Original Article

Binocular vs. Monocular Pecking in Pigeons :
An Analysis of Peck Location

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Preference in using one eye or both in terms of integrating visual information was investigated in 11 pigeons. Subjects were trained to peck 8 light emitting diodes (LED) within a specified range. After reaching the desired criterion, they were tested in three viewing conditions; binocular, monocular-right and monocular-left. A black electrical tape was used to occlude vision on one side. Both the latency of response and peck location accuracy were taken as behavioral parameters. Results showed that pigeons pecked significantly better and faster when both eyes were open than when only one eye was being used (either left or right). There was no difference recorded between the left and the right viewing conditions. The superiority of the two-eye condition was explained in terms of the probability principle and the overlap of the two visual fields.

Key words : right-left vision, binocular, monocular, pigeons, LED, peck location, target area

Numerous studies were done on the differences of the right and left hemispheres in terms of processing information. With the use of ablation, decortication (Gunturkun et al., 1989; Gunturpun & Hoferichter, 1985; Jager, 1983), spreading depression (Kukleta, 1968), occlusion (Goodale & Graves, 1980) and monocular training (Andrew et al., 1982; Gaston & Gaston, 1984; Gunturkun, 1983;

Meier et al., 1974), the difference of the two hemispheres in function, structure and system of integrating environmental information were examined and appreciated better. Two hemispheric integration in learning was observed and this can be illustrated by comparing the effects of the left-or right-and both eye-viewing conditions (Andrew et al., 1982; Menkhaus, 1957).

Binocular and monocular discrimination performance varies across species. Although with completely crossed optic chiasm, fish needed more training trials for monocular than binocular discrimination task (Schulte, 1970). But for pigeons, even though they also

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have completely crossed optic chiasms, findings were conflicting. The monocular-binocular difference was not clearly demonstrated in the experiment of Levine (1945) in training pigeons to discriminate patterns on a jumping stand. The same phenomenon was reported by Siegel (1953) among the ring doves. When Meier (1971) sectioned the supra-optic commissure of pigeons after they were trained in an operant paradigm, the birds did not show any discrimination performance difficulty. They were able to monocularly discriminate color and pattern stimuli as learned.

The binocular and monocular discrimination performance differences in chickens were reported by Menkhaus (1957), Schulte (1970) and Rahmann-Esser (1964). Binocular discrimination learning was faster than monocular learning in the experiment of Menkhaus but Schulte and Esser discovered otherwise. Watanabe (1980) noted that binocular learning in pigeons is superior to monocular learning. Even during the acquisition of discriminative task, birds learned faster binocularly than monocularly. However, Watanabe, Hodos and Bessette (1980) concluded that when pigeons are permitted to view binocularly, some pigeons prefer to use one eye to discriminate. This indicates that there is a more dominant eye eventhough two eyes seem to be looking.

The purpose of this study is to clarify whether pigeons have preference in using one eye or both eyes in terms of integrating visual information.

METHOD

Animals

Eleven experimentally naive adult homing pigeons (*Columba livia*) weighing 350-450g at the start of the experiment were used. They were individually housed in a wiremesh cage and maintained at 80% of their free feeding body weight throughout the experiments.

Apparatus

The apparatus consisted of a conventional black operant chamber (30x30x30cm), a monochrome TV camera (Sanyo VC-1650), an image memory board (Photron FDM98-1), and a microcomputer system (NEC PC9801 VF2) (Figure 1). The front wall of the chamber had a horizontal slot (22x2cm) centered at a height of 18cm above the floor (Figure 2). A transparent acrylic response key was mounted behind this slot. Responses were detected by any one of three microswitches attached to the response key, regardless of response location. A white plastic strip (22x1cm) protruded from the front wall along the lower edge of the response slot. This strip provided a background with a high degree of contrast with a pigeon's beak. The ceiling of the chamber was a transparent acrylic panel having an opening (5x30cm) along the front wall. Through this opening, responses were monitored by a TV camera located 50cm above the key. Illumination was provided by a 30 watt bulb positioned 40cm above and centered on the ceiling. The camera transmitted a standard video signal to the image memory board to measure peck location. Eight LEDs horizontally attached on the wall and were 25mm from each other

Fig. 1 The experimental apparatus consisted of a conventional black operant chamber, a monochrome TV camera, an image memory board and a microcomputer system.

served as stimuli (Figure 3). Reinforcements were delivered by a food-hopper, situated below the response key. A hopper light accompanied food reinforcement. The box was illuminated by a houselight (For a more detailed description of the system for measuring peck location consult Hori and Watanabe (1987)).

Procedure

Stimuli were mounted 5mm behind the key at the center of the target area. Once key pecking had been established, pigeons were trained to peck the target area. Using the successive approximation procedure, pecks within 50mm from the target LED was reinforced and later narrowed slowly. Shaping was considered finished when the pigeon

was able to peck within 2.5mm from the center of the LED. Shaping required about 20 correct pecks within 10-15 minutes for each animal. Each response to the target area terminated the trial and was reinforced with food.

Discrimination training started 24 hours after shaping. One of the eight LEDs is presented randomly for 10sec. When the pigeon pecked the LED within 5mm, it was reinforced for 3sec at the food-hopper. Responses to the other area produced no food and was followed by a 10sec time-out during which the chamber illumination was turned off and responding had no programmed consequences. The data recorded were exact peck location and the latency of pecking response. Training was done in sessions of

Fig. 2 The front wall of the chamber had a horizontal slot (22x2cm) in which the transparent acrylic response key was mounted behind it.

120 trials per day. Criterion of discrimination was 80% of correct trials for three consecutive sessions.

After reaching criterion, the subjects were randomly assigned to three viewing conditions; binocular, monocular-right and monocular-left. Prior to experimentation, black electrical tape was used to serve as eye-patch to occlude vision on one side. All birds were subjected to the three conditions randomly. Each animal was trained for 10 times each in binocular, monocular-right and monocular-left treatment-conditions.

RESULTS

Generally, it took 6-10 sessions before the pigeons reached the criterion. During the occlusion session, most of the pigeons habituated to the black eye-patch quite rapidly. A few animals that attempted to remove them during sessions were habituated to wearing them for about 30 minutes before each session began. The pigeon's performance was assessed in two respects; (a) in the peck location accuracy of peck responses

Fig. 3 Eight LEDs horizontally attached on the wall and were 25mm from each other served as stimuli.

and (b) in the latency of all responses.

The measure of (a) was calculated by taking the ratio of the peck location accuracies to the total number of responses. The measure of (b) was the ratio of the ratio of the latency of correct and incorrect responses to the total number of responses. For each pigeon, monocular (left and right) and binocular peck location and reaction time were collected. Subjects completed 30 sessions of 120 trials each on separate days. Only the last three sessions of each condition per subject were considered for data analysis.

In Figures 4 and 5, the means of the average latency and average peck location accuracy of responses for each eye condition are shown respectively. The correctness of pecking responses was maximal for the binocular condition as compared with either monocular one (left or right).

There was no right-left difference recorded for the two behavioral parameters used. However, it was again proven the superiority of the two-eye condition over the one-eye condition.

Figure 4 shows that the peck location accuracy scores were also affected by the black eye-patch condition. There was virtually no difference when comparing results from tests with the left and the right eyes. But there was again a binocular over monocular advantage.

Figure 5 shows the mean latency scores of the three viewing conditions. The two-eye condition shows a faster response in comparison with one-eye condition. There is no significant difference between the right and the left conditions.

Fig. 4 The peck location accuracy is measured from the center of the target stimulus. A 0 score is perfect. Pecks from the left and the right were recorded as absolute values in reference to the target area. The binocular has higher peck location accuracy than the monocular conditions. The difference is statistically significant at .05 level (student's *t*-test; *df*=2.037; two-tailed).

Fig. 5 The latency of response is defined as the time from the onset of the target stimulus to the actual pecking response. The maximum time allotted was 3000 msec. A no response was recorded as miss. The binocular pecked faster than the monocular conditions. The difference is statistically significant at .05 level (student's *t*-test; *df*=2.037; two-tailed).

DISCUSSION

It is again proven in this study the superiority of the binocular condition as compared with the monocular (left or right) in peck location and latency of response. This shows a better correct pecking score (correctness and preciseness to the target area) and latency of response of the binocular condition. This finding does not agree with what Levine (1945) discovered in the study of discrimination pattern but consistent with what Watanabe, Hodos and Besette (1980) reported in comparing the percentage of binocular and monocular visual learning.

In the study of Watanabe (1980) using the horizontal and vertical line discrimination task, it has been shown that there was no difference between the right and the left eye-performance. This finding agrees well with the results of the present study. Whether left or right monocular condition, the mode of viewing is lateral way (Bloch & Martinoya, 1978). Since both use the lateral mode, there should be no difference between the left and right conditions to be expected. However, the binocular condition uses the frontal viewing mode and hence a marked difference with the monocular conditions (Maldonado & Marurana, 1988). Therefore the difference in pecking response can be due to the mode of viewing.

Because of the interaction or the overlap of two visual fields, the stimulus can be seen more precisely in the binocular condition. This happens because the two visual information join together in the same population of central neuron responsible for the overlap or integration (Cowan et al., 1961; Meier et al., 1974). Therefore, two eyes at the same time

seeing are better than only one eye (either left or right) (Distefano et al., 1987; Watanabe et al., 1980).

The binocular condition has faster latency of response than the monocular condition. Watanabe (1980) discovered that in training of pigeons in interdimensional discrimination, excitatory and inhibitory interdimensional discrimination, the left eye-performance in visual discrimination task is slower in comparison with the binocular and right-monocular condition. This also agrees with the study of Watanabe (1980) regarding the binocular discrimination training of horizontal and vertical stimuli and the reversal discrimination of horizontal and vertical stimuli in the left eye. All of the subjects reached the specified criterion faster when two eyes were used than only one eye (the left eye).

The superiority of the two eye-condition can be explained in terms of the principle of probability (Blake et al., 1980). The binocular has a higher opportunity to see the stimuli than the monocular condition due to the presence of two visual fields. In statistical consideration, the subjects are given two independent chances in order to see the visual stimulus and then to produce a response (Blake et al., 1980). This additional opportunity will tend to yield superior binocular performance (Distefano et al., 1987).

According to psychophysical data, visual tasks involving both threshold measures and reaction times are better performed when two eyes are used simultaneously as compared to monocular viewing (Blake et al., 1980; Blake et al., 1981). This improvement in two-eyed performance, referred to as binocular summation is thought to arise from

some forms of excitatory neural interaction between the two eyes, an effect known as neural summation (Distefano et al., 1987).

In contrast to earlier report, the present data do not provide support for a difference in performance with the left and right eye which might indicate lateralization of function in the central nervous system. Instead, the main findings of this study are the differences in speed of response and peck location accuracy in all subjects between binocular and monocular viewing conditions, a difference favoring binocular viewing which are consistent with the findings of Distefano, Kusmic and Musumeci (1987).

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