Sensitivity of the pigeon to changes in the magnetic field¹

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Talkington has suggested that birds use changes in the magnetic field to navigate. He hypothesized that when the bird flies through the magnetic field, signals arise from the pectens of the bird's eyes and the bird navigates on the basis of these stimuli. This study investigated bird's ability to make such discriminations and concluded that the pigeon does not have the sensitivity for such discriminations.

The nature of the stimulus for navigation by birds has constituted one of the most challenging questions in animal behavior. During the last two decades there have developed four experimental lines of approach toward the understanding of this problem (Meyer, 1964b). It has been pointed out that of the various theories, the geomagnetic field theory is perhaps the oldest. Yeagley (1947, 1951) explained the fact of navigation of birds by the Coriolis force for the measurement of latitude and the longitude from the variations of the earth's magnetic field. Talkington (1964a, b) has recently suggested that when birds fly through such a field, signals arise from the pectens of the bird's eyes and that the bird navigates on the basis of these stimuli. The various tests of the magnetic theory have been in field experiments where many other environmental stimuli may conceal the accuracy of the bird's ability to make the discriminations.

At present, no one has produced unequivocal experimental evidence that birds are sensitive to the magnetic "stimuli." Orgel & Smith (1954) in their laboratory experiment obtained negative results when they attempted to condition birds using a magnetic field 25 times greater than the earth's field as the conditioned stimulus. However, such a magnitude of the stimulus may have been well outside the general range of sensitivity of the "receptor." As very limited data are available for the measurement of discrimination of the magnetic field, it was the purpose of this study to provide data on the pigeon's ability to discriminate changes in magnitudes from the earth's normal field.

General Experimental Procedures

Subjects. The Ss were four, 3-yr. old, homing pigeons, two cocks, No. 3845 and 170, and two hens, No. 2308 and 167. These birds had no prior experimental history in the laboratory. All Ss had had successful homing experience during the previous year. The Ss were held at 80%± 10 gm of their ad lib weight and were run on 22-hr. food deprivation throughout the experiment. Each S was magazine trained and then shaped to peck the response key. The Ss were given two daily sessions of 50 reinforcements on a continuous reinforcement

schedule, followed by two daily sessions of 50 reinforcements under a schedule with variable intervals averaging 1 min. (VI 1).

Apparatus. The experimental chamber was a modified operant box for pigeons constructed from Plexiglas. The operant box was then housed in the center of a large chamber which contained magnetic coils. These coils generated a magnetic field which could be systematically varied and measured from .000 to 15,000 gauss. A white noise was used throughout the study as an auditory mask. The food magazine was programmed to give free access to grain for an interval of 4-sec. The presentation of the various stimuli and their various timings, and all the scheduling of the reinforcement contingencies, as well as the recording of the responses, were automatic. The number of responses was recorded on counters and on a cumulative recorder. At the end of the experimental session, the house light and the response key light was automatically shut off and the stimuli were no longer presented.

Procedures for the experimental conditions. The Ss were presented a magnetic field as the discriminative stimulus (S^D) along with a VI 1 reinforcement schedule. On the other hand, when the earth's normal mean magnetic field for this station of .582 gauss was introduced, no reinforcement occurred (S^A). The S^D and S^A periods consisted of a series of time intervals ranging from 2 to 4 min., in 15 sec. steps with a mean value of 3-min. These nine various time intervals, 2 min., 2 min. 15 sec., 2 min. 30 sec., etc., to 4 min., were presented in random order, and each S^D period was followed by a S^A period. During each daily experimental session, each bird had a total of 32 trials of 18 intervals of S^D and 18 intervals of S^A . The total time per day for each bird was 108 min. The variable length of time intervals was used to prevent the birds from learning to respond to time. The response key remained white throughout the sessions. The conditioning procedures were essentially that suggested by Meyer (1964a).

Procedures for the control conditions. Four various procedures were used for the control conditions. A bird was presented a response key of green as the S^D and a change of the key to white as the S^A . In the second condition, a red key was given as the S^D and a green key as the S^A . The third method, no S^D or S^A magnetic field was given and the key was white. For the last method, a magnetic field below the earth's normal field was presented during the S^D periods and the normal mean magnetic field of .582 gauss during the S^A periods.

Except for these procedures, the methods were similar to those for the experimental procedures.

Results and Discussion

The general results for the experimental and control conditions are given in Table 1. The conditions are in the order of presentation for each S.

Bird No. 2308 was given a S^D of a green response key and the S^A of white during the discrimination training. The bird reached the criterion of 80% or more of the total responses during the S^D periods on the second day of training. After ten days of such training this bird was shifted to a further control condition. This S^D was a magnetic field of .560 gauss which is below the normal mean of the earth's field and the S^A of .582 gauss. After 20 daily sessions or 640 trials, the data suggests no biasing from the general experimental procedures, in that approximately one-half of the total responses occurred during the S^D periods.

Under the condition where no S^D or S^A magnetic field was presented to Bird No. 3845, no discrimination was observed after 640 trials. When this bird was then later shifted to a S^D of .567 gauss, which is again below the mean field and the S^A of .582 gauss, no discrimination likewise occurred after 640 trials. In the last of three conditions, Bird No. 170 was presented a S^D of .579 gauss and a S^A of .582 gauss, and after 640 trials

this bird failed to make any discriminations. In general, the conclusions of no biasing can be made from these data.

The major research interests are under the conditions where the S^D was greater than the normal mean of the earth's magnetic field. Bird No. 3845 received 640 trials where the S^D was .591 gauss and the S^A of .582 gauss. Bird No. 170 had 640 trials with the same S^A and the S^D was .585 gauss and also 640 trials with 1.000 gauss as the S^D . And Bird No. 167 was presented a S^D of .600 gauss and also .588 gauss, likewise for 640 trials each. In no case did these birds learn the discrimination. In general, half of the total responses were made during the S^D periods. As a further control, following the S^D - S^A of the magnetic field, Bird No. 167 was shifted to a S^D of a red light and a S^A of green. At the end of the second day of such training the bird was responding well above the stated criterion and showed the same general results as Bird No. 2308.

From these data, it may be concluded that the pigeon does not have the sensitivity to discriminate changes in magnitudes from the earth's magnetic field to enable the bird to navigate.

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Note

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Table 1. The general results for the experimental and the control conditions in the order of presentation for each subject.

Subjects	S^D	S^A	Results
No. 2308	green	white	rapid discrimination
	.560 gauss	.582 gauss	no discrimination
No. 3845	none	none	no discrimination
	.591 gauss	.582 gauss	no discrimination
	.567 gauss	.582 gauss	no discrimination
No. 170	.585 gauss	.582 gauss	no discrimination
	1.000 gauss	.582 gauss	no discrimination
	.579 gauss	.582 gauss	no discrimination
No. 167	.600 gauss	.582 gauss	no discrimination
	.588 gauss	.582 gauss	no discrimination
	red	green	rapid discrimination