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INTERACTION BETWEEN REFLEXIVE FIGHTING AND COOPERATIVE ESCAPE[1]

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Subjects separated by a Plexiglas partition were trained to follow a cooperative escape procedure which produced behavior like the escape responding of individual subjects. Removal of the partition produced fighting and less efficient escape. Efficient escape behavior was restored and fighting disappeared when the partition was replaced. Neither increased space nor a moving toy affected escape behavior. The results indicate that switching animals from an isolated to a social situation produced a change in the effect of shock upon escape which was related to shock-induced fighting.

CONTENTS

Electric shock produces a stereotyped fighting response in pairs of rats (Ulrich and Azrin, 1962), and has also been used to condition escape and avoidance responding (Mower, 1940; Sidman, 1953). In these studies, fighting could not occur because the shock was presented to a single organism with no extraneous objects or events in the environment. Other studies have shown that the presence of other animals of the same or different species (Ulrich, Wolff, and Azrin, 1964; Ulrich, Hutchinson, and Azrin, 1965; Hutchinson, Ulrich, and Azrin, 1965), deceased animals (Ulrich and Azrin, 1962), and inanimate objects (Azrin, Hutchinson, and Sallery, 1964) will produce fighting behavior. Use of an identical stimulus in studies of both fighting and escape-avoidance raises a question as to how these behaviors might interact when both are possible. For example, will both occur or will one dominate the other? The present study investigated this question in regard to fighting and escape in response to electric shock.

EXPERIMENT I: ALTERNATING SESSIONS OF INDIVIDUAL AND COOPERATIVE ESCAPE

Subjects

Four male Sprague-Dawley rats of the Holtzman strain, approximately 100 days old and 270 to 355 g in weight at the beginning of the experiment, were used. All were experimentally naive, individually housed, and had access to food and water at all times.

Apparatus

The experimental chamber contained two response bars, each 4½ in. above the floor. A removable Plexiglas partition was located between the bars and, when present, divided the chamber into two equal parts. Since the bars did not protrude into the chamber, there was little probability that random jumping movements by the rats would depress the bars. With the partition removed the chamber measured 15 in. by 15 in. by 14 in. With the partition present, each compartment measured 15 in.

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by 7½ in. by 14 in. The chamber floor was constructed of parallel steel bars through which electric shock from a Grason-Stadler generator could be delivered. The sides and back of the chamber were aluminum, the front and top Plexiglas. The experimental chamber was housed in a larger, sound-attenuating chest. The front floor of the chest included a one-way mirror which permitted a clear view of the subjects through the transparent door of the inner chamber. A 25-w bulb at the top provided illumination, and a speaker produced a "white" masking noise. An exhaust fan provided additional masking noise and ventilation. The temperature was maintained at about 75° F. The various stimulus conditions used were programmed by electrical equipment located in another room. A cumulative recorder and counters provided a record of the escape responding, the shocks, and the fights. Typically, rats struck at each other for only a brief duration after shock was delivered. Fighting responses were recorded by an observer who depressed a microswitch to indicate a single response when one or both rats lunged or struck at the other. A new fighting response was recorded for each striking movement separated by a brief pause from previous strikes. Frequent reliability checks were accomplished by having more than one individual simultaneously record the fighting. The number of fighting responses recorded by each observer agreed within 6%. A more detailed account of the aggressive response and of the recording procedure is given in Ulrich and Azrin (1962).

Procedure

The aversive stimulus was a 1-ma shock of 0.5-sec duration presented every 1 sec. A bar press following the onset of the shock produced a 20-sec shock-free period. Responses during this period had no effect in relation to subsequent shocks. The experimental sessions were 2 hr long and were always separated by at least 24 hr.

During the first phase of this experiment, four rats were conditioned individually in the chamber with the partition present. Half were trained to escape shock by pressing the left bar and half were trained to press the right bar. A single bar press escaped shock. After responding had stabilized, subjects were paired and placed into the chamber with the partition separating them. The shock did not terminate until both rats had pressed the bar in their portion of the experimental chamber within 15 sec of each other. Either animal could press the bar first, but two responses, one on each bar, were required to terminate the shock. During the second phase, the partition was removed, although cooperative responses were still required to escape shock. In the third phase, the partition was returned and the rats were again tested individually as in the first phase with a single bar press required to escape the shock. This alternating sequence, *i.e.*, (a) cooperative-escape partition present, (b) cooperative-escape partition removed, (c) individual-escape partition present, was repeated over a number of sessions. The rationale behind the cooperative-escape requirement and the removable partition was to: (1) provide each animal with an operant response which would be a sensitive measure of a change in the effect of shock, and, (2) alter the experimental environment so that the animals could be either isolated or given access to one another. If fighting developed as the dominant reaction to the shock, escape responding would be expected to change. The amount of fighting and the changes in cooperative escape were used to indicate the nature of the interaction between reflexive fighting and cooperative escape.

Results

The results of the procedure are shown in Fig. 1. The right-hand side of each graph (upper part) shows that with the partition present (dash-dot lines) the escape responding (circles) of both Pair A and Pair B was much the same as that observed when these same animals were isolated (solid lines, upper right and left). In both cases, the escape responding occurred at a rate of about 6 to 7 responses per min.

Escape responding was much different when the partition was removed (right hand sides, dashed lines). Under these conditions (Sessions 12, 15, 18, 21, 24, and 27), escape responding fell to and varied around a mean of 3 responses per min. However, as can be seen from the shock record (Fig. 1, bottom graphs, dashed lines, triangles), this did not always represent efficient escape responding. In many instances, the subjects went for long periods of time without pressing the bar and thus failed both to escape shock and to reinstate

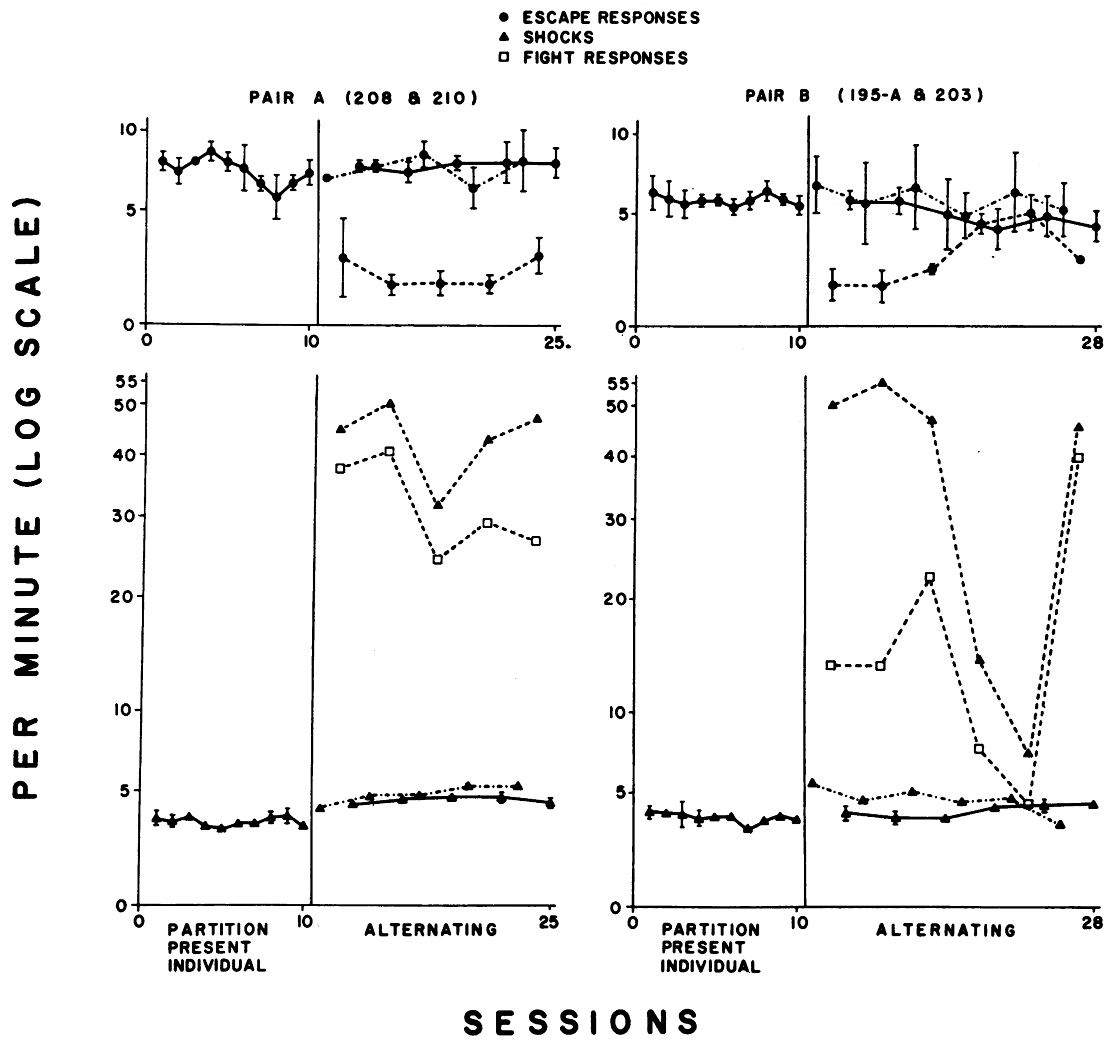

Fig. 1. Escape responding, shock and fighting results during the alternating procedure. The upper portion depicts mean escape responses per minute. The bottom portion depicts mean shocks per minute during the individual phase and shocks per minute and fights per minute during the partition-present and partition-removed phase of the alternating sequence. Solid lines indicate the mean number of escape responses and the mean shock frequencies observed in individual subjects. Dash-dot lines indicate the mean number of escape responses and the shock frequencies observed in paired subjects with the partition present. Dashed lines indicate the mean number of escape responses, the shock frequencies and the number of fighting responses observed in paired subjects with the partition removed. The perpendicular lines attached to the circles and triangles indicate the range of escape responding and shocks.

the 20-sec shock-free interval. Occasionally one subject alone would press its bar while the other subject engaged in other behaviors. The first subject would often then stop pressing the bar, only to have the other animal begin. Since presses on each bar had to occur within 15 sec of one another, such responding was ineffective as an escape response. This appeared to account for the fact that shock frequency when the partition was removed was often exceptionally high, even though escape responding was occurring.

Visual observation revealed that occasionally during these sessions, one subject would press its bar while the other animal merely jumped about or directed an attack toward the bar-pressing subject. Also, one subject would sometimes press both bars and thus terminate the shock. This occurred very rarely since the other partner frequently assumed the stereotyped fighting posture and blocked access to the second bar. The majority of time during the partition-removed phase was spent with each animal facing and fighting the other from the vicinity of their respective bars. The fighting was often very intense, and frequently, the session was discontinued to avoid permanent damage being inflicted on one or the other of the subjects.

As already suggested, the shock record provides the strongest indication of the interaction between reflexive fighting and cooperative escape. Indeed, most of the escape responding which occurred with the partition removed was ineffective. During the sessions in which the subjects were isolated (solid lines), the number of shocks (triangles) varied around a mean of 4 per min. The number of shocks (triangles) for paired subjects with the partition present (dash-dot lines) varied around a mean of 5 per min. When the partition was removed (dashed lines) the mean shock rate increased to 40 per min (triangles). Since the shock interval was 20 sec, it was possible for a subject, by responding immediately at the onset of a shock, to receive no more than 3 shocks per min. Thus, responses above the 3 per min rate provided a measure of the amount of responding which occurred during the safe interval. When no effective escape responses were made, shocks occurred at a rate of 60 per min. Since paired subjects spent the majority of time during the partition-removed phase either fighting or facing one another in the stereotyped fighting posture, shock frequency was often quite high. An additional observation was that the paired subjects did not make aggressive responses toward one another through the Plexiglas partition. Furthermore, escape behavior of single subjects was not affected by either removing the partition or by adding a toy which moved its arms at the onset of shock.

EXPERIMENT II: ESCAPE-FIGHT INTERACTION AFTER STABILIZED COOPERATIVE ESCAPE

Although the changes in the cooperative escape behavior shown in Fig. 1 were closely related to the removal of the separating partition, it should be noted that Pair B did complete a full session with the partition removed (Fig. 1, Session 24) with only a minimal amount of fighting (5 fights per min). The present procedure was designed to determine if a longer period of time spent in cooperative escape, with the partition present, would produce less fighting and more efficient escape during subsequent sessions with the partition removed.

Method

After 10 sessions of being trained individually, the animals were allowed to stabilize as pairs with the partition present. The same paired subjects were then given a series of sessions with the partition removed. Subjects 197, 204, 207, 209A, 301, and 302 were naive. Subjects 203, 208, and 210 had been used previously in the alternating sequence of Exp. I. Subject 208 was used both as a member of Pair A and later as a member of Pair C. The apparatus was the same as in Exp. 1.

Results

The results most closely related to those of the alternating sequence in Exp. 1 were produced by a pair which were subjects in that experiment (Pair A). After Pair A had stabilized (Fig. 2), first as individuals (left-hand side), then as a pair (middle), escape responding decreased from an overall mean of approximately 6 escape responses per min to an overall mean of approximately 2 escape responses per min (right-hand side). Likewise, the overall high rate of shock, an average of 47 per min, (right-hand side, dashed lines, triangles) was similar to that observed during the partition-removed phase of Exp. I (Fig. 1). The amount of fighting for Pair A varied between a high of 38 responses per min and a low of 11 responses per min and was highest for all the pairs observed during Exp. II.

Other results portrayed in Fig. 2 indicate that one animal of a pair was occasionally more responsible than the other (Pair C) for the poor cooperative escape behavior. Subject 208 of Pair C had previously been a member of Pair A, during both Exp. I and Exp. II. The cooperative escape behavior (partition removed) of 208 as a member of Pair A during both of these experiments was consistently poor. However, when Subject 208 of Pair A was given Subject 207 as a partner (Pair C), the escape performance with the partition removed became more efficient and fighting was less prevalent. As with all subjects, the less

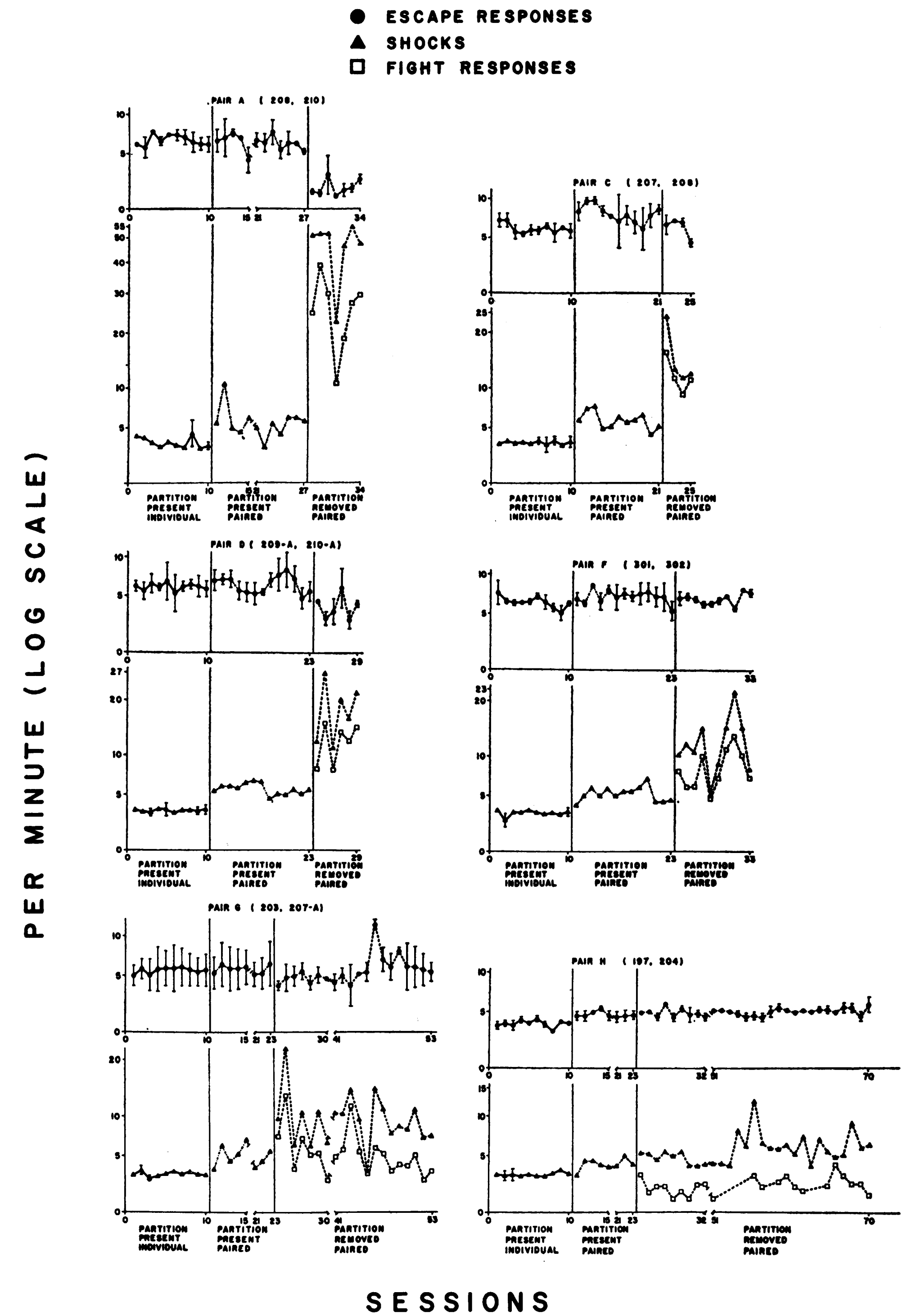

Fig. 2. Escape responding, shock, and fighting results for Pairs A, C, D, F, G, and H during the study of escape-fight interaction after stabilized cooperative escape. Circles indicate the mean number of escape responses; triangles indicate the mean number of shocks during the individual phase and actual shocks during the partition-present (paired) phase and partition-removed (paired) phase. Squares depict fighting.

efficient escape responding of both Pair A and C during the partition-removed phase was related to fighting. Although the same general pattern existed within Pair C (Fig. 2), the average number of shocks (15 per min) and fights (12 per min) was less than that observed in Pair A.

Similar results occurred with Pair D. Pair F, however, (Fig. 2, middle right) maintained better escape behavior during the partition removed sessions than did either Pair A, C, or D. During sessions 25, 26, 28, 29, and 33 the number of fighting responses per minute fell below the mean number of escape responses per minute. Nevertheless, fighting continued throughout the partition-removed phase for Pair F just as it had for Pairs A, C, and D. In all four cases, sessions were discontinued for one or the other of the subjects because of the debilitating effects of fighting.

Such debilitation was not apparent with Pair G or H. Both of these pairs responded for many sessions (30 sessions for Pair G; 47 for Pair H) with the partition removed in a manner similar to their individual and paired (partition present) performances. On only 10 occasions (sessions 54, 55, 56, 57, 60, 62, 64, 68, 69, and 70) did Pair H allow shocks to occur above a 6 shock per min rate. From the beginning, fighting for Pair H was lower (1 to 4 responses per min) than for all other pairs. It should be emphasized, however, that fighting in Pair H never completely disappeared, and, as with other pairs, escape responding frequently occurred while the subjects faced each other from the stereotyped fighting posture. When the shock came on, the animals would often strike at one another and almost immediately press the bar. A general observation throughout all sessions was that fighting occurred during the shock period and not during the interval of safety after effective escape.

DISCUSSION

Previous investigations have studied the relation between fighting and avoidance as a reaction to electric shock (Ulrich and Craine, 1964; Ulrich, Stachnik, Brierton, and Mabry, 1966). These studies indicated that paired rats both avoided shocks and engaged in fighting. Individual rats, however, performed better in the avoidance situation than did the paired rats. They learned the avoidance response more quickly and consistently responded more efficiently than did the paired animals, which often spent the majority of their time fighting. When the paired animals were separated, avoidance responding became more effective. When the individuals were given a partner, previously well-established avoidance behavior changed drastically, allowing many shocks, and thus more fighting to occur. Furthermore, this effect occurred only with another live animal; the presence of inanimate partners did not disrupt avoidance responding (Ulrich and Craine, 1964). When the live partner was some distance away, or when efficient avoidance responding assured fewer shocks, fighting was less probable.

The present findings concur with these earlier results. Escape responding, like avoidance responding, was less effective in the social than in the individual situation. Pairs of rats with a history of stable escape behavior with a partition separating them, showed significant increases in escape latencies during sessions in which they were allowed access to one another when the partition was removed. When the Plexiglas partition was present, no attempted attacks of one rat toward its partner were observed. When the partition was removed, fighting occurred which affected escape responding. This effect was similar to that observed in the avoidance studies when a second naive rat was added to the experimental environment of a well-trained rat.

When paired animals in the present study were again separated by the partition, after being allowed access to one another, both escape responding and shock frequency returned to levels which closely paralleled individual rates. The change in escape responding in the present study was not found to be a function of either increased space or a moving toy. This ineffectiveness of inanimate objects to produce either fighting or avoidance has previously been noted among rats by Ulrich and Azrin (1962) and Ulrich and Craine (1964). The fact that fighting was never completely suppressed in the present study, even when the cooperative escape rate was fairly stable (Pair H), is also in agreement with previous studies which showed that some fighting and aggressive postures tended to remain whenever rats were paired in the presence of shock, regardless of the escape-avoidance opportunity (Ulrich *et al*, 1966).

Another observation from the present study which corresponds to previous results concerns the frequent simultaneity of both the escape and fighting response. Ulrich *et al,* (1966) noted in their study of the interaction of fighting with avoidance that the stereotyped fighting posture was typically maintained by both animals in the vicinity of the bar, and when shock occurred it would often produce a fighting response as well as an avoidance response. Furthermore, it was found that one animal typically became the avoider. When the shock occurred the nonavoiders attacked, whereas the avoiders struck both at the bar and toward the other animal. A similar relationship occasionally evolved in the present study when one animal would fail to make the escape response and instead attacked its partner, which was pressing its bar. In such cases, the animal pressing the bar was apparently more vulnerable to injury resulting from the attack; the escape response put it into a position which appeared to be incompatible with the defensive aspects of reflexive fighting.

The present results and those of other studies using avoidance procedures, suggest that the interaction between reflexive fighting and escape avoidance varies mainly as a function of the shock which occurs during actual physical accessibility. Shock presented to animals that can fight raises the probability of fighting and lowers the probability of escape or avoidance. If the animals are close but cannot reach one another, fighting does not develop and escape is relatively unaffected. It therefore does not seem meaningful to speak of either reflexive fighting or escape avoidance as having dominance over the other without specifying the attending conditions.

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