

BINOCULAR AND MONOCULAR TILTDISCRIMINATION
IN THE RABBIT: EVIDENCE FOR HEMISPHERIC DOMINANCE?

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Abstract. Twenty eight rabbits were trained to discriminate striated patterns of different orientation, first binocularly, than with each eye separately. There was no evidence of systematic dominance of either the left or the right hemisphere.

Hemispheric dominance in humans is well established (9), although stimulus dependent (15). In 95% of right-handed humans the left hemisphere is dominant for speech and language (12). In spatial orientation tasks however, such as the detection of lines of different orientation, the right hemisphere is dominant (1, 2, 11).

Dominance of one hemisphere has been described in animals. In monkeys no lateralization was found in the formation of memory traces in a visual discrimination task (8). However, in an auditory-dependent memory task a hemispheric lateralization is likely to exist in monkeys (4, 5). In adult cats hemispheric dominance pattern discrimination (21, 22) has been found. Left-hemidecorticated rats showed less active exploring behavior than right-hemidecorticated ones, when handled in early life (3, 10). In rats Zimmerberg et al. (7, 23), found a correlation of spatial preferences and asymmetries of striatal dopamine contents. Finally in birds, lateralization of the left half of the brain has been found in vocalization (14).

Within a series of studies on visual discrimination carried out in our

laboratory, we were interested in a possible dominance of either the left or the right hemisphere in the rabbit. In the present study rabbits were trained, first binocularly then monocularly, to discriminate vertical versus oblique striated patterns of different orientation.

Twenty-eight Dutch belted rabbits were used. The pattern discrimination apparatus and the automatic control system have been described elsewhere (16, 17). The apparatus consisted of a box with one wall having two hinged panels on which visual patterns could be back projected. To make a correct choice, the animal had to press the panel illuminated by the correct pattern. This response was rewarded by a food pellet. When the animal chose the incorrect pattern, no reward was given and the trial was terminated. The food rewarded pattern was placed randomly right or left. Per day 100 trials were given.

As shown in Fig. 1 the animals first learned to discriminate between a horizontal and a vertical striated pattern. The vertical one was always rewarded. After reaching the 90% criterion the horizontal bars were rotated 45 degrees either clockwise or counterclockwise. First this task was presented to both eyes, then to each eye separately, one eye a day. A maximum of five days was allowed to reach criterion. The same procedure was followed for 25 and 15 degrees.

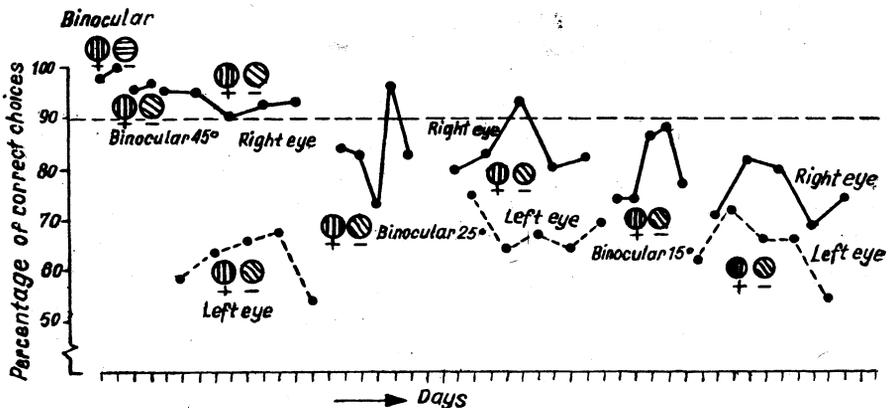


Fig. 1. Example of a training curve of an animal in which the right eye was dominant throughout the training procedure.

The two most extreme training curves are shown in Figs. 1 and 2. The animal in Fig. 1 shows a profound dominance of the right eye which persisted for all angular differences, whereas the second animal was symmetrical through the whole training procedure. The average scores of the last two training days are shown in Fig. 3 for each angular dif-

ference. The differences between binocular and monocular vision were statistically significant (Student-test, $t = 5.11$ for 25° , 4.71 for 25° and 4.17 for 15° , $P < 0.01$). No significant differences were seen between the average scores of the left and right eye. Thereafter the individual training curves were studied. The scores with the left and right eye open, during the last 2 days of training with the 45° , 25° and 15° angle differences were compared. Arbitrarily an animal was considered "a-symme-

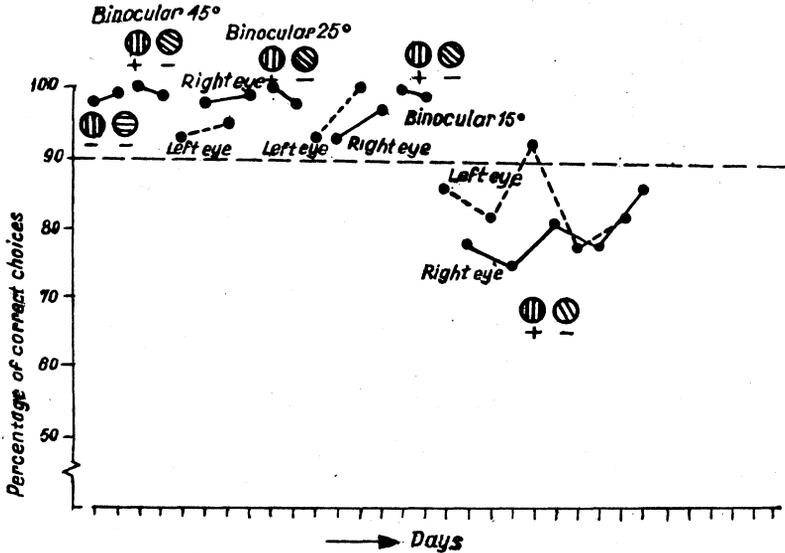


Fig. 2. Example of a training curve of a symmetric animal.

trical" if there was a 10% score difference at any of the angle-differences. This was found to be the case in 68% of the animals. If an animal was "asymmetrical" at more than one angle-difference, it was always the same eye which dominated. Figure 4 shows that the average score differences increased with the angle differences (Student-test $t = 2.60$, $P < 0.05$). In 58% of the asymmetric animals the righteye was dominant, in 42% the left eye.

As described, in 68% of the animals performance with the left and right eye open differed. This is in agreement with a previous publication in which rabbits were trained to discriminate vertical from horizontal striations, mirror image striations and inverted triangles (19). No systematic dominance of either the left or right eye was found in the present results. However, as stated the percentage of asymmetric animals increased with the decrease of angular differences. Once established, no shift was seen in ocular dominance (20).

Since 90 percent of the optic nerve fibers cross in the chiasm (6, 18), it is tempting to interpret these differences in performance of either the left or the right eye as a hemispheric one. Hemispheric dominance, as

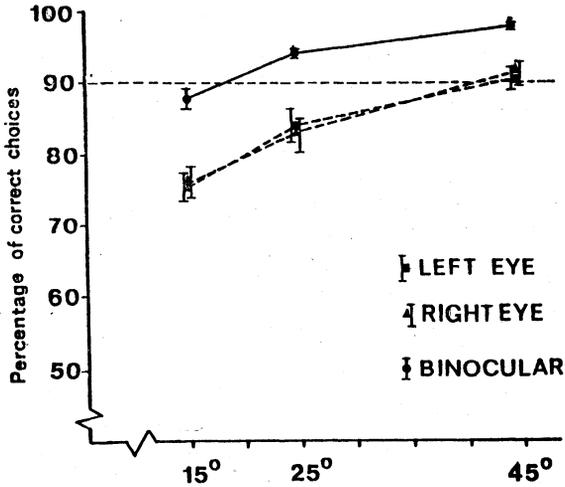


Fig. 3. Average scores of day 4 and 5 for each angular difference in binocular and monocular trained rabbits ($n = 28$, Mean and Standard Error).

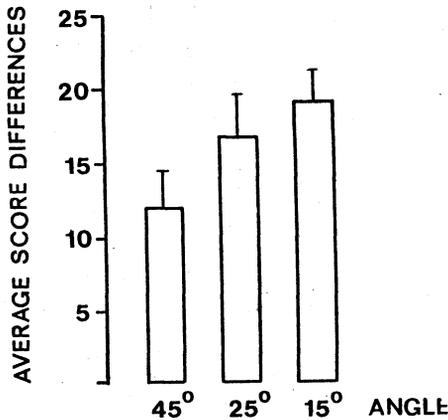


Fig. 4. Average score differences and standard errors of the mean in 19 asymmetrical animals for each angular difference.

a working hypothesis for further studies, is supported by the fact that hemispheric asymmetry in the rabbit was described in two EEG studies. Nelson (13) has found EEG asymmetries between the hemispheres of the rabbit during a water reinforced discrimination task. During the perfor-

mance phase of this task a consistent hemispheric asymmetry was found, whereas during the non-reinforced phase no asymmetries could be demonstrated. Although the direction was always the same within one animal, the direction of the asymmetry varied between the animals. Webster (22) reports that in the rabbit during the REM sleep one hemisphere is more active than the other one, while during the non-REM sleep the situation is reversed. In 3 out of 5 rabbits studied, the left hemisphere was the most active one during the non-REM sleep, whereas in the other two animals, the right hemisphere was the most active one.

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1. BENTON, A., HANNAY, H. J. and VARNEY, N. R. 1975. Visual perception of line direction in patients with unilateral brain disease. *Neurology* 25: 907-910.
2. BENTON, A., VARNEY, N. R. and HAMSHER, K. 1987. Visuospatial judgment: a clinical test. *Arch. Neurol.* 35: 364-367.
3. DENENBERG, V. H., GARBANATI, J., SHERMAN, G., YUTZEY, P. A. and KAPLAN, R. 1974. Infantile stimulation induces brain lateralization in rats. *Science* 185: 623-625.
4. DEWSON, J. H. 1977. Preliminary evidence of hemispheric asymmetry in auditory function in monkeys. *In* S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krautzhamer (ed.), *Lateralization in the nervous system*. Academic Press, New York, p. 63-71.
5. DOTY, R. W. and OVERMAN, W. H. 1977. Mnemonic role of forebrain commissures in macaques. *In* S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes, and G. Krautzhamer (ed.), *Lateralization in the nervous system*. Academic Press, New York, p. 75-88.
6. GIOLLI, R. A. and GUTHRIE, M. D. 1969. The primary optic projections in the rabbit. An experimental degeneration study. *J. Comp. Neurol.* 136: 99-126.
7. GLICK, S. D., JERUSSI, T. P. and ZIMMERBERG, B. 1977. Behavioral and neuropharmacological correlates of nigrostriatal asymmetry in rats. *In* S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krautzhamer (ed.), *Lateralization in the nervous system*. Academic Press, New York, p. 213-249.
8. HAMILTON, C. R. 1977. Investigations of perceptual and mnemonic lateralization in monkeys. *In* S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krautzhamer (ed.), *Lateralization in the nervous system*. Academic Press, New York, p. 45-62.
9. KUPFERMANN, J. 1985. Hemispheric Asymmetries and the cortical localization of higher cognitive and affective functions. *In* E. R. Kandel and J. H. Schwartz (ed.), *Principles of Neuroscience*. Elsevier, New York, p. 673-687.
10. LEVINE, S., HALTMEYER, G. C., KARAS, G. G. and DENENBERG, V. H. 1976. Physiological and behavioral effects of infantile stimulation. *Physiol. Behav.* 2: 55-59.

11. MEERWALDT, J. D. 1982. The rod orientation test in patients with right-hemisphere infarction. Ph. D. Thesis, Rotterdam.
12. MOHR, J. P. 1984. Aphasia, apraxia, and agnosia. In L. P. Rowland (ed.), Merrit's textbook of neurology. Lea and Febiger, Philadelphia, p. 6-11.
13. NELSON, J. M., PHILLIPS, R. and GOLDSTEIN, L. 1977. Interhemispheric EEG laterality relationships following psychoactive agents and during operant performance in rabbits. In S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krautzhamer (ed.), Lateralization in the nervous system. Academic Press, New York, p. 451-470.
14. NOTTEBOHM, F. 1977. Asymmetries in neural control of vocalization in canary. In S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krautzhamer (ed.), Lateralization in the nervous system, Academic Press, New York, p. 23-44.
15. SPRINGER, S. P. 1977. Tachistoscopic and dichotic listening investigations of laterality in normal human subjects. In S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes, and G. Krautzhamer (ed.), Lateralization in the nervous system, Academic Press, New York, p. 325-336.
16. VAN DER MARK, F. and MEYER, J. H. C. 1974. Automatic control of installations for experiments relating to physiological research of the visual system. Comput. Programs Biomed. 4: 35-41.
17. VAN HOF, M. W. 1966. Discrimination between striated patterns of different orientation in the rabbit. Vision Res. 6: 89-94.
18. VAN HOF, M. W. and LAGERS VAN HASELEN, G. C. 1975. Monocular pattern discrimination in rabbits after unilateral ablation of the visual cortex. Exp. Neurol. 46: 257-259.
19. VAN HOF, M. W. and VAN DER MARK, F. 1976. Monocular pattern discrimination in normal and monocularly light-deprived rabbits. Physiol. Behav. 16: 257-259.
20. VAN HOF, M. W. and WIERSMA, C. A. G. 1967. The angular threshold of discrimination for striated patterns of different orientation in the rabbit. Vision Res. 7: 265-270.
21. WEBSTER, W. G. 1972. Functional asymmetry between the cerebral hemispheres of the cat. Neuropsychologica 10: 75-87.
22. WEBSTER, W. G. 1977. Hemispheric asymmetry in cats. In S. Harnad R. W. Doty, L. Goldstein, J. Jaynes and G. Krautzhamer (ed.), Lateralization in the nervous system. Academic Press, New York, p. 471-480.
23. ZIMMERBERG, B., GLICK, S. D. and JERUSSI, T. P. 1974. Neurochemical correlate of spatial preference in rats. Science 185: 623-625.