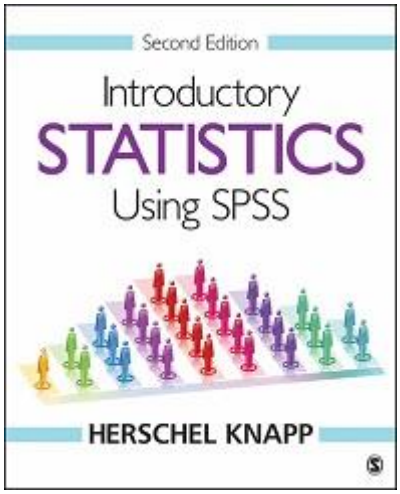


Chapter 6

ANOVA and Kruskal-Wallis Test

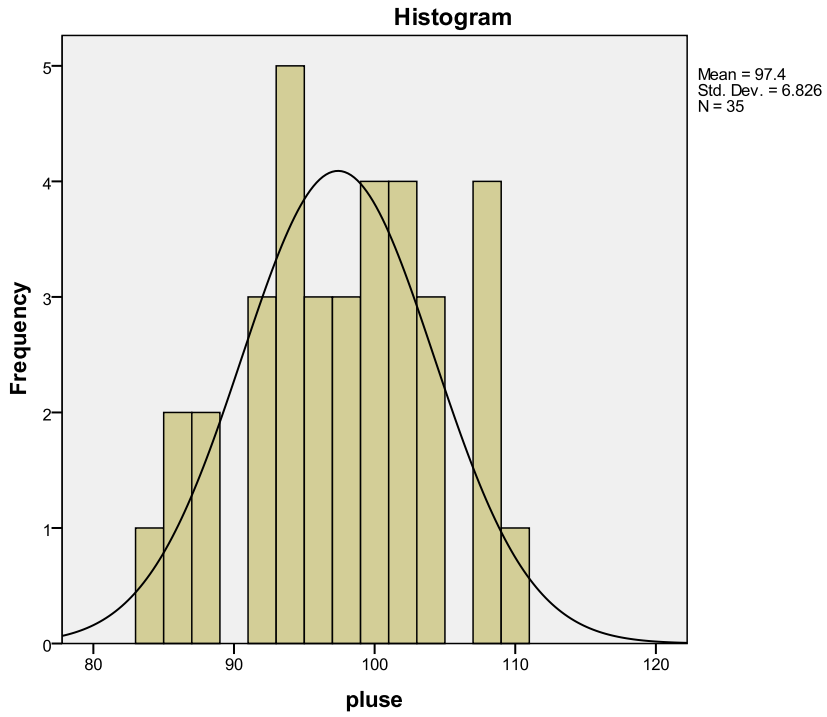
Solutions to All Exercises

Exercise 6.1, Data Set A

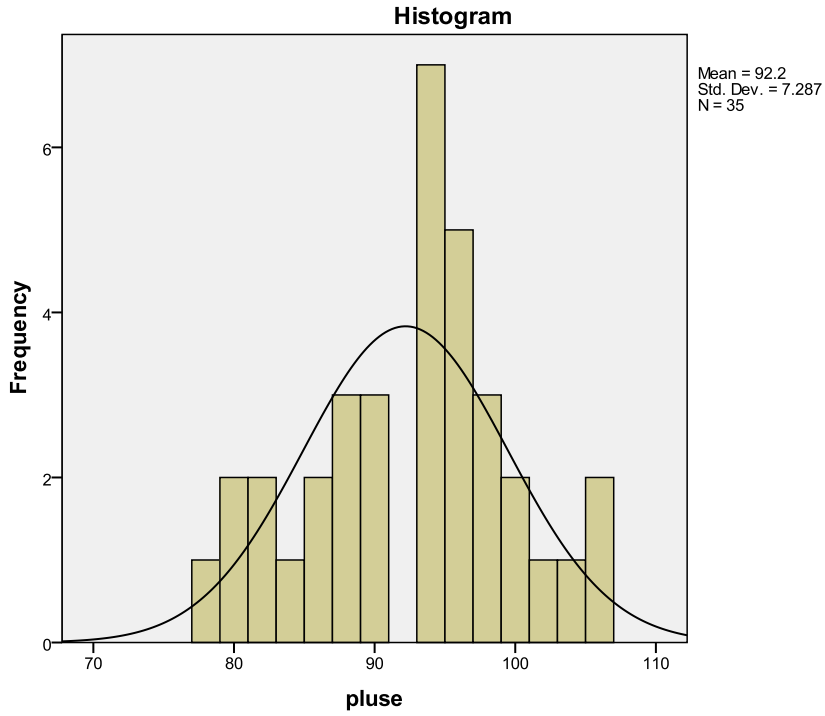
(a)
H_0: Practicing meditation has no effect on resting pulse rate.
H_1: Practicing meditation reduces resting pulse rate.

(b) Histograms with normal curve plots show a normal distribution of *pulse* for the groups as shown in the three figures below, hence, the pretest criteria of *normality* is satisfied.

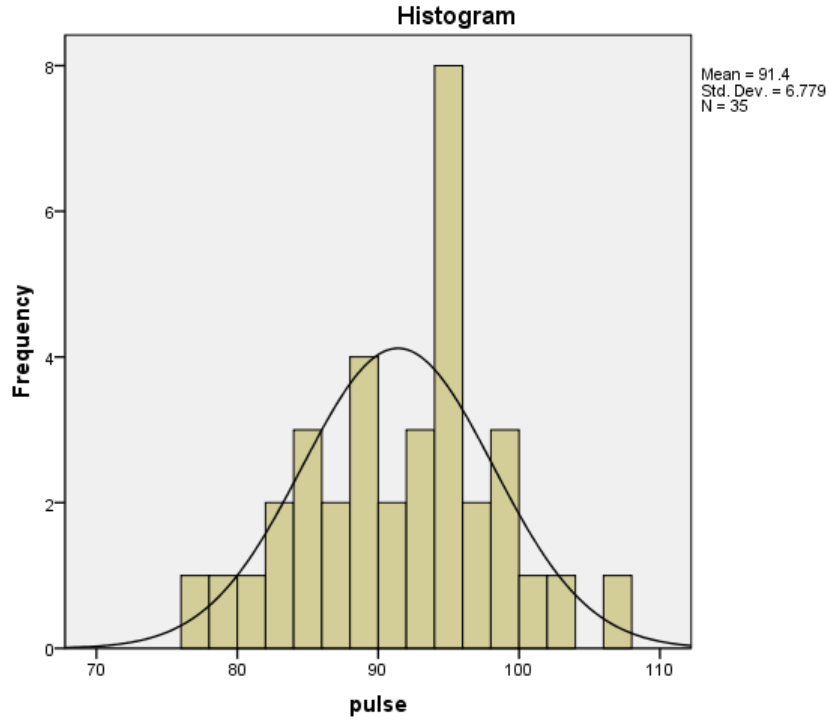
Normal distribution for *pulse* in Group 1 (No meditation)



Normal distribution for *pulse* in Group 2 (meditated 30 minutes a day, 3 days per week)



Normal distribution for *pulse* in Group 3 (meditated 30 minutes a day, 6 days per week)



Test of Homogeneity of Variances

pulse

Levene Statistic	df1	df2	Sig.
.083	2	102	.920

The homogeneity of variance score shows a significance (*p*) of .920; since this is greater than the α level of .05, this suggests that there is no statistically significant difference among the variances of the three groups, hence, this pretest criterion passes.

The *n* for each group, as shown in the *Descriptives* table below is 35 for each group; since the *n*s are greater than 30, this criterion passes also.

(c)
The ANOVA revealed the following:

Descriptives

pulse

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
No meditation	35	97.40	6.826	1.154	95.06	99.74	84	109
Meditates 3 days	35	92.20	7.287	1.232	89.70	94.70	78	105
Meditates 6 days	35	91.40	6.779	1.146	89.07	93.73	77	106
Total	105	93.67	7.400	.722	92.23	95.10	77	109

ANOVA

pulse

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	742.933	2	371.467	7.651	.001
Within Groups	4952.400	102	48.553		
Total	5695.333	104			

Multiple Comparisons

pulse
Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No meditation	Meditates 3 days	5.200*	1.666	.007	1.24	9.16
	Meditates 6 days	6.000*	1.666	.001	2.04	9.96
Meditates 3 days	No meditation	-5.200*	1.666	.007	-9.16	-1.24
	Meditates 6 days	.800	1.666	.881	-3.16	4.76
Meditates 6 days	No meditation	-6.000*	1.666	.001	-9.96	-2.04
	Meditates 3 days	-.800	1.666	.881	-4.76	3.16

*. The mean difference is significant at the 0.05 level.

The Tukey post hoc test was used since the *n*s for each group were the same (35 each).

NOTE: Since the ANOVA test renders results involving multiple comparisons, it may be helpful to organize the findings as shown in the table below. SPSS does not generate this table directly, but you can construct it manually. You can copy the *group names* and *means* from the *Descriptives* table, and the *p* values from the *Sig.* column in the *Multiple Comparisons* table.

Groups (μ = resting pulse rate after 2 weeks)	***p***
No meditation (μ = 97.40) : Meditation 3x / wk. (μ = 92.20)	*.007
No meditation (μ = 97.40) : Meditation 6x / wk. (μ = 91.40)	*.001
Meditation 3x / wk. (μ = 92.20) : Meditation 6x / wk. (μ = 91.40)	.881

*Statistically significant difference (α = .05).

Practicing meditation for 2 weeks was effective in statistically significantly reducing resting pulse rate, however there was no statistically significant difference in resting pulse rate when comparing those who meditated for 30 minutes three times a week to those who meditated for 30 minutes six times a week. Based on these findings, we reject H_0, and we do not reject H_1.

(d)

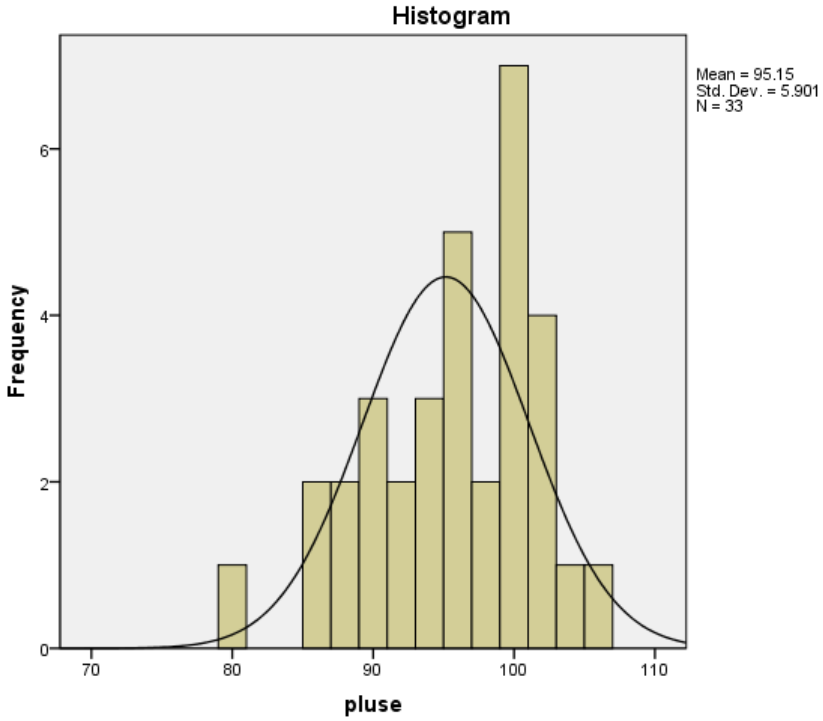
This study analyzed the effects that meditation had on resting pulse rates. The subjects were randomly assigned to one of three groups; members of the control group did not meditate, those in the second group meditated for 30 minutes on Monday, Wednesday and Friday, and members of the third group meditated for 30 minutes Monday through Saturday. After 2 weeks, those who meditated (3x / wk., μ = 92.20; 6x / wk. μ = 91.40) showed a statistically significant reduction (*p* = .007 and *p* = .001, respectively) in resting pulse rate compared to those who did not meditate (μ = 97.40) using a .05 α level. We found no statistically significant difference in the resting pulse rates between those who meditated 3 days per week, compared to those who meditated 6 days per week (*p* = .881).

Exercise 6.1, Data Set B

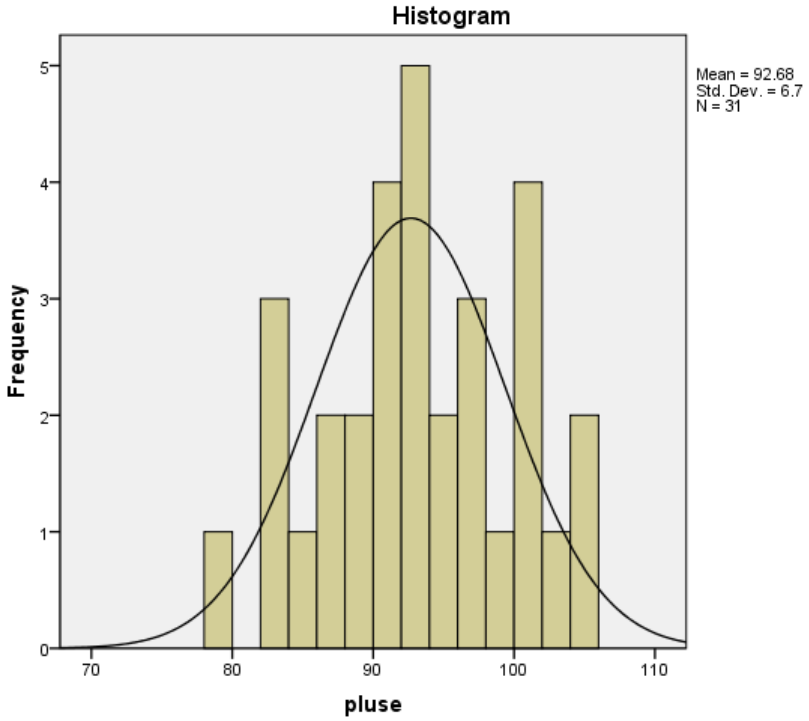
(a)
H_0: Practicing meditation has no effect on resting pulse rate.
H_1: Practicing meditation reduces resting pulse rate.

(b)
Histograms with normal curve plots show a normal distribution of *pulse* for the three groups as shown in the three figures below, hence, the pretest criteria of *normality* is satisfied.

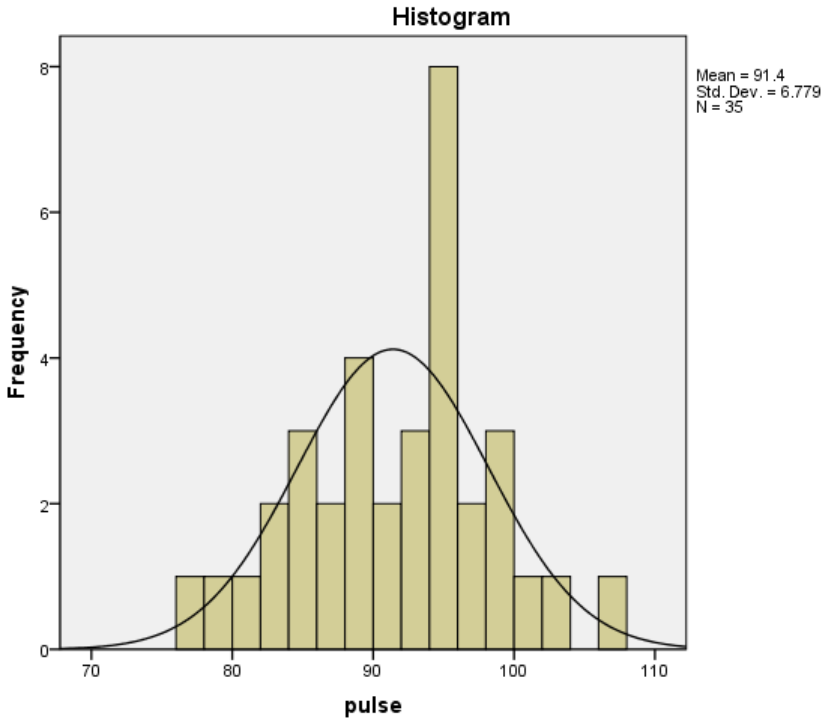
Normal distribution for *pulse* in Group 1 (No meditation)



Normal distribution for *pulse* in Group 2 (meditated 30 minutes a day, 3 days per week)



Normal distribution for *pulse* in Group 3 (meditated 30 minutes a day, 6 days per week)



Test of Homogeneity of Variances

pluse

Levene Statistic	df1	df2	Sig.
.241	2	96	.786

The homogeneity of variance score shows a significance (*p*) of .786; since this is greater than the α level of .05, this suggests that there is no statistically significant difference among the variances of the three groups, hence, this pretest criterion passes.

The *n* for each group, as shown in the *Descriptives* table below are 33, 35, and 31; since the *n*s are greater than 30, this criterion passes also.

(c)
The ANOVA revealed the following:

Descriptives

pluse

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
No meditation	33	95.15	5.901	1.027	93.06	97.24	80	105
Meditates 3 days	35	93.54	6.797	1.149	91.21	95.88	79	107
Meditates 6 days	31	92.68	6.700	1.203	90.22	95.14	79	104
Total	99	93.81	6.494	.653	92.51	95.10	79	107

ANOVA

pluse

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	101.651	2	50.826	1.210	.303
Within Groups	4031.702	96	41.997		
Total	4133.354	98			

Multiple Comparisons

pluse
Sidak

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No meditation	Meditates 3 days	1.609	1.572	.670	-2.21	5.43
	Meditates 6 days	2.474	1.621	.342	-1.46	6.41
Meditates 3 days	No meditation	-1.609	1.572	.670	-5.43	2.21
	Meditates 6 days	.865	1.598	.931	-3.02	4.75
Meditates 6 days	No meditation	-2.474	1.621	.342	-6.41	1.46
	Meditates 3 days	-.865	1.598	.931	-4.75	3.02

The Sidak post hoc test was used since the *n*s for each group were not the same (*n*s = 33, 35, 31).

Groups (μ = resting pulse rate after 2 weeks)	*p*
No meditation (μ = 95.15) : Meditation 3x / wk. (μ = 93.54)	.670
No meditation (μ = 95.15) : Meditation 6x / wk. (μ = 92.68)	.342
Meditation 3x / wk. (μ = 93.54) : Meditation 6x / wk. (μ = 92.68)	.931

Per the table above, practicing meditation for 2 weeks produced no statistically significant reduction in resting pulse rate using a .05 α level. Based on these findings, we would not reject H_0, and we would reject H_1.

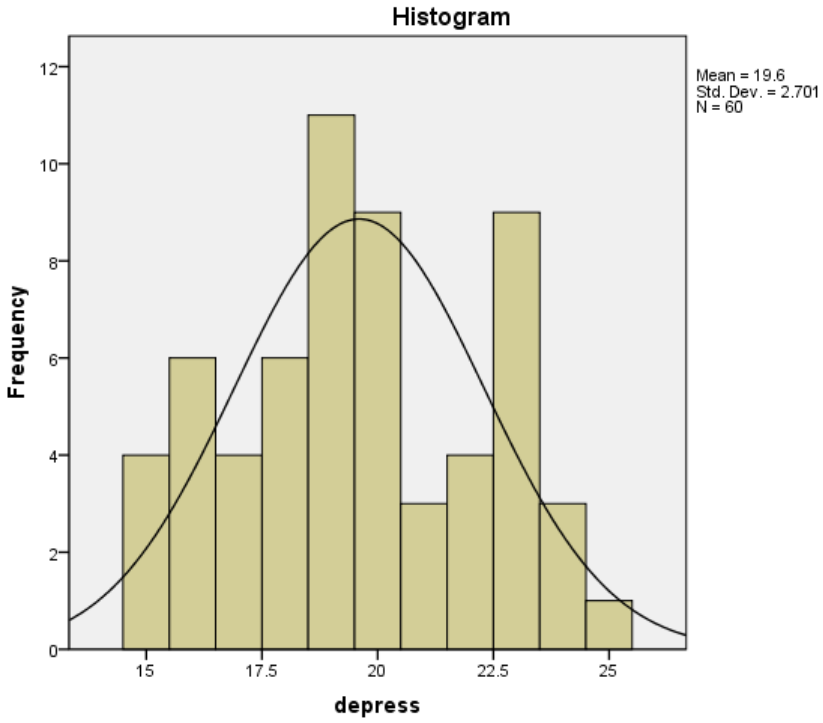
(d)
This study analyzed the effects that meditation had on resting pulse rates. The subjects were randomly assigned to one of three groups; members of the control group did not meditate, those in the second group meditated for 30 minutes on Monday, Wednesday and Friday, and members of the third group meditated for 30 minutes Monday through Saturday. After 2 weeks, resting pulse rates were recorded for each participant. Those who did not meditate had a mean resting pulse rate of 95.15, which was slightly higher than those who meditated (3 days per week: μ = 93.54, 6 days per week: μ = 92.68); however, we detected no statistically significant differences among any of the three groups using a .05 α level, suggesting that the meditation schedules tested were not effective in reducing resting pulse rates.

Exercise 6.3, Data Set A

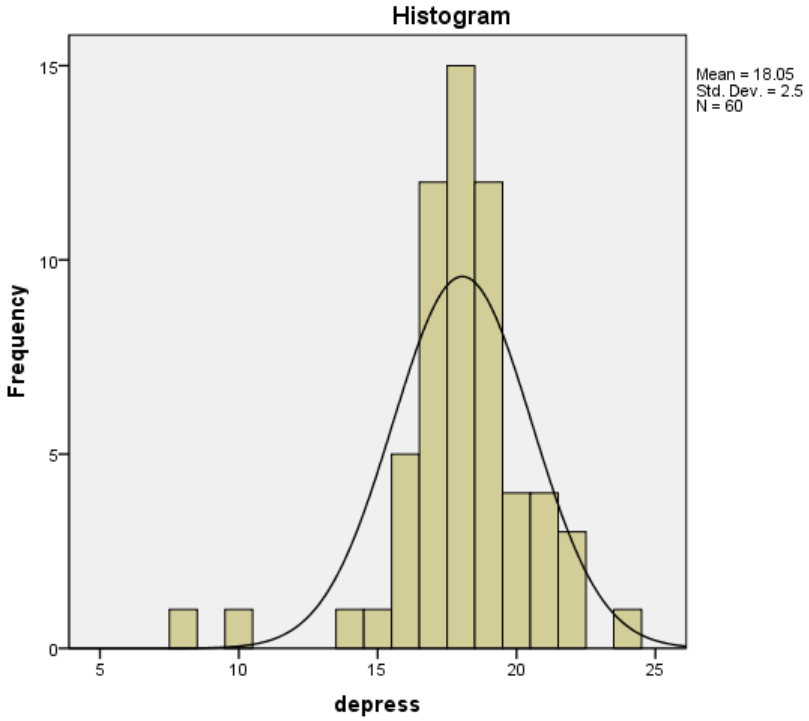
(a)
H_0: Tending to a plant has no effect on depressive mood.
H_1: Tending to a plant reduces depressive mood.

(b)
Despite the few low score outliers shown in the histogram for Group 2, the *Histograms with normal curve* plots exhibit a normal distribution of the *depress* variable for all groups as shown in the three figures below, hence, the pretest criteria of *normality* is satisfied.

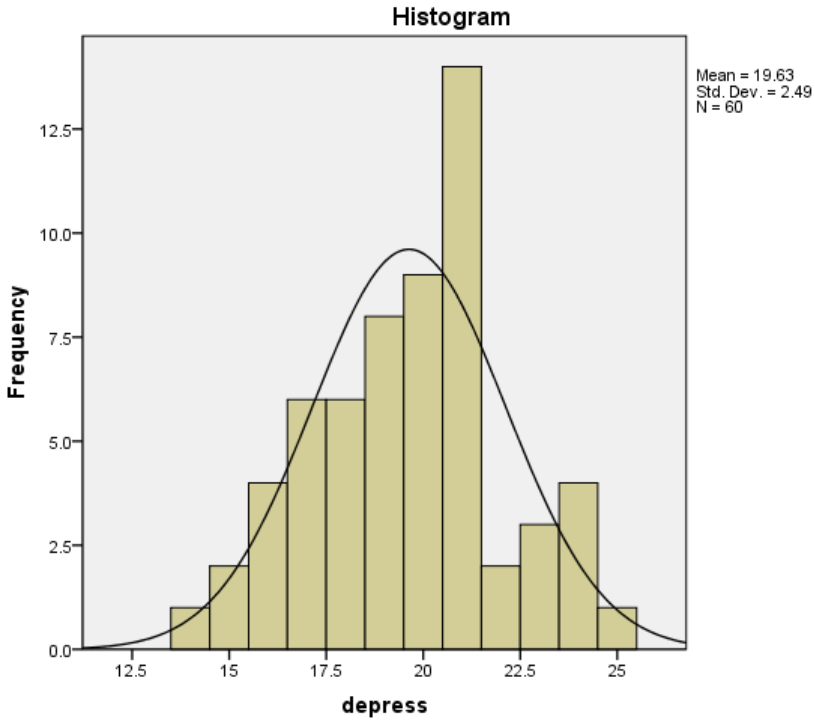
Normal distribution for *depress* in Group 1 (No plant)



Normal distribution for *depress* in Group 2 (Bamboo)



Normal distribution for *depress* in Group 3 (Cactus)



Test of Homogeneity of Variances

depress

Levene Statistic	df1	df2	Sig.
2.037	2	177	.133

The homogeneity of variance score for *mood* shows a significance (*p*) of .133; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances among the three groups, hence, this pretest criterion passes.

The *n* for each group is 60 (see *Descriptives* table below), which satisfies the 30 per group minimum criterion.

(c)
The ANOVA test revealed the following:

Descriptives

depress

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
No plant	60	19.60	2.701	.349	18.90	20.30	15	25
Bamboo	60	18.05	2.500	.323	17.40	18.70	8	24
Cactus	60	19.63	2.490	.322	18.99	20.28	14	25
Total	180	19.09	2.657	.198	18.70	19.49	8	25

ANOVA

depress

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	98.211	2	49.106	7.459	.001
Within Groups	1165.183	177	6.583		
Total	1263.394	179			

Multiple Comparisons

depress
Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No plant	Bamboo	1.550*	.468	.003	.44	2.66
	Cactus	-.033	.468	.997	-1.14	1.07
Bamboo	No plant	-1.550*	.468	.003	-2.66	-.44
	Cactus	-1.583*	.468	.003	-2.69	-.48
Cactus	No plant	.033	.468	.997	-1.07	1.14
	Bamboo	1.583*	.468	.003	.48	2.69

*. The mean difference is significant at the 0.05 level.

Groups (μ = depression)	***p***
No plant (μ = 19.60) : Bamboo (μ = 18.05)	*.003
No plant (μ = 19.60) : Cactus (μ = 19.63)	.997
Bamboo (μ = 18.05) : Cactus (μ = 19.63)	*.003

*Statistically significant difference (α = .05).

There is no statistically significant difference in the average scores between those who received no plant (μ = 19.60) and those who received a cactus (μ = 19.63) (p = .997, α = .05). The mean depression score for those who received a bamboo plant (μ = 18.05) was statistically significant lower than those who received no plant (p = .003) and those who received a cactus (p = .003).

Since those in the Bamboo group had a statistically significantly lower depression score than those who received no plant, we would reject H_0. By that same reasoning, we would not reject H_1.

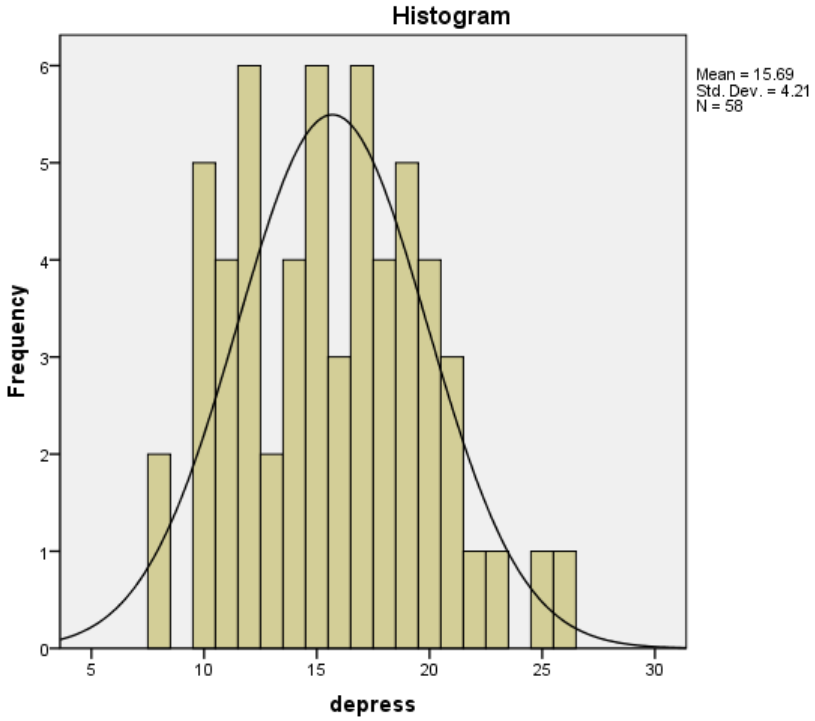
(d)
We hypothesized that empowering nursing home residents with an opportunity to provide nurturance would help reduce depression. To test this hypothesis, 180 residents were randomly assigned to one of three groups: Those in Group 1 constituted the control group, and were given no plant. Those in Group 2 were given a small bamboo plant to tend to along with a card providing care instructions. Participants in Group 3 were given a cactus plant along with a card providing care instructions. After 90 days, we administered the Acme Depression Scale (1 = Low depression, 100 = High depression) to members of all three groups. We found that those who were given the bamboo plant scored an average of 18.05; using a .05 α level, we found that their depression level was statistically significantly lower than those who were given no plant (μ = 19.60, p = .003), and those who were given a cactus (μ = 19.63, p = .003). We found that those who received a cactus had a slightly higher average depression level (μ = 19.63) than those who were given no plant (μ = 19.60), however, there was no statistically significant difference in depression scores when comparing those who were given no plant to those who were given a cactus (p = .997). These findings suggest that tending to a small plant has the potential to reduce depression in nursing home residents, but the cactus, which essentially requires no tending, did not provide the desired effect, whereas the bamboo, which required monitoring and watering, did.

Exercise 6.3, Data Set B

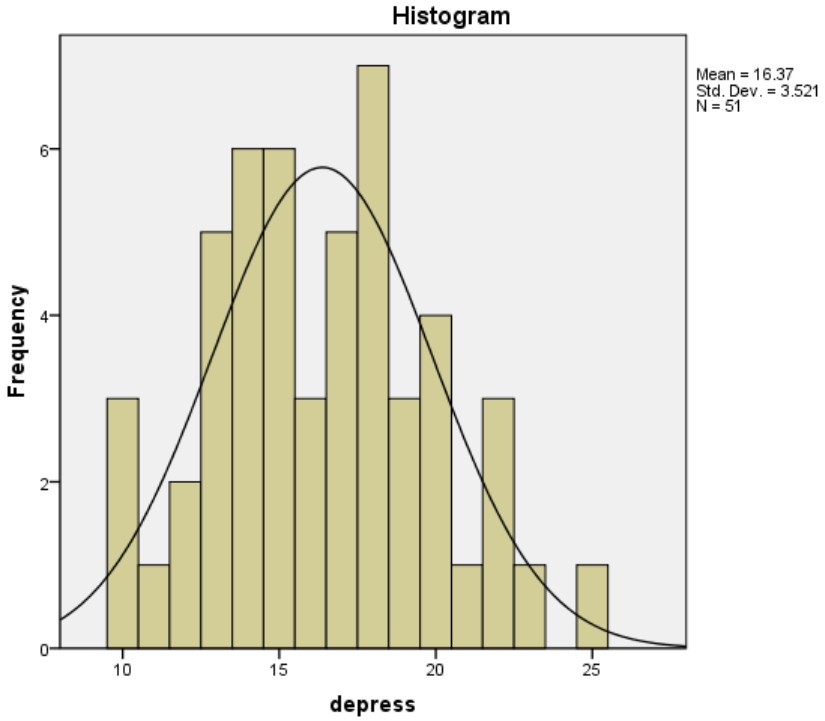
(a)
H_0: Tending to a plant has no effect on depressive mood.
H_1: Tending to a plant reduces depressive mood.

(b)
The *Histograms with normal curve* plot exhibits a normal distribution of the *depress* variable for all groups as shown in the three figures below, hence, the pretest criteria of *normality* is satisfied.

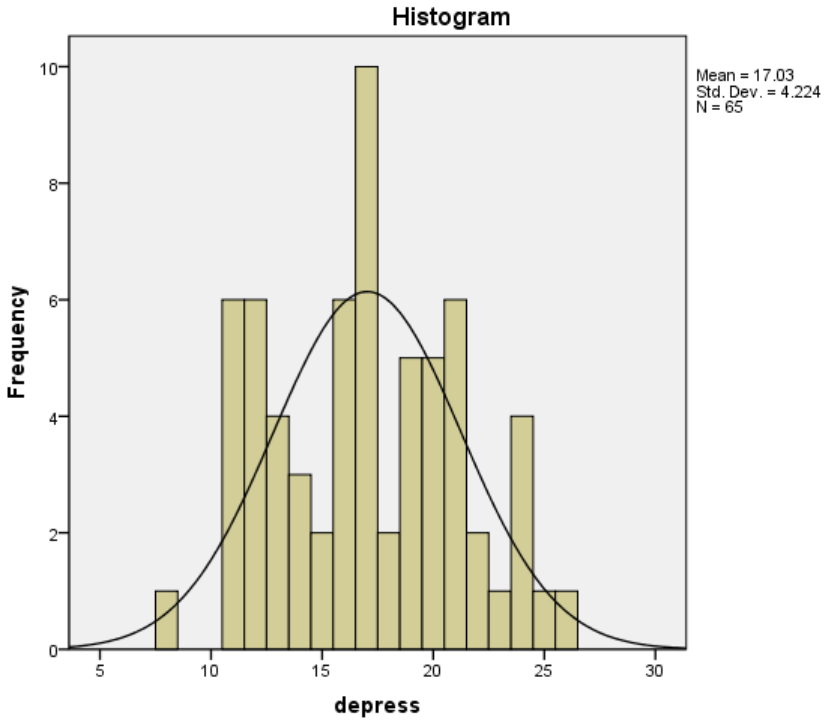
Normal distribution for *depress* in Group 1 (No plant)



Normal distribution for *depress* in Group 2 (Bamboo)



Normal distribution for *depress* in Group 3 (Cactus)



Test of Homogeneity of Variances

depress

Levene Statistic	df1	df2	Sig.
1.108	2	171	.333

The homogeneity of variance score for *mood* shows a significance (*p*) of .333; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances of among the three groups, hence, this pretest criterion passes.

The *n*s for the groups are 58, 51, and 65 (see *Descriptives* table below), which satisfies the 30 per group minimum criterion.

(c)
The ANOVA test revealed the following:

Descriptives

depress

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
No plant	58	15.69	4.210	.553	14.58	16.80	8	26
Bamboo	51	16.37	3.521	.493	15.38	17.36	10	25
Cactus	65	17.03	4.224	.524	15.98	18.08	8	26
Total	174	16.39	4.043	.306	15.79	17.00	8	26

ANOVA

depress

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	55.151	2	27.576	1.701	.186
Within Groups	2772.274	171	16.212		
Total	2827.425	173			

Multiple Comparisons

depress
Sidak

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No plant	Bamboo	-.683	.773	.760	-2.55	1.18
	Cactus	-1.341	.727	.188	-3.09	.41
Bamboo	No plant	.683	.773	.760	-1.18	2.55
	Cactus	-.658	.753	.766	-2.47	1.16
Cactus	No plant	1.341	.727	.188	-.41	3.09
	Bamboo	.658	.753	.766	-1.16	2.47

Groups (μ = depression)	***p***
No plant (μ = 15.69) : Bamboo (μ = 16.37)	.760
No plant (μ = 15.69) : Cactus (μ = 17.03)	.188
Bamboo (μ = 16.37) : Cactus (μ = 17.03)	.766

Inspection of the Sig. (*p*) figure in the ANOVA table (*p* = .186, which is greater than the .05 α level) tells us that there is no statistically significant difference(s) detected in the *depression* scores among any of the groups.

Upon reviewing the comparisons presented in the *Multiple Comparisons* table, we see that this finding is confirmed; we see that the *p* level for each pair of depression scores is greater than the specified .05 α level, hence there are no statistically significant differences between any of the groups as shown in the table above.

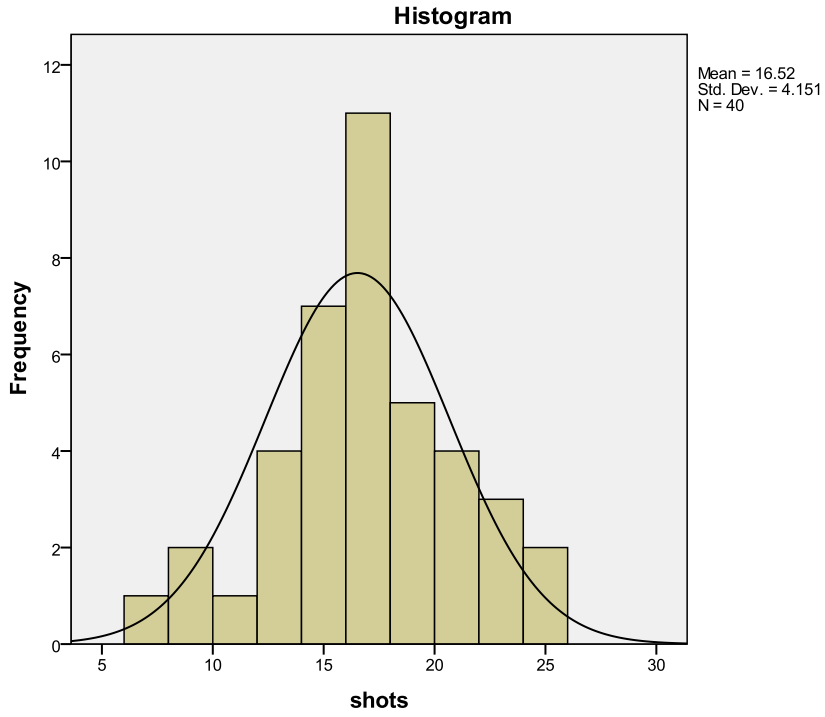
(d)
We hypothesized that empowering nursing home residents with an opportunity to provide nurturance would help reduce depression. To test this hypothesis, 174 residents were randomly assigned to one of three groups: Those in Group 1 constituted the control group and were given no plant. Those in Group 2 were given a small bamboo plant to tend to along with a card providing care instructions. Participants in Group 3 were given a cactus plant along with a card providing care instructions. After 90 days, we administered the Acme Depression Scale (1 = Low depression, 100 = High depression) to members of both groups. We found that those who were given the cactus scored an average of 17.03, those who were given a bamboo plant had an average score of 16.37, and those who were given no plant scored an average of 15.69.; using a .05 α level, we found no statistically significant differences among any of these groups (*p* ranged from .188 to .766). We found that these plants were not helpful in reducing depression among these nursing home residents.

Exercise 6.5, Data Set A

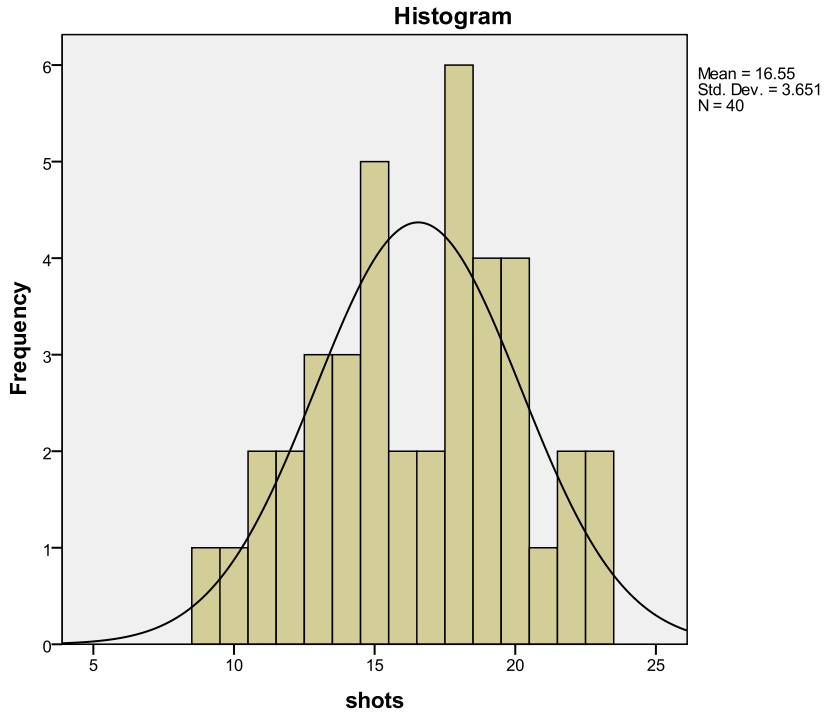
(a)
H_0: Providing flu shot informational media has no impact on flu shot receptivity.
H_1: Providing flu shot informational pamphlet has a positive impact on flu shot receptivity.

(b)
The histograms (below) for all groups show normal distributions of flu shots, hence the pretest criterion of normality is satisfied.

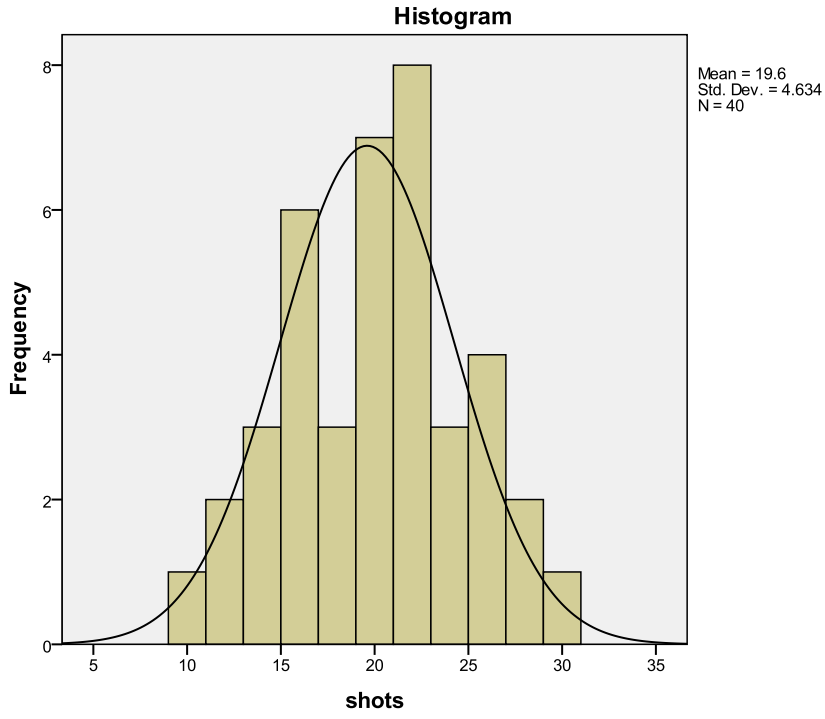
Group 1—No flu shot informational media



Group 2—Flu shot informational pamphlet



Group 3—Flu shot informational video



Test of Homogeneity of Variances

shots

Levene Statistic	df1	df2	Sig.
.855	2	117	.428

The homogeneity of variance score shows a significance (*p*) of .428; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances of the groups; hence, this pretest criterion passes. The *n* for each group, as shown in the *Descriptives* table below, is over 30 for each group, which satisfies that criterion.

(c)
The ANOVA test revealed the following:

Descriptives

shots

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Nothing	40	16.52	4.151	.656	15.20	17.85	7	25
Flu shot pamphlet	40	16.55	3.651	.577	15.38	17.72	9	23
Flu shot video	40	19.60	4.634	.733	18.12	21.08	10	29
Total	120	17.56	4.377	.400	16.77	18.35	7	29

ANOVA

shots

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	250.117	2	125.058	7.210	.001
Within Groups	2029.475	117	17.346		
Total	2279.592	119			

Multiple Comparisons

shots
Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Nothing	Flu shot pamphlet	-.025	.931	1.000	-2.24	2.19
	Flu shot video	-3.075*	.931	.004	-5.29	-.86
Flu shot pamphlet	Nothing	.025	.931	1.000	-2.19	2.24
	Flu shot video	-3.050*	.931	.004	-5.26	-.84
Flu shot video	Nothing	3.075*	.931	.004	.86	5.29
	Flu shot pamphlet	3.050*	.931	.004	.84	5.26

*. The mean difference is significant at the 0.05 level.

Groups (μ = Flu Shots)	*p*
μ(Nothing) = 16.52 : μ(Flu shot pamphlet) = 16.55	1.000
μ(Nothing) = 16.52 : μ(Flu shot video) = 19.60	.004*
μ(Flu shot pamphlet) = 16.55 : μ(Flu shot video) = 19.60	.004*

*Statistically significant difference (α = .05).

The Tukey post hoc test was run since the groups all had the same *n*s (*n* = 40). The Sig(nificance), or *p* level, rendered on the ANOVA table is .001, which is less than the .05 α level, indicating that there are statistically significant differences among these (three) groups. This is confirmed by inspecting the *Multiple Comparisons* table; upon reviewing the mean number of flu shots given per day for each group, the flu shot video (μ = 19.60) statistically significantly outperformed no media (μ = 16.52) and the flu shot informational pamphlet (μ = 16.55) with *p* = .004 (α = .05) for both comparisons. Hence, I would reject H_0 and not reject H_1.

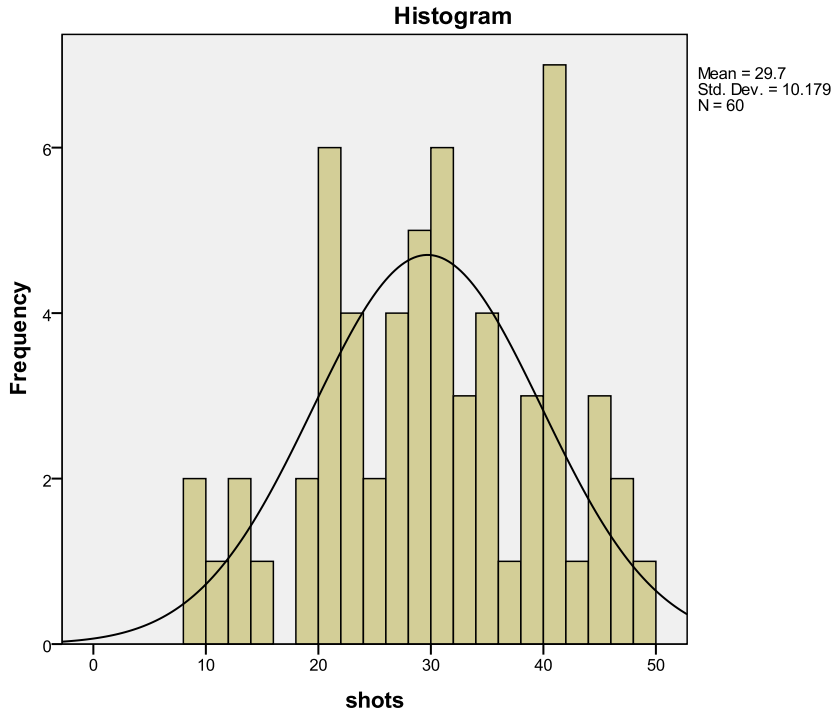
(d)
In an effort to discover if the media was effective in promoting flu shot receptivity among patients, individuals at a walk-in health clinic were randomly assigned to one of three groups: Group1 constituted the control group, and received no media or messaging promoting the utility of the flu shot (which is available to all who request it at this clinic), members of Group 2 were issued a flu shot informational pamphlet, and members of Group 3 were shown a brief flu shot informational video, containing the same educational points as the pamphlet. Group 1 (No information) and Group 2 (Pamphlet) rendered an average of 16.52 and 16.55 flu shots per day respectively, whereas Group 3 (Video) statistically significantly outperformed both other groups with an average of 19.60 flu shots per day (*p* = .004 for both comparisons; α = .05). These findings suggest that giving a pamphlet is essentially equivalent to giving nothing (Group 1 : Group 2 rendered *p* = 1.00), whereas this cohort seemed most receptive to a brief informational video promoting the flu shot. Our future studies will focus on assessing the effectiveness of such videos by varying parameters such as duration, content, graphics, and complexity of message.

Exercise 6.5, Data Set B

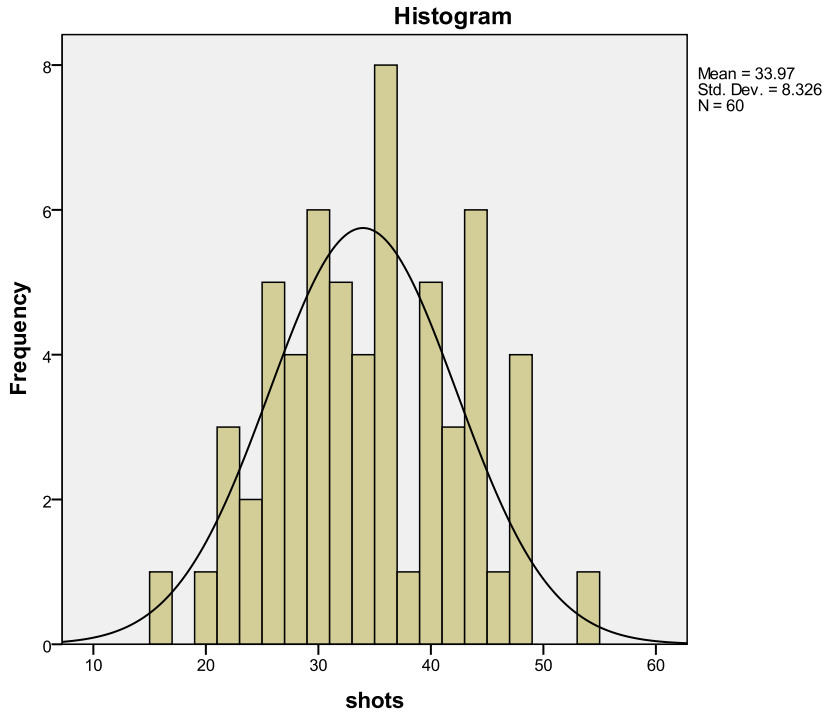
(a)
H_0: Providing flu shot informational media has no impact on flu shot receptivity.
H_1: Providing flu shot informational pamphlet has a positive impact on flu shot receptivity.

(b)
The histograms (below) for the groups show normal distributions of flu shots, hence the pretest criterion of normality is satisfied.

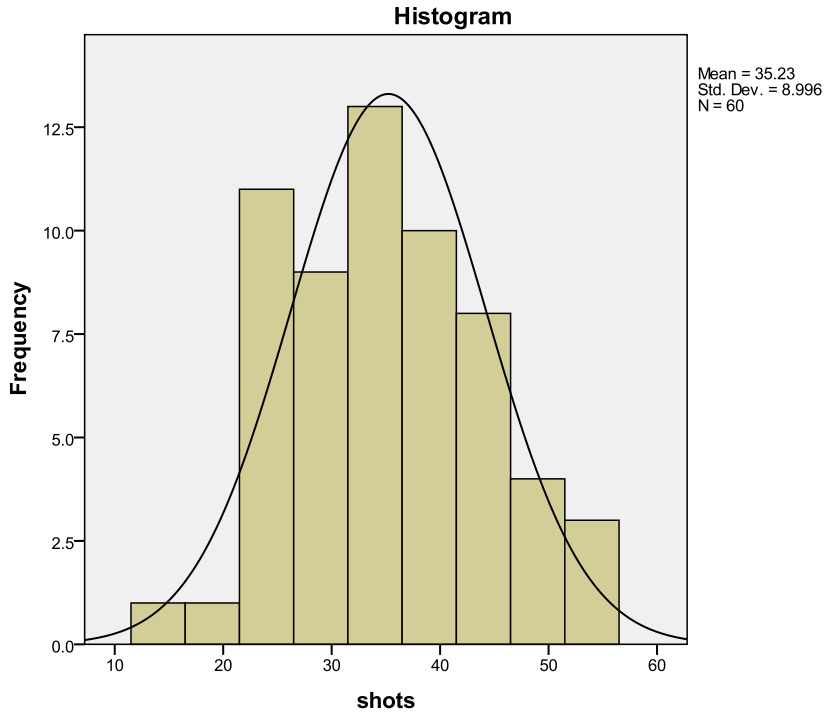
Group 1—No flu shot informational media



Group 2—Flu shot informational pamphlet



Group 3—Flu shot informational video



Test of Homogeneity of Variances

shots

Levene Statistic	df1	df2	Sig.
1.177	2	177	.310

The homogeneity of variance score shows a significance (*p*) of .310; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances of the groups; hence, this pretest criterion passes. The *n* for each group, as shown in the *Descriptives* table below, is over 30 for each group, which satisfies that criterion.

(c)

The ANOVA test revealed the following:

Descriptives

shots

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Nothing	60	29.70	10.179	1.314	27.07	32.33	9	48
Flu shot pamphlet	60	33.97	8.326	1.075	31.82	36.12	16	53
Flu shot video	60	35.23	8.996	1.161	32.91	37.56	14	55
Total	180	32.97	9.450	.704	31.58	34.36	9	55

ANOVA

shots

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1008.533	2	504.267	5.959	.003
Within Groups	14977.267	177	84.617		
Total	15985.800	179			

Multiple Comparisons

shots

Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Nothing	Flu shot pamphlet	-4.267*	1.679	.032	-8.24	-.30
	Flu shot video	-5.533*	1.679	.003	-9.50	-1.56
Flu shot pamphlet	Nothing	4.267*	1.679	.032	.30	8.24
	Flu shot video	-1.267	1.679	.731	-5.24	2.70
Flu shot video	Nothing	5.533*	1.679	.003	1.56	9.50
	Flu shot pamphlet	1.267	1.679	.731	-2.70	5.24

*. The mean difference is significant at the 0.05 level.

Groups (μ = Flu Shots)	*p*
μ(Nothing) = 29.70 : μ(Flu shot pamphlet) = 33.97	.032*
μ(Nothing) = 29.70 : μ(Flu shot video) = 35.23	.003*
μ(Flu shot pamphlet) = 33.97 : μ(Flu shot video) = 35.23	.731

*Statistically significant difference (α = .05).

The Tukey post hoc test was run since the groups all had the same *n*s (*n* = 60). The Sig(nificance), or *p* level, rendered on the ANOVA table is .003, which is less than the .05 α level, indicating that there are statistically significant differences among these (three) groups. This is confirmed by inspecting the *Multiple Comparisons* table; upon reviewing the mean number of flu shots given per day for each group, we find that the pamphlet group (μ = 33.97) and the video group (μ = 35.23) statistically significantly outperformed the group that got no media (μ = 29.70) with *p* = .032 and *p* = .003 respectively (α = .05). Hence, I would reject H_0 and not reject H_1.

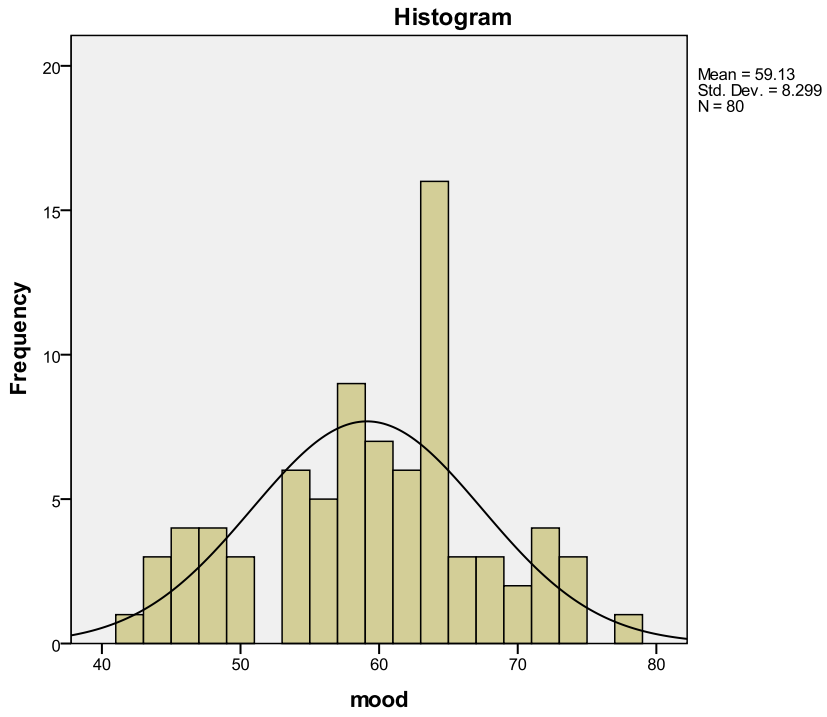
(d)
In an effort to discover if educational media was effective in promoting flu shot receptivity among patients, individuals at a walk-in health clinic were randomly assigned to one of three groups: Group1 constituted the control group, and received no media or messaging promoting the utility of the flu shot (which is available to all who request it at this clinic), members of Group 2 were issued a flu shot informational pamphlet, and members of Group 3 were shown a brief flu shot informational video, containing the same educational points as the pamphlet. Group 1 (No information) (μ = 29.70 flu shots per day) was outperformed by Group 2 (Pamphlet) (μ = 29.70, *p* = .032) and Group 3 (Video) (μ = 35.23, *p* = .003). Although the video faired best, we detected no statistically significant difference (1.26 tests daily) between the pamphlet and the video when it came to average daily testing. This suggests that paper or video messaging perform essentially equivalently, and both are more effective than providing no such media. Our future research will focus on variations on this media to assemble optimal and cost effective messaging most suitable to our patient population.

Exercise 6.7, Dataset A

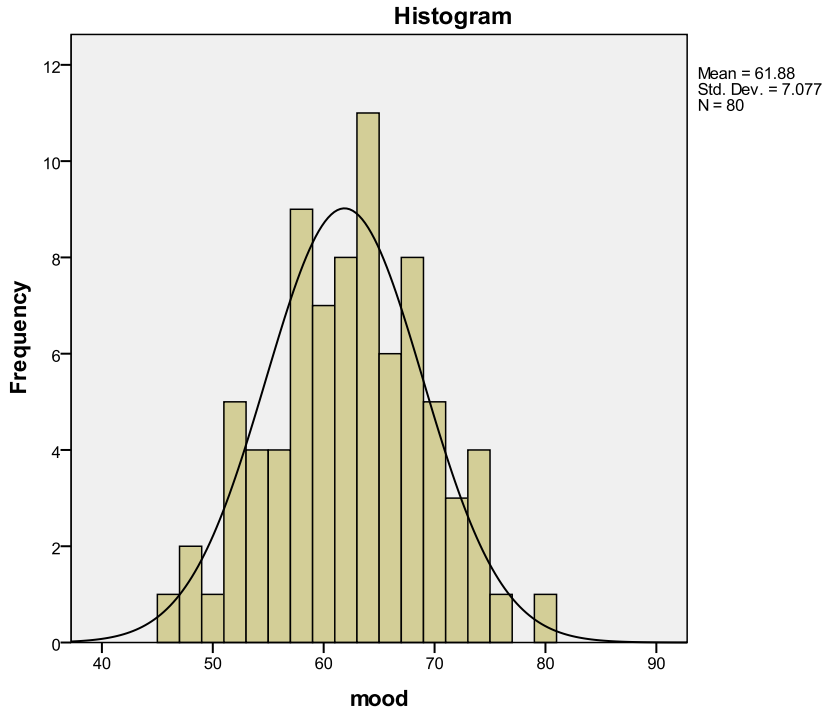
(a)
H_0: Light therapy has no effect on depression.
H_1: Light therapy is effective in reducing depression.

(b)
Histograms with normal curve plots show a normal distribution of *mood* for all groups as shown in the three figures below, hence, the pretest criteria of *normality* is satisfied.

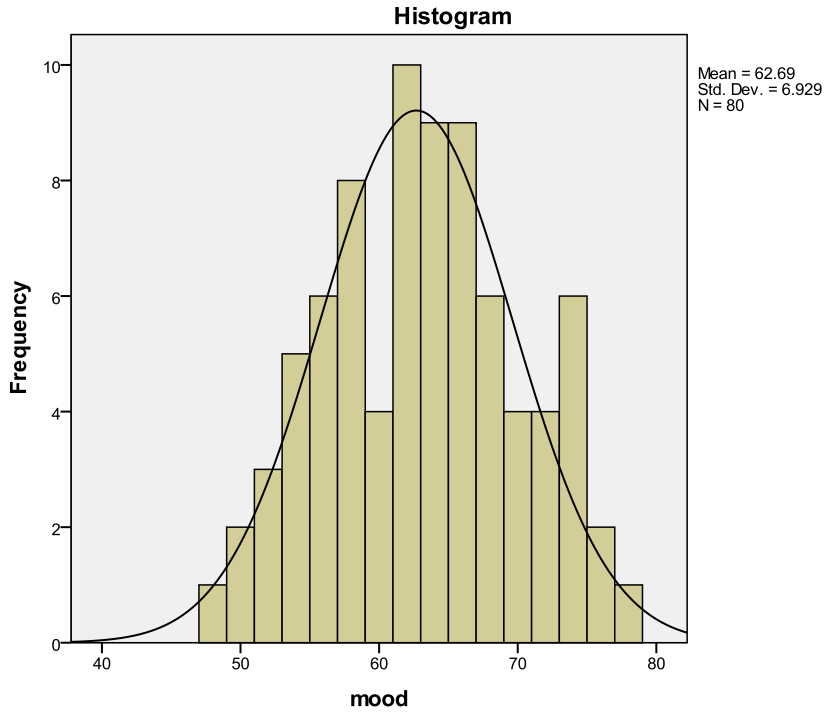
Group 1 (No light therapy)



Group 2 (Light therapy: even days)



Group 3 (Light therapy: every day)



Test of Homogeneity of Variances

mood

Levene Statistic	df1	df2	Sig.
1.409	2	237	.246

The homogeneity of variance score for *mood* shows a significance (*p*) of .246; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances of the three groups, hence, this pretest criterion passes.

The *n* for each group is 80 in each group, which satisfies the 30 per group minimum criterion (see *Descriptives* table below).

(c)
The ANOVA test revealed the following:

Descriptives

mood

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
No light therapy	80	59.13	8.299	.928	57.28	60.97	42	77
Light therapy: even days	80	61.88	7.077	.791	60.30	63.45	46	79
Light therapy: every day	80	62.69	6.929	.775	61.15	64.23	48	78
Total	240	61.23	7.585	.490	60.26	62.19	42	79

ANOVA

mood

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	557.708	2	278.854	5.010	.007
Within Groups	13190.688	237	55.657		
Total	13748.396	239			

Multiple Comparisons

mood
Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No light therapy	Light therapy: even days	-2.750	1.180	.053	-5.53	.03
	Light therapy: every day	-3.563*	1.180	.008	-6.34	-.78
Light therapy: even days	No light therapy	2.750	1.180	.053	-.03	5.53
	Light therapy: every day	-.813	1.180	.770	-3.59	1.97
Light therapy: every day	No light therapy	3.563*	1.180	.008	.78	6.34
	Light therapy: even days	.813	1.180	.770	-1.97	3.59

*. The mean difference is significant at the 0.05 level.

Groups (μ = mood)	*p*
μ(No light th.) = 59.1 : μ(Light th. even days) = 61.9	.053
μ(No light th.) = 59.1 : μ(Light th. every day) = 62.7	.008*
μ(Light th. even days) = 61.9 : μ(Light th. every day) = 62.7	.770

Means rounded to one decimal digit.
*Statistically significant difference (α = .05).

After 1 month of treatment, participants who received light therapy for 1 hour a day scored an average of 62.7 on a mood test, compared to 59.1 among those who had no light therapy; this 3.6 difference in their scores is statistically significant (p = .008, α = .05). Those who received 1 hour of light therapy every other day showed a better mood score (61.9) than those who received no light therapy, however, the improvement is not considered to be statistically significant (p = .053) using the .05 α level. Incidentally, comparing the mean mood score of those who received light therapy (61.9) for every-other-day, and for daily use (62.7) revealed no statistically significant difference between those two groups (p = .770, α = .05).

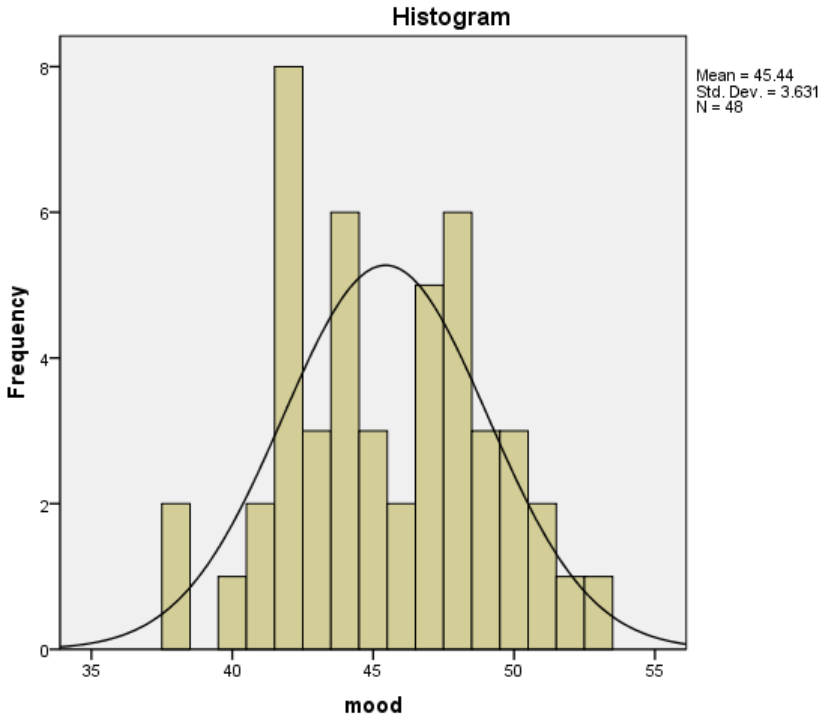
(d)
In order to determine if light therapy is a viable supplement to treating depression, 240 subjects diagnosed with depression were randomly assigned to one of three groups: The control group received no light therapy; the second group received 1 hour of light therapy every other day for a month; the third group received light therapy for 1 hour every day for a month. After 30 days, all participants completed the Acme Mood Scale, a 10 question survey that renders a score from 1 to 100 (1 = Extremely bad mood, 100 = Extremely good mood). The group average scores on the mood test were similar among the two light therapy groups—61.9 for the every-other day group, and 62.7 for the daily group. Although these differences were not statistically significantly different from each other (p = .770, α = .05), only the group that received light therapy on a daily basis (μ = 62.7) showed a statistically significant improvement in mood, when compared to those who received no light therapy (μ = 59.1) (p = .008, α = .05).

Exercise 6.7, Data Set B

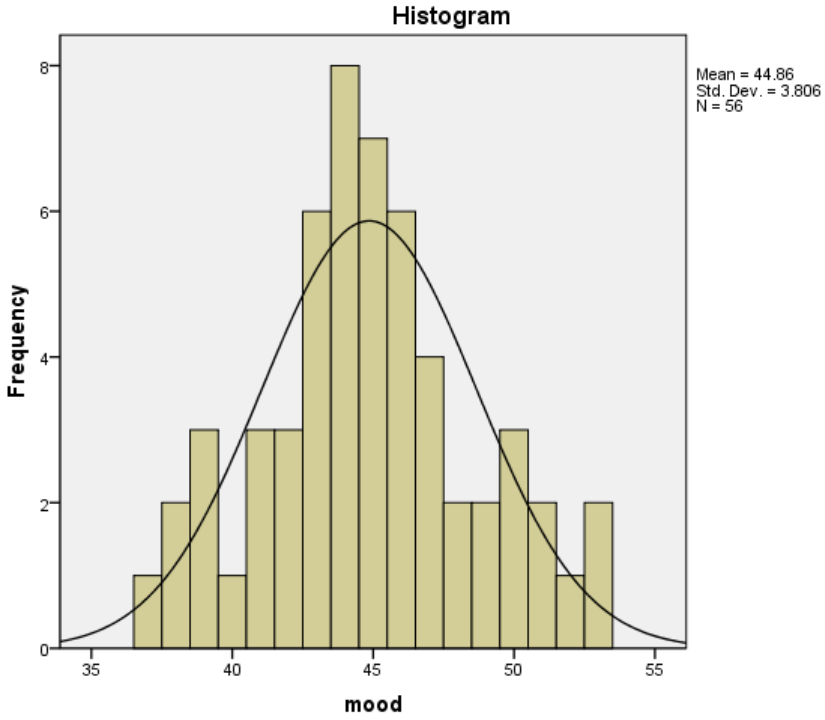
(a)
H_0: Light therapy has no effect on depression.
H_1: Light therapy has is effective in reducing depression.

(b)
Histograms with normal curve plots show a normal distribution of *mood* for all groups per the three figures below, hence, the pretest criterion of *normality* is satisfied.

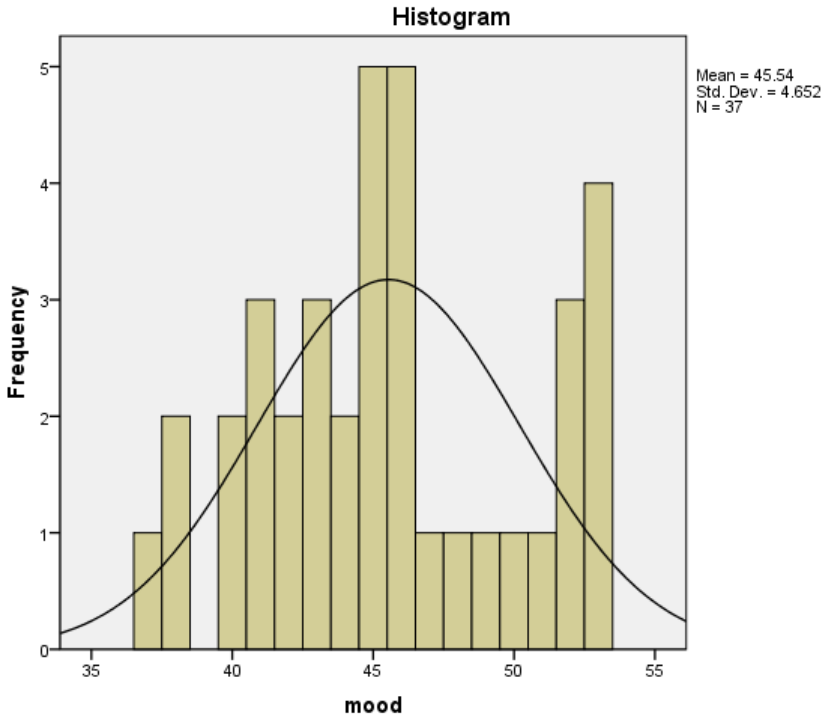
Group 1 (No light therapy)



Group 2 (Light therapy: even days)



Group 3 (Light therapy: every day)



Test of Homogeneity of Variances

mood

Levene Statistic	df1	df2	Sig.
1.352	2	138	.262

The homogeneity of variance score for *mood* shows a significance (*p*) of .262; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances among the three groups, hence, this pretest criterion passes.

The *n*s for these groups are 48, 56, and 37, which satisfies the 30 per group minimum criterion (see *Descriptives* table below).

(c)
The ANOVA test revealed the following:

Descriptives

mood

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
No light therapy	48	45.44	3.631	.524	44.38	46.49	38	53
Light therapy: even days	56	44.86	3.806	.509	43.84	45.88	37	53
Light therapy: every day	37	45.54	4.652	.765	43.99	47.09	37	53
Total	141	45.23	3.972	.335	44.57	45.90	37	53

ANOVA

mood

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.418	2	6.709	.422	.657
Within Groups	2195.859	138	15.912		
Total	2209.277	140			

Multiple Comparisons

mood
Sidak

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No light therapy	Light therapy: even days	.580	.785	.843	-1.32	2.48
	Light therapy: every day	-.103	.873	.999	-2.21	2.01
Light therapy: even days	No light therapy	-.580	.785	.843	-2.48	1.32
	Light therapy: every day	-.683	.845	.805	-2.73	1.36
Light therapy: every day	No light therapy	.103	.873	.999	-2.01	2.21
	Light therapy: even days	.683	.845	.805	-1.36	2.73

Groups (μ = mood)	***p***
μ(No light th.) = 45.44 : μ(Light th. even days) = 44.86	.843
μ(No light th.) = 45.44 : μ(Light th. every day) = 45.54	.999
μ(Light th. even days) = 44.86 : μ(Light th. every day) = 45.54	.805

*Statistically significant difference (α = .05).

After 1 month of treatment, participants who received light therapy for 1 hour a day scored an average of 45.54 on a mood test; those who had light therapy every other day scored an average of 44.86, and those who had no light therapy had an average score of 45.44. The ANOVA table reports a Sig. (*p*) value of .657 which is greater than the .05 α level, indicating that there are no statistically significant differences among the groups. This is confirmed by the Sig. column on the *Multiple Comparisons* table, wherein the *p* values range from .805 to .999, which is well above the .05 α level. Hence, we can conclude that for this sample, the light therapy protocol produced no statistically significant improvement in mood.

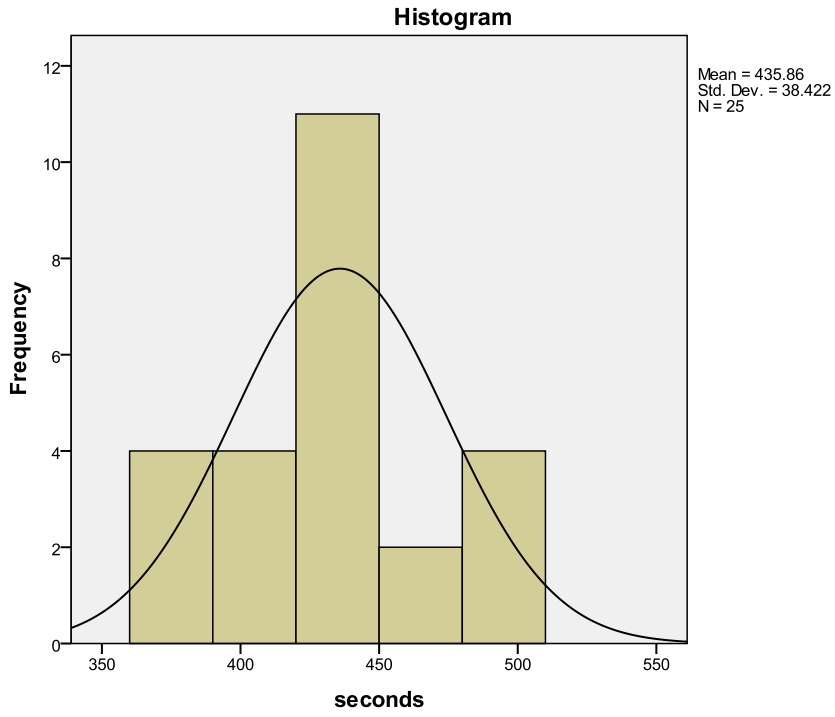
(d)
In order to determine if light therapy is a viable supplement to treating depression, 141 subjects diagnosed with depression were randomly assigned to one of three groups: The control group received no light therapy; the second group received 1 hour of light therapy every other day for a month; the third group received light therapy for 1 hour every day for a month. After 30 days, all participants completed the Acme Mood Scale, a 10 question survey that renders a score from 1 to 100 (1 = Extremely bad mood, 100 = Extremely good mood). The group average scores on the mood test were similar; 45.44 for those who received no light therapy, 44.86 for those who had light therapy every other day, and 45.54 for those who had light therapy daily. The *p* values among these three groups ranged from .805 to .999; using an α level of .05, we conclude that this schedule of light therapy did not produce a statistically significant improvement in mood for these participants.

Exercise 6.9, Data Set A

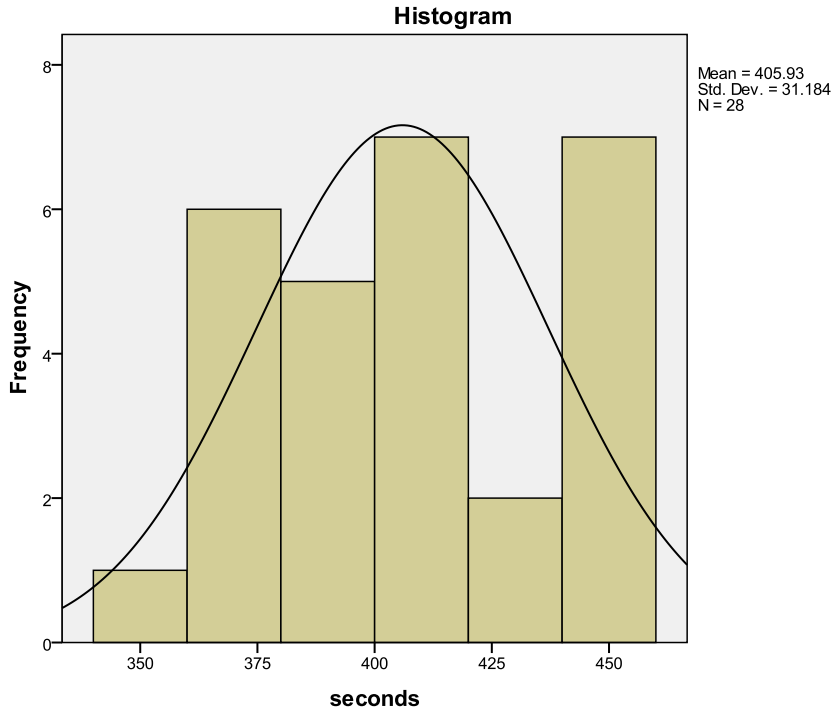
(a)
H_0: Lighting source has no effect on reading rate.
H_1: Lighting source has an effect on reading rate.

(b) Histograms with normal curve plots show a normal distribution of *seconds* for all groups as shown in the four figures below, hence, the pretest criterion of *normality* is satisfied.

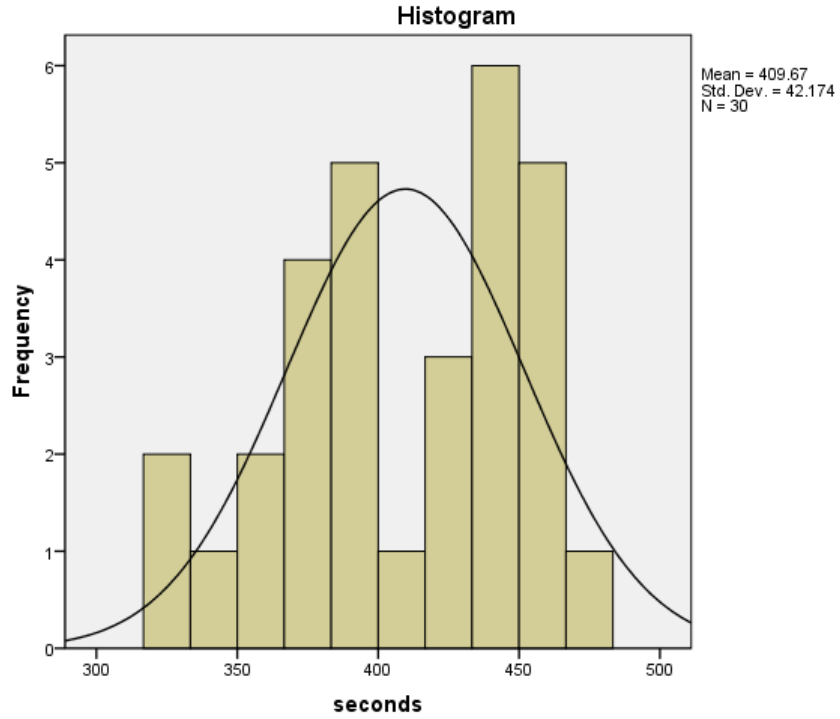
Normal distribution for *seconds* in Group 1 (Room lighting)



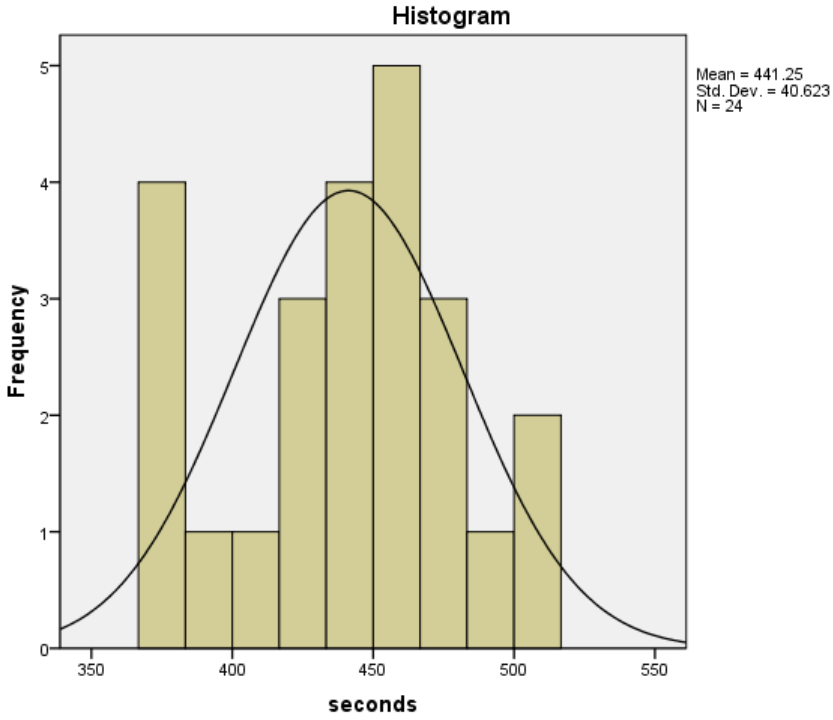
Normal distribution for *seconds* in Group 2 (Acme reading lamp)



Normal distribution for *seconds* in Group 3 (Generic reading lamp)



Normal distribution for *seconds* in Group 4 (Flashlight)



Test of Homogeneity of Variances

seconds

Levene Statistic	df1	df2	Sig.
1.499	3	103	.219

The homogeneity of variance score for *seconds* shows a significance (*p*) of .219; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances among the four groups, hence, this pretest criterion passes.

The Generic lamp group was the only group that had the minimal *n* of 30. The Room lighting, Acme lighting, and Flashlight groups had *n*s of 25, 28 and 24 respectively (see *Descriptives* table below). The findings of the ANOVA test would be more robust if the *n*s were slightly higher for these three groups.

(c) The ANOVA test revealed the following:

Descriptives

seconds

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Room lighting	25	435.88	38.511	7.702	419.98	451.78	374	509
Acme lamp	28	405.93	31.184	5.893	393.84	418.02	357	455
Generic lamp	30	409.67	42.174	7.700	393.92	425.41	328	470
Flashlight	24	441.25	40.623	8.292	424.10	458.40	368	512
Total	107	421.90	40.851	3.949	414.07	429.73	328	512

ANOVA

seconds

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25504.205	3	8501.402	5.784	.001
Within Groups	151385.664	103	1469.764		
Total	176889.869	106			

Multiple Comparisons

seconds
Sidak

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Room lighting	Acme lamp	29.951*	10.549	.032	1.65	58.25
	Generic lamp	26.213	10.382	.076	-1.64	54.06
	Flashlight	-5.370	10.956	.997	-34.76	24.02
Acme lamp	Room lighting	-29.951*	10.549	.032	-58.25	-1.65
	Generic lamp	-3.738	10.074	.999	-30.76	23.29
	Flashlight	-35.321*	10.665	.008	-63.93	-6.71
Generic lamp	Room lighting	-26.213	10.382	.076	-54.06	1.64
	Acme lamp	3.738	10.074	.999	-23.29	30.76
	Flashlight	-31.583*	10.499	.020	-59.75	-3.42
Flashlight	Room lighting	5.370	10.956	.997	-24.02	34.76
	Acme lamp	35.321*	10.665	.008	6.71	63.93
	Generic lamp	31.583*	10.499	.020	3.42	59.75

*. The mean difference is significant at the 0.05 level.

Groups (μ = reading time in seconds)	***p***
Room lighting (μ = 436) : Acme Lamp (μ = 406)	.032*
Room lighting (μ = 436) : Generic lamp (μ = 410)	.076
Room lighting (μ = 436) : Flashlight (μ = 441)	.997
Acme lamp (μ = 406) : Generic lamp (μ = 410)	.999
Acme lamp (μ = 406) : Flashlight (μ = 441)	.008*
Generic lamp (μ = 410) : Flashlight (μ = 441)	.020*

Means rounded to nearest second.
*Statistically significant difference (α = .05).

Per the table above, since the mean reading time in the Acme reading lamp group is statistically significantly lower than scores of those who read using Room lighting and by Flashlight, we reject H_0. For the same reason, we would not reject H_1.

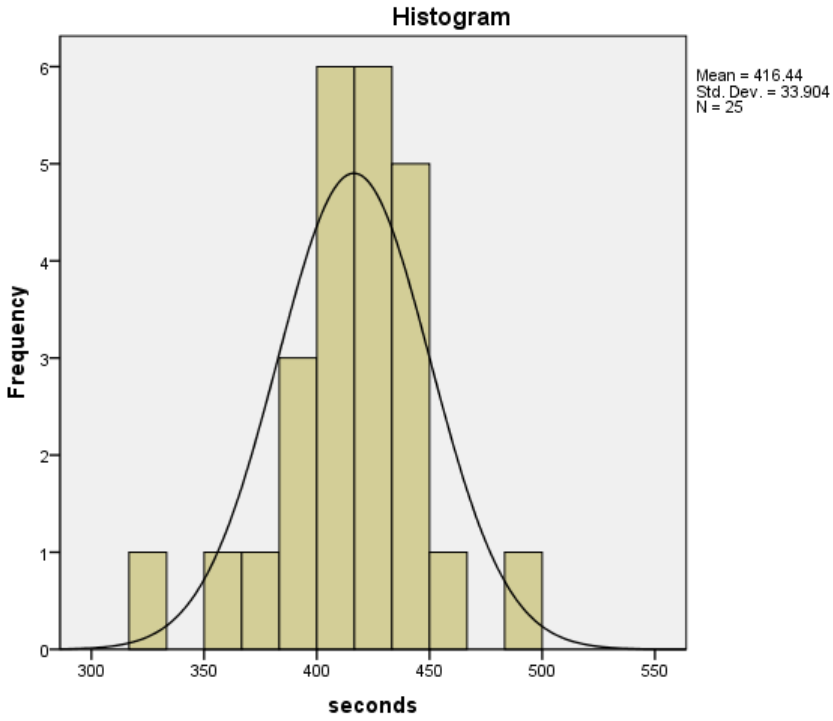
(d)
This study analyzed the effects that the Acme reading lamp had on reading speed. The 107 participants were randomly assigned to one of four groups; one group read a 1,000-word essay using regular room lighting, the second group read the same essay using the new Acme reading lamp, the third group read using a generic reading lamp, and the fourth group read using a flashlight. Results revealed that on the average, those who read using the Acme reading lamp read significantly faster ($\mu = 406$) than those who read using a flashlight ($\mu = 441$, $p = .008$), or regular room lighting ($\mu = 436$, $p = .032$) using an α level of .05. Incidentally, those who used a generic reading lamp ($\mu = 410$) finished reading the essay significantly faster than those who read by flashlight ($\mu = 441$, $p = .020$). We also discovered that those who read using a Acme reading lamp ($\mu = 406$) completed the essay faster than those who used the generic reading lamp ($\mu = 410$), however this difference was not found to be statistically significant ($p = .999$).

Exercise 6.9, Data Set B

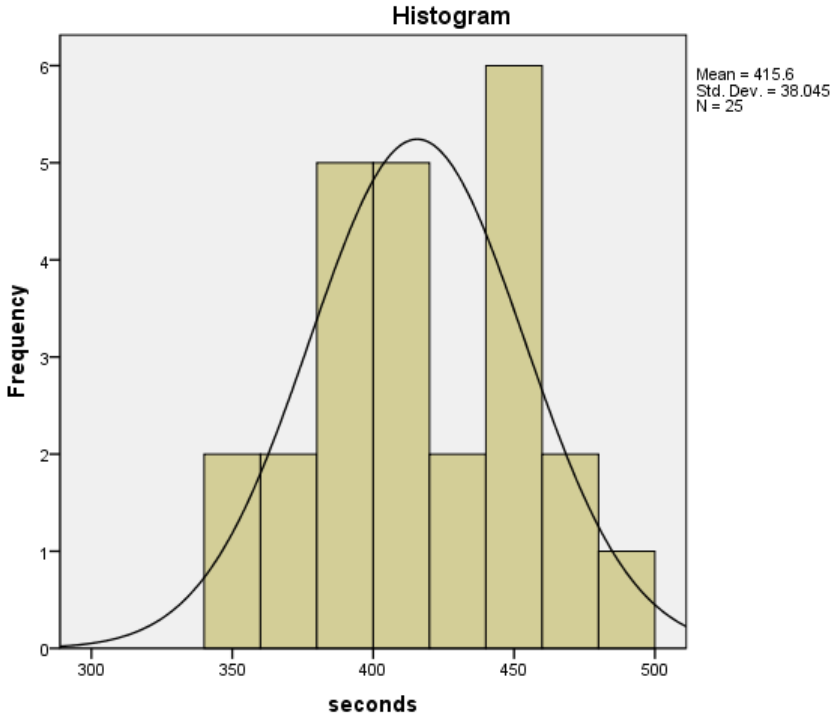
(a)
H_0: Lighting source has no effect on reading rate.
H_1: Lighting source has an effect on reading rate.

(b)
Histograms with normal curve plots show a normal distribution of *seconds* for all groups as shown in the four figures below, hence, the pretest criterion of *normality* is satisfied.

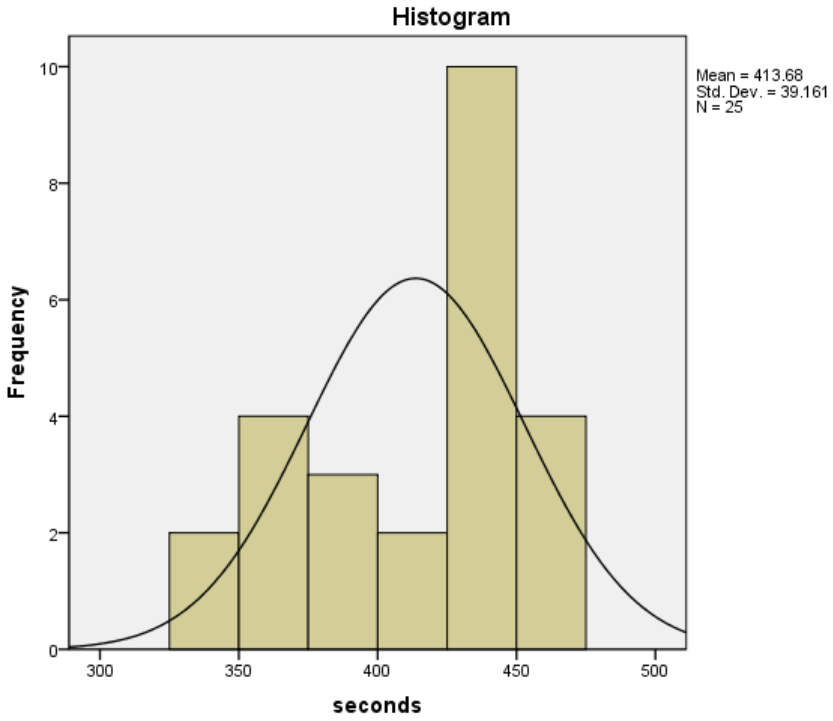
Normal distribution for *seconds* in Group 1 (Room lighting)



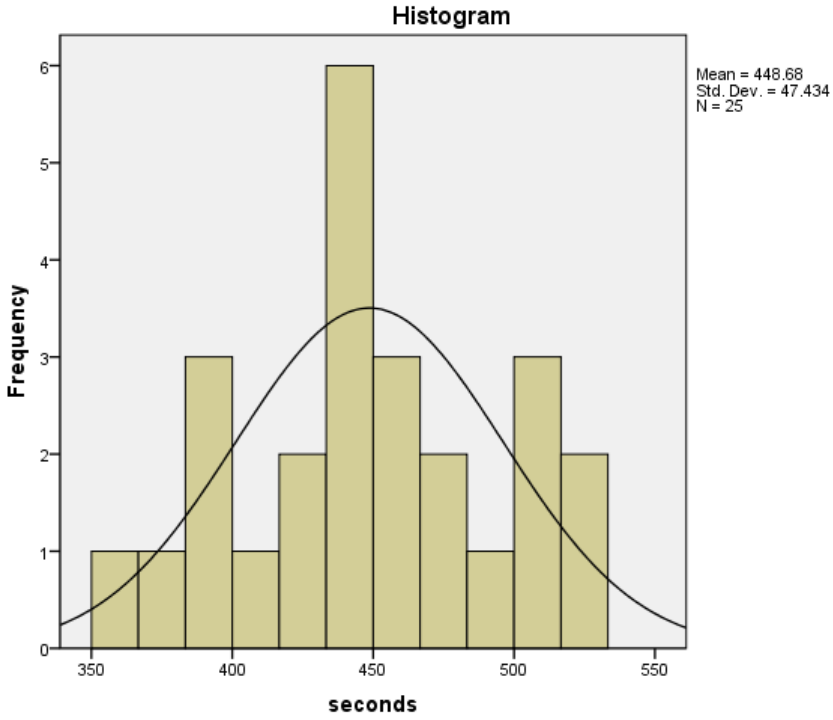
Normal distribution for *seconds* in Group 2 (Acme reading lamp)



Normal distribution for *seconds* in Group 3 (Generic reading lamp)



Normal distribution for *seconds* in Group 4 (Flashlight)



Test of Homogeneity of Variances

seconds

Levene Statistic	df1	df2	Sig.
1.163	3	96	.328

The homogeneity of variance score for *seconds* shows a significance (*p*) of .328; since this is greater than the α level of .05, this suggests that there is no statistically significant difference between the variances among the four groups, hence, this pretest criterion passes.

The groups each had an *n* of 25 (see *Descriptives* table below). The findings of the ANOVA test would be more robust if the *n*s were at least 30 per group.

(c)
The ANOVA test revealed the following:

Descriptives

seconds

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Room lighting	25	416.44	33.904	6.781	402.44	430.44	331	489
Acme lamp	25	415.60	38.045	7.609	399.90	431.30	344	481
Generic lamp	25	413.68	39.161	7.832	397.52	429.84	338	470
Flashlight	25	448.68	47.434	9.487	429.10	468.26	361	525
Total	100	423.60	41.947	4.195	415.28	431.92	331	525

ANOVA

seconds

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21066.960	3	7022.320	4.402	.006
Within Groups	153131.040	96	1595.115		
Total	174198.000	99			

Multiple Comparisons

seconds
Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Room lighting	Acme lamp	.840	11.296	1.000	-28.70	30.38
	Generic lamp	2.760	11.296	.995	-26.78	32.30
	Flashlight	-32.240*	11.296	.027	-61.78	-2.70
Acme lamp	Room lighting	-.840	11.296	1.000	-30.38	28.70
	Generic lamp	1.920	11.296	.998	-27.62	31.46
	Flashlight	-33.080*	11.296	.022	-62.62	-3.54
Generic lamp	Room lighting	-2.760	11.296	.995	-32.30	26.78
	Acme lamp	-1.920	11.296	.998	-31.46	27.62
	Flashlight	-35.000*	11.296	.013	-64.54	-5.46
Flashlight	Room lighting	32.240*	11.296	.027	2.70	61.78
	Acme lamp	33.080*	11.296	.022	3.54	62.62
	Generic lamp	35.000*	11.296	.013	5.46	64.54

*. The mean difference is significant at the 0.05 level.

Groups (μ = reading time in seconds)	***p***
Room lighting (μ = 416) : Acme Lamp (μ = 416)	1.000
Room lighting (μ = 416) : Generic lamp (μ = 414)	.995
Room lighting (μ = 416) : Flashlight (μ = 449)	.027*
Acme lamp (μ = 416) : Generic lamp (μ = 414)	.998
Acme lamp (μ = 416) : Flashlight (μ = 449)	.022*
Generic lamp (μ = 414) : Flashlight (μ = 449)	.013*

Means rounded to nearest second.
*Statistically significant difference (α = .05).

Per the table above, since the mean reading time in the Acme lamp group (μ = 416) is statistically significantly lower than those who read using a Flashlight (μ = 449, p = .022), based on the .05 α level, we reject H_0 and not reject H_1. Additionally, Room lighting (μ = 416) statistically significantly outperformed the reading rate of the Flashlight (μ = 449, p = .027), and finally, the reading rate for the generic lamp (μ = 416) outperformed the Flashlight (p = .013).

(d)
This study analyzed the effects that the Acme reading lamp had on reading speed. The 100 participants were randomly assigned to one of four groups; one group read a 1,000-word essay using regular room lighting, the second group read the same essay using the new Acme reading lamp, the third group read using a generic reading lamp, and the fourth group read using a flashlight. There was no statistically significant difference in reading times among those who used the Acme reading lamp (μ = 416), Room lighting (μ = 416) or the Generic lamp (μ = 414) using an α level of .05. All three of those groups read statistically significantly faster than the fourth group, who read using a flashlight (μ = 449); *p* values ranged from .013 to .027.