PSYCHOLOGY

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The Effects of Exploration and Test Frequency on Maze Learning[1, 2]

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Introduction

Thorndike (4) demonstrated that common *Fundulus* with 6 to 8 trials a day took less time moving and hunting through a maze after a period of time with a food reinforcement placed in the shady half of an aquarium. Either one partition or three partitions with a single opening and of wood, glass, or wire construction were used. No quantitative data were reported.

Goldfish (*Carassius auratus*) were studied in a maze with one trial per day where the aquarium had two partitions each with one opening 2.5 cm. square (1). A 40-watt lamp was suspended over the maze aquarium, and food reinforcements cut in 4 mm. squares were used. Fish were maintained in individual pens and elapsed time was measured from the moment they were placed in the aquarium until they touched the reinforcement. The elapsed time was reduced quickly after 5 to 10 days. Partitions of wire mesh alone or wire mesh where the opening was banded with black 2.5 cm. wide were negotiated faster initially than ones of unpainted wood. After learning, however, the wooden or banded mesh partitions were passed more quickly than wire mesh ones. This led Churchill to conclude that sight was important in learning in goldfish.

Welty (5) allowed his goldfish to become accustomed to the maze aquarium with one screen partition and a simple opening 7.5 cm. in diameter by housing them in it for 7 days. After the preliminary period they were kept in the rear compartment. Goldfish were tested daily by opening the gate in the partition and simultaneously turning on a red light. As soon as a fish went through the opening, the food reinforcement (piece of earthworm) was placed in the appropriate part of the front compartment. A maximum reduction in elapsed time from the opening of the gate to the taking of the reinforcement was reached after 6 or 7 days.

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The present experiment was devised to test the effects of exploration (familiarization) and frequency of testing on learning ability since prior work had not investigated these variables.

Materials and Methods

This experiment was designed as a 2 x 2 factorial trial testing aquarium familiarization versus naivete and one trial versus two trials per day.

The 40-liter aquarium was 51.2 x 26.9 cm., with the water height maintained at 18.0 cm. The partition was placed 34.0 cm. from the end where the reinforcement was to be placed. A 3.8 cm. red circle was painted on the end window equidistant between sides and 1.3 cm. from the bottom. The green plexiglass partition (0.3 cm. thick) had a 3.8 cm. hole in the same relative location as the red target. The aquarium was placed on a table by a window with a southern exposure and fluorescent lights were left on in the room during all tests. A cardboard shield was placed completely around the aquarium to a height of 20 cm.

Twelve goldfish (*Carassius auratus*) 4.5 to 6 cm. long were divided at random into individual gallon stock jars (15 cm. diameter with water height at 19 cm.) and to treatment. Each jar was aerated through a standard bluestone aerator. Three fish died during the familiarization (exploration) period reducing the test fish to nine. One-half of the fish were experienced to the aquarium for 7 days (omitting day 5) once daily by placing them individually in the tank. The partition was not in location in the water during this treatment. As the fish was placed in the water a portion of rolled oat was dropped in the opposite end beneath the red target. Elapsed time from placement in water to touching the reinforcement was measured. The remaining fish (naive group) were given an equivalent amount of rolled oat in the stock jar.

Whole rolled oats were used as a reinforcement. During the two periods the amount varied from ½ to 1 rolled oat with all fish being treated similarly on a given day. Fish being tested once daily were given another portion in the stock jar to approximately the amount received by those tested twice daily. The goldfish were purchased locally and knowledge of their prior feedings was not known. The fish were not starved and the daily oat reinforcement was their only food source.

At the end of the familiarization period the partition was inserted and the same procedure followed for six days on all fish except that half were run through the maze twice daily, one trial immediately after the other.

Results and Discussion

The five surviving fish during the familiarization phase learned quickly to swim from the release point to the reinforcement. On the first day the elapsed time averaged 3.7 minutes, but by the second day this was reduced to 0.8 minutes and the third day to 0.5 minutes. Over the remainder of this phase the average varied from 0.2 to 0.6 minutes.

The elapsed time during the six test days is presented in Table 1.

TABLE 1

Time from release to reinforcement—by day (summated mean values)

Day	Familiarized	Naive	Once Daily	Twice Daily
	Minutes			
1	4.3	12.2	6.0	9.2
2	2.7	4.1	4.7	2.4
3	0.9	3.4	3.0	1.5
4	0.5	0.8	0.5	0.7
5	1.1	3.5	3.6	1.4
6	1.4	0.8	0.6	1.5

The numbers of fish in each mean in Table 1 are 5, 4, 5, and 4, respectively. The data were analyzed statistically by the analysis of variance (3) as a 6 x 2 x 2 factorial trial with 6 days, familiarized or naive, and once daily or twice daily tested fish. The results are shown in Table 2.

TABLE 2

Analysis of variance of data from Table 1

Main Effect	df	Mean Square
Times daily (T)	1	1.41
Familiarized (F)	1	103.22*
Day of test (D)	5	90.66**
First Order Interactions		
TXF	1	49.30
TXD	5	13.89
FXD	5	28.51
Second Order Interaction		
TXFXD	5	2.81
Error	54	20.40

* Probability <0.05.
** Probability <0.01.

This indicates that differences due to previous familiarization with the test aquarium and day of test were statistically significant whereas number of trials per day was without effect. The Duncan multiple range test (2) indicated the difference in test day was between day 1 and subsequent days. The data did not appear to change this sharply after the first day.

Analysis of variance between elapsed times of familiarized and naive fish on a given day, or once daily versus twice daily trials on a

given day, showed no significance. In the former case this was due to lack of numbers as indicated by the results of Table 2.

Elapsed time was also studied per trial as opposed to per day. This means that an attempt was made to equate the second trial on day 1 for the two times daily group to day 2 of the once daily fish, etc. The data (summated means) are given in Table 3.

TABLE 3

Time from release to reinforcement—by trial (summated mean values)

Trial	Familiarized	Naive	Once Daily	Twice Daily
	Minutes			
1	4.1	13.5	6.0	11.1
2	3.5	8.7	4.7	7.2
3	1.6	4.1	3.0	2.3
4	1.5	1.3	0.5	2.6
5	1.1	5.1	3.6	2.0
6	0.9	0.7	0.6	1.0

Analysis of variance was applied to the crude data again as a 6 x 2 x 2 factorial trial. No differences were statistically significant. Analysis of variance by days was carried out as well with negative results. When trials 1, 2 and 3 were combined and tested, the difference between familiarized and naive fish was statistically significant. A combination of days 4, 5 and 6 was not significant.

Testing fish twice daily as compared to once daily appeared to be ineffective whether considered as a comparison by days or by trials through the maze. It seems reasonable to project that the difference in testing (once versus twice daily) is an inadequate one, and another group should have been tested many times per day.

Prior familiarization with the test aquarium (even with the partition removed) was of importance particularly in the first few test days when elapsed time was changing relatively rapidly. After three days any difference had disappeared.

Elapsed time decreased over the test period as in the work of Churchill (1), Thorndike (4), and Welty (5). In this study with a limited number of fish the statistically significant decrease appeared between days 1 and 2. Larger numbers might well alter this observation and yield a smoother curve.

The experienced fish showed considerable exploratory behavior on test day 1 in contrast to the naive group. Elapsed time was also measured from the time the fish went through the partition hole until they touched the reinforcement. The familiarized and naive groups averaged 0.1 and 1.0 minutes, respectively, but this elapsed time was quite variable and due to a relatively few individual observations.

Summary

Twelve goldfish (*Carassius auratus*) 4.5 to 6 cm. long were randomly allotted in a 2 x 2 factorial study testing prior exploration with the test aquarium versus naivete and once versus twice daily testing. The nine surviving fish were placed in one end of an aquarium and required to swim about 17 cm. and pass through a 3.8 cm. hole in a plexiglass partition and swim an additional 34 cm. to a food reinforcement. Elapsed time in the aquarium was measured. The difference in elapsed time between familiarized and naive fish was statistically significant ($P < 0.05$). This difference was most pronounced during the first three days. Testing twice daily as compared to once daily was without statistical significance. The differences in elapsed time per day over a six-day test period were statistically highly significant ($P < 0.01$). The only statistically significant difference was between days 1 and 2, but an increase in the number of experimental fish would in all likelihood alter the shape of the response curve.

Literature Cited

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