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SOME ASPECTS OF SELF AVERSIVE STIMULATION IN THE HOODED RAT[1]

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Three hooded rats were trained to bar press for variable-ratio liquid reinforcement after which an electric shock was delivered following the response. Initially, the shock was presented on a FR 100 basis but the frequency was gradually increased until all responses were punished. Finally, a partial extinction procedure was conducted to determine if the shock resulted in increased bar pressing. No durable suppression of responding occurred, although one subject's rate was reduced during continuous shock. The overall trend for the three animals was one of increased responding. Changes in the pattern of responding were also observed suggesting that the suppressive effects of the punishment were largely restricted to the first response following reinforcement. Increased responding as a function of shock reintroduction during extinction was also observed.

In his analysis of self aversive stimulation, Skinner (1953) outlined some of the conditions under which such behavior might develop. Thus, aversive stimuli might be paired with the reinforcer which follows a given activity and the end result may be that "the aversive stimulus becomes positively reinforcing in the same process" (p. 367). One example of this would be provided where it can be shown that punishing stimuli strengthen and maintain instrumental acts. Several recent investigations (Holz and Azrin, 1961; Sandler, 1962) have actually demonstrated these effects. Such efforts may be important in helping to explain certain forms of "pathological" behavior, *e.g.*, continued responding in the face of punishing consequences.

One obviously important consideration in this issue is the nature of the aversive event. Typically, self aversive stimulation will not be maintained if an operant is followed by intense continuous punishment (Appel, 1961; Storms, Boroczi and Brown, 1962). However, no studies have been reported where the aversive stimulus has been introduced on an infrequent basis and only gradually increased to a continuous schedule. Consequently, the author sought to determine what effects the presentation of such a noxious stimulus would have on a liquid reinforced operant in rats if the aversive event were introduced infrequently and gradually increased to 100%, and whether such a stimulus would actually result in increased responding in the manner described by Skinner.

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METHOD

Subjects

Three experimentally naive, male, hooded rats (M1, M2, and M3), bred in the psychology laboratory colony were used. They were from 180 to 200 days old and their weights ranged from 295 to 338 g at the beginning of the experiment. Food was always available in the home cages and weight fluctuation was less than 30 g during the course of the experiment.

Apparatus

A 10 in. by 10 in. by 12 in. (approximately) Foringer 1102M1 test chamber with a Plexiglas ceiling was enclosed in a lightproof, sound attenuating compartment. The apparatus was equipped with a dipper style liquid feeder and a bar which operated a microswitch (the manipulandum). The bar was located 8.5 cm above the chamber floor and a 25-g downward force closed the microswitch. Shock could be delivered through the grid floor, the aluminum walls, and the bar by means of a Foringer #1154 ac 60 cycles per sec shock supply with adjustable voltage from 0 to about 800 v. A 250 K resistor was in series with the animal to reduce the variability in current flow. A Foringer shock scrambler randomly reversed the polarity of the voltage on the grids during shock delivery.

The occurrence of experimental events was programmed automatically by timers and relays. Numbers of responses, reinforcements and shocks were tabulated on counters, and a Gerbrands cumulative recorder provided a continuous record of the experimental events.

Procedure

Subjects were initially maintained on 23 hr liquid deprivation and trained to press the bar for continuous liquid reinforcement. The reinforcement consisted of about .1 ml of a 5% sugar-water solution presented for 3 sec. After the response was established, *S*s were shifted to a VR:55 schedule. They were run for 12, 2 hr sessions under these conditions with no liquid available outside the experimental session. All subsequent experimental sessions were 1 hr in duration and conducted daily, Monday through Friday. On weekends, *S*s were provided with a 1 hr daily ration of water equal to the daily average water worked for during the preceding week. Response rates stabilized within 12 to 16 sessions under these conditions.

An electric shock was then introduced as a second contingency to the bar press and delivered on a gradually increasing basis as outlined below. The input shock was .67 ma in intensity (approx. 160 v) and 250 msecs in duration. Prior observation of four litter mates revealed that a shock of this nature resulted in rapid signal instrumental avoidance conditioning within five days (mean of 82% correct trials, 110 trials per day). Shock frequency was scheduled on a gradually increasing basis: FR 100, FR 75, FR 60, FR 45, FR 35, FR 25, FR 15, FR 10, FR 5 and FR 1 (continuous). There was no attempt to follow any predetermined method in this approach other than to provide a gradual, relatively systematic increase in number of responses shocked. The actual shock percentages were 1, 1.3, 1.7, 2.2, 2.9, 4.0, 10.0, 20.0, and 100. Each new shock condition was maintained until *S*s were stabilized at or above their pre-shock rates before the next shock contingency was introduced. This required a minimum of six sessions and usually more for each *S* under each of the different conditions.

In the final phase, a modified extinction procedure was introduced to determine the extent to which the aversive stimulus might result in increased responding. Each of five successive 1-hr experimental sessions was divided into three periods: 20 min of the combined VR reinforcement-FR 1 shock contingencies, followed by 20 min of extinction (both contingencies withdrawn) and 20 min during which continuous shock alone was reintroduced. In addition, the first response emitted during the last 5 min of each "shock alone" condition was reinforced.

RESULTS AND DISCUSSION

Table 1 presents a summary of response rates for the first and last day under each experimental condition. Inspection of the first day

Table 1
Total Number of Responses for the First and Last Day of Each Shock Condition for the Three Subjects.

	Subject					
	M1		*M2*		*M3*	
Shock Condition	*First Day*	*Last Day*	*First Day*	*Last Day*	*First Day*	*Last Day*
----		4105		3642		3410
FR 100	1438	3844	2143	3960	4067	3531
FR 75	4101	4212	4158	4234	2522	3843
FR 60	4180	4311	4380	4301	3448	3623
FR 45	4888	4401	3830	3506	3830	3419
FR 35	5230	5620	3831	4826	2689	6223
FR 25	5270	5503	4304	4605	6682	8025
FR 15	6259	6064	4761	4705	7202	7961
FR 10	5354	5870	4740	4615	7327	7093
FR 5	5723	6185	4117	4586	6770	7875
FR 1	5226	3565	3565	3832	5179	6279

column reflects the impact of the new shock contingency. On only a few occasions did an increase in shock frequency result in reduced responding when compared with pre-shock rates. These reductions were restricted to the initial introduction of shock in animals M1 and M2, the first increase in shock frequency in M1 and M3, the fourth increase in shock frequency in M3 and the introduction of continuous shock in M2. However, in almost every instance, the last day rate for each new shock frequency equaled or exceeded the last day's pre-shock rate. On only three instances were these effects not revealed.

On the other hand, over half the changes to higher shock frequencies resulted in reduced responding from the last day's rate under the previous shock condition. All three *Ss* revealed this effect under FR 5 and FR 1 shock.

Ultimately, *Ss* were shocking themselves on an average of 55 times per reinforcement (roughly 99% of the time) with interference in pre-shock rates revealed only by M1. The overall trend for the *Ss* throughout the investigation was actually one of increased responding up until the final shock contingencies. This trend appears most systematic in the case of M1 but can also be observed in the results of the other two *Ss*. The most dramatic increase occurred in M3 during FR 35. Its rate increased sharply during the early part of these sessions and remained at a relatively high level throughout the remainder of the experiment (Fig. 1). Total daily response rates are plotted for the three *Ss* under all the shock conditions. Note the initial drop in response rate after the introduction of shock in M1 and M2, followed by a successive increase in response rates until M2 appeared to level off at around FR 25 and M1 at about FR 5. No large reduction in response rates was observed for M3 under any of the early or intermediate shock conditions.

No durable decrease in responding was displayed by any of the *Ss* before continuous shock.

Analysis of the records revealed that session-to-session rates within a given experimental condition were fairly uniform, especially for M1 and M2. However, changes in the pattern of responding did seem to occur. Before the introduction of shock, and under infrequent shock delivery, *Ss* revealed typical VR reinforcement response patterns; high overall, uniform rates throughout the entire session with relatively few pauses. However, during the latter stages of the investigation,

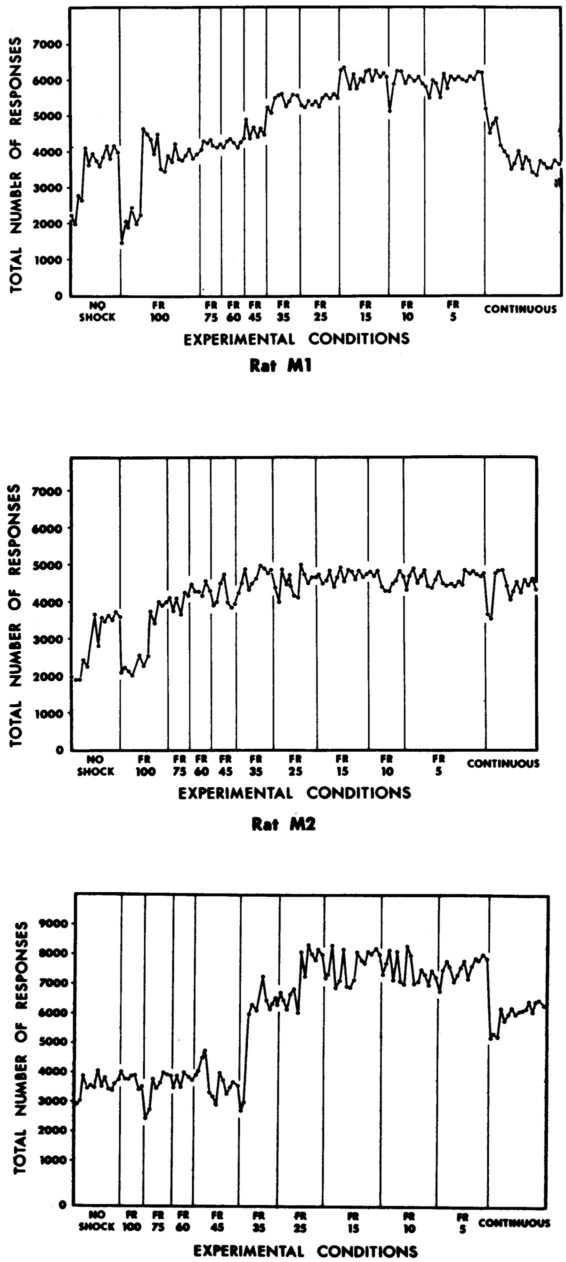

Fig. 1. Total number of responses for each *S* for each day under the 11 experimental conditions prior to extinction. The records are for M1, M2, and M3 respectively from top to bottom.

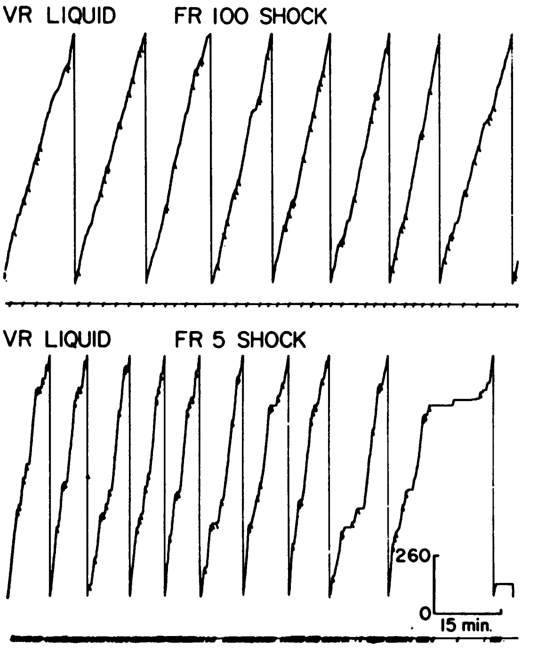

Fig. 2. Representative cumulative records for M1 for one session under VR 55 liquid reinforcement and low shock frequency, and one session under VR 55 liquid reinforcement and high shock frequency. Reinforcements are indicated by the small diagonal mark on the upper part of the record, shocks are indicated by the small downward mark on the lower part of the record.

under high shock frequency, changes began to appear. While overall rate increased, fluctuation between bursts of responding and extended pauses also increased. Figure 2 presents two typical records for M1 which reveal some of these changes. Exaggerated shifts between responding and pausing, especially late in the high frequency shock sessions are revealed, despite the fact that rapid response bursts remain uniform throughout the session. Similar effects were observed for the other *S*s. It can be seen then, that the increase in responding was characterized by a shift from a relatively uniform set of conditions to rather high bursts of responding throughout the session, followed by gradually lengthening post-reinforcement delays especially concentrated during the latter half of the sessions.

With regard to performance during the five extinction sessions, Fig. 3 presents average response rates for each *S* over 5-min time periods. During the first 20 min (Reinforcement plus shock) *S*s revealed an accelerated performance typical of their performance under high shock frequencies and possibly related to the usual warmup effect reflected in punishment studies. Following the first 5 min of extinction, a rather sharp decline in response rate was evidenced such that almost complete extinction took place within 20 min. The reintroduction of shock, however, resulted in an immediate increase in responding. Although the levels achieved here were relatively low (mean of about 175 responses during the first 5 min) they are roughly equivalent to the rates produced during the second 5 min of extinction and higher than the rates emitted during the previous two, 5-min periods. This brief increase in responding is followed once again by a sharp decline until the single reinforcement is administered during the last 5 min, at which time a rapid increase in responding once again was revealed.

These changes are demonstrated in Fig. 4 which reveals the cumulative record for the first extinction session for M3. Note the initial brief warmup period followed by rapid press activity during the first 20 min. Withdrawal of the shock and reinforcement (first arrow) was immediately followed by an extremely high rate. This was shortly reduced and replaced by gradually lengthening pauses. Reintroduction of the shock (second arrow) resulted in a return to a higher bar press rate of a relatively brief duration. This was also shortly followed by gradually lengthening pauses until the reinforcement was presented late in the session, which in turn, led to increased responding once again.

In the present study, it cannot be concluded that there has been a change in response to a punishing stimulus, since this would have required introducing a high shock frequency condition on control animals trained under similar reinforcement histories.

There is some suggestion that whatever suppressive effects were revealed by the shock were restricted to the interval following reinforcement, creating a change in the usual variable-ratio reinforcement pattern. The increase in responding following the reintroduction of shock during extinction also extends the Holz and Azrin findings (1961) which employed an S^{Δ} condition.

The increase in responding during the course of the experiment was surprising. It is difficult to determine what factors were responsible for these results, although other

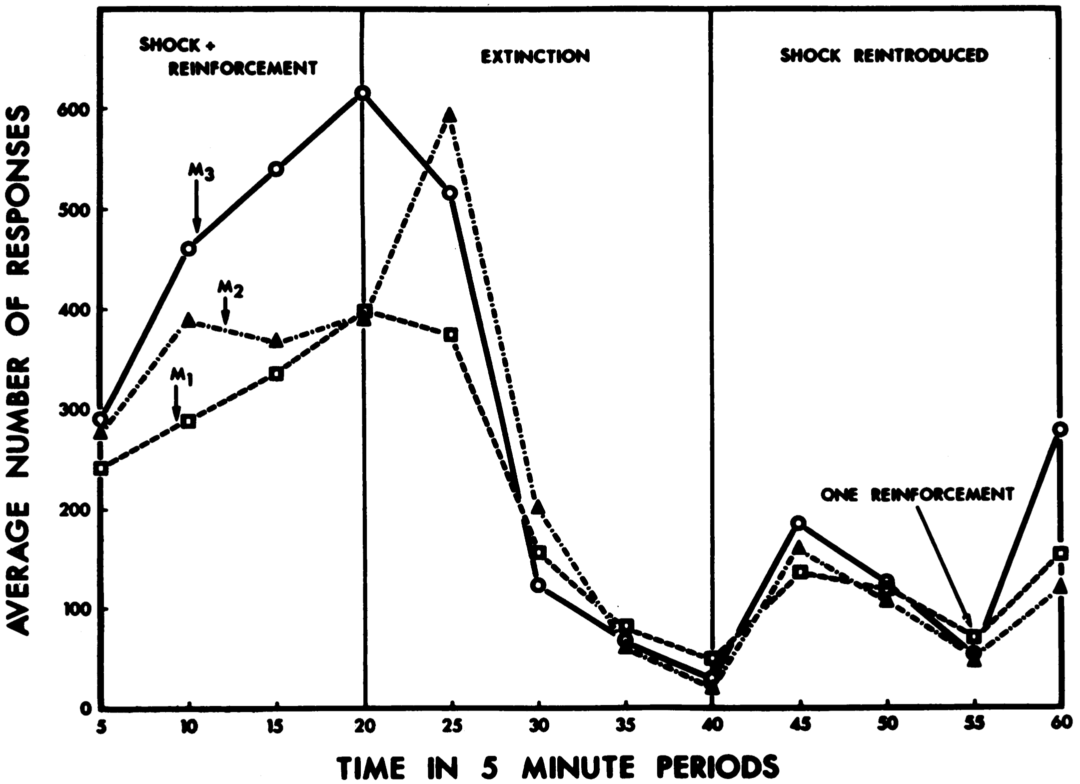

Fig. 3. Mean response rate during the five extinction sessions for each *S* under the three experimental conditions.

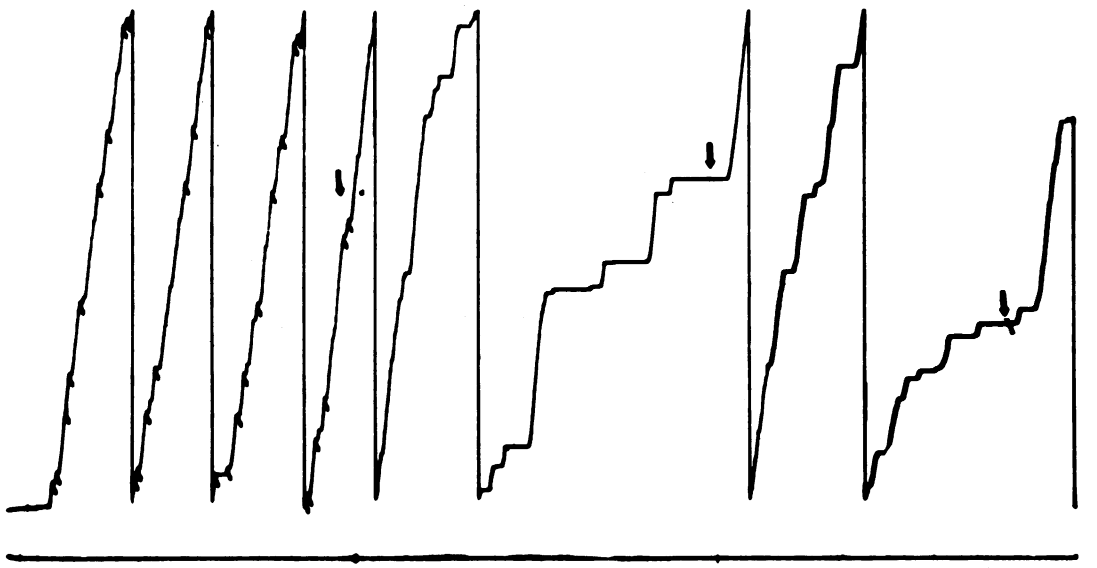

Fig. 4. Cumulative record for M1 for the first extinction session. Each arrow represents a change in experimental conditions. Reinforcements are indicated by the small diagonal on the upper part of the record; the shock event pen on the lower part of the record was made inoperable since no clear record of continuous shocks could be obtained.

investigators have attributed similar findings (Amsel and Maltzman, 1950; Ullman, 1951) to some aspect of the response chain developing a generalized reinforcement capacity. Whether or not this is so, there is little doubt that concurrent scheduling of reinforcing and noxious stimuli has complex effects on behavior as reflected in the numerous inconsistencies in the punishment literature (Solomon, 1964). Paradigms such as the present one seem to offer a means of analyzing situations involving self-aversive stimulation.

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