STA 215 --------WINTER 2006

SUMMARY of Confidence Interval & Hypothesis Testing on SPSS

Data from n = 173 college students in two different statistics classes. One class was for students not in the liberal arts (n = 148), while the other class was for students in the liberal arts (n = 25). The data were collected in the Spring quarter of 2000. (*Source:* Utts|Heckard Minds on Statistics, 2nd Edition)

There are twelve columns of data:

Column	*Name*	*Description*
C1	**Sex**	Male or Female
C2	**TV**	Hours spent watching television each week.
C3	**computer**	Hours spent at a computer each week.
C4	**Sleep**	Hours of sleep previous night.
C5	**Seat**	Typical classroom seat location (1=Front 2=Middle 3=Back)
C6	**alcohol**	Number of alcoholic beverages consumed each week
C7	**Height**	Self-reported height, inches
C8	**momheight**	Mother's height, inches
C9	**dadheight**	Father's height, inches
C10	**exercise**	Hours spent exercising each week
C11	**GPA**	Student's GPA
C12	**class**	Liberal Arts or Non Liberal Arts

NOTE: Complete data set is available on BB under SPSS Materials (***UCDavis.sav***).

A portion of the data is given below:

Sex	TV	computer	Sleep	Seat	alcohol	Height	momheight	dadheight	exercise	GPA	class
Female	13	10	3.5	3	12	66	66	71	10	4	NonLib
Female	2	5	4	3	0	64	62	68	5	.	NonLib
Male	20	7	9	3	0	72	64	65	2	2.3	NonLib
Male	15	15	6	3	0	68	62	74	3	2.6	NonLib
Male	8	20	6	2	0	68	59	70	6	2.8	NonLib
Female	2.5	10	5	1	5	64	65	70	6.5	2.62	NonLib
Male	2	14	9	2	0	68.5	60	68	2	2.2	NonLib
Female	4	28	8.5	1	1.5	69	66	76	3	3.78	NonLib
Female	8	10	7	2	4.5	66	63	70	4.5	3.2	NonLib
Male	1	15	8	2	1	70	68	71	3	3.31	NonLib
Male	8	25	4.5	3	0	67	63	66	6	3.39	NonLib
Female	28	30	6.5	1	0	63	61	68	1.5	.	NonLib
Male	3.5	9	8	2	7	68	62	64	8	3	NonLib
Female	11	20	5	2	3	68	64	69	0	2.5	NonLib
Male	10	14	8	3	15	68	61	72	10	2.8	NonLib
Male	1	84	5	1	2.5	61	62	62	3	2.34	NonLib
Female	10	11	9	2	1	65	62	66	5	2	NonLib
Female	10	1	9	3	15	64	70	73	4	2.4	NonLib
Female	1	5	6.5	2	5	65	70	75	3	1.05	NonLib
Female	4	37.5	5.5	2	5	65	.	.	0	2.1	NonLib

CASE #7 [CHAPTER 15: CATEGORICAL VARIABLES]

1. Comparing two categorical variables – Chi-Squared Test

A *categorical variable* represents a set of discrete events, such as groups, decisions, or anything else that can be classified into categories. In contrast to a continuous variable, a value of a categorical variable indicates a discrete category, whereas a value of a continuous variable can fall on any point on a numeric continuum. One example of a categorical variable is a person's sex, which can be represented by two exhaustive and mutually exclusive categories: male and female. A categorical variable may also consist of more than two categories. For example, a person's major in college can be categorized as biology, history, engineering, psychology, etc.

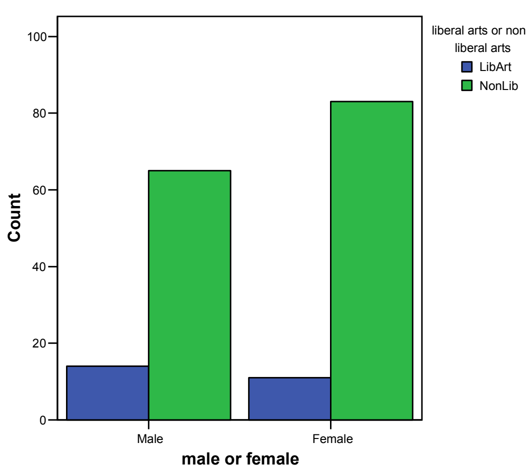
A categorical variable can be *ordered* or *unordered*. For instance, a person's level of schooling is an ordered variable; a person's sex is an unordered variable. Although the levels of a categorical variable are often represented by numerals, these symbols are not interpreted numerically if the variable is unordered. Categorical data are often presented in a *contingency table* which tabulates the number of observations that fall into each cell of the table.

H_0: The two variables are not related.
H_a: The two variables are related.

CLAIM : Gender and Class are not related.

1. *Analyze → Descriptive Statistics → Crosstabs*
2. Click on the desired row *variable name[**sex**]* in the left box.
3. Click on the ▷ next to *Row.*
4. Click on the desired column *variable name* [**class**]in the left box.
5. Click on the ▷ next to *Column.*
6. choose the *clustered* option.
7. Get the row percents by clicking on *Cells*, checking the box for *row,* and then clicking *Continue.*
8. Get the χ^2 test statistic and p-value by clicking on *Statistics*, checking the box for *Chi-Square,* and then clicking *Continue.*
9. Click *OK*.

Bar Chart



male or female * liberal arts or non liberal arts Crosstabulation

			liberal arts or non liberal arts		
			LibArt	NonLib	Total
male or female	Female	Count	11	83	94
		% within male or female	11.7%	88.3%	100.0%
	Male	Count	14	65	79
		% within male or female	17.7%	82.3%	100.0%
Total		Count	25	148	173
		% within male or female	14.5%	85.5%	100.0%

Table above is a simple 2 x 2 contingency table that crosstabulates whether male or female are in liberal arts on non liberal arts college. Each cell represents a *joint event* which is a unique combination of the categorical variables. This crosstabulation results in four possible outcomes, or joint events. For example, the joint event representing LibArt females contains 11 observations. *Marginal events* refer to the total number of observations for a category of a particular variable. Here, the marginal event for the category female is 94.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.258[b]	1	.262		
Continuity Correction[a]	.818	1	.366		
Likelihood Ratio	1.253	1	.263		
Fisher's Exact Test				.285	.183
N of Valid Cases	173				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.42.

Assumptions for Tests of Independence

1. **Observations are probabilistically independent of each other**. Each categorical entry of an observation is independent of other observations in the dataset. This results in a single categorical entry for every unit of observation, whether it be an individual participant, a dyad such as a married couple, or a group such as a student organization.
2. **Each observation must represent one and only one joint event**. An example of such observations is given in the above table in which applicants are categorized on the basis of their sex and whether they were LibArt or NonLibArt. Each applicant must be classified as representing exactly one of the four possible joint events in the above contingency table.
3. **The number of observations is large**. This third condition ensures that you get a good approximation of your test's *p* values. One common rule of thumb is that the expected frequency of each cell in a contingency table should be greater than 5. This rule of thumb is met if the total sample size is large.

CASES 2, 3 & 4 [CHAPTERS 12 & 13: INFERENCES ABOUT POPULATION MEANS]

2. Comparing the mean to a test value – One sample T-test [CASE#2]

Procedure	Variable type and number	C.I. for μ	Ho	Assumptions	Test statistic	SPSS name
t-test	1 quantitative	$\bar{x} \pm t\left(\frac{s}{\sqrt{n}}\right); df = n-1$	$\mu = \mu_0$	1. Individuals are independent 2. $\bar{x} \sim Normal$	$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}; df = n-1$	C.I.: Explore H.T.: One-sample

CONFIDENCE INTERVAL FOR population mean (μ) GPA (without a hypothesis test)

1. Analyze ↦ Compare Means ↦ One-Sample T Test
2. Select variable(s) of interest
3. Move variable(s) of interest to "Test Variable(s):" box
4. Click "Options" button to select Confidence Interval (95% is the default setting)
5. Click "Continue" button
6. Click "OK" button

You should generate output that looks something like this:

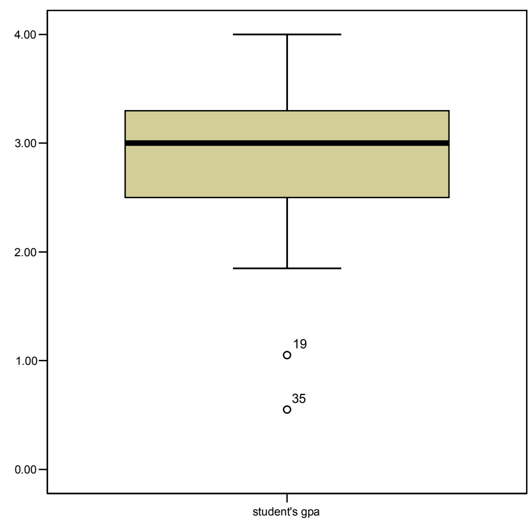
One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
gpa	164	2.91532	.595342	.046488

$$SE = \frac{SD}{\sqrt{N}} = \frac{0.59534}{\sqrt{164}} = .0464$$

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
gpa	62.711	163	.000	2.915323	2.82353	3.00712

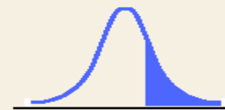


Graphical Display of data

<u>Boxplot</u> All of the data should be entered into one column.

1. *Graphs* → *Boxplot* →Click on *Simple.*
2. Check the circle *Summaries of separate variables* and then click on *Define*.
3. Click on the *variable name* corresponding to the quantitative variable. [***gpa***]
4. Click on the ⊳ next to *Box Represent*.
5. Click on *OK*.

HYPOTHESIS TEST FOR population mean (μ) GPA

Statement of H_a		*p*-Value Area	*t*-Curve Region
$\mu < \mu_0$	(less than)	Area to the left of t (even if $t > 0$)	
$\mu > \mu_0$	(greater than)	Area to the right of t (even if $t < 0$)	
$\mu \neq \mu_0$	(not equal)	$2 \times$ area to the right of $\lvert t \rvert$	

CLAIM: The population mean (μ) GPA is 2.5. That is, H0: $\mu = 2.5$ versus Ha: $\mu \neq 2.5$ (two-sided)

To compare X-bar to μ

1. Analyze ↦ Compare Means ↦ One-Sample T Test
2. Select variable(s) of interest
3. Move variable(s) of interest to "Test Variable(s):" box
4. **<u>Set "Test Value:" to μ (here, 2.5)--DO NOT FORGET THIS! OTHERWISE, SPSS ASSUMES THE HYPOTHESIS TEST IS H0: $\mu = 0$ versus Ha: $\mu \neq 0$ (two-sided)</u>**
5. Click "Options" button to select Confidence Interval (95% is the default setting)
6. Click "Continue" button
7. Click "OK" button

You should generate output that looks something like this:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
student gpa	164	2.9153	.59534	.04649

$$SE = \frac{SD}{\sqrt{N}} = \frac{0.59534}{\sqrt{164}} = .0464$$

One-Sample Test

	Test Value = 2.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
student gpa	8.934	163	.000	.4153	.3235	.5071

CAUTION: Compare the confidence interval obtained when we were not doing a hypothesis test (previous page) vs. the confidence interval when we tested H0: $\mu = 2.5$ versus Ha: $\mu \neq 2.5$. WHY ARE THEY DIFFERENT?

Answer: In our mind H0: $\mu = 2.5$, but in SPSS's mind the null hypothesis is H0: $\mu - 2.5 = 0$. Hence the "95% Confidence Interval of the difference" is the difference between μ & 2.5--in other words, their confidence interval comes out as $0.3235 \le \mu - 2.5 \le 0.5071$. To get the desired confidence interval, add the 2.5 back into the endpoints of the intervals above. This will give us 2.5 + 0.3235 and 2.5 + 0.5071 as endpoints, or 2.8235 and 3.0071, the same as the previous page.

3. Comparing two dependent means (matched-pair) – Paired Sample T-test [CASE#3]

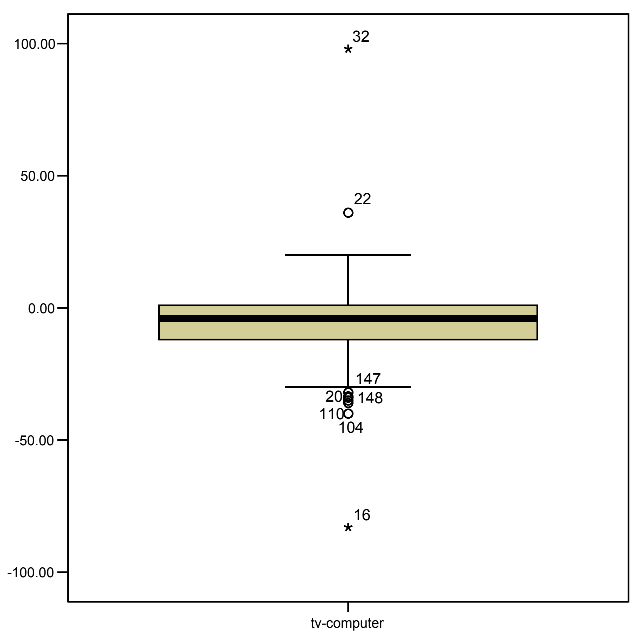
Procedure	Variable type and number	C.I. for μ_d	Ho	Assumptions	Test statistic	SPSS name
Paired t-test	1 quantitative, 1 categorical (2 groups)	$\bar{d} \pm t\left(\frac{s_d}{\sqrt{n_d}}\right); df = n_d - 1$	$\mu_d = 0$	1. paired or matched data 2. pairs are independent 3. $\bar{d} \sim Normal$	$t = \frac{\bar{d} - \mu_0}{s_d / \sqrt{n_d}}; df = n_d - 1$	compare means paired samples t-test

CLAIM: There is no difference between tv hours (variable 1) and computer hours (variable 2)

Step1: Graphical display

To create the new variable (diff):

a. We use the **Transform** menu.
b. Scroll down to the **Compute…** option.
c. A window opens up. Type a variable name to represent the difference in the **Target Variable:** box, e.g. **diff**.
d. Under Numeric Expression, type variable1 (*tv*) – variable2 (*computer*) then Click **OK**.
e. To get boxplot
   - *Graphs* → *Boxplot* →Click on *Simple.*
   - Check the circle *Summaries of separate variables* and then click on *Define*.
   - Click on the *variable name* corresponding to the quantitative variable. [***diff***]
   - Click on the ▷ next to *Box Represent*.
   - Click on *OK*.



Step2: Paired-Samples T Test

Say you wanted to compare how a sample evaluates two different variables. That is, you want to know if X-bar1 is significantly different from X-bar2. For this, you need to conduct a "Paired-Sample T Test." In the following example, *tv hours* are compared to *computer hours* for the whole sample.

1. Analyze ↦ Compare Means ↦ Paired-Samples T Test
2. Select variables of interest. They will appear in "Current Selections" box.
3. Move paired variables of interest to "Paired Variables:" box
4. Click "Options" button to select Confidence Interval (95% is the default setting)
5. Click "Continue" button
6. Click "OK" button

You should generate output that looks something like this:

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	hours spent watching television each week	8.8815	173	10.40204	.79085
	hours spent at a computer each week	14.2659	173	11.48768	.87339

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	hours spent watching television each week - hours spent at a computer each week	-5.38439	15.27256	1.16115	-7.67633	-3.09245	-4.637	172	.000

Notes:

(1). Confidence intervals and t-ratio are for the differences. You may ignore the "Paired Samples Correlations" output for now.

(2). Note that the reported *p*-value is 2-sided, so for a 1-sided *p*-value, the reported value needs to be divided in half. If the alternative hypothesis was 1-sided, the correct *p*-value would be 0.000/2 = 0.000.

4. Comparing two means – Independent Samples T-test [CASE#4]

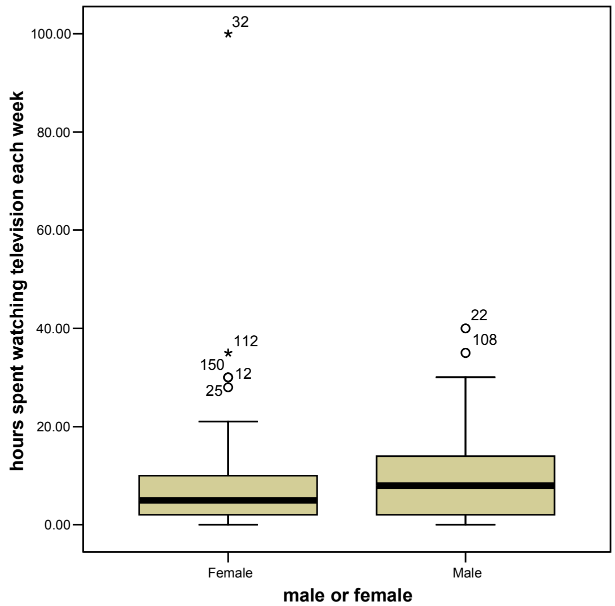
Procedure	Variable type and number	C.I. for $\mu_1 - \mu_2$	Ho	Assumptions	Test statistic	SPSS name
Two sample t-test	1 quantitative, 1 categorical (2 groups)	$(\bar{x}_1 - \bar{x}_2) \pm t^* \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$ **df from technology**	$\mu_1 - \mu_2 = 0$	1. two independent samples 2. data in each sample are independent 3. $\bar{x}_1 \sim Normal$; $\bar{x}_2 \sim Normal$	$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$	compare means independent samples t-test

CLAIM: The mean TV hours of males is equivalent to the mean TV hours of females

Step1: Graphical display

Boxplot – Side by Side – All of the data should be entered into one column. A second column should have a grouping variable to identify group membership.

- *Graphs* → *Boxplot* →Click on *Simple.*
- Check the circle *Summaries for groups of cases* and then click on *Define*.
- Click on the *variable name* corresponding to the quantitative variable. [***tv***]
- Click on the ⊳ next to *Variable*.
- Click on the *variable name* corresponding to the categorical variable. [***sex***]
- Click on the ⊳ next to *Category Axis* →Click on *OK*.



Step2: Independent-Samples T Test

1. Analyze ↦ Compare Means ↦ Independent-Samples T Test 2. Select variable(s) of interest
3. Move variable(s) of interest to "Test Variable(s):" box, [TV hours]
4. Select "Grouping Variable" [gender], NOTE: **Define the groups the same as you entered the data.**
5. Click "Define Groups" button
6. Tell SPSS the values for the groups in your grouping variable you wish to compare. (HINT:Often you will use a dichotomous variable like gender. The values are often coded "1" if a person has the characteristic of the variable [in gender this usually entails being female], and "0" if they do not have that characteristic. **Check the coding of your grouping variable before specifying these values!**)
7. Click "Options" button to select Confidence Interval (95% is the default setting)
8. Click "Continue" button9. Click "OK" button

You should generate output that looks like this:

Group Statistics

	male or female	N	Mean	Std. Deviation	Std. Error Mean
hours spent watching television each week	Female	94	8.3723	11.83305	1.22049
	Male	79	9.4873	8.42424	.94780

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
hours spent watchi television each we	Equal variance assumed	.010	.920	-.701	171	.484	-1.1150	1.59004	-4.25363	2.02362
	Equal variance not assumed			-.722	166.705	.472	-1.1150	1.54529	-4.16586	1.93585

NOTES:

(1). Ignore the "Equal variances assumed" output and "Levene's Test for Equality of Variances."

(2). Look at the row "Equal variances not assumed" output

(3). Everything is the same as it was in the one-sample case except that we are dealing with the difference of group 1's sample mean less group 2's sample mean as opposed to X-bar - μ.

(4). Note that the reported *p*-value is 2-sided, so for a 1-sided *p*-value, the reported value needs to be divided in half. If the alternative hypothesis was 1-sided, the correct *p*-value would be 0.472/2 = 0.236.

CASE #5 [CHAPTER 14: REGRESSION]

5. Comparing two quantitative variables - Regression and line of best fit

Procedure	Variable type and number	C.I. for β_1 (popn slope)	Ho	Assumptions	Test statistic	SPSS name
Simple Linear Regression	2 quantitative: one is explanatory, one is response	$b_1 \pm t\left(s_{b_1}\right)$	See below	1. (x,y) pairs independent. 2. form of relationship between x and y is linear 3. errors are independent 4. std dev. same for all x, i.e variability of errors is constant 5. errors are normally distributed	$t = \frac{b_1}{s_{b_1}}; df = n-2$	regression linear y = dependent x = independent

QUESTION: Does the observed relationship also occur in the population?

H0: $\beta_1 = 0$ (the population slope is 0, so *y* and *x* are *not linearly related.*)

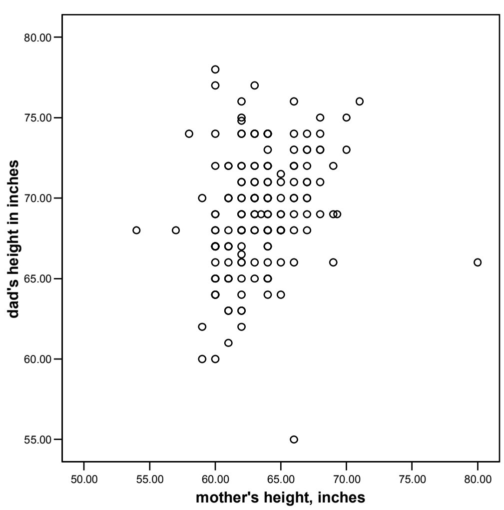
Ha: $\beta_1 \neq 0$ (the population slope is not 0, so *y* and *x are linearly related.*)

NOTE: When you fit a linear regression, about the only hypothesis of interest is if the true slope is zero. This would correspond to no linear relationship between the response and predictor variable.

<u>CLAIM:</u> momheight and dadheight are NOT linearly related

Step1: **Scatter Diagram**

- *Graphs* → *Scatter* → Click on *Simple*
- Click on *Define*.
- Click on the *variable name* corresponding to the response (dependent) variable [**dadheight**]
- Click on the ▷ next to *Y-Axis*.
- Click on the *variable name* corresponding to the explanatory (independent) variable[**momheight**]. Click on the ▷ next to *X- Axis*. Click on *OK*.



<u>**Step2:**</u> **Analyze/Regression/Linear**

Put in the independent variable (momheight) and the dependent variable (dadheight) (note: dependent = y) . Click the statistics button and choose Confidence Intervals. Click Continue. Click OK.

Regression

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.257[a]	.066	.060	3.62178

a. Predictors: (Constant), mother's height, inches

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	153.101	1	153.101	11.672	.001[a]
	Residual	2164.356	165	13.117		
	Total	2317.457	166			

a. Predictors: (Constant), mother's height, inches

b. Dependent Variable: dad's height in inches

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	49.257	5.829		8.450	.000	37.748	60.766
	mother's height, inches	.314	.092	.257	3.416	.001	.132	.495

a. Dependent Variable: dad's height in inches

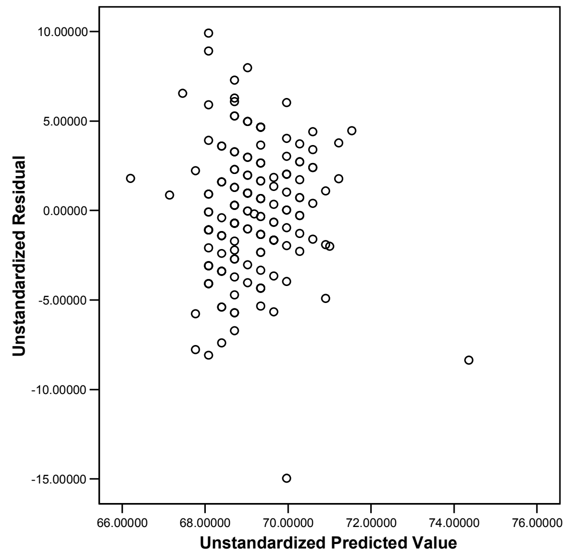
<u>Residual plot (scatter diagram)</u>:

1. Click on **Analyze** then **Regression** then **Linear**.
   Put in the independent variable (momheight) and the dependent variable (dadheight)
2. In the "Linear Regression" dialog box, click on **Save** to get the "Linear Regression: Save New Variable" dialog box.
3. In the "Predicted Values" box click on **Unstandardized**.
4. In the "Residuals" box click on **Unstandardized** then click **Continue** then click **OK**.

<u>Note: For each option you selected, one or more variables will be added to the working data file.</u>

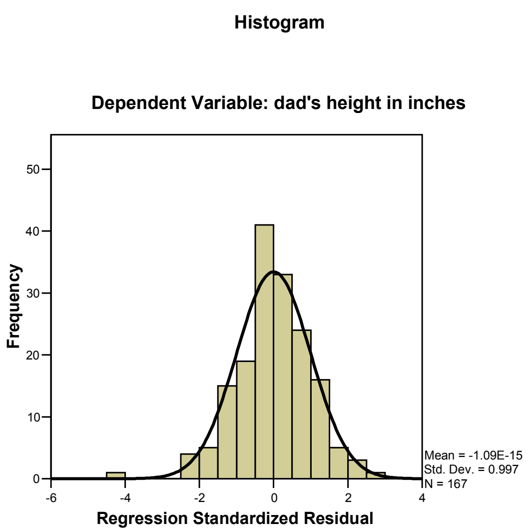
5. **<u>Scatterplot</u>**

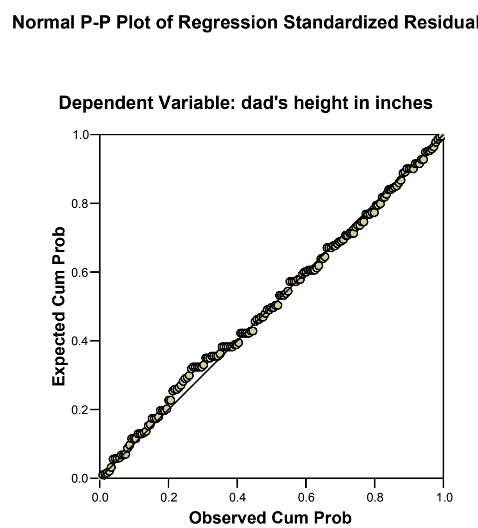
- *Graphs* → *Scatter* → Click on *Simple* → Click on *Define*.
- Click on the *variable name* corresponding to the response (dependent) variable [**Unstandardized** Residuals]
- Click on the ▹ next to *Y-Axis*.
- Click on the *variable name* corresponding to the explanatory (independent) variable[**Unstandardized Predicted values]**. Click on the ▹ next to *X- Axis*. Click on *OK*.



<u>Normality check on Residuals</u>:

1. Click on **Analyze** then **Regression** then **Linear**.
   Put in the independent variable (momheight) and the dependent variable (dadheight)
2. In the "Linear Regression" dialog box, click on **Plots** to get the "Linear Regression: Plots" dialog box.
   In the **"Standardized Residual Plots"** choose Histogram and Normal Probability Plot.
   Click Continue. Click OK.





CASE #6 [CHAPTER 16: ANOVA]

6. Comparing more than 2 means – Analysis of Variance (ANOVA)

Procedure	Variable type and number	C.I. for $\mu_1 - \mu_2$	Ho	Assumptions	Test statistic	SPSS name
One-Way Anova	1 quantitative, 1 categorical (more than 2 groups)	Tukey HSD on $\mu_1 - \mu_2$: $\bar{x}_1 - \bar{x}_2 \pm q\left(\sqrt{\frac{MSE}{n}}\right)$ assumes equal n	See below	1. data are independent random samples 2. the populations are normally distributed 3. popln std dev are equal across groups (treatment levels). Rule of Thumb, largest sample sd is not more than twice smallest sample sd.	$F = \frac{Mean\ Square\ Between}{Mean\ Square\ Within}$ $dfnum = \#\,groups - 1;$ $dfdenom = n - \#\,groups$	compare means one-way anova y = dependent x = factor

H_0: $\mu_1 = \mu_2 = \ldots = \mu_k$
H_a: The means are not all equal.

- Extension of ***independent-t*** test to two or more groups.
- Used to test for *any* difference among the set of groups; used to evaluate experiments where there are more than two treatment groups; note examples.
- Logic involves computing two measures of variability, one based on within-group variability, the other based on between-group variability. See ANOVA Table below:

ANOVA TABLE

Source	Sums of Squares	df	MS	F	Sig.
Between Groups (Treatment)	SSG	k-1	MSG	MSG/MSE	p-value
Within Groups (Error)	SSE	n-k	MSE		
Total	SST	n-1			

$$F = \frac{\text{Variation among sample means}}{\text{Natural variation within groups}}$$

CLAIM: The mean **GPA** for the three Typical classroom seat location are the same

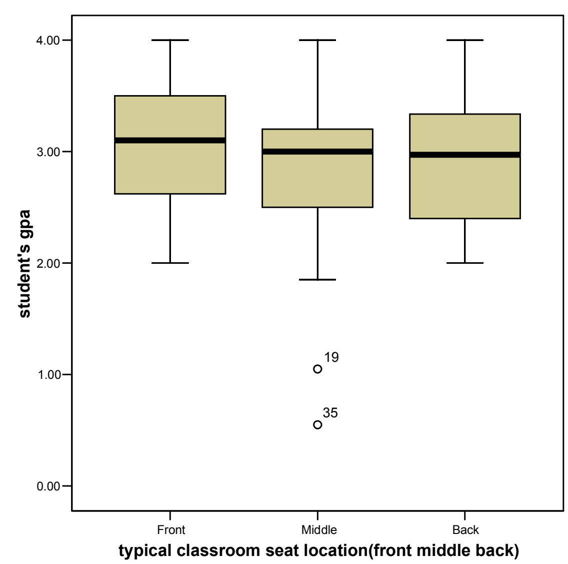
Analysis of Variance (ANOVA)

So far we have compared two groups. Many times, however, we are interested in the differences of means between more than two groups. For this, we turn to analysis of variance, or "ANOVA" for short. The example that follows looks, we wish to test if the mean **GPA** for the three Typical classroom seat locations are the same

Step#1: Obtain boxplots

<u>Boxplot – Side by Side</u> – All of the data should be entered into one column. A second column should have a grouping variable to identify group membership.

- *Graphs* → *Boxplot* →Click on *Simple.*
- Check the circle *Summaries for groups of cases* and then click on *Define*.
- Click on the *variable name* corresponding to the quantitative variable. [***gpa***]
- Click on the ▷ next to *Variable*.
- Click on the *variable name* corresponding to the categorical variable. [***typical classroom seat location***]
- Click on the ▷ next to *Category Axis* →Click on *OK*.



Step#2: Obtain Descriptive Statistics, ANOVA table & Post HOC analysis [Important! The factor variable must be defined as a numeric variable (numerically coded).]

1. Analyze ↦ Compare Means ↦ One-Way ANOVA
2. Select variable(s) of interest
3. Move variable(s) of interest to "Dependent Variable(s):" box
4. Select grouping variable of interest. Move grouping variable to "Factor:" box
5. Click "Post Hoc" button. Click "**Tukey**". Please ignore all other options. Click "Continue.
6. Click "Options" button. To see the raw differences between groups, check "Descriptive" in the "Statistics" box and/or "Means Plot." Please ignore all other options. Click "Continue.")

You should generate output that looks like this:

Descriptives

student's gpa

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Front	38	3.1171	.56362	.09143	2.9318	3.3024	2.00	4.00
Middle	91	2.8398	.60858	.06380	2.7130	2.9665	.55	4.00
Back	35	2.8929	.55842	.09439	2.7010	3.0847	2.00	4.00
Total	164	2.9154	.59535	.04649	2.8236	3.0072	.55	4.00

ANOVA

student's gpa

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.084	2	1.042	3.013	.052
Within Groups	55.689	161	.346		
Total	57.774	163			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: student's gpa
Tukey HSD

(I) typical classroom seat location(front middle back)	(J) typical classroom seat location(front middle back)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Front	Middle	.27733*	.11359	.041	.0086	.5460
	Back	.22425	.13779	.237	-.1017	.5502
Middle	Front	-.27733*	.11359	.041	-.5460	-.0086
	Back	-.05308	.11698	.893	-.3298	.2236
Back	Front	-.22425	.13779	.237	-.5502	.1017
	Middle	.05308	.11698	.893	-.2236	.3298

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

Mean Plots