TECHNICAL NOTE

OPERANT RESPONDING IN THE BOTTLENOSE
DOLPHIN (*TURSIOPS TRUNCATUS*)¹

An interesting facet of the analysis of behavior is the manner in which specific operants occur and stabilize in different species. This has been demonstrated in a wide variety of animals from fish to man (Cohen, 1969). While the dolphin has been the subject of a number of fairly exotic investigations, more basic behavioral studies have been neglected.

The present study sought to determine the ease with which a dolphin could be trained to press an underwater paddle for fish reinforcers delivered automatically, and if this response could be reliably maintained on intermittent schedules of reinforcement.

The subject, a female *Tursiops truncatus* weighing 105 kg, had been in captivity for approximately 1.5 yr and was estimated to be 4 to 5 yr old.

Throughout the period of testing the subject was maintained on its normal ration of 6.9 kg of fish per day. Approximately 2.3 kg of Columbia River smelt (*Osmerus sp.*) was earned during the daily testing, and an additional 2.3 kg of smelt plus 2.3 kg of Spanish mackerel (*Scomberomorus maculatus*) was hand fed at the end of the day. The subject was 19 to 20 hr food deprived at the start of each test session.

The subject was housed and tested in a 6 by 6 m floating pen enclosure (Steele, 1970), in Kaneohe Bay, Hawaii. A Davis Scientific Instruments Universal Feeder (Model #320) was mounted at one corner of the pen. During test sessions, a response paddle was mounted on one side of the pen 1.95 m from the feeder and submerged to a depth of 0.6 m. A push on the response paddle closed a microswitch that activated both the feeder and a reinforcer tone (700 Hz). The tone remained on for the 4 sec required for the feeder to deliver one fish. Responses and reinforcements were recorded on a Rustrac Instruments four-track Event Recorder (Model #309) housed in an adjacent instrument/observation van.

The dolphin was trained to approach and press the paddle with the tip of its rostrum in a single training session by reinforcing successive approximations of the response. After shaping, the dolphin was exposed to three reinforcement schedules; continuous reinforcement (CRF) where every response was reinforced, a variable-ratio schedule (VR 6) where reinforcement occurred on the average of every sixth response, and a

fixed-ratio schedule (FR 38) where every thirty-eighth response was reinforced.

Test sessions were initiated with the presentation of the response paddle. Sessions consisted of 60 reinforcements each and were conducted daily, five days per week. Seven sessions were run under CRF, with behavior apparently stabilized by the third session. Three extinction sessions were then administered. On the day after the CRF extinction series was completed, the subject was retrained to paddle-press before testing under the VR 6 schedule. Following 17 conditioning sessions under the VR 6 schedule, a number of extinction sessions were run. In all extinction sessions, a dual criterion of zero responses in 15 min or a single response in 20 min was employed.

Following extinction under the VR 6 schedule, the animal was again trained to paddle-press and the fixed ratio of responses to reinforcements was gradually increased (by two per session) until the animal was responding on an FR 38 schedule. Several attempts to extend the reinforcement ratio further resulted in the dolphin refusing to respond after a small number of reinforcements, therefore the animal's performance over 10 sessions on an FR 38 schedule were recorded.

RESULTS AND DISCUSSION

Acquisition under CRF reached a stable rate by the end of the third session, with the mean rate for the seven sessions at 6.73 responses per minute. This rate is somewhat higher than that shown in the only other reported study of free-operant feeding by the dolphin (Johnson, 1966). Johnson's lower rate (3.73) may be attributed in part to the fact that his subject was required to push a lever and retrieve fish at opposite ends of the tank.

Conditioning under the VR 6 schedule resulted in a steady increase in response rate across sessions seen in Figure 1. After the first three VR 6 sessions, response rate under this schedule consistently exceeded the rate under CRF, and the mean rate for the 17 VR 6 sessions was 11.84 responses per minute. The maximum rate under VR 6 occurred in the final session when the subject responded on the average of every 2.69 sec throughout the session.

The mean response rate obtained under the FR 38 schedule was substantially higher than that under VR 6 and similar to rates produced by conventional laboratory animals. Boren (1961) reported a mean response rate for the rat of approximately 30 per minute under FR 35, which is comparable to the mean rate of 33.84 obtained from the dolphin under FR 38. The

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Fig. 1. Mean responses per minute over conditioning sessions.

maximum rate produced by the dolphin over any one session of FR 38 was one response every 1.36 sec.

Response rates were generally equivalent over the various portions of the sessions, with very few appreciable periods of non-responding noted. Pauses after reinforcement were quite evident with subsequent responses occurring in rapid bursts leading to reinforcement. Typically, a reinforcement would be followed by a short period of non-responding, 15 to 20 sec in VR 6, and 40 to 60 sec in FR 38, followed in turn by another burst of responding until reinforcement occurred.

The first extinction session after CRF produced 22 responses over a 37-min period. The second session produced seven responses and lasted 7 min, while the final extinction session lasted 3 min and produced three responses. The mean rate of responding in all CRF extinction sessions combined was 0.86 responses per minute, compared to 6.73 responses per minute during conditioning.

Figure 2 shows that extinction following VR 6 was much more prolonged than following CRF. The initial extinction session after conditioning under the variable-ratio schedule lasted for over 2 hr, producing a total of 530 responses before the extinction criterion was met. Subsequent sessions showed a steady decrease in responding until evidence of spontaneous recovery was seen in the sixth extinction session. In this session, which lasted only 36 min, there were 124 responses, more than the combined total of the three sessions before Session 6 and exceeded only by the initial extinction session. By the end of Session 10, in which it emitted a single response in 13 min, the dolphin's paddle-press response was apparently extinguished.

Fig. 2. Responses to extinction over sessions.

The mean response rate per minute over all VR 6 extinction sessions combined was 1.88, over twice that produced during CRF extinction. This stronger resistance to extinction was reflected again in the mean session durations, 32.3 min in VR 6 as opposed to 15.7 min in CRF.

The results indicate that the dolphin's underwater paddle-push response rates under the schedules investigated are comparable to those typically found in conventional laboratory animals, such as the rat, in operant conditioning chambers.

REFERENCES

- Boren, J. J. Resistance to extinction as a function of the fixed ratio. *Journal of Experimental Psychology*, 1961, 61, 304-308.
- Cohen, J. *Operant behavior and operant conditioning*. Chicago: Rand McNally, 1969.
- Johnson, C. S. Auditory thresholds of the bottlenose porpoise (*Tursiops truncatus*, Montagu). Naval Ordnance Test Station (China Lake, Calif.) Technical Publication 4178, November 1966.
- Steele, J. W. *Marine environment catacean holding and training facilities*. Ocean Sciences Dept., Bio-Systems Division, Naval Undersea Research and Development Center, Technical Publication. (in press)

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