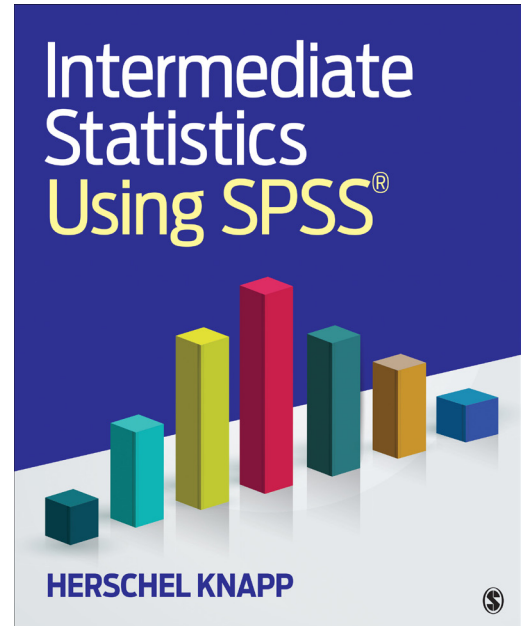


# C H A P T E R 6

## ANCOVA

### Solutions to Odd-Numbered Exercises



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## EXERCISE 6.1A

Data set: Ch 06 – Exercise 01A.sav

(a)

 $H_0$ : The number of students in a tutoring group has no effect on student satisfaction. $H_1$ : The number of students in a tutoring group has an effect on student satisfaction.

(b)

Tests of Between-Subjects Effects					
Dependent Variable: TSS					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	474.931 <sup>a</sup>	5	94.986	7.977	.000
Intercept	41209.268	1	41209.268	3460.566	.000
Group	47.290	2	23.645	1.986	.143
Tutor_months	.923	1	.923	.078	.781
Group * Tutor_months	8.308	2	4.154	.349	.706
Error	1178.916	99	11.908		
Total	70259.000	105			
Corrected Total	1653.848	104			

a. R Squared = .287 (Adjusted R Squared = .251)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .706  $p$  value for the *Group \* Tutor\_months* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model, hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable: TSS			
F	df1	df2	Sig.
.676	2	102	.511

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Tutor\_months + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .511  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects					
Dependent Variable: TSS					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	466.624 <sup>a</sup>	3	155.541	13.232	.000
Intercept	41243.290	1	41243.290	3508.666	.000
Tutor_months	1.119	1	1.119	.095	.758
Group	450.911	2	225.456	19.180	.000
Error	1187.224	101	11.755		
Total	702599.000	105			
Corrected Total	1653.848	104			

a. R Squared = .282 (Adjusted R Squared = .261)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .000 for *Group*, which is less than  $\alpha$  (.05); this indicates that a statistically significant difference has been detected between at least one pair of groups. For further details as to which group(s) significantly outperformed which, we look to the *Pairwise Comparisons* table.

Estimates				
Dependent Variable: TSS				
Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
One-to-one	83.966 <sup>a</sup>	.590	82.797	85.136
Two-to-one	82.224 <sup>a</sup>	.585	81.064	83.384
Five-to-one	78.924 <sup>a</sup>	.580	77.772	80.075

a. Covariates appearing in the model are evaluated at the following values:  
Tutor\_months = 15.20.

Pairwise Comparisons						
Dependent Variable: TSS						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
One-to-one	Two-to-one	1.742	.841	.122	-.304	3.789
	Five-to-one	5.043 <sup>*</sup>	.831	.000	3.019	7.067
Two-to-one	One-to-one	-1.742	.841	.122	-3.789	.304
	Five-to-one	3.301 <sup>*</sup>	.821	.000	1.302	5.299
Five-to-one	One-to-one	-5.043 <sup>*</sup>	.831	.000	-7.067	-3.019
	Two-to-one	-3.301 <sup>*</sup>	.821	.000	-5.299	-1.302

Based on estimated marginal means  
a. Adjustment for multiple comparisons: Bonferroni.  
\*. The mean difference is significant at the .05 level.

Drawing the means from the *Estimates* table and the  $p$  values from the Sig. column on the *Pariwise Comparisons* table, the following table summarizes the results of this ANCOVA:

Groups (Tutor Satisfaction Survey)	$p$
One-to-one ( $M = 83.97$ ) : Two-to-one ( $M = 82.22$ )	.122
One-to-one ( $M = 83.97$ ) : Five-to-one ( $M = 78.92$ )	.000*
Two-to-one ( $M = 82.22$ ) : Five-to-one ( $M = 78.92$ )	.000*

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for number of months each tutor has been providing service ( $M = 15.20$ ).

These findings reveal that the highest student satisfaction was in the 1:1 tutoring group, however the 2:1 group was a close second, with no statistically significant difference between these two groups, controlling for the number of months each tutor has been providing service. Both the 1:1 and 2:1 tutor groups statistically significantly outperformed the (lowest) 5:1 group. Based on these findings, we reject  $H_0$ , and we do not reject  $H_1$ .

(d)

This study analyzed the effects that tutor group size had on student satisfaction scores. We recruited 105 students and randomly assigned to one of three tutoring conditions: 1:1, 2:1, or 5:1. At the end of the term, each student completed the Tutor Satisfaction Survey (0 = very unsatisfied . . . 100 = very satisfied). We detected no statistically significant difference between the students who received 1:1 tutoring ( $M = 83.97$ ) and those who received 2:1 tutoring ( $M = 82.22$ ) ( $p = .122$ ,  $\alpha = .05$ ). The students in both of these groups had a statistically significantly higher Tutor Satisfaction score than those in the 5:1 group ( $M = 78.92$ ), ( $p < .001$ ,  $\alpha = .05$ ). These figures have been adjusted to control for the number of months that each tutor has been providing service. Based on these findings, we reject  $H_0$  and accept  $H_1$ .

## EXERCISE 6.1B

Data set: Ch 06 – Exercise 01B.sav

(a)

 $H_0$ : The number of students in a tutoring group has no effect on student satisfaction. $H_1$ : The number of students in a tutoring group has an effect on student satisfaction.

(b)

Tests of Between-Subjects Effects					
Dependent Variable:TSS					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1928.136 <sup>a</sup>	5	385.627	22.130	.000
Intercept	42237.042	1	42237.042	2423.887	.000
Group	102.768	2	51.384	2.949	.056
Tutor_months	11.060	1	11.060	.635	.427
Group * Tutor_months	21.662	2	10.831	.622	.539
Error	2003.913	115	17.425		
Total	716882.000	121			
Corrected Total	3932.050	120			

a. R Squared = .490 (Adjusted R Squared = .468)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .539  $p$  value for the *Group \* Tutor\_months* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model, hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable:TSS			
F	df1	df2	Sig.
.230	2	118	.795

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Tutor\_months + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .795  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

**Tests of Between-Subjects Effects**

Dependent Variable: TSS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1906.474 <sup>a</sup>	3	635.491	36.707	.000
Intercept	42479.082	1	42479.082	2453.650	.000
Tutor_months	11.269	1	11.269	.651	.421
Group	1891.357	2	945.679	54.624	.000
Error	2025.575	117	17.313		
Total	71682.000	121			
Corrected Total	3932.050	120			

a. R Squared = .485 (Adjusted R Squared = .472)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .000 for *Group*, which is less than  $\alpha$  (.05); this indicates that a statistically significant difference has been detected between at least one pair of groups. For further details as to which group(s) significantly outperformed which, we look to the *Pairwise Comparisons* table.

**Estimates**

Dependent Variable: TSS

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
One-to-one	80.873 <sup>a</sup>	.650	79.585	82.160
Two-to-one	78.152 <sup>a</sup>	.686	76.795	79.510
Five-to-one	71.642 <sup>a</sup>	.635	70.385	72.899

a. Covariates appearing in the model are evaluated at the following values:  
Tutor\_months = 18.59.

**Pairwise Comparisons**

Dependent Variable: TSS

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
One-to-one	Two-to-one	2.720	.946	.014	.423	5.018
	Five-to-one	9.231 <sup>*</sup>	.908	.000	7.025	11.437
Two-to-one	One-to-one	-2.720	.946	.014	-5.018	-.423
	Five-to-one	6.511 <sup>*</sup>	.935	.000	4.239	8.782
Five-to-one	One-to-one	-9.231 <sup>*</sup>	.908	.000	-11.437	-7.025
	Two-to-one	-6.511 <sup>*</sup>	.935	.000	-8.782	-4.239

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Bonferroni.

Drawing the means from the *Estimates* table and the  $p$  values from the Sig. column on the *Pariwise Comparisons* table, the following table summarizes the results of this ANCOVA:

Groups (Tutor Satisfaction Survey)	$p$
One-to-one ( $M = 80.87$ ) : Two-to-one ( $M = 78.15$ )	.014*
One-to-one ( $M = 80.87$ ) : Five-to-one ( $M = 71.64$ )	.000*
Two-to-one ( $M = 78.15$ ) : Five-to-one ( $M = 71.64$ )	.000*

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for number of months each tutor has been providing service ( $M = 18.59$ ).

These findings reveal that small tutor groups produced higher student satisfaction scores. We found that the 1:1 tutoring group significantly outperformed both of the other groups, and that the 2:1 group significantly outperformed the 5:1 group. Based on these findings, we reject  $H_0$ , and we do not reject  $H_1$ .

(d)

This study analyzed the effects that tutor group size had on student satisfaction scores. We recruited 121 students and randomly assigned to one of three tutoring conditions: 1:1, 2:1, or 5:1. At the end of the term, each student completed the Tutor Satisfaction Survey (0 = very unsatisfied . . . 100 = very satisfied). Our findings revealed that students seem to prefer smaller tutoring groups; we detected a statistically significant difference between the students who received 1:1 tutoring ( $M = 80.87$ ) and those who received 2:1 tutoring ( $M = 78.15$ ) ( $p = .014$ ,  $\alpha = .05$ ). Additionally, students who received 2:1 tutoring had statistically significantly higher satisfaction scores than those in the 5:1 tutoring groups ( $M = 71.64$ ) ( $p < .001$ ). These figures have been adjusted to control for the number of months that each tutor has been providing service. Based on these findings, we reject  $H_0$  and accept  $H_1$ .

## EXERCISE 6.3A

Data set: Ch 06 – Exercise 03A.sav

(a)

 $H_0$ : Having a mentor will have no effect on probation compliance. $H_1$ : Having a mentor will have an effect on probation compliance.

(b)

Tests of Between-Subjects Effects					
Dependent Variable: Probation compliance					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1527.429 <sup>a</sup>	5	305.486	2.311	.046
Intercept	5748.922	1	5748.922	43.485	.000
Group	184.214	2	92.107	.697	.500
Age	63.014	1	63.014	.477	.491
Group * Age	265.653	2	132.826	1.005	.368
Error	24061.507	182	132.206		
Total	841352.000	188			
Corrected Total	25588.936	187			

a. R Squared = .060 (Adjusted R Squared = .034)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .368  $p$  value for the *Group \* Age* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model, hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable: Probation compliance			
F	df1	df2	Sig.
.534	2	185	.587

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Age + Group



**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .587  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects					
Dependent Variable: Probation_compliance					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1261.776 <sup>a</sup>	3	420.592	3.181	.025
Intercept	5871.920	1	5871.920	44.413	.000
Age	73.294	1	73.294	.554	.457
Group	1232.968	2	616.484	4.663	.011
Error	24327.160	184	132.213		
Total	841352.000	188			
Corrected Total	25588.936	187			

a. R Squared = .049 (Adjusted R Squared = .034)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .011 for *Group*, which is less than  $\alpha$  (.05); this indicates that a statistically significant difference has been detected among the groups.

Estimates					
Dependent Variable: Probation_compliance					
Group	Mean	Std. Error	95% Confidence Interval		
			Lower Bound	Upper Bound	
No mentor	62.686 <sup>a</sup>	1.431	59.863	65.508	
Peer mentor	66.252 <sup>a</sup>	1.427	63.437	69.068	
Adult mentor	69.018 <sup>a</sup>	1.511	66.036	72.000	

a. Covariates appearing in the model are evaluated at the following values:  
Age = 15.316.

Pairwise Comparisons						
Dependent Variable: Probation_compliance						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
No mentor	Peer mentor	-3.567	2.023	.239	-8.455	1.322
	Adult mentor	-6.332*	2.085	.008	-11.370	-1.295
Peer mentor	No mentor	3.567	2.023	.239	-1.322	8.455
	Adult mentor	-2.766	2.077	.554	-7.784	2.252
Adult mentor	No mentor	6.332	2.085	.008	1.295	11.370
	Peer mentor	2.766	2.077	.554	-2.252	7.784

Based on estimated marginal means  
a. Adjustment for multiple comparisons: Bonferroni.  
\*. The mean difference is significant at the .05 level.

Drawing the means from the Estimates table and the  $p$  values from the Sig. column on the Pairwise Comparisons table, the following table summarizes the results of this ANCOVA:

Groups (Probation Compliance %)	$p$
No mentor ( $M = 62.69$ ) : Peer mentor ( $M = 66.25$ )	.239
No mentor ( $M = 62.69$ ) : Adult mentor ( $M = 69.02$ )	.008*
Peer mentor ( $M = 66.25$ ) : Adult mentor ( $M = 69.02$ )	.554

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for the age of the parolees ( $M = 15.32$ ).

Since those in the Adult mentor group had a statistically significantly higher probation compliance than those who had no mentor, we would reject  $H_0$ . By that same reasoning, we would not reject  $H_1$ .

(d)

A judge appointed us to evaluate the effectiveness of a new mentorship program for juvenile offenders with priors. The 188 juveniles were randomly assigned to one of three groups: no mentor, a trained peer mentor who is 3 to 5 years older than the offender, or a trained adult mentor. Those paired with an adult mentor had the highest average level of probation compliance ( $M = 69.02$ ), statistically significantly outperforming those who had no mentor ( $M = 62.69$ ) ( $p = .008$ ,  $\alpha = .05$ ). No statistically significant differences in probation compliance were detected between those in no mentor group ( $M = 62.69$ ) and the peer mentor group ( $M = 66.25$ ) ( $p = .239$ ,  $\alpha = .05$ ), or the peer mentor ( $M = 66.69$ ) and the adult mentor ( $M = 69.02$ ) ( $p = .554$ ,  $\alpha = .05$ ). Based on these findings, we reject  $H_0$  and accept  $H_1$ . These results suggest that adult mentors are the optimal choice for enhancing probation compliance for this population.

## EXERCISE 6.3B

Data set: Ch 06 – Exercise 03B.sav

(a)

 $H_0$ : Having a mentor will have no effect on probation compliance. $H_1$ : Having a mentor will have an effect on probation compliance.

(b)

## Tests of Between-Subjects Effects

Dependent Variable: Probation\_compliance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	83.000 <sup>a</sup>	5	16.600	.653	.660
Intercept	3517.477	1	3517.477	138.423	.000
Group	34.522	2	17.261	.679	.510
Age	31.937	1	31.937	1.257	.265
Group * Age	32.538	2	16.269	.640	.530
Error	2287.000	90	25.411		
Total	538776.000	96			
Corrected Total	2370.000	95			

a. R Squared = .035 (Adjusted R Squared = -.019)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .530 *p* value for the *Group \* Age* term, which is greater than (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model, hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances<sup>a</sup>

Dependent Variable: Probation\_compliance

F	df1	df2	Sig.
.360	2	93	.699

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

a. Design: Intercept + Age + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .699  $p$  value, which is greater than (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects					
Dependent Variable: Probation compliance					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50.461 <sup>a</sup>	3	16.820	.667	.574
Intercept	3606.546	1	3606.546	143.047	.000
Age	34.274	1	34.274	1.359	.247
Group	13.340	2	6.670	.265	.768
Error	2319.539	92	25.212		
Total	538776.000	96			
Corrected Total	2370.000	95			

a. R Squared = .021 (Adjusted R Squared = -.011)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .768 for *Group*, which is greater than  $\alpha$  (.05); this indicates that no statistically significant differences have been detected among the groups.

Estimates				
Dependent Variable: Probation compliance				
Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
No mentor	74.264 <sup>a</sup>	.888	72.500	76.029
Peer mentor	75.172 <sup>a</sup>	.889	73.408	76.937
Adult mentor	74.813 <sup>a</sup>	.888	73.051	76.576

a. Covariates appearing in the model are evaluated at the following values:  
Age = 14.868.

Pairwise Comparisons						
Dependent Variable: Probation compliance						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
No mentor	Peer mentor	-.908	1.258	.472	-3.406	1.590
	Adult mentor	-.549	1.256	.663	-3.044	1.945
Peer mentor	No mentor	.908	1.258	.472	-1.590	3.406
	Adult mentor	.359	1.256	.776	-2.135	2.853
Adult mentor	No mentor	.549	1.256	.663	-1.945	3.044
	Peer mentor	-.359	1.256	.776	-2.853	2.135

Based on estimated marginal means  
a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Drawing the means from the Estimates table and the *p* values from the Sig. column on the Pairwise Comparisons table, the following table summarizes the results of this ANCOVA:

Groups (Probation Compliance %)	<i>p</i>
No mentor (M = 74.26) : Peer mentor (M = 75.17)	.472
No mentor (M = 74.26) : Adult mentor (M = 74.81)	.663
Peer mentor (M = 75.17) : Adult mentor (M = 74.81)	.776

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for the age of the parolees (M = 14.87).

All of the *p* values are greater than .05 indicating that there are no statistically significant differences among these groups, hence would accept  $H_0$  and reject  $H_1$ .

(d)

A judge appointed us to evaluate the effectiveness of a new mentorship program for juvenile offenders with priors. The 96 juveniles were randomly assigned to one of three groups: no mentor, a trained peer mentor who is 3 to 5 years older than the offender, or a trained adult mentor. Those paired with a peer mentor had the highest average level of probation compliance (M = 75.17) had the highest probation compliance, followed by those who had an adult mentor (M = 74.81), and finally, those who had no mentor (M = 74.26), controlling for the age of the parolee. No statistically significant differences were detected among these groups; pairwise *p* values ranged from .427 to .776 ( $= .05$ ). Based on these findings, we accept  $H_0$  and reject  $H_1$ . These results suggest that we need to review and enhance our mentor training program and possibly our mentor recruitment criteria.

## EXERCISE 6.5A

Data set: Ch 06 – Exercise 05A.sav

(a)

 $H_0$ : Increasing paid time off will not affect employee morale. $H_1$ : Increasing paid time off will affect employee morale.

(b)

## Tests of Between-Subjects Effects

Dependent Variable: Morale

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	135.530 <sup>a</sup>	5	27.106	2.211	.057
Intercept	7575.375	1	7575.375	618.018	.000
Site	6.009	2	3.004	.245	.783
Seniority	4.419	1	4.419	.361	.549
Site * Seniority	18.765	2	9.383	.765	.467
Error	1679.281	137	12.258		
Total	51929.000	143			
Corrected Total	1814.811	142			

a. R Squared = .075 (Adjusted R Squared = .041)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .467 *p* value for the *Site \* Seniority* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model; hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances<sup>a</sup>

Dependent Variable: Morale

F	df1	df2	Sig.
2.626	2	140	.076

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

a. Design: Intercept + Seniority + Site

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .076 *p* value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects					
Dependent Variable: Morale					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	116.765 <sup>a</sup>	3	38.922	3.186	.026
Intercept	7775.371	1	7775.371	636.482	.000
Seniority	7.053	1	7.053	.577	.449
Site	111.029	2	55.514	4.544	.012
Error	1698.047	139	12.216		
Total	51929.000	143			
Corrected Total	1814.811	142			

a. R Squared = .064 (Adjusted R Squared = .044)

The *Tests of Between-Subjects Effects* table indicates a *p* value of .012 for *Site*, which is less than  $\alpha$  (.05); this indicates that statistically a significant difference has been detected among the groups.

Estimates				
Dependent Variable: Morale				
Site	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
2 Weeks PTO	17.486 <sup>a</sup>	.510	16.478	18.494
2 Weeks PTO + 4th Fridays off	19.511 <sup>a</sup>	.472	18.577	20.444
3 Weeks PTO	19.075 <sup>a</sup>	.547	17.994	20.156

a. Covariates appearing in the model are evaluated at the following values: Seniority = 10.0245.

Pairwise Comparisons						
Dependent Variable: Morale						
(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
2 Weeks PTO	2 Weeks PTO + 4th Fridays off	-2.024 <sup>*</sup>	.695	.013	-3.708	-.340
	3 Weeks PTO	-1.589	.747	.106	-3.400	.222
2 Weeks PTO + 4th Fridays off	2 Weeks PTO	2.024 <sup>*</sup>	.695	.013	.340	3.708
	3 Weeks PTO	.435	.723	1.000	-1.317	2.188
3 Weeks PTO	2 Weeks PTO	1.589	.747	.106	-.222	3.400
	2 Weeks PTO + 4th Fridays off	-.435	.723	1.000	-2.188	1.317

Based on estimated marginal means  
 \*. The mean difference is significant at the .05 level.  
 a. Adjustment for multiple comparisons: Bonferroni.

Drawing the means from the Estimates table and the  $p$  values from the Sig. column on the Pairwise Comparisons table, the following table summarizes the results of this ANCOVA:

Sites (Morale)	$p$
2 Weeks PTO ( $M = 17.49$ ) : 2 Weeks PTO + 4th Fridays off ( $M = 19.51$ )	.013*
2 Weeks PTO ( $M = 17.49$ ) : 3 Weeks PTO ( $M = 19.08$ )	.106
2 Weeks PTO + 4th Fridays off ( $M = 19.51$ ) : 3 Weeks PTO ( $M = 19.08$ )	1.000

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for years of employment ( $M = 10$ ).

Controlling for seniority, we discovered that employees working at a site which provides 2 weeks of PTO per year with the last Friday of the month off (with pay) had a statistically significantly higher morale ( $M = 19.51$ ) compared to those at a different site that had 2 weeks of PTO per year ( $M = 17.49$ ) ( $p = .013$ ). We detected no statistically significant differences in morale between the site that received 2 weeks of PTO ( $M = 17.49$ ) and the site that received 3 weeks of PTO ( $M = 19.08$ ) ( $p = .106$ ) or the site that had 2 weeks of PTO + the last Friday of the month off ( $M = 19.51$ ) and the site that had 3 weeks of PTO off per year ( $M = 19.08$ ) ( $p = 1.000$ ). Since a difference was detected between one pair of sites, I would reject  $H_0$  and accept  $H_1$ .

(d)

In order to assess methods of improving employee morale, we conducted a study of our 143 employees distributed over three sites statistically controlling for employment seniority: The employees at site 1 received the usual 2 weeks of PTO (Paid Time Off) per year scored a mean of 17.49 on the Acme Morale Scale, wherein 1 = extremely low morale, and 25 = extremely high morale. The employees at site 2 received the same 2 weeks of PTO per year plus the last Friday of each month off (with pay); their mean morale score was 19.51. The employees at site 3, who have 3 weeks of PTO per year had a mean morale score of 19.08. Pairwise comparisons showed that employees who received 2 weeks of PTO plus every 4th Friday off had statistically significantly higher morale compared to those who received (only) 2 weeks of PTO ( $p = .013$ ,  $\alpha = .05$ ). No statistically significant differences were detected between the site that received 2 weeks of PTO and the site that received 3 weeks of PTO ( $p = .106$ ). Additionally, no statistically significant differences were detected between the site that received 2 weeks of PTO plus the 4th Friday off and the site that received 3 weeks of PTO ( $p = 1.000$ ). Based on these findings, we would reject  $H_0$  in favor of  $H_1$ . Since we detected no statistically significant difference in morale between sites 2 and 3, we are considering changing site 2 to 3 weeks of PTO per year.



## EXERCISE 6.5B

Data set: Ch 06 – Exercise 05B.sav

(a)

 $H_0$ : Increasing paid time off will not affect employee morale. $H_1$ : Increasing paid time off will affect employee morale.

(b)

Tests of Between-Subjects Effects					
Dependent Variable: Morale					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	182.190 <sup>a</sup>	5	36.438	1.756	.128
Intercept	4014.349	1	4014.349	193.490	.000
Site	3.382	2	1.691	.082	.922
Seniority	106.391	1	106.391	5.128	.026
Site * Seniority	14.921	2	7.460	.360	.699
Error	2219.934	107	20.747		
Total	26612.000	113			
Corrected Total	2402.124	112			

a. R Squared = .076 (Adjusted R Squared = .033)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .699  $p$  value for the *Site \* Seniority* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model; hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable: Morale			
F	df1	df2	Sig.
.535	2	110	.587

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Seniority + Site

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .587  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

#### Tests of Between-Subjects Effects

Dependent Variable: Morale

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	167.270 <sup>a</sup>	3	55.757	2.719	.048
Intercept	4720.430	1	4720.430	230.228	.000
Seniority	100.477	1	100.477	4.901	.029
Site	52.830	2	26.415	1.288	.280
Error	2234.854	109	20.503		
Total	26612.000	113			
Corrected Total	2402.124	112			

a. R Squared = .070 (Adjusted R Squared = .044)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .280 for *Site*, which is greater than  $\alpha$  (.05); this indicates that no statistically significant differences have been detected among the groups.

#### Estimates

Dependent Variable: Morale

Site	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
2 Weeks PTO	14.242 <sup>a</sup>	.796	12.664	15.820
2 Weeks PTO + 4th Fridays off	14.059 <sup>a</sup>	.724	12.624	15.494
3 Weeks PTO	15.574 <sup>a</sup>	.726	14.135	17.014

a. Covariates appearing in the model are evaluated at the following values: Seniority = 5.6748.

#### Pairwise Comparisons

Dependent Variable: Morale

(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
2 Weeks PTO	2 Weeks PTO + 4th Fridays off	.183	1.094	1.000	-2.477	2.843
	3 Weeks PTO	-1.332	1.084	.666	-3.969	1.305
2 Weeks PTO + 4th Fridays off	2 Weeks PTO	-.183	1.094	1.000	-2.843	2.477
	3 Weeks PTO	-1.515	1.021	.422	-3.998	.968
3 Weeks PTO	2 Weeks PTO	1.332	1.084	.666	-1.305	3.969
	2 Weeks PTO + 4th Fridays off	1.515	1.021	.422	-.968	3.998

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Drawing the means from the Estimates table and the *p* values from the Sig. column on the Pairwise Comparisons table, the following table summarizes the results of this ANCOVA:

Sites (Morale)	<i>p</i>
2 Weeks PTO ( <i>M</i> = 14.24) : 2 Weeks PTO + 4th Fridays off ( <i>M</i> = 14.06)	1.000
2 Weeks PTO ( <i>M</i> = 14.24) : 3 Weeks PTO ( <i>M</i> = 15.57)	.666
2 Weeks PTO + 4th Fridays off ( <i>M</i> = 14.06) : 3 Weeks PTO ( <i>M</i> = 15.57)	.422

NOTE: Figures adjusted to account for years of employment (*M* = 5.67).

Controlling for seniority, we discovered that employees working at a site which provides 3 weeks of PTO per year have the highest morale (*M* = 15.57), followed by the site that 2 weeks of PTO (*M* = 14.24), and finally the site that gives 2 weeks of PTO per year plus the last Friday of each month off (*M* = 14.06). We detected no statistically significant differences in morale among these three sites; *p* values ranged between .422 and 1.00, hence, I would accept  $H_0$  and reject  $H_1$ .

(d)

In order to assess methods of improving employee morale, we conducted study of our 113 employees distributed over three sites statistically controlling for employment seniority: The employees at site 1 received the usual 2 weeks of PTO (Paid Time Off) per year scored a mean of 14.24 on the Acme Morale Scale, wherein 1 = extremely low morale, and 25 = extremely high morale. The highest level of morale was found at Site 3 (*M* = 15.57), followed by site 1 (*M* = 14.24), and finally, site 2 (*M* = 14.06). The pairwise *p* values comparing these groups to each other ranged from .422 to 1.000, suggesting that there is no statistically significant difference between these groups ( $\alpha = .05$ ); as such, we accept  $H_0$  and reject  $H_1$ . We note an unexpected outcome: The mean moral for site 1 (the site that gets 2 weeks of PTO) is .18 points higher than the mean morale score for site 2, wherein the employees receive two weeks of PTO plus 12 additional days off per year with pay (the last Friday of each month off). These findings suggest that workplace factors other than PTO have an influence over morale.

## EXERCISE 6.7A

Data set: Ch 06 – Exercise 07A.sav

(a)

 $H_0$ : Advertising media will not influence voter choice. $H_1$ : Advertising media will influence voter choice.

(b)

Tests of Between-Subjects Effects					
Dependent Variable: Prop_86					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	37.215 <sup>a</sup>	5	7.443	3.639	.005
Intercept	110.948	1	110.948	54.248	.000
Group	4.646	2	2.323	1.136	.325
Income	.590	1	.590	.288	.593
Group * Income	7.563	2	3.782	1.849	.163
Error	204.520	100	2.045		
Total	1478.000	106			
Corrected Total	241.736	105			

a. R Squared = .154 (Adjusted R Squared = .112)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .163  $p$  value for the *Group \* Income* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model; hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable: Prop_86			
F	df1	df2	Sig.
2.766	2	103	.068

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Income + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .068  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects					
Dependent Variable: Prop_86					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	29.652 <sup>a</sup>	3	9.884	4.754	.004
Intercept	109.103	1	109.103	52.472	.000
Income	.381	1	.381	.183	.670
Group	29.578	2	14.789	7.113	.001
Error	212.084	102	2.079		
Total	1478.000	106			
Corrected Total	241.736	105			

a. R Squared = .123 (Adjusted R Squared = .097)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .001 for *Group*, which is less than  $\alpha$  (.05); this indicates that a statistically significant difference has been detected among the groups.

Estimates				
Dependent Variable: Prop_86				
Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	2.735 <sup>a</sup>	.243	2.254	3.217
Print	3.492 <sup>a</sup>	.244	3.008	3.976
Video	4.037 <sup>a</sup>	.245	3.552	4.522

a. Covariates appearing in the model are evaluated at the following values: Income = \$89,245.28.

Pairwise Comparisons						
Dependent Variable: Prop_86						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
Control	Print	-.757	.346	.093	-1.598	.085
	Video	-1.302 <sup>*</sup>	.347	.001	-2.146	-.458
Print	Control	.757	.346	.093	-.085	1.598
	Video	-.545	.345	.350	-1.384	.294
Video	Control	1.302 <sup>*</sup>	.347	.001	.458	2.146
	Print	.545	.345	.350	-.294	1.384

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

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

Drawing the means from the Estimates table and the  $p$  values from the Sig. column on the Pairwise Comparisons table, the following table summarizes the results of this ANCOVA:

Groups (Prop 86)	$p$
Control ( $M = 2.74$ ) : Print ( $M = 3.49$ )	.093
Control ( $M = 2.74$ ) : Video ( $M = 4.04$ )	.001*
Print ( $M = 3.49$ ) : Video ( $M = 4.04$ )	.350

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for annual gross household income ( $M = \$89,245$ ).

The video group scored significantly higher than the control group; based on these results, I would reject  $H_0$  and accept  $H_1$ .

(d)

In order to determine the most persuasive form of advertisement to encourage people to vote *yes* on Proposition 86, we convened focus groups consisting of registered voters. We recruited 106 participants and randomly assigned them to one of three media groups: control (no media), print advertisement, and video advertisement. Prior to dismissing the participants, each was asked to indicate the likelihood that they would vote *yes* on proposition 86 using a 1 to 7 scale (1 = Will definitely vote *no* . . . 7 = Will definitely vote *yes*), controlling for income. The video ( $M = 4.04$ ) significantly outperformed the control group ( $M = 2.74$ ) ( $p = .001$ ). Although the video group produced a higher mean than the print group ( $M = 3.49$ ), the difference between the groups is insignificant ( $p = .093$ ). Additionally, there was no statistically significant difference detected between the control group and the print group ( $p = .350$ ). Based on these findings, we reject  $H_0$  and accept  $H_1$ . Considering that there is no statistically significant difference between the video and the print version of the ad, if video is not accessible or affordable, the print version could be used.

## EXERCISE 6.7B

Data set: Ch 06 – Exercise 07B.sav

(a)

 $H_0$ : Advertising media will not influence voter choice. $H_1$ : Advertising media will influence voter choice.

(b)

Tests of Between-Subjects Effects					
Dependent Variable: Prop_86					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.951 <sup>a</sup>	5	3.390	1.124	.352
Intercept	123.145	1	123.145	40.825	.000
Group	3.095	2	1.548	.513	.600
Income	.288	1	.288	.095	.758
Group * Income	6.885	2	3.443	1.141	.323
Error	352.919	117	3.016		
Total	2306.000	123			
Corrected Total	369.870	122			

a. R Squared = .046 (Adjusted R Squared = .005)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .323  $p$  value for the *Group \* Income* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model; hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable: Prop_86			
F	df1	df2	Sig.
2.054	2	120	.133

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Income + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .133  $p$  value, which is greater than (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

**Tests of Between-Subjects Effects**

Dependent Variable: Prop\_86

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.066 <sup>a</sup>	3	3.355	1.110	.348
Intercept	132.110	1	132.110	43.694	.000
Income	.485	1	.485	.160	.690
Group	10.058	2	5.029	1.663	.194
Error	359.804	119	3.024		
Total	2306.000	123			
Corrected Total	369.870	122			

a. R Squared = .027 (Adjusted R Squared = .003)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .194 for *Group*, which is greater than  $\alpha$  (.05); this indicates that no statistically significant difference has been detected among the groups.

**Estimates**

Dependent Variable: Prop\_86

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	4.022 <sup>a</sup>	.262	3.503	4.541
Print	3.563 <sup>a</sup>	.285	2.999	4.127
Video	4.284 <sup>a</sup>	.274	3.741	4.827

a. Covariates appearing in the model are evaluated at the following values: Income = \$55,146.34.

**Pairwise Comparisons**

Dependent Variable: Prop\_86

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
Control	Print	.459	.387	.713	-.481	1.399
	Video	-.262	.380	1.000	-1.183	.660
Print	Control	-.459	.387	.713	-1.399	.481
	Video	-.721	.399	.221	-1.690	.249
Video	Control	.262	.380	1.000	-.660	1.183
	Print	.721	.399	.221	-.249	1.690

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.



Drawing the means from the Estimates table and the *p* values from the Sig. column on the Pairwise Comparisons table, the following table summarizes the results of this ANCOVA:

Groups (Prop 86)	<i>p</i>
Control (M = 4.02) : Print (M = 3.56)	.713
Control (M = 4.02) : Video (M = 4.28)	1.000
Print (M = 3.56) : Video (M = 4.28)	.221

\*Statistically significant ( $p \leq .05$ ).

NOTE: Figures adjusted to account for annual gross household income (M = \$55,146).

These findings indicate that there are no statistically significant differences in voter likelihood among the three groups; the means range from 3.56 to 4.28 and the *p* values range from .221 to 1.000. Since none of the pairwise comparisons produced a *p* value less than .05, I would accept  $H_0$  and reject  $H_1$ .

(d)

In order to determine the most persuasive form of advertisement to encourage people to vote *yes* on Proposition 86, we convened focus groups consisting of registered voters. We recruited 106 participants and randomly assigned them to one of three media groups control (no media), print advertisement, and video advertisement. Prior to dismissing the participants, each was asked to indicate the likelihood that they would vote *yes* on proposition 86 using a 1 to 7 scale (1 = Will definitely vote *no* . . . 7 = Will definitely vote *yes*), controlling for household income. Pairwise assessments of the control group (M = 4.02), print group (M = 3.56), and video group (M = 4.28) produced *p* values between ranging from .221 to 1.000, indicating that no statistically significant differences were detected among these groups ( $\alpha = .05$ ). Based on these findings, we accept  $H_0$  and reject  $H_1$ . These findings indicate that these print and video advertisements were essentially ineffective when it comes to prompting a change in voter opinion on Proposition 86. Further, it is notable that the print advertisement produced a lower score than the control group, which reviewed no advertisement(s).

## EXERCISE 6.9A

Data set: Ch 06 – Exercise 09A.sav

(a)

 $H_0$ : Lighting source has no effect on reading rate. $H_1$ : Lighting source has an effect on reading rate.

(b)

Tests of Between-Subjects Effects					
Dependent Variable:Seconds					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	170335.858 <sup>a</sup>	7	24333.694	367.567	.000
Intercept	2065505.800	1	2065505.800	31199.987	.000
Group	465.986	3	155.329	2.346	.077
Age	137804.348	1	137804.348	2081.569	.000
Group * Age	398.783	3	132.928	2.008	.118
Error	6554.012	99	66.202		
Total	1.922E7	107			
Corrected Total	176889.869	106			

a. R Squared = .963 (Adjusted R Squared = .960)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .118 *p* value for the *Group \* Exercise* term, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model; hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable:Seconds			
F	df1	df2	Sig.
.740	3	103	.530

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Age + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .530  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects

Dependent Variable:Seconds

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	169937.074 <sup>a</sup>	4	42484.269	623.259	.000
Intercept	2166627.153	1	2166627.153	31785.200	.000
Age	144432.869	1	144432.869	2118.882	.000
Group	157.872	3	52.624	.772	.512
Error	6952.795	102	68.165		
Total	1.922E7	107			
Corrected Total	176889.869	106			

a. R Squared = .961 (Adjusted R Squared = .959)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .512 for *Group*, which is greater than  $\alpha$  (.05); this indicates that no statistically significant differences have been detected between among the groups.

Estimates

Dependent Variable:Seconds

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Room lighting	423.818 <sup>a</sup>	1.672	420.502	427.134
Acme lamp	421.049 <sup>a</sup>	1.594	417.887	424.212
Generic lamp	420.578 <sup>a</sup>	1.526	417.551	423.604
Flashlight	422.535 <sup>a</sup>	1.734	419.097	425.974

a. Covariates appearing in the model are evaluated at the following values: Age = 37.77.

Pairwise Comparisons

Dependent Variable:Seconds

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
Room lighting	Acme lamp	2.768	2.347	1.000	-3.547	9.084
	Generic lamp	3.240	2.291	.962	-2.924	9.404
	Flashlight	1.282	2.364	1.000	-5.078	7.643
Acme lamp	Room lighting	-2.768	2.347	1.000	-9.084	3.547
	Generic lamp	.472	2.171	1.000	-5.371	6.314
	Flashlight	-1.486	2.411	1.000	-7.974	5.002
Generic lamp	Room lighting	-3.240	2.291	.962	-9.404	2.924
	Acme lamp	-.472	2.171	1.000	-6.314	5.371
	Flashlight	-1.958	2.351	1.000	-8.283	4.368
Flashlight	Room lighting	-1.282	2.364	1.000	-7.643	5.078
	Acme lamp	1.486	2.411	1.000	-5.002	7.974
	Generic lamp	1.958	2.351	1.000	-4.368	8.283

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Drawing the means from the *Estimates* table and the  $p$  values from the Sig. column on the *Pariwise Comparisons* table, the following table summarizes the results of this ANCOVA:

Groups (Reading Time in Seconds)	$p$
Room lighting (M = 424) : Acme lamp (M = 421)	1.000
Room lighting (M = 424) : Generic lamp (M = 421)	.962
Room lighting (M = 424) : Flashlight (M = 423)	1.000
Acme lamp (M = 421) : Generic lamp (M = 421)	1.000
Acme lamp (M = 421) : Flashlight (M = 423)	1.000
Generic lamp (M = 421) : Flashlight (M = 423)	1.000

NOTE: Means rounded to nearest second.

Figures adjusted to account for the age of each participant (M = 37.77).

Since all of the all of the  $p$  values are greater than .05, I would accept  $H_0$  and reject  $H_1$ .

(d)

We divided 107 participants into four groups to discover if the lighting source had an effect how long it took them to read a 1,000-word essay, controlling for age. The mean reading times were as follows: Acme Lamp M = 421 seconds, Generic lamp M = 421 seconds, Flashlight M = 423 seconds, room lighting M = 424 seconds. All pairwise comparisons rendered  $p = 1.000$  except for room lighting : generic lighting ( $p = .962$ ). Using the traditional .05  $\alpha$  level, no statistically significant differences were detected. As such, we accept  $H_0$  and reject  $H_1$ . These findings reflect a 3 second range (421 – 424) in mean reading speed across these four groups, which at face value is essentially insignificant. Our recommendation is that individuals select a lighting source that fits their taste and price preference.

## EXERCISE 6.9B

Data set: Ch 06 – Exercise 09B.sav

(a)

 $H_0$ : Lighting source has no effect on reading rate. $H_1$ : Lighting source has an effect on reading rate.

(b)

Tests of Between-Subjects Effects					
Dependent Variable:Seconds					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	24806.097 <sup>a</sup>	7	3543.728	2.182	.043
Intercept	362818.186	1	362818.186	223.434	.000
Group	3186.105	3	1062.035	.654	.582
Age	112.809	1	112.809	.069	.793
Group * Age	3585.649	3	1195.216	.736	.533
Error	149391.903	92	1623.825		
Total	1.812E7	100			
Corrected Total	174198.000	99			

a. R Squared = .142 (Adjusted R Squared = .077)

**Pretest criterion 1: Homogeneity of regression slopes:** The *Tests of Between-Subjects Effects* table produced a .118  $p$  value for the *Group \* Exercise* term, which is greater than (.05), indicating that there are no statistically significant differences among the slopes of the regression lines involved in this model; hence, this criterion is satisfied.

(c)

Levene's Test of Equality of Error Variances <sup>a</sup>			
Dependent Variable:Seconds			
F	df1	df2	Sig.
1.243	3	96	.298

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.  
a. Design: Intercept + Age + Group

**Pretest criterion 2: Homogeneity of variance (Levene's test):** The *Levene's Test of Equality of Error Variances* table produced a .298  $p$  value, which is greater than  $\alpha$  (.05), indicating that there are no statistically significant differences among the variances; hence, this criterion is satisfied.

Tests of Between-Subjects Effects

Dependent Variable:Seconds

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21220.448 <sup>a</sup>	4	5305.112	3.295	.014
Intercept	378696.896	1	378696.896	235.173	.000
Age	153.488	1	153.488	.095	.758
Group	20611.291	3	6870.430	4.267	.007
Error	152977.552	95	1610.290		
Total	1.812E7	100			
Corrected Total	174198.000	99			

a. R Squared = .122 (Adjusted R Squared = .085)

The *Tests of Between-Subjects Effects* table indicates a  $p$  value of .007 for *Group*, which is less than  $\alpha$  (.05); this indicates that a statistically significant difference has been detected between among the groups. For further details as to which group(s) significantly outperformed which, we look to the *Pairwise Comparisons* table.

Estimates

Dependent Variable:Seconds

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Room lighting	416.516 <sup>a</sup>	8.030	400.576	432.457
Acme lamp	415.931 <sup>a</sup>	8.097	399.857	432.006
Generic lamp	413.476 <sup>a</sup>	8.053	397.489	429.463
Flashlight	448.476 <sup>a</sup>	8.053	432.489	464.463

a. Covariates appearing in the model are evaluated at the following values: Age = 27.04.

Pairwise Comparisons

Dependent Variable:Seconds

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. <sup>a</sup>	95% Confidence Interval for Difference <sup>a</sup>	
					Lower Bound	Upper Bound
Room lighting	Acme lamp	.585	11.380	1.000	-30.080	31.250
	Generic lamp	3.040	11.386	1.000	-27.641	33.722
	Flashlight	-31.960 <sup>*</sup>	11.386	.036	-62.641	-1.278
Acme lamp	Room lighting	-.585	11.380	1.000	-31.250	30.080
	Generic lamp	2.455	11.482	1.000	-28.484	33.394
	Flashlight	-32.545 <sup>*</sup>	11.482	.034	-63.484	-1.606
Generic lamp	Room lighting	-3.040	11.386	1.000	-33.722	27.641
	Acme lamp	-2.455	11.482	1.000	-33.394	28.484
	Flashlight	-35.000 <sup>*</sup>	11.350	.016	-65.584	-4.416
Flashlight	Room lighting	31.960	11.386	.036	1.278	62.641
	Acme lamp	32.545 <sup>*</sup>	11.482	.034	1.606	63.484
	Generic lamp	35.000 <sup>*</sup>	11.350	.016	4.416	65.584

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

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

Drawing the means from the *Estimates* table and the  $p$  values from the Sig. column on the *Pairwise Comparisons* table, the following table summarizes the results of this ANCOVA:

Groups (Reading Time in Seconds)	$p$
Room lighting (M = 417) : Acme lamp (M = 416)	1.000
Room lighting (M = 417) : Generic lamp (M = 413)	1.000
Room lighting (M = 417) : Flashlight (M = 448)	.036*
Acme lamp (M = 416) : Generic lamp (M = 413)	1.000
Acme lamp (M = 416) : Flashlight (M = 448)	.034*
Generic lamp (M = 413) : Flashlight (M = 448)	.016*

\*Statistically significant ( $p \leq .05$ ).

NOTE: Means rounded to nearest second.

Figures adjusted to account for the age of each participant (M = 27.04).

Since at least one of the  $p$  values is less than .05, I would reject  $H_0$  and accept  $H_1$ .

(d)

We divided 100 participants into four groups to discover if the lighting source had an effect how long it took them to read a 1,000-word essay, controlling for age. The mean reading times were as follows: Generic lamp M = 413 seconds, Acme Lamp M = 416 seconds, room lighting M = 417 seconds, Flashlight M = 448 seconds,. All pairwise comparisons between the generic lamp, the Acme lamp, and room lighting produced a  $p$  value of 1.000, indicating that there no statistically significant differences in reading time(s) among these groups using the traditional  $\alpha$  level of .05. Those who were assigned to read using a flashlight had a statistically significant longer mean read time compared to the other three groups: Flashlight : Generic lamp ( $p = .016$ ), Flashlight : Acme lamp ( $p = .034$ ), and Flashlight : room lighting ( $p = .036$ ). These findings lead us to reject  $H_0$  and accept  $H_1$ . These lighting sources seem to be equivalent in terms of reading time, with the exception of the flashlight, which seems to slow down reading time.