FREQUENCY OF REINFORCEMENT AS A PARAMETER OF CONDITIONED SUPPRESSION

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Two pigeons were trained on a multiple VI-1; VI-4 min schedule for food reinforcement until a stable differential rate of response was established. Each component of the multiple schedule was in effect for 10 min and was separated from the other by 1 min time out. An Estes-Skinner conditioned suppression procedure was superimposed on each component of the schedule. The relative magnitude of the suppression behavior was measured during its acquisition and extinction, and at CS durations of 100, 200, and 300 sec. The initial magnitude of the suppression behavior was less severe on the VI-1 baseline than on the VI-4, and it extinguished more rapidly on the VI-1. As the relative duration of the CS was increased, the suppression behavior became less severe on both baselines, but the initial differential magnitude in the suppression remained intact.

Recent studies of the Estes-Skinner conditioned suppression procedure indicate that the procedure used to maintain the baseline performance is an important variable in determining the degree of suppression that will be achieved. In particular, studies by Stein, Sidman, and Brady (1958) and by Carlton and Didamo (1960) point to the frequency with which the reinforcement is provided as a significant feature of the situation. In the present study, this variable is examined directly, through the use of a multiple schedule baseline. Thus, the degree of suppression obtained with two different reinforcement schedules can be compared within the same organism. The effects of these schedules are also compared as the relative duration of the conditioned stimulus is increased, to determine the interaction between these two factors.

METHOD

Subjects

Two adult white Carneaux, barren hen pigeons, were maintained at $70\% \pm 15$ grams of their original weight. Kellogg Utility Pigeon Feed was given when necessary to maintain the deprivation rhythm, and the reinforcement grain consisted of 50% Kaffir,

40% Vetch, and 10% Hempseed. Water was available at all times.

Apparatus

An aluminum response chamber, with a Plexiglas top and rear wall, measuring $12 \times 9.5 \times 13.5$ in. was enclosed in a light tight, sound attenuated shell, fitted with a 15 cfm blower. The response key was a .75 in. lighted translucent disc mounted on one wall 9.5 in. above the chamber floor, and was adjusted to operate at approximately 6 gm pressure. Reinforcement was made available for 4 sec through a 2×2.5 in. opening 4.5 in. below the key. The inside illumination was provided by a 40 watt, 10 in. show case lamp mounted behind the rear wall. During reinforcements this house light extinguished and a white lamp in the reinforcement chamber came on. The house light was also programmed through a flashing device set at 100 per min, to serve as the shock correlated stimulus (CS); it did not extinguish during reinforcements when serving this function.

The apparatus for delivering the shock was similar to the device described by Hoffman and Fleshler (1959). It consisted of a phone jack mounted in the rear wall 11.5 in. above the floor, and a short piece of retractable cord connected to permanent wing bands on the birds with alligator clips. A 90 volt AC shock source was programmed through a 20 msec. pulse former to provide the aversive stimulus.

The procedure was programmed on ap-

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appropriate mechanical and electronic timers and relay circuitry. The data were recorded on electrical impulse counters, running time meters, and a Gerbrands recorder.

Training Procedure

Following the establishment of the key pecking response on CRF, and stabilization on a variable interval 1 min schedule, (VI-1), a multiple VI-1; VI-4 schedule was introduced. The VI schedules were programmed so that when a reinforcement was set up, the program tape was stopped until the animal responded and collected the reinforcement. Each schedule was in effect for 10 min and was correlated with a red or green key light. A time out of 1 min duration, during which the response chamber was dark and the key inoperative, was interspersed between the VI schedules. Each schedule was presented five times, with only a few variations, yielding an experimental session of approximately 110 min.

When a stable differential rate was obtained between the two schedules, the shocking device was attached to the permanent wing bands, followed by five sessions of adaptation.

Suppression Procedure

Interruption of the house light was initiated 2 min after the onset of the particular component of the multiple schedule and was terminated with the delivery of the shock. The CS-shock pairings were presented five times on each component, with only a few slight variations.

Following the stabilization of the suppression behavior, requiring approximately 180 pairings on each schedule, with a CS duration of 100 sec, the length of the CS was successively increased to 200 and 300 sec, until the behavior was stable for each value, which required approximately 75 pairings. The results were taken from the 25 pairings of the last five sessions. Replications of the suppression ratios with 100 or 200 sec CS durations were obtained using the above procedure, but separated from it by a series of shock-free (extinction of suppression) sessions at a 200 sec CS.

RESULTS

The results were analyzed in terms of the mean rate (response per min) for the CS in-

Fig. 1. Acquisition and extinction of the suppression behavior on the VI-1 and VI-4 schedules for both birds as a function of sessions. The VI schedules are identified by the numbers 1 and 4 adjacent to the curves.

terval divided by the mean rate in the absence of the CS for each session. This measure is defined as the suppression ratio (Stein *et al.*, 1958).

The suppression ratios for the first 10 daily sessions for each bird are presented in the first half of Fig. 1. Although there was a good deal of variation during the first few days of acquisition, a fairly stable differential ratio between schedules was established for each bird. The curves for PC-1 show a gradual suppression of the response rate during the CS interval. The suppression ratio for the VI-4 decreased to zero, indicating complete suppression, after six sessions, and the ratio for the VI-1 decreased to .093 after 10 sessions. The sharp decrease in the suppression ratio for PC-2 in the initial stages of acquisition was partially due to the severe disruption of the ongoing behavior when the shock was first introduced. After 10 sessions, the suppression ratio for PC-2 decreased to .087 on the VI-1 and .014 on the VI-4.

The apparent strength of the suppression behavior during the given schedules was measured during a series of sessions without shocks at a 200 sec CS, as described in the procedure. These data are presented in the second half of Fig. 1. For each bird the suppression ratio for the VI-1 recovered faster than for the VI-4. In particular, the suppression ratio for PC-1 on the VI-4 failed to rise above .006 after 50 presentations, while the suppression ratio on the VI-1 rose to .349. The suppression ratio for PC-2 on the VI-4 rose to .299 after 30 presentations and on the VI-1 to .940.

The median suppression ratio for the last five sessions at each CS duration are presented in Fig. 2. In all cases, as the length of the CS was progressively increased from 100 to 300 sec, there was a general recovery of the response rate during the CS as indicated by the rise in the suppression ratio. For both birds the original and replicated values approximate one another very closely. There appears to be an interaction between the rate of change in the magnitude of the suppression ratio as the CS was increased and the reinforcement baseline. The curves describing these functions for the VI-4 schedule are positively accelerated, while if anything, the curves for the VI-1 tend to be negatively accelerated.

Fig. 2. Suppression behavior on the VI-1 and VI-4 schedules as a function of the CS duration. The obtained suppression ratios are represented on separate ordinates for the two birds, PC-1 and PC-2, as indicated.

Cumulative records representing the days plotted in Fig. 2 are presented in Fig. 3 and 4 for the two birds. In each case the distribution of the responses during the CS is fairly stable throughout the experimental session under all conditions. The curves indicate the differential magnitude of the suppression between schedules, and the recovery of the rate of response during the CS as the relative duration of the CS was increased.

DISCUSSION

The results of the present study confirm and extend the findings of Stein *et al.*, (1958) and Carlton and Didamo (1960). The relative duration of the CS was found to be an important parameter of conditioned suppression, in accord with the previous findings. This parameter was effective with both the high and low reinforcement frequency baselines, but the point at which it became critical appeared to differ for the two schedules, as suggested by the variation in the acceleration of the curves in Fig. 2. The present findings also confirm the suggestion of Carlton and Didamo (1960) that the degree of suppression would be less severe when the baseline performance was maintained by a high reinforcement frequency.

In interpreting the present findings, the differences in the magnitude of suppression for the two schedules might be directly attributed to the differences in the reinforce-

Fig. 3. Sample cumulative records for one bird (PC-1) representing the days plotted in Fig. 2. The vertical displacement on each curve, followed by a change in the behavior for a fixed interval, indicates CS onset. This should not be confused with the reset marks indicated by a greater displacement at various positions on the curve.

Fig. 4. Sample cumulative records for one bird (PC-2) representing the days plotted in Fig. 2. The vertical displacement on each curve, followed by a change in the behavior for a fixed interval, indicates CS onset. This should not be confused with the reset marks indicated by a greater displacement at various positions on the curve.

ment frequency. Stein *et al.*, (1958) have suggested that an animal will suppress in the CS only to an extent that does not markedly reduce the total number of opportunities for positive reinforcement. Thus one might expect only moderate suppression on the VI-1 but almost complete suppression on the VI-4, as on this schedule almost all the reinforcements that set up during the CS can be collected during the following CS off period. This is a tenable interpretation for the present data, but the possibility should not be overlooked that the degree of suppression may be related to differences in the resulting rate of respond-

ing rather than to differences in the frequency of reinforcement *per se*.

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