Loss of Y-Cells in the Lateral Geniculat

E Effectively Deprived Tree Shrews

Abstract. In tree shrews (Tupaia glis) reared with one eye closed, Y-cells were almost entirely absent in the binocular segment of the lateral geniculate laminae receiving input from the deprived eye. Y-cells were found in the monocular segment of these laminae, and in the binocular segment of the laminae with input from the normal eye. X-cells were present in both the deprived and normal laminae and appeared unaffected by the deprivation. A number of abnormal cells were also found, and these were located primarily in the binocular segment where Y-cells were absent.

Tree shrews share with primates a well-developed geniculostriate visual pathway and may bear strong resemblance to the common ancestor of the primate line (1). They differ from the cat, on which so much of our knowledge of visual functioning is based, not only in evolutionary history, but in a number of features of their visual system. For example, compared with cats, tree shrews have more retinal cones, a larger, more differentiated superior colliculus, and a lateral geniculate nucleus which projects solely to the striate cortex (1-3). Despite these and other important differences, we previously found that tree shrews have X- and Y-cells in their lateral geniculate nucleus (4). Our suggestion that other more disparate species might also possess X- and Y-cells has recently been confirmed (5). In this report, we extend the analogy between the X- and Y-cells of cat and tree shrew to include the effec

T he deprivation on X-cells (11).

The amounts of \( ^{3}H \) estradiol bound by the tissues of the adult ovariectomized rat, in terms of disintegrations per minute per milligram of nuclear protein, were: uterus, 2.0 \( \times \) 10^4; vagina, 1.4 \( \times \) 0.3 \( \times \) 10^4; diaphragm, 0.3 \( \times \) 0.02 \( \times \) 10^4; and kidney, 0.3 \( \times \) 0.05 \( \times \) 10^4. These values are similar to those shown in Fig. 1 for the corresponding tissues of the adult ovariectomized rat.


G. L. Dryden observed mating by two female shrews that were sexually experienced before they were ovariectomized. M. J. Hasfer (personal communication) has found that behavioral receptivity in ovariectomized females from a separate colony. To test more rigorously the ability of females to mate after ovariectomy, we bilaterally ovariectomized three mature (6 weeks old) but sexually inexperience shrews. Beginning 1 month after ovariectomy, they were exposed for 1 hour at weekly intervals to studs. All three females exhibited sexual receptivity and all copulated, allowing intromission and ejaculation (as judged from male behavior; see (12)). Three age-matched control females all copulated the second time they were exposed to studs. The ovariectomized shrews first copulated on test days 1, 14, and 28.


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diameter, but could only find their approximate location in the visual field and the eye through which visual stimuli affected their firing. However, we obtained conduction latencies in most of these cells from stimulation of the optic chiasm (orthodromic OX latency) or the visual cortex (antidromic VC latency), or both. The OX latencies of the abnormal cells were quite long (average, 2.0 msec), significantly longer than the OX latencies of even normal X-cells (that is, 1.7 msec) (t-test, P < .001) (4). The VC latencies obtained in ten of these abnormal cells were quite variable. Three in the binocular visual field had very short latencies (0.75 to 1.0 msec) usually seen only in normal Y-cells, while the others had VC latencies (1.4 to 2.1 msec), as long or longer than most X-cells (4). Thus the abnormal cells generally had very long OX and VC latencies, with the exception of the three cells with VC latencies in the Y-cells’ range.

Since abnormal cells were not found in normal tree shrews (4), we presume they resulted from the effects of the monocular deprivation on either developing X- or Y-cells, or both. Although we could not determine their origin in this study, several factors suggest to us that at least some, and perhaps all, of them may represent “missing” Y-cells in the deprived laminae. First, the very short VC latencies in some of the abnormal cells were consistent with a Y-cell origin. Second, if the number of Y-cells and abnormal cells in the deprived binocular segment are combined, the proportion of these two groups (28 percent) is not significantly different from the level of Y-cells (45 percent) in normal tree shrews (χ², P > .1) (4). Thus the appearance of the abnormal cells can account statistically for the disappearance of the Y-cells in the deprived binocular segment.

While it is possible that the abnormal cells resulted from the effects of deprivation on X-cells, it seems more parsimonious to suggest that they may be derived from the effects of the deprivation on developing Y-cells. Recent experiments in monocularly deprived cats have revealed similar abnormal cells with long OX latencies in the deprived portion of the medial interlaminar nucleus (I2). Since this nucleus in the cat receives only Y-cell input (I3), these data in cat also suggest that one effect of visual deprivation on Y-cells may be to produce abnormal cells. It is interesting that some abnormal cells were seen in the monocular segment of the deprived tree shrews, indicating that cells in this portion of the visual field are not immune from the effects of monocular deprivation.

The pattern of Y-cell loss in monocularly deprived tree shrews is accompanied by anatomical and behavioral results which also indicate differences between the binocular and monocular segments. A proportional loss of large cells, which is restricted to the binocular segment of the deprived laminae, has been reported in monocularly deprived tree shrews tested after reverse suturing (I4). In preliminary behavioral tests in monocularly deprived tree shrews (I5) we found that the animals failed to respond to visual stimuli presented to the binocular visual field of the deprived eye, but did respond when the stimuli entered the monocular field. Thus the absence of normal Y-cells in the binocular segment is accompanied by a morphological loss of large cells and a loss of behavioral responsiveness, while the presence of normal Y-cells in the monocular segment is associated with relatively normal cell size and the presence of behavioral responsiveness. This same pattern has been reported in the cat (I6).

In extending the analogy between the X- and Y-cells of the cat and tree shrew to include the effects of visual deprivation on the postnatal development of these cells, this study leads to three suggestions. First, the similarity of the effects suggests that similar mechanisms may be involved in the development of the X- and Y-cell systems in both species. Second, the presence of closely similar cell types and deprivation effects in two quite disparate species suggests that other species, particularly those recently shown to have X- and Y-cells (5), may show similar deprivation effects. Finally, the analogous behavioral effects of the deprivation in cat and tree shrew suggest that the Y-cell system may play a similar, although yet undefined, role in the visual behavior of these and possibly other species.

References and Notes

Fig. 1. Distribution of the receptive-field positions of 64 cells recorded in the lateral geniculate laminae receiving afferents from the deprived eye in tree shrews reared with one eye closed (I7). The binocular and monocular segments of visual field are shown. While normal proportions of Y-cells were present in the monocular visual field of the deprived laminae, only two Y-cells were found in the binocular field, and these were located near the boundary of the monocular field. We also found a few “mixed” cells and some abnormal cells which are described in the text.

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7. We measured five properties: hand-plotted receptive-field center diameter (X < P < Y), latency to optic chiasm shock (Y < 1.4 msec < X), antidromic latency to striate cortex shock (Y < 1.2 msec < X), duration of response to presentation of standing contrast

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Ultrasound Emission in Infant Rats as an Indicant of Arousal During Appetitive Learning and Extinction

Abstract. Infant rats rewarded for crawling by being allowed to suckle on the dry nipple of an anesthetized dam showed a decreasing rate of ultrasound production during acquisition and an increasing rate during extinction. These results suggest that infant rats can be stressed and are aroused as a result of successive nonrewards just as adult rats are. In addition, these results do not support the hypothesis that infant rats lack inhibitory mechanisms related to poorly developed neural centers.

Infants of most rodent species emit sounds at frequencies above the range of human hearing. These ultrasonic vocalizations, investigated in a number of species, typically occur when the infants are exposed to conditions of environmental stress (1, 2). Thermal and tactual stressors, unusual odors, pain, and hunger evoke the ultrasonic calls of infant rats (1, 3, 4). Developmentally, the rate of ultrasound production decreases as homiothermy is attained (4).

Ultrasonics appear to be important signals for altitracial infant rodents. They seem, for example, to initiate infant retrieval by the dam in rats (5) and to coordinate maternal behaviors in mice (6). Bell (6) has emphasized that ultrasound pulses in the range of 20 to 50 kHz (louder than 30 db) are counted by a specially constructed digital counter. The microphone was positioned over the intersection of the alley with the goalbox in such a way that ultrasonics anywhere in the apparatus were not detected.

The subjects, eight albino rat pups bred in our laboratory but originally of Holtzman stock, were 11 days of age and weighed between 25 and 30 g. Each pup was separated from its dam 10 hours before runway training began and was kept in a covered plastic breeding cage maintained at 37°C. Approximately 20 minutes before runway training began, the dam was anesthetized with Equithesin (2 ml per kilogram of body weight, injected intraperitoneally). Additional amounts of anesthetic were used as necessary to maintain the dam at a body temperature of 37°C.