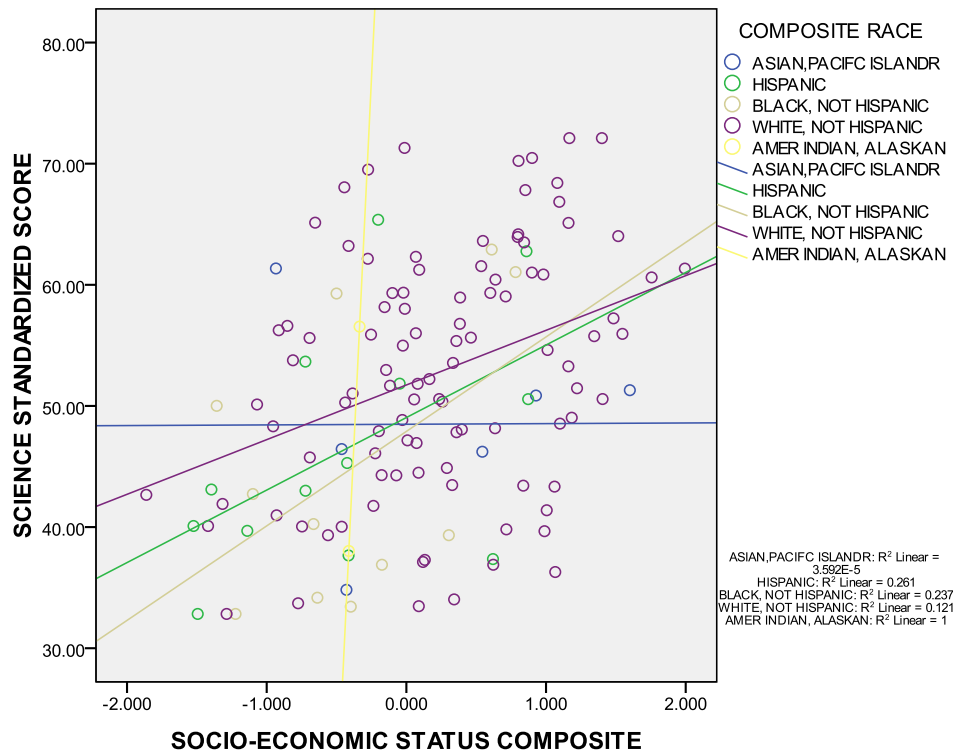


Homework #3

1. Make a scatterplot of *f1ses* and *f1txstd*. Be sure to set markers by race, *f1race*, so you can check for an interaction. Does SES appear to be a good potential predictor of student science standardized scores? Do you see any hint of an interaction with race?



COMPOSITE RACE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ASIAN, PACIFIC ISLANDER	8	5.0	5.1	5.1
	HISPANIC	19	11.9	12.1	17.2
	BLACK, NOT HISPANIC	14	8.8	8.9	26.1
	WHITE, NOT HISPANIC	114	71.7	72.6	98.7
	AMERICAN INDIAN, ALASKAN	2	1.3	1.3	100.0
Total	157	98.7	100.0		
Missing	MISSING	2	1.3		
Total		159	100.0		

Based on the scatterplot above (generated by SPSS), SES (*f1ses*) appears to be a moderately good potential predictor of student science standardized scores. This is shown by the regression lines for the White, Black, and Hispanic races. The R^2 values range from 0.121 to 0.261 for

these three races; while these are not especially high amounts of variance explained, they are still relatively substantial. SES does not appear to be as good a predictor for the student science standardized score of the Asian and American Indian races, based on the regression lines for those races and the extremely low R^2 value for the Asians. While the R^2 value for the American Indians is 1, this is because there are only two American Indians in the dataset, as shown in the descriptive statistics (above) on the *fIrace* variable. The small number of Asians in the sample (8) may also have affected the predictive power of *fIles* for that race group.

There does appear to be evidence of some interaction between SES (*fIles*) and race (*fIrace*), as particularly shown by the regression lines for the White, Black, and Hispanic races. These lines cross and overlap as shown on the right side of the scatterplot. We do not know yet, however, if this is a significant interaction.

2. Compute the regression of *fIles* and your four dummy variables on *fIxsstd* for the students in the data set. Be sure to make a histogram and a residual plot (residuals versus predicted values) for the analysis.

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.442 ^a	.195	.163	9.49953	.195	6.111	5	126	.000

a. Predictors: (Constant), White, not Hispanic, SOCIO-ECONOMIC STATUS COMPOSITE, Asian, Pacific Islander, Black, not Hispanic, Hispanic

b. Dependent Variable: SCIENCE STANDARDIZED SCORE

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2757.374	5	551.475	6.111	.000 ^a
	Residual	11370.380	126	90.241		
	Total	14127.753	131			

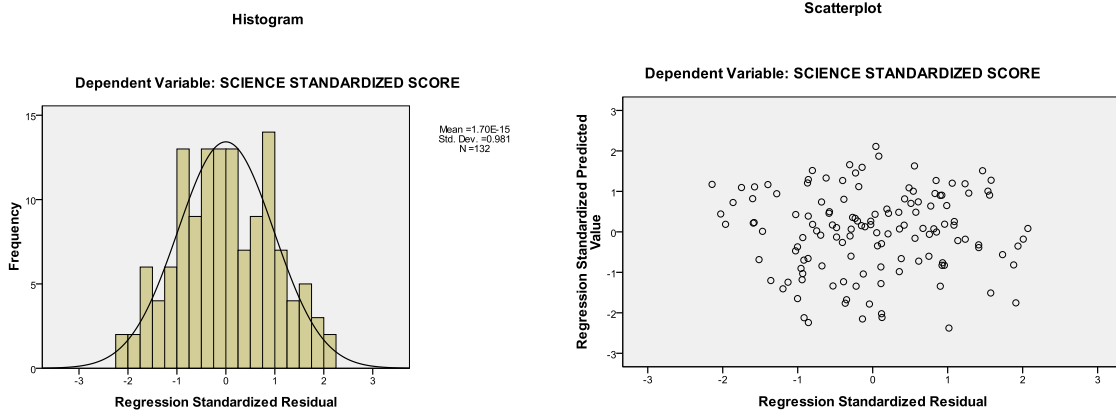
a. Predictors: (Constant), White, not Hispanic, SOCIO-ECONOMIC STATUS COMPOSITE, Asian, Pacific Islander, Black, not Hispanic, Hispanic

b. Dependent Variable: SCIENCE STANDARDIZED SCORE

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	49.020	6.729		7.285	.000		
	SOCIO-ECONOMIC STATUS COMPOSITE	4.633	1.079	.363	4.295	.000	.895	1.118
	Asian, Pacific Islander	-1.484	7.782	-.030	-.191	.849	.260	3.843
	Hispanic	-.575	7.216	-.017	-.080	.937	.148	6.762
	Black, not Hispanic	-2.378	7.302	-.064	-.326	.745	.168	5.958
	White, not Hispanic	2.680	6.817	.111	.393	.695	.080	12.484

a. Dependent Variable: SCIENCE STANDARDIZED SCORE



a. Does *f1ses* seem to be a good predictor? Also, check assumptions.

Based on the results of the regression (shown above as output by SPSS), *f1ses* does appear to be a good predictor of *f1txstd*. The p-value is less than 0.001 and so we would reject the null hypothesis ($H_0: \beta_{f1ses} = 0$) and conclude that it is a significant predictor.

Checking the assumptions, based on the histogram the residuals appear to be approximately normal, perhaps ever-so-slightly negatively skewed but not so much as to be an issue. The assumption of homogeneity of variance of the residuals is also not violated, as shown by the even spread in the scatterplot of residuals vs. predicted values. Based on the scatterplot used in question 1, there does appear to be a linear relationship between *f1ses* and *f1txstd* across groups, so that assumption is also not violated. We are also required to assume independence between *f1ses* and *f1race*, although we cannot determine this based on the data provided.

We cannot be sure that all of the important predictors are in the model because we did not include all the possible variables in the regression (there are other variables in the data set). We do appear to have irrelevant predictors in the model, since the dummy variables for race are all non-significant. In addition, there does appear to be multicollinearity between the four dummy variables for race and *f1ses* because the VIF values for the four dummy variables are more than 3 (and more than 10 for whites). Because of the multicollinearity involving the four dummy

variables, as well as their lack of significance, these variables should probably be removed from the model, depending on whether there is any significant interaction effect.

b. What do the dummy variables seem to tell you about differences among the races? (Are any of the dummy variables significant? Report *p*-values.)

Because none of the dummy variables for race are significant (p-values of 0.849, 0.937, 0.745, and 0.695 for Asian, Hispanic, Black, and White respectively), we conclude that there are no differences amongst the races on student science standardized scores when controlling for socio-economic status. Because of the multicollinearity identified in part (a) and their non-significance, these variables should probably be dropped from the regression model, depending on whether there is any significant interaction effect.

c. What does the overall *F*-test for this regression tell you? Report *R*². Is it significant? What is your conclusion?

The F-statistic for the overall model is $F = 6.111$, with a p-value of $p < 0.001$. This tells us that we should reject the null hypothesis ($H_0: \rho_{Y\hat{Y}}^2 = 0$) and conclude that at least one of the predictors has a significant effect on *flxsstd*. In this case, it appears that only *flses* has an effect as shown in parts (a) and (b). $R^2 = 0.195$; $R_{adj}^2 = 0.163$. It is possible that these R^2 values are lowered because of the non-significant dummy variables.

3. Next, use the Analyze, General linear model, and Univariate menu to run an ANCOVA for the *flxsstd* outcome. Use *flses* as the covariate and *flrace* (not the race dummy variables) as a fixed factor. You will first need to verify that the covariate and treatment (i.e., race) do not interact. Use the Model window to create a custom model with both predictors plus their interaction. (Highlight both names at once and click on the arrow to build this interaction.)

Is the interaction of *flses* with *flrace* significant? What evidence do you have to support your decision?

Tests of Between-Subjects Effects

Dependent Variable: SCIENCE STANDARDIZED SCORE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3090.127 ^a	9	343.347	3.795	.000
Intercept	2329.688	1	2329.688	25.750	.000
f1race	357.535	4	89.384	.988	.417
f1ses	198.350	1	198.350	2.192	.141
f1race * f1ses	332.753	4	83.188	.919	.455
Error	11037.627	122	90.472		
Total	360921.134	132			
Corrected Total	14127.753	131			

a. R Squared = .219 (Adjusted R Squared = .161)

The interaction between *fIses* and *fIrace* does not appear to be significant. This is shown by the p-value in the source table for the ATI model (labeled by SPSS as “Tests of Between-Subjects Effects” and shown above), which for the interaction term *fIrace* * *fIses* is $p = 0.455$. Since this is greater than $\alpha = 0.05$, we cannot conclude that the interaction is significant and must remove it from this ATI model and use an ANCOVA model instead.

4. Remove the interaction from the model and run the model with only the main effects of *fIrace* and *fIses*. When you run this model, click on the [Options...] button and select the following items:

- estimated marginal means by race (to get these, move *fIrace* to the right in the top of the options window)
- descriptive statistics
- parameter estimates
- homogeneity tests, and
- residual plot

Also click the [Plots...] button and make the plot of *fIrace* means (click the name into the Horizontal axis box, then click Add, and then Continue.

a. Look at the homogeneity tests. Do the group variances seem to be equal?

Levene's Test of Equality of Error Variances^a

Dependent Variable: SCIENCE STANDARDIZED SCORE

F	df1	df2	Sig.
.511	4	127	.728

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

a. Design: Intercept + *f1ses* + *f1race*

Based on Levene’s test (as shown in the SPSS output above), the variances across the race groups appear to be equal. This is because the F-statistic for Levene’s test is not significant ($p = 0.728$) and thus we cannot reject the null hypothesis that all five race groups have the same error variance for student science standardized scores in the population.

b. Compare the marginal mean estimates to the means from the descriptive statistics output. Add (e.g., draw on by hand) the values of the marginal means to the plot of means that was produced by SPSS. Discuss differences between the two sets of means.

1. COMPOSITE RACE

Dependent Variable: SCIENCE STANDARDIZED SCORE

COMPOSITE RACE	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
ASIAN,PACIFC ISLANDR	48.064 ^a	3.879	40.387	55.742
HISPANIC	48.973 ^a	2.702	43.626	54.320
BLACK, NOT HISPANIC	47.171 ^a	2.917	41.399	52.943
WHITE, NOT HISPANIC	52.228 ^a	.961	50.327	54.129
AMER INDIAN, ALASKAN	49.548 ^a	6.738	36.215	62.882

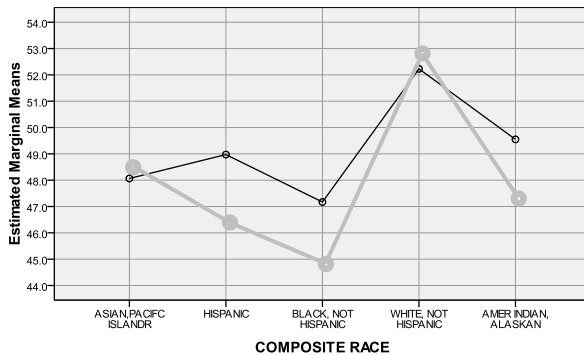
a. Covariates appearing in the model are evaluated at the following values: SOCIO-ECONOMIC STATUS COMPOSITE = .11395.

Descriptive Statistics

Dependent Variable: SCIENCE STANDARDIZED SCORE

COMPOSITE RACE	Mean	Std. Deviation	N
ASIAN,PACIFC ISLANDR	48.4983	8.66160	6
HISPANIC	46.4015	9.90884	13
BLACK, NOT HISPANIC	44.8073	11.54071	11
WHITE, NOT HISPANIC	52.8418	10.03966	100
AMER INDIAN, ALASKAN	47.2900	13.09562	2
Total	51.2564	10.38487	132

Estimated Marginal Means of SCIENCE STANDARDIZED SCORE



Covariates appearing in the model are evaluated at the following values: SOCIO-ECONOMIC STATUS COMPOSITE = .11395

As shown by the SPSS output for the observed and marginal (adjusted) means above, there are some differences between the means. In the scatterplot above, the marginal (adjusted) means are the thin black line and the observed means are the thicker gray line. We can see that the marginal (adjusted) means for Hispanics, Blacks, and American Indians are substantially higher than the observed means (by 2.5715, 2.3637, and 2.2580 respectively). This means that when we adjust for the effect of the covariate, *flses*, the estimated student science standardized scores for Hispanics, Blacks, and American Indians are higher than when we do not control for the covariate. The marginal (adjusted) means for Asians and Whites are slightly lower than the

observed means (by 0.4343 and 0.6138 respectively). This means that the estimated student science standardized scores for Asians and Whites are lower when we control for the covariate.

c. Compare the parameter estimates from the ANCOVA to the ones you obtained for the regression in item 2. What does the parameter for *f1ses* in the ANCOVA model represent?

Parameter Estimates

Dependent Variable: SCIENCE STANDARDIZED SCORE

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	49.020	6.729	7.285	.000	35.703	62.337
f1ses	4.633	1.079	4.295	.000	2.498	6.767
[f1race=1]	-1.484	7.782	-.191	.849	-16.884	13.915
[f1race=2]	-.575	7.216	-.080	.937	-14.855	13.704
[f1race=3]	-2.378	7.302	-.326	.745	-16.829	12.074
[f1race=4]	2.680	6.817	.393	.695	-10.810	16.171
[f1race=5]	0 ^a

a. This parameter is set to zero because it is redundant.

Coefficients^a

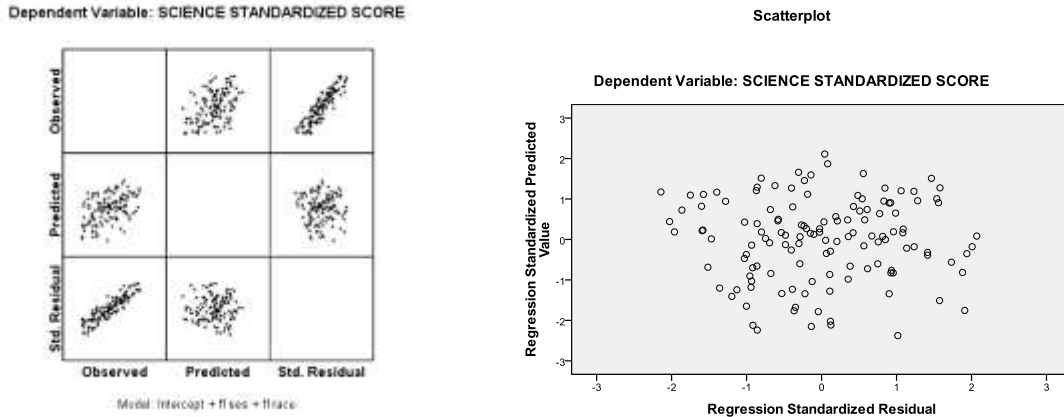
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	49.020	6.729		7.285	.000		
	SOCIO-ECONOMIC STATUS COMPOSITE	4.633	1.079	.363	4.295	.000	.895	1.118
	Asian, Pacific Islander	-1.484	7.782	-.030	-.191	.849	.260	3.843
	Hispanic	-.575	7.216	-.017	-.080	.937	.148	6.762
	Black, not Hispanic	-2.378	7.302	-.064	-.326	.745	.168	5.958
	White, not Hispanic	2.680	6.817	.111	.393	.695	.080	12.484

a. Dependent Variable: SCIENCE STANDARDIZED SCORE

The top table shown above is the SPSS output from the ANCOVA model run in this question; the bottom table is from the regression model run in question 2. The unstandardized coefficients for the intercept and *f1ses* (“socio-economic status composite”) in the regression coefficients table are the same as those shown in the ANCOVA parameter estimates table (under the column labeled “B”). The standard errors, t-statistics, and p-values are also the same between the tables for the intercept and *f1ses*. We used dummy variables in the regression model and did not in the ANCOVA model; nevertheless the coefficients shown for four of the race groups (Asian, Hispanic, Black, and White) are equal, as are the standard errors, t-statistics, and p-values. The fifth race group, American Indians, is not shown in the regression table because we did not need a dummy variable for that group (if all other dummy variables were equal to zero then a student was in that group). It is shown in the ANCOVA parameter estimates table, but is correctly labeled as redundant and given an estimate of 0, equivalent to the regression model.

The parameter for *f1ses* in the ANCOVA model, $b_{f1ses} = 4.633$, signifies the amount of change in student science standardized scores for every one unit of change in socio-economic status composite score, controlling for the race of the student.

- d. Look at the ANCOVA residual plot and compare it to the residual plot from item 2. What error assumption is this plot meant to examine? Do you think the data satisfy that assumption?



The ANCOVA residual plot generated by SPSS is on the left; the scatterplot of standardized residuals vs. standard predicted values from item 2 is on the right. The ANCOVA residual plot is meant to examine the assumption of homogeneity of variance of the residuals. For assessing this assumption we look at the scatterplot of standardized residuals vs. predicted values, shown in the scatterplot matrix in the second row and third column. If one looks closely, this scatterplot is extremely similar to the scatterplot from item 2. In both cases, it does not appear the assumption of homogeneity of variance of the residuals has been violated, because the residuals are evenly spread and there is no significant pattern in the dots.

- e. What is your conclusion about racial differences in student science standardized score, based on the results of this ANCOVA?

Tests of Between-Subjects Effects

Dependent Variable: SCIENCE STANDARDIZED SCORE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2757.374 ^a	5	551.475	6.111	.000
Intercept	69512.914	1	69512.914	770.302	.000
f1ses	1665.009	1	1665.009	18.451	.000
f1race	381.522	4	95.381	1.057	.381
Error	11370.380	126	90.241		
Total	360921.134	132			
Corrected Total	14127.753	131			

a. R Squared = .195 (Adjusted R Squared = .163)

Based on the source table for the ANCOVA model (labeled by SPSS as “Tests of Between-Subjects Effects” and shown above), we conclude that racial differences are not a significant factor in determining student science standardized scores. This is shown by the p-value of $p = 0.381$ for *fIrace* in the table above, which means we cannot reject the null hypothesis ($H_0: \beta_{fIrace} = 0$) and therefore say that there is no evidence that *fIrace* is a significant predictor in the ANCOVA model. It should be noted that the model as a whole is significant as shown in the top line of the table ($p < 0.001$) and *fIles* is a significant predictor as shown in the third line ($p < 0.001$); however we should remove *fIrace* from the model because it is a non-significant predictor. No other assumptions are known to be violated; as shown in question 1 there is a linear relationship between the covariate (*fIrace*) and the dependent variable (*fIxsstd*), there is no interaction, there is homogeneity of variance of the residuals, and the residuals are normally distributed (as shown by the histogram below). We cannot test for the independence of the predictors and assume there is no treatment effect caused by the group design.

