



Test of Hypothesis using SPSS

Dr. Md. Atiqul Islam

M.Sc. (SUST, BD), M.Sc. (UHasselt, BE), PhD (RuG, NL)

Professor

Department of Statistics

Jagannath University, Dhaka-1100

E-mail: atique@stat.jnu.ac.bd

Concept Covered

- ▷ Hypothesis testing
- ▷ Errors in Hypothesis testing
- ▷ Hypothesis testing procedure
- ▷ Hypothesis testing – case studies
- ▷ t -test
- ▷ Nonparametric Test

Introduction





Statistical Hypothesis

- ▷ **Hypothesis:** Any statement regarding the parameter of a random variable is called hypothesis.
- ▷ If the hypothesis is stated in terms of population parameters (such as mean, variance etc.), the hypothesis is called **statistical hypothesis**.
- ▷ Data from a sample (which may be an experiment) are used to test the validity of the hypothesis.
- ▷ A procedure that enables us to agree (or disagree) with the statistical hypothesis is called a **test of the hypothesis**.

Hypothesis Testing

- ▷ The main purpose of statistical hypothesis testing is to choose between two competing hypotheses.

Example

- ▷ One hypothesis might claim that wages of men and women are equal, while the **alternative** might claim that men make more than women.
- ▷ Hypothesis testing start by making a set of two statements about the parameter(s) in question.
- ▷ **Null Hypothesis:** The hypothesis which is usually tested under rejection, is call null hypothesis. It is denoted by H_0 .
- ▷ **Alternative Hypothesis:** The alternative hypothesis is the hypothesis used in hypothesis testing that is contrary to the null hypothesis. It is denoted by H_1 or H_A .

Hypothesis Testing



Statistical inference



Null hypothesis



Sample



Alternative hypothesis

Assumptions

- ▷ Independence
- ▷ Normality
- ▷ Homogeneity (variances are equal)



Conceptions in Hypothesis Test

- ▷ One-sided and Two-sided tests
- ▷ Type-I error and Type-II error
- ▷ Level of Significance
- ▷ Conclusion with probability
- ▷ Means of P -value
- ▷ Significance

The Hypotheses

- ▷ **One-sided test:** A statistical test in which the **alternative** hypothesis specifies that the population parameter lies entirely **above** or **below** the value specified in H_0 is called a one-sided (or one-tailed) test. e.g.,

$$H_0: \mu \leq 100 \text{ vs. } H_1 > 100$$

$$\text{or, } H_0: \mu \geq 0 \text{ vs. } H_1 < 100$$

- ▷ **Two-sided test:** An **alternative** hypothesis that specifies that the parameter can lie either sides of the value specified by H_0 is called a two-sided (or two-tailed) test. e.g.,

$$H_0: \mu = 100 \text{ vs. } H_1 \neq 100$$

Errors in Hypothesis Testing

Type I error:

A type I error occurs when we incorrectly reject H_0 (i.e. we reject the null hypothesis, when H_0 is true).

Type II error:

A type II error occurs when we incorrectly fail to reject H_0 (i.e. we accept H_0 when it is not true).

Observation	Decision	
	Reject H_0	Do not reject H_0
H_0 is true	Type I error (α)	Decision is Correct
H_0 is false or H_1 is true	Decision is Correct Power ($1 - \beta$)	Type II error (β)

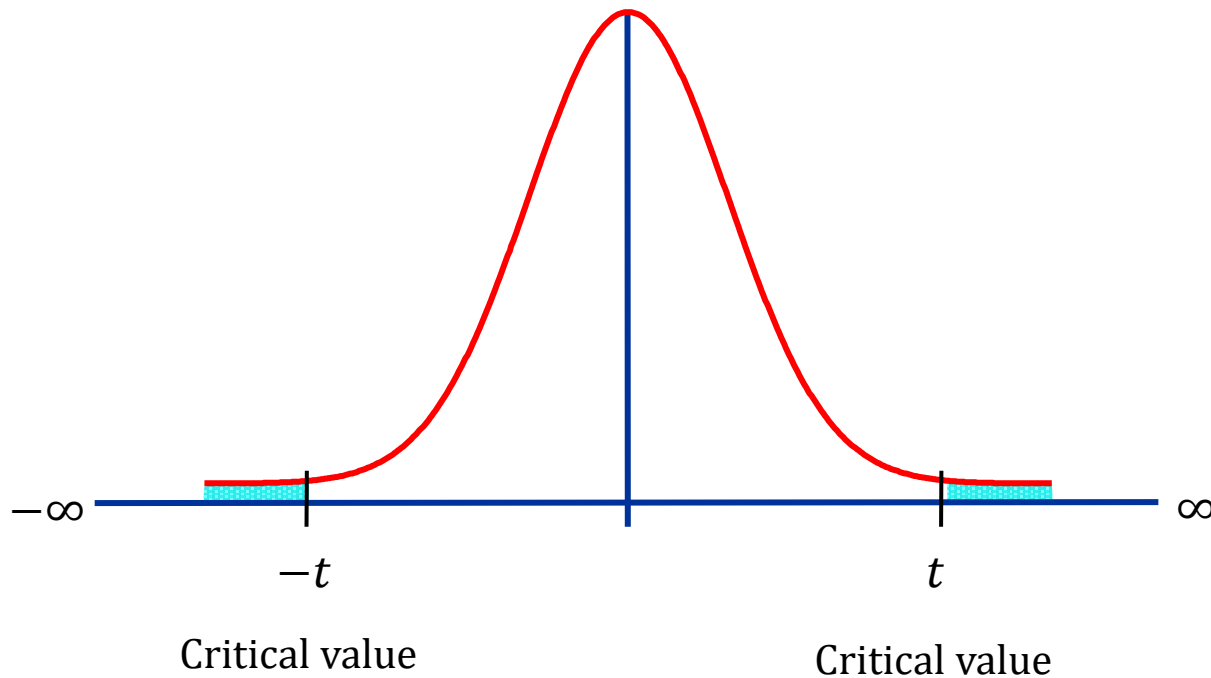


Probability of Making Errors

- ▷ **Level of Significance:** The probability of rejecting the null hypothesis when it is true is called level of significance. It is the probability of Type-I error. It is denoted by α .
- ▷ **Power of the Test:** The probability of rejecting the null hypothesis when it is false is called power of the test. It is denoted by $(1 - \beta)$.
$$\therefore \text{Power} = 1 - (\text{probability of Type - II error}) = 1 - \beta$$
- ▷ ***p* -value:** A *p* -value (probability value) describes the exact significance level associated with a particular result.
 - ▷ For example: The *p*-value of 0.01 indicates that the test is statistically significant at 1% level.

p -value

- ▷ The p -value of a test is the smallest value of α (level of significance) for which null hypothesis can be rejected.



What does mean by P -value?

- ▷ If $P \leq \alpha$, H_0 is statistically significant.
 - ▷ If the data are not consistent with the null hypothesis, the difference is said to be statistically significant.
- ▷ If $P > \alpha$, No statistical significance.
 - ▷ No sufficient evidence.

5 Steps of Hypothesis test

- 1 Specify H_0 and H_1 , the null and alternate hypothesis, and an acceptable level of α (*significance level*).
- 2 Determine an appropriate sample-based test statistics and the rejection region for the specified H_0 .
- 3 Collect the sample data and calculate the test statistics.
- 4 Make a decision to either reject or fail to reject H_0 .
- 5 Interpret the result in common language suitable for practitioners.

T-test: One sample

- ▷ **Example:** An outbreak of Salmonella-related illness was attributed to ice cream produced at a certain factory. Scientists measured the level of Salmonella in 9 randomly sampled batches of ice cream. The levels (in MPN/g) were: 0.593, 0.142, 0.329, 0.691, 0.231, 0.793, 0.519, 0.392, 0.418
- ▷ **Question:** Is there evidence that the mean level of Salmonella in the ice cream is greater than 0.3 MPN/g?
- ▷ **Solution:** The null and alternative hypotheses are

$$H_0: \mu \leq 0.3 \text{ vs. } H_1: \mu > 0.3$$

- Let's input the above data in SPSS

T-test: One sample



*Untitled2 [DataSet1] - IBM SPSS Statistics Data Editor

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

10 : Sal

	Sal	var
1	.593	
2	.142	
3	.329	
4	.691	
5	.231	
6	.793	
7	.519	
8	.392	
9	.418	
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

Analyze > **Compare Means** > **One-Sample T Test...**

One-Sample T Test

Test Variable(s):
Salmonella Level [S...]

Test Value: .3

Options...
Bootstrap...

OK Paste Reset Cancel Help

Click on it

T-test: One sample

$$H_0: \mu \leq 0.3 \text{ vs. } H_1: \mu > 0.3$$

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Salmonella Level	9	.45644	.212844	.070948

One-Sample Test

	Test Value = .3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Salmonella Level	2.205	8	.059	.156444	-.00716	.32005

$$P = 0.059/2$$

$$= 0.0295 < 0.05$$

▷ **Conclusion:** Since the *p* – value (0.0295) < α (0.05), we may reject the H_0 . Therefore, we may conclude that the mean level of Salmonella in the ice cream is greater than 0.3 MPN/g.

T-test: Two independent samples



- ▷ **Body Temperature data description (.sav):** The data represent the 100 people with heart rate and body temperature.

Let's import the data first!

- ▷ Question 1: Is there any significant changes in the heart rate of male and female?
- ▷ Recode the Gender variable into numerical coding (0 = *Male*, 1 = *Female*)
- ▷ Check the distribution of heart rate variable!
- ▷ **Solution:** The null and alternative hypotheses are
 $H_0: \mu_1 = \mu_2$ (mean HR of male and female are same)
 $H_1: \mu_1 \neq \mu_2$ (mean HR of male and female are different)

Checking the distribution of heart rate variable



Body Temperature.sav [DataSet2] - IBM SPSS Statistics Data Editor

	ID	Gender	Age			
1	1	M	33			
2	2	M	32	72	98.80	0
3	3	M	42	68	96.20	0
4	4	F	33	75	97.80	1
5	5	F	26	68	98.80	1
6	6	M	37	79	101.30	0
7	7	F	32	71	97.80	1
8	8	F	45	73	97.40	1
9	9	F	31	77	99.20	1
10	10	M	49	81	99.20	0
11	11	M	40	69	97.50	0
12	12	F	45	70	97.70	1
13	13	F	49	71	98.30	1
14	14	F	37	74	98.80	1
15	15	F	47	79	98.50	1
16	16	M	34	73	97.30	0
17	17	F	41	71	98.90	1
18	18	M	33	77	98.60	0
19	19	F	38	70	99.20	1
20	20	F	31	69	97.90	1
21	21	F	41	67	97.10	1
22	22	F	45	67	97.00	1

Legacy Dialogs

- Bar...
- 3-D Bar...
- Line...
- Area...
- Pie...
- High-Low...
- Boxplot...
- Error Bar...
- Population Pyramid...
- Scatter/Dot...
- Histogram...

Histogram

Variable: HeartRate

☒ Display normal curve

Panel by

Rows:

Columns: Sex

Template

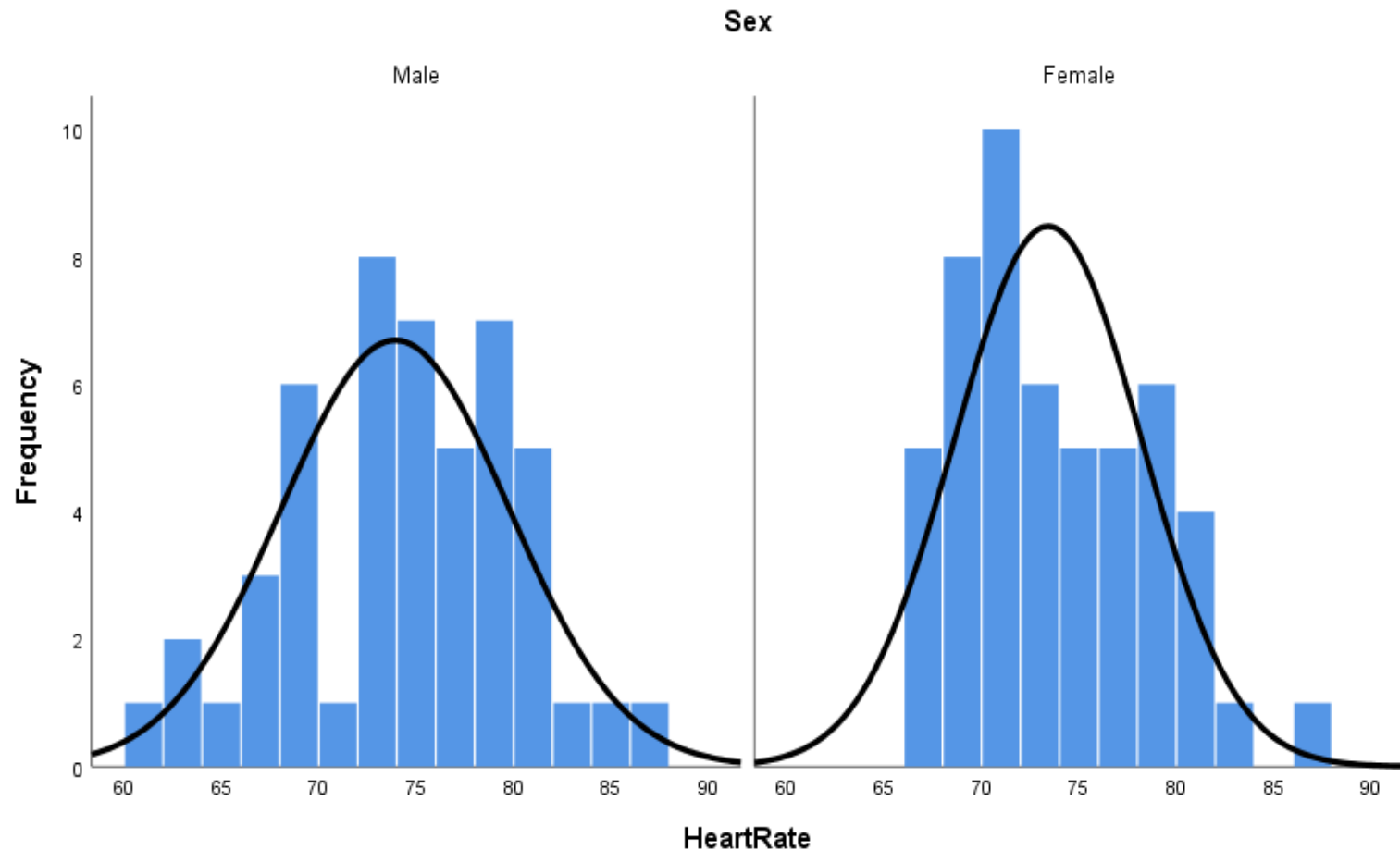
☐ Use chart specifications from:

File...

OK Paste Reset Cancel Help

Click it

Checking the distribution of heart rate variable



- ▷ **Summary:** The distribution of HR for male seems normal but the distribution of HR for female looks a bit skewed to the right. For both gender, the HR is approximately normally distributed.

T-test: Two independent samples



Body Temperature.sav [DataSet5] - IBM SPSS Statistics Data Editor

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

Reports
Descriptive Statistics
Tables
Compare Means
General Linear Model
Generalized Linear Models
Mixed Models
Correlate
Regression
Loglinear
Neural Networks
Classify
Dimension Reduction
Scale
Nonparametric Tests
Forecasting
Survival
Multiple Response
Missing Value Analysis...
Multiple Imputation
Complex Samples
Simulation...
Quality Control
ROC Curve...

Means...
One-Sample T Test..
Independent-Samples T Test...
Paired-Samples T Test..
One-Way ANOVA...

Independent-Samples T Test

Test Variable(s):
HeartRate

Grouping Variable:
Sex(? ?)

Define Groups

☒ Use specified values
Group 1: 0
Group 2: 1
☐ Cut point:

Click on it

	ID	Gender
79	79	F
80	80	M
81	81	M
82	82	F
83	83	F
84	84	M
85	85	F
86	86	M
87	87	M
88	88	M
89	89	F
90	90	M
91	91	F
92	92	F
93	93	M
94	94	M
95	95	F
96	96	M
97	97	F
98	98	F
99	99	F
100	100	M
101		

Data View Variable View

T-test: Two independent samples



Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
HeartRate	Female	51	73.41	4.797	.672
	Male	49	73.92	5.841	.834

$$H_0: \text{var}(HR_{\text{male}}) = \text{var}(HR_{\text{female}})$$

$$H_1: \text{var}(HR_{\text{male}}) \neq \text{var}(HR_{\text{female}})$$

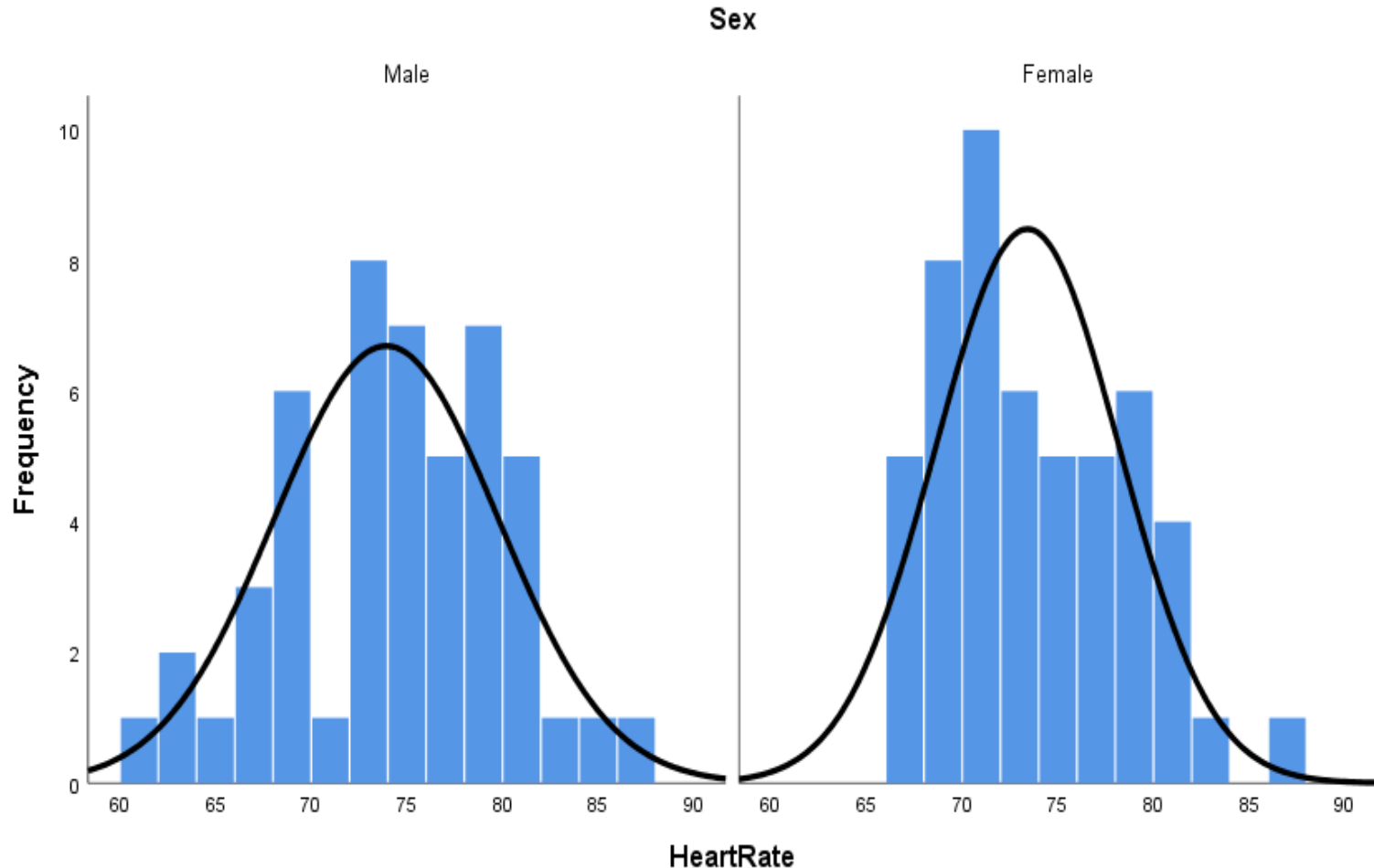
Independent Samples Test

		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	
HeartRate	Equal variances assumed	1.366	.245	-.475	98	.636	-.507	1.067	-2.624	1.611
	Equal variances not assumed			-.473	92.907	.637	-.507	1.071	-2.634	1.621

Which one will you choose??

$P > 0.05$

Checking the distribution of heart rate variable



- ▷ **Summary:** The distribution of HR for male seems normal but the distribution of HR for female looks skewed to the right (positively skewed). Overall, the HR is not normally distributed.

Non-parametric: Mann-Whitney U test



Body Temperature.sav [DataSet5] - IBM SPSS Statistics Data Editor

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

Reports
Descriptive Statistics
Tables
Compare Means
General Linear Model
Generalized Linear Models
Mixed Models
Correlate
Regression
Loglinear
Neural Networks
Classify
Dimension Reduction
Scale
Nonparametric Tests
Forecasting
Survival
Multiple Response
Missing Value Analysis...
Multiple Imputation
Complex Samples
Simulation...
Quality Control
ROC Curve...

Sex

ID	Gender
79	F
80	M
81	M
82	F
83	F
84	M
85	F
86	M
87	M
88	M
89	F
90	M
91	F
92	F
93	M
94	M
95	F
96	M
97	F
98	F
99	F
100	M
101	

Two-Independent-Samples Tests

Test Variable List: HeartRate

Grouping Variable: Sex(0 1)

Test Type:
☒ Mann-Whitney U
☐ Kolmogorov-Smirnov Z
☐ Moses extreme reactions
☐ Wald-Wolfowitz runs

OK Paste Reset Cancel Help

Define Groups

Use specified values
Group 1: 0
Group 2: 1
Cut point:
Continue Cancel Help

Legacy Dialogs
Chi-square...
Binomial...
Runs...
1-Sample K-S...
2 Independent Samples...
K Independent Samples...
2 Related Samples...
K Related Samples...

Data View Variable View

Mann-Whitney U test



Ranks

Sex		N	Mean Rank	Sum of Ranks
HeartRate	Male	49	52.76	2585.00
	Female	51	48.33	2465.00
	Total	100		

Test Statistics^a

	HeartRate
Mann-Whitney U	1139.000
Wilcoxon W	2465.000
Z	-.763
Asymp. Sig. (2-tailed)	.445

a. Grouping Variable: Sex

$P > 0.05$

Paired t-test

- ▷ Weight of the mice before treatment
- ▷ 200.1, 190.9, 192.7, 213, 241.4, 196.9, 172.2, 185.5, 205.2, 193.7
- ▷ Weight of the mice after treatment
- ▷ 392.9, 393.2, 345.1, 393, 434, 427.9, 422, 383.9, 392.3, 352.2
- ▷ **Question:** Is there any significant changes in the weights of mice before and after treatment?

Let's Import the data in SPSS

Paired t-test



▷ The null hypothesis (two-sided) is:

$$H_0: d_{\text{difference}} = 0$$

(The population average weight loss is zero)

$$H_1: d_{\text{difference}} \neq 0$$

(The population average weight loss is not zero)

Paired t-test



*Untitled5 [DataSet6] - IBM SPSS Statistics Data Editor

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

10 :

	Before	After
1	200.10	392.90
2	190.90	393.20
3	192.70	345.10
4	213.00	393.00
5	241.40	434.00
6	196.90	427.90
7	172.20	422.00
8	185.50	383.90
9	205.20	393.30
10	193.70	352.20
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

Analyze > **Compare Means** > **Paired-Samples T Test...**

Paired-Samples T Test

Paired Variables:

Pair	Variable1	Variable2
1	[Before]	[After]
2		

OK Paste Reset Cancel Help

Data View Variable View

Paired t-test



Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	199.1600	10	18.47354	5.84185
	After	393.7500	10	29.39460	9.29539

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Before & After	10	.313	.379

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
				Std. Error Mean	95% Confidence Interval of the Difference				
					Mean	Std. Deviation			
Pair 1	Before - After	-194.59000	29.42491	9.30497	-215.63931	-173.54069	-20.912	9	.000

Thank You!