Dimensional preferences with object and pattern stimuli in monkeys with inferotemporal lesions¹

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Preference tests with multidimensional stimuli indicated that different dimensions are salient depending upon whether the discriminanda are raised forms (objects) or printed forms (patterns). Animals with inferotemporal lesions were able to learn to attend to all dimensions with the objects but not with the patterns. The results suggest that inferotemporal Ss may have difficulty in learning to attend to a dimension when another extremely salient dimension is present and irrelevant.

Previous investigations have demonstrated that monkeys with lesions in the inferior convexity of the temporal lobe exhibit a marked impairment in learning two-choice visual discriminations. Although this impairment does not seem to be attributable to alterations in visual acuity (Weiskrantz & Cowey, 1963), the magnitude of the deficit is dependent on the nature of the discriminanda.

On the basis of stimulus generalization tests, Butter, Mishkin, & Rosvold (1965) concluded that inferotemporal animals attend to only the most distinctive features of the stimulus and that the less distinctive features exert little control over the organism's performance. These results suggest that inferotemporal Ss would have little difficulty in learning visual discriminations when the most salient stimulus dimension was made relevant, but

would be impaired when required to attend to a dimension which was not the most salient.

In the present experiment, a preference-testing paradigm was employed in a series of two-choice problems. This design was used to see: (1) what dimensions are most salient when the stimuli are raised forms (objects) and printed forms (patterns), (2) whether the same dimensions are salient for normal and inferotemporal animals, and (3) whether inferotemporal Ss have difficulty in learning to attend to a less distinctive dimension.

SUBJECTS

The Ss were seven adolescent rhesus monkeys. All had had previous experience in both tactual and visual discrimination tasks (Rothblat & Wilson, 1968). One S developed severe position preferences during preoperative testing and was not continued on postoperative problems.

PROCEDURE

Preoperative Preference Testing

All testing was done in a modified Wisconsin General Test Apparatus. Ss were initially presented with a series of eight two-choice discriminations. The discriminanda in this first series were *pattern* stimuli consisting of colored forms, approximately 1½ in. in height and width, printed on 2½-in. white cardboard squares. Within a problem the stimuli involved two values of color and two of form, but they were so paired with each other and with position over trials that there was no correlation among these three variables. Thus in each problem one of two pairs of

stimuli (e.g., red square vs green circle or green square vs red circle) was presented on each trial. Each stimulus appeared twice in both the right and left positions in an eight-trial block. The stimuli served as foodwell covers. Both foodwells were baited on every trial so that a response to any stimulus was rewarded. It was therefore possible for Ss to choose the same cue on every trial or to choose randomly among the cues. If Ss did respond consistently, this response could be made to any one of six cues (e.g., right, left, red, green, circle, square) within three dimensions: position, color, or form. One problem was presented each day. Testing was continued on each problem either until S responded to one of the cues on seven trials within an eight-trial block or to a maximum of 32 trials. This procedure was carried out with eight different stimulus pairings. The forms were: square, diamond, triangle, T, cross, star, plus, and circle; the colors were: red, green, orange, blue, black, yellow, grey, and brown.

All Ss then received a second series of problems following the same procedure. The discriminanda were Masonite *objects* consisting of colored forms, approximately 1½ in. in height and width and ¼ in. in thickness; the forms and colors were similar to those used in the patterns.

Surgery

Six Ss were assigned to operate and control groups. The three Ss in the operate group underwent one-stage bilateral resection of the middle and inferior temporal gyri (Mishkin, 1954). Postmortem inspection of the operated brains showed that the ablations were confined to the intended site with some additional superficial damage to the superior temporal gyrus.

Postoperative Preference Testing

All six Ss were retested for preferences on the series of problems using Masonite *objects* that had just preceded surgery.

Differential Training

The Ss were again presented with the same series of object stimuli; however, in this case, differential training was introduced on each problem. After S established a consistent mode of responding to one cue in the preference situation, a different cue was placed on a 100% reinforcement contingency. This cue was either the other cue in the same dimension (reversal shift) or a cue in one of the nonpreferred dimensions (extradimensional shift). The stimulus that embodied this cue

Fig. 1. Dimensional preferences with object and pattern stimuli. Each set of three columns represents the preferences shown in a total of 56 presentations.

was always rewarded; the other stimulus of a given pair was not. In the extradimensional shifts, position was always irrelevant. Of the eight problems, four were reversal and four were extradimensional shifts. The extradimensional and reversal shifts were randomly interspersed. During differential training, 30 noncorrection trials were presented each day until a criterion of at least nine correct responses in both of two consecutive 10-trial blocks was reached.

All Ss were subsequently trained on a two-choice *pattern* form discrimination (x vs plus). Training was continued until S made at least 27 correct responses within a 30-trial session or received a total of 600 trials.

RESULTS

Preoperative Preference Testing

Dimensional preferences with object and pattern stimuli as reflected by the number of problems on which one cue was consistently chosen are shown in Fig. 1. Analyses of variance (Friedman test) on the ranked preference scores were performed separately for the object and pattern tests. A significant difference ($\chi^2 = 12.02$, $df = 2$, $p < .01$) was disclosed for the patterns, but not for the objects. Difference scores of the individual Ss indicated that position was chosen more ($p < .01$, Wilcoxon rank-sum) and form less ($p < .05$) in patterns than in objects.

Postoperative Preference Testing

Changes in dimensional preferences with the object stimuli were examined by computing preoperative-postoperative difference scores for each S. With a postoperative increase represented by a positive number, the mean changes for form, color, and position, respectively, were +2.7%, +0.4%, and -3.1% for normal Ss and

lesion by shift interaction was significant ($F = 8.7$, $df = 1/4$, $p < .05$). Closer inspection of the data, however, revealed that this result was due to the high scores of the inferotemporal Ss on reversal shifts after position preferences, a type of reversal which none of the control animals happened to receive. When reversal shifts within color and form were considered alone, there was no significant difference between the groups. The problem main effect also reached a reliable level ($F = 4.6$, $df = 3/12$, $p < .05$), indicating interproblem improvement for both groups.

Whereas all of the normal Ss reached criterion on the pattern form discrimination (range: 80-270 trials), none of the Ss with inferotemporal lesions succeeded in meeting the criterion within 600 trials.

DISCUSSION

On discrimination training with the pattern forms (X vs plus), the inferotemporal Ss showed the expected deficit in acquisition. With the object stimuli, however (either reversal or extradimensional shifts), these animals were able to attend to all dimensions and learn problems at a normal rate. The results of the preference tests indicated that the dimensional relationships were quite different, depending upon whether the stimuli were raised forms (objects) or printed forms (patterns). In the former case, position, color, and form were equally preferred. With the patterns, position was by far the most salient dimension, while form appeared to exert little control over the organism's performance.

These results may be helpful in understanding the impairment of inferotemporal Ss in learning visual

discriminations. Even though inferotemporal animals displayed some tendency to shift their preferences to position, their ability to learn to attend to all dimensions in *objects* is not surprising in light of the fact that none of the dimensions appeared in the preference testing to be of disproportionate strength. The magnitude of the temporal deficit in solving *patterns*, however, suggests that these Ss may have difficulty in learning to attend to a dimension (e.g., form) when another extremely strong dimension (e.g., position) is present and irrelevant.

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NOTES

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Table 1
Mean Trials to Criterion on Shift Problems

Group	Shift	Color	Form	Position
Normal	Reversal	18.3	11.7	-
	Extra-dimensional	30.0	10.0	-
	Reversal	22.9	20.0	57.5
Infero-temporal	Extra-dimensional	33.8	12.5	-

-17.5%, -2.6%, and +20.1% for inferotemporal Ss. The only difference between groups supported by statistical test was a greater change toward position for the inferotemporal Ss than for the normals ($p = .05$, one-tail Mann-Whitney).

Differential Training

Table 1 gives the mean scores on the reversal and extradimensional shift problems in the different dimensions for the two groups. Although the lesion main effect failed to reach a reliable level in a lesion by shift by problem analysis of variance, the

Counterconditioning and fear reduction in the rat¹

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Three groups of rats were conditioned to escape shock in a two-compartment Miller box. One group was then confined in the shock compartment with food, the second confined without food, and the third not

confined at all. Confinement with food was significantly more effective in reducing fear than confinement without food or no confinement, as measured by latency of escape from the shock compartment during extinction trials. However, both confinement with food and confinement without food were equally effective in reducing fear as measured by avoidance of