Maze alternation in the planarian, *Dugesia tigrina*¹

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Abstract

600 planarians (*Dugesia tigrina*) made 0, 1, 2, 3, 4, or 5 forced 90° right-hand turns immediately before reaching a T choice point. There were 100 Ss in each of 6 groups, and each S was given one trial only. The proportion of Ss that turned left at the choice point increased with the number of forced 90° right turns preceding the choice point. The proportions ranged from .43 to .76.

Problem

Recent studies have investigated alternation in the maze behavior of paramecia, planarians, and meal worms, using a one-trial technique in which S proceeds along a groove or channel, turning through one or more forced 90° turns in the same direction, and finally arriving at a T where its choice is noted. In those studies with positive results, the general finding is that experimental Ss tend to turn in the direction opposite from the forced turns preceding the choice point, while control Ss (no forced turns preceding the choice point) show no bias in their choice-point behavior. Lepley & Rice (1952) tested paramecia (*Paramecium multimicronucleatum*) and found a significant proportion of opposite turns after either one or two forced turns. Lachman & Havlena (1962) tested paramecia (*P. caudatum*) in mazes providing from 0 to 9 forced 90° right turns, and obtained results strikingly different from those of Lepley and Rice; behavior at the choice point did not differ significantly from chance expectancy in 9 of the 10 groups. The discrepancy in the results of these two experiments may have been due to major apparatus differences: e. g., the channels in the Lachman and Havlena mazes were 3 times as wide as those in the Lepley and Rice mazes, and ended in a Y rather than a T choice point. Rice & Lawless (1957) repeated the Lepley and Rice experiment, using planarians (*D. dorotocephala*) as Ss. They found that choice-point behavior did not differ significantly from chance expectancy in any experimental group. Grosslight & Ticknor (1953) studied the maze behavior of meal worms (*Tenebrio molitor*), and found that after one forced turn, the proportion of opposite turns varied inversely with the distance between the forced turn and the choice point, and also that the proportion of opposite turns was greater in a two-forced-turn group than in the groups given one forced turn. Jensen (1960) has argued that these data may be explained most parsimoniously by the combined effects of centrifugal swing and thigmotaxis. However, Grosslight & Harrison (1960) repeated part of the experiment, using a maze channel which formed

a deep V in cross-section, and obtained results very similar to those of Grosslight and Ticknor. Since Ss traversing the maze were in continual contact with both walls, the possibility of centrifugal swing or differential thigmotaxis was effectively ruled out.

The purpose of the present experiment was to study the choice behavior of planarians, using an increased range of forced turns.

Method

The Ss were 600 naive planarians (*D. tigrina*), averaging about 1 cm in length. The apparatus (Fig. 1) was a maze, milled into the face of a block of clear Lucite. The maze channel was semicircular in cross-section, .75 mm deep in the center and 1.5 mm wide at the top. Illumination was provided by two 17-in 15-w white fluorescent bulbs, centered 12 in above and parallel to the arms of the T. The maze rested on a level white surface.

Planarians were maintained in a covered pan and introduced individually into the maze. There were 6 groups, with 100 Ss in each group. The Ss in group 1 were placed in the first leg of the maze, facing towards the choice point, and thus constituted a control group to test for any turning preference due to mechanical imperfections in the T maze, differences in illumination, faulty leveling, etc. The Ss in groups 2 through 6 were placed in the second, third, fourth, fifth and sixth legs of the maze, respectively. Thus 600 planarians were tested individually, 100 in each of the six conditions: 0, 1, 2, 3, 4, and 5 forced 90° right-hand turns preceding the T choice point. At the choice point, S traveled .5 cm along the left or right arm of the T, after which it was removed and its choice recorded. Some Ss attempted to turn around in the maze before reaching the choice

Fig. 1. Maze apparatus.

Table 1. T choice-point behavior of *D. tigrina* after forced right turns

Group	N	Number of forced 90° right-hand turns preceding choice point	Number of Ss that turned left at choice point
1	100	0	43
2	100	1	57
3	100	2	63
4	100	3	65
5	100	4	65
6	100	5	76

point. When this occurred, the rounded end of a glass rod was used to force S to continue along in the proper direction. Animals that refused to move, or repeatedly attempted turning around, were discarded.

Two additional control procedures were used: (1) all 0-turn Ss were run first, after which on any particular day the same number of Ss was tested in each of the forced-turn groups, and (2) within each group, half of the Ss were tested with the T maze pointing away from E, and half were tested with the maze pointing towards E.

Results and Discussion

The results appear in Table 1. The number of planarians that turned left at the choice point increased with the number of forced 90° right turns preceding the choice point. Chi-square tests showed that the proportion of left turns exceeded chance expectancy in groups 3, 4, 5, and 6 ($p < .01$), and did not differ significantly from chance expectancy in group 1 (the 0-turn control group) or in group 2. Additional 2 x 2 chi-square tests showed (1) no significant association in any group between response (left or right) and orientation of the maze (choice point facing towards or away from E), and (2) no significant difference in any group between the responses of Ss that attempted turning while traversing the maze, and were turned back, and the responses of Ss that did not.

During all trials the level of water in the maze, channel remained low, with a concave meniscus. Also, the width of the channel was nearly equal to the average width of the planarians. These arrangements prevented S from deviating appreciably from the center of the channel, and ensured that S's contact with the walls of

the channel was nearly equal on both sides. Finally, the rate at which the planarians traversed the maze was clearly insufficient to generate centrifugal tendencies affecting progress at the forced turns. From these considerations, it may be concluded that the data in Table 1 are not explained by centrifugal swing and thigmotaxis. Evidently, an explanation is required in terms of stored or persisting effects of the forced turns.

It may be noted that the present data do not agree with the results of Rice & Lawless (1957), who used planarian Ss and failed to obtain significant differences in left and right turns. Since the largest effects in the present experiment occurred with greater numbers of forced turns, however, it is possible that Rice & Lawless would have obtained positive results had they extended the number of forced turns beyond two.

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Notes

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