SOME SCHEDULES INVOLVING AVERSIVE CONTROL[1,2]

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Since Ferster and Skinner (1957) described a number of schedules of reinforcement, investigation of the properties of multiple contingencies has largely been limited to situations involving positive reinforcement. Recently, however, Brady (1959) and Verhave (1959) have described experiments in which an avoidance contingency of the kind described by Sidman (1953) and simple extinction were studied during single experimental sessions. Appel (1960) has reported on some of the properties of this schedule, and, in addition, has investigated the effects on discriminatory behavior of a variable known to influence the rate of avoidance responding, *viz.*, the introduction of free, unavoidable, shocks (Sidman, Herrnstein, & Conrad, 1957; Sidman, 1958). The present report continues the examination of schedules that involve various kinds of multiple aversive control.

METHOD

Subjects

The *S*s were two mature Macaca mulatta monkeys, maintained at approximately 90% of their free-feeding body weights. One animal, M3, had prior experience in experiments involving food rewards and time out from positive reinforcement (Ferster, 1960); the other subject, M5, was experimentally naive.

Apparatus

The apparatus consisted of an experimental chamber enclosed in an ordinary refrigerator shell and has been described in detail elsewhere (Ferster, 1960). Several modifications were necessary to facilitate the presentation of electric shock. The experimental area was equipped with a grid floor of the kind described by Dinsmoor (1958). Stainless steel tubing was spaced 1 inch apart. The panel at which the monkeys worked served as one of the shock electrodes; the other four walls could not be electrified. Stimuli were colored lights behind a translucent Plexiglas panel on which a lever was mounted. In addition, a speaker connected to the output of a Grayson-Stadler 901 noise generator provided a white noise which was used as a supplementary discriminative stimulus.

Shock was delivered from a Grayson-Stadler E1064GS shock generator set at either 3 or 4 milliamperes in intensity and 0.5 second in duration. (See below.) All experimental events were programmed automatically by relay and timing circuits. Responses were recorded on magnetic impulse counters and a cumulative recorder.

General Procedure

It will be convenient to describe the details of procedure when considering each individual experiment. The two *S*s were run successively in all the studies. In general, both animals received the same treatments. Procedures were changed when, in the judgment of the experimenter, rates of response were stable under a given set of conditions.

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EXPERIMENTS

I. Preliminary Training: Avoidance Conditioning

Procedure. Animal M5 had had considerable training in a lever-pressing situation before the commencement of the present investigation. The animal was placed in the apparatus, and an avoidance schedule of RS 20 seconds, SS 20 seconds was put into effect (Sidman, 1953). During this time the white noise and the white light were on. It was found that a shock of 3-milliampere intensity and 0.5-second duration was sufficient to condition and maintain the avoidance response in this animal. A total of 27 daily 4-hour sessions of training was given.

Avoidance behavior had to be approximated for the naive animal, M5. To do this, the monkey was introduced to the experimental situation with a large extension attached to the lever. Gradually, the lever was shortened. In addition, an SS interval of 5 seconds was used for the first six sessions. The schedule was then changed to RS 20 seconds, SS 20 seconds, and five more 4-hour sessions of avoidance conditioning were run in the presence of the green light and no noise. It was deemed necessary to increase the shock intensity to 4 milliamperes to sustain responding.

Results. Cumulative records of avoidance responding during the last session of training are presented for the two *S*s in Fig. 1. A large difference in rate exists between the two

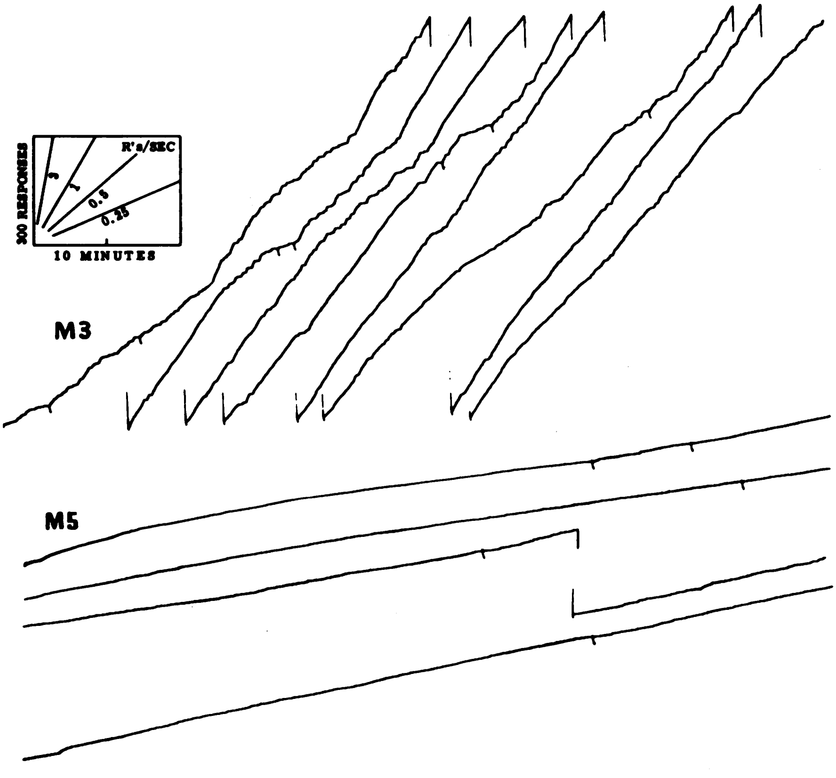

Figure 1. Cumulative records of avoidance responding during the final session of preliminary training for Animals M3 and M5. Shocks are indicated by vertical strokes.

animals. This difference persists throughout most of the experiments. In every other respect, the results of the two *S*s are comparable.

II. Multiple Avoidance Punishment: Discrimination Reversal, Extinction

Procedure. On the 28th day of experimentation, a control procedure was instituted for M3. Following 5 minutes of avoidance training in the presence of the white light and noise, the stimuli were discontinued and replaced by a green light which remained on for 10 minutes. The two lights alternated for the remainder of each 4-hour session, the avoidance contingency being present during both sets of stimulus conditions. After 14 days, a multiple avoidance punishment schedule was put into effect. The avoidance contingency was withdrawn in the presence of the green light and replaced by a punishment schedule of VI 6. Shocks were now presented every 20 seconds if the animal failed to respond in the white light, and the first response after a mean interval of 6 minutes was punished by a 0.5-second shock in the presence of the green light. In subsequent sessions, the degree to which responding was under the control of external stimuli was studied by reversing the lights associated with each component of the multiple schedule. The green light was later associated with avoidance and the white with punishment. In addition to VI 6, 1- and 3-minute punishment intervals were also used.

No control sessions were given to M5, which therefore went directly to the multiple avoidance punishment schedule after 11 sessions of avoidance conditioning in the presence of the green light. Changes in the VI punishment program and stimulus reversals roughly paralleled those of M3. Extinction after exposure to the multiple avoidance punishment schedule was studied in both animals by disconnecting the shock circuit.

Results. The major findings of this experiment are summarized in Fig. 2 and 3. Figure 2 is a plot of rates of avoidance responding in the presence of both stimuli during control sessions, and the avoidance and punishment rates during discrimination training and the

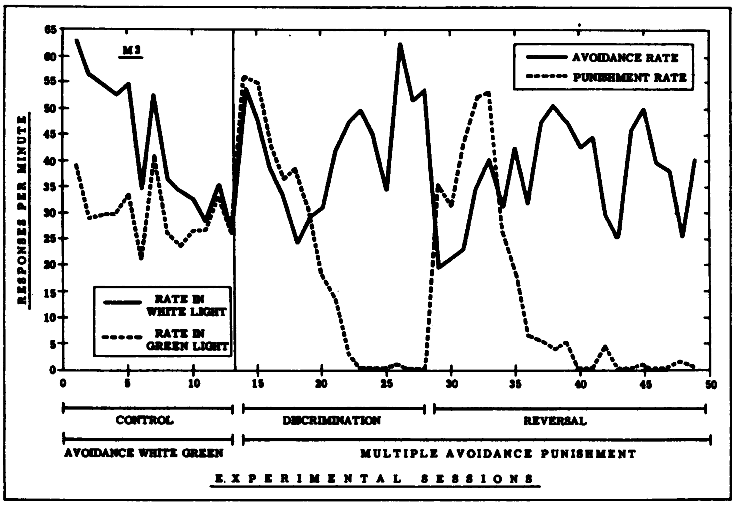

Figure 2. Average rates of avoidance responding during the white- and green-light phases of control sessions are shown for M3 in the first panel. Rates of avoidance and punishment responding upon this *S*'s initial exposure to a multiple avoidance punishment schedule and during the first discrimination reversal are then plotted as a function of experimental sessions.

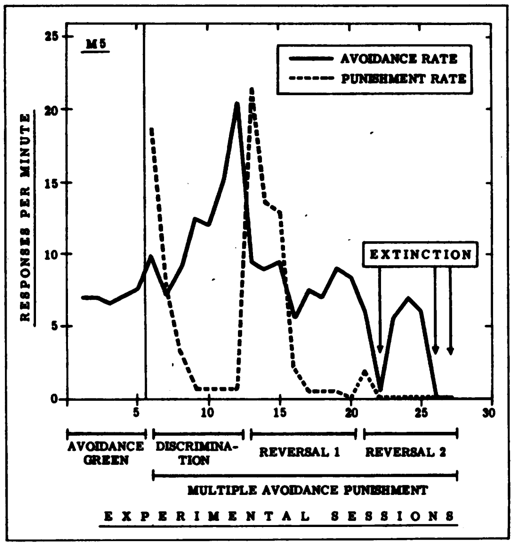

Figure 3. Average rates of avoidance and punishment responding are plotted against sessions during all phases of Experiment I for M5.

first reversal, against sessions for M3. While more responding initially occurs in the presence of the white light (in which training took place for this animal), the rate declines to a level comparable with that in the green light by the 11th control session.

Upon the animal's first exposure to the multiple schedule, the rates of response in the presence of both stimuli more than double, and, for the first time, the rate in the green light (now correlated with punishment) exceeds that in the white light. This increase in rate resembles a result of an experiment (Appel, 1960) in which unavoidable shocks were presented to rats avoiding shock in a discrimination situation similar to the present one. Before the animal learns to stop responding in the presence of the punishment contingency, additional shocks occur; these shocks have the effect of raising the level of avoidance responding (Sidman, Herrnstein, & Conrad, 1957). For the next 6 days, the rate in the green light remains higher than that in the white, while both rates decrease. The rates cross on the 7th day and the punishment rate thereafter falls to zero, while the avoidance rate fluctuates but seems to be generally rising. The monkey has learned to discriminate a situation in which the failure to press a lever is punished (avoidance) from one in which pressing the lever is punished.

The results of the second animal, M5, throughout the experiment are shown in Fig. 3. After five sessions of stable avoidance responding in the presence of the green light, the punishment contingency associated with the white light was introduced. The rate of response in the white light was initially more than double the base-line avoidance rate; the avoidance rate in the green light rises only slightly. However, the punishment rate falls very sharply to nearly zero during the next 3 days, while the avoidance rate increases.

Figure 2 shows the effect of one discrimination reversal. When the stimuli associated with each contingency are changed, a rise in the punishment rate and decline in the avoidance rate occur. These rates soon return to their original levels. Figure 3 shows two reversals.

Figure 4 shows cumulative records from the last session of conditioning on the multiple avoidance punishment contingency. Although shocks often occur when stimulus conditions change, the shocks are not necessary for discrimination; changes in stimuli often take place without an accompanying shock, and the animals are probably responding to shifts in light and noise conditions.

When the shock circuit was disconnected, the rate of avoidance responding fell to near zero, while no effects were noted during the punishment intervals. This can be seen during

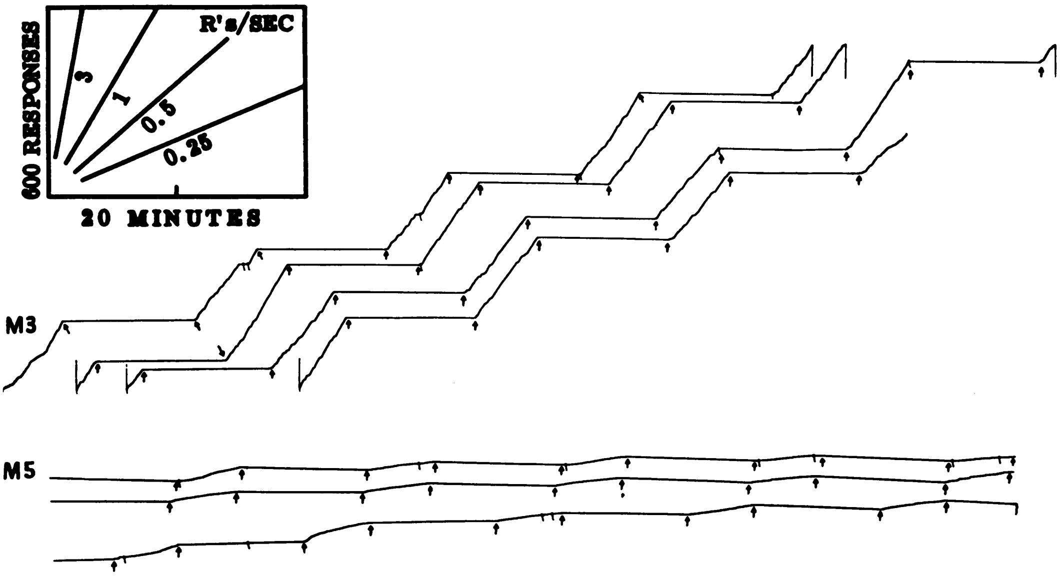

Figure 4. Cumulative records during the last session of a multiple avoidance punishment schedule. Shocks are indicated by vertical strokes; stimulus changes occur at the arrows. The performance by M3 starts during an avoidance cycle, while that of M5 begins during a punishment cycle.

Sessions 22, 26, and 27 of Fig. 3. Figure 5 shows a cumulative record of the first extinction session for M3. The rate of extinction was somewhat more rapid for M5.

III. Mixed Avoidance Punishment

Procedure. At the end of the extinction sessions, neither animal was responding in either the white- or green-light conditions. The latter stimuli were then removed, and the translucent panel above the lever was illuminated by a red light; the white noise was also present. These stimuli remained on throughout the entire session in the mixed-schedule experiments. Contingencies were shifted without any programmed changes in the external environment.

Animal M3 was run for 17 sessions and M5 for 13 sessions under a mixed avoidance punishment schedule. Periods of 5 minutes of avoidance conditioning alternated with 10-minute periods of punishment. During the punishment phase of the first experiment, the first response after a mean interval of 1 minute was accompanied by a 0.5-second shock. The length of the punishment cycle was later changed to 5 minutes.

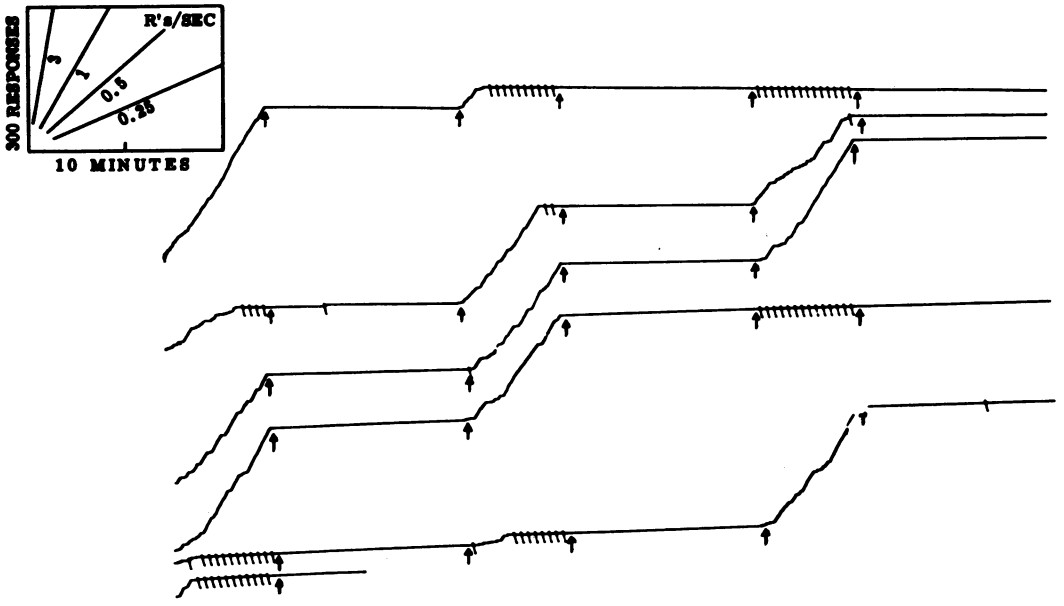

Figure 5. Cumulative record of the first extinction session for M3. Vertical strokes indicate when shocks would have occurred, had they been programmed. Arrows indicate changes in stimuli. The performance begins during the stimulus condition previously associated with the avoidance component of the multiple schedule.

Results. The results of switching the two *S*s to the mixed avoidance punishment schedule are summarized in Fig. 6. Except for the previously noted differences in absolute rates, the data from the two animals are very similar. Removing the visual stimuli had little effect on the discriminatory behavior of the monkeys. The difference in rates in the presence of the two contingencies was as large as hitherto reported. Two explanations seemed possible. The first involves a temporal discrimination of the length of each component of the mixed schedule. The animals could simply respond for 5 minutes and then stop responding for 10; few, if any, shocks would occur.

The second explanation involves the shock as a discriminative stimulus. If the animal is shocked when it is not responding, the shock might act as a cue for avoidance. If the animal is shocked while it is responding, the shock might be a cue for punishment. If this explanation is correct, shocks will occur each time the contingency shifts.

Three findings support the latter hypothesis. 1) Changing the length of the punishment cycle to 10 minutes did not disrupt the performance as it would have if the temporal discrimination hypothesis were correct. Figure 6 shows that although the punishment rate may have increased slightly when the cycle was changed, the avoidance rate either went up or stayed at its same high level. 2) Shifts in rate of responding from one component of the schedule to the next were often accompanied by a shock. This can be seen in the cumulative-response curves of Fig. 7. A comparison of these records with those of Fig. 4 shows that many more shocks accompany the change in experimental contingencies during the mixed schedule than during the multiple schedule. 3) When the punishment schedule is removed and the animals are run on a mixed avoidance extinction schedule, the discrimina-

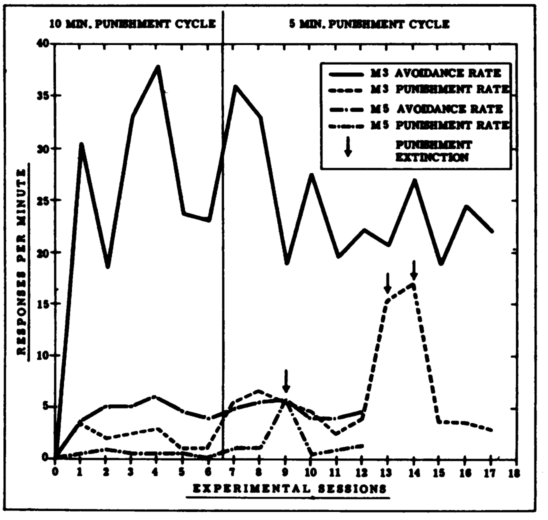

Figure 6. Average rates of avoidance and punishment responding during two components of a mixed avoidance punishment schedule. The length of the punishment cycle was decreased from 10 to 5 minutes after the sixth session of the experiment.

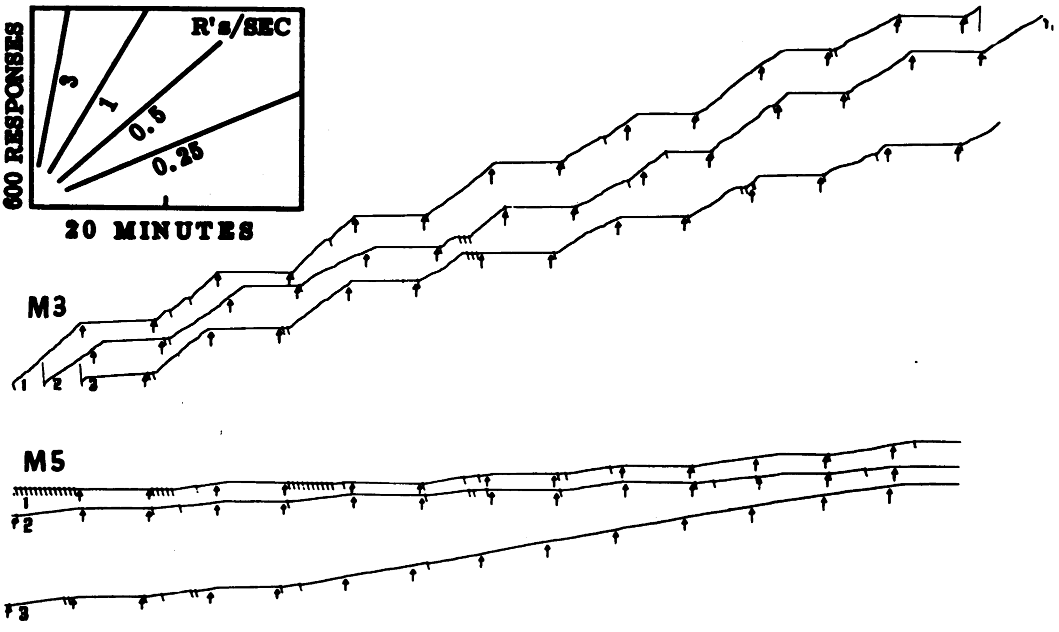

Figure 7. Cumulative records of the last session of a mixed avoidance punishment schedule. Shocks are indicated by vertical strokes; changes in the experimental contingencies occur at the arrows. The performances of both animals begin during an avoidance cycle.

tion breaks down completely. The rate of extinction responding equals that of avoidance responding. This is shown in Fig. 6, where, during several sessions, the punishment programmer accidently broke down. It can also be seen to a much greater extent in Fig. 8 (below). When the punishment program was reintroduced, the discrimination was once again established. (See Fig. 6.)

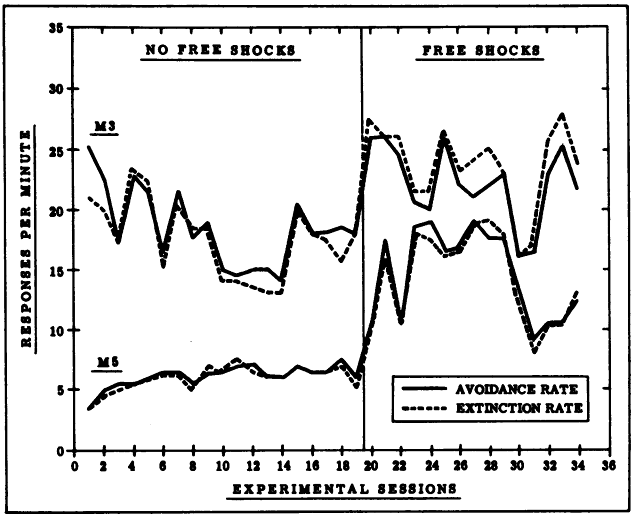

Figure 8.. Average rates of avoidance and extinction responding during exposure to a. mixed avoidance extinction schedule. Free shocks were introduced during the extinction cycle after the 19th session. These were presented an average of once every 3 minutes (VI 3).

One cannot conclude that the second hypothesis is the full explanation. Many shifts in response rate still occur without an accompanying shock (Fig. 7). There may be an interaction with temporal factors. It is clear, however, that the punishment component of the mixed schedule is necessary for discrimination; when punishment is removed, there is no discrimination at all.

IV. Mixed Avoidance Extinction: The Effect of Unavoidable Shock

Procedure. The punishment programmer was disconnected following the last day of the procedure just discussed. All other conditions remained the same, so that the animals were now running for 4 hours per day in the presence of the red light and white noise under a mixed avoidance extinction schedule. The two components alternated at 5-minute intervals. This procedure continued for 19 sessions.

On the 20th day, free shocks were introduced during the extinction component of the mixed schedule. These shocks, of 0.5-second duration, were given on a VI 3 schedule. The animals' behavior had no effect on the onset or offset of unavoidable shocks. During the avoidance component, of course, the onset of shock could be delayed by the lever-pressing response. This condition lasted 15 days.

Results. Removing the punishment contingency destroys the discrimination observed in Fig. 6. In spite of the fact that the mixed avoidance extinction procedure was carried out for 19 days, there is no evidence that the rates during the two components of the schedule are even beginning to diverge (Fig. 8). The effect of unavoidable shocks is also illustrated in Fig. 8. Shocks in extinction increase the rate of response, not only during the extinction component of the schedule but also in the avoidance component, so that no new discrimination occurs.

V. Multiple Avoidance Extinction: The Effect of Unavoidable Shock

Procedure. The procedure of the final experiment resembled that of an earlier study (Appel, 1960), but different parameters and a different species of *S*s were used.

The stimuli of Experiment I were reintroduced, so that periods of white light and noise alternated at 5-minute intervals with periods of green light and no noise. In the presence of the white light, the avoidance contingency (RS 20 seconds, SS 20 seconds) was in effect. Extinction was programmed during the green periods. For the first 26 days of the experiment, free, unavoidable shocks were given intermittently (VI 3) during the extinction component of the schedule. Responding had no effect on the occurrence of these shocks (as in Experiment IV). On Session 27 the free shocks were removed and the animals run on a multiple avoidance extinction schedule. Later, the shocks were again present.

Results. The results are summarized in Fig. 9. Animal M3 shows little evidence of discrimination when unavoidable shocks are present during extinction. The rates of response

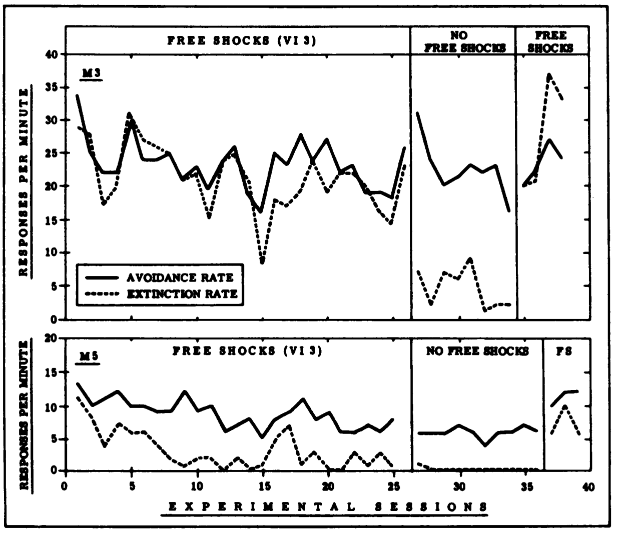

Figure 9. Average rates of avoidance and extinction responding on a multiple avoidance extinction schedule when free shocks were occasionally presented (VI 3) during the extinction component of the schedule. The free shocks were removed after the 26th session and later reintroduced.

in the two components of the multiple schedule do not diverge until the free shocks are removed on the 27th session. Reintroducing the shocks destroys the discrimination. (See Sessions 35 to 38.)

The data of M5 are somewhat different. The rate of extinction responding falls rapidly, while unavoidable shocks are present, and generally remains considerably lower than the avoidance rate. On the 37th session, when free shocks are reintroduced following multiple avoidance extinction, the extinction rate increases somewhat.

DISCUSSION AND CONCLUSIONS

The results of all of these experiments may be summarized as follows:

1. The monkeys in these experiments were able to discriminate an avoidance contingency, in which the failure to respond is punished, from a punishment contingency, in which responding is punished. Rates were high during the avoidance phase and approached zero during the punishment phase of the experiment (Experiment II: multiple avoidance punishment).

2. It was not necessary for changes in stimulus conditions to accompany changes in the experimental contingencies for this discrimination to occur (Experiment III: mixed avoidance punishment).

3. When the punishment contingency was not present, the *S*s were able to discriminate an avoidance situation from extinction only when different stimuli were associated with changes in the experimental contingencies (Experiment IV: mixed avoidance extinction; Experiment V: multiple avoidance extinction).

4. Free, unavoidable shocks presented intermittently (VI 3) during extinction resulted in an increase of rates of response in both the extinction and avoidance phases of the experiment (Experiment IV; mixed avoidance extinction, free shocks; Experiment V: multiple avoidance extinction, free shocks).

5. Discrimination of unavoidable from avoidable shock environments did not occur when these conditions were not accompanied by changes in external stimulation (Experiment IV: mixed avoidance extinction, free shocks).

Under favorable conditions, i.e., when gross changes in the experimental environment accompany changes in aversive reinforcement contingencies, the monkey appears to discriminate conditions of aversive reinforcement. Both animals learn the multiple avoidance punishment and multiple avoidance extinction paradigms. Stimulus control is excellent in at least one of these situations, multiple avoidance punishment, as the reversal data show.

When contingencies are shifted without accompanying experimentally controlled changes in the stimulus situation, the monkey discriminates only when bar pressing at the inappropriate time is intermittently punished (mixed avoidance punishment). Otherwise, the animals continue to respond throughout a session (mixed avoidance extinction).

The presence of punishment appears to be a condition conducive to the formation of a discrimination when other stimuli are not present. When stimulus changes are associated with changes in the reinforcement schedule, however, the monkey responds to them.

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