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Spontaneous alternation as a function of number of forced-choice responses in the goldfish (*Carassius auratus*)

FREDERICK G. FIDURA* and MARK R. LEBERER†
State University of New York, College at Geneseo, Geneseo, New York 14454

This experiment assessed the role of the number of forced-choice trials on spontaneous alternation in the goldfish. Goldfish were forced to the preferred reinforced arm of a T-maze for 1, 5, 7, 10, or 15 trials. Following these forced-choice trials, the direction of turn on a free-choice trial was recorded. The likelihood of alternation was found to be a function of the number of previous forced-choice trials. The similarity of the functional relationship found in this experiment was related to that found in similar experiments using other species as Ss.

Spontaneous alternation, a behavioral phenomenon found in two-choice experimental situations such as T- or Y-mazes, usually refers to S's tendency not to repeat the response made on the previous trial (Dember & Fowler, 1958). While alternation behavior can be seen in any choice situation, it can be seen most clearly in experiments where a free-choice trial follows some number of forced-choice trials to one arm of a maze (Dember & Fowler, 1958; Denny, 1957; Denny & Leckart, 1965). In a number of forced-choice experiments, the likelihood of alternation has been shown to be an increasing function of the number of forced-choice trials (Denny, 1957; Denny & Leckart, 1965). The potency of spontaneous alternation is indicated by the experimental finding that alternation phenomena appear even when the forced trials have been reinforced (Dember & Fowler, 1958).

The literature on spontaneous alternation in the rat is extensive, including at least one experiment which attempted to isolate the stimulus and response variables causing alternation (Douglas, 1966). Douglas concluded that alternation in rats is based on a relatively weak odor-trail avoidance tendency interacting additively with a much more powerful tendency to turn in a direction spatially opposite the previous turn at a choice point. Evidence for spontaneous alternation in vertebrate species other than rats is meager and equivocal (Dember & Fowler, 1958). The data on alternation behavior in various species of birds is especially confusing. Using chicks as Ss, Hayes and Warren (1963) failed to find alternation behavior in a Y-maze. And while Thompson, Estell, and Loomis (1965) found some evidence of alternation in Japanese quail (*Coturnix coturnix japonica*), Farris (1964), using the same Ss in both a free- and forced-choice T-maze situation, with and without reinforcement, actually found evidence for the opposing process of perseveration. The experimental designs of these last two experiments were somewhat different, particularly in regard to the pattern of free- and forced-choice trials, which may account for the contradictory findings.

Fewer studies appear on alternation behavior in invertebrate species. An experiment by Leply and Rice (1952) and another by Grosslight and Ticknor (1953) found that for paramecia and mealworms, the probability of a turn in a particular direction at a choice-point was a function of the direction of the previous forced turn. Such manifestations of spontaneous alternation in invertebrate species tend to be quite reliable (Dember & Fowler, 1958). Aderman and Dawson (1970) compared alternation behavior in goldfish and planaria following five forced turns in a five-segment continuous maze. The distance between the five forced turns was gradually increased or decreased. For both species, alternation was not seen under conditions where the distance between the forced turns was progressively incremented. Where the distance between the forced turns was progressively decremented, however, both planaris and goldfish showed a significantly reliable tendency to alternate (Aderman & Dawson, 1970).

While spontaneous alternation in rats has been shown to be a function of the number of forced-choice trials (Denny, 1957; Denny & Leckart, 1965), little data is available concerning the role of this variable in most other species. The reliability of alternation phenomena (Dember & Fowler, 1958), including the finding that alternation often means turning away from reinforcement, suggests a relatively potent behavioral process. This study assessed alternation behavior in the goldfish (*Carassuis auratus*) as a function of the number of forced-choice responses to one arm of a T-maze.

METHOD

Subjects

The Ss were 50 goldfish (*Carassius auratus*), varying in size from 3.8 to 8.9 cm (1-1/2 to 3-1/2 in.). They were housed in a 75-liter (20-gal) aquarium prior to the experiment and were

*Reprint requests should be sent to Frederick G. Fidura, Department of Psychology, State University College, Geneseo, New York 14454.
†Now at the Department of Psychology, University of Mississippi.

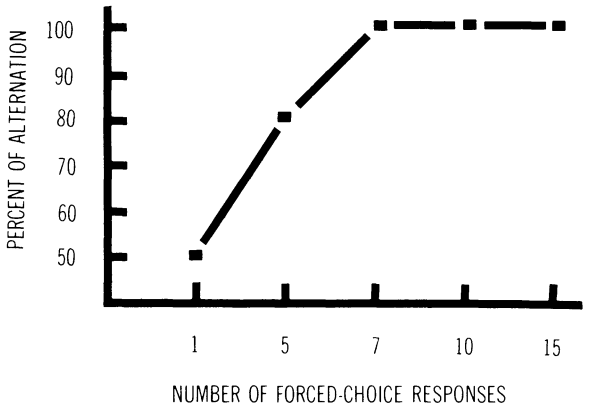

Fig. 1. Percentage of alternations on the free-choice trial as a function of the number of previous forced-choice trials.

deprived for 24 h in a 19-liter (5-gal) aquarium prior to the experimental session.

Apparatus

A T-maze, constructed out of 3/8-in (.95-cm) wire mesh, was submerged into 7.6 cm (3 in.) of water contained in a gray tray with sides 96.5 cm (38 in.) long and 12.7 cm (5 in.) deep. The approach stem of the maze was 53.9 cm (22 in.) long, with 25.4-cm-long (10-in.-long) arms, all 7.5 cm (3 in.) wide and 10.2 cm (4 in.) deep.

Procedure

The Ss were assigned randomly to one of five groups of 10 Ss each. Preliminary training for all groups consisted of 30 min free exploration of the two arms with the approach stem of the T-maze blocked off. Following this exploration period, Ss received one nonreinforced free-choice trial in which position preference was recorded. Each S then received 1, 5, 7, 10, or 15 forced-choice reinforced trials to the preferred side of the maze. Following the forced-choice reinforced trials, all Ss received one free-choice trial on which the direction of turn was recorded.

Reinforcement in all groups consisted of 40 tubifex worms delivered with an eye-dropper. All the experimental procedures were completed during a single experimental session. All filtering and aeration of the maze water took place at times other than during the experimental sessions.

RESULTS

The percentage of alternations (turns to the arm opposite the forced-choice arm) on the free-choice trials as a function of the number of previous forced-choice trials is shown in Fig. 1. As the figure shows, with one forced trial, choice-point behavior was at chance level ($\chi^2 = .10$, df = 1, n.s.). While, with five forced trials, the percentage of alternations increased to 80%, this percentage did not differ significantly from chance ($\chi^2 = 2.5$, df = 1, n.s.). For 7, 10, and 15 forced-choice trials, the percentage of alternations increased to 100% and differed significantly from chance ($\chi^2 = 10.1$, df = 1, $p < .005$). Aside from the statistical analysis, the regularity and negatively accelerated ascending nature of the function should be noted.

DISCUSSION

As in the Aderman and Dawson (1970) experiment, the results of this study suggest that goldfish do exhibit spontaneous alternation when forced to one arm of a T-maze for a sufficient number of trials. Further, this tendency to alternate appears to be an increasing function of the number of forced trials, the same functional relationship found in rats by Denny (1972) and Denny and Leckart (1965). In light of the fact that alternation in this experiment meant turning away from the reinforced and preferred side, clearly, the tendency to spontaneously alternate appears to be a potent one. On the other hand, allowing the two variables of reinforcement and position preference to operate selectively against the tendency to alternate probably accounts for the difference between the minimum number of trials required for alternation in this experiment (7) and the Aderman and Dawson (1970) study (5).

Finally, Denny (1957) and Denny and Leckart (1965) have noted both the same functional relationship and the significant strength of the alternation tendency in rats. While the direct comparison of widely divergent species is inappropriate, the similarity in the functional relationship found both in this and the above papers, supports the view that spontaneous alternation may have the phyletic generality of other behavioral variables such as learning and habituation.

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