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Rat behaviors during unsignaled avoidance and conditioned suppression training

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The behaviors of three rats were observed during unsignaled avoidance, conditioned suppression (CS-US), and CS-alone sessions. Behavioral observations, based on 10 response categories, were made in the initial and final sessions of each training condition. A variety of leverpress behaviors characterized an avoidance-trained subject, for example, lever holding, crawling over the lever, pressing with a back paw. By the end of CS-US training, the lever behaviors which typified avoidance training were reduced during the CS, but a different class of lever response had emerged. Moreover, nonlever behavior was increased, for example, locomotions and postural responses. Finally, the frequency of unavoided shocks in CS was elevated over baseline. When the US was removed, the differences in nonlever behaviors between CS and baseline diminished markedly, and an elevated response rate associated with a reduced shock rate appeared during the CS.

When signaled response-independent shock (CS-US) is superimposed on avoidance-maintained behavior (Sidman, 1953), shock avoidance in the CS is improved early in CS-US training. With additional CS-US pairings, avoidance during CS declines to match that in non-CS periods and then worsens. That is, many more unavoided shocks are received during CS than in baseline (see review by Hurwitz & Roberts, in press).

While changes in the criterion measures (e.g., lever-pressing, unavoided shocks) have been documented, surprisingly few studies attempt to identify what the subject does during the CS when not engaging in the criterion response. We found only two experiments addressed to this question. Hoffman and Barrett (1971) and Stein, Hoffman, and Stitt (1971) found reductions in food-reinforced responding and other overt activities of pigeons during the CS. A parallel experiment with an avoidance baseline has not been done and was the primary purpose of this experiment.

The second purpose arose as we reviewed the literature relevant to the first: Reports on the behaviors of a subject during free operant avoidance training were not found. An exception would be procedures in which two or more subjects are trained simultaneously (cf., Davis, 1969). That is, as avoidance learning progressed, did behavior become more or less stereotypic, or did one form of stereotype replace an earlier form? The present experiment was undertaken to provide information on the behaviors of rats during avoidance and CS-US training.

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METHOD

Subjects

Four female hooded rats, purchased from Blue Spruce Farms, New York, were used. Subjects were experimentally naive and weighed about 150 g at the beginning of the experiment.

Apparatus

Two standard LVE operant chambers (Model 143-20) measuring 31 x 30 x 30 cm (1 x w x d) were used. A 2.5-cm-wide lever was mounted on the right side of the wall and protruded 2.5 cm into the chamber, 6 cm above the grid floor. A deadweight of 20 g (.2 N) on the lever activated the microswitch. Each chamber was modified to include a houselight in the center of the plastic ceiling and a relay on the outside of the intelligence panel. The floor grids were .25-cm brass rods spaced 1.3 cm apart parallel to the width of the lever.

A constant-power shock generator (BRS, SG-901) delivered shock via a relay scrambler (BRS, SC-901) to the grids, lever, and metal sides of the chamber. Each chamber was housed in a sound-attenuated chest, with a blower fan providing ventilation and masking noise (79 dB). The relay, activated at 5 clicks/sec (the CS), added 2 dB to the resting noise level.

Procedure

The experiment consisted of three phases: avoidance training, CS-US training, and giving CS without US (CS alone). In the first phase, 26 avoidance training sessions, a .5-sec 1-mA electric shock was delivered every 5 sec. Each leverpress postponed shock for 15 sec and briefly (.3 sec) turned off the houselight. This avoidance schedule was present throughout the experiment. The first three sessions were 30 min, and all sessions thereafter were 2 h.

In the second phase, a 60-sec CS immediately followed by a 1-sec 1-mA response-independent shock (US) was superimposed on avoidance behavior once every 6 min, that is, 20 CS-US pairings each session. Subjects 1 and 3 received 15 sessions in this phase. On Session 12, the US was disconnected accidentally for Subject 2, and additional CS-US training was given to insure stable performance (a total of 25 sessions).

In the final phase, the CS was given without US for 10 sessions, that is, the extinction of the effects of CS-US training. Otherwise, the conditions described for the second phase were maintained.

Recording Techniques

The number of leverpresses and unavoided shocks during each session were recorded automatically. During the CS-US and CS-alone conditions, leverpresses and unavoided shocks were recorded separately during the 60 sec immediately preceding (the baseline) and during the CS.

Two observers were trained to recognize and count instances of 10 response categories using both naive and avoidance-trained subjects not associated with this experiment.

Locomotions. Each chamber floor was marked into quadrants, and a locomotion was recorded if the subject moved from one quadrant to another during a shock-free period.

Shock-elicited behaviors. Two responses to the delivery of unavoided shock were counted: Lever responses, including leverpresses and lever bites, and jumping from one quadrant to another.

Postural behaviors. The subject remained relatively immobile while not in physical contact with the lever: a semierect or crouching posture, or a freezing posture in which all four paws were in contact with the grids.

Lever behaviors. Three leverpressing styles were identified: (1) lever holding, that is, the lever continually depressed by the subject's forepaws; (2) a back paw being used to activate the lever; and (3) a darting response with the subject in a crouching posture, emitting a leverpress and returning to the crouching posture.

General behaviors. These included (1) grooming behavior in which the subject washed, licked, or preened its body, and (2) the subject making climbing movements on the side of the chamber with forepaws while standing.

Following observation training, observer disagreements with respect to response categories were infrequent; on the last training session, the observers' records were correlated ($r = +.88$).

Observations were made in the first and final three avoidance training sessions and in the first and final sessions of the CS-US and CS-alone phases. A small low-wattage red light located above the sound-attenuated chest and not visible to the subjects was used to signal the baseline periods to the observers.

RESULTS

Table 1 gives the mean number of leverpress responses and unavoided shocks recorded during the observational sessions. The data from the first three, as well as the final three, avoidance training sessions were combined to obtain mean values. Figure 1 gives the observational data for each response category in terms of the percentage of total observations for that phase or condition.

Avoidance Training

As expected, lever activity became less shock related over training, but the "kind" of lever behavior, itself, was more varied: crawling over the lever, using a back paw to leverpress, as well as alternations of lever holding and pressing. Actually, Subjects 1, 2, and 3 appeared nonchalant as they executed the response requirement. But Subject 4 failed to reach our criterion of receiving less than 1 shock/min and was dropped from further experimentation. The response pattern of Subject 4 was most stereotypic and consisted of lever holding alternating with shock-elicited responses.

Table 1
Responses and Shocks Per Minute

		S-1		S-2		S-3	
		BL	CS	BL	CS	BL	CS
		Responses per Minute					
Training	First 3	6.2		6.0		10.2	
	Final 3	13.2		14.6		13.8	
CS-US	First	11.0	16.0	14.0	23.0	16.4	18.1
	Final	12.0	11.8	13.6	12.4	16.8	17.6
CS Alone	First	11.2	12.6	14.8	13.4	14.6	20.8
	Final	12.0	18.2	11.4	19.6	15.0	19.0
		Shocks per Minute					
Training	First 3	4.50		5.30		4.20	
	Final 3	.92		.68		.68	
CS-US	First	1.76	.95	.82	.90	1.50	1.90
	Final	.66	1.16	.75	1.66	.60	1.80
CS Alone	First	.90	1.10	1.16	.96	1.20	1.90
	Final	.66	.33	.96	.46	.72	.56

Note—Response and shock rates obtained for each subject over the three phases of the experiment. The values given for the training sessions are means based on the first and final three sessions, respectively. Baseline values (BL) were obtained in the 60-sec period preceding each CS.

CS-US Training

In the first sesison, baseline shock rate was increased over training levels, while baseline response rate was not altered consistently (see Table 1). On the other hand, the rate of response during the CS was elevated over baseline, but, at the same time, so was the rate of unavoided shock (for Subjects 2 and 3). The observational data clearly show both the increase and diversity of nonlever activity during CS, that is, an increase in locomotions, climbing, and crouching with reductions in lever-holding and back-paw responses.

In the final session the elevated response rate in CS had diminished to match baseline for Subjects 1 and 2 but remained slightly elevated for Subject 3. But particular notice should be made of the rate of unavoided shock: More unavoided shocks occurred during the CS than in baseline.

The CS changed the regularly spaced leverpressing which was typical of baseline (and avoidance training) performance in two ways. First was a stereotypic leverpressing pattern, found over the first 20 sec of CS. At the onset of the CS, the subjects emitted a burst of leverpresses and then held the lever until the delivery of an unavoided shock, which, in turn, elicited leverpresses. Second, behavior was less stereotypic (i.e., showed more between-subject diversity) in the final 40 sec. For Subjects 1 and 2, considerable nonlever activity was prominent (locomotions, crouching) but the appearance of the darting response is noteworthy. The shock-elicited responses seen for Subject 3 reflect the development of a pattern similar to that noted for the discarded Subject 4.

CS-Alone

Behavior during the CS (compared to baseline) showed changes even in this CS-alone first session. For example, the difference in crouching, lever holding, and the darting response seen in Figure 1 (final CS-US session) had all but disappeared. By the final CS-alone session, behavior was much more lever oriented, as the response category levels were similar to those of the final avoidance training sessions (see Figure 1). However, the response rate during CS was greater, and shock rate less, than baseline (see Table 1).

DISCUSSION

Before considering the behaviors observed under CS-US, the changes in behavior associated with avoidance training merit comment. First, nonlever activities (locomotive, climbing, and postural behaviors) which were frequent early in training lessened over sessions. Second, lever behavior, itself, changed from leverpresses which were primarily shock elicited (escape) to those which were regularly spaced (avoidance). In this regard, Bolles has suggested that a subject's response repertoire would "expand" in conjunction with avoidance acquisition (1971, p. 220). We found this suggestion warranted only with respect to leverpressing, as a variety of leverpress "styles" typified a well-trained avoidance pattern. Indeed, the failure of the leverpress repertoire to expand beyond lever holding seems to preclude the development of an effective avoidance response rate (cf. Subject 4). But the overall response repertoire of the three subjects which met our avoidance criterion actually had narrowed compared to the initial sessions.

Turning to CS-US training, three noteworthy changes in behavior were produced by the preshock CS, compared to baseline. First, lever holding was observed less often. Second, nonlever activity had increased, particularly the locomotive and

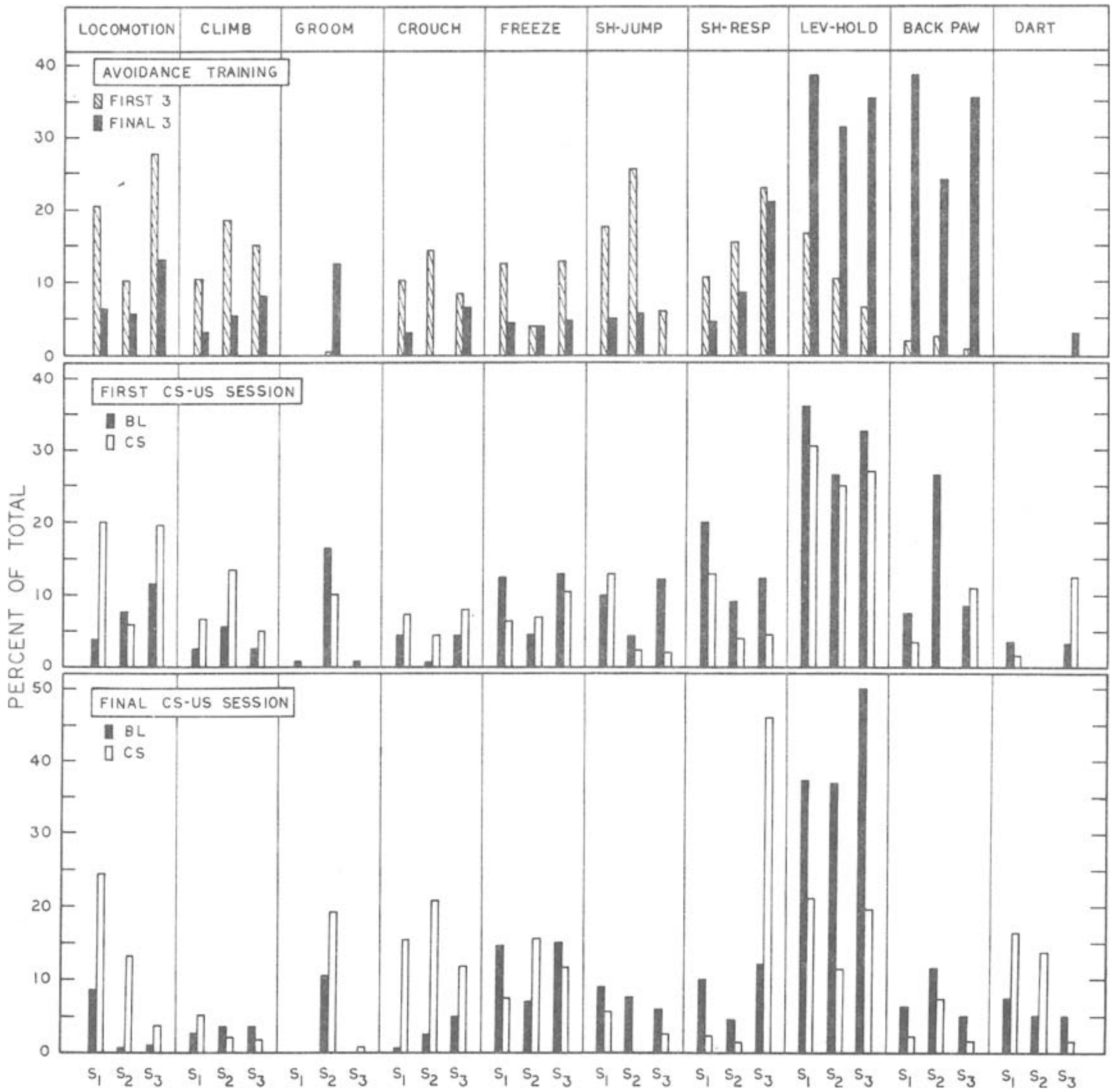

Figure 1. The relative frequency of each response category in terms of the percentage of the total. Baseline (BL) values are based on frequencies obtained during the baseline period for that session, and CS values are based on CS period frequencies. Values for avoidance training are based on the first three and final three sessions, respectively.

postural behaviors. Finally, a third class of lever responses, emitted from a crouching posture, had emerged: the darting response and shock-elicited lever biting. In general, the overall behavior of Subjects 1 and 2 toward the lever was similar to that described for a rat in an approach-avoidance conflict.

These observations indicated, as Estes and Skinner (1941) noted over 30 years ago, that the CS changed the relative frequency of the various responses in a subject's repertoire, compared to both avoidance training and baseline. In this experiment the style of lever behavior changed during the CS, but lever behavior was not eliminated. Thus, the reports of dramatic reductions in almost all behaviors during the CS (Hoffman & Barrett, 1971; Stein et al., 1971) may be specific to a food-motivated baseline. When a shock postponement baseline is used, a subject must contend not only with the continually present requirement of the avoidance schedule but also with the schedule of the shock US. The response topography which finally developed during the CS in this experiment seemed to represent a "best attempt" to adjust to and contend with both schedules of shock (cf. Hurwitz & Roberts, in press).

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