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# EFFECTS OF LONG-TERM SHOCK AND ASSOCIATED STIMULI ON AGGRESSIVE AND MANUAL RESPONSES[1]

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Squirrel monkeys were exposed to response-independent, fixed-frequency shock that produced biting attack upon a pneumatic hose. Attacks decreased within and across sessions at low intensities and high frequencies of shock, but increased within and across sessions at higher intensities and lower shock frequencies. Stimuli paired with shock, when presented alone, came to produce biting, and stimuli correlated with shock parameters that produced increases in responding within sessions produced similar increases when presented alone. Further experiments showed that continuing exposure to shock also produced lever pressing or chain pulling, with longer shock exposure again producing higher response rates. Whereas biting generally decreased throughout the intershock interval, manual responding generally increased as shock time approached, but immediately before shock was often suppressed. Following shock, biting attack predominated over manual behavior. The results suggest a possible explanation for the extreme resistance of avoidance behavior to extinction, and may also partially explain the persistence of responding during schedules of response-produced shock. Relationships of the present findings to naturalistic observations of relations between fleeing, freezing, and fighting performances are discussed.

CONTENTS



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Biting attack, following brief but "painful" stimulation, can be elicited from the squirrel monkey toward other squirrel monkeys, members of other species, and inanimate objects (Azrin, Hutchinson, and Hake, 1963; Azrin, Hake, and Hutchinson, 1965; Azrin, Hutchinson, and Sallery, 1964; Hutchinson, Azrin, and Hake, 1966). Attack is most probable immediately after delivery of the painful stimulus, and shows a progressive decrease over the next 15- to 30-sec period (Azrin *et al.*, 1964; Azrin, Rubin, and Hutchinson, 1968; Hutchinson, Azrin, and Renfrew, 1968). The frequency and duration of attacks are a direct function of both shock intensity and shock duration (Hutchinson *et al.*, 1968). Each of these relationships has developed upon relatively brief exposure to electric shocks.

There is some indication, however, that longer exposure to shock conditions might produce other effects. For example, Ulrich and Azrin (1962) showed that extended exposure to very frequent grid-shock produced consistent though moderate reduction in elicited attack between rats. Conversely, Azrin, Ulrich, Hutchinson, and Norman (1964) showed that, under some conditions, shock-elicited attack

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between rats can be increased over initial levels. Similarly, Hutchinson, Ulrich, and Azrin (1965) found that continued shock exposure in prepuberal rats produced eventual progressive elevations in attack. Thus, there is reason to expect that extended shock exposure may produce either temporary or more permanent changes in attack reactions. Additionally, of course, classical conditioning processes may change performance over time. Prolonged exposure to electric shocks in a context of repetitive stimuli might produce such learned attack reactions (Vernon and Ulrich, 1966; Thompson and Sturm, 1965).

The present experiments were designed to investigate systematically the effects of long-term exposure to shock and associated stimuli. Squirrel monkeys were exposed to frequent electric shock over many sessions. Shock was always delivered independently of any feature of the subjects' performance. Biting a rubber hose, depressing a response lever, and pulling a hanging chain were the particular responses studied.

## EXPERIMENT I: EFFECTS OF SHOCK INTENSITY AND FREQUENCY UPON HABITUATION AND FACILITATION OF BITING ATTACK

### Method

*Subjects*

Eight adult male squirrel monkeys, which weighed between 0.7 and 1.1 kg, were used. Four (M-28, M-92, M-98, M-96) had been previously exposed to electric shock; the others were naive and had been acclimated to the laboratory for one month. Subjects were housed individually with free access to food and water except during testing.

*Apparatus*

The general method has been described in detail elsewhere (Hutchinson *et al.*, 1966). Basically, a squirrel monkey was restrained in an isolated Plexiglas chair (Hake and Azrin, 1963) with electrodes resting upon its shaved tail. Electrode paste was used to maintain constant tissue resistance. Two standout supports on the front panel bracketed a 5-in. (13-cm) length of 16 mm (O.D.) gum rubber tubing. Biting the hose activated a pressure-transducing device that was insensitive to other behaviors. The required pneumatic pressure was 2 mm of mercury.

In earlier studies, subjects' canines were routinely clipped off flush with the first premolars to prevent hose puncture during sessions. This may expose the tooth nerve, however, and a satisfactory alternative is the more frequent exchange of the rubber hose; daily usually suffices.

Data were collected continuously on counters, cumulative recorders, and a multipen polygraph. Experimental conditions were arranged with either electromechanical circuitry or solid-state logic.

*Procedure*

Experimental sessions of 30 or 60-min duration were conducted seven days a week for several months. Shock intensities and intershock intervals tested ranged from 50 to 600 v ac and from 15 to 300 sec, respectively. All subjects were tested at a minimum of two intensity and/or two intershock interval values. Each intensity and interval employed is shown in Table 1 for each subject. Except where noted, shock intensity and interval were constant during a session. Shock duration was 100 msec and the initial shock for each session was delivered at the end of the first intershock interval except where noted. All shocks were delivered through a 50-K resistor independently of any response by the subject.

### Results and Discussion

Subjects initially displayed biting attack subsequent to each shock delivery. Biting frequency was highest immediately after shock, then decreased progressively (See Hutchinson *et al.*, 1968). Figure 1 shows, however, that continued exposure to some shock intensities and frequencies caused this behavior to become progressively weaker and in many cases finally disappear. All subjects' performances reflect a gradual decrease in biting over successive shock applications.

Within- and between-session decreases in biting attack upon continued exposure to shock are more completely illustrated in Fig. 2. Biting typically decreased across both successive shocks and sessions. In some cases, biting completely recovered between the end of one session and the following day's test. In other cases, little or no recovery was apparent.

Table 1

*Order of Experimental Procedures for Each Subject*

| Sessions | Shock Voltage | S-S Int. (sec) | Sessions | Shock Voltage | S-S Int. (sec) | Sessions | Shock Voltage | S-S Int. (sec) | Sessions | Shock Voltage | S-S Int. (sec) | Sessions | Shock Voltage | S-S Int. (sec) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Subject M 117* | | | *Subject M 28* | | | *Subject M 103* | | | *Subject M 121* | | | *Subject M 96* | | |
| 1 | 200-300 | 60 | 1 | 200 | 120 | 1-5 | 100 | 60 | 1 | 100 | 60 | 1-2 | 100 | 60 |
| 2 | 300 | 15[a] | 2 | 200 | 60 | 6-7 | 150 | 60 | 2-3 | 400 | 60 | 3-4[2] | 100 | 60 |
| 3 | 300-400 | 20[a] | 3-7 | 100 | 60 | 8-9 | 200 | 60 | 4-17 | 200 | 60 | 5 | 150 | 60 |
| 4 | 400 | 20 | 8 | 50 | 60 | 10-13 | 0 | 60 | 18-25 | 100 | 60 | 6-9 | 200 | 60 |
| 5 | 100-300(5) | 60 | 9-16 | 25 | 60 | 14 | 100 | 240 | 26-33 | 50 | 60 | 10-12 | 400 | 60 |
| 6 | 100(10) | 60 | 17[2] | 25 | 60 | 15-16 | 200 | 240 | 34-38 | 25 | 60 | 13-21 | 400 | 240 |
| 7 | 100(5) | 20 | 18-24[2] | 50 | 60 | 17-18 | 300 | 240 | 39-45[2] | 25 | 60 | 22-27 | 300 | 240 |
| 8-9 | 200(5) | 20 | 25[2] | 100 | 60 | 19-22 | 400 | 240 | 46-51 | 25 | 60 | 28-35 | 200 | 240 |
| 10-16[b] | 300(3) | 20 | 26[2] | 0 | 60 | 23-27 | 400(2) | 240 | 52-57 | 200 | 60 | 36-40 | 100 | 240 |
| 17 | 400(3) | 20 | 27[2] | 100-0 | 60 | 28-29 | 400(3) | 240 | 58-65 | 200 | 240 | 41-42 | 200 | 240 |
| 18 | 400(5) | 60 | 28-42[2] | 100 | 60 | 30 | 400[c] | 60 | 66-73 | 0 | 240 | 43-54 | 300 | 240 |
| 19-22 | 600(1) | 20 | 43-47[2] | 100 | 60 | 31-36 | 600 | 60 | 74 | 0 | 240 | 55-57 | 400 | 240 |
| 23 | 200(5) | 20 | 48-54[2] | 75 | 60 | 37 | 400 | 60 | 75-77 | 0 | 240 | 58-103 | 300 | 240 |
| 24-30 | 300(3) | 20 | 55-63[2] | 200 | 60 | 38-41 | 200 | 60 | 78-80 | 400 | 240 | 104-114 | 400 | 240 |
| 31-39 | 300(3) | 60 | 64-82[2] | 200 | 240 | 42-51 | 400 | 60 | 81-83 | 400 | 60 | 115[g] | 400 | 240 |
| 40-50 | 400(3) | 60 | 83-87 | 200 | 240 | 52-62 | 400 | 120 | 84[1] | 400 | 60 | 116-138[h] | 400 | 240 |
| 51-54 | 400(4) | 60 | 88-89 | 100 | 240 | 63-70 | 400 | 240 | 85-100[1] | 400 | 60 | | | |
| 55-58 | 100(3) | 60 | 90 | 100-0 | 240 | 71-76 | 400 | 120 | 101[1] | 0 | 60 | *Subject M 107* | | |
| 59-68 | 50[c] | 60 | 91 | 100 | 240 | 77-84 | 400 | 240 | 102-105[1] | 200 | 60 | 1-3 | 0 | 60 |
| 69-87[d] | 100 | 60 | 92-96 | 0 | 240 | 85-90[1] | 400 | 30 | 106-118[1] | 200 | 120 | 4 | 300 | 60 |
| 88 | 400 | 60 | 97-101 | 100 | 240 | 91-100[1] | 400/200 | 30 | 119-127[1] | 200 | 60 | 5 | 400 | 60 |
| 89-97 | 400 | 240 | 102-111 | 0 | 240 | 101-103[1] | 400/400 | 30 | | | | 6-15 | 600 | 60 |
| 98[e] | 400 | 240 | 112-116 | 400 | 240 | 104-110[1] | 400/400 | 60 | *Subject M 92* | | | 16 | 400 | 60 |
| 99-108 | 300 | 240 | 117-119 | 400 | 60 | | | | 1-6 | 100 | 60 | 17-24 | 400 | 240 |
| 109-113 | 400 | 240 | 120-125 | 400 | 30 | *Subject M 98* | | | 7-17 | 200 | 60 | 25-32 | 400 | 120 |
| 114-120 | 400 | 60 | 126-136 | 400 | 240 | 1-10 | 100 | 60 | 18-30[2] | 200 | 60 | 33-37 | 400 | 60 |
| 121-122 | 400 | 30 | 137-145 | 400 | 30 | 11-30 | 200 | 60 | 31-43 | 200 | 240 | 38-48 | 400 | 30 |
| 123 | 400 | 120 | 146-151[1] | 400 | 30 | 31-40 | 300 | 60 | 44-51 | 100 | 240 | 49-55 | 400 | 60 |
| 124-127 | 400 | 30 | 152-160[1] | 200 | 30 | 41-55 | 400 | 60 | 52-56 | 150 | 240 | 56-61 | 400 | 120 |
| 128 | 200 | 30 | 161-178[1] | 100 | 30 | 56-64 | 400 | 240 | 57-61 | 125 | 240 | 62-78 | 400 | 240 |
| 129 | 200 | 240 | 179[1] | 0 | 30 | 65 | 400 | 60 | 62-68 | 150 | 240 | 79-80 | 400 | 120 |
| 130-133 | 200 | 30 | 180[1] | 400 | 30 | 66-68[2] | 400 | 240 | 69-71 | 125 | 240 | 81[f] | 400 | 120 |
| 134-139 | 200 | 60 | 181-191[1] | 0 | 30 | 69-71[2] | 300 | 240 | 72-76 | 200 | 240 | 82-92 | 400 | 120 |
| 140-148 | 400 | 240 | 192-202[1] | 400 | 30 | 72[2] | 300 | 30 | 77-81 | 300 | 240 | | | |
| 149-187[f] | 400 | 240 | 203-209[1] | 400 | 60 | 73-82[2] | 400 | 240 | 82-85 | 400 | 240 | | | |
| 188-195[1] | 400 | 60 | | | | | | | | | | | | |

Voltage columns—One 100-msec shock was given at level shown unless indicated as follows:
Number following dash is second voltage;
Number in parentheses is shock bursts;
Number following slash is msec shock duration.

[1]Alternate signalled periods of shock removal
[2]CS paired with shock
[a]60 sec rate also used during session
[b]5 min shock occurred before onset of twelfth session
[c]Three-shock burst used for remaining sessions
[d]Testosterone given during seven days
[e]Each bite punished by 400-v shock
[f]VI shock sessions run
[g]Shock bursts varied within session
[h]Shock bursts varied between sessions

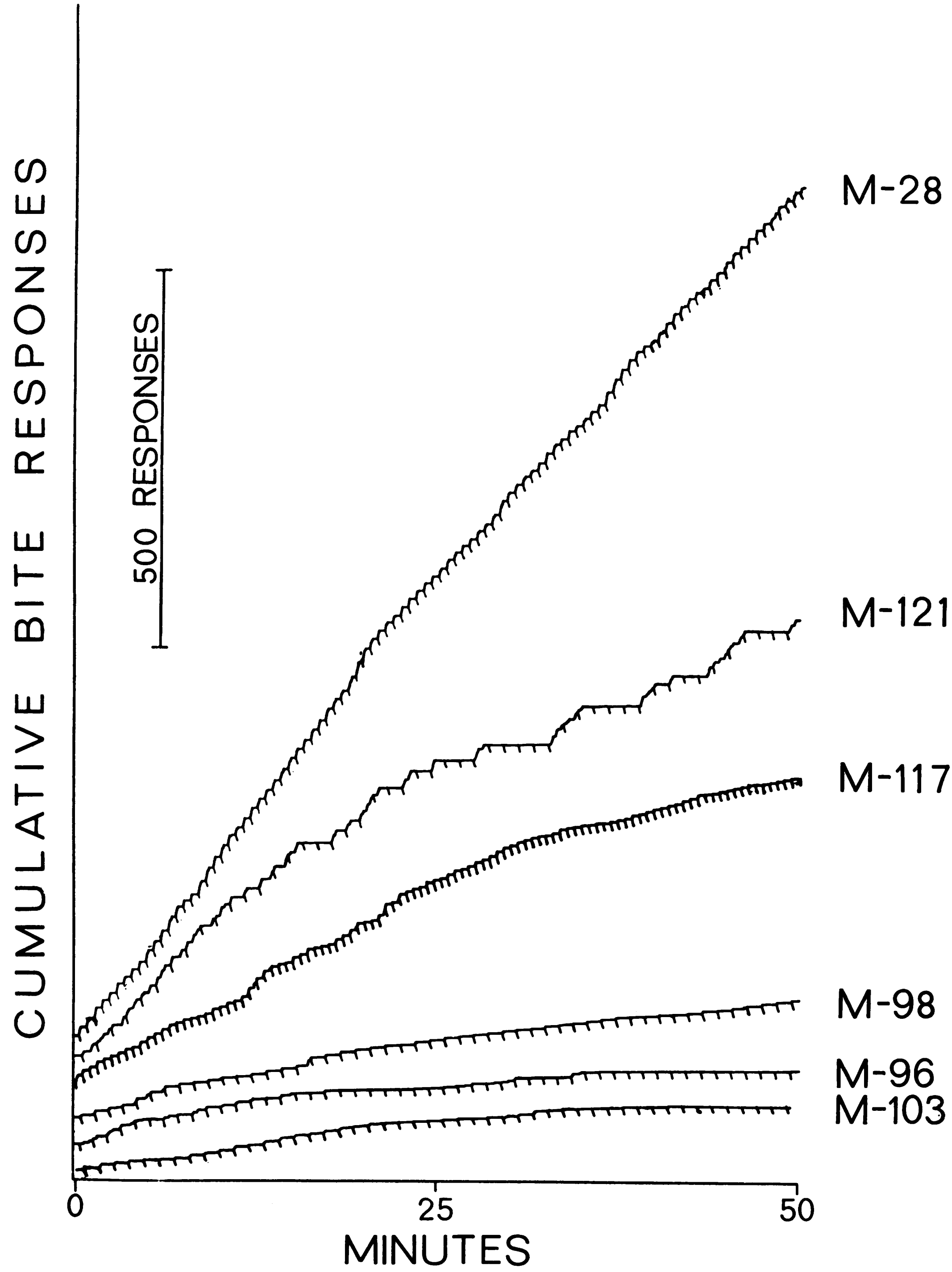


Fig. 1. Representative records demonstrating progressive response decreases within the experimental session. M-28 and M-98 received 400-v shocks; M-121, M-117, and M-103 received 200-v shocks; and M-96 received 100-v shocks. Subjects received shocks every 60 sec, except for M-28 and M-117, which received shocks every 30 sec. A range of performances has been chosen to illustrate the large differences in the decremental process. Shock deliveries are indicated by vertical deflections of the response record. Sessions illustrated are: M-28, Session 123; M-121, 55; M-117, 131; M-98, 46; M-96, 2; and M-103, 38 (see Table 1).

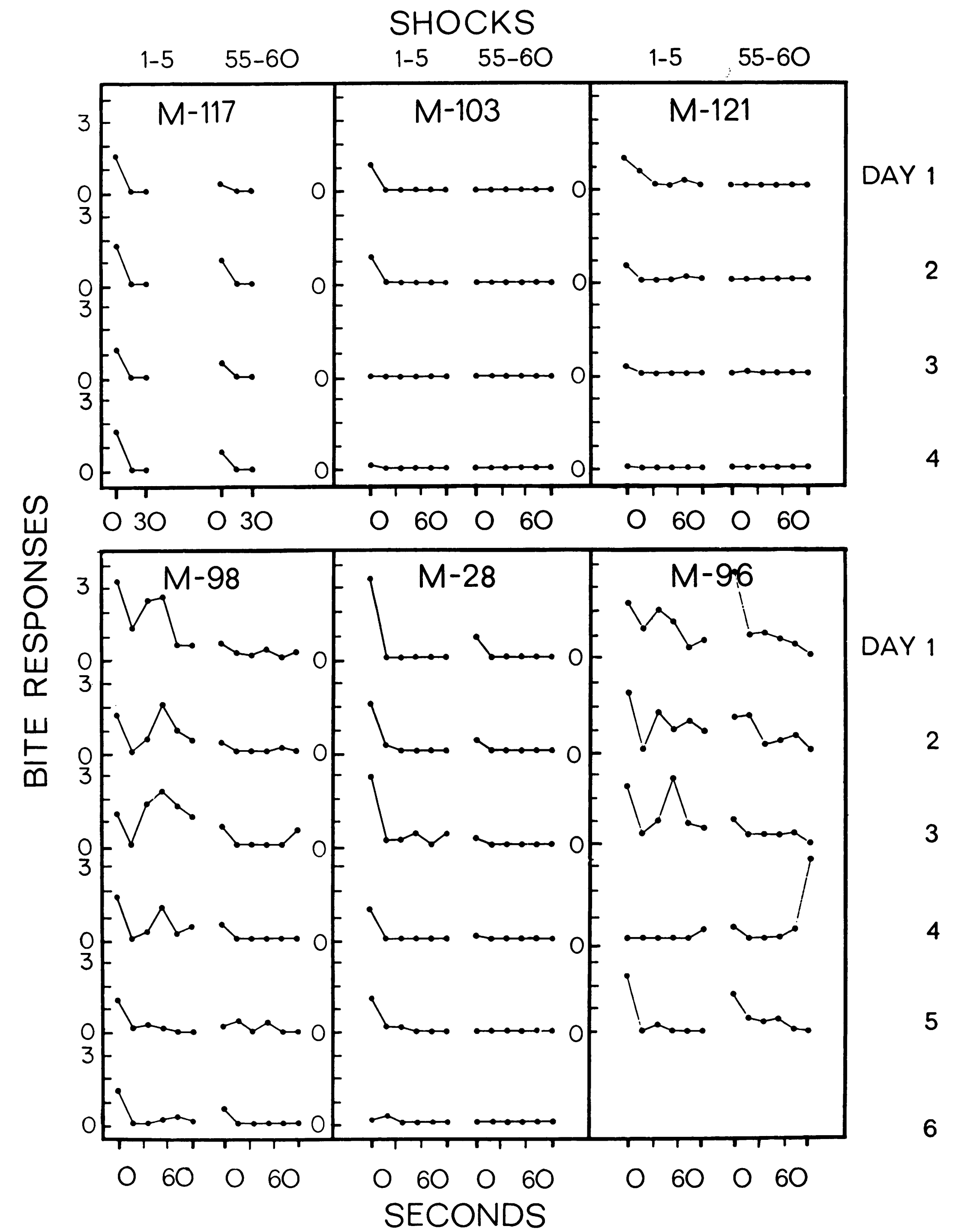


Fig. 2. Decreases in biting-attack frequency within the intershock interval for early and late portions of a session and across several sessions. Each horizontal pair of curves for a subject shows mean values of the data from the first five and last five intershock intervals of a session. Successive sessions are arranged vertically. Each data point is the mean number of bites in a successive 10-sec portion of the intershock interval, averaged over the five intershock intervals. Day 1 represents: for M-117, Session 130; M-103, 38; M-121, 52; M-98, 41; M-28, 9; M-96, 2 (see Table 1).

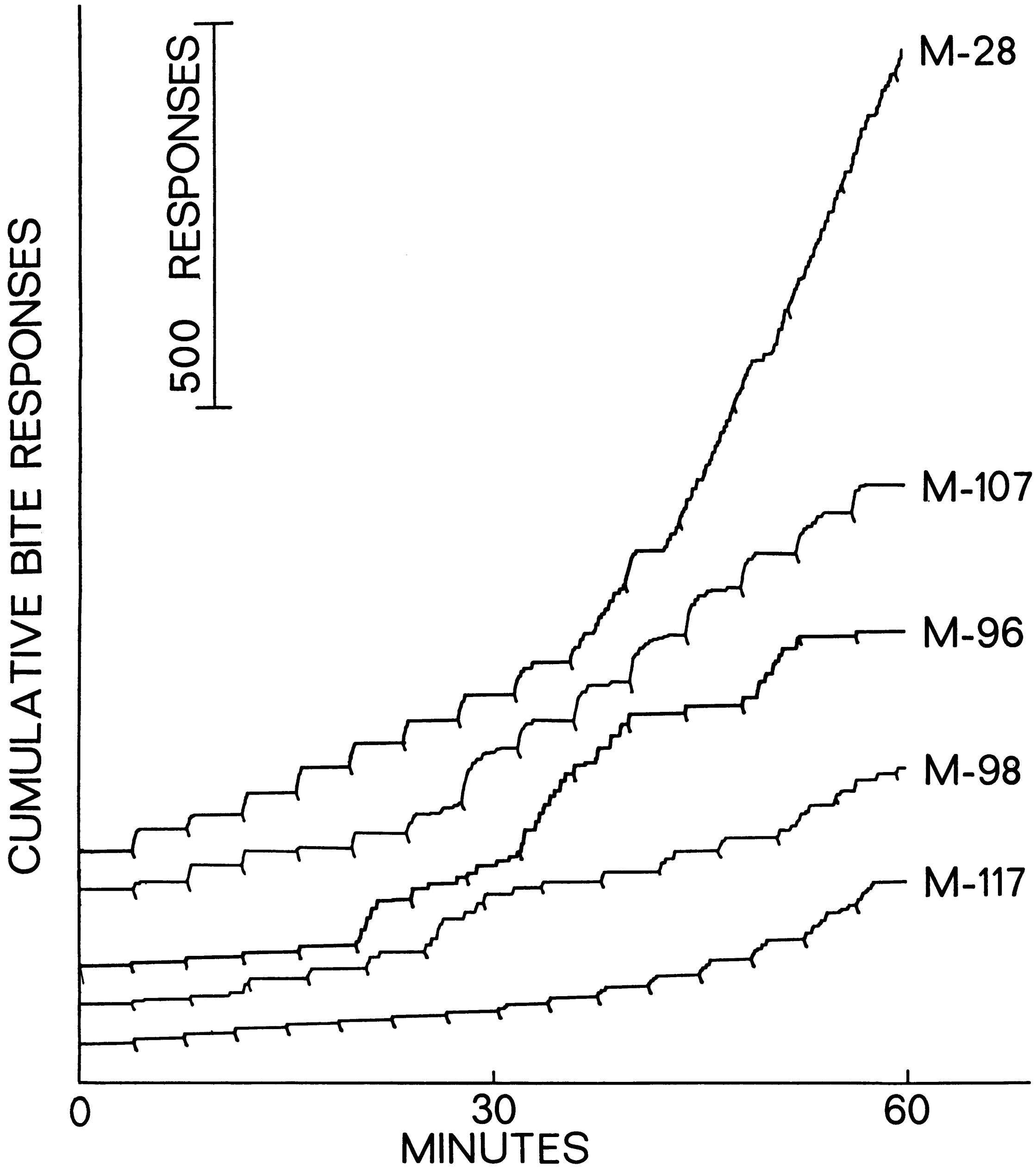


Fig. 3. Representative records illustrating progressive response increases within the experimental session. Each subject received 400-v shocks every 240 sec. A range of performances has been chosen to illustrate the large differences in the terminal incremental process. Shock deliveries are indicated by the vertical deflection of the response record. Sessions illustrated are: for M-28, 87; M-107, 66; M-96, 50; M-98, 79; M-117, 95 (see Table 1).

In contrast to these response decrements, other shock intensities and frequencies produced marked incremental effects. Figure 3 presents terminal performance, where each subject showed increased frequencies of biting attack upon continued exposure to shock. These increments developed progressively, both within and between daily experimental sessions. Five to 15 sessions were necessary for the full development of performance as shown in Fig. 3.

Figure 4 shows these increases in biting attacks throughout the intershock interval for the first five and last five shock intervals over

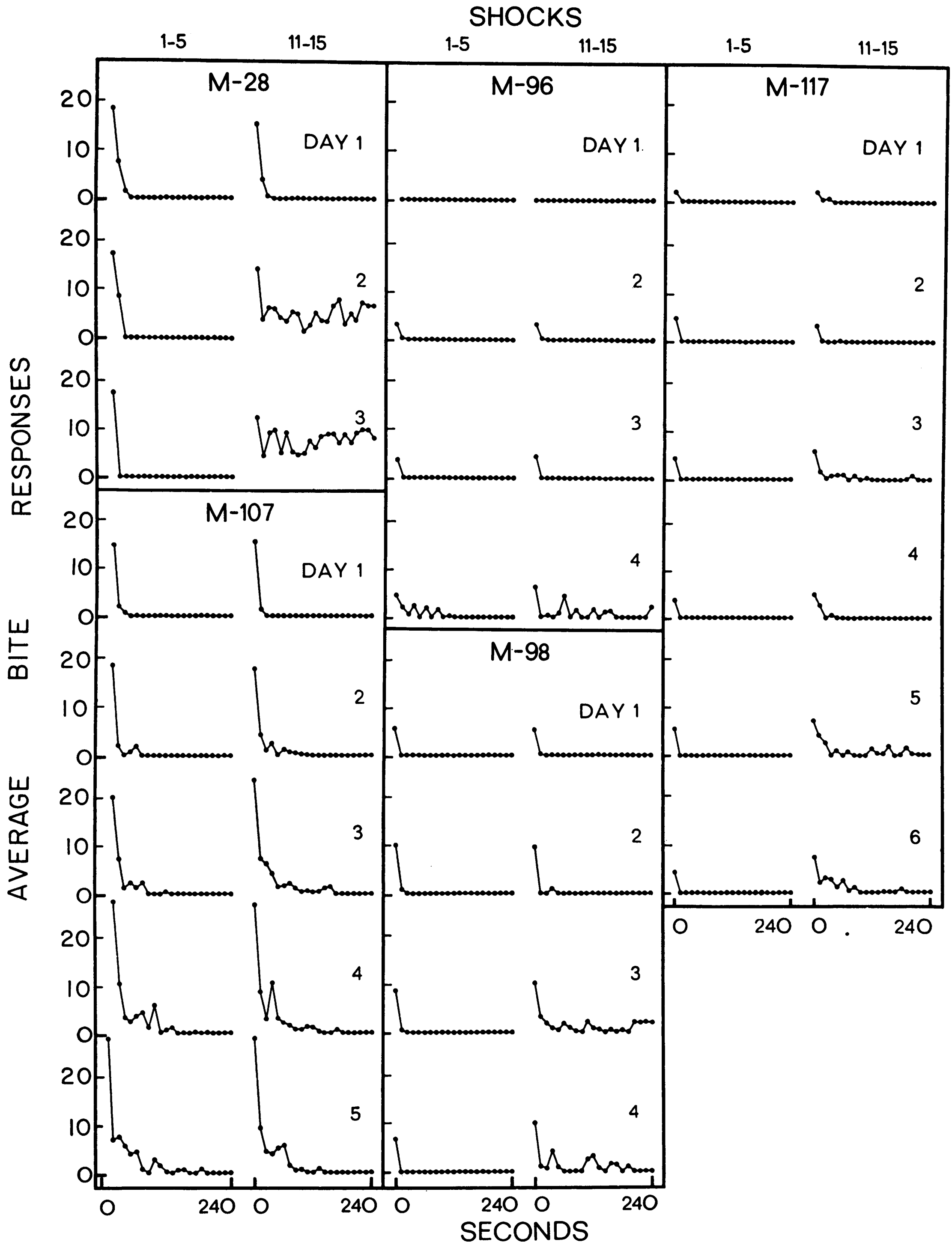


Fig. 4. Increases in biting attacks within the intershock interval, for early and late portions of a session and across several sessions. Each horizontal pair of curves for a subject represents mean values of the data from the first five and last five intershock intervals of a session. Successive sessions are arranged vertically. Each data point is the mean number of bites in a successive 10-sec portion of the intershock interval, averaged over the five intershock intervals. Day 1 represents: for M-28, Session 85; M-96, 47; M-117, 90; M-107, 62; M-98, 76 (see Table 1).

successive daily sessions. The subjects show increases in responding in the latter parts of the intershock interval and during the last intervals, and show greater increases in the later sessions.

Shock frequency and shock intensity were systematically varied and produced consistent and similar changes in performance for all subjects. Low shock intensities resulted in consistent and recurrent decreases in biting attack. Conversely, higher shock intensities produced the within- and between-session increases of attack noted earlier. Figure 5 shows sample cumulative records for M-96 at four different shock intensities. At 100 v, biting attack occurred after only the first three shocks. At 200 v, biting followed each shock delivery. Similarly, at 300 v, attack occurred after each shock but at roughly twice the 200-v frequency. When shock intensity was raised to 400 v, the cumulative effect of shock upon biting attack was evident.

The frequency of shock administration and the number of biting attacks produced by each shock were found to be inversely related. Additionally, as shock frequency decreased, within- and between-session changes in responding changed from a decreasing to an increasing pattern at longer intershock intervals. Figure 6 presents sample records of cumulative biting attack responses at three different shock frequencies for M-107. At a 30-sec intershock

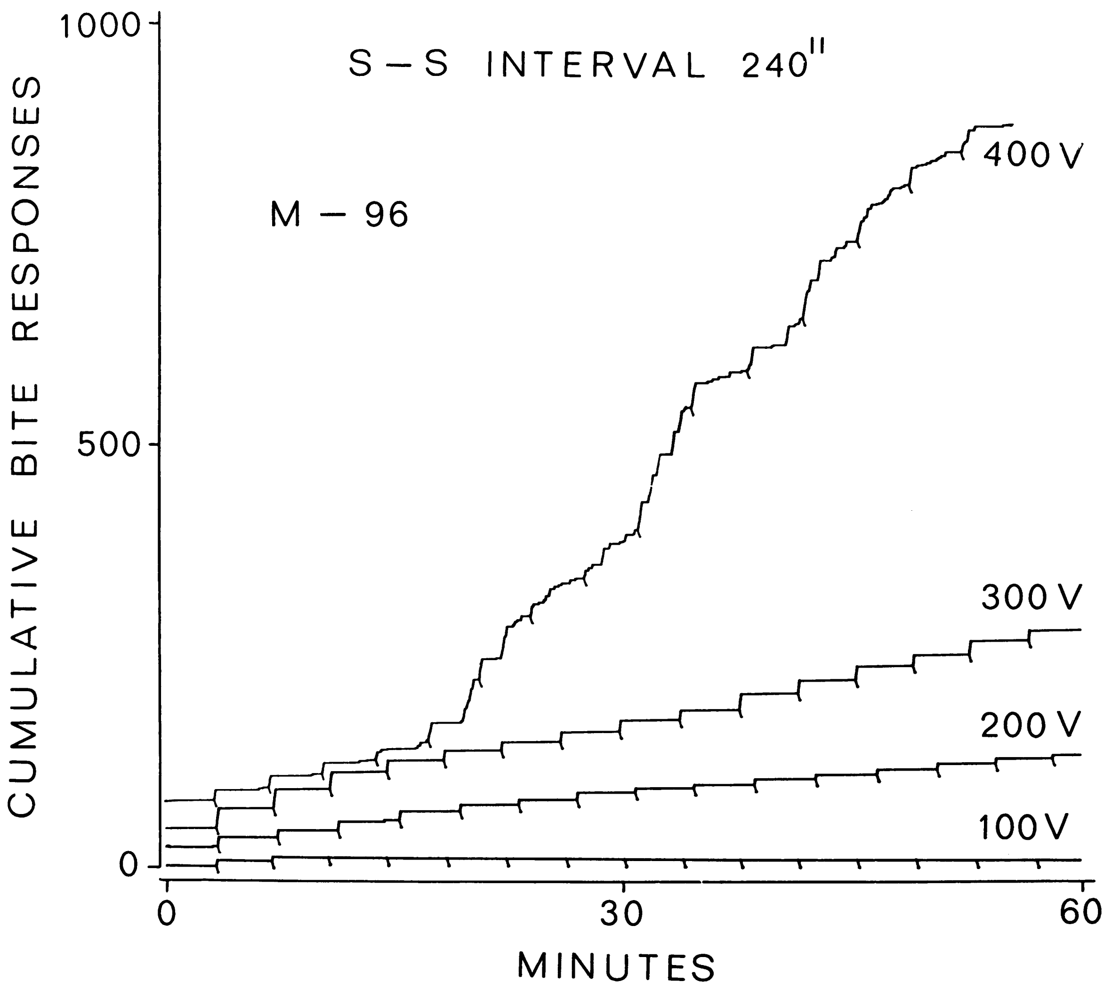


Fig. 5. Representative cumulative records for one subject, illustrating the progressive decreases and increases in biting attack within a session produced by continued exposure to shocks of the intensities noted. Sessions illustrated are: 100 v, Session 37; 200 v, 28; 300 v, 26; and 400 v, 127 (see Table 1).

interval, biting attack responses showed a progressive decline over the 60-min session. At an intershock interval of 120 sec, more biting occurred after each shock and the pattern of responding appeared relatively constant, showing neither increase nor decrease. When shocks occurred every 240 sec, the number of attacks after each shock markedly increased and an incremental pattern developed. This is illustrated in the upper record of Fig. 6. This response pattern always became most pronounced after approximately 20 to 40 min of exposure to the experimental procedure.

These effects, of progressive increases and decreases in responding within and between successive experimental sessions, were noted with all subjects. The extent and direction of these increments and decrements were, for all subjects, dependent upon shock intensity and

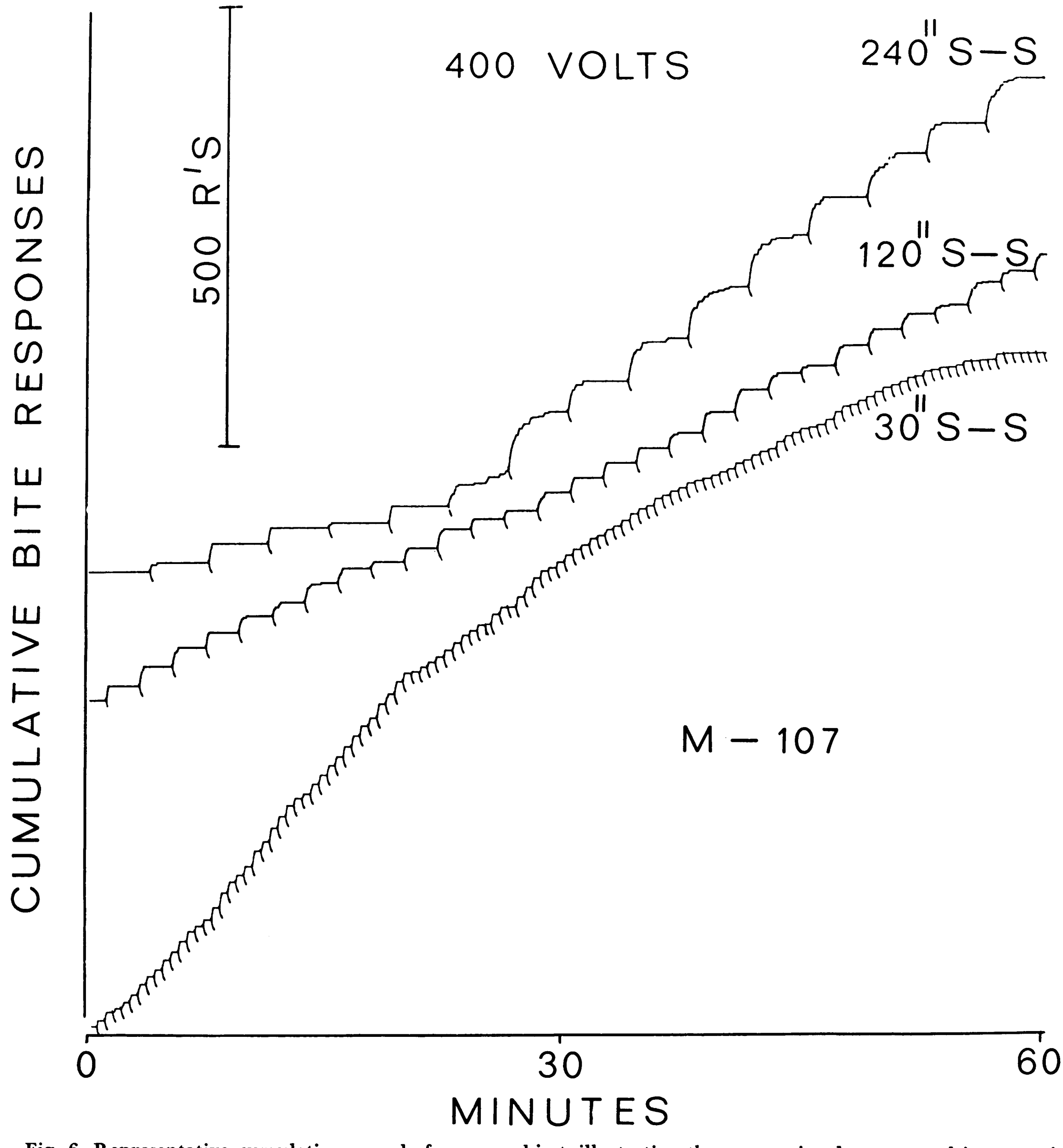


Fig. 6. Representative cumulative records for one subject, illustrating the progressive decreases and increases in biting attack within a session produced by continued shocks at the intershock intervals noted. Sessions illustrated are: 24-sec S-S interval, Session 73; 120-sec, 83; 30-sec, 40 (see Table 1).

the interval between shocks. Higher intensities and longer intervals increased the amount of biting. Lower intensities and shorter intervals between shocks produced less biting per shock. Figure 7 summarizes several features of these relationships. Biting responses were greater at higher voltages and at the 240-sec than at the 60-sec intershock interval.

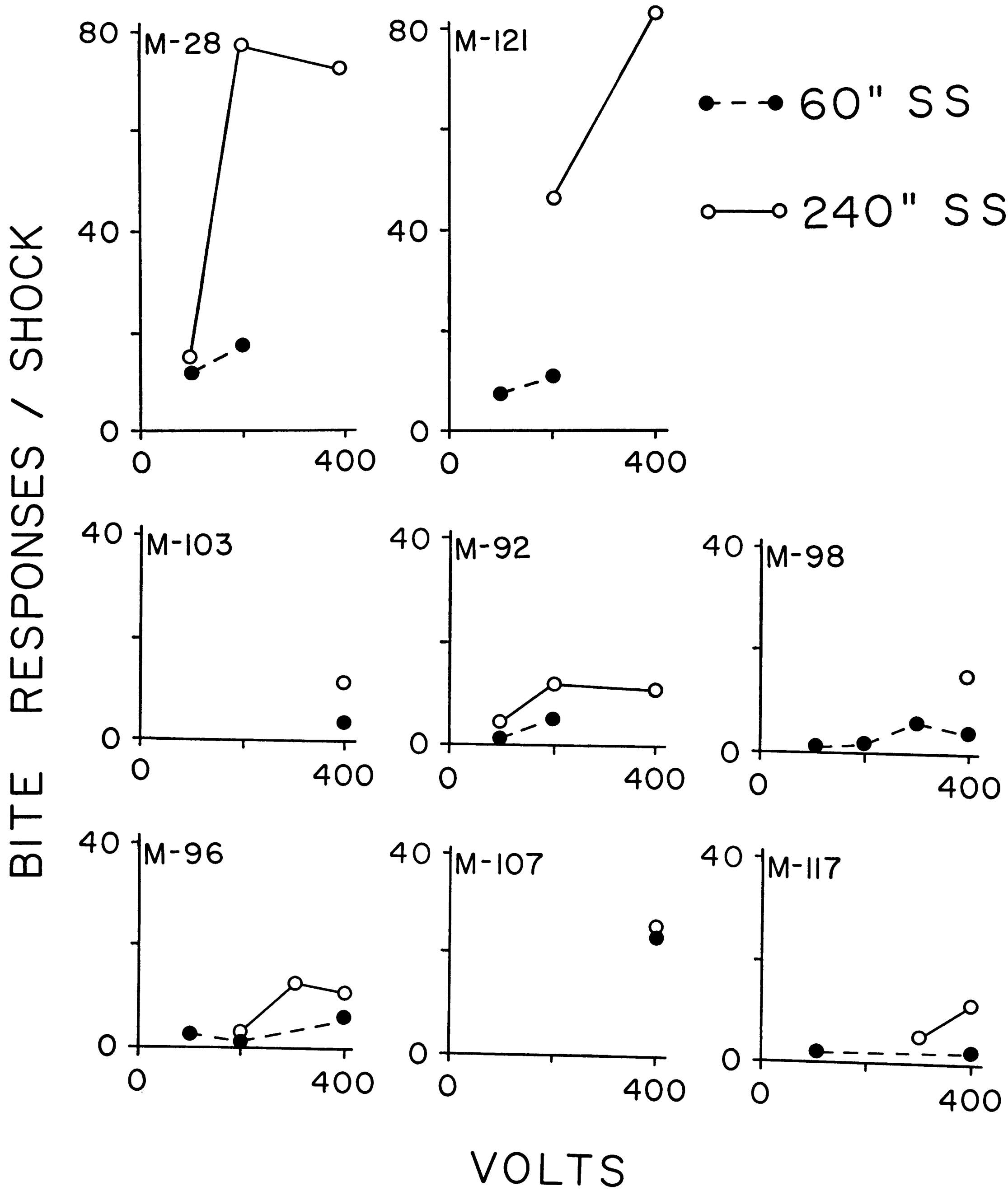


Fig. 7. Biting attack responses per shock as a function of shock intensity and intershock interval duration. Each point is calculated by dividing the daily total of bites by the number of shocks delivered during that session. Calculations were for the final session of initial exposures at the respective indicated values. No correction for response increases and decreases occurring within sessions is provided. Identity for specific sessions shown may be obtained by referencing Table 1.

The present experiments demonstrate development of the progressive reduction of biting attack with certain values of shock. Thompson and Spencer (1966) presented a thorough discussion of such decremental, or habituation, processes in numerous biological preparations. In the present studies, response decrements had certain replicable characteristics common to other habituational phenomena. Decreases were progressive through the session (Fig. 1, 2, 5, 6), but temporary cessation of stimulation between sessions resulted in some recovery of the previously reduced response rate (Fig. 2). Further, progressively more rapid decreases in responding occurred as a function of repeated sessions (Fig. 2). The decrements were also of greater magnitude with more frequent stimulus applications and more pronounced at lower stimulus intensities (Fig. 5, 6, 7). These findings agree with the criteria elaborated by Thompson and Spencer as characteristic of the process of habituation.

Though it had not previously been noted to occur with attack reactions, signs of habituation may be seen in several previous studies (Hutchinson *et al.,* 1968, Fig. 1 and 2; Azrin *et al.,* 1968, Fig. 7; O'Kelly and Steckle, 1939; Ulrich and Azrin, 1962, Fig. 5).

The present experiments also sometimes demonstrated the development of increasing responding, or a facilitation process, to continued shock. The process was shown to have several unique and replicable characteristics. First, biting increased as a function of successive shock applications (Fig. 3, 4, 5, 6). Second, the elevated response level decreased when shock was no longer applied (Fig. 4). Third, increments occurred more rapidly over successive sessions (Fig. 4). Fourth, the increase was greater at longer intervals between shock (Fig. 6, 7). Perhaps it will be found in future research that this fourth effect is really due to the removal of a sufficient condition, frequent stimulation, for the counter-effect of an habituation process. Fifth, the incremental process was greater at higher shock intensities (Fig. 5, 7).

Though facilitation of aggressive responses has not previously been described, data in the literature provide several examples of changes in behavior over time that may be indicators of facilitation. Each of the studies either demonstrates increments in existing aggressive reactions or emergence of new reactions to repetitive, intense stimuli (Azrin *et al.,* 1968; Hutchinson *et al.,* 1965; O'Kelly and Steckle, 1939; Azrin *et al.,* 1964).

## EXPERIMENT II: EFFECTS OF UNSIGNALLED SHOCK REMOVAL UPON BITING ATTACK

In Exp. I, it was shown that biting could be affected by a recurrently developing incremental process termed facilitation, rather than being only the immediate result of specific shock deliveries. This finding suggested that the termination of shocks might not instantly result in a cessation of biting. Several different procedures were employed to examine the degree of relationship between specific shocks and specific instances of biting.

### METHOD

*Subject*

The subject (M-28) had been tested before.

*Apparatus*

The apparatus described in Exp. I was used.

*Procedure*

The initial test omitted shock during the final 30 min of a 60-min session. Before shock was omitted, response facilitation had already developed to 100-v, 100-msec shocks at 240-sec intervals. No other stimuli were normally presented. This omission of shock was not signalled by any stimulus change and was conducted only once. Following this test, the subject was exposed to several consecutive sessions each of shock, no shock, shock, and no shock.

### RESULTS AND DISCUSSION

No immediate reduction in biting attacks resulted from shock omission subsequent to the development of accelerated biting, and responding continued for several hours with no apparent decrease. Figure 8 presents the cumulative record showing this effect. After approximately 30 min, all further shocks were omitted by disabling the shock generator. Biting attack continued without apparent change for the remainder of the experimental session.

Following this test, repetitive and successive groups of sessions with shock and without

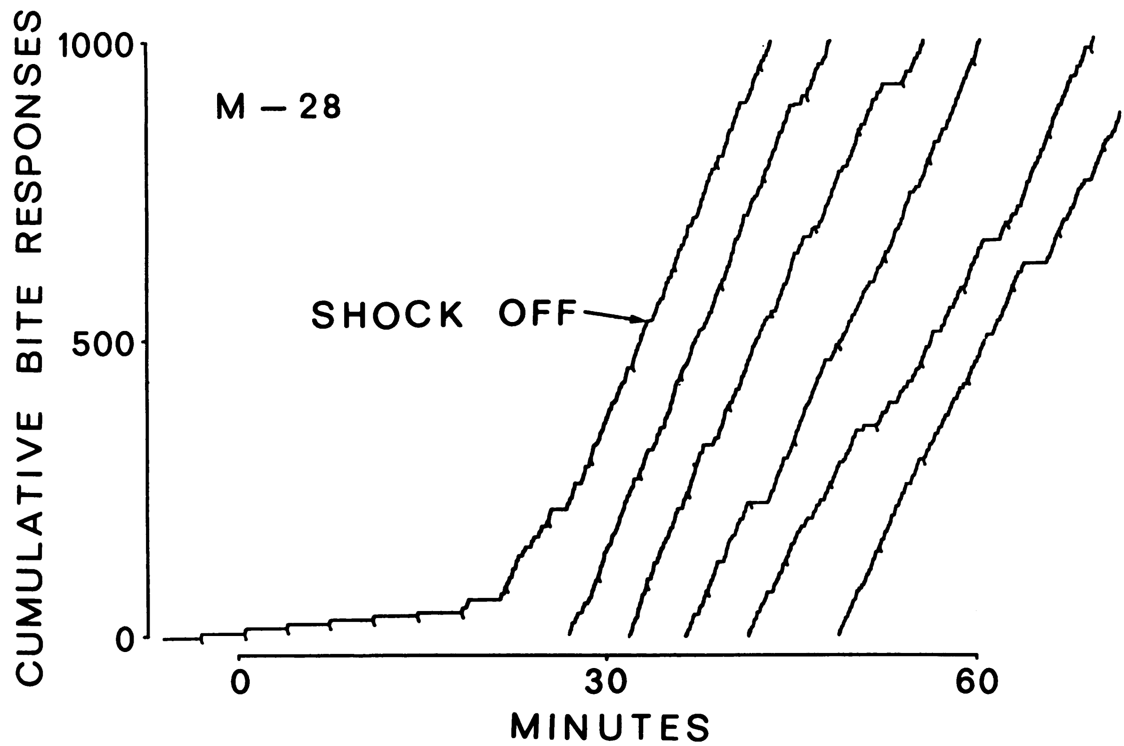


Fig. 8. Record illustrating the absence of immediate effect after removal of shock subsequent to facilitation of biting attack. Downward deflections of the response record indicate delivery of shock before SHOCK OFF. Subsequent deflections indicate only where shocks would ordinarily have been delivered. Session shown is M-28's ninetieth (See Table 1). Note that separate record segments have been compressed along the abscissa, and that total performance shown occurred over a period of approximately 140 min.

shock were instituted. Figure 9 displays the results of two successive shock termination and restoration sequences.

As in the initial test (Fig. 8), Fig. 9 demonstrates that the cumulative effect of shocks upon biting attack, once produced, does not decrease immediately after shock delivery ceases. Figure 9 shows that biting persisted during several subsequent sessions (Days 2 to 6). The results further indicate that the facilitation process was produced not only by shock, but also apparently by other conditions of the experiment that had been temporally associated with shock. This is shown by: (1) increases in biting, produced directly by shock on a particular day, were absent during early portions of the following day, and yet; (2) continued exposure to chamber conditions without shock did produce and facilitate biting. After continued dissociation between these presumed conditions and shock, however, they lost the capacity to produce such effects.

On Day 17, the masking-noise generator failed (Fig. 9, point A). The resulting increase in biting attack subsequent to a novel stimulus is discussed later.

## EXPERIMENT III. CLASSICAL CONDITIONING OF BITING ATTACK

In Exp. I, habituation and facilitation of biting attack as direct reactions to periodic shock delivery were observed. Behavior may also be altered through extended exposure to environmental conditions through Pavlovian or classical conditioning. Indeed, the second portion of Exp. II provided several indications that such processes might be occurring in the context of fixed-interval shock delivery. Experiment III specifically investigated the possibility of modifying biting attack via classical conditioning procedures.

### Method

*Subjects*

Four naive male squirrel monkeys, between 0.7 and 0.9 kg, served.

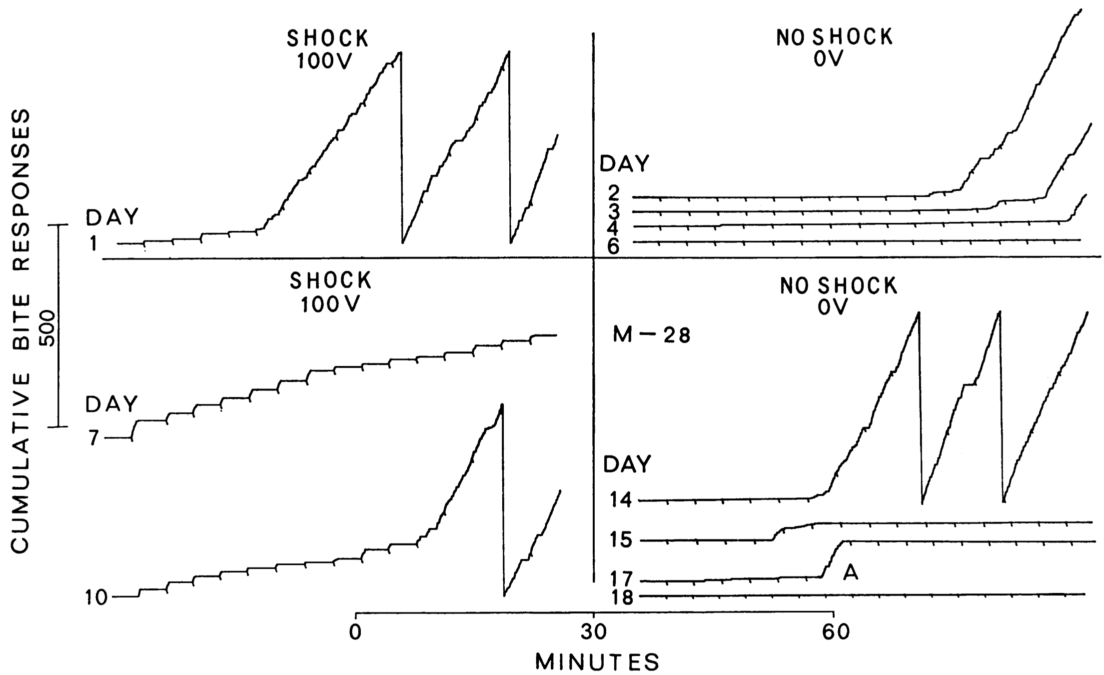


Fig. 9. Cumulative records for one subject, illustrating decay, reestablishment, and subsequent decay of facilitation of biting attacks over consecutive days of testing. Regular downward deflections on records for NO SHOCK days indicate where shock would ordinarily have been delivered, as it actually was on Days 1 and 7 to 12. The short flurry of biting at point A on Day 17 occurred upon failure of the masking-noise generator. Day 1 of the series shown was M-28's ninety-first session (see Table 1).

### *Apparatus*

The apparatus described in Exp. I was used, with a white lamp on the front panel and a "Sonalert" 900-Hz tone generator in the upper left corner of the chamber. Both were scheduled for a 0.5-sec on, 0.5-sec off pattern once each second, when activated.

### *Procedure*

A 400-v ac, 100-msec shock was presented independently of responding every 220 sec. A shock-paired stimulus (either tone or light) was presented for 10 sec before, and terminated with, shock termination. Fifteen pairings were provided in each 1-hr daily session. As a pseudo-conditioning control procedure, the other stimulus (light or tone) was presented for 10 sec, starting 80 sec after the previous shock terminated. For M-259 and M-263, the tone was initially paired with shock while the light (control) occurred at the 80-sec intertrial point. For M-266 and M-247, the light was initially shock-paired and the tone (control) was presented at the intertrial point. These conditions were maintained for 75 to 225 stimulus-shock pairings. Temporal assignments of the two stimuli were then reversed for all four subjects, and additional trials were conducted until behavior appeared stable.

## Results and Discussion

The left column of Fig. 10 presents performances for all subjects after maximal conditioning had developed. Each graph shows average performance for an entire session. The curve presents the pattern of biting attacks in response-per-minute through the shock-shock interval. Following a high frequency of biting just after shock, responding decreased until the last 10 sec before shock, when biting increased during the shock-paired stimulus. Though Subject M-259 responded during the intertrial (control) stimulus, approximately twice as many bites occurred during the stimulus associated with shock. M-259 also had the highest biting-attack frequency in the shock-shock interval. The other three subjects showed little or no biting to the control stimulus.

Next, the shock-paired and intershock control stimuli were reversed. The graphs in the right-hand column of Fig. 10 demonstrate that

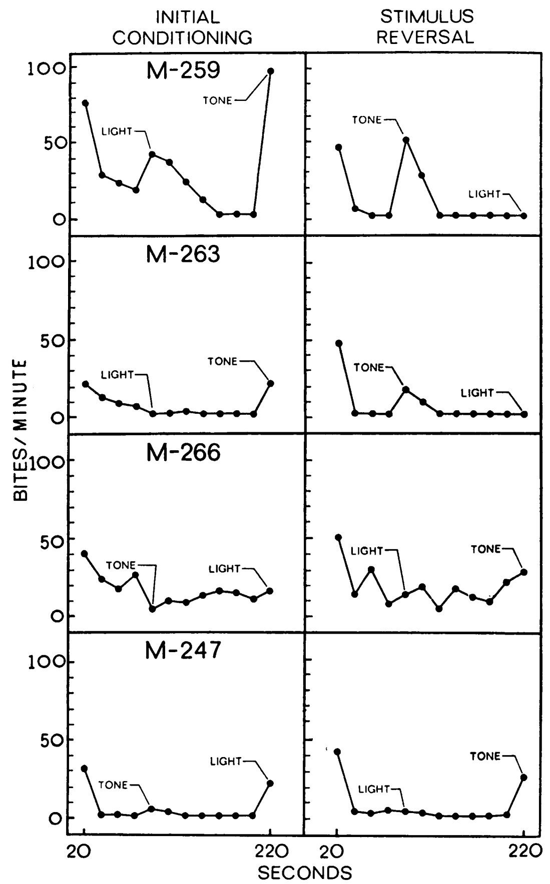


Fig. 10. Distribution of biting attacks throughout the intershock interval during initial conditioning, and after reversal of shock-paired and intertrial control stimuli. Each curve represents the average for an entire session. Each point was calculated by dividing the total number of bites for a session that occurred within a particular time interval by the total number of seconds in that time interval. Time-interval durations were 10 sec for the intershock and shock-paired stimuli intervals, and 20 sec for all other intervals. Data for initial conditioning are from: for M-259, Session 16; M-263, 20; M-266, 3; and M-247, 8. Stimulus reversal sessions shown are: for M-259, Session 7; M-263, 9; M-266, 3; and M-247, 7. The rationale for choosing earlier than final performance during initial conditioning and for stimulus-reversal sessions was similar and is explained in Fig. 11 and the text.

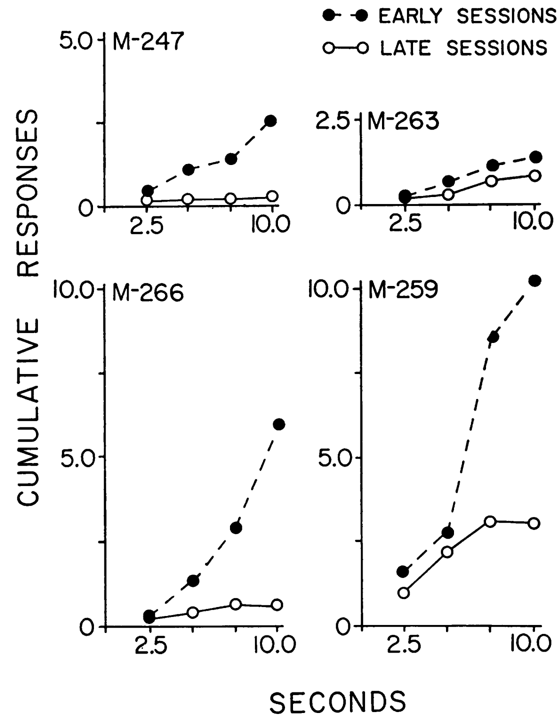


Fig. 11. Cumulative response distribution of biting attacks throughout the shock-paired stimulus interval during early and late pairings. Each point is a mean calculated by dividing the total number of bites occurring within a time interval by the number of such intervals accumulated across class intervals. Data are for sessions where the auditory signal was the conditional stimulus for M-259 and M-266, and the paired signal was visual for M-247 and M-263.

the two subjects that had previously received the tone as the shock-paired stimulus (M-259, M-263) continued to bite when this stimulus was delivered. No indication of any conditioning to the light was evident, even after 465 additional presentations for M-259 and 345 additional deliveries for M-263. For those subjects that had initially received the light as the shock-associated stimulus and the tone as the control stimulus, stimulus reversal produced rapid extinction of responding to the light and simultaneous conditioning to the tone (90 presentations for M-266, 45 for M-247).

These results provide direct evidence for the possibility of classical conditioning of biting attack, and indicate that auditory and visual stimuli may, in certain situations, not be functionally equivalent after association with shock. Indeed, a second and extended stimulus reversal series for M-266 and M-247 was not successful.

Several additional effects were observed in these experiments that are not apparent from Fig. 10. Figure 11 displays changes in biting frequency within the shock-paired stimulus period for the four subjects during 15 early and 15 late stimulus-shock pairings where tone was associated with shock. More biting occurred during early pairings than in later ones. Further, during early pairings responding occurred steadily throughout the stimulus interval, whereas later, each subject showed a negatively accelerated pattern of biting rather than demonstrating the positively accelerated "inhibition of delay" characteristic of classical conditioning procedures.

The present experiment demonstrates classical conditioning of biting attack responses. Previous studies have shown that at least certain of the components of an aggressive display and attack sequence may be conditioned. Vernon and Ulrich (1966) showed that a stimulus associated with delivery of grid shock could produce standing and lunging in a pair of rats. Thompson and Sturm (1965) demonstrated that fin and gill erection could be classically conditioned in fish. These response components appear at early or intermediate points in the complete reaction sequences normally exhibited in the natural environment (Eibl-Eibesfeldt, 1961), but delivery of even the unconditional stimulus is frequently insufficient to produce these reactions repetitively. Since a bite or blow *per se* will often produce the same response in the opponent, the punishment of counter aggression may reduce the likelihood of further attack instances (Azrin *et al.*, 1963; Ulrich, Wolfe, and Dulaney, 1969). The non-social methodology employed in the present experiments was advantageous for the study of both shock-produced and shock-paired stimulus-produced attack reactions, since no punishment through counter aggression could occur.

## EXPERIMENT IV. EFFECTS OF SIGNALLED SHOCK REMOVAL ON BITING ATTACK

The results of Exp. III showed that biting attack could be "conditioned" in the sense that other stimuli, after association with shock, could at least temporarily produce effects like those generated by shock.

Further, Exp. II (Fig. 9) suggested that the facilitation process resulting from continued, intense, infrequent shock exposure might influence this conditioning process. A conflicting observation seen in the second portion of Exp. III (Fig. 11) was that responding immediately before shock tended to reduce upon extended exposure to the signal-shock combinations. This finding suggested the possibility that different temporal portions of a shock-paired stimulus might serve either to enhance or suppress biting attack responses.

In an attempt to establish more explicit stimulus control over facilitation during biting produced by shock-paired stimuli and response suppression during a shock-paired stimulus immediately before shock, subjects were exposed to signalled periods of shock that alternated with signalled periods of no-shock.

### METHOD

*Subjects*

Six adult male squirrel monkeys between 0.7 and 1.2 kg served; M-120 and M-104 were naive.

*Apparatus*

The apparatus described in Exp. III was used.

*Procedure*

All subjects were exposed to alternating 10-min periods of response-independent shock and no shock. The tone and light stimuli described in Exp. III were presented coincidentally, signalling the 10-min period of intermittent shock delivery for three subjects, and the 10-min period of shock absence for the other three subjects. Three shock cycles and three no-shock cycles were given each day. Subject M-120 always received no-shock cycles as first cycle of the day. The others always received shock during initial cycles. The first shock was always delivered at the end of the first inter-shock interval. Details of test procedures for M-104 and M-120 are shown in Table 2. Test procedures for the other four subjects are available from Table 1.

Table 2
Signalled Shock Removal Procedures for Two Subjects

| *Subject* | *Sessions* | *Voltage* | *S-S Interval* |
|---|---|---|---|
| M-104 | 51[a]-55 | 150 | 60 sec |
| | 56-57 | 300 | 60 sec |
| M-120 | 113[b]-115 | 400 | 60 sec |
| | 116 | 600 | 60 sec |
| | 117-125 | 400 | 60 sec |
| | 126-161 | 500 | 60 sec |
| | 162-164 | 400 | 60 sec |

[a]Preceded by 50 days of response-independent shock procedures.
[b]Preceded by 112 days of response-independent shock procedures.

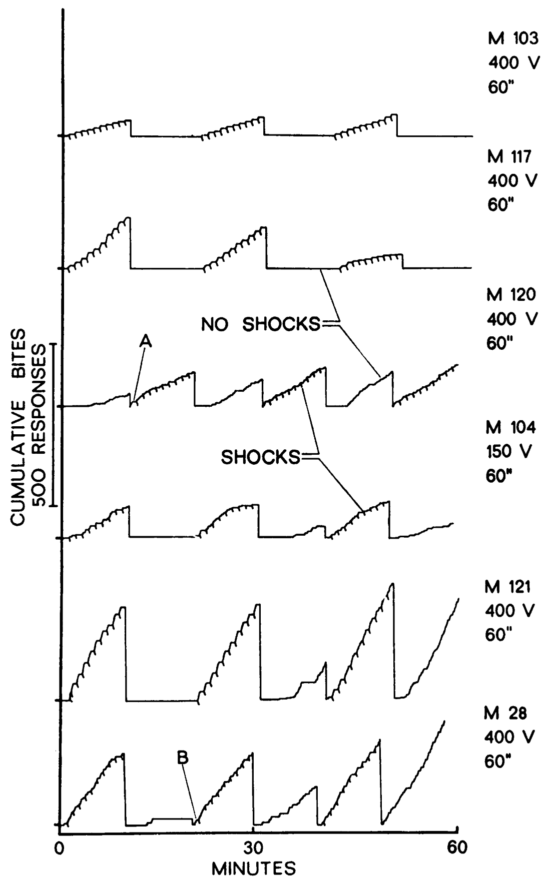


Fig. 12. Representative records of final performance illustrating the effects upon biting attack of alternating, 10-min, signalled periods of shock and no shock. The recorder pen reset to baseline at the end of each period. Sessions illustrated are: for M-103, Session 104; M-117, 195; M-120, 164; M-104, 54; M-121, 99; and M-28, 208 (see Table 1).

## Results and Discussion

Figure 12 shows final performance on these conditions for the six subjects. The procedure did not produce biting attack during periods of no-shock for two subjects. The upper two curves in Fig. 12 show that Subjects M-103 and M-117 eventually came to bite after each shock, but at no other time. The other four subjects, however, showed evidence of each of the conditioning reactions first detected in Exp. II and III. (a) Each subject showed increases in biting attack in successive periods of shock and also in successive periods of no-shock. (b) Biting during no-shock periods showed a pattern of positive acceleration toward the next period of shocks. And, (c) responding was always absent a moment before actual shock delivery during the shock period stimulus (see examples at A and B, Fig. 12).

Though the results showed that biting attacks occurred in successive presentations of the stimuli signalling shock absence, and this was interpreted as additional evidence favoring the possibility of classical conditioning of biting attack, shock was present during other portions of the session and might have been the cause of the biting noted during the safe-period stimuli. Accordingly, two subjects were tested over two or five experimental sessions with no shock presented during either stimulus. Figure 13 depicts the results of this test for one subject. On Day 1, the day before shock removal, biting attacks developed during the no-shock periods after four such 10-min periods. On Day 2, even though no shocks were delivered, the same pattern of attacks developed during successive "no-shock" periods.

In both Fig. 12 and 13, successive presentation of the stimuli signalling shock absence resulted in greater frequencies of biting attack during that stimulus. The progressive increase in biting was first observed in Exp. I and was there termed facilitation. The development and/or maintenance of facilitation of biting in the absence of shock in Exp. II (Fig. 8 and 9) first suggested both the possibilities of classical conditioning of biting attack and further, an interaction between the facilitation process and the classical conditioning process. Experiment III confirmed the possibility of classical conditioning of biting attack. The present experiment confirms that continued exposure to explícit, identifiable shock-paired stimuli, even in the absence of shock can result in progressive increases, or facilitation, of biting attack. Yet this demonstration of the presence of, and interaction between, these two processes does not clearly test between two separate possible explanations. First, since continued, intense, infrequent shocks produce more vigorous reactions, those stimuli associated with later shocks might essentially be paired with stronger response-evoking shocks and might thus themselves be stronger response-producing events. The greater effects produced by stimuli, subsequent to association with more intense unconditional stimuli, are well known (Hilgard and Marquis, 1940).

An alternative explanation might be that continued presentation of shock-paired stimuli

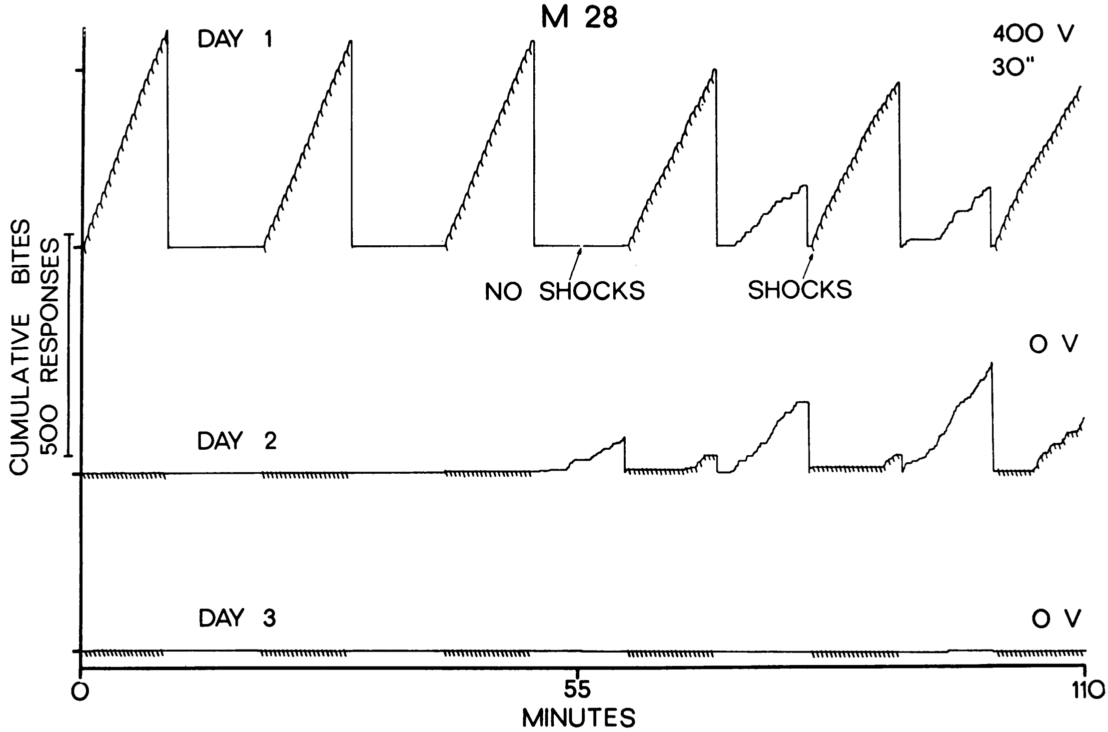


Fig. 13. Representative records illustrating the effect of shock removal upon the decline in biting attack, both during stimuli earlier associated with shock and during stimuli not associated with shock. The upper record shows the last day of final performance during scheduled shock. The middle and lower records are of the first and second days without shock. The downward deflections of the response pen indicate either where shock was delivered (Day 1) or where it would have been delivered (Days 2 and 3). The recorder pen reset to baseline at the end of each 10-min stimulus period. Days 1 to 3 of the series shown were Sessions 180 to 182 for M-28 (see Table 1).

directly produces progressively stronger reactions subsequent to pairing with unconditional eliciting stimuli (presumably those that produce response facilitation themselves). A choice between these two possible explanations cannot now be certain, however. Although the separate processes necessary to the former account are already well established, no evidence exists to support the latter explanation.

In Fig. 13, biting during a stimulus previously associated most directly with shock weakened more rapidly. This differential rate of response decrease may be the result of a stimulus generalization decrement, though no confirmation is possible in the present data. Extinction testing for the other subject produced essentially the same results.

In Exp. III (Fig. 11), it was shown that biting attacks, though elevated during a brief stimulus paired with shock, tended to decrease during later conditioning sessions; and that this reduction resulted from the development of the negative acceleration of responding in later portions of the shock-paired stimulus as the time of shock approached. This response suppression was also observed here (Fig. 12) each time that the shock-paired stimulus was delivered just before shock delivery.

## EXPERIMENT V. ESTABLISHMENT AND MAINTENANCE OF LEVER PRESSING BY SHOCK

Experiments I through IV studied the habituation, facilitation, and classical conditioning or suppression of biting attack upon a rubber hose that occurred upon delivery of response-independent shocks. In other studies, a small standard rodent response lever was added. Responding on the lever had no effect on shock delivery. Shock consistently produced both biting attack upon the rubber hose and manual depressions of the response lever, indicating that certain of the processes considered unique to biting attack might also be characteristic of other reactions. To test this, subjects were exposed to periodic response-independent shocks while having access to both a rubber hose and a response lever.

### METHOD

*Subjects*

Three adult male squirrel monkeys and one adult female, all between 0.7 and 1.0 kg, served. M-34 had been tested for the effects of certain drugs on biting-attack responses; the other three subjects were naive.

*Apparatus*

The experimental chamber was the same as that described earlier, except that a metal response lever (Lehigh Valley Electronics, Rat Lever, model 1352), centered 2.5 in. (6.4 cm) from the left wall and 3.75 in. (9.2 cm) above the waist panel, was added. Depression of the lever with a force of 15 g (0.15 N) produced an audible "click" of a relay mounted on the outside of the panel.

*Procedure*

Subjects were exposed to response-independent shocks of 400-v ac, 200-msec duration, every 240 sec. Sessions were 1 hr each day, except that the first eight sessions for MC-23 were 2 hr long.

### RESULTS

All subjects developed regular patterns of biting the hose and pressing the lever. Biting attack toward the response lever was never observed during any of the frequent observation periods. Figure 14 displays sample cumulative records of lever pressing and biting attack for each subject for one complete experimental session after extended exposure to the experimental conditions.

Each of the subjects demonstrated a consistent pattern of responding within the intershock interval. In Fig. 15, performance from an entire session is plotted to illustrate the distribution of lever pressing and hose biting over successive seconds of the intershock interval. Figures 14 and 15 together illustrate that, after shock delivery, biting attack occurs at a high frequency for some seconds, then decreases to a lower level. Alternatively, lever pressing occurs at a relatively lower rate immediately after shock. As the time for the next shock approaches, both lever pressing and hose biting may increase, but lever pressing comes to occur at a higher relative frequency. Later, as shock time approaches, responding tends to occur at a lower rate for several subjects.

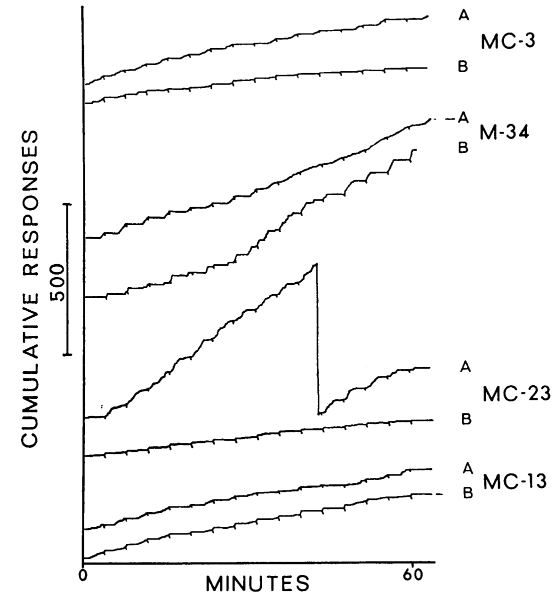


Fig. 14. Representative records illustrating the final pattern of both lever pressing and hose biting, produced by 240-sec S-S, response-independent shock. The upper records (marked A) show lever pressing; the lower records (marked B) show biting attack. Each pair of records was obtained simultaneously during a single experimental session. Sessions illustrated are: for MC-3, Session 79; M-34, 198; MC-23, 39; and MC-13, 45.

The development of the lever-pressing patterns seen in Fig. 14 and 15 resulted after a number of experimental sessions. Figure 16 portrays the increases in responding that developed for each subject. Though behavior is absent or reduced during earlier sessions, continued exposure to shock over several sessions produced increased responding.

## EXPERIMENT VI. ESTABLISHMENT AND MAINTENANCE OF CHAIN PULLING BY SHOCK

The results of Exp. V demonstrate that the delivery of response-independent electric shock can, under some circumstances, generate a complex manual response and that continued exposure to shock can produce response facilitation. To determine whether these effects of shock were specific to features of the par-

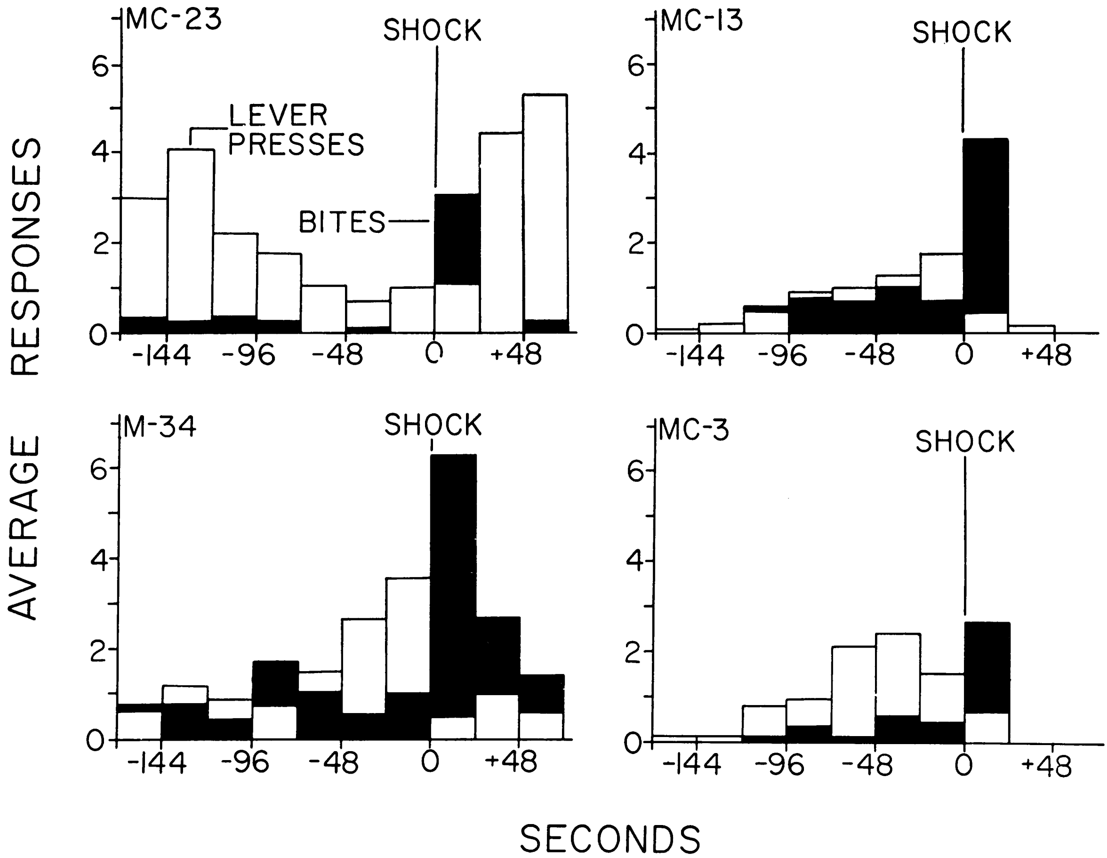


Fig. 15. Distributions of biting attack and lever pressing, illustrating the progressive changes in responding both before and after shock delivery. Each bar is the average total of responses occurring in each successive 24-sec portion of an intershock interval for the sessions portrayed in Fig. 14. No correction for within-session response increments is provided.

ticular manual response chosen for study, two subjects were tested consecutively for a lever-press and a chain-pull response, as well as for biting attacks upon a rubber hose.

## Method

### *Subjects*

The two adult, male, naive subjects weighed 0.9 kg and 0.8 kg respectively.

### *Apparatus*

The experimental chamber was identical to that used in earlier experiments, except that during certain sessions the response lever was completely covered by an aluminum baffle while a loose link-chain was suspended down into the chamber to 2.25 in. (6.2 cm) above, and 1 in. (2.5 cm) to the left of, the center of the bite hose. Pulling the chain 1 in. (2.5 cm) downward with 80 g (0.80 N) force produced the audible "click" of a relay closure (the same relay used at other times during studies of lever pressing).

### *Procedure*

Subject MC-2 was first shocked in the presence of the chain only, and then later in another chamber with the lever only. MC-12 was shocked in the presence of the lever only and then later in the presence of the chain only (in the same chamber). Response-independent shock duration was 500 v ac for MC-2 and 600 v ac for MC-12. Shock intensity was 200 msec, and intershock interval was 240 sec.

## Results

Figure 17 illustrates the progressive development of manual chain pulling and lever pressing for each subject.

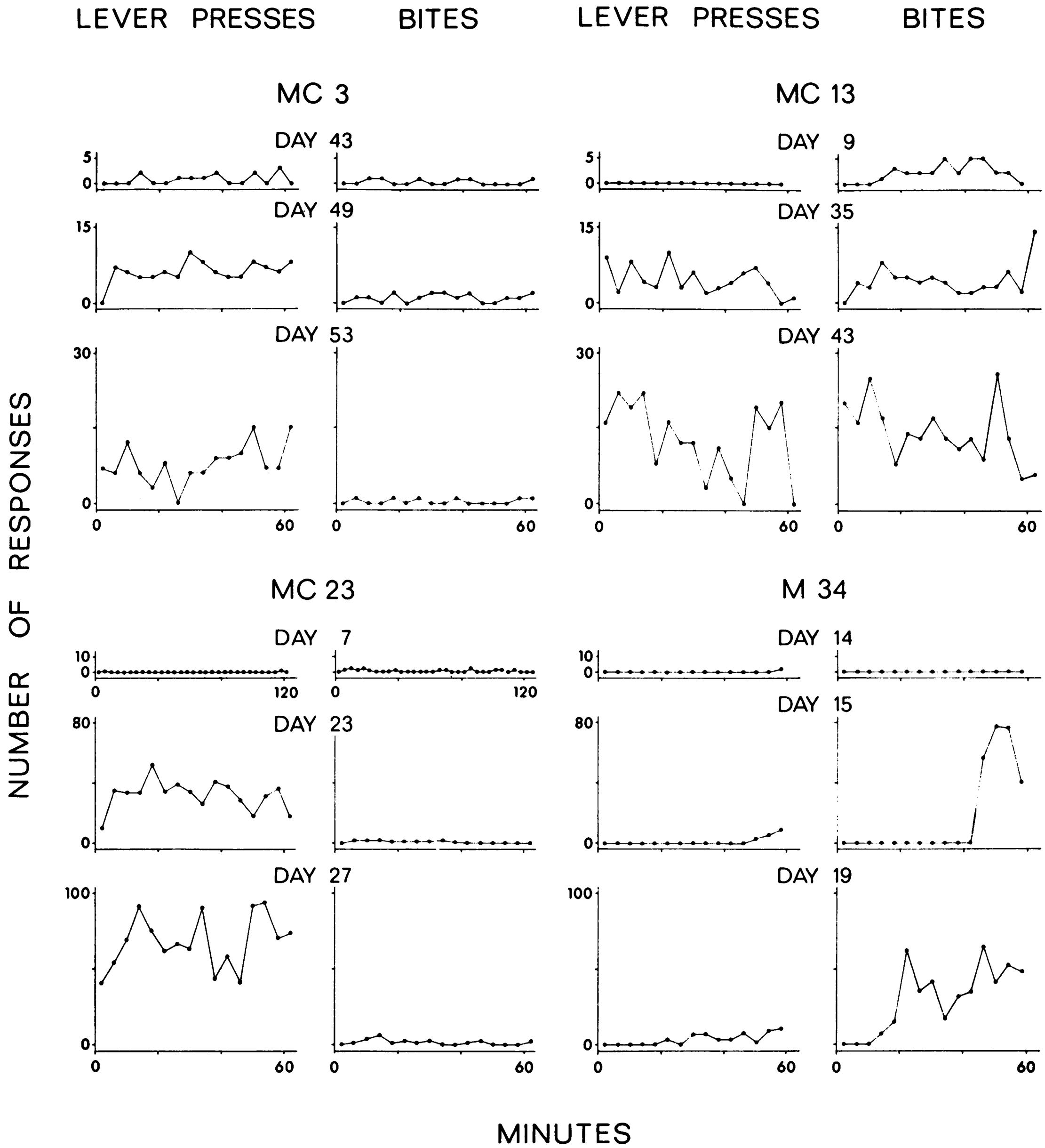


Fig. 16. Lever-press and hose-bite responses for several sessions, illustrating the progressive increases in both responses during the response-independent shock schedule. Data points are totals for successive 240-sec periods. Consecutive experimental sessions are indicated above each record.

Upon continued exposure to the fixed-frequency shock deliveries, responding assumed the temporal pattern seen in Exp. V for lever pressing. Here again, lever pressing and chain pulling each tended to increase progressively toward the time of scheduled shock. Shortly before shock, responding was often reduced or absent. MC-12 infrequently attempted to bite the chain immediately after shock, but all other recorded chain responses were by manual grasping and pulling only.

These results extend the findings of Exp. V in showing that the periodic application of electric shock can produce at least several topographically different manual responses. This is evidence that the lever pressing seen in Exp. V was not a unique, automatistic reaction produced by the shock. Additionally, the

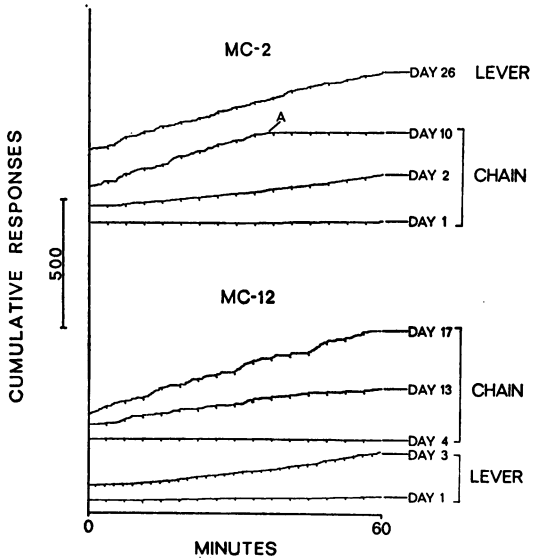


Fig. 17. Representative records illustrating progressive shock-produced increases in chain pulling and lever pressing over successive sessions. MC-2 was tested for shock-produced chain pulling in Sessions 1 through 10. The absence of responding from the point marked A on Day 10 resulted when the chain mechanism became physically disconnected. This subject was then tested in all subsequent sessions in another chamber that contained a standard response lever but no chain. The sixteenth session of shock-produced lever pressing is shown (Day 26). MC-12 was initially tested for shock-produced lever pressing for three sessions. The lever was then removed and a chain was installed in the same chamber. All subsequent testing for MC-12 was with the chain.

temporal patterning that developed for each response confirms the observations of Exp. V for lever pressing and those of II, III, and IV for biting attack, showing that each of these responses might eventually be produced or suppressed by temporal features of the shock delivery program.

Hose-biting responses followed a temporal pattern essentially identical to that reported in Exp. V.

The results demonstrate that electric shock can generate and maintain a complex manual response sequence. This occurs without any prior or current contingency between any property of the shock stimulus and the response. Additionally it was shown that continued shock exposure over several sessions resulted in increased rates of responding and the development of a "temporal discrimination", *i.e.,* responding was positively accelerated later in the intershock interval.

Several distinctly different response sequences were each elevated by the same temporal conditions. If the positive inflections in responding occurring later in the intershock interval were in fact due to classical conditioning, then it is clear that "conditioning" in these experiments was of some general nature that could simultaneously influence at least the responses of biting attack and lever pressing or chain pulling. Several authors have noted that classical conditioning effects seem to involve processes capable of influencing several response systems simultaneously (Bitterman, 1965; Pavlov, 1927; Schlosberg, 1937).

Experiments V and VI each provided frequent evidence of response reductions or suppression immediately before shock delivery. The effects were similar to those noted in Exp. III and IV. The general response reduction during stimuli present immediately preceding shock, first discovered by Estes and Skinner (1941), is frequently referred to as conditioned suppression (Lyon, 1968). An interesting feature of the present results is that both increased and decreased responding were generated within the same experiment by different temporal portions of the schedule. Figures from earlier studies employing schedules of response-independent periodic shock illustrate this same bivalued response pattern (Kelleher, Riddle, and Cook, 1963, Fig. 5, 6, and 8; Sidman, 1960, Fig. 3, 4, 5, 6, 7; and Sidman, Herrnstein, and Conrad, 1957, Fig. 5 and 6).

The manual responses of lever pressing and chain pulling followed a different temporal pattern within the interval between shocks than did biting. Biting frequency was maximal immediately after shock, but lever-pressing and chain-pulling frequencies were relatively lower than biting immediately after shock.

As the time of shock approached, biting attack and the two manual responses increased in frequency, but the manual responses occurred at a relatively higher frequency than did biting. Thus, two separate and topographically distinct performances (biting and manual manipulation) were differentially affected by the same experimental event. Differences in the absolute frequencies of biting and manual responses did not seem due to any gross topographic incompatibility, since both performances occurred in close temporal proximity and in alternation toward the end of the intershock interval.

Though the frequency of biting, and lever pressing or chain pulling, may have been affected by momentary proximity of the responding member to the two response-sensor devices, the relative frequency of the two response classes was nevertheless seen, in Exp. V, to reverse after shock. This reversal in relative probabilities after shock provides the necessary control against the possibility that differences in response topography or absolute response strength were primary determinants of relative response frequency. Thus, it is safe to conclude that conditions before shock tend to produce manual responding, whereas conditions after shock tend to produce biting attack.

Several earlier studies have demonstrated that attack reactions can predominate over other manual responses immediately after shock delivery (Azrin *et al.,* 1967; Ulrich, 1967) but in those studies, a factor known to strengthen reactions was present before shock, *i.e.,* a shock avoidance or escape contingency.

## GENERAL DISCUSSION

Several considerations suggest the term facilitation to subsume the incremental effects seen in the present experiments. First, the behavioral increases are not exclusively changes in response. Previously ineffective stimuli can eventually produce responding. Thus, terms implicating effect or changes could be misleading. Alternatively, reactions to invariant stimuli may become progressively stronger and continue after stimulation. Terms indicating changes in sensory systems alone may therefore be inappropriate. In fact, there were changes in relationship between several sensory and several motor systems. Other terms, emphasizing just such relations, have other difficulties. The incremental process appears to be qualitatively opposite to that of habituation. Dishabituation, however, as normally defined, is the ability of a neutral or novel stimulus application to foster the immediate and often pronounced return to strength of some stimulus-response relationship that had been lost (Thompson and Spencer, 1966). The process here termed facilitation was not uniquely defined by the application of a neutral stimulus, nor by the restrengthening of an already weakened response.

Sensitization typically refers to the increment in a response normally evoked by the to-be-employed conditioned stimulus, but seen subsequent to conjoint application of the conditioned and unconditioned stimuli (Hilgard and Marquis, 1940). In the present experiment, however, the responses involved are produced directly and with high probability following electric shock, the unconditioned stimulus.

Pseudo-conditioning is an effect where a new stimulus may evoke a response similar to that of the unconditioned stimulus, whether or not the two stimuli have been uniquely associated. Such an effect was occasionally noted in the present experiments. Facilitation, however, does not exist only because of an interest in other stimulus-response relations. After intense noxious stimulation, increases of several reactions (biting, lever pressing, and chain pulling) occur upon further applications of the unconditioned stimulus, conditioned stimuli, and novel stimuli. It seems likely that pseudo-conditioning effects result from response facilitation.

Several studies have reported response facilitation upon continued application of elicting stimuli. Stimuli employed have typically been intense and were frequently described by the authors as noxious, biologically relevant, emotion-producing, or arousing. Sometimes, such effects have been reported as examples of pseudo-conditioning or sensitization during conditioning experiments. For example, Prosser and Hunter (1936) demonstrated that intense electrical shocks increased the startle responses to a click stimulus in rats. Sears (1934), after adapting fish to both light and vibratory stimuli, demonstrated that an interposition of shock later caused vigorous swimming reflexes to the light and vibratory stimuli when each was again presented. Grether (1938) showed that, subsequent to the discharge of powder flashes or blowout noises, the ringing of a bell produced "flight" and "fright" responses in monkeys. Reinwald, as cited by Keller and Schoenfeld, 1950 (page 29) found that rats showed running and jumping to a tone after receiving electric shocks. More recently, Wilson (1959) reported that electric shocks produced long-term facilitation of a swimming reaction in a sea anemone. Hinde (1966) reviewed several examples of the effect of application of intense peripheral stimuli upon behavior. Increments in overt reactions to both the same and previously neutral stimuli may be produced. Hutchinson *et al.*

(1965) noted marked increases in fighting reactions between rats upon continued shock delivery.

Thus, there is a fragmented but pertinent literature suggesting the general principle that continued application of "noxious", "aversive", "painful", or intense stimulation will result in increases in several different reactions to such stimuli and/or to previously neutral stimuli. The general character of these reactions appears, on gross inspection, to be similar or identical to behaviors typically termed fleeing, freezing, and fighting when observed in the natural environment (Eibl-Eibesfeldt, 1961; Hinde, 1966).

The present experiments demonstrated several parametric stimulus-response relations between shock and biting attack and lever pressing or chain pulling. Each of the responses became progressively more frequent with continued stimulus application. Originally neutral stimuli, if associated with intense noxious stimuli, also came to produce similar effects on these reactions. Whether a response increased or showed suppression depended upon the temporal proximity between the noxious event and the specific reaction. Generally, manipulative reactions were more probable than attack responses before shock. Both behaviors were reduced when shock was imminent; after shock, biting-attack reactions became predominant.

The temporal relations between shock and increases and decreases in the response classes studied here may be confirmed by future research to provide a suitable laboratory parallel to the temporal (and spatial) relations between noxious events and episodes of fleeing, freezing, and fighting as often observed in the natural environment.

In Exp. V and VI, periodic shock delivery was shown to be a sufficient condition for the occurrence of a complex manual response. No prior experimental history was necessary for these performances to develop.

The features of the manual behaviors here generated directly by shock are similar or identical to features of avoidance behavior reported in the literature. In the present studies, responses increased both within and across successive experimental sessions, and the processes were shown to be effects of facilitation and classical conditioning. In studies of avoidance, the increases in responding within and across early sessions are generally attributed to operant reinforcement learning (Kimble, 1961). Response increases within experimental sessions, after learning is presumed to be established, are referred to as "warm up" (Hoffman, Fleshler, and Chorny, 1961). In the present studies, it was also shown that the temporal pattern of the manual responses that developed between successive response-independent shocks was highly similar to avoidance performance. Here, as there, responding was characterized by a low response frequency immediately after shock, followed by a progressive increase in responding up to (Anger, 1963; Hoffman, 1966; Sidman, 1954 and 1966) or slightly before the instant of the next shock delivery (Hoffman, 1966).

These similarities may place some constraint upon traditional estimates of the contribution of the avoidance contingency to response strength. Extinction testing is a technique often employed for assaying this contribution. Unfortunately, studies interested in the effects of "extinction" upon avoidance-response strength often eliminate shock delivery rather than the shock-avoidance contingency. The procedure seems to owe its popularity to several historical and theoretical factors (see the review by Herrnstein, 1969). When shock is removed, the avoidance reactions are typically soon reduced to low levels, Sidman (1966). Removing only the shock-avoidance contingency and continuing to deliver response-independent shocks may result in a considerable degree of responding to the shock alone (Byrd, 1969; Kelleher *et al.*, 1963; Sidman, 1960; Sidman *et al.*, 1957). The pattern of behavior found in those studies is essentially identical to the results of Exp. V and VI reported here. The common experimental procedure employed here and in earlier studies is the delivery of unavoidable, noncontingent shock. The common behavioral result is a marked increase in responding up toward the moment of the next shock, but with a decrement in responding just before shock. The persistence of responding during free-shock testing after avoidance conditioning has usually been analyzed as exceptional resistance to extinction or superstitious reinforcement (Kelleher *et al.*, 1963; Sidman, 1960; Sidman *et al.*, 1957). Data from the present experiments suggest an alternative explanation: shock and associated stimuli can produce response(s) directly.

It is not suggested that the experimentally arranged contingencies in schedules of avoidance are unimportant. No aspect of the present data argues against the likelihood of further increases in responding if shock avoidance and shock-associated stimulus terminations were possible. Such tests are not reported here. Further, numerous reports are presently available in the literature indicating the power of such contingencies (Brogden, Lipman, and Culler, 1938; Herrnstein and Hineline, 1966; Miller, 1948).

The present results support a modified "two-factor" theoretical account of avoidance responding. More exactly, they demonstrate the existence of at least the first of the commonly postulated factors; the elicitation of unlearned and associatively learned reactions. Yet, proponents of two-factor theories have often placed greater emphasis upon the reinforcement of responses by shock or shock-associated stimulus termination than upon the eliciting and facilitating functions of the onset of these same stimuli (Anger, 1963; Dinsmoor, 1954; Schoenfeld, 1950; Sidman, 1953); or have emphasized the reactions generated by shock-associated stimuli rather than those to the shock *per se* (Mowrer, 1939; Solomon and Wynne, 1954). Alternatively, Herrnstein and Hineline (1966) argued that reduction in shock frequency alone is sufficient to generate and maintain avoidance responding. However, the present experiments showed that shock or shock-associated stimuli could produce responding directly, even though no avoidance or escape was possible. Such data suggest that a more complete "two-factor" explanation of avoidance should reasonably emphasize the eliciting and facilitating effects of both shock and, where present, shock-associated stimuli. Further experimental studies must also account for both of these contributions to the strength of the avoidance performance.

The present experiments also appear related to recent studies that have reported the maintenance of responding under schedules of response-produced shock (Byrd, 1969; Kelleher and Morse, 1968; McKearney, 1968 and 1969; Morse, Mead, and Kelleher, 1967). Several of these reports discussed or illustrated a final pattern of responding that is similar to that of lever pressing or chain pulling in Exp. V and VI, where periodic shocks were delivered independently of the subject's performance. Shortly after shock, responding is reduced or absent; behavior increases toward the time of next shock; immediately before shock, however, responding is again reduced or absent (Morse *et al.,* 1967, Fig. 1, Subject 41; McKearney, 1968, Fig. 1, panels B and D, Fig. 1, Subject 65; McKearney, 1969, Fig. 4, panels D and E, Subject S101; Fig. 4, panels D, E, F, G, Subject S65; Fig. 4, panels B, C, E, F, Subject S85, Fig. 5, panels B, C, D, Subject S85; Byrd, 1969, Fig. 1, lower panel, Subject FC-1). Since the present studies showed that the presentation of shock and associated stimuli could produce responding directly and of a temporal and intensive character similar to the studies discussed above, it is possible that the response-producing shock performances are actually shock-produced response effects. In fact, response strength was shown to be due, in part, to other historical or concurrent schedules (shock-avoidance history, ongoing response-independent shock, contingent food, contingent timeout from shock, *etc.*) and important in countering the intermittent punishment contingency that those studies employed (Morse *et al.,* 1967; McKearney, 1968; Kelleher and Morse, 1968). Also, further research may demonstrate that the response-eliciting and facilitating effects of shock and associated stimuli can, under some circumstances, be greater than the punishing effects of contingent shock of equivalent intensities and frequencies.

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