Conditioned reinforcing vs punishing properties of electric shock

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Two naive rats were trained on Mult $VI_1 VI_1$ (clicker + reinforced response shock). On this schedule, a clicker sounded through the delivery of every other 13 reinforcements. Each response in the clicker that delivered reinforcement also received an immediate shock. The shock intensity was varied, which produced the following effects in both animals: little or no effect on response rate at low intensity, regular facilitation or increase over nonshock rates at intermediate values, and reliable suppression at higher intensities. Facilitative effects were described as due to conditioning reinforcing functions; suppressive effects were defined as punishment.

A number of reviews in the area of punishment (Church, 1963; Solomon, 1964; Azrin & Holz, 1966) have indicated that stimuli that act as suppressors of behavior on some occasions may also maintain behavior on other occasions (Brown, Martin, & Morrow, 1964; Sandler, Davidson, Greene, & Holzschuh, 1966; Sandler, Davidson & Malagodi, 1966; Sandler & Davidson, 1967; Sidman, Herrnstein, & Conrad, 1957) and even reinforce behavior during acquisition (Muenzinger, 1934; Muenzinger, Bernstone, & Richards, 1938; Harrington & Linder, 1962; Morse & Kelleher, 1966).

Azrin (1958), using aversive noise, demonstrated that this stimulus will suppress behavior when programmed in response-contingent schedules but may also maintain behavior when programmed as an S^D (discriminative stimulus) for reinforcement and facilitate behavior when paired with reinforcement.

The study reported here was designed to demonstrate similar multiple effects of a stimulus (electric shock) by manipulating only one parameter (intensity).

Fig. 1. Mean response rates on Mult $VI_1 VI_1$ (reinforced response-contingent shock) for R9. As indicated by the legend, the solid lines are a graph of rates in nonshock components, while broken lines portray rates in shock components. Each panel is a plot of rates during the last 10 days at each of the depicted shock intensities (with the exception of the last panel, which shows 1 day after shock was removed).

SUBJECTS

Two naive male Sprague-Dawley rats were caged individually until they were 90 days of age, at which time they were food-deprived to 80% of their free-feeding weights. The animals were maintained on dry Purina rat chow and water, with the addition of a weekly dietary supplement of 50-75 cc Sustagen (Mead Johnson) and antibiotic (Terramycin, Pfizer). The animals were fed enough chow to maintain their weights following each weekday session.

APPARATUS

A standard rat chamber (Foringer 1102TC) allowed access to a single lever, which, when pressed with 25 g downward force, completed a circuit and recorded a response. A motor-driven dipper feeder delivered .2 cc liquid reinforcement. The grid floor of the chamber could be electrified by a shock source (Foringer 1154) supplying up to 800 V ac current through a 250K resistor in series with the S to reduce variability. A shock scrambler (Foringer 1155) served to alternate rapidly the polarity between all possible pairs of grids. A milliammeter in series with the S was used to monitor delivered shock intensities. Electromechanical relay equipment automatically programmed the schedules. Cumulative recorders and counters supplied records of the S's behavior.

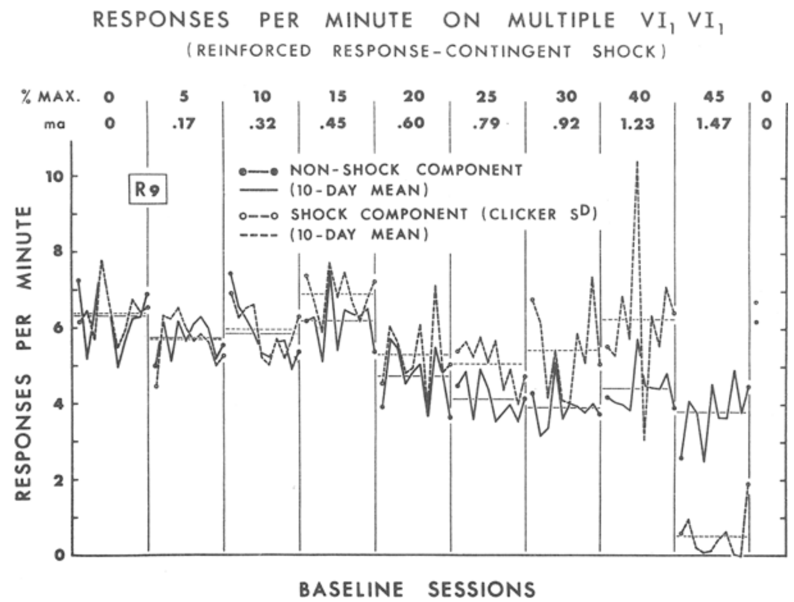
PROCEDURE

Once the Ss were properly food-deprived, they were trained to approach the magazine and accept the reinforcement (.2 cc 12% sucrose, by weight) each time it was delivered. The animals were then trained, by successive approximations, to press the lever, first on FR 1 (one response per reinforcement), then on FR 5, VI .5 (reinforcement available contingent on the first response after an average of 30 sec), and finally VI 1 min, the terminal schedule. In addition, R1 was exposed for some time to VR 12 and 25 (reinforcement contingent on 12 or 25 responses, on the average) to maintain a higher rate of response.

After the Ss showed stable responding on VI_1, each was introduced to Mu' $i_1 VI_1$. On this schedule, each session was divided into four segments, each segment consisting of 13 sucrose presentations. During alternate segments, a clicking sound was present. Following stability in both components (less than 10% difference between component rates over 10 days), shock of low intensity (.15 mA) and 300-msec duration was introduced contingent on each reinforced response in the clicker component. After response rates again met the same criterion, shock intensity was increased in small steps (about .15 mA each) following some stability at each step, until each S showed shock-controlled suppression to 33% or less of nonshock rates.

RESULTS

The results of the experiment are summarized in daily plots and cumulative records in Figs. 1-4. The summary plots demonstrate that each of the Ss showed regular increases in response rate during clicker-shock components under intermediate levels of shock intensity (.60



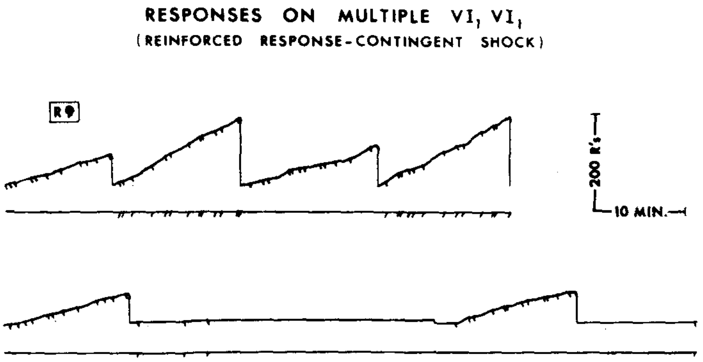


Fig. 2. Cumulative records of R9's responses on Mult $VI_1 VI_1$ (reinforced response-contingent shock) at 1.23-mA (upper) and at 1.47-mA shock intensity (lower record). In each record, hatch marks on the event line denote delivery of shock. The response pen automatically reset after each 13 reinforcements, marking the end of each multiple component. Hatch marks on the response line indicate reinforcements. The upper record shows higher rates in shock than nonshock components (conditioned reinforcement); the lower record shows punishment suppression at higher-intensity shock.

to .91 mA in R1, .45 to 1.23 mA in R9). Both Ss showed the required amount of response suppression in shock components at 1.40 or 1.47 mA intensity.

Figure 1 summarizes the data from the entire experiment for S R9. This figure plots mean responses per minute in nonshock components (solid lines) as well as in clicker-shock (broken lines) through the course of the experiment. From this figure, one can see that the clicker alone did not affect the behavior differentially (left panel). Initial low-intensity shock values did not show noticeable effects on behavior (Panels 2 and 3, .17- and .32-mA intensity). However, shock intensities of .45 to 1.23 mA were correlated with definite increases in response rate during clicker-shock components beyond the rates in nonshock components. The differential increase in shock components was manifest in every daily session illustrated at shock intensities from .45 to 1.23 mA, with only two exceptions, as shown in Fig. 1. The differences in 10-day means and individual session component rates demonstrate that this facilitative effect was greatest at .92- and 1.23-mA shock intensity, after which the relationship was reversed and suppression resulted. The final points in the last panel of the graph indicate return to base rates following removal of the shock contingency.

In Fig. 2, the upper panel is a cumulative record illustrating the maximal amount of increase in response rate at 1.23-mA intensity, while the lower panel is a similar record showing maximal suppression at 1.47-mA intensity. Note that responding in the nonshock legs was stably maintained at about the same rates in both sessions.

A summary of daily mean rates in shock and nonshock components for S R1 appears in Fig. 3. As in Fig. 1, rates in nonshock components are indicated by solid lines, while rates in shock components with clicker S^D are indicated by broken lines. This graph was simplified by leaving out some shock intensities to which R1 was exposed. This animal, like R1, showed little effect of shock at low intensity (.30 mA) but some differential increase in rates at .60- and .91-mA intensity, compared to nonshock rates in the same sessions. The maximal increase in rates occurred at .91-mA intensity, where the shock rates were higher each day than were nonshock rates in the same sessions. Shock of 1.22- and 1.40-mA intensity showed progressive shock-controlled suppression, with the maximal effect at the latter value. The points in the last panel demonstrate that the rates again returned to high values after removal of the shock schedule.

The top panel in Fig. 4 is a cumulative record of maximal increase in response rates at .91-mA shock intensity compared to two nonshock components, while the lower record illustrates typical shock-controlled suppression at 1.40-mA intensity.

DISCUSSION

The data from this experiment demonstrate the various effects of manipulation of the intensity of shock that was delivered contingent on reinforced responses in one component of a multiple schedule. Two Ss responded similarly to increasing intensities of shock, showing

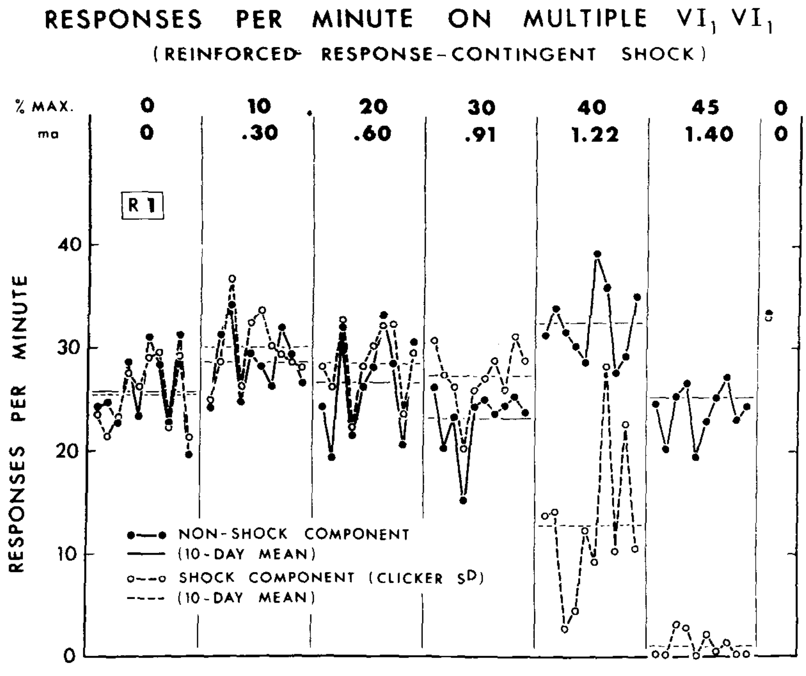


Fig. 3. Mean response rates on Mult $VI_1 VI_1$ (reinforced response-contingent) shock for R1. The solid lines plot rates in nonshock components, while the broken lines depict rates in shock components. Each panel is a plot of rates during the last 10 days at each of the depicted shock intensities (with the exception of the last panel, which shows rates on 1 day following removal of shock). R1 responded at higher rates than did R9, reflecting a history of training on VR reinforcement schedules.

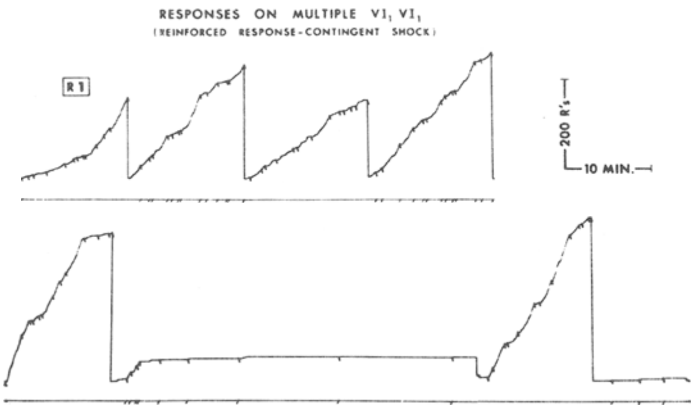


Fig. 4. Cumulative records of responses by R1 on Mult $VI_1 VI_1$ (reinforced response-contingent shock), illustrating conditioned reinforcement at .91-mA in the upper record and shock-controlled suppression at 1.40-mA shock intensity in the lower record. In each record, hatch marks on the lower event line denote delivery of shock. The response pen automatically reset after each 13 reinforcements, marking the end of each multiple component. Hatch marks on the response line indicate reinforcements.

little or no effect at low intensities, increases in rates at intermediate intensities and shock-controlled suppression at high intensities. The latter two phenomena were reversible following removal of the shock contingency.

Since the delivery of shock contingent on reinforced responses met the procedural definition of conditioned reinforcement (Kelleher & Gollub, 1962), increases in response rate in shock components were regarded as due to conditioned reinforcement functions, while shock suppression of responses was regarded as punishment, consistent with the definition advanced by Holz & Azrin (1966). Thus, the data from this experiment have demonstrated little or no effect of shock at low intensities, conditioned reinforcement at intermediate, and punishment at higher intensities of shock, without other changes in the schedule parameters.

The finding that shock can function as a conditioned reinforcer under certain conditions represents a systematic replication of the earlier studies by Muenzinger (1934), who found a facilitation of reinforced responses by shock. Similarly, Azrin (1958) and Ayllon & Azrin (1966) demonstrated how aversive noise may function as a conditioned reinforcer when paired with positive reinforcements. There may also be some relationship to the studies of Sandler (1964) and Holz & Azrin (1961), both of whom found an increase in rate of responding in extinction correlated with reintroduction of a shock schedule that had formerly been a discriminative stimulus (S^D) for positive reinforcement.

Suppressive functions of shock have been reported by too many Es to be individually itemized here, although many such reports may be found in the primary reviews (Church, 1963; Solomon, 1964; and Azrin & Holz, 1966).

It should perhaps be noted that neither the conditioned reinforcing nor punishing functions of shock in this study were dependent upon a particular rate of response, since the two animals showed such functions at quite different initial rates of response (R9 responded at 5-7 responses per minute, R1 at 20-30 responses per minute after a history of VR reinforcement). The fact that R9 showed a greater degree of conditioned reinforcement over a wider range of shock intensities may, however, have had some connection with his lower rate of response. For example, it might be that animals with intermediate initial rates show more facilitative function because of a greater range of potential increase than animals with initially high rates.

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