

Escape learning in the plains garter snake, *Thamnophis radix*

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Five plains garter snakes (*Thamnophis radix*) received five daily trials on each of 10 successive days in a water maze in which escape was possible through a hole in the correct end box. The snakes showed a significant reduction in latency to escape after 2 or 3 days of training. However, the animals did not acquire a discrimination between the correct and incorrect paths since the probability of turning into the incorrect arm did not decrease over days. Reduction in escape latency could be interpreted as an arousal effect of incentive learning (i.e., snakes learned that escape was possible, and this energized behavior even though they did not learn the correct pathway). However, an alternative view is offered wherein snakes are presumed to have learned not only that escape was possible but also a systematic pattern of searching behavior (which was somewhat less efficient than could have been acquired if the position discrimination had been mastered).

Although various researchers have demonstrated learning in turtles and tortoises (Kirk & Bitterman, 1963; Spigel, 1963; Wise & Gallagher, 1964), experiments employing snakes, beginning with Takemasa and Nakamura (1935), have typically produced equivocal results. Kellogg and Pomeroy (1936) observed water snakes (*Natrix rhombifera*) in a cold-water-filled maze where the reinforcer for an escape response was exposure to a warm goal compartment. This data revealed a decrease in escape latency and great variation within and between subjects. (One source of variation was ecdysis during which snakes exhibited extremely long response latencies, probably reflecting the generally low activity level which characterizes snakes during this period. But see Porter and Czaplicki, 1974.) Wolfe and Brown (1940) also studied escape behavior in *Natrix rhombifera* but employed heat as the aversive stimulus in a multiple T maze. Absolutely no evidence of learning was produced in this situation. Additional negative results were produced by Mills (Note 1), who attempted to train rattlesnakes to avoid shock. However, Crawford and Holmes (1966) examined the extent to which yellow rat snakes *Elaphe obsoleta* learned to escape from vibratory stimulation in a two-compartment box. Although two of the eight subjects showed no evidence of escape learning, the group curve for the remaining six snakes exhibited a statistically reliable decrease in response latency over five blocks of 10 trials per block (see also Crawford & Bartlett, 1966; Kleinginna, 1970).

Although the evidence is far from uniform, it seems reasonable to conclude that some snakes are capable of mastering certain tasks. It is likely that interacting

factors such as motivation, magnitude of reward, task difficulty, degree to which the required association is ethologically prepared, etc. are contributing in unknown ways to the success or failure of particular experiments. However, until an adequate data base is accumulated through the results of numerous experiments, it will be difficult even to guess about the manner in which these factors are operating.

The present study was designed to examine the performance of garter snakes in an enclosed maze where the reinforcer was escape through a narrow tunnel-like passageway to the dry exterior. It was hypothesized that such a situation would resemble the sorts of avenues normally travelled by these snakes and that the subjects would be ethologically prepared for the task demands. However, since *T. radix* is a semiaquatic species, there was no guarantee that the animals would actively attempt to escape from the interior of the maze. Since these organisms typically enter watery places mainly to feed, we guessed that prolonged immersion would be aversive enough to inspire searching and, eventually, escape.

METHOD

Subjects and Maintenance Conditions

The five garter snakes were captured approximately 9 months prior to service in the present study. During the first 6 months of captivity, the animals were housed in a large cage with other snakes at a temperature of $22 \pm 1^\circ\text{C}$. Subsequently, the snakes were housed in individual plastic cages ($17.5 \times 20.5 \times 15.0$ cm) with paper bedding, a rock, and water. Temperature averaged $22 \pm 2^\circ\text{C}$, and photoperiod was provided by electrically controlled overhead fluorescent lights which were on from 0700 to 2100. For 4 weeks prior to the beginning of maze trials, the animals were handled about 5 min three times weekly. Food was freshly thawed ocean perch, and each subject was fed to satiation once weekly.

Apparatus

The T maze was 15 cm high and 12.5 cm wide throughout and

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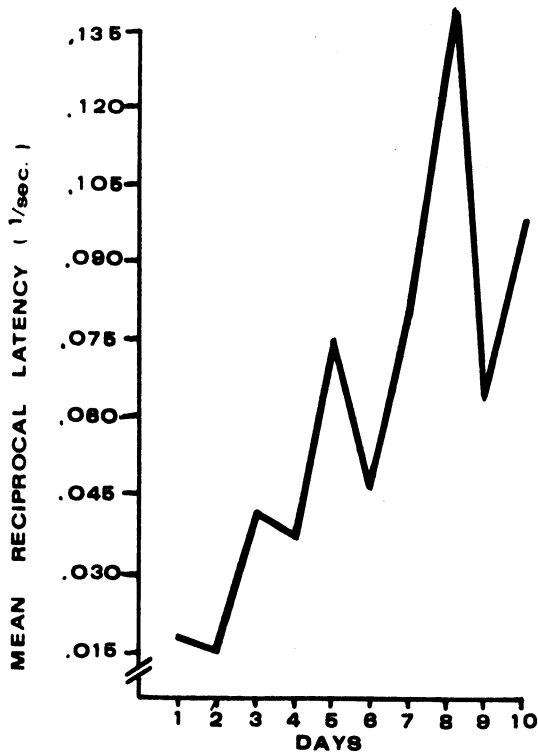


Figure 1. Mean reciprocal escape latency as a function of successive days of training.

was constructed of black Plexiglas (.31 cm thick) except for the lid which was transparent. The startbox was 25 cm long and was separated from the alley (20 cm long) by a guillotine door. Each arm was 22.5 cm long, and guillotine doors separated the arms from the end boxes (25 cm long). Situated in each end box was a 45-deg ramp constructed of clear Plexiglas (21 cm long and 11 cm wide) to which was glued small pebbles and several pieces of sandpaper (these items were necessary in order for the snakes' ventral scales to gain sufficient purchase to permit locomotion). Each ramp led to a 4-cm-square escape hole opening to the exterior. However, only one of these would be open, the other being shut by a black Plexiglas insert.

Procedure

The maze was filled with water to 1 cm from the top, and the water was allowed to reach room temperature ($22 \pm 2^\circ\text{C}$). Additional water was placed into the maze as needed to make up for evaporation. On each of 2 days before the start of learning trials, each snake was placed into the water-filled maze for 5 min with all doors open and with both escape holes blocked. Hence, escape was not possible on these days.

Maze trials began by placing a snake into the startbox, and after 1 min the startbox door was raised. At this point, a hand-held stopwatch was activated by an assistant and was stopped when the front half of the snake's body passed through the escape hole (for three snakes, the right arm was correct, and, for two, the left arm was correct). After leaving the startbox, the guillotine door was lowered to prevent retracing. The subject was then free to traverse the alley and select an arm. However, retracing within and between arms was possible until the subject actually entered the correct end box, after which the guillotine door was lowered. Hence, subjects could enter the correct arm and retrace immediately many times before finally entering the correct end box. Record was kept of the number of times each

subject entered 15 cm into the incorrect arm (Type I error) as well as the number of times the entire incorrect arm was traversed (Type II error). Finally, if a subject did not escape within 5 min, the trial was concluded, and a latency of 300 sec was assigned to the animal. In such cases, the subject was gently prodded into the end box and allowed to travel through the escape hole.

Five trials (ITI = 20 min; snakes spent the ITI in the home cage) were administered daily on each of 10 days. After each day's trials, the snakes were carefully dried and placed into their home cages. Daily trials were always administered between 1600 and 1800.

RESULTS

Figure 1 plots mean reciprocal escape latency over the 10 successive days, and the significant increase in this measure is obvious ($F = 4.55$, $df = 9/36$, $p < .01$). Figure 2 plots mean percentage of successful escapes (i.e., trials with latency less than 300 sec), and it is again clear that considerable improvement occurred over the 10 days of training ($F = 3.37$, $df = 9/36$, $p < .01$).

It is interesting that the error measures showed no change over days. First of all, the frequencies of the two types of errors were highly correlated ($r = .82$, $df = 248$, $p < .001$), indicating that subjects had a high probability of traversing the entire incorrect arm if they entered it. Secondly, the mean number of Type I and II errors per day was 5.2 and 4.5, respectively, and, in neither case was there a significant days main effect ($F_{\text{Type I}} = 1.40$, $df = 9/36$, $p > .05$; $F_{\text{Type II}} = 1.76$, $df = 9/36$, $p > .05$).

DISCUSSION

These data clearly reveal that latency to escape decreased over

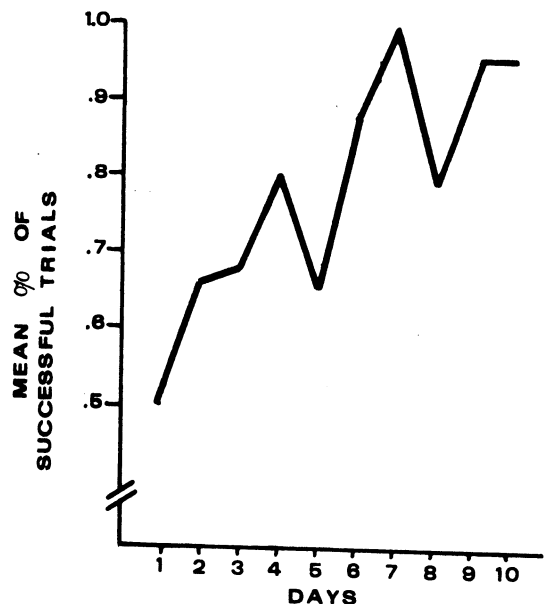


Figure 2. Mean percentage of trials ending in a voluntary escape from the maze (i.e., trials with latency less than 300 sec) as a function of successive days of training.

days, and this probably represents the occurrence of learning. Since the subjects were handled extensively and exposed to the water maze prior to the experiment, it seems reasonable to rule out "nonlearning" factors such as habituation to handling and/or water as explanations of the latency reduction during the 10 days of maze trials.

The fact that the subjects did not show reductions in the error measures is puzzling. This renders the latency change difficult to interpret because it cannot be attributed to the acquisition of a discrimination between the alternative paths in the maze. Rather, it seems that the snakes learned mainly that escape was possible (i.e., incentive learning occurred) and that the latency reduction represents an incidental nonspecific arousal effect. This view implies that escape latency was not under the control of the discriminative instrumental contingency. Yet, observation of the snakes while they negotiated the maze suggests that this conclusion is only partially correct. After the initial days, the subjects behaved as if they were searching for the escape hole. They swam down the arm to the ramp and rubbed their nasal scales along the Plexiglas surface in the vicinity of the escape hole. If the subject was in the correct end box, he would quickly discover the hole and escape would follow. If the subject was in the incorrect end box, his nasal scales would meet with pressure from the insert, and he immediately turned around and swam to the correct side, repeated the nasal-scale rubbing, and soon escaped. The organized systematic character of this searching behavior argues that it is incorrect to attribute the increase in response speed entirely to nonspecific "activational" effects of incentive learning.

A concept which might be appropriate is the ethological notion of "search image" wherein an animal's perception of stimuli within a field changes as a consequence of experience with the field (Tinbergen, 1960). Some stimuli may become more or less salient as a consequence of contingencies associated with them. Accordingly, animals may come to attend differentially to such stimuli, and they may even acquire "cue-producing responses" to facilitate observation of important stimuli. Such responses are clearly instrumental in that they are reinforced by production of stimuli and consequent generation of information. It is suggested that our snakes formed search images (i.e., some representation of the escape hole) which motivated and/or reinforced subsequent searching responses, and these, in turn, resulted in decreased escape latencies. This behavior could have become much more efficient if the subjects

had attended to the position cue. That is, subjects could have attained mastery of this task if they had incorporated into their search images the cue which we designated as relevant in the experimental situation. Why they failed to do so remains a mystery. But, the fact that they failed in this respect does not mean that the animals had no search images; it means only that they did not form the most efficient one possible.

REFERENCE NOTE

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