EFFECTS OF ENRICHED AND RESTRICTED EARLY ENVIRONMENTS ON THE LEARNING ABILITY OF BRIGHT AND DULL RATS[1]

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SEVERAL RECENT SURVEYS of the literature (2, 3, 4, 9) reflect the increased emphasis being placed upon study of the relationship between early environment and later behaviour in animals. Learning ability has received particular attention, and several studies have shown that the learning ability of adult animals is affected by the quality of their infant environment. More specifically, they indicate that animals raised in "enriched" or "stimulating" environments are superior in adult learning ability to animals raised in "restricted" or "unstimulating" environments.

These results were obtained with animals possessing a *normal* heritage of learning ability; hence there remains the possibility of differential effects for animals of superior or inferior endowment. The present study was designed to explore this possibility. Its specific object was to test for possible differential effects of enriched and restristed early environments on the problem-solving ability of bright and of dull rats.

METHOD

Subjects

Forty-three rats of the McGill bright and dull strains (F_{13}) served as subjects. They were divided into 4 experimental groups: a bright-enriched group containing 12 rats (6 males, 6 females); a dull-enriched group containing 9 rats (4 males, 5 females); a bright-restricted group containing 13 rats (6 males, 7 females); and a dull-restricted group containing 9 rats (4 males, 5 females). Normally reared rats served as controls.

Environments

The 4 groups of experimental animals were placed in 4 cages which occupied a grey painted room 12′ × 6′ × 8′. At one end of the room a window allowed diffuse light to pass through. A large rectangular partition, suspended from the ceiling, divided the room lengthways. The two restricted cages were placed on one side of the partition, the two enriched cages on the other side. The side of the partition facing the restricted cages was grey, matching the colour of the room. The side of the

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partition facing the enriched cages was white with "modernistic" designs painted upon it in black and luminous paint. The partition was so placed that animals in the restricted environment were unable to see the enriched cages.

The 4 cages, each measuring 40" × 25" × 13", were covered with ½-inch wire mesh. Each of the enriched cages contained the following objects: ramps, mirrors, swings, polished balls, marbles, barriers, slides, tunnels, bells, teeter-totters, and springboards, in addition to food boxes and water pans. Some of the objects were painted black and white, and all were constructed so that they could easily be shifted to new positions in the cage. The restricted cages were identical with the enriched ones in size and mesh coverings, but contained only a food box and a water pan.

Test Apparatus

The 12 problems of the Hebb-Williams closed field maze were administered in the manner described by Rabinovitch and Rosvold (8).

Procedure

The 4 groups of animals were kept in their respective environments from the time of weaning at 25 days of age until the age of 65 days, when testing on the Hebb-Williams maze was begun. They were also kept there throughout the testing period.

Since one of the restricted and one of the enriched cages received more light than the others did from the window, the animals were shifted every three days to equate for this difference. In addition, the objects in each of the enriched cages were moved about at random every three or four days. During these moving periods and while the cages were being cleaned all animals were given the same amount of handling.

Results

For purposes of statistical analysis and interpretation of the data the performances of the enriched and restricted animals were compared with the performances of 11 bright and 11 dull animals raised in a "normal" laboratory environment. These were the animals that formed two control groups in an experiment by Hughes and Zubek (6).

Effect of the Enriched Environment

In Table I are recorded the mean error scores for the bright-enriched group, the dull-enriched group, and the bright and dull animals raised in a normal environment. It can be seen that the average number of errors

TABLE I

Mean Error Scores for Bright and Dull Animals Reared in Enriched and Normal Environments

	Enriched environment	Normal environment
Bright	111.2	117.0
Dull	119.7	164.0

made by the bright animals in the enriched environment is only slightly below that of the bright animals raised under normal conditions (111.2 *vs.* 117.0). This difference is not statistically significant ($t = 0.715$, $p >$ .4). On the other hand, the error scores of the dull animals raised in an enriched environment are considerably below those of dull animals reared in a normal environment (119.7 *vs.* 164.0). This difference of 44.3 errors is significant ($t = 2.52$, $p > .02 < .05$). The results indicate, therefore, that an enriched early environment can improve considerably the learning ability of dull animals, while having little or no effect on that of bright animals.

Effect of the Restricted Environment

Table II shows the mean error scores of the bright-restricted group, the dull-restricted group, and the bright and dull animals raised in a normal environment. It is seen that the bright-restricted group made many more errors than the normally raised bright animals. The difference of 52.7 errors is statistically significant ($t = 4.06$, $p < .001$). On the other hand there is no significant difference between the dull-restricted group and the normally raised dull animals ($t = 0.280$, $p > .7$). Thus the dull animals were not affected by their restricted early experience while the bright animals were significantly impaired in learning ability.

Comparative Effects of Enriched and Restricted Environments

Tables I and II also indicate the degree of improvement produced in the dull animals by their period of enriched experience, and the degree of retardation which the bright animals suffered because of their impoverished experience. Although the dull-enriched group averaged 8.5 more errors than did the bright-enriched, this difference is not significant ($t = .819$, $p > .5$). In other words, after undergoing a period of enriched experience the dull animals became equal in learning ability to the bright animals. The difference between the bright- and dull-restricted groups in Table II is also obviously insignificant; thus, the bright animals, after a period of early impoverished experience, showed no better learning ability than did the dull animals.

TABLE II

MEAN ERROR SCORES FOR BRIGHT AND DULL ANIMALS REARED IN RESTRICTED AND NORMAL ENVIRONMENTS

	Restricted environment	Normal environment
Bright	169.7	117.0
Dull	169.5	164.0

Discussion

The results clearly show that both enriched and restricted early environments have differential effects on the learning abilities of bright and of dull rats. A period of early enriched experience produces little or no improvement in the learning ability of bright animals, whereas dull animals are so benefited by it that they become equal to bright animals. On the other hand, dull animals raised in a restricted environment suffer no deleterious effects, while bright animals are retarded to the level of the dulls in learning ability.

Although it had been anticipated that the two extremes of environment would have differential effects on the bright and dull animals, the bright-enriched animals were still expected to perform better than the dull-enriched animals. Bright animals, with their presumably better cerebral functioning, would be expected to make better use of the extra experience afforded by an enriched environment than would dull animals, with their presumably inferior cerebral functioning. The bright-enriched group did in fact make fewer errors, and the difference, though not statistically significant, suggests the possibility of a real difference in learning ability which the twelve problems of the Hebb-Williams test failed to reveal. The ceiling of the test may have been too low to differentiate the animals, that is, the problems may not have been sufficiently difficult to tax the ability of the bright rats. This has happened with tests of human intelligence such as the Stanford-Binet (1), on which adults of varying ability may achieve similar I.Q. scores although more difficult tests reveal clear differences between them. It might also be suggested that it is relatively more difficult for the bright animals to reduce their error scores, say from 120 to 100, than for the dull animals to reduce theirs from 160 to 140.

In spite of these possible qualifications of the present results for the enriched environment, it seems reasonable to accept them pending future experimentation.

The effects of the restricted environment are not so difficult to accept. Under such conditions the bright animals, even with their superior learning capacity, would be expected to show an inferior performance. Learning is a function of experience as well as of capacity, and hence, under *conditions that severely limit experience, the superior capacity of the* bright animals is never fully utilized and they perform far below their potential level. On the other hand, not much decrement would be expected in the dull animals, since they are already functioning at a low level of intellectual capacity.

What physiological mechanism or mechanisms underlie these changes in learning ability? Several theories have attempted to explain the relationship between sensory stimulation and learning behaviour, perhaps the most systematic being that of Hebb (5). Hebb has suggested that neural patterns or "cell assemblies," which he regards as the physiological basis of learned behaviour, are built up over a period of time through varied stimulation coming through specific sensory pathways. This stimulation is especially effective if it occurs during infancy. Others (7, 9) also believe that varied stimulation coming through non-specific projection pathways (e.g., the thalamic-reticular system) aids in the learning process by keeping the brain in an alert state. Thus at the neurophysiological level varied stimulation seems to play a dual role in the learning process; it may act directly on cerebral cells to form cell assemblies, and may also aid learning by keeping the brain "primed" or alert.

If, then, varied stimulation has such an important role in establishing the physiological components (e.g., cell assemblies) underlying learned behaviour, it seems reasonable to assume that a certain level of varied stimulation is necessary if learning (i.e., establishment of cell assemblies) is to occur with maximum efficiency. It may also be assumed that the initial difference in learning ability between the bright and dull rats in some way reflects an underlying neurophysiological difference in their capacity to "utilize" such stimulation. On the basis of these assumptions the present findings might be explained as follows.

In a *normal* environment the level of stimulation is sufficient to permit the building up of cell assemblies (or some other neurophysiological unit underlying learned behaviour) in the superior brains of the bright animals. It is not sufficient, however, to permit them to be readily built up in the inferior brains of the dull animals. In a *restricted* environment the level of stimulation is so low that it is inadequate for the building up of cell assemblies even with the superior cerebral apparatus of the bright rats, who therefore show a retardation in learning ability. The dulls, however, are not retarded further, since the level of stimulation provided by the normal environment was already below their threshold for the establishment of cell assemblies. In the *enriched* environment the level of stimulation is above the higher threshold of the dull animals, who consequently show improvement in learning ability. The brights show little or no improvement because the extra stimulation is largely superfluous, that provided by a normal environment being adequate for the building up of cell assemblies.

Such an interpretation is open to several criticisms. For instance, the assumption that bright and dull rats differ in their inherited capacity to utilize stimulation is open to question. Furthermore, as pointed out above, possible inadequacies of the Hebb-Williams test may throw doubt on the findings for the bright-enriched rats. Nonetheless, although this theoretical interpretation obviously needs a more adequate foundation, it seems best fitted to account for the experimental data in the light of present neurophysiological knowledge.

Summary

Forty-three rats of the McGill bright and dull strains were used as experimental subjects in an investigation of possible differential effects of enriched and restricted early environments on learning ability.

At 25 days of age, 12 bright rats and 9 dull rats were placed in enriched environments, and 13 brights and 9 dulls were placed in restricted environments. At 65 days of age all animals were introduced to the training and testing procedures of the Hebb-Williams maze, their performances being compared with those of normally reared bright and dull controls.

The bright animals reared in enriched environments showed no improvement in learning ability over bright controls reared under normal laboratory conditions. The dull animals, on the other hand, benefited greatly from the enriched experience and attained a level of performance equal to that of the bright animals. Rearing in restricted environments had converse effects. The dull animals suffered no impairment as compared with dull controls, while the bright animals were retarded to the level of the dulls in learning performance.

Possible neurophysiological explanations are suggested.

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