the present text. However, coverage of these tests can be found in more comprehensive statistics texts.

Summary

In this chapter, we discussed designs that use more than two levels of an independent variable. Advantages to such designs include being able to compare more than two kinds of treatment, to use fewer participants, to compare all treatments with a control group, and to use placebo groups. In addition, we discussed the statistical analyses most appropriate for use with these designs—most commonly, with interval-ratio data, an ANOVA. A randomized one-way ANOVA is used for between-subjects designs, and a repeated measures one-way ANOVA is used for correlated-groups designs. Also discussed were appropriate post hoc tests (Tukey's HSD) and measures of effect size (eta-squared). After completing this chapter, you should appreciate the advantages of using more complicated designs and understand the basic statistics used to analyze such designs.

KEY TERMS

Bonferroni adjustment
ANOVA (analysis of variance)
one-way randomized ANOVA
grand mean
error variance
within-groups variance
between-groups variance
F-ratio
total sum of squares
within-groups sum of squares
between-groups sum of squares
mean square
eta-squared (η^2)
post hoc test
Tukey's honestly significant difference (HSD)
one-way repeated measures ANOVA

CHAPTER EXERCISES

(Answers to odd-numbered exercises appear in Appendix C.)

1. What is/are the advantage(s) of conducting a study with three or more levels of the independent variable?
2. What is the difference between a randomized ANOVA and a repeated measures ANOVA? What does the term *one-way* mean with respect to an ANOVA?
3. Explain between-groups variance and within-groups variance.
4. If a researcher decides to use multiple comparisons in a study with three conditions, what is the probability of a Type I error across these comparisons? Use the Bonferroni adjustment to determine the suggested alpha level.
5. If H_0 is true, what should the *F*-ratio equal or be close to? If H_a is supported, should the *F*-ratio be greater than, less than, or equal to 1?
6. When should post hoc comparisons be performed?
7. What information does eta-squared (η^2) provide?
8. Why is a repeated measures ANOVA statistically more powerful than a randomized ANOVA?

9. A researcher conducts a study of the effects of amount of sleep on creativity. The creativity scores for four levels of sleep (2 hours, 4 hours, 6 hours, and 8 hours) for $N = 20$ subjects are presented here.

Amount of Sleep (in hours)			
2	*4*	*6*	*8*
3	4	10	10
5	7	11	13
6	8	13	10
4	3	9	9
2	2	10	10

a. Complete the following ANOVA summary table. (If your instructor wants you to calculate the sums of squares, use the preceding data to do so.)

Source	*df*	*SS*	*MS*	*F*
Between groups		187.75		
Within groups		55.20		
Total		242.95		

b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.

10. In a study of the effects of stress on illness, a researcher tallied the number of colds people contracted during a 6-month period as a function of the amount of stress they reported during that same time period. There were three stress levels: minimal, moderate, and high stress. The sums of squares appear in the following ANOVA summary table. The mean for each condition and the number of subjects per condition are also noted.

Source	*df*	*SS*	*MS*	*F*
Between groups		22.167		
Within groups		14.750		
Total		36.917		

Stress Level	*Mean*	*N*
Minimal	3	4
Moderate	4	4
High	6	4

a. Complete the ANOVA summary table.
b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.

11. A researcher interested in the effects of exercise on stress had participants exercise for 30, 60, or 90 minutes per day. The mean stress level on a 100-point stress scale (with 100 indicating high stress) for each condition appears next, along with the ANOVA summary table with the sums of squares indicated.

Source	*df*	*SS*	*MS*	*F*
Between groups		4,689.27		
Within groups		82,604.20		
Total		87,293.47		

Exercise Level	*Mean*	*n*
30 minutes	75.0	10
60 minutes	44.7	10
90 minutes	63.7	10

a. Complete the ANOVA summary table.
b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.

12. A researcher conducted an experiment on the effects of a new "drug" on depression. The researcher had a control group that received nothing, a placebo group, and an experimental group that received the "drug." A depression inventory that provided a measure of depression on a 50-point scale was used (50 indicates that an individual is very high on the depression variable). The ANOVA summary table appears next, along with the mean depression score for each condition.

Source	*df*	*SS*	*MS*	*F*
Between groups		1,202.313		
Within groups		2,118.00		
Total		3,320.313		

"Drug" Condition	*Mean*	*n*
Control	36.26	15
Placebo	33.33	15
"Drug"	24.13	15

a. Complete the ANOVA summary table.
b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.

13. A researcher is interested in the effects of practice on accuracy in a signal-detection task. Subjects are tested with no practice, after 1 hour of practice, and after 2 hours of practice. Each person participates in all three conditions. The following data indicate how many signals each participant detected accurately at each level of practice.

	Amount of Practice		
Subject	*No Practice*	*1 Hour*	*2 Hours*
1	3	4	6
2	4	5	5
3	2	3	4
4	1	3	5
5	3	6	7
6	3	4	6
7	2	3	4

Source	*df*	*SS*	*MS*	*F*
Subject		16.27		
Between		25.81		
Error		4.87		
Total		46.95		

a. Complete the ANOVA summary table. (If your instructor wants you to calculate the sums of squares, use the preceding data to do so.)
b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.

14. A researcher has been hired by a pizzeria to determine which type of crust customers prefer. The restaurant offers three types of crust: hand-tossed, thick, and thin. Following are the mean number of 1-inch pieces of pizza eaten for each condition from 10 subjects who had the opportunity to eat as many pieces with each type of crust as they desired. The ANOVA summary table also follows.

Source	*df*	*SS*	*MS*	*F*
Subject		2.75		
Between		180.05		
Error		21.65		
Total		204.45		

Crust Type	*Mean*	*n*
Hand-tossed	2.73	10
Thick	4.20	10
Thin	8.50	10

a. Complete the ANOVA summary table.
b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.

15. A researcher is interested in whether massed or spaced studying has a greater impact on grades in a course. The researcher has her class study for 6 hours all in one day for one exam (massed study condition). She has them study for 2 hours each day for 3 days for another exam (3-day spaced condition). Last, she has them study for 1 hour a day for 6 days for a third exam (6-day spaced condition). The mean exam score (out of a possible 100 points) for each condition appears next, along with the ANOVA summary table.

Source	*df*	*SS*	*MS*	*F*
Subject		136.96		
Between		3,350.96		
Error		499.03		
Total		3,986.95		

Study Condition	*Mean*	*n*
Massed	69.13	15
3-day spaced	79.33	15
6-day spaced	90.27	15

a. Complete the ANOVA summary table.
b. Is F_{obt} significant at $\alpha = .05$; at $\alpha = .01$?
c. Perform post hoc comparisons if necessary.
d. What conclusions can be drawn from the *F*-ratio and the post hoc comparisons?
e. What is the effect size, and what does this mean?
f. Graph the means.