Limits of intraocular transfer in pigeons

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Introduction

The retina of the pigeon has two areas of enhanced vision: the red field in the dorsotemporal retina pointing into the frontal binocular field and the yellow field projecting into the lateral monocular field. The entire retina projects to the contralateral optic tectum and continues via the diencephalic nucleus rotundus to the entopallium (tectofugal pathway). The monocular area also projects to the contralateral geniculate thalamic nucleus and continues to the wulst (thalamofugal pathway). These two different visual systems possibly operate independently in the pigeon's eye.

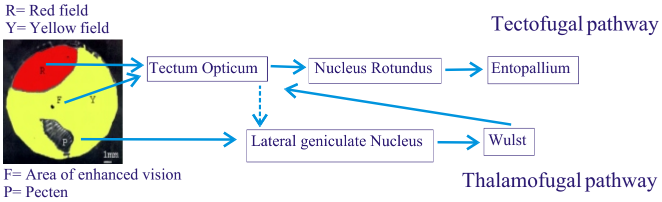


Fig. 1: Tectofugal and Thalamofugal pathways in the pigeon

Previous investigations in pigeons have demonstrated that there is information transfer from the lateral to the frontal visual field. However, a lack of transfer was found from the frontal visual field to the lateral visual field. (Nye, 1973; Mallin & Delius, 1983; Remy & Emmerton, 1991; Roberts et al, 1996). Those experiments were done in static or head fixed pigeons. This creates a very unnatural situation and might deprive pigeons from important cues such as visual flow.

The present experiment tests the transfer of information between the tectofugal and the thalamofugal pathways in free walking pigeons.

References:

Mallin, H. D. and Delius, J. (1983). Inter- and intraocular transfer of colour discriminations with mandibulation as an operant in the head-fixed pigeon. *Behaviour Analysis Letters* **3**, 297-309.

Nye, P. W.(1973). On the functional differences between frontal and lateral visual fields of the pigeon. *Vision Research* **13**, 559-74.

Remy, M. and Emmerton, J. (1991). Directional dependence of intraocular transfer of stimulus detection in pigeons (Columba livia). *Behavioral Neuroscience* **105**, 647-52.

Roberts, W. A., Phelps, M. T, Macuda, T., Brodbeck, D. R. and Russ, T.(1996). Intraocular transfer and simultaneous processing of stimuli presented in different visual fields of the pigeon. *Behavioral Neuroscience* **110**, 290-9.

Methods

Participants and material:

We investigated intraocular transfer in 8 freely walking pigeons. For this purpose we constructed an experimental chamber of 125 cm length and 54 cm width. On either end of it, we placed a feeder and two pecking keys. A 15" LCD screen was mounted on the side in a track surrounding the arena (Fig. 2). A computer controlled the stimulus presentation on the screen, delivered food as a reward or emitted a sharp sound as a punishment.

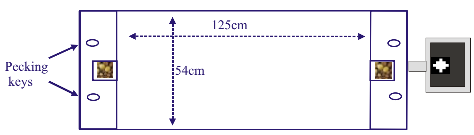


Fig. 2: Experimental arena

Stimuli:

Two shapes, stimulus A and stimulus B (Fig. 3), were randomly presented on an LCD screen at different positions around the experimental arena:

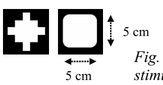


Fig. 3: From left to right: stimulus A and stimulus B

Procedure:

Pigeons' initial task was to discriminate between two shapes presented in the frontal visual field, by pecking on one of the two keys located under the screen, while walking between the two feeders. (Fig. 4). A correct response was rewarded with food, an incorrect response was punished with a sharp tone. When a criterion of 75% correct responses in 3 consecutive sessions of 20 trials each was reached, we started to move the screen to the lateral side, from 0° until 90°, approximately in 7° steps (Fig. 5).

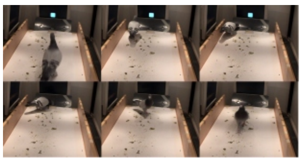


Fig. 4: Pigeon perfoming the task. The screen is located at 0° in the frontal visual field

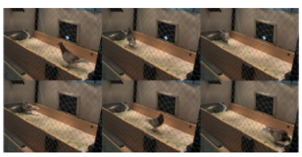


Fig. 5: Pigeon performing the task. The screen is located at 90° in the lateral visual field

Results

Performance of the pigeons for each position of the stimuli

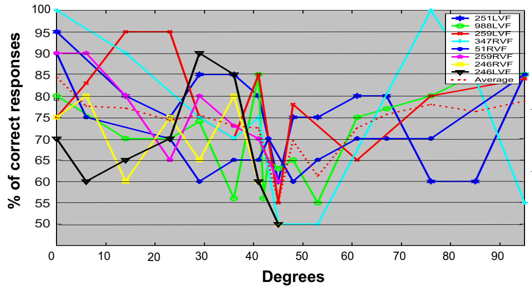


Fig. 6: Average performance of the birds in the first 20 trials for each position of the stimuli

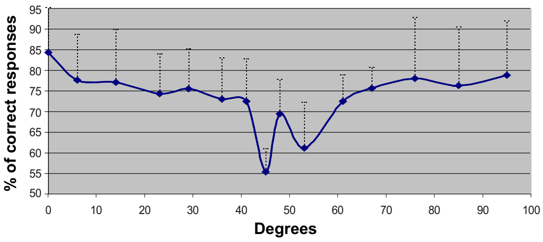
At 0° the stimuli are located in the frontal visual field. At 90° the stimuli are placed in the lateral visual field.

All pigeons showed a consistent and dramatic decrease of performance when the stimuli were presented at 45°.

Three pigeons never managed to learn the task beyond 45°.

Average performance of all pigeons for each position of the stimuli

Fig. 7: % of correct responses in the first 20 trials for each position of the stimuli



Up to 45° eccentricity the percentage of correct responses was never below 73%.

In contrast at 45° the percentage of correct responses dropped to 55%.

Trials needed to achieve the criterion for each position of the stimuli

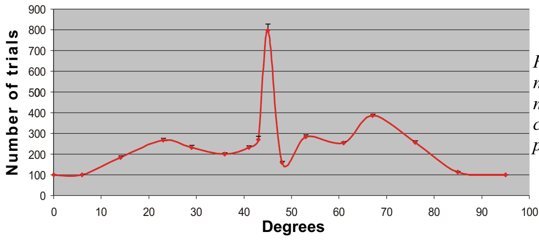


Fig. 8: Average number of trials needed to achieve the criterion at each position of the screen

At 45° the birds needed an average of 797 trials in order to relearn the task.

Up to 45° eccentricity, moving the screen by 7° steps required 217 trials of retraining, on average.

Discussion

A. Summary of the results:

1. A dramatic and very consistent decrease in discrimination performance was observed at 45° in all pigeons.

2. On average, birds needed 797 trials to achieve the criterion at 45°, while up to 45° eccentricity, moving the screen by 7° required only 217 trials.

B. Conclusions:

1. There is no information transfer from the frontal visual field to the lateral visual field.

2. Pigeons cannot generalize information from the tectofugal system into the thalamofugal system.

C. Current experiment:

We are currently running a second experiment: the screen is situated in the lateral visual field, at 90°, during the training. After achieving the criterion, we move the screen from lateral to frontal in 7° steps. Preliminary data indicate that there are no significant differences in performance while moving the screen from lateral to frontal.

Therefore, our findings confirm that pigeons can generalize information from the thalamofugal system into the tectofugal system, but not vice versa.

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