Conditioned suppression of a VI baseline using a two-bar multiple VI shock-avoidance schedule*

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Albino rats were trained to respond on a multiple variable-interval (VI) shock-avoidance schedule, where VI responses were reinforced on one bar, and shock-avoidance responses were reinforced on another in alternating components. Tone-shock pairs were superimposed upon the VI components, and conditioned suppression was obtained. These results are in opposition to those obtained when stimulus-shock pairs are superimposed upon baselines in Ss with shock-avoidance histories where a single manipulandum has been used for both schedules.

The conditioned emotional response (CER) procedure was first described by Estes and Skinner in 1941. They trained rats to barpress for food reinforcement on a fixed-interval schedule. Subsequently, a 3-min tone was presented in the same situation and was terminated by a brief unavoidable shock. After several tone-shock pairings, the barpressing behavior came to be suppressed during the presentation of the tone. The conditioned suppression effect has been demonstrated for a variety of reinforcement schedules (Azrin, 1956; Brady, 1955; Brady & Hunt, 1955; Valenstein, 1959).

It has been demonstrated (Sidman, Herrnstein, & Conrad, 1957) in research with monkeys that, if the baseline behavior upon which stimulus-shock pairs were superimposed is shock avoidance, the preaversive stimulus controls gradually diminishing facilitation of responding rather than suppression. Furthermore, Herrnstein and Sidman (1958) demonstrated that, if shock-avoidance training is given prior to superimposing stimulus-shock pairs on a *positively* reinforced baseline, responding is facilitated during the preaversive stimulus. In another demonstration of this phenomenon (Kelleher, Riddle, & Cook, 1963), monkeys were first trained to respond on a multiple VI 1.5-min shock-avoidance schedule. Then 2-min periods of blue light terminated by shock were superimposed on the VI 1.5 components. An increase in responding was observed whenever the blue light was presented.

Waller and Waller (1963) used a three-component multiple schedule with dogs to determine the effects of stimulus-shock pairs superimposed on a variable-interval 1-min (VI 1) baseline, a shock-avoidance baseline, and a time-out (TO) period. When responding was stable in all three components of this schedule, buzzer-shock pairs were superimposed on each component. In this case, responding during the VI 1 component was virtually unaffected by the buzzer-shock presentations. An increase in responding occurred during TO components for the duration of the buzzer, and an increase during

the buzzer was apparent on the shock-avoidance components.

In all of the above studies, the same response manipulandum was used for food-reinforced responding and shock-avoidance responding. Sidman (1958) trained monkeys to respond on a concurrent food-reinforcement shock-avoidance schedule, where two manipulanda were used, a bar for shock avoidance and a chain for food. Sidman has a great deal of difficulty in eliminating superstitious chaining under this procedure, but finally did succeed in separating the two responses. When stimulus-shock pairs were superimposed on this concurrent schedule, *suppression* of responding on the chain and gradually declining response facilitation on the bar occurred.

The present study was designed to determine whether response facilitation commonly obtained during a preaversive stimulus superimposed on a VI baseline in Ss with a shock-avoidance history would occur if different manipulanda were used for food-maintained vs shock-avoidance responding. In Sidman's procedure, it is not clear whether the suppression of responding on the food manipulandum was due to a suppressive effect of the preaversive stimulus on that behavior or to the competing facilitative effect on the shock-avoidance response.

The procedure used here was similar to that of Kelleher, Riddle, and Cook (1963), involving a two-component multiple schedule of VI-1 and shock avoidance with stimulus-shock pairs superimposed on VI components. However, in this case, food-reinforced responding occurred on the left bar of a two-bar animal conditioning chamber, and shock avoidance occurred on the right bar. The use of the multiple schedule greatly reduced the likelihood of superstitious chaining and allowed for its clearer identification if it did occur.

METHOD

Subjects

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Ss were four naive Sprague-Dawley albino rats, approximately 90 days old at the start of the experiment. Their ad lib weights ranged between 233 and 245 g. Each animal was individually

Fig. 1. Average suppression ratios per session for individual Ss.

housed, with water available at all times except during experimental sessions. Each S was deprived to 85% normal body weight throughout the experiment and was maintained on Purina lab chow.

Apparatus

A two-bar Grason-Stadler operant-conditioning chamber with dimensions $11\frac{1}{2} \times 9\frac{1}{4} \times 7\frac{1}{4}$ in. ($29.2 \times 23.5 \times 19.7$ cm) was used. The bars were 2 in. (5 cm) wide, located at $3\frac{3}{4}$ in. (8.3 cm) above the grid floor. To the left and below the left bar was a food magazine. Cue lights were mounted $1\frac{1}{4}$ in. (3.2 cm) to the left and to the right of the two bars, slightly higher than the bars.

The 18 grids constituting the floor of the chamber were 2 mm in diam and $\frac{1}{2}$ in. (1.3 cm) apart. Shock was delivered through the grids by means of an Applegate shock generator and a Grason-Stadler shock scrambler. Shock intensity was set at 1.0 mA with a duration of .3 sec.

A 1000-Hz 85-dB tone, when required, was produced by a tone generator and was delivered through a speaker mounted directly on one wall of the operant chamber. The chamber was placed inside an acoustical shell, where the ambient noise level was 75 dB. All programming was controlled by electromechanical equipment located in an adjacent room.

Procedure

Shock-avoidance training on the right bar of the operant chamber, with the right cue light on, was given each S for three to four 100-min sessions. The interval between shocks in the absence of responding was 5 sec (SS-5); each response postponed the next shock for 20 sec (RS-20).

A shaping technique was used to train the barpress avoidance response because pilot animals did not readily acquire the avoidance response in the two-bar box. Animals were placed in the box and received a number of shocks on the SS-5 schedule. The E manually operated the shock-avoidance bar from outside the box whenever S approached the bar. Barpressing behavior was gradually shaped by requiring closer approximations by Ss to the bar before operating it manually. Shaping time ranged from 8 to 20 min.

After the shock-avoidance response was well established, Ss were trained to press the left bar, with its associated cue light on,

for food reinforcement (45-mg Noyes pellets). Animals were run under food-reinforcement conditions for half of the 100-min sessions and under shock-avoidance for the other half. The food-reinforcement schedule was gradually increased to VI-1 min (e.g., VI-6, VI-20, VI-40 sec). When Ss' responding on each bar under the two-component condition stabilized as determined by visual inspection of response and shock rates (five to eight sessions), the components of the multiple schedule were gradually shortened and increased in number (three 30-min components, four 25-min components, etc.) until there were six 15-min components, alternating VI-1 min and shock avoidance.

When responding stabilized on this schedule (5 to 18 sessions), 1-min 1000-Hz 85-dB tones, terminated by a .3-sec 1-mA shock, were superimposed on the VI-1 components. Presentation of the tone-shock pairs was varied in a random fashion, with the qualification that no pair was given during the first or last 3 min of the component, and no tone was presented less than 2 min following a shock.

S D-5 received 60 presentations of tone shock (10 sessions); D-6 received 54 presentations (9 sessions); and D-7 and D-8 each received 36 presentations (6 sessions).

All Ss received tone-alone presentations prior to tone-shock presentations. No change in rate was observed during these trials.

RESULTS

Average suppression ratios were calculated for each S for each session (where six stimulus-shock pairs were presented per session). The ratio used was $A/A + B$, where A is rate during the preaversive stimulus and B is the average rate during VI components, excluding the 6 min the preaversive stimulus was on. Using this ratio, a value of 0.0 indicates total suppression, 0.5 indicates no change, and above 0.5 indicates facilitation.

The average response rate was used for B (following Sidman, 1958), rather than the rate during the 1-min period preceding stimulus onset because, at times during early stimulus-shock presentations, the animals' baseline response rates were disrupted to the extent that long pauses in responding occurred, which sometimes preceded stimulus presentations. In these cases, the ratio $A/A + B$, or any other ratio, would have resulted in a meaningless equation when rate during the stimulus was zero. The procedure used appears to be justified by the fact that the ratios were quite stable even after baseline rate recovery.

Figure 1 shows the suppression ratios for each of the four Ss per session. Suppression clearly was obtained rapidly by all Ss. Three Ss showed a small amount of facilitation of responding during the first stimulus-shock presentation session. During the next session, suppression was obtained for all Ss and was maintained.

Table 1 shows mean response rates on the two bars for each S for 6-10 sessions before tone-shock pairs were introduced (multiple) and after introduction of tone-shock pairs (tone-shock). Overall reductions in rate of responding during VI components is clear, following the institution of the tone-shock procedure (where these rates were computed only for the time when the tone was not present). Response rate during the shock-avoidance components was virtually unaffected by the procedure.

Also shown in Table 1 are the mean rates of occurrence of errors, where an error is defined as a response on the food bar during a shock-avoidance component or a response on the shock-avoidance bar during a VI-1 component. A somewhat clearer picture of these errors is given in Table 2.

Table 2 shows ratios of mean response rate on the incorrect bar/mean response rate on the correct bar for the last 6-10 sessions prior to tone-shock pairings (multiple) and for all sessions following institution of the pairings (tone-shock). These ratios show the proportion of responses occurring on the shock bar during VI components and responses occurring on the food bar during shock-avoidance components. With one exception, D-6, the ratios are fairly low, showing that the Ss did learn to perform appropriately on the two bars. D-6 developed a superstitious chain during shock-avoidance components involving the food bar, which elevated his error ratio.

It may be noted that the error rate on the food bar during shock avoidance is higher in all cases than that on the shock bar during VI components. Upon beginning the tone-shock pairings, error rate on the shock bar changed very little, while that on the food bar during shock avoidance increased for each animal.

Two Ss, D-5 and D-6, made some responses on the shock-avoidance bar during the preshock stimulus and following the unavoidable shock. On the 7 days that D-5 switched over to the shock bar during tone presentation, average response rate on that bar was 1.2 during the tone and .8 during nontone periods. On all but 2 days, rate was higher during tone presentation. S D-6's rate on the shock bar was lower during tone presentations than between tones (.3 vs .5). At no time after Session 1 was the absolute rate during the tone higher on either bar than that when it was absent. Nor did the combined

Table 2
Error Rates for Multiple and Tone-Shock Sessions

S and Type of Session	Mean Rate	
	Shock Bar/Food Bar VI Comp	Food Bar/Shock Bar Shock Avoid Comp
D-5		
Multiple	.001	.273
Tone Shock	.043	.365
D-6		
Multiple	.045	.843
Tone Shock	.033	.962
D-7		
Multiple	.012	.265
Tone Shock	.006	.447
D-8		
Multiple	.017	.081
Tone Shock	.003	.106

rates on the two bars during the tone approach the rates during nontone periods.

DISCUSSION

The results of this study indicate that, in this case, a history of shock-avoidance conditioning alone was not *sufficient* to obtain response facilitation during a preshock stimulus superimposed upon a VI baseline. When separate manipulanda were used for the food-reinforced and shock-avoidance responses, suppression occurred during the preaversive stimulus.

It is possible that an increase in responding during a preaversive stimulus will occur only if the behavior that is being emitted at the time has in the past been in part controlled by the *aversive* stimulus presented. This seems to be the case in previous studies in which facilitation was obtained—the response was occurring on the same manipulandum on which a similar shock-avoidance response occurred. In Sidman's 1958 concurrent procedure, separate manipulanda were used; suppression occurred on the food manipulandum and facilitation on the shock-avoidance manipulandum.

There is no experimental literature to indicate that rats with an avoidance history would typically respond during a preaversive stimulus superimposed upon a positive reinforcement baseline in a manner similar to monkeys or dogs. However, in general, the CER procedure has generated similar cross-species behaviors. Also, Hurwitz and Roberts (1971) have shown that rats show a transitory facilitation effect during a preaversive stimulus on a shock-avoidance baseline, although their interpretation of this phenomenon differs from other investigators. They believe that the increase in rate is due to postshock responding rather than to a general facilitation effect.

Additionally, it should be pointed out that the avoidance behavior of rats is frequently less efficient than that of monkeys and, thus, their shock rate is higher. It is possible that there is an interaction of Shock Rate by Effects of Preaversive Stimuli on baseline

Table 1
Response Rates on Food and Shock Bars During VI 1-Min and Shock Avoidance Components

S and Type of Session	Mean Rate				Total Shocks
	Food Bar		Shock Bar		
	VI 1-Min Comp	Shock Avoid Comp	Shock Avoid Comp	VI 1-Min Comp	
D-5					
Multiple	16.20	1.37	5.01	.02	37.3
Tone Shock	13.13	1.93	5.42	.56	21.7
D-6					
Multiple	8.75	4.48	5.31	.11	18.9
Tone Shock	5.12	4.33	4.50	.17	22.5
D-7					
Multiple	8.29	1.13	4.27	.14	111.3
Tone Shock	3.33	1.99	4.45	.02	99.5
D-8					
Multiple	9.58	.54	6.63	.07	72.0
Tone Shock	3.70	.71	6.70	.01	58.4

behavior, although relevant parametric studies remain to be done.

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