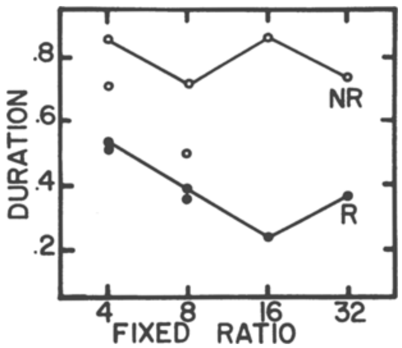

Fig. 1. Mean response durations for reinforced (lower curve) and nonreinforced (upper curve) responses across the four ratios employed in Experiment 1. The individual points are the data for S 14 in Experiment 2.

duration differences of Experiment 1 were cued by some exteroceptive stimulus complex other than the reward schedule itself, three additional Ss were run under a somewhat modified procedure. For two of the animals, a relatively strong stimulus was deliberately paired with the reward contingencies of the schedule. In addition, a powerful blower was installed in the test cage enclosure to provide a masking noise (intensity of 76 dB re .0002 dynes/cm^2).

For S 16, the light on the front of the chamber was always on during the nonreinforced portion of the FR chain. For S 20, the light was turned on immediately preceding each reinforced response and terminated when the response was completed. Two sessions of continuous reinforcement were provided primarily to accustom the Ss to the relatively intense masking noise. During the following four sessions, responses were rewarded on an FR-4 schedule. On the next day, Animals 16 and 20 were exposed to a series of discrimination reversals. The first 10-min period of the session was identical to the previous sessions. During the second 10 min the stimulus conditions were reversed so that now the light signaled reward for S 16 and nonreward for S 20. Conditions were reversed again after the 20th, 30th, 40th, and 50th min of the 1-h session. During the next 5 days the original stimulus contingencies were in effect and all Ss worked on an FR-8 schedule of reinforcement. On the next day Ss 16 and 20 were again subjected to five 10-min reversals.

Results

The duration behavior of Animal 14 was, on all sessions, similar to Ss in Experiment 1. In all cases the nonreinforced response durations were higher than reinforced ones. Mean performance during the last two sessions on FR-4 and FR-8 are plotted separately in Fig. 1.

During the first 10 min of the FR-4 reversal session Ss 16 and 20 showed the characteristic response duration differentiation. Mean reinforced duration for Animal 16 was .44 sec as opposed to .69 sec for nonreinforced responses. The corresponding values for S 20 were .47 and 1.44 sec, respectively. The successive reversals of stimulus conditions had the effect of attenuating the difference between mean reinforced and mean nonreinforced response durations, but did not affect the ordinal relationships.

On the second reversal day under FR-8 conditions, S 20 continued to show duration differentiation. Duration differences for S 16 were no longer related systematically to either the reward or stimulus conditions. Parenthetically, it might be noted that if such a breakdown were to occur it would be more likely under more stringent scheduling (e.g., FR-8 vs FR-4).

DISCUSSION

In general it appears that under the conditions of the present study Ss will emit response duration classes of different means depending upon whether the response is to be reinforced or not reinforced. In other words, intensive measures such as force (Mintz, 1962) and, in the present study, duration are schedule controlled just as the frequency of response datum. Furthermore, contingent exteroceptive stimulation can enhance, attenuate, or obliterate such control. That Millenson et al (1961) were unable to provide evidence for such differentiation might have been related to the properties of their manipulandum. Kellicutt[1] has demonstrated convincingly that the difference between mean acquisition and extinction durations is primarily a function of the amount of movement available in the manipulandum after response definition requirements have been met. The available movement in the present manipulandum was 2 in. as compared with 1 mm in the Millenson study.

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Shock-induced response bursts and suppression[1]

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The effects of signaled unavoidable shock on positively reinforced lever-pressing behavior were investigated. Rats were alternately presented with periods of "safe" and "warning" signals. During the "warning" periods brief shocks occurred randomly and independent of the animals' behavior. Rats with a history of positively reinforced lever-pressing showed both postshock bursts of responding (attack) and suppression of appetitive lever-pressing. These two effects of shock were described as occurring concurrently but with each predominating in one of two stages. Control Ss with no history of positively reinforced lever-pressing failed to attack the lever when shocked, suggesting that such a history was crucial to the production of aggressive behavior.

Operant behavior may be suppressed in the presence of a stimulus which has been paired with unavoidable shock. Suppression of on-going behavior has been termed "anxiety" (Estes & Skinner, 1941). Electric shock has also been used to elicit attack, avoidance, and escape reactions (Ulrich & Azrin, 1962; Azrin, Hutchinson, & Hake, 1967). This may take the form of postshock bursts of responding which may be termed "aggression." However, these two types of behavior have not been studied in the same situation. In a traditional conditioned suppression procedure the shocks occur only at the termination of the warning signal. With such a design anxiety and aggression would not be pitted against each other. Lever-pressing for food has been thought to be incompatible with the fear or anxiety elicited by the warning stimulus and shock (Estes, 1944). On the other hand, postshock behavior may take the form of bursts of lever-pressing characteristic of aggression. Bidirectional effects of aversive stimuli on lever-pressing behavior were noted by Skinner (1938) and since then

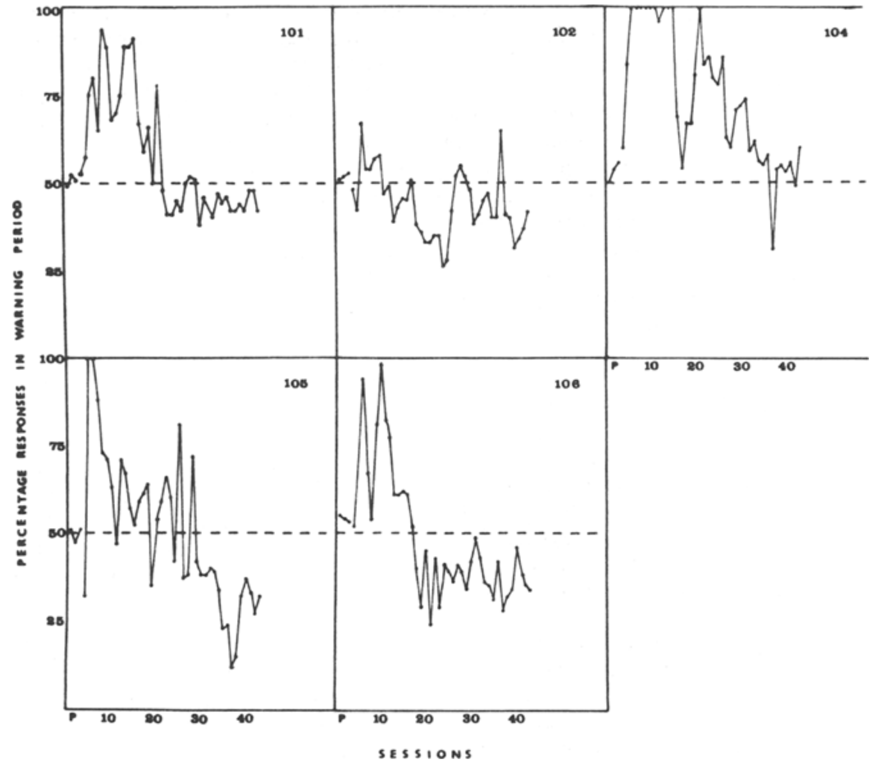

Fig. 1. The percentage of lever-pressing in the warning period for each of the experimental animals for the last three preshock (P) sessions and the 40 shock sessions. The 50% points represent equal response rates in the warning and safe periods.

numerous other investigators have found a facilitation and suppression of lever-pressing with shock (e.g., Strongman, 1967; Weiss, 1968). The present study was a further investigation of this problem with special reference to response bursts and suppression.

SUBJECTS

Nine male albino rats of the Wistar strain, approximately 90 days old at the beginning of the experiment, served as Ss.

APPARATUS

The experimental chamber was a modified Lehigh Valley Electronics student Skinner box, Model 1578. Half-second shock was supplied by a constant current, half-wave rectified source, pulsing 50 times per second and scrambled by a relay-sequencing device. Standard programming and recording equipment was housed in an adjacent room. Throughout the experiment a masking noise generator was in operation.

PROCEDURE

All Ss were maintained at 80% of ad lib weight. Five randomly selected Ss were trained to lever-press on a variable-interval (VI) 1-min schedule of reinforcement. Reinforcement was the presentation of a 45-mg Noyes standard-formula food pellet. During all phases of the experiment a clicker and flashing light stimulus (warning signal) was presented for 3-min periods, alternating with 3 min of its absence (safe signal). After 21 days of this procedure, when all Ss had stabilized their rate of responding in the two stimulus conditions, 0.2 mA/0.5-sec shocks were administered randomly with a mean interval of 2 min when the warning signal was present. Daily sessions were 1 h in duration.

The remaining four Ss (control group) were treated similarly except that lever-pressing was not reinforced.

This procedure is essentially the same as that reported by Azrin (1956, Procedure C).

RESULTS

In the food reinforcement group all Ss showed a greatly depressed rate of lever-pressing with the addition of shock to the procedure. The mean response rate during the second, third, and fourth sessions of shock was only 6% of the rates calculated from the last three preshock sessions. At first this suppression of response rate was greater in the "safe" periods. All Ss in this group gradually showed recovery from the effects of shock on lever-pressing. As recovery progressed, the previously established higher rate in the warning periods disappeared and the traditional finding of a higher rate in the "safe" period developed. Figure 1 illustrates the percentage of lever-pressing responses in the warning period for each animal for the last three preshock sessions and the 40 shock sessions.

Except for the first two sessions of No. 102, all Ss at first showed a greater percentage of responding in the warning periods than in the safe periods. The percentage of warning-period responses gradually decreased for all animals.

The pattern of responding in the warning periods can be determined by examination of cumulative records which reveals that responding in these periods was largely restricted to short bursts following the shocks (see Fig. 2). These shock-induced bursts of responding were clearly evident in all five Ss in this group for at least the first 6 days of shock, after which the response rate was more constant both within warning periods and overall.

When these bursts of responding had nearly disappeared, the warning-period response rate was often maintained at, or above, that of the safe rate for several further sessions. However, during these sessions responses approached the constant rate typically accompanying VI schedules.

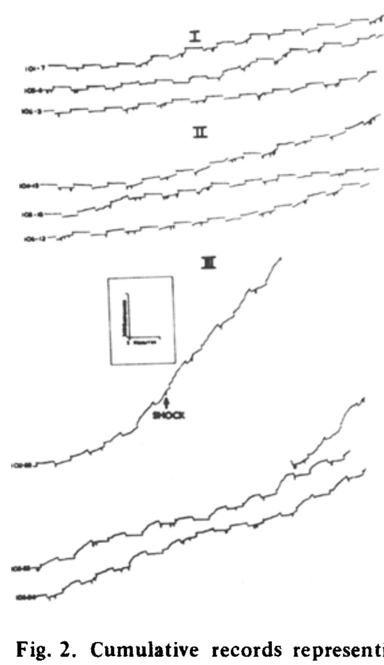

Fig. 2. Cumulative records representing the three stages of the effects of shock (warning periods are indicated by downward deflections of the pen). Stage I indicates that nearly all responding was in the form of bursts (attack) during the warning period, usually immediately following shock. Stage II shows the relatively higher rate in the warning period but with fewer bursts of responding. Stage III illustrates substantial recovery of lever-pressing in the safe period and relative suppression in the warning period. The figures to the left of each record indicate S and session number.

The remaining animals who had not been rewarded for lever-pressing, demonstrated no bursts of responding when shocked. Response rates in this group never progressed above preshock operant levels. In fact, these Ss often failed to respond at all within a session.

DISCUSSION

Sidman (1960) has outlined a two-stage process to describe the behavior which develops in a standard conditioned suppression procedure (Estes & Skinner, 1941). He notes that the S may initially cease pressing when the warning signal is both on and off, and concludes that this may be thought of as a generalized effect of unavoidable shock. He further argues that a second stage occurs when the initially generalized effect of shock is channeled into the warning period. Hendry & Van Toller (1966) have illustrated a third stage of this development which is an increasing recovery of responding in the warning period.

The present study shows that under certain circumstances, the initial effect of shock is to suppress responding generally and to cause short bursts of postshock responding. The second stage is characterized by a fairly even warning-period response rate which is relatively higher than that during the safe period. The generalized suppressive effects of shock are still evidenced by the greatly reduced rate of responding compared to the preshock baseline. The third stage found in the present study corresponds to the second stage described by Sidman (1960), i.e., a substantial recovery of responding during the safe period and continued relative suppression in the warning period.

The control group Ss did not develop a consistent response pattern. The introduction of shock failed to elicit the bursts of responding from these Ss which had been found in the experimental group. This suggests that the history of lever-pressing for food was critical in the development of the response bursts.

Using the Estes-Skinner procedure, Brimer & Kamin (1963) have reported increased response rates in preshock signal periods during the first few sessions. However, their Ss differed from the present ones in two important ways: (1) before conditioned suppression training, they had received 10 days of unwarned shock, and (2) when training with a CS was begun, shock occurred only at the termination of that CS. The addition of a new stimulus condition, the CS, facilitated responding because, unlike the non-CS, it had never been paired with shock. When introduced, it was therefore functionally a safe-signal (Seligman, 1968).

The bursts of responding found in the first stage of the present study appear similar to those found by Azrin, Hutchinson, & Hake (1967) in their study of attack, avoidance, and escape reactions, and by Sidman (1958) in his study of free-operant avoidance. This would indicate that lever-pressing of this pattern was predominantly controlled by shock rather than food reinforcement. When regular responding like that normally associated with VI schedules later replaced the pattern of bursts, it may be contended that the control of lever-pressing behavior was being maintained predominantly by the food-reinforcement schedule.

On the other hand, one might prefer to argue that this relatively steady rate is being maintained "superstitiously" as an avoidance response. Such superstitious avoidance has been demonstrated by presenting unavoidable shock to monkeys that had a history of free-operant avoidance training (Sidman, Herrnstein, & Conrad, 1957). However, two considerations cast doubt on this interpretation. First, the animals in the present study had no such avoidance training history; and second, the control group failed to develop this lever-pressing behavior. Herrnstein & Hineline (1966) note that when brief shock is used virtually no instrumental response could occur in its presence, thus disposing of the superstitious escape argument.

Rachlin (1966), studying punishment, has concluded that there are two effects of mild shock on positively reinforced bar-pressing. He describes them as "A. A strong, sudden, temporary emotional effect independent of any correlation between aversive stimulation and specific responses. B. A gradually appearing permanent instrumental effect acting opposite to reward and depending on correlation between aversive stimulation and specific responses [p. 263]." The present study also found strong, sudden, and temporary behavior as the initial effect. However, there was a correlation between the aversive stimulation and specific responses in the case of the animals which had a previous bar-training history. The attack on the bar may be considered instrumental "from the rat's point of view." Such attack behavior in the natural environment may serve to ward off aggressive and threatening animals.

Finally, it should be noted that previous descriptions of unavoidable shock with a correlated stimulus have typically terminated the stimulus with a single shock (Estes & Skinner, 1941). In such a situation, postshock responding would necessarily occur at the beginning of the safe period. The effects of the offset of the warning signal would therefore be confounded with the concurrent onset of the shock. Some authors (e.g., Estes & Skinner, 1941) have noted that the beginning of the safe period is often characterized by a particularly high rate of responding. They have called this "compensation" for the lowered response rate in the warning period. The present procedure enables postshock effects to be examined independently of the termination of the warning signal. It also illustrates two forms of shock-induced behavior with a single experimental paradigm.

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NOTE

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