

Summary

In this chapter, we described experimental designs that use more than one independent variable. We discussed several advantages of using such designs and introduced the concepts of factorial notation, main effects, and interaction effects. After reading the section on main and interaction effects, you should be able to graph data from a factorial design and interpret what the graph means. We then discussed the statistical analysis of such designs by using a two-way randomized ANOVA. We presented the various calculations necessary to compute a two-way randomized ANOVA, along with the assumptions of the test and a description of how to interpret the results.

KEY TERMS

factorial design
factorial notation
main effect

interaction effect
sum of squares factor A
sum of squares factor B

sum of squares interaction
sum of squares error

CHAPTER EXERCISES

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

- What is the advantage of manipulating more than one independent variable in an experiment?
- How many independent variables are in a 4×6 factorial design? How many conditions (cells) are in this design?
- In a study, a researcher manipulated the number of hours that participants studied (either 4, 6, or 8), the type of study technique they used (shallow processing versus deep processing), and whether subjects studied individually or in groups. What is the factorial notation for this design?
- What is the difference between a cell (condition) mean and the means used to interpret a main effect?
- How many main effects and interaction effects are possible in a 2×6 factorial design?
- What is the difference between a complete factorial design and an incomplete factorial design?
- The cell means for two experiments appear next. Determine whether there are any effects of factor A, factor B, and $A \times B$ for each experiment. In addition, draw a graph representing the data from each experiment.

Experiment 1

	A ₁	A ₂
B ₁	3	5
B ₂	5	8

Experiment 2

	A ₁	A ₂
B ₁	12	4
B ₂	4	12

- Explain the difference between a two-way ANOVA and a three-way ANOVA.
- If you find two significant main effects in a 2×6 factorial design, should you compute Tukey's post hoc comparisons for both main effects?
- Complete each of the following ANOVA summary tables. In addition, answer the following questions for each of the ANOVA summary tables:
 - What is the factorial notation?
 - How many conditions were in the study?

- c. How many subjects were in the study?
 d. Identify significant main effects and interaction effects.

Source	df	SS	MS	F
A	1	60		
B	2	40		
A × B	2	90		
Error	30			
Total	35	390		

Source	df	SS	MS	F
A	2	40		
B	3	60		
A × B	6	150		
Error	72			
Total	83	400		

Source	df	SS	MS	F
A	1	10		
B	1	60		
A × B	1	20		
Error	36			
Total	39	150		

11. In a study, a researcher measures the preference of men and women for two brands of frozen pizza (one low-fat and one regular) based on the number of 1-inch pieces of each type of pizza eaten when both types are available to the participants. The following table shows the number of pieces of each type of pizza eaten for each of the 24 subjects in the study.

	Women	Men
Brand 1	3	9
(low-fat)	4	7
	2	6
	2	8
	5	9
	3	7
Brand 2	8	4
(regular)	9	2
	7	5
	10	6
	9	2
	10	5

Source	df	SS	MS	F
Gender		0.167		
Pizza brand		6.00		
Gender × Pizza		130.67		
Error		35.00		
Total		171.83		

- 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. Are the values of F_{obt} significant at $\alpha = .05$? At $\alpha = .01$?
 c. What conclusions can be drawn from the F -ratios?
 d. What is the effect size, and what does this mean?
 e. Graph the means.

12. A researcher is attempting to determine the effects of practice and gender on a timed task. Participants in an experiment are given a computerized search task. They search a computer screen of various characters and attempt to find a particular character on each trial. When they find the designated character, they press a button to stop a timer. Their reaction time (in seconds) on each trial is recorded. Subjects practice for 2, 4, or 6 hours and are either female or male. The reaction time data for the 30 subjects appear here.

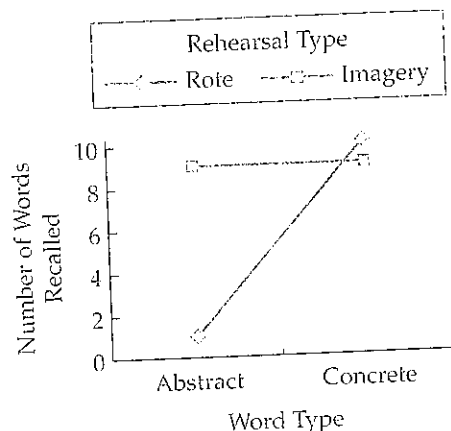
	Women	Men
2 Hours	12	11
	13	12
	12	13
	11	12
	11	11
4 Hours	10	8
	10	8
	10	10
	8	10
	7	9
6 Hours	7	5
	5	6
	7	8
	6	6
	7	8

Source	df	SS	MS	F
Gender		0.027		
Practice		140.60		
Gender × Practice		0.073		
Error		28.00		
Total		168.70		

- Complete the ANOVA summary table. (If your instructor wants you to calculate the sums of squares, use the preceding data to do so.)
- Are the values of F_{obt} significant at $\alpha = .05$? At $\alpha = .01$?
- What conclusions can be drawn from the F -ratios?
- What is the effect size, and what does this mean?
- Graph the means.

CRITICAL THINKING CHECK ANSWERS

- This would be a 3×5 design. There are three types of crust and five types of toppings, so there are 15 conditions in this study.
- A 4×6 factorial design has two independent variables. Thus, there is the possibility of two main effects (one for each independent variable) and one interaction effect (the interaction between the two independent variables).
- There appears to be a main effect of word type, with concrete words recalled better than abstract words. There also appears to be a main effect of rehearsal type, with those who used imagery rehearsal remembering more words than those who used rote rehearsal. In addition, there appears to be an interaction effect. When imagery rehearsal is used, word type makes no difference; recall is very high for both types of words. When rote rehearsal is used, word type makes a large difference; concrete words are recalled very well and abstract words very poorly.



12.2

- Tukey's HSD would not need to be calculated for the main effect of the variable with two levels because if there is a significant main effect for a variable with two levels, then we know that the difference between those two levels is significant. We would need to calculate Tukey's HSD for the variable with four levels to determine exactly which groups among the four differed significantly from each other.
- a. This is a 2×3 design.

	Gender		Row Means (Practice)
Practice	Female	Male	
1 hour	1,778.125	1,763.375	1,770.75
2 hours	1,512.375	1,764.25	1,638.31
3 hours	1,182.75	1,662	1,422.38
Column means (gender)	1,491.08	1,729.88	

b. Two-Way ANOVA Summary Table

Source	df	SS	MS	F
Factor A (gender)	1	684,264	684,264	9.68
Factor B (practice)	2	989,504	494,752	7.00
A $\times$ B	2	489,104	244,552	3.46
Error	42	2,967,768	70,661.143	
Total	47	5,130,640		

- Gender: $F(1, 42) = 9.68, p < .01$
Practice: $F(2, 42) = 7.00, p < .01$
Interaction: $F(2, 42) = 3.46, p < .05$
- The significant main effect of gender indicates that females performed more quickly than males. The significant main effect of practice indicates that as the amount of time spent practicing increased, reaction time