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The shuttle-avoidance response chains of rats

ALBERT E. ROBERTS
Catawba College, Salisbury, North Carolina

Three female hooded rats received free-operant avoidance training that incorporated a shuttle requirement. The rats' activities during the final portions of Sessions 5, 10, and 15 were systematically analyzed. The rats showed minimal within- and between-subject differences in their shuttle-avoidance response chains: They walked across and beyond the midline, paused, turned, and again walked across and beyond the midline. Comparisons between shuttle- and leverpress-avoidance response chains are offered.

Work in my laboratory currently is directed toward documenting the behaviors of rats during the shock-postponement period that is provided by a free-operant avoidance schedule (Sidman, 1953). An initial report on this work (Hann & Roberts, 1984) indicated that when faced with a leverpress-avoidance requirement, rats incorporate that criterion response into a more general stream of repetitive activities. That is, a major characteristic of the behavior of rats who become proficient in shock avoidance is a prominent avoidance response chain (see also, Roberts, 1985). In one common chain, a rat walked on, across, and a few steps away from the lever. After remaining in a prone position, the rat turned and retraced its steps over the lever to pause in a prone position on the opposite side of the chamber.

In describing these activities at a professional meeting, I commented that the rats showed "shuttle-type" avoidance response sequences, in reference to the tendency of rats to travel back and forth across the lever. A colleague noted later that my descriptor, "shuttle-type" response sequences, could easily refer to behaviors generated in a shuttlebox apparatus and that drawing a parallel between leverpressing and shuttle behaviors, albeit unintended, was premature. The point was well taken, as we have little documentation on the rat's activities within the free-operant shuttle-avoidance circumstance.

This study was undertaken to provide this documentation. Rats were given 15 90-min sessions of free-operant shuttle-avoidance training; Sessions 5, 10, and 15 were selected for observational analysis. Rats typically show rapid mastery of free-operant shuttle avoidance (Riess, 1971; Riess & Farrar, 1972), and previous work in our laboratory (Roberts, & Porter, 1976) confirms that this number of training sessions is more than sufficient to ensure asymptotic levels in shock-avoidance measures.

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METHOD

Subjects

Three female hooded rats, obtained from Blue Spruce Farms, New York, served as subjects. The rats were experimentally naive and weighed about 190 g at the beginning of avoidance training.

Apparatus

An LVE shuttlebox (Model 146-04, with 45 × 20 × 20 cm interior dimensions) was used. The shuttlebox had a toggle grid floor, and each side consisted of 20 stainless steel rods (2 mm diameter) spaced 9 mm apart, parallel to the width of the box. A deadweight of 32 g (0.32 N) on the grids 10 cm from the toggle center was required to close the microswitch. A 1-mA, 0.33-sec shock was delivered to all grids and metal sides of the shuttlebox from a constant-current shock generator (BRS, SG-901) via a scrambler (BRS, SC-901). A Chicago Miniature lamp assembly was placed in the center of each endpanel (14 cm above the grid floor) to serve as houselights. The houselight in the postshuttle side was turned off briefly (0.3 sec) to provide a feedback stimulus; the houselight in the preshuttle side remained on.

The shuttlebox was placed on a table in a small room that, except for the houselights, had no illumination source. The houselights provided sufficient illumination for videotaping. Electromechanical programming and recording equipment was placed in an adjacent room.

Procedure

Under the free-operant avoidance schedule, each shuttle response (R) postponed shock (S) for 15 sec (the R-S interval) and provided the feedback event. In the absence of the response, shock was given once every 5 sec (the S-S interval). Each daily session was 90 min.

The number of responses and unavoided shocks in each session was recorded automatically. The final 25 min of Sessions 5, 10, and 15 were videotaped for later analysis using the behavioral categories developed by Hann and Roberts (1984): crouching position (CR), the rat in a relatively immobile, semierect position; prone position (P), the rat in a relatively immobile position with all four paws in contact with the grid floor; standing position (S), the rat in a relatively immobile position of standing erect; turning response (T), the rat's rotating its body position by at least 90°; walking response (W), a locomotor response resulting in the rat's changing its location in the shuttlebox. Two observers separately viewed the videotapes to obtain frequency counts of each activity during the R-S interval as well as to note the serial position of each activity within a sequence. Activities produced by unavoided shock were not counted. The videotapes then were reviewed by the experimenter to verify the accuracy of the transcript obtained for each rat.

RESULTS AND DISCUSSION

The response and shock rate values of each rat from Sessions 5, 10, and 15 appear in Table 1. Response rates

Table 1
Response and Shock Rates (per Minute) for the Three Rats

Rat		Session 5	Session 10	Session 15
423	R/M	5.00	5.20	5.20
	S/M	0.98	0.74	0.72
424	R/M	8.30	8.50	7.80
	S/M	0.29	0.53	0.50
425	R/M	5.40	5.60	6.10
	S/M	0.91	0.36	0.45

obtained for each rat in Session 5 were comparable to their respective rate values obtained in Sessions 10 and 15. Shock rate values reached steady state levels between Sessions 5 and 10. For purposes of discussion, the 3 rats had become proficient in shock avoidance.

Table 2 highlights frequent shuttle-avoidance behavior chains present during the R–S interval. The chains that appear in this table accounted for at least 10% of the total number observed from each side of the shuttlebox for each rat in a session. That is, right-side and left-side values are presented separately. Table 2 shows that (1) each rat showed a prominent avoidance response chain in Session 5; (2) the prominent avoidance response chain that was observed was the same for each rat (i.e., W-P-T-W_2, although this chain was observed less often for Rat 424 on the left side of the shuttlebox); (3) this avoidance response chain continued to be prominent in the subsequent sessions; and (4) following Session 5, this prominent avoidance response chain characterized avoidance behavior in each side of the shuttlebox. Moreover, the total number of activity sequences (*N*) for each rat and the number of qualitatively different sequences (*k*) remained unchanged over the three observation sessions.

In the prominent W-P-T-W_2 shuttle-avoidance response chain, the rat walked (W) into the postshuttle side of the box to stop in a prone (P) position in a corner with its body parallel to the endpanel. The rat subsequently turned (T) and walked (W_2) from the preshuttle side to stop in the diagonally opposite corner of the postshuttle side. Thus, the W_2 component to one chain became the W component of the subsequent chain. Those other chains that were observed (mainly in Session 5) consisted of variations on this prominent chain. That is, after walking into the postshuttle side, Rat 424 emitted a crouching (CR) or standing (S) response instead of stopping in a prone position. In the W-P-W_2 chain of Rats 424 and 425, the rats turned toward the diagonally opposite corner of the postshuttle side as part of the walking response (i.e., prior to stopping in a prone position).

The experiment yielded three outcomes that should be highlighted. First, a single shuttle-avoidance response chain emerged for each of the 3 rats. The shuttle-avoidance requirement demands that the rat locomote over the midline of the chamber, and this demand was incorporated into the rat's stream of activities. This "shuttle-type" avoidance response chain consisted of walking across and beyond the midline,[1] pausing, turning, and again walking across and beyond the midline. Rats presented with a leverpress-avoidance requirement also develop a high-frequency avoidance response chain (see Hann & Roberts, 1984). Thus, the presence of a prominent chain of repetitive responses seems a major attribute to a rat's avoidance performance, albeit with a shuttle or leverpress requirement.

Second, the avoidance response chain that was found to characterize shuttle avoidance was the same for each of the 3 rats. This stereotypy in shuttle-avoidance response chains is indexed further by the small number of total sequences as well as by different kinds of sequences (the *N*- and *k*-values, respectively, in Table 2) recorded for the rats. Leverpress-avoidance behavior, on the other hand, shows less stereotypy. The W-P-T-W_2 avoidance response chain is common under a leverpress requirement, but other sequences, which incorporate elements peculiar

Table 2
Prominent Shuttle-Avoidance Response Sequences

Rat 423 Right	Rat 423 Left	Rat 424 Right	Rat 424 Left	Rat 425 Right	Rat 425 Left
Session 5					
W-P-T-W_2=91	W-P-T-W_2=97	W-P-T-W_2=57	W-S-T-W_2=50	W-P-T-W_2=87	W-P-T-W_2=78
		W-CR-T-W_2=24	W-P-T-W_2=27		W-P-W_2=18
		W-S-T-W_2=11	W-P-W_2=11		
N=64	*N*=65	*N*=114	*N*=113	*N*=78	*N*=79
k= 6	*k*= 3	*k*= 11	*k*= 9	*k*= 8	*k*= 7
Session 10					
W-P-T-W_2=87	W-P-T-W_2=93	W-P-T-W_2=87	W-P-T-W_2=85	W-P-T-W_2=88	W-P-T-W_2=91
N=69	*N*=70	*N*=130	*N*=131	*N*=65	*N*=66
k= 8	*k*= 6	*k*= 9	*k*= 9	*k*= 7	*k*= 6
Session 15					
W-P-T-W_2=93	W-P-T-W_2=94	W-P-T-W_2=86	W-P-T-W_2=94	W-P-T-W_2=85	W-P-T-W_2=85
N=67	*N*=67	*N*=104	*N*=105	*N*=68	*N*=67
k= 4	*k*= 4	*k*= 6	*k*= 4	*k*= 8	*k*= 7

Note—Activity sequences for each rat, recorded in the final 25 min of Sessions 5, 10, and 15. The values indicate the percent of the total number of sequences (N) observed for a given rat in that session. The number of qualitatively different sequences (k) also are noted. See text for symbols and additional details.

to that requirement (e.g., leverholding), also are common. The net result is that rats, provided with comparable training parameters, show considerable between-rat differences in the topographies of their response chains (see Hann & Roberts, 1984; Roberts, 1985). Moreover, these rats tend to generate more total sequences and more different kinds of sequences.

Finally, the shuttle-avoidance response chain that became prominent emerged early in training (prior to Session 5) and was maintained without substantive modification over the training period. In contrast, a prominent leverpress-avoidance response chain does not appear with the same degree of reliability until considerably later in training (see Roberts, 1985): a response chain that is present in an early training session is likely to be transitory (i.e., will be reorganized and refined with additional training sessions). The prominent leverpress-avoidance response chain that finally does appear may have little similarity to the one that initially appeared.

In summary, rats presented with a shuttle-avoidance response requirement performed that task as we intuitively would expect: they walked back and forth across the midline. The rats performed this task in similar manners; that is, the rats showed minimal within- and between-subject variations in their shuttle-avoidance response chains.

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NOTE

1. It may be important to note that the shuttle activity sequence did not terminate coincident with the occurrence of the feedback stimulus, that is, the environmental indicator that shock had been postponed. Most leverpress avoidance response sequences similarly do not terminate with the occurrence of the feedback stimulus.

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