EFFECTS OF PREVIOUS HOUSING CONDITIONS ON SHOCK-INDUCED AGGRESSION¹

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This study investigated shock-induced aggression as a function of housing rats in single or communal cages for varying periods of time before testing. Rates of fighting were unaffected by housing conditions when rats spent seven or 14 days in either of these settings before testing. Placing rats in these settings for 21 or 28 days before testing, however, did affect rates of fighting. Communal caging of subjects for 28 days before testing was particularly deleterious to shock-induced aggression. How rats are housed outside the experimental chamber is a variable affecting shock-induced aggression and should be considered both in designing future studies and as a topic for future investigation.

Environmental variables and shock-induced aggression have been the focus of several studies (Creer, 1974; Creer and Powell, 1971; Hutchinson, Ulrich, and Azrin, 1965). In one of the experiments reported by Hutchinson and his colleagues (1965), groups of rats ranging from 24 to 93 days of age were taken from community cages and exposed to 100 shocks. Results indicated a monotonic relationship between age and aggressive behavior, with an 85% probability of fighting for the oldest subjects. A second experiment conducted by Hutchinson and his co-workers examined probability of fighting in groups of rats exposed to 100 shocks at 30, 60, and 90 days of age, respectively. The subjects had been isolated at 22 days of age and maintained in individual cages until reaching the age appropriate for testing. Results showed a direct relationship between probability of fighting and subject age, with average levels of fighting at 0, 38, and 48% for groups aged 30, 60, and 90 days of age, respectively. Thus, considering both experiments, aggression in response to foot shock occurred less frequently in subjects from individual cages (Experiment II) than in subjects from community cages (Experiment I).

In a later investigation (Creer and Powell, 1971), rats were divided at 20 days of age into three groups of four pairs each and tested at 30, 60, and 90 days of age, respectively. Two pairs in each group were housed in individual cages and brought together with a partner only during test sessions. The remaining two pairs in each group, on the other hand, lived two to a cage; these same pairings were maintained when the animals were tested in the experimental chamber. Results indicated that how subjects were housed outside the experimental chamber did affect rates of shock-induced fighting. Rats housed in individual cages and brought together only during testing displayed fighting rates that steadily increased over sessions until a stability criterion was attained. This criterion, defined as aggressive responses remaining within a range of 10 responses during four consecutive sessions, was achieved in seven to 14 sessions for all subjects. By the end of the investigation, subjects were fighting, on the average, to over 90% of the shocks. The fighting rates of rats both housed and tested together, however, were highly variable, requiring 16 to 38 sessions to stabilize. The rates observed from one session to another were highly variable. It was not uncommon, for example, for a given pair to fight to over 90% of the shocks for one session, but to only 20% of the shocks the following session. In fact, one pair showed no evidence of rate stabilization when testing was halted after 35 sessions. After each age group was tested for a number of sessions, age was demonstrated not to be an enduring determinant of elicited aggression,

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since animals in all three age groups exhibited high rates of fighting.

There are several points about this previous work that merit discussion. First, shock-induced fighting does appear to be a function of age when rats are less than 60 days of age. This was shown in the studies by Hutchinson *et al.* (1965) and by Powell and Creer (1969). While Creer and Powell (1971) reported what appear to be contradictory findings, the subjects participated in an unusually large number of sessions—up to 35. This also meant that the rats aged, so that by the end of the study subjects ranged in age up to 128 days. Hence, the tentative conclusion regarding age and shock-induced fighting remains unchallenged. Second, a broad spectrum of housing conditions has been investigated in previous studies. Whereas there are no apparent differences between the conditions employed by Hutchinson and his colleagues (1965) and by Creer and Powell (1971) when rats were housed in individual cages, housing rats two to a cage before testing (Creer and Powell, 1971) is not analogous to housing 20 rats in a cage before testing (Hutchinson *et al.*, 1965). In fact, housing rats two to a cage seems especially deleterious to the formation of stable rates of shock-elicited fighting. Finally, investigations of age and shock-induced fighting may have automatically introduced another variable—differences in the amount of time spent in the investigated housing conditions before testing. Thus, when tested at 60 days of age, subjects had remained 30 more days in assigned housing conditions than had subjects tested at 30 days of age.

The present study investigated shock-induced fighting in rats housed in single or communal cages for varying numbers of days before testing. The subjects were 60 days of age when placed in these conditions in order to minimize the interaction of age and shock-induced fighting in younger rats.

METHOD

Subjects

Ninety-six male Sprague-Dawley rats, approximately 60 days of age when obtained from Flow Laboratories in Dublin, Virginia, were evenly divided into single or communal cages. Thus, 48 subjects were placed in single cages, measuring 12 by 9.5 by 8 in. (0.30 by 0.24 by 0.20 m) and 48 subjects were placed,

six in a unit, in communal cages measuring 20 by 18 by 8 in. (0.51 by 0.46 by 0.20 m). The animals remained in these quarters until the end of the study.

Apparatus

A Grason-Stadler sound-attenuated rat chamber, in which the inner enclosure measured 11.5 by 9.25 by 7.6 in. (0.29 by 0.24 by 0.19 m), with two sides constructed of metal and two of clear plastic, was used. Scrambled shock from a Grason-Stadler #1964 GS shock source was delivered to a grid floor consisting of stainless-steel rods spaced 0.5 in. (0.13 m) apart. The outer door to the insulated cubicle was removed to permit an unobstructed view of the animals through the Plexiglas door of the inner chamber. The various stimulus conditions were arranged remotely by a modular programming system. The shock parameters were monitored regularly by attaching a meter to the grid floor and measuring the electrical current. The grid was wiped clean after each session to remove feces and other foreign matter.

Procedures

The design permitted an analysis of shock-elicited aggression as a function of housing groups of rats in single or communal cages for 7, 14, 21, or 28 days before testing. Thus, after seven days, 12 rats living in single cages were randomly paired and testing began. Concurrently, testing was initiated for six subjects, randomly paired with a cagemate, from each of two communal cages. Thereafter, at seven-day intervals, the test period commenced for an equal number of subjects selected and paired in an identical manner. In other words, testing was initiated for 12 rats from single cages and six rats from each of two communal cages at 7, 14, 21, and 28 days. All subjects were tested for seven sessions over seven consecutive days.

Fighting responses were defined in a manner originally described by Ulrich and Azrin (1962). Two observers used separate sheets of paper to record each shock that the rats made striking movements from an upright position. To preserve further the independence of the two observers and to prevent either from responding to the other's behavior, a different notation was placed opposite each trial when no fighting occurred to the shock. This recording method permitted a comparison of whether

either observer noted aggression during any given trial. Greater than 95% agreement was obtained between the two observers in registering shock-elicited fighting.

Azrin, Ulrich, Hutchinson, and Norman (1964) reported that 2-mA shocks of 0.5 sec duration were optimal for inducing fighting. These parameters were used in the present study. The shock was presented at a frequency of 20 shocks per minute; 100 shocks were administered daily to each pair. Frequency or rate of aggression was calculated daily for each pair as the number of trials fighting occurred in response to the 100 shocks. During the initial session, the animals were observed for 5 min without shock to determine if any spon-

taneous fighting occurred. None of the pairs exhibited this behavior.

RESULTS

The data from individual pairs are summarized in Table 1; group data are shown in Figures 1 and 2. Rates of fighting increased over sessions for the subjects housed in single and communal cages for seven days before testing. There appeared to be no appreciable differences in mean rates of fighting attributable to housing conditions. Similar trends were noted with subjects placed in both housing conditions for 14 days before testing. Overall,

Table 1
The Rates at Which Each Pair of Subjects Fought over Seven Test Sessions

Session	Single Cages						Communal Cages					
	Pairs 1	2	3	4	5	6	Cage 1			Cage 2		
							7	8	9	10	11	12
Seven Day												
1	56	61	69	32	74	53	33	15	82	57	53	62
2	67	61	65	25	69	56	14	34	78	65	91	62
3	68	63	61	48	78	77	47	28	91	76	92	75
4	90	75	84	60	85	80	48	61	90	76	96	89
5	90	79	85	64	86	86	70	89	90	78	99	90
6	93	89	90	75	85	73	74	92	98	66	95	92
7	95	94	92	82	93	85	80	95	98	71	90	95
Fourteen Day												
1	45	78	61	61	47	58	75	83	56	22	82	82
2	58	79	71	64	43	60	88	87	57	27	91	79
3	87	88	90	91	86	79	95	96	71	60	93	91
4	94	98	84	98	66	86	93	96	99	65	96	97
5	97	99	89	99	83	82	95	98	100	71	98	95
6	96	97	91	100	77	90	96	99	99	74	99	96
7	98	95	94	99	87	96	92	100	100	81	100	98
Twenty-One Day												
1	84	62	73	87	77	73	17	36	23	60	32	75
2	91	69	52	92	68	66	70	79	50	79	47	73
3	85	61	50	96	71	73	50	90	30	81	58	76
4	93	82	28	87	88	78	19	95	37	87	81	91
5	94	78	34	79	87	75	76	86	68	93	91	94
6	97	85	40	90	91	77	51	90	60	85	85	85
7	99	92	49	77	96	77	11	94	84	77	95	90
Twenty-Eight Day												
1	90	19	69	17	28	16	1	0	21	4	0	12
2	88	37	82	31	28	24	1	0	15	4	0	12
3	92	62	91	24	51	22	4	5	59	15	6	60
4	94	70	95	6	42	23	0	0	85	6	3	27
5	97	91	89	2	37	35	6	0	88	2	9	23
6	98	97	84	0	27	20	0	0	31	8	17	13
7	100	98	96	2	22	2	0	0	84	13	3	4

Fig. 1. The mean rate of fighting exhibited over seven sessions by subjects housed in single cages for 7, 14, 21, or 28 days before testing.

Fig. 2. The mean rate of fighting exhibited over seven sessions by subjects housed in communal cages for 7, 14, 21, or 28 days before testing.

however, subjects in the two 14-day conditions displayed the highest frequencies of fighting.

Figures 1 and 2 show that lower mean rates of fighting were obtained with animals placed in single cages for 21 days before testing. The frequencies of fighting remained about the same over sessions. On the other hand, greater variability across sessions was noted in the mean fighting rates of subjects housed in communal cages for 21 days than in the rates of subjects housed under similar conditions for seven and 14 days.

Variability in fighting over sessions was noted for individual pairs of subjects in both housing conditions for 21 days before testing. Table 1 shows that the rates of fighting varied markedly for three pairs of subjects: Pair 3 from a single cage, and Pairs 7 and 9 from communal cages. These rates contrast with the general increment in fighting over sessions for pairs housed for seven or 14 days before testing.

Lower mean rates of shock-induced aggression occurred over sessions with subjects housed in both communal and single cages for 28 days before testing. Figures 1 and 2

point out that this was more prevalent with subjects in communal cages. Table 1 shows that only one pair in each of two communal cages—Pair 9 in Cage 1 and Pair 12 in Cage 2—exhibited low to moderate rates of shock-induced aggression. Even then, however, there was evidence of session-to-session variability in fighting frequencies. The remaining four pairs from the communal cages—Pairs 7, 8, 10, and 11—displayed stable, albeit low, rates of fighting across the test sessions.

Variability in rates of fighting was also noted over sessions for pairs housed in single cages for 28 days before testing. Pairs 1, 2, and 3 displayed increasing rates of shock-induced fighting; Pair 4, however, exhibited a general decrease in fighting over the same period. Finally, the rates obtained with Pairs 5 and 6 increased during the initial sessions, but decreased during later sessions.

The data were analyzed by a repeated measures ANOVA. This showed the differences among groups housed in the two conditions for varying periods to be statistically significant ($F = 16.24$; $df = 3,40$; $p < 0.01$). Differences between housing conditions alone, how-

ever, were not statistically significant ($F = 3.87$; $df = 1,40$; $p > 0.05$), nor was the interaction between housing conditions and days spent in these settings before testing ($F = 2.82$; $df = 3,40$; $p > 0.05$). The trend of increased aggression over sessions was statistically significant ($F = 32.31$; $df = 6,240$; $p < 0.01$). However, the interaction between housing conditions and sessions was not significant ($F = 0.97$; $df = 6,240$; $p > 0.05$), nor was the three-way interaction of sessions by housing conditions by days spent in these settings before testing ($F = 1.33$; $df = 18,240$; $p > 0.05$).

Weiner's (1971, p. 385) procedure for individual comparisons was employed to compare differences between individual groups of subjects. Results indicated statistically significant differences between subjects living in single cages for 14 and 28 days before testing ($F = 7.45$; $p < 0.01$), and between subjects living in these same conditions for 21 and 28 days before testing ($F = 4.87$; $p < 0.05$). The differences between other combinations of groups living in single cages before testing were statistically nonsignificant. Statistically significant differences were noted between groups living in communal cages for seven and 28 days ($F = 28.53$; $p < 0.01$), between groups living in communal cages for 14 and 28 days ($F = 41.32$; $p < 0.01$), and between groups living in communal cages for 21 and 28 days ($F = 23.48$; $p < 0.01$). Comparisons between other groups living in communal cages were statistically nonsignificant. The only other statistically significant comparison was between groups housed in single and communal cages for 28 days before testing ($F = 11.64$; $p < 0.01$).

DISCUSSION

The results indicate that the amount of time spent in a particular housing condition before testing affects shock-induced aggression to a greater extent than does type of housing condition. Hence, while high rates of aggression were observed when rats were placed in single or communal cages for seven or 14 days before testing, fighting decreased when rats spent 21 or 28 days in either setting before testing. Subjects housed in either single or communal cages for seven or 14 days before testing also exhibited increasing rates of aggression over sessions. This trend of increased aggression over test sessions supports previous

findings (e.g., Creer, 1973; Creer and Powell, 1971; Powell and Creer, 1969).

When rats were in either housing condition for 21 or 28 days before testing, two trends were noted. First, increased session-to-session variability in fighting rates was exhibited by some pairs. Second, low rates of aggression were displayed across sessions by other pairs of subjects, a finding more pronounced among rats housed in communal cages for 28 days before testing. In fact, only one pair housed in each of the two communal cages for 28 days before testing fought to any extent, a finding similar to that reported by Creer (1974).

The finding that time spent in housing conditions before testing affects shock-induced aggression generates more questions than answers. For example, what variables could account for the inverse relationship between fighting and time in single or communal cages before testing? Unidentified social factors are one suggestion, because some subjects were together in the same cage both before and between test sessions. Hence, there was the opportunity for social patterns to form, e.g., dominance-submission relationships, that may have later influenced shock-elicited fighting. This explanation is also applicable to previous findings (e.g., Creer and Powell, 1971; Hutchinson *et al.*, 1965). If such social variables were important, however, what accounts for the low rates obtained with subjects housed in single cages for 28 days before test sessions? Since animals were placed in these environments when they were 60 days of age, there was no opportunity for social interactions outside of the experimental chamber. Thus, social factors do not constitute a plausible explanation of the present results. On the other hand, it might be speculated that isolation affected shock-induced fighting. Since isolation, a method widely used to induce aggression in mice (e.g., Scott, 1971; Valzelli, 1969), was coupled with shock, it might have been anticipated that the interaction of events would have led to an increase in fighting. In other words, the longer the rats were isolated, the greater the probability that rats would fight in response to foot shock. This was contrary to the results, however, because there was a statistically significant decrease in fighting for the subjects housed in single cages for 28 days before testing. Hence, neither unidentified social interactions nor social isolation adequately explains

the present findings. The fact that shock-induced fighting is a function of environmental determinants outside the experimental chamber, however, does merit consideration both in designing future studies of aggression and as a topic, in and of itself, for further investigation.

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