normalities in DA innervation patterns, such as hyperinnervation of areas already receiving a dopaminergic input or growth of DA terminals into areas previously lacking this type of nerve, should also be considered. In this case, the changes in DA innervation may be secondary to a primary lesion in other pathways leading to plasticity changes, as described by Raisman (*19*).

It is desirable to investigate possible cortical DA innervation in other species, especially man. Nyström *et al.* (*20*) and Olson *et al.* (*21*) have shown that surgical biopsies as well as postmortem brains may be used to study central CA with histochemical techniques. Such studies, with the improved methods we used, might indicate whether tentative cortical DA networks have a similar extent and distribution in normal and schizophrenic humans.

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Cleaning Symbiosis Provides a Positive Reinforcer for Fish

Abstract. Chaetodon auriga, *a common marine fish in Hawaii, can be conditioned by presentation of a moving model of a cleaner fish as a positive reinforcement on an instrumental schedule. Reinforcement is probably through tactile stimulation and might help to shape the response of fish to cleaners. Tactile stimulation might serve as a valuable reinforcer in studies of fish learning.*

Cleaning behavior is a symbiotic relationship that is particularly common in marine fish (*1*, *2*). Cleaning organisms (cleaners) remove ectoparasites and other material from host animals. In fish, communication between cleaners and hosts includes recognition and signal movements by both symbionts that favor initiation and maintenance of cleaning interactions (*2*). Cleaners inspect a host by swimming close and occasionally contacting the host's body. Hosts pose for cleaning by assuming an unusual posture or swimming pattern, erecting fins, or changing coloration. Many hosts pose in this manner for artificial models that resemble cleaners such as the wrasses *Labroides dimidiatus* or *L. phthirophagus* (*2*, *3*).

The pose response appears subject to modification through experience. The most compelling evidence is that fish pose for previously neutral stimuli, such as unrealistic fish models and pieces of wire, after presentation of these stimuli has been paired with tactile stimulation (*2*, *4*). Our study indicates that the major mode of modification may be through tactile reinforcement of the host by the cleaner.

Marine butterfly fish (*Chaetodon auriga*) were trapped in Kaneohe Bay, Oahu, and groups of three were placed in 450-liter aquariums. These fish had undoubtedly encountered the cleaner *L. phthirophagus* before capture. A motorized model of *L. phthirophagus* on the end of a thin piece of wire was moved to the center of the aquarium during the reinforcement procedure (Fig. 1), which consisted of moving the model back and forth over a distance of about 5 cm at about 2 hertz for 25 seconds and then returning it to the side of the tank. During an initial screening period, the groups of *C. auriga* were given 37 reinforcements on a 1.2-minute variable interval schedule. Fish that posed for the model during the screening period were isolated and retained for conditioning. During conditioning, the cleaner model was partially concealed in an enclosure at the surface of the water, and a photocell was placed behind and 15 cm below the enclosure (Fig. 1). Behavior was shaped so that the fish would occlude the photo-

Table 1. Results of a three-way analysis of variance of the number of responses per session during instrumental conditioning. Variables tested for differences were individual fish, training versus extinction reinforcement schedules, and the day of the session (two each for training and extinction); interaction terms were also tested. Probability values are not corrected for multiple testing (*5*).

Source of variance	Degrees of freedom	*F*	*P*
Variables			
Training-extinction	1	75.58	$\ll .0005$
Individuals	8	4.95	$< .0005$
Day	1	0.21	.25
Interaction terms			
Day and training-extinction	1	8.37	$< .005$
Individuals and training-extinction	8	2.18	$< .05$
Individuals and day	8	1.00	.5
Individuals and day and training-extinction	8	1.21	.5

cell to receive a 25-second model presentation. Behavior was considered shaped after the fish showed at least ten responses per hour on a 100 percent reinforcement schedule.

Training was confined to four 30-minute sessions daily, with a 45-minute intersession interval. At the beginning of each session, two 100-watt overhead lights were turned on, and an initial reinforcement was triggered by the experimenter. Training was on a 7-second fixed interval schedule. Fish were trained for 2 days and then subjected to 2 days of extinction sessions, during which occluding the photocell had no effect. The number of correct responses per session (maximum of 60) was recorded on an event recorder.

Nine individuals were trained and subjected to extinction once. The number of responses per session was analyzed by a three-way analysis of variance for differences between training and extinction, between days 1 and 2 of training or extinction, and between individuals (Table 1). The comparison between training and extinction showed the greatest difference. The mean numbers of responses per session (30.2 and 35.0 for days 1 and 2 of training, respectively, and 15.8 and 7.1 for days 1 and 2 of extinction) resulted in the expected interaction between day and training-extinction. Differences between individuals were significant, with a range of 7.2 to 26.6 for the mean number of responses per session under all conditions. Correction for the multiple testing procedure indicated that the interaction between individuals and training-extinction was not statistically significant (*5*), but considerable individual variability was evident.

The moving model was sufficient reinforcement for conditioning of the photocell-crossing response. The natural posing behavior of the hosts probably facilitated formation of this conditioned response. Several of the fish posed in front of the photocell. Others merely swam past or developed persistent adventitious behavior such as swimming across the tank before crossing the photocell. Many of the differences between individuals were probably due to this variability in behavior.

During reinforcement, the fish almost always positioned itself next to the model so that the model repeatedly contacted the fish's side. This behavior, as well as response to a variety of models, suggests that the tactile portion of this stimulus is primarily responsible for the reinforcing value. Cleaner fishes

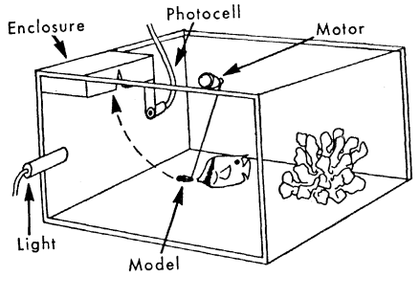

Fig. 1. Apparatus used for conditioning *C. auriga*. The cleaner model is pictured in the reinforcement position.

of the genus *Labroides* deliver similar stimulation by rubbing the host with their pelvic fins and prodding them with their jaws. This study demonstrates how the frequently reported cleaning in captivity between normally allopatric species [for example (*1*)] might come about: Hosts might quickly learn to recognize any new cleaner as a source of tactile stimulation. This explanation avoids the need to hypothesize world-wide characteristics or "guild signs" for cleaners (*6*) to account for this recognition.

Presentation of models to a variety of reef fish species during the development of these techniques indicated that this reinforcement method might be applied to discrimination and classical conditioning studies in reef fishes. This might provide a valuable check for research in which food has traditionally been used as a positive reinforcer for fishes. Tactile reinforcement may also avoid many problems of satiation during training: Fish can be tested for several hours per day with little decrement in performance.

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Orientation of Homing Pigeons Altered by a Change in the Direction of an Applied Magnetic Field

Abstract. *Homing pigeons were equipped with a pair of small coils around their heads. Birds with an induced field of 0.6 gauss and the south magnetic pole up, oriented toward home normally under both sun and overcast. Birds with the polarity reversed oriented toward home when the sun was visible but often flew away from home under overcast.*

Evidence has accumulated that magnetic fields may be involved in the orientation of birds. The directional preferences of ring-billed gull chicks are upset during periods when the magnetic field of the earth is disturbed (*1*). European robins show a tendency to orient in relation to a real or artificial earth field (*2*). The initial orientation of tactile stimulation. This explanation small bar magnets attached to the pigeon's backs (*3*). We present evidence here suggesting that the orientation of pigeons is altered by changing the polarity of the applied magnetic field.

A flock of approximately 50 homing pigeons was kept in a small loft on the university campus at Stony Brook, New York. These birds were progressively trained along a line to the east of the loft under both sunny and overcast conditions. Experimental releases were made from three locations: Cunningham Park, 68 km, 251° (compass direction, from the loft); Hempstead, 59 km, 242°; and Spring Valley, 92 km, 287°. At the release site each pigeon was equipped with a pair of coils. One coil, 35 mm in diameter, was fitted around the pigeon's neck like a collar and the other, 23 mm in diameter, was glued to the top of the head like a hat. Each coil was made of 200 turns of No. 36 enameled wire, and the two coils were connected in series with a 1.4-volt mercury battery. This combination produced a relatively uniform magnetic field of about 0.6 gauss around the pigeon's head. A