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HUMAN MAZE LEARNING AS A FUNCTION OF STRESS AND PARTIAL REINFORCEMENT[1]

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Summary.—96 *S*s learned a 23-row button maze under 1 of 3 stress conditions and partial or continuous reinforcement. Stress conditions were error, error and speed instruction, or error and speed instruction plus irrelevant shock. Number of errors were an increasing function of stress, but rate (responses per second) suggested a non-monotonic function. Reinforcement schedule was not an effective variable. Results were discussed with relation to competing response tendencies associated with motivation.

The present study was designed to investigate the effects of stress and partial reinforcement (PR) on acquisition and performance of human *S*s in a complex button maze. Amsel (1962) has recently reviewed the extensive research concerned with PR-induced frustration effects (FE) with animals. PR over trials has generally been shown to produce an initial decrement in response speed followed by a facilitating effect when compared with continually reinforced behavior (Weinstock, 1954). However, little has been done with FE in combination with different levels of motivation. The results of the few animal studies investigating FE as a function of drive (D) are equivocal. McHose and Ludvigson (1964), employing a double alley situation, found an FE by D interaction with high D *S*s demonstrating a reliably greater magnitude of FE. Badia (1965), in a single straight alley, failed to obtain an FE $\times$ D interaction. The present study was designed to investigate the effects of PR in complex human learning under several levels of stress.

There is no implication that the parameters employed for investigating human behavior in this area are directly analogous to those used in the animal studies. However, as long as the operations for defining the parameters are specified in each case, research on the behavior of one type of organism may serve as a basis for hypothesis about the behavior of a different type of organism.

A second question, *ad hoc* to the results of the study, concerned a discrepancy between the two measures of response strength used; rate of response and number of errors. Certain questions were raised and are elaborated in the discussion section, pertaining to the interpretation of rate of response as a measure of motivational effects.

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Method

Subjects

Ninety-six male undergraduates from Northeastern University served as *Ss*. All volunteered under the stipulation that shock might be used in the study and they were paid.

Apparatus

The button maze was constructed of 12 rows of 4 electrically NO push-button switches per row built into a 9-in. × 18-in. metal chasis. The buttons were spaced 1¼ in. apart. Separate start and stop buttons were mounted on the end of the chasis nearest *S*. Errors were recorded on a Sodeco counter when any of the three incorrect buttons in each row was pressed. A telephone extension bell rang when *S* made a correct response. Time was recorded on a Standard Electric clock which was activated by *S*'s start button and terminated by his stop button.

Shock was delivered by a 4-v D.C. rectifier modified and amplified by a Harvard Inductor Stimulator set at 40 × 10. Electrodes 2 in. apart were mounted on a cuff worn on the forearm of the non-preferred arm. The shock duration of 1 sec. was controlled by a Hunter Electric Timer, Model 115.

Reinforcement was presented by lighting up 1¼-in. high words "GOOD" or "POOR" in a reinforcement box next to *S*.

Procedure

All *Ss* were instructed, when told to begin each trial, to press the start button at the bottom of the maze and begin working up the maze. Only one button, which sounded the bell, was correct in each row, and the correct button had to be depressed before going on to the next row. After the twelfth row was completed, *S* then proceeded back down toward row 1. Buttons wired as the correct responses going up were independent of those wired as the correct responses going down. Therefore, 23 rows composed a trial. *S* pressed the stop button upon completing the trial. After time and number of errors were recorded, *E* then flashed "GOOD" if *S* was to be informed that he did "better than the average person" or flashed "POOR" if *S* was to be informed he did "worse than the average person." Each *S* received a total of 40 trials.

Ss were randomly assigned to one of six conditions based on a 2 × 3 factorial design with 2 reinforcement conditions and 3 levels of stress. Sixteen *Ss* served in each condition. Half of the *Ss* received continuous reinforcement (C) where "GOOD" was flashed after every trial. The remaining *Ss* received a partial reinforcement schedule (P) where "POOR" was flashed on a random predetermined 50% of the trials and "GOOD" on the other trials, with only the restriction that the same reinforcement could not occur more than twice in succession.

Within each reinforcement condition three levels of stress were used. The lowest level (E) was distinguished by instructions emphasizing only errors with regard to level of performance. Under the next level of stress (Error, Speed) speed, as well as errors, were emphasized in the instructions. Under the highest stress condition (Error, Speed, Shock) both speed and errors were emphasized, but *S* was told he would receive occasional random shocks throughout the study. A sample shock was given before the start of the experiment and an additional four shocks were presented between Trials 9 and 10 and Trials 22 and 23 (following "GOOD" in the P condition and "GOOD" in the C condition) and between Trials 14 and 15 and Trials 31 and 32 (following "POOR" in the P condition and "GOOD" in the C condition).

It was emphasized to *S* that shock was not in any way related to the level of his performance and that a shock would never be presented during a trial.

All *S*s wore the shock cuff on the forearm of their non-preferred hand. *S*s who would not receive shock were told that the cuff was for control purposes and that no shock would be presented. In their reiteration of the instructions, non-shock *S*s gave no indication that they feared they would receive shock in spite of *E*'s reassurance.

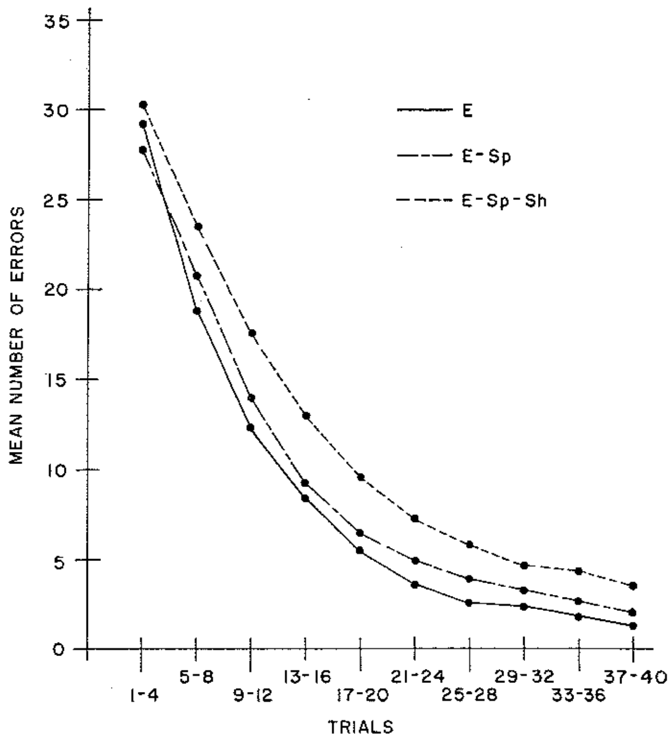

FIG. 1. Mean number of errors over trial blocks as a function of level of stress

RESULTS

Two measures of response were made on each trial for the 96 *Ss*: errors and rate. Means were computed over four-trial blocks, yielding ten data points for each *S*.

The error data were subjected to an analysis of variance of mixed design with Reinforcement (R), Stress (S) and the R × S interaction as between-subject effects and Trials (T), the T × R, T × S, and T × R × S interactions

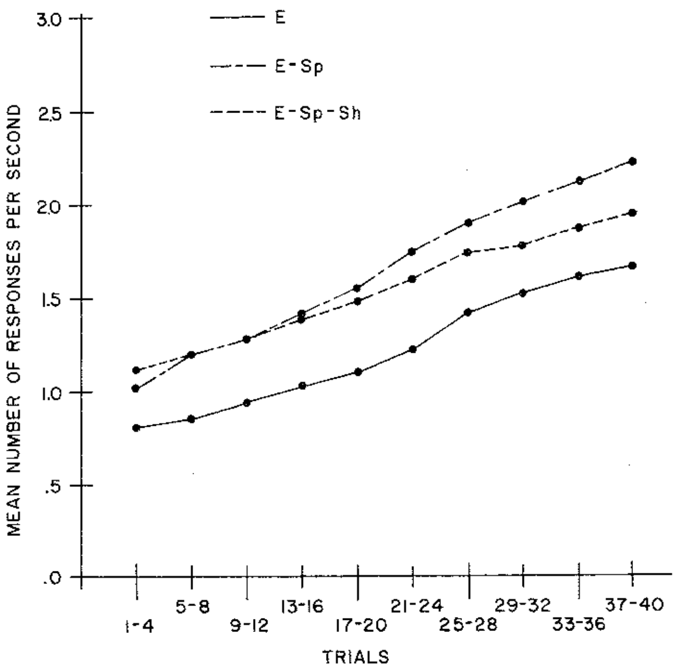

FIG. 2. Mean number of responses per second over trial blocks as a function of level of stress

as within-subject effects. Only Stress ($F = 3.50$, $df = 2/90$, $P < .05$), Trials ($F = 852.59$, $df = 9/810$, $P < .001$) and the T × S interaction ($F = 1.83$, $df = 18/810$, $P < .05$) were significant effects. A *t* test of mean differences within stress showed that the Error-Speed-Shock condition yielded significantly more errors than the Error condition ($P < .02$). The difference between the Error-Speed-Shock and Error-Speed conditions reached only the .10 level of probability. Fig. 1 presents the effects of different levels of stress on number of errors over trials. There was no significant difference between the Error-Speed and Error conditions.

The rate data were computed by dividing the mean number of total responses (23 correct responses, a start response and stop response plus number of errors) by the mean time in seconds to complete the trial. Means were computed over four trial blocks for each *S*. The rate data were subjected to an analysis of variance of the same design as the error data. Again only Stress ($F = 14.07$, $df = 2/90$, $P < .001$), Trials ($F = 180.79$, $df = 9/810$, $P < .001$), and the T $\times$ S interaction ($F = 2.32$, $df = 18/810$, $P < .025$) were significant effects. A *t* test of mean differences within stress showed both the Error-Speed-Shock condition and the Error-Speed condition to be significantly faster than the Error condition ($P < .01$) but not significantly different from each other. Fig. 2 presents the effects of different levels of stress on response rate over trials.

Discussion

The failure to obtain a significant PR effect or a stress by PR interaction in this study is not conclusive. Compared with animal studies which have used simple instrumental running responses and varied reinforcement ratios of a primary drive, the present study utilized a situation involving a large number of discrete serial responses in a multi-alternative complex, and varied reinforcement ratio of higher order secondary-motivations (achievement, aspiration, etc.). In addition, it is conceivable that the degree of frustration induced by the "good-poor" reinforcement was of a low level. However, there was a tendency, though not significant, for PR to produce a consistently greater number of errors throughout learning, with a mean difference of 1.59 errors per trial over the first 20 trials and .43 errors per trial over the last 20 trials.

The study was initially designed so that two measures of response strength would be available for analysis, number of errors and rate. It was anticipated that, in as complex a situation as a four-alternative, 23-choice-point maze, errors would be an increasing function of level of stress. The results were in this direction. Several previous studies in both psychomotor and verbal learning have documented the debilitating effects of increased motivational levels on learning where interfering responses are prominent (Castaneda, 1956; Castaneda & Palermo, 1955; Farber & Spence, 1953). These results may be attributed to the energizing effects of motivation which increase the probability of competing responses by raising them to a superthreshold level, and also by maintaining incorrect responses which are already dominant (Spence, 1956). Another interpretation would attribute performance decrements to interfering and/or distracting responses associated with the stress itself.

A study of Cicala (1961) provides an interesting contrast to these results. Cicala showed that increased hunger drive resulted in *fewer* competing responses with rats in a straight alley running to food. On the basis of these conflicting results, it is suggested here that the discordant effects of motivational level in producing interfering responses may be a function of the incentive relevancy of the drive manipulated and the complexity of the learning situation. The following hypothesis is proposed. In simple learning situations, the associative properties of motivation are the major contributors to performance decrements. Here a greater number of drive-associated competing response tendencies would be encountered under a low relevant drive condition, since irrelevant drives which are present would have a relatively greater effect on performance and the interfering responses (conditioned or unconditioned) associated with them would play a more dominant role. Increases in the relevant drive in this situation would strengthen the dominant correct response relative to the interfering responses and reduce the probability of their occurrence. In more complex learning situations containing a greater number of response alternatives, the energizing properties of motivation are the major contributors to performance decrements. High motivational levels would raise more competing responses above threshold and more strongly sustain incorrect responses which may be initially dominant. This hypothesis would require a greater emphasis on the selective properties of motivation, in addition to its more general effects.

In addition to errors, rate of response (responses per second) was also anticipated to be an increasing function of stress, based on the simple energizing effects of motivation. It should be noted that the rate measure, unlike a simple time measure, was adjusted for number of errors. Whereas an increase in number of errors would increase time per trial, it would not necessarily affect response rate as it was calculated. The finding that increased stress (Error-Speed-Shock) did not produce an increase in response rate over that of the Error-Speed condition as contrasted with the error measure, suggests an important difference between these two dependent variables. One possible interpretation is that, while both lower and higher level increments in stress increase errors and rate in complex learning, higher level increments would increase the number of superthreshold competing responses. This would increase the probability of vicarious trial and error (vacillation) responses which increase the time per trial but which are not recorded as responses and which do not enter into the calculated response rate. If some means could be developed to record these vacillation responses as such, it would be expected that response rate would be an increasing function of stress. A simpler interpretation, which ignores the nonsignificant decrement between the Error-Speed and Error-Speed-Shock conditions, is that response rate had reached an asymptote under the Error-Speed condition and that the addition of shock was inconsequential, or that rate was affected only by a "speed set" mediated by the instructions.

These results receive some support from a study by Matarazzo, Ulett, and Saslow (1955). Using a complex stylus maze, they reported trials to criterion as an increasing monotonic function, and time to learn to criterion as a U-shaped function of anxiety as measured by the Taylor Manifest Anxiety Scale.

The present results indicate that more emphasis should be given to the nature of the dependent variable in describing the function relating motivational level to performance. Especially in complex learning, where the probability of interfering responses is high, the unrecorded responses may be critical to that function.

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