

Titration of punishment

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Pigeons obtaining food by pecking a key and rats obtaining food by pressing a lever were exposed to continuous electric shock of variable intensity. After each response, the intensity of the shock increased by ΔI mA. Between responses, intensity decreased at R mA/minute. With several values of R , all animals responded at $R/\Delta I$ responses/minute.

One of the most common objections to the use of punishment in controlling behavior is that an aversive stimulus not only punishes behavior (i.e., reduces the frequency of the response it follows) but also produces undesired emotional side effects. These emotional effects are said to disrupt behavior generally and thereby prohibit precise control of specific responses (Skinner, 1953).

The objection implies that such disruptive emotional effects are not present, or are minimal, with positive reinforcement. Indeed, food reward may control behavior with great precision (Ferster & Skinner, 1957), while the suppression during electric shock punishment is often highly variable and sometimes transitory (Estes, 1944; Dinsmoor, 1952; Azrin, 1956, 1959, 1960; Rachlin, 1966).

One may question, however, whether differences between behavior produced with punishment and behavior produced with reward are inextricably part of the punishment and reward procedures or whether these differences lie in the particular punishments and rewards usually used in the laboratory.

Food or water rewards are always familiar to the S , have always, prior to the experiment, been obtained via instrumental responses and are usually presented to the S to consume at its own pace. Furthermore, deprivation, the aversive component of reward, takes place over days (this is not true of brain-stimulation reinforcement but, like electric shock, brain stimulation seems to produce variable and transitory "emotional" effects when applied in brief pulses not under the S 's control). Electric shock, on the other hand, is usually unfamiliar to the S , its consumption is out of the S 's control, and it is usually applied suddenly. The variable and transitory effects of punishment may well be due to variations in sensitivity to a new stimulus. There is some evidence with

pigeons that sensitivity to electric shock varies considerably over short durations of exposure to sudden shocks (Rachlin & Himeline, 1967).

The present experiment examines the stability of behavior when the intensity of electric-shock punishment is continuously variable and under the S 's control.

METHOD

The S s were eight rats and six pigeons kept at 80% of free-feeding weight. In a daily 30-min session the rats occasionally obtained 3-sec access to condensed milk by pressing a bar; the pigeons obtained 3-sec access to mixed grain by pecking an illuminated response key. Both rat and pigeon experimental chambers contained an overhead light and a source of white noise to mask extraneous sounds.

A baseline of responding, upon which punishment could be superimposed, was established as follows: After training with the response manipulandum, half of the rats and half of the pigeons were exposed to 30-sec variable-interval (VI) schedules. (A response was reinforced with food every 30 sec on the average.) The rate of reinforcement with this schedule remains at about 2/min over wide ranges of response rate. The remaining S s were exposed to variable-ratio (VR) schedules of 25 responses. (Reinforcement was delivered after an average of 25 responses.) The rate of reinforcement with this schedule varies directly with rate of responding.

After 30 days of baseline training, punishment was superimposed. The rats received footshock through a scrambler connected to the grid floor of the chamber. The pigeons received shock through two gold wires implanted under their pubis bones. The shock was continuously present and could vary from 0 to 6 mA for the rats and from 0 to 25 mA for the pigeons.

At the beginning of each session, the shock intensity was 0 for all animals. Each response increased the shock by an amount ΔI . Between responses the shock decreased at a rate of R mA per minute. This procedure is the inverse of that used by Weiss & Laties (1963) to study escape. In the present experiment the increase and decrease were programmed by pulses transformed into shaft rotations of a differential mechanism. One input came from responses. The other input came from pulses at regular intervals. The differential mechanism subtracted the second input from the first. The resultant shaft rotation was fed, through gears and pulleys, to a variac with a 120-V input. The output voltage of the variac was boosted 4:1 by a transformer and then went through variable and fixed resistors to the animals.

If the pigeons and rats paused long enough between responses, the intensity would stay very near zero. If they responded at a rate above $R/\Delta I$, intensity would steadily increase. If they responded at a rate lower than $R/\Delta I$, intensity would decrease. If they responded at a rate exactly equal to $R/\Delta I$, intensity would remain constant.

For the rats, $\Delta I = 0.023$ mA and R was kept for five sessions at each of the following values, in order: 0.68 mA/min, 0.45 mA/min, 0.18 mA/min, 0.09 mA/min, 0.68 mA/min. For the pigeons, $\Delta I = 0.093$ mA and R was kept for five sessions at each of the following values, in order: 2.78 mA/min, 1.85 mA/min, 0.74 mA/min, 0.37 mA/min, 1.85 mA/min.

RESULTS

Figure 1 shows the rates of responding during the second half of the sessions for typical pigeons and rats under both conditions of reinforcement. The variability of the functions shown is near the average for each group. The solid lines indicate $R/\Delta I$. The aversive contingencies determined the rate of responding of the animals: Both pigeons and rats responded at a rate approximately equal to $R/\Delta I$ so as to maintain shock at a level between zero and maximum intensity. Precise control of rates of response was obtained with shock without use of any additional external stimuli. In fact, the variation of rates, in all cases, was less after shock had been imposed than before. Furthermore, this control superseded differences due to species or to differing schedules of positive reinforcement.

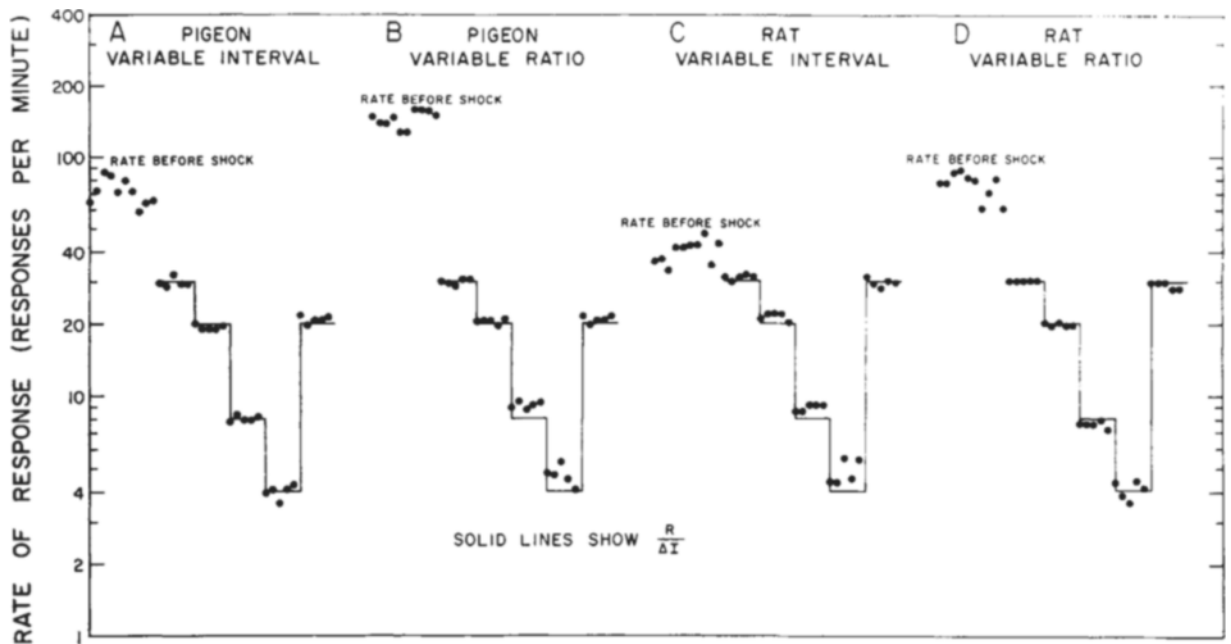


Fig. 1. Rate of responding during the second half of successive sessions (final 15 min) for typical pigeons and rats.

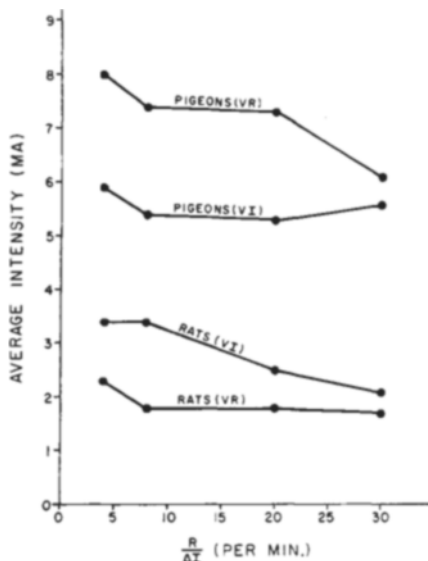


Fig. 2. Average intensity maintained by the four groups as a function of $R/\Delta I$. The intensities were determined from recording millimeters as follows: (1) For each animal, the intensity at the end of each of the last 15 min of the session was read. (2) The median of these 15 readings represented the session intensity for that animal. (3) The median of the five-session intensities at each value of $R/\Delta I$ represented the condition intensity for each animal. (4) The arithmetic mean of the condition intensities for the animals within each group is shown in this figure.

When the rate of responding was constant and equal to $R/\Delta I$, the shock would remain at a constant value. Typically, the rats and pigeons would respond rapidly at the beginning of the session and then slow down to a rate of $R/\Delta I$. Once a given intensity of shock was reached, a rate of $R/\Delta I$ would keep the intensity constant at that value. Even though all rats and pigeons responded at a rate about equal to $R/\Delta I$, they did not all keep the shock intensity at the same value. Each animal, however, was fairly consistent from day to day with regard to its terminal intensity as long as the experimental conditions remained constant.

Figure 2 shows average intensities of shock maintained by the rats and pigeons as a function of R . There was a tendency for the intensity to decrease slightly as R increased. The rats kept the intensity at lower values (ranging from about 1 to 3.5 mA) than the pigeons (ranging from about 5 to 10 mA). There was some overlap in intensity of individual VI and VR pigeons and between VI and VR rats, but no overlap between pigeons and rats.

The intensities of Fig. 2 are higher than those reported as completely suppressing responding with brief pulses. This may reflect either adaptation to the steady shock or the fact that organisms will tolerate higher shock under their control than without control.

DISCUSSION

The suppression observed in these experiments may be a genuine instrumental effect of the punishment or simply interference by elicited

emotional responses. However, if the suppression is emotional interference, it cannot be argued that such interference necessarily increases variability or contributes to transience. With respect to the mechanics of aversive control, it seems that, as with positive reinforcement, titration schedules which provide precise feedback, produce greatest control.

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