Shuttleboxes, Skinner boxes, and Sidman avoidance in rats: Acquisition and terminal performance as a function of response topography

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Two studies compared the Sidman avoidance performance of rats in shuttleboxes and Skinner boxes during both acquisition (Experiment 1) and terminal performance (Experiment 2). During acquisition, shuttle avoiders reached asymptotic response rates and near-zero shock rates by Session 3. In contrast, three equivalent ½-h sessions in the Skinner box resulted in virtually no acquisition, and after six additional sessions, shock rates were still over 4/min. Comparison of Ss with extended experience showed substantially sharper temporal discriminations and lower shock rates in the shuttlebox. A "species-specific defense reaction" hypothesis was invoked as a possible account for the superior performance of the shuttlebox Ss.

Historically, the shuttlebox apparatus and the free operant paradigm have been almost totally divorced in the study of avoidance behavior. The use of the former has been confined almost exclusively to the signaled, discrete-trial, secondary escape contingency type of avoidance with the associated between-group design and statistical methodology, while the latter has been associated with the free responding, unsignaled, leverpress type of avoidance with its reliance on within-S design and single organism methodology. Exceptions to this do exist (Black & Morse, 1961; Grossen & Bolles, 1968; Riess & Farrar, in press, a, b) but are not as yet employed on any routine scale. Consequently, comparisons of the shuttlebox and Skinner box on any major dimensions of Sidman avoidance are lacking.

In previous studies (Martin & Riess, 1969; Riess & Martin, 1969), a free operant avoidance situation (Sidman, 1953) was employed while the more traditional shuttlebox apparatus was retained. The shuttlebox produced considerably faster acquisition than normally obtained with the leverpress. Grossen & Bolles (1968) reported that shock rates in the shuttlebox were considerably lower than for the leverpress, and this has been confirmed by separate experience with both types of apparatus in this laboratory (Riess, 1970; Riess & Farrar, in press, b).

The purpose of the present experiments was to compare formally free operant avoidance in the shuttlebox and Skinner box under otherwise identical parameters during both acquisition and terminal performance.

EXPERIMENT 1: SIDMAN AVOIDANCE ACQUISITION AS A FUNCTION OF RESPONSE TOPOGRAPHY

Subjects

Ten naive female albino Wistars from the Galesburg home colony were raised in standard group cages and then housed individually at 72 days of age when the present experiment began.

Apparatus

The experimental chamber was a Model E 3125B-100, 29 x 25 x 20 cm, two-lever Skinner box, of which only the right bar was operative for this experiment. The bar was 1 cm thick, 6 cm wide, projected 1 cm into the box, and located 9 cm above the grid. A 32-g dead weight was required to depress it over a 2-mm excursion to produce a response. The chamber was housed in a Model E 3125AA-3 sound-attenuating chest. Programming was accomplished by a solid-state

Fig. 2. Sidman avoidance shocks/minute. The open figures represent Skinner box Ss. The horizontal lines indicate the number of shocks due (S.D.) as scheduled by the S-S and R-S intervals.

Series 1200 modular programming system with a 1231 control panel and a 1231-2 plug board. Additional equipment included a Model 901B white-noise generator, a Model E-1064GS combination shock generator and scrambler, a 1208 power supply, a Model 2138 three-channel cumulative digital printer, and a Model 1209 28-V power supply. Specific modules used for programming were two 100-sec timers, two 10-sec timers, a S station interface, an AND gate, an OR gate, and an output control. Three cumulative counters, one timing session length, another counting responses, and a third counting shocks, were also in use. The printout counter recorded interresponse times on one channel and shocks preceding each response on another. All equipment

was from Grason-Stadler Co., except for a Dayton Co. Model 1C939 blower which circulated fresh air into the sound chest.

The shuttlebox has been described in detail previously (Riess, in press), and the combination shock generator and scrambler, white-noise generator, and air fan were identical to those used with the Skinner box.

Procedure

Five Ss each were assigned to either a hurdle-cross or leverpress group at otherwise identical parameters. Two litters (Ns = 6, 4) were split so that each litter was represented equally in both experimental groups. The Ss received nine daily ½-h sessions of Sidman avoidance. Each response postponed the next shock 20 sec (R-S interval), and shocks followed each

other every 5 sec (S-S interval) in the absence of a response. The shock intensity was 2 mA, and the shock duration was .2 sec. The white-noise level was set at 88 dB for both groups so that it would mask the auditory feedback from the leverpress and effectively deprive the Skinner box Ss of the advantage of a conditioned reinforcer not available to the shuttlebox Ss.

Results

The data are presented as responses/minute (Fig. 1) and shocks/minute (Fig. 2). All five shuttlebox Ss responded in the first session at a rate which would have been sufficient to avoid 100% of all shocks due if responding had been ideally distributed. The corresponding rate (3+/min) in the Skinner box was not reached until the ninth session. Asymptotic response rates were reached in the shuttlebox by Session 3 and were not even approached in the Skinner box after nine sessions. The hurdle cross Ss showed their only rate increases between the first session and either the second or third sessions and, following Session 3, began to respond more slowly but *without* any corollary increases in shock rates. In contrast, the Skinner box Ss improved only slowly (Sessions 2-5) until they achieved a rate capable of avoiding most or all of the shocks scheduled by a previous shock but few or none of the shocks scheduled by the R-S interval. When this level of avoidance was reached, the rates in the Skinner box reached a "plateau," and little further progress was made toward the acquisition of responding during the R-S interval during Sessions 6-9. Apparently there are *two* nominally distinct acquisition processes in Sidman avoidance, the first necessary for avoiding shocks scheduled by the S-S interval and the second for avoiding shocks scheduled by the R-S interval.

This explanation for the response rate plateau in the Skinner box (Sessions 6-9) is confirmed quite dramatically in Fig. 2, which shows that the leverpress Ss in Sessions 6-9 continued to be shocked at a rate just slightly above that which would have occurred if every response followed the delivery of one shock at the end of every R-S interval. In contrast, the shock rates in the shuttlebox reached their terminal levels by Session 3 and remained at these near-zero levels for the duration of the experiment.

EXPERIMENT 2: SIDMAN AVOIDANCE TERMINAL PERFORMANCE AS A FUNCTION OF RESPONSE TOPOGRAPHY

Subjects and Apparatus

The Ss were six terminal avoiders

with extensive previous experience. The three shuttlebox Ss were holdovers from a long-term study (Riess, 1969) with 4 months of hurdle-cross avoidance experience under parameters identical to those used in the present experiment. The three Skinner box Ss had about 5 months of leverpress experience at $R-S = 20$ (Riess, 1970).

The apparatus consisted of a modified Miller-Mowrer shuttlebox, a Grason-Stadler shock source and scrambler, a white-noise generator, and an air blower, all described previously (Riess, 1969). The Skinner box was identical to that in Experiment 1.

Procedure

Immediately following the conclusion of the earlier two experiments, all six Ss were given 1 month of avoidance sessions at the parameters used in Experiment 1. Interresponse time (IRT) data for the final 4 days of this period were taken as a representative index of terminal performance in both types of apparatus.

Results

The data are presented (Fig. 3) as percentage of responses per 4-sec IRT block rather than as conditional probability curves, as it was felt that the latter practice would obscure the sharp drops in responding which occurred in the later segments of the R-S interval. The most striking aspect of the shuttlebox data was the sharp, discontinuous rise in responding which occurred at the midpoint of the R-S interval, with 91.6% of all responding occurring in the last 10 sec (not shown). The mean distribution for the Skinner box Ss for the six IRT blocks scarcely deviated from the 17% which would be predicted on the assumption of random responding. Although S 35, taken individually, did show a decisive temporal discrimination, this was achieved only at the expense of the highest shock rate of all six Ss. The far right-hand column shows that three of the four Ss with the lowest percentage of IRTs exceeding the R-S interval were hurdle crossers. The fact that this superior shock avoidance occurred in spite of lower response rates demonstrated a vastly greater efficiency of response spacing in the shuttlebox.

DISCUSSION

Possibly the most important finding from the two combined experiments was the reversal in the relative response rates in these two types of apparatus which occurred somewhere between acquisition and terminal performance. During acquisition, response rates were markedly higher in the shuttlebox, but by the time stable terminal response rates emerged, shuttlebox avoiders were responding at

Fig. 3. Percent of total responses per 4-sec IRT blocks for six terminal avoiders. Mean distributions are separately presented for each apparatus.

lower rates while at the same time avoiding a higher percentage of shocks.

One possible account of the present results has been recently advanced by Bolles (1970). According to this formulation, the effect on an organism of exposure to an aversive laboratory situation is to reduce the effective behavioral repertoire (at least temporarily) to a narrow range of species-specific defense reactions (SSDRs). The speed of avoidance acquisition is then held to a direct function of the compatibility of these innate reactions with the topographical requirements of the avoidance response (R_A). No specific hierarchy of such reactions (in terms of initial probability) for rats is offered in this account, although the classic triad of flight-fright-flight reactions is repeatedly alluded to. If one can assume that the flight response is the dominant one in rats and, further, that running is the most probable flight response (abortive jumping and climbing being two other possibilities), then the results of Experiment 1 would follow. The SSDR of random running is more likely to produce a hurdle cross in the shuttlebox than it is to produce a leverpress in the Skinner box because of the greater width and lower height of the hurdle. The probability of reinforcement would therefore be correspondingly greater in the shuttlebox so that learning would proceed faster.

A closer look at the Bolles account,

however, reveals some ambiguities. The accuracy of the prediction generated for the present results depends entirely on two assumptions: (1) flight responses do, in fact, constitute the dominant SSDR for rats; and (2) running is the specific form in which the flight response will appear. While casual observation of rats receiving shocks would certainly lead one to believe that this is indeed the case, it is not clearly stated as part of the theory, nor are there any data known to the author to substantiate it. This assumption is crucial for the present study because there are two other possible assumptions permitted by this account: (1) fright responses (i.e., freezing) are dominant; and (2) fight responses (i.e., pseudoaggressive and aggressive SSDRs) are dominant. These other assumptions generate quite different predictions. If the assumption were made that freezing responses were dominant, one could predict no differences, since immobility is equally incompatible with both leverpressing and hurdle crossing. If we assume that the pseudoaggressive (threat) and aggressive SSDRs are dominant, one could actually make a good case for predicting superior learning in the Skinner box. In the first place, the classic pseudoaggressive threat response in rats which involves rearing with the forepaws extended comprises a posture almost made to order for the barpress but one which would be highly incompatible with the hurdle

cross. Secondly, the emission of genuinely aggressive responses in these two situations (i.e., grid and manipulandum biting) would favor faster learning in the Skinner box because lever biting does, in fact, postpone shocks at least part of the time, whereas hurdle biting never does. What apparently is needed in order to make an unambiguous prediction from the Bolles account about the present study is basic data on the relative probability of flight, fright, and fight SSDRs in rats (as well as other species) in some situation in which *all* SSDRs are ineffective in postponing shock. If the primacy of the running SSDR could be established by such a study, then the prediction of the present results would be unequivocal.

Although currently untested with studies using comparative apparatus which contain comparison data on relative probability of various types of SSDRs, there are scattered studies with rats which support the SSDR hypothesis, given the assumption that the dominant SSDR is running. Keehn (1967) has shown that avoidance acquisition in a wheel-turn manipulandum operated by running is faster than that obtained with a leverpress apparatus. Nakamura & Anderson (1964) have shown that avoidance behavior in a shuttlebox is superior to that obtained in a wheel box. The latter results are compatible with the former in that the wheel in the Nakamura & Anderson apparatus was operated *externally* and thus penalized the running SSDR relative to

the same wheel operated internally. Fontaine, Beaujot, Didelez, & Leclercq (1966) have shown that Sidman avoidance acquisition in rats in a standard leverpress apparatus is inferior to that found in a specially constructed circular alley permitting a running response. More indirect support for the SSDR hypothesis can be found in studies manipulating response topography for avoidance behavior within the same apparatus. For example, Bolles (1969) found that rats avoided nearly 100% of all shocks in a running wheel apparatus when the avoidance response was running but only about 50% when the avoidance response was rearing. The results of all four of these studies taken together with the present one can be summarized in a single generalization that any apparatus and/or topography requirement compatible with a running response in rats will produce faster avoidance acquisition than any arrangement which is incompatible with this response.

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