Conditioned Reinforcement in the Goldfish

Abstract. Goldfish were trained to press a lever on a 10:1 fixed-ratio schedule of reinforcement. They were extinguished under three conditions. Responding was followed by (i) solenoid noise and water delivery formerly associated with food reinforcement, (ii) solenoid noise only, or (iii) nothing. The number of extinction responses was largest in condition 1, less in condition 2, and smallest in condition 3, thus providing evidence for conditioned reinforcement in goldfish.

There has been a resurgence of interest in the comparative study of conditioning. Bitterman (1), who contributed much in this area, suggested that the role of the brain can be effectively studied by comparing learning in different species. Therefore, the process of conditioned reinforcement in the fish has been investigated to see whether the fish, like the rat, can be controlled by conditioned reinforcement.

A conditioned reinforcement is a stimulus which acquires its reinforcing attribute through the process of conditioning, whereas a primary reinforcement, such as food, does not depend on conditioning history. Conditioned reinforcement is a central concept in many theories of behavior (2); it allows many kinds of stimuli to control the behavior of animals.

In our experiments, six goldfish (Carrasius auratus, 12 to 16 cm long), were conditioned in the following manner. Each fish was housed individually in a 10-liter tank with a filter. During the experiment a target was placed inside the tank. The response consisted of striking the target and displacing it approximately 0.3 cm; the displacement of the target closed the switch and activated a worm-dispenser that dropped tubifex worms into the tank right over the target (3). Each time a worm was dispensed, there was a noise produced by the solenoid, and the water and worm were dropped from an eye dropper into the tank. The noise of the solenoid was used as one potential conditioned reinforcer, and the combination of noise and water was used as the other potential conditioned reinforcer.

The fish were initially fed about 75 worms each in their home tanks every 2 days for 2 weeks. After they had learned to strike the target, the fish were reinforced continuously, and then they were gradually brought up in ratio so that ultimately they had to make ten responses for every worm. Each fish was given 75 reinforcements per session; each experiment took place every 2 days at approximately the same time of day. All fish responded on the 10 to 1 schedule by the third session. After seven sessions of conditioning, the fish were put on extinction. Two fish were extinguished with every tenth response followed by the solenoid noise and the delivery of water through the eye dropper; two fish had every tenth response followed by the solenoid noise only; the last two fish received no feedback at all, that is, neither the solenoid noise nor the water delivery. The extinction periods were continued until the fish reached a criterion of 10 minutes of no response. Thirty minutes after the end of each extinction period (each extinction period lasted 45 minutes) the fish were fed 75 worms. The extinction sessions occurred every 2 days.

The results showed the following: the two fish receiving noise and water after every tenth response in extinction took 25 and 26 sessions to reach criterion; the two fish receiving only noise after every tenth response required 9 and 17 sessions to reach criterion; and the two fish receiving neither noise nor water took 15 and 4 sessions to reach criterion. The relatively rapid and immediate drop in response rate in the group receiving no feedback at all for responding (Figs. 1 and 2) differs from

![Fig. 1. Cumulative number of responses for one fish in the course of the last conditioning session before extinction and the first extinction session. The subscripts refer to the order in which the fish was run through the three different conditions. C, conditioning; E, extinction; N, noise; NW, noise and water; O, nothing. The downward "blips" indicate the receipt of food under the C condition, the noise under the EN condition, and the noise and water under the ENW condition.](image-url)
extinction data for other animals, perhaps because the fish receives less feedback for responding than the pigeon which at least hears the noise of the peck, or the rat which at least hears the noise of the bar hitting a contact. In our experiments the fish is in a sound-attenuated cubicle, and there is almost no feedback for simply hitting the target except the proprioceptive stimulation from contact with the target.

Three of the fish were run through all three conditions of extinction. They took a mean of 6.7 sessions to extinguish under the condition without feedback, 5.0 sessions with noise reinforcement, and 13.7 sessions with noise and water reinforcement. (The other three fish died before they could be run through the remaining conditions.) The fish were reconditioned after each extinction period for 7 sessions, as in the conditioning sessions. Figures 1 and 2 show the last conditioning session and the first extinction session for each type of extinction. Although the three conditioning rates (C₁, C₂, C₃, Fig. 1) are similar, the rate of extinction is already different in the first extinction session (E₁, E₂, E₃, Fig. 1). Figure 2 shows the fish that was extinguished in an order opposite to that of the fish in Fig. 1. The rates of extinction in the different conditions within the fish shown, as well as in the third fish (not shown), are in the same order as the group results presented above.

One fish (Fig. 2) was reconditioned with worm reinforcement and then extinguished without feedback. Subsequently, it was again put into the noise-and-water reinforcement condition. The noise and water (Fig. 3, curves ENW) acted as a reinforcer and gradually increased the rate of response from that achieved after extinction with no feedback (Fig. 3, curves EO).

As a final control, an attempt was made to shape striking of the target in two naive goldfish by using the noise and water stimuli (without the worms) as reinforcers. Neither fish struck the target, a result invalidating the interpretation that the noise-and-water stimulus by itself acts as a sensory reinforcer of some kind.

Our data demonstrate that the goldfish can acquire a conditioned reinforcer by a procedure quite similar to that used with other animals (2). In this respect the goldfish does not differ from other animals higher on the phylogenetic scale.

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References and Notes
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