Measurement of consummatory behavior in octopuses

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A liquid feeding technique suitable for the study of appetitive conditioning in octopuses is described.

Although automated techniques for the study of instrumental behavior in octopuses and for dispensing food rewards have been reported (Dews, 1959; Hales, Crancher, & King, 1972; Nixon, 1969), none has been altogether satisfactory. The required responses have been erratic and difficult to control, while the food (small crabs or bits of prawn dropped to the animal) has been of a form which produces hoarding (under the mantle) and unpredictable consummatory behavior.

We have developed an automated consummatory technique which elicits rapid and stable responding with minimal pretraining and permits continuous consumption of food with accurate specification of the amount consumed. The required behavior is much like that exhibited during the normal feeding of octopuses on small crustaceans and gastropods (Wodinsky, 1969): the animal sucks liquid food from a small orifice in a nipple designed to detect the consummatory activity. The basic technique, which maximizes spatial-temporal contiguity of response and reinforcement, has proved useful for the study of appetitive conditioning in several other animals, such as turtles (Pert & Bitterman, 1969) and fishes (Holmes & Bitterman, 1969; Woodard & Bitterman, 1974).

The critical parts of the apparatus, which are diagramed in Figure 1, consist of a response detector (a suction-sensing device), and a nipple incorporating a sensor tube and a feeding tube. The sensor tube, normally filled with air, is connected to the bellows of a Sensiflex fluidic switch (Model SF1, 2-in. bellows, Gagne Associates, Inc.). The original microswitch, which the bellows activated on sufficient vacuum, was replaced by a wire probe clamped in the needle holder of an Astatic 16 crystal phonograph cartridge connected to the detector circuit described by Woodard and Bitterman (1974). The phonograph cartridge increases sensitivity and ensures that only a change in suction will be recorded as a response. The feeding tube is connected to a syringe filled with liquid

Figure 1. Response-detecting and feeding mechanism.

food and driven by a Harvard Petipump (Model 1152) controlled by standard relay programming equipment. The liquid food is prepared by mixing 125 g of cleaned, dried, frozen squid with 300 ml of seawater in a high-speed blender for 1 min, straining the mixture through a No. 40 sieve, and evacuating the strained mixture to remove bubbles of air. The liquid food then is frozen in small containers and defrosted as needed.

The animal may be trained in its home tank (36 cm long x 18 cm wide x 37 cm high), through which seawater continuously flows and to which the training apparatus may be brought on a wheeled cart, or the animal may be transported to an isolated experimental tank of the same dimensions by the method of Walker, Longo, and Bitterman (1970). The nipple (which is both manipulandum and feeder) is mounted at the end of a section of PVC pipe of the same diameter and lowered through a hole in the cover of the tank to a point about 13 cm above the floor. For the inexperienced animal, a few drops of food are pumped from the nipple as an attractant. The octopus locates the nipple, grasps it with its arms, and inverts its body beneath the nipple while bringing the mouth parts into contact with the orifice. Sucking the food from the nipple activates the detector, which, during initial training, is programmed to cause immediate replacement of the consumed food. Very little pretraining is necessary under these conditions,

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Figure 2. CRF performance of a 164-g *ornatus*. Each full-scale deflection of the pen represents 100 responses, and the total time of the record is 1,226 sec.

and the entire procedure may be automated by programming occasional free feedings until reliable responding is generated. Although free food is necessary initially to attract the animal to the nipple, response to the empty nipple is readily conditioned.

An example of CRF performance, from initiation of a session until satiation, is presented in Figure 2. The animal (*Octopus ornatus*, 164 g, reinforced with .012 ml food for each response) exhibits tables responding for approximately 10 min, then shows increasingly frequent and prolonged periods without sucking, and finally leaves the nipple at the end of the record. Figure 3 shows the performance of another animal of the same species (169 g, reinforced with .007 ml of food) on a VI 10-sec schedule. There is no indication of satiation in the 20-min session shown here, and responding is reasonably stable. The usefulness of the technique both for the study of feeding and for study of learning should be readily apparent.

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Figure 3. VI 10-sec performance of a 169-g *ornatus*. Each full-scale deflection of the pen represents 200 responses, and the total time of the record is 1,200 sec.

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