Black-white discrimination and orienting behavior in the desert iguana (*Dipsosaurus dorsalis*)

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Six desert iguanas (*Dipsosaurus dorsalis*) were trained on a black-white discrimination problem using a modified Lashley maze I. The results, in terms of number of trials to criterion, compared favorably to those reported for turtles on the same brightness difference. Efficiency of learning was attributed to (1) the angle separating the discriminanda, (2) intertrial substrate temperature, and (3) visual attentional characteristics of the apparatus. In addition, orienting responses (VTE) varied in expected directions according to speed of learning and difficulty of maze choice points.

Although black-gray-white discrimination in the turtle has been demonstrated (Casteel, 1911; Kuroda, 1933; Kirk & Bitterman, 1963; Spigel, 1963; Wise & Gallagher, 1964), it has been difficult to generalize these findings to all reptiles. The results reported for lizards on a black-white problem have been puzzling and inconclusive. In 1965, Vance, Richardson, and Goodrich, using the collared lizard (*Crotaphytus collaris*) on a 30-deg-angle Y maze with shock for incorrect choice and animals at room temperature (25°C), established black-white discrimination only after 350 trials. These results compared very unfavorably in terms of number of trials required by turtles to acquire this discrimination. Alkov and Crawford (1966) demonstrated black-white discrimination in the lizard *Iguana iguana* run at a room temperature of 22°C but gave these animals only 30 trials, since the study involved successive reversal problems. Thus, it is not clear to us how many trials would be necessary for these animals to reach adequate criterion levels. In 1970, Richardson, Garzanit, and Albano, using the desert iguana and the same (Vance, Richardson, & Goodrich, 1965) 30-deg-angle Y maze without shock, failed entirely to establish a black-white discrimination after 425 trials. The present study attempts to clarify the question of such discrimination capability in the lizard. In addition, as in all our work, the orienting responses (VTE) which accompany discrimination learning in lizards and other vertebrates were closely observed. We, like Tolman (1948) and Bruner, Matter, and Papanek (1955), regard this choice point behavior as an index of selective attention to maximize utilization of cues. Such an assumption seems well supported by the findings that VTE always occurs at choice points in a maze, decreases as learning progresses, and increases with increment in problem difficulty (Tolman, 1938; Tolman & Ritchie, 1948; Goss & Wischner, 1956; Richardson, 1959; Julian & Richardson, 1968; Richardson & Graf, 1970; Richardson, Garzanit, & Albano, 1970; Mortel, Richardson, Amber, & Peterson, 1971). It is also true that there is greater frequency of VTE at more difficult

choice points (Julian & Richardson, 1968) and that slower learners and brain damaged animals exhibit fewer of these orienting responses (Tolman, 1948; Richardson, 1959; Mortel, Richardson, Amber, & Peterson, 1971).

METHOD

Subjects

The Ss were six desert iguana (*Dipsosaurus dorsalis*) collected from the Palm Springs area. Their mean weight was 38 g and mean snout-vent length was 109 mm. The animals were maintained in wire mesh cages with sand and rocks on the floor. Daily feeding consisted of fresh lettuce and meal worms (*Tenebrio* larvae). Water with multivitamins and calcium was given ad lib. Infrared lamps (250 W) suspended 90 cm above the cage floor provided heat and light for 10 h a day.

Apparatus

Two identical Lashley maze I were used (Fig. 1), modified to appropriate dimensions for this lizard. The floor and walls of the right arm and goalbox of one maze were painted flat black and the left arm, floor, and walls flat white. The second maze had the reverse relationship. That is, the left arm and goalbox were black and the right arm white. A wire mesh ladder led to a choice stand, painted an intermediate gray, from which the S could proceed into either alley. The mazes, for purposes of detailed scoring, were marked in terms of areas and choice points. Lighting was provided by a 150-W bulb suspended 60 cm above the floor of each maze. The floor of the positive goal always consisted of a hot plate maintained at 40°C. The floor of the negative goal contained a pseudo-hot plate at room temperature (22°-25°C). Radiation of goal plate heat to adjacent maze areas was controlled. The hot plate was insulated by asbestos side panels and spatially separated by 6 mm on all sides from the maze floor and walls. Between trials the Ss were kept in a glass holding jar maintained at a temperature of 30°-32°C.

Procedure

The lizards were gentled daily during 5-min sessions for 3 weeks (15 days). Each S was then given eight orientation trials, that is, allowed to explore each maze for four 3-min trials. On the basis of the performance during these trials, each animal was assigned a nonpreferred brightness as the positive goal. Preference was defined as over 50% choice of either the black or white alley.

The lizards were given five trials a day with an ITI of 15 min. Two mazes were used to avoid interchanging the arms of the mazes, a cumbersome time-consuming procedure when hot plates are used. Instead, an animal was placed on each maze so

Fig. 1. Diagram of modified Lashley maze I: choice stand and alley areas designated numerically, choice points marked alphabetically. Scale 1 : 8.

Fig. 2. Course of learning, latency, and VTE.

that the positive alley (either black or white) appeared in an abba sequence position requiring both left and right turns.

For each trial the lizard was placed on the wire mesh ladder leading to the choice stand. If he proceeded to the positive goal, he was allowed to lie on the hot plate for 3 min. If he made an incorrect turn, he was allowed 3 min to retrace and reach the positive goal. The criterion of learning was defined as 90%-100% correct choice (errorless trials) on 2 consecutive days. Scoring was in terms of (1) latency, or time on the choice stand, (2) correct choice, (3) number of errors at each choice point, and (4) number of orienting responses (VTEs), defined as alternating head movements at a choice point.

RESULTS AND DISCUSSION

All lizards reached criterion learning with a mean of 65 trials, a remarkable improvement over our two

previous attempts with collared lizards and desert iguanas. The results compare very favorably, in spite of differences of method and apparatus, with those reported for turtles, who apparently can achieve a brightness discrimination in 50-100 trials, and for laboratory rats, who master the problem in 105 trials (Richardson, 1959) and 96-120 trials (Tolman, 1941, 1943).

Since in our study the lizards reached criterion on different days (15-90 trials), all scores were handled in terms of Vincent fifths. Figure 2 indicates the course of learning (errorless goals), latency, and VTEs. A matched-pair *t* test of mean percent errorless goals between the first and last Vincent fifths of the total trials yielded a *t* of 6.33, SE_{MD} of 0.06, and a $p < .005$. Orienting responses and latency decreased as learning progressed (Fig. 2). A comparison of mean VTE frequency between the first and last Vincent fifths showed a significant decrement ($t = 3.7$, $SE_{MD} = 0.19$, $p < .01$).

Again, in the present study, it was found that lizards who learned black-white discrimination in the fewest trials showed the highest frequency of orienting responses. A Spearman ρ of 0.97 and p of .01 confirmed the relationship. An independent means *t* test for unequal *N*s between frequencies of VTE for slow ($N = 4$) and rapid ($N = 2$) learners (Fig. 3) yielded $t = 3.7$, $SE_{MD} = 0.30$, $p < .05$.

Conversely, those animals who had the highest frequency of errors exhibited the lowest frequency of VTE ($\rho = 0.94$, $p = .01$). As mean number of errors decreased, the mean frequency of VTEs decreased ($\rho = 0.90$, $p = .05$). When Choice Points A, B, and C

Fig. 3. Comparison of VTE frequency for slow and rapid learners.

were ranked in terms of difficulty (mean number of errors the animals made at each choice point), it was again found that the more difficult the choice point, the higher the VTE frequency ($\rho = 1.00$, $p = .01$).

It seems apparent that optimal conditions for black-white brightness discrimination were achieved by apparatus and methodological changes involving (1) increasing the angle between discriminanda from 30 to 180 deg, (2) painting the total discrimination pathway, including the floor, black and white (the original 30-deg Y maze goalboxes had black and white wall inserts but all floors were white), and (3) maintenance of intertrial substrate temperature of these animals at 30°-32°C. Efficient learning, then, with its accompanying orienting behavior seems to depend, in this heliothermic animal, upon both temperature factors (Krekorian, Vance, & Richardson, 1968) and the spatial and visual attentional qualities of the relevant stimuli.

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