Eye preference in hemicerebrectomized monkeys¹

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Following the surgical removal of either a left or a right cerebral hemisphere, eight monkeys were tested for eye preference. Although both eyes project fibers to the remaining hemisphere, each S showed a preference for use of the eye homolateral to the ablation.

The observation of a temporary position response preference in monkeys with visual field defects (Kruper, Patton, & Koskoff, 1965) led us to investigate their lateral eye preferences. While most normal monkeys prefer using a particular eye (Cole, 1957; Hall & Mayer, 1966; Kounin, 1938; Kruper, Boyle, & Patton, 1966), we have found no similar reports for monkeys with brain lesions. We did, however, locate two studies of eye preference in humans who had loss of the lateral half of the total visual field (homonymous hemianopia). In one of these (Rothschild & Streifler, 1952), each of seven Ss preferred to sight with the eye contralateral to the lesion. In the other study (Williams & Gassel, 1962), seven of 10 patients were reported to prefer the eye homolateral to the lesion. Repeated reading of these reports did not allow us to clarify the reason for these contradictory findings for humans.

The present study reports measurement of eye preference in monkeys from which one cerebral hemisphere has been surgically removed (hemicerebrectomy).

Method

Of 15 monkeys (*Macaca mulatta*), eight had one cerebral hemisphere removed from eight to 12 months before testing; seven were unoperated controls.² Ss of the surgical group weighed from 4.1 to 6.1 kg with a mean of 5.1 kg. The normal animals averaged 5.8 kg with a range of 4.5 to 7.3 kg. All Ss had experience on one or more lever pressing tasks, but no prior testing related to eye preference measurements.

Hemicerebrectomy (Koskoff, Patton, Migler, & Kruper, 1959), or total hemispherectomy (White, Schreiner, Hughes, McCarty, & Grindley, 1959) involves the unilateral removal of all cerebral structures rostral to the midbrain. The hemisphere that was removed in these Ss had been selected on the basis of observations of hand preference during lever pressing. Of the eight operated Ss, four had the hemisphere homolateral to the preferred hand and four the contralateral hemisphere removed. One result of this surgery is that vision becomes restricted to the nasal half of one retina and the temporal half of the other, thus presenting a homonymous hemianopia.

Ss were placed in an enclosed chamber (60 x 60 x 70 cm) and could see outside only through an aluminum

tube (10 mm diameter x 60 mm length). The tube was embedded in a piece of rough textured gray Plexiglas through which a S's head could be seen by E who sat about 60 cm in front of the chamber in dim ambient light. Direct food reinforcement of a given response was avoided, although S's interest was maintained by pushing food through the tube. One hundred monocular responses were recorded for each animal over three or four days of observation.

Results

The results of observations of eye preference are shown in Table 1 along with other data pertinent to the study. Some of these results are as follows: (1) The number of operated animals showing a preference for the eye homolateral to the ablation was significantly greater than the 50% chance expectancy, based on the availability of either eye for viewing.³ (2) Between normal and operated Ss, no significant difference occurred in the frequency with which the monkeys used their preferred eye.⁴ (3) Eye preference did not seem to depend on whether the removed hemisphere had been homolateral or contralateral to the pre-operatively preferred hand, since Ss, grouped accordingly, showed complete overlap of scores.

Discussion

As one ascends the phylogenetic scale, the completely crossed visual input of fishes, amphibians, reptiles and birds gives way to a partial decussation in rats, cats, monkeys and men (Polyak, 1957). The degree of decussation of the optic nerves of monkeys, as described by Polyak (1957) seems to be indeterminate, but presumably close to half (pp. 303-306, 788). Thus, the residual influence of a phylogenetically-early preponderance of crossed fibers could still provide a slight bias for use of the nasal hemiretina in monkeys. Certain experiments may also be cited, which point

Table 1. A summary of subjects, hemisphere removed, relation of removed hemisphere to preferred hand and percentage of responses with preferred eye. Asterisk follows only score that was not significantly different from chance. The letter R means right, L means left, c means hemisphere contralateral to preferred hand, h means homolateral to preferred hand.

Operated Subjects	Percent Response	Hemisphere Removed	Normal Subjects	Percent Response
No. 39	91 R	R c	No. 48	83 L
No. 52	87 L	L h	No. 28	82 R
No. 54	85 R	R h	No. 40	79 R
No. 36	74 L	L c	No. 193	77 L
No. 38	72 R	R h	No. 29	74 R
No. 51	70 R	R c	No. 32	68 L
No. 53	67 L	L c	No. 26	51 R*
No. 42	66 L	L h		

to a relatively greater importance of the nasal retinae in humans: (1) a wider visual field (Polyak, 1957), (2) a faster reaction time to light stimuli (Rains, 1963), and (3) a predominant response to certain color rivalry phenomena (Crovitz, 1964; Crovitz & Lipscomb, 1963).

While we do not wish to suggest that what is found in humans will be the same for monkeys, or vice versa, a close similarity is expected in visual functions. Interestingly, the reasons for eye preference in humans are not yet clear. Both a sensory factor (acuity-dominance) and a motor factor (sighting-dominance) and their relationship have been discussed by Crovitz (1961). Since, in the hemisectomized monkey, only one hemiretina is functional in each eye, and part of the motor system for the eyes has suffered loss, acuity-dominance, sighting-dominance, or both could be relevant to the preference for the eye homolateral to the ablation.

Although the surgical intervention appeared to determine which eye was preferred, it did not seem to alter the degree of that preference, since normal and operated Ss used their preferred eye with about equal frequencies.

In concurrence with previous studies reporting a lack of correlation between hand and eye preference in normal monkeys (Cole, 1957; Kounin, 1938; Kruper et al, 1966), the data here did not suggest that post-operative eye preference was related to the hand which had been preferred pre-operatively. However, it should be noted that the measured behavior involved no hand-eye coordination.

Some additional factors that should be investigated in relation to eye preference in unilaterally lesioned animals are eye deviation, head and body turning, and changes in posture, each of which usually follows hemisectomy. Similar ipseversive movements are known to occur, at least temporarily, following smaller unilateral lesions that include the area of the arcuate sulcus of monkeys (Kennard & Ectors, 1938). These authors also report a contralateral field defect which was not a hemianopia, but rather, a disregard of objects appearing in that visual field. The relationship of this disregard to eye preference needs attention. Lastly, the permanence of the preference has not yet been assessed, since only one test series was completed here. Perhaps post-operative changes in degree of preference may take place at a later time, as the result of testing procedures, general adaptation to the field defect, or other variables.

Replication and investigation of some of these variables are presently being conducted.

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Note

1. This investigation was supported by a Public Health Service research career program award (NB-K3-16,610) and research grant (NB-01601-08) both from the National Institute of Neurological Diseases and Blindness.
2. All but one subject are still alive, so histology of these Ss is not done. A histological report of similar preparations can be found in Locke, S., Kruper, D. C., & Yakovlev, P. I., Limbic nuclei of thalamus and connections of limbic cortex. *Arch. Neurol.*, 1965, 11, 571-582.
3. For the .05 level, we used the formula: $50\% \pm 2 \sqrt{N(p)(q) \cdot \frac{100}{N}}$, with N equal to all left and right responses, assuming p of p and q equal to .50.
4. Using scores that represented each subject's difference from chance of 50%, a Mann-Whitney U test indicated no significant difference between groups ($p > .86$, 2-tailed).