0.2 sec. thus covers approximately the first 370 msec of the cortical response after stimulus onset. The stimulus onset point in the records was checked by putting a photo-cell signal through the cortical response channel and recording it with the computer. The stimulus periods were checked and found to be consistent.

Each tape recording is analyzed four times by an average response computer (Mnemotron CAT or Fabri-Tek signal averager). The four analyses are: (1) response to the right eye stimulus when the right eye is dominant, (2) response to the right eye stimulus when the left eye is dominant, (3) response to the left eye stimulus when the left eye is dominant, and (4) response to the left eye stimulus when the right eye is dominant.

As the responses are averaged from the tape record of the simultaneous functioning of both eyes, the degree of control inherent in this procedure is great. If one eye is misaligned, the effective brightness of the stimulus to that eye is decreased. If this produces a smaller response when that eye is suppressing, it also produces a smaller response when the same eye is dominant. Hence the effects of misalignment or other stimulus artifacts are cancelled out and cannot account for the differences between dominant and suppressed evoked potentials from the same eye. Similarly, changes in attention or arousal over time are not confounded with rivalry changes as the responses from both eyes are recorded simultaneously.

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NOTE

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A runway for the fish¹

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A runway and a training procedure are described. Acquisition and extinction curves for a sample of 12 goldfish trained in spaced trials are plotted in terms of three measures.

The apparatus here described for the study of learning in the fish is directly analogous to the runway which has played so large a part in work with the rat. In our previous experiments on food-rewarded instrumental learning in the fish, we have used a manipulative rather than a locomotor response—nosing or biting a lever introduced into the animal's individual living tank, in which it is carried to the experimental situation (Longo & Bitterman, 1959). The lever is, of course, more efficient in many respects and more objective than the runway, but there are kinds of experiments that can be done more conveniently with the runway than with the lever, or not at all with the lever, response to which must be shaped by special training procedures (Bitterman, 1966). The only serious difficulty that we encountered in our attempt to develop a runway for the fish stemmed from the fish's aversion to handling (or netting) and its consequent reluctance to enter a goalbox from which it has been removed by such means. Our solution to the problem of transferring the animal from one place to another is simply to scoop it up in a container of clear plastic, a procedure which minimizes its contact with injurious surfaces.

A satisfactory runway for 3-4 in. goldfish is diagrammed in Fig. 1. It is made of ½-in. black Plexiglas. The ends of the main pieces are milled, drilled, and tapped, then fastened together with brass screws, after which Plexiglas solvent is run over the joints. A hinged cover divided into four parts (one for the starting compartment, two for the main section, and one for the goalbox) is made of ½-in. diffusing Plexiglas. The inside depth of the runway, which is 3½ in. wide throughout, is 6 in., and it is filled to a depth of 4 in. The starting compartment, 12 in. long, is set

Fig. 1. The runway. D₁ and D₂, guillotine doors; P, photocell; L, lamps; F, opening for base of funnel through which worms are discharged by the feeder.

Fig. 2. The course of acquisition and extinction in the runway plotted in terms of three different measures.

off from the rest of the runway (in all, 4 ft long) by a string-operated guillotine door. A second such door gives entrance to the goalbox, which is fixed at a 90 deg angle to the runway and entered by a left turn. The goalbox is 10½ in. long by 3½ in. wide. To the end wall of the goalbox, a piece of 1/16-in. white Plexiglas is cemented to make it easier for the fish to see the Tubifex worms with which it is rewarded. The worms are injected into the water through a small Teflon funnel by an automatic feeder (Longo & Bitterman, 1963). The funnel is attached to the lid of the goalbox at the far end.

The progress of the fish through the runway is monitored by three sets of photocells. Each set consists of a vertical array of three photocells (Clairex CL-3) which are wired in series and mounted in the walls of the runway—one set 2 in. beyond the first guillotine door, a second set 6 in. before the second guillotine door, and a third set 2 in. beyond the left turn in the goalbox. The photocells in each set are 1 in. apart center-to-center, the lowest 1 in. above the floor of the runway, and the highest 1 in. below the surface of the water. On the side of the runway opposite each set of photocells is a corresponding set of three No. 222 (2.25-V) lamps, one facing each photocell. The light from the lamps is transmitted from one side of the runway through the water to the photocells on the opposite side by way of ¼-in. circular plugs of clear Plexiglas which are cemented into holes drilled in the black Plexiglas walls. The first set of photocells provides a measurement of latency by stopping a clock which is started when E raises the first door. The second set of photocells provides a measure of runway time by stopping a second clock, which is started by the first photocell relay. The third set of photocells triggers the worm feeder (on reinforced trials) and provides a measure of goal time by stopping a third clock, which is started by the second photocell relay.

In Fig. 2, acquisition and extinction curves for a sample of 12 goldfish are plotted in terms of mean log latency, runway time, and goal time. The animals were purchased from a local dealer and maintained in individual 2-gal aquaria, their water filtered, aerated, and temperature-controlled. After a week on a 24-h

feeding schedule with dry food, the animals were given experience with Tubifex worms, which were introduced singly into their living tanks with an eyedropper. There followed five days of adjustment to handling: once a day, each animal was scooped up from its living tank in a container of clear 1/8-in. Plexiglas, which was 3¼ in. wide (barely narrower than the inside width of the runway), 4½ in. long, and 3½ in. deep, carried to the runway area of the room, returned to its living tank, and given four worms in quick succession. Then there were three days of goalbox training, on each of which the animal was deposited in the goalbox (closed off from the rest of the runway by the second door), fed four worms from the automatic feeder, and returned to its living tank.

In acquisition, each animal was given 25 trials at the rate of one trial per day. On each trial, the animal was transferred to the starting compartment, and the first door was raised 5 sec later. The second door, up at the start of the trial, was lowered behind the animal as soon as the third photocell relay was triggered, and the animal was returned to its living tank as soon as it had taken the reward—a single worm discharged from the feeder. On the 25 extinction trials, also given at the rate of one trial per day, the feeder did not operate, and the animal was returned to its living tank 20 sec after entering the goalbox. If an animal did not enter the goalbox within 5 min on any trial, both doors were lowered, and the animal was returned to its home tank. As the curves of Fig. 2 demonstrate, this procedure yields results very much like those for the rat. It is interesting to note that here the goal time seems to be the most sensitive of the three measures to the effects of extinction.

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NOTE

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