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An Experimental Analysis of Selective Stimulus Control Following Binocular Mirror Image Discrimination Training in Pigeons

*Shigeru Watanabe**

Four pigeons were trained binocularly on 150° vs. 45° obliqued line discrimination which they did not show difficulty in learning. Then, stimulus control tests with bisected line stimuli which were a portion of the original stimuli were carried out under three different eye conditions (both eyes, the left eye, and the right eye). Three subjects preferred the right portion of S^D under every test condition. A reverse of selective stimulus control depending on the eye used in a test was not observed.

A pigeon monocularly trained to discriminate between a line obliqued 135° and a line obliqued 45° shows a tendency to respond more often to S^Δ than to S^D when it is tested with its untrained eye. In other words, the stimulus which is preferred is reversed to its mirror image when the subject is tested with untrained eye. This phenomenon, the mirror image reversal effect, was first reported by Mello (1965) and examined systematically in our laboratory (Watanabe and Ogawa, 1973, Watanabe, 1974, 1975, 1976a, 1976b, 1977). Similar phenomenon was obtained from goldfishes (Ingle, 1967, Campbell, 1971), monkeys with sectioned optic chiasm (Noble, 1966, 1968) but not from intact monkeys, cats with sectioned optic chiasm

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(Berruchi and Marzi, 1970, Hranchuck and Webster, 1975), and intact rabbits (van Hof, 1970, van Hof and van der Mark, 1976).

Watanabe and Ogawa (1973, Watanabe, 1974) trained pigeons monocularly on a mirror image discrimination and then tested them with a bisected stimuli (illustrated in Fig. 1). The subject which

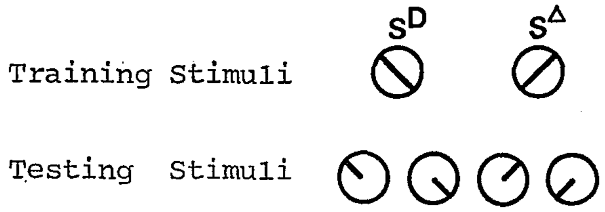

Fig. 1. Training stimuli and tesing stimuli used in Watanabe and Ogawa (1973).

were trained with their left eye responded maximally to the left portion of S^D when tested with their trained eye while they responded maximally to the right portion of S^Δ when tested with their right eye. On the other hand, the subjects which were trained with their right eye responded most often to the right portion of S^D when tested with the untrained eye. Therefore, a portion of the original stimulus selectively controlled the behavior of the subjects. This type of stimulus control is called selective stimulus control. The most interesting point in this case was that selective stimulus control by a portion of the original stimulus was consistently reversed when the eye used was changed.

A similar selective stimulus control was obtained from monkeys with sectioned optic chiasm after binocular discrimination training (Lehman and Spencer, 1973). Stimulus presented during discrimination training and stimulus used in testing are represented in Fig. 2. The subjects preferred the test stimulus A in the test with the left eye while they preferred the test stimulus B in the test with the right eye. These results suggest that the monkey attended the op-

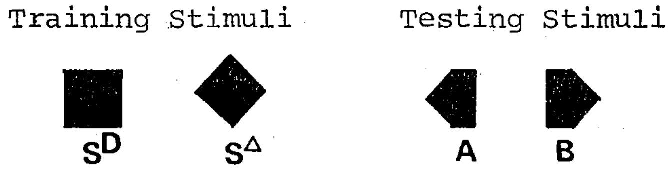

Fig. 2. Training stimuli and testing stimuli used in Lehman and Spencer (1973).

posite side of the stimulus of the eye used in the test. The monkey preferred the stimulus A with its left eye because the right half of this stimulus is a portion of S^D, and it preferred the stimulus B with its right eye because the left half of this stimulus is a portion of S^D.

In the present experiment, selective stimulus control is examined after binocular mirror image discrimination training in pigeons.

METHOD

Subjects: Four experimentally naive pigeons (Columba livia) were used. They were maintained at about 80 percent of their free feeding weights.

Apparatus: An experimental chamber was a modified Skinner-box with a single key on which a dark line stimulus, 2 mm in width and 30 mm in length, was projected. The diameter of the key was 30 mm. A grain feeder for reinforcement was attached 15 cm below the key. Presentation of stimulus and reinforcement were controlled by a hand-made controller. The pecking response was counted by an electromagnetic counter.

Procedure: All subjects were shaped up binocularly to peck the key on which no line stimulus was presented. Then, plastic goggles were placed over each eye of the subjects and a mirror image discrimination training was begun. No cover was fastened over the goggles during the discrimination training. S^D was a line obliqued 135° and S^Δ a line obliqued 45°. Schedule of reinforcement was mult CRF–EXT, that is, reinforcement was available for each peck when S^D was presented and not available when S^Δ was presented. One daily training session consisted of ten presentations of S^D and S^Δ each. They were presented in accordance with the Gellerman series and each presentation period was 25 sec followed by a five sec blackout period. Five sessions of mult CRF-EXT were followed by ten sessions of mult VI 25″-EXT. The subjects were reinforced on variable interval 25 sec during the S^D period and extinguished during the S^Δ period. In the first test, S^D and S^Δ were presented in the same series as those in the daily training sessions but no reinforcement was available. The subjects were tested under three eye conditions, i. e., both eyes, the left eye, and the right eye. In the monocular tests, one side of the goggles was covered.

In the second test, four partial test stimuli, such as those illustrated in Fig. 1, were presented five times in random order. Each presentation period was 25 sec followed by a five sec blackout period. During the test session, no reinforcement was given. This test was also carried out under the three eye conditions described above. Only one test was carried out in a day and subjects received one daily training session between the tests.

RESULTS

Fig. 3 represents the number of responses emitted for S^D and S^Δ by each subject during the mult VI-EXT sessions. Every subject responded more often to S^D than to S^Δ throughout the ten sessions. All subjects, except 74021, emitted only few responses for S^Δ in the final session. Thus, clear stimulus control was observed in the mult VI-EXT sessions.

Table 1 summarizes the results of the first stimulus control test. In all cases, high correct response ratio was obtained and restriction of the eye did not affect the correct response ratio. However, overall rate of responding to S^D decreased in monocular tests in every subject. Two subjects (74021 and 74023) responded more often with their left eye than with the right eye, one responded more often with the right eye, and another responded slightly more often with the left eye. There is no consistent difference of overall rate of

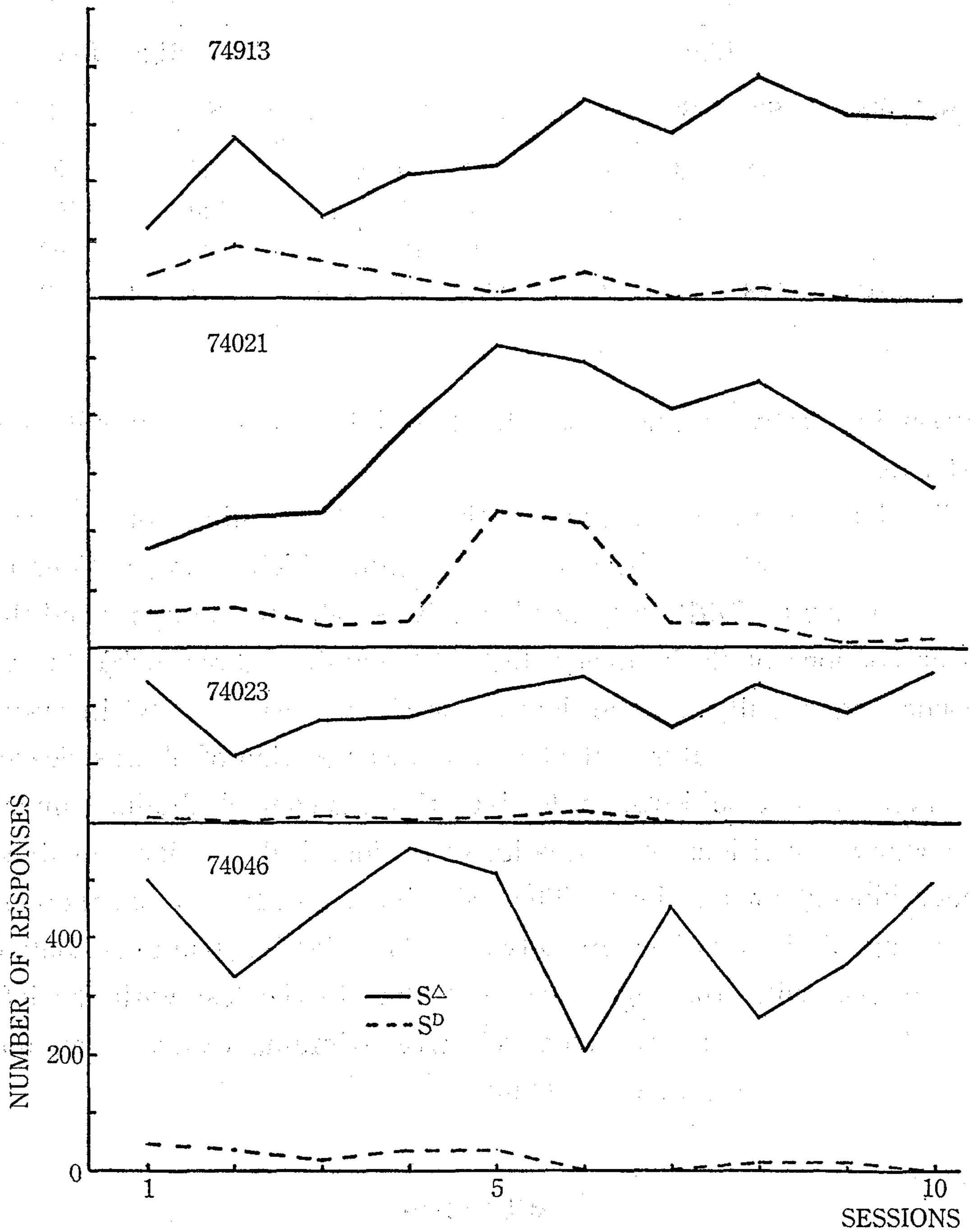

Fig. 3. Rates of responding by pigeons during mult VI-EXT sessions. The solid lines represent responses emitted for S^D and the broken lines those emitted for S^Δ.

Table 1. Overall rates of responding for S^D and S^Δ during three tests.

Eye Conditions	Binocular			Left Eye			Right Eye		
Subjects	S^D	S^Δ	% to S^D	S^D	S^Δ	% to S^D	S^D	S^Δ	% to S^D
74913	278	3	99	122	10	92	80	4	95
74021	471	11	97	277	1	100	120	0	100
74023	368	15	95	290	12	96	93	0	100
74046	728	11	99	85	0	100	202	0	100

responding between the test with the right eye and that with the left eye.

Fig. 4 represents the results of the second stimulus control test. Few responses were emitted for the stimuli which were portions of S^Δ in all cases. 74913 responded nearly equally to the upper and the lower portions of S^D in every test. Remaining three subjects responded maximally to the lower (or right) portion of S^D in every test. Selective stimulus control by the lower portion of S^D was clearly observed in these subjects. Selective stimulus control obtained under monocular conditions was qualitatively identical to that obtained under binocular conditions. The most important fact is that there is no antagonistic relationship between the selective stimulus control in the test with the right eye and that in the test with the left eye. In other words, reversed selective stimulus control was not obtained in the present experiment.

DISCUSSION

In the present experiment, the pigeons learned the mirror image discrimination without difficulty. This result is in agreement with Zeigler and Schmerler (1965) in which learning of the mirror image discrimination was compared with learning of other obliqued line discrimination in pigeons. However, if pigeons were trained on

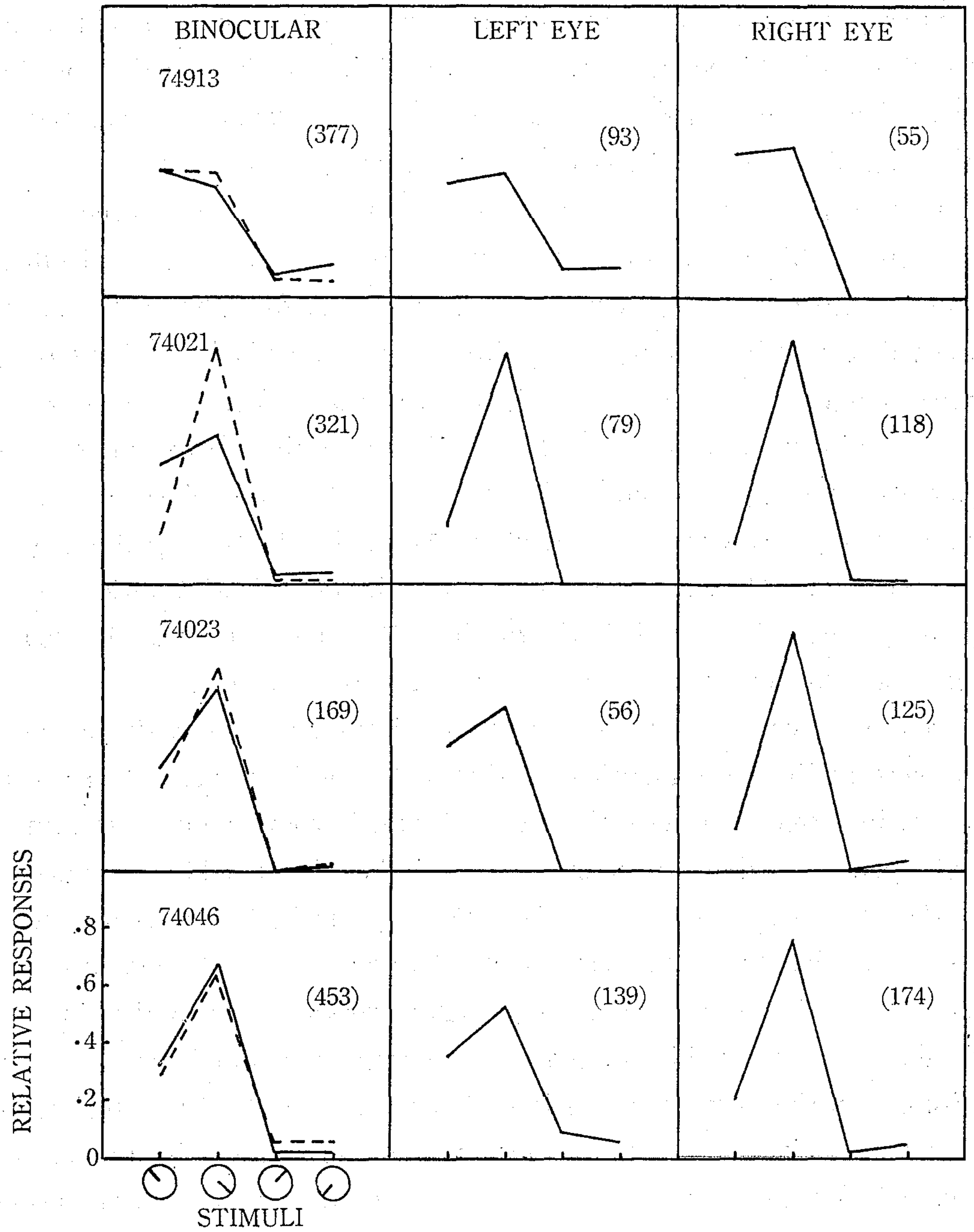

Fig. 4. Relative responses in the tests with the portions of the original stimuli. The left panel shows result of the binocular test, the middle panel that of the test with the left eye and the right panel that of the test with the right eye in each subject. The broken lines in the left panels represent average of score with the left eye and that with the right eye. Number in parentheses in each panel represents overall rate of responding in each test.

a mirror image discrimination with each eye but were not trained on this task binocularly, they showed difficulty in learning of this task (Watanabe, 1976a). If the mirror image reversal effect occurred, learning of the mirror image discrimination with one of the eyes retarded learning of this discrimination with the other eye. Therefore, this result suggests that the mirror image reversal effect occurred in these cases. On the other hand, the fact that the pigeons learned the mirror image discrimination binocularly without difficulty suggests that the mirror image reversal effect did not occur in the binocular learning. Thus, discriminative behavior of the pigeons trained binocularly differs from that of the pigeons trained monocularly. However, it must be pointed out that pigeons can accomplish the learning of the mirror image discrimination with each eye after long period of training (Watanabe, 1976a). It means that they can overcome the mirror image reversal effect.

In the present experiment, selective stimulus control with the right eye was qualitatively identical to that with the left eye. This result is not in agreement with the result obtained from monkeys (Lehman and Spencer, 1973). Monkeys attended the visual field contralateral to the eye used in the tests. But the pigeons in the present experiment attended the right portion of S^D regardless of the eye used in the tests. A section of optic chiasm caused abnormality in the monkey's visual field. It may be difficult for monkeys to see a stimulus in the visual field ipsilateral to the eye used. But a binocular visual field is narrow in the pigeon and monocular viewing is not unusual for pigeons. In fact, pigeons exhibited a generalization gradient along line-tilt dimension around the center of the key with one eye (Watanabe, 1975). This means that they could see the whole area of the key with one eye. Therefore, it is reasonable that the pigeons attended the right portion of S^D also in the test with their left eye.

Selective stimulus control similar to the present result was observed in the pigeons which accomplished learning of the mirror image discrimination with each eye (Watanabe, 1976a). On the other hand, the pigeons which were trained on the mirror image discrimination with one eye and were trained on the reversed mirror image discrimination with the other eye showed selective stimulus control similar to that exhibited by the pigeons which showed the mirror image reversal effect in traditional situation of interocular transfer of learning (Watanabe, 1976a). Therefore, a correlation between the mirror image reversal effect and selective stimulus control is recognized.

Another point to be discussed is that there is little individual differences in the selective stimulus control obtained in the present experiment. If the selective stimulus control represents the subject's strategy to learn the task, it will be more plausible that different subjects show different selective stimulus control. Such intersubject agreement of selective stimulus control was observed in our previous experiments. It is not clear that these intersubject agreement was caused by a behavioral tendency of the pigeons, or was caused by some instrumental condition such as height of the key or diameter of the key.

In summary, the pigeons showed a selective stimulus control after binocular mirror image discrimination but they did not exhibit systematic change of control depending on the eye used.

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