THE RABBIT AS A SUBJECT IN BEHAVIORAL RESEARCH¹

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Domestic rabbits were exposed to a wide variety of variables employed in behavioral research. It was found that: (1) Although food could be used as a reinforcer, the long periods of severe deprivation required to reduce body weight made its use impractical. (2) Water was an efficient reinforcer in that it maintained high rates of behavior after 22 hr of deprivation. (3) Except that rates of responding were higher, fixed-ratio and variable-interval schedules of reinforcement produced patterns of behavior similar to those demonstrated by rats and pigeons. (4) Although the duration of the post-reinforcement pause was a function of the duration of the interval under fixed-interval schedules, scalloping, as defined as a gradually increasing rate of responding between reinforcement, was not evident. (5) When provided with the means to both turn on and turn off intracranial stimulation, the duration of the stimulation and the frequency with which it was turned on and off was a function of the intensity of the stimulation. (6) Electric shock could suppress behavior and maintain escape responding, but would maintain avoidance responding only in a few subjects.

During the nineteenth century the rabbit was a favorite animal in neurological research (Sawyer, Everett, and Green, 1954). Although, in more recent years, the rabbit has continued to be used extensively in physiological and medical research (see, for example, *Biological Abstracts*, 1967), it has been generally ignored in favor of the rat, the pigeon, and the monkey in behavioral research.

The American Dutch breed of rabbit has proved to be an excellent research subject in this laboratory. This is a small breed (an adult male weighs about 2500 g) that can be individually housed in a cage 55 by 25 by 28 cm high. Cages measuring 55 by 50 by 28 cm are available in racks from Harford Metal Products and can be modified to house two animals individually by inserting a wire mesh or Plexiglas divider in the center of the cages. Maintenance of rabbits is similar to that of rats or guinea pigs, but cleaning is somewhat more

difficult because the rabbit tends to spray urine beyond the area covered by the drop pans.

A Lehigh Valley chamber measuring 64 by 34 by 45 cm was found to be an excellent experimental space for this size of rabbit. The response mechanism employed was a standard rat lever (Lehigh Valley Model #1352) mounted 10 cm above the floor of the chamber.

Although food-deprived rabbits would readily learn to respond for a 3-sec access to food, reducing their body weight proved to be a time-consuming task. Approximately 30 days of severe deprivation (5 g of food per day compared to free-feeding of 100 g per day) was required to reduce each of four rabbits to 80% of free-feeding body weight; 40 to 60 days of deprivation were necessary to achieve 70% of free-feeding weight. Similarly, it took 10 to 40 days of free-feeding to regain 90% of free-feeding body weight and 40 to 100 days to reach 100%. Rabbits deprived of food for 22 to 48 hr could not be trained to eat consistently from a food magazine.

In contrast, 22 hr of water deprivation effectively maintained responding when the reinforcer was the delivery of from 0.2 to 0.7 cc of water. Water reinforcement was delivered from a water reservoir located outside the chamber through a solenoid (Skinner Model #V52DB1100) to a 10-cc capacity plastic dish mounted on wall inside the chamber, 9 cm

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above the floor. Both within-session and between-session responding was maintained when subjects were limited to 50 cc of water per day (70 to 250 reinforcements). Shaping a lever response was routinely performed in one or two 2-hr sessions. All subjects responded by grasping the lever in their teeth and depressing it with head movements. Some subjects were trained to depress the lever with their forepaw, but all of these soon reverted to mouth-grasping response topography.

After learning to respond by depressing the lever, the subjects were exposed to several different schedules of reinforcement. As can be seen in Fig. 1, the rabbits responded to fixed-ratio and variable-interval schedules of reinforcement in a pattern similar to that of pigeons and rats. Fixed-ratio schedules resulted in a steady rate of responding until the ratio was completed and reinforcement was delivered. Each reinforcement was typically followed by a post-reinforcement pause, even during small ratios (FR 10). Variable-interval schedules resulted in similar stable patterns of responding except that post-reinforcement pausing was not as evident. The rates of responding, however, were comparatively insensitive to the schedule of reinforcement. FR 10 and FR 25 resulted in rates of about 100 responses per min; FR 150 and VI 30-sec resulted in rates of about 150 responses per min. These high rates were very stable both between subjects and between sessions. As can be seen in Fig. 2, fixed-interval schedules

Fig. 1. Cumulative records of rabbits' responding on fixed-ratio and variable-interval schedules of reinforcement. Each section represents a 5-min segment of a typical session. Reinforcement was 0.5 cc of water delivered at points indicated by the downward pips on the records. The recorder stopped for 3 sec after each reinforcement.

Fig. 2. Cumulative records of a rabbit's responding on fixed-interval schedules of reinforcement. Reinforcement was 0.5 cc of water delivered at points indicated by the downward pips on the records. The recorder stopped for 3 sec after each reinforcement.

produced the same high rate once the subject started to respond. Although the duration of the post-reinforcement pause was a function of the duration of the interval, the rate of responding within the interval was not. Scalping, as defined as a gradually increasing rate of responding between reinforcements, was not evident at any fixed-interval duration scheduled. Subjects that had never been exposed to any other schedule continued to demonstrate this all-or-nothing pattern of responding even after 150 sessions of fixed-interval reinforcement. The similarity of rates of responding across the schedules of reinforcement may have been due to the nature of the response, *i.e.*, shaking the bar after grasping it with the teeth. Response mechanisms that would have excluded this response topography (e.g., a panel requiring depression) were not utilized.

Discriminative behavior was readily obtained with extinction as one component of a multiple schedule. Figure 3 shows the behavior of two rabbits on a multiple FR 1 EXT schedule. In this schedule, short periods of time, during which every response was reinforced, alternated with longer periods when reinforcement was never available. The reinforcement periods had a duration of 2 min and were signalled by the illumination of a

panel light and the sounding of a low-intensity, 1000-Hz tone. The extinction periods averaged 15 min in duration and were identifiable by the absence of the light and tone (as well as reinforcement). By the fifth 1-hr session, almost all responding was occurring during the short stimulus presentations (see Fig. 3).

The rabbit is also suitable for studies involving intracranial stimulation. A rabbit adaptor for stereotaxic instruments is commercially available (Kopf Instruments Model #1240) and an atlas of the diencephalon has been published (Sawyer, Everett, and Green, 1954). In this laboratory, a rabbit was implanted with bilateral monopolar electrodes in the posterior hypothalamus with a third electrode resting on top of the skull and serving as a reference. It was found that the subject would press a lever to receive a 500-msec duration train of 100-Hz biphasic rectangular pulses (0.20-msec pulse duration, 0.10-msec interval between pulses) of 0.35-v intensity either across both deep electrodes or across a deep electrode and the reference electrode. When two levers were arranged so that a response on one lever would turn the stimulation on and a response on the second would turn it off, the subject rapidly learned to alternate responding between the two levers. Figure 4 shows that as the intensity of the stimulation was increased, the total duration of "on" time decreased and the rate of responding on both levers decreased, a phenomenon that has been described in other animals (see

Fig. 4. Patterns of rabbit responding to turn hypothalamic stimulation on and off. Stimulation was a train of 100-Hz biphasic rectangular pulses that could be turned on by a response on one lever and terminated by a response on another. The recording pen was down when stimulation was on, up when it was off.

review by Valenstein, 1964). This phenomenon is generally (but not always) considered evidence of both positive and aversive control (Bower and Miller, 1958; Pliskoff and Hawkins, 1967; but see Valenstein and Valenstein, 1964).

It was possible to bring rabbit behavior under control of the conditioned suppression procedures of Estes and Skinner (1941). In applying this procedure, the bar-press responding of three rabbits was maintained by a VI 30-sec schedule for 0.5 cc of water. A conditioned stimulus (a blinking light that had been determined not to affect ongoing behavior when presented alone) was scheduled to occur three times during the 1-hr session with an average inter-stimulus interval of 15 min (VI 15-min). Each stimulus presentation had a duration of 2 min and was terminated by a 100-msec ac shock. The shock was delivered

Fig. 3. Cumulative records of rabbits' responding on a multiple FR 1 extinction schedule of reinforcement. Every response was reinforced during the 2-min duration FR 1 components (identified by the downward deflection of the stepping pen); no reinforcements were delivered during the extinction components which averaged 15 min in length. The recorder stopped for 3 sec after each reinforcement.

Fig. 5. Cumulative record of an entire conditioned suppression session. The conditioned stimulus was a blinking light of 2-min duration. Shock intensity was 6.5 ma. Responding was maintained by a VI 30-sec schedule for 0.5 cc of water.

through gold wire electrodes subcutaneously implanted in the nape of the neck (Rubin and Azrin, 1967). Figure 5 shows an example of conditioned suppression when shock intensity was 6.5 ma. This level of shock resulted in almost total suppression, though there was occasional "running" into the shock as can be seen just before the first shock presentation in the figure. Lower intensities of shock resulted in intermediate levels of suppression. A warmup effect, characterized by little or no responding during the first few minutes of a session, was typically seen; an effect that has been reported in other species under similar conditions (see, for example, Azrin, 1956; Hake and Azrin, 1965).

Although electric shock stimulation was effective in producing conditioned suppression in rabbits, simple signalled avoidance was very difficult to demonstrate. Even with repeated shocks at short intershock (S-S) intervals, the probability of a subject accidentally hitting the lever and thus terminating the shock train was very low in the comparatively spacious experimental chamber. In an attempt to overcome this problem, a much smaller (12 by 37 by 20 cm) chamber was constructed. The new chamber, small enough to prevent a rabbit from turning more than a few degrees, was fitted with a response bar that extended its entire width. This design guaranteed that a subject's head could never be further than about 8 cm from the bar.

Shock was delivered in the same manner as during conditioned suppression, but at an intensity of 12.5 ma (intensities greater than 12.5 ma were found to be detrimental to the survival of the animal). This high intensity was used because of the lack of visible reaction by the subjects to lower shock intensities. The warning stimulus was the illumination of a panel light and the sounding of a 1000-Hz tone. The warning stimulus was on for the final 10 sec of the 36-sec interval between a response and a delivery of shock (R-S = 36 sec). If no response occurred during the R-S interval, the warning stimulus remained on and shocks were delivered at 5-sec intervals until a response was made (S-S = 5 sec). All responses reset the R-S interval. Sessions lasted 2 hr or until 500 shocks had been delivered. If a subject consistently responded before delivery of the shock that terminated the R-S interval, all shocks could be avoided. If a sub-

ject consistently responded within 5 sec after receiving a shock, it could receive as few as 200 shocks during the 2-hr session. If a subject did not respond at all, it would receive all 500 shocks within the first 40 min of the session and the session would terminate.

Six naive rabbits were exposed to this procedure and all demonstrated escape-like behavior in that they rapidly learned to respond within a few seconds after receiving a shock. However, even after 25 sessions, four of the six subjects were still making an average of 95% (range 87 to 100%) of their responses almost immediately after the first shock delivery, and were receiving about 200 shocks per session. Only 2% of their responses were made during the last 10 sec of the R-S interval in which the warning stimulus preceded a shock. In these subjects, the warning stimulus did not control shock avoidance. The two remaining subjects learned to avoid the shock during the warning stimulus. By the eighth session for one, and the twentieth session for the other, more than 60% of their responses were occurring during the last 10 sec of the R-S interval, and they were receiving fewer than 50 shocks per session. It appears, therefore, that although some rabbits can perform adequately in a discriminative avoidance paradigm, the wide range of individual differences makes them poor subjects in avoidance research.

In spite of the unpredictability of its avoidance responding, the rabbit has some important advantages for specialized areas of behavioral research. The accessibility of its ear veins for intravenous injection makes it valuable for pharmacological studies of behavior. Its comparatively long life expectancy (6 to 8 yr) makes it valuable for long-term studies of mammalian behavior. And, finally, its extreme docility makes it a highly acceptable subject for inexperienced students.

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