ceived the drug for 11 consecutive days.

Whether or not treatment with *p*CPA may be applied to the problem of human alcoholism is unknown, especially because of the difficulty inherent in postulation of an animal analogue to the human disease state (*13*). It would be premature to infer that *p*CPA would have some value in ameliorating the causal factors related to human imbibition, including social, psychological, and possible metabolic defects associated with the abnormal intake of alcohol. However, our findings do suggest that restoration of normal neurochemical function in an organism that drinks alcohol excessively, regardless of the etiology of an aberrant drinking pattern, may now be within the realm of possibility.

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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

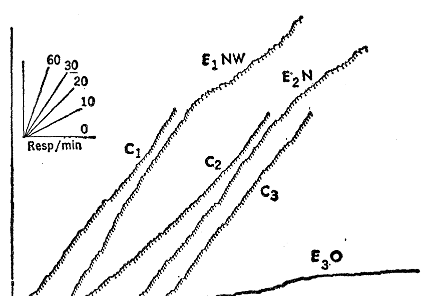

Fig. 1. Cumulative number of responses for one fish in the course of the last conditioning session before extinction and the first extinction session. The subscripts refer to the order in which the fish was run through the three different conditions. *C*, conditioning; *E*, extinction; *N*, noise; *NW*, 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.

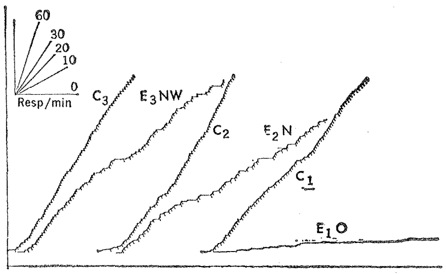

Fig. 2. Cumulative number of responses for one fish in the course of the last conditioning session before extinction, and the first extinction session. The subscripts refer to the order in which the fish was run through the three different conditions. Abbreviations as explained in Fig. 1.

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 (C_1, C_2, C_3, Fig. 1) are similar, the rate of extinction is already different in the first extinction session (E_1, E_2, E_3, 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.

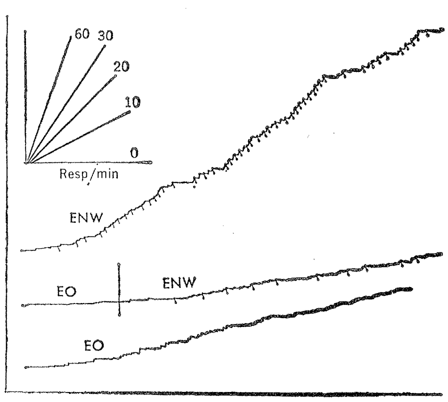

Fig. 3. Cumulative number of responses for a fish starting under conditions of extinction with no feedback at all (*EO*) and proceeding to conditions in which every tenth response is reinforced by the noise and water (*ENW*). The delivery of noise and water is indicated by the downward "blips."

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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Dimethyl Sulfoxide: Breakdown of Blood-Brain Barrier?

Brink and Stein (*1*) have found that the levels of radioactivity in the blood and brain of rats injected intraperitoneally with ^{14}C-pemoline (^{14}C-PIO) dissolved in dimethyl sulfoxide (DMSO) were about twice as high as those given the labeled material suspended in 0.3 percent tragacanth. These authors attributed the increased levels of radioactivity found in the brains of animals treated with DMSO "to a partial breakdown of the blood-brain barrier" induced by DMSO "within the first 30 minutes." However, whether the higher brain levels of radioactivity found in the animals treated with ^{14}C-PIO in DMSO are anything more than a reflection of the increased blood levels may be questioned on the basis of the data presented.

From the data reported by Brink and Stein it may be calculated that at 30 minutes after injection the radioactivity in the blood of DMSO-treated rats was 25.8 times higher than that found in the brain, whereas the analogous value in the group treated with tragacanth was 31.6 times higher. Since the ratio of the former value (25.8 times) to that of the latter (31.6 times) is less than 1.00, namely 0.817, it seems to take a lower blood level in the group treated with DMSO to achieve a given brain level.

On this basis the authors conclude that "a partial breakdown of the blood-brain barrier within the first 30 minutes" has occurred in the group treated with DMSO. If the ratio between the two groups had been 1.00, one could argue that the brain levels were simply related to the blood values despite the marked differences in brain levels between the two groups. At 60 minutes after injection the relationship between the two groups was reversed, and the ratio of the values in the group treated with DMSO (22.4 times) to that in the group treated with tragacanth (18.4 times) was 1.20, the inverse of the ratio found at 30 minutes. The authors did not conclude from this value, however, that DMSO inhibited transport across the blood-brain barrier at 60 minutes. And at 120 minutes the ratio between the same groups is (16.1 times)/(15.3 times), or 1.05. Thus, an average of the three ratios obtained between the groups treated with DMSO and those treated with