*EFFECTS OF SHOCK INTENSITY AND DURATION
ON THE FREQUENCY OF BITING ATTACK
BY SQUIRREL MONKEYS¹*

R. R. HUTCHINSON,² N. H. AZRIN, AND J. W. RENFREW²

ANNA STATE HOSPITAL

Squirrel monkeys were periodically exposed to brief tail-shocks in the presence of a rubber tube connected to a pneumatic switch. Biting attack upon this tube was found to be a decreasing function of time since shock delivery and a direct function of shock intensity and duration. These results parallel findings in investigations employing more "naturalistic" social situations, indicating that attack against the inanimate and animate environment is a direct function of the intensity of an aversive stimulus. The results also demonstrate that frequency of biting attack as a datum is sensitive to several experimental manipulations.

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Experiment I: *Temporal distribution of biting attack responses.*

Experiment II: *Effect of shock intensity on biting attack frequency.*

Experiment III: *Effect of shock duration on biting attack frequency.*

The experimental analysis of aggression has been accompanied by a series of methodological refinements. Ulrich and Azrin (1962) placed several experimental subjects in a chamber and visually observed their responses to electric shock. With the discovery by Azrin, Hutchinson, and Sallery (1964), that tail shocks produce biting attacks against inanimate objects, it became feasible to study the response in the absence of a second organism. Hutchinson, Azrin, and Hake (1966) described an automatic method for studying the biting attack of a squirrel monkey by using a rubber tube connected to a pneumatic switch. With each of these methodological refinements, progressively fewer components of the shock-aggression reaction in a social situation are

measured. A question naturally arises as to whether data obtained in the non-social situation are comparable to those from a more "natural" situation. The present report summarizes a series of experiments designed to answer this question.

EXPERIMENT I:
TEMPORAL DISTRIBUTION OF
BITING ATTACK RESPONSES

The first experiments studied the temporal characteristics of biting attack produced by shock. Ulrich and Azrin (1962) described the attack behavior of paired rats produced by grid shock as "reflexive" in nature. Shock increased the probability of attack and tended to produce it immediately after shock delivery. Probabilities of attack later in the shock-shock interval were often lower. Azrin, Hutchinson, and Hake (1963) reported a similar temporal pattern of attack between paired squirrel monkeys.

The present experiment was designed to assess temporal changes in biting attack, employing response frequency as the dependent datum.

Method

Subjects. Six experimentally naive squirrel monkeys, weighing between 700 and 1000 g, had free access to food and water throughout the experiment.

Apparatus and procedure. The general method has been described elsewhere (Hutchinson *et al.*, 1966). A squirrel monkey was re-

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²Now at Department of Psychology, Western Michigan University, Kalamazoo, Michigan 49001. Reprints may be obtained from R. R. Hutchinson at that address.

strained in a chair and shock delivered via electrodes placed on its tail. A rubber hose was located on the panel facing the monkey and was connected to a pneumatic switch adjusted to record frequency of biting attack automatically. Pressure calibration of the switch allowed only biting attack contacts above 2 mm Hg to be recorded. The biting sensor could not detect any other behaviors.

Behavioral data were collected continually on counters, cumulative recorders, and multi-pen polygraphs. Experimental programming was accomplished with conventional relays, steppers, timers, *etc.* A stepper-counter arrangement recorded the distribution of post-shock biting attacks in 3-sec class intervals during study of four of the subjects. Shocks were delivered by an ac generator through a series resistance of 50 K ohms. Resistance between the electrodes was checked both at the beginning and end of each experimental session to determine any change in tail resistance.

All monkeys were given at least one month to adapt to the living cages before being placed in the restraining chair for one to five daily 1-hr sessions before any shock was delivered; this was done to assess the likelihood of biting attack in the absence of the shock. If, as sometimes occurred, a monkey displayed some biting attack in the absence of shock on the first session, shock-free sessions were continued until the monkey did not bite more

than 30 times per session for three consecutive sessions. Each monkey was then subjected to 300- or 400-v non-contingent shocks during daily 1-hr sessions. Shock duration was 100 msec and intershock interval was 240 sec. The first shock of any session was not delivered until after one completed interval.

Results

Figure 1 presents the results of the first day of shock testing for three subjects. A burst of biting attack responses occurred immediately after each shock for each monkey. No biting attacks occurred until after a given shock ended. The other three monkeys displayed similar results.

The frequency of biting attack appeared to decrease in time from the moment of shock delivery. Although the general pattern displayed by each subject was highly similar, the absolute number of bites with equal shock levels differed. This is reflected by the three different slopes of the biting records shown in Fig. 1.

Data for four subjects were plotted as a function of time since shock in 3-sec class intervals. Table 1 shows that biting frequency is a decreasing function of time since shock delivery. Subject M-259 showed an initial increase in biting followed by a progressive decrease. Subjects differed in duration of biting episodes, as shown in Fig. 1.

Fig. 1. Cumulative bite responses as a function of session time from the first day of shock testing for each subject.

Table 1
Mean Bites as a Function of Time Since Shock in 3-Sec Class Intervals

Subject	Interval in seconds									
	0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30
M-261	2.9	2.1	0.6	0.3	0.1	0.1	0.3	0.1	0.1	0.1
M-254	3.7	3.7	1.9	1.1	0.7	0.1	0	0.2	0	0
M-259	0.3	0.9	1.3	0.6	0.2	0.3	0	0	0	0
M-96	13.2	0	0	0	0	0	0	0	0	0

EXPERIMENT II: EFFECT OF SHOCK INTENSITY ON BITING ATTACK FREQUENCY

Ulrich and Azrin (1962) demonstrated that the probability of attack between paired rats increased as shock intensity increased. The present experiment was conducted to determine the relationship between shock intensity and the frequency of biting attack against an inanimate object.

Method

Subjects. Seven squirrel monkeys, weighing from 700 to 1000 g, were used.

Procedure. Shocks of 100-msec duration were delivered at intervals of 240 sec for four monkeys and 60 sec for three monkeys. Shock

intensities were varied in a double ascending and decending series over 16 days while the effects of these changes on the frequency of biting attacks were noted. Thus, the order of testing was: 100, 200, 300, 400, 400, 300, 200, 100, 100, 200, 300, 400, 400, 300, 200, 100 v. Four subjects were tested on only three of the four intensities. Only one shock intensity was employed for the 10 shocks delivered on any given day.

Results

Figure 2 presents sample cumulative records for Subject M-28 at shock intensities of 0, 100, 200, 400 v. At higher intensities of tail shock, more biting attacks were produced by each shock.

Table 2 depicts the results of this experi-

Fig. 2. Cumulative bite responses as a function of time at four different shock intensities.

ment for the seven monkeys. For each subject, biting attack frequency is a direct function of shock intensity.

Table 2
Mean Bites as a Function of Shock Intensity

Subject	Shock Intensity				S-S Interval
	100 v	200 v	300 v	400 v	
M-254	4	15	19	20	240 sec
M-28	22	29	—	41	"
M-92	5	6	12	16	"
M-96	0	4	11	14	"
M-98	—	2	5	15	60 sec
M-109	—	0	3	16	"
M-121	1	11	—	24	"

Large individual differences were noted in the absolute number of bites for different subjects. Alternatively, there was relatively little intrasubject variability from day to day. A given shock intensity tended to produce a given frequency of biting attack and variability of number of bites in a session ranged from 5 to 15%.

EXPERIMENT III:
EFFECT OF SHOCK DURATION
ON BITING ATTACK FREQUENCY

Azrin, Ulrich, Hutchinson, and Norman (1964) demonstrated with paired rats that attack probability increased as shock duration increased. The present experiment was conducted to determine the relationship between shock duration and the frequency of biting attack against an inanimate object.

Method

Subjects. Four squirrel monkeys, weighing between 700 and 1000 g, were used.

Procedure. Subjects were tested on a double ascending and descending series of shock durations of 100 and 800 msec. Shock intensity and interval were adjusted for each subject to minimize biting at the shorter duration value. Each daily session consisted of delivery of five shocks at one duration. Thus, the order of testing for the eight sessions was: 100, 800, 800, 100, 100, 800, 800, 100 msec.

Results

Table 3 shows that in each case, a higher frequency of biting attack was obtained at the longer duration shock value.

Table 3
Mean Bites for Two Shock Durations

Subject	Shock Duration		Condition
	100 ms	800 ms	
M-28	1.5	4.2	S-S 60 sec; 50 v
M-92	9.5	12.5	S-S 240 sec; 400 v
M-254	16.0	27.5	S-S 240 sec; 100 v
M-260	4.0	6.0	S-S 240 sec; 400 v

Figure 3 plots the results of an extended test series for Subject M-28. Shock intensity was set at 50 v and intershock interval at 60 sec. The average number of biting attacks per shock was again a direct function of shock duration.

DISCUSSION

The results of Exp. I, showing a high biting frequency immediately after shock, indicate that the shock precipitated the biting. This was demonstrated by each subject. This finding parallels closely the observations made in earlier studies of attack produced by shock, tail pinch, *etc.*, employing a social paradigm. For instance, Ulrich and Azrin (1962) described the "reflexive" nature of attack responses elicited by the delivery of grid shock in pairs of rats, and Azrin *et al.* (1963) reported the same close temporal relationship between grid shock and attack behavior between two squirrel monkeys. Azrin *et al.* (1966) have also produced attack between pi-

Fig. 3. Mean bite responses as a function of shock duration. Each point is the average for 20 shocks.

geons during extinction immediately after a period of continuous food reinforcement.

Experiment I further showed that the frequency of biting fell nearly to zero approximately 30 sec after the shock. Azrin *et al.* (1964) reported that for squirrel monkeys biting a tennis ball, biting probability is reduced to near zero by 15 sec after shock. Precise quantitative figures on the duration of attack episodes had not been reported in articles involving social paradigms until Azrin *et al.* (1966) found that extinction-induced attack between pigeons lasted as long as 150 sec. Lengthened attack durations in social paradigms were observed earlier by Azrin *et al.* (1963) with squirrel monkeys. They postulated that the social situation tended to enhance prolonged attacks due to mutual and continuing infliction of painful stimuli by one subject upon the other. Perhaps such a process accounts for the differences in duration of attack episodes in the non-social *vs* social paradigms.

It is possible that the low frequencies of biting attack later in the shock-shock interval could be attributed to the increasing probability of an ensuing shock. In other words, an imminent shock might serve to act as a superstitious punisher or general suppressor (Azrin, 1956). However, such an interpretation does not appear tenable since all subjects showed the same negatively accelerated pattern of hose-biting attack from the very beginning of the present experiments, even during the period of the first few shocks.

The finding in Exp. II that biting frequency is a direct function of shock intensity parallels the results of earlier investigations of attack which employed either a social or a single organism paradigm. Ulrich and Azrin (1962), in their studies with pairs of rats demonstrated a direct relationship between shock intensity and probability of attack. Azrin *et al.* (1965), using a single squirrel monkey found that probability of biting a tennis ball was a direct function of force of tail pinch. Similarly, Azrin *et al.* (1964) showed that probability of biting a tennis ball was a direct function of shock intensity. Azrin *et al.* (1966), employing pairs of pigeons, found that attack by one pigeon against the other was a function of the level of deprivation of the subject exposed to extinction.

In Exp. III the result of increased biting at

longer shock durations parallels the results obtained in the social situation employing two rats and grid shock by Azrin *et al.* (1964).

All previous research on shock-elicited attack from this laboratory has employed probability of any attack after shock as the response measure. This has been necessary due to the impossibility of reliably measuring the frequency of individual biting attacks in an extended attack episode. The method employed in the present study allowed for an analysis of the actual frequency of attack contacts after individual shocks. It should be noted that if simple probability of any biting attack as a function of shock had been the experimental datum, each of the subjects would have shown identical performance. That is, each subject did bite at least once after practically 100% of the shocks in these experiments.

The results of Exp. I, II, and III demonstrate that there can be large individual differences in the magnitude of biting attack produced by equivalent shock parameters. Azrin *et al.* (1963), studying paired squirrel monkeys, and Azrin *et al.* (1966) in their studies with paired pigeons, have also reported large individual differences in the magnitude of attack. Explanation of these effects must await further research effort.

The present study reveals that the temporal characteristics of biting attack, as influenced by both the duration and intensity of tail-shock, mirror earlier reports employing social paradigms. Such comparability justifies use of the method in further investigations of the causes of aggression. Since the method is a non-social one in the sense that only one organism is being studied, it might appear that it would not be useful in the further understanding of the interaction of the behavior of two organisms, as it may modify aggression. A second organism, however, represents an agency which can alter the environment of the first through reinforcement, punishment, *etc.* It would appear quite possible to manipulate such influences within the present procedure and at the experimenter's discretion.

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