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ABSTRACT

In learning experiments, individual trial performances are typically represented as a composite of two independent components. The first is associated with systematic variation, and the second is a residual component interpreted as error. From the systematic variation, mean trial performance is typically computed across trials to obtain a simple learning curve or function. Tucker has proposed representing systematic variations as two or more curves or components representing generalized learning functions. In an illustration of this method, Tucker reanalyzed data from a probability learning experiment performed by Gardner, finding in one condition that performances of individuals were best represented by three generalized learning functions. This study attempted to replicate Tucker's findings and to assess the relationship between cognitive and personality traits and individual scores associated with generalized learning functions. Specifically the study was concerned with (1) determining the number of learning functions required to determine individual variations in performance on a probability learning task, and (2) determining, through multiple regression analysis, a composite of cognitive and personality variables that are significant predictors of individual scores on each of the learning functions. (AF)

GENERALIZED LEARNING CURVES AND THEIR ABILITY AND PERSONALITY CORRELATES

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In learning experiments, individual trial performances are typically represented as a composite of two independent components. The first is associated with systematic variation, and the second is a residual component interpreted as error. From the systematic variation mean trial performance is typically computed across trials to obtain a single learning curve or function. The practice of deducing functional relations from mean performance has been criticized by Skinner (1958), and by Estes (1956). Tucker (1960) has proposed representing systematic variation as two or more curves or components representing generalized learning functions. Methodologically, this is simply a problem of expressing the individual by trials data matrix as the product of a trials by function factor matrix (representing the generalized learning functions) and an individual by function factor score matrix (representing individual scores on those functions). In an illustration of the method, Tucker reanalyzed data from a probability learning experiment performed by Gardner (1958), finding, in one condition, that performances of individuals were best represented by three generalized learning functions.

This study is an attempt to replicate Tucker's findings and to assess the relationship between cognitive and personality traits and individual scores associated with generalized learning functions. Specifically, the study is concerned with (a) determining the number of learning functions required to determine individual variations in performance on a probability learning task, and (b) determining, through multiple regression analysis, a composite of cognitive and personality variables which are significant predictors of individual scores on each of the learning functions.

Procedure

One hundred eighteen college students at Illinois State University were given a four-choice probability learning task. The task was administered by randomly presenting four alphabet letters--S, L, D, and N--with probabilities of .70, .10, .10, and .10 respectively. Scores were obtained from the number of times the predominant letter was correctly guessed when presented.

A matrix of intertrial correlations was factored to determine the minimum number of generalized learning functions required to determine individual variations in performance. The factor matrix of trial coefficients (factor loadings) was rotated graphically to the criteria of positive manifold and positive slope to obtain the derived learning functions. Since the natural origin was displaced in the computation of a correlation matrix, the loading for the first trial on each factor was subtracted from all other loadings on that factor in order to provide a common origin for all generalized learning functions. Using the mean function as a base line, the family of generalized learning functions was generated by using the orthogonally rotated trial loadings translated to a common origin, as deviations from this baseline. The resulting learning functions are presented in Figure 1.

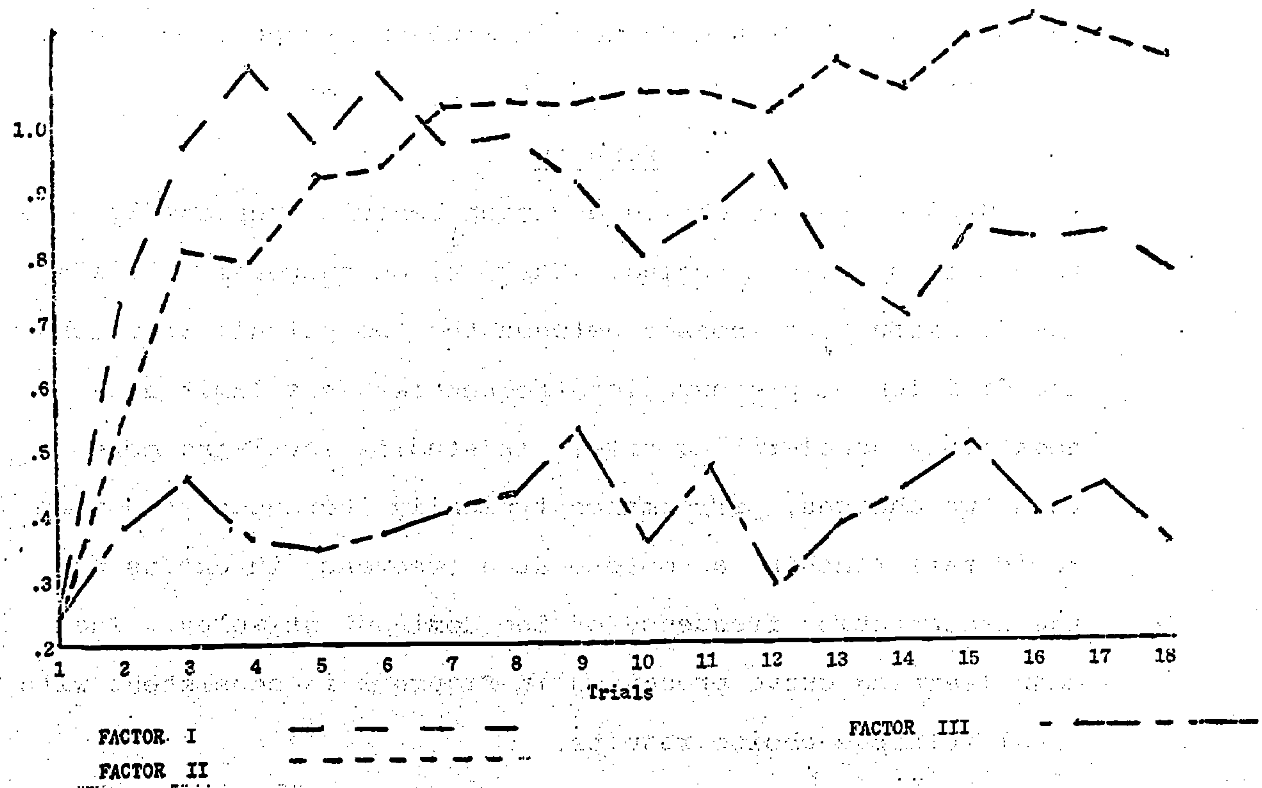

FIG. 1
GENERALIZED LEARNING CURVES

Individual scores (analogous to factor scores) for each subject on each learning function were computed using a procedure outlined by Harman (1960, p. 352). The meanings of factors were deduced by examining the observed learning curves for subjects with high individual scores on one factor and low scores on the other two. Relationships of cognitive and personality factors to individual scores were determined using stepwise multiple linear regression, forward selection procedure. A separate analysis was performed for each learning function with individual scores as criterion variables; Numerical and Verbal scores from the American College Test (ACT) and Cattell's Sixteen Personality Factor Test (16PF) were used as predictor variables.

Results

Studies of two-choice decision behavior repeatedly report asymptotic matching. That is, on successive trials, the division of responses between the two stimuli approaches the division of presentation frequencies as a limit at a negatively accelerating rate. In studies involving more than two choices, performance typically increases at a more rapid rate reaching asymptote at a frequency in excess of the presentation frequency of the dominant stimulus. The mean learning curve presented in Figure 2 is consistent with usual multiple-choice results.

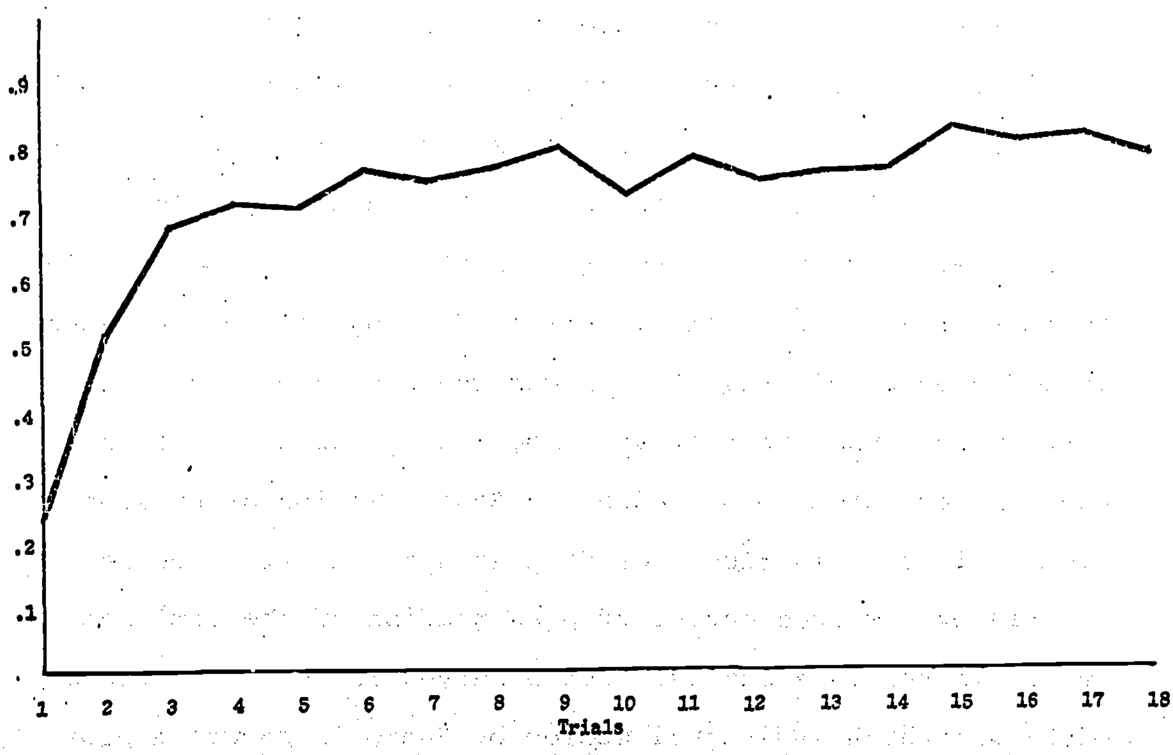

FIG. 2

MEAN LEARNING CURVE - PERCENT SCORES

In the research reported here, three factors, representing three generalized learning functions, were interpreted as significant contributors to total variance among the 18 trials. A factor was regarded as a significant contributor if its associated eigenvalue was greater than unity. Interpretation of each factor was based upon examination of learning curves plotted from rotated trial coefficients in combination with examination of observed learning curves of selected individuals.

The learning function represented by Factor I is similar in form to a function predicted by Estes' (1950) stimulus sampling theory. In Estes' formulation, the probability of a particular response in a choice situation is a function of the probability of presentation of the associated stimulus in a selected trial and the probability of the response prior to that trial. In trials in which, for any reason, the absolute frequency of presentation was reduced, the number of correct responses in that and immediately succeeding trials could be expected to be reduced. Randomization of presentation of letters in blocks of 50 presentations resulted in relatively low frequencies of presentation of the dominant letter in trials 4 and 12. The observed learning functions of Ss with high individual scores on Factor I showed a pronounced drop between trials 12 and 14. Regression analysis indicated that the variables most significantly related in composite with individual scores on this factor were Variable 12, Guilt Proneness; Variable 9, Adaptability; Variable 13, Radicalism; and Variable 10, External Regulation.

The function represented by Factor II shows a rapid rise in correct responses, reaching asymptote within the first few trials. This function seems to correspond to the "pure strategy" described in research of Weir (1964) and Kender (1962). Weir has reasoned that the reinforcement provided by confirmation of Ss guesses results in rapid association of the dominant stimulus with maximized payoff. He argued further that the maximization strategy is associated with inability to consider more complex hypotheses for achieving 100 percent payoff. In this research, the significant predictors of individual scores on Factor II were Variable 7, Reactivity to Threat; Variable 2, Intelligence; and Variable 1, Sociability. The implication is that factors other than intelligence are associated with the failure to consider more complex hypotheses.

Factor III may represent very little more than random variation in performance, since the associated eigenvalue was 1.05, and trial loadings fluctuate greatly from trial to trial. Furthermore, none of the ability or personality factors was significantly correlated with individual scores on Factor III. On the other hand, the individual functions of Ss with high individual scores on this factor are generally similar to each other and to the generalized function in two respects: they show both erratic responding and a slow rise through the 18 trials. These characteristics are consistent with what Weir has described as a "hypothesis testing" strategy generally used by Ss of high ability. Ss whose performance is characterized by this strategy are presumed to gather information in early trials which may be used to form and test hypotheses in later trials. The erratic responding is explained by presuming that initial hypotheses may be faulty and must be modified. Although none of the cognitive and personality factors was significantly correlated with individual scores, the fact that ability factors were selected first in the stepwise multiple regression is consistent with Weir's argument. The fact that correlations between factors and individual scores are near zero may be due to restrictions in range of individual scores on Factor III.

Discussion

Variations in performance on a 70-10-10-10 probability learning task were found to be characterized by three generalized learning functions obtained by factor analysis of intertrial correlations. The three generalized functions appeared to be consistent with three different theoretical explications of learning in choice situations.

The first generalized function appeared to be consistent with Estes' (1950) stimulus sampling theory. Although Estes' model predicts an asymptotic level of 70 percent guesses of the predominant letter, a result not obtained in this research, it also predicts gradual acquisition, a feature of both the generalized function and of individual functions of Ss having high individual scores on the factor representing this function. The failure to obtain a 70 percent asymptote may be an artifact of the mode of scoring performance on separate trials. The gradual acquisition feature of the function is attributed by Estes to an assumed conditioning process. A composite predictor significantly related to individual scores on the first factor included the factors of Guilt Proneness, Radicalism, Adaptability, and External Regulation.

It may reasonably be argued that this set of traits could be expected to facilitate conditioning.

A second generalized function appeared to be similar in form to a function associated with "pure strategy" (Weir, 1964). Weir interpreted the rapid rise to asymptote in response of the dominant stimulus as indicative of a primitive acquisition strategy because of its common occurrence among preschool children. Although the function associated with Factor II was interpreted as representing pure strategy, our results do not support identification of this mode of acquisition as primitive for two reasons. First, the second function appeared in a population of adults; and, second, the factors contributing significantly to multivariate prediction of individual scores on Factor II were Sensitivity to Threat, Intelligence, and Sociability. These results suggest that factors other than ability are important in determining the use of pure strategy.

Factor III was tentatively interpreted as representing a learning function characterizing hypothesis-testing. Learning functions characterizing hypothesis-testing (using averaged adult data) typically show a slower rise to asymptote. This feature was observed both in the generalized learning function and in individual learning functions of Ss with high individual scores on Factor III. Our interpretation is highly tentative because of the apparently high level of random responding and because none of the cognitive or personality factors was significantly related to individual scores on this factor.

In summary, our results suggest that both conditioning and cognitive processes may be operative in the 70-10-10-10 probability learning task. For a single subject, both processes may contribute to acquisition of the dominant response, as exemplified by variance in individual scores on factors. Variations in individual scores suggest that the component processes are differentially combined by different Ss. However, performance on separate trials was scored as number of correct guesses rather than frequency of response of the dominant stimulus. Although the correlation between scores obtained from the two procedures is undoubtedly high, it may be argued that the two scoring procedures might affect the above conclusions. There is some evidence to suggest that it might not. Second, our results are based on factor analysis of a matrix of intertrial correlations rather than on a matrix containing sums of squares and cross products of scores on separate trials, the method used by Tucker. At present, we are uncertain as to the consequences of this variation in analytical procedure. At this time, work is in progress to investigate the consequences of variations in scoring procedure and analytical method.

REFERENCES

Estes, W. K. The problem of inference from curves based on group data. *Psychological Bulletin*, 1956, 53, 134-140.

Estes, W. K. Toward a statistical theory of learning. *Psychological Review*, 1950, 57, 94-107.

Gardner, R. A. Multiple choice decision behavior. *American Journal of Psychology*, 1958, 71, 710-717.

Harman, H. *Modern factor analysis*. Chicago: University of Chicago Press, 1960.

Kendler, H. H., and Kendler, T. S. Vertical and horizontal processes in problem solving. *Psychological Review*, 1962, 69, 1-16.

Skinner, B. F. Reinforcement today. *The American Psychologist*, 1958, 13, 94-99.

Tucker, L. R. *Determination of generalized learning curves by factor analysis*. Technical Report, Princeton, N. J.: Educational Testing Service, 1960.

Weir, M. Developmental changes in problem solving strategies. *Psychological Review*, 1964, 71, 473-491.