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# THE CREATIVE PORPOISE: TRAINING FOR NOVEL BEHAVIOR[1]

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Two rough-toothed porpoises (*Steno bredanensis*) were individually trained to emit novel responses, which were not developed by shaping and which were not previously known to occur in the species, by reinforcing a different response to the same set of stimuli in each of a series of training sessions. A technique was developed for transcribing a complex series of behaviors on to a single cumulative record so that the training sessions of the second animal could be fully recorded. Cumulative records are presented for a session in which the criterion that only novel behaviors would be reinforced was abruptly met with four new types of responses, and for typical preceding and subsequent sessions. Some analogous techniques in the training of pigeons, horses, and humans are discussed.

The shaping of novel behavior, that is, behavior that does not occur or perhaps cannot occur, in an animal's normal activity, has been a preoccupation of animal trainers for centuries. The fox-terrier turning back somersaults, the elephant balancing on one front foot, or ping-pong playing pigeons (Skinner, 1962) are produced by techniques of successive approximation, or shaping. However, novel or original behavior that is not apparently produced by shaping or differential reinforcement is occasionally seen in animals. Originality is a fundamental aspect of behavior but one that is rather difficult to induce in the laboratory.

In the fall of 1965, at Sea Life Park at the Makapuu Oceanic Center in Hawaii, the senior author introduced into the five daily public performances at the Ocean Science Theater a demonstration of reinforcement of previously unconditioned behavior. The subject animal was a female rough-toothed porpoise, *Steno bredanensis*, named Malia.

Since behavior that had been reinforced previously could no longer be used to demonstrate this first step in conditioning, it was necessary to select a new behavior for reinforcement in each demonstration session. Within a few days, Malia began emitting an unprecedented range of behaviors, including aerial flips, gliding with the tail out of the water, and "skidding" on the tank floor, some of which were as complex as responses normally produced by shaping techniques, and many of which were quite unlike anything seen in Malia or any other porpoise by Sea Life Park staff. It appeared that the trainer's criterion, "only those actions will be reinforced which have not been reinforced previously", was met by Malia with the presentation of complete patterns of gross body movement in which novelty was an intrinsic factor. Furthermore, the trainers could not imagine shaped behaviors as unusual as some emitted spontaneously by the porpoise.

To see if the training situation used with Malia could again produce a "creative" ani-

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mal, the authors repeated Malia's training, as far as possible, with another animal, one that was not being used for public demonstrations or any other work at the time. A technique of record keeping was developed to pin-point if possible the events leading up to repeated emissions of novel behaviors.

## METHOD

A porpoise named Hou, of the same species and sex as Malia, was chosen. Hou had been trained to wear harness and instruments and to participate in physiological experiments in the open sea (Norris, 1965). This individual had a large repertoire of shaped responses but its "spontaneous activity" had never been reinforced. Hou was considered by Sea Life Park trainers to be "a docile, timid individual with little initiative".

Training sessions were arranged to simulate as nearly as possible Malia's five brief daily sessions. Two to four sessions were held daily, lasting from 5 to 20 min each, with rest periods of about half an hour between sessions. Hou was given normal rations; it is not generally necessary to reduce food intake or body weight in cetaceans to make food effective as a reinforcer. Any food not earned in training sessions was given freely to the animal at the end of the day, and it was fed normal rations, without being required to work, on weekends. During the experimental period, no work was required of Hou other than that in the experiment itself. A bell was rung at the beginning and end of sessions to serve as a context marker. The appearance and positioning of the trainers served as an additional stimulus that the opportunity for reinforcement was now present.

To record the events of each session, the trainer and two observers, one above water and one watching the underwater area through the glass tank walls, wore microphones and made a verbal commentary; earphones allowed the experimenters to hear each other. The three commentaries, and the sound of the conditioned reinforcer, the whistle, were recorded on a single tape. A typed transcript was made of each tape; then, by comparing transcript to tape, the transcript was marked at 15-sec intervals. Each response of the animal was then graphed on a cumulative record, with a separate curve to indicate each type of response in a given session (Fig. 2 to 6).

It was necessary to make a relatively arbitrary decision about what constituted a reinforceable or recordable act. In general, a reinforceable act consisted of any movement that was not part of the normal swimming action of the animal, and which was sufficiently extended through space and time to be reported by two or more observers. Such behavior as eye-rolling, inaudible whistling, and gradual changes in direction may have occurred, but they could not be distinguished by the trainers and therefore could not be reinforced, except coincidentally. This unavoidable contingency probably had the effect of increasing the incidence of gross motor responses. Position and sequence of responses were not considered. An additional criterion, which had been a contingency in much of Hou's previous training, was that only one type of response would be reinforced per session.

The experimental plan of reinforcing a new type of response in each session was not fully met. Sometimes a previously reinforced response was again chosen for reinforcement, to strengthen the response, to increase the general level of responding, or to film a given behavior. Whether the "reviewing" of responses was helpful or detrimental to the animal's progress is open to speculation.

Inter-observer reliability was judged from the transcripts of the taped sessions, in which a new behavior was generally recognized in concert by the observers. Furthermore, each new behavior chosen for reinforcement was later diagrammed in a series of position sketches. At no time did any of the three observers fail to agree that the drawings represented the behaviors witnessed. These behavior diagrams were matched, at the end of the experiment, with film of each behavior, and were found to represent adequately the topography of those behaviors that had been reinforced (see Fig. 1).

After 32 training sessions, the topography of Hou's aerial behaviors became so complex that, while undoubtedly novel, the behaviors exceeded the powers of the observers to discriminate and describe them. This breakdown in observer reliability was one factor in the termination of the experiment.

*Steno bredanensis*, the species of which Hou and Malia are members, has not been kept in captivity in the United States except at Sea Life Park. Therefore, data pertaining to nor-

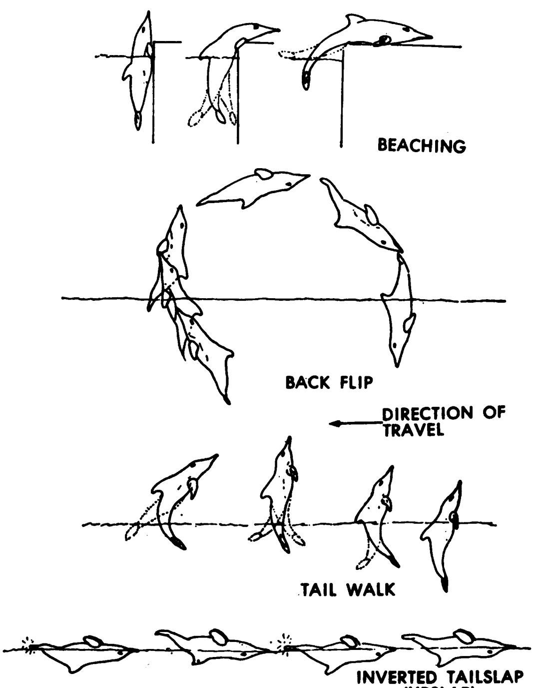


Fig. 1. Diagrams of four reinforced novel behaviors, including one shaped behavior, the tailwalk.

mal behavior, plentiful for more common species such as *Tursiops truncatus*, are lacking. To corroborate the experimenters' observation that certain of Hou's responses were not in the normal repertoire of the species, and constituted genuine novelties, the diagrams of each reinforced behavior were shown or sent to the 12 past and present staff members who had had occasion to work with animals of this species. Each trainer was asked to rank the 16 behaviors in order of frequency of occurrence in a free-swimming untrained animal. The sketches were mounted on index cards and presented in random fashion to each rater separately. A coefficient of concordance (W) of 0.598 was found for agreement between trainers on the ranking of various behaviors; this value is significant at the 0.001 level, indicating a high degree of agreement (Siegel, 1956).

To test the possibility that the trainers were judging complexity rather than novelty in ranking, another questionnaire was prepared requesting ranking according to relative degree of complexity of action. Because some of the original group of 12 trainers were unavailable for retesting, the questionnaire was presented to a group of 49 naive students. The coefficient of concordance (W) for agreement between students was +0.295, significant at the 0.001 level. When the rankings for complexity and frequency were contrasted for each behavior, it was found that some agreement existed between the scores given by the two rating groups, Spearman Rank Correlation (RHO) +0.54, significant at the 0.05 level.

Thus, there seems to be some agreement between complexity and frequency, which should be expected, since complex behaviors require more muscle expenditure than simple ones. Furthermore, analysis was biased by the fact that the experienced group was asked to rate all behaviors serially, and had no way other than complexity to rate the several behaviors which many of them stated they had never seen. However, the agreement between complexity and frequency was not as large between groups as it was within groups; allowing for the fact that the use of two rating groups makes it impossible to generalize the rating comparisons in a strict sense, the low frequency assigned to some non-complex behaviors by the experienced group suggests that complexity and novelty are not necessarily positively correlated.

## RESULTS

### *Sessions 1 to 14*

In the first session, Hou was admitted into the experimental tank and, when given no commands, breached. Breaching, or jumping into the air and coming down sideways, is a normal action in a porpoise. This response was reinforced, and the animal began to repeat it on an average of four times a minute for 8 min. Toward the end of the 9-min session it porpoised, or leaped smoothly out of the water and in, once or twice. It continued to breach in the absence of the trainer, during a half-hour break. In the second session porpoising was reinforced and was repeated several times.

Hou began the third session by porpoising; when this behavior was not reinforced, the animal rapidly developed a behavior pattern of porpoising in front of the trainer, entering the water in an inverted position, turning right side up, swimming in a large circle, and returning to porpoise in front of the trainer again. It did this 25 times without interruption over a period of 12.5 min. Finally, it stopped and laid its head against the pool edge at the trainer's feet. This behavior, nicknamed "beaching", was reinforced and repeated (Fig. 2).

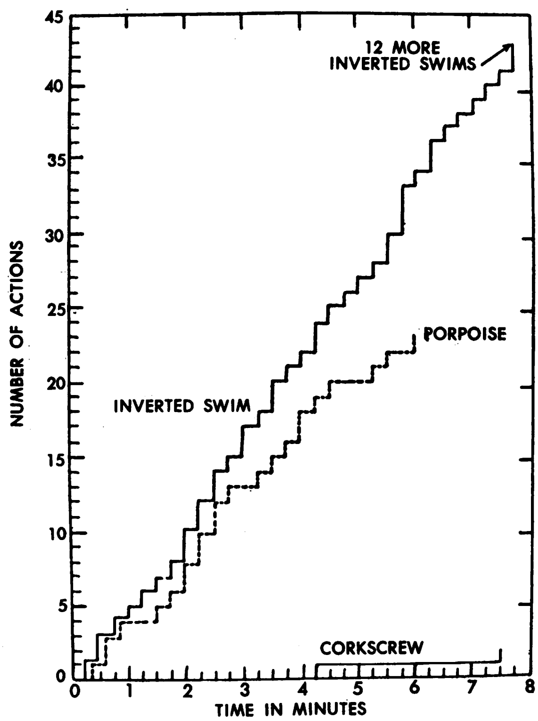


Fig. 2. Cumulative record of Session 7, a typical early session, in which the porpoise began by emitting the previously reinforced response. This response gradually extinguished when another response was reinforced.

Sessions 5, 6, and 7 followed the same pattern. Hou began each session with the behavior that had been reinforced in the previous session. Occasionally this behavior was chosen for reinforcement when the trainer felt it had not been strongly established in the previous session. If the first response was not reinforced, Hou ran through its repertoire of responses reinforced in previous sessions: breaching, porpoising, beaching, and swimming upsidedown. If no reinforcement was forthcoming, it took up the rigid pattern of porpoising, inverting, circling.

The trainers decided to shape specific responses in order to interrupt Hou's unvarying repetition of a limited repertoire. Session 8 was devoted to shaping a "tail walk", or the behavior of balancing vertically half out of the water. The tail walk was reinforced in Session 9, and Sessions 10 and 11 were devoted to shaping a "tail wave", the response of lifting the tail from the water. The tail wave was emitted and reinforced in Session 12.

While this represented a departure from the primary goal of conditioning novel behavior, the experimenters realized that Malia, the show animal, had experienced some training sessions in which, no new spontaneous action being emitted, some specific response was shaped. It was not known whether or not the shaping sessions had contributed to Malia's ability to emit novel responses. Therefore, the inclusion of shaping in Hou's training seemed permissible. It also seemed desirable to prevent a low level of reinforcement from leading to extinction of all responses.

At the end of Session 10, Hou slapped its tail twice, which was reinforced but not repeated. At the end of Session 12, Hou departed from the stereotyped pattern to the extent of inverting, turning right-side up, and then inverting again while circling. The experimenters observed and reinforced this underwater revolution from a distance, while leaving the experimental area.

Although a weekend then intervened, Hou began Session 13 by swimming in the inverted position, then right-side-up, then inverted again. This behavior, dubbed a "corkscrew", was reinforced, and by means of an increasing variable ratio, was extended to five complete revolutions per reinforcement. In Session 14, the experimenters rotated their positions, and reinforced any descent by the animal toward the bottom of the tank, in a further effort not only to expand Hou's repertoire but also to interrupt the persistent circling behavior.

*Sessions 15 and 16*

The next morning, as the experimenters set up their equipment, Hou was unusually active in the holding tank. It slapped its tail twice, and this was so unusual that the trainer reinforced the response in the holding tank. When Session 15 began, Hou emitted the response reinforced in the previous session, of swimming near the bottom, and then the response previous to that of the corkscrew, and then fell into the habitual circling and porpoising, with, however, the addition of a tail-slap on re-entering the water. This slap was reinforced, and the animal then combined slapping with breaching, and then began slapping disassociated from jumping; for the first time it emitted responses in all parts of the tank, rather than right in front of the trainer. The 10-min session ended when 17 tailslaps had been reinforced, and other non-reinforced responses had dropped out.

Session 16 began after a 10-min break. Hou became extremely active when the trainer appeared and immediately offered twisting breaches, landing on its belly and its back. It also began somersaulting on its long axis in mid-air. The trainer began reinforcing the last, a "flip", common in the genus *Stenella* but not normally seen in *Steno*, and Hou became very active, swimming in figure eights (unprecedented) and leaping repeatedly. The flip occurred 44 times, intermingled with some of the previously reinforced responses and with three other responses that had not been seen before: an upside-down tailslap, a sideswipe with the tail, and an aerial spin on the short axis of the body (see Fig. 3).

The previous maximum number of types of responses offered in a single session was five. The average number of types was less than two per session. At no time before Session 16 was more than one new behavior seen, and in all but three cases—breaching, beaching, and porpoising—the new behavior was at least partly developed by the trainer. In Session 16, Hou emitted a total of eight behaviors, each one many times, including four completely new, unreinforced behaviors, two of which, the spin and the flip, were elaborately performed from the beginning.

This session also differed from previous ones in that once the flip had become established, the other behaviors did not tend to drop out. After 24 min, the varied activity—tailslaps, breaches, sideswipes with the tail, and the new behavior of spinning in the air—occurred more rather than less frequently, until the session was brought to a close by the trainer. The previous maximum number of responses in a given session was 110 (in Session 9, a 31-min session). In Session 16, Hou emitted 192 responses in a 23-min session, an average of 8.3 per min compared to a previous maximum average of 3.6 per min.

By Session 16, the experimenters had apparently been successful in establishing a class of responses characterized by the description, "only new kinds of responses will be reinforced", and consequently the porpoise was emitting an extensive variety of new responses. The differences between Session 16 and previous sessions may be seen by comparing the cumulative record for Session 16 (Fig. 3) with that of Session 7, a typical earlier session (Fig. 2).

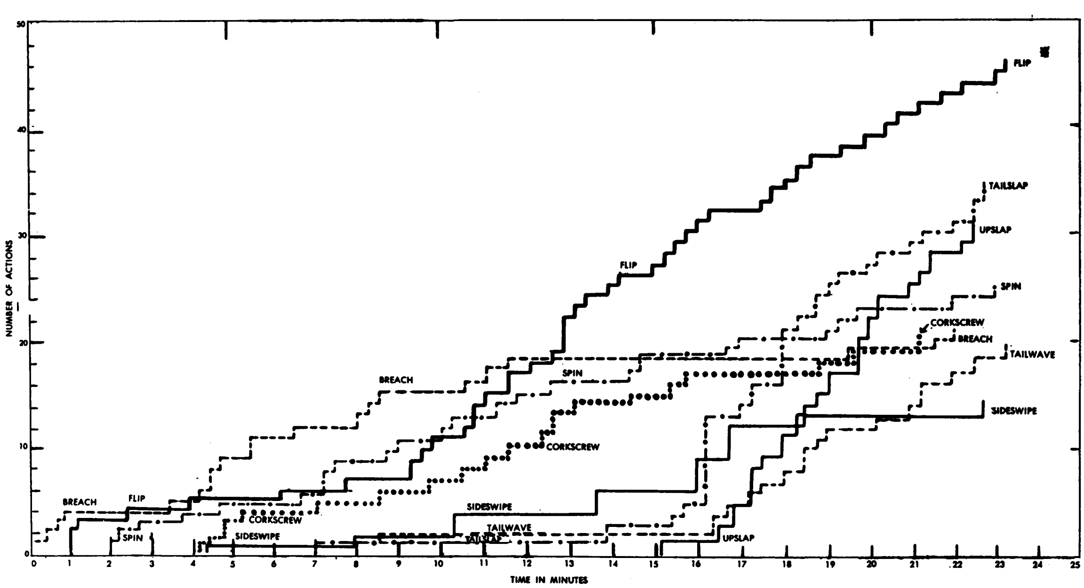


Fig. 3. Cumulative record of Session 16, in which the porpoise emitted eight different types of responses, four of which were novel (flip, spin, sideswipe, and upslap).

*Sessions 17 to 27*

In Sessions 17 to 27, the new types of responses emitted in Session 16 were selected, one by one, for reinforcement, and some old responses were reinforced again so that they could be photographed. Other new responses, such as unclassifiable twisting jumps, and sinking head downwards, occurred sporadically. The average rate of response and the numbers of types of responses per session remained more than twice as high as pre-Session 16 levels.

Hou's general activity changed in two other ways after Session 16. First, if no reinforcement occurred in a period of several minutes, the rate and level of activity declined but the animal did not necessarily resume a stereotyped behavior pattern. Secondly, the animal's activity now included much behavior typically associated in cetaceans with situations producing frustration or aggressiveness, such as slapping the water with head, tail, pectoral fin, or whole body (Burgess, 1968).

*Sessions 28 to 33*

In all of the final sessions, the criterion that the behavior must be a new one was enforced. A new behavior that had been seen but not reinforced previously, the inverted tailslap, had been reinforced in Session 27. Session 28 began with a variety of responses, including another that had been seen but not reinforced before, a sideswipe at water surface with the tail, which was reinforced. In Session 29, Hou's activity included an inverted leap that fulfilled the criterion (Fig. 4). In Session 30, Hou offered 60 responses over a period of 15 min, none of which were considered new, and were not therefore reinforced.

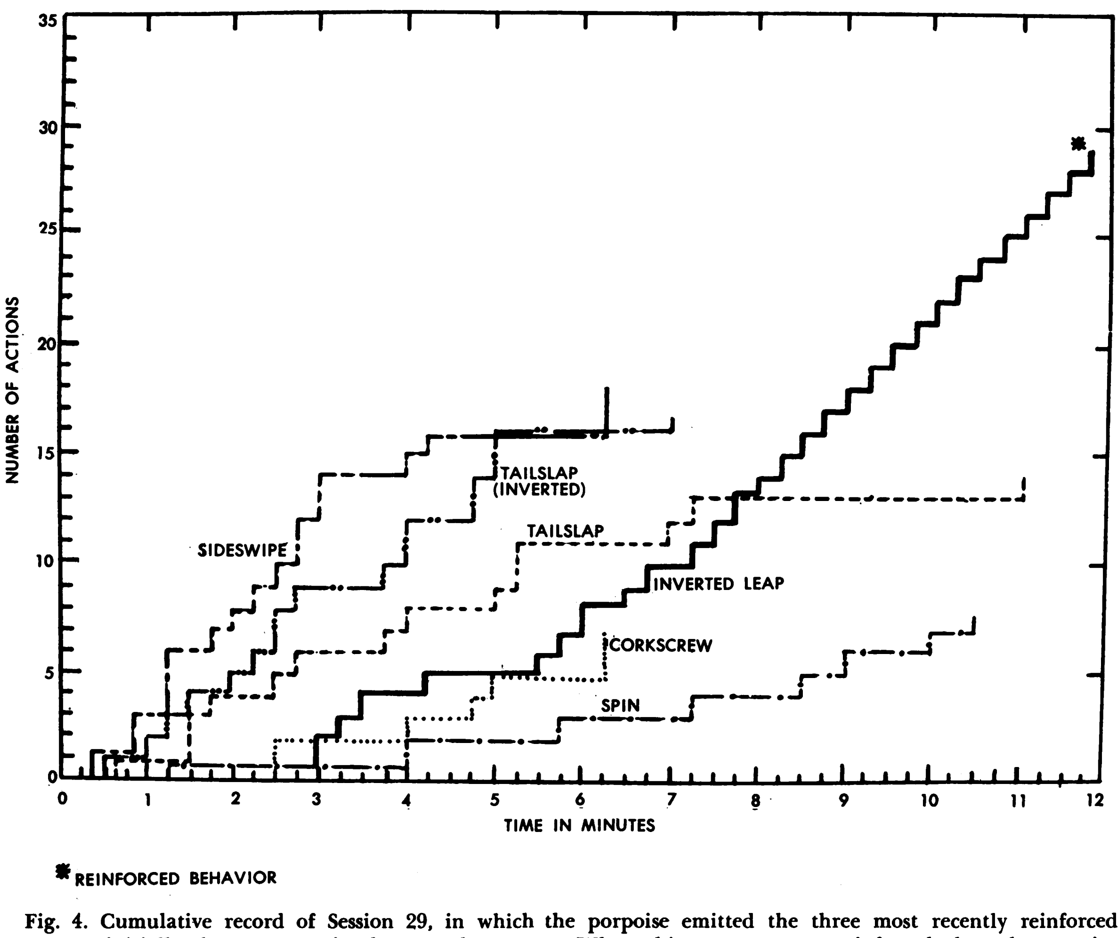


Fig. 4. Cumulative record of Session 29, in which the porpoise emitted the three most recently reinforced responses initially, but soon emitted a novel response. When this response was reinforced the others extinguished.

In Sessions 31, 32, and 33, held the next day, Hou's behavior was more completely controlled by the criteria that only new types of responses were reinforced and that only one type of response was reinforced per session. In Session 31, Hou entered the tank and, after a preliminary jump, stood on its tail and clapped its jaws at the trainer, who, taken by surprise, failed to reinforce the maneuver. Hou then emitted a brief series of leaps and then executed a backwards aerial flip that was reinforced and immediately repeated 14 times without intervening responses of other types. In Session 32, after one porpoise and one flip, Hou executed an upside-down porpoise, and, after it was reinforced, repeated this new response 10 times, again without other responses (Fig. 5, 6).

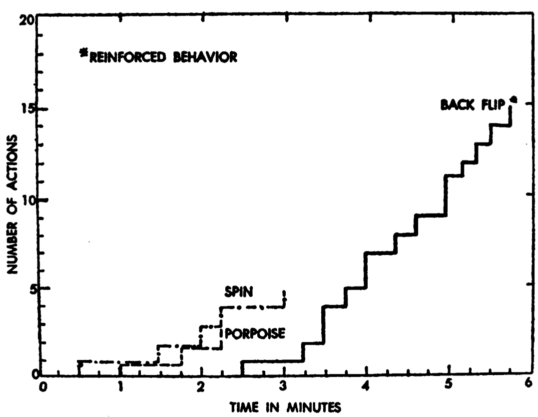


Fig. 5. Cumulative record of Session 31. The porpoise emitted a novel response early in the session, and other responses extinguished immediately when the novel response was reinforced.

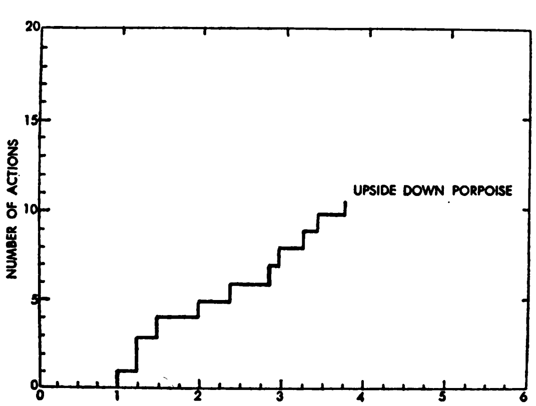


Fig. 6. Cumulative record of Session 32. The porpoise emitted only a novel response in this session.

In the third session of the day, Hou did not initially emit a response judged new by the observers. After 10 min and 72 responses of variable types, the rate of response declined to 1 per min and then gradually rose again to seven responses per minute after 19 min. No reinforcements occurred during this period. At the end of 19 min, Hou stood on its tail and clapped its jaws, spitting water towards the trainer; this time the action was reinforced, and was repeated five times.

Hou had now produced a new behavior in six out of seven consecutive sessions. In Sessions 31 and 32, Hou furthermore began each session with a new response and emitted no unreinforceable responses once reinforcement was presented. This establishment of a series of new types of responses was considered to be the conclusion of the experiment.

## DISCUSSION

Over a period of 4 yr since Sea Life Park and the neighboring Oceanic Institute were opened, the training staff has observed and trained over 50 cetaceans of seven different species. Of the 16 behaviors reinforced in this experiment, five (breaching, porpoising, inverted swimming, tail slap, sideswipe) have been observed to occur spontaneously in every species; four (beaching, tailwalk, inverted tail slap, spitting) have been developed by shaping in various animals but very rarely occur spontaneously in any; three (spinning, back porpoise, forward flip) occur spontaneously only in one species of *Stenella* and have never been observed at Sea Life Park in other species; and four (corkscrew, back flip, tailwave, inverted leap) have never been observed to occur spontaneously. While this does not imply that these behaviors do not sometimes occur spontaneously, whatever the species, it does serve to indicate that a single animal, in emitting these 16 types of responses, would be engaging in behavior well outside the species norm.

A technique of reinforcing a series of different, normally occurring actions, in a series of training sessions, did therefore serve, in the case of Hou, as with Malia, to establish in the animal a highly increased probability that new types of behavior would be emitted.

This ability to emit an unusual response need not be regarded as an example of cleverness peculiar to the porpoise. It is possible that the same technique could be used to achieve a similar result with pigeons. If a different, normally occurring action in a pigeon is reinforced each day for a series of days, until the normal repertoire (turning, pecking, flapping wings, *etc.*) is exhausted, the pigeon may come to emit novel responses difficult to produce even by shaping.

A similar process may be involved in one traditional system of the training of five-gaited show horses, which perform at three natural gaits, the walk, trot, and canter, and two artificial gaits, the slow-gait and the rack. The trainer first reinforces the performance of the natural gaits and brings this performance under stimulus control. The discriminative stimuli, which control not only the gait, but also speed, direction, and position of the horse while executing the gait, consist of pressure and release from the rider's legs, pressures on the reins and consequently the bit, shifting of weight in the saddle, and sometimes signals with whip and voice. To elicit the artificial gait, the trainer next presents the animal with a new group of stimuli, shaking the bit back and forth in the horse's mouth and vibrating the legs against the horse's sides, while preventing the animal from terminating the stimuli (negative reinforcement) by means of the previously reinforced responses of walking, trotting, or cantering. The animal will emit a variety of responses that eventually may include the pattern of stepping, novel to the horse though familiar to the trainer, called the rack (Hildebrand, 1965). The pattern, however brief, is reinforced, and once established is extended in duration and brought under stimulus control. (The slow-gait is derived from the rack by shaping.)

Upon conclusion of this experiment, Hou was returned to the care of Sea Life Park trainers and introduced as a performer in five daily shows six days a week until the time of writing (April, 1969). Hou performs a number of behaviors under stimulus control, some of which first appeared during this experiment. Spitting, for example, is now offered in response to the discriminative stimulus of a hand signal, and, as is the case for all conditioned behaviors used for performance, has been successfully extinguished in the absence of the stimulus. The trend towards the emission of novel behavior has, in the case of both Hou and Malia, been reversed during normal training and performance; they respond to learned stimuli correctly, with no more than normal unconditioned activity, and a single new response can be reinforced and shaped with no great increase occurring in types of responses offered. However, both animals can be stimulated to a high rate of activity, including novel behavior, if the trainer leaves the normal demonstration training platform and takes up position across the tank in the station used during the experiment. Thus, a session of reinforcing novel behavior can be introduced occasionally into a show without interfering with the normal presentation of behaviors under stimulus control. This occurs perhaps once a month. At least one behavior—flapping the last third of the body in the air, while hanging head down in the water—has been first reinforced, later to be brought under stimulus control, during such a session.

Comparison may be made here between this work and that of Maltzman (1960). Working in the formidably rich matrix of human subjects and verbal behavior, Maltzman described a successful procedure for eliciting original responses, consisting of reinforcing different responses to the same stimuli, essentially the same procedure followed with Hou and Malia. It is interesting to note that behavior considered by the authors to indicate anger in the porpoise was observed under similar circumstances in human subjects by Maltzman: "An impression gained from observing Ss in the experimental situation is that repeated evocation of different responses to the same stimuli becomes quite frustrating; Ss are disturbed by what quickly becomes a surprisingly difficult task. This disturbed behavior indicates that the procedure may not be trivial and does approximate a non-laboratory situation involving originality or inventiveness, with its frequent concomitant frustration."

Maltzman also found that eliciting and reinforcing original behavior in one set of circumstances increased the tendency for original responses in other kinds of situations, which seems likewise to be true for Hou and Malia. Hou continues to exhibit a marked increase in general level of activity. Hou has learned to leap tank partitions to gain access to other porpoises, a skill very seldom developed by a captive porpoise. When a trainer was occupied at an adjoining porpoise tank Malia jumped from the water, skidded across 6 ft of wet pavement, and tapped the trainer on the ankle with its rostrum or snout, a truly bizarre act for an entirely aquatic animal.

Maltzman also observed that under some conditions originality may be increased by evoking a relatively large number of different responses to different stimuli. The confirmation of this hypothesis is suggested by our informal observations of performing cetaceans, at least some of which develop a tendency to original behavior after a year or two of reinforcement with respect to many different kinds of stimuli and responses. We do not observe this "sophistication" developing in animals that are trained with respect to one group of responses and stimuli and then continue in the same pattern, however complex, for months or years.

Individual differences in the ability to create unorthodox responses no doubt exist; Malia's novel responses, judged *in toto*, are more spectacular and "imaginative" than Hou's. However, by using the technique of training for novelty described herein, it should be possible to induce a tendency towards spontaneity and creative or unorthodox response in most individuals of a broad range of species.

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