THE INFLUENCE OF THE VICTIM ON SHOCK-INDUCED AGGRESSION IN RATS

MICHAEL T. HYNAN¹

UNIVERSITY OF IOWA

In two studies, free-roaming male rats (aggressors) were shocked in the presence of male target rats restrained in either an upright or a supine posture. In addition, in Experiment II, two levels of aggressor shock intensity (0.8 mA or 2.0 mA) were used while targets received one of three levels of shock (0.5 mA, 1.5 mA, or 2.5 mA). In both studies, upright targets were attacked less than supine targets. Frequency of aggression was directly related to level of aggressor shock intensity in Experiment II. Also, attack by 0.8-mA aggressors against supine targets was inversely related to level of target shock intensity. The low level of attack against upright targets was interpreted in terms of a threat display. Similarly, it was concluded that the target shock-intensity effect in Experiment II was due to specific threat behaviors displayed by those supine rats that received the highest-intensity shocks.

Key words: aggression, target postures, shock intensity, rats

Several investigators (Creer, 1974; Knutson, 1971; Knutson and Hynan, 1972; Powell, Francis, Braman, and Schneiderman, 1969) have stressed the importance of the behavior of a single member of a pair of rats in determining the occurrence of attack by a conspecific when both animals are being shocked. These studies tested the assumption that one rat can display response topographies that influence the probability of attack by another rat. Powell *et al.* (1969) demonstrated that when a rat that characteristically fought at a low rate under shock stimulation was later paired with a highly aggressive rat, attack continued to occur at a low rate. Various target behaviors that may account for these individual differences include movement by targets (Knutson, 1971; Powell *et al.*, 1969; Ulrich and Azrin, 1962), the orientation of two rats toward each other at the onset of shock (Ulrich, 1967), and an upright posture (Knutson and Hynan, 1972). While these studies have enabled a broader understanding of shock-induced aggression between rats, aspects of the typical ag-

gression test situation have limited the investigation of target influences.

The traditional test situation for shock-induced aggression in rats involves placing two free-roaming rats in an enclosed chamber and administering a series of footshocks. This procedure has posed some conceptual and methodological problems for target variable research. First, specific target behaviors have been difficult to control in the usual test situation. One strategy of investigation has involved training individual rats through an escape-avoidance procedure to display specific target behaviors during intermittent shocks. Two similarly trained rats are then tested for aggression (Knutson and Hynan, 1972; Hynan and Knutson, *in press*). For example, Knutson and Hynan (1972) trained rats to avoid shock either by remaining upright on their hind legs, or by keeping all four paws in contact with the grids. The difficulty with this strategy has been the rapid decrement of the trained responses during testing (Knutson and Hynan, 1972). This disruption appears to be influenced both by the mere presence of a shocked conspecific, and by the topography of the trained response (Hynan and Knutson, *in press*).

A second problem arises from the dual role played by each rat in the traditional procedure. When both rats are allowed free movement within the chamber, each animal can serve as both aggressor and target. Manipula-

¹This experiment was performed as part of a doctoral dissertation carried out at the University of Iowa. I greatly appreciate the guiding wisdom of John F. Knutson and the assistance of Kurt Carlson. Reprints may be obtained from the author, Department of Psychology, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201.

tion of the topographical characteristics of a rat's response to shock may influence the probability of attack either as a target variable or as an aggressor variable. A specific postural response to shock may function as a target variable by influencing the attack behavior of the fighting mate. For example, a rat responding with all four paws in contact with the grid may influence the probability of fighting because this posture may minimize the cues that provoke attack from the conspecific. On the other hand, the rat on all fours may be less likely to initiate attack because this posture is incompatible with fighting. Any statement concerning the role of a specific posture as a target variable influencing attack is precluded due to this possible confounding.

A better way to assess the influence of target variables on shock-induced aggression in rats is to make sure that only one member of a pair (the aggressor) is able to initiate and terminate attack. The other member is restrained and serves as the target. Experiment I employed a target preparation that enabled a variation in target postures (upright and supine) in order to determine the influence of these two topographies on the aggressive behavior of a shocked free-roaming rat. The choice of postures was predicated on observations of aggression between rats in naturalistic settings: an upright posture usually increases the probability of attack, whereas the supine posture usually inhibits attack (Barnett, 1963; Eibl-Eibesfeldt, 1961; Scott, 1970; Seward,

1945). Therefore, I expected that upright targets would be attacked more than supine targets.

EXPERIMENT I

METHOD

Subjects

Eighteen naive Long-Evan's strain male hooded rats served. Six were designated as targets and the remainder served as aggressors. Each target was matched with two aggressor rats on the basis of weight. Subjects were 110 to 120 days old and ranged in weight from 280 to 350 g. Rats were housed, six per cage, in 66.0 by 24.1 by 17.8 cm community cages with food and water continuously available. Targets were segregated from aggressors. Rats were housed under continuous light.

Apparatus

A clear Plexiglas chamber, measuring 34.5 by 34.5 by 22.2 cm, was used to contain the fighting pairs during aggression sessions. This chamber was placed on a grid floor constructed of 1.6-mm stainless steel rods spaced 12.7 mm apart, center to center.

The target restraint consisted of an adjustable leather harness with Velcro strips sewn on to serve as fasteners. At 12.7-mm intervals, nine grid bars were attached to the outside of the harness at the ventral area of the target. These harness grids were wired in parallel with the grid floor and served to minimize the avoid-

Fig. 1. The left panel shows a harnessed rat restrained in the upright posture, and the right panel shows a rat in the supine posture. Upright targets were secured by inserting the ends of the two metal rods (A) into the slots (B) of a metal plate. Harness grids (C) were wired to the grid floor by a cable (D). Supine targets were secured by passing the metal rods (A) and bead chains (E) through small holes in the chamber. Metal clips (not shown) were used to secure the rods and bead chains outside the chamber. Two metal plates (F) were wired in parallel with the grid floor and served to deliver shock to the aggressor's forepaws if the aggressor stood on the target's head. The tail of both targets was insulated from grid shock by rubber tubing. The tail was then passed between the two grids directly below, and secured in a clamp.

ance of shock when aggressors climbed on the targets. Details of the upright and supine target preparations are illustrated in Figure 1.²

The chamber was housed in a 2.4 by 2.3 by 2.1 m Industrial Acoustics sound-attenuating chamber within 0.3 m of an observation window. Equipment to control experimental events and record data consisted of conventional electronic timers and relay circuitry and was located outside the sound-attenuating chamber.

Shock was delivered to the grid floor by a tube-type constant-current dc power supply. Polarity scrambling of the grid floor was accomplished using a Gerbrands carbon brush scrambler. Target rats were not shocked. A piece of Moleskin was wrapped around each foot of all targets to ensure insulation from grid shocks.

Procedure

A harnessed target was restrained in either the upright or supine posture at the beginning of each of the four daily test sessions. Three targets (T_1 , T_2 , and T_3) were always restrained in an upright posture for the first half of each session, and then placed in the supine position for the second half. The sequence of postures was reversed for the remaining targets (T_4 , T_5 , and T_6). The target's first matched aggressor was then placed in the chamber and was presented 100, 0.5-sec duration, 2.0-mA shocks, with 2.5 shock-free seconds between shocks. After 100 shocks, the first aggressor was removed and the same target was then restrained in the alternate posture. The target's second matched aggressor was then placed in the chamber and presented an identical 100 shock presentations. Each aggressor was always exposed to the same posture displayed by its matched target during each session. After the second 100 shocks, both the target and aggressor were removed from the chamber and the process was repeated with the other rats.

During each session, both avoidance and aggressive responses were recorded. Relay noises from the equipment signalled shock delivery to the observer. A maximum of one avoidance and one aggressive response were recorded for each shock delivered. An avoidance response was recorded whenever the ag-

gressor rat did not have its paws in contact with at least two grids (either harness or floor grids) for the complete duration of a shock presentation. An aggressive response was recorded if either of two criterion responses occurred for the duration of one shock or during the 2.5 shock-free seconds that followed a shock presentation. The criterion responses were (a) contact made when the aggressor pawed an upright or supine target's head and (b) contact made when the aggressor bit the target. These defining criteria have been previously utilized as the definition of shock-induced fighting between rats (Baenninger and Grossman, 1969; Ulrich and Azrin, 1962). Reliability of the recordings of aggressive behavior was periodically assessed using additional observers. An observer, uninformed as to the conditions of the experiment, recorded behavior simultaneously with the principal aggression recorder. Agreement between the two observers was determined on a shock-by-shock basis and was never less than 96%.

RESULTS

Avoidance

Avoidance of scheduled shocks occurred at a moderate level. There were large individual differences in the avoidance displayed by aggressors. For example, aggressors paired with T_1 and T_4 avoided 49% and 47% of the shocks, respectively. However, aggressors paired with T_2 and T_3 avoided only 16% and 17% of the scheduled shocks, respectively. The majority of avoidance responses occurred when aggressors climbed on targets and came into contact with only one harness grid. On the average, aggressors in the presence of a supine target avoided 28% of the scheduled shocks while aggressors with upright targets avoided 34% of the shocks.

Aggression

Figure 2 shows the fighting frequencies directed against each of the six targets, by the matched aggressor over the four sessions. T_1 and T_4 received the fewest total attacks, 143 and 110, respectively. The most frequently attacked targets were T_2 (270) and T_3 (297). During most sessions when every target was in the supine posture, it was attacked more frequently than when it was in the upright posture. Proportions of attacks directed against the supine posture over the upright posture

²A detailed description of the target preparation can be obtained from the author upon request.

were 2.5, 2.9, 1.6, 6.3, 1.4, and 2.2 for T₁ to T₆, respectively.

EXPERIMENT II

The results of Experiment I were surprising, in that they contradicted many repeated naturalistic observations of the role of target posture in controlling the attack behavior of an aggressor. While the postural effect was consistent across all six targets, the amount of differential avoidance by aggressors associated with the two targets' topographies may have confounded the results. Experiment II was designed to replicate the target posture manipulation and minimize avoidance by aggressors.

I anticipated that delivery of shock to targets would diminish avoidance substantially. So, in Experiment II shock was delivered to upright and supine targets in the context of manipulating the levels of shock intensity delivered to both targets and aggressors. This permitted an assessment of the influence of shock intensity on the initiation of attack (aggressor variable), with the assessment independent of the role shock intensity may have as a target variable.

METHOD

Subjects

Four hundred and eight naive Long-Evan's strain, male hooded rats served in Experiment

Fig. 2. Frequencies of attack by aggressors during shock-induced aggression test sessions.

II. One hundred and two of these rats were designated as aggressors and the remainder served as targets. All rats ranged in age from 110 to 143 days and weighed from 235 to 460 g. Housing conditions were identical to Experiment I, with one exception. The colony was maintained under a light-dark cycle with the lights on between 7:00 a.m. and 7:00 p.m.

Apparatus

All of the equipment employed in Experiment I was again used. Also, electrodes consisting of two 1.9-cm tinned wires (#18 stranded) were used to deliver footshock to the target rats. One electrode was in contact with the sole of each hind foot of the target. A piece of Moleskin was used to attach the electrodes and to cover each foot, ensuring insulation from the grid floor. Target shock was not scrambled, and was delivered by a North Hills Electric tube-type constant-current dc power supply. The two shock sources were independently grounded so that one rat would not receive any current from coming into contact with the other rat.

Procedure

Twenty-four hours before testing, rats were removed from the colony cages, weighed, and randomly assigned to one of 12 groups. Two levels of aggressor shock intensity (0.8 mA and 2.0 mA) were combined factorially with three levels of target shock intensity (0.5 mA, 1.5 mA, and 2.5 mA) and the two target postures (upright and supine) to form the 12 groups. Each of the six supine groups contained 10 aggressors and 30 targets. Each of the six upright groups contained seven aggressors and 21 targets.

On the day of aggression testing, each target was removed from its cage, placed in the harness, and electrodes were attached. The target was then restrained in the appropriate posture and the aggressor was placed in the center of the fighting chamber. Both rats were then administered 100, 0.5-sec shocks of the appropriate intensities with 2.5 shock-free seconds between shocks. Shock presentations to both rats were controlled by the same relay. Subsequently, both rats were removed and returned to their respective cages. The same procedure was then repeated for the next pair.

Each aggressor rat received three such sessions, with a 24-hr interval between sessions. A

naive target rat was used for each of the three sessions. This strategy was adopted to ensure that there would be no systematic changes in target behavior between sessions.

During each session, both avoidance and aggressive responses were recorded in the manner specified previously. In addition, all bites made by the target on the aggressor were recorded.

RESULTS

Avoidance

Recording of the avoidance behavior of aggressor rats revealed that on the average, aggressor rats avoided only 1.9% of the 100 shocks scheduled each session. Avoidance was not influenced by variations in target posture, target shock intensity, or aggressor shock intensity.

Aggression

Table 1 shows the individual fighting frequencies by aggressors in Experiment II. The group means are illustrated in Figure 3. The left panel of Figure 3 shows the mean fighting frequencies by aggressors in the presence of supine targets; the right panel shows attack against upright targets.

Aggressor shock intensity was a potent determinant of attack frequency. Aggressors receiving 2.0-mA shocks fought much more than aggressors receiving 0.8-mA shocks, $F(1/90) = 118.31$, $p < 0.001$, based on a four-way mixed analysis of variance. Also, fighting in all groups increased across the three sessions. However, the rate of increase in attack was much greater for 2.0-mA aggressors than for 0.8-mA aggressors, $F(2/180) = 12.4$, $p < 0.001$.

Target posture also influenced the attack behavior of aggressor rats. Upright targets were again attacked much less than supine targets, $F(1/90) = 13.5$, $p < 0.001$. Target shock intensity influenced aggression only when aggressors received 0.8-mA shocks in the presence of supine targets, $F(2/90) = 8.3$, $p < 0.01$. This effect is shown in the lower-left panel of Figure 3. Supine targets receiving 2.5-mA shocks in this condition were attacked less than targets receiving 0.5-mA and 1.5-mA shocks. Aggressors receiving 0.8-mA shocks in the presence of supine targets receiving 2.5-mA shocks spent a large proportion of time crouching in the corner diagonally opposite the target. When aggressors in this group did approach

Fig. 3. Mean frequencies of aggression by groups during shock-induced aggression test sessions. The left panel shows attack by aggressors in the presence of supine targets. The right panel refers to attack against upright targets.

the target, the supine rat frequently oriented its upper torso and head toward the aggressor, extended its forepaws, and exposed its teeth. When this happened, the aggressor frequently retreated without making contact and returned to the diagonally opposite corner. This sequence occurred much less frequently when supine targets received the two lower levels of shock.

Counterattack in the form of biting by targets occurred only 20 times in this experiment. Biting by targets was unrelated to the experimental conditions.

GENERAL DISCUSSION

In both experiments, upright targets were attacked less than supine targets. These results appear to be difficult to explain in the context of most naturalistic observations of fighting between rats. However, a closer look at the ethology literature suggests that the upright and supine postures do not always facilitate and inhibit aggression in rats. Some observers (Eibl-Eibesfeldt, 1961; Seward, 1945) have reported isolated incidents of continuous attack on a motionless supine target. Also, Grant

Table 1
Frequencies of Attack by Aggressors during Each Session

Sessions	Pairs	Supine										Upright						
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7
0.8-mA AGGRESSOR SHOCK																		
TARGET SHOCK INTENSITY 0.5 mA																		
1	13	00	39	11	45	26	08	00	05	14	00	13	03	00	00	03	27	
2	31	00	37	05	51	01	50	29	00	47	00	15	01	00	00	12	33	
3	38	00	63	09	21	00	38	64	01	69	00	20	04	14	00	18	53	
TARGET SHOCK INTENSITY 1.5 mA																		
1	24	17	40	20	29	08	76	21	54	25	00	00	00	01	00	30	02	
2	32	06	46	05	19	00	28	03	42	48	00	00	12	16	00	06	36	
3	16	04	79	28	33	00	88	53	94	67	00	00	00	29	00	40	75	
TARGET SHOCK INTENSITY 2.5 mA																		
1	03	08	02	03	03	04	00	01	17	09	00	01	05	00	11	03	01	
2	10	02	04	03	00	00	00	00	39	13	00	20	00	04	29	09	00	
3	39	05	01	22	01	00	16	00	13	02	00	23	01	00	53	16	02	
2.0-mA AGGRESSOR SHOCK																		
TARGET SHOCK INTENSITY 0.5 mA																		
1	23	32	35	41	47	38	71	22	16	39	17	15	33	28	12	33	20	
2	42	41	47	56	71	42	59	67	46	54	46	27	53	58	65	26	49	
3	60	68	55	63	51	50	45	84	31	28	80	83	54	48	80	68	51	
TARGET SHOCK INTENSITY 1.5 mA																		
1	38	48	62	43	28	66	51	34	30	43	03	02	13	28	21	22	23	
2	83	31	48	64	69	82	77	44	35	66	15	10	65	45	83	05	47	
3	87	91	55	83	42	94	76	75	08	76	24	43	83	69	95	10	51	
TARGET SHOCK INTENSITY 2.5 mA																		
1	36	49	18	49	24	32	23	39	43	49	27	51	23	29	23	04	40	
2	98	88	32	89	52	55	26	15	61	42	45	66	70	43	68	26	48	
3	45	53	42	86	87	65	73	76	79	56	55	78	66	57	64	28	48	

(1963) identified subtle variations in the upright posture (*i.e.*, offensive and defensive) that appear to influence differentially the probability of attack. Certain aspects of the upright posture (*e.g.*, rat leans forward) have been observed to dissuade a conspecific from attacking. Ritualized response topographies, such as an upright posture, which serves to minimize attack, are characteristic of many species and are frequently labelled as threat behaviors (Mayr, 1974).

Any consideration of the target posture data in these experiments should take into account the fact that most observations of fighting between rats have been based on instances of intermale or territorial aggression, rather than shock-induced aggression (*cf.*, Moyer, 1968). In intermale and territorial aggression, a supine posture displayed by one rat appears either to remove the instigation to attack or to inhibit it. However, in the present studies of shock-induced aggression, the stimulus that induced attack was repeatedly presented. Thus, the instigation to attack a supine rat

was continuous in these experiments; this may not be the case in intermale or territorial aggression. In this light, it is not surprising that, under conditions of shock stimulation, a supine rat is attacked more frequently than a rat harnessed in an upright posture that resembles a threat display.

The manipulation of target shock intensity in Experiment II influenced attack only when aggressors received low-intensity shocks in the presence of supine targets. In this condition, targets receiving the high-intensity shocks were attacked less than targets receiving shocks of low or intermediate intensities. Observations of aggressor-target interactions in these conditions suggested that the targets receiving high-intensity shocks frequently displayed behaviors (*i.e.*, orienting toward aggressors, extending forepaws, and exposing teeth) that served to lower the probability that aggressors would attack. The low and intermediate levels of target shock resulted in less of this behavior. This suggests that the specific behaviors of the supine targets receiving high-intensity shocks

functioned as a threat display in a manner analogous to the function of the upright posture observed in this study.

This formulation of the data concerning the influence of target variables on attack implicates the importance of specific target behaviors that function as threat displays before attack is initiated. However, another hypothesis is also feasible. This alternative suggests that the differences in fighting associated with target shock intensity and target posture were due to differential counterattack by targets after fighting had begun.

It is reasonable to assume that counterattack by targets would decrease the probability of attack by aggressors. Furthermore, it is possible that targets receiving high-intensity shocks or targets in an upright posture would be more likely to counterattack. This formulation suggests that the low levels of attack by aggressors observed in the present study were the result of punishment of attack by counterattack. This is in contrast to the explanation of the results in terms of specific target behaviors, which inhibited the initiation of attack by aggressors through a mechanism of threat display. While both hypotheses are feasible, counterattack in the form of biting was quite infrequent in Experiment II. Also, biting by targets was not influenced by either target shock intensity or target posture. Thus, an explanation of the target variable influences on attack does not appear to lie in the consequences of attack initiated by aggressors, but rather in the behavior displayed by targets before attack is initiated.

When shock was administered to targets in Experiment II, avoidance by aggressors was much lower than the level observed in Experiment I. Observations indicated that the gross motor activity of shocked targets precluded the development of any consistent avoidance by aggressors climbing on targets. The target posture effect of Experiment II occurred in the context of a near-zero level of avoidance by all aggressors. So, it is difficult to account for the target effect of Experiment I in terms of the observed differential avoidance.

The observed increase in attack frequency across sessions in Experiment II is consistent with previous investigations of shock-induced aggression between two free-roaming rats (Knutson and Hynan, 1972; Powell and Creer, 1969). In Experiment II, a naive target was

used for each aggression session. Thus, the observed increase in attack can be considered as an aggressor variable because the procedure precluded any systematic change in target behavior across sessions.

The inconsistency between the target variable effects in this study and observations of target effects observed in territorial and intermale aggression suggests that the shock-induced aggression paradigm may not be ideally suited for generalization to other types of aggression. However, the data presented here do indicate that different target topographies influence shock-induced aggression. Also, the postulated mechanism of influence (threat displays) is understandable from more naturalistic observations. This study does show that the experimental manipulation of target variables is possible and that further research manipulating other target topographies may help us understand aggressive behavior.

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Received 25 July 1976.

(Final Acceptance 8 January 1976.)