**PERSISTENT SHOCK-ELICITED RESPONDING
ENGENDERED BY A NEGATIVE-REINFORCEMENT
PROCEDURE¹**

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A procedure in which responses reduced intermittently presented electric shocks to one quarter of their originally scheduled intensity, effectively engendered and maintained lever pressing in hooded rats. This contingency also markedly increased the response rates of rats initially trained under an unsignaled avoidance procedure. The responding of all animals extinguished rapidly when shock was withdrawn. Subsequently, it was discovered that high response rates could be maintained solely through presentation of shocks that were not affected by responses. Variations in the interval between shocks and changes in shock intensity over a wide range did not attenuate responding. Terminal performance was characterized by a consistent pattern of shock-elicited responses. Responses were also elicited by a tone following repeated tone-shock pairings. Finally, responding that was maintained by response-independent shocks was quickly suppressed by response-contingent shocks of the same intensity.

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Discussion

Several recent experiments have shown that instrumental responding can be maintained in monkeys solely through the presentation of intense electric shocks (McKearney, 1968; Stretch, Orloff, and Dalrymple, 1968; Kelleher and Morse, 1968; McKearney, 1969). In the present experiment, instrumental responding was engendered by a procedure in which responses reduced the intensity of intermittent electric shocks. Eventually, responses were maintained solely through the presentation of shocks that were not affected by the response.

Procedures based upon negative reinforcement are used frequently in operant conditioning to increase the probability of a response. The usual functional definition given for negative reinforcement is an increase in the future probability of a response as a consequence of the termination or postponement of an aversive stimulus by the response. Typically, the intensity of an aversive stimulus is reduced to zero under these procedures. The present experiments were initiated to assess the reinforcing properties of a contingency in which intermittently presented electric shocks were reduced in intensity, but not eliminated, as a consequence of a response. To specify more clearly the effects of this procedure, a comparison group trained under a conventional avoidance procedure was studied.

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Earlier experiments by Weiss and Laties (1959, 1963) showed that response-contingent reduction in electric shock intensity maintains operant responding. Their procedure permitted the animal to reduce shock intensity to zero by sufficiently frequent responding. It has also been shown that when rats are placed upon an electrified grid, with different shock intensities applied to each half of the grid, the animals learn to remain upon the low-shock area (Campbell, 1956).

The initial procedure employed here was similar to the unsignaled avoidance procedure developed by Sidman (1953). The principal difference was that the intermittently presented electric shocks were reduced in intensity, rather than eliminated as a consequence of a response. When we found that lever-pressing of animals trained under this procedure could be maintained effectively through presentation of electric shocks that were not affected by responses, we decided to study this phenomenon in detail. This paper gives an account of the initial training procedure, and the conditions which were subsequently studied as we attempted to establish the basis for the maintenance of responding by non-contingent shocks.

EXPERIMENT I: UNSIGNALLED AVOIDANCE (SIDMAN) COMPARED WITH RESPONSE-PRODUCED REDUCTION IN THE INTENSITY OF INTERMITTENT SHOCKS

METHOD

Subjects

Eight adult male hooded rats, all experimentally naive, had free access to water and Purina lab chow in their home cages throughout the experiment. All subsequent experiments studied rats from this same group, so the same number refers to the same rat throughout this study.

Apparatus

A Gerbrands rat test chamber, 8 in. by 9 in. by 7.5 in. (203 by 229 by 190 mm), with a single lever at the center of one end, 3 in. (76 mm) from the floor, was enclosed in a sound-attenuated chamber. The experiment was scheduled by standard relay circuitry. Electric shock was provided by a 110-v ac

shock source that included 200 K in series with the output and was scrambled to the grid floor of the test chamber. A specially constructed relay operated rheostat was used to deliver two different shock intensities within a session. A lever press started the response-shock timer and simultaneously opened the relay so that the shock was routed through the rheostat while this timer operated. When the relay was closed, the shock by-passed the rheostat. The module also contained a milliammeter and a control knob for adjusting shock intensity. These data were recorded by digital counters and a Gerbrands cumulative recorder.

Procedure

An unsignaled avoidance procedure was used to train three rats (1, 2, 3). Under this procedure, there is a fixed time period between the presentation of brief electric shocks in the absence of a lever press (shock-shock interval) while each lever press postpones the next shock for a fixed time period (response-shock interval). The shock-shock and response-shock intervals were 5 and 20 sec, respectively. The shock intensity was 2.0 ma and shock duration was 0.5 sec. Responses in the presence of shock did not terminate it.

Five rats (4, 5, 6, 7, 8) were initially trained under the procedure in which responses reduced shock intensity. This consisted of a 0.5-sec electric shock delivered every 5 sec over the entire experimental session. Shock intensity was 2.0 ma in the absence of a response for all animals. Each response resulted in the delivery of reduced shocks for the next 20 sec. The intensity of these shocks was 0.5 ma for three rats (4, 5, 6) and 1.0 ma for the remaining animals (7, 8). When the latter two rats failed to acquire the response, the intensity of the reduced shocks was lowered to 0.5 ma.

The initial procedures remained in effect for all eight rats until stable performance was achieved. Stability was defined as a range of 20 or fewer shocks over five consecutive sessions for the avoidance-trained rats, and a range of 20 or fewer high shocks (2.0 ma) for the rats trained under response-reduced shock, also over five consecutive sessions. The maximum number of 2.0-ma shocks a rat could receive was approximately 650 per session under either procedure.

The next step was a reversal of procedures, so that the three avoidance-trained rats (1, 2, 3) were exposed to the reduced-shock contingency, and then were returned to unsignaled avoidance. Also, three rats (4, 5, 6) initially trained under response-reduced shock were studied under the avoidance procedure. All of the rats exposed to the changes in procedure were studied for a minimum of 10 sessions, and for additional sessions as re-

quired to attain the criterion for stable performance. Experimental sessions were 60 min per day under all procedures.

RESULTS

The rats trained under the unsignaled avoidance procedure (1, 2, 3) generally required more sessions to achieve stable performance than did those trained under the

Fig. 1. The response rate and number of high shocks (2.0 ma) during each successive fifth session under the two procedures.

response-reduced shock procedure. The data, summarized in Fig. 1, also show that terminal response rates were much higher under the reduced-shock procedure than under the conventional avoidance procedure.

Fig. 2. The mean response rate and mean number of high shocks (2.0 ma) over the final five sessions, during successive exposures to the two training procedures.

The five rats trained under response-reduced shock developed very consistent patterns of responding, which resulted in fewer than 15 high shocks (2.0 ma) per hour being received in every case. Only one of the avoidance-trained rats (1) lowered the number of shocks to this level. Rats 7 and 8 responded very infrequently to reduce shock from 2.0 to 1.0 ma. When the contingency was changed after 10 sessions, so that responses reduced shock to 0.5 ma, both animals developed consistent responding.

As training continued under the reduced-shock procedure, response rates generally increased. Also, the number of high shocks decreased as response rate increased. On the other hand, the response rates of avoidance-trained animals changed little after the first 10 sessions, although the number of shocks continued to decrease for many sessions after this for Rats 1 and 3. The decrease in shocks is attributable to more effective distribution of responses by these animals.

When the procedures were reversed, the reduced shock contingency produced higher response rates in the three rats (1, 2, 3) originally trained under avoidance. This resulted in the delivery of fewer 2.0-ma shocks. The data, summarized in Fig. 2, also show that rats initially trained under reduced shock performed ineffectively when exposed to the avoidance procedure. They responded consistently to the presentation of shock, but made few responses in its absence. The animals originally trained under avoidance performed at approximately the same level when returned to this schedule after exposure to reduced shock. The asymptotic performance of this group showed less intersubject variation during the second period of avoidance training as compared to the first. Representative cumulative records under both procedures are presented in Fig. 3.

EXPERIMENT II: EXTINCTION OF RESPONDING THROUGH A SHOCK WITHDRAWAL PROCEDURE

METHOD

Two different procedures have been used to study the extinction of responding following escape and avoidance conditioning. Herrnstein and Hineline (1966) studied extinction by eliminating the effect of the animal's response upon the shock schedule. The second procedure consisted of withdrawing the aversive stimulus (Shnidman, 1968).

Five rats were studied under a procedure in which all shock was withdrawn during the final 50 min of the 1-hr sessions. For the first 10 min of these sessions, the original reduced-shock contingency (2.0-0.5 ma) was in effect. Before the extinction sessions, four rats (1,

Fig. 3. Typical cumulative records for two rats successively studied under the two procedures. Rat 1 was initially trained under unsignaled avoidance (panel A), was studied under response-reduced shock (B), and then returned to unsignaled avoidance (C). Rat 4 was initially trained under response-reduced shock (D), was studied under unsignaled avoidance (E) and then returned to response-reduced shock (F). The downward pips indicate shocks. High shocks (2.0 ma) and low shocks (0.5) are not differentiated here under the response-reduced shock procedure, but most high shocks were received in the first minute of the session.

3, 5, 6) were given five additional training sessions under the reduced-shock contingency; the fifth rat (7) was studied following criterion

performance on its initial exposure to response-reduced shock. Extinction was continued until the animal made one response or fewer per minute, averaged over five consecutive sessions, in the absence of shock.

Fig. 4. Cumulative response curves for each rat during the 50 min of each extinction session when shock was withdrawn.

RESULTS

All animals except Rat 1 met the extinction criterion in five sessions, the minimum number possible. The curves presented in Fig. 4 show that few responses occurred when shock was withdrawn during the final 50 min of the extinction sessions. On the other hand, responding continued at a high rate when shock was presented during the initial 10 min of these sessions. The average number of responses during these avoidance periods ranged from 143 (Rat 7) to 343 (Rat 1) over the last five extinction sessions. These results indicate that the presentation of shocks was primarily responsible for the maintenance of responding after training under the response-reduced shock contingency.

EXPERIMENT III: THE EFFECT OF INCREASES IN THE INTENSITY OF RESPONSE-REDUCED SHOCKS WITH EVENTUAL MAINTENANCE OF RESPONDING BY NON-CONTINGENT SHOCK PRESENTATIONS

METHOD

Five rats (1, 2, 3, 5, 7) were studied when responses reduced shocks from 2.0 to 1.0 ma for 20 sec after each response. This procedure was continued until the criterion for stable performance was attained. Stability was again defined as a range of 20 or fewer high (2.0-ma) shocks over five consecutive sessions. Three rats (1, 3, 5) were then studied for five sessions each when responses reduced shocks from 2.0 to 1.5 ma for 20 sec after each response. Finally, the same three rats were studied when responses had no effect on the 2.0-ma shocks. Rats 1 and 3 were studied for two sessions each, while Rat 5 was studied for five sessions. The shock-shock interval was 5 sec in all cases.

RESULTS

Responding was maintained effectively for all five rats when responses reduced shocks from 2.0 to 1.0 ma. Rat 7 had previously failed to acquire the response when exposed to this same contingency. The data presented in Table 1 show also that further increases in

Table 1

Performance during the final session under each procedure with successive increases in the intensity of the response-reduced shocks.

Rat		Reduced-Shock Contingency		Non-Contingent Shock (2.0 ma)
		(2.0-1.0 ma)	(2.0-1.5 ma)	
1	No. of Sess.	8	5	2
	Resp/min	33.6	42.8	44.1
	2.0-ma shocks	1	4	654
2	No. of Sess.	18		
	Resp/min	21.8		
	2.0-ma shocks	24		
3	No. of Sess.	5	5	2
	Resp/min	25.9	28.1	28.8
	2.0-ma shocks	2	6	654
5	No. of Sess.	5	5	5
	Resp/min	15.4	10.7	7.9
	2.0-ma shocks	12	104	654
7	No. of Sess.	15		
	Resp/min	16.3		
	2.0-ma shocks	8		

the reduced shock to 1.5 ma resulted in increased responding for two rats (1, 3) while the third rat (5) showed a decrease in rate. When only non-contingent 2.0-ma shocks were presented, responding for Rats 1 and 3 was maintained effectively, while the response rate for Rat 5 showed further attenuation. It seems noteworthy that all three rats responded at rates that ranged from moderate to extremely high, even though responses had no scheduled effect upon the shocks the rats received.

The number of sessions under non-contingent shock was probably insufficient to allow for extinction, as indicated by the results of Herrnstein and Hineline (1966). Subsequent experiments in the present study showed, however, that non-contingent shocks maintained responding effectively over 50 and more sessions.

EXPERIMENT IV: MODULATION OF RESPONDING THROUGH VARIATIONS IN THE SHOCK-SHOCK INTERVAL

METHOD

The effect of successive increases and then a decrease in the length of the shock-shock interval was studied in four rats (1, 3, 4, 6). All shocks presented under this procedure were 2.0 ma, and they were not affected by the response. There were five sessions each under shock-shock intervals of 5, 9, 17, and 5 sec respectively for Rats 1, 3, and 4. Rat 6 was studied for only two sessions with the 9-sec shock-shock interval because this animal subsequently became sick and was withdrawn from the study.

RESULTS

Figure 5 shows that responding was effectively modulated by changes in the shock-shock interval. Responses per shock increased moderately for three rats (1, 3, 4) at the longer shock-shock intervals. This increase in responses per shock was not sufficient to offset the lower shock rate in maintaining response rate, however. The number of responses per shock for Rats 1, 3, and 4 was fairly consistent, when sessions before and after increases in the shock-shock interval are compared. These

Fig. 5. The mean number of responses per shock over the final two sessions with successive changes in the shock-shock interval.

results show further that responses engendered by the reduced-shock procedure can be maintained solely through the presentation of non-contingent shocks. The time between shocks was not critical to the effective maintenance of responding over the intervals studied here.

EXPERIMENT V: EFFECTS OF NON-CONTINGENT SHOCK INTENSITY AND RESPONSE-CONTINGENT SHOCK UPON RESPONDING MAINTAINED BY NON-CONTINGENT SHOCK

METHOD

Six rats (1, 3, 4, 5, 7, 8) were studied as shock intensity was gradually decreased and then increased. Each intensity remained in effect for one session. Shock was decreased until the animal made one response per minute or less over one session. The shock-shock interval was 5 sec in all cases and the responses had no scheduled effect upon the shocks.

This examination of the effects of contingent shocks upon responding maintained by non-contingent shocks was the last procedure in the chronological sequence of experiments. The procedure seems to relate most logically

to the effects of non-contingent shock intensity, and is included here to facilitate presentation.

Immediately after extended training under the response-reduced shock procedure (2.0-0.5 ma), three rats (3, 5, 7) received non-contingent shocks, with a 5-sec shock-shock interval over 60-min sessions. Shock intensity was 0.5 ma and shock duration was 0.5 sec. During the second 30 min of each session, the animal also received 0.5-ma shocks 0.5 sec in duration after each response. This procedure continued until responding was suppressed by the punishment shock to a criterion of 100 or fewer responses in 30 min.

RESULTS

Figure 6 shows that the non-contingent shocks maintained stable responding over a range of intensities from 2.0 to approximately 0.20 ma. Responding declined rapidly with further decreases in shock intensity. Response rates were higher during the descending series than during the ascending series. It is interesting to note that high response rates were maintained in the different rats by shock intensities (0.05-0.3 ma) that have been ineffective in both punishment and avoidance experiments with rats in this laboratory. It would appear that responses depended on the shock intensities that the animal could detect, rather than those that were aversive.

Responding recovered for all rats when shock intensity was gradually increased, but the rates attained were generally lower than those during the sessions in which shock was decreasing. A positive correlation is evident in the rates for each animal before and after shock reduction.

Response-contingent shock quickly suppressed responding in all three rats. The responding of each animal temporarily increased when punishment was introduced, but decreased rapidly after this. Cumulative records of the first punishment session for each rat are presented in Fig. 7.

Each rat met the suppression criterion in the second punishment session. The data are presented in Table 2. The results of this procedure clearly show that responses maintained solely by non-contingent shocks will, nevertheless, be effectively suppressed by additional shocks of the same intensity delivered immediately after each response.

Fig. 6. The response rate for each session with successive decreases followed by successive increases in shock intensity.

Fig. 7. Cumulative records for each of the three rats for the first session in which punishment shock was presented concurrently during the final 30 min of the session. The downward pips indicate response-independent shocks.

Table 2

The number of responses for each rat during the two sessions in which punishment shock was present for the second half of the session.

Rat	Session One		Session Two	
	1st 30 min Non-Cont. Shock	2nd 30 min Non-Cont. Shock + Pun.	1st 30 min Non-Cont. Shock	2nd 30 min Non-Cont. Shock + Pun.
3	672	191	177	22
5	923	130	54	11
7	1344	149	1580	57

EXPERIMENT VI: THE DISTRIBUTION OF RESPONSES DURING THE SHOCK-SHOCK INTERVAL AND CLASSICAL CONDITIONING WITH AN AUDITORY CS

METHOD

Earlier experiments showed that number of responses was a function of the number of

shocks presented. It had also been observed that most responses occurred immediately after shock presentation; that is, they were shock elicited. The present experiment was undertaken to quantify the distribution of responses during the shock-shock interval and to see if the apparently elicited responses could be classically conditioned.

The distinction that Skinner (1953) made between "operants" and "respondents" is based partially on the definition that a response elicited or evoked by a stimulus belongs to the class "respondents". Skinner further defined "respondents" as being unconditioned, but being susceptible to elicitation by an originally ineffective (neutral) stimulus through a classical Pavlovian conditioning procedure.

If lever presses in the present study were in fact elicited by shocks, it seemed reasonable to investigate the possibility that they could be classically conditioned, even though the

responses in question had initially been acquired through an operant conditioning procedure.

Response distributions were measured for Rats 1, 3, 4, 5, 7, and 8 with a Grason-Stadler multiple class time analyzer, #E3950A. The responses were divided into eleven 0.5-sec intervals, with the first interval corresponding to the shock duration. Intervals 2 to 11 corresponded to the 5-sec shock-shock interval. During the classical conditioning trials, a 1.0-sec, 590 CPS(Hz) sine wave tone of approximately 80 db began 0.5 sec before shock onset and ended with shock offset. The tone, which served as the conditioned stimulus (CS), was provided by a Knight sine-square wave generator, model KG-688. There were approximately 650 tone-shock pairings in each conditioning session. A baseline procedure, used to measure classical conditioning effects, compared the percentage of responses in the 0.5-sec interval preceding shock with the CS absent and with it present for Rats 3, 4, 5, 7, and 8.

Both non-contingent and response-reduced shock procedures were used in this experiment. A particular procedure remained in effect until responding during the 0.5-sec interval preceding shock was stable over three consecutive sessions. Stability was defined as a range of $\pm 10\%$ or less of the mean number of responses over the three sessions.

RESULTS

The mean response rate over the final three sessions under each procedure is presented for each animal in Table 3. High rates of response were maintained with both non-contingent and response-reduced shock. Response rates generally decreased during classical conditioning, but the differences were small.

The analysis of responses, presented in Fig. 8, show a uniform distribution for all rats studied. Responding peaked immediately after shock, then gradually declined to nearly the zero level, and then increased slightly immediately before the next shock. For four of the five rats studied, classical conditioning markedly increased responses during the 0.5-sec interval before shock with the CS present relative to the same interval with no CS. Thus, lever presses had, in fact, become shock elicited and could also be elicited by a stimulus paired with shock.

DISCUSSION

The main findings of the present experiments can be summarized as follows: (1) Lever presses are engendered and maintained when they reduce intermittently presented electric shocks to one-quarter of their originally scheduled intensity. This contingency produces uniformly high rates and stable patterns of re-

Table 3

The shock procedure, number of sessions and mean response rate over the final three sessions before, during, and after classical conditioning. For Rat 8, two series of classical conditioning sessions were employed, and they are designated 1 and 2 below. Responding with no CS present was studied following series 1. Non-contingent shock is abbreviated N.C. Response-reduced shock is abbreviated R.S.

Rats	Pre-Classical Conditioning			Classical Conditioning			Post-Classical Conditioning		
	Procedure	Number of Sessions	Response Rate	Procedure	Number of Sessions	Response Rate	Procedure	Number of Sessions	Response Rate
1	0.40 ma N.C.	6	26.9						
3	0.40 ma N.C.	7	22.6	2.0-0.5 ma R.S.	11	19.5	2.0-0.5 ma R.S.	3	20.2
4	0.40 ma N.C.	8	22.6	2.0-0.5 ma R.S.	11	21.1	2.0-0.5 ma R.S.	7	25.6
5	0.40 ma N.C.	6	21.3	2.0-0.5 ma R.S.	11	18.5	2.0-0.5 ma R.S.	5	30.4
7				2.0-0.5 ma R.S.	9	23.6	2.0-0.5 ma R.S.	10	32.6
8				(1) 2.0-0.5 ma R.S.	10	21.3	2.0-0.5 ma	5	21.8
				(2) 2.0-0.5 ma R.S.	14	15.0

Fig. 8. Distribution of the mean percentage of responses during the final three sessions under each procedure. Responses have been divided into eleven 0.5-sec class intervals, corresponding to the interval from the onset of one shock to the onset of the next shock. Class interval 1 corresponds to the period in which shock was presented. The sequence of experimental procedures is indicated by the order in which the data are presented on the figure, from left to right.

sponding in rats. (2) Responding established by this procedure can eventually be maintained by response-independent shocks. Both the interval between shocks and shock intensity can be varied substantially, with little effect upon responding. (3) Eventually, the majority of responses under this procedure come to be shock produced or shock elicited. As such, they can also be elicited by an originally neutral stimulus through a classical-conditioning procedure. (4) Responding that is maintained by response-independent shocks is quickly suppressed when response-contingent shocks of the same intensity are scheduled concurrently.

The results of the response-reduced shock procedure here, and several earlier findings

(Campbell, 1956; Weiss and Laties, 1959, 1963), suggest that the definition of negative reinforcement should be broadened to include response-produced reductions in the intensity of aversive stimuli. A more important consideration, however, was the long-term maintenance of responding by response-independent shocks. This effect cannot be explained by either positive or negative reinforcement, as these concepts are presently defined. It is possible that an explanation for the maintenance of responding based upon reinforcement is superfluous in many cases, particularly where aversive stimuli are involved.

Three recent experiments (McKearney, 1968; Stretch *et al.*, 1968; Kelleher and Morse, 1968) showed that a fixed-interval schedule of

electric shock presentation can maintain a pattern of positively accelerated responding in monkeys. The response pattern was similar to that under fixed-interval schedules of food reinforcement. Earlier, Migler (1963) showed that the presentation of inescapable shocks to rats trained to escape shock resulted in frequent responding, even though the responses had no scheduled consequences. Although performance varied from session to session, the typical response pattern was a short burst of responding with shock onset, similar to the terminal performance of the animals studied here. The present experiments demonstrated another procedure that maintains responding through the presentation of electric shocks. As both McKearney (1968) and Kelleher and Morse (1968) have stated, two of the most important determinants of the effects of a stimulus are the reinforcement history of the subject, and the manner in which the stimulus is presented relative to responses. These two factors seem critical in all of the experiments cited.

Certainly, the lever pressing of the present rats would not have been maintained by non-contingent shock presentations without their history of shock-reduction and shock-postponement training. Further, it seems unlikely that animals with avoidance training only would have continued to respond when their responses had no effect upon the presentation of shocks. This assumption probably should be empirically tested. Few studies of extinction following avoidance conditioning have been conducted, and in these the procedure has been to remove shock entirely (Shnidman, 1968). Since responding is ostensibly maintained because it postpones shock, a more appropriate extinction procedure would be to eliminate the effect of the response upon shock. Herrnstein and Hineline (1966) did employ this type of extinction procedure following conditioning in which responses reduced the overall rate of shock. Response rates were directly related to the amount by which the response had reduced shock frequency; but in extinction, the response total was inversely related to the amount by which the response had reduced shock frequency during prior conditioning. Up to 20,000 extinction responses occurred when the shock frequency reduction had been relatively small.

The development of a stable pattern of

shock-elicited responses in all of the rats studied is the most difficult result to explain in all of these experiments. Migler (1963) reported a similar pattern of shock-elicited lever pressing and suggested "superstitious conditioning" as the most reasonable explanation for this effect. This would be a plausible explanation for the maintenance of responding by non-contingent shocks in the present experiments, because all shocks in these sessions were of the same intensity. The inference made here is that the rats responded "as if" their responses resulted in the delivery of lower-intensity shock. This hypothesis could be tested by randomly presenting non-contingent shocks of two substantially different intensities in the same session.

Observation of the rats during the experimental sessions revealed that many responses were biting attacks upon the bar. This suggests that an explanation based upon shock-elicited aggression should be considered in further analyses of this behavior. Brief electric shocks often elicit stereotyped patterns of behavior in rats and monkeys. When shock is delivered the animal will attack other members of the same species or certain nearby objects (Ulrich and Azrin, 1962; Hutchinson, Azrin, and Hake, 1966). Conventional avoidance procedures usually do not result in shock-elicited aggressive responses toward the operandum, because the animal eventually emits the majority of its responses when shock is absent. The high frequency of shock presentation throughout the present experiments may have produced a pattern of shock-elicited aggressive responses toward the lever.

Unavoidable electric shocks increase the responding of animals with a history of avoidance conditioning (Sidman, Herrnstein, and Conrad, 1957; Herrnstein and Sidman, 1958). Sidman (1966) suggested, however, that this effect is usually only temporary and probably diminishes more rapidly with more frequent presentation of the unavoidable shocks. The low shocks under the response-reduced shock procedure were unavoidable, but they did constitute part of a contingency. The unavoidable shocks in the earlier studies mentioned were presented independently of the animal's behavior, and their frequency of presentation was much lower than in the present case. Despite the high frequency of shock presentation, very persistent responding was main-

tained over the entire duration of the experiment for most of the rats.

The marked increase in responding when the tone was presented, after repeated tone-shock pairings, could be the result of classical conditioning. This same effect could be attributed to sensitization, however, and it will be necessary to perform certain control experiments before a decision can be reached. Whatever the outcome of these experiments, the effect here demonstrates further the control that shock delivery exerted upon responding.

Sidman (1966) hypothesized that shock may assume discriminative properties under certain avoidance procedures. The shocks act as stimuli correlated with events to come, and thus come to control responding. The reliable relationship of low shocks to a high shock following a response under the reduced-shock procedure would permit the low shocks to serve as discriminative stimuli. The stable response rates that were maintained over a wide range of shock intensities in Exp. V suggest that the discriminative function of shock was very important. This inference is supported by the maintenance of responding in some rats by shocks of 0.2 ma and lower. In our experience, shock intensities in this range have been ineffective when employed in either punishment or avoidance contingencies.

The experiment, in which response-contingent shocks suppressed responding maintained by response-independent shocks of the same intensity, again demonstrates the importance of the contingency in controlling behavior. Powell and Morris (1969) showed that responses maintained by a shock-postponement procedure were immediately suppressed by the introduction of punishment shock of equal intensity to avoidance shock. When punishment shock was introduced at intensities lower than avoidance shock, all rats showed systematic decreases in response rate and increases in avoidance shocks as punishment shock intensity was gradually increased. Similarly, McKearney (1968, 1969) has shown that electric shocks of the same intensity, at various times in the experiment, maintain responses that postpone them, and finally suppress responding when a shock immediately follows each response. It is now apparent that a given stimulus can have dif-

ferent and even opposite effects in the same organism at the same time. The results of the above experiments reinforce Morse and Kelleher's conclusion that the schedule of reinforcement can be more important in the control of behavior than the nature of the reinforcer (Morse and Kelleher, 1966; Kelleher and Morse, 1968).

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