lowered and the trial scored. If S had chosen the incorrect alley, the knife switch was thrown so that 8 sec later the concealed light went on, beginning the ITI, and E exchanged the stem and appropriate end section, thereby setting up for the next trial. The same procedure was followed for a correct choice, except that the ITI was not begun until S began drinking or until 3 min had elapsed. Drinking was typically immediate and failed to occur on a total of only two trials. Two mice refused the run on a total of seven sessions and such sessions were terminated after 20 min. These sessions were scored as if a completed noncriterion session. The maze was cleaned of boluses or urine before the next S was run, and at the end of the day it was washed.

RESULTS AND DISCUSSION

The results are shown in Fig. 1. The ITI parameter had no significant main effect ($F = 1.07$, $df = 2/36$) and did not significantly interact with strain ($F = .62$, $df = 6/36$). It was suspected that the absence of a main effect of ITI might be due to compensation for a loss of short-term memory by a gain in overall reverberatory time for long-term memory formation as ITI increased. Therefore, the probabilities of incorrect initial and of incorrect final choices on the session following each criterion session were calculated for each level of ITI, with the prediction that probability of error on the first trial would increase with increasing ITI. It was found that the initial trial probabilities were .62, .75, and .68 and the last trial probabilities were .49, .60, and .57 for the 13-, 24-, and 60-sec ITIs, respectively. While tending to the direction predicted, the trend of these results is not striking and it seems that ITI makes little difference within the range studied.

The effect of strain was highly significant ($F = 16.57$, $df = 3/36$, $p < .001$). Calculating "heritability" after Fuller & Thompson (1960), but setting $\sigma_b^2 = \sigma_g^2$

and $\sigma_w^2 = \sigma_e^2$ for full genetic correlation, gave heritabilities of .53, .39, and .70, respectively, for the 13-, 24-, and 60-sec ITIs. These estimates should of course be regarded as liberal pending subsequent biometric analysis for maternal environmental effect. Little environmental variance was due to maternal age which correlated low with number of reversals of offspring ($r = -.10$, $t = -2.30$, $df = 46$, $p < .05$). Data were grouped with respect to strain only and test of homogeneity of variance made. Despite the grouping, no significant interaction of heredity and environment was found ($F_{max} = 3.33$, $df = 4/11$).

Since the count of reversals was made only over 50 sessions, regardless of S's record, data on sessions to criterion as a function of reversal number are quite incomplete except for 129/J mice, all of which completed the sixth reversal. Nonetheless, it was quite clear that sessions required for the first reversal did not show the increase over sessions for original learning found quite typically in the case of the rat. Except for the Balb strain, which showed little variation as a function of reversal number, it appeared that most of any learning to learn occurred during original learning. Mean sessions to criterion of the 129/J mice was representative of this trend and, beginning with original learning, was 7.0, 5.3, 4.2, 4.7, 5.7, 4.3, and 4.8. In further distinction from the rat, reversal learning in one session was quite infrequent, occurring only 11 times.

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presence of the line to 0.5 sec while holding it constant in the presence of green did not produce any consistent rate increase or decrease. This change did result, however, in a higher response rate in the presence of the stimulus correlated with the higher reinforcement magnitude.

Relatively few experiments have investigated the effect of different amounts of reinforcement within a session under a multiple schedule in the free-operant setting (Dickson & Thomas, 1963; Beer & Trumble, 1965; Shettleworth & Nevin, 1965). The general finding has been that the rate of responding in the presence of a stimulus correlated with the greater amount of reinforcement is higher than in the presence of the stimulus correlated with the lesser amount. In none of the previous studies has a baseline level of responding been firmly established in which amount of reinforcement was the same and then reduced in the presence of one stimulus and held constant in the presence of the other stimulus. If reducing the reinforcement magnitude reduces the rate of responding in the presence of its correlated stimulus, then an increase in the rate of responding in the constant component (behavioral contrast) should result (Terrace, 1968).

SUBJECTS AND APPARATUS

Six adult White Carneaux pigeons, maintained at 80% of their free-feeding weights, served as Ss. The testing chamber was a standard three-key operant-conditioning chamber enclosed in an ice chest. An exhaust fan provided masking for extraneous noise. An Industrial Electronic Engineers multistimulus projector, mounted behind the center key, could illuminate this key with five wavelength stimuli (501, 538, 555, 576, and 606 nm and five orientations of a white line, 7/8 in. high and 1/8 in. wide, on a black background (± 60 deg, ± 30 deg, and 0 deg from vertical)).

A photocell was mounted in the opening of the magazine. Operation of the magazine lighted the opening and closed the photocell circuit. To eat, the bird had to occlude the photocell which opened the circuit and produced a short electrical pulse. Programming and recording was accomplished with standard electromechanical equipment located in an adjacent room.

PROCEDURE

After the pecking response was shaped to the center key, pecking this key was reinforced on a variable interval schedule of 30 sec (VI 30-sec). The 555 nm stimulus (S1) and the white vertical line (S2) alternated every 1 min separated by a 10-sec blackout. Each animal received 30 1-min cycles daily, 15 of each stimulus. No other illumination

Effects of lowering the magnitude of reinforcement on the response rate from a baseline during a successive discrimination¹

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The pecking response of pigeons was

reinforced for 20 days with a reinforcement duration of 4 sec in the presence of both a green light and a white vertical line in order to establish a baseline response rate. Reducing the reinforcement duration in the

Fig. 1. The rate of responding as a function of reinforcement duration expressed as a per cent of the average rate of responding for the last 6 baseline days.

was provided. For the first 20 sessions the reinforcement duration in both components was 4 sec, timed from the moment at which the bird occluded the photocell. Thus, the time between presentation of the magazine and the bird placing its head in the magazine was not counted as part of the access-to-grain time. After 20 sessions the reinforcement duration in the presence of S2, the white vertical line, was reduced to 0.5 sec. The duration in the presence of S1, the green light, remained at 4 sec. All other aspects of the procedure remained the same.

After 12 sessions a generalization test was conducted in extinction. The five wavelength stimuli and the five line-tilt stimuli were presented in a random order. Each presentation lasted 30 sec followed by a blackout of 10 sec. Each of the 10 stimuli was presented eight times to each bird.

RESULTS AND DISCUSSION

Figure 1 shows the rates of responding for each bird for the 12 sessions during which reinforcement durations differed. Each daily rate is expressed as a per cent of the average rate to the same stimulus computed on the 6 days prior to the change in reinforcement duration. A per cent above 100 indicates a rate increase—a per cent less

Fig. 2. Relative generalization gradients for all birds combined. The center point on the wavelength dimension (555 nm) was correlated with the 4-sec reinforcement duration and the center point on the line-tilt dimension (0 deg from vertical) was correlated with the 0.5-sec reinforcement duration.

than 100, a rate decrease. The effect of reducing reinforcement duration from 4 sec to 0.5 sec in S2 produced large individual differences. Birds 648 and 52 showed behavioral contrast: an increase in S1 response rate accompanied by a decrease in S2 response rate. Bird 641 showed an increase in both S1 and S2 response rate, while Bird 580 showed an increase in S1 response rate and no consistent rate change in S2. Bird 211 showed a decrease in both S1 and S2 response rates. Conclusions with regard to Bird 26 are difficult due to the variability in response rate.

Statistical analysis indicated that there was no significant difference between baseline rates in S1 and S2, that there was no significant change in response rate during S1 for either the first six or the last six experimental sessions when compared to the last six baseline sessions, and no significant change in the S2 response rate for the same comparisons (all probabilities $> .10$). On the other hand, reducing the reinforcement duration in S2 produced a significant difference between the response rates in S1 and S2 ($F = 25.21, p < .005, df = 1/5$). This result is similar to that found by previous investigators.

Group generalization curves are presented in Fig. 2 for both the wavelength and the line-tilt dimensions. The generalization stimuli from both dimensions were placed at the same point along the abscissa for convenience, and are not meant to imply equal psychological distances between matched points on the different dimensions. Each point was determined by computing the average per cent of the total responses emitted to each stimulus during the entire generalization test. More responses were emitted to the 555 nm stimulus, S1, which was correlated with the 4-sec duration, than were emitted to the white vertical line, S2, correlated with the .05-sec duration. The generalization curve for the wavelength dimension has a steeper slope than that for the line-tilt dimension.

The time between presentation of the food magazine and the occluding of the photocell by the bird eating was recorded throughout the experiment. Reduction of the reinforcement duration did not change this latency. This suggests that the birds may not have been discriminating the reinforcement duration prior to eating.

Direct observation of the birds eating showed that they made about six times as many pecks at the grain during the longer reinforcement duration. From results where reinforcement frequency was five times as great in one component than in the other (multiple VI 1-VI 5), it can be concluded that reduction in reinforcement duration does not produce a reduction in response rate to as great a degree as does a comparable reduction in reinforcement frequency (cf. Terrace, 1968).

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NOTE

1. This research was supported in part by PHS Research Grant No. 5R01 MH 13343 from the National Institute of Mental Health.