Practice Problems: Answers

One-Way ANOVA Contrast Code Problems

This file contains the original problems and the answers for the one-way ANOVA coding problems. Note that many other answers are possible. In particular, any row for a code given below can be multiplied by any constant, including -1, to produce an equivalent contrast code in terms of orthogonality. For example, the code (1/3, 1/3, -2/3) is equivalent to the code (5, 5, -10) and to the code (-1, -1, 2). Also some problems allow you to ask alternative questions that might not be the same questions for which I have suggested codes.

1. An advertising director tests the effectiveness of three types of ads: those with color pictures, those with black and white photos, and those with no pictures. Subjects rate each type of ad. Specify a contrast code to test picture vs. no picture and specify the other orthogonal contrast code. What does the other contrast code test?

Color	B&W	NoPhoto	
1/3	1/3	-2/3	Picture vs. No Picture
1/2	-1/2	0	Color vs. B&W

2. A drug company wishes to test the side effects of a new drug. They used five groups: a control group which received no medication (C1), a control group which received an inert placebo (C2), a treatment group which received the regular formulation of Drug A (A1), another treatment group which received a buffered version of Drug A (A2), and a final treatment group which received a different Drug B which is presumed to have the same therapeutic effects as Drug A (B). Generate a set of contrast codes for groups C1, C2, A1, A2, and B to answer these questions:

1. Do the drug groups differ from the control groups?
2. Do the two control groups differ from each other?
3. Do the Drug A groups differ from the Drug B group?
4. Do the two formulations of Drug A differ from each other?

Verify that all of your contrast codes are orthogonal to each other.

C1	C2	A1	A2	B	
-3/5	-3/5	2/5	2/5	2/5	Drugs vs. Conrols (#1)
1/2	-1/2	0	0	0	Control1 vs. Control2 (#2)
0	0	1/3	1/3	-2/3	Drug A (both) vs. Drug B (#3)
0	0	1/2	-1/2	0	Drug A1 vs. Drug A2 (#4)

To verify orthogonality, multiply each pair of codes, element-by-element, and sum them. They are orthogonal if that sum is zero. For example, to show that #1 and #3 are orthogonal

$$(-3/5)(0) + (-3/5)(0) + (2/5)(1/3) + (2/5)(1/3) + (2/5)(-2/3) =$$
$$0 + 0 + 2/15 + 2/15 - 4/15 = 0.$$

3. Subjects are given some material to learn for 10 trials, with the independent variable intertrial interval (the interval between successive trials) being manipulated at intervals of 0 seconds (massed practice) and 20, 40, and 60 seconds (distributed or spaced practice). 80 subjects are randomly assigned to one of the four groups for a total of 20 subjects per group. Specify a code for testing the hypothesis that performance will steadily increase as the intertrial interval increases (linear trend). Specify another code that will test the hypothesis that performance will be better for the middle levels than for either extreme (quadratic trend). If you can, specify the third code that will complete the set of contrast codes (cubic trend), but you may need a table of orthogonal polynomials to find the third code.

0	20	40	60	
-3/2	-1/2	1/2	3/2	Linear Trend
-1/2	1/2	1/2	-1/2	Quadratic Trend
-1/2	3/2	-3/2	1/2	Cubic Trend

These polynomial contrasts are availabile in Table A.1 on p. 92 of Contrast Analysis by Rosenthal and Rosnow.

4. Fifth-grade students representing five ethnic groups are compared in terms of school attitude. The five ethnic groups are Afro-Americans, Hispanics, Native Americans , Asian-Americans, and Whites. Generate any complete set of contrast codes which you believe would be appropriate for analyzing these data. Indicate the question asked by each code you generate.

Afro-American	Hispanics	Native Americans	Asian-Americans	Whites	
1/5	1/5	1/5	1/5	-4/5	Minorities vs. Whites
3/4	-1/4	-1/4	-1/4	0	Afro-Amer. vs. Other Minor.
0	-1/3	2/3	-1/3	0	Native Amer. vs. Hispanic & Asian-Amer.
0	1/2	0	-1/2	0	Hispanics vs. Asian-Amer.

N.B. Many other sets of codes would be reasonable.

5. Four different groups of subjects are asked to study a set of materials describing automobiles. One group (MEMORY) is told to prepare for a memory test after the study period, another group (CHOOSE BEST) is told to prepare for choosing the best alternative after the study period, yet another group (CHOOSE WORST) is told to prepare for choosing the worst alternative, and a final group (RATE) is told to prepare for rating the desirability of each alternative. In fact, all groups are given a memory test after the study period. Generate an appropriate set of contrast codes for analyzing these data. Indicate the question asked by each code you generate.

MEMORY	BEST	WORST	RATE	
-3/4	1/4	1/4	1/4	Memory vs. Evaluation
0	1/3	1/3	-2/3	Choosing vs. Rating
0	1/2	-1/2	0	Choose Best vs. Choose Worst

N.B. Many other sets of codes could also be reasonable.

6. No statistics course would be complete without an example from the field (pardon the pun) which generated so much of the early work on statistical methods. This example is from the classic textbook by Snedecor and Cochran. The field is agriculture....

An experiment on sugar beets compared times and methods of applying mixed artificial fertilizers. Yields were measured for the following conditions: no artificials; artificials applied in January by plowing; artificials applied in January with broadcast spreaders; and artificials applied in April with broadcast spreaders.

Generate contrast codes to test the following questions.

1. Do the artificials have an effect?
2. Are January applications better than April?
3. Given that fertilizer is applied in January, does method of application make a difference?

Show that the codes for these questions generate a complete set of orthogonal contrast codes.

None	Jan. Plow	Jan. Bcast	Apr,Bcast	
-3/4	1/4	1/4	1/4	Artificail Fert. vs. None (#1)
0	1/3	1/3	-2/3	January vs. April (#2)
0	1/3	-1/3	0	Plow vs. Broadcast for Jan (#3)