Shaping of free-operant avoidance in the wood rat. *Neotoma floridana**

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A shaping procedure was used with wild wood rats to initiate leverpressing under a free-operant avoidance procedure. The wood rats eventually developed very effective avoidance, but much higher shock intensities were required than have been employed with domesticated rats to produce similar behavior. The wood rats did not display warm-up during avoidance, with shocks being rather evenly distributed over time.

The acquisition of lever-press avoidance depends, to a large extent, upon the animal's unconditioned response to electric shock. Animals that display consistent crouching and freezing rarely contact the manipulandum and are not exposed, therefore, to the experimental contingency. While this pattern is sometimes observed in albino rats, it is an almost invariant characteristic of the wood rat *(Neotoma floridana)*.

The present experiment reports the use of a shaping procedure to engender free-operant avoidance in wild wood rats. Keehn & Webster (1968) successfully employed shaping to instate discriminated leverpress avoidance in albino and hooded rats. Terminal performance of the present rats was analyzed in terms of response rates, shock rates, and warm-up effects. Warm-up during avoidance conditioning can be characterized as a persistent tendency by the animal to take a disproportionate number of shocks early in the experimental session. This effect was of interest here because a recent study in this laboratory (Powell & Peck, 1969) found consistent warm-up in domesticated rats, but an absence of warm-up in Mongolian gerbils during free-operant avoidance conditioning.

SUBJECTS

Five adult wood rats *(Neotoma floridana)* were used, all experimentally naive. Three of the rats (1, 2, 3) were trapped locally in the field, while the other two animals (4, 5) were born and raised in the laboratory. The animals ranged in weight from approximately 325 to 450 g. The wood rat, also known as the eastern packrat, belongs to the order *Rodentia*, the suborder *Myomorpha*, and the family *Cricetidae* (New World rats and mice). The animals were housed in individual cages and had free access to water and Purina Lab Chow throughout the experiment.

APPARATUS

A Gerbrands rat test chamber was used. Electric shock was provided by a 110-V ac shock source that included 200K in series with the output, and was scrambled to the grid floor of the test chamber. Data were recorded by digital counters and a Gerbrands cumulative recorder.

PROCEDURE

A free-operant avoidance procedure (Sidman, 1953) was used. Under this procedure, a fixed time period occurs between the presentation of brief electric shocks in the absence of a leverpress (shock-shock interval), and each response

postpones the next shock for a fixed period of time (response-shock interval). In the present case, shock-shock and response-shock intervals were 2 and 15 sec, respectively. The shock duration was 0.5 sec. Response in the presence of shock did not terminate it. Experimental sessions were 2 h per day.

The initial shock intensity was .75 or 1.50 mA. This was increased as required to initiate effective responding, which was defined as 200 responses or more per hour. The usual sequence of shock intensities was as follows: .75, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, and 7.0 mA. Each intensity remained in effect for a minimum of 1 h. When effective responding developed, the shock intensity then in effect and all subsequent intensities were studied for at least 10 h. In addition, shock intensity was not increased until stable avoidance was observed in five consecutive sessions. Successively higher shock intensities were employed until no further improvement in avoidance occurred.

It was not the original plan of this experiment to use a shaping procedure. However, when it became apparent that exposure to the experimental contingencies alone would rarely engender responding,
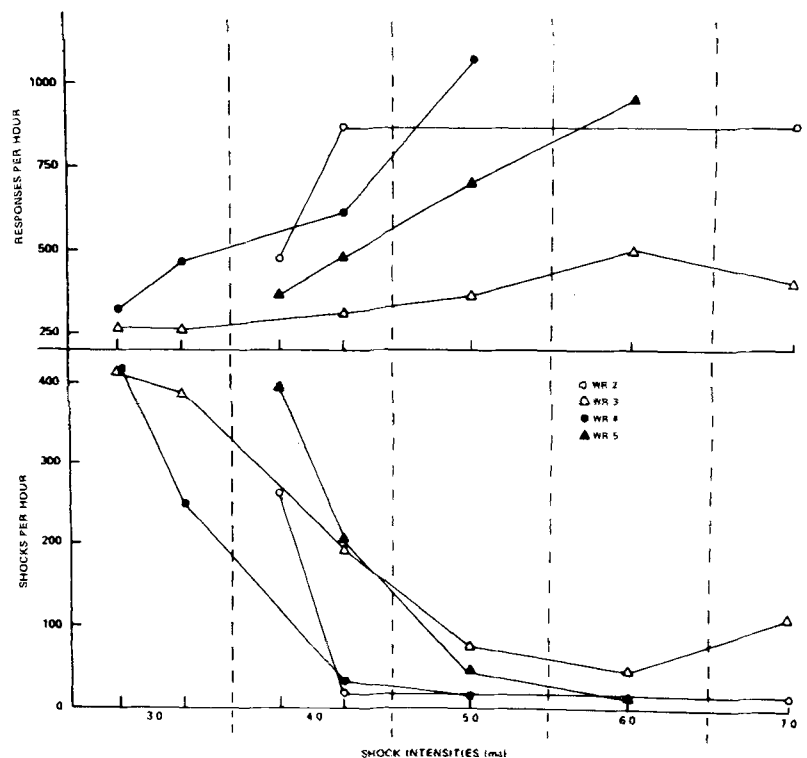

Fig. 1. The performance of each rat following the development of effective responding. Each data point represents the mean performance during the three consecutive 2-h sessions in which the rat avoided most effectively at that shock intensity. Two sets of data points are presented for each rat at the first shock intensity where effective responding occurred. The first set of data points represents the initial session, while the second set represents the most successful performance.

Table 1
The Performance of Each Rat During the Early Stages of Training. The sequence of procedures is indicated numerically.

Subjects	(1) Avoidance			(2) Shaping		(3) Avoidance		
	Number of Hours	Responses Per Hour	Range of Shock Intensity	Number of Hours	Range of Shock Intensity	Number of Hours	Responses Per Hour	Shock Intensity
1	10	1	.75-2.5					
2	9	0	.75-4.0	3	4.0	6	485	4.0
3				2.75	.75-3.0	6	261	3.0
4	5	181	1.5-2.5			6	193	3.0
5	4	21	1.5-3.0	3.5	4.0	6	367	4.0

shaping was introduced. Shaping consisted of reinforcing successive approximations to a leverpress by withdrawing shock for 15 sec. This continued until leverpressing was reliably established.

RESULTS

Table 1, which summarizes the data during response acquisition, shows that four of the five rats learned to respond. One rat (1), which was not shaped, never acquired the response and one rat (4) learned to avoid without shaping. Wood Rat 3 was exposed to shaping immediately, while Rats 2 and 5 were shaped after several hours' exposure to the avoidance contingency. The performance of each rat during the first 6 h following the development of leverpressing is presented

and shows that responding was maintained in all cases.

Figure 1 summarizes the performance for each rat subsequent to the establishment of effective responding. The animals generally responded more and reduced the number of shocks as shock intensity increased. Each of the rats learned to avoid very effectively, with three animals reducing the number of shocks to less than 20/h. Each rat was studied for the following number of hours: 72 (2), 76 (3), 72 (4), 55 (5).

Warm-up effects were analyzed by dividing the first hour of the experimental sessions into three 20-min intervals and determining the number of responses and shocks in each interval. None of the rats
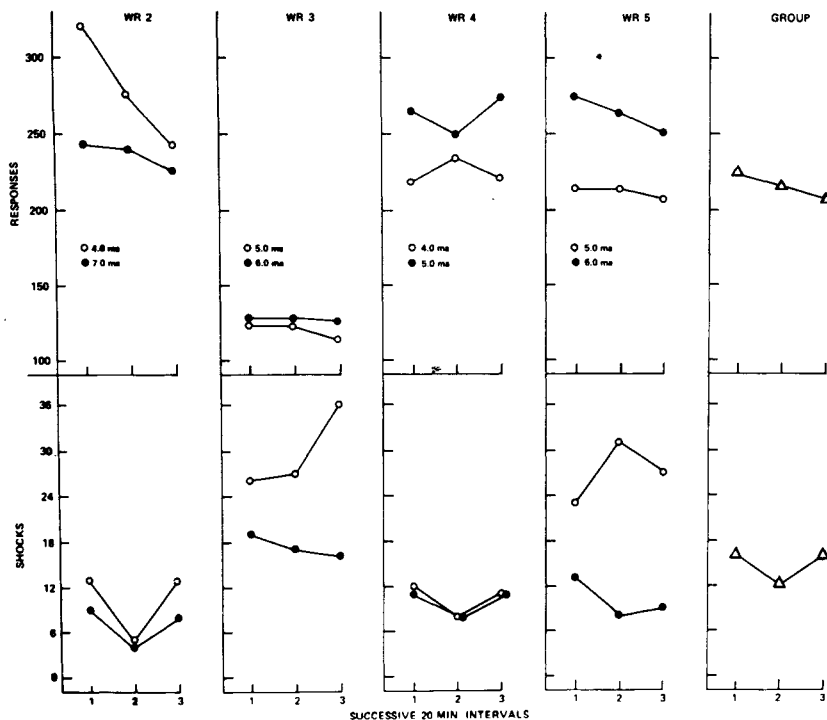

Fig. 2. Individual and group curves showing the distribution of responses and shocks in the first hour of the experimental session. The individual curves are based upon data pooled over six consecutive sessions, at each of two successive shock intensities, during which the rat avoided most effectively. The group curve is the mean of the individual performances.

showed appreciable warm-up at either of the two shock intensities where they avoided most successfully. Figure 2 shows that, as a group, the rats received the same number of shocks during the first and third 20-min intervals of the session, with fewer shocks occurring during the second interval. There was also a group tendency for the number of responses to decrease during each succeeding interval.

DISCUSSION

The major finding of this experiment was that a shaping procedure involving negative reinforcement was effective in training wild wood rats to leverpress in order to avoid unsignaled shocks. The wood rat typically crouches and freezes in response to shock, so that accidental leverpresses rarely occur. When an animal does not behave in such a way that it comes into contact with the experimental contingency, it cannot be expected to acquire the appropriate response.

It is noteworthy that once the response was established in four of the five rats studied, the four developed very effective avoidance. The best performance of the wood rats was generally superior to that of domesticated rats studied in this laboratory (Powell & Morris, 1968; Powell & Peck, 1969). On the other hand, the wood rats performed optimally at much higher shock intensities (4.0-6.0 mA) than are required to produce the best avoidance in albino rats (1.0-2.0 mA) studied under nearly identical experimental conditions. This suggests that more potent motivational stimuli are required to control effectively the behavior of wild than domesticated species.

The wood rats did not show warm-up during avoidance, receiving approximately the same number of shocks during successive 20-min intervals in the experimental session. In this respect, their performance was similar to that of Mongolian gerbils (Powell & Peck, 1969). Albino rats show consistent warm-up in both signaled (Hoffman, Fleshler, & Chorny, 1961) and unsignaled avoidance procedures (Powell & Peck, 1969). In the latter study the albino rats received 60% to 80% of the total session shocks in the initial one-third of the session. None of the wood rats received more than 43% of the shocks in the first interval, and the mean for the group was 36%.

Hoffman et al suggested that warm-up reflects the development of a motivational process resulting from the occurrence of shock itself. Differences in warm-up between albino rats as compared to gerbils and wood rats appear to arise from differences in levels of activation or arousal between domesticated and wild species.

In summary, the results show that wild

wood rats learn to avoid very effectively, even though initial acquisition of the response is difficult because of the animal's unconditioned response to electric shock.

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Pattern of daily water consumption in relation to intake of saccharin solution

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Twelve nondeprived rats were presented with a bottle (B2) containing .25% saccharin solution for 1 h each day in addition to the maintenance water bottle (B1). After 18 days (preshift), the contents of B2 were changed to plain tap water for 6 days (postshift). Intake from B1 in the 2 h preceding the time of B2 presentation increases during preshift while overnight intake decreased, suggesting the emergence of a B1 drinking schedule as intake from B2 increased. However, detailed aspects of the results were not consonant with this possibility. During postshift, intake from B1 returned to the initial preshift level while intake from B2 settled at a much higher level, suggesting the operation of secondary reinforcement.

If a bottle (B2) containing saccharin solution is presented for 1 h each day in addition to the maintenance water bottle (B1) in the home cage of nondeprived rats, the intake from B2 gradually increases to an asymptotic level (Di Lollo & Meyer, 1970). The daily growth of intake from B2 suggests the operation of a learning factor, but the nature of the habit is not immediately obvious. The gradualness of the daily increments could merely represent the development of an association between the sight of B2 and the taste of saccharin or could represent, as suggested by Di Lollo & Meyer (1970), the development of a daily drinking schedule set to maximize the volume of saccharin intake.

The detection of any such schedule would be aided by monitoring the level of water intake from B1, particularly during the daily period just preceding the time of presentation of B2.

In the study reported here, volume of water intake from B1 was measured during an 18-day preshift stage while saccharin intake from B2 climbed to an asymptotic level, and during a 6-day postshift stage when the contents of B2 were changed to plain tap water, the same as B1.

METHOD

The Ss were 12 male albino rats from the colony maintained at the University of Western Australia. They were approximately 120 days old at the beginning of the experiment and were housed individually. All Ss were maintained on ad lib food and water throughout the experiment. All testing took place in the home cages.

The experiment was conducted in two stages: preshift (18 days), and postshift (6 days). In both stages a second bottle (B2) was presented in addition to the maintenance water bottle (B1) always present in the cage. All bottles were fitted with leakproof metal spouts manufactured by Atco Manufacturing Co., Napa, California. During preshift, B2 contained 0.25% (w/v) saccharin solution (sodium saccharin and plain tap water) while B1 contained just tap water. During postshift both bottles contained plain tap water.

The quantity of fluid contained in each bottle was read with a resolution of 0.25 cc from a transparent graduated scale attached to each bottle. Readings from B1 were taken every day at 30-min intervals beginning 2 h before the presentation of B2 and ending 2 h after its withdrawal. With respect to B1, this procedure yielded four daily intake scores for the 2 h before the presentation of B2, two scores while B2 was available, and four scores for the 2-h period following the withdrawal of B2. In addition, an intake score was available for the 19-h period intervening between the last reading on a given day and the first reading on the next day. Daily readings from B2 were taken at the beginning, the middle, and the end of the 1-h period during which B2 was available. This procedure yielded two daily intake scores for B2.

RESULTS AND DISCUSSION

The principal aspects of the results are illustrated in Fig. 1. Missing from Fig. 1, because of widely different scale requirements, is a plot of the mean daily intake from B2 during preshift (the scores, in milliliters, from Day 1 to Day 18 were: 5.4, 8.9, 9.4, 10.0, 11.6, 11.8, 14.3, 15.9, 14.3, 15.6, 21.9, 20.5, 20.9, 21.4, 22.0, 20.6, 18.6, and 17.2). The abbreviations used in Fig. 1 are used in the remainder of this paper in referring to the daily measurement periods.

During preshift the mean *B1 overnight* intake decreased steadily from about 1.00 ml to about 0.75 ml/h, $F(17,187) = 10.64$, $p < .001$. During the same period the mean *B1 before* intake increased from about 1.00 ml to almost 3.00 ml/h, $F(17,187) = 6.69$, $p < .001$. In terms of total daily intake, the increment in *B1 before* matches almost exactly the decrement in *B1 overnight*. In fact, when plotted, the level of total 24-h intake from B1 remains practically unchanged throughout preshift.

Clearly, the regular availability of B2 during preshift brought about a rearrangement in the daily pattern of drinking from B1, with maximum B1 intake occurring in the 2-h period just preceding the time of B2 presentation. This pattern of B1 intake has all the appearances of a drinking schedule culminating at the time of B2 presentation. Indeed, there is a compelling impression of the development during preshift of an FI 24-h schedule from *B1 overnight* through *B1 before* to B2. However, this possibility is disconfirmed by the half-hourly distribution of B1 intake in the 2-h period preceding saccharin availability. Over the last 5 days of preshift, mean *B1 before* intake was high during the first ½-h period