On fighting in mice: Situational determinants of intragroup dyadic stimulation¹

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Two experiments are reported in which it was shown that small groups of C57BL/10 mice intensively investigate animals that are introduced into their living compartments. The effects were obtained regardless of whether the animal was a member of the group or was unfamiliar to it. Whether or not the investigatory activity escalates into fighting seemed dependent upon the reactivity of the animal being stimulated, with previously isolated mice being most reactive.

On two separate occasions, we have attempted in this laboratory to trace the development of fighting behavior among male C57 mice that were maintained in small groups. Both attempts were failures. The problem was that mice reared with littermates simply do not fight very much. Observation of eight groups of C57 mice in both the light and dim phases of their light cycles over a 6-week period indicated that the mean number of spontaneous fights per ½-h observation period was only 0.07. This incidence rate was scarcely sufficient to permit a reliable plot of the ontogeny of the behavior.

These results were peculiar because intragroup conflict had seemed to be commonplace during the course of normal maintenance and testing activities in the laboratory. More systematic observation of the circumstances under which fighting occurred in our C57BL/10 groups indicated that it was obtained usually when the compartment in which the animals were being housed was disturbed in some way (e.g., removal and replacement of one animal for testing, changing the litter). Fighting frequently occurred within 5-10 min after the disruption, whatever its nature.

Fig. 1. (a) depicts the relationships between time since the reintroduction and the number of social behaviors initiated by members of the group toward S under two conditions (removal-replacement and nonremoval). (b) shows the relationship between time since introduction and number of social behaviors initiated by group members toward an unfamiliar animal (previously isolated or group-reared).

Further analysis of the phenomenon seemed warranted because of its relevance to the processes of group cohesion and territoriality. In the first experiment, we attempted to identify the changes in behavior interaction that occurred when animals were removed from their groups for a short time and then replaced. The problem was to plot the type, duration, and consequences of the behavioral changes that were evoked in the group and in the individual by this operation.

EXPERIMENT 1

Subjects

Thirty-nine C57BL/10 male mice, 112 days (± 2) of age at the beginning of the experiment, were maintained in compartments of five animals each, except for one compartment that had four. Twenty-four of the mice (three from each compartment) served as Ss in the study.

Apparatus and Procedures

The observations of the animals were made in their home compartments (clear plastic containers, 7 x 11 x 5½ in. high, with wire-mesh removable roofs). Two types of observations were conducted. The *experimental* observation began when a group member was replaced after a 5-min removal from the group. During the separation, the animal was maintained alone in a clean neutral compartment. The mouse was transported approximately

10 in. by grasping his tail with forceps, a procedure that minimized odor cues and was accomplished easily. Upon replacement, S's physical interaction with other members of the group and their reactions to his stimulation, and the group members' physical interaction with S and his reactions to such stimulation, were observed for a 10-min period. The social interaction categories used included sniffing, climbing, grooming, attack, withdrawal, freezing, and boxing. A composite score was simply a summary of the total interactions that occurred. Judgments as to the occurrence of a behavior and reaction to it were made each 5 sec. The interrater reliability of the observation categories was adequate ($r = .98$ for the composite score, and product-moment correlations ranging from .87 to .96 for the separate categories). The tails of all animals were color-coded to permit individual identification.

The *control* observations were identical to the experimental observations, except that the animal was not removed prior to observation. For half of the animals, the control test preceded the experimental series by a day; for the remainder, the control series was conducted on the following day. Tests were conducted in a dimly illuminated experimental room (indirect lighting from a 25-W bulb), the same room in which the animals were maintained.

Results

The primary findings are shown in Part a of Fig. 1. Virtually all of the interaction sequences that occurred were initiated by the members of the group that remained

and were directed at S. In the first minute, the mean dyadic initiation score was 0.13 for the replaced S and 7.50 for the group [$t(23) = 14.06$, $p < .001$]. The primary effects were of rather short duration, and by the end of the 10-min period, the particular investigatory activities of the group, with respect to S, had diminished to the control or baseline levels. Statistical analysis of decline in investigation over time for the experimental series indicates that the effect was highly reliable [$F(4,28) = 31.30$, $p < .001$].

Fighting erupted in 50% of the cages on the first experimental removal. In every instance, the attacks followed a period of highly intensive investigation of S by one of the animals that had remained. Once fighting began, other animals became fortuitously involved, usually by virtue of having had a collision with one of the fighters.

EXPERIMENT 2

If a member of a group is only briefly separated from his compartment mates, he becomes the object of intensive investigation upon reintroduction. In the readaptation phase, the removed S is nonresponsive to the stimulation directed toward it and does not initiate interactions. The next experiment in this series was conducted to determine whether or not the groups would respond differentially to unfamiliar C57BL/10 mice of the same age (i.e., conspecific animals). In one instance, the unfamiliar animal was from another group; in the second instance, the unfamiliar animal had been isolated since weaning.

Subjects, Apparatus, and Procedures

The eight groups of C57BL/10 mice that had been in the previous experiment, and eight additional C57BL/10 male mice that had been maintained in isolation from 25 days of age, were used in this experiment. All animals were 122 days old (± 2 days). The eight group-reared animals used as Ss in this experiment had not served as Ss in Experiment 1.

The procedures for testing and scoring were identical to those followed in Experiment 1, with the following exception: After one animal had been removed from a group for 5 min, he was replaced in the group by a different animal. On one occasion, the "different" S was from another group-rearing compartment; on the other occasion, S was from an isolation compartment. Order of presentation was counterbalanced, and each group was tested only once daily.

Results

The findings of the second experiment are shown in Part b of Fig. 1. The groups responded to unfamiliar group-reared mice in a fashion that was not distinguishable

from the way they had responded to other members of their group. However, the rearing experiences of the unfamiliar animals exercised a profound influence upon their integration into the groups. While the unfamiliar group-maintained animals responded, and were responded to, much like Ss in Experiment 1, quite a different pattern was obtained among the previously isolated Ss. Rather than passively responding to stimulation, the previously isolated animals sharply reacted to it or took the initiative in interacting. The isolated animals thus initiated more interactions ($\bar{X} = 3.40$) than did group-reared Ss ($\bar{X} = 0.83$) [$t(7) = 4.34$, $p < .01$], and they were stimulated less by animals in the test groups [$t(7) = 3.44$, $p < .01$] (see Part b, Fig. 1).

The upshot of this difference in reactivity was a situation where the isolated Ss investigated the group members rather than vice versa. Although outnumbered four to one, the isolated Ss initiated attacks and dominated the group by the end of the observation period in four of the eight instances. In every case, the previously isolated S was involved in fighting during the 10-min observation period. In contrast, group-reared Ss fought in only 25% of the observations.

DISCUSSION

According to Barnett (1963), rats recognize other members of their group by a distinctive colony odor, and it is this odor that acts as a "suppressor" of fighting. Rats that do not share this odor

reportedly are viciously attacked upon being introduced to the intact group. The evidence for this hypothesis, as summarized by Barnett, is incomplete. The results of the present work indicate that the "colony odor" in mice is not sufficient to inhibit heightened investigation of the newly returned animal. Indeed, the pattern of investigation seems similar whether the animal has been a member of that group or of another group. The results of this work suggest that the effective variable in eliciting heightened investigation is the presence of a relatively salient animal, whether or not he has the odor of the group.

Whether or not the investigatory activity escalates into fighting seems to be dependent in part upon the way in which the object of stimulation responds. If the animal has been previously isolated and is hyperreactive to dyadic stimulation, the probability of fighting is significantly increased. The reciprocal interaction process by which the reactions of the one animal to stimulation act to intensify the investigatory activities of the other seems worthy of further detailed investigation. Such interaction sequences, however elicited, are reliable precursors of "spontaneous" fighting in mice.

REFERENCE

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NOTE

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hypoxia and retrograde amnesia

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Recent studies have questioned the phenomenon of hypoxia-produced RA on the premise that intracellular hypoxia cannot be produced rapidly enough to prevent the memory-consolidation process. Sixteen albino rats were trained to lever press for sucrose and were subjected to one of four treatments: shock only, hypoxia only, shock plus rapid decompression, and shock plus delayed decompression. Results showed that hypoxia following rapid decompression produced amnesia for the foot shock.

Hebb (1949) has suggested that a consolidation of memory is effected

through the reverberation of impulses in CNS neural circuits, following sensory input, resulting in a modification of the excitability of one neuron by another. That some such time-consuming process is involved in memory storage is suggested by the phenomenon of retrograde amnesia (RA), wherein retrieval of recent events is lost, while older memories are unaffected (Deutsch, 1962; Glickman, 1961).

Since the metabolism of cortical neurons is adversely affected by any treatment that severely disturbs the oxygen balance, any physiological process of memory consolidation should likewise be affected, and such treatment should produce RA. Hayes (1953) reported retarded maze learning in rats subjected to hypoxia 1 h after each learning trial, and Thompson & Pryer (1956) and Thompson (1957)