

## More About Bivariate Regression LAB

A school psychologist wanted to predict reading T-scores using the number of hours the parents worked per week. The psychologist also wanted to know whether the relationship was similar for students attending private (school=1) and public schools (school=2). The data are given below.

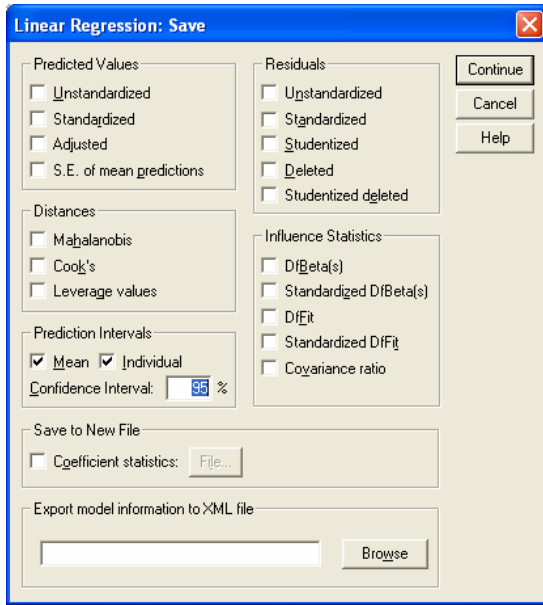
School	Reading	ParentHours	School	Reading	ParentHours
Private	67	41	Public	56	39
Public	58	44	Private	71	46
Private	35	51	Private	54	46
Private	73	48	Private	40	53
Private	52	43	Public	42	45
Private	61	39	Private	64	49
Private	55	49	Private	51	48
Public	34	52	Private	41	44
Private	65	37	Public	43	49
Private	51	49	Private	58	49
Private	47	46	Public	35	46
Public	28	46	Public	43	46
Public	56	46	Public	52	43
Public	44	53	Public	46	52
Private	48	39	Public	51	43
Private	47	53	Public	53	47
Private	36	53	Private	30	46
Private	51	56	Public	44	44
Private	36	50	Public	50	51
Private	39	45	Private	57	43
Public	52	49	Private	65	52
Private	63	56	Private	40	47
Private	50	36	Private	54	42
Private	60	48	Private	59	44
Public	65	37	Public	52	55
Public	49	41	Public	62	46
Public	55	44	Public	36	51
Public	35	47	Private	62	50
Private	46	45	Private	58	49
Private	46	40	Public	48	47
Private	54	42	Private	71	44
Public	51	51	Public	47	51
Public	35	47	Private	51	43
Private	73	54	Public	33	48
Private	49	44	Public	51	48
Public	35	41	Private	25	58
Public	52	41	Private	60	50
Private	58	50	Public	53	46
Private	46	54	Public	54	40
Private	67	44	Private	48	50
Public	46	42	Public	46	41
Private	50	49	Private	44	48
Private	71	41	Private	43	46
Public	55	38	Private	38	48
Public	48	47	Private	48	43

### Obtaining Confidence Intervals when Estimating a Linear Regression Model

The screenshot shows the SPSS Data Editor window titled 'Untitled - SPSS Data Editor'. The menu bar includes File, Edit, View, Data, Transform, Analyze, Graphs, Utilities, Add-ons, Window, and Help. The 'Analyze' menu is open, showing options like Reports, Descriptive Statistics, Compare Means, General Linear Model, Mixed Models, Correlate, Regression, Loglinear, Classify, Data Reduction, Scale, Nonparametric Tests, Survival, and Multiple Response. The 'Regression' submenu is also open, with 'Linear...' selected. The data grid shows 12 rows with columns for 'school' (Private/Public) and 'reading' (67.0, 58.0, 35.0, 73.0, 52.0, 61.0, 55.0, 34.0, 65.0, 51.00, 47.00, 28.00).

The 'Linear Regression' dialog box is shown. On the left, a list of variables includes 'school' and 'parentwork'. The 'Dependent:' field contains 'reading'. The 'Independent(s):' field contains 'parentwork'. The 'Method:' dropdown is set to 'Enter'. There are buttons for 'OK', 'Paste', 'Reset', 'Cancel', and 'Help' on the right side.

The 'Linear Regression: Statistics' dialog box is shown. Under 'Regression Coefficients', the following options are checked: 'Estimates', 'Confidence intervals', and 'Model fit'. Other options include 'Covariance matrix', 'R squared change', 'Descriptives', 'Part and partial correlations', and 'Collinearity diagnostics'. Under 'Residuals', 'Durbin-Watson' and 'Casewise diagnostics' are unchecked. The 'Outliers outside:' field is set to 3 standard deviations. There are 'Continue', 'Cancel', and 'Help' buttons.



## Regression

### Descriptive Statistics

	Mean	Std. Deviation	N
reading	50.2556	10.61117	90
parentwork	46.4889	4.71489	90

### Correlations

		reading	parentwork
Pearson Correlation	reading	1.000	-.211
	parentwork	-.211	1.000
Sig. (1-tailed)	reading	.	.023
	parentwork	.023	.
N	reading	90	90
	parentwork	90	90

### Variables Entered/Removed<sup>a</sup>

Model	Variables Entered	Variables Removed	Method
1	parentwork <sup>a</sup>	.	Enter

a. All requested variables entered.

b. Dependent Variable: reading

### Model Summary<sup>b</sup>

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.211 <sup>a</sup>	.044	.034	10.43170

a. Predictors: (Constant), parentwork

b. Dependent Variable: reading

### ANOVA<sup>b</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	444.937	1	444.937	4.089	.046 <sup>a</sup>
	Residual	9576.185	88	108.820		
	Total	10021.122	89			

a. Predictors: (Constant), parentwork

b. Dependent Variable: reading

Coefficients<sup>a</sup>

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	72.302	10.958		6.598	.000	50.525	94.079
	parentwork	-.474	.235	-.211	-2.022	.046	-.940	-.008

a. Dependent Variable: reading

Residuals Statistics<sup>a</sup>

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	44.7967	55.2296	50.2556	2.23591	90
Std. Predicted Value	-2.441	2.225	.000	1.000	90
Standard Error of Predicted Value	1.106	2.915	1.495	.429	90
Adjusted Predicted Value	44.7054	55.6035	50.2448	2.23810	90
Residual	-22.48740	26.30639	.00000	10.37293	90
Std. Residual	-2.156	2.522	.000	.994	90
Stud. Residual	-2.168	2.573	.001	1.006	90
Deleted Residual	-22.74284	27.39182	.01079	10.62465	90
Stud. Deleted Residual	-2.216	2.661	.002	1.017	90
Mahal. Distance	.011	5.961	.989	1.258	90
Cook's Distance	.000	.165	.012	.025	90
Centered Leverage Value	.000	.067	.011	.014	90

a. Dependent Variable: reading

	school	reading	parentwork	LMCI_1	UMCI_1	LICI_1	UICI_1
1	Private	67.00	41.00	49.49406	56.22296	31.85647	73.86055
2	Public	58.00	44.00	48.96183	53.90986	30.55794	72.31375
3	Private	35.00	51.00	45.08386	51.14871	27.16487	69.06770
4	Private	73.00	48.00	47.24304	51.83486	28.68140	70.39650
5	Private	52.00	43.00	49.18624	54.63390	31.00108	72.81905
6	Private	61.00	39.00	49.68900	57.92492	32.67111	74.94280
7	Private	55.00	49.00	46.58584	51.54362	28.18624	69.94321
8	Public	34.00	52.00	44.26973	51.01440	26.63875	68.64537
9	Private	65.00	37.00	49.82251	59.68829	33.44579	76.06502
10	Private	51.00	49.00	46.58584	51.54362	28.18624	69.94321
11	Private	47.00	46.00	48.29033	52.68446	29.64050	71.33430
12	Public	28.00	46.00	48.29033	52.68446	29.64050	71.33430
13	Public	56.00	46.00	48.29033	52.68446	29.64050	71.33430
14	Public	44.00	53.00	43.42831	50.90737	26.10246	68.23322
15	Private	48.00	39.00	49.68900	57.92492	32.67111	74.94280
16	Private	47.00	53.00	43.42831	50.90737	26.10246	68.23322
17	Private	36.00	53.00	43.42831	50.90737	26.10246	68.23322

LMCI\_1 represents the lower limit of the confidence interval for a mean.

UMCI\_1 represents the upper limit of the confidence interval for a mean.

For example, we are 95% confident that the interval (49.49, 56.22) covers the *mean* predicted reading score *of children* whose parents work 41 hours per week.

LICI\_1 represents the lower limit of the confidence interval for an individual.

UICI\_1 represents the upper limit of the confidence interval for an individual.

For example, we are 95% confident that the interval (31.86, 73.86) covers the predicted reading score *for a child* whose parents work 41 hours per week.

***How would the LMCI\_1, UMCI\_1, LICI\_1, and UICI\_1 be interpreted for observations 11, 12, and 13?***

A graph of the prediction intervals also can be obtained.

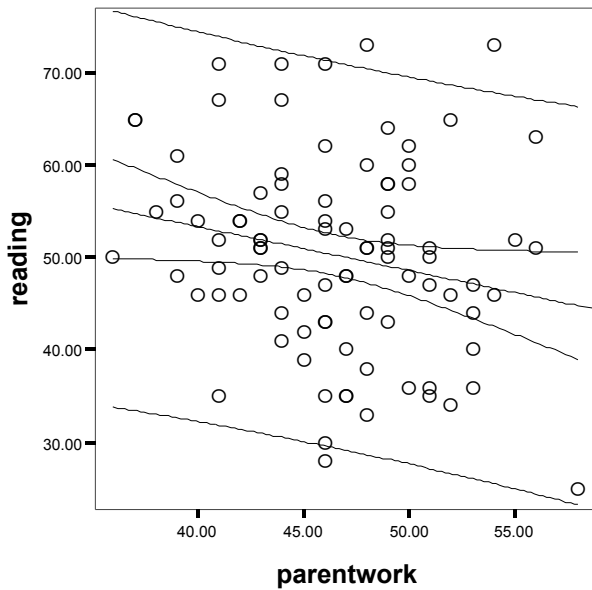
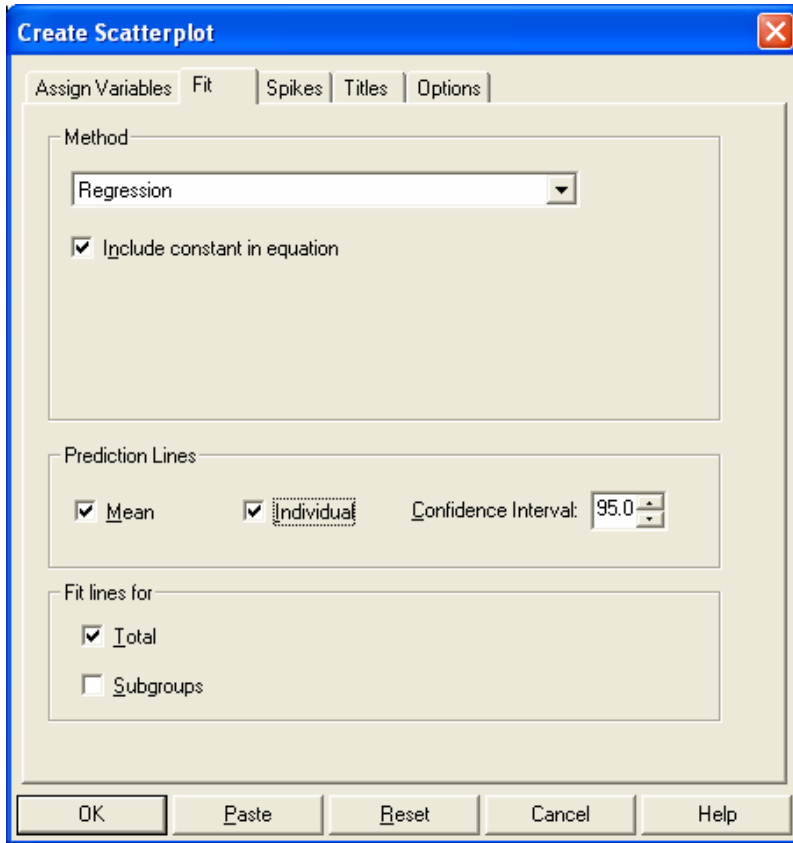
The screenshot shows the SPSS Data Editor window with a data table and the 'Create Scatterplot' dialog box open. The data table contains the following information:

	school	reading	parentwork
1	Private	67.00	
2	Public	58.00	
3	Private	35.00	
4	Private	73.00	
5	Private	52.00	
6	Private	61.00	
7	Private	55.00	
8	Public	34.00	
9	Private	65.00	
10	Private	51.00	
11	Private	47.00	
12	Public	28.00	
13	Public	56.00	
14	Public	44.00	
15	Private	48.00	

The 'Create Scatterplot' dialog box is configured as follows:

- Assign Variables:** [reading] is assigned to the vertical axis and [parentwork] is assigned to the horizontal axis.
- Coordinate System:** 2-D Coordinate.
- Legend Variables:** Color, Style, and Size fields are empty.
- Panel Variables:** The panel variable list is empty.
- Label Cases By:** The label cases by field is empty.

Buttons at the bottom of the dialog include OK, Paste, Reset, Cancel, and Help.



Linear Regression with  
95.00% Mean Prediction Interval and  
95.00% Individual Prediction Interval

reading = 72.30 + -0.47 \* parentwork  
R-Square = 0.04

**Checking for Independence among the Residuals**

The screenshot shows the SPSS Data Editor interface. The data table contains the following information:

	school	reading	var	var
1	Private	67.0		
2	Public	58.0		
3	Private	35.0		
4	Private	73.0		
5	Private	52.0		
6	Private	61.0		
7	Private	55.0		
8	Public	34.0		
9	Private	65.0		
10	Private	51.00	49.00	
11	Private	47.00	46.00	
12	Public	28.00	46.00	

The 'Analyze' menu is open, showing the 'Regression' option selected, with a sub-menu containing 'Linear...', 'Curve Estimation...', 'Binary Logistic...', 'Multinomial Logistic...', 'Ordinal...', 'Probit...', 'Nonlinear...', 'Weight Estimation...', and '2-Stage Least Squares...'.

The 'Linear Regression' dialog box is shown. The 'Dependent' variable is 'reading' and the 'Independent(s)' variable is 'parentwork'. The 'Method' is set to 'Enter'. There are buttons for 'OK', 'Paste', 'Reset', 'Cancel', and 'Help'.

The 'Linear Regression: Statistics' dialog box is shown. Under 'Regression Coefficients', 'Estimates', 'Confidence intervals', and 'Model fit' are checked. Under 'Residuals', 'Durbin-Watson' is checked. The 'Outliers outside' option is selected with a value of 3 standard deviations.

## Regression

**Variables Entered/Removed<sup>a</sup>**

Model	Variables Entered	Variables Removed	Method
1	parentwork <sup>a</sup>	.	Enter

a. All requested variables entered.

b. Dependent Variable: reading

**Model Summary<sup>b</sup>**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.211 <sup>a</sup>	.044	.034	10.43170	2.231

a. Predictors: (Constant), parentwork

b. Dependent Variable: reading

**ANOVA<sup>b</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	444.937	1	444.937	4.089	.046 <sup>a</sup>
	Residual	9576.185	88	108.820		
	Total	10021.122	89			

a. Predictors: (Constant), parentwork

b. Dependent Variable: reading

**Coefficients<sup>a</sup>**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	72.302	10.958		6.598	.000	50.525	94.079
	parentwork	-.474	.235	-.211	-2.022	.046	-.940	-.008

a. Dependent Variable: reading

**Residuals Statistics<sup>a</sup>**

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	44.7967	55.2296	50.2556	2.23591	90
Residual	-22.48740	26.30639	.00000	10.37293	90
Std. Predicted Value	-2.441	2.225	.000	1.000	90
Std. Residual	-2.156	2.522	.000	.994	90

a. Dependent Variable: reading

## Are the residuals independent?

## Checking for Violations of Assumptions and Identifying Outliers

Untitled - SPSS Data Editor

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

14:

	school	reading		
1	Private	67.0		
2	Public	58.0		
3	Private	35.0		
4	Private	73.0		
5	Private	52.0		
6	Private	61.0		
7	Private	55.0		
8	Public	34.0		
9	Private	65.0		
10	Private	51.00	49.00	
11	Private	47.00	46.00	
12	Public	28.00	46.00	

Analyze > Regression > Linear...

Linear Regression

Dependent: reading

Block 1 of 1

Independent(s): parentwork

Method: Enter

Selection Variable:

Case Labels:

WLS Weight:

Statistics... Plots... Save... Options...

Linear Regression: Statistics

Regression Coefficients

- Estimates
- Confidence intervals
- Covariance matrix

Model fit

- R squared change
- Descriptives
- Part and partial correlations
- Collinearity diagnostics

Residuals

- Durbin-Watson
- Casewise diagnostics
  - Outliers outside: 3 standard deviations
  - All cases

Continue Cancel Help

**Linear Regression: Save**

**Predicted Values**

- Unstandardized
- Standardized
- Adjusted
- S.E. of mean predictions

**Distances**

- Mahalanobis
- Cook's
- Leverage values

**Prediction Intervals**

Mean  Individual

Confidence Interval: 95 %

**Residuals**

- Unstandardized
- Standardized
- Studentized
- Deleted
- Studentized deleted

**Influence Statistics**

- DfBeta(s)
- Standardized DfBeta(s)
- DfFit
- Standardized DfFit
- Covariance ratio

**Save to New File**

Coefficient statistics: File...

**Export model information to XML file**

\_\_\_\_\_ Browse

Continue  
Cancel  
Help

**Linear Regression: Plots**

Scatter 1 of 1

DEPENDNT  
\*ZPRED  
\*ZRESID  
\*DRESID  
\*ADJPRED  
\*SRESID  
\*SDRESID

Previous Next

Y: \*SDRESID

X: \*ZPRED

Standardized Residual Plots

- Histogram
- Normal probability plot

Produce all partial plots

Continue  
Cancel  
Help

## Regression

### Descriptive Statistics

	Mean	Std. Deviation	N
reading	50.2556	10.61117	90
parentwork	46.4889	4.71489	90

### Correlations

		reading	parentwork
Pearson Correlation	reading	1.000	-.211
	parentwork	-.211	1.000
Sig. (1-tailed)	reading	.	.023
	parentwork	.023	.
N	reading	90	90
	parentwork	90	90

### Variables Entered/Removed<sup>b</sup>

Model	Variables Entered	Variables Removed	Method
1	parentwork <sup>a</sup>	.	Enter

a. All requested variables entered.

b. Dependent Variable: reading

### Model Summary<sup>b</sup>

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### ANOVA<sup>b</sup>

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		B	Std. Error	Beta			Lower Bound	Upper Bound
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a. Dependent Variable: reading

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	Minimum	Maximum	Mean	Std. Deviation	N
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Adjusted Predicted Value	44.7054	55.6035	50.2448	2.23810	90
Residual	-22.48740	26.30639	.00000	10.37293	90
Std. Residual	-2.156	2.522	.000	.994	90
Stud. Residual	-2.168	2.573	.001	1.006	90
Deleted Residual	-22.74284	27.39182	.01079	10.62465	90
Stud. Deleted Residual	-2.216	2.661	.002	1.017	90
Mahal. Distance	.011	5.961	.989	1.258	90
Cook's Distance	.000	.165	.012	.025	90
Centered Leverage Value	.000	.067	.011	.014	90

a. Dependent Variable: reading

**Determine whether there are outliers in the data set.**

**Identify the outlier(s) in the data set.**

	school	reading	parentwork	SDR_1	COO_1	LEV_1	SDB0_1	SDB1_1
1	Private	67.00	41.00	1.38090	.02553	.01523	.18662	-.17269
2	Public	58.00	44.00	.63161	.00290	.00313	.04215	-.03560
3	Private	35.00	51.00	-1.27554	.01766	.01029	.11647	-.13077
4	Private	73.00	48.00	2.31851	.03179	.00115	-.05418	.07925
5	Private	52.00	43.00	.00865	.00000	.00615	.00077	-.00068
6	Private	61.00	39.00	.70152	.01017	.02835	.12748	-.12051
7	Private	55.00	49.00	.57088	.00238	.00319	-.02622	.03246
8	Public	34.00	52.00	-1.33121	.02388	.01535	.15205	-.16716
9	Private	65.00	37.00	1.01124	.03068	.04551	.23200	-.22210
10	Private	51.00	49.00	.18583	.00025	.00319	-.00853	.01057
11	Private	47.00	46.00	-.33450	.00064	.00012	-.00724	.00370
12	Public	28.00	46.00	-2.21551	.02669	.00012	-.04793	.02449
13	Public	56.00	46.00	.52926	.00160	.00012	.01145	-.00585
14	Public	44.00	53.00	-.30715	.00160	.02143	.04218	-.04571
15	Private	48.00	39.00	-.56578	.00663	.02835	-.10281	.09719
16	Private	47.00	53.00	-.01626	.00000	.02143	.00223	-.00242
17	Private	36.00	53.00	-1.08958	.01992	.02143	.14962	-.16216
18	Private	51.00	56.00	.51653	.00811	.04572	-.10753	.11373
19	Private	36.00	50.00	-1.22094	.01308	.00623	.08370	-.09722
20	Private	39.00	45.00	-1.15594	.00824	.00112	-.05104	.03893

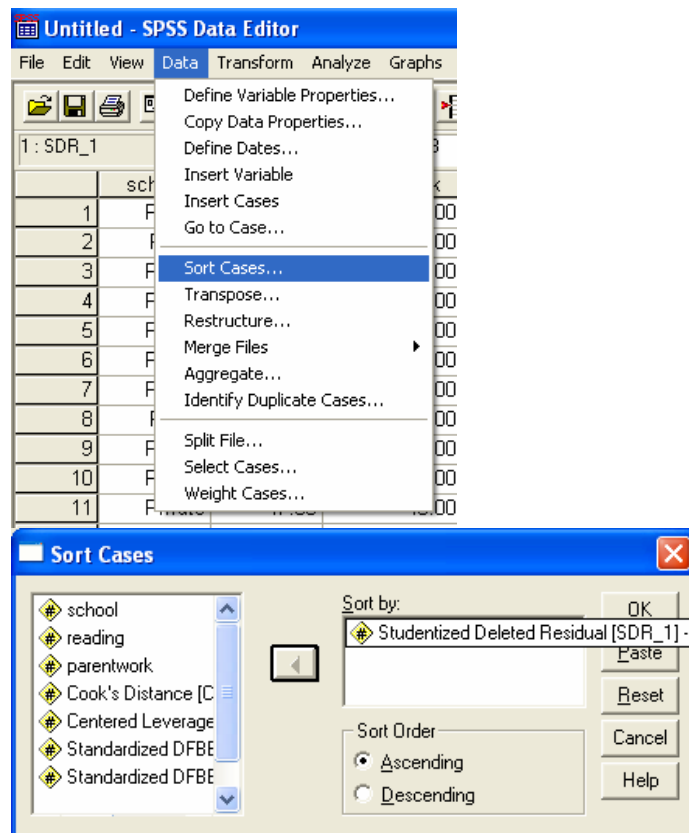
SDR\_1 represents the studentized deleted residuals.

COO\_1 represents Cooks' D.

LEV\_1 represents the leverage values.

SDB0\_1 represents the standardized dfbetas for the intercept (i.e., constant).

SDB1\_1 represents the standardized dfbetas for the first predictor (i.e., parentwork).



**Lowest studentized deleted residuals...**

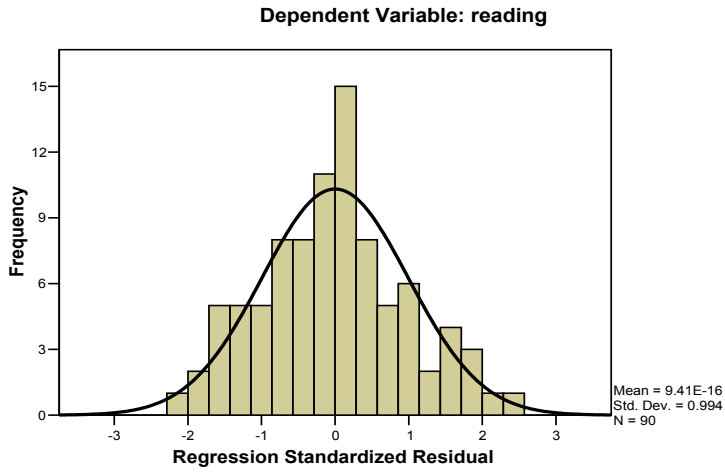
	school	reading	parentwork	SDR_1	COO_1	LEV_1	SDB0_1	SDB1_1
1	Public	28.00	46.00	-2.21551	.02669	.00012	-.04793	.02449
2	Private	25.00	58.00	-2.01035	.16544	.06697	.51696	-.54185
3	Private	30.00	46.00	-2.00886	.02216	.00012	-.04346	.02220
4	Public	35.00	41.00	-1.75534	.04071	.01523	-.23723	.21952
5	Public	33.00	48.00	-1.60962	.01580	.00115	.03761	-.05502
6	Public	35.00	46.00	-1.50372	.01266	.00012	-.03253	.01662
7	Public	35.00	47.00	-1.45654	.01191	.00013	.00125	-.01683
8	Public	35.00	47.00	-1.45654	.01191	.00013	.00125	-.01683
9	Public	34.00	52.00	-1.33121	.02388	.01535	.15205	-.16716
10	Private	35.00	51.00	-1.27554	.01766	.01029	.11647	-.13077
11	Private	36.00	50.00	-1.22094	.01308	.00623	.08370	-.09722
12	Public	36.00	51.00	-1.17668	.01507	.01029	.10744	-.12063
13	Private	39.00	45.00	-1.15594	.00824	.00112	-.05104	.03893
14	Private	38.00	48.00	-1.11452	.00769	.00115	.02604	-.03810
15	Private	36.00	53.00	-1.08958	.01992	.02143	.14962	-.16216
16	Private	41.00	44.00	-1.00769	.00733	.00313	-.06724	.05679
17	Private	40.00	47.00	-.96494	.00530	.00013	.00083	-.01115

**Highest studentized deleted residuals.**

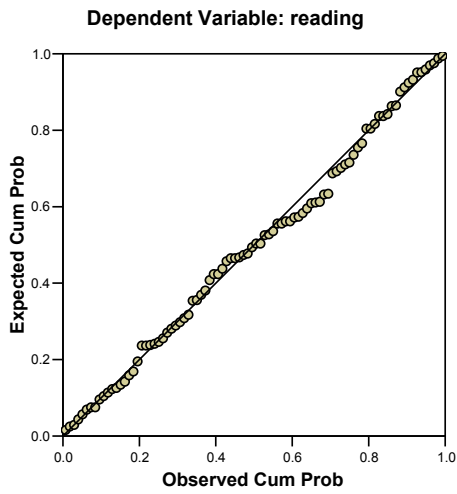
	school	reading	parentwork	SDR_1	COO_1	LEV_1	SDB0_1	SDB1_1
72	Private	58.00	49.00	.86148	.00540	.00319	-.03956	.04899
73	Private	58.00	49.00	.86148	.00540	.00319	-.03956	.04899
74	Private	58.00	50.00	.90904	.00731	.00623	-.06232	.07239
75	Private	60.00	48.00	1.00913	.00632	.00115	-.02358	.03449
76	Private	65.00	37.00	1.01124	.03068	.04551	.23200	-.22210
77	Public	65.00	37.00	1.01124	.03068	.04551	.23200	-.22210
78	Private	60.00	50.00	1.10472	.01074	.00623	-.07574	.08797
79	Public	62.00	46.00	1.11135	.00700	.00012	.02404	-.01228
80	Private	62.00	50.00	1.30186	.01484	.00623	-.08925	.10367
81	Private	67.00	41.00	1.38090	.02553	.01523	.18662	-.17269
82	Private	64.00	49.00	1.45110	.01508	.00319	-.06664	.08251
83	Private	67.00	44.00	1.51373	.01631	.00313	.10101	-.08531
84	Private	65.00	52.00	1.70459	.03865	.01535	-.19470	.21405
85	Private	63.00	56.00	1.72210	.08740	.04572	-.35850	.37917
86	Private	71.00	41.00	1.78417	.04201	.01523	.24112	-.22313
87	Private	71.00	44.00	1.91747	.02578	.00313	.12795	-.10806
88	Private	71.00	46.00	2.01144	.02221	.00012	.04352	-.02223
89	Private	73.00	48.00	2.31851	.03179	.00115	-.05418	.07925
90	Private	73.00	54.00	2.66067	.13661	.02852	-.42744	.45847

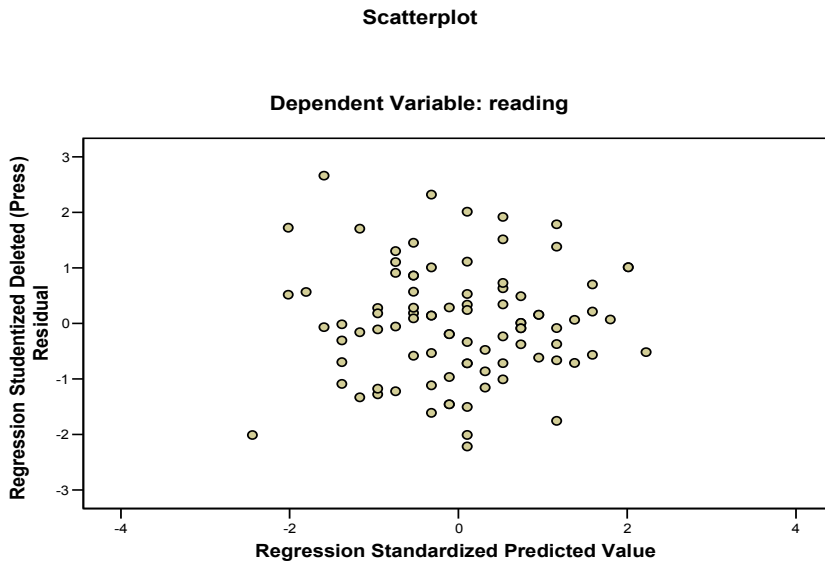
# Checking for Violations of Assumptions

Histogram



Normal P-P Plot of Regression Standardized Residual





### Residual-Predictor Plots

Untitled - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Add-ons

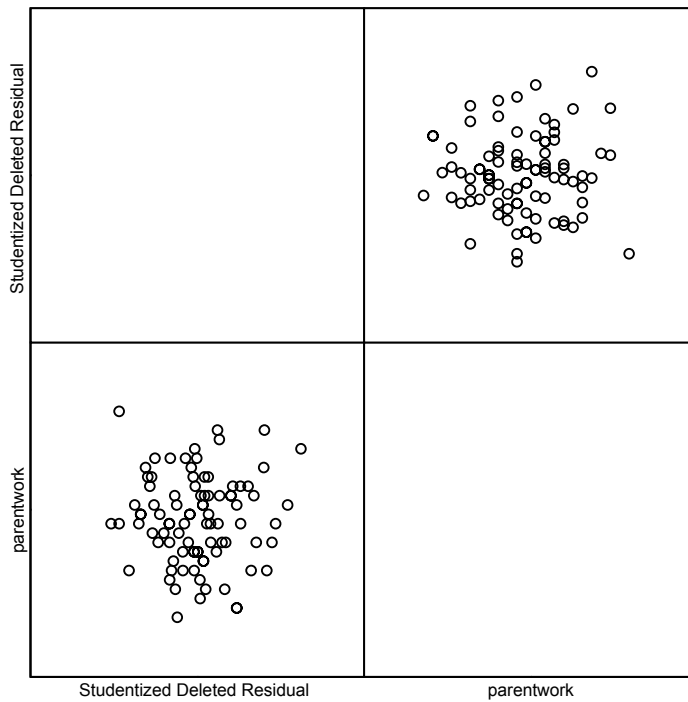
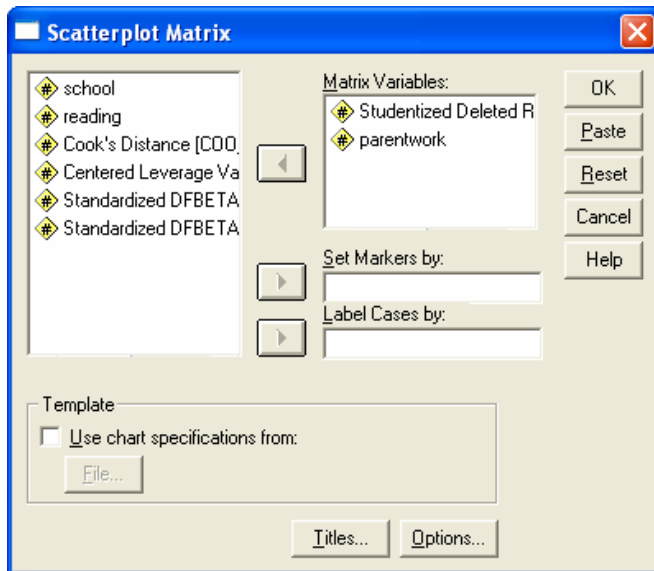
74 : parentwork			
	school	reading	pare
72	Private	58.00	
73	Private	58.00	
74	Private	58.00	
75	Private	60.00	
76	Private	65.00	
77	Public	65.00	
78	Private	60.00	
79	Public	62.00	
80	Private	62.00	
81	Private	67.00	
82	Private	64.00	
83	Private	67.00	
84	Private	65.00	
85	Private	63.00	
86	Private	71.00	

Graphs menu options:

- Gallery
- Interactive
- Bar...
- Line...
- Area...
- Pie...
- High-Low...
- Pareto...
- Control...
- Boxplot...
- Error Bar...
- Scatter...**
- Histogram...
- P-P...
- Q-Q...
- Sequence...
- ROC Curve...
- Time Series

**Scatterplot** dialog box options:

- Simple
- Matrix
- Overlay
- 3-D
- Define
- Cancel
- Help



Finally, an example of partial regression plots. (SPSS does not produce these if there is only ONE predictor so I added another predictor.)

## Regression

**Variables Entered/Removed<sup>d</sup>**

Model	Variables Entered	Variables Removed	Method
1	parentreading, parentwork	.	Enter

- a. All requested variables entered.
- b. Dependent Variable: reading

**Model Summary<sup>b</sup>**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.910 <sup>a</sup>	.829	.825	4.43926

- a. Predictors: (Constant), parentreading, parentwork
- b. Dependent Variable: reading

**ANOVA<sup>b</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8306.607	2	4153.304	210.752	.000 <sup>a</sup>
	Residual	1714.515	87	19.707		
	Total	10021.122	89			

- a. Predictors: (Constant), parentreading, parentwork
- b. Dependent Variable: reading

**Coefficients<sup>a</sup>**

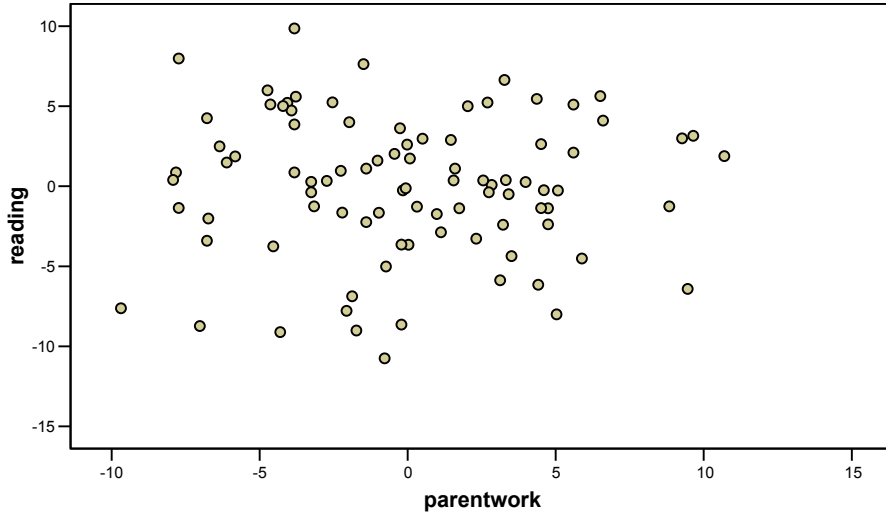
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-14.824	6.385		-2.321	.023	-27.516	-2.132
	parentwork	-.017	.102	-.008	-.169	.866	-.221	.186
	parentreading	.872	.044	.909	19.973	.000	.785	.959

- a. Dependent Variable: reading

# Charts

Partial Regression Plot

Dependent Variable: reading



Partial Regression Plot

Dependent Variable: reading

