A fully automated two-way locomotor training apparatus*

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A fully automated two-way locomotor training apparatus is described. The device employs two bilevel chambers that are separated by a length of straight alley. The rat is dropped from the distinctively cued upper level of one chamber onto the grid floor of its lower level. To escape shock, the rat must leave this lower level, traverse the alley segment, and jump into the upper level of the opposite compartment. Although the animal is required to traverse the same alley in two directions, its terminal response always carries it into a distinctive goal region where shock never occurs. A brief experiment is described that was designed to assess the effectiveness of this device in the acquisition and extinction of a locomotor escape response with rats.

Investigations involving locomotor reactions in the conventional straight alley have been characterized by the necessity of handling and transporting Ss between trials. In addition to their tedious and time-consuming nature, frequent E-S interactions could have at least two undesirable consequences. The first is the possibility that handling itself may have a significant effect on the behavior under consideration. Recent evidence has indicated, for example, that between-trial handling may be aversive inasmuch as rats exhibit a preference for situations in which handling is minimized (Candland, Faulds, Thomas, & Candland, 1960). Second, it is possible that E effects may not be uniform within or across groups, and thus E bias can be introduced.

The recognition of one or more of these problems has led to the development of at least one automated runway designed for use in the study of appetitively motivated behavior (Hanford, Zimmerman, & Leckrone, 1967). This apparatus consists of sections of straight alley arranged in the shape of a square, one leg of which constitutes a common start-goal area. The S is required to traverse the alley and return to the start-goal area where reinforcement can be delivered. Similar devices, used in the study of aversively motivated behavior, involve circular (Mowrer, 1940) or octagonal alleys (Hunter, 1935) divided into a series of compartments, each of which serves as a combination start-goal area. In these devices, as in the common two-way shuttle apparatus, start-goal stimuli are necessarily ambiguous inasmuch as the S is shocked in the presence of cues that must be escaped at one moment and approached at another. Thus, start-goal cues may come to elicit competing tendencies that can retard acquisition and accelerate extinction of instrumental responding (Kruger, Galvani, & Brown, 1969).

The purpose of the present paper is to describe a fully automated, two-way, locomotor training apparatus that employs a trap-door-floor mechanism (cf. Brown, Martin, & Morrow, 1964) to drop the S automatically at the start of a trial from a distinctive goal area into a markedly different starting compartment. This arrangement was intended to minimize the possibility that competing tendencies would become conditioned to the cues of the goal area. In addition, the stimuli produced by dropping might further enhance the distinctiveness of the conditions present at the start of a trial, thereby increasing the possibility that those cues would come to elicit either the locomotor response itself or a response which functions motivationally to potentiate the locomotor tendency during extinction (cf. Whittleton, Kostanek, & Sawrey, 1965). It was hoped, therefore, that this would be a device in which locomotor escape responses could be readily established and maintained for reasonable periods during extinction with little or no E-S contact.

APPARATUS

As the drawing in Fig. 1 indicates, the apparatus consists of two start-goal compartments, one on either end of a straight alley. Initially, the S is placed in one of the trap-door-floored goal compartments, from which it is dropped onto the lower grid-floored start chamber at the beginning of a trial. The entire response sequence involves traversing the alley and jumping approximately 15 cm up into the opposite goal compartment. The floor of the box out of which an animal has been dropped is reset automatically at the start of the next trial, and that chamber becomes the goalbox into which the S must leap to terminate its next response sequence. Since the cues of the goal compartments are distinctive and unlike those of the alley, a marked change in the environment occurs when the S is dropped. While the S must traverse the same alley in both directions, the terminal jumping response always carries the animal into a goal region where shock never occurs.

Both start-goal and alley segments are constructed of plywood, 1.27 cm thick, covered on the inside by thin sheets of stainless steel. The hinged tops of all segments are made from 6.4-mm clear Plexiglas. Each segment rests on its own grid-floor base. All grids consist of 2.3-mm stainless steel rods, spaced 1.27 cm apart, inserted through clear Plexiglas sides, 6.4 mm thick.

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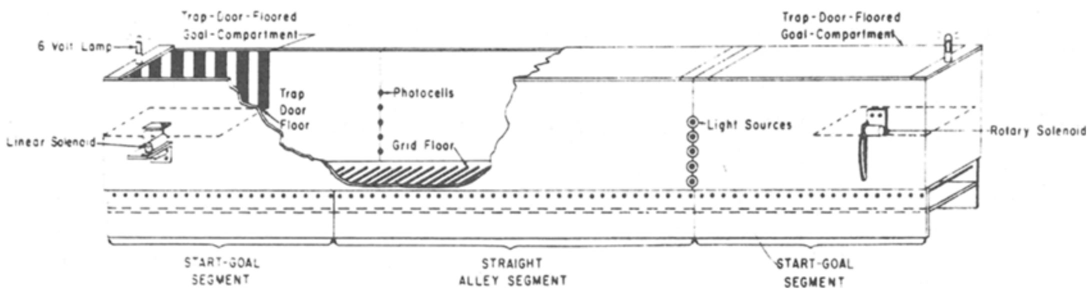

Fig. 1. Side view of fully automated two-way locomotor training apparatus.

Scrambled shock can be delivered separately to the grid bars and stainless steel sides of each segment.

Each start-goal segment is 48 cm long, 12 cm wide, 36 cm deep, and closed on one end. An aluminum flap, 23 cm long and 12.5 cm wide is hinged to one side wall 15 cm above the grid. When in a horizontal position, this flap is perpendicular to the sides and closed end of this segment and serves as the trap-door floor of the goal compartment. Figure 2 depicts an open end view of one of the two identical start-goal segments illustrating the features of the goal and start compartments. The sides and end walls of each goal compartment are covered with a black-and-white striped contact adhesive plastic. A 6-V lamp mounted on the Plexiglas cover above the wall of each upper compartment is turned on from the time the floor of that chamber is reset until it is released. In the present arrangement, therefore, only one goal compartment is illuminated at a time, since one floor is released at the same time the floor in the opposite chamber is reset. The trap-door floor of each goal chamber is held in place by a latch formed by the core of a linear solenoid (Ledex No. 7210-171707-001) that extends through one side wall. The solenoid coil is hinged and spring-mounted on the outside wall in such a

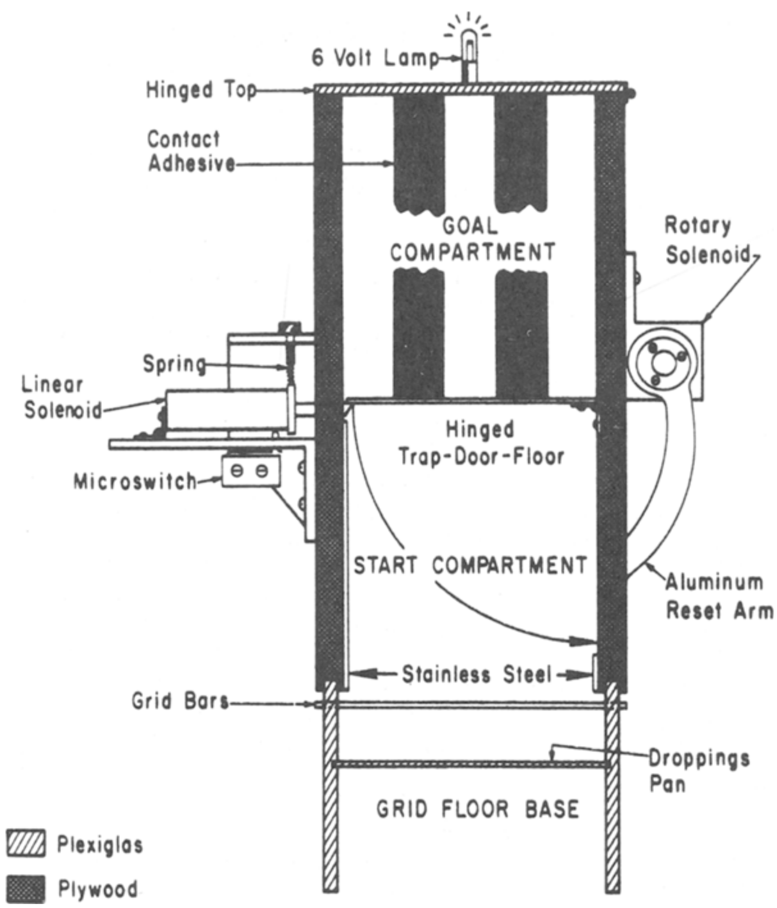

Fig. 2. Open end view of one start-goal segment.

way that the weight of the animal on the trap-door floor exerts sufficient downward force to close the contacts of a microswitch mounted beneath the core of the solenoid. Spring action returns the switch to its normally open position after the animal's weight is removed from the floor. The trap-door floor is released whenever the linear-solenoid coil is energized. A rotary solenoid (Ledex No. 7140-H-3117-082), with recoil spring removed, is mounted on the outside wall of each start-goal segment, opposite the linear solenoid, and is used to reset the flap to a horizontal position. A curved aluminum arm, attached to the core of the rotary solenoid, extends through the side wall and pushes the flap upward to the latch when its coil is energized.

One or more alley segments may be interpolated between the open ends of the start-goal segments. In the experiment presented below, one alley segment was used. It was identical in width and depth to the start-goal segments and was 61 cm in length. Thus, with one runway segment, the length of the alley between flaps is 111 cm. Vertical banks of five series-connected photocells, spaced 3.7 cm apart, are positioned at the junctions of adjacent segments. The lowest photocell in each set is 3.7 cm above the grid floor.

EXPERIMENT

In an attempt to evaluate the effectiveness of this apparatus, an experiment was conducted involving the acquisition and extinction of a two-way locomotor escape response.

Method

The Ss were eight female albino rats, 120-140 days old and weighing 230-260 g at the beginning of the experiment.

All rats were given 10 shaping trials and 40 automated escape trials on the first day, 50 automated escape trials on the second and third days, and 20 automated escape trials on the fourth day. Following the last escape trial on the fourth day, shock was discontinued in the alley and start-goal segments as a conventional extinction procedure. Each rat was run to a limit of 100 extinction trials or to a criterion of failing to complete a trial within 120 sec after being dropped onto the grid. The intertrial interval throughout the experiment was 60 sec. On each trial, starting, running, and jumping times were recorded. Starting time was the time from trap-door floor release until the S reached the first photocell bank at the beginning of the alley segment; running time was the time spent in the interpolated 61-cm alley segment; and jumping time was the time taken to make the terminal response after occluding a photobeam at the end of the alley section.

Shaping consisted of trials on which fully automated conditions were gradually approximated. On the first four shaping trials, a wooden ramp was placed from the grid floor up to the flap of the to-be-entered goal compartment. When the S was dropped from one goalbox, it could escape shock by running up onto the ramp at the opposite end of the apparatus. This procedure was repeated for the next three trials. Scrambled ac shock intensities were 130 V (though 10 kilohms) on Trials 1 and 2, and 110 V on Trials 3 and 4. A similar procedure was used on the last six shaping trials, except that a wooden block was placed under the trap-door floor of the to-be-entered goal compartment in place of the ramp. This block prevented the rat from running all the way under the trap-door floor. On succeeding trials, this block was moved farther and farther under the trap-door floor of the appropriate compartment, being eliminated entirely after Trial 10. The shock intensity on these six trials began at 90 V and was progressively decreased in 5-V increments per trial until 65 V was reached. This value was used throughout the remainder of acquisition. Starting with Trial 11, the trap-door floors were raised and released automatically.

Results

The median start, run, and jump times were determined for each block of 10 acquisition and extinction trials, for every rat, and were converted to speeds in cm/sec. Figure 3 presents mean-median jumping speeds during acquisition and extinction as a function of blocks of 10 trials. Spaces separate the curves obtained from successive days of the experiment and a dashed line connects the last block of acquisition trials, with the first block of extinction trials administered on Day 4. Mean-median jumping speed increased significantly from the first to the last pair of 10-trial blocks during acquisition ($F = 16.96$, $df = 1,14$, $p < .05$). A warm-up-like effect is apparent, however, during the first 3 days of training. Comparisons of mean-median speed from the first and last block of each day indicated that the improvement in performance was significant on Days 1 and 3 ($Fs = 30.14$ and 12.32, $dfs = 1,14$, $ps < .05$), but not on Day 2. The performance decrease from the last block of trials on one day to the first block on the next day was reliable only for the Day 1-Day 2 comparison ($F = 6.15$, $df = 1,14$, $p < .05$). During extinction, jumping speed decreased significantly from the first to the last pair of 10-trial blocks ($F = 12.32$, $df = 1,14$, $p < .05$).

The results of similar analyses applied to the starting and running speed measures indicated that starting speeds increased significantly during acquisition ($F = 4.37$, $df = 1,14$, $p < .05$), while running speeds did not. During extinction, however, running speeds decreased significantly ($F = 70.06$, $df = 1,14$, $p < .05$), but starting speeds did not. Only one rat failed to reach the limit of 100 extinction trials, meeting the extinction criterion after 92 nonshock trials.

DISCUSSION

The results of this study indicate that a locomotor escape response can be established and maintained for a considerable period of time during extinction in an automated two-way runway. It is noteworthy in this regard that each rat completed at least 90 extinction trials. Of the three speed measures examined in this study, only jumping speed changed as a function of trials during both acquisition and extinction phases. Also, a warm-up effect was observed during acquisition only for the jumping speed measures. These comparisons among speed measures indicate that the running and jumping components of the response sequence established in this device are not identically affected by the practice variable. In fact, the performance loss revealed by the jumping measures early in training suggests that jumping is more difficult to acquire than running in this device.

While a relatively large number of acquisition trials was employed in this experiment, additional work has suggested that reasonable levels of extinction performance can be obtained with fewer than half this number of training trials. More acquisition trials may be required in this apparatus, however, than in conventional straight alleys for comparable extinction performance.

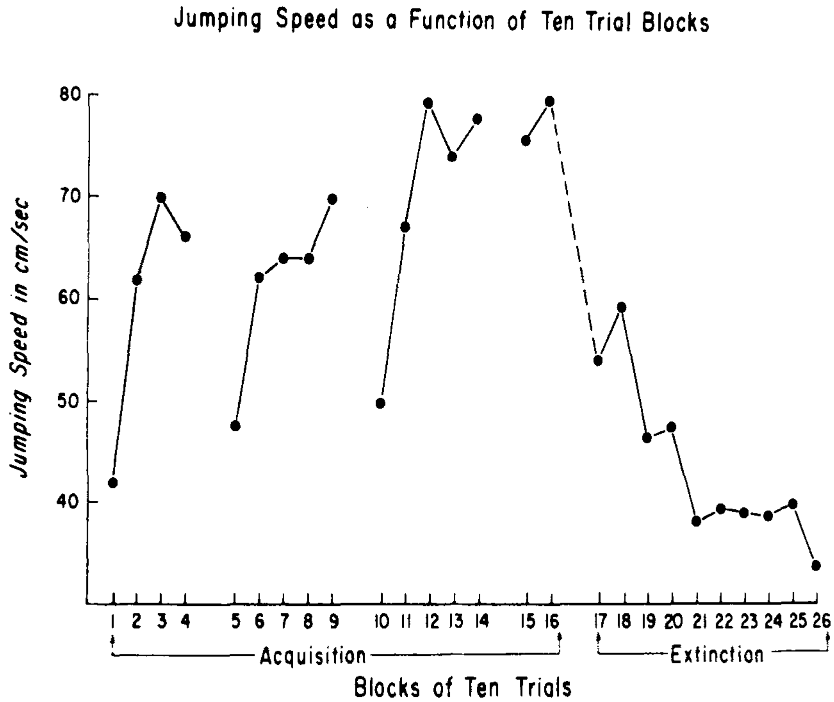

Fig. 3. Mean-median jumping speed as a function of 10-trial blocks during acquisition and extinction.

This automated alley may also be used for studies employing avoidance contingencies. In fact, without an interpolated alley section, the adjacent start-goal segments form an enclosure in which typical shuttlebox studies can be performed. Preliminary research has indicated that the locomotor avoidance response is readily acquired in this apparatus and is markedly resistant to extinction.

In short, the apparatus described herein appears to provide an alternative to the conventional straight alley as a training device for the study of aversively motivated locomotor reactions. It has been remarkably trouble free, is versatile in function, and offers the advantage of little or no E-S interaction.

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