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INVESTIGATIONS OF A MIRROR-IMAGE TRANSFER EFFECT IN PIGEONS[1]

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In two separate experiments, pigeons trained binocularly to peck a key on which an oblique line (*e.g.*, 60° counter-clockwise rotation from horizontal) was projected yielded bi-modal angularity generalization gradients in extinction, with peaks of responding at both the training stimulus and its mirror image (in this case 120°). This mirror-image transfer effect may be analogous to an "octave effect" in auditory generalization, but Mello's finding of a mirror-image reversal transfer effect following monocular training in pigeons suggests an alternative interpretation.

In a series of ingenious experiments, Mello (1965a, 1965b, 1966) has presented evidence for interocular transfer of a mirror image reversal following monocular training in the pigeon. In the first of these studies, pigeons were trained (with one eye covered) to peck (for variable interval reinforcement) at a key illuminated by a 45° oblique line (S^D). In subsequent generalization testing to a wide range of angular orientations, when the trained eye was open (and the other covered) maximal responding occurred to the 45° stimulus. With the untrained eye open (and the trained eye covered) the gradient peaked at 135°. In no case did the gradient peak at both of these values.

In a subsequent experiment (Mello, 1965b), different groups of pigeons were trained monocularly on three mirror-image discrimination problems, right-left and up-down mirror images involving a pattern of perpendicular lines, and a right-left red-green mirror image problem. In each case the negative stimulus was the mirror image of the positive (up-down or right-left as indicated). Interocular transfer tests revealed mirror-image reversals with both right-left problems, but the up-down mirror images transferred veridically.

In a third study (Mello, 1966), three of four pigeons trained monocularly to discriminate between an oblique line and its mirror image showed a mirror image reversal in the transfer test; the fourth showed no transfer at all.

Mello has suggested that her studies indicate an interhemispheric transfer of visual information between the two optic tecta. This interpretation has been challenged (Cumming, Siegel, and Johnson, 1965) and defended (Mello, 1965c). Regardless of the mechanism involved, in these studies visual information directly available to only one brain half was somehow relayed in reversed form to the opposite side of the brain. The present study was designed to determine the consequences of this transfer occurring in both directions simultaneously, *i.e.*, with pigeons both trained and tested binocularly with an oblique line S^D. If a mirror image reversal transfer effect similar to that observed with monocular training and testing occurs in this experimental situation, the generalization gradients should show two peaks of responding, one at the S^D and one at its mirror image. In effect, each eye should "recognize" both the actual S^D (which stimulated it) and the mirror image of the S^D which stimulated the other eye during training.

Though a number of angularity generalization studies have employed horizontal or vertical line S^Ds (*e.g.*, Honig, Boneau, Burstein, and Pennypacker, 1963; Hearst, Koresko, and Poppen, 1964; *etc.*) no relevant study using an oblique line stimulus is known. With a horizontal or vertical S^D, the generalization gradient is typically unimodal with a peak of responding at the S^D and a roughly symmetrical decrease in both directions from this value.

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EXPERIMENT 1

Subjects

Eight homing pigeons, obtained from a local supplier, had been used in an earlier study on wave-length generalization, but were naive with regard to the angularity dimension. They were maintained at approximately 75% of their free-feeding weight throughout the study.

Apparatus

Two identical Grason-Stadler pigeon Chambers (Model 1100PB), with associated automatic programming and recording equipment, were used. In each chamber the opening to the food magazine was situated 4½ in. directly below the pecking key. Stimuli were provided by Industrial Electronics Engineers In-line display cells (Grason-Stadler Model 4580) and consisted of a white line ⅛ in. wide by ⅞ in. high on a black surround in inclinations of 30° (30° counter-clockwise rotation from horizontal), 60°, 90° (vertical), 120°, and 150°.

Procedure

Subjects were divided at random into two groups of four. For Group 1 the S^D was a 30° line, for Group 2 it was 60°. Both groups were given 10 daily half-hour sessions in which 2-sec rewards were presented on the average of every 30 sec on a variable interval schedule (VI 30 sec). The S^D was always present; there were no blackout (time out) periods.

On the day after the tenth training session, a generalization test in extinction was administered to all subjects. The five test stimuli were randomized within a series and six different random series were presented to each subject. Each stimulus was presented for 60 sec; stimulus changes were instantaneous without blackouts intervening.

Results

The generalization gradient for each subject was plotted as the mean per cent of total responding emitted in the presence of each of the test stimuli. The average gradient for the group was the mean of these individual per cent gradients. As indicated in Fig. 1, the gradient of Group 1 shows peaks of responding at both 30° and 150° and as the inserts indicate, this represents typical individual performance. All four subjects responded more to 150° than to 90°. If there were no right-left mirror image effect the order of responding to these two stimuli should have been the reverse. Subjects X-3, X-4, and X-5 actually responded more to the mirror image (150°) than to the S^D (30°).

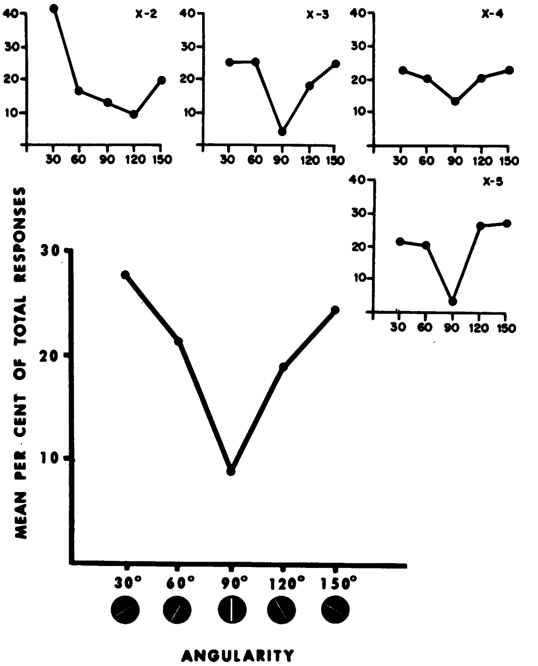

Fig. 1. Mean generalization gradient and individual gradients for subjects trained to respond to the 30° line (Group 1).

Figure 2 presents the gradients of the subjects trained at 60° (Group 2). The mean gradient of the group shows peaks at both 60° and 120°. Again, individual performance is well represented by the group average with the exception of X-9 which shows no stimulus control by the angularity dimension.

EXPERIMENT 2

This replicated Exp 1 but with somewhat different experimental procedures and with naive rather than sophisticated subjects.

Subjects

Nine experimentally naive homing pigeons, obtained from a local supplier, were maintained at approximately 75% of their free feeding weight.

Apparatus

The same as that used in Exp 1.

Procedure

After one week of free feeding subjects were reduced by total food deprivation to 75% of base weight. Magazine and key-peck training occupied one experimental session. During this session and throughout training, the stimulus on the key was a 120° line. After an additional session of 50 continuous reinforcements, the subjects were put on a discrimination training schedule with VI 1 reinforcement in the presence of the 120° line (S^D) and extinction in the presence of a dark key (S^Δ). Because no house light was used, the chamber was dark during S^Δ presentations. S^D and S^Δ periods were of 60-sec duration, nonsystematically alternated, with no more than two successive periods under the same condition. Discrimination training continued for eight daily half-hour sessions with the last followed immediately by a generalization test in extinction. During the test the five stimuli, 30°, 60°, 90°, 120°, and 150°, were randomized within a series and nine different series were presented to each subject. Each stimulus was presented for 60 sec; stimulus changes were instantaneous without blackouts intervening.

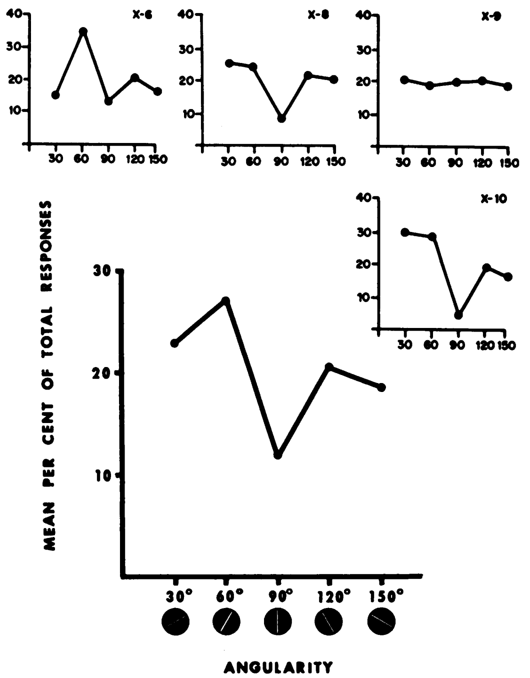

Fig. 2. Mean generalization gradient and individual gradients for subjects trained to respond to the 60° line (Group 2).

RESULTS

The mean generalization gradient for the nine subjects is presented in Fig. 3. A peak of responding does occur at both the S^D (120°) and at its mirror image (60°). As the individual gradients in Fig. 4 reveal, seven of the nine subjects responded more to 60° (the mirror

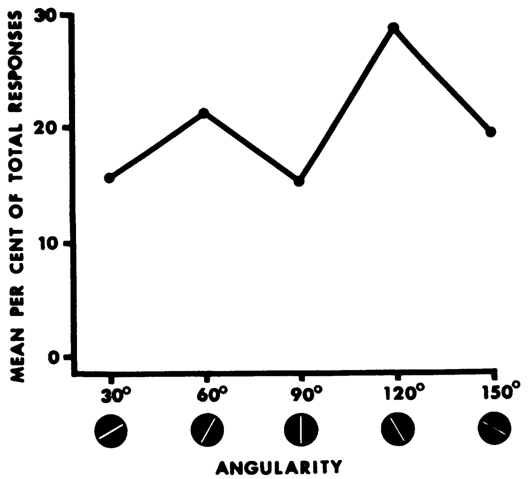

Fig. 3. Mean generalization gradient following discrimination training with 120° as S^D and a dark key as S^Δ.

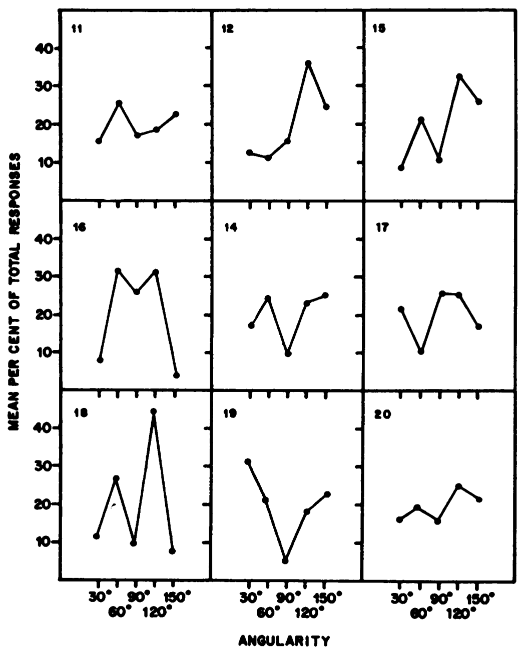

Fig. 4. Individual generalization gradients following discrimination training with 120° as S^D and a dark key as S^Δ.

image of the 120° S^D) than they did to the (physically) more proximal stimulus of 90°. Four of the nine responded more to the mirror image (60°) than they did to the S^D (120°).

DISCUSSION

In both experiments, bimodal angularity generalization gradients were obtained after training to respond to a single oblique line S^D. Thus, neither the prior experience with the wavelength dimension for the subjects in Exp 1 nor the discrimination training between presence and absence of the oblique line in Exp 2 is crucial to demonstrate this effect.

Research with the octopus (Southerland, 1957), fish (Mackintosh and Southerland, 1963), rats (Lashley, 1938), and human children (Rudel and Teuber, 1963) has indicated in each of these species that discrimination between oblique lines is more difficult than between horizontal and vertical lines. The ability of the pigeon to make such discriminations has, however, been demonstrated in a discrimination learning study by Zeigler (1965) and is incontrovertible in view of the many studies which have obtained generalization gradients along the stimulus dimension of angularity. It thus cannot be maintained that the subjects in the present study merely "confused" the S^D with its mirror image.

It might be argued that the presence in the present experiment of a bimodal generalization gradient means simply that the subject learned the angle that the S^D makes with the vertical (or horizontal) instead of (or in addition to) the direction of inclination. In this case the mirror image stimulus would be more "similar" to the S^D than are stimuli whose angular distance from the S^D is less, because the relation of the mirror image to the vertical (or horizontal) standard is exactly the same as for the S^D. The bimodal gradient would thus be analogous to the enhanced responding to octaves along the stimulus dimension of auditory frequency (Humphreys, 1939; Blackwell and Schlosberg, 1943, *etc.*). Though the present data are amenable to such a relational interpretation, it should be recalled that in Mello's (1965) experiment involving monocular training and testing the generalization gradients peaked at the S^D *or* at its mirror image (depending on which eye was covered). In no case did the gradient peak at both values. It does not seem reasonable to assert that the learning and/or perception of the relationship between a particular oblique line and a vertical (or horizontal) standard requires the use of both eyes. It would clearly be more parsimonious to maintain an interpretation of these data which could apply equally to the Mello findings as well.

In a similar vein it is impossible to determine on the basis of the present study whether the mirror-image reversal effect presumably obtained here constitutes a right-left reversal, an up-down reversal, or both. Mello (1965b) performed a study (utilizing the monocular training and testing procedure) which was designed specifically to answer this question. She found a reversal only with the right-left problem. This, therefore, would seem the most likely interpretation of the present data as well.

As indicated earlier, Mello's demonstration of a right-left mirror image reversal transfer effect following monocular training provided the rationale for the present study. Predictions based upon what appears to be a logically justifiable inference from her data were clearly supported. Certainly, however, in the absence of any acceptable explanation of the monocular mirror image reversal effect (*c.f.*, Mello, 1966) it would be premature to argue that the mechanism responsible for the monocular and binocular effects must necessarily be the same. An opposed position would be equally tenuous, however, and would also violate the rule of parsimony. Regardless of how this issue is resolved, it seems clear that both monocular and binocular mirror image transfer effects are puzzling and fascinating phenomena in their own right. Further research from both neurological and behavioral standpoints is surely justified.

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