Behavior Research Methods & Instrumentation
1982, Vol. 14(3), 348-349

PROGRAM ABSTRACTS/ALGORITHMS

A computer program for a randomization test for factorial analysis of variance

EUGENE S. EDGINGTON and OTTO HALLER
University of Calgary, Calgary, Alberta T2N 1N4, Canada

RANDFACT is a computer program that can be used to test main effects of factors in independent-groups factorial experiments for dichotomous, ordinal, or interval data, given random assignment of subjects to treatment levels. It can accommodate proportional or disproportional cell frequencies, including cases with empty cells or only one observation per cell. Also, the program can test effects within levels of factors or within single contrasts.

The program performs a randomization test on the basis of random permutations (divisions) of a given set of experimental data. The number of random permutations to be performed is user-defined. The test statistic (F or the between-groups mean square) is calculated for the experimental data and for each of the random data permutations. The probability value is defined as the proportion of the test statistics that have a value as large as, or larger than, the test statistic value for the experimental data. As randomization tests are nonparametric, parametric assumptions such as homogeneity of variance, normality, or even random sampling are unnecessary.

The statistic F is based on a special definition for the between-groups sum of squares (SS_B). This SS_B is based on deviations of treatment level means from expected means instead of deviations from the grand mean:

$$SS_B = n_1 [\bar{X}_1 - E(\bar{X}_1)]^2 + n_2 [\bar{X}_2 - E(\bar{X}_2)]^2 + \ldots,$$

where the subscripts indicate the treatment levels and $E(\bar{X}_i)$ indicates the expected mean of the ith level. The expected mean is the average value of a treatment level mean over all possible data permutations for the test being conducted. The expected mean is equal to the grand mean when cell frequencies are proportional but not when cell frequencies are disproportional. Thus, the new SS_B is equivalent to the traditional SS_B when cell frequencies are proportional but not when cell frequencies are disproportional (Edgington, 1980, pp. 164-173).

Aside from the new definition of SS_B, F is calculated in the usual manner: $F = MS_B/MS_W$, where $MS_B = SS_B/(j-1)$ and $MS_W = SS_W/(N-c)$. SS_W is the sum of squares within cells, j is the number of treatment levels, N is the number of measurements for all cells combined, and c is the number of cells.

For ordinal and interval data, the user can select F (as calculated above) for the test statistic to ensure that the test statistic is the conventional one for proportional cell frequencies and similar to the conventional test statistic for disproportional cell frequencies. For dichotomous data, where 0s and 1s can be used to represent the presence and absence of some attribute, the use of F as a test statistic might frequently provide $SS_W = 0$ and, thus, an undefined F value. For this reason and because the absence of a conventional test statistic for factorial designs with dichotomous data renders the issue of conventionality irrelevant, the between-groups mean square is the test statistic to use with dichotomous data.

RANDFACT consists of a main program and three subroutines. The main program accepts input and arranges data for the subroutines. Subroutine EXPV calculates expected values, subroutine SUMM calculates test statistics, and subroutine RAND permutes the data and calculates the probability value.

Limitations. The program cannot be employed with factorial designs in which there are repeated measures on a factor. Also, the program does not determine the significance of interactions. (An explanation of the impossibility of testing the significance of interactions by means of a randomization test for independent-groups factorial experiments is given in Edgington, 1980, pp. 160-164.) The program is limited to five factors, and the total number of cells in a design, including empty cells, cannot exceed 125. The maximum number of data points is 6,250. The number of random permutations can be set at any number less than one million.

Input. Program RANDFACT should be placed after the call for FORTRAN used by the computer system. After the program deck, the following input is required: (1) total number of data points, (2) number of factors, (3) total number of cells in design (including empty cells), (4) number of random permutations to be performed, (5) whether data are ordinal, interval, or dichotomous data, (6) format for data vector (measurements), (7) format for an input/output vector giving the number of data points for each cell, (8) format for the input/output of a vector containing the number of levels for each factor, (9) format for data output, (10) format for the output of expected values, (11) title, (12) data deck, as specified by the format on Card 2, (13) number of

The development of this program was supported by Grant A5571 from the Natural Sciences and Engineering Research Council of Canada.

0005-7878/82/030348-02$00.45/0

measurements per cell, (14) number of levels per factor, and (15) option card, where a 0 is used to indicate that no test is required for a particular factor and a 1 indicates a test is required for that factor.

Output. The computer output for the program includes the title, a list of the user's input, and the following information for each factor: test statistic used (MS_B or F), expected values, means for each level of the factor, MS_W, MS_B, F, and probability value.

Language and Computer. The program is written in FORTRAN and has been tested on a Multics system.

Transportability. The language in the program conforms to ANSI Standard FORTRAN 66, except for the statement calling the random number generator, that statement being specific to the Multics system.

Availability. A program listing and user's guide, which includes sample problems, may be obtained without charge by writing E. S. Edgington, Department of Psychology, University of Calgary, Calgary, Alberta T2N 1N4, Canada.

REFERENCE

EDGINGTON, E. S. *Randomization tests.* New York: Marcel Dekker, 1980.

(Accepted for publication February 12, 1982.)