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LEVER ATTACKING BY RATS DURING FREE-OPERANT AVOIDANCE[1]

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Rats pressed a lever to avoid shock on a free-operant avoidance schedule. Some subjects were also exposed to extinction in which the response-shock contingency was eliminated while the shock-shock contingency remained in effect. A specially constructed lever was used that registered not only presses, but also biting attacks on the lever. Throughout various phases of the study, shocks often elicited lever biting as well as post-shock responding. The results suggested that shock-elicited attacks that are forceful enough to activate the operandum might account for some of the responding that occurs in experiments on free-operant avoidance behavior. In particular, shock-elicited operandum attacking might account for post-shock response bursting during free-operant avoidance and the extreme persistence of responding sometimes noted when shocks are delivered during the extinction of avoidance behavior. To the extent that this is true, these phenomena should not be characterized as operant behavior in interpreting the results of experiments on free operant avoidance.

Aversive stimuli can cause animals to attack other organisms and inanimate objects. For example, O'Kelly and Steckle (1939) and Ulrich and Azrin (1962) found that when painful electric foot-shock is delivered to paired rats, a stereotyped fighting reaction results. This attacking occurs almost immediately after a shock presentation, and is therefore said to be elicited by the shock. Ulrich and Azrin (1962) were not able to demonstrate shock-elicited attack by freely moving rats towards inanimate objects (a small doll and a stationary dead rat); however, Azrin, Rubin, and Hutchinson (1968) obtained reliable biting attacks towards metal, wood, and rubber targets when the rat was forced to face the target and was close to it.

Azrin, Hutchinson, and Hake (1963) found that shock will elicit fighting in squirrel monkeys, and Azrin, Hutchinson, and Sallery (1964) showed that squirrel monkeys, when shocked, will attack not only other monkeys, rats, and mice, but also a stuffed doll and a cloth covered ball. Moreover, Hutchinson, Azrin, and Hake (1966) demonstrated that shocking squirrel monkeys, restrained in a special chair, causes them to bite a rubber hose placed in front of them.

Since shock-elicited attack can be directed towards inanimate objects, operanda might also be attacked and activated during operant experiments on aversive control that are not explicitly concerned with such behavior. Attack behavior might thus be mistaken for operant behavior in experiments concerned only with the latter.

For example, Azrin, *et al.*, (1964, p. 227) stated: "Our laboratory experience has been that Sidman avoidance performance (Sidman, 1953) is acquired almost immediately with squirrel monkeys. The squirrel monkey often bites the projecting response bar as well as other projecting objects shortly after the shock delivery. It may well be that acquisition of bar-pressing in a shock avoidance situation is facilitated by the existence of the pain-aggression reaction." And Azrin, *et al.*, (1967, p. 144) stated: "The attack reaction has probably been an undetected factor in previous studies of shock avoidance and escape. For example, we have often noted that a rat or a monkey will bite a projecting object in the experimental enclosure during the initial stages of shock-avoidance conditioning." After presenting evidence that there was an unusually rapid conditioning of an avoidance response when its topography was similar to the attack reaction,

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these authors cited a case in which a monkey started avoidance training by biting the lever after each shock. Many of these bites activated the lever and thus were recorded as lever presses. Eventually, this unconditioned lever pressing gave rise to conditioned lever pressing when the monkey began grasping the lever before biting it.

Lever biting may account, at least in part, for the post-shock response "bursting"—*i.e.*, a series of closely spaced responses that occurs almost immediately after a shock—that has been noted in free-operant avoidance experiments (*e.g.*, Sidman, 1958). Boren (1961) found that rats trained to avoid shock by pressing one lever and to escape it by pressing another lever exhibited post-shock bursting only on the escape lever. He argued that post-shock bursting might therefore be a form of escape behavior. But, by the nature of his procedure, his subjects were undoubtedly near the escape lever immediately after a shock, and thus would have been more likely to attack that lever than the other one.

Powell and Peck (1969) found that a procedure in which intermittently scheduled shocks were reduced in intensity (but not avoided) by lever-press responses markedly increased the response rates of rats initially trained under a free operant avoidance procedure. They also found that high response rates could be maintained solely through the presentation of shocks that were not affected by responses. Many responses occurred as post-shock bursts which, observation revealed, often were attacks on the lever. Moreover, Powell and Peck demonstrated that this post-shock responding could be respondently conditioned and also that it could be suppressed by punishment—procedures that research has shown are effective with shock-elicited aggression (*e.g.*, Vernon and Ulrich, 1966; Ulrich, Wolf, and Dulaney, 1969).

The present experiment was conducted to document objectively the occurrence of lever attacking by rats responding on a free operant avoidance schedule, and to provide an indication of whether it might account for a substantial amount of non-operant lever pressing. To achieve these objectives, a special lever was constructed that consisted essentially of two parallel metal plates which, when pushed together, recorded a "bite". This apparatus was similar to one described by Azrin, *et al.*, (1968), except that it could also be depressed to record lever presses as well as lever bites. Moreover, the rats in the present study were freely moving rather than restrained close to the bite lever.

METHOD

Subjects

Seven experimentally naive Holtzman strain male albino rats, bred and raised in our laboratory animal facilities, served. Since the subjects were extras that had originally been intended for a different experiment (Persinger, 1971), the histories of some of them were somewhat unusual. Two subjects (S4 and S5) had been exposed on prenatal days 13-16 to a 0.5 Hz, 0.5-3 gauss rotating magnetic field. For two other subjects (S6 and S7), the mother had been moved to and returned from another location on the sixteenth day of gestation. The other subjects (S1, S2, and S3) had not received any special treatment. All subjects were between 80 and 100 days old at the start of the experiment.

Apparatus

The experimental chamber was 11 in. wide by 9 in. long by 8 in. high (29 by 24 by 20 cm). A response lever mounted 3.3 in. (8.3 cm) from the grid floor, and 3 in. (7.6 cm) from the right-hand wall, protruded 0.8 in. (2.1 cm) from the front wall. The lever was 2.0 in. (5.0 cm) wide and 0.5 in. (1.3 cm) thick, and was divided into two parts in such a way that a force of about 1050 g (10.3N) applied to the front bottom part of the lever forced it a slight distance towards the top. When this occurred, a microswitch was activated resulting in an audible click and the recording of a bite on equipment located in another room. (The high force requirement was chosen to ensure that only bites would activate the microswitch.) Downward pressure on the lever of 34 g (0.33N) activated another microswitch that recorded responses.

The response lever was manufactured to order out of 2024-T4 structural aluminum alloy by DRT Associates, Winnipeg, Canada (Type 3206 Bite Bar). A drawing of the lever is shown in Figure 1.

Illumination was provided throughout all sessions by a 7-w lamp located slightly above and 1.3 in. (3.2 cm) to the right of the lever. Electric shocks with an intensity of 3 mA and

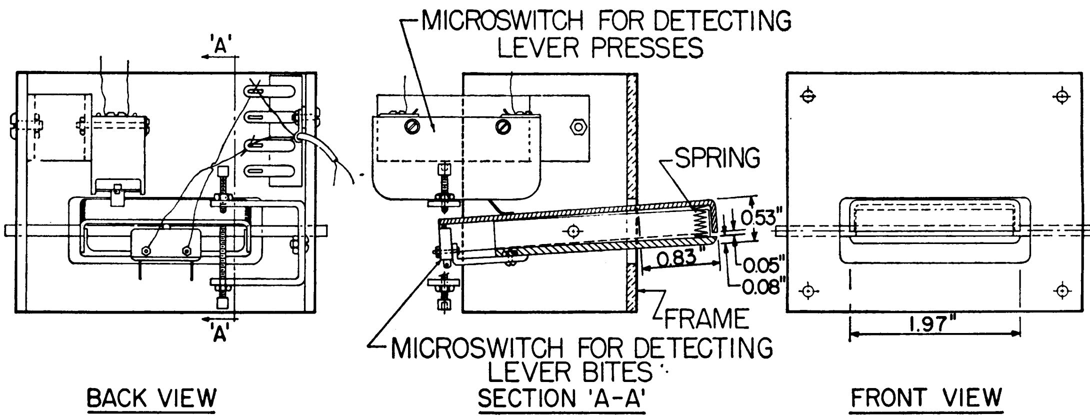

Fig. 1. Drawing of the bite lever used in this study.

a duration of 0.5 sec were delivered to the grid floor by means of a Grason-Stadler shock generator and scrambler. Ventilation and a partial masking noise were provided by a fan in the sound-insulated cubicle housing the experimental chamber.

Procedure

The experiment contained four phases, each consisting of a number of 3-hr daily sessions per subject. Sessions were conducted six days a week.

Phase 1. The subjects were first placed on a free-operant avoidance schedule (Sidman, 1953) with a shock-shock interval of 5 sec (SS = 5 sec) and a response-shock interval of 20 sec (RS = 20 sec). That is, shock was scheduled 5 sec after the previous shock, unless a lever press intervened between the two in which case shock was scheduled 20 sec after the last lever press.

Phase 2. After the number of shocks received appeared to have decreased to a low, stable level, the shock-shock interval was changed to 20 sec (SS = 20 sec) while the response-shock interval remained at 20 sec (RS = 20 sec). Because of apparatus problems, S2 was discarded from the experiment before this stage began. S1 became sick during this stage and died during the seventh session. S3 and S6 also became sick and were discarded before the end of this stage.

Phase 3. The remaining subjects (S4, S5, and S7) were next placed on extinction, in which lever presses had no scheduled effect but the shock-shock interval remained at 20 sec (Extinction, SS = 20 sec).

Phase 4. In the final phase, reconditioning was scheduled in which the subjects were again placed on RS = 20 sec, SS = 20 sec.

RESULTS

All subjects activated the bite switch at some point in the experiment, and most subjects activated it many times. Frequent visual observations during sessions indicated that the rats never activated the bite switch except by biting the lever, although, due to the large force on the top and bottom of the lever that was required to register a bite, bites sometimes occurred that were not recorded. Visual observation and continuous event pen recordings indicated that all bites occurred almost immediately after a shock, and further that bites were usually accompanied by lever presses. Thus, at least some lever presses occurring soon after shocks apparently resulted from elicited attacks on the lever rather than conditioned operant behavior.

Additional data are presented in Figures 2 to 4. Figure 2 shows the number of recorded lever bites, lever presses (responses), and shocks per session for three subjects (S1, S2, and S3) that developed high biting rates early during Phase 1 (RS = 20 sec, SS = 5 sec). Note that for each of these subjects, biting accelerated rapidly, and then appears to have decreased to form a peak between the sixth and ninth sessions. This decrease appears to have been followed by a second increase, although this is not very evident for S3 until after the introduction of Phase 2 (RS = 20 sec, SS = 20 sec). For all three of the subjects whose data

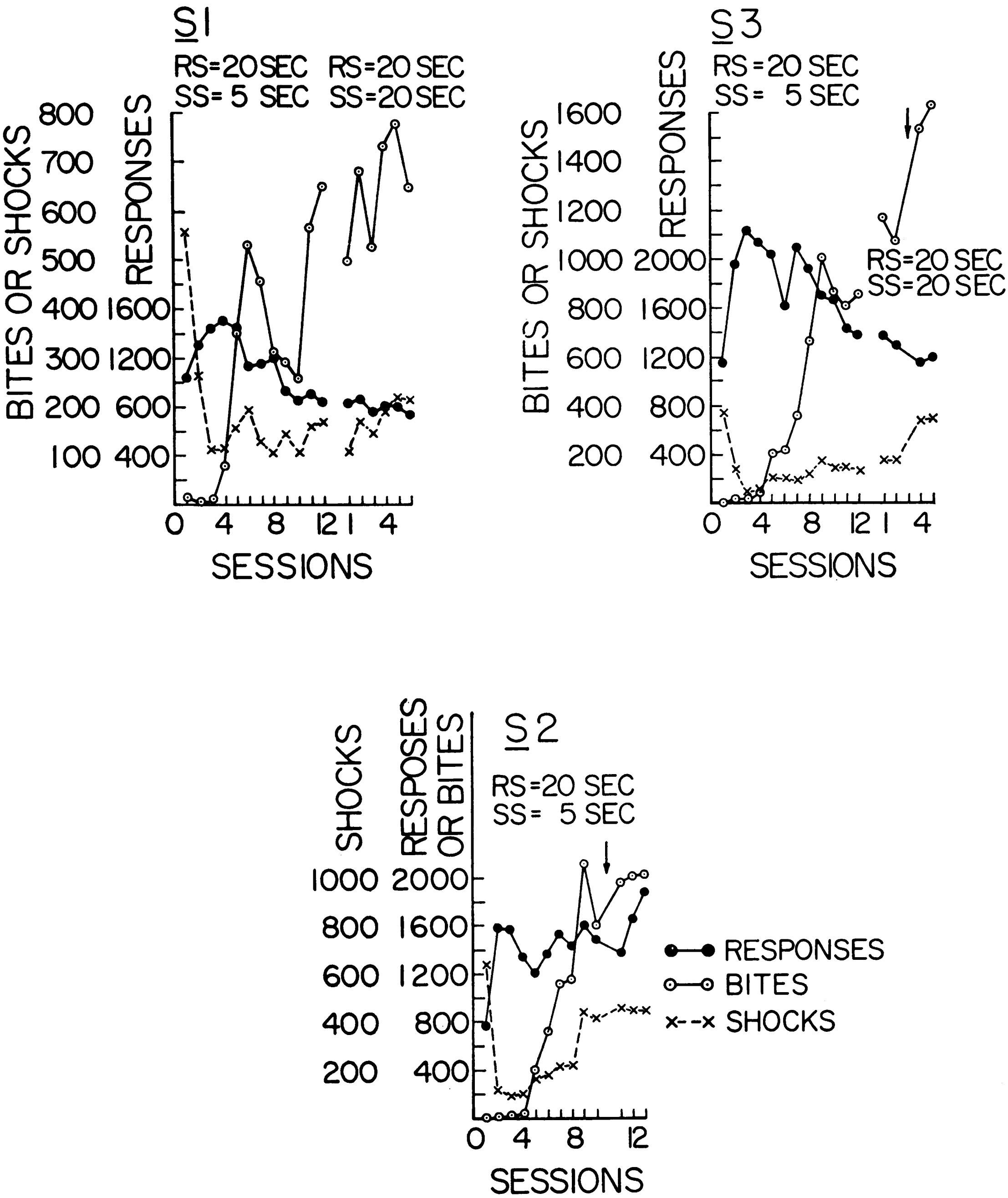

Fig. 2. Number of lever presses (responses), lever bites, and shocks per 3-hr session for S1, S2, and S3. The arrows indicate sessions for which data are omitted because of apparatus failure.

are presented in Figure 2, the initial increase in biting appears to have been associated with an increase in shock frequency.

As shown in Figure 3, the other subjects (S4, S5, S6, and S7) did not develop the above rapid acceleration in lever biting during Phase 1. Although the number of lever bites was quite small during Phase 1, only S4 failed to register any at all. The scales in Figure 3 are too small to show it, but S6 registered six bites in Session 1 and one bite in Session 5, and S7 registered two bites in Session 1. S5 showed a

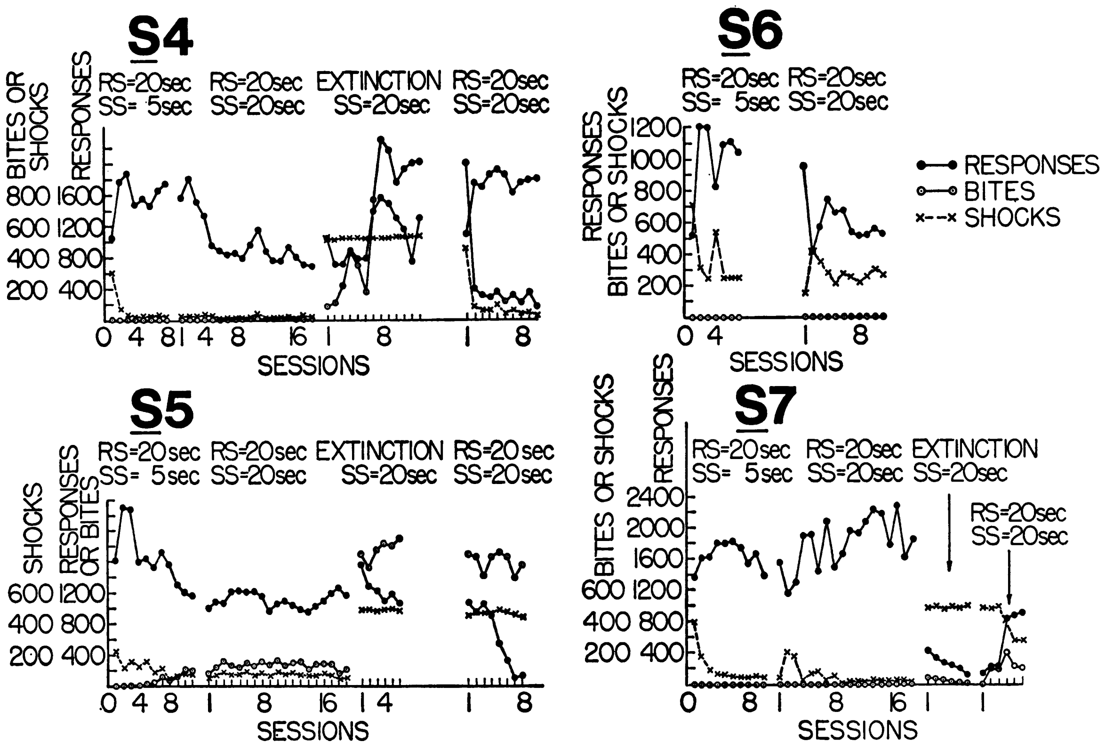

Fig. 3. Number of lever presses (responses), lever bites, and shocks per 3-hr session for S4, S5, S6, and S7.

gradual increase in biting throughout the first phase.

In Phase 2, the shock-shock interval was changed from 5 sec to 20 sec, while the response-shock interval remained at 20 sec. S5 continued to bite at a moderately high rate, but the other subjects still showed very little biting. Only S6 failed to register any bites at all. S4 registered one bite in Session 7, four in Session 9, two in Session 10, six in Session 11, one in Session 12, three in Session 14, eight in Session 15, one in Session 16, and one in Session 17. S7 registered one in Sessions 4, 6, and 8, two in Sessions 10 and 12, and one in Sessions 15 and 16.

In Phase 3, extinction with SS = 20 sec was carried out for S4, S5, and S7 (see Figure 3). All three subjects showed a definite increase in biting resulting from the higher frequency of shocks. This increase was slight and temporary for S7 whose biting gradually decreased to zero over six sessions. S7's responding also decreased during the extinction phase, while both biting and responding were maintained at high rates for the other two subjects. Event pen recordings and visual observation of the subjects revealed that this lever-press responding occurred almost entirely just after shocks, and thus was usually associated with bites. For S4 and S5, most shocks were closely followed by bites and lever presses; and, after the first few sessions, lever pressing seldom occurred at any time other than almost immediately after a shock. These observations suggest that the large number of lever presses these subjects made during extinction was the result of attacks on the lever, and should not be taken to indicate a strong resistance to extinction of the lever-press operant. Further evidence in this direction is provided by the fact that S7, the subject that showed a clear decrease in responding during the extinction phase, showed very little biting during that phase in comparison with the other two subjects.

In the final phase, the three subjects that had been exposed to the extinction procedure were returned to RS = 20 sec, SS = 20 sec. Avoidance behavior returned in S4 and S7, as indicated by the substantial decreases in the number of shocks these subjects received. This was not the case, however, for S5. Although a sizeable number of lever presses were recorded during the first few sessions of the reinstated avoidance contingency, the vast majority of these lever presses occurred almost immediately after shocks and, consequently, had little effect on the time intervals between shocks. In other words, S5 persisted in the behavior pattern it had exhibited during extinction—*i.e.*, biting and pressing the lever after almost every shock, but seldom emitting responses later in the intervals between shocks. Therefore, the number of shocks received by S5 during the reconditioning phase was only slightly less than the number it received during the extinction phase. It appears that most of the lever presses S5 made during Phase 4, as well as during Phase 3, should not be regarded as operant behavior, but instead were probably the result of attacks on the lever. Over the last four or five sessions of Phase 4, the topography of S5's lever attacking appears to have changed in such a way that, while recorded lever bites remained at a high, steady level, the number of lever presses due to attacks markedly decreased. Avoidance behavior was not re-established in S5 during the eight sessions that this subject was exposed to Phase 4.

Figure 4 presents some sample cumulative records of lever responding and biting (top and bottom lines of each pair, respectively). Note that these two variables appear often to have closely tracked each other when shock occurred frequently—for example, during extinction. Close examination of each pair of records indicates that this effect was evidently due to a correlation between bursts of responses and bursts of bites occurring shortly after shock (see insert, Figure 4).

DISCUSSION

The results document the occurrence of lever attacking by rats trained to press a lever

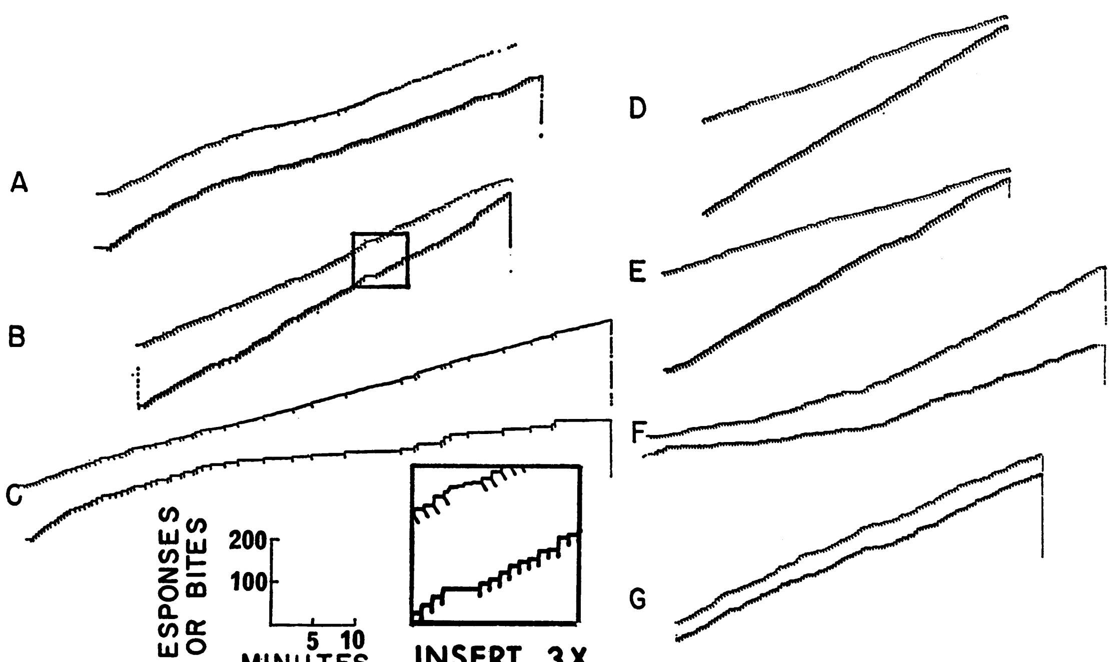

Fig. 4. Simultaneous cumulative response records (top line of each lettered pair) and cumulative bite records (bottom line of each pair). Downward deflections of the pens indicate shocks. The segments shown began:
(A) Near the start of session 10 on RS = 20 sec, SS = 5 sec for S2.
(B) About 90 min after the start of Session 10 on RS = 20 sec, SS = 5 sec for S2.
(C) Near the start of Session 13 on RS = 20 sec, SS = 20 sec (Phase 2) for S5.
(D) Near the start of Session 6 on Extinction, SS = 20 sec for S5.
(E) About 110 min after the start of Session 6 on Extinction, SS = 20 sec for S5.
(F) Near the start of Session 8 on Extinction, SS = 20 sec for S4.
(G) About 90 min after the start of Session 8 on Extinction, SS = 20 sec for S4.

to avoid shock on a free-operant avoidance schedule. Further, they suggest that this attacking is elicited by shock and that it might account for many lever presses that, therefore, should not be classified as operant behavior. This assumes, of course, that the lever bites observed in this study were not adventitiously conditioned by avoidance of shocks. This possibility seems to be ruled out by the observations that bites occurred only almost immediately after shocks, and that for two subjects bites persisted with no sign of decreasing over a number of extinction sessions. Moreover, for two of the three subjects tested on the extinction procedure, no substantial amount of biting was recorded until that procedure was introduced, and it therefore seems unlikely that biting had been reinforced by shock avoidance. Thus, the lever biting that occurred, and hence the lever pressing associated with it, appears to have been shock-elicited rather than operantly conditioned.

Hutchinson, Renfrew, and Young (1971) showed that unconditioned lever pressing and unconditioned chain pulling can occur in squirrel monkeys on schedules of unavoidable shock presentation. Unlike what appears to have been the case in the present study, however, this responding was not caused by bites on the operanda, nor did it bear the same temporal relation to shock as does shock-elicited biting. The present study thus provides another line of evidence that not all responding on the operandum during schedules of aversive stimulation is necessarily operant behavior. (This may be true also for some schedules of positive reinforcement; see Pear and Roy (1971).

The present findings indicate that the possibility of elicited aggression towards the operandum should be considered in accounting for some of the data obtained in studies on conditioned avoidance responding. Shock-elicited aggression might produce, for example, post-shock response bursting during free-operant avoidance (*e.g.*, Sidman, 1958) and the extreme persistence of responding sometimes noted when shocks are delivered during the extinction of avoidance behavior (*e.g.*, Herrnstein and Hineline, 1966; Powell and Peck, 1969).

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