A BASIC package for N-way ANOVA with repeated measures, trend analysis, and user-defined contrasts

MICHAEL J. HACKER

and JOEL S. ANGIOLILLO-BENT

Harvard University, Cambridge, Massachusetts 02138

This package of two BASIC programs allows the user to analyze any fixed-effects factorial design with equal sample sizes in all cells. There are no inherent limits on the numbers of factors or levels per factor other than those imposed by the availability of core memory. Standard output consists of factorial mean and ANOVA summary tables. Optionally, the user may interactively test for polynomial trends and their interactions. Finally, there is an option to decompose any one factor (and its interactions) in accordance with a user-defined set of orthogonal contrasts. These programs have been implemented on a TRS-80 and require a single-disk drive. Modifications for other BASIC systems should be minimal.

ANVA1, the first program in this two-pass process, converts an input file of N raw data scores into an output file of $N - 1$ orthogonal contrasts. A FORTRAN routine for this procedure, which is a modification of Yates' interaction algorithm, was published by Howell (1969), but it seems to have been underutilized, probably because researchers often lack the understanding and patience to make sense of such a large table of contrasts. The compactness of the algorithm, however, is ideally suited to microcomputing.

ANVA2, the second program in the package, is a general interactive sorting routine that can be applied to either a raw data or a contrast file. When applied to a raw data file, ANVA2 outputs mean tables for all of the main effects and higher order interactions. When applied to a contrast file, ANVA2 outputs an ANOVA summary table. Once again, there are no limits on the number of within- and between-subjects factors. With very little additional effort (responding to interactive

prompts), the user may follow the standard ANOVA with tests of either polynomial (the default) or user-defined contrasts and their interactions. These tests include the normally bothersome computation of separate error terms for each within-subjects component.

Input. As presently implemented, both ANVA1 and ANVA2 accept input from a sequential disk file. Instructions accompany the program for other sorts of data input. In addition, a third program, INPUT, is provided to help the user create and edit raw data files.

Output. While ANVA1 must output to the same file device that inputs to ANVA2, the tables and F tests output by ANVA2 are presently directed to a line printer. It is a simple matter to redirect output to the screen.

Limitations. The core requirement for ANVA1 (program plus data) is conservatively estimated by the formula, $[2.0 + (.0078 \times N)]K$ bytes, where N is the number of single-precision data points. The requirement for ANVA2 is, similarly, $[3.0 + (.0039 \times N)]K$ bytes. Clearly, as little as 8K bytes of available memory would handle most of the designs encountered in practice.

In a typical application, a six-factor mixed design with 1,000 data points, F values were accurate to four significant figures. However, precision is indirectly proportional to N . The programs have been written so that the relevant arrays and variables can be easily converted to double precision. Instructions are given in the accompanying documentation. Run time could be a more significant limitation. ANVA1 required nearly 15 min for the design described above, although this is not atypical of less general BASIC ANOVA programs. The run times are appreciably lower for simpler designs and smaller data sets.

Availability. The program listings are available for the cost of copying and mailing from either author. Send requests to the Department of Psychology and Social Relations, Harvard University, Cambridge, Massachusetts 02138.

REFERENCE

HOWELL, J. R. Algorithm 359: Factorial analysis of variance. *Communications of the ACM*, 1969, 12, 631-632.

(Accepted for publication August 26, 1981.)

This research was supported by National Science Foundation Grant BNS-79-21028 awarded to W. K. Estes.