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Generalization of an operant response to photographs and drawings/silhouettes of a three-dimensional object at various orientations

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Generalization gradients were obtained to the S+ object at 0-, 45-, 90-, 135-, and 180-deg orientations and to mounted photographs and drawings/silhouettes of the S+ object at these orientations following discrimination training between this object at 45 deg (S+) and other three-dimensional objects at various orientations. Although the "photo" gradient was virtually identical to the "object" gradient, the pigeon did subsequently learn to discriminate between the real S+ object and a mounted photo of the object at 45 deg; this discrimination generalized to photos of other orientations as well. Although the shape of the "drawings/silhouettes" gradient was similar to the "object" gradient, the overall level of responding was considerably less. The basis for these differences in response level is discussed in terms of the cues to spatiality that are preserved in the mounted photos and drawings/silhouettes of the object at the various orientations.

Due to a recent renewal of interest in the perceptual equivalence of photographs and line drawings to three-dimensional objects, one of the researchers (Cabe, 1976a, 1976b) has encouraged me to publish the results of an experiment with pigeons which was performed several years ago.[1]

GENERAL METHODS

The following general methods and procedures were used in all experiments; differences were primarily in the stimulus displays utilized. These are described as appropriate for each experiment.

Subject

One adult white Carneaux pigeon served as the subject. Having been maintained at ad-lib weight, the bird was reduced to 80% of the free-feeding weight and maintained there throughout the experiment.

Apparatus

A standard single transparent key, operant-conditioning chamber for pigeons was utilized. The transparent key was mounted on the outside of the box against a 2-in. circular hole in the back wall of the chamber, through which the bird viewed into a sandblasted Plexiglas tube 2 in. in diam. The stimulus object was located at a distance of 7 in. down the tube. The object was illuminated by two 15-W fluorescent tubes (6 in. in length) positioned parallel to the Plexiglas tube in such a manner that there were no attached shadows on the surfaces of the stimulus object. The object utilized as the S+ during all the experiments to be reported was the object depicted in Figure 1, at an orientation of 45 deg. Other objects utilized as training S−s during the discrimination phase of the experiment were of the same height (1-1/8 in.) but of very different shapes.

Procedure

Pretraining. After being reduced to 80% free-feeding weight, the bird was magazine trained and trained to peck the transparent key by successive approximation. The continuous reinforcement schedule was gradually changed to a variable-interval 30-sec schedule before beginning discrimination training.

EXPERIMENT 1

Method

Discrimination training. Training consisted of utilizing the object pictured in Figure 1 at 45 deg as the S+ and using two other white objects of the same height as S−s (one a wedge-shaped object and the other a flat hourglass-shaped object). The hourglass-shaped object was always positioned in the frontal parallel position when presented to the pigeon. The wedge-shaped object was presented at 0, 45, 90, 135, and 180 deg during training. Discrimination training continued until the rate of responding to the S+ object at 45 deg was in a ratio of 80:5 relative to the rate emitted to any of the S− objects at any orientation.

Generalization testing. In addition to testing for generalization to all the orientations (0, 45, 90, 135, and 180 deg) of all the objects, generalization was tested to photographs of the S+ object at those orientations. The photographs had been taken of the object at each of the orientations from the distance and position that the pigeon would occupy from 1 in. behind the middle of the transparent key. They had been enlarged to the same size as the objects and cut along the outline of the photograph of the object itself. The cutout photographs were cemented to thin sheets of aluminum of the same shape, with the back edge of the aluminum sheeting feathered so as not to be visible from the front. So mounted, the cutout photographs were positioned in the tube in precisely the same way as were

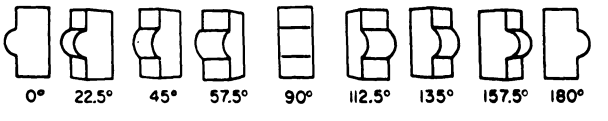

Figure 1. The projective geometry of the S+ object at orientations differing by 22½ deg.

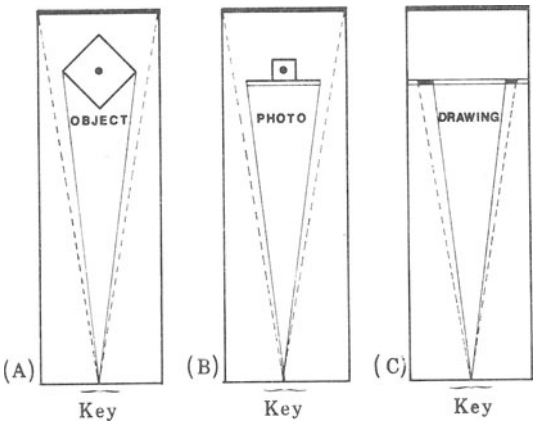

Figure 2. The stimulus presentation arrangement for the object (A), the photograph (B), and the drawing/silhouette (C).

the objects themselves, that is, secured to the bottom of the tube by a vertical bolt. In the case of the photograph, the bolt was screwed into a solid piece of metal behind the aluminum sheeting at the same distance from the key as was the bolt in the real object (see Figures 2A and 2B). Such a photographic representation of each of the orientations of the S+ object was prepared and presented with the other test stimuli as part of randomized blocks during the testing procedure on alternate testing days (1, 3, and 5). All testing was done during extinction. On Days 2 and 4 of testing, the mounted photographs of the various orientations of the S+ were omitted, and line drawings/silhouettes of the S+ object at those orientations were presented. The latter were prepared by cutting white construction paper in the shape of the object at those orientations and drawing the internal edges of the object on the paper in pencil. These were mounted on black circular construction paper of such a diameter as to project the same visual angle from that distance as did the black end of the tube from its slightly greater distance (see Figure 2C). (This circular black background was mounted on a sandblasted Plexiglas disk of the same surface characteristics as the rest of the tube.) Thus, this representation of the object and the background laid in the same plane and provided the same contrast as did the object or the mounted photograph against the black background. The drawings/silhouettes were presented during testing in the same manner as had been the mounted photographs. Again, the orientations represented were 0, 45, 90, 135, and 180 deg.

Results and Interpretation

The gradients emitted to the various orientations of each of the S– objects were virtually flat and approached a zero rate of responding throughout the entire series of generalization tests. Figure 3 portrays the gradients obtained to the three-dimensional S+ object at its various orientations and the other representations of that object at those orientations. It will be seen that the mounted photographic representations of the S+ object were functionally equivalent to the three-dimensional object itself. This finding seems to suggest that, under the conditions of observation permitted in this arrangement, the cues to spatiality provided by the real three-dimensional object that were not preserved in the mounted photographs were without consequence for stimulus control. This should not be too surprising, insofar as no such discrimination was required to reach criterion during discrimination training. Whether or not the pigeon had the capacity to discriminate such a subtle cue was addressed directly in Experiment 2.

Although the drawings/silhouettes of the object were generally responded to at a lower rate than the corresponding orientations of the object itself, the pattern of responding to the different orientations was quite similar. This seems to suggest that contour is of some significance for stimulus control, insofar as there is little else remaining of the stimulus array that characterizes the orientation of the real three-dimensional S+ object.

EXPERIMENT 2

Method

Discrimination training. Training consisted of four sessions, again using the object pictured in Figure 1 at 45 deg as the S+ stimulus but utilizing only the mounted photograph of that object at 45 deg as the S– stimulus.

Generalization testing. Generalization testing followed, using the 0-, 45-, 90-, 135-, and 180-deg orientations of the S+ object and the mounted photographs of the object at those orientations. Each of the displays was presented to the subject in randomized blocks.

Results

Figure 4 portrays the generalization gradients generated by responding to each of the stimulus displays. Although the pigeon was able to discriminate between the mounted photograph and the object itself during discrimination training, the subject failed to generalize a high rate of responding to the object at 135 deg as he had done on previous tests and as other pigeons and monkeys have done since (Lumsden, 1970). Consequently, the finding that the subject did not respond to the mounted photograph of the object at 135 deg is uninterpretable. It would be possible to make a statement about failure to respond to the mounted photograph of the object at 135 deg only if the subject had responded rather highly to the object itself at that orientation. To insure that this condition was met, the following experiment was performed.

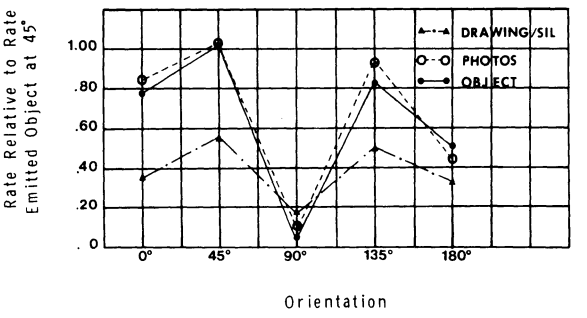

Figure 3. Generalization gradients for the object at the various orientations, the corresponding photographs, and the corresponding drawings/silhouettes.

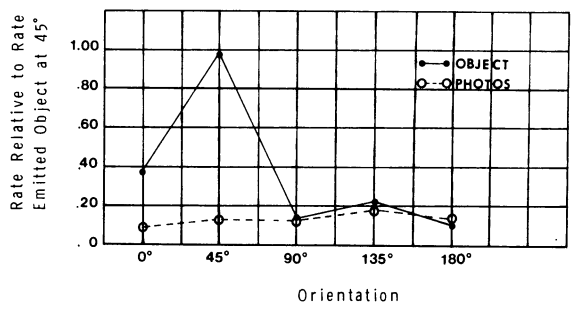

Figure 4. Generalization gradients to the S+ object at various orientations and the corresponding photographs following discrimination training with the object at 45 deg as the S+ and the corresponding photograph as the S–.

EXPERIMENT 3

Method

Discrimination training. The S+ stimuli utilized in this experiment were the S+ object pictured in Figure 1 at 45 deg and at 135 deg. The S– display was a mounted photograph of that object at 45 deg.

Generalization testing. The S+ object was used at orientations of 0, 22½, 45, 67½, 90, 112½, 135, 157½, and 180 deg. Also, mounted photographs of that object positioned at each orientation were presented. As usual, generalization was conducted during extinction.

Results

Figure 5 portrays the stimulus generalization gradients generated to the object and the mounted photograph of the object at each of the nine orientations indicated. It is, of course, not surprising that the pigeon continued to respond to the object at 135 deg during generalization testing inasmuch as the response had been explicitly reinforced during discrimination training. The pigeon had not, however, been extinguished to the mounted photograph of the object at that orientation. Consequently, the flat gradient to the mounted photograph of the object at all orientations can now more justifiably be taken as indicating generalization from the discrimination training using the mounted photograph of the object at 45 deg as an S–.

DISCUSSION

The matter of object orientation as a dimension of stimulus generalization has been addressed elsewhere (Lumsden & Pullen, 1970), as has the bimodal form of the stimulus generalization gradients obtained with such an object (Lumsden, 1970). Consequently, our concern here will be limited to addressing the different activity levels evident across these similarly shaped gradients. To this end, I would like to point out the cues to spatiality that are available in the displays of the real three-dimensional object at the various orientations that are also preserved in the mounted photographs of the object at those orientations, then note those cues that are retained, even in the drawings/silhouettes of the object at those orientations.

Given that all of the stimulus arrays are viewed from the same distance and under the same lighting conditions, it would seem that the following cues to spatiality would exhaust those available to the pigeon in viewing the various orientations to the real three-dimensional object: (1) parallax of the object relative to its background, (2) parallax of one surface of the object relative to the other surface, (3) texture gradient provided by the receding surfaces of the object at nonfrontal orientations, (4) perspective of the receding surfaces of the object at nonfrontal orientations, and (5) the edges corresponding to the intersecting receding surfaces of the object at nonfrontal orientations.

The presentations of the mounted photographs retained all of these cues to spatiality except "parallax of one surface of the object relative to the other surface." On the other hand, the drawings/silhouettes of the object at those orientations preserved none of the cues to spatiality except "perspective for the receding surfaces of the object at nonfrontal orientations" and "the edges corresponding to the intersecting receding surfaces of the object at nonfrontal orientations."

Noting that there is only one cue to spatiality absent in the display using the mounted photographs, and especially remembering the redundancy of cues to spatiality under normal viewing conditions, it is not surprising that the levels of responding to the mounted photographs is equivalent to the level of responding to the object itself at those orientations. On the other hand, the relatively low level of responding to the drawings/silhouettes is quite consistent with the markedly reduced number of cues to spatiality that are preserved from training with the three-dimensional S+ object.

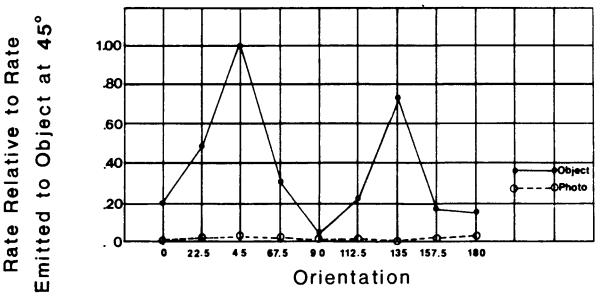

Figure 5. Generalization gradients for the S+ object at various orientations and the corresponding photographs following discrimination training with the object at 45 and 135 deg as the S+s and the photograph corresponding to the object at 45 deg as the S–.

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NOTE

1. Early 1962, as a graduate student working under the supervision of Dr. Norman Guttman at Duke University.

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