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The effects of social isolation on two shock-induced aggressive responses in rats

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This experiment investigated the effects of social isolation during development and during adulthood on the topography of the shock-induced aggressive behavior of rats. Rats isolated during development from weaning to adulthood displayed more shock-induced biting than rats housed in groups during that period. Isolation during development did not affect the frequency of the upright boxing behavior, but isolation during adulthood reduced the frequency of the boxing response regardless of rearing conditions during development.

Isolation is a frequently used procedure for investigating the role of social deprivation on aggressive behavior in laboratory rodents. Moyer (1976) recently noted that isolation results in increased aggression or aggression that is topographically atypical for the species. Increased aggression in mice following isolation has been reported when testing involved placing two males in a neutral chamber or when a resident-intruder paradigm was adopted (e.g., Cairns, 1973; Denenberg, 1973; Goldsmith, Brain, & Benton, 1976; Valzelli, 1969; Welch & Welch, 1971). Similarly, isolation has been shown to increase the spontaneous home-cage aggression of rats (Wahlstrand, 1977) and to increase serious fighting in resident-intruder tests (Luciano & Lore, 1975). These procedures presumably assess the response of intermale aggression, a behavior described by Moyer (1973, 1976) when he distinguished among the different kinds of aggression in his taxonomy of aggressive behavior.

Two recent analyses of the effect of social isolation on aggressive behavior (Cairns, 1973; Welch & Welch, 1971) have implicated hyperreactivity or irritability as the factor mediating the increased aggression in isolated subjects. Such analyses suggest that isolation should result in an increase in an irritable aggressive response (Moyer, 1973, 1976). However, when shock-induced aggression is the test procedure, the effects of social isolation on irritable aggression are quite inconsistent. Hutchinson, Ulrich, and Azrin (1965) and Hutzell and Knutson (1972) presented data indicating that isolation from weaning to adulthood results in less shock-induced aggression between rat pairs. Thor and Ghiselli (1974) tested community-reared and isolation-reared rats for shock-induced aggression in a round-robin test procedure, and indicated that isolation resulted in reduced shock-induced aggression during only the first of five test sessions and that rats raised in isolation displayed more aggression on succeeding sessions. Creer and Powell (1971) housed rats in isolation or in pairs from 20 days of age until shock-induced aggression testing commenced at 30, 60, or 90 days of age. Although there were no systematic differences as a function of housing conditions, Creer and Powell (1971) noted that isolation resulted in less variability in aggression across test sessions. Since Creer and Powell (1971) used only a single pair of rats per cell in an experiment designed to test the effects of age, sex, and housing conditions, the absence of an effect of housing on aggression could be due to the lack of statistical power. In another investigation, Creer (1975) housed rats in either group cages or in isolation from 60 days of age until they were tested for shock-induced aggression 7, 14, 21, or 28 days later. Although the overall analysis of variance indicated that there was neither an effect of the housing condition nor an interaction between the housing condition and other experimental factors, based on an individual comparison test Creer (1975) concluded that housing in communal cages for 28 days resulted in a significant reduction in shock-induced aggression.

Another apparent inconsistency in the research on the effects of isolation on shock-induced aggression is found in the study by Hutzell and Knutson (1972). Although the isolation-reared subjects displayed less shock-induced aggression, the authors noted that subjects from the isolation condition experienced more tissue damage due to biting than did rats that had been raised in group cages. Futhermore, Hutzell and Knutson (1972) reported that isolation and community reared rats did not differ when biting an inanimate target was the measure of shock-induced aggression. The Hutzell and Knutson (1972) data suggest the possibility that isolation and group housing could have differential effects on different shock-induced aggressive responses in the repertoire of the subjects. Blanchard, Takahashi, Fukunaga, and

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Blanchard (1977) have concluded that shock-induced aggression is largely a defensive behavior, because the predominant response during testing is the upright boxing behavior. The work of Blanchard and Blanchard (1977), Flannelly and Thor (1976), and Luciano and Lore (1975) suggests that isolation early in development reduces the opportunity for subjects to learn species-typical defensive behaviors. If the Blanchard et al. (1977) analysis is correct, isolation rearing should result in a reduced frequency of the upright defensive boxing behavior recorded during shock-induced aggression testing. In addition, Blanchard et al. (1977) have argued that the defensive boxing behavior maintains vibrissal orientation and serves to reduce biting responses during agonistic exchanges. Thus, if isolation during development reduces boxing, there could be concomitant increases in tissue-damaging biting behavior.

The purpose of the present experiment was to determine the effect of community and isolation housing from weaning to adulthood on the upright boxing behavior and the biting behavior of adult rats tested for shock-induced aggression. Since the housing conditions immediately prior to testing have been shown to influence shock-induced aggression (e.g., Nelson & Knutson, 1978), the experiment was also designed to determine whether the housing conditions immediately prior to and during testing would influence the biting and boxing behaviors.

METHOD

Subjects

Experimentally naive male hooded rats from the colony maintained by the Department of Psychology of the University of Iowa were used. For the duration of the study, the rats were housed in a colony room maintained on an LD schedule (lights on from 0700 to 1900 h) and provided free access to food and water.

Apparatus

Two 22.86 × 29.21 × 19.05 cm Plexiglas chambers housed in sound-attenuating enclosures were used for shock-induced aggression testing. The grid floors of these chambers were constructed of 2.38-mm-diam stainless steel rods spaced 1.27 cm from center to center. A two-channel tube-type constant current dc shock source and Gerbrands carbon brush scramblers were used to deliver shock through the grid floors. The chambers were illuminated by a 7.5-W bulb located at 20 cm from the chamber. Electronic timers and relays programmed the delivery of shock. Electromechanical counters were used to record aggression and avoidance responses.

Procedure

In a series of replications, potential subjects were whelped in a colony room maintained on the LD schedule. When the pups were 23-26 days old, they were weaned and the males were assigned to one of two housing conditions. One-half of the males from each litter were assigned to an isolation condition and housed in 24.13 × 17.78 × 17.78 cm stainless steel and wire mesh cages. The remaining subjects were housed six per cage in 24.13 × 66.04 × 17.78 cm stainless steel and wire mesh cages. When the rats were 90 days of age, they were handled and rehoused. One-half of the animals raised in isolation were returned to isolation cages (Group II), and one-half of the previously isolated rats were housed in 24.13 × 66.04 × 17.78 cm community cages, six rats per cage (Group IG). One-half of the subjects reared in community cages were rehoused six per cage in the community-rearing cages (Group GG) and one-half of the group-reared rats were housed in the isolation cages (Group GI). When rehousing the GG group, the subjects were assigned to cages so that at least one-half of the cagemates were unfamiliar. Whenever the number of rats per community cage was reduced to fewer than five by mortality, the subjects in that cage were discarded and were replaced in a subsequent replication.

Fourteen rats in each of the four groups were used for shock-induced aggression testing. Twenty-one days following rehousing, the subjects were weighed and pairs within housing conditions were constructed according to weight. Pairs from the GG and IG groups were constructed with animals from different cages so all shock-induced aggression testing was accomplished with unfamiliar subjects (cf. Galef, 1970). On each of the following 3 days, rat pairs were submitted to shock-induced aggression testing commencing between 1930 and 2030 h. At each test session, 100 2-mA shocks of .5 sec duration were delivered at a rate of 20 shocks/min. Trained observers, uninformed with respect to group membership, recorded two aggressive behaviors. Boxing in response to shock was recorded when a pair member adopted the stereotypical upright response and made physical contact with the other member of the pair by striking with the forelimbs. Shock-induced biting was recorded when one member of the pair bit the other; the observer also noted the locus of the bite on the body of the recipient. When a bite response was initiated during one shock presentation and continued through one or more subsequent shocks, the bite response was recorded for each of the shocks during which it occurred. Because the avoidance of shock by a single member of a pair will virtually eliminate shock-induced aggression (Knutson, 1971), observers also recorded the number of shocks that rats avoided by adopting postures that precluded shock delivery (e.g., standing on a single grid bar). Periodic assessments of observer reliability in this laboratory demonstrated that percent agreement among observers on whether a shock produces an aggressive response or was avoided exceeds 90% when evaluated on a shock-by-shock basis. In addition to scoring the aggression and avoidance, these experienced observers were asked to note patterns of responding that departed from the response topographies usually observed during shock-induced aggression testing.

RESULTS

Before analyzing the data of the two aggressive behaviors, the number of shocks avoided was analyzed in a mixed analysis of variance, with the first housing condition and the second housing condition as between-subjects factors and shock-induced aggression test sessions as the within-subjects factor. The avoidance of shock occurred infrequently and was distributed among groups. Neither the three main effects nor the four interactions were statistically significant (all $Fs < 1$). Thus, the groups did not differ with respect to the avoidance of shock during shock-induced aggression testing and shock avoidance could not contribute to group differences in aggression. To eliminate the contribution of the avoidance of shock to error variance in the analyses of the aggression scores, the analyses of the two aggressive responses were based

on the percentage of shocks administered to both members of a pair that induced the aggressive response.

Figure 1 shows the percentage of shocks presented to both members of a pair that evoked the boxing response in each group at each test session. A three-factor mixed analysis of variance of these boxing scores indicated that the rats that had been group housed during the period immediately preceding shock-induced aggression testing (Groups IG and GG) had higher boxing scores than did the rats housed in isolation during that period (Groups II and GI) [$F(1,24) = 20.22$, $p < .001$]. None of the other effects were statistically significant.

Figure 2 shows the mean percentage of shocks presented to both members of a pair that evoked biting behavior in each group at each session. Because of the large number of zero scores in the GG and GI groups, there was heterogeneity of variance according to the procedure of Cochran (Winer, 1962). Appropriate data transformations could not eliminate the heterogeneity of variance, so these biting data could not be submitted to analysis of variance procedures. An alternative way of considering these biting data is by contrasting the number of pairs within treatment conditions that displayed biting during at least one of the test sessions. All 14 pairs housed in isolation from weaning to 90 days of age (Groups II and IG) displayed biting, and only five pairs of rats housed in group cages from weaning to 90 days of age (Groups GI and GG) displayed biting, a difference that is statistically significant on the basis of a test of proportions ($z = 4.17$, $p < .01$). Thus, based on the proportion of rat pairs within experimental conditions that displayed biting,

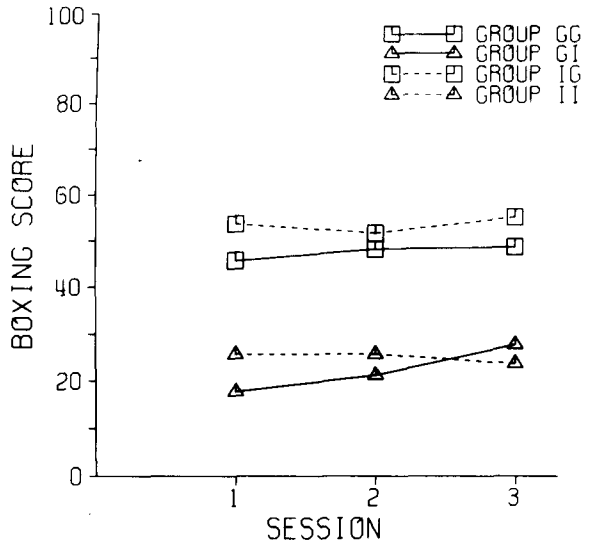

Figure 1. The mean percentage of shocks presented to both pair members that induced the stereotypical upright boxing behavior in each group at each shock-induced aggression test session.

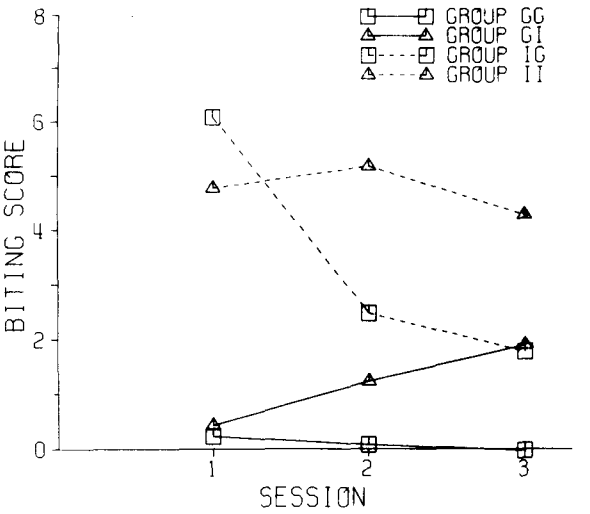

Figure 2. The mean percentage of shocks presented to both pair members that induced biting in each group at each shock-induced aggression test session.

isolation from weaning to adulthood resulted in more biting between pair members than did group housing during that time. The second housing condition did not affect the proportion of rats that displayed biting; 11 of 14 pairs housed in isolation (Groups II and GI) displayed biting and 8 of the 14 group-housed pairs (Groups IG and GG) displayed biting during shock-induced aggression testing ($z = .475$). Regardless of rearing condition, all biting behavior was directed at the head and snout of the conspecific; no biting was directed to other body loci.

In order to relate these data to similar studies of isolation and shock-induced aggression that did not distinguish between boxing and biting behavior (Creer, 1975; Hutchinson et al., 1965; Hutzell & Knutson, 1972; Thor & Ghiselli, 1974), the percentage of shocks presented to rat pairs that evoked biting *or* boxing were analyzed in a three-factor mixed analysis of variance. The only statistically significant effect was due to the second housing condition; the groups isolated during this period (GI and II) had lower scores on this combined aggression measure [$F(1,24) = 17.56$, $p < .001$].

DISCUSSION

The results of this experiment indicate that different housing conditions at different times during development can have differential effects on specific responses displayed by rats during shock-induced aggression testing. Shock-induced biting behavior, directed to the head and snout of a conspecific, is displayed by rats that had been housed in isolation from weaning to adulthood, and shock-induced boxing behavior is reduced when rats are housed in isolation during the 3 weeks immediately prior to testing. Blanchard et al. (1977) and Blanchard, Blanchard, and Takahashi

(Note 1) have argued that shock-induced aggression is a defensive behavior, since the boxing behavior and biting the head of an opponent can be distinguished from the offensive attack that alpha males display toward intruders. Blanchard et al. (1977) hypothesized that the boxing behavior serves to reduce tissue-damaging biting responses, suggesting that an inverse relationship between boxing and biting should be obtained. However, the present data indicate that isolation from weaning to 90 days of age increases biting but does not affect boxing, and isolation from 90 to 111 days of age decreases boxing but does not increase biting. Thus, the data of the present experiment do not support the Blanchard et al. (Note 1) hypothesis of a simple inverse relationship between boxing and biting behaviors. The fact that all biting was directed toward the head of the conspecific is quite consistent with data reported by Blanchard et al. (Note 1) and indicates that shock-induced biting is not topographically similar to the offensive alpha attack observed in resident-intruder tests.

The analysis of the percentage of shocks evoking boxing *or* biting in the present experiment is consistent with the data reported by Hutchinson et al. (1965) and Hutzell and Knutson (1972); those two studies reported that isolation results in less shock-induced aggression. Furthermore, the greater biting displayed by the II and IG groups in the present study is consistent with the Hutzell and Knutson (1972) paper. In that study, aggression was defined as boxing or biting, and it was noted that the isolation-reared groups displayed less shock-induced aggression but experienced more tissue damage. The analysis of the percentage of shocks evoking boxing or biting was not consistent with the conclusion that isolation results in more shock-induced aggression (Creer, 1975; Thor & Ghiselli, 1974). While the difference between the results of the present study and the data reported by Creer (1975) and Thor and Ghiselli (1974) could have been due to subtle differences in recording aggressive behavior, it seems more plausible that the differences in data are due to procedural differences among studies. Thor and Ghiselli (1974) used a round-robin procedure, and in the Creer (1975) study the test of housing conditions was confounded with familiarity between pair members. In addition, the length of time in the two housing conditions was confounded with the age of the subjects in the Creer (1975) study.

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