GUIDE FOR ANALYZING A FOUR DIMENSIONAL DESIGN (ONE BETWEEN AND THREE WITHIN SUBJECTS) VIA MULTIPLE REGRESSION TECHNIQUE*

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Problem

In recent years there has been increasing use in the behavioral sciences of an analysis of variance design utilizing three within subject and one between subject effects. Recognizing that multiple regression procedure is gradually becoming a preferred way of doing analysis of variance, it seemed appropriate to fit the complex design into a multiple regression framework. The purpose of this paper is to set up a stepwise procedure for doing a four-way analysis of variance (one between, three within subjects) using the multiple regression technique.

Method

The multiple regression utilized for the problem was Corr03 (Barker and Barker, 1977). This program involves input and output features of particular interest to the behavioral scientist; however, most computer programs for regression analysis are satisfactory computer programs. The variables were coded according to the effect coding method described by Overall and Spiegel (1969). A series of multiple regression runs were executed. From the model referred to as the full model, the total sum of squares was obtained. Reduced models then provided the sum of squares for everything except a main or interaction effect. By subtracting each reduced model in turn from the full model the sum of squares related to the omitted effect was found. In many designs not involving repeated measures the residual sum of squares from the full model is the appropriate error term for calculating F ratios. In the design of interest in this paper, however, the residual error term must be broken up into seven different error terms.

The hypothetical example of a four dimensional study used for this paper follows a dissertation from the Department of Psychology of The University of Alabama. The A effect is a between subjects organismic variable consisting of Alcoholics versus Social Drinkers. All remaining effects are within subjects; i.e., the subjects each receive all remaining three treatments. The B effect is a stimulus male or female counselor, the C effect is a positive or negative stimulus scene, and the D effect is a familiar or an unfamiliar stimulus person. The B, C, and D effects are related to scenes shown to the subjects (Alcoholics or Social Drinkers) on a TV monitor. The reaction of the subjects under each of the possible combinations was measured on a single scale providing eight repeated measures for each subject (see figure 1). To simplify the model for the purpose of this paper very simple measures were provided for the scores and the number of subjects per group was limited to two.

Calculations were done first by hand using the classic analysis of variance approach. Multiple regression models were then set up to provide sums of squares corresponding to those that were hand calculated and to develop the procedure for determining correct error terms.

Results

Table 1 illustrates how the variables were coded. Note that the blank spaces in coding columns were interpreted by the computer as zeros, as was intended, and zeros may be added for clarification of the coding procedure if desired.

Table 2 exemplifies how the coded variables were designated for the multiple regression runs to calculate the sums of squares necessary for the analysis of variance computations. The variables used in Table 2 are numbered according to the designated numbers in Table 1. Variable 1, for instance, refers to the A dimension, variable 2 to B, variable 11 to AXBXC, etc.

The first model regresses the dependent variable (#32) onto all main effects and treatment interactions. This model is designated a full model. The value of multiple R2 represents the proportion of the variance of the dependent variable which is associated with all treatments. Models 3 through 17 represent reduced models; that is, the dependent variable is regressed onto all treatment effects except the one treatment under consideration. The difference in multiple R2 for the full and reduced models represents the proportion of variance of the dependent variable associated only with the treatment under consideration. The remaining models are of particular interest in this paper because they enable computation of the numerous error terms required for the F ratios.

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Information provided by the multiple regression models was then used to calculate the F ratios as shown in Table 3.

The A effect in this design is a between subjects effect. As can be seen from the tables a reduced model (Model 2) provided the between subjects error term directly by regression onto the subject variable. For all other main effects and treatment interactions, an error term which involves an interaction with both the treatment and the subjects is required. For the AXB interaction, for instance, an AXBXSubject interaction was needed for the error term; AXC was tested against an AXCXSubjects; AXD, against an AXDXSubjects. Again referring to the tables it can be seen that these subject interactions were coded, regressed onto directly, and used as the error term for the appropriate interaction.

Summary

A procedure has been presented which enables a frequently used analysis of variance design to be accomplished by a multiple regression computer program. The design involves one between subject effect and three within subject effects.

References

Barker, H. R. and Barker, B. M. Behavioral Sciences Statistics Program Library. University of Alabama, 2nd rev. edition, 1977.

Overall, J.E., and Spiegel, D.K. Concerning Least Squares Analysis of Experimental Data. Psychological Bulletin, 1969, 72, 311-322.

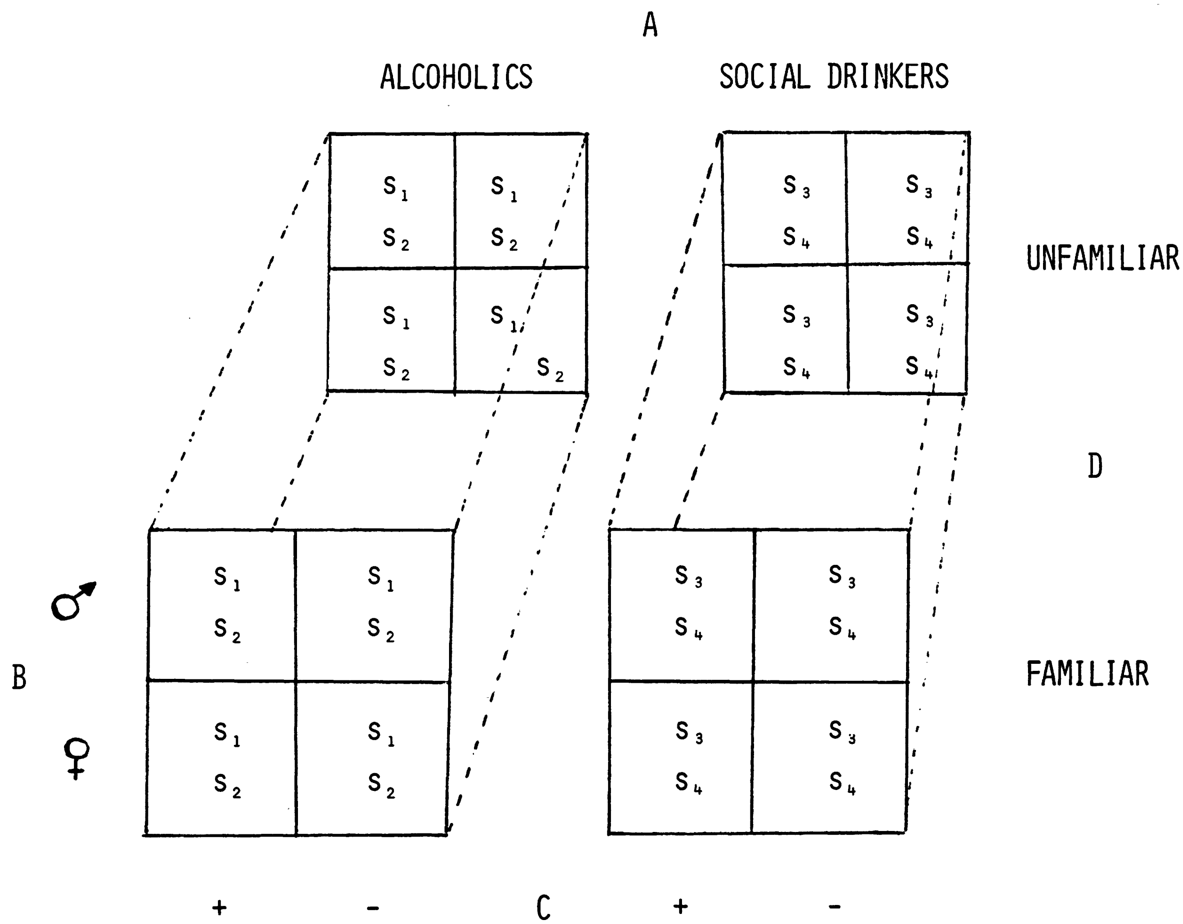

FIGURE 1

FOUR DIMENSIONAL DESIGN

TABLE 1

CODING VARIABLES FOR USE IN MULTIPLE REGRESSION

VARIABLE NUMBER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
A	B	C	D	A X B	A X C	A X D	B X C	B X D	C X D	A X B X C	A X B X D	A X C X D	B X C X D	A X B X C X D	S_1	S_3	A X B X S_1	A X B X S_3	A X C X S_1	A X C X S_3	A X D X S_1	A X D X S_3	A X B X C X S_1	A X B X C X S_3	A X B X D X S_1	A X B X D X S_3	A X C X D X S_1	A X C X D X S_3	A X B X C X D X S_3	A X B X C X D X S_3	D V
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		1		1		1		1		1		1		1
1	-1	1	1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1	1		-1		1		1		-1		-1		1		-1		3
1	1	-1	1	1	-1	1	-1	1	-1	-1	1	-1	-1	-1	1		1		-1		1		-1		1		-1		-1		2
1	-1	-1	1	-1	-1	1	1	-1	-1	1	-1	-1	1	1	1		-1		-1		1		1		-1		-1		1		4
1	1	1	-1	1	1	-1	1	-1	-1	1	-1	-1	-1	-1	1		1		1		-1		1		-1		-1		-1		5
1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	1	1	1		-1		1		-1		-1		1		-1		1		7
1	1	-1	-1	1	-1	-1	-1	-1	1	-1	-1	1	1	1	1		1		-1		-1		-1		-1		1		1		6
1	-1	-1	-1	-1	-1	-1	1	1	1	1	1	1	-1	-1	1		-1		-1		-1		1		1		1		-1		8
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1		-1		-1		-1		-1		-1		-1		-1		1
1	-1	1	1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1	-1		1		-1		-1		1		1		-1		1		3
1	1	-1	1	1	-1	1	-1	1	-1	-1	1	-1	-1	-1	-1		-1		1		-1		1		-1		1		1		3
1	-1	-1	1	-1	-1	1	1	-1	-1	1	-1	-1	1	1	-1		1		1		-1		-1		1		1		-1		7
1	1	1	-1	1	1	-1	1	-1	-1	1	-1	-1	-1	-1	-1		-1		-1		1		-1		1		1		1		3
1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	1	1	-1		1		-1		1		1		-1		1		-1		6
1	1	-1	-1	1	-1	-1	-1	-1	1	-1	-1	1	1	1	-1		-1		1		1		1		1		-1		-1		9
1	-1	-1	-1	-1	-1	-1	1	1	1	1	1	1	-1	-1	-1		1		1		1		-1		-1		-1		1		4
-1	1	1	1	-1	-1	-1	1	1	1	-1	-1	-1	1	-1		1		-1		-1		-1		-1		-1		-1		-1	1
-1	-1	1	1	1	-1	-1	-1	-1	1	1	1	-1	-1	1		1		1		-1		-1		1		1		-1		1	7
-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1		1		-1		1		-1		1		-1		1		1	4
-1	-1	-1	1	1	1	-1	1	-1	-1	-1	1	1	1	-1		1		1		1		-1		-1		1		1		-1	7
-1	1	1	-1	-1	-1	1	1	-1	-1	-1	1	1	-1	1		1		-1		-1		1		-1		1		1		1	3
-1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-1		1		1		-1		1		1		-1		1		-1	7
-1	1	-1	-1	-1	1	1	-1	-1	1	1	1	-1	1	-1		1		-1		1		1		1		1		-1		-1	4
-1	-1	-1	-1	1	1	1	1	1	1	-1	-1	-1	-1	1		1		1		1		1		-1		-1		-1		1	9
-1	1	1	1	-1	-1	-1	1	1	1	-1	-1	-1	1	-1		-1		1		1		1		1		1		1		1	2
-1	-1	1	1	1	-1	-1	-1	-1	1	1	1	-1	-1	1		-1		-1		1		1		-1		-1		1		-1	5
-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1		-1		1		-1		1		-1		1		-1		-1	5
-1	-1	-1	1	1	1	-1	1	-1	-1	-1	1	1	1	-1		-1		-1		-1		1		1		-1		-1		1	9
-1	1	1	-1	-1	-1	1	1	-1	-1	-1	1	1	-1	1		-1		1		1		-1		1		-1		-1		-1	1
-1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-1		-1		-1		1		-1		-1		1		-1		1	6
-1	1	-1	-1	-1	1	1	-1	-1	1	1	1	-1	1	-1		-1		1		-1		-1		-1		-1		1		1	4
-1	-1	-1	-1	1	1	1	1	1	1	-1	-1	-1	-1	1		-1		-1		-1		-1		1		1		1		-1	7

TABLE 2

VARIABLES USED IN MULTIPLE REGRESSION PROGRAMS

	DEP. VAR. #	INDEPENDENT VARIABLE NUMBERS (VARIABLE NUMBERS FROM TABLE 1)																
MODEL 1	32	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MODEL 2	32	16	17															
MODEL 3	32	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
MODEL 4	32	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
MODEL 5	32	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
MODEL 6	32	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	
MODEL 7	32	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	
MODEL 8	32	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	
MODEL 9	32	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	
MODEL 10	32	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	
MODEL 11	32	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	
MODEL 12	32	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	
MODEL 13	32	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	
MODEL 14	32	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	
MODEL 15	32	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	
MODEL 16	32	1	2	3	4	5	6	7	8	9	10	11	12	13	15	16	17	
MODEL 17	32	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	
MODEL 18	32	18	19															
MODEL 19	32	20	21															
MODEL 20	32	22	23															
MODEL 21	32	24	25															
MODEL 22	32	26	27															
MODEL 23	32	28	29															
MODEL 24	32	30	31															

TABLE 3

MODELS FOR SUBTRACTION PROCESS

MODELS	TREATMENT	ERROR TERM	MODELS
1-3	A	BETW.S	2
1-4	B	ABS	18
1-5	C	ACS	19
1-6	D	ADS	20
1-7	AB	ABS	18
1-8	AC	ACS	19
1-9	AD	ADS	20
1-10	BC	ABCS	21
1-11	BD	ABDS	22
1-12	CD	ACDS	23
1-13	ABC	ABCS	21
1-14	ABD	ABDS	22
1-15	ACD	ACDS	23
1-16	BCD	ABCDS	24
1-17	ABCD	ABCDS	24