Work Problems Chapter 9

1. What type of research question would you use ANOVA to answer?

   Any research question that involves comparing the means of two or more independent samples is appropriate for a one-way ANOVA.

2. Why would we use ANOVA rather than multiple t-tests?

   Every time you do a *t* test, you have a certain alpha level which determines your Type I error rate. If you do three *t* tests to compare three groups, your Type I error rate increases from .05 to .15 (if you set alpha at .05). To account for the number of comparisons being made, and control the Type I error rate, you need to do an ANOVA. The *df* between groups takes into consideration how many groups are being compared.

3. Describe what an *F* ratio is. What does it tell you?

   It is the ratio of the mean squares between groups divided by the mean squares error. It tells us how large the average squared difference between the group means and the grand mean is compared to the average squared difference between individual scores and their group means. The mean squares error is considered to be random variation, so it is just random sampling error. The *F* ratio tells us if the differences between our group means is large or small relative to our random sampling error.

4. How should we interpret a significant *F* ratio? That is, what does a statistically significant F-ratio tell us? What does it not tell us?

   A statistically significant *F* ratio tells us that there is a difference between the population means that our samples represent. But it does not tell us which specific population means differ from each other. We need to conduct post-hoc tests for this information.

5. Suppose I want to know whether drivers in Ohio, Texas, and California differ in the average number of miles they commute to work each day. So I select random samples of 5 drivers from each state and ask how far they drive to work. I get the data that is summarized in Table 9.9 Please answer the following questions based on these data.

Table 9.9 Data for numbers of hours Ohio, Texas, and California drivers spend commuting per day.

	Ohio		Texas		California	
	X	$(X-\overline{X})^2$	X	$(X-\overline{X})^2$	X	$(X-\overline{X})^2$
Driver 1	11	.36	11	23.04	13	49
Driver 2	5	29.16	13	7.84	16	16
Driver 3	12		15	.64	19	1
Driver 4	16	31.36	19		24	16
Driver 5	8	5.76	21	27.04	28	64
Group means	10.40				20.00	
SS (each group)		69.20				146
Grand mean						

a. Calculate the missing values in the blank cells in the table. **SEE TABLE**

b. Perform all of the necessary calculations to determine whether the *F* value is statistically significant with an alpha level of .05—DO NOT perform the Tukey tests here.

The SSe = 69.2 + 68.8 + 146 = 284.
The MSe = 284/12 = 23.67

The SSb = $5(10.4 - 15.4)^2 + 5(15.8 - 15.4)^2 + 5(20 - 15.4)^2$
SSb = 5(25) + 5(.16) + 5(21.16) → 125 + .8 + 105.8 → 231.6
The MSb = 231.6/2 = 115.8

$F_{\text{-obs}}$ = 115.8/23.67 = 4.89.

$F_{\text{-crit}\ (2,\ 12)}$ = 4.75

c. Interpret your results. What can you say now about the differences between the population means?

Because *F*-o > *F*-c, the result is statistically significant. The results were not due to chance. I conclude that there is a difference, somewhere, between population means of Ohio, Texas, and California drivers in average commute distance, but I'm not sure which means differ from each other.

d. Conduct the Tukey post-hoc tests to determine which means differ significantly using an alpha level of .05, then interpret your results. Now what can you say about the differences between the population means?

Tukey critical: 3.77 at .05 level

Standard error of tukey: $\sqrt{23.67/5} \rightarrow \sqrt{4.73} = 2.18$

Tukey observed (CA-TX): $(20-15.8)/2.18 \rightarrow 4.2/2.18 = 1.93$. $1.93 < 3.77$, so not significant.

Tukey observed (TX-OH): $(15.8-10.4)/2.18 \rightarrow 5.4/2.18 = 2.48$. $2.48 < 3.77$, so not significant.

Tukey observed (CA-OH): $(20-10.4)/2.18 \rightarrow 9.6/2.18 = 4.40$. $4.40 > 3.77$, so significant.

The population mean of CA is higher than the population mean of OH, but there is no difference between the population means of TX and CA or between TX and OH in the miles commuting.

6. I recently conducted an experiment with college students to examine whether telling them about the expectations for how well they would perform on a test influenced how well they actually performed. Students were randomly assigned to one a three groups: Neutral, in which students were simply told they would be given a test and to try to do well; Encouraged, in which students were told they were expected to do well because they were good students attending a good school; and Disrespected, in which they were told the test was created for students at a more prestigious school so the test creator did not expect them to do very well. Then the students in my study completed a set of test questions. I conducted a one-way ANOVA to compare the means of the participants in the three groups, and the SPSS results of this analysis are presented in Table 9.8. In this analysis, test performance is the total number of test questions that were correctly answered by participants. The independent variable is labeled “Group” in the SPSS output. Take a look at the results presented in Table 9.8 and answer the following questions.

Table 9.8 SPSS output for one-way ANOVA comparing test performance of three groups (Neutral, Encouraged, and Disrespected).

Descriptive Statistics

Dependent Variable: Test performance

Group	Mean	Std. Deviation	N
1=neutral	10.9423	2.60778	52
2=encouraged	10.5577	2.93333	52
3=disrespected	9.8519	2.92940	54
Total	10.4430	2.84749	158

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

Dependent Variable: Test performance

F	df1	df2	Sig.
.887	2	155	.414

Tests of Between-Subjects Effects

Dependent Variable: Test performance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	32.519[a]	2	16.259	2.032	.135	.026
Intercept	17250.573	1	17250.573	2155.507	.000	.933
Group	32.519	2	16.259	2.032	.135	.026
Error	1240.469	155	8.003			
Total	18504.000	158				
Corrected Total	1272.987	157				

a. R Squared = .026 (Adjusted R Squared = .013)

a. Report the means for each group.

Neutral group: 10.9423, Encouraged group: 10.5577, Disrespected group: 9.8519

b. Report whether the assumption of equal variances is violated and explain how you know.

The Levene's test for equality of error variances was not statistically significant ("Sig." = .414), so the assumption of equal variances was not violated.

c. Report the *F* value for the one-way ANOVA examining differences between the groups.

$\boldsymbol{F_{(2,155)} = 2.032}$.

i. Is this a statistically significant *F* value? How do you know?

This is NOT a statistically significant *F* value. I know this because the *p* value is larger than .05 ("Sig." = .135).

d. Report the effect size for the independent Group variable and explain what it means.

The effect size for the Group variable is .026. I can see this in the far right column of the last part of the table, under "Partial Eta Squared." This tells us that which group one belongs to explained 2.6% of the variance in test performance.

e. Write a sentence or two to summarize what this ANOVA reveals about the differences in test performance between the groups.

Because the *F* value for the one-way ANOVA was not statistically significant, I conclude that there are no differences in the average test performance of students in the Neutral, Encouraged, or Disrespected populations that these samples represent. Because this was an experiment, I can conclude that the experimental manipulation did not affect the test performance of students.