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Human ability to randomize sequences as a function of information per item*

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Sixteen Ss were asked to produce a random sequence of binary and ternary numbers in a counterbalanced within-S design. For each S and each condition, relative redundancy up to the fifth order was determined. Relative redundancy increased as a function of order of redundancy estimate significantly faster in the ternary-digit condition. It was concluded that it is more difficult to randomize items containing greater amounts of information.

Human ability to randomize sequences has been investigated previously. Ross (1955) found only slight deviation from chance in Ss' randomization of binary symbols. Bakan (1960) found no first-order preference for either of the binary symbols, but reported a significantly greater incidence of alternations than expected by chance. Rath (1966) investigated Ss' randomization of binary, decimal, and alphabetic symbols (2, 10, and 26 alternatives, respectively) and reported significant first-order deviations from chance in most Ss in the binary condition and in all Ss in the other two conditions. The rate of character production decreased as the number of alternatives to be randomized increased.

None of the above authors used the information measure in order to obtain higher order estimates of redundancy. Attneave (1959, pp. 13-26) describes the method of determining n^{th} order estimate of relative entropy (R_n) or relative redundancy (C_n), so that $C_n = 1 - R_n$ and $R_n = H_n/H_{max}$, where H_n is the estimate of average information given n − 1 preceding elements and H_{max} the maximum possible information.

The purpose of the present study is to determine relative redundancy up to the 5th order (C_0 to C_5) for S-produced random sequences of binary and ternary digits with maximum of 1 and 1.585 bits of information per digit, respectively. While it is reasonable to expect that relative redundancy will increase as n increases from 0 to 5, it is also predicted that the relative redundancy will increase at a faster rate in the case of ternary digits because of their greater information content. This is to say that in the ternary condition Ss are asked to produce a greater amount of information and will actually produce a smaller proportion of the maximum amount of information than in the binary condition.

METHOD

Subjects

A total of 16 randomly selected introductory psychology students of both sexes served as Ss.

Materials

Two sets of IBM 509 scoring sheets were used. In Set A, the last three of five columns were covered with an overlay, leaving the first two columns visible. In Set B, the last two columns were covered, with the first three columns visible. IBM electrographic pencils were provided.

Procedure

All Ss were assigned to both binary and ternary conditions, with half of the Ss assigned to binary condition first and with a 5-min pause between conditions. In the binary condition, the Ss produced a binary digit by filling Space 1 or Space 2 with an IBM pencil. In the ternary condition, they filled Spaces 1, 2, or 3. They were instructed to proceed from line to line in such a manner as to produce a random sequence of numbers. Ss were told what a random sequence was. In the binary condition, they produced 196 items on two sheets, and in the ternary condition, 733 items on five sheets. The spot where Ss had to stop was indicated on the sheets. The task was self-paced.

RESULTS AND DISCUSSION

A computer program for the redundancy analysis was prepared for computation of C_1 to C_5 for every S in both conditions. The mean relative redundancy scores for both conditions for estimates of redundancy up to the fifth order are presented in Fig. 1. Since C_n scores are not statistically independent for different values of n, the two curves were differenced to give successive increments in redundancy (ΔC) for orders of estimate from 0 to 5, so that $\Delta C_n = C_n - C_{n-1}$. ΔC_n scores were then analyzed as a 2 by 5 factorial with factors of information per item (binary vs ternary) and order of redundancy, with repeated measures on 16 Ss for both factors.

ΔC_n scores for ternary digits were significantly higher than for binary digits ($F = 35.53$, df = 1/15, $p < .001$); that is, the rate of relative redundancy increase was greater for ternary than for binary digits. There were significant overall differences in ΔC_n as a function of order of redundancy estimate ($F = 51.64$, df = 4/60, $p < .001$). Interaction between the two factors was also significant ($F = 4.28$, df = 4/60, $p < .01$); this interaction apparently signifies that ΔC was greater for greater values of C. In short, the results strongly support the hypothesis that relative redundancy increases as the

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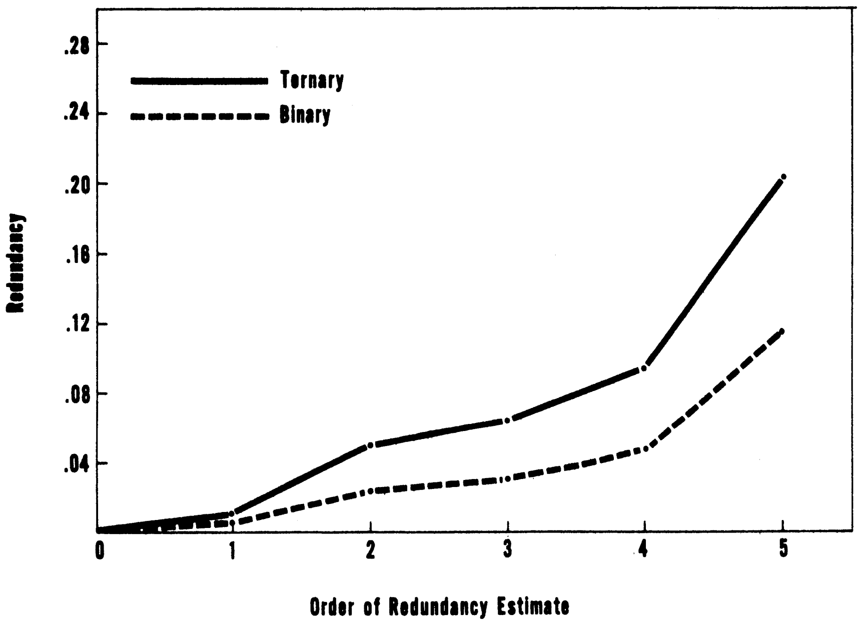

Fig. 1. Average relative redundancy as a function of order of redundancy estimate for S-randomized binary and ternary digits.

function of increase in the information per item. As previous studies showed, the first-order redundancy is minimal; most of the structuring occurs at levels beyond the first-order redundancy, an effect not dealt with in previous studies.

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