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POLYANOVA: A general-purpose FORTRAN IV program for trend analysis with equally or unequally spaced levels of the independent variable

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There are a number of general-purpose ANOVA computer programs available which perform orthogonal polynomial tests. Notable are the BMD programs, BMDO8V (Dixon, 1970) and BMDP2V (Dixon, 1975), and the ANOVA routine provided in the most recent SPSS package (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). In these programs it is assumed that the trial factors range over equally spaced points. When the trial factor consists of unequally spaced intervals (e.g., 200-, 500-, and 2,000-msec delay times), a tailored set of orthogonal coefficients must be generated and alternative computational procedures sought. Dunlap (1975) reported a FORTRAN procedure for computing trend analysis with one unequally scaled trial factor.

POLYANOVA is a general-purpose procedure for computing orthogonal polynomial trend tests. The program is structured to compute more elaborate designs, permitting trend tests for multiple trial and group factors.

Computation in POLYANOVA is based on the procedures in Winer (1971, pp. 577-594) for tests on trends. An appropriate set of coefficients is input to the program by the user. The coefficients define an equally or unequally spaced polynomial trend for a given trial component. A trial component represents a main trial effect or an interaction between trial effects at some polynomial degree, i.e., linear, quadratic, cubic. Table 1 shows sets of linear coefficients generated for a design with two unequally spaced trial factors (repeated measures): Stimulus duration (S) and Interstimulus interval (I), both at 200, 500, and 2,000 msec. The coefficients for interactions are obtained by multiplying the coefficients corresponding to the factors involved in the interaction.

The POLYANOVA algorithm is essentially an analysis of variance for a factorial design as specified by the grouping variables, with equal numbers of observations per cell, an observation being defined as a weighted sum of the observations for each subject. The weights are a given set of coefficients for a trial component. If data for the above example were to be grouped on two variables, Age (A) and Task (B), then a POLYANOVA analysis of the linear trial component for the interaction (SI) of the repeated measures would produce the sample output shown in Table 2. The program will recursively test any number of trial components.

Procedures for determining coefficients are available (Kirk, 1968; Robson, 1959). This writer uses the ORTH (Note 1) computer routine, an orthogonal polynomial generator using a Gram-Schmidt orthogonialization, to compute the coefficients.

Input. Data to be processed are input on Tape 8, control cards and coefficients on Tape 5. This arrangement permits multiple runs on the same data base. Data are format compatible with the BMDP2V program (Dixon, 1975). Format specifications are variable. Data for each case are hierarchically ordered to correspond to the trial factors with the right most index moving fastest. Data coding for each case must numerically specify the levels of the grouping factor(s) to which a subject belongs.

Table 1
Sets of Linear Orthogonal Coefficients for Two Unequally Scaled Factors

Trial Component	S_1I_1	S_1I_2	S_1I_3	S_2I_1	S_2I_2	S_2I_3	S_3I_1	S_3I_2	S_3I_3
S Linear	−1.75	−1.75	−1.75	−1.00	−1.00	−1.00	2.75	2.75	2.75
I Linear	−1.75	−1.00	2.75	−1.75	−1.00	2.75	−1.75	−1.00	2.75
SXI Linear	3.06	1.75	−4.81	1.75	1.00	−2.75	−4.81	−2.75	7.56

Table 2
Sample Output from POLYANOVA

```
POLYANOVA RUN
        // TRIAL COMPONENT = SI LINEAR
           TRIAL LEVELS = 9
           COEFFICIENTS =  3.06      1.75      -4.81      1.75      1.00
                          -2.75     -4.81      -2.75      7.56
        // GROUPS = A  B
           LEVELS = 2  3
        // ANALYSIS OF VARIANCE:
```

SOURCE	SS	DF	MS	F
TRIAL COMPONENT (SI LINEAR)	19.88	1	19.88	9.07
A X COMPONENT (SI LINEAR)	7.43	1	7.43	3.39
B X COMPONENT (SI LINEAR)	.08	1	.08	.03
AB X COMPONENT (SI LINEAR)	.03	1	.03	.01
COMPONENT X SUBJ W. GROUPS (SI LINEAR)	52.61	24	2.19	

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Output. Table 2 illustrates a sample output. An ANOVA table is generated for each trial component to be processed.

Parameters. The number of observations per cell must be equal. All factors, except subjects, are assumed fixed. The program handles designs with up to four grouping variables.

Total memory requirements, with current array dimensions sufficient for most designs, is $150K_{10}$ bytes. Array parameters can be easily adjusted by the user. The number of trend tests POLYANOVA will run is limited only by time constraints. For 12 runs–with 3 grouping variables, 28 levels to the trial components, and 32 cases–the total run time was 5.37 sec.

Computer and language. POLYANOVA is written in standard FORTRAN IV, with the possible exception of some I/O functions. The program was developed on an IBM 360 Model 91 computer.

Availability. Description and listing of the program, POLYANOVA, are available free on request to the author.

REFERENCE NOTE

1. Orthogonal Polynomial Generator (ORTH). Unpublished Manuscript, *Health Sciences Computing Facility,* University of California, Los Angeles, 1971.

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