the p-value is 0.472, we can not reject the alternative hypothesis and conclude that the fitness program is not effective at 5% significant level.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	128.70	10	9.334	2.952
	After	128.00	10	9.031	2.856

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Before & After	10	.949	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Before - After	.700	2.946	.932	-1.407	2.807	.751	9	.472

Analysis of Variance
ANOVA

Example

- Suppose that we have five educational levels in our population denoted by 1, 2, 3, 4, 5
- We measure the hours per week that each level watches TV and we repeat this experiment for 6 weeks.
- So we will enter our data in the following table

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1	20	23	18	29	30	23
2	24	24	29	31	19	19
3	31	25	25	26	20	28
4	27	29	29	34	19	27
5	23	29	34	32	27	29

- We want to know that whether educational level affect on the weekly hours watching TV or not.
- So we define this hypothesis

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$$

$$H_1: \ Otherwise$$

- For testing this hypothesis we use ANOVA in SPSS by using following order

1- Entering data in the variable view

2- Analyze

3- Compare Means

4- One-Way ANOVA

*Untitled1 [DataSet0] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Add-ons Window Help

30 : H.W.TV | 29

	E.L	H.W.TV	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
1	1	20																
2	1	23																
3	1	18																
4	1	29																
5	1	30																
6	1	23																
7	2	24																
8	2	24																
9	2	29																
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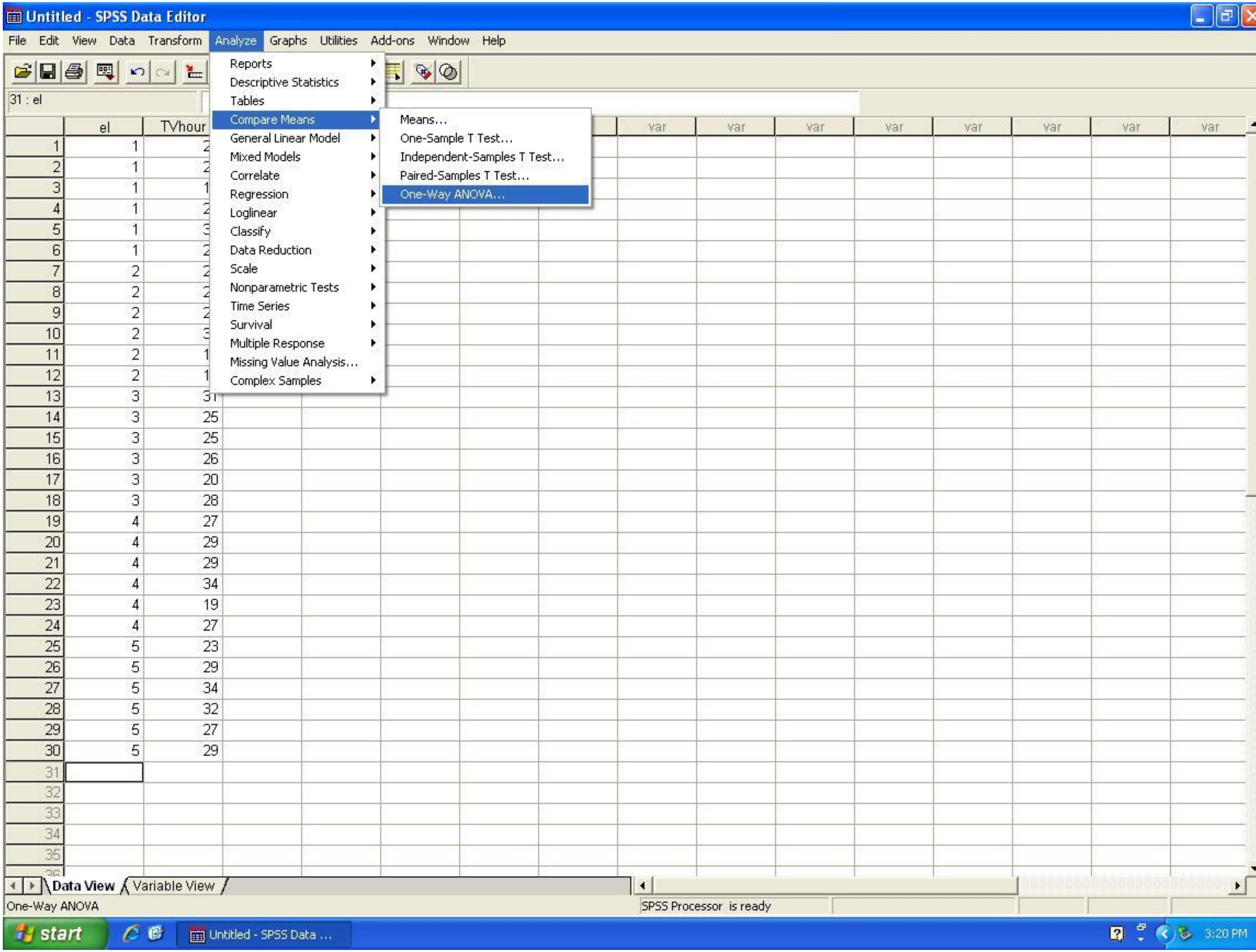
27	5	34																
28	5	32																
29	5	27																
30	5	29																
31																		

Data View | Variable View

SPSS Processor is ready

EN 12:36 AM


Untitled - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Add-ons Window Help
31 : el
Reports
Descriptive Statistics
Tables
Compare Means
General Linear Model
Mixed Models
Correlate
Regression
Loglinear
Classify
Data Reduction
Scale
Nonparametric Tests
Time Series
Survival
Multiple Response
Missing Value Analysis...
Complex Samples
Means...
One-Sample T Test...
Independent-Samples T Test...
Paired-Samples T Test...
One-Way ANOVA...
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TVhour
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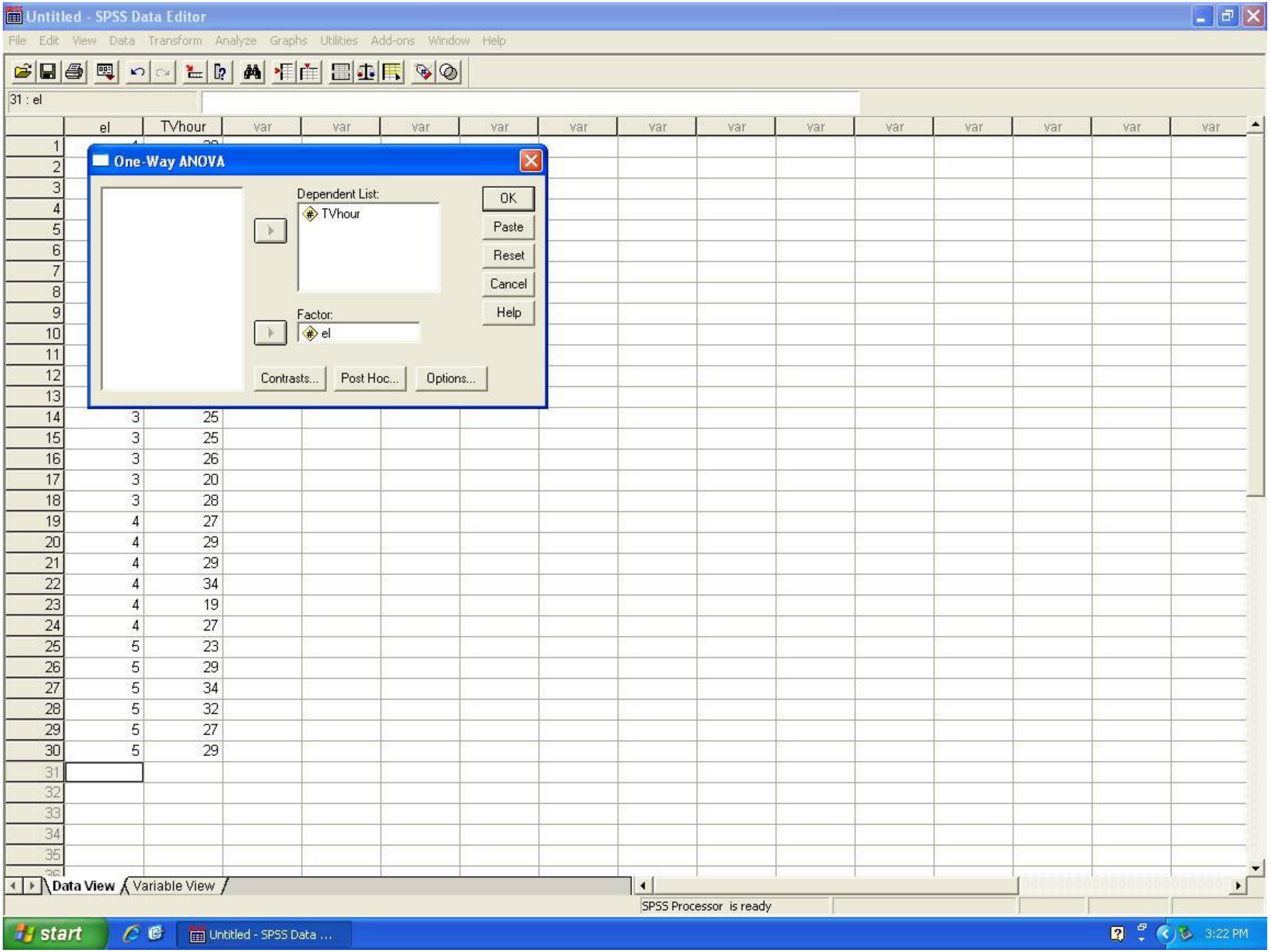
Data View
Variable View
One-Way ANOVA
SPSS Processor is ready
start
Untitled - SPSS Data ...
3:20 PM


Untitled - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Add-ons Window Help
31 : el
el TVhour var var var var var var var var var var var var var
One-Way ANOVA
Dependent List:
TVhour
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Contrasts...
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Options...
14 3 25
15 3 25
16 3 26
17 3 20
18 3 28
19 4 27
20 4 29
21 4 29
22 4 34
23 4 19
24 4 27
25 5 23
26 5 29
27 5 34
28 5 32
29 5 27
30 5 29
Data View
Variable View
SPSS Processor is ready
start
Untitled - SPSS Data ...
3:22 PM

Output10 - SPSS Viewer

Oneway

[DataSet0]

ANOVA

H.W.TV

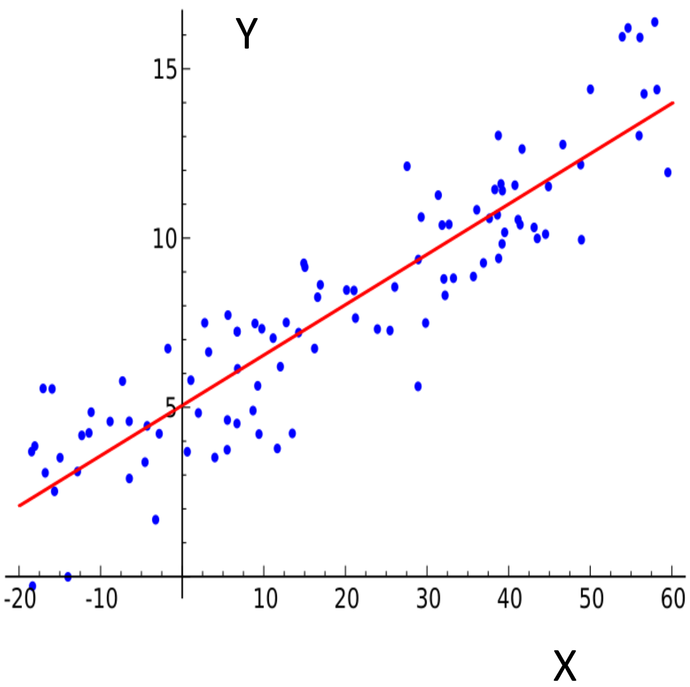
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	112.200	4	28.050	1.407	.261
Within Groups	498.500	25	19.940		
Total	610.700	29			

SPSS Processor is ready

Linear regression

What is linear regression ?

linear regression is a **linear approach** to modelling the relationship between a scalar response (or **dependent variable y**) and one or more explanatory variables (or **independent variables x**).



Example :

In this set of data, we wanted to predict a person IQ scores if we know how much caffeine they consume.

Our set of Data is as follows :

Caffeine Dose	IQ Score
50	100
60	102
80	107
90	105
110	112
150	108
150	103
160	109
180	109
200	112
200	120
210	114
210	118
220	121
220	120
250	130
260	127
260	131
280	132
300	135

Step 1 : input our data

Write the variables

Name	Type	Width	Decimals	Label	Values	Missing	Columns	
Caffeine_Dose	Numeric	8	2		None	None	11	Ri
IQ_score	Numeric	8	2		None	None	8	Ri

And the data :

Caffeine_Dose	IQ_score
50.00	100.00
60.00	102.00
80.00	107.00
90.00	105.00
110.00	112.00
150.00	108.00
150.00	103.00
160.00	109.00
180.00	109.00
200.00	112.00
200.00	120.00
210.00	114.00
210.00	118.00
220.00	121.00
220.00	120.00
250.00	130.00
260.00	127.00
260.00	131.00
280.00	132.00
300.00	135.00

Step 2 : Plot the Data

In this step , we are going to plot our data in order so see the shape of the graph $y = f(x)$

What are y and x ??

Remember that in our example we wanted to know the effect of the consumption of caffeine on the IQ Score (Intelligence quotient).

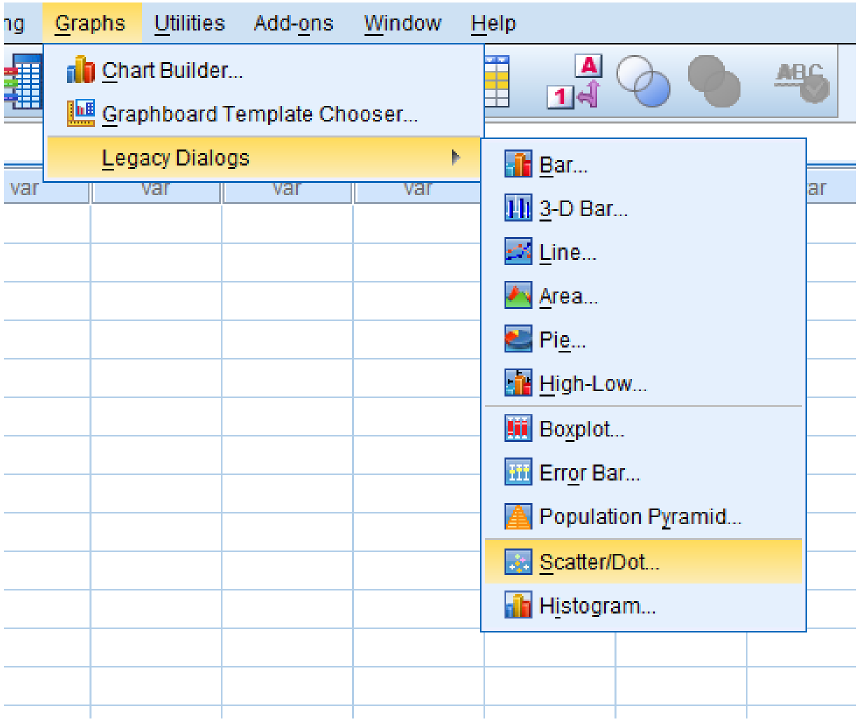
Otherwise , we want to know if the IQ score depends on the caffeine dose.

So y is IQ score

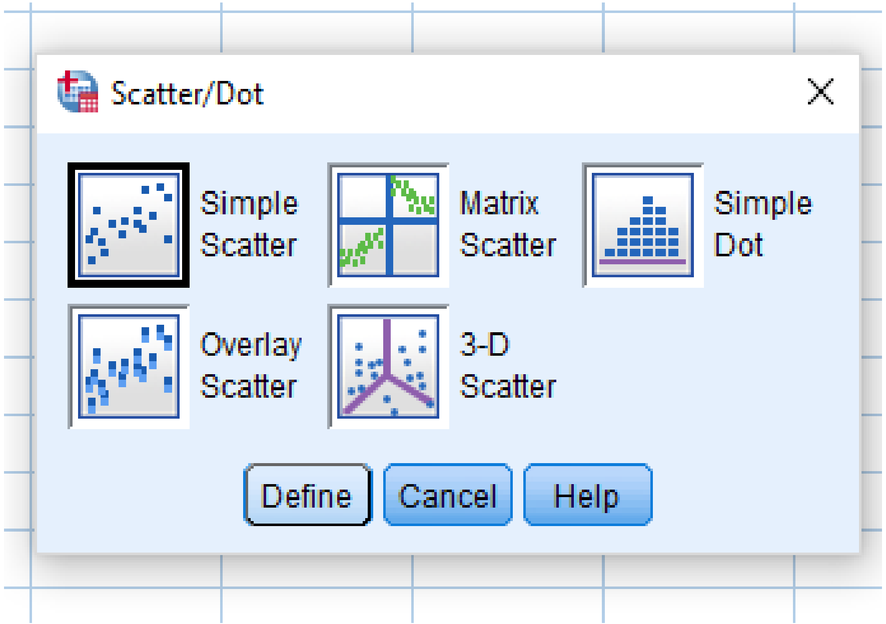
And x is caffeine dose

In order to plot the data ,we use the graphs tool :

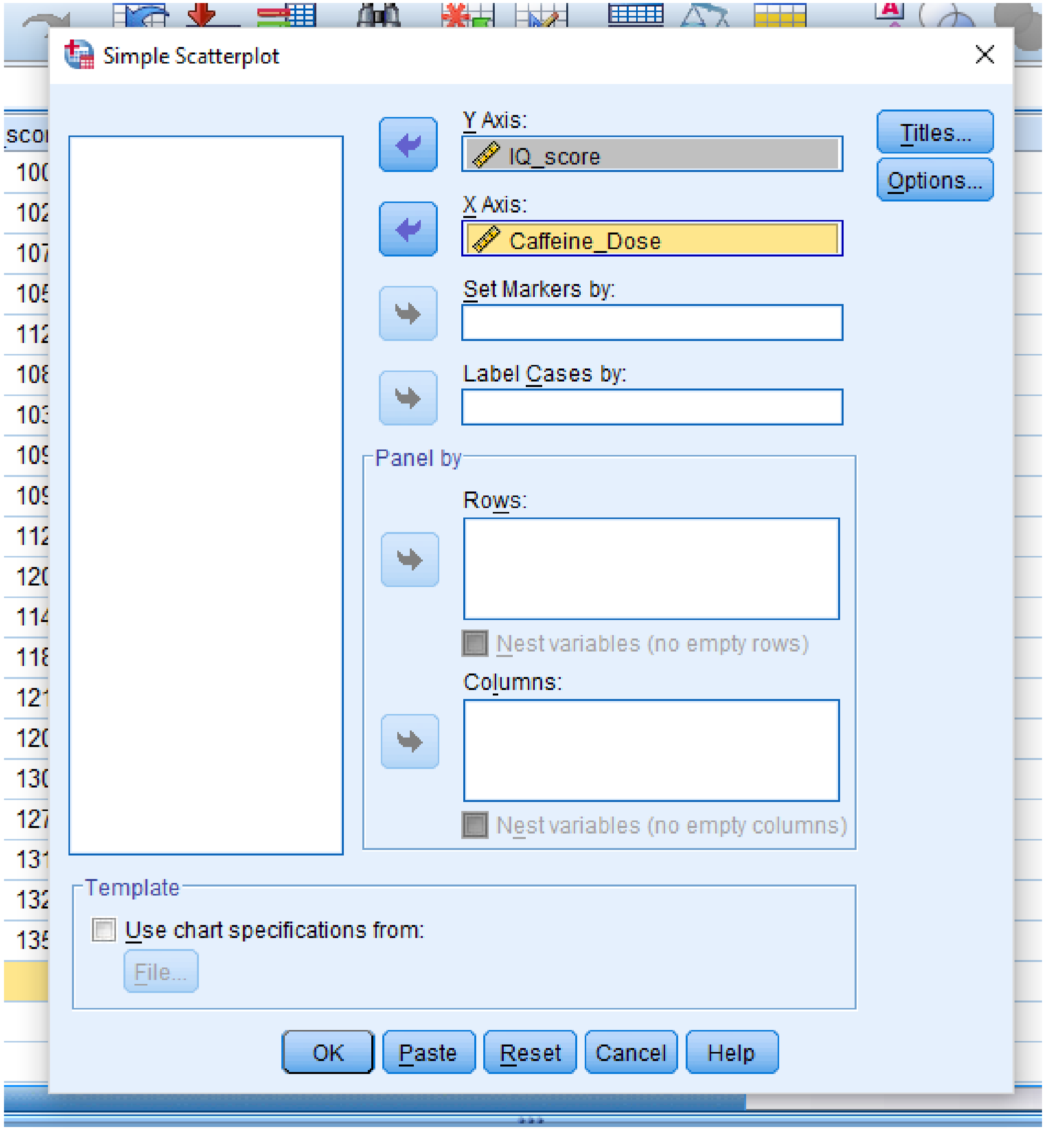
1- Go “Graph” then “Legacy Dialogs” and choose “Scatter Dot”



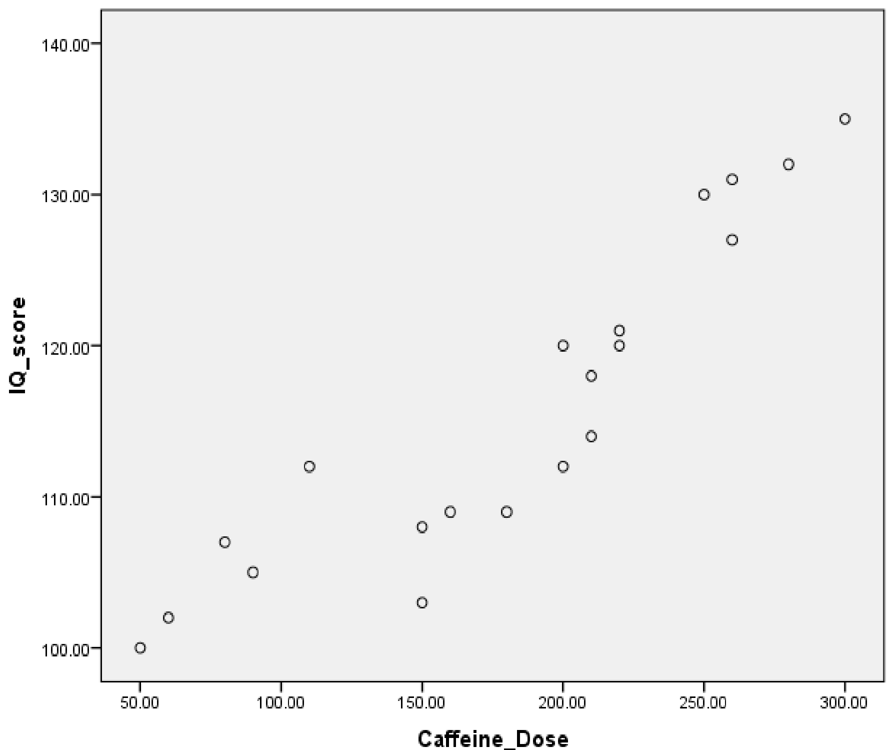
2- Then choose “Simple Scatter” and click “Define



3- So remember variable you're trying to predict is y variable, we should put "IQ_scores" in y axis and, and the variable that you are using to predict y variable is the x variable which is "Caffeine dose" in this case



We obtain :



So as you can see on the graph relationship is almost like a straight line. So, linear regression will be most appropriate one for this example.

Step 3 : find the function y

In this step we will find the regression equation

$$y_i = b_0 + b_1 x_i$$

Where :

y = value of dependent variable (IQ score in this case)

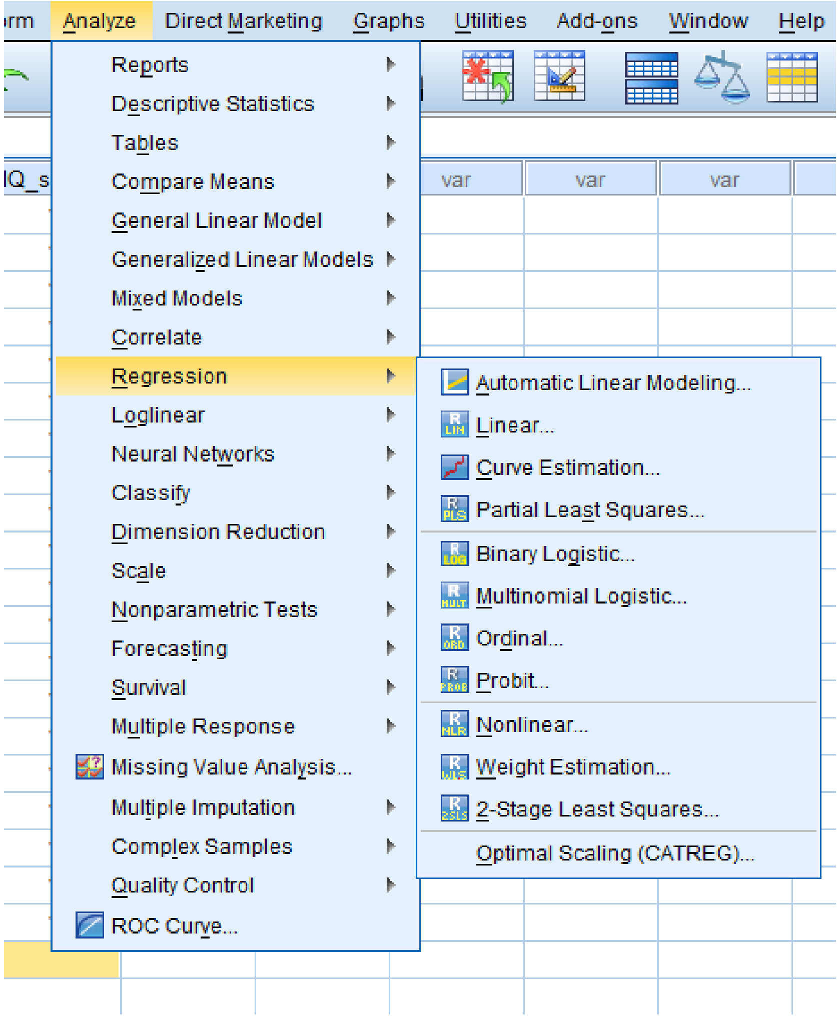
x = value of independent variable

b_0 = intercept

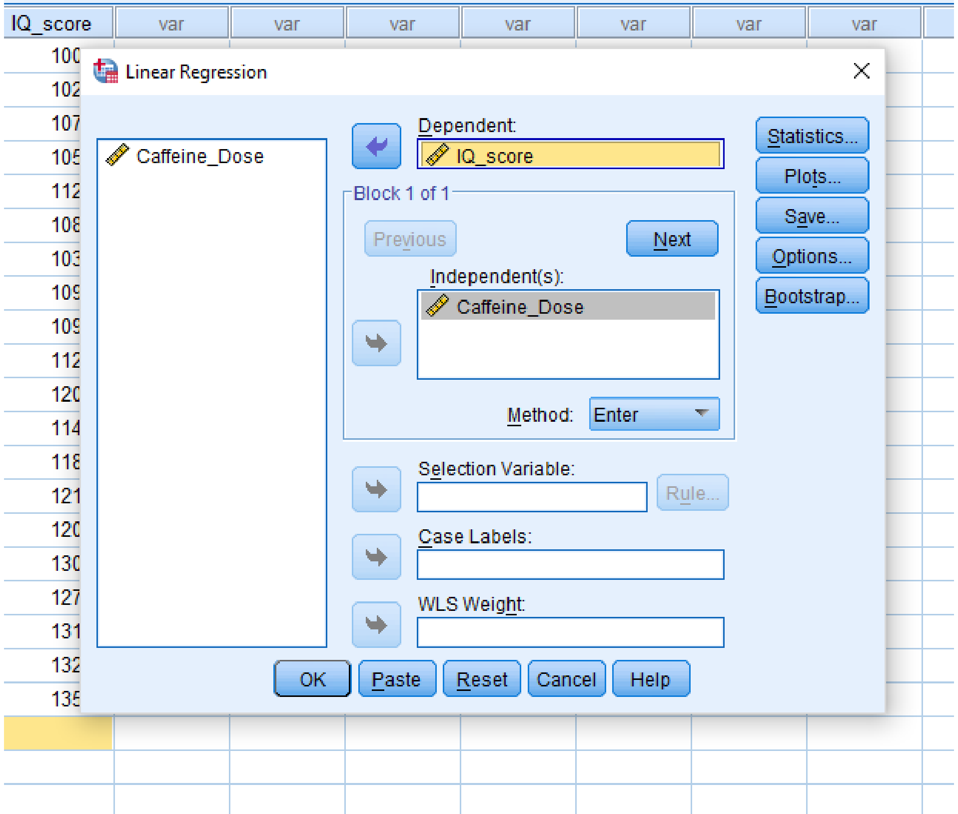
b_1 = slope

1-Go “Analyze” then “Regression” So there are many different kind of relationship style between two variables it could be linear, or bell shaped or any other kind.

pick “Linear”



2- pick your "Caffein_Dose" as independent variable because you are using it to predict, and "IQ_score" will be your dependent variable because you're looking for its value.



We obtain:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.917[a]	.840	.831	4.46113

a. Predictors: (Constant), Caffeine_Dose

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1881.519	1	1881.519	94.541	.000[b]
	Residual	358.231	18	19.902		
	Total	2239.750	19			

a. Dependent Variable: IQ_score

b. Predictors: (Constant), Caffeine_Dose

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	91.308	2.705		33.761	.000
	Caffeine_Dose	.134	.014	.917	9.723	.000

a. Dependent Variable: IQ_score

- R-squared is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination, or the coefficient of multiple determination for multiple regression.

- R-squared is always between 0 and 100%:

- 0% indicates that the model explains none of the variability of the response data around its mean.
- 100% indicates that the model explains all the variability of the response data around its mean.
- In general, the higher the R-squared, the better the model fits your data.
- In this example R Square is 0.840, it’s near to 0.85. So it is acceptable.

- Under standardized Coefficients at B section first one 91.308 is you're "b_0" means it's your y intercept and the second value .134 is your "b_1" means slope so if you put this numbers in your $y_i = b_0 + b_1 x_i$ you can predict a person's IQ score according to how much caffeine which he/she consumed.

For example , how much will be the IQ score of a person who consumed 70 dose of caffeine ?

Answer :

We know that $y_i = b_0 + b_1 x_i$

=0,134 x + 91.308

y = 0,13 * 70 + 91,308

= 100,408

Good Luck