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ATTACK PRODUCED BY INTERMITTENT REINFORCEMENT OF A CONCURRENT OPERANT RESPONSE[1]

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Squirrel monkeys pressed a lever to produce food on several fixed-ratio schedules; they could also bite a rubber hose. Biting attack occurred during the postreinforcement pause and in early portions of the ratio response run. Also, biting attacks increased after transitions to higher values of the fixed-ratio requirement and in extinction. The results show that extinction-induced aggression effects occur in primates.

Aggressive behavior is elicited by several different types of noxious stimulation (negative reinforcers). Ulrich and Azrin (1962) demonstrated that electric shock, as well as intense heat, would elicit attack by a rat against another rat. Azrin, Hake, and Hutchinson (1965) demonstrated that a physical blow could also elicit attack in monkeys.

More recently, Azrin, Hutchinson, and Hake (1966) have shown that removing food from a food-deprived pigeon will produce attack against another pigeon. Subjects attacked when a transition was made from a high frequency of reinforcement to extinction.

The present experiments sought to determine the effects of intermittent reinforcement of an independent operant response upon attack behavior. An additional objective was to discover whether extinction-induced aggression effects occurred in primates.

Squirrel monkeys were trained to press a lever for food pellets delivered on various fixed-ratio schedules. Biting attack on a rubber hose could be recorded simultaneously during each of the different schedules. Occasionally, subjects were exposed to extinction.

METHOD

Subjects

Four naive adult male squirrel monkeys, weighing between 600 and 1000 g, were housed individually and retained for one month in the laboratory before any experimental routines.

Apparatus

Subjects were restrained in a seated position in a modified Lehigh Valley squirrel monkey restraining chair (Hake and Azrin, 1963). Mounted on the operandum panel was a Lehigh Valley response bar set for a force requirement of 15 g. This bar was mounted 2 in. above the waist yoke and 1 in. from the left wall. The food cup was mounted 2 in. above the waist yoke and 1 in. from the right wall of the chamber. Above the bar and food cup was a rubber tube which the subject could bite; biting closed a pneumatic switch (see Hutchinson, Azrin, and Hake, 1966). The inner chamber was housed in a sound-attenuating shell. Masking noise was provided by a standard white-noise generator. Illumination of the inner chamber was provided by two 15-w bulbs mounted directly above the inner chamber on the outer chamber. Bar responses, biting responses, and food deliveries were recorded and programmed automatically by standard electromechanical devices in an adjacent room. Biting and bar-pressing responses were recorded separately on two cumulative recorders and on an Esterline Angus recorder with high-speed paper feed (30 in. per min). One 45-mg Noyes rat pellet was delivered by a Davis feeder at reinforcement.

Procedure

After the one-month acclimatization period, subjects were deprived of food until their weights reached approximately 80% of free-

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feeding weight. They were then magazine trained and shaped to press the response bar for food pellets on a continuous reinforcement (CRF) schedule. The ratio requirement was then progressively increased. Frequently, lower ratio requirements were reinstated in an attempt either to improve strained performance (long pauses after reinforcement and during response runs) or to recapture response rates produced earlier in an experimental series. Occasionally, responding was extinguished. Sessions were typically terminated by the delivery of the fiftieth food pellet or after 1.5 hr, whichever came first. Extinction sessions were up to 8 hr long. A subject was usually kept on a particular ratio requirement until performance had stabilized. Sometimes the ratio value was rapidly increased to determine effects on bar-pressing and biting. The number of sessions at different ratio values varied between 10 and 50.

RESULTS

The behavior of several animals was extinguished after reinforcement on low ratios.

Figure 1 shows the effect of extinction on bar-pressing and hose-biting for Subject M-188. The lower curve of Fig. 1 is a record of food-pellet deliveries; the top curve displays bar-pressing. The response pen reset to the baseline after each reinforcement. After 100 reinforcements the pellet feeder was disconnected. Response feedback was otherwise unaltered. At this point, the response pen no longer reset to the baseline. After approximately 750 responses, the subject started biting the rubber hose. Every bite produced a brief downward deflection of the response pen, as shown in the circled section of the top figure. The middle tracing in Fig. 1 displays a cumulative record of the biting. Biting did not start when extinction was introduced, but only after some minutes. When biting started, it continued at a frequency of 20 to 30 responses per min for the next 20 min. After this extinction probe, the FR 2 requirement was reinstated. The upper and middle curves show that biting ceased immediately upon the reintroduction of reinforcement. This subject had previously been studied for a four-month period on various fixed-interval (10, 30, 60, 90, and 180 sec) and fixed-ratio (2, 3, 5, 7, 10, 15, 25, 35, and 45) requirements before this experiment. The subject had most recently been on FR 2 for six days before the extinction test. On only the first of these days did any biting occur (25 bites). In each of the three subjects so tested, a transition from low ratios to extinction produced biting attack against the rubber hose.

With increases in the ratio requirement, subjects began biting during ongoing intermittent reinforcement. Figure 2 shows sample cumulative records for three subjects. Biting is shown by the momentary downward deflection of the response pen.

Each subject had been exposed to numerous fixed ratios before those days presented. M-121 had been studied at ratio requirements of from 2 to 75 over a four-month period. The day shown in Fig. 2 was the sixty-fourth session at FR 50. M-100 had been studied at ratios from 2 to 250 during the previous four months. The session shown in Fig. 2 was the fifth at FR 200. M-150 had a three-month history including ratios from 2 to 100. The data in Fig. 2 were collected on the sixth day of FR 100. Figure 2 shows that biting tended to occur during the postreinforcement pause, or early in the ratio run, rather than immediately before reinforcement.

Figure 3 shows the interreinforcement distribution of biting for three subjects after responding had stabilized. Data of Fig. 3 were obtained from M-121 on the fourteenth day, from M-150 on the ninth day, and M-100 on the eighth day of exposure to the ratio values indicated. Biting distribution was divided into seven class intervals. The first interval included all bites between reinforcement for the last response run and the first bar-press in the new run. The next six intervals are divisions of the current bar-press ratio run. Figure 3 shows a marked bias in the distribution of biting for each subject. Bites occurred in the postreinforcement pause or in the early sections of the bar-pressing run.

When subjects were initially exposed to higher ratios, biting was not distributed as indicated in Fig. 3. Figure 4 presents the distribution of biting attack within the interreinforcement interval for the first and twelfth days of FR 150 for M-100. This subject had previously been exposed to ratio schedules from 2 to 250. Biting occurred throughout the response run on the first day of exposure to FR 150. The response requirement had been raised from FR 20 to FR 100 over the five ses-

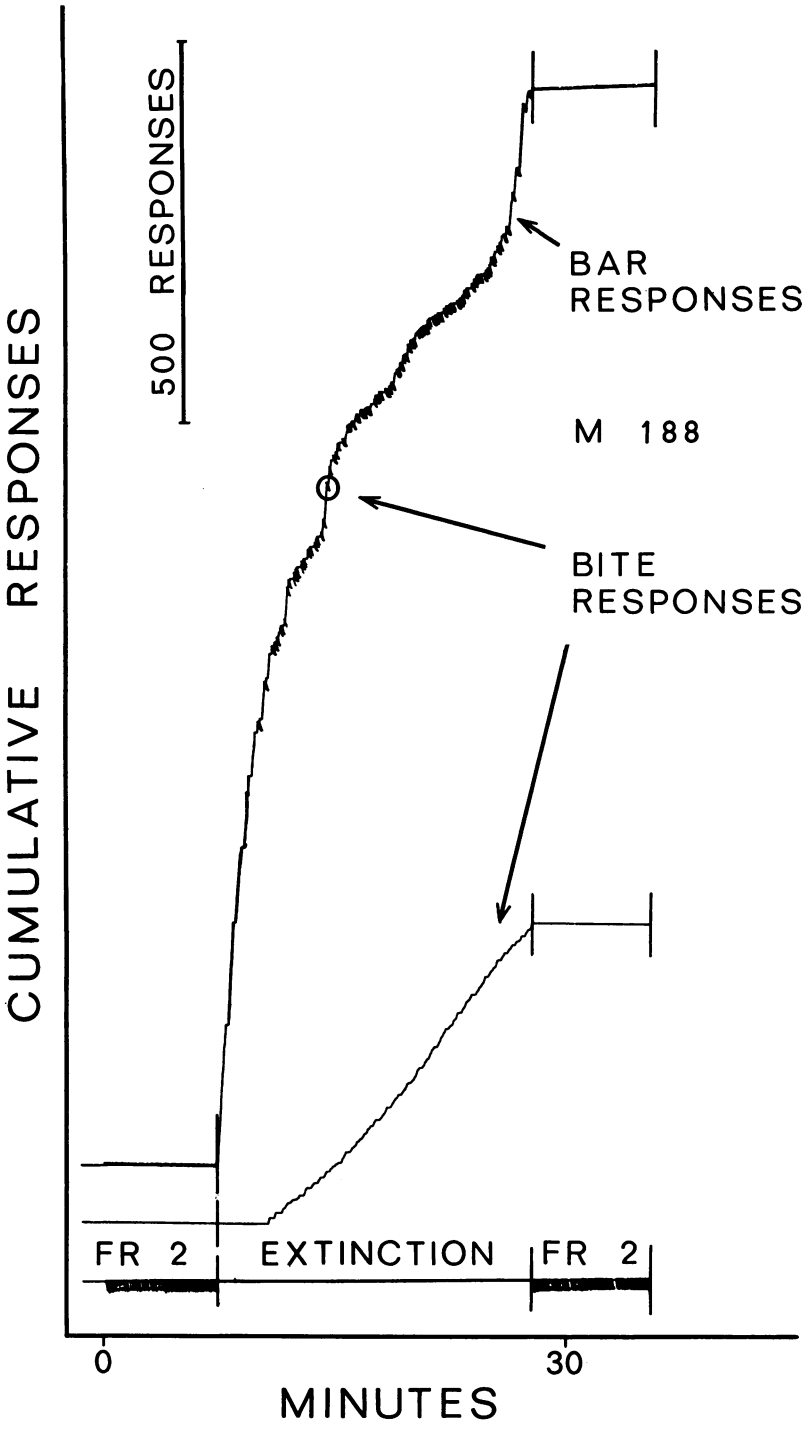

Fig. 1. Effect of extinction on bar-pressing and hose-biting following FR 2. Bar-pressing was recorded by the cumulative upward excursion of the pen in the upper curve. The response pen was reset to the baseline with each reinforcement. Hose-biting was recorded by the brief downward deflections of the pen in the upper curve and by the cumulative upward excursion of the pen in the center curve. Food deliveries were recorded by the brief downward movement of the pen in the lower curve.

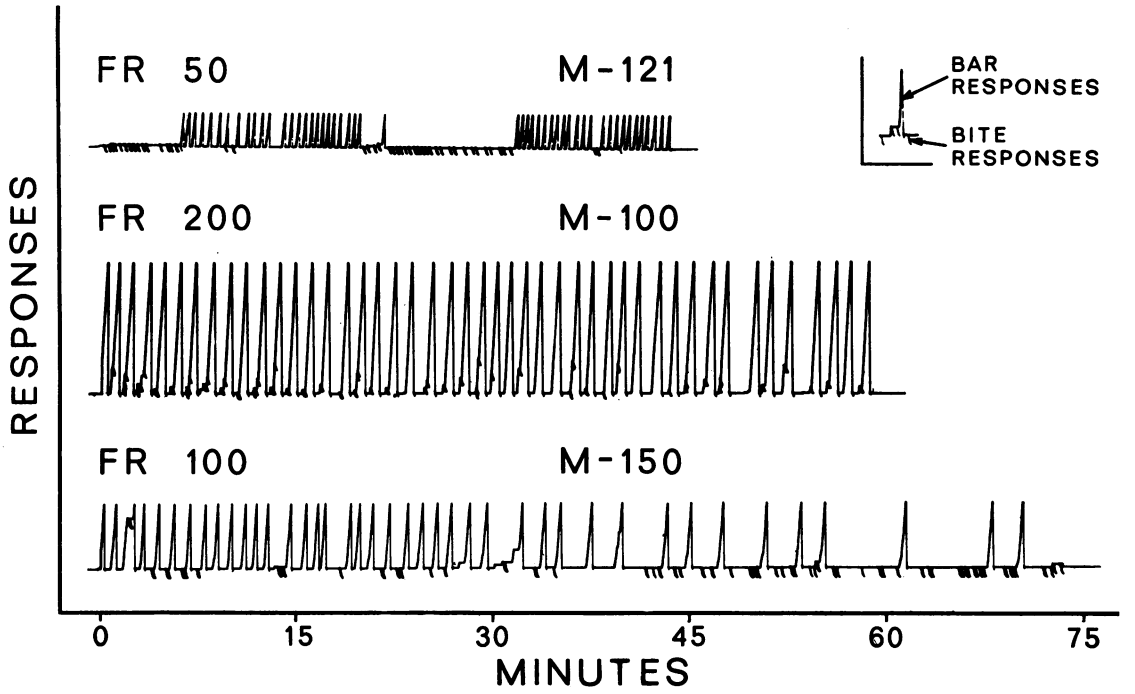

Fig. 2. Bar-pressing and biting attack during ongoing intermittent reinforcement. Bites are indicated by the brief downward deflections of the response pen. The pen resets to baseline after each reinforcement.

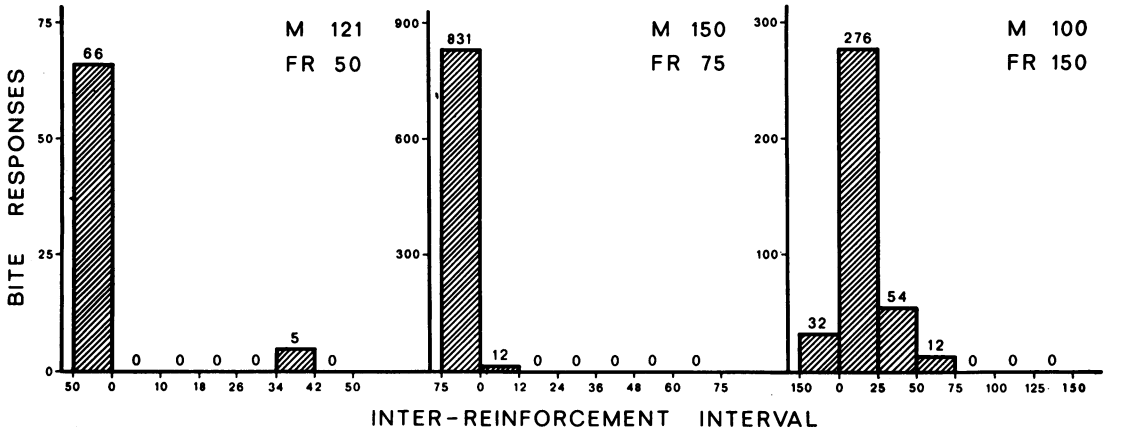

Fig. 3. Distribution of biting responses within the interreinforcement interval. Data in the first cell include all bites occurring in the interval between reinforcement and the initial bar-press of the ensuing ratio requirement. The bar-press ratio requirement was divided into six intervals.

sions just before that shown on the left in Fig. 4. By the twelfth session, biting was localized within the postreinforcement pause and early stages of the ratio run.

Occasionally the ratio requirement was greatly increased. Figure 5 presents data from two subjects for a series of sessions under several different ratio requirements. Subject M-121 was on FR 50 and later on FR 75 for 15 sessions. The original FR 50 requirement was then reinstated and produced little biting. Upon transition to the higher ratio requirement, biting increased progressively over the 15 sessions. Upon return to FR 50, biting did not immediately decrease to a low level for four sessions. The right-hand plot of Fig. 5 shows similar results obtained with another subject. On FR 50, Subject M-150 displayed

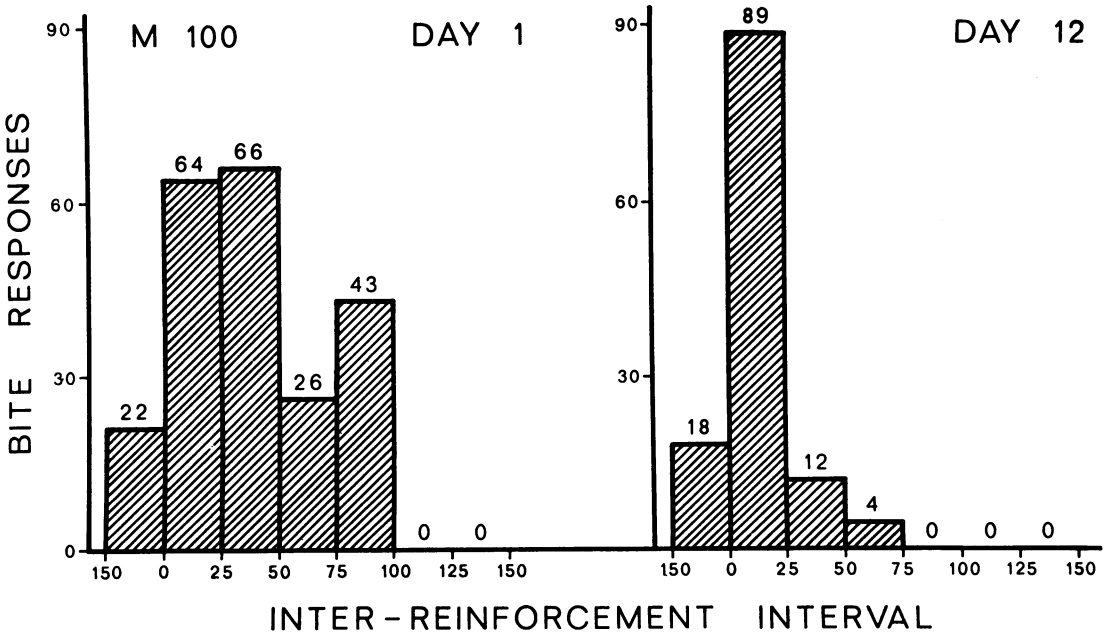

Fig. 4. Changes in the distribution of biting responses within the interreinforcement interval for the first and twelfth days of exposure to an FR 150 ratio requirement.

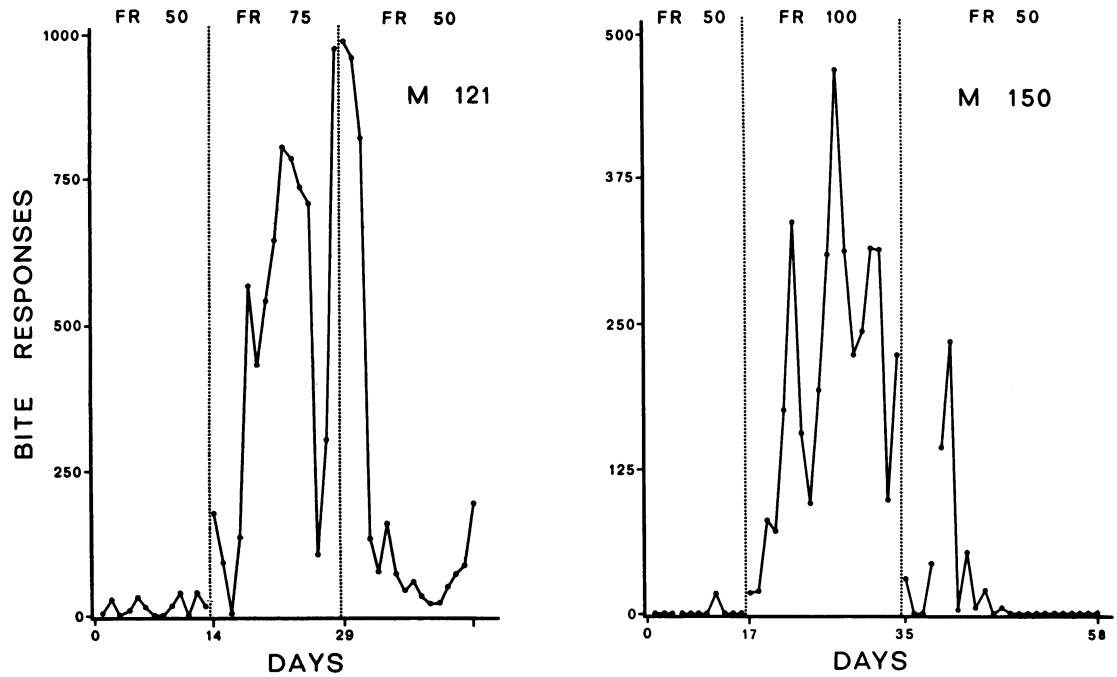

Fig. 5. Effect of changes in the bar-press ratio requirement on biting attack for two subjects. Data are total bites during successive daily sessions.

little biting. Introduction of the FR 100 requirement increased biting. With the reintroduction of FR 50, biting gradually decreased but continued to occur for about another 12 days.

During these experiments, apparatus failures sometimes occurred, such as when the pellet dispenser became disconnected. Subject M-188 had just received the fourth reinforcement of the fifth session of FR 20. It had

previously been exposed to several fixed-ratio values up to FR 35 and fixed-interval schedules up to 3 min. The inadvertent extinction condition was continued for an extra-long period (8 hr) and following that for forty 4-hr daily sessions. Figure 6 is a plot of both bar-pressing and hose-biting during these 41 days. On the five days of FR 20 before extinction, only one bite had occurred. When exposed to extinction, biting occurred at a high frequency, gradually decreasing only after the sixth extinction session. The general parallel in decreases of bar-pressing and hose-biting over the extinction series is evident. Over the course of the 41 extinction sessions, a total of 25,729 bar-presses and 75,090 bites occurred. The extreme resistance to extinction provided by the previous history of intermittent reinforcement appeared to contribute to the lengthened display of biting.

DISCUSSION

The present experiments demonstrated that a transition from reinforcement, under a fixed-ratio schedule, to extinction will produce biting attack by squirrel monkeys. This finding extends the results reported by Azrin *et al.* (1966) in their studies of extinction-induced aggression in pigeons, demonstrating that the effect occurs in primates as well.

The results also demonstrated that fixed-ratio schedules produce biting attack. Several investigators (Azrin, 1961; Thompson, 1964; Thompson, 1965) have shown that a subject will escape from fixed-ratio schedules depending upon several variables. One of the principal escape-generating characteristics of these schedules seemed to be a high response requirement and/or a low frequency of reinforcement. They demonstrated that escape was most likely during the postreinforcement pause or early parts of the response run. The present study found that biting attack was also maximal in the postreinforcement pause and early portions of the ratio run. Since biting attack is elicited by negative reinforcers, or aversive stimuli, it appears likely that some features of ratio schedules are aversive, and

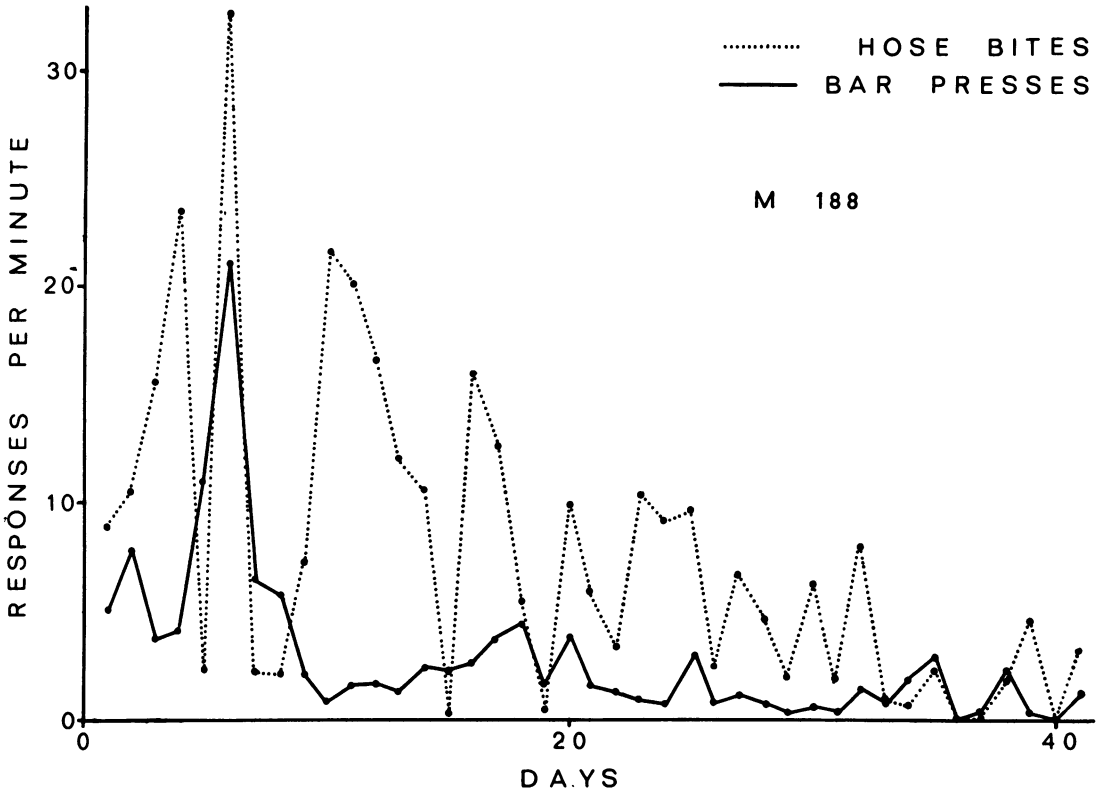

Fig. 6. Bar-pressing and hose-biting during 41 days of extinction. The subject received four reinforcements during the first several minutes of the first plotted session. The pellet feeder became electrically disconnected at that time. All other response feedback was continued for all sessions.

that aversiveness is greatest shortly after reinforcement or when the response requirement is greatest. This speculation is consistent with the interpretation of the Azrin and Thompson studies.

Biting increased, although not immediately, after a transition to a higher ratio requirement; nor did introduction of a lower ratio requirement immediately reduce biting attack. Ferster and Skinner (1957, p. 57) have shown that the development of final performance on a ratio schedule usually requires several sessions at the new ratio value.

Previous studies of aggression have discovered several conditions which can produce attack episodes. Electric shocks and intense heat (Ulrich and Azrin, 1962), a physical blow (Azrin *et al.*, 1965), or extinction after continuous positive reinforcement (Azrin *et al.*, 1966) have produced aggressive episodes of from 1 to 300 sec. In the present study, extinction after intermittent reinforcement produced recurring attack episodes lasting hours and weeks. The extreme discrepancy between amounts of attack observed under the present circumstances and that noted in any previous study supports the tentative conclusion that an intermittent reinforcement history produces greater attack during extinction than does a history of continuous reinforcement. Additional research will be necessary to understand fully such an effect. The observation of human behavior provides many examples of the long-term display of aggressive behavior in the apparent absence of any immediately preceding change in the environment. Perhaps such aggression is the result of present or past intermittent positive reinforcement.

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