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ERRORLESS DISCRIMINATION-REVERSAL LEARNING IN THE CALIFORNIA SEA LION

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Terrace (1963) has demonstrated that pigeons can be transferred errorlessly from a previously well-learned color discrimination to a more difficult line orientation or shape discrimination. This was accomplished by superimposing a white vertical line (positive shape) on a red key (positive color) and superimposing a white horizontal line (negative shape) on a green key (negative color). The color backgrounds of these compound stimuli were gradually faded until only the vertical and horizontal lines served as discriminative stimuli. Thus, during the initial stages of training, compound stimuli were presented with positive and negative cues congruent in both the color and shape dimensions. Subsequent to obtaining errorless shape discrimination the pigeons were returned to the previous color-discrimination task without any deleterious effects.

The present experiment was designed: (a) to determine the effectiveness of a progressive-dimensional-change technique, or programed-stimulus technique similar to Terrace's on the discrimination-reversal performance of a California sea lion, and (b) to gain some information regarding shifts in "attention" from one stimulus dimension to another.

METHOD

Subject

The experimental S was a wild-born female California sea lion judged to be approximately 26-29 months old at the time this study was initiated. Previously, S received training on an underwater size-discrimination task and a psychophysical function on the size dimension had been obtained with both circular- and triangular-shaped stimulus targets (Schusterman et al., 1965). In addition, S had been tested in turbid water with circular-shaped targets of different size and sound-transmission quality in attempts to demonstrate its echo-ranging capabilities (Schusterman, 1965a). Throughout all these tests S was reinforced for responding to the smaller of two targets. It is important to note that prior to this study S had never been confronted with a shape discrimination in an experimental situation.

Apparatus and Procedure

The S was tested in an oval-shaped tank which is 15 x 30 x 6 feet and holds 18,000 gallons of fresh water. The testing conditions and apparatus have been previously described in detail (Schusterman et al., 1965). The S's task was to push one of two targets in order to obtain a small piece of herring weighing approximately five gm. During the experiment a non-correction technique was used and position of the target was an irrelevant cue.

Two Es were present throughout testing. One E presented the stimulus display and reinforced appropriate responses while the other E observed S, recording correct responses and the presence of orienting responses. An orienting response was defined as postural changes of the head or body occurring within seven feet of the stimulus display. Previous data have indicated that such orienting responses occur either in conflict situations or under conditions of poor visibility (Schusterman, 1965b).

Progressive Dimensional Change

The sequence of progressive training stages, stimulus dimensions, reinforcement values, and the number of trials per training stage are outlined in Table 1. The first stage of training was designed to reveal which of the stimulus forms S preferred. Subsequently, Stage 2 was begun with the aim of "forcing"

Table 1
Description and Results of Training

Training Stages	Stimuli[a]		Size-Difference Ratio	No. of Trials	No. of Responses to Circle or Errors
	Triangle Area ($cm.^2$)	Circle Area ($cm.^2$)	Larger: Smaller		
1	42.8	42.8	1.00:1	12	11
2	6.35	289.8	45.64:1	10	0
3	16.5	111.5	6.77:1	10	0
4	26.6	111.5	4.20:1	10	0
5	26.6	69.1	2.60:1	20	0
6	34.1	69.1	2.02:1	20	0
7	34.1	54.3	1.59:1	20	0
8	38.0	54.3	1.43:1	30	2
9	38.0	48.4	1.27:1	20	0
10	40.3	48.4	1.20:1	10	0
11	40.3	45.4	1.13:1	10	0
12	40.3	42.8	1.06:1	10	0
13	42.8	42.8	1.00:1	50	2
14	45.4	42.8	1.06:1	10	0
15	45.4	40.3	1.13:1	10	0
16	48.4	40.3	1.20:1	10	0
17	48.4	38.0	1.27:1	10	0
18	54.3	38.0	1.43:1	10	0
19	54.3	34.1	1.59:1	10	0
20	69.1	34.1	2.02:1	10	1
21	69.1	26.6	2.60:1	20	3
22	111.5	26.6	4.20:1	2	2
23	54.3	34.1	1.59:1	10	0
24	69.1	34.1	2.02:1	7	0
25	69.1	26.6	2.60:1	100	2
26	111.5	16.5	6.77:1	10	0
Blocks of Trials	Triangle	Triangle			
1	69.1	26.6	2.60:1	25	18
2	69.1	26.6	2.60:1	25	2
3	69.1	26.6	2.60:1	25	1

[a]Except for the first training stage, in which responses to either stimulus were reinforced, the positive stimulus for each pair is on the left and the negative stimulus on the right.

Erratum: Multiply absolute stimulus sizes in Table 1 by 2.54 to obtain corrected values in $cm.^2$

S to respond to the nonpreferred form on the basis of its previous size preference (small). Thus, from Stages 2 through 12 the nonpreferred form and the preferred size constituted the positive compound stimulus, and the nonpreferred size and the preferred form constituted the negative compound stimulus. The size cue was progressively diminished until Stage 13 at which point S was confronted with targets differing only in the form dimension. Following Stage 13 the original nonpreferred form and nonpreferred size constituted the positive stimulus, and the original preferred form and preferred size constituted the negative stimulus. The final phase was undertaken to determine whether during Stages 14-26 S was responding to size or form cues.

RESULTS

Column 6 of Table 1 shows the number of errors or responses to the circular target during each stage of training. As anticipated on the basis of much more previous testing experience with circular-shaped stimuli, S showed a significant ($p < .01$) preference for the circular as compared to the triangular target but was able to reverse the original form preference virtually without errors. The table also reveals that when the size cue was gradually reinstated so that the previous negative size (large) was combined with the new positive form (triangle) S still responded virtually without errors. However, when the form cue was eliminated abruptly, S showed a strong preference for the smaller stimulus. This indicates that the form cue rather than the size cue was controlling performance during Stages 14-26.

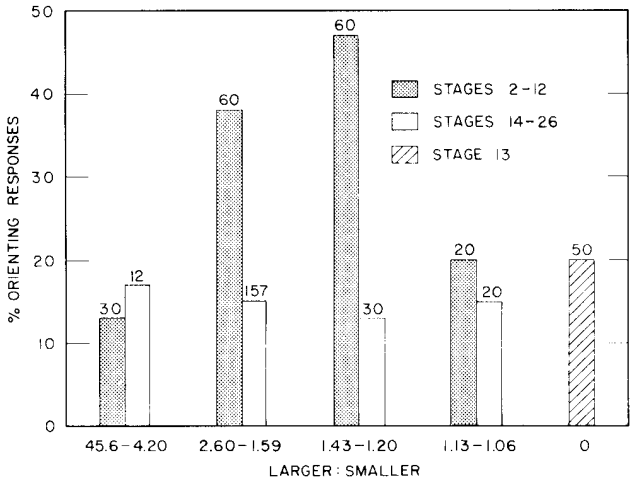

Figure 1. Orienting responses as a function of size-difference ratios and training stages. Numerals at each data point represent number of trials.

Figure 1 presents the percentage of orienting responses that S made as a function of the size-difference ratios and training stages. Whereas a significant change ($p < .01$) in orienting responses occurred as a function of the size-difference ratios during Stages 2-13, there was relatively little change during Stages 13-26; also, there were significantly more orienting responses ($p < .01$) throughout Stages 2-12 than there were during Stages 14-26.

DISCUSSION

The results of this experiment show that a sea lion can reverse a previously well-established habit on a form-discrimination task virtually without making any errors. The critical training requirements appear to be the combining of a previously well-established size-cue preference with the nonpreferred form cue, followed by the progressive dimunition of the former cue. Moreover, it was shown that the new form preference remained relatively unaffected when the previously positive and negative aspects of the size dimension were reversed and gradually reinstated. Although the results reported here were based on performance of a single animal, the progressive-dimensional-change technique has been used successfully with another sea lion resulting in five successive discrimination reversals without errors (Schusterman, in preparation). In addition, further experimentation has shown that when sea lions are confronted with successive discrimination reversals without progressive-dimensional-change training they commit 30 to 116 errors on the first two reversal problems.

The increase and subsequent decrease of orienting responses during form-reversal training suggests that there are critical stages in the transition of attention from the size dimension to the form dimension. These critical stages appear to be well above the differential size threshold for sea lions tested underwater (Schusterman et al., 1965). That orienting responses do reflect a shift in the animal's attention from one stimulus dimension to another is borne out by the finding that such behavior was little displayed during Stages 14-26—a period throughout most of which it was indicated that only one cue (form) was controlling behavior.

Although it is not yet possible to describe the precise nature of the errorless reversal-learning process, the present results appear to favor interpretation in terms of the following brief statement by Guthrie: "What is being noticed becomes a signal for what is being done (Guthrie, 1959, p. 186)."

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