used to produce recordings of any desired length by repeating all or part, separated by intervals of 5 to 10 sec of silence. These recordings were broadcast to gulls with a repeating tape player (*9*) through an ordinary amplifier and loudspeakers.

The immediate reaction of groups of gulls to the sound is striking. At the attention call they rise into the air; they approach the speakers when the alarm notes sound. After this they slowly circle away and leave. The broadcast of only 1 or 2 unit calls will produce this reaction; the gulls continue to fly away even after the call is ended.

This call was tested for immediate repellent effect against gulls feeding on 3 dumps (16 trials), at a sardine cannery (2 trials), on the seashore at 5 different places (7 trials), and at a fish-meal factory (2 trials). At an intensity of approximately 95 db at a distance of 1 m from the speakers, the call was effective in lifting all gulls within a radius of at least ½ mi. At distances of about 100 ft, lower intensities drove all gulls from food. The gulls remained away, after one sequence, for 15 to 90 min, but mostly 30 to 45 min, equalling the repellency obtained by displaying a captive gull for a few minutes.

The most extensive tests (*10*) were made at a dump near Salisbury Cove, Me., where the gulls had fed regularly for many years. At the time of the tests, about 300 gulls were present at all times. The alarm call was broadcast to the gulls in a 1-min sequence consisting of five repetitions of the unit call separated from each other by about 7 sec of silence. This was sounded only when the birds tried to return to the feeding area. The gulls were driven from the dump at 8:45 A.M. EST 9 Aug. 1954, and were denied return until nightfall, 6:45 P.M., the next day. The total potential feeding time during the two days, since the gulls do not feed at night, was 25 hr. The call was broadcast 29 times during that interval. The longest time of clearance was 3 hr, 27 min, the shortest 10 min. For the most part the gulls did not try to return to the feeding area until 30 to 45 min after each treatment. On the afternoon of the second day, the times of individual treatments were reduced to 10 to 20 sec. These worked just as well. Other tests, of 3- to 4-hr duration, at a sardine cannery in McKinley, Me., and a fish-meal processing plant at Eastport, Me., gave similar results.

This call is effective for other gulls. Great black-backed gulls (*Larus marinus*) in Maine and laughing gulls (*Larus atricilla*) on a dump at Atlantic City, N. J., were also repelled. This cross-reactivity is probably the result of the fact that these species often feed together and have similar calls. The alarm call of great black-backed gulls, for instance, is like that of herring gulls, except that it is pitched about one octave lower.

During these tests, a study was made of the food-finding behavior of herring gulls, and a food-finding call was noted. When recorded and played to gulls this proved to be highly attractive. With this call, 20 to 30 gulls could be drawn within a few minutes. These were driven away equally rapidly with the alarm call at the same intensity. The alarm call, therefore, does not depend upon intensity alone for its effect. The biological significance of the call gives it power far beyond that conferred merely by high intensity.

It may be that birds will cease responding to warning sounds. Only long-range tests will show whether this is the case with gulls. Tests with permanently installed, automatically repeating tape players are planned. If habituation to the alarm call sets in, a shift to the attractive call, broadcast from some spot away from the area to be cleared, may give the desired result.

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9. Bird-E-Vict, a device using continuous recorded tape cartridges that play for set intervals and then automatically stop until reactivated.

10. Authorized for publication as paper No. 1918 in the Journal Series of the Pennsylvania Agricultural Experiment Station. This work was sponsored in part by the U.S. Air Force by the Aero-Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio, under contract No. AF 33(038)-786. The studies were carried out at the Mount Desert Island Biological Laboratory, Salisbury Cove, Me.

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Behavior of Two Species of Worms in the Same Maze

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Yerkes (*1*) demonstrated that, in the course of learning a T-maze, the manure worm *Allolobophora foetida* (*2*) learned an avoidance response to stimuli in close spatial contiguity to noxious stimulation. Yerkes interpreted this result as being indicative of association of stimuli and further concluded that learning in worms could be adequately described in those terms. However, in a recent experiment, Robinson (*3*) found that the earthworm, *Lumbricus terrestris,* exhibited a generalized avoidance to many maze stimuli remote from noxious stimulation under comparable conditions. Robinson criticized Yerkes' conclusion about association of stimuli, and suggested that there are two factors in the learning of a T-maze by annelids: generalized avoidance and correct turning. The problem at issue in this report is whether or not the results of Robinson's investigation with *L. terrestris* are an adequate basis on which to evaluate Yerkes' study with another species of annelid.

Two species of worms were observed with respect to avoidance behavior in a single-unit T-maze. The two species were *L. terrestris,* an earthworm, and *Eisenia foetida,* a manure worm. Fourteen *Lumbricus* and eight *Eisenia* were run to a criterion of 10 consecutive errorless trials (trials without shock).

The apparatus in the experiment was five simple T-mazes, the stems of which were 8 in. long and each arm was 4 in. long. The alleys were ½ in. wide and ½ in. deep. There was a grid consisting of two No. 18 (B&S) copper bell wires placed ¼ in. from each other. The nearest wire was 2 in. from the choice point in the right arm. The magnitude of shock was 15 ma at 7.4 v. A piece of 0/0 sandpaper 1 cm by ½ in. was placed 1 cm from the grid on the choice-point side. There was an exit tube at the end of the left arm of the maze. The exit tube was 6 in. long and had a groove ½ in. by ½ in. milled into it. The exit tube was covered with a piece of wood. The floor of the exit tube and the maze were covered with strips of paper towel that were kept moist with biological water.

The experiment was conducted in a dimly illuminated room. With the exception of a white strip 3 ft wide at the bottom of the wall, the walls and ceiling of the room were painted black. Illumination was provided by four 60-w incandescent bulbs placed in a line parallel to the maze stems. The lights were placed so that the nearest maze was 3 ft from them and the farthest was 9 ft.

The procedure was to remove a worm from its glass dish and place it in a maze. If the worm did not start to crawl readily, it was stroked with a camel's-hair brush. A trial ended when the worm had crawled into the exit tube either with or without shock. The worm was allowed to remain in the exit tube for approximately 20 min before the next trial began. Ten trials were given every other day. When a day's trials had ended, the worm was removed from the maze and placed in a refrigerator maintained at 7°C.

The mean number of trials to the criterion of 10 consecutive errorless trials was 60.5 for *L. terrestris* and 69 for *E. foetida.* A test of the significance of the difference between means indicated that there was no reason to reject the hypothesis that there is no difference.

An important difference was noted in the avoidance behavior of the two species of worms. *L. terrestris* gave avoidance responses to the whole maze, including the stem, as evidenced by backing out of the maze and increased response latency. These first signs of avoidance began between trials 30 and 50. On the other hand, *E. foetida* gave avoidance responses to only a limited circumstance, that is, by moving more slowly only when it was in contact with the sandpaper. In both cases it is clear that the avoidance behavior exhibited is learned, since it appears only after considerable experience in the maze.

It would be misleading to point only to the differences in avoidance behavior without noting one important similarity between the species. Animals of both species would occasionally make contact with the sandpaper and turn around with the pivotal point on the sandpaper rather than make contact and retreat. This turning response is not tropistic and is extremely unstable. The evidence against the response being tropistic is that the worms would cross the sandpaper readily prior to being shocked a few times. It appears to be unstable because it would appear around the 15th trial and might not appear in any other contacts with the sandpaper.

The finding that *L. terrestris* avoids maze cues remote from the noxious stimulation is the same as the result Robinson obtained with the same species. Similarly, the finding of specific avoidance of stimuli in close spatial contiguity to the source of noxious stimulation by *E. foetida* is in accord with what Yerkes said about that species. Consequently, Robinson's experiment with *Lumbricus* is not a proper basis for his criticism of Yerkes' study in which *Eisenia* was used as the experimental animal.

The results of this study suggest that the problem at issue is not whether a two-factor theory is required to account for learning in worms but rather the proper use of species as an experimental condition. The most satisfactory rule that can be stated at present is: The behavior of different species must be regarded as different until it is proved to be the same. Thus, if that rule is accepted, species would constitute a relevant condition in the comparison, control, and evaluation of behavioral data.

References and Notes

1. R. M. Yerkes, *J. Animal Behav.* **2**, 332 (1912).
2. *Eisenia foetida* is also known as *Allolobophora foetida* and *Heliodrilus foetidus. Eisenia* is currently used in preference to other generic names.
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Succinic Dehydrogenase Activity in the Goldfish Gill

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Succinic dehydrogenase has been demonstrated chemically in the rat kidney by Handley and Lavik (*1*). Mustakallio and Telkkä (*2*) have localized this enzyme histochemically in the kidney tubule. The former authors have shown that mercurial diuretics significantly depress total succinic dehydrogenase activity and have suggested that this enzyme system may be involved in active reabsorption of sodium chloride and water from the kidney tubule. In the light of this suggestion, it seemed desirable to check for the presence of succinic dehydrogenase in another tissue where active uptake of sodium occurs. Such a tissue is readily available in the gills of goldfish, which have been shown by Krogh (*3*), Meyer (*4*), and others to transport the sodium ion against a diffusion gradient.