RESPONSE RATE AS A FUNCTION OF SHOCK-FOOD ASSOCIATION AND SHOCK-RESPONSE CONTINGENCY

by

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B.A., University of Victoria, 1967

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the Department

of

Psychology

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

March, 1969

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Date March 1969

ABSTRACT

The present study examined the following two hypotheses: (a) shock which has been associated with food will reduce responding less than shock which has not been associated with food; (b) response-contingent shock will reduce responding more than response-noncontingent shock. Response rates and the number of reinforcements received in Punishment training, and response rates in Punishment-Extinction training were examined for the following five groups: (a) shock and pellet for the same response (Pun-Rft Group); (b) shock and food for different responses (Pun Group); (c) response-noncontingent shock delivered automatically as response-contingent food becomes available for the next response (Shock-S^D Group); (d) response-noncontingent shock delivered automatically independent of the availability of reinforcement (NC-Shock Group); (e) no shock (Control Group). The results indicated that (a) response-contingent and response-noncontingent shock reduced responding equally in Punishment training, and that (b) following Punishment training, response-contingent shock reduced responding in Punishment-Extinction training whereas response-noncontingent shock had no effect on rate of responding in Punishment-Extinction training. The results also indicated that shock which had been associated with food had the same overall effect on response rates as shock which had not been associated with food. The relevance of these results to the discriminative and conditioned reinforcing functions of shock was discussed.

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Acknowledgment

The writer would like to express his appreciation to Dr. G. A. Raymond, Dr. F. P. Valle and Dr. R. Wong without whose help, encouragement and criticism this study could not have been done.

Aversive stimulation in the form of electric shock has been widely used in experimental studies of punishment. Three basic paradigms have evolved from these studies: (a) aversive stimulation immediately following a response; (b) aversive stimulation several seconds after a response; (c) aversive stimulation introduced in a random fashion unrelated to the response. While the specific results of such experiments have varied, the general effect has usually been suppression of the "punished" response.

Suppressive Effects of Contingent Versus Noncontingent Shock

Estes (1944) asserted that " . . . it is not the correlation of the punishment with the response *per se* that is important, but the contiguity of the punishment with the stimuli which formerly aroused the response" (Estes, 1944, p. 38).

Estes based this assertion on the results of two experiments. In one (Estes, 1944, Experiment E), two groups of rats were trained to press a lever on a +1-min. variable-interval schedule of reinforcement. One group was then given a 10-min. session of punishment extinction in which each lever press was followed by a brief severe shock. The other group was given a 10-min. session of regular extinction. The group given punishment extinction exhibited significantly greater response suppression than the group given no shock. In the other experiment (Estes, 1944, Experiment I), rats were again trained on a 1-min. variable-interval schedule of reinforcement and then given either a 10-min. session of regular extinction of a 10-min. session with response-noncontingent shocks administered at intervals of about 30 sec., but not during or immediately following a lever press. Once again the group receiving shock exhibited significantly more response suppression than the group receiving no shock. In short, bar pressing was suppressed under both response-contingent and response-noncontingent shock.

More recently Camp, Raymond, and Church (1967, Experiment I) trained rats on a 1-min. variable-interval schedule of reinforcement and then introduced shock either immediately after the response or 30 sec. after the response. They found that the magnitude of response suppression was greater for the group receiving immediate shock than for the group receiving shock delayed by 30 sec. In a related experiment, Camp, Raymond, and Church (1967, Experiment III) trained rats on a 1-min. variable-interval schedule of reinforcement. One group then received shock 30 sec. after the response while a second group received response-noncontingent shock. The experimenters found no difference in magnitude of response suppression between the two groups. Thus shock delivered immediately after the response produced greater suppression than either 30-sec. delayed shock (Experiment I) or noncontingent shock (Experiment III).

Earlier work by Hunt and Brady (1955) examined resistance to extinction of groups which received either response-contingent shock (Punishment group) or response noncontingent shock (CER group) in the presence of a CS. They found (a) a greater generalization of suppression effects for the CER group than for the Punishment group, and (b) a greater resistance to extinction for the CER group than for the Punishment group. These results are similar to those of the earlier study by these experimenters (Hunt and Brady, 1951). The experiments of Hunt and Brady (1951, 1955) and Camp, Raymond, and Church (1967), unlike those of Estes (1944), support Church's conclusion that

> " . . . the contingent punishment procedure, relative to the noncontingent procedure, produces (a) greater suppression of the punished response, (b) less suppression of other responses, and (c) less resistance to extinction (Church, 1963, p. 376).

It is now generally recognized that noncontingent shock has different effects from contingent shock not only on response rates in training but also on resistance to extinction.

Discriminative and Reinforcing Functions of Shock

Muenzinger (1934) has suggested that shock may serve functions other than that of suppressing a response. He found that mild punishment of the correct (food-rewarded) response in a selective learning situation led to an increase in the rate of learning. Subsequent studies by Muenzinger (1935, 1936, 1937, 1938, 1948, 1951, 1952), Wischner (1947, 1948, 1963) and others have led to the conclusion that, in certain situations, punishment of a correct response in a discrimination-learning task results in an increase in the number of correct responses emitted. This finding suggests (a) that shock may serve a discriminative function in addition to its widely demonstrated aversive function, and (b) that in becoming a discriminative stimulus, shock may actually become a conditioned reinforcer.

If a response is reinforced in the presence of one stimulus but not reinforced in the presence of a second stimulus, the tendency to respond in the presence of the second stimulus is gradually extinguished and a discrimination is formed (Ferster & Skinner, 1957). Skinner refers to the first stimulus as an S^D (a discriminative stimulus) and to the second stimulus as an S^Δ. An S^D then is a stimulus in the presence of which S has been reinforced for emitting a response, and an S^Δ is a stimulus in the presence of which S has not been reinforced for emitting a response. If a response following an aversive stimulus is always reinforced, and if responses which do not follow the aversive stimulus are never reinforced, the aversive stimulus should become an S^D for the response. Furthermore, according to the discriminative stimulus hypothesis of secondary reinforcement proposed by Keller and Schoenfeld (1950, p. 236), a stimulus must become a discriminative stimulus for some response in order to become a conditioned reinforcing stimulus and, to the extent that a stimulus has been established as a discriminative stimulus, it has also acquired conditioned reinforcing properties. If an aversive stimulus is associated with food in such a way as to become a discriminative stimulus (S^D), the aversive stimulus should acquire secondary reinforcing properties. These secondary reinforcing properties could then serve to reverse the suppressive effects of a mildly aversive stimulus or to attenuate the suppressive effects of a more severely aversive stimulus. The reversibility of the aversive properties of electric shock has been demonstrated within the classical conditioning paradigm by Pavlov (1927) and more recently by Lohr (1959).

Pavlov reports:

> Thus in one particular experiment a strong nocuous stimulus--an electric current of great strength--was converted into an alimentary conditioned stimulus, so that its application to the skin did not evoke the slightest defense reaction. Instead, the animal exhibited a well-marked alimentary conditioned reflex, turning its head to where it usually received food and smacking its lips, at the same time producing a profuse secretion of saliva (Pavlov, 1927, p. 30).

Keller and Schoenfeld's hypothesis has important implications for the analysis of punishment. If shock, through association with food can become a discriminative stimulus for a response which is reinforced by food, and hence become a conditioned reinforcer, then Ss which have experienced shock-response-food sequence should respond more when shock is presented than Ss who have experienced no contingency between food and shock although having received both. This difference should be found not only in extinction (the usual test for a conditioned reinforcer), but also in punishment training if the shock-food contingency acts to reduce the aversive properties, and therefore suppressive effects, of shock.

In 1961, Holz and Azrin found that pigeons responded more rapidly under conditions of punishment extinction than under conditions of regular extinction if they had previously been given interspersed sessions of both punishment training and regular extinction. Moreover the same result was obtained whether they used a shock intensity which, during acquisition, reduced the response rate to one-half of its previous level, or a shock intensity which, during acquisition, had no influence on the response rate.

In a further study of the discriminative-reinforcing function of shock, Holz and Azrin (1962) trained pigeons on a fixed-interval schedule of reinforcement and punished all responses during various portions of the interval with shocks of various intensities. They found that at milder intensities, the discriminative property of shock predominated to influence responding, while at the more severe intensities the aversive property was the dominant influence. If a mild shock had been associated with reinforcement, it served to increase responding. If it had been associated with nonreinforcement, it suppressed responding. However, when the shock intensity was increased, the aversive property of the shocks became more apparent. If the shocks had been associated with nonreinforcement, the aversive property acted with the discriminative control to further reduce responding. If the shocks had been associated with reinforcement, the aversive property acted to reduce the level of responding (while the discriminative control acted to maintain responding). Holz and Azrin concluded that whenever punishment is differentially associated with reinforcement, a discriminative property will probably influence the effectiveness of the punishment.

These experiments indicate that in addition to its widely demonstrated aversive property, electric shock possesses a potential discriminative-reinforcement property which must be considered if a full understanding of the function of electric shock is to be achieved. Although the work of Holz and Azrin lends some initial insight into the discriminative properties of electric shock, it leaves certain questions unanswered.

For example, due to the lack of an appropriate control group (no shock in either training or extinction), the possibility cannot be excluded that shock per se had a dynamogenic effect and increased responding not only in extinction but in training as well, under the conditions of the Holz and Azrin (1961) experiment.

Furthermore, because there was greater dissimilarity between punishment training and regular extinction than there was between punishment training and punishment extinction, it is possible that the reduced response rate in regular extinction was the result of a differential generalization decrement between the two extinction procedures.

Holz and Azrin (1961) report that when response-noncontingent shocks were introduced into the extinction period (following punishment training), responding increased but not as much as when response-contingent shocks were introduced. The interpretation offered by the experimenters was that response-contingent shock had become an S^D for the reinforced bar-press response and in so doing had become a conditioned reinforcer (Azrin & Holz, in Honig, 1966, p. 420). The noncontingent shock was similar enough to the contingent shock to cause an increase in responding, but not similar enough to cause as great an increase as did contingent shock. Without including a group which received noncontingent shock in training, the possibility cannot be exluded that noncontingent shock in extinction had a dynamogenic effect independent of its cue properties.

Moreover, since noncontingent shock in extinction was (a) more similar to punishment training than was regular extinction, but (b) less similar to punishment training than was punishment extinction, the observed differences between the three extinction conditions could be due to differential generalization decrements.

In their 1962 study, Holz and Azrin did not examine differences in extinction but merely compared cumulative response records in punishment training for subjects receiving shock at different segments of a fixed-interval schedule. As a result it is impossible to tell whether or not shock, acting as a discriminative stimulus, acquires secondary reinforcing properties. This difficulty would have been overcome if punishment extinction had been examined. Furthermore, since a fixed-interval schedule was used by Holz and Azrin, the possibility arises that shock merely enhances the discriminative control exerted by the interreinforcement interval in the same way that shock at a choice point will improve the rate of learning in a discrimination task. The problem could have been overcome if a variable interval schedule of reinforcement had been used since the mere passage of time is not as relevant a stimulus for the increased probability of reinforcement during a variable-interval schedule as during a fixed-interval schedule.

The present study was undertaken in an attempt to clarify some of the issues raised by the Holz and Azrin studies and thus aid in the delineation of the discriminative-reinforcement properties of punishment. An extended and modified form of the 1961 Holz and Azrin study was conducted in order to examine the relationship of response-contingent and response-noncontingent shock to food reward.

Specifically, it was hypothesized, on the basis of the evidence cited by Church (1963), that in both punishment training and in punishment-extinction training, response-contingent aversive stimulation (electric shock) would suppress responding more than response-noncontingent electric shock. It was also hypothesized that shock would not have a dynamogenic effect on responding, but that both response-contingent and response-noncontingent shock would suppress responding relative to a no-shock control group. It was further expected, on the basis of the Holz and Azrin findings (1961, 1962), that shock associated with reinforcement would suppress responding less than shock associated with nonreinforcement. Finally, it was predicted that shock delivered before the to-be-rewarded response would acquire greater discriminative control over the response than other less specific stimuli also correlated with reinforcement, e. g. time elapsed since the last reinforcement (Catania & Reynolds, 1968). The discriminative control acquired by this shock would be evidenced by increased responding immediately following the shock and decreased responding during other periods. The pattern of responding produced in this way would mean increased "efficiency" of responding as measured by responses per reinforcement relative to a comparison group receiving the same amount of shock independent of food.

Method

Subjects

Fifty naive, male rats derived from the Long-Evans strain were used.

The rats were obtained from the National Breeding Laboratories Company when approximately 60 days of age and were approximately 94 days old at the beginning of experimentation. Their average weight during experimentation was 216 gm.

Apparatus

The experiment was conducted in four identical lever boxes (Scientific Prototype Model 100-A) located in one room, with electromechanical control and recording equipment located in a separate room. The lever boxes were 8 in. wide, 9 1/2 in. long, and 7 3/4 in. high. Two sides and the hinged top were clear plastic while the other two sides were aluminum. The food cup, a 1 1/2 in. square brass container, 3/4 in. deep, was mounted in the middle of one aluminum side, 1 1/2 in. above the grid floor. The lever was stainless steel, 5/8 in. thick and 2 in. wide. The floor was constructed of 16 stainless steelbars 5/16 in. in diameter, mounted on 1/2 in. centers. Each lever box was enclosed in a sound deadened chamber which also contained a pellet dispenser (Davis Model PD 101), a fan, and a 7-w incandescent lamp which was mounted directly above the lever box. The grid floor was electrified by a constant current stimulator (150K ohms in series with the rat). All shocks used were of 120-v intensity for 0.1-sec. duration. Positive reinforcement consisted of 45 mg. Noyes rat-food pellets.

Procedure

The Ss were housed in individual cages with water available at all times. Prior to experimentation each S was picked up every day and handled for approximately 10 sec. Once experimentation had begun, the handling of Ss consisted of the rats being placed in and removed from the lever box on each day of experimentation. For 14 days after arrival in the laboratory Ss were allowed free access to Purina Laboratory Chow. On the 14th day food was removed from the cages and on the 15th day and each day thereafter, Ss were given approximately 12 gm. of dry Purina mash mixed with approximately 25 cc. of water. On all days of experimentation Ss were fed 1 hour after being returned to the home cages. All experimentation was conducted on a Monday through Friday basis.

Pretraining. On each S's first day in the lever box the lever was not present and one pellet was delivered automatically each min. for 30 min. On the following day the lever was present and one food pellet was delivered for each lever-press response (continuous reinforcement). Each S was removed from the box after 30 reinforced lever presses. The Ss that did not reach the criterion of 30 lever presses after 1 hr. in the lever box were removed from the box and returned to it for another hr. the next day, without having been fed. By the end of the second hr. on the continuous-reinforcement schedule, all Ss had reached the criterion of 30 lever responses.

Reinforcement training (Sessions 1-10). Following pretraining, Ss were placed in the lever box for a 30-min. period each day for 10 days. During this time response-contingent reinforcement was available on a 2-min. variable-interval schedule (VI-2') (see Appendix A).

Punishment training (Sessions 11-20). Following Reinforcement training, Ss were randomly assigned to one of the following five groups: (a) shock and food pellet for the same response (Pun-Rft Group); (b) shock and food for different responses (Pun Group); (c) response-noncontingent shock delivered automatically as response-contingent food becomes available for the next response (Shock-S^D Group); (d) response-noncontingent shock delivered automatically independent of the availability of reinforcement (NC-Shock Group);

(e) no shock (Control Group). A schematic representation of the punishment training conditions for all groups is presented in Figure 1.

During Punishment training all groups received response-contingent reinforcement on the same VI-2' schedule as was used during Reinforcement training. The Pun-Rft Group received shock and food for the same response. The Pun Group received response-contingent shock (punishment) on a separate VI-2' schedule in which shock occurred only on nonreinforced responses not less than 30 sec. either before or after reinforcement. The punishment and reinforcement schedules were interdependent in that both stopped until S responded when an event on either schedule was available. The two schedules were also arranged to avoid a simple alternation and consequent predictability of food and shock. For both the Shock-S^D Group and the NC-Shock Group, shock was delivered automatically regardless of whether or not Ss responded. The Shock-S^D Group received automatically-delivered response-noncontingent shock immediately as food became available for the next response and thus shock was on the same VI-2' schedule as reinforcement, i.e. a single shock was automatically delivered at each point in the session when the next response would produce food. As in all other groups, the reinforcement remained available until the animal responded. The normal 0.10-sec. shock however, being response-noncontingent, continued to be delivered on the average of every 2 min. even if the subject did not respond. The controlling apparatus did not stop, but automatically delivered the shock at the end of each interval. At the end of each interval, if the reinforcement had not been received, i.e. if the S had not responded, response-contingent reinforcement was again made available but at no time was there more than one reinforcement available for a single response. The NC-Shock Group received noncontingent shock automatically delivered on a VI-2' schedule arranged to minimize the probability of continual pairing of shock with food and to maximize the variability of the shock-food interval. The Control Group received response-contingent reinforcement on the same VI-2' schedule as all other groups but received no shock. Punishment training consisted of one 30-min. session per day for 10 days.

Punishment-Extinction training (Sessions 21-30). Following Punishment training all groups received Punishment-Extinction training. Each day for 8 days Ss were placed in the lever box for 30 min. During this period the five shock conditions were maintained but food was no longer available.

Response Measures

For all Ss, the number of responses emitted, the number of reinforcements, and number of shocks were recorded for each experimental session. The number of responses per reinforcement was computed for each S for each session by dividing the number of responses in a given session by the number of reinforcements received in that session.

Results

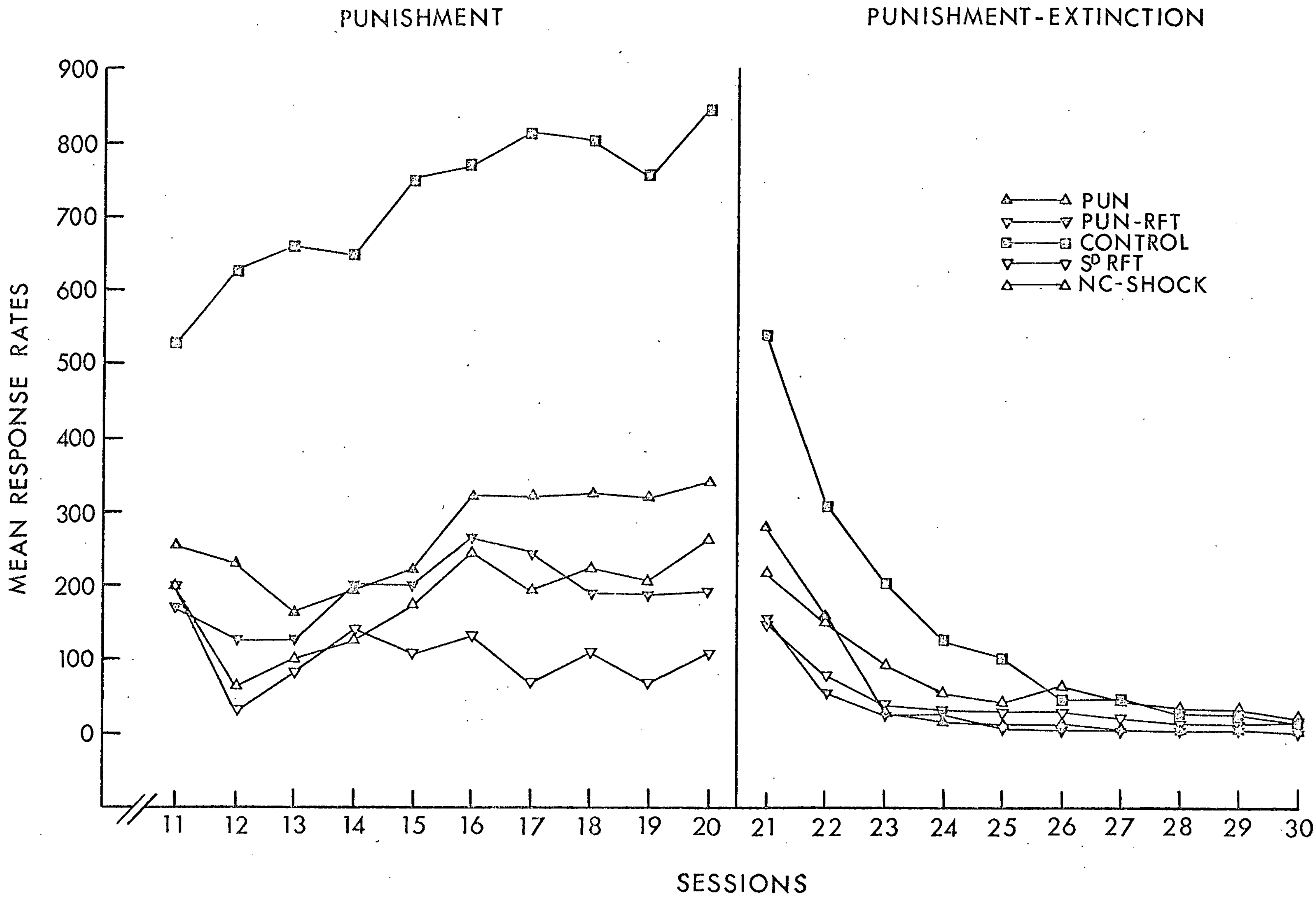
Reinforcement Training (Sessions 1-10)

A one-way analysis of variance of the mean response rate for each S during Sessions 1-10 indicated that the groups did not differ significantly ($F=1.17$, 4&45 df, $p>.25$). A similar analysis for Sessions 6-10 indicated that the groups did not differ significantly on the last five days of Reinforcement training ($F=.22$, 4&45 df, $p>.25$).

Punishment Training (Sessions 11-20)

Response rates. Figure 1 depicts for each group the mean response rates

Fig. 1 The mean response rate as a function of Punishment training and Punishment-Extinction training for the five groups: shock and food for the same response (Pun-Rft Group), shock and food for different responses (Pun Group), response-noncontingent shock delivered automatically as response-contingent food becomes available for the next response (Shock-S^D Group), response-noncontingent shock delivered automatically independent of the availability of reinforcement (NC-Shock Group), and no shock (Control Group).


PUNISHMENT
PUNISHMENT-EXTINCTION
MEAN RESPONSE RATES
900
800
700
600
500
400
300
200
100
0
PUN
PUN-RFT
CONTROL
S^D RFT
NC-SHOCK
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
SESSIONS

as a function of Punishment and Punishment-Extinction training (Sessions 11-30). The Control Group responded more than all other groups, with response rates stabilizing over the last five days for all groups. A two-way analysis of variance, i.e. "Factorial Experiment with a Single Control Group" (Winer, 1962, p. 263), of the mean response rate for each S during Sessions 16-20 indicated that the Control Group responded significantly more than the other groups ($F=26.32$, 1&45 df, $p<.005$). The response-contingent main effect was not significant ($F=1.192$, 1&45 df, $p>.25$). The main effect of association of shock with food also failed to reach significance ($F=1.421$, 1&45 df, $p>.25$). In addition the interaction between the two main effects was not significant ($F=.011$, 1&45 df, $p>.25$). A form of the Dunnett t test (Winer, 1962, p. 264) comparing the Control Group with each experimental group indicated that the Control Group responded significantly more than all other groups (Control versus Pun, $t=3.29$, $df=45$, $p<.005$; Control versus Pun-Rft, $t=4.05$, $df=45$, $p<.005$; Control versus Shock-S^D, $t=4.90$, $df=45$, $p<.005$; Control versus NC-Shock, $t=3.98$, $df=45$, $p<.005$). In addition an F test between the response rates for the Shock-S^D Group and the response rates for the NC-Shock Group indicated that the Shock-S^D Group responded significantly less than the NC-Shock Group ($F=10.77$, 1&18 df, $p<.005$). Table 1 presents the significant F ratios together with their sources.

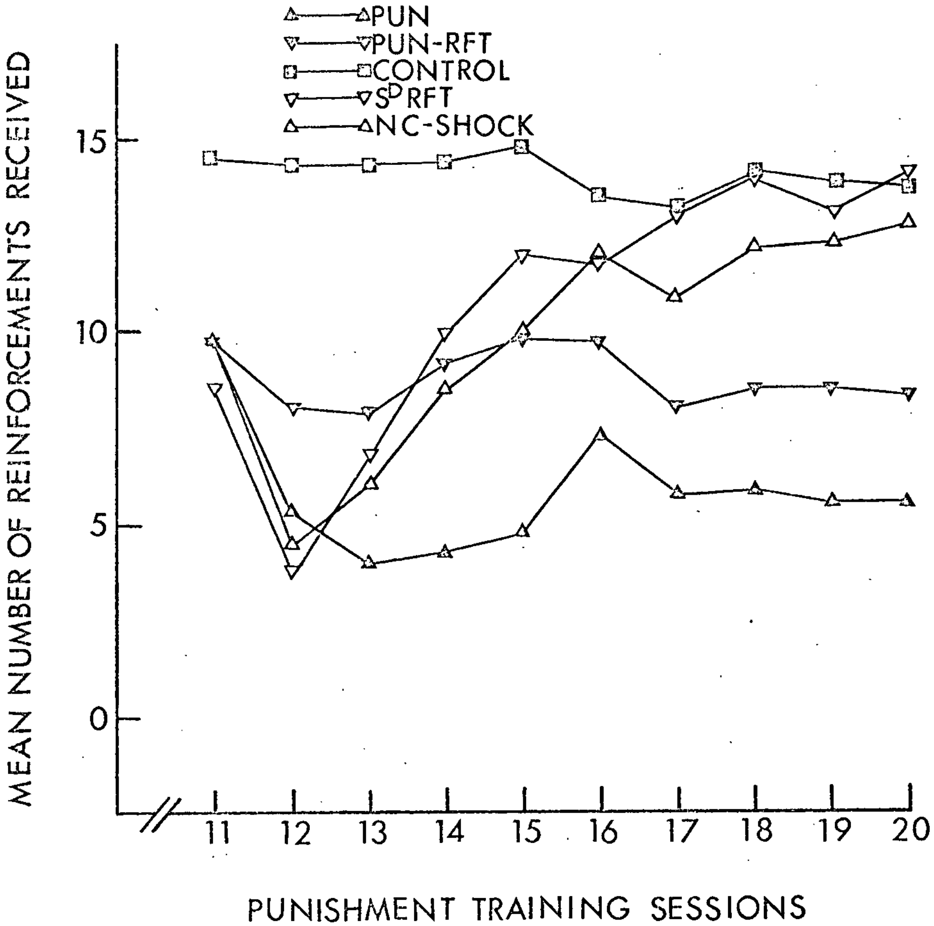
Reinforcements. Figure 2 depicts for each group the mean number of reinforcements received as a function of Punishment training (Sessions 11-20). Inspection of Figure 3 revealed that all groups which received shock showed a decrease in the number of reinforcements received during the first few sessions of Punishment training. During the later sessions the two groups which received noncontingent shock exhibited an increase in the number of

Table 1

Source Table for Analysis of Variance of Mean Response Rates During Last Five Days of Punishment Training (Sessions 16-20)

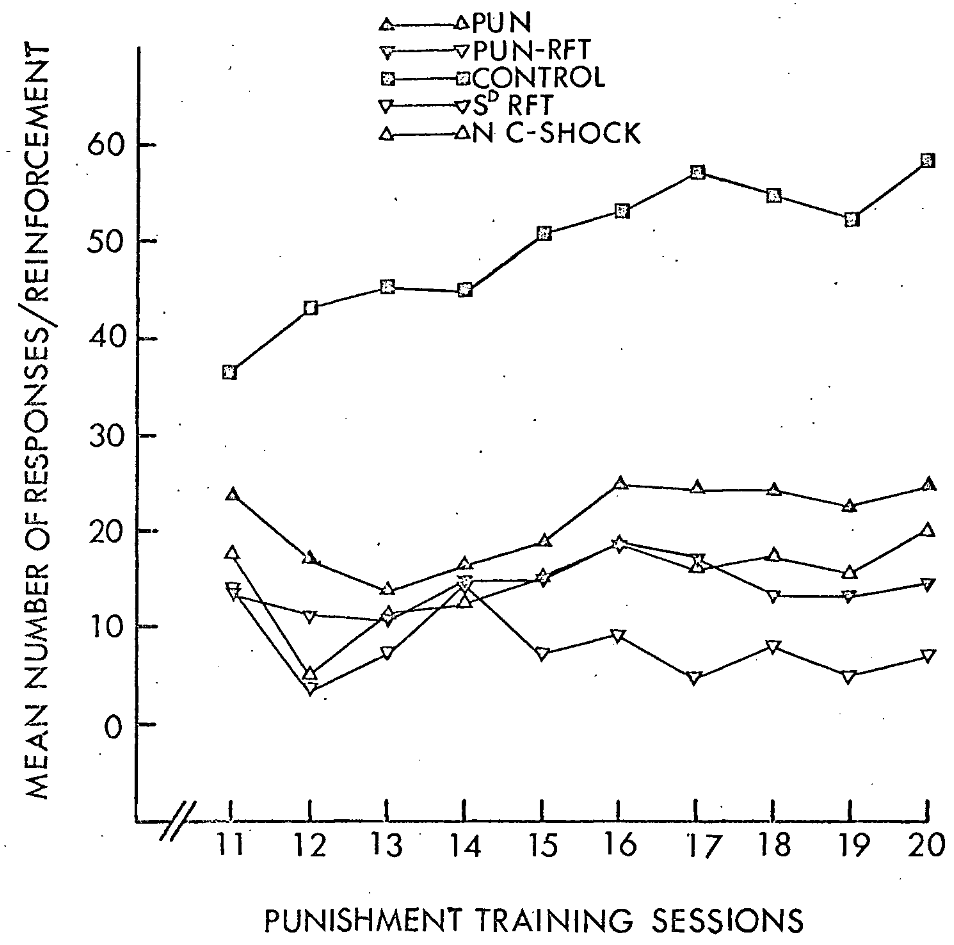
Source	df	Sum of Squares	Mean Square	F	p
Between Groups	4	3,005,473.6			
Control versus All Others	1	2,733.028.5	2,733,028.5	26.32	<.005
A (Contingency)	1	123,743.4	123.743.4		
B (Association with Food)	1	147,573.9	147,573.9		
A X B	1	1,127.8	1,127.8		
Within Cell	45	4,672,004.3	103,822.3		
Total	49				

Fig. 2 The mean number of reinforcements received as a function of Punishment training and Punishment-Extinction training for the five groups: shock and food for the same response (Pun-Rft Group), shock and food for different responses (Pun Group), response-noncontingent shock delivered automatically as response-contingent food becomes available for the next response (Shock-S^D Group), response-noncontingent shock delivered automatically independent of the availability of reinforcement (NC-Shock Group), and no shock (Control Group).



PUN
PUN-RFT
CONTROL
S^D RFT
NC-SHOCK
MEAN NUMBER OF REINFORCEMENTS RECEIVED
15
10
5
0
11
12
13
14
15
16
17
18
19
20
PUNISHMENT TRAINING SESSIONS

Fig. 3 The mean number of responses per reinforcement as a function of Punishment training and Punishment-Extinction training for the five groups: shock and food for the same response (Pun-Rft Group), shock and food for different responses (Pun Group), response-noncontingent shock delivered automatically as response-contingent food becomes available for the next response (Shock-S^D Group), response-noncontingent shock delivered automatically independent of the availability of reinforcement (NC-Shock Group), and no shock (Control Group).


PUN
PUN-RFT
CONTROL
S^D RFT
N C-SHOCK
MEAN NUMBER OF RESPONSES/REINFORCEMENT
60
50
40
30
20
10
0
11
12
13
14
15
16
17
18
19
20
PUNISHMENT TRAINING SESSIONS

reinforcements received so that they received almost as many reinforcements as the Control Group in the final few sessions of Punishment training. A two-way analysis of variance of the mean number of reinforcements received by each S during Sessions 15-20 indicated that the Control Group received significantly more reinforcements than other groups ($F=5.535$, 1&45 df, $p<.05$). The response-contingency main effect was also significant ($F=14.362$, 1&45 df, $p<.005$), indicating that the groups receiving response-contingent shock received significantly less reinforcements than the groups receiving response-noncontingent shock. The main effect of association of shock with food was not significant ($F=1.469$, 1&45 df, $p>.25$). The interaction between the two main effects also failed to reach significance ($F=.128$, 1&45 df, $p>.25$). A form of the Dunnett t test comparing the Control Group with each experimental group indicated that the Control Group received significantly more reinforcements than either the Pun Group ($t=3.76$, $df=45$, $p<.005$) or the Pun-Rft Group ($t=2.65$, $df=45$, $p<.025$). Table 2 presents the significant F ratios together with their sources.

Responses/Reinforcement. Figure 3 depicts for each group the mean number of responses per reinforcement as a function of Punishment training (Sessions 11-20). Inspection of Figure 3 revealed that all groups which received shock exhibited a decrease in the number of responses per reinforcement over the 10 Punishment-training sessions. The Shock-S^D Group exhibited the greatest decrease. The Control Group exhibited an increase in the number of responses per reinforcement over the same period. A two-way analysis of variance of the mean number of responses per reinforcement for each S during Sessions 15-20 indicated that the Control Group responded significantly more per reinforcement than the other groups ($F=26.167$, 1&45 df, $p<.005$). The

Table 2

Source Table for Analysis of Variance of Mean Number of Reinforcements Received During the Last Five Days of Punishment Training (Sessions 16-20)

Source	df	Sum of Squares	Mean Square	F	p
Between Groups	4	438.0			
Control versus All Others	1	112.8	112.8	5.54	<.05
A (Contingency)	1	292.7	292.7	14.36	<.01
B (Association with Food)	1	29.9	29.9		
A X B	1	2.6	2.6		
Within Cell	45	917.0	20.4		
Total	49	1,355.0			

response-contingency main effect was not significant ($F=1.181$, 1&45 df, $p>.25$). The main effect of association of shock with food also failed to reach significance ($F=1.924$, 1&45 df, $p>.10$). In addition, the interaction between the two main effects was not significant ($F=.024$, 1&45 df, $p>.25$). A form of the Dunnett t test comparing the Control Group with each experimental group indicated that the Control Group responded significantly more per reinforcement than all other groups (Control versus Pun, $t=3.147$, df=45, $p<.01$; Control versus Pun-Rft, $t=4.017$, df=45, $p<.005$; Control versus Shock-S^D, $t=4.896$, df=45, $p<.005$; Control versus NC-Shock, $t=3.805$, df=45, $p<.005$). In addition an F test between the responses per reinforcement for the Shock-S^D Group and the response rates for the NC-Shock Group indicated that the Shock-S^D Group responded significantly less per reinforcement than did the NC-Shock Group ($F=17.67$, 1&18 df, $p<.001$). Table 3 presents the significant F ratios together with their sources.

Punishment-Extinction Training (Sessions 21-30)

Response rates. Inspection of Figure 1 indicated that response rates for all groups declined sharply over the first few days of Punishment-Extinction training (Sessions 21-30). The response rates for the Pun and Pun-Rft Groups quickly dropped to a lower level than the other three groups and remained lower throughout the Punishment-Extinction training. A two-way analysis of variance of the mean response rate for each S during Sessions 26-30 indicated that the Control Group responded significantly more than other groups ($F=7.59$, 1&45 df, $p<.005$). The response-contingency main effect was also significant ($F=14.45$, 1&45 df, $p<.005$), indicating that the groups receiving response-noncontingent shock responded significantly more than did the groups receiving response-contingent shock. The main effect of association

Table 3

Source Table for Analysis of Variance for Mean Number of Responses Per Reinforcement During the Last Five Days of Punishment Training (Sessions 16-20)

Source	df	Sum of Squares	Mean Square	F	p
Between Groups	4	13,871.0			
Control versus All Others	1	12,337.2	12,337.2	25.17	<.01
A (Contingency)	1	578.7	578.7		
B (Association with Food)	1	943.1	943.1		
A X B	1	11.9	11.9		
Within Cell	45	22,059.4	490.2		
Total	49	35,930.4			

of shock with food was not significant (F=3.03, 1&45 df, p>.05). The interaction between the two main effects also failed to reach significance (F=2.65, 1&45 df, p>.10). A form of the Dunnett t test comparing the Control Group with each experimental group indicated that the Control Group responded significantly more than either the Pun Group (t=3.314, df=45, p<.005) or the Pun-Rft Group (t=3.393, df=45, p<.005). Table 4 presents the significant F ratios together with their sources.

Discussion

The present study yielded no evidence for a dynamogenic effect of electric shock. With one exception, the response rates of the four groups receiving shock were consistently lower than the response rate of the no-shock Control Group. The one exception was found in the last five days of Punishment-Extinction training where the Control Group was observed to respond significantly more than the two-response-contingent shock groups but not significantly more than the two response-noncontingent shock groups. Although there was no significant difference between the responding of the two response-contingent shock groups and that of the two response-noncontingent shock groups in Punishment training, the response-contingent shock groups responded significantly less than the response-noncontingent shock groups in Punishment-Extinction training. These results suggest the following generalizations: (a) response-contingent and response-noncontingent shock will reduce responding equally in Punishment training: (b) following Punishment training, response-contingent shock will reduce responding in Punishment-Extinction training whereas response-noncontingent shock will have no effect on rate of responding in Punishment-Extinction training.

Table 4

Source Table for Analysis of Variance of Mean Response Rates During the Last Five Days of Punishment-Extinction Training (Sessions 26-30)

Source	df	Sum of Squares	Mean Square	F	p
Between Groups	4	9,094.7			
Control versus All Others	1	2,488.3	2,488.3	7.59	<.01
A (Contingency)	1	4,744.2	4,744.2	14.47	<.01
B (Association with Food)	1	993.6	993.6		
A X B	1	868.6	868.6		
Within Cell	45	14,430.7	328.0		
Total	49	23,525.5			

The results also indicate that shock delivered before the to-be-rewarded response acquired greater discriminative control over the response than other less specific stimuli such as time elapsed since last reinforcement. This conclusion is based on the comparisons made between the Shock-S^D Group and the NC-Shock Group in Punishment training. It was observed that while both groups received the same number of shocks and approximately the same number of reinforcements, the Shock-S^D Group not only responded significantly less but also responded significantly less per reinforcement and thus more "efficiently" than did the NC-Shock Group. The increased efficiency of the Shock-S^D Group over the NC-Shock Group can only be attributed to the relationship between shock and the availability of food since the two groups were otherwise treated identically.

In Punishment-Extinction training, on the other hand, no significant differences in response rates were observed between the Shock-S^D Group and the NC-Shock Group. This finding suggests that establishing shock as a discriminative stimulus for a positively reinforced response is not a sufficient conditon for reducing the suppressive effects of shock in Punishment-Extinction. Furthermore, the failure of the association-of-shock-with-food variable to produce significant effects in either Punishment or Punishment-Extinction training indicates that mere temporal association of shock with food is not a sufficient condition for reducing the suppressive effects of shock in either Punishment training or Punishment-Extinction training.

These results raise certain questions about the Holz and Azrin (1961, 1962) studies. It had been expected on the basis of the Holz and Azrin work that shock associated with food would suppress responding less than shock not associated with food. This expectation was not confirmed. The discrepancy between the present data and those of Holz and Azrin reflect a species difference: Holz and Azrin used pigeons as subjects. It seems more probable, however, that the Holz and Azrin (1961) findings were a result of differential generalization decrements between the two extinction procedures and the acquisition conditions. Because all subjects in the Holz and Azrin (1961) study received punishment training (and none received regular training), the greater response rate in punishment extinction as compared with regular extinction may simply reflect the greater similarity of the punishment-extinction situation to the punishment-training situation. The intermediate rates of responding observed when noncontingent shock was introduced into regular extinction may also be accounted for by a generalization decrement between extinction conditions and acquisition conditions. In light of the present data this interpretation seems more plausible than the "conditioned-reinforcer" interpretation suggested by Holz and Azrin (1961).

In their 1962 study Holz and Azrin did not test for the secondary reinforcing power of shock. They simply state that, under appropriate conditions, shock can serve a discriminative function. The results of the present study do not contradict this statement since shock served as a discriminative stimulus in the Shock-S^D Group. However, the possibility remains that in the Holz and Azrin study shock merely enhanced the discriminative control of stimulis associated with the fixed-interval schedule, and it did not itself acquire any discriminative control.

In summary then, the results of the present study support statements by Holz and Azrin (1961, 1962) that shock may serve a discriminative function in addition to its widely demonstrated aversive function. The present data do not, however, support the discriminative stimulus hypothesis of secondary reinforcement as proposed by Keller and Schoenfeld (1950, p. 236), or the statement by Holz and Azrin (1966) that in becoming an S^D for a reinforced bar-press, shock becomes a conditioned reinforcer. In particular the present data (i.e. Shock-S^D Group versus NC-Shock Group in Punishment-Extinction training) contradict the Keller-Schoenfeld hypothesis which states that to the extent that a stimulus has been established as a discriminative stimulus, it has also acquired conditioned reinforcing properties--at least inasmuch as these conditioned reinforcing properties would be expected to reduce the suppressive effects of electric shock when it is established as a discriminative stimulus.

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Appendix A

Throughout experimentation all events were programmed on 2-min. variable-interval schedules (VI-2'). These schedules were composed of 1, 1½, 2, 2½, and 3 min. intervals, with an average interval length of 2 min. The five intervals comprised a 10-min. continuous cycle. The intervals were employed in one of the following orders: (a) 2½, 3, 1½, 2 and 1 min., or (b) 1, 2, 1½, 3, and 2½ min. Order (b) is simply the reverse of order (a). For response contingent events (shock or food) the control apparatus stopped at the end of each interval until the response occurred producing the given event. The occurrenceoof the event started the control apparatus and began the next interval. Response noncontingent events were delivered automatically by the control apparatus which did not stop but continued on to the next interval. The point in the 10-min. cycle of intervals at which the 30-min. experimental session began was randomized throughout the experiment. As a result, the maximum number of times each event could occur in a session varied between 14 and 16.

Reinforcement was programmed on a VI-2' schedule with the intervals in order (a) for both Reinforcement training and Punishment training. In Punishment training the Pun Group received response-contingent shock on a VI-2' schedule with the intervals in order (b). The punishment schedule was also staggered relative to the reinforcement schedule by 30 sec. so that the shock was beginning its first interval for shock when the reinforcement cycle had already completed 30 sec. of the first interval. In Punishment training the NC-Shock Group also received shock on a VI-2' schedule with the intervals in order (b). The shock however was response-noncontingent and was delivered automatically. These variations in programming the basic VI-2' schedule were provided to meet the conditions described in the Procedure section.