

## Additional Exercises

1. An experimenter often uses a randomized block design to reduce variation by comparing the treatments in homogeneous groups of experimental units called blocks. In many cases, differences in treatments are more likely to be detected with such a design than if the blocking factor were ignored. In each of the following situations, give an example of how one would run a randomized block design to make the comparison in each case. Be aware that there may be more than one correct answer in each example.
  - a. Three different methods of teaching science are to be analyzed by comparing final exam scores from classes taught by the different methods. Assume that the same final exam is given to each class.
  - b. Five hypertensive treatments are to be compared based on their ability to reduce systolic blood pressure. It is felt that the performance of the drugs is affected by the weight of the participant in the study.
  - c. It is desired to compare three different ethnic groups on their knowledge of American history. Each person in the study will be given a 50-question multiple choice test to determine their overall knowledge of the subject.
  
2. A pharmacist is interested in studying the rate at which three different sinus headache drugs are absorbed into the bloodstream. She randomly selects 12 people, and then randomly assigns four people to try each drug. She administers the drug to each participant and measures the time it takes for the drug to be absorbed into the patient's bloodstream (in minutes). The results of the study are as follows.

Drug Absorption Time (Minutes)		
Drug 1	Drug 2	Drug 3
5	10	6
4	11	7
6	9	5
3	8	5

- a. Can the pharmacist conclude at  $\alpha = 0.01$  that there is a significant difference among the average times required for absorption into the bloodstream for the three drugs?
  - b. What assumptions did the pharmacist make in performing the test procedure in part a.? Does the data appear to satisfy these assumptions? Explain.
  - c. Describe an alternate design that the pharmacist could have used for the above analysis. What are the advantages and disadvantages of this design?
  
3. An FDA representative is interested in knowing if there is a difference in the average fat contents of three different brands of margarine. The representative randomly selects six samples of each of the brands of margarine and measures the average fat contents per serving. The results of the study are displayed in the following table.

Fat Content per Serving (Grams)		
Margarine #1	Margarine #2	Margarine #3
6	5	9
7	6	8
6	5	7
8	4	8
6	6	9
8	5	7

- Does the data indicate a difference among average fat contents per serving for the three brands of margarine at  $\alpha = 0.01$ ?
  - What assumptions were made for the test in part **a.**? Does the data appear to satisfy these assumptions? Explain.
  - Why wouldn't a randomized block design be appropriate for this experiment?
4. Psychological reactance may be viewed as the motivational state resulting when someone's freedom is threatened or eliminated. A study relating psychological reactance to one's age was reported in "Psychological Reactance: Effects of Age and Gender" in the *Journal of Social Psychology*.<sup>6</sup> In order to determine the degree of psychological reactance, participants were asked to fill out a questionnaire which was then scored. The higher the score, the more acute the degree of psychological reactance. The means, standard deviations, and group sizes (for different age groups) are given in the following table.

Psychological Reactance			
Age Group	Mean	Standard Deviation	Group Size
18–24	3.36	0.60	1011
24–29	3.28	0.65	321
30–40	3.16	0.64	385

Although the summary statistics were given in the article, the actual data values upon which the statistics were based were not listed. This is standard procedure in many scientific journals.

- Compute the sums of squares and their degrees of freedom for treatments and error based upon the statistics given in the table.
  - Compute MST and MSE.
  - With  $\alpha = 0.01$ , can we conclude that there is a significant difference among the degrees of psychological reactance for the different age groups?
  - What assumptions are necessary for performing the test in part **c.**? Can they be checked in this instance?
5. Interviews of fans following an Australian Football League game were summarized in the article "On Being a Sore Loser: How Fans React to Their Team's Failure" in the *Australian Journal of Psychology*.<sup>7</sup> The study divided the fans interviewed into losers (those who supported the losing team), winners (those who supported the winning team), and non-partisans (those who were indifferent to the outcome of the game). Each fan was asked several questions, all dealing with the fan's perceptions of the game. The purpose of the study was to see if the groups differed

on their responses to any of the questions. One question asked the fans to rate the umpire's performance on a five-point scale from *very bad* (1) to *very good* (5). The mean responses and group sizes associated with this question are given in the following table.

Umpire Performance		
Group	Mean	Group Size
Losers	2.8	49
Winners	3.7	35
Non-Partisans	3.5	57

- Compute the grand mean and the sum of squares for treatments (SST).
  - Compute the  $F$ -statistic for testing for equality of the group means. The sum of squares for error (SSE) was given in the article as 39.3.
  - With  $\alpha = 0.01$ , can we conclude that there is a significant difference among the groups in the perception of the umpire?
  - What assumptions are necessary for performing the test in part **c.**? Can they be checked in this instance?
6. Consider the following partially completed ANOVA table for a  $3 \times 4$  factorial experiment with two replications.

ANOVA				
Source of Variation	SS	df	MS	F
Factor A	0.800	2		
Factor B	5.300	3		
Interaction	9.600			
Within				
Total	17.000	26		

- Complete the ANOVA table.
  - At the 0.05 level, is there evidence of significant interaction between A and B? Justify your answer.
  - At the 0.05 level, is there evidence of a significant Factor A effect? Justify your answer.
  - At the 0.05 level, is there evidence of a significant Factor B effect? Justify your answer.
  - Does the result of the test for interaction suggest further investigation? Justify your answer.
7. In an experiment to determine the best method by which to assess college students, a group of students were exposed to one of three types of tests. The three methods were: all multiple choice questions, all free-response questions, and mixed questions (a mixture of multiple choice and free-response questions). The scores were recorded for each test taken. Fifteen students were used in the study and were grouped by class level (freshman, sophomore, junior, senior, and graduate). The following table contains the results of the experiment.

Test Scores			
	Testing Methods		
Class Level	Multiple Choice	Free-Response	Mixed
Freshman	78	84	90
Sophomore	82	90	95
Junior	90	94	98
Senior	88	96	100
Graduate	95	98	99

- Identify the dependent variable, the treatment variable, and the blocking variable.
  - Graphically plot the test scores by class level and testing method. Discuss the graph.
  - Perform an analysis of the data using the class-level blocks. Are blocking effects significant at the 0.05 level of significance? Explain.
  - Is the experiment useful having been analyzed as a randomized block design? Explain.
8. A randomized block design yielded the following ANOVA table.

ANOVA				
Source of Variation	SS	df	MS	F
Treatment	500.000	5	100	7.502
Block	230.000	3	76.67	5.752
Error	120.000	9	13.33	
Total	850.000	17		

- How many blocks are used in the experiment?
  - How many treatments are used in the experiment?
  - How many observations are used in the experiment?
  - What are the null and alternative hypotheses to test if there is a difference among the treatment means?
  - What test statistic should be used to conduct the test in part **d.**?
  - What is the rejection region for the test in parts **d.** and **e.**?
  - Carry out the test and state your conclusion based on a significance level of 0.05.
9. JAS & Associates, a commercial developer, usually gets three cost estimates for many of the jobs for their building projects. Even though one contractor normally works on each potential job, it is in the best interest of the company to get additional estimates and compare them for consistency, no matter who gets the job. To check the consistency of the estimates, several projects are selected and three contractors are asked to submit estimates. The estimates (in thousands of dollars) for the 10 jobs are given in the following table.

Contractor Cost Estimates (Thousands of Dollars)			
Job	Contractor A	Contractor B	Contractor C
1	27	26	28
2	20	18	22
3	14	13	17
4	18	21	20
5	23	20	22
6	19	17	19
7	12	14	15
8	10	12	13
9	16	20	19
10	40	42	47

- Perform the appropriate analysis on the data given and generate the ANOVA table for the analysis.
  - Does the data provide sufficient evidence to conclude that there is a difference among the cost estimates supplied by the contractors? Use a significance level of 0.05 to make your decision.
  - What is the  $P$ -value for the test performed in part **a.**? Interpret this value.
10. The following table is a  $3 \times 3$  factorial design with three observations for each factor level.

Factorial Design Data			
	Factor B		
Factor A	1	2	3
1	30	47	36
	30	42	37
	30	42	38
2	12	27	35
	14	24	31
	15	22	33
3	10	34	24
	13	31	20
	12	31	22

- Make an interaction plot of the treatment means using Factor A along the  $x$ -axis and each level of Factor B as a different plotting symbol (see Figure 15.4.1). Do the means appear to be different? Does interaction between factors A and B appear to be present? Justify your answers.
- Perform the analysis using a software package, generating the ANOVA table.
- Test for significant interaction using a 0.05 level of significance. Discuss your findings.
- Test for A and B effects using a 0.05 level of significance. Discuss your findings.

11. Tech SportsPlex (TSP) is conducting a study to determine the effectiveness of three types of marketing/advertising methods: e-coupons, newspaper ads, and price discounts. Three counties (believed to be of equal size and close driving distance to TSP) were selected for the marketing campaign. Each strategy was used for a three-month period. It is known that the sales would be seasonal (i.e., TSP's management expects less activity during the summer months). The revenue data (in thousands of dollars) from the study is given in the following table.

Quarter	e-Coupons	Newspaper Ads	Price Discounts
1	48	42	37
2	25	18	21
3	20	15	18
4	40	30	24

- Identify the dependent variable, the treatment variable, and the blocking variable.
  - Specify the null and alternative hypotheses to determine if there is a significant difference among average revenues for the three advertising strategies.
  - Generate the ANOVA table to test the hypotheses in **b**.
  - Conduct the test in **c**. using a significance level of 0.05.
  - Was the variation among the observed revenues significantly reduced by blocking? Explain using  $\alpha = 0.05$ .
12. In "Death Anxiety in Malaysian and Australian University Students" (The Journal of Social Psychology, 128(1)),<sup>8</sup> the results of an experiment measuring death anxiety was reported. In the study, a total of 153 students were administered the Templer Death Anxiety Scale, a questionnaire which assesses the extent to which the respondent is preoccupied with issues surrounding death. Scores ranged from 0 to 15, with higher scores indicating greater death anxiety. The students were classified into one of three ethnic groups: Chinese, Indian, or Australian. The means, standard deviations (s.d.) and group sizes are given in the following table.

Group	mean	s.d.	size
Chinese	6.0	3.1	62
Indian	4.8	3.1	15
Australian	6.5	2.7	76

Although, the above summary statistics were given in the article, the actual data values upon which the statistics were based were not listed. This is standard procedure in many scientific journals.

- Compute the sums of squares and their degrees of freedom for treatments and error based upon the statistics given in the above table. Compute MST and MSE.
- With  $\alpha = 0.05$ , can we conclude that there is a difference in the degree of death anxiety for the 3 groups?
- What assumptions are necessary for performing the test in part **b**? Can they be checked in this instance?