Effects of population density on emotionality and transfer of perceptual learning in rats*

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Albino rats were preexposed to circles and triangles in an otherwise visually sparse environment where the number of Ss per cage was varied. Animals that received no early experience with the forms were reared under identical population densities. In a subsequent circle-triangle discrimination task, both early experience and crowding were found to be significant sources of variance. Preexposed Ss learned the task in significantly fewer trials than nonexposed Ss, and crowded Ss mastered the task significantly faster than uncrowded Ss. In addition, it was found that crowded nonexposed Ss did not differ in their rate of task acquisition from Ss preexposed to the to-be-discriminated stimuli in uncrowded cages. It is possible that the observed effects of crowding on learning arose indirectly through the effects of crowding on emotionality.

Although a number of investigators have, in recent years, examined the effects of overcrowding on various behaviors and associated physiological indices, relatively few researchers have attempted to investigate the effects of population density on learning ability, *per se*. Those studies that have examined this latter question have, in general, shown that crowded animals exhibit decreased emotionality and, in some instances, an increase in learning and performance (Dolger, 1954; Taylor, 1969). The Dolger and Taylor studies assessed learning ability by Hebb-Williams maze performance to index the effects of overcrowding. The present investigation attempted to extend these findings by examining the effects of population density on transfer to a later situation of information acquired in the early environment.

The general experimental procedure in the research reported below followed the early-experience paradigm of Gibson & Walk (1956). Basically, this procedure involves rearing animals in a visually sparse environment, except that half of the Ss have cut-out circles and triangles hanging in their cages from the time of weaning, 21 days of age, through the duration of the experiment. At 90 days of age, the early-experience and nonexposed animals learn a circle-triangle discrimination as a test of the effects of the preexposure conditions. It has generally been found that animals that receive early experience with the to-be-discriminated shapes reach criterion in significantly fewer trials

than do nonexposed animals. We have used this paradigm a number of times in recent years in attempts to elucidate this early-experience effect (e.g., Bennett, Anton, & Levitt, 1971; Bennett & Ellis, 1968). The basic early-experience paradigm was used in the current research, except that half of the Ss within each early-experience condition were reared in a crowded environment. In addition, differences in open-field performance and relative adrenal weights, indices normally thought to reflect emotionality, were assessed.

METHOD

Charles River albino rats served as Ss. The animals were reared in cages measuring 15 x 9.5 x 10 in. Each cage was placed in a compartment measuring 24 x 24 x 13 in. and painted flat white to provide a visually sparse environment. The opening of each compartment was 2 ft from the white wall of the room in which the animals were housed. Each of the compartments was illuminated from 7:00 a.m. until 6:00 p.m. Food and water were available ad lib.

The experiment was conducted in two stages. Stage 1 began at 21 days of age when 10 Ss were assigned to each of the four experimental conditions: (1) In Group CE (crowded/early stimulus experience) the animals were reared 10 per cage and received early experience with the to-be-discriminated forms. (2) The animals in Group CNE (crowded/no early stimulus experience) were also reared 10 per cage but did not receive early form experience. (3) Ss in Group UCE (uncrowded/early stimulus experience) were reared 2 per cage and received early experience with the to-be-discriminated shapes. (4) Group UCNE Ss (uncrowded/no early stimulus experience) were reared 2 per cage and received no early stimulus experience. For those rats receiving

early experience with the shapes, the stimuli consisted of two circles, 2 in. in diam, and two equilateral triangles, 3½ in. per side. The forms were constructed from 1/8-in.-thick black Plexiglas and were suspended from the cage ceiling by a wire, one stimulus in front of each wall.

The area of the living space was increased as the Ss matured. Initially, the wire mesh screen in each cage was fastened 5 in. from the entrance of the cage, thereby decreasing the actual living space for Ss in crowded cages and uncrowded cages to 5 x 9.5 x 10 in. Thus, in the uncrowded cages, each individual S had five times the amount of floor area as each S in the crowded cages. This distance was determined from the crowded cages. When there was just enough floor space for all Ss without any animal lying on top of another, the screen was fastened in place. All other cages were set at this distance. As the animals increased in size, the screens were moved back to allow more living space for the animals. At 58 days of age, the screens were moved from 5 in. to 8 in. from the entrance, and at 80 days of age, from 8 in. to 10 in., where they remained until the end of the experiment. This procedure allowed the animals to experience approximately the same amount of crowding as they increased in size.

At 80 days of age, the rats were placed on a 23-h food-deprivation schedule in preparation for the beginning of Stage 2 on the 90th day of age. Body weight for all Ss was recorded 1 day prior to the onset of deprivation and again on the day Ss were sacrificed. Upon entering Stage 2 of the experiment at 90 days of age, Ss were given 5 days of discrimination pretraining. Following pretraining, the rats were given a circle-triangle discrimination problem in a modified Grice discrimination apparatus (Gibson & Walk, 1956) as a test of the effects of the various rearing conditions. Details of the discrimination training procedure are described in Bennett & Ellis (1968). Ss were administered 12 trials per day until they reached a criterion of 18 out of 20 correct responses with the last 10 consecutive responses correct, or for a total of 300 trials.

To assess the effects of the various rearing conditions on emotionality, each S was given a 4-min trial in an open-field apparatus on three separate occasions: 1 day prior to the onset of food deprivation, 1 day prior to the beginning of pretraining, and 1 day after reaching criterion. The number of squares crossed, rearings, and fecal boli were recorded. Twenty-five days after discrimination training began, all Ss were sacrificed by a lethal dose of

*This research was supported by a grant from the National Institute of Mental Health (MH 20076-01). Requests for reprints should be addressed to Thomas L. Bennett, Department of Psychology, Colorado State University, Fort Collins, Colo. 80521.

Table 1
Mean Trials to Criterion on the Circle-Triangle Discrimination Task

	Uncrowded	Crowded
Experimental	114.5	59.9
Control	211.5	89.5

ether. Within 1 h after death, body weight and paired adrenal weights were obtained.

RESULTS

One CNE animal died during rearing and another S in this group was not run on the tasks due to pronounced motor impairment. The mean trials to criterion on the discrimination task for each group are presented in Table 1. A Kruskal-Wallis one-way analysis of variance by ranks indicated a significant difference between the groups ($H = 18.99$, $df = 3$, $p < .001$). Mann-Whitney U tests (two-tailed) were applied to assess the differences in trials to criterion between the groups. Overall, the preexposed Ss learned the task in significantly fewer trials than the no-early-experience Ss ($U = 103$, $df = 18/20$, $p < .05$) and the crowded Ss learned the task in significantly fewer trials than did the uncrowded Ss ($U = 47$, $df = 18/20$, $p < .002$). Group CE learned the task in significantly fewer trials than the UCE Ss ($U = 17$, $df = 10/10$, $p < .02$) and the UCNE Ss ($U = 2$, $df = 10/10$, $p < .002$). There were no significant differences between the CE and the CNE groups ($U = 29$, $df = 8/10$, $p = n.s.$). The CNE Ss learned the task in significantly fewer trials than the UCNE group ($U = 9$, $df = 10/8$, $p < .02$) but did not differ significantly from the UCE Ss ($U = 22$, $df = 8/10$, $p = n.s.$). Finally, Group UCE learned the task in significantly fewer trials than did Group UCNE ($U = 19$, $df = 10/10$, $p < .02$).

Table 2 presents measures of open-field performance, body weight, and adrenal weights (absolute and relative) for crowded vs uncrowded Ss. t tests were employed to assess differences. In the open-field test, no reliable differences between the crowded and uncrowded Ss emerged for the number of squares crossed during any 4-min testing session or for the number of rearings made in the open-field test. Since there was a total of only six fecal boli for all Ss during all open-field test sessions, this index was not analyzed. The body weights of the crowded Ss were significantly less than those of the uncrowded Ss, both 1 day prior to deprivation ($t = 7.859$, $df = 36$, $p < .001$) and on the day the animals were sacrificed ($t = 4.890$, $df = 36$, $p < .001$). There were no significant differences between the

absolute adrenal weights of crowded and uncrowded animals, but the relative adrenal weights, absolute adrenal weight/100 g body weight, of the crowded Ss were significantly heavier than those of the uncrowded rats ($t = 3.703$, $df = 36$, $p < .001$).

DISCUSSION

Analysis of the results indicated that no significant differences occurred between crowded and uncrowded Ss in terms of their open-field performances. Hence, in terms of emotionality as assessed by this behavior measure, the animals did not differ. These findings are contrary to the generally reported finding that crowding leads to decreased emotionality (e.g., Morrison & Thatcher, 1969; Taylor, 1969). It is possible that crowded vs uncrowded Ss in the present study differed in emotionality, but the open-field test was not sufficiently sensitive to reflect these differences. In support of this interpretation, previous investigations (e.g., Hunt & Otis, 1963) have found the open field to be insensitive for distinguishing between Ss that appeared to differ in their degree of emotionality. On the other hand, physiological indices suggested that the crowded animals might, indeed, have been less emotional than the uncrowded rats. The relative adrenal weights of the crowded Ss were significantly heavier than those of the uncrowded Ss. This latter finding has been found by a number of researchers to be a reliable correlate of emotionality, with emotionality varying inversely with relative adrenal weight (e.g., Morrison & Thatcher, 1969; Thiessen, 1963).

The results of the discrimination learning task were intriguing. The early experience effect was obtained, in that the preexposed animals learned the triangle-circle discrimination in significantly fewer trials than did the nonexposed Ss. In addition, crowded animals learned the task in

significantly fewer trials than did uncrowded Ss. When groups were equal in terms of their early experience with the to-be-discriminated stimuli, crowding was found to be a critical factor. The crowded preexposed rats learned the task in significantly fewer trials than did the uncrowded preexposed animals, and similarly, for the the nonpreexposed rats, the crowded Ss learned the problem in significantly fewer trials than did the uncrowded group.

A very interesting result emerged when a comparison was made of the learning rates of animals whose conditions of preexposure had been different. The group that was reared in crowded cages and not exposed to the to-be-discriminated stimuli did not differ significantly in its rate of task acquisition from the group that was preexposed to the to-be-discriminated stimuli in uncrowded cages. In fact, the nonpreexposed crowded Ss were slightly superior to the preexposed uncrowded Ss.

It is possible that the observed effects of crowding on learning and performance may have arisen indirectly through the effects of crowding on emotionality. However, the present results were inconclusive regarding the effects of crowding on emotionality. Future research, employing additional indices of emotion, will be required to elucidate this relationship.

REFERENCES

- BENNETT, T. L., ANTON, B. S., & LEVITT, L. Stimulus relevancy and transfer of perceptual learning. *Psychonomic Science*, 1971, 25, 159-160.
- BENNETT, T. L., & ELLIS, H. C. Tactual-kinesthetic feedback from manipulation of visual forms and nondifferential reinforcement in transfer of perceptual learning. *Journal of Experimental Psychology*, 1968, 77, 495-500.
- DOLGER, G. The effect of social isolation

Table 2
Open-Field Performance, Body Weight, and Adrenal Weights for the Crowding Conditions

	Uncrowded	Crowded
Open Field (Mean Number of Squares Crossed in 4 Min)		
1 Day Prior to Deprivation	86.92	86.93
1 Day Prior to Pretraining	69.20	70.78
1 Day After Criterion	88.81	97.83
Open Field (Mean Number of Rearings in 4 Min)		
1 Day Prior to Deprivation	23.00	25.93
1 Day Prior to Pretraining	21.60	20.78
1 Day After Criterion	18.13	20.89
Absolute Adrenal Weight (mg)	34.05	33.11
Relative Adrenal Weight (absolute adrenal weight/100 g body weight)	11.00	12.40
Body Weight (g)		
1 Day Prior to Deprivation	304.00	288.44
Day Sacrificed	312.45	268.11

- on the behavior of the albino rat. Unpublished doctoral dissertation, New York University, 1954.
- GIBSON, E. J., & WALK, R. D. The effect of prolonged exposure to visually presented patterns on learning to discriminate them. *Journal of Comparative & Physiological Psychology*, 1956, 49, 239-242.
- HUNT, H. F., & OTIS, L. S. Early experience and its effects on later behavior processes in rats. I. Initial experiments. *Transactions of the New York Academy of Sciences*, 1963, 25, 858-870.
- MORRISON, B. M., & THATCHER, K. Overpopulation effects on social reduction of emotionality in the albino rat. *Journal of Comparative & Physiological Psychology*, 1969, 69, 658-662.
- TAYLOR, J. The effects of population density upon correlations of emotionality and learning efficiency. *Journal of General Psychology*, 1969, 80, 205-218.
- THIESSEN, D. D. Population density, gene action, and endocrine function in behavior. Unpublished doctoral dissertation, University of California, Berkeley, 1963.