AN ANALYSIS OF THE BEHAVIOR OF RATS AND MONKEYS ON CONCURRENT FIXED-RATIO AVOIDANCE SCHEDULES

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On one type of concurrent schedule of reinforcement, operant behavior is maintained by positive reinforcers and also by the avoidance of aversive events. Ferster and Skinner (1957) studied the behavior of rats on a concurrent schedule composed of a fixed-interval (FI) schedule of food reinforcement and a Sidman schedule of shock avoidance (Sidman, 1953). Using signal detection as a positive reinforcer (Azrin, 1958) and loud noise as an aversive event (Holland, 1957), Azrin studied the behavior of humans on a comparable concurrent schedule. On the FI schedule alone, subjects (rats or humans) characteristically pause for several minutes and then respond at a positively accelerating rate until reinforcement. On the concurrent FI avoidance schedule the usual initial pause was replaced by a low, stable rate which is characteristic of the avoidance schedule alone (Azrin, 1958; Ferster & Skinner, 1957).

In the present experiments, fixed-ratio (FR) schedules of food reinforcement were combined with a Sidman schedule of shock avoidance. Performance on FR schedules alone is characterized by high, stable response rates. Pauses occur at the start of each FR segment when the response requirement is high or when the animals approach food satiation. The behavioral characteristics of the concurrent FR avoidance schedule were analyzed by the following procedures:

1. No shocks were delivered (avoidance extinction).
2. No food was delivered (FR extinction).
3. Animals were fed before each session (prefeeding).

METHOD

Subjects

The subjects were male albino rats and squirrel monkeys. The feeding regimen maintained each animal at about 75% of its estimated free-feeding weight. Average free-feeding weights were 450 grams for the rats and 700 grams for the monkeys. The monkeys' diet was supplemented with vitamins. Reinforcers were 94-milligram food pellets (P. J. Noyes Co., Lancaster, N. H.).

Apparatus

Standard rat experimental chambers (Grason-Stadler Co.) were used with both species. The lever (Gerbrands lever for rats; telephone key for monkeys), mounted in one wall, could be activated by a pressure of about 15 grams. Each depression of the lever activated the controlling and recording circuits and produced a distinct relay "click." Shocks of 0.6 milliampere with a duration of 0.5 second were delivered through a grid scrambler to the floor of the experimental chamber.

Procedure

The animals were magazine-trained and shaped to press the lever for food. After 20 reinforcements had been delivered on a continuous reinforcement schedule, the concurrent FR avoidance schedule was initiated. When the animal did not respond on this concurrent schedule, shocks were delivered at 30-second intervals. Each response postponed shock for

30 seconds. The FR requirement was gradually increased to FR 50 (three rats), FR 150 (two monkeys), or FR 200 (three rats). Experimental sessions lasted about 2 hours for rats and 4 hours for monkeys. Stable performances developed within 10 experimental sessions.

RESULTS AND DISCUSSION

Concurrent FR Avoidance (Rat)

Representative control performance on concurrent FR 50 avoidance and concurrent FR 200 avoidance are presented in the cumulative records of Fig. 1 and 2, respectively.

For convenience in presentation, each curve has been displaced along the abscissa. (See Ferster and Skinner, 1957, p. 27). The diagonal pips and small arrows indicate reinforcements and shocks, respectively. Coordinates and representative rates of responding are shown at the lower right of the figures. The cumulative records reveal two distinct rates of responding. In many FR segments, the rats initially responded at a low rate for a short period of time and then abruptly shifted to and maintained a very high rate until food was delivered. The duration of the initial low rate tended to increase as the session continued. These results suggest that shock avoidance maintained the low response rate, whereas food reinforcement maintained the high response rate. The abrupt shifts in response rate might indicate a minimal amount of interaction between the two component schedules. This possibility was assessed by extinguishing the avoidance component.

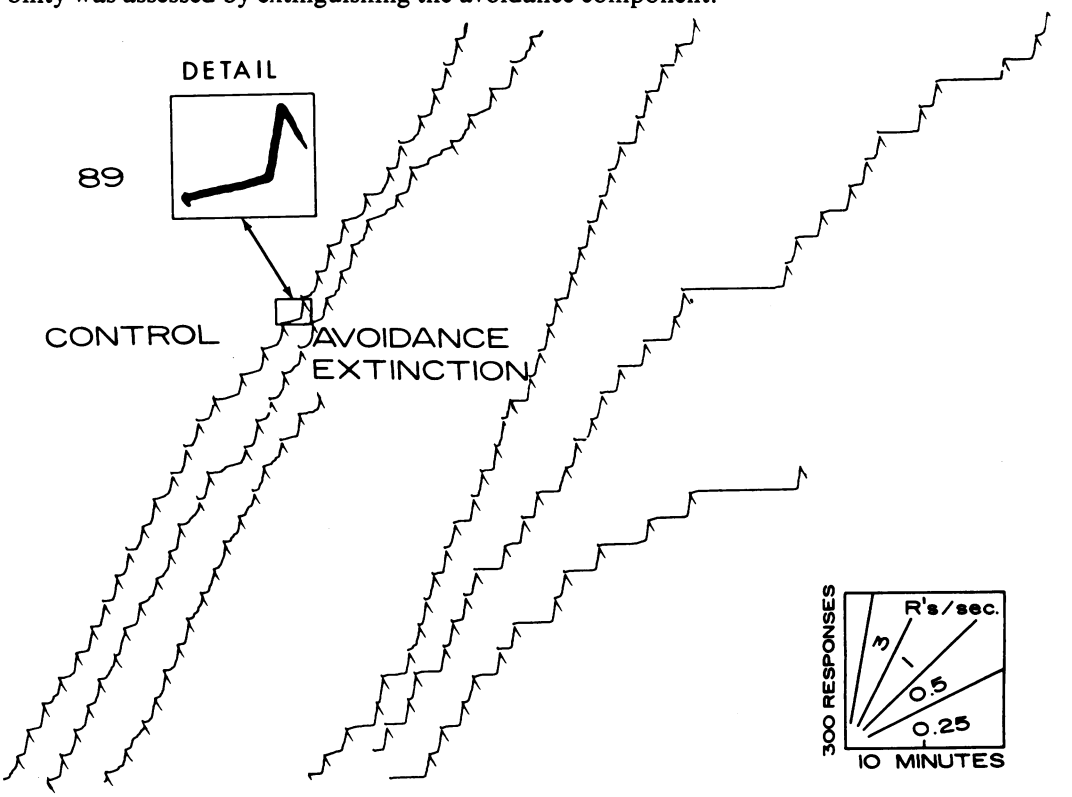

Figure 1. Representative control session on concurrent FR 50 avoidance is shown at the left. The second day of avoidance extinction is shown at the right. Pips indicate reinforcements. Coordinates and representative response rates are shown at the lower right.

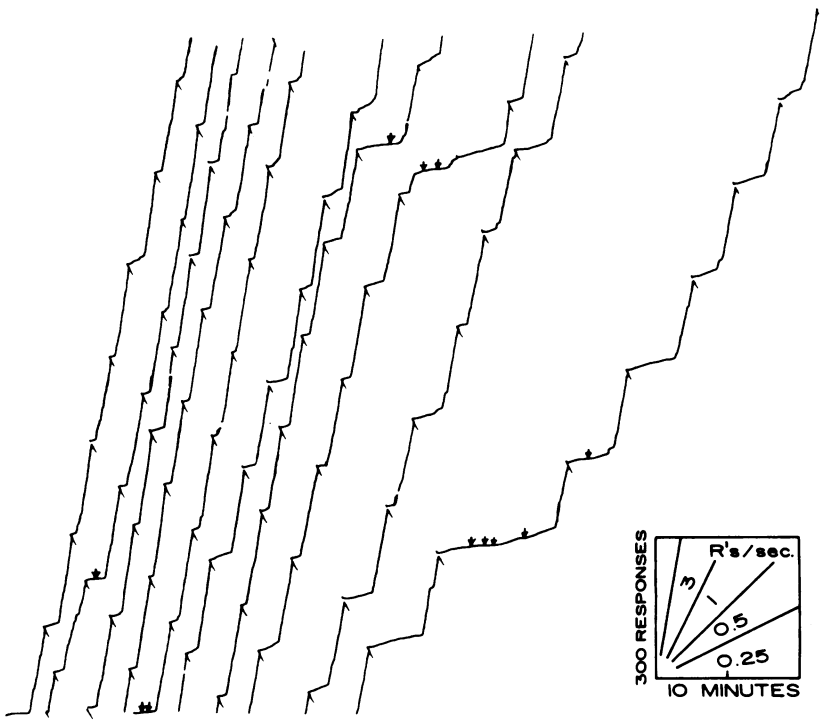

Figure 2. Representative control session on concurrent FR 200 avoidance. Pips indicate reinforcements, and small arrows indicate shocks.

Avoidance Extinction (Rat)

The effects of extinguishing the avoidance component by disconnecting the shock source are presented in Fig. 1 and 3. The cumulative records at the right of Fig. 1 are from the second session on avoidance extinction. The pauses following reinforcement became more frequent as the session proceeded. Record A in Fig. 3 shows the second hour under avoidance extinction. At the start of each FR segment, either the avoidance rate was maintained (as at *a*) or a brief pause occurred (as at *b*). The first indication of the effects of the avoidance extinction appears at *c*, where a relatively prolonged pause occurred at the start of an FR segment. Record B at the right of Fig. 3 was taken from the last 30 minutes of the sixth session without shock. Many pauses were brief (as at *d*); however, more prolonged pauses (as at *e* and *f*) were frequent. These results demonstrate that shock avoidance maintained the low rates following reinforcement on the concurrent schedule. The pauses following reinforcement on avoidance extinction were occasionally more prolonged than the comparable periods of slow responding on the concurrent schedule. Nevertheless, the main effect of removing the avoidance component by extinction was to eliminate the low response rates following reinforcement.

The length of the pauses following reinforcement on avoidance extinction indicates that the avoidance component of the concurrent schedule does facilitate the occurrence of the

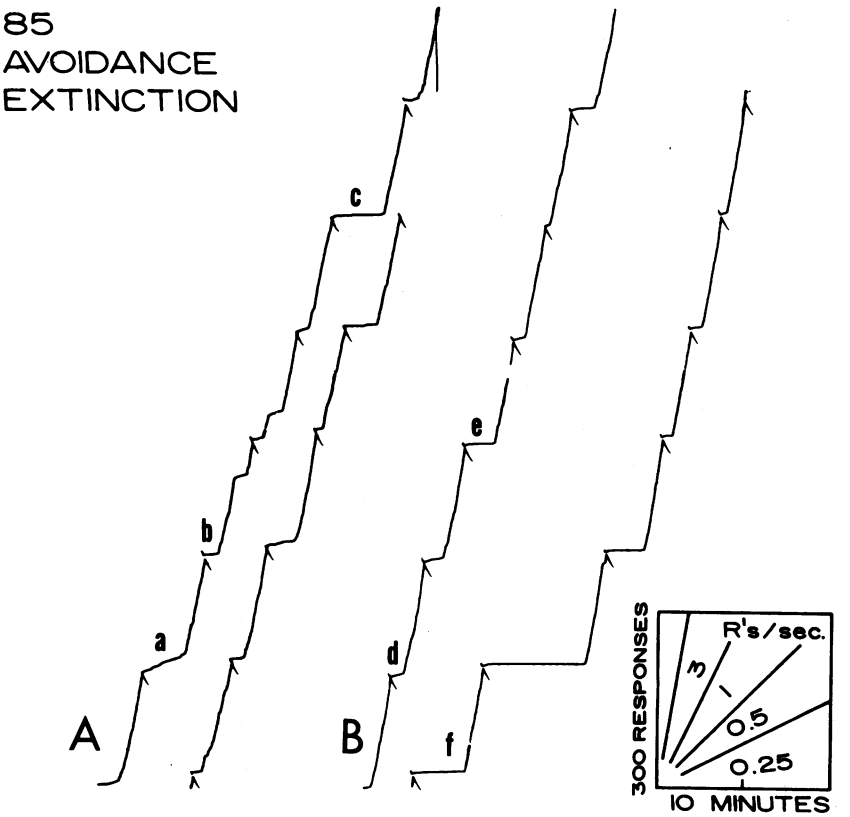

Figure 3. Performances after 1 hour (Record A) and 14 hours (Record B) of avoidance extinction.

high response rate. Possibly, the FR component affects the avoidance component. This possibility was assessed by extinguishing the FR component.

FR Extinction (Rat)

The effects of extinguishing the FR component by disconnecting the food magazine are presented in Fig. 4 and 5. The first and third days of FR 50 extinction are presented in Records A and B, respectively, of Fig. 4. The first and second days of FR 200 extinction are presented in Records A and B, respectively, of Fig. 5. In each figure the initial portions of Record A show the prevalence of characteristic high FR rates. As the first session continued, the high rates occurred less frequently. In subsequent sessions (Records B), the avoidance rates prevailed.

After training on FR alone, extinction is characterized by high rates alternating with pauses (Ferster & Skinner, 1957). After training on the concurrent schedule, FR extinction was typical except that the avoidance rate replaced the usual pauses. FR extinction had little effect upon the avoidance component of the concurrent schedule. Another way to affect the FR component is to change the animal's level of deprivation.

Prefeeding (Rat)

The effects of allowing the animals 24 hours of free feeding are presented in Fig. 6 and 7. In Fig. 6, prolonged low rates of responding alternate with frequent high rates, which

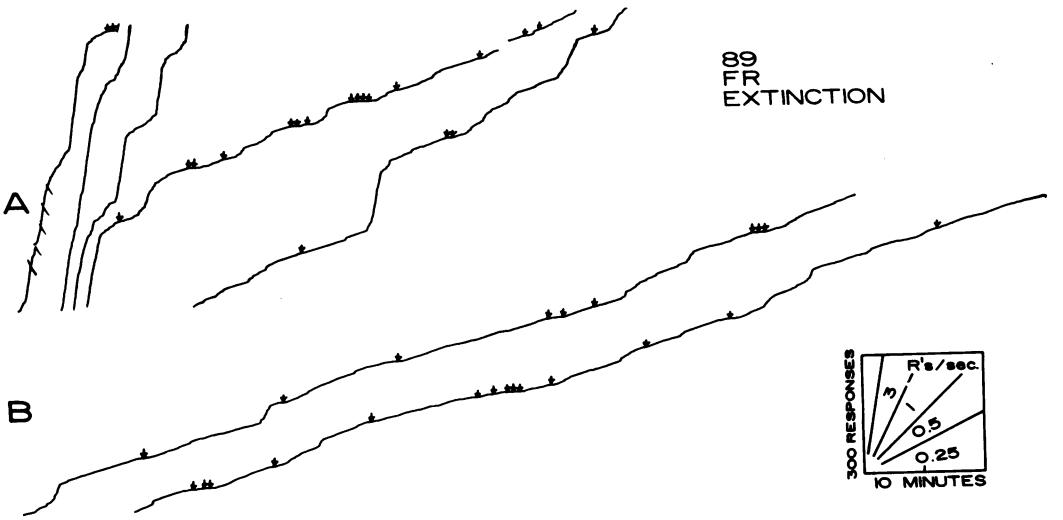

Figure 4. Performances from the first (Record A) and third (Record B) sessions on FR 50 extinction. The pips at the left of Record A do not indicate reinforcements.

terminate at reinforcement. In Record A of Fig. 7 the characteristic avoidance rate prevailed; however, a higher rate occurred occasionally (as at *a*).

Record B of Fig. 7 shows the effects of 72 hours of free feeding. The avoidance rate prevailed throughout this session; however, the animal ate each food pellet that was delivered.

In summary, the results show that rats develop two distinct response rates on concurrent FR avoidance. Each rate is controlled by one of the schedule components. Pauses following the reinforcement on FR alone are longer than the comparable periods of slow responding on the concurrent schedule. Otherwise, interactions between the FR and avoidance components of the schedule are slight.

Concurrent FR 150 Avoidance (Squirrel Monkey)

Representative control records for a monkey (K1) are presented in Fig. 8 (upper left). The performance of the other monkey was almost identical. The performances were similar to those of the rats. Again, two distinct response rates alternated (as at *a* and *b*). The low response rate (avoidance component) following reinforcement (as at *a*) was consistently higher with monkeys than with rats. As a result, the monkeys were seldom shocked. Only one or two shocks were delivered in each 4-hour session. When shocks did occur (as at *c*), the high rate soon followed.

Avoidance Extinction (Squirrel Monkey)

Three phases of avoidance extinction are presented in Fig. 9. After 1 hour of avoidance extinction (Record A), the performance remained at control levels. After 3 hours of avoidance extinction (Record B), low response rates had become more prolonged (as at *a* and *b*). However, the number of 30-second pauses (which would usually result in shock) was no higher than in control sessions. After 6 hours of avoidance extinction (Record C), pauses after reinforcement had become frequent (as at *c* and *d*). Thirty-six pauses of more than 30 seconds occurred before the concurrent schedule was again put in effect at D. Pausing decreased almost immediately, and the monkey received only four shocks in the curves shown after D.

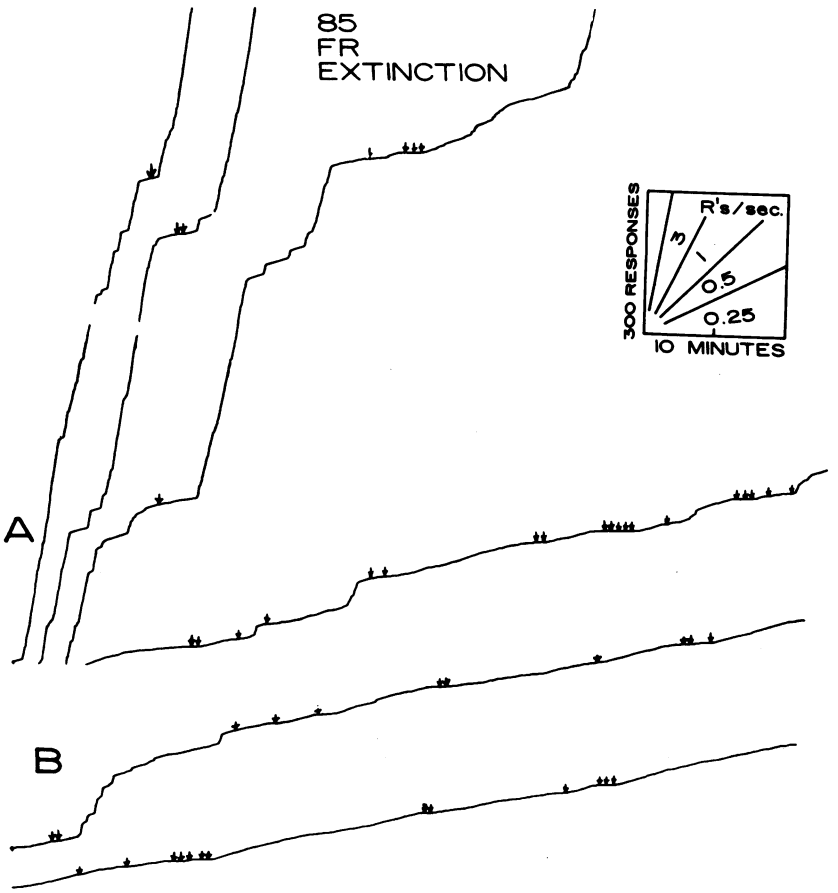

Figure 5. Performances from the first (Record A) and second (Record B) sessions on FR 200 extinction.

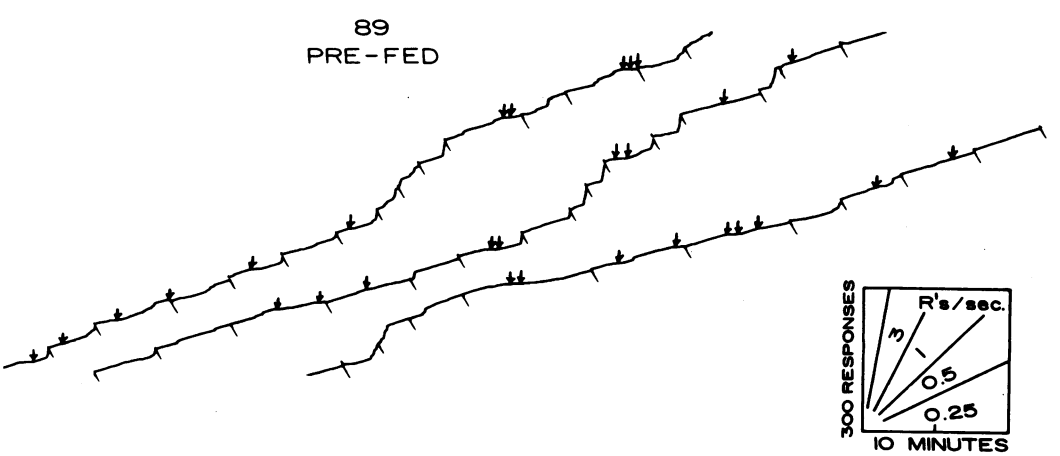

Figure 6. The effects of 24 hours of free feeding on concurrent FR 50 avoidance.

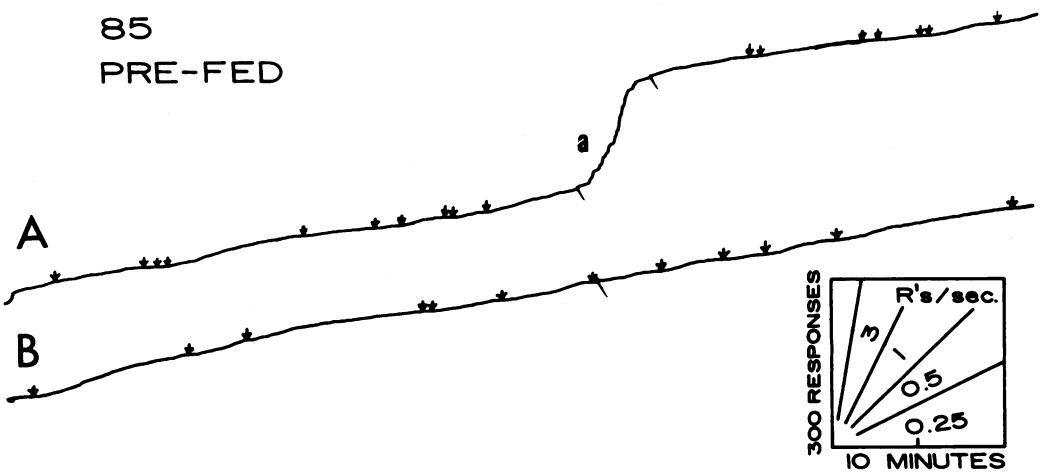

Figure 7. The effects of 24 hours (Record A) and 72 hours (Record B) of free feeding on concurrent FR 200 avoidance.

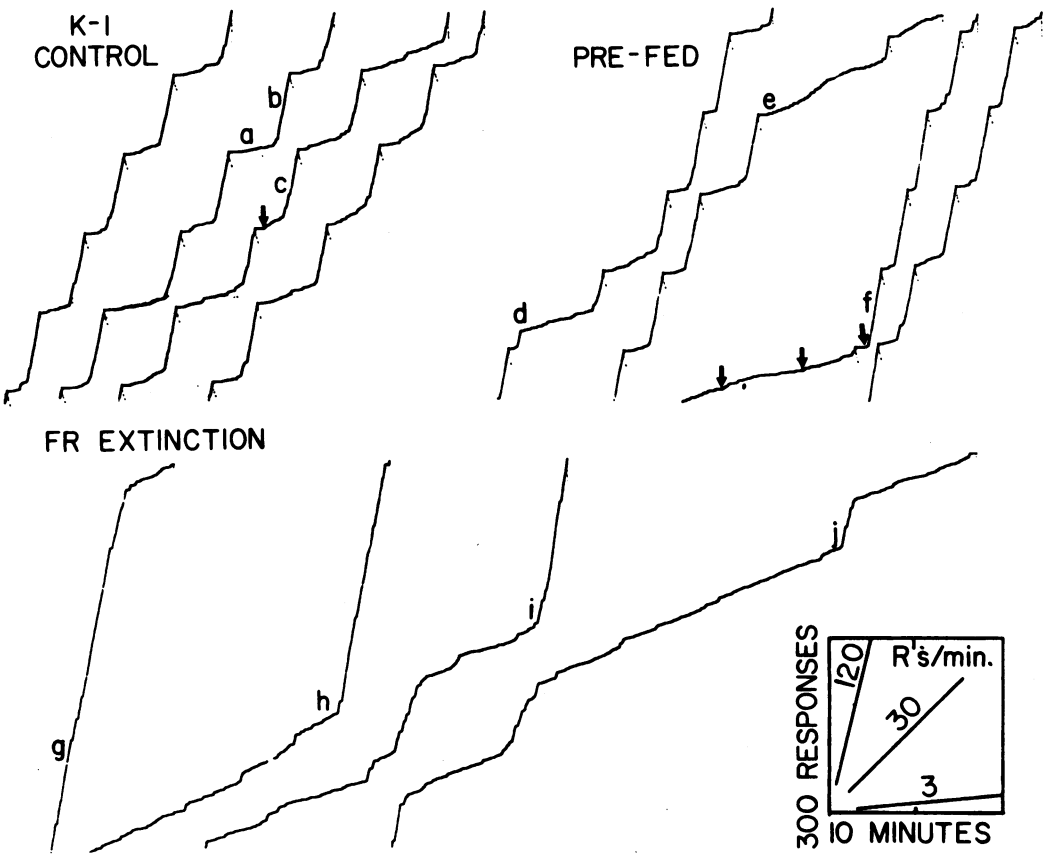

Figure 8. Control performance on concurrent FR 150 avoidance, and the effects of prefeeding and FR extinction on this performance.

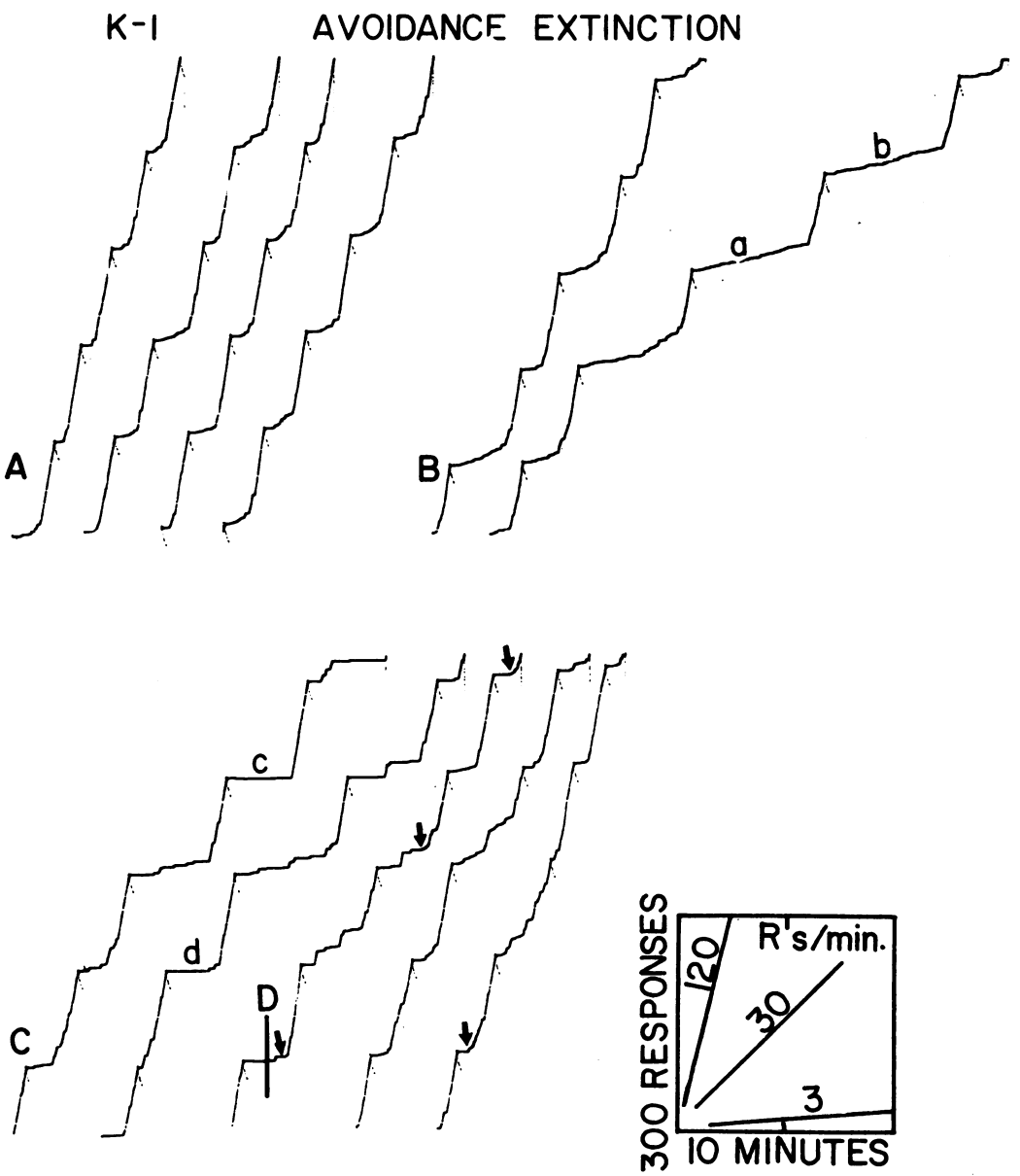

Figure 9. Performance after 1 (Record A), 3 (Record B), or 6 (Record C) hours of avoidance extinction. Shock was re-introduced at D.

The avoidance behavior of the monkeys was quite resistant to extinction. Nevertheless, the extinction of the avoidance component had little effect upon the behavior which was characteristic of the FR component.

FR Extinction (Squirrel Monkey)

The effects of extinction of the FR component of the monkeys' performance (Fig. 8, bottom) were qualitatively similar to the effects obtained with rats. The duration of the

high response rates (as at *g*, *h*, *i*, and *j*) became less prolonged as the session proceeded. Shocks were as infrequent during FR extinction as in control sessions.

Prefeeding (Squirrel Monkey)

After 5 days on free feeding the performance shown in Fig. 8 (upper right) had developed. High response rates were frequent, although not always sustained until reinforcement (as at *d*). Low response rates were often prolonged (as at *e*). Apparently, free feeding did not result in complete satiation.

In summary, the results obtained with squirrel monkeys were qualitatively similar to those obtained with albino rats. The monkeys' rates of responding on the avoidance component of the concurrent schedule were higher than the comparable rates for rats. Also, the avoidance component of the monkeys' performances was more resistant to extinction than the comparable component for rats. However, the monkeys were at different FR values than the rats.

With both species, pauses following reinforcement on FR alone were longer than the comparable periods of slow responding on the concurrent schedule; otherwise, only slight interactions occurred between the FR and avoidance components of the schedule. This schedule should be useful in assessing variables which might differentially affect behavior controlled by appetitive and aversive contingencies.

SUMMARY

Albino rats and squirrel monkeys pressed a lever to obtain food on an FR schedule and also to avoid shock on a Sidman avoidance schedule. On this concurrent FR avoidance schedule, both of the component schedules were in effect concurrently, and no exteroceptive stimulus was associated with either schedule.

In control sessions the animals responded at a low, stable rate for a short period of time following reinforcement. Then, the response rate shifted abruptly from this very low rate to a very high rate, which was maintained until reinforcement. When no shocks were delivered, pauses developed following reinforcement, and all responding occurred at very high rates. When no food was delivered or when the animals were on free feeding, low rates of responding prevailed.

The results with both species demonstrated that performance on the concurrent schedule is characterized by avoidance behavior immediately after reinforcement and FR behavior just before reinforcement. Interactions between these two components are slight.

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