Behavior in a complex learning situation involving five stimulus-differentiated paths

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Six male albino rats were tested daily for 39 days on a five-choice multiple path elimination problem in which paths were differentially covered (by sandpaper, burlap, velure, etc.) and in which the order of elimination was not controlled in any way by the E. All Ss solved the problem, attaining the criterion much more rapidly than a parallel group had achieved such solution with uniformly surfaced wood paths. Variation in patterns of response on successive trials was characteristic of Ss while they maintained high accuracy. Strong preferences were displayed for selecting, on successive runs, paths that diverged maximally from each other.

The alternation behavior frequently observed and reported for the two-path problem (Dennis, 1939) may be considered a specific instance of a more general principle, namely, that animals, given the opportunity, will vary their behavior and tend to choose, on successive runs, paths that diverge maximally from each other. Evidence of the trend toward maximum divergence in path selection on successive runs has been obtained for three-path problems, four-path problems, and five-path problems (Lachman, 1965, 1966).

In those situations, the task for the animal was to choose successively different paths on consecutive runs; the sequence of selection was not controlled by the E. The mean number of trials was 19.4 for solving the three-path problems, 74.6 for the four-path problem, and 93.4 for the five-path problem.

In those problem situations, the paths were identical except for their positions in space. Under such circumstances, in order to solve the problem and assuming that distinctive olfactory cues were not operative, the animals were required to remember, on a given day's trial, which paths it had previously run on that day's trial and to avoid repeating such runs. It was, therefore, inferred that if the pathways could be further differentiated in terms of distinctive stimulus characteristics, learning would be facilitated. One primary purpose of the research reported here was to test that hypothesis. Another was to ascertain whether or not maximum divergence in path selection on successive runs would persist; or be eliminated in favor of a more stereotyped or systematic approach under conditions in which paths could be distinguished by an increased number of sensory cues.

APPARATUS

The apparatus consisted of five elevated pathways radiating from a circular platform 15 in. in diam. These pathways were each 5 ft long and 3 in. wide, and adjacent paths diverged by an angle of 30 deg, i.e., the five paths thus occupied a 120-deg angle. Eight inches from the distal end of each pathway, a vertical obstruction plate was mounted. A door in this plate was kept closed by a special spring weak enough to allow a rat to push through easily. The door could be locked without indication of the fact visible to the O. A small quantity of food was provided behind each door. A tunnel just large enough for the rat to squeeze through was mounted on the circular platform in such a way that it was directly in line with the middle runway, and an 8-in. platform was attached distally to the tunnel. To insure constancy of initial orientation, animals, after being placed backwards on this starting platform, were admitted to the circular choice-point platform through the tunnel. The apparatus was elevated 30 in. above the floor.

Paths were numbered, left to right, from 1 to 5. Path No. 1 was covered with masking tape, No. 2 with coarse-grained sandpaper, No. 3 with burlap, No. 4 with velure, and No. 5 with fine-grained sandpaper. These coverings served to provide a variety of cues. Not only were the paths different in terms of position, but their surface appearances were discrete, odor cues were distinctive, tactual cues were unique, and sound patterns elicited by locomotion on them were idiosyncratic. Probably different gustatory and thermal cues were also available.

SUBJECTS

Subjects were six male albino rats, all without previous research participation. All were about 6 months of age at the beginning of the research. All were handled daily and fed daily for several days before preliminary training began.

PRELIMINARY TRAINING

Before the experiment began, animals were given training in opening the doors in the obstruction plate. At first, the doors were kept fully open and the animal was placed on the path a few inches from the door and allowed to obtain food. On successive training days, the door was less and less widely opened until—by the third day—it was completely closed, so that it was necessary for the animal to exert pressure with its nose in order to open the door. Animals received an equal number of practice runs on each path.

PROCEDURE

The S was placed on the starting platform as already described. If the S chose correctly, it received food at the end of the pathway. If it chose incorrectly, it was blocked by a locked door. In either case, the animal was returned by the E to the starting point. Each door was locked after the animal had passed through it and received the food reward. Solution to the problem was choice of each path once and only once in any order on five successive runs. (Each time a S chose a particular pathway after having chosen it previously, it would find the door locked and the choice would be tabulated as an error.) The animal was allowed about 10 sec in which to eat its food at the end of each run. After the last run, it was transferred to a separate feeding table where it remained for at least 20 min. A day's trial consisted of as many runs as necessary for the animal to make five correct choices; in other words, the number of runs in a trial was equal to five correct choices plus any incorrect choices. All Ss were run for 39 trials.

THE LEARNING CRITERION

The learning criterion was: *choosing five successively different paths on each of four*

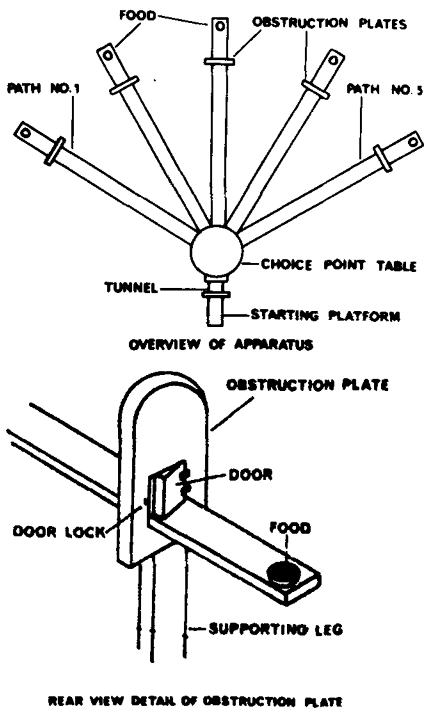

Fig. 1. Five-path problem.

Table 1

Sequences of Correct Responses for All Subjects During 39 Trials*

Degrees of Divergence	4	5	6	7	8	9	10	11
Representative Sequences	12345 54321	12354 54312	12435 45312	12534 35412	13425 23154	15342 41325	14253 52413	31524 25143
Absolute Number Choices	0	2	5	21	35	57	53	60
Weighting Factor	1/2	1/4	1/14	1/32	1/18	1/28	1/14	1/8
Degree of Preference	0	.5	.4	.7	1.9	2.0	3.8	7.5

* *One S did not complete the first trial*

successive trials. The probability of behaving in this manner as a result of random choices is less than three in a million.

RESULTS

Learning Rate

All six animals attained the criterion of learning. The best learner required 7 trials, the poorest 32; the mean number of trials was 14.7. These findings contrast with corresponding data for the undifferentiated five-path problem, in which the best learner required 35 trials, the poorest, 138 trials, and the mean number of trials was 93.4 (Lachman, 1965).

Choice Sequence: Stereotypy and Variability

Statistical treatment suggests a definite avoidance of adjacent paths and a preference by Ss for selecting pathways that diverge most from each other on successive runs; that is, there was avoidance of the sequences having minimum divergence (4 units) and strongest preference for the successions of pathways having maximum divergence (11 units), with definite preference trends in the minimum-to-maximum divergence direction for the sequences of intermediate divergence values (Table 1).

DISCUSSION

Results indicate that rats in a free-choice, five-path elimination problem with stimulus-differentiated pathways solve the problem dramatically more readily than rats confronted with the identical problem without such differential-path cues. The distributions of scores for comparable groups confronted with differentiated and undifferentiated five-path problems do not overlap. These results suggest that stimulus differentiation of the pathways markedly facilitates learning. The mean number of trials (19.4 trials) for attaining the criterion of learning on the *three-path* problem with *uniform runways* (Lachman, 1966) was greater than the mean number of trials for attaining the same criterion of learning on the *five-path* problem with *stimulus-differentiated runways* (14.7 trials).

Three aspects of these results are worthy of note: (1) Ss did not develop stereotyped sequences of response, i.e., they did not adopt any precise order or pattern of path elimination, either prior to or after attainment of the learning criterion. (2) There was a trend toward employing different response sequences to solve the problem on consecutive days, while maintaining high accuracy of performance. (3) Successive pathways selected in any given pattern (or day's trial) tended to diverge maximally, i.e., the Ss tended to select on a given run a pathway which was maximally different in terms of spatial orientation from the pathway chosen on the immediately previous run.

These results are in harmony with results of previously reported research on undifferentiated multiple-path problems involving three, four, and five paths (Lachman & Brown, 1957; Lachman, 1965, 1966).

The results are also consistent with and support the idea that there is a need for stimulus variability. Apparently, there is something inherently attractive about a *change* of stimulus. Perhaps the organism, given the opportunity, displays an innate preference for a change in stimulus and tends to search for it; such an innate preference is accommodated by this kind of learning situation.

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Chemical changes in the rat brain following escape training

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Sprague-Dawley albino rats were given maze exploration and escape training in a straight-runway maze. Ss in Control Group 1 were given only maze exploration, and those in Control Group 2 had no maze experiences. Half the Ss from each of the groups were sacrificed immediately, and the remainder were sacrificed 2 h after completing training. The brains were analyzed for protein, RNA, and total nitrogen. A significant increase in brain protein was found for the 2-h sacrifice escape condition. Moreover, estimates of NPN (nonprotein nitrogen) were significantly lower in this experimental condition.

In previously reported donor-recipient transfer experiments with rats (Kleban, Altschuler, Lawton, Parris, & Lorde, 1968; Altschuler, Kleban, Gold, & Lawton, 1968), we found an increase in the amount of brain protein following shock-escape and shock-avoidance training conditions. This increase was found in the donor brain extract. The present experiment is an attempt to determine the effect of sacrifice time interval (immediate vs delay) on brain protein synthesis following training. Brain RNA and total nitrogen were also analyzed.

METHOD

The experimental apparatus was a straight-runway, shock-escape maze. The start box and stem, 26 in. long, was painted flat black and had a grid floor. The goal box, 16 in. long, was painted flat white and had a wooden floor. [Refer to Kleban et al (1968) for a more complete description of the apparatus.]

The Ss were 72 female Sprague-Dawley albino rats between 60 and 75 days of age. The animals were assigned randomly to six cells in a 3 by 2 design situation. There were three behavioral conditions: (1) shock-escape training, (2) exploration experience (Control Group 1), and (3) no