11. You are most likely to get a significant F if between-group variability is large (your group means are very different from each other) and within-groups variability is small (within each group, most scores are close to each other).
12. If you get a significant F, you know that the groups are not all the same. If you have more than two groups, you have to find out which groups differ. To find out which groups are different, do not just look at the means to see which differences are biggest. Instead, do post hoc tests to find out which groups are reliably different.
13. The following table summarizes the mathematics of an ANOVA table.

Source of Variance (*SV*)	Sum of Squares (*SS*)	Degrees of Freedom (*df*)	Mean Square (*MS*)	*F*
Treatment (*T*)	*SST*	Levels of $T - 1$	$SST/df\ T$	MST/MSE
Error (*E*)	*SSE*	Participants − Groups	$SSE/df\ E$	
Total	$SST + SSE$	Participants − 1		

KEY TERMS

analysis of variance (ANOVA) *(p. 439)*
confounding variables *(p. 427)*
empty control group *(p. 430)*
error variance *(p. 436)*
eta squared (η^2) *(p. 445)*
F ratio *(p. 440)*
functional relationship *(p. 421)*
hypothesis-guessing *(p. 430)*
linear relationship *(p. 421)*
post hoc tests *(p. 446)*
post hoc trend analysis *(p. 447)*
treatment variance *(p. 438)*
variability between group means *(p. 433)*
within-groups variance *(p. 436)*

EXERCISES

1. A researcher randomly assigns each member of a statistics class to one of two groups. In one group, each student is assigned a tutor who is available to meet with the student 20 minutes before each class. The other group is a control group not assigned a tutor. Suppose the researcher finds that the tutored group scores significantly better on exams.
   a. Can the researcher conclude that the experimental group students learned statistical information from tutoring sessions that enabled them to perform better on the exam? Why or why not?
   b. What changes would you recommend in the study?
2. Suppose people living in homes for older adults were randomly assigned to two groups: a no-treatment group and a transcendental meditation (TM) group. Transcendental meditation involves more than sitting with eyes closed. The technique involves both "a meaningless sound selected for its value in facilitating the transcending, or settling-down, process and a specific procedure for using it mentally without effort again to facilitate transcending" (Alexander, Langer, Newman, Chandler, & Davies, 1989, p. 953). The TM group was given instruction in how to perform the technique; then "they met with their instructors half an hour each week to verify that they were meditating

correctly and regularly. They were to practice their program 20 minutes twice daily (morning and afternoon) sitting comfortably in their own room with eyes closed and using a timepiece to ensure correct length of practice" (Alexander et al., 1989, p. 953).
Suppose that the TM group performed significantly better than other groups on a mental health measure.[11]

a. Could the researcher conclude that it was the transcendental meditation that caused the effect?
b. What besides the specific aspects of TM could cause the difference between the two groups?
c. What control groups would you add?
d. Suppose you added these control groups and then got a significant *F* for the treatment variable? What could you conclude? Why?

3. Assume you want to test the effectiveness of a new kind of therapy. This therapy involves screaming and hugging people in group sessions followed by individual meetings with a therapist. What control group(s) would you use? Why?
4. Assume a researcher is looking at the relationship between caffeine consumption and sense of humor.
   a. How many levels of caffeine should the researcher use? Why?
   b. What levels would you choose? Why?
   c. If a graph of the data suggests a curvilinear relationship, can the researcher assume that the functional relationship between the independent and dependent variables is curvilinear? Why or why not?
   d. Suppose the researcher used the following four levels of caffeine: 0 mg, 20 mg, 25 mg, and 26 mg. Can the researcher easily do a trend analysis? Why or why not?
   e. Suppose the researcher ranked participants based on their sense of humor. That is, the person who laughed least got a score of 1, the person who laughed second-least scored a 2, and so on. Can the researcher use these data to do a trend analysis? Why or why not?
   f. If a researcher used four levels of caffeine, how many trends can the researcher look for? What are the treatment's degrees of freedom?
   g. If the researcher used three levels of caffeine and 30 participants, what are the degrees of freedom for the treatment? What are the degrees of freedom for the error term?
   h. Suppose the *F* is 3.34. Referring to the degrees of freedom you obtained in your answer to "g" (above) and to Table 3 (Appendix F), are the results statistically significant? Can the researcher look for linear and quadratic trends?
5. A computer analysis reports that $F(6, 23) = 2.54$. The analysis is telling you that the *F* ratio was 2.54, and the degrees of freedom for the top part of the *F* ratio = 6 and the degrees of freedom for the bottom part = 23.
   a. How many groups did the researcher study?
   b. How many participants were in the experiment?
   c. Is this result statistically significant at the .05 level? (Refer to Table 3 of Appendix F.)
6. A friend gives you the following *F*s and significance levels. On what basis would you want these *F*s—or significance levels—rechecked?
   a. $F(2, 63) = .04$, not significant
   b. $F(3, 85) = -1.70$, not significant
   c. $F(1, 120) = 52.8$, not significant
   d. $F(5, 70) = 1.00$, significant

[11] A modification of this study was actually done. The study included appropriate control groups.

7. Complete the following table. (Hint: See main point #13.)

Source of Variance (*SV*)	Sum of Squares (*SS*)	Degrees of Freedom (*df*)	Mean Square (*MS*)	*F*
Treatment (*T*) 3 levels of treatment	180	—	—	—
Error (*E*), also known as within-groups variance	80	8	—	

8. Complete the following table. (Hint: See main point #13.)

Source of Variance (*SV*)	Sum of Squares (*SS*)	Degrees of Freedom (*df*)	Mean Square (*MS*)	*F*
Treatment (*T*) (between groups variance)	50	5	—	
Error (*E*), (within-groups variance)	100	—	—	—
Total	—	30		—

9. A study compares the effect of having a snack, taking a 10-minute walk, or getting no treatment on energy levels. Sixty participants are randomly assigned to a condition and then asked to rate their energy level on a 0 (not at all energetic) to 10 (very energetic) scale. The mean for the "do nothing" group is 6.0, for having a snack 7.0, and for walking 7.8. The *F* ratio is 6.27.
   a. Graph the means.
   b. Are the results statistically significant?
   c. If so, what conclusions can you draw? Why?
   d. What additional analyses should you do? Why?
   e. How would you extend this study?
   f. If you only knew the group means, could you do an ANOVA? Why or why not?

WEB RESOURCES

1. Go to the Chapter 11 section of the book's student website and
   a. Look over the concept map of the key terms.
   b. Test yourself on the key terms.
   c. Take the Chapter 11 Practice Quiz.
2. Do an analysis of variance using a statistical calculator by going to the "Statistical Calculator" link.
3. If you want to write your method section, use the "Tips on Writing a Method Section" link.
4. If you want to write up the results of a one-factor, between-participants experiment, click on the "Tips for Writing Results" link.