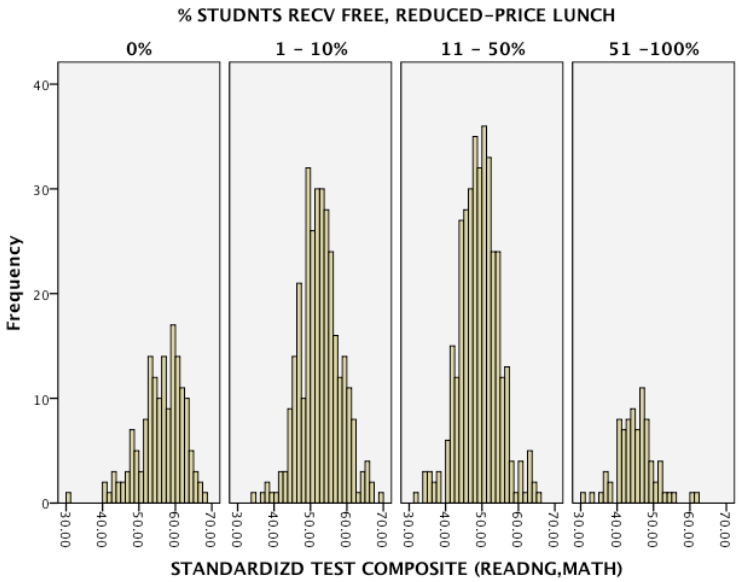
Lawrence Bruce

Part A: One-way ANOVA

Using the NELS school level data, investigate the effect of the categorical predictor chplunch (% STUDENTS RECEIVING FREE/REDUCED-PRICE LUNCH; 0=0%;1=1%-10%; 2=11%-50%; 3=51%-100%) on any continuous outcome.

1. *Identify the outcome variable you chose and provide descriptives and a histogram for this variable.*

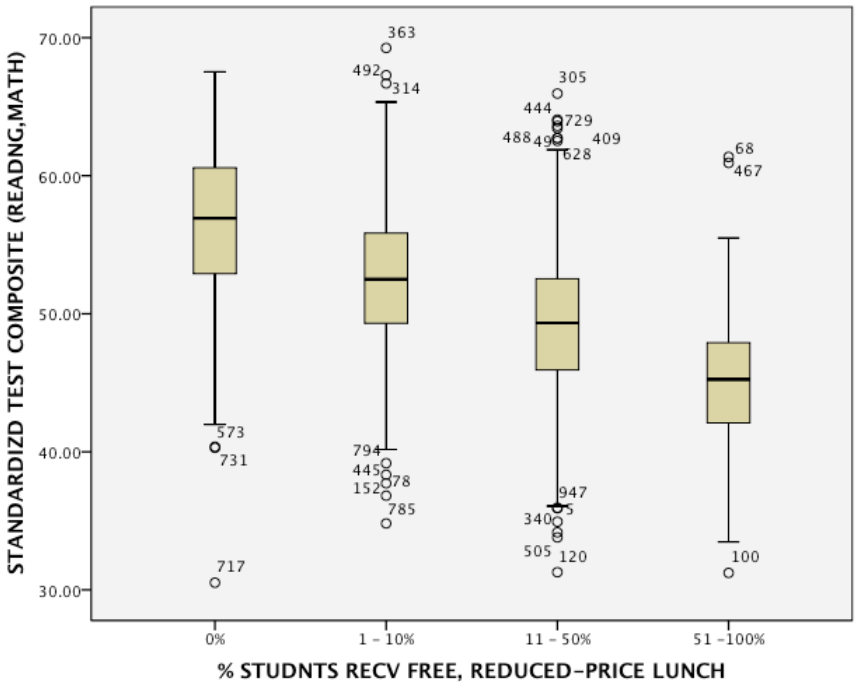
   I hope to measure the effect of Free and Reduced Lunch on Standardized Test Composite Reading, Math (***f1txcomp***)



2. *What is your prediction about the relationship between this outcome variable and* ***chplunch****.*

   My prediction is that students receiving free and reduced lunch represent a group whose scores would differ from students not on free and reduced lunch.

3. *Use SPSS to construct box and whisker plots for* ***chplunch*** *with the outcome variable on the y-axis. Include the output here. Compare the box and whisker plots.*



There is a visible decline in the scores medians for each of the categories of free-reduced lunch. This suggests that our study has identified a trend in achievement as the percentage of free-reduced lunch increases.

4. *Specify the population model for this ANOVA and define each term in the model.*

$$SA_i = b_0 + b_2 0_i + b_3 1_i + b_4 2_i b_5 3_i + \varepsilon_i$$

where: SA_i = scores from composite math/reading

b_0 = the intercept and the mean

$b_1 \ldots b_4$ = the categorical groups of the independent predictors

ε_i = residual for person *i*

5. *Specify in words and symbols the null and alternative hypotheses being tested by the F-test for the model you specified in A.4.*

$H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ The null hypothesis is that all of the alpha values is equal to zero.

$HA : \alpha_J \neq 0$ The alternative hypothesis is that the alpha value from at lease one group is not equal to zero

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1. *Use SPSS to estimate the ANOVA model– include all relevant output.*

Descriptives

STANDARDIZD TEST COMPOSITE (READNG,MATH)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0%	159	56.1056	6.15495	.48812	55.1415	57.0697	30.52	67.52
1 - 10%	308	52.6160	5.49075	.31286	52.0004	53.2316	34.81	69.25
11 - 50%	357	49.3065	5.39982	.28579	48.7444	49.8685	31.28	65.95
51 -100%	81	45.2025	5.25338	.58371	44.0408	46.3641	31.23	61.36
Total	905	51.2600	6.35105	.21112	50.8457	51.6744	30.52	69.25

ANOVA

STANDARDIZD TEST COMPOSITE (READNG,MATH)

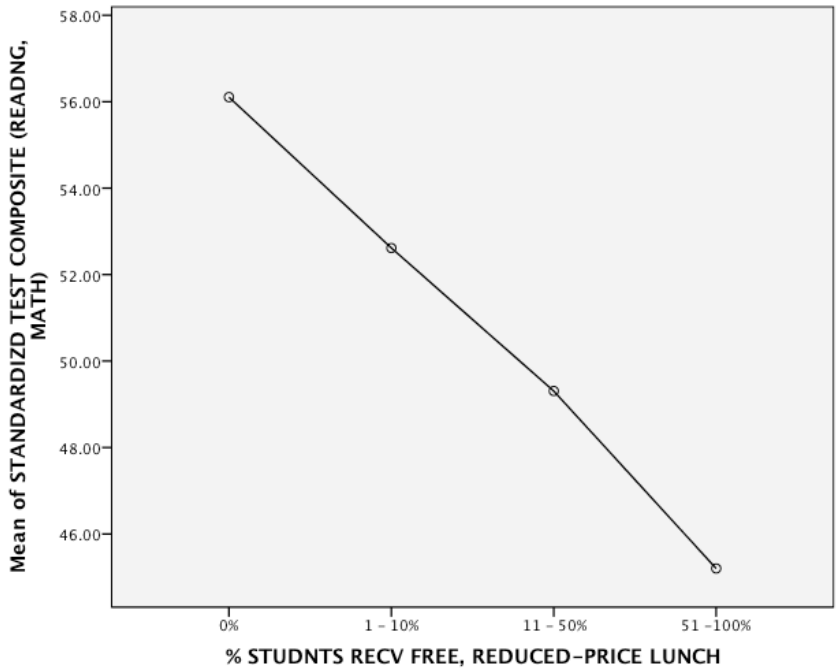
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8634.310	3	2878.103	93.182	.000
Within Groups	27829.233	901	30.887		
Total	36463.543	904			

Robust Tests of Equality of Means

STANDARDIZD TEST COMPOSITE (READNG,MATH)

	Statistic[a]	df1	df2	Sig.
Welch	89.540	3	291.267	.000
Brown-Forsythe	91.953	3	543.306	.000

a. Asymptotically F distributed.



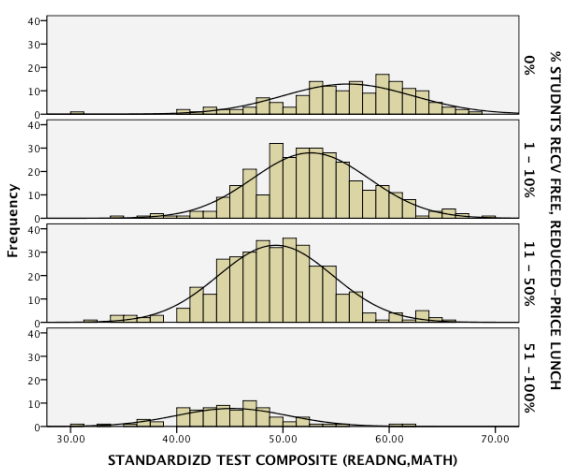
2. *Discuss whether the assumptions of homogeneity of variances and normality of the dependent variable are reasonable and support your conclusion with relevant output.*

   The assumption of the homogeneity of variances is met. Levene's Statistic from the output is 1.85 with a significance of 0.136, well above the usual 0.05 that would cause us to reject the null hypothesis. This also means the outputs for Welch and Forsythe tests can be ignored.

Test of Homogeneity of Variances

STANDARDIZD TEST COMPOSITE (READNG, MATH)

Levene Statistic	df1	df2	Sig.
1.852	3	901	.136



Left is the histogram paneled by rows and I added the normal curve for each categorical variable. The histograms for each of the groups demonstrated normality, meeting the assumption of normality.

3. *Interpret the results you obtained for A.6 and A.7.*

   We were testing the equality of the means of the four groups categorically identified as being different in terms of receiving free and reduced lunch in terms of their effect on achievement on standardized math and reading scores. After seeing the box and whisker plot of the medians, as well as the output of the means plots, it is clear that the scores drop steadily as the percentage of the group with free and reduced lunch increases.

   The null hypothesis must be rejected for the following reasons. The critical assumptions have been met, therefore the results of the test are valid. The null hypothesis that all means are equal can be evaluated using the F-statistic, which is the ratio of the mean square (MS) between groups to the MS within the groups. If this ratio is 1, that means that the two mean squares that we are evaluating are equal and the null will be retained. In this case, using the SPSS output above, the F statistic is 93.182 with a significance at $p<.001$. This tells us that the difference in the squared means between the groups was far greater than squared means within the groups leading us to assume there is at least one group whose mean is not equal to the grand mean or whose alpha is not equal to zero.

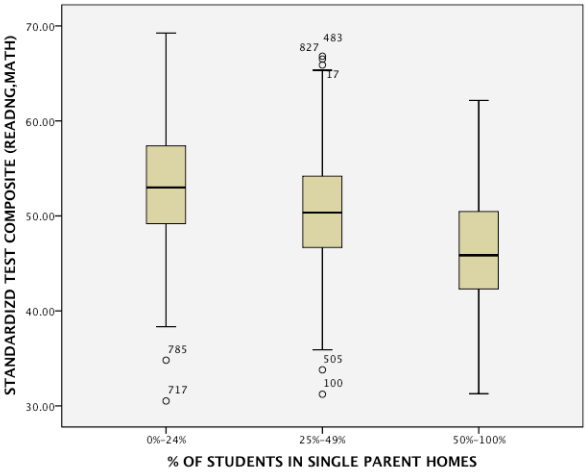
Part B: Two-way ANOVA

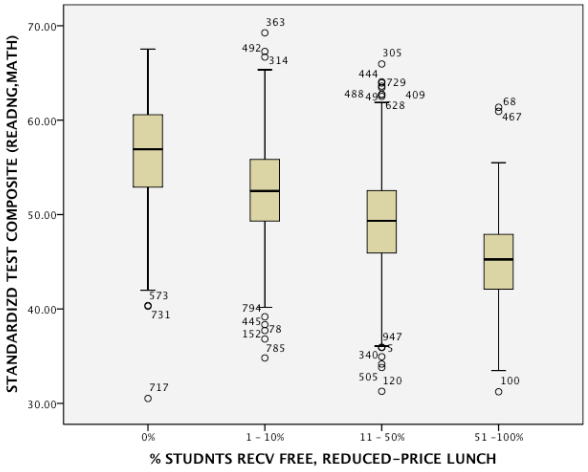
Using the NELS school level data, investigate the effect of both of the categorical predictors **chplunch** (% STUDENTS RECEIVING FREE/REDUCED-PRICE LUNCH; 0=0%;1=1%-10%; 2=11%-50%; 3=51%-100%) and **snglepar3** (% OF STUDENTS IN SINGLE PARENT HOMES; 1=0%-24%; 2=25%-49%; 3=50%-100%) on the same outcome you investigated in Part A.

1. *What is your prediction about the relationship between this outcome variable and* chplunch *and* snglepar3.

   The relationship that came as a result of Part A was that means of student achievement according to the categories from free and reduced were significantly different. Given that as a starting point to this new analysis, I predict that both single parentage and free and reduced lunch to impact student achievement, but also that single parentage will have an impact on free and reduced status. The hope is that the addition of this second factor will allow us to explain the difference in SA means more.

2. *Construct separate box and whisker plots for each categorical predictor with your outcome on the y-axis.*





3. *Specify the population model for this two-way ANOVA model and define each term in the model (include an interaction term).*

   There will be two main factors in this Two-way ANOVA: percentage of students receiving free and reduced lunch (F/R Lunch) and percentage of students coming from single parent households (SPH). The dummy coding for the categories are described in the directions - three groups of SPH and four groups of F/R Lunch. We believe these factors have an effect on student achievement on the standardized math and reading composite scores (SA).

   The model for this factorial analysis is as follows:

   $SA_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijk}$ where:

   SA = student achievement of any student in the respective groups of both factors

   μ = grand mean of the entire population

   α_i = population factor A (F/R Lunch) treatment effect for group *i*

   β_j = population factor B (SPH) treatment effect for group *j*

   $\alpha\beta_{ij}$ = interaction of factors A (F/R Lunch) and B (SPH)

   ε_{ijk} = the residual of any student in respective groups of both factors

4. *State in words and symbols the null and alternative hypotheses tested by the three F-tests of the model you specified in B.3.*

   There will be three separate F-tests run for this factorial analysis to test the 2 main effects on SA and then one of the interaction of the two main effects (factors).

   Hypotheses 1 for Factor A:

   $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ or all alpha values will be equal to zero.

   $H_A : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 \neq 0$ at least one of the alpha values will be unequal to zero.

   Hypothesis 2 for Factor B:

   $H_0 : \beta_1 = \beta_2 = \beta_3 = 0$ or all beta values equal zero

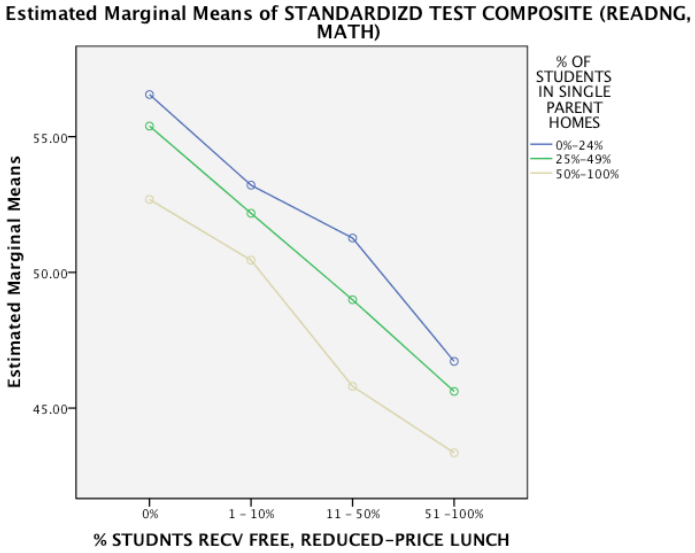
   $H_A : \beta_1 = \beta_2 = \beta_3 \neq 0$ or at least one of groups will have a beta that is unequal to zero

   Hypothesis 3 for the Interaction Between A and B:

   $H_0 : \alpha\beta_{11} = \alpha\beta_{12} = \alpha\beta_{ij} = ... = \alpha\beta_{IJ} = 0$ or all of the alpha and beta values from both factors will be equal to zero

   $H_A : \alpha\beta_{11} = \alpha\beta_{12} = \alpha\beta_{ij} = ... = \alpha\beta_{IJ} \neq 0$ or of all interactions between A and B, one product of alpha and beta will be unequal to zero

5. *Create a profile plot that shows your outcome on the y-axis,* chplunch *on the x-axis, and separate lines for* snglepar3.



Clear visual showing that there is significant change in the mean and that both have an effect on SA, but there may be no interaction as all three lines show parallel tendencies.

6. *Use SPSS to estimate the two-way ANOVA model– include relevant output.*

Between-Subjects Factors

		Value Label	N
% OF STUDENTS IN SINGLE PARENT HOMES	1.00	0%-24%	396
	2.00	25%-49%	412
	3.00	50%-100%	88
% STUDNTS RECV FREE, REDUCED-PRICE LUNCH	.00	0%	158
	1.00	1 - 10%	304
	2.00	11 - 50%	354
	3.00	51 -100%	80

Descriptive Statistics

Dependent Variable:STANDARDIZD TEST COMPOSITE (READNG,MATH)

% OF STUDENTS IN SINGLE PARENT HOMES	% STUDNTS RECV FREE, REDUCED-PRICE LUNCH	Mean	Std. Deviation	N
0%-24%	0%	56.5533	5.75181	108
	1 - 10%	53.2146	5.67276	152
	11 - 50%	51.2642	5.30505	115
	51 -100%	46.7215	4.40078	21
	Total	53.2145	6.06328	396
25%-49%	0%	55.3931	6.76609	46
	1 - 10%	52.1776	5.11273	137
	11 - 50%	48.9910	4.87401	193
	51 -100%	45.6146	5.42671	36
	Total	50.4704	5.83476	412
50%-100%	0%	52.6878	9.83532	4
	1 - 10%	50.4488	6.05009	15
	11 - 50%	45.8012	5.90499	46
	51 -100%	43.3501	5.39029	23
	Total	46.2658	6.47175	88
Total	0%	56.1177	6.17263	158
	1 - 10%	52.6108	5.47359	304
	11 - 50%	49.3150	5.41840	354
	51 -100%	45.2541	5.26579	80
	Total	51.2702	6.35294	896

Tests of Between-Subjects Effects

Dependent Variable:STANDARDIZD TEST COMPOSITE (READNG,MATH)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Model	2.365E6	12	197097.278	6646.905	.000	.989	79762.855	1.000
snglepar3	606.132	2	303.066	10.221	.000	.023	20.441	.987
chplunch	3129.589	3	1043.196	35.181	.000	.107	105.542	1.000
snglepar3 * chplunch	115.122	6	19.187	.647	.693	.004	3.882	.260
Error	26212.802	884	29.652					
Total	2.391E6	896						

a. R Squared = .989 (Adjusted R Squared = .989)

b. Computed using alpha =

Lack of Fit Tests

Dependent Variable:STANDARDIZD TEST COMPOSITE (READNG,MATH)

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Lack of Fit	.000	0	.	.	.	.000	.000	.
Pure Error	26212.802	884	29.652					

a. Computed using alpha =

7. *Specify which of the F-tests (for the main effects and the interaction) are statistically significant. If the null hypotheses for the interaction term are retained, drop the interaction from the model and re-run the ANOVA model without the interaction term. Include the SPSS output for this revised model.*

The output above shows the effects tests between subjects. The profile plot from B.5 is affirmed in the F-values. The null hypothesis for the main effects A and B are rejected with a significance p<.001:

Factor A (F/R Lunch) F=35.18, p<.001

Factor B (SPH) F=10.22, p<.001

Of the several F-tests run for this model, the interaction F-value is insignificant (p=.647). Therefore, we must re-run the ANOVA with this removed and verify the F-tests of A and B.

Tests of Between-Subjects Effects

Dependent Variable:STANDARDIZD TEST COMPOSITE (READNG,MATH)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Model	2.365E6	6	394175.369	13324.867	.000	.989	79949.201	1.000
snglepar3	1286.255	2	643.127	21.741	.000	.047	43.481	1.000
chplunch	5829.747	3	1943.249	65.690	.000	.181	197.071	1.000
Error	26327.924	890	29.582					
Total	2.391E6	896						

a. R Squared = .989 (Adjusted R Squared = .989)

b. Computed using alpha =

In the revised model output, the F-values for out main effects remain as significant and we reject the null hypothesis for factors A and B.

8. *Is the assumption of homogeneity of variances reasonable? Include relevant SPSS output. If plots suggest a violation of this assumption, then examine the cell variances and describe the differences in cell variances.*

Lack of Fit Tests

Dependent Variable:STANDARDIZD TEST COMPOSITE (READNG,MATH)

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Lack of Fit	115.122	6	19.187	.647	.693	.004	3.882	.260
Pure Error	26212.802	884	29.652					

a. Computed using alpha =

The Lack of Fit Test comes with an insignificant F-value at p>.001 which tells us that we declare that this model fits the population.

Using the output for Levene's test (right) which was taken from the revised test run after removing the interaction of the factors. We can see that the test statistic (F=1.77) is not significant and therefore we *retain* the null hypothesis that the error variance of the dependent variable (SA) is equal across the groups.

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

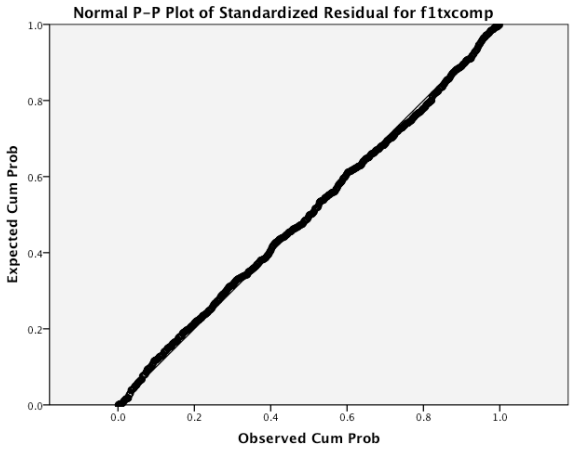
Dependent Variable:STANDARDIZD TEST COMPOSITE (READNG,MATH)

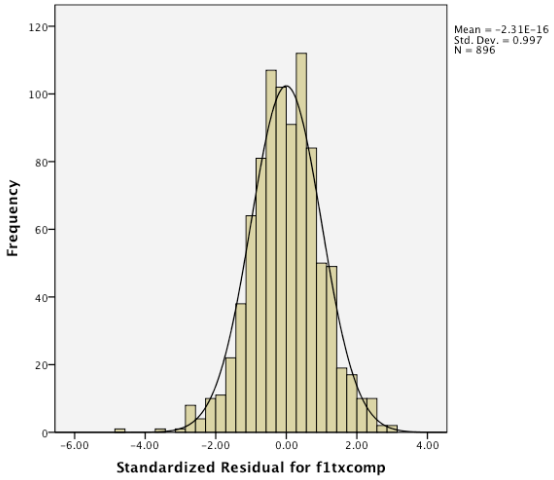
F	df1	df2	Sig.
1.771	11	884	.055

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

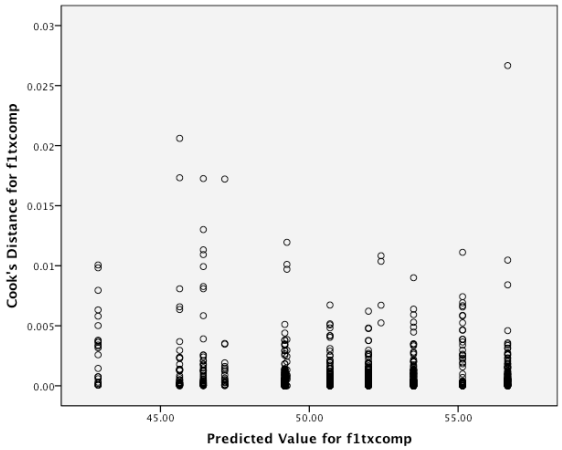
a. Design: snglepar3 + chplunch

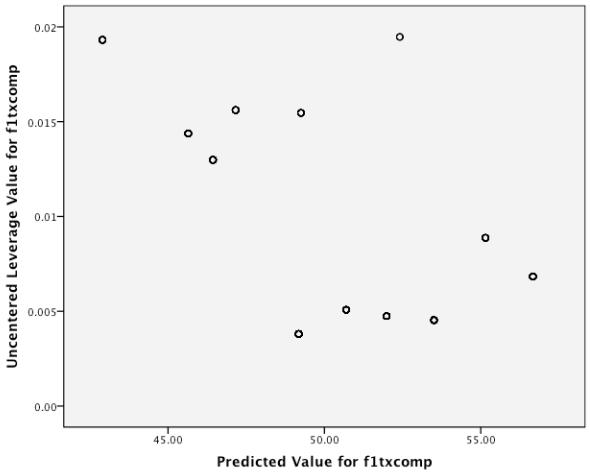
9. *Determine if the assumption of normality of residuals is reasonable using a P-P plot and a histogram. Also examine the residuals for potential outliers using plots of Cook's Distance and leverage.*





Yes, the two outputs above (P-P plot and the histogram of the standardized residual) both show normality with vary little variance from normal.





Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Cook's Distance for f1txcomp	896	.00	.03	.0012	.00233
Uncentered Leverage Value for f1txcomp	896	.00	.02	.0067	.00402
Valid N (listwise)	896				

The above two graph outputs allow us to identify the possibility of outliers that demonstrate deviance from the model. Descriptive statistics from Cook's and leverage values do not provide us with the necessary decimal places to evaluate the possibility of outliers.

Using Belsley's model for identifying leverage values we can gain an upper bound for determining high leverage. This suggested that if leverage > 2p/n where p=predictors, and n=number of total data points, then these are considered high. For this data we can see that:

$$\frac{2p}{n} = \frac{2(2)}{896} = .0046$$

Using this value as a very conservative upper bound for high leverage, we have many point clusters that can demonstrate concern. However, none of these values come close to reaching a value of 1, which is the traditional model for determining high leverage. The items high on this leverage plot suggest clusters of points in the data stemming from the categorical input.

The plot of Cook's distance suggests the same: that there are points that seem to be high, but none are close to 1, much less greater than one. A very conservative approach would be to use 4/n, which would give us a value of .004 to measure high Cook's scores. This seems unnecessary because of the still very low value of even the highest Cook's scores present in out output.

Therefore, the assumptions of homogeneity of variance and normality of residuals have been met.

10. *Interpret the results you obtained in B.6-B.9.*

Once again, in the simplest terms, both free and reduced lunch status (factor A) as well as single-parentage (factor B) have a negative effect on student achievement. However, the interaction between the factors has no significant effect on the student achievement.

The null hypothesis for factors A and B were that the means of their test scores across all groups would be equal. The F-statistic used to calculate the differences between those means came back as greatly different and significant. However, the F-statistic associated with the interaction between factors A and B and it's effect on student achievement was not. Even after the tests were re-run with the interaction remove, the F-values for factors A and B continued to exert their significance.

Therefore, the null hypothesis was rejected for factors A and B, declaring that the negative relationship between student achievement and free and reduced lunch is significant, as well as that the relationship between single-parent households and decreased student achievement.