A program to generate random sequences of multidimensional stimuli with constraints on first-order and second-order contingencies

NICHOLAS V. HAMMOND
*University College Hospital Medical School
London, England WC1*

Many psychological experiments involve the presentation of ordered sequences of stimuli. It is usually the case that the experimenter is primarily concerned with the subject's response to different classes of stimuli rather than with the ordering of the stimuli per se. However, failure to control adequately for artifacts arising from order of presentation can be serious. For example, Kornblum (1969) and Remington (1970) have emphasized the importance of the sequential determinants of reaction time in serial tasks, and have demonstrated the confounding of such variables as stimulus probability and stimulus set size with second-order properties of the stimulus sequences.

Description. The program described here allows the user to generate sequences of codes with specified numbers of instances of each type of code, and with specified constraints on second-order contingencies (arrangements of pairs of consecutive codes). Each code can be considered to represent a stimulus which can vary on up to five independent dimensions, each dimension having up to eight levels. The user specifies the number of dimensions to be represented (one to five), the number of levels on each dimension (two to eight), the sequence length, the number of stimuli of each type (the number of stimulus types will be the product of the number of levels on each dimension), and, optionally for each stimulus dimension taken alone, the number of instances of every possible transition between consecutive stimuli. The number of different transitions for each dimension will be the square of the number of levels on that dimension. For frequencies of these second-order configurations, the user can also specify a tolerance about the specified frequency which is acceptable. The program performs random shuffles of the stimuli and compares the frequencies of the second-order configurations with the requested frequencies until an acceptable sequence is found. The number of attempts at forming an acceptable sequence can be specified, as strict limitations on the second-order configurations can result in a low probability of finding an acceptable sequence and a prohibitively long search time. The second-order transitions from one trial to the next are considered for each dimension taken alone in turn; the program

does not check transitions on several dimensions in parallel.

The following example should help to clarify the operation of the program. Suppose that the task requires the presentation of a sequence of tones, each of one of three different intensities, directed to either the left or the right ear; the codes would represent stimuli with two dimensions (intensity and location), the first with three levels, the second with two levels. The number of possible intensity transitions from one stimulus to the next would be nine, three where the intensity repeated, and six where the intensity changed. Similarly, there would be four possible ear transitions from one stimulus to the next. Were a sequence of 36 stimuli required, with six instances of each of the six possible stimulus types (three intensities by two ears), the user could specify four instances of each of the possible intensity transitions and nine instances of each of the possible ear transitions. Since a sequence of 36 stimuli contains only 35 transitions from one stimulus to the next, the user would have to specify a tolerance about these frequencies of at least one to allow an acceptable sequence to be found. In this case, acceptable sequences would contain three, four, or five of each of the intensity transitions, and 8, 9, or 10 of each of the ear transitions.

The program consists of two segments. The routine RANSEQ, when called with the parameters described above, searches for a random sequence with the required properties. The generated sequence is returned in an integer array with each stimulus represented in the low-order 15 bits of an integer. The lowest 3 bits of the integer define the level on the first stimulus dimension (Levels 1 to 8 coded as binary 000 to 111), the next 3 bits define the level on the second dimension, and so on. The routine also returns the number of attempts before an acceptable sequence was found, or, if none was generated, an error flag indicating the reason. The second segment is a calling program, RANDOM, which requests the sequence parameters interactively via a terminal console, seeds the random number generator using the date and time of day, calls the subroutine RANSEQ, and either outputs the generated sequences in a decoded form or stores them on file for subsequent use.

Computer and Language. The program was developed for use on a DEC PDP-11/40 running the RT-11 operating system. The subroutine RANSEQ is written in standard FORTRAN IV and should be directly transferable to other systems, provided a similar random number generator function call is supported. The decoding routine called by RANSEQ is available in either FORTRAN IV or MACRO-11; use of the latter on the PDP-11 speeds the search time considerably. The calling program RANDOM is also written in

This work was carried out with the support of the Sir Jules Thorn Medical Research Endowment Trust.

FORTRAN IV, but the format of calls to the routines which are used to seed the random number generator and to deal with terminal and file input and output would require changes for use on other machines. The program could be fairly easily adapted for batch operation if required.

Availability. Complete listings and sample outputs can be obtained free of charge from the author, MRC Applied Psychology Unit, 15 Chaucer Road, Cambridge, England CB2 2EF.

REFERENCES

- KORNBLUM, S. Sequential determinants of information processing in serial and discrete choice reaction time tasks. *Psychological Review*, 1969, **76**, 113-131.
- REMINGTON, R. J. The repetition effect: A methodological consideration. *Psychonomic Science*, 1970, **20**, 221-222.

(Accepted for publication July 26, 1977.)