*FREQUENCY OF ATTACK IN SHOCK-ELICITED
AGGRESSION AS A FUNCTION OF THE
PERFORMANCE OF INDIVIDUAL RATS¹*

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Fighting rates between paired rats were investigated as a function of the probability of attack by a single animal. Animals from stable high-fighting and low-fighting frequency pairs were intermatched to detect individual high-fighting and low-fighting rats. Pairs of high-fighting animals then received saline or different chlorpromazine dosages during successive sessions. Finally, single high-fighting members of each pair also received the different drug dosages. The chief findings were that: (a) rats showing high fighting rates when matched against each other revealed low fighting rates when matched against one, but not the other member of a low-fighting pair; and (b) high-fighting rats decreased their fighting rates as their own or their opponent's chlorpromazine dosage increased. These results indicated that a low rate of fighting on the part of one rat results in a low fighting rate on the part of its opponent.

Experiment I:

Stability of aggression over multiple sessions.

Experiment II:

Intermatching of low- and high-frequency fighters.

Experiment III:

Drug manipulation of an opponent's fighting frequency.

Electric shock produces stereotyped fighting in rats (Daniel, 1943; O'Kelley and Steckle, 1939). Ulrich and Azrin (1962) further observed that when appropriate stimulation parameters were used their animals showed high rates of fighting with little within-pair variability. However, Creer (1967) found that when conditions were held constant over sessions, some pairs of rats continued to fight at low rates even at parameters described as optimum by Azrin, Ulrich, Hutchinson, and Norman (1964), although most pairs do stabilize at high rates. Examination of animals run with these parameters indicates that in most high-fighting pairs both animals attack, whereas in low-fighting pairs neither animal attacks. These informal data suggest that the fighting frequency of a given pair may be determined largely by the performance of a

single animal. To examine this possibility a series of three experiments was conducted.

In the first experiment, shock intensity and shock duration were manipulated in order to obtain consistent intersession baseline fighting behavior from different pairs of rats. In a second experiment, the animals from stable high-fighting pairs were matched with animals from consistent low-fighting pairs. This procedure permitted assessment of whether a particular rat was responsible for the performance of a high-fighting or a low-fighting pair. Finally, in the third experiment, relative fighting frequency was manipulated in opposing high-fighting subjects by injecting one or both members of the pair with different dosages of chlorpromazine.

EXPERIMENT I:
STABILITY OF AGGRESSION OVER
MULTIPLE SESSIONS

Subjects

Nine pairs of 180-day-old Sprague-Dawley rats of the Dublin strain were paired according to weight and sex. There were four pairs of males and five pairs of females; each pair shared a living cage.

Apparatus

The experimental enclosure, housed in a sound-attenuating compartment with a one-way mirror, consisted of a 23.5 cm by 20.3 cm

¹This research was supported by National Science Foundation Grants GB-5307 and GB-7944. Reprints may be obtained from N. Schneiderman, Department of Psychology, University of Miami, Coral Gables, Florida 33124.

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by 29.8 cm Grason-Stadler test chamber. The sides and back of the chamber were aluminum and the front and top were Plexiglas. A 25-w bulb at the top provided illumination. Scrambled shock was delivered to the standard 1.6 mm diameter, parallel bar, stainless steel grid floor by a Grason-Stadler shock generator. A system of relays and timers scheduled shock duration, shock frequency, and the intershock interval. Switches were depressed manually to record fighting frequency on counters.

Procedure

Each pair of rats was placed in the experimental chamber and given 100 shocks per daily session at an intershock interval of 3 sec. The frequency and intensity of the shocks were continuously monitored with a milliammeter. Shock intensities used in the different sessions were 2, 3, and 4 ma and durations were 0.1, 0.5, and 1.0 sec. In the first stage, shock duration was 0.5 sec and each animal was given 2-ma shocks for 27 days, followed by seven days at 3 ma, seven days at 4 ma, and seven days again at 3 ma. Two pairs of rats that stabilized at 2 ma were then given 2-ma shocks for seven additional days.

In the second phase, the four pairs of rats that stabilized at 3-ma intensity, 0.5-sec duration were given 14 additional sessions at 3 ma. However, for the first seven sessions, shock duration was 0.1 sec and for the next seven, duration was 1.0 sec.

Coincident with each shock presentation a cue light was activated and each of two observers then independently depressed one of two microswitches to tabulate fighting or nonfighting responses. Using the criterion of Azrin *et al.* (1964), a fighting response was defined as one in which either one or both rats lunged or struck at the other and produced physical contact. Interobserver reliability exceeded 90%. The criterion of asymptotic performance under each experimental condition was a range of daily responses differing by no more than 10% over five consecutive sessions. Pairs of animals stabilizing above 60% responses each day were classified as high-fighting pairs; pairs stabilizing below 20% were classified as low-fighting pairs.

RESULTS

Figure 1 shows the fighting frequency of the seven of nine pairs of rats that demonstrated

stable performance during the experiment. Each frame represents the final six days of training at each intensity using 0.5-sec duration. The pairs shown in each frame are those that had already stabilized (continuous lines) or were to stabilize (dashed lines) at the next higher intensity. Pairs P1 and P2 shown in the first frame stabilized at 6% and 0%, respectively, during the first week of training at 2 ma. Pairs P3 and P4 stabilized at a high rate during the third week. It can be seen that P5, which did not stabilize at 2 ma, became stable at 3 ma.

Figure 1 shows also that pair P1, which revealed stable low-fighting frequencies at 2 ma, became unstable at 3 ma, but stabilized at a high-fighting frequency at 4 ma. Likewise, pairs P6 and P7, which were also unstable at 3 ma, became stable at 4 ma. Thus, at 4 ma five pairs of rats stabilized at fighting frequencies above 80%; an additional pair, P6, stabilized at about 65%; one pair, P2, was a stable non-fighter, and two of the original nine pairs did not stabilize. When the shock intensity was again decreased from 4 to 3 ma however, pairs P1, P6, and P7 again became unstable.

In the second phase, the three pairs of rats that stabilized at 3-ma intensity, 0.5-sec duration continued to give high-frequency stable responses when the shock duration was changed to 0.1 or 1.0 sec.

DISCUSSION

In this experiment, animals showed increased stability as a function of increases in shock intensity. The finding that at 4 ma pairs 1, 5, 6, and 7 showed high rates of asymptotic performance at levels well below 100% indicates that this increased stability was not an artifact imposed by the ceiling. In contrast, the consistent low rate or nonresponding of pair 2 was due to the failure of these animals to respond at all.

Although other investigators besides Creer (1967) have examined shock-elicited fighting during successive sessions (*i.e.*, Azrin *et al.*, 1964; Hutchinson, Ulrich, and Azrin, 1965; Vernon and Ulrich, 1966), data had not been reported for individual pairs of animals over sessions, nor had the stimulus conditions been kept constant across sessions. The results of the present experiment examining frequency of fighting across sessions as a function of

Fig. 1. Fighting frequencies of pairs of rats during the final six days of training at each shock intensity.

shock intensity confirmed Creer's (1967) contention that between-pair variability continues to exist even when so-called optimum conditions are held constant over sessions.

EXPERIMENT II: INTERMATCHING OF LOW- AND HIGH-FREQUENCY FIGHTERS

Subjects

Two pairs of stable high-fighting and two pairs of consistent low-fighting rats from Exp. I were rematched in Exp. II.

Procedure

One subject from each pair of high-fighting rats was paired with a subject from a pair of

low-fighting rats. The other member of each pair was similarly matched. During each daily session, 100 shocks were delivered at an inter-shock interval of 3 sec and a shock duration of 0.5 sec. The shock intensity selected for each pairing was one that had elicited stable fighting previously for both pairs of subjects. Thus, the rats in pairs P1 and P3, having reached consistent low-fighting and high-fighting levels respectively at 2 ma (see Fig. 1), were rematched at this intensity. Pairs P2 and P7, which were consistent low- and high-fighting performers respectively at 4 ma, were rematched at that intensity.

The original pairs of rats were matched at a shock intensity that had produced stable high-fighting and low-fighting frequency be-

havior. Then, the new pairs of rats were given five to seven experimental sessions. During the next block of sessions, the rats were again rematched with their original high- or low-fighting opponents. Each high-fighting subject was then matched for several sessions with the low-fighting subject with which its high-fighting opponent had previously been matched. Meanwhile, its original high-fighting opponent was matched with the remaining subject of the low-fighting pair. Finally, each pair was again rematched with its original opponent.

RESULTS

Figure 2 depicts the frequencies of fighting during successive blocks of sessions in which

Fig. 2. Fighting frequencies of rats matched over successive blocks of sessions against their original and two new opponents. The first, third, and fifth panels in each replication show the fighting rates of pairs classified as either high- or low-fighting on the basis of the original matching. When the individual rats (A1, A2) of the high-fighting pair were further intermatched with rats (B1, B2) of the low-fighting pair, as shown in panels two and four, rat B2 proved to be a high-fighting animal.

each rat was matched against its original and then two new opponents. The first, third, and fifth panels in each replication represent the fighting frequencies of the original high- and low-fighting pairs. Panel 2 represents the effects of matching one rat (A1) of the high-fighting frequency pair with a rat (B1) from the low-fighting pair, while the other high-fighting animal (A2) was matched with the remaining rat (B2) in the low-frequency pair. Similarly, panel 4 represents the effects of matching rat A2 with rat B1 and rat A1 with rat B2.

It can be seen in both replications of Fig. 2 that the B2 animal originally classified as a low-fighter in Fig. 2, because it fought at a low frequency with animal B1, fought at high frequencies when matched against A1 or A2. In contrast, the animal in each replication that fought at a low frequency with animal B2 continued to fight at a low frequency when matched against either A1 or A2. Thus, it appears that in both replications, animal B1 was responsible for the frequency of low fighting behavior in the other three rats. In this respect, it should be noted that had animal B2 originally been matched with either A1 or A2 it would have been classified as a high-fighting animal. Conversely, in each replication, the nonfighting of a single low-fighting subject effectively reduced the fighting frequency of its other three opponents. A distinction must thus be made between individual low-fighting animals and low-fighting pairs. In both replications, animal B2 should be classed with A1 and A2 as a high-fighting rat, while its original partner B1 is the only low-fighting animal of the group.

DISCUSSION

This experiment indicated that high-fighting rats showed low fighting rates when matched against low-fighting rats. The significance of this finding rests upon the definition of the response as an attack made by either rat. Had the response definition required both rats to attack, the obtained results would seem somewhat trivial, since no attack would be counted when the high-fighting rat attacked the low-fighting one. In contrast, the present findings emphasize the extent of the role played by the individual rat in eliciting aggression.

EXPERIMENT III: DRUG MANIPULATION OF AN OPPONENT'S FIGHTING FREQUENCY

Subjects

Four pairs of rats, previously revealing stable high-fighting frequency behavior at 3 ma, were used in this experiment. Three of the pairs had previously been matched in Exp. I.

Procedure

In the first phase, each pair of rats was alternately injected with saline and six dosages of chlorpromazine over a period of 11 days. Then, in the second phase, each dosage of drug was alternatively administered to a single member of each pair while its opponent received saline. Thus, in this second phase, on alternate days only a single subject of each pair received chlorpromazine. The dosages of chlorpromazine, administered in a random order, were 0.5, 1.0, 2.0, 5.0, and 10.0 mg/kg and were administered subcutaneously 30 min before the experimental session.

During experimental sessions, each pair of rats was given 100 shocks at an intensity of 3 ma and a shock duration of 0.5 sec. The intershock interval for 75 of these shocks was 3 sec, whereas the interval for 25 interspersed shocks was 6 sec. The purpose of this was to examine another measure of observer reliability.

In contrast to the procedure of Exp. II and III, one rather than two observers was used. For this reason, 25 nonshock trials were randomly interspersed throughout the session. On these trials the observer's cue light, which was not visible to the rats, was illuminated but shock was not presented. Since the probability of these rats fighting in the absence of shock had previously been essentially zero, the extent to which fighting was reported on nonshock trials could be attributed to observational error. The three observers used in the experiment were rotated on successive days and were naive to the purposes of the experiment. Since the individual pairs of subjects showed highly stable behavior over the saline days, and since reports of fighting on nonshock trials were less than 5%, observer reliability appeared to be as great for this as for the previous two experiments.

RESULTS

Figure 3 shows the mean fighting probability of four separate pairs of subjects at each of five chlorpromazine dosages. It can be seen that when either one or both subjects of each pair were drugged, fighting frequency decreased as an increasing function of chlorpromazine dosage. In addition, Fig. 3 indicates that during the saline control sessions pre-drug baselines were successfully reestablished.

DISCUSSION

The finding that chlorpromazine decreased the fighting behavior of rats supports previous findings (*e.g.*, Tedeschi, Tedeschi, Mucha, Cook, Mattis, and Fellows, 1959). Of considerably more importance, however, was the present finding that chlorpromazine injection to one subject reduced the fighting behavior of its opponent.

In the first phase of the present experiment, pre-drug baselines were established during control sessions administered on alternate days. These control sessions conclusively demonstrated an absence of cumulative drug effects in any animal when the drug was administered on alternate days. Although it is remotely possible that cumulative effects could have begun to occur suddenly after this period, the dose-response curves obtained in the second phase of the experiment would seem to preclude even this possibility. Thus, in this portion of the experiment, in which animals received drug injections on alternate days, the three pairs of animals receiving the 0.5-mg doses of chlorpromazine towards the end of training were little debilitated by the drug.

GENERAL DISCUSSION

The chief findings of the present study were that (a) stability of aggression in paired rats over multiple sessions increased as a function of shock intensity, (b) high-fighting rats revealed low fighting rates when matched with stable low-fighting rats, and (c) high-fighting rats decreased their fighting rate as a function of chlorpromazine dosages administered to their opponents.

In agreement with Ulrich and Azrin (1962), it was found that high-frequency fighting behavior increased with shock intensity. In at

Fig. 3. Mean fighting probabilities of four pairs of rats (a, b, c, d) at each of five chlorpromazine dosages.

least one instance, a pair of rats showing stable between-session low-frequency fighting behavior at one intensity revealed unstable behavior at an intermediate intensity, and stable high-frequency fighting behavior at a higher intensity. The usual pattern was for a subject to show unstable behavior at the shock intensity immediately below high-frequency stabilization of the fighting response.

In contrast to the findings of the Ulrich and Azrin (1962) study, not all pairs of rats in the present study stabilized at a high fighting rate, and 4 ma rather than 2 ma provided the optimal intensity for eliciting stable high-fighting behavior. However, in the present experiment, more pairs of rats were examined, the subjects

were run over multiple sessions, Dublin rather than Holtzman strain animals were used, females as well as males were employed, and the subjects were 190 rather than 100 days old at the start of the experiment. In the present study, the millimeter also indicated that the dial settings on the shock generator could sometimes be in error by as much as 1 ma due to accumulations of waste matter on the grid floor.

The finding in Exp. I that rats stabilizing at 4 ma again became unstable when shifted to 3 ma, and the finding in Exp. II that stable low- and high-fighting frequency pairs successfully regained their original baselines after being exposed to various other opponents, sug-

gest that at least in these instances later fighting performance was not modified as a function of the previous experiences.

Of considerable interest in the present study were the findings that (a) stable high-fighting frequency rats revealed low fighting frequencies in the presence of low-fighting frequency rats; and (b) high-fighting frequency rats decreased their fighting frequencies as a function of the dosages of chlorpromazine administered to opponent rats. Taken together, these findings suggest that in shock-elicited aggression the shock elicits aggression responses in the presence of a moving opponent.

The present findings that high-fighting rats revealed low fighting frequencies against low-fighting rats are consistent with the report of Ulrich and Azrin (1962) that laboratory rats do not show shock-elicited aggression against dolls or non-moving dead rats. In addition, Lorenz (1966) and others have pointed out how submissive posturing inhibits attack. In contrast, Lorenz (1966, p. 159) also reported Steiniger's findings that dominant settled rats "in nature" may attack submissive rats in the latter's territory. Although the frequency of the fighting response, its antecedent conditions, and the role of movement in the latter situation described by Lorenz have yet to be determined, the apparent inconsistency of the report with current laboratory findings does raise the unanswered question of the relationship between shock-induced fighting and other aggressive behaviors.

A final point to be made in the present study concerns the failure of some subjects to show stable high-fighting frequencies at intensities as high as 4 ma. This, of course, may indicate merely that the shock intensity was subthreshold for eliciting fighting behavior. Alternatively, the recent finding by Powell and Creer (in press) that single rats exposed to

prolonged periods of unavoidable shock show severe decrements in their later fighting probabilities, suggests that environmental contingencies such as dominance-submission relationships operating in the low-fighting rats pre- or extra-experimental environment may have contributed to the low fighting rates.

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Received 23 October 1968.