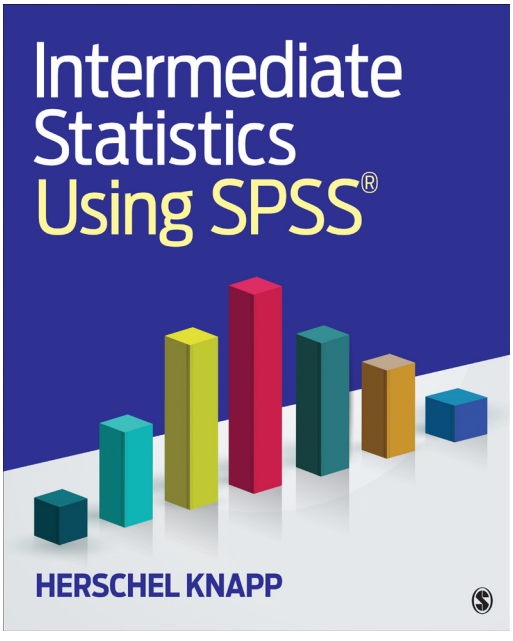


C H A P T E R 9

ANOVA Repeated Measures

Solutions to Odd-Numbered Exercises

Contents

EXERCISE 9.1A

Data set: Ch 9 – Exercise 01A.sav

(a)

H_0: Data entry time will not change.

H_1: Data entry time will change.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	.987	1.751	2	.417	.987	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Time

Mauchly's Test of Sphericity produced a *p* value of .417; since this is greater than α (.05), this indicates that there are no statistically significant differences among the variances, hence this pretest criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	372533.886	2	186266.943	1124.226	.000
	Greenhouse-Geisser	372533.886	1.974	188721.478	1124.226	.000
	Huynh-Feldt	372533.886	2.000	186266.943	1124.226	.000
	Lower-bound	372533.886	1.000	372533.886	1124.226	.000
Error(Time)	Sphericity Assumed	44072.114	266	165.685		
	Greenhouse-Geisser	44072.114	262.540	167.868		
	Huynh-Feldt	44072.114	266.000	165.685		
	Lower-bound	44072.114	133.000	331.369		

The *p* value for Time, Sphericity Assumed is .000; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Week1	301.89	14.550	134
Week2	240.91	12.636	134
Week3	234.23	11.719	134

The Descriptive Statistics table provides the mean, SD and *n* for each of the three time points.

Pairwise Comparisons

Measure:MEASURE_1

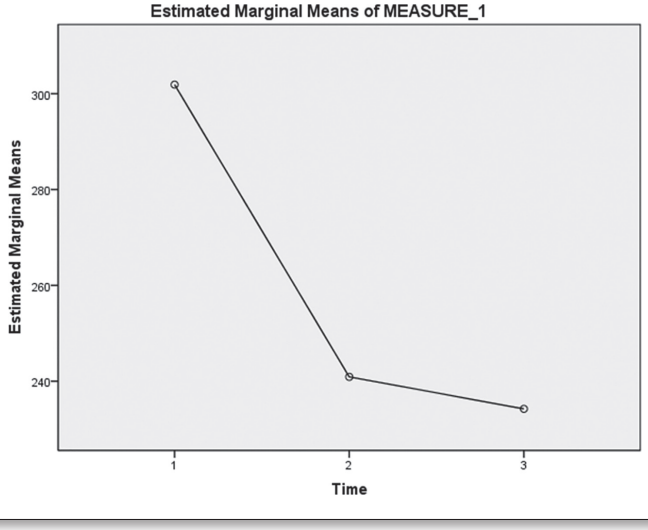
(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	60.978*	1.508	.000	57.995	63.960
	3	67.657*	1.658	.000	64.378	70.935
2	1	-60.978*	1.508	.000	-63.960	-57.995
	3	6.679*	1.549	.000	3.616	9.742
3	1	-67.657*	1.658	.000	-70.935	-64.378
	2	-6.679*	1.549	.000	-9.742	-3.616

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically significant decrease from Time1 to Time2, and Time2 to Time3.

Times (in Seconds)	*p*
$Time_1$ (M = 301.89) : $Time_2$ (M = 240.91)	.000*
$Time_2$ (M = 240.91) : $Time_3$ (M = 234.23)	.000*
$Time_1$ (M = 301.89) : $Time_3$ (M = 234.23)	.000*

*Statistically significant difference detected between groups ($p \leq .05$).

Based on these results, I would reject H_0 and accept H_1.

(d)

In order to assess the efficiency of a new website for employees to enter their hours, we gathered data on 134 employees tracking how long it took them to make the necessary entries correctly. In the first week, mean completion time was 302 seconds; by week 2, that was down significantly to 241 seconds ($p < .001$, $\alpha = .05$); in the third week, another significant drop to 234 seconds was also observed ($p < .001$, $\alpha = .05$). This steady decline seems to characterize a progressive learning curve for this website. Based on these findings, we reject H_0 and accept H_1.

EXERCISE 9.1B

Data set: Ch 9 – Exercise 01B.sav

(a)

H_0: Data entry time will not change.

H_1: Data entry time will change.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	.943	1.458	2	.482	.946	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Time

Mauchly's Test of Sphericity produced a *p* value of .482; since this is greater than α (.05), this indicates that there are no statistically significant differences among the variances; hence, this pretest criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	39372.247	2	19686.123	119.248	.000
	Greenhouse-Geisser	39372.247	1.893	20801.608	119.248	.000
	Huynh-Feldt	39372.247	2.000	19686.123	119.248	.000
	Lower-bound	39372.247	1.000	39372.247	119.248	.000
Error(Time)	Sphericity Assumed	8584.420	52	165.085		
	Greenhouse-Geisser	8584.420	49.212	174.439		
	Huynh-Feldt	8584.420	52.000	165.085		
	Lower-bound	8584.420	26.000	330.170		

The *p* value for Time, Sphericity Assumed is .000; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Week1	301.78	10.282	27
Week2	331.26	13.008	27
Week3	277.33	13.519	27

The Descriptive Statistics table provides the mean, SD and *n* for each of the three time points.

Pairwise Comparisons

Measure:MEASURE_1

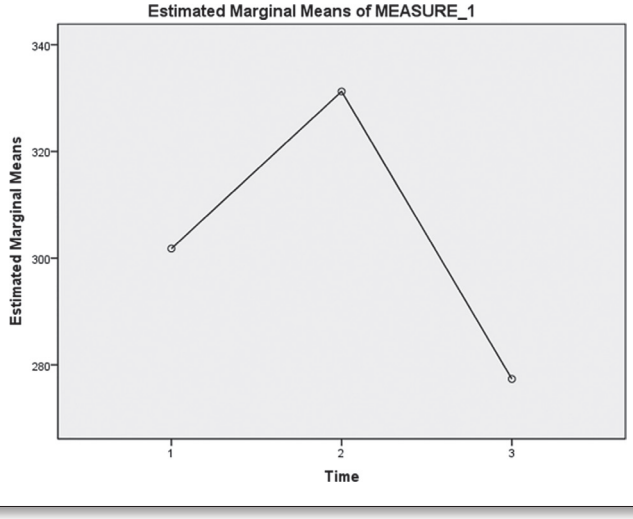
(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-29.481*	3.281	.000	-36.226	-22.737
	3	24.444*	3.284	.000	17.695	31.194
2	1	29.481*	3.281	.000	22.737	36.226
	3	53.926*	3.891	.000	45.928	61.924
3	1	-24.444*	3.284	.000	-31.194	-17.695
	2	-53.926*	3.891	.000	-61.924	-45.928

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically significant increase from Time1 to Time2 and the significant decrease from Time2 to Time3.

Time (in Seconds)	*p*
$Time_1$ (M = 302) : $Time_2$ (M = 331)	.000*
$Time_2$ (M = 331) : $Time_3$ (M = 227)	.000*
$Time_1$ (M = 302) : $Time_3$ (M = 227)	.000*

*Statistically significant difference detected between groups ($p \leq 05$).

Based on these results, I would reject H_0 and accept H_1.

(d)

In order to assess the efficiency of a new website for employees to enter their hours, we gathered data on 27 employees tracking how long it took them to make the necessary entries correctly. In the first week, mean completion time was 302 seconds; by week 2, mean completion showed a significant increase to 331 seconds ($p < .001$, $\alpha = .05$), however in the third week that decreased significantly to 227 seconds ($p < .001$, $\alpha = .05$) – the shortest time yet. Based on these findings, we reject H_0 and accept H_1. We will continue to monitor the completion time on a weekly basis, and investigate possible anomalies that may have caused the unexpected increase in week 2 (e.g., high internet traffic, office distractions, software glitch).

EXERCISE 9.3A

Data set: Ch 9 – Exercise 03A.sav

(a)

H_0: Short-term therapy is effective in reducing depression.

H_1: Short-term therapy is ineffective in reducing depression.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	.401	14.618	2	.001	.625	.651	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Time

Mauchly's Test of Sphericity produced a *p* value of .001; since this is less than α (.05); this indicates that there is a statistically significant difference among the variances.

According to the Descriptive Statistics table, the variance increased for each session (based on the Standard Deviations); for Session 1 it was 79.09 (8.893^2), for Session 2 it was 116.25 (10.782^2), and for Session 3 it was142.83 (11.951^2). Since this criterion is not fully satisfied, this will be mentioned in the results section.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	111.815	2	55.907	6.389	.004
	Greenhouse-Geisser	111.815	1.251	89.392	6.389	.015
	Huynh-Feldt	111.815	1.303	85.839	6.389	.013
	Lower-bound	111.815	1.000	111.815	6.389	.022
Error(Time)	Sphericity Assumed	297.519	34	8.751		
	Greenhouse-Geisser	297.519	21.264	13.992		
	Huynh-Feldt	297.519	22.144	13.435		
	Lower-bound	297.519	17.000	17.501		

The *p* value for Time, Sphericity Assumed is .004; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Baseline	53.83	8.893	18
Week05	52.44	10.782	18
Week10	50.33	11.951	18

The Descriptive Statistics table provides the mean, SD and *n* for each of the three time points.

Pairwise Comparisons

Measure:MEASURE_1

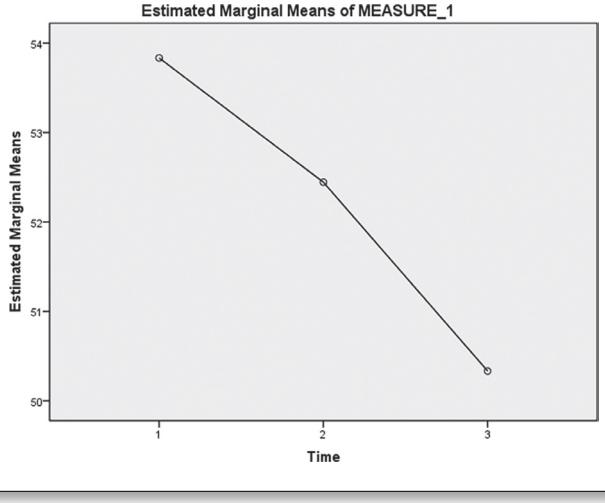
(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	1.389	.994	.180	-.708	3.486
	3	3.500*	1.271	.014	.818	6.182
2	1	-1.389	.994	.180	-3.486	.708
	3	2.111*	.559	.002	.931	3.291
3	1	-3.500*	1.271	.014	-6.182	-.818
	2	-2.111*	.559	.002	-3.291	-.931

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

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

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically insignificant decrease from Time1 to Time2 and the significant decrease from Time2 to Time3.

Times (ADI Score)	*p*
Baseline (M = 53.83) : Weeks 5 (M = 52.44)	.180
Week 5 (M = 52.44) : Week 10 (M = 50.33)	.002*
Baseline (M = 53.83) : Week 10 (M = 50.33)	.014*

*Statistically significant difference detected between groups ($p \leq .05$)

Based on these results, I would reject H_0 and accept H_1.

(d)

To determine the effectiveness of a short term therapeutic intervention designed to reduce depression, we gathered data at three time points using the Acme Depression Inventory (0 = low depression . . . 75 = high depression) from 18 voluntary patients in our outpatient clinic. At five weeks the mean ADI score of 52.44 (SD = 10.76) showed a moderate decline from the mean baseline score of 53.83 (SD = 8.89) ($p = .180$, $\alpha = .05$). The sessions concluded at week 10, wherein the mean ADI score dropped further to 50.33 (SD = 11.95), signifying a significant improvement compared to week 5 ($p = .002$, $\alpha = .05$). Overall, this form of therapy demonstrated a significant 6.5% reduction in depression over the course of the 10 weeks ($p = .014$, $\alpha = .05$) suggesting the efficacy of this treatment. However, the significant difference in variances between the three sessions suggests reason to suspect the reliability of these findings. We plan to collect additional data with a larger sample of patients and test for the effects again.

EXERCISE 9.3B

Data set: Ch 9 – Exercise 03B.sav

(a)

H_0: Short-term therapy is ineffective in treating depression

H_1: Short-term therapy is effective in treating depression

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	.822	2.554	2	.279	.849	.953	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Time

Mauchly's Test of Sphericity produced a *p* value of .279; since this is greater than α (.05), this indicates that there are no statistically significant differences among the variances, hence this pretest criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	71.644	2	35.822	10.198	.000
	Greenhouse-Geisser	71.644	1.697	42.211	10.198	.001
	Huynh-Feldt	71.644	1.907	37.572	10.198	.001
	Lower-bound	71.644	1.000	71.644	10.198	.007
Error(Time)	Sphericity Assumed	98.356	28	3.513		
	Greenhouse-Geisser	98.356	23.762	4.139		
	Huynh-Feldt	98.356	26.696	3.684		
	Lower-bound	98.356	14.000	7.025		

The *p* value for Time, Sphericity Assumed is .000; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Baseline	69.80	2.007	15
Week05	67.00	3.485	15
Week10	67.27	3.634	15

The Descriptive Statistics table provides the mean, SD and *n* for each of the three time points.

Pairwise Comparisons

Measure:MEASURE_1

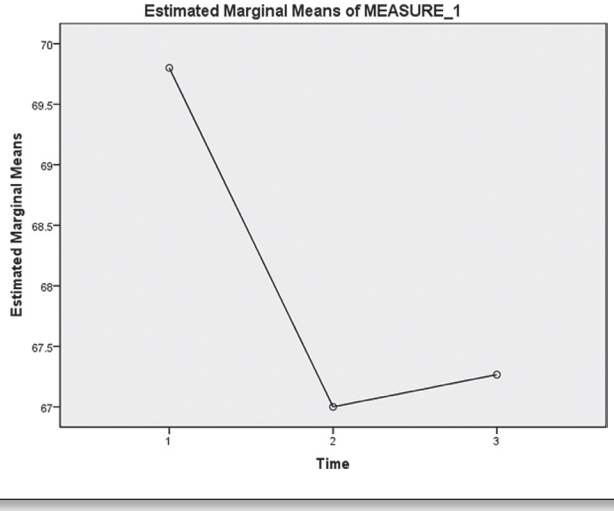
(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	2.800*	.745	.002	1.203	4.397
	3	2.533*	.761	.005	.900	4.166
2	1	-2.800*	.745	.002	-4.397	-1.203
	3	-.267	.521	.617	-1.383	.850
3	1	-2.533*	.761	.005	-4.166	-.900
	2	.267	.521	.617	-.850	1.383

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically significant decrease from Time1 to Time2 and the insignificant increase from Time2 to Time3.

Times (ADI Score)	*p*
Baseline (M = 69.80) : Weeks 5 (M = 67.00)	.002*
Week 5 (M = 67.00) : Week 10 (M = 67.27)	.617
Baseline (M = 69.80) : Week 10 (M = 67.27)	.005*

*Statistically significant difference detected between groups ($p \leq .05$)

Based on these results, I would reject H_0 and accept H_1.

(d)

To determine the effectiveness of a short term therapeutic intervention designed to reduce depression, we gathered data at three time points using the Acme Depression Inventory (0 = low depression . . . 75 = high depression) from 15 voluntary patients in our outpatient clinic. At five weeks the mean ADI score of 67.00 (SD = 3.48) showed a significant decline from the mean baseline score of 69.80 (SD = 2.01) ($p = .002$, $\alpha = .05$). The sessions concluded at week 10, wherein the mean ADI score showed an insignificant increase to 67.27 (SD = 3.63) compared to week 5 ($p = .617$, $\alpha = .05$). Overall, this form of therapy demonstrated a significant 3.6% reduction in depression over the course of the 10 weeks ($p = .005$, $\alpha = .05$) suggesting the efficacy of this treatment.

EXERCISE 9.5A

Data set: Ch 9 – Exercise 05A.sav

(a)

H_0: Providing free coffee has no effect on productivity.

H_1: Providing free coffee has an effect on productivity.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Week	.996	.034	2	.983	.996	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Week

Mauchly's Test of Sphericity produced a *p* value of .983; since this is greater than α (.05), this indicates that there are no statistically significant differences among the variances; hence, this pretest criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Week	Sphericity Assumed	8.867	2	4.433	.579	.571
	Greenhouse-Geisser	8.867	1.992	4.452	.579	.570
	Huynh-Feldt	8.867	2.000	4.433	.579	.571
	Lower-bound	8.867	1.000	8.867	.579	.466
Error(Week)	Sphericity Assumed	137.800	18	7.656		
	Greenhouse-Geisser	137.800	17.925	7.688		
	Huynh-Feldt	137.800	18.000	7.656		
	Lower-bound	137.800	9.000	15.311		

The *p* value for Time, Sphericity Assumed is .571; since this is greater than α (.05); this indicates that no statistically significant difference have been detected among of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Productivity_1	80.00	2.357	10
Productivity_2	78.80	2.974	10
Productivity_3	78.90	3.381	10

The Descriptive Statistics table provides the mean, SD and *n* for each of the three time points

Pairwise Comparisons

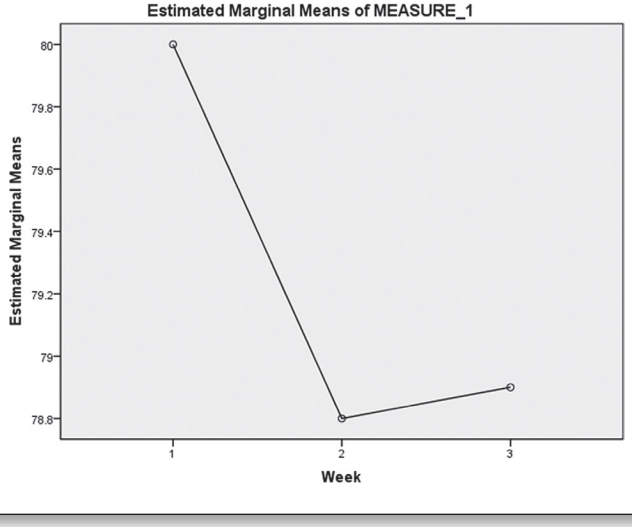
Measure:MEASURE_1

(I) Week	(J) Week	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	1.200	1.254	.364	-1.637	4.037
	3	1.100	1.197	.382	-1.607	3.807
2	1	-1.200	1.254	.364	-4.037	1.637
	3	-.100	1.260	.938	-2.950	2.750
3	1	-1.100	1.197	.382	-3.807	1.607
	2	.100	1.260	.938	-2.750	2.950

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically insignificant decrease from Productivity_1 to Productivity_2 and a statistically insignificant increase Productivity_2 to Productivity_3.

Weekly Productivity	*p*
M(Productivity_1) = 80.0 : M(Productivity_2) = 78.8	.364
M(Productivity_2) = 78.8 : M(Productivity_3) = 78.9	.938
M(Productivity_1) = 80.0 : M(Productivity_3) = 78.9	.382

*Statistically significant difference detected between groups ($p \leq .05$).

Based on these results, I would accept H_0 and reject H_1.

(d)

In an effort to boost weekly productivity, a manger introduced free gourmet coffee to all (10) employees. Mean productivity unexpectedly dropped from 80.0 in the week before the coffee to 78.8 in the week after introducing the coffee. This 1.5% decrease is statistically insignificant ($p = .364$, $\alpha = .05$). In week 3, we recorded a mean productivity of 78.9; this .12% increase in productivity is also statistically insignificant ($p = .938$). Contrary to our expectations, we observed an insignificant 1.4% decrease in productivity (comparing week 1 to week 3). Based on these results, I would accept H_0 and reject H_1. We speculate that the coffee may have become a distraction, or perhaps there are factors more relevant than coffee when it comes to influencing/predicting productivity.

EXERCISE 9.5B

Data set: Ch 9 – Exercise 05B.sav

(a)

H_0: Providing free coffee has no effect on productivity.

H_1: Providing free coffee has an effect on productivity.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Week	.779	5.006	2	.082	.819	.879	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Week

Mauchly's Test of Sphericity produced a *p* value of .082; since this is greater than α (.05), this indicates that there are no statistically significant differences among the variances; hence, this pretest criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Week	Sphericity Assumed	458.818	2	229.409	7.352	.002
	Greenhouse-Geisser	458.818	1.637	280.210	7.352	.004
	Huynh-Feldt	458.818	1.757	261.115	7.352	.003
	Lower-bound	458.818	1.000	458.818	7.352	.013
Error(Week)	Sphericity Assumed	1310.515	42	31.203		
	Greenhouse-Geisser	1310.515	34.386	38.112		
	Huynh-Feldt	1310.515	36.900	35.515		
	Lower-bound	1310.515	21.000	62.405		

The *p* value for Week, Sphericity Assumed is .002; since this is less than α (.05), this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Productivity_1	181.00	5.674	22
Productivity_2	186.68	6.806	22
Productivity_3	186.50	4.522	22

The Descriptive Statistics table provides the mean, SD and *n* for each of the three time points

Pairwise Comparisons

Measure:MEASURE_1

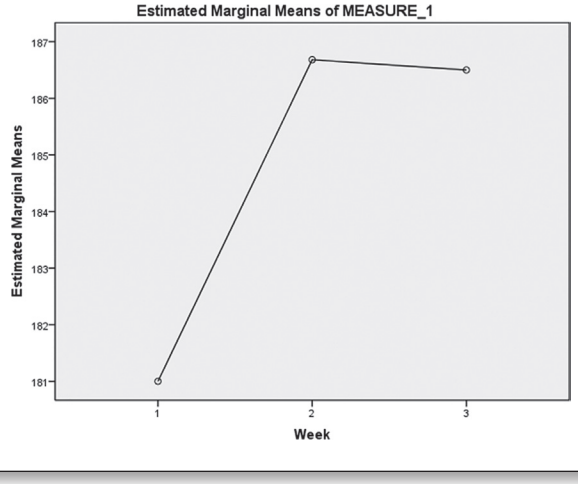
(I) Week	(J) Week	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-5.682*	1.442	.001	-8.681	-2.683
	3	-5.500*	1.504	.001	-8.628	-2.372
2	1	5.682*	1.442	.001	2.683	8.681
	3	.182	2.041	.930	-4.063	4.427
3	1	5.500*	1.504	.001	2.372	8.628
	2	-.182	2.041	.930	-4.427	4.063

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically significant increase from Productivity_1 to Productivity_2 and a statistically insignificant decrease Productivity_2 to Productivity_3.

Weekly Productivity	*p*
M(Productivity_1) = 181.0 : M(Productivity_2) = 186.7	.001*
M(Productivity_2) = 186.7 : M(Productivity_3) = 186.5	.930
M(Productivity_1) = 181.0 : M(Productivity_3) = 186.5	.001*

*Statistically significant difference detected between groups ($p \leq .05$)

Based on these results, I would reject H_0 and accept H_1.

(d)

In an effort to boost weekly productivity, a manger introduced free gourmet coffee to all (22) employees. Mean productivity significantly increased 3.1%, from 181.0 in the week before the coffee to 186.7 in the week after introducing the coffee ($p = .001$, $\alpha = .05$). In week 3, we observed an insignificant drop to 186.5 ($p = .930$, $\alpha = .05$). Based on these results, we reject H_0 and accept H_1. We will continue to gather data to determine if this increase in productivity is sustainable in the long run.

EXERCISE 9.7A

Data set: Ch 9 – Exercise 07A.sav

(a)

H_0: Media influences voter opinion.

H_1: Media does not influence voter opinion.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Opinion	.999	.035	2	.983	.999	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Opinion

Mauchly's Test of Sphericity produced a *p* value of .983; since this is greater than α (.05), this indicates that there are no statistically significant differences among the variances; hence, this pretest criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Opinion	Sphericity Assumed	67.786	2	33.893	26.830	.000
	Greenhouse-Geisser	67.786	1.997	33.938	26.830	.000
	Huynh-Feldt	67.786	2.000	33.893	26.830	.000
	Lower-bound	67.786	1.000	67.786	26.830	.000
Error(Opinion)	Sphericity Assumed	68.214	54	1.263		
	Greenhouse-Geisser	68.214	53.928	1.265		
	Huynh-Feldt	68.214	54.000	1.263		
	Lower-bound	68.214	27.000	2.526		

The *p* value for Time, Sphericity Assumed is .000; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Opinion1_Baseline	2.64	1.311	28
Opinion2_Audio	3.46	1.232	28
Opinion3_Video	4.82	1.188	28

The Descriptive Statistics table provides the mean, SD and *n* for each of the three opinions gathered over time.

Pairwise Comparisons

Measure:MEASURE_1

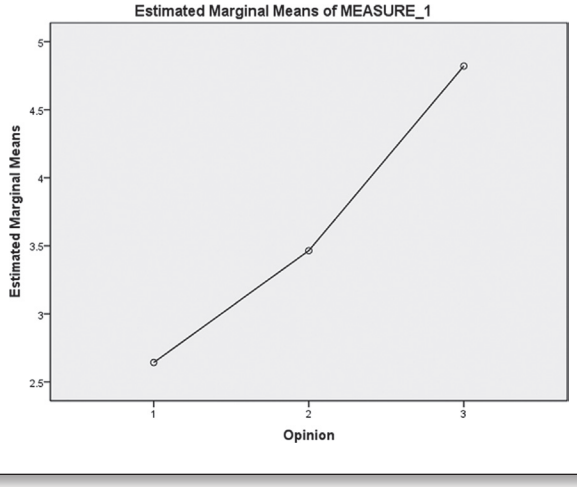
(I) Opinion	(J) Opinion	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-.821*	.296	.010	-1.428	-.215
	3	-2.179*	.300	.000	-2.794	-1.563
2	1	.821*	.296	.010	.215	1.428
	3	-1.357*	.305	.000	-1.983	-.731
3	1	2.179*	.300	.000	1.563	2.794
	2	1.357*	.305	.000	.731	1.983

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the statistically significant increase across the three time points.

Media (Opinion)	*p*
M(Opinion1_Baseline) = 2.64 : M(Opinion2_Audio) = 3.46	.010*
M(Opinion2_Audio) = 3.46 : M(Opinion3_Video) = 4.82	.000*
M(Opinion1_Baseline) = 2.64 : M(Opinion3_Video) = 4.82	.000*

*Statistically significant difference detected between groups ($p \leq .05$).

Based on these results, I would reject H_0 and accept H_1.

(d)

A political consultant convened a focus group consisting of 28 registered voters to evaluate the effectiveness of an audio (radio) commercial promoting a candidate. Prior to running any media, the participants were asked one question: *Do you intend to vote for Jones in the upcoming election?* The participants responded using a 7-point scale (1 = absolutely will not vote for Jones . . . 7 = absolutely will vote for Jones). The baseline mean of the focus group is 2.64; after hearing the audio advertisement, their mean increased by 31% to 3.46 ($p = .010$, $\alpha = .05$). Next, they were shown the shown the video advertisement, which rendered a mean rating of 4.82; this 39% increase from the score attained on the audio advertisement, was statistically significant ($p < .001$). As such, we would reject H_0, and accept H_1.

EXERCISE 9.7B

Data set: Ch 9 – Exercise 07B.sav

(a)

H_0: Media influences voter opinion.

H_1: Media does not influence voter opinion.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Opinion	.792	9.791	2	.007	.828	.857	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Opinion

Mauchly's Test of Sphericity produced a *p* value of .007; since this is less than α (.05), this indicates that there are statistically significant differences among the variances; hence, this should be reported in the results section.

(c)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Opinion	.792	9.791	2	.007	.828	.857	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Opinion

The *p* value for Time, Sphericity Assumed is .000; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Opinion1_Baseline	4.02	1.607	44
Opinoin2_Audio	4.18	1.483	44
Opinoin3_Video	4.70	1.534	44

The Descriptive Statistics table provides the mean, SD and *n* for each of the three opinions gathered over time.

Pairwise Comparisons

Measure:MEASURE_1

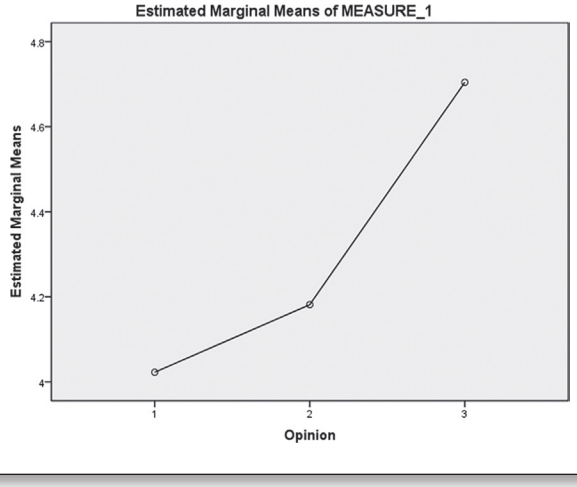
(I) Opinion	(J) Opinion	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-.159	.117	.181	-.395	.077
	3	-.682*	.165	.000	-1.015	-.349
2	1	.159	.117	.181	-.077	.395
	3	-.523*	.124	.000	-.772	-.273
3	1	.682*	.165	.000	.349	1.015
	2	.523*	.124	.000	.273	.772

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

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

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows a statistically insignificant increase, followed by a statistically significant increase across the three time points.

Media (Opinion)	*p*
M(Opinion1_Baseline) = 4.02 : M(Opinion2_Audio) = 4.18	.181
M(Opinion2_Audio) = 4.18 : M(Opinion3_Video) = 4.70	.000*
M(Opinion1_Baseline) = 4.02 : M(Opinion3_Video) = 4.70	.000*

*Statistically significant difference detected between groups ($p \leq .05$).

Based on these results, I would reject H_0 and accept H_1.

(d)

A political consultant convened a focus group consisting of 44 registered voters to evaluate the effectiveness of an audio (radio) commercial promoting a candidate. Prior to running any media, the participants were asked one question: *Do you intend to vote for Jones in the upcoming election?* The participants responded using a 7-point scale (1 = absolutely will not vote for Jones . . . 7 = absolutely will vote for Jones). The baseline mean of the focus group is 4.02; after hearing the audio advertisement, their mean increased insignificantly by 4% to 4.18 ($p = .181$, $\alpha = .05$). Next, they were shown the shown the video advertisement, which rendered a mean rating of 4.70 which significantly raised the score an additional 12.4% ($p < .001$, $\alpha = .05$). As such, we would reject H_0, and accept H_1. Per these findings, the video appears to be the best form of advertisement for this group. Note: Mauchly's Test of Sphericity produced a *p* value of .007, indicating that there are statistically significant differences among the variances; our findings would be more robust had this value been less than .05.

EXERCISE 9.9A

Data set: Ch 9 – Exercise 09A.sav

(a)

H_0: *Zzzleep Zzzound* has no effect on sleep hours.

H_1: *Zzzleep Zzzound* has an effect on sleep hours.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Sleep	.964	3.626	5	.604	.977	1.000	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Sleep

Mauchly's Test of Sphericity produced a p value of .604 since this is greater than α (.05), this indicates that there are no significant differences among the variances of the data gathered; hence, this criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Sleep	Sphericity Assumed	45.740	3	15.247	9.872	.000
	Greenhouse-Geisser	45.740	2.931	15.604	9.872	.000
	Huynh-Feldt	45.740	3.000	15.247	9.872	.000
	Lower-bound	45.740	1.000	45.740	9.872	.002
Error(Sleep)	Sphericity Assumed	458.681	297	1.544		
	Greenhouse-Geisser	458.681	290.203	1.581		
	Huynh-Feldt	458.681	297.000	1.544		
	Lower-bound	458.681	99.000	4.633		

The p value for Time, Sphericity Assumed is .000; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Sleep1	7.3050	1.21053	100
Sleep2	7.3600	1.24839	100
Sleep3	8.0375	1.25196	100
Sleep4	7.9750	1.11719	100

The Descriptive Statistics table provides the mean, SD and *n* for each of the four time points.

Pairwise Comparisons

Measure:MEASURE_1

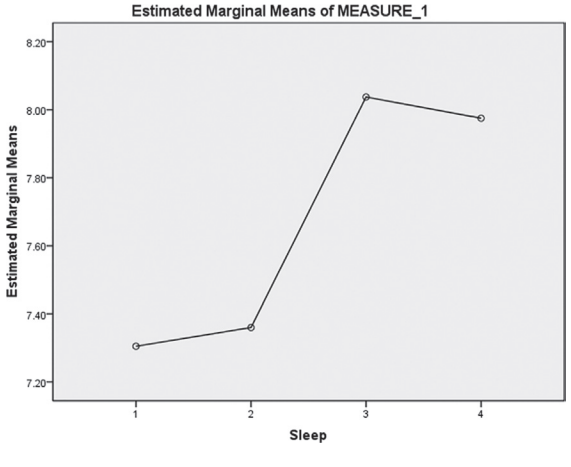
(I) Sleep	(J) Sleep	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-.055	.181	.762	-.415	.305
	3	-.732*	.175	.000	-1.079	-.386
	4	-.670*	.159	.000	-.986	-.354
2	1	.055	.181	.762	-.305	.415
	3	-.677*	.177	.000	-1.029	-.326
	4	-.615*	.178	.001	-.968	-.262
3	1	.732*	.175	.000	.386	1.079
	2	.677*	.177	.000	.326	1.029
	4	.063	.183	.734	-.301	.426
4	1	.670*	.159	.000	.354	.986
	2	.615*	.178	.001	.262	.968
	3	-.063	.183	.734	-.426	.301

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

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

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the insignificant change in sleep hours from week 1 to week 2, followed by a significant increase from week 2 to week 3, and an insignificant drop from week 3 to week 4.

Weekly Sleep Hours	*p*
M(Sleep1) = 7.31 : M(Sleep2) = 7.36	.762
M(Sleep2) = 7.36 : M(Sleep3) = 8.04	.000*
M(Sleep3) = 8.04 : M(Sleep4) = 7.98	.734
M(Sleep1) = 7.31 : M(Sleep4) = 7.98	.000*

*Statistically significant difference detected between groups ($p \leq .05$)

NOTE: It is possible to compare other pairs of groups, however in ANOVA Repeated Measures, adjacent means (Time1 : Time2, Time2 : Time3, Time3 : Time4) are typically compared along with comparing the first mean to the last mean (Time1 : Time4).

Based on these results, I would reject H_0 and accept H_1.

(d)

The *Zzzleep Zzzound* app provides audio selections (e.g., gentle rain, ocean waves, soothing music) to help induce peaceful sleep. During the night, the app uses the camera and motion sensor to gather sleep data. If the user wakes during the night, the app senses it and plays the selected sound for 10 minutes. For the first week, the app runs without any audio to gather baseline data. Once a week, the software transmits the mean sleep time per night for that week to the sleep researcher's database. During week 1 (the baseline week) the 100 subscribers got a mean of 7.31 hours of sleep per night. We detected an insignificant increase to 7.36 hours in week 2 ($p = .762$, $\alpha = .05$), however, there was a statistically significant spike to 8.04 hours in week 3 ($p < .001$, $\alpha = .05$), which dropped slightly to 7.98 in week 4 ($p = .734$, $\alpha = .05$). Over the course of this study, we detected a significant 9.3% increase in sleep hours (from baseline to week 4), suggesting the effectiveness of this app.

EXERCISE 9.9B

Data set: Ch 9 – Exercise 09B.sav

(a)

H_0: *Zzzleep Zzzound* has no effect on sleep hours.

H_1: *Zzzleep Zzzound* has an effect on sleep hours.

(b)

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Sleep	.915	6.384	5	.271	.947	.990	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Sleep

Mauchly's Test of Sphericity produced a *p* value of .271 since this is greater than α (.05), this indicates that there are no significant differences among the variances of the data gathered; hence, this criterion is satisfied.

(c)

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Sleep	Sphericity Assumed	18.445	3	6.148	2.759	.043
	Greenhouse-Geisser	18.445	2.842	6.489	2.759	.046
	Huynh-Feldt	18.445	2.970	6.211	2.759	.044
	Lower-bound	18.445	1.000	18.445	2.759	.101
Error(Sleep)	Sphericity Assumed	488.008	219	2.228		
	Greenhouse-Geisser	488.008	207.496	2.352		
	Huynh-Feldt	488.008	216.779	2.251		
	Lower-bound	488.008	73.000	6.685		

The *p* value for Time, Sphericity Assumed is .043; since this is less than α (.05); this indicates that a statistically significant difference has been detected among at least two of the time points.

Descriptive Statistics

	Mean	Std. Deviation	N
Sleep1	6.9324	1.42825	74
Sleep2	7.5338	1.39736	74
Sleep3	7.4628	1.37223	74
Sleep4	7.5203	1.46930	74

The Descriptive Statistics table provides the mean, SD and *n* for each of the four time points.

Pairwise Comparisons

Measure:MEASURE_1

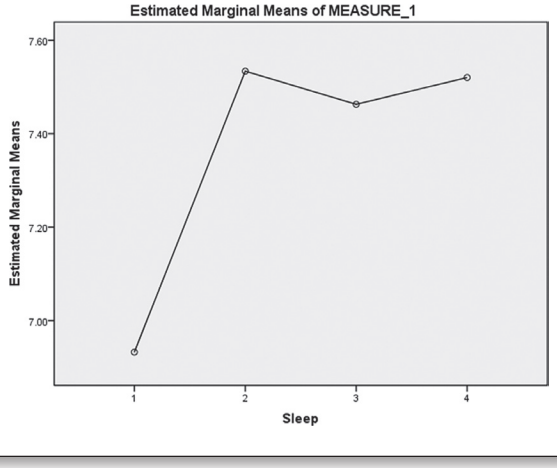
(I) Sleep	(J) Sleep	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-.601*	.235	.013	-1.071	-.132
	3	-.530*	.218	.017	-.964	-.097
	4	-.588*	.267	.031	-1.119	-.056
2	1	.601*	.235	.013	.132	1.071
	3	.071	.256	.782	-.439	.581
	4	.014	.241	.955	-.466	.493
3	1	.530*	.218	.017	.097	.964
	2	-.071	.256	.782	-.581	.439
	4	-.057	.253	.821	-.562	.447
4	1	.588*	.267	.031	.056	1.119
	2	-.014	.241	.955	-.493	.466
	3	.057	.253	.821	-.447	.562

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The Pairwise Comparisons table indicates how each group compared to each other group via the Sig. (*p*) values.



The time series plot shows the significant change in sleep hours from week 1 to week 2, followed by insignificant changes among weeks 2, 3, and 4.

Weekly Sleep Hours	*p*
M(Sleep1) = 6.93 : M(Sleep2) = 7.53	.013*
M(Sleep2) = 7.53 : M(Sleep3) = 7.46	.782
M(Sleep3) = 7.46 : M(Sleep4) = 7.52	.821
M(Sleep1) = 6.93 : M(Sleep4) = 7.52	.031*

*Statistically significant difference detected between groups ($p \leq .05$).

NOTE: It is possible to compare other pairs of groups, however in ANOVA Repeated Measures, adjacent means (Time1 : Time2, Time2 : Time3, Time3 : Time4) are typically compared along with comparing the first mean to the last mean (Time1 : Time4).

Based on these results, I would reject H_0 and accept H_1.

(d)

The *Zzzleep Zzzound* app provides audio selections (e.g., gentle rain, ocean waves, soothing music) to help induce peaceful sleep. During the night, the app uses the camera and motion sensor to gather sleep data. If the user wakes during the night, the app senses it and plays the selected sound for 10 minutes. For the first week, the app runs without any audio to gather baseline data. Once a week, the software transmits the mean sleep time per night for that week to the sleep researcher's database. During week 1 (the baseline week) the 74 subscribers got a mean of 6.93 hours of sleep per night. We detected a statistically significant increase to 7.53 hours in week 2 ($p = .013$, $\alpha = .05$), which appeared to be sustained. We detected no statistically significant difference between week 2 and week 3 ($M = 7.46$) ($p = .782$, $\alpha = .05$); further we detected no statistically difference between week 3 and week 4 ($M = 7.52$) ($p = .821$, $\alpha = .05$). Over the course of this study, we detected a significant 8.5% increase in sleep hours (from baseline to week 4), suggesting the effectiveness of this app, which appears to provided longer sleep. Our goal is to increase our sample and to continue to monitor the functionality of this software over longer periods.