Alternation in the fruit fly, *Drosophila melanogaster*[1]

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One hundred fruit flies were individually tested in a modified T maze. Each S made two successive 90 deg turns, the first one forced and the second one free or unrestricted. A significantly large proportion of the Ss alternated by turning right at the free turn if the force had been left and vice versa.

Alternation has been commonly observed in rats (Dember & Fowler, 1958) and humans (Schultz, 1964). In many of the rat studies, an individual animal is given two successive trials in a one choice point maze. The tendency to enter a different maze arm on each trial is labelled alternation. In studying alternation in Drosophila melanogaster, Murphy (1965) deviated from this procedure by simultaneously testing large numbers of flies and by using a six choice point maze. Murphy concluded that "The present population of flies was more apt to exhibit stereotypy than alternation behavior under each of the four conditions taken separately" (p. 199). The conditions to which he referred included testing flies in a brightly lit apparatus and in total darkness.

In the present experiment flies were tested individually in a maze where a forced turn was followed by a nonforced or free choice turn. In addition, the effects of long and short term exposure to illuminated and dark environments were studied.

SUBJECTS AND DESIGN

Fruit flies, vestigial winged Drosophila melanogaster, were bred from the stock maintained by the Department of Biology at the University of Victoria.[1] Half the population were raised to maturity in a well lighted laboratory in which the light-dark cycle paralleled the day-night cycle for the month of February. The remaining half were raised to maturity in a light proof container and exposed to dim illumination for an average of 2 min each day throughout their development. Fifty Ss were randomly selected from each rearing condition for testing which began seven days after the first S reached maturity.

One half of the dark reared and one half of the light reared Ss were exposed to 30 ft-c of light for a period varying from 1-1/2 to 4 h prior to testing. The remaining Ss were dark exposed in light proof capsules for identical time periods.

APPARATUS

The maze, shown in Fig. 1 was constructed from a 2-in. cube of transparent lucite. Four holes, 3/16 x 2 in. were drilled through the cube to provide maze pathways. Three of these holes were parallel (1/2 in. center to center) and were bisected by the fourth at 90 deg. The pathways were translucent, diffusing the light.

Translucent vinyl plugs, cut to the contours of the choice point, were inserted through the openings on the middle pathways allowing the choice points to be blocked. Manipulations of the plugs permitted a forced turn at the first choice point T_1, and an unrestricted choice of a right or left turn at the second choice point T_2.

The sides of the cube were fitted with black paper which had holes cut to the dimensions of the openings in the maze. A frame of this material, 1/4 in. wide, edged the top surface of the maze. The bottom surface of the maze was left uncovered.

The maze was placed on a clear Plexiglas platform which was raised 8 in. above a table surface. A magnifying mirror lay on the table surface directly beneath the maze enabling E to observe S's performance. To provide even illumination throughout the maze, a 15 A, 125 V ac, 1/10 W General Electric electroluminescent lamp, 2 in. x 1-3/4 in. was fitted to the top surface of the maze, its edges covering the black paper frame.

The experimental room was windowless and dark except for the short-term light exposure chamber, which was well shielded from the maze area. The light intensity in the exposure chamber was 30 ft-c. For short-term light-dark exposure Ss were housed in 25 capsules which consisted of 2 in. lengths of translucent 1/8 in. ID vinyl tubing. A small brass rod was forced into the midpoint of the tube forming two equal compartments and the surface area of one of these was covered with black plastic electricians' tape. Light proof metal caps covered the ends of the exposure capsules.

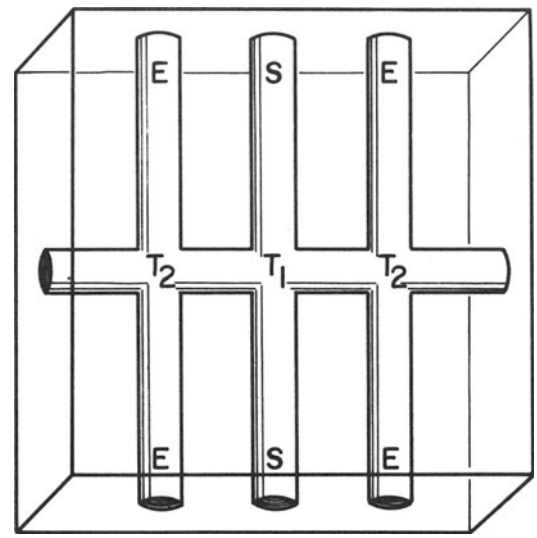

Fig. 1. Top view of maze embedded in Lucite showing starting point (S), forced choice turn (T_1), free-choice turns (T_2) and exits (E).

PROCEDURE

All Ss were tested within a two-day period, the dark reared Ss on Day 1 and light reared on Day 2. Beginning at noon and working in a light intensity of 30 ft-c, Ss were placed in either the dark or light compartment of the exposure capsules which were then placed in a shielded light chamber for a minimum of 1-1/2 h prior to testing.

Ss were tested in tandem pairs, the short term light exposed S first and the short term dark exposed partner remaining in the dark compartment until completion of the trial of its capsule mate the preceding S. An average of four Ss in each experimental group died in the adaptation capsules or escaped before they could be placed in the maze and were replaced with healthy Ss from a reserve maintained in identical experimental conditions.

When S entered the maze, a vinyl plug was inserted into the starting point to prevent escape. Following the forced turn, the forced choice plug was pushed through the T_1 choice point to prevent retracing. After making the nonforced turn, a puff of air blew S from the maze. The direction of the forced turn and side of maze used as starting point were counterbalanced across treatment conditions.

Table 1
Frequency of Alternation in Four Experimental Groups and for Total Sample Tested

Rearing Illumination	Short-term Illumination	f/25	p* (one-tailed)
Dark	Dark	17	.054
	Light	18	.022
Light	Dark	18	.022
	Light	18	.022
Total		71/100	.0001

**binomial test applied to individual groups and z applied to total*

A record was kept of whether S's turn at T_2 was in a different (alternation) direction from the forced turn at T_1.

RESULTS AND DISCUSSION

The number of Ss which alternated in each group of 25 is shown in Table 1. Frequency of alternation appeared to be independent of long-term dark or light exposure and independent of short-term dark or light exposure. However, pooling the data for the four groups, one finds that 71 of the 100 Ss alternated ($z = 4.2$, $p < .0001$).

The present experiment demonstrates that Drosophila do alternate when tested individually and given a forced turn prior to a nonforced turn. However, no attempt was made to test any of the several theoretical explanations of alternation phenomena which have been discussed by Dember (1961), O'Connell (1965) and others.

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NOTE

1. The authors gratefully acknowledge the technical assistance of Mrs. Mary Dennis, Department of Biology, University of Victoria.