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BINOCULARLY DEPRIVED CATS ARE NORMAL IN VISUAL DISCRIMINATION LEARNING IN A SIMPLE APPARATUS

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Abstract. Pattern discrimination learning was compared in three groups of cats: reared in normal conditions, reared in the laboratory with opened eyes, and deprived of patterned vision from birth. A four-choice apparatus without partitions was used. The figure of a disc was reinforced with food, whereas a cross, triangle and square were not. All groups reached criterion after similar numbers of trials and errors, indicating that in binocularly deprived cats, simple perceptual and associative learning are not impaired.

INTRODUCTION

We found previously (8, 10) that in binocularly deprived cats (BD cats) visual discrimination learning is impaired as compared with control cats (C cats) reared with opened eyes in the laboratory. The majority of BD cats were not able to master the discrimination at all when the proper task was not preceded by an easier task: object vs. no object discrimination. Moreover in the control cats, the learning was impaired as compared with cats that spent the early period of life outside the laboratory, in normal conditions (N cats).

In the present study the problem of visual discrimination learning in binocularly deprived cats was investigated further. The same kinds of cats were used, but the experimental procedure was somewhat different, mainly involving use of a new discrimination training apparatus (Fig. 1). The differences were as follows:

1. In the previous studies we used a two-choice apparatus, whereas the present apparatus offered four choices.

2. The earlier choice-box was divided by a partition, whereas the present apparatus had no partitions.

3. Previously, objects (a black ping-pong ball and a black three-dimensional cross) were discriminated, whereas in this study black figures (Fig. 2) were used.

4. We previously mounted the objects on small white screens behind which the food was located, whereas in this study the figures were on swinging gates behind which the food was available.

MATERIALS

Sixteen cats of both sexes were used. Six N cats were introduced to the laboratory at the age of 2-3 months and were considered to be normally reared animals. The other 10 cats were born in the laboratory. Of these, 5 C cats were reared with open eyes, whereas 5 BD cats were deprived of patterned visual experience by means of white double linen masks fitted on their heads. The masks were put on before eyelid opening and were taken off at the age of 6 months. Further details of our deprivation technique are described elsewhere (3).

Care was taken to avoid motor deprivation of cats born in the laboratory. During the first 2 months the C and BD kittens were reared in family cages (180 × 50 × 40 cm). During the last 2 weeks of this period they spent 30 min daily in the laboratory room, walking around on the floor. At the age of 2 months the kittens were moved into a big wire cage (3 × 4 × 3 m), in which a few boxes of different sizes were available.

METHODS

Discrimination training began when the C and BD cats were 6.5 months old and the N cats were at a similar age. Thus the BD cats were allowed a “recovery” period of 2 weeks. During discrimination learning a four-choice apparatus without partitions was used (Fig. 1). The apparatus was constructed according to that used by Prazdnikova (4) for visual discrimination learning in dogs. It consisted of a start-box and a choice-box separated by an opaque guillotine door. The stimuli were four figures (disc, cross, triangle and square) of 3.5 cm diameter each, mounted on gates. The distance between the door and the gates was 56 cm. The gates could be opened by pushing them with a paw. Behind the gate with the disc (positive figure) a piece of raw meat was available in a bowl, whereas behind the gates with other figures the bowls were empty.

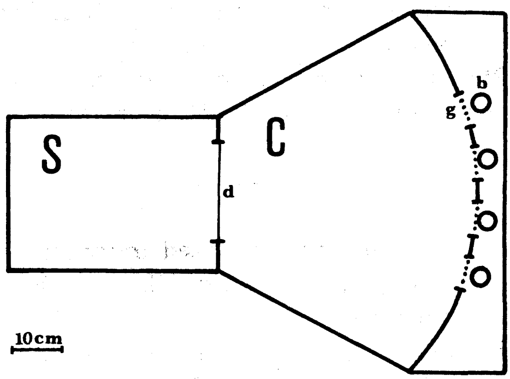

Fig. 1. Apparatus. S, start box; C, choice box; d, opaque lift door; g, gate with stimulus; b, bowl.

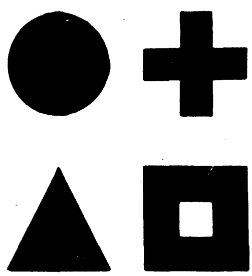

Fig. 2. Visual figures used in learning. The diameter of each figure was 3.5 cm.

During the first few sessions the cats were familiarized with the apparatus. They learned to push the gates and take food. Then, daily discrimination sessions started. In the first stage, labeled pretraining, the cats were trained to discriminate the disc (reinforced with food) vs. no figure. The disc was placed randomly in one of the four gates. After a cat reached criterion in the pretraining stage the proper training, labeled simply training, started. Four patterns were presented randomly in four gates. The disc was further reinforced with meat.

The sessions consisted of 24 food-rewarded trials. After opening the lift door by the experimenter a cat could enter the choice box and make a choice. After making an error, a re-run followed. The first error was labeled an initial error, those that followed were called repetitive errors. The animals were allowed only two repetitive errors. The third repetitive run was passive, the cat was pushed by hand to the gate with the disc. The cats were trained to a criterion of 10% or less of initial errors in 2 consecutive sessions in the pretraining and in 5 consecutive sessions in the training. Statistical significance of the results was assessed by a 1-way analysis of variance and by the Duncan tests.

RESULTS

In all groups of cats there were marked individual differences in the course of both pretraining and training. This shows Fig. 3 with individual numbers of initial errors.

Surprisingly, the numbers of trials, initial errors and repetitive errors to criterion during both pretraining and training were on the average similar in all groups (Table I, Fig. 3). Moreover, in the BD group the number of initial errors was even somewhat lower than in the N and C groups, but the differences were statistically insignificant.

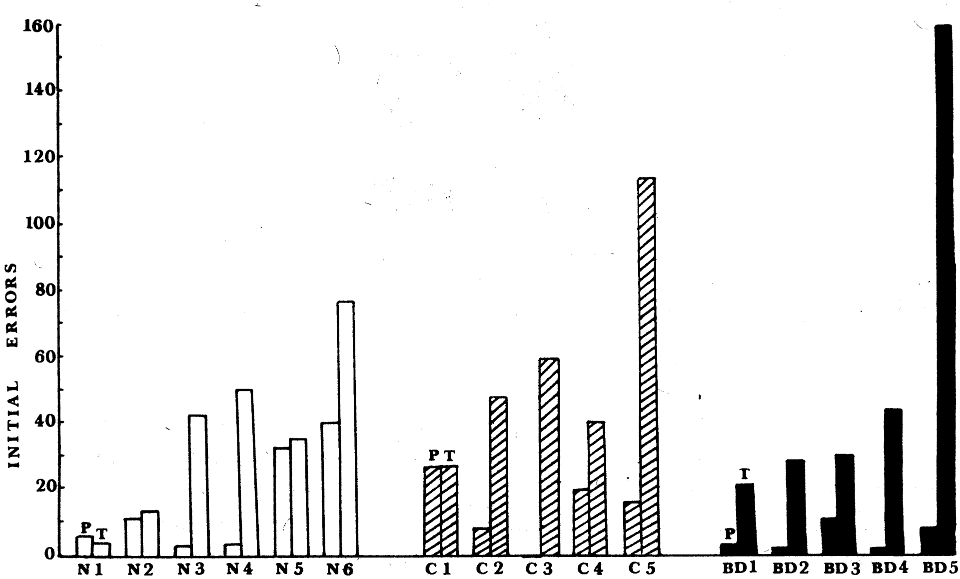

Fig. 3. The numbers of initial errors to criterion in normal cats (white bars), control cats (hatched bars) and binocularly deprived cats (black bars) during pretraining (P) and training (T). Cat C3 committed no errors during pretraining.

TABLE I

Median numbers of trials and errors to criterion during the pretraining (P) and training (T). Criterion sessions are excluded

Group	Trials		Initial errors		Repetitive errors	
	P	T	P	T	P	T
Normal	60	96	9	40	4	20
Control	96	92	15	48	3	44
Deprived	48	108	3	28	0	25

On the other hand, reaction time was longer in BD and C cats than in the N cats. This measure represented the time from the opening the lift door to the opening of the gate and was recorded on all runs. The mean reaction times for N, C and BD cats, respectively, were 2.2 s, 3.6 s and 4.1 s, for pretraining, and 1.4 s, 2.9 s and 3.8 s in training. The difference between the BD and N groups was significant ($P < 0.01$) for both pretraining and training and the difference between the C and N groups was significant as well ($P < 0.05$ for the pretraining; $P < 0.01$ for training). Those differences seemed to reflect more the locomotor slowness of the BD and C cats and not their deficit in discrimination learning. As pretraining and training proceeded, the reaction times diminished similarly in all groups. During the last 3 criterion sessions of training they were on the average about two times smaller than in the 3 first training sessions.

DISCUSSION

In the present study the numbers of trials and errors to criterion were similar in the N cats to those found for N cats in the previous studies (8, 10). In contrast, however, similar numbers of trials and error to criterion were found in all groups of cats. Mastering the discrimination task certainly required perceptual learning — discriminating the positive figure from the negative ones — as well as associative learning — elaboration of associations between the visual system and the alimentary and motor systems (see 11, p. 191). Although both types of learning could not have occurred in the BD cats during the six month of their deprivation and were limited in the laboratory reared C cats, they appeared to be satisfactory for quick mastering the discrimination task.

These results suggest that one or more of the four changes introduced in this study (see Introduction) made the task markedly easier for the deprived cats. It is not probable that this might be the change from the two-choice to the four-choice situation and the replacement of the natural by artificial visual stimuli. Thus, the two remaining changes should be considered.

The lack of a partition in the present apparatus seemed to play the main role. In a subsequent study (in preparation), we found that the addition of the partition in the two-choice apparatus makes the discrimination task much more difficult for the deprived cats. The deficit of the BD cats in the partitioned apparatus cannot be simply the result of their lower visual acuity. Visual acuity has been reported to be reduced in BD cats to 3.25 cycle/deg (6), whereas the acuity required in our partitioned apparatus was only about 0.5 cycle/deg. Moreover, the acuity of the C cats was presumably normal. One can hypothesize, therefore, that the essential factor responsible for the deficit of the BD and C cats in the partitioned apparatus was that of visuo-motor coordination. The separation between choice and reward required different and more complex visuo-motor behavior than in the simple apparatus without a partition. In the previous apparatus this difference was additionaly increased since the cats had to evade the screen to get the food behind it. Further investigations are necessary to understand the mechanism of this deficit.

Our data are supported by Van Hof-van Duin's results, described in an abstract form together with the preliminary results of this study (9, see also 7). She used a simple apparatus which was similar to ours: it had no partition and the stimuli (two grating patterns of different orientation) were mounted on the gates. The C and BD cats reached criterion after similar numbers of trials and errors. However, the discrimination of gratings is perceptually a relatively simple task (see 1). Riesen (5, quoted after 1) and Ganz et al. (2) found that in the apparatus with partition the grating discrimination task is much easier for BD cats than X vs. N or upright vs. inverted triangle discriminations.

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