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29 January 1973

Control of Their Environment Reduces Emotionality in Rats

Abstract. *Rats reared from birth in a "contingent environment" in which they controlled lighting conditions and the delivery of food and water were compared as adults to rats reared in an environment in which they received the same food, water, and lighting conditions, but without control over their occurrence. Rats reared in the contingent environment were less emotional, as judged by activity and defecation scores in open-field testing.*

Effects of infantile stimulation on adult "emotionality" in rats have been widely investigated. Stimulation has included manipulations such as handling for a few minutes a day (*1*), exposure to mild electric shock (*2*), cooling (*3*), and maternal deprivation (*4*). Application of these procedures to rats prior to weaning has affected their emotional behavior in adulthood, as measured by open-field performance (*5*).

The degree to which the animal has control over its early environment has never been systematically investigated for its effect on adult behavior. Several cognitive theorists (*6, 7*) have suggested that this variable is important in much human behavior. In particular, Rotter (*7*) devised a rating scale designed to differentiate individuals who perceive a contingency between their behavior and environmental events (internal locus of control) from individuals who perceive that their behavior has little effect on their environment (external locus of control). Rotter theorized that the differences between the two groups of individuals are caused by variations in their early reinforcement histories.

Since controlled long-term manipulation of reinforcement in humans would be impossible, a systematic investigation with rats appeared to be one way to evaluate the importance of this variable for adult behavior. In view of the fact that open-field "emotionality" is sensitive to early environmental manipulations in rats, this test was used. One of the personality traits that seems to be correlated with differences in perceived locus of control in humans is variation in "anxiety" levels (*8*). Therefore, insofar as "anxiety" in humans is similar to "emotionality" in rats, the test appeared appropriate.

In the present study, two groups of animals that had different degrees of control over their early environments were compared on a behavioral measure—open-field behavior—that is susceptible to many other forms of environmental manipulation. In this test, the "emotional" animals defecate more throughout the test and are less active after the first day (*9*).

Animals in the contingent group were housed in cages in which the delivery of food and water and control of lighting were response-contingent. That is, three levers were available; one controlled the delivery of food (one 45-mg Noyes pellet per press) to an adjacent trough, the second controlled the delivery of water (0.05 ml per press), and the third controlled a house light (*10*), switched on and off by alternate presses. Animals in the noncontingent group lived in chambers that were physically identical to those of the contingent group (*11*) but the delivery of food and water and the operation of the light were controlled by lever presses in one of the contingent group cages. Consequently, animals in the noncontingent group had levers available and received the same presentations of food and water and changes in lighting as did the contingent animals, but did not have control over the occurrence of these events.

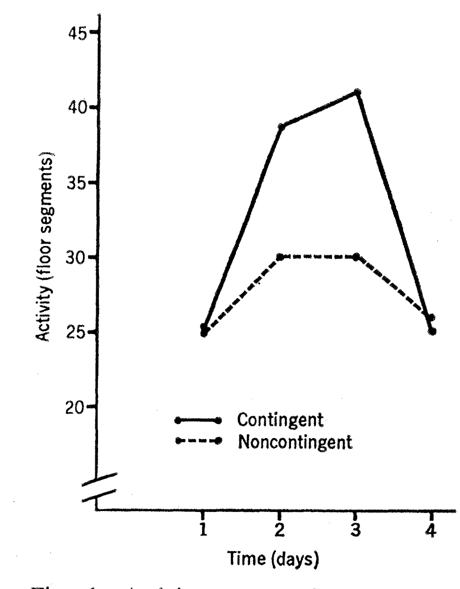

Fig. 1. Activity scores (floor segments entered) during 4 days of open-field testing.

Four chambers were used. Presses on the three levers in chamber 1 produced food, water, or a change in lighting in chambers 1 and 2; lever presses in chamber 4 controlled these conditions in chambers 4 and 3. In other words, chamber 2 was yoked to chamber 1 and chamber 3 was yoked to chamber 4, with control of food, water, and lights available in chambers 1 and 4 only (contingent chambers). Levers were available in chambers 2 and 3 and lever presses in these chambers were recorded, but presses did not affect the delivery of food or water or the lighting (noncontingent chambers).

The chambers were located in a darkened room and were arranged in such a way that lights in one chamber provided very little general room illumination. Electromechanical relay programming and recording equipment were located in an adjacent room. The apparatus was operated continuously from day 1 until the end of adult testing.

At the start of the experiment one pregnant Long-Evans hooded female rat (*12*) was placed in each of the four chambers. The pregnant females in two contingent chambers acquired the lever-pressing response within 2 days and provided adequate amounts of food and water. After the four litters had been delivered 18 to 20 days later, all pups were removed briefly from their mothers, and four males and four females from the pooled litters were assigned randomly to each mother. When the pups were 21 days old, the mothers were removed, the litters were weighed, and each litter was randomly reduced to two male and two female pups. The four males from the two contingent litters were placed in one contingent chamber, and the four females from these litters were placed in the other. The males from the noncontingent litters were placed in the chamber yoked to the contingent males, and the noncontingent females were placed in the chamber yoked to the contingent females. As a result of this rehousing, males were yoked to males and females were yoked to females. The four groups were housed as follows: chamber 1, contingent males; chamber 2, noncontingent males; chamber 3, noncontingent females; and chamber 4, contingent females.

The animals remained undisturbed until they were 60 to 62 days old; daily filling of pellet dispensers and water reservoirs was done briefly in the dark with a minimum of disturbance. At this point, each animal was tested in the open field for 2 minutes per day for four consecutive days. The open field, similar to that described by Broadhurst (*5*), was a walled circular arena 83 cm in diameter; walls and floor were painted white, and black concentric circles and sections of radii divided the floor into segments used to score activity. Subjects were removed from their chambers for testing in a different random order daily and were returned to the chambers immediately after testing. On day 86, all subjects were weighed..

The defecation scores for the 4 days of testing are shown in Table 1. Animals reared in contingent chambers defecated significantly less than those reared in noncontingent chambers ($F_{1,12} = 6.34$; $P < .05$). As the mean values and the lack of a significant treatment by sex interaction indicate, the differences were consistent for both sexes.

Table 1. Number of defecations in 4 days of open-field testing; S.E., standard error.

Group	Defecation score (mean ± S.E.)
Contingent males	8.5 ± 1.12
Noncontingent males	11.0 ± 2.10
Contingent females	4.75 ± 2.52
Noncontingent females	12.0 ± 1.62

The mean activity scores for the two groups are shown in Fig. 1. The mean activity of the contingent animals was higher than that of the noncontingent animals on days 2 and 3. An analysis of variance of activity scores indicated that, for the two groups, the difference in these patterns of activity scores across the 4 days of testing approached significance (groups-by-days interaction: $F_{1,12} = 2.56$; $.10 > P > .05$). Weights of the groups were compared by *t*-test to determine whether the defecation difference was due to some nutritional difference between the two groups. The weights of the two groups were not significantly different ($t = 1.56$, d.f. = 14, $P > .10$).

The data indicate that control of aspects of their environment affected the adult behavior of the rats. The results do not indicate whether the contingent environment reduced emotionality or whether the noncontingent environment increased it in relation to rats reared in normal laboratory conditions; however, the amount of control experienced by the noncontingent subjects appears to be comparable to that experienced in a normal laboratory setting. In addition, the effects obtained are not clearly attributable to environmental conditions in early life, since the animals were housed in the environments from birth to early adulthood. However, in a subsequent study of rats that were not placed in the chambers until they were weaned (21 days), there were no differences in open-field behavior, a result suggesting that the effect may, in fact, be developmental. Further investigation is necessary before any substantive conclusions can be reached on this point.

It appears that animals with a substantial amount of control over certain environmental consequences display a behavior pattern in the open field which can be characterized as less "emotional" than that of animals not in direct control of these consequences. This reduction in emotionality is similar to the effects of other treatments—including handling, shock, cooling, and social contact—none of which were systematically different in this experiment. Consequently we appear to have identified control over environment as another variable that affects emotionality. Further studies of the effects of environmental contingencies during development on learning ability and reactions to stress should indicate the extent of the effect produced by differences in the amount of early environmental control, and should give further evidence concerning the similarity of the effects of this manipulation to the effects of perceptions about locus of control.

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10. Six-watt, 28-volt bulbs were used. One response on the appropriate lever turned the lights on, the next response turned them off.
11. The four chambers in which subjects were reared, each 24 by 45 by 60 cm, had wooden walls and ceilings and wire mesh doors and floors. Each chamber contained a food dish, a water dish, three response levers, and a light mounted above the chamber. The levers were 5 by 8 cm and were mounted approximately 1 cm above the floor. The use of large levers eliminated the need to shape or formally train the lever-pressing response. All levers and dishes were mounted on one wall of each chamber. Scientific Prototype (model L700) feeders served as the food delivery system and Skinner electric valves (model C2DA1081) delivered water.
12. Rats were obtained from Blue-Spruce Farms, Altamont, New York.

29 November 1972; revised 23 March 1973

Geyser Eruptions and the 18.6-Year Tidal Component

Rinehart (*1*) stated that "over 40 years of records from Yellowstone National Park, Wyoming, show that the 18.6-year tidal component strongly regulates the frequencies of eruption of Grand and Steamboat geysers." However, an important event in the recent history of the park overshadows the tidal effect and invalidates his claim for its control on the geyser eruptions. This event was the earthquake of 17 August 1959 (magnitude 7.1 on the Richter scale) whose epicenter was located within 47 km of Grand and Steamboat geysers (*2*). A number of aftershocks were observed in the months following the main event, some with magnitudes between 5 and 6.5 on the Richter scale. Because geysers and hot springs depend on heated groundwater and are mainly located in alluvium, glacial till, or highly altered rhyolite, they were immediately affected and their activity either increased, decreased, or became erratic. On 18 August 1959 the activity of Grand Geyser ceased completely, and it remained dormant for several months (*2*). These events stand out clearly in figure 1 of Rinehart's report (*1*). To conclude that tidal forces are directly responsible for this behavior of Grand Geyser is therefore very risky.

Because of the earthquake, the