*REMOTE EFFECTS OF AVERSIVE CONTINGENCIES:
DISRUPTION OF APPETITIVE BEHAVIOR BY
ADJACENT AVOIDANCE SESSIONS*

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Disruption of ongoing appetitive behavior before and after daily avoidance sessions was examined. After baselines of appetitive responding were established under a fixed-interval 180-s schedule of food presentation, 4 rats were exposed to 40-min sessions of the appetitive schedule just prior to 100-min sessions of electric shock postponement, while another 4 rats received the 40-min appetitive sessions just following daily sessions of shock postponement. In all 8 subjects, fixed-interval response rates decreased relative to baseline levels, the effect being somewhat more pronounced when the avoidance sessions immediately followed. The disruption of fixed-interval responding was only partially reversed when avoidance sessions were discontinued. During the initial exposure to the avoidance sessions, patterns of responding under the fixed-interval schedule were differentially sensitive to disruption, with high baseline response rates generally more disturbed than low rates. These disruptions were not systematically related to changes in reinforcement frequency, which remained fairly high and invariant across all conditions of the experiment; they were also not systematically related to the response rates or to the shock rates of the adjacent avoidance sessions. The results, while qualitatively resembling patterns of conditioned suppression as typically studied, occurred on a greatly expanded time scale. As disruption of behavior extending over time, the present data suggest that some forms of conditioned suppression are perhaps best viewed within a larger temporal context.

Key words: conditioned suppression, operant/Pavlovian interactions, avoidance, fixed-interval schedule, scales of analysis, lever press, rats

Estes and Skinner (1941) found that a 3-min tone followed by an unavoidable electric shock, when superimposed on a baseline of appetitively reinforced behavior, suppressed responding in the presence of the tone. More than four decades later, this experimental preparation remains the prototypical procedure for the study of conditioned suppression and has been widely used to assess the suppressive and inhibitory effects of various conditioned stimuli. In fact, the operant baseline provides a very sensitive index of the effects of Pavlovian conditioning procedures in general (Rescorla & Solomon, 1967). Similar to conventional Pavlovian procedures, the stimulus-shock pairings (whether presented on or off baseline) are response independent. Unlike traditional Pavlovian procedures, however, the primary dependent measure is the change that the conditioned stimulus produces in the on-

going pattern of operant behavior. The nature and the extent of suppression depend on a number of critically defined parameters, both Pavlovian and operant (see Blackman, 1977, for a review).

The conditioned suppression procedure has also been offered as a laboratory paradigm for the study of emotional phenomena, commonly labeled "fear" or "anxiety." Within such a framework, the suppression of operant responding is said to be the result of a "conditioned emotional response" (CER) elicited by the preshock stimulus, which has acquired aversive properties by virtue of its repeated pairings with shock. (Autonomic changes presumed to accompany the mediating CER have not, however, been found to covary with the suppression of responding, e.g., Brady, Kelly, & Plumlee, 1969.) As Blackman (1977) has noted: "Some workers have preferred to describe this CER as conditioned anxiety, a term which has a degree of superficial validity in a situation in which a stimulus precedes an unavoidable aversive event" (p. 360).

Outside the laboratory, however, aversive events and the stimuli that reliably precede them are seldom so brief as those used in typ-

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ical conditioned suppression procedures. But perhaps the laboratory versions need not be so brief, either. For instance, Hineline (1972, 1978) found disruption of appetitive responding on second-order schedules during sessions that immediately preceded and immediately followed 120-min sessions of shock postponement, suggesting that entire avoidance sessions may function as unitary aversive events. It was suggested that the suppression just prior to and immediately following the avoidance sessions may be a form of conditioned suppression qualitatively similar to that reported by Estes and Skinner (1941), but on a greatly expanded time scale.

Hineline's procedures, however, produced suppression immediately following the avoidance session, an unlikely outcome with conventional conditioned suppression parameters in which postshock stimuli delineate the intertrial interval (the time between successive stimulus-shock pairings). Such stimuli, inversely related to shock, tend to produce accelerations rather than depressions of responding (Davis, Memmott, & Hurwitz, 1975). However, because in Hineline's (1972) Experiment 1 all subjects were exposed to identical appetitive sessions immediately before and immediately following the daily avoidance sessions, disruption just after the avoidance sessions may be attributed to stimulus generalization from the preavoidance context, with which it shared a number of distinct features. Although the effect was slightly attenuated in Experiment 2, when the appetitive sessions immediately before and after avoidance were differentially correlated with distinct exteroceptive stimuli, the postavoidance effect was still robust.

The present experiment also examined disruption of appetitive responding before and after daily avoidance sessions. The rationale was twofold: First, to control for possible effects of stimulus generalization between the appetitive conditions just prior to and immediately following avoidance, each animal's avoidance sessions either preceded or followed its daily appetitive sessions, but not both. Thus, responding was compared across two groups of rats, each of which was exposed to only one or the other sequence of events. Second, because Hineline's (1972, 1978) previous studies used second-order schedules to maintain the

operant baseline, suppression of appetitive responding was accompanied by changes in the frequency of reinforcement. Therefore, the present study examined the disruption of responding maintained on a fixed-interval schedule in which changes in reinforcement frequency are dissociable from changes in response rate. This permits an assessment of the relationship between baseline response rate and the degree of disruption, unbiased by correlated changes in the frequency of reinforcement.

METHOD

Subjects

Eight experimentally naive male albino rats, maintained at approximately 80% of their free-feeding weights (range, 320 to 353 g), served as subjects. The rats, designated A101, A104, A106, A108, B202, B203, B205, and B221, were housed individually and had continuous access to water in their home cages. Three rats (A104, B203, and B205) died of respiratory illness midway through the experiment.

Apparatus

A standard one-lever Gerbrands operant conditioning chamber was modified with a Plexiglas ceiling and side walls to prevent rearing, thus ensuring reliable contact with the grid floor. The dimensions of the modified chamber were as follows: 25 cm between side walls, 30 cm between the front and rear walls, and 13.5 cm from floor to ceiling. A Grason-Stadler (Model E1064GS) Shock Generator delivered 1.0 mA electric shock (0.3 s duration) of scrambled polarity to the grid floor. The metal front and rear walls of the chamber were also included in the scrambler circuit. A speaker, which produced a 500-Hz tone, was mounted outside the rear wall of the chamber. A standard Gerbrands pellet dispenser delivered 45 mg Noyes Precision food pellets into a food magazine located on the lower inside rear wall, 3 cm below and 3.5 cm to the left of the lever. The lever was positioned 9 cm above the grid floor. The chamber was enclosed within a sound-attenuating shell. A cumulative recorder and standard electromechanical programming and recording equipment were located in an adjacent room.

Procedure

Following food-magazine and lever-press training, each rat was exposed to 40-min sessions during which responding was reinforced by delivery of food according to a fixed-interval (FI) 180-s schedule of reinforcement (appetitive sessions). When responding was deemed stable over sessions (via visual inspection of plots of mean response rates), rats were matched in pairs on the basis of similar rates and were assigned randomly to one of two groups. Each rat was exposed daily to a 40-min appetitive component and to another 100-min component, which was accompanied by a 500-Hz tone. During some conditions of the experiment, a shock-postponement procedure (or avoidance schedule; Sidman, 1953) was operative during this 100-min period. During the avoidance conditions, each lever press postponed a brief (0.3-s) shock for 20 s (response-shock interval = 20). In the absence of an intervening response, shocks occurred at 5-s intervals (shock-shock interval = 5). Avoidance sessions always began with the shock-shock interval in effect.

The only difference between the two groups was the order in which the two components occurred each day. For one group of rats (A101, A104, A106, and A108), the appetitive (FI) components preceded the 100-min (avoidance) components (Appetitive-Avoidance). The other group of rats (B202, B203, B205, and B221) received the 100-min (avoidance) component of the session just prior to the 40-min appetitive component (Avoidance-Appetitive). All other experimental conditions were identical. Houselight illumination marked the onset of each session and remained on for its duration. Neither tone nor shock was ever presented during the FI components. Experimental sessions were conducted 5 days per week.

Six of the 8 rats underwent a sequence of conditions constituting an A-B-A experimental design; the "A" (baseline) conditions consisted of the appetitive component of the session either immediately preceded by (Avoidance-Appetitive group) or immediately followed by (Appetitive-Avoidance group) a 100-min extinction period in the presence of the tone, but without an accompanying avoidance procedure. The shock-postponement contingency was presented in conjunction with the

tone during the "B" phases. The other 2 rats (A104 and B203) died of respiratory infections before a return to the initial (baseline) conditions could be accomplished. The sequences and numbers of sessions per condition are summarized in Table 1.

To assess stability, overall FI response rates were analyzed in weekly (five-session) blocks. Due to equipment failures, some blocks consisted of only four sessions. Any block consisting of fewer than four sessions was discarded from the analysis. Experimental conditions were changed five sessions after visual inspection of the weekly median FI response rates revealed (a) no new high or low points for the previous 3 weeks, and (b) no systematic trends in either direction. Thus, conditions remained in effect for 1 week (five sessions) after the stability criterion was met. Two exceptions were Subjects A108 and B221 who, following baseline, were run for 15 sessions per condition. Overall response rates, shock rates, and reinforcement rates were recorded daily, as were response distributions in successive 10-min blocks throughout each session.

RESULTS

Table 1 shows the mean FI response rates for each subject, also expressed as percentages of the original baseline rate, calculated over the final five sessions of each condition. During the initial exposure to the avoidance sessions, FI responding decreased relative to baseline levels in all 8 animals. The degree of this disruption differed, however, between the two groups. As Figures 1 and 2 show, responding was generally more suppressed for rats in the Appetitive-Avoidance group (Figure 1), reaching an overall mean of .28 of the baseline rate, than for rats in the Avoidance-Appetitive group (Figure 2), with an overall mean of .48 of the baseline rate.

In all 4 Appetitive-Avoidance subjects, FI responding decreased to less than half of the baseline rate. The degree of suppression was also partially related to absolute baseline response rates, with the greatest relative degree of suppression (to .14 of baseline) occurring at the second highest baseline response rate (16.2 responses per minute), and the least relative suppression (to .41 of baseline) occurring

Table 1

Means of performance measures for the final five sessions in each experimental phase. During (A) conditions, FI responding was juxtaposed with extinction sessions, and during (B) conditions, with avoidance sessions.

Subject	FI resp/min	Range	% Baseline	Av resp/min	Shock/min	Reinf/min	Sessions
Appetitive-Avoidance							
A101	(A)	30.3	24.7-34.9	—	—	0.34	97
	(B)	11.3	5.4-19.5	37	5.8	0.9	43
	(A)	11.9	9.0-14.6	39	—	0.33	44
	(B)	11.0	7.4-15.2	36	5.1	0.6	62
	(A)	21.1	16.9-24.7	70	—	0.35	39
	(B)	16.7	13.2-25.3	55	5.7	0.7	59
A104	(A)	6.5	5.8-7.4	—	—	0.33	95
	(B)	1.3	0.7-2.2	20	5.6	0.5	25
A106	(A)	16.2	13.9-18.0	—	—	0.33	54
	(B)	2.3	0.6-4.9	14	3.6	2.2	41
	(A)	6.2	3.7-9.0	38	—	0.32	80
	(B)	2.8	1.4-3.9	17	5.0	1.9	78
A108	(A)	6.3	5.6-7.2	—	—	0.32	29
	(B)	2.6	1.3-3.5	41	1.7	7.0	15
	(A)	4.7	4.0-5.4	75	—	0.33	15
	(B)	4.0	2.7-5.0	63	3.1	2.3	15
Avoidance-Appetitive							
B202	(A)	32.8	20.9-39.9	—	—	0.35	97
	(B)	11.6	3.4-16.6	35	7.5	1.2	55
	(A)	30.0	23.6-35.3	91	—	0.35	48
	(B)	16.0	10.1-19.5	49	9.7	0.7	33
	(A)	18.1	14.4-21.8	55	—	0.32	38
B203	(A)	8.8	7.8-10.0	—	—	0.33	69
	(B)	4.9	1.9-6.7	56	3.4	2.8	72
B205	(A)	13.7	10.1-16.7	—	—	0.32	83
	(B)	7.0	4.6-9.9	51	6.2	1.7	37
	(A)	8.4	5.7-14.2	61	—	0.33	12
B221	(A)	18.6	15.7-22.0	—	—	0.32	40
	(B)	9.5	5.7-10.8	51	5.9	3.3	15
	(A)	10.6	4.1-15.5	57	—	0.29	15
	(B)	14.3	10.2-16.9	77	3.1	3.4	15
	(A)	18.8	16.1-20.2	101	—	0.31	15

at the lowest baseline response rate (6.3 responses per minute).

Responding of only 1 rat in the Avoidance-Appetitive group (B202) was within the range of suppression values found in the Appetitive-Avoidance group. For the other 3 rats in this group, FI responding was suppressed to approximately half the baseline rate. In addition, across rats in this group, there was a direct relationship between absolute baseline response rate and the degree of suppression: Disruptions were most pronounced at the highest baseline response rate and least pronounced at the lowest baseline response rate.

As Figures 1 and 2 indicate, successive reexposures to avoidance conditions resulted in

progressively less disruption of ongoing appetitive behavior. When the avoidance contingency was reinstated for the first time, the mean FI response rates for rats in the Appetitive-Avoidance group decreased only 23% (from .51 to .39 of the original baseline) from the immediately prior (extinction) condition, compared to a 72% decrease during the original exposure to the avoidance sessions. Similarly, FI response rates for rats in the Avoidance-Appetitive group were less disturbed during the second exposure to the avoidance contingency than during the first.

Under extinction conditions, during which the avoidance sessions were discontinued, FI response rates recovered, but only partially.

Fig. 1. Rate of FI lever pressing during the final three sessions of baseline and the first three and final three sessions of each of the other experimental conditions for rats in the Appetitive-Avoidance group. The first three sessions of a condition are represented by open circles and the last three by closed circles. Data points for contiguous sessions are connected. During "A" conditions, fixed-interval sessions were juxtaposed with extinction periods, and during "B" conditions, with avoidance sessions. The overall number of sessions per condition is shown in Table 1.

During the first extinction condition, response rates of all 6 rats in both groups increased; however, in only two cases did they recover to a level near the original baseline (.91 and .75 of the baseline rate for Rats B202 and A108, respectively). As with the original degree of suppression, between-group differences in the mean rate of recovery were also evident. Appetitive-Avoidance response rates increased from .28 to .51 of the baseline rate, thus regaining 32% of their original losses, whereas Avoidance-Appetitive response rates recovered 42% of their initial loss, increasing from .48 to .70 of the baseline rate. Although

these data are based on sessions that occurred long after the avoidance contingency was discontinued, examination of the transition data in Figures 1 and 2 also reveals between-group differences, with Appetitive-Avoidance rates showing somewhat greater residual effects of the immediately prior condition during which avoidance sessions were present.

Some degree of recovery was also evident when the avoidance contingency was discontinued for a second time. For A101, the only rat from the Appetitive-Avoidance group exposed to this condition, FI response rate increased 92% from the prior avoidance condi-

Fig. 2. Rate of FI lever pressing during the final three sessions of baseline and the first three and final three sessions of each of the other experimental conditions for rats in the Avoidance-Appetitive group. See Figure 1 for other details.

tion, recovering to .70 of the original baseline rate. Similarly, for B221 (Avoidance-Appetitive) responding increased 31% from the prior condition, a change that represented a complete recovery of the original baseline. The change was less substantial for B202, whose response rate recovered to only .55 of the original baseline after having reached .91 of baseline during the first extinction condition.

Session-to-session variability in FI response rates is illustrated in Table 1. In absolute terms, there were no systematic differences across experimental conditions or between the two groups. However, low response rates (such as

those occurring in conjunction with avoidance sessions) suffer from floor effects, resulting in less variability at the low end. Therefore, Figure 3 expresses an unbiased measure of variability—range/response rate $\times 100$ —over the final five sessions of each condition. By this measure, Appetitive-Avoidance variability (top panel) was related to the presence or absence of the avoidance sessions; FI responding was most variable when it was adjacent to an avoidance session. Although the differences were most pronounced in the early conditions of the experiment, a similar pattern was still evident across later conditions. The effect was most

striking for A106, whose relative range during the initial exposure to the avoidance sessions was approximately twice that of the overall mean response rate. For only 2 of 4 Avoidance-Appetitive subjects (bottom panel of Figure 3) did a similar relationship hold; the other 2 rats showed an inconsistent pattern of session-to-session variability across conditions.

The relationship between FI response rate and obtained reinforcement rate can be seen in Table 1. Despite substantial fluctuations in response rate, rates of reinforcement remained high and stable across all conditions of the experiment. It should be noted that the stability in obtained reinforcement rate across subjects and across conditions was not a foregone conclusion. An obtained reinforcement rate of .30 represents collecting 12 of 13 potentially available reinforcers in a given 40-min FI period. Across the 31 conditions of the experiment, only three times did the mean obtained rate of reinforcement of the final five sessions for any subject fall below .30.

Neither shock rate nor response rate during avoidance components was systematically related to the disruption of appetitive behavior. As Table 1 shows, for the 5 subjects with more than a single exposure to an avoidance condition, FI and avoidance response rates failed to covary in a consistent manner across subjects: The rates were inversely related for 1 rat and directly related for another, whereas for the other three rats changes in appetitive and avoidance rates, although in the same direction, were negligible.

The relationship between FI response rate and shock rate during the adjacent avoidance component is depicted in Figure 4, which includes the corresponding Pearson product-moment correlation coefficients (r). Each data point represents a correlation between FI response rate and the shock rate of the immediately *prior* avoidance session, computed over the final 10 sessions of each exposure to an avoidance condition. Thus, for Avoidance-Appetitive rats, each data point represents a correlation within a single session. For Appetitive-Avoidance rats, however, the correlation involves shock rates from the avoidance component of the previous session. The number of regression lines for each subject corresponds to the number of exposures of each to "B" (avoidance) conditions.

For 3 of the 4 rats in the Avoidance-App-

Fig. 3. Relative variability of session-to-session FI response rates for rats in the Appetitive-Avoidance group (top panel) and Avoidance-Appetitive group (bottom panel). Each bar represents the range of values during the final five sessions of an experimental condition divided by the mean response rate during that same period and multiplied by 100. The open bars represent the "A" (no-avoidance) conditions, and the hatched bars denote the "B" (avoidance) conditions.

petitive group (right side of Figure 4), the r value during the initial determination was positive (+.65, +.48, and +.25 for B202, B205, and B221, respectively). Conversely, for all 4 rats in the Appetitive-Avoidance group (left side of Figure 4), the initial r value was negative (−.52, −.47, −.34, and −.30 for A106, A104, A101, and A108, respectively). However, for 4 of the 5 rats in both groups with more than a single exposure to an avoidance condition, the direction of these initial r values was subsequently reversed; that is, the correlations were generally not consistent within individual subjects. The only exception was A108, whose r values were both negative. But even in that case, during the second determination r approached 0, decreasing from −.30 to −.09.

Figure 5 portrays the temporal distribution

Fig. 4. Regression lines depicting the relationship between FI response rate and shock rate of the immediately preceding avoidance session for rats in the Appetitive-Avoidance group (left panel) and Avoidance-Appetitive group (right panel). Also shown are the corresponding values of r (Pearson product-moment correlations). The circles (and solid regression lines) represent the initial exposure to avoidance conditions, the triangles (and dashed regression lines) the second exposure, and the squares the third exposure. The data are based on the final 10 sessions of each avoidance condition. Note that the axes are scaled individually for each animal.

of appetitive behavior, subdivided into successive 10-min quarters of the 40-min FI session. Each point represents a mean computed over either the final five sessions of "A" (baseline) or over the final five sessions of the first exposure to the "B" (avoidance) condition. The open data points represent the 10-min periods nearest the avoidance session. These data were chosen as representative cases: Of the 2 rats selected from each group, 1 had a high baseline response rate (over 30 responses per minute) and the other had a low baseline response rate (less than 10 responses per minute) (see Table 1).

With the exception of B203 (Avoidance-Appetitive), the addition of the avoidance contingency not only lowered the local FI response rates in each quarter-session but also disrupted the normal temporal pattern of behavior. A major function of the avoidance contingency seemed to be that of substantially reducing within-session variability, and concomitantly, local rates of responding. In two cases, local FI response rates were lowest during the quarter of the session contiguous with avoidance, but in only one case did this represent a change from the baseline pattern, and even then, the difference was negligible. In short, the disruption of ongoing appetitive behavior was clearly evident over the course of the entire 40-min session, rather than simply in those periods proximal to shock.

DISCUSSION

The present study was undertaken to examine the characteristics of ongoing appetitive behavior in temporal conjunction with an avoidance session. Although the procedure shares a number of features with more conventional conditioned-suppression preparations, the use of such an expanded time scale permits a more global evaluation of some of the long-term effects of aversive contingencies than do conventional parameters.

A major finding was that appetitive behavior was disrupted by the adjacent avoidance sessions, replicating and extending the findings of Hineline (1972, 1978), who also found suppression of food-reinforced responding just prior to and immediately following sessions of shock postponement. In Hineline's earlier studies, however, the disruptions observed just after the avoidance session may have been re-

Fig. 5. Temporal distribution of mean FI response rates in successive 10-min blocks across the 40-min appetitive component during the final five sessions of baseline (A) and of the initial sequence of exposures to avoidance (B). The data for rats A101 and A104 (Appetitive-Avoidance) are shown on the left half of the figure, and the data for rats B202 and B203 (Avoidance-Appetitive) are shown on the right half. The open data points denote the 10-min component contiguous with the avoidance session.

lated, at least in part, to stimulus generalization from the preavoidance context. In the present experiment, disruptions in appetitive behavior following the avoidance session were shown to be a direct effect of the juxtaposed avoidance session, insofar as the rats in that group (Avoidance-Appetitive) never received daily appetitive sessions prior to their daily avoidance sessions. Furthermore, it was shown that the disruptions in appetitive behavior were not due to correlated changes in reinforcement frequency, a relationship that was confounded in the relevant prior studies. Despite substantial fluctuations in FI response rate, obtained reinforcement rate remained fairly high and invariant across all conditions of the experiment.

For rats in the Appetitive-Avoidance group (for whom avoidance sessions immediately followed appetitive periods) behavior was par-

ticularly sensitive to the avoidance manipulations, showing both a greater degree of suppression when exposed to the avoidance sessions than the Avoidance–Appetitive rats and a slower recovery rate when the avoidance sessions were discontinued. The differential rates of suppression may have been partially related to between-group differences in session-to-session variability. When FI periods were immediately followed by an avoidance session, overall response rates were more erratic, showing less regularity from one session to the next. Across both groups, high response rates were generally less resistant to disruptions than were low response rates. When disruptions in FI behavior did occur, they were not systematically related to the shock rate or to the response rate of the juxtaposed avoidance session.

The present results may warrant closer examination, particularly as they relate to those obtained with more conventional parameters. The results may also help identify the effective range of behavioral sensitivity to the environment. These issues will be discussed in turn.

Relationship to Conventional Studies of Conditioned Suppression

As Hineline (1972, 1978) previously noted, suppression of food-reinforced responding by an adjacent avoidance session is qualitatively similar to the widely reported phenomenon of conditioned suppression, originally cited by Estes and Skinner (1941). In the more typical conditioned-suppression preparation, operant behavior is disrupted in the presence of relatively brief stimuli that reliably precede even briefer shocks. In general, the degree of suppression is a direct function of conventional parameters used in Pavlovian conditioning, such as the intensity of the unconditioned stimulus (US) (Annau & Kamin, 1961; Blackman, 1968) and the contingency between the conditioned stimulus (CS) and the US (Davis & McIntire, 1969), supporting the central role of Pavlovian conditioning in conditioned-suppression phenomena. When the parameters are extended beyond the conventional ranges, however, as they were in the present study, the role of Pavlovian processes deserves a closer look.

Before comparing the present results with those found with conventional parameters, let us first examine several of the procedural dif-

ferences. First, the aversive event in the present experiment was an entire situation (100 min of shock postponement) rather than a single brief shock. In addition to the unusually long duration, this aversive event differed from conventional forms of aversive stimulation in that all shocks within the situation were avoidable. In conventional studies of conditioned suppression, all shocks are unavoidable. The only inevitable aversive event in the present experiment was the onset of the avoidance situation itself. This difference in response contingency may have contributed independently to the aversiveness of the situation (e.g., Sidman & Boren, 1957, discussed in Hineline, 1981). Another difference concerns the stimuli that accompanied appetitive responding (the nominal CS period) before and after the aversive event. In the present study, these stimuli constituted an entire 40-min period with a cluster of correlated events rather than a brief, discrete stimulus. Finally, unlike many conventional studies, the aversive event occurred only once per session. Thus, in Pavlovian terms, there was only a single CS–US (or US–CS) pairing per session.

The disruption of behavior in the present study differed from that found using conventional parameters, especially with regard to the time scale over which the disruption took place and to the degree of recovery when the aversive event was discontinued. First, with respect to the within-session effects, the disruption of FI behavior adjacent to avoidance sessions occurred over the entire 40-min period, suppressing behavior remote from shock, in some cases, at least as much as behavior contiguous with shock (see Figure 5). The expanded scale of this disruption dwarfs the within-session changes normally obtained with conventional parameters in which behavior is suppressed primarily in the presence of brief preshock stimuli (but see Coleman, Hemmes, & Brown, 1986).

These differences may be related, in part, to the characteristics of the aversive event used in the present study. Other research, however, indicates that long-term suppression is not peculiar to aversive events of such extended duration. For example, Imada et al. (1983) and Imada, Kondo, and Imada (1985) also found disruption of behavior on a greatly expanded time scale. In the more recent of these studies, rats, living in experimental chambers, were

maintained on a 12:12-hr light:dark cycle. One hour after the onset of the dark phase, eight 3-s response-independent shocks were delivered at 12-s intervals. Eating and drinking were completely suppressed during the first hour in the dark (the hour immediately preceding the series of shocks). Suppression of eating was also observed toward the end of the light phase (i.e., at least 1 hr prior to the shocks). As in the present study, postshock behavior was also suppressed, although to a lesser degree than preshock behavior. These results suggest that suppression may occur on a time scale quite distinct from that of immediate or local events, and that such effects can be produced by a relatively brief (2-min) aversive situation.

Another difference between the present results and those obtained with conventional parameters was the degree of recovery from suppression when the aversive event was discontinued. With conventional parameters, behavior tends to recover within a few sessions (Blackman, 1968). Although in the present experiment appetitive responding eventually recovered to a moderate degree for some subjects, the residual effects of shock were longer lasting than those found with conventional parameters. It is perhaps not surprising that entire avoidance sessions produce larger scale behavioral disruptions than brief shocks, especially when experimental conditions are in effect for so long. But again, these long-term effects are not unique to extended-duration aversive events, nor are they unique to steady-state conditions. The large-scale within-session effects reported by Imada et al. (1985) were based on only 20 sessions of exposure to shock. Moreover, behavior failed to return to baseline levels during a 10-session recovery phase. In the present experiment, Rats A108 and B221 showed effects comparable to the other subjects, despite being run for only 15 sessions per condition. Therefore, the present results, together with the data of Imada et al. (1985), suggest that aversive events may affect behavior on a time scale quite different from that suggested by conventional parameters, both within sessions (on the order of minutes or hours) and between sessions (on the order of days or weeks).

Despite these differences in scale, certain features of the present results are consistent with those reported with conventional param-

eters, particularly with respect to the relationship between the degree of suppression and the baseline response rate. Blackman (1977) reviewed a number of studies showing that low baseline response rates are more resistant to suppression than are high baseline response rates, even when other factors (such as reinforcement frequency) are held constant. Similarly, in the present experiment, high baseline response rates were generally more suppressed by the adjacent avoidance session than were low response rates. This effect was consistent across both groups of rats and, as shown in Table 1, cannot be attributed to differences in obtained reinforcement frequency.

One final comparison involves the status of postshock behavior. In the present study, disruption of behavior immediately following daily avoidance sessions was found. Such a finding is in direct contrast with results obtained with more conventional conditioned-suppression parameters, where postshock responding is generally accelerated rather than suppressed (Davis et al., 1975). However, such accelerations may only occur with conventional parameters in which appetitive responding is bounded on either side by shock; only in these cases do postshock stimuli (i.e., the intertrial interval) delineate shock-free ("safety") periods (Coleman et al., 1986; Davis & Memmott, 1984). In the present study, no shocks were ever presented during or following the appetitive component immediately after an avoidance session.

In strict Pavlovian terms, these results may suggest a case of backward conditioning. Historically, backward conditioning has been regarded as a rather tenuous phenomenon open to alternative interpretations (e.g., as a case of forward trace conditioning). However, as Spetch, Wilkie, and Pinel (1981) have suggested, there may now exist sufficient empirical support for such a relationship. A strongly noxious US seems to be a necessary condition to produce backward conditioning. With respect to the present experiment, if the entire avoidance session is construed as a unitary aversive event (comparable to a highly intense US), the procedure might be viewed as particularly well suited to provide a basis for backward conditioning.

However, another interpretation of the post-avoidance suppression is possible, one that emphasizes the role of the static background, or

context, in which the manipulations were carried out (e.g., Rescorla & Wagner, 1972). Insofar as the daily avoidance and appetitive sessions were conducted in the same apparatus, contextual cues may have been strengthened by the addition of the avoidance contingency. Since these contextual cues were also present during the appetitive session that immediately followed, the disruption of ongoing FI behavior may have been modulated by stimulus control exerted by the apparatus itself.

Time Integration and Scales of Analysis

In addition to the extended within-session time frame over which FI disruptions were evident, there are other reasons for considering the present results within a larger temporal context. The patterns of FI disruptions were not systematically related to the shock rates or to the response rates of the adjacent avoidance sessions (see Figure 4 and Table 1). Orderly relations were apparent only over much longer time periods, thus enlarging the effective scale of behavior/environment interaction. This does not necessarily preclude organization on another scale of analysis (e.g., orderly relations between avoidance responding and shock rates on the shock-postponement schedule). However, with respect to the major purpose of the experiment—examining the range of sensitivity to aversive contingencies—the avoidance session seemed to retain its functional integrity (through an orderly relation with FI behavior) somewhat independent of the local contingencies or of the local behavioral patterns embedded within it.

This characterization of aversive events is consistent with Baum's (1973) notion of behavioral situations, whereby entire situations (or the transitions between different situations) are designated as either rewarding or aversive, capable of affecting behavior outside the situation (as in the present experiment, and as in experiments with chained and multiple schedules). When these situations function as consequences of behavior, the local contingencies (e.g., Sidman & Boren, 1957) or the local temporal pattern of events (e.g., Fantino, 1969, 1981; Lewis, Gardner, & Hutton, 1976) within each situation help to define the overall aversiveness or value of the situation as a whole. In the present study, the aversive situation was defined somewhat irrespective of these local

events. However, within-situation manipulations were not undertaken, thereby making detailed comparisons difficult.

The present experiment might also be conceptualized as the concurrent organization of behavior on different time scales—appetitive patterns of behavior were simultaneously maintained by local appetitive consequences in one situation and disrupted by relationships that spanned well beyond it. In a similar vein, an experiment by Mellitz, Hineline, Whitehouse, and Laurence (1983) revealed a sensitivity to two distinct, yet simultaneous, sources of negative reinforcement. In their study, a local shock-postponement contingency was embedded within a superordinate long-term contingency, whereby escape from the entire avoidance session could be achieved. Rats' responses on either of two levers produced identical short-term consequences—postponement of impending shock. Responses on one of these levers (designated as the conjoint alternative), however, also subtracted 1 min from the total session time. Thus, conjoint responses were simultaneously related to local events within the situation (postponement of individual shocks), and to temporally remote events superordinate to that situation (escape from the avoidance session as a whole). Responding came to predominate on the conjoint alternative, a finding which, along with the present results, suggests a tentative framework for characterizing the multiple scales upon which behavior may come to be organized. Such a view declines to endorse either extreme of a molar/molecular dichotomy; instead, it seeks to emphasize the complementarity between action on different time scales. This type of framework may enable us to begin identifying the effective temporal range of behavioral sensitivity to the environment—one dimension of the so-called "natural lines of fracture" (Skinner, 1935). At the same time, examinations of expanded time frames, as in the present experiment, may enable us to address experimentally phenomena that we encounter outside the laboratory that are not well captured by relationships spanning only brief intervals.

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