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Extinction for systems learning

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With a group procedure, 72 Ss learned associations between pairs of colored figures and nonsense words taken from a 4 by 4 miniature system. In a factorial design, the number of different associations from the system that were learned was varied at two levels, and an extinction procedure that followed learning was applied in three ways. Systems learning occurred. The number of different associations that were learned was not related to accuracy in reproducing the system. For Ss who learned half of the system, the extinction procedure was effective on those associations produced without learning.

One argument for studying artificial linguistic systems is that they demonstrate characteristics of natural languages, e.g., the tendency to regularize inflection of irregular verbs was reproduced by Palermo & Eberhart (1968). Artificial linguistic systems consist of a set of stimuli and responses arranged so that specific characteristics of the stimuli are systematically associated with particular parts of the responses. An S-R explanation of the observation that, after part of a system was learned, unlearned parts could be produced (Jenkins & Palermo, 1964), though controversial, offers heuristic focus for investigation of systems learning.

The present study examined the relationships of two variables to systems learning. One concerned an unreplicated relationship reported by Foss (1968) that the larger the number of different associations learned from a system, the more accurate was reproduction of the system. As the second variable, previously unstudied for systems learning, extinction

was inserted following learning and before reproduction of the system to determine its effect on the learned and unlearned responses of the system.

SUBJECTS

Seventy-two male and female college students, from 81 volunteers, met the learning criterion (discussed below) and were assigned randomly and evenly among groups.

SYSTEMS LEARNING

The first experimental step used the miniature system of Foss (1968). It can be represented by a 4 by 4 matrix in which all entries in a single column were the same geometric figure, and each column was a circle, square, triangle, or heart. All entries in a single row were the same color, and each row was red, blue, green, or yellow. Each figure and each color had an associated CVC nonsense syllable for a total of eight CVCs, e.g., ZIN for red and TEP for circle, selected for equal meaningfulness. The possible combinations of colors and shapes produced 16 colored figures and each one had associated with it a six-letter nonsense name, which was the combination of the color CVC and the shape CVC, in that order. For example, the

red circle was named ZINTEP. S's task was to learn the names of the colored figures.

The learning materials were sheets of paper partitioned into 16 columns and 16 rows (or 8 by 16 depending on the experimental condition). The columns, headed by the colored figures, and the rows, headed by the nonsense names of figures, were ordered randomly. Each learning sheet was covered by a transparent plastic sheet on which the column and row intersections were covered by black wax that could be scraped away to expose the learning sheet. Each colored figure had one correct six-letter name associated with it, and their intersection on the learning sheet was marked with the letter "c" (reinforcement). All other intersections were blank. The packet for learning contained five learning sheets in their waxed plastic covers. Each of the five sheets had a different random order of rows and columns.

Ss were instructed to discover and remember the one correct name for each colored figure, but were not told of the systematic relations among CVCs, colors, and shapes. Ss started with the colored figure heading the left-hand column by selecting a name and scraping the wax at the intersection of the row for the name and the left-hand column. At his own pace, S continued until the "c" name was selected for each colored figure in succession on the first learning sheet. After memorizing the associations he had discovered, S placed the first learning sheet in a folder (out of sight) and repeated the procedure for each of the remaining learning sheets until he reached the criterion of selecting the correct nonsense name for each colored figure without error on one sheet. If, on Sheet 5, S had errors, he was excluded from the experiment.

SYSTEMS EXTINCTION

In the second experimental step, a packet contained five learning sheets, each 8 by 16, without "c"s (nonreinforcement), and with new random orders of columns and rows. The procedure varied from learning in that S made only one selection of a nonsense name for each colored figure. Extinction was nonreinforcement following correct responses. Ss were told that the procedure was like learning except that they were to make one choice per figure, could not ask questions, and should complete all five sheets. Ss were not told that there were not "c"s.

SYSTEMS TEST

Next, Ss completed a systems test, which was a page on which all colored figures and nonsense names of the system formed a 16 by 16 matrix, like that for learning, but with new random orders of columns and rows. S wrote directly on the

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test sheet and was instructed to mark the one correct name for each colored figure.

QUESTIONNAIRE

As a final experimental step, Ss wrote short answers to five questions worded to elicit Ss' verbal statements about (awareness of) the presence of a system, when during the experiment such awareness occurred, and reactions to the extinction process.

DESIGN

The six experimental groups varied in terms of the number of colored forms for which Ss learned names (two levels), and the nature of extinction (three ways) in a 2 by 3 factorial design. Three groups (L8) learned eight associations (A associations) selected so that each color and each shape occurred twice. The other three groups (L16) learned 16 associations (A associations plus the remaining eight B associations of the system). For each of the following three pairs of groups, one was L8 and the other L16. Two control groups were not extinguished but moved directly from learning to the test. Two other groups were extinguished on the eight A associations learned by all Ss. The final groups were extinguished on the eight B associations, those learned only by Ss who learned 16 associations.

RESULTS

To check on Ss' learning of the system, the two groups without extinction were compared in terms of the mean number of test errors on the eight B items learned only by the L16 group. By Duncan's range test, at $p < .05$, the differences were not significant. The mean number of errors for the L8 and L16 groups were 0.42 and 0.08, respectively. Clearly, there was systems learning, since the L8 group produced at least seven of the eight unlearned B associations.

Next a 2 by 3 factorial analysis of variance was computed on the number of test errors for all 16 (A + B) items. The number of associations learned was not a significant source of variance at $p < .05$. The mean errors for L8 Ss combined was 1.78 and for L16 Ss was 1.08. In contrast, extinction was a significant source of variance ($F = 5.61$, $df = 2/66$, $p < .01$). To identify the underlying differences among individual groups, Duncan's range test was applied. The L8 group, which was extinguished on the eight B items they did not learn, had significantly more errors than did the other groups at $p < .05$. Mean errors on all 16 items were 4.50 and 0.60, respectively (five combined groups). No other differences between groups were significant.

Two additional 2 by 3 factorial analyses of variance were computed, one for each of the sets of eight items. For the eight A

items learned by all groups, there were no significant sources of variance. But for errors on the eight B items learned by only L16 groups, the analysis of variance indicated three significant sources of variance: number of associations ($F = 4.24$, $df = 1/66$, $p < .05$), extinction ($F = 7.35$, $df = 2/66$, $p < .01$), and their interaction ($F = 4.00$, $df = 2/66$, $p < .05$). The L8 groups had more mean errors (1.19) than did the L16 groups (0.36) on the eight B items. The two groups that were extinguished on the eight B items had more mean errors (1.88) than did the other four groups combined (0.23). The L8 group for which the eight B items that had not been learned were extinguished made the most mean errors (3.08) on the B associations. By Duncan's range test, this group differed significantly from the other groups at $p < .01$.

Questionnaire responses supplement the findings on test errors. First, 69 of the 72 Ss reported that they had discovered the systematic relationships among the nonsense words and colored figures. And Ss who were extinguished indicated that when they found no "c"s during extinction they reacted with affective responses such as frustration and confusion (24 of 48 Ss). The other Ss listed cognitive responses, such as recognizing that conditions had changed or describing strategies for discovering that there were no "c"s. The group that made the largest number of errors had more affective and fewer cognitive responses than the other groups.

DISCUSSION

The finding that the number of associations learned was not significantly related to the total number of errors is contradictory to Foss's (1968) report that the more associations, the fewer errors. However, this difference seems reconciled when the comparison between studies is based on the groups that had the nearest to comparable conditions (the control groups in this study and Foss's nonoverlap groups). The mean total errors for 8- and 16-item learning, respectively, were 1.31 and 0.31 for Foss and 0.75 and 0.08 here. In all probability, such differences between the studies would not be statistically significant.

The challenging finding of this study is that the group which learned eight items and was extinguished for the remaining eight unlearned associations, compared to all other groups, had the greatest number of errors—and more were on the unlearned than on the learned associations. An explanation based on extinction needs to assume two things: First, associations produced as part of the system, but not actually reinforced, are weaker than associations that were reinforced; second,

the nonreinforcement for the previously reinforced associations had negligible effect because of the relatively large number of reinforced compared to nonreinforced responses. Five extinction trials occurred for each association compared to the potentially large amount of learning during memorization between learning sheets. An added complication is that, if we follow the S-R explanation of Jenkins & Palermo (1964), then we assume that both the associations between each figure and name and the associations among the implicit responses, the stimuli they produce, and the overt responses and stimulus figures, must also be extinguished.

That Ss from the group with the greatest number of test errors also reported the most affective reactions to the extinction process supports the explanation that the process was extinction, which typically involves a frustration reaction (Kimble, 1961).

Most Ss in this study reported awareness of systematic relationships, which is at variance with Esper's (1925) report that Ss were unaware that the unlearned associations they produced were unlearned. Our explanation of these reports on awareness of systematicity, and their relationship to learning, is based on comparable reports of awareness of the response-reinforcement contingency in verbal operant conditioning. Miller (1967) has shown, for systematically ordered complex verbal stimuli and responses, that awareness can be operantly conditioned to either vary with, or be independent of, conditioning of other responses. For systems learning, this would mean that whether Ss were aware of systematicity or unaware of it would depend upon the reinforcement contingencies arranged for awareness while Ss were learning associations of the system.

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