An efficient one- and two-way avoidance apparatus capable of producing identical one- and two-way avoidance performance

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A platformed one- and two-way avoidance apparatus is described in which the need for handling the subjects in the one-way task is eliminated and the two-way task is very quickly learned. The acquisition curves obtained for these two tasks are indistinguishable.

Discriminated one- and two-way shuttle avoidance have been extensively used in the medical and behavioral sciences. They have been particularly useful in isolating the neuroanatomical bases of emotional behavior in the subcortical structures (Bohus & DeWeid, 1967; McCleary, 1961; Papez, 1937). Interest in these tools has grown in recent years with the discovery that some subcortical, especially the limbic, structures differentially affect these two seemingly similar behaviors (Olton, 1973).

Despite their obvious utility in scientific research, both procedures involve undesirable aspects. The standard one-way avoidance responding, for example, although quickly obtainable, entails tedious and often troublesome manipulations such as handling the subjects after each trial. In this manner they are transported from the safe to the shock side of the apparatus. Two-way shuttle avoidance conditioning, on the other hand, involves a reverse difficulty: although the apparatus in this case may be easily automated, the subjects normally are run some hundred or more trials before a high rate of learning is achieved. The problem, apparently, is that rats tend to freeze when required to go the location where they were previously shocked. Handling of the subjects in the one-way task and the difficult nature of the two-way task involve greater labor and more experimenter time.

This report describes an apparatus and the corresponding procedures in which both of these difficulties were overcome.

METHOD

Subjects and Apparatus

A total of 12 male hooded rats, 3-5 months old, were used. The subjects initially received 2 weeks of daily handling.

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Figure 1. A cut-away drawing of the main features of the automated one- and two-way avoidance apparatus; (A and B) reversible motors to which pinions are attached, (C) movable walls, (D) platforms, 1.3 cm above the grid floor, (E) racks attached to platforms and walls. Only the middle portion of the box was used in the experiment.

The apparatus consisted of a flat black Plexiglas chamber (51 x 23 x 23 cm high, i.d.) with a dark Plexiglas top and an electrically chargeable grid floor, made of .19-cm stainless steel rods, 1.9 cm apart, center to center (Figure 1). Each half of the floor could be independently charged. Inside the chamber, two movable horizontal platforms (D), 1.3 cm above the floor, and two movable end walls (C) could be independently slid along the side walls from one end to center of the chamber. The end walls functioned as barriers when placed, one at a time, in the latter position. When completely pushed in, each platform extended from one end of the chamber to a point 1.3 cm from the center line, which was demarcated by a row of three 2.5-W lights, 3 cm below the grid floor and perpendicular to the side walls. The center light was continuously illuminated, but the other two, equidistant from it by approximately 4 cm, functioned as the warning signals (WS). The shock intensity was about 2.2 mA from an ac constant-current shock source.

Experimental manipulations were automated through several microswitches and a set of Grason-Stadler relays and timers. Trials were terminated (immediately following subject's response) by a push-button switch manually operated by the experimenter. The movable components of the apparatus were driven by silent reversible ac Bodine motors, 9.3 rpm, by means of racks and pinions attached to movable components (C and D in Figure 1) and motors (A and B in Figure 1). Motors were mounted in pieces of Plexiglas bolted on both sides to two metal rods connecting one side wall to the other through the slots in the Plexiglas pieces. Pinions attached to motors could be adjusted for their positions relative to racks by accordingly adjusting positions of the Plexiglas pieces holding the motors.

Figure 2. Top half—Position of the subject (Group 1) relative to various components inside the experimental chamber (1) just prior to start of a trial, (2) during onset of the WS light (not shown in the drawing) under the grid floor, (3) following the response (escape or avoidance) during the ITI, and (4) just prior to the next trial. Bottom half—Position of the subject (Group 2) relative to various components inside the experimental chamber (1) just prior to start of a trial, (2) during onset of the WS light, (3) following the response (escape or avoidance) during the ITI, and (4) during onset of the WS light on the following trial. Circles represent the grid floor. Sizes of various components shown in these drawings are not proportional to sizes of actual components of the apparatus.

Procedure

Four groups of three randomly assigned rats were used. Rats in Group 1 were trained in a one-way discriminated avoidance, while the other three groups involved two-way discriminated shuttle avoidance conditioning. With one platform removed, the one-way task consisted of running from the grid floor onto the platform in the opposite side, under standard one-way active avoidance procedures. Once on the platform, however, the subject was not transported to the original side at the end of the intertrial interval (ITI) as it is normally done. Instead, it was transferred to the grid side by gently sliding the appropriate end wall over the occupied platform toward the opposite end of the chamber (wall displacement time = 8 sec). The next trial started 5 sec later when the appropriate WS light under the grid floor was turned on and, simultaneously, the same wall moved back over the platform to its original position at the end of the chamber. The sequence of events in this group is presented in the top half of Figure 2 in terms of relative positions of the subject, platforms, and walls at various stages of a single trial.

Both platforms were used for the other three groups. Group 2 differed from Group 1 in that subjects in the former group were not pushed to the grid side of the apparatus. Instead, at the end of the ITI, the platform was pulled out from under the subject and, 5 sec later, the wall at the center moved back to its end position, thus exposing the unoccupied platform, and the subject was required to enter from the grid floor onto the platform which now covered the grid floor on the opposite side of the chamber. If such a response was not made within duration of the WS, shock was turned on until the subject was entirely on the platform. Once on the platform following an escape or an avoidance response, the subject was confined during the ITI by placing the appropriate end wall at the center of the chamber (wall displacement time = platform displacement time = 8 sec). These manipulations are graphically represented in the bottom half of Figure 2 in terms of positions of the subject, platforms, and walls, at various stages of a single trial.

The next trial consisted of exactly the same sequence of events, but in the opposite direction. In Group 2, therefore, each trial started following removal of the platform from beneath the subject, followed, 5 sec later, by onset of the appropriate WS light, and simultaneously, backward displacement of the wall at center to its

original end position, which, in turn, exposed the to-be-entered platform.

Group 3 differed from Group 2 only in that no platform was employed for Group 3. The avoidance responding for this group, which was the analogue of a conventional two-way shuttle task, consisted of running, within the WS duration, from one grid side to the other. A graphical representation of events in this group would be identical to that presented in the bottom half of Figure 2 except that no platform would have been used. Subjects in Group 2 and Group 3 were given 50 trials in a single session, while Group 1 received a single session of 30 trials.

Conditions in Group 4 consisted of a within-group comparison of the platform and no-platform procedures as administered, respectively, in Groups 2 and 3. The first 50 trials received by subjects in Group 4 were divided into two consecutive 25-trial blocks of no-platform and platform conditions, in that order. The final 10 trials consisted of a reversal to the original condition, i.e., the no-platform condition.

The WS duration was 8 sec, and the ITI duration was 35 sec for all subjects in all groups.

RESULTS AND DISCUSSION

Figure 3 presents the results of individual subjects in terms of avoidance responses as a function of blocks of five trials. All subjects in Group 1 similarly quickly reached the 100% level of avoidance performance. Such rapid acquisition is consistent with avoidance learning under conventional one-way procedures. Group 3, also expectedly, showed the usual trend found in conventional two-way shuttle learning. Of the three subjects in this group, only one, R5, may be said to have shown any acquisition at all. Group 2, on the other hand, was the most interesting. Performance in this group was indistinguishable from that of Group 1. Note that the avoidance task in this

group was two-way in that it required the subject to return to the spatial locations of previous shocks. Yet the three subjects in this group readily acquired a perfect level of performance. The profound effect of the platform condition is particularly apparent in the performance of the subjects in Group 4; avoidance performance was almost instantaneously improved when the platform was introduced on Trials 26-50, whereas it dropped to a low level again as soon as the platform was withdrawn. These results are consistent, although not identical, with those of Kruger, Galvani, and Brown (1969), who reported a significant improvement in two-way shuttle avoidance learning when subjects were required, on each trial, to enter a retractable compartment (the floor, walls, and ceiling). A one-way avoidance control group was not employed in that experiment, however, so that a direct comparison between retractable compartment group and one-way group performances could not be made.

The near identity of performance of Group 1 and Group 2 in the present experiment raises some interesting questions: What factors differentiate the one-way task from the two-way task? What are the experimental conditions sufficient and necessary for avoidance behavior characteristic of each task? The answers to these questions are particularly significant because of the apparent differential effects of brain damage on these two shock-motivated emotional behaviors (Olton, 1973). In view of the present results, however, the previously reported functional distinctions between subcortical structures on the basis of usual differences in one-way and two-way emotional behaviors suddenly becomes questionable. Finer parametric analysis of these avoidance tasks is obviously needed.

On this account, the present apparatus may prove to be valuable by allowing further isolation of factors differentially involved in one-way and two-way avoidance behaviors. For example, by making the platform available to subjects both at the start of trials and during the intertrial intervals, only at the start of the trials, or only during intertrial intervals, independent and joint contribution of a safe place during each of these intervals may be measured. Similarly, assuming that platform removal may function as a directional cue, by properly manipulating the speed and the manner of removal of the platforms, the role of directional cues may be studied. Others (e.g., Theios, Lynch, & Howe, 1966) have already pointed out the importance of directional cues in facilitating two-way avoidance. Yet no systematic study of such variables has been done. The absence of an appropriate apparatus may, at least partly, explain such a vacuum.

Of particular interest is the utility of the present apparatus for studying freezing responses at the start of two-way avoidance trials. By manipulating the time interval between the removal of the platform and the

Figure 3. Avoidance frequency in blocks of five trials: Group 1, one-way avoidance; Group 2, two-way platformed avoidance; Group 3, two-way no-platform avoidance; Group 4, two-way avoidance with the sequence, no-platform condition during Trials 1-25, platform condition during Trials 26-50, and no-platform condition during Trials 51-60.

start of the next trial in conjunction with the presence or absence of the safe platform in the to-be-entered compartment, the role of, as well as the necessary conditions for, initial freezing responses may be investigated. Wahlsten and Sharp (1969) have shown that freezing may be of primary importance in deteriorating two-way avoidance learning.

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