caudal forebrain injection) appeared, first in the ventromedial fountain and then more caudally again in the dorsomedial cluster as well (Fig. 1). In the caudal end of the DR nucleus and further caudal in the B6 area (*15*), however, only DAPI-primuline labeled cells were seen (*9*).

In the lateral SNC at rostral levels (Fig. 1), separate groups of similar size of DAPI-primuline and EB-labeled cells were seen. In the medial SNC and VTA at these rostral levels, DAPI-primuline-labeled cells constituted small clusters surrounded by large numbers of EB-labeled cells. More caudally the distribution of EB-labeled cells remained roughly the same, but the DAPI-primuline-labeled cell clusters vanished laterally and thus became restricted to the medial SNC and VTA. At the caudal end of the SN, only EB-labeled neurons were present.

Previous reports have demonstrated that the groups of SNC-VTA cells projecting to different forebrain areas overlap (*8, 16, 17*), but also in several instances that SNC-VTA cells projecting to one forebrain area are different from those projecting to another (*8, 17, 18*). With a fluorescent retrograde double-labeling technique, we have demonstrated within individual animals, that the SNC-VTA cells innervating the lateral-caudal forebrain form interlocking cell clusters with those innervating the anterior-medial forebrain. This should be considered in light of a report that removing the striatum produces retrograde cell changes in clusters of SN cells interspersed with clusters of normal cells (*19*).

Different afferent inputs to certain brain regions may form mosaics of segregated terminal zones, for example, the ocular dominance columns in the visual cortex (*20*) and also the various cortical (*21*) and thalamic (*22*) terminal clusters in the monkey striatum. This is obviously reminiscent of the alternating efferent cell clusters in the SNC-VTA demonstrated in the present study. The interdigitation of cell clusters projecting to the anterior-medial versus lateral-caudal forebrain may allow both these forebrain areas to partake of information received from fiber systems terminating in different medio-lateral portions of the SNC-VTA.

The fluorescent retrograde double-labeling technique has also made it possible to demonstrate that, in contrast to cells of the SNC-VTA, a number of single raphe cells sends axon collaterals to two widely divergent forebrain areas. This result may explain why cells in one area of the DR are consistently labeled (in different animals) by horseradish peroxidase injections into different forebrain regions (*9*).

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3 November 1978; revised 9 February 1979

Binocularity in Kittens Reared with Optically Induced Squint

Abstract. *The effects of conflicting visual images were studied without the confounding influences of oculomotor abnormalities: strabismus was simulated by rearing kittens with ophthalmic prisms before the eyes. After the animals had matured, the response properties of neurons in the visual cortex were studied. The proportion of binocularly excited neurons decreased; however, the extent of the ocular dominance alterations was related to the amount and direction of the prism-induced deviation.*

It has been consistently demonstrated that a nonconcomitant (paralytic) strabismus produced in kittens by surgically severing one or more of the extraocular muscles results in a severe loss of cortical binocularity (*1*). Depending on the direction of the deviation of the visual axes, a squint can also cause a loss in the spatial resolving capacity of lateral geniculate (LGN) neurons, a decrease in LGN cell size, and a functional loss in visual fields (*2*). Because fusion is usually impossible after such manipulations, it is tempting to attribute all of these alterations to the asymmetrical and conflicting visual inputs originating from the two eyes. In this respect, however, Maffei and Bisti (*3*) have recently shown that asymmetrical visual inputs to the cortex are not a necessary condition for the breakdown in binocularity that results from a surgically induced strabismus. Instead, their results indicate that asymmetrical ocular motility alone is sufficient to disrupt the binocular inputs to cortical neurons.

Since impaired ocular motility is a necessary consequence of surgically induced strabismus, it is not possible to evaluate completely the effects of conflicting visual inputs in such animals. Conflicting visual inputs can be produced without necessarily inducing oculomotor abnormalities by depriving one eye of form vision (for example, by unilateral occlusion). With this procedure, the deprived eye is put at a competitive disadvantage, and, as a result, the neurons in the visual cortex of the developing kitten become almost totally dominated by the normal eye (*4*). Therefore, with this type of manipulation, it is not possible to isolate the effects of conflicting visual inputs without one eye's being given a definite competitive advantage. Even when the occlusion is alternated

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daily, one eye always has a competitive advantage. In order to evaluate the effects of conflicting visual inputs, we simulated a concomitant strabismus (one in which the angle of deviation is constant for all directions of gaze) optically by rearing kittens with ophthalmic prisms over one or both eyes. Ophthalmic prisms deviate the path of light and the apparent direction of objects without significantly altering the quality of the image presented to the eye. Thus if the power of the prism exceeds the fusional ranges of the kitten, it will experience diplopic and conflicting visual images of approximately equal optical quality. Moreover, eye motility is unencumbered for all eye positions by this method. When we subsequently recorded from cells in the visual cortex of kittens reared with such an optically induced squint, we found a decrease in cortical binocularity. The extent of the ocular dominance changes, however, appears to be related to the degree and direction of the deviation produced by the prisms.

Nine kittens were reared in a totally dark room from the time of eye opening until they were 4 weeks of age. Beginning on day 29, the kittens were allowed 2 to 3 hours of visual experience each day, but only when each animal wore a pair of goggles containing ophthalmic prisms (*5*). Four of the kittens wore goggles that held 15-diopter prisms in front of the right eye. For two of these kittens, the prisms were mounted in the "base-in" direction; for the other two, in the "base-out" direction. To help balance the images presented to the right and left eyes, plano ophthalmic blanks were mounted in the goggles in front of the left eyes. Four kittens wore goggles that held 15-diopter prisms in front of both eyes. Both prisms were mounted in the base-out direction for two kittens (a total of 30 prism diopters base-out) and in the base-in direction for the other two kittens (30 prism diopters base-in). The remaining kitten was fitted with goggles that contained plano ophthalmic lenses in front of both eyes. This animal, along with two additional kittens reared in a normally lighted environment, served as normal controls. All the kittens adapted rapidly to the goggles; their general behavior while running and playing was not obviously different from other normal kittens in the colony. Each animal received a minimum of 208 hours of visual experience through the goggles during the first 21 weeks of life. Between the 21st and 24th weeks of age, the animals were prepared for single unit recording under barbiturate anesthesia (Nembutal; 35 mg per kilogram of body weight) (*6*).

Neural activity was recorded from cortical units with tungsten microelectrodes according to conventional procedures. Several relatively short ($\approx$ 2 mm) electrode penetrations were made into the left visual cortex during each experiment. When a neural unit was isolated from the background activity, hand-held stimuli of various shapes (slits, spots, bars, and edges) were used to map its receptive fields. The receptive fields were plotted separately for the two eyes, with care taken to determine whether a given neuron could be driven by both eyes. Units demonstrating the characteristics of geniculate afferents were omitted from the results. Each neuron was classified according to the seven-category ocular dominance scheme described by Hubel and Wiesel (*7*). Judgments concerning ocular dominance were made primarily on the basis of the "best response" elicited from the audiomonitor. A maximum of ten units were analyzed during a given penetration. We studied a total of 320 cells from the 11 subjects. The receptive fields for the majority of the units studied were located between 3° and 10° from the center of the area centralis; the receptive fields for all of the units were located within the central 20° of the visual field (*8*).

Ocular dominance histograms are shown in Fig. 1; the data for the prism-reared animals have been segregated according to the amount and direction of the prism-induced deviation. The ocular dominance distributions for the three control kittens (Fig. 1A) and for the prism-reared kittens (Fig. 1, B to E) are quite different. While the majority (76 percent) of the neurons encountered in the control animals were excited by stimuli presented to either eye, the majority of the neurons recorded from the prism-reared animals were classified as monocular. However, the percentage of monocular cells encountered in a given prism-reared animal depended on the direction and magnitude of the prism worn. For example, 76 percent of the units encountered in the animals that wore a 15-diopter prism mounted base-in over the right eye (Fig. 1B) were classified as monocular. In comparison, in the animals that wore a 15-diopter prism mounted base-out over the right eye (Fig. 1C), only 40 percent of the units studied were classified as monocular. These observed differences between the effects of base-in and base-out prisms are apparently eliminated by increasing the total amount of prism worn from 15 to 30

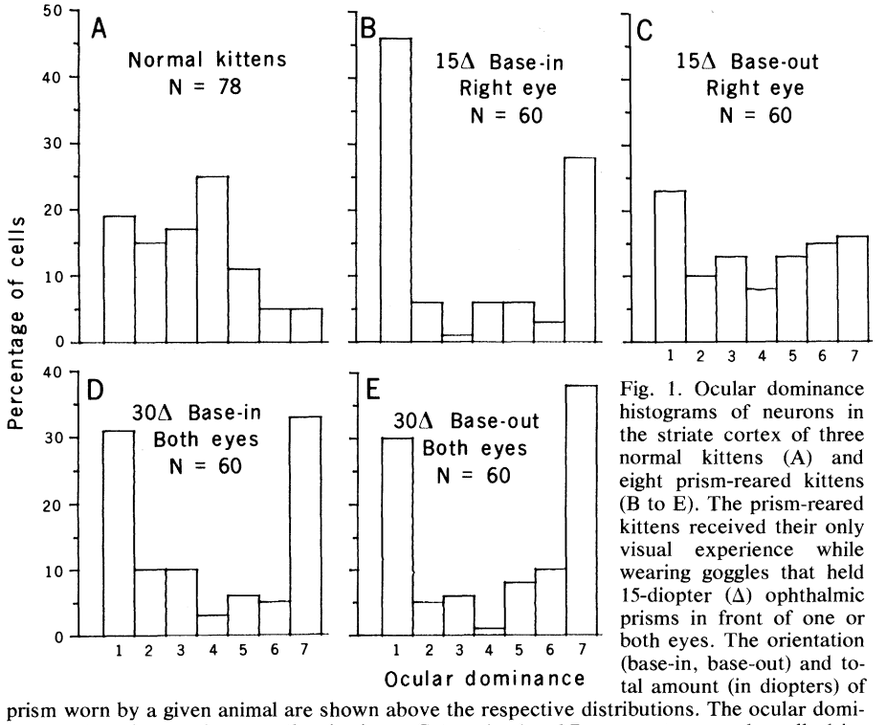

Fig. 1. Ocular dominance histograms of neurons in the striate cortex of three normal kittens (A) and eight prism-reared kittens (B to E). The prism-reared kittens received their only visual experience while wearing goggles that held 15-diopter (Δ) ophthalmic prisms in front of one or both eyes. The orientation (base-in, base-out) and total amount (in diopters) of prism worn by a given animal are shown above the respective distributions. The ocular dominance categories are shown on the abscissas. Categories 1 and 7 represent monocular cells driven only by the contralateral and ipsilateral eyes, respectively. Since all the electrode penetrations were made into the left hemisphere, categories 1 and 7 represent cells dominated by the right and left eyes, respectively. Cells in all other groups are binocularly driven. The relative influence of the contralateral eye (right) decreases, while the influence of the ipsilateral eye (left) increases from groups 2 through 6. Category 4 represents binocular cells driven equally by both eyes.

prism diopters. There is little difference between the ocular dominance distributions for the animals that wore a total of 30 diopters of prism in either the base-in or base-out direction (Fig. 1, D and E).

In addition to the alterations in ocular dominance, two of the prism-reared kittens demonstrated abnormal interocular alignments [as judged by the eye positions during paralysis (*9*)]. The two kittens reared with the 15-diopter prisms mounted base-in in front of the right eye demonstrated inward or esotropic deviations. In both cases these deviations appeared to be symmetrical with respect to the two eyes. The interocular alignments for the other six prism-reared animals were within the range of eye alignments for the normal kittens.

Whereas Maffei and Bisti (*3*) have shown that asymmetrical ocular motility causes a breakdown in cortical binocularity, our results demonstrate that conflicting visual images that do not always give one eye a definite competitive advantage can also disrupt the binocular inputs to the cortex. Even though two of the prism-reared kittens manifested a strabismus, it is unlikely that their oculomotor abnormalities resulted in the decrease in binocular connectivity, because the prism-rearing procedures did not induce an asymmetry in ocular motility. Ocular motility was not encumbered for either eye. The altered eye alignment, however, may have contributed to the differences in ocular dominance noted between the animals that wore a single 15-diopter prism mounted in front of the right eye (Fig. 1, B and C). That monocular units driven by the right and left eyes were encountered in approximately equal numbers in all of the prism-reared kittens supports the notion that neither eye was given a definite competitive advantage and suggests that the animals may have developed an alternating fixation pattern. These results, along with those of others (*1*–*4*), emphasize that the development and maintenance of normal single binocular vision is an extremely complex process requiring a delicate balance in both the motor and sensory processes of vision.

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6. The procedure included trephining a hole through the skull over the left posterior lateral gyrus, removing the dura, attaching a head restraint to the skull, performing a tracheotomy, and cannulating a femoral vein. The animals were immobilized by infusing Flaxedil intravenously and were artificially respirated. The electrocardiogram was monitored, and the expired CO_2 and core temperature were maintained at normal levels throughout the recording session. All the wound margins were infiltrated with a local anesthetic (Xylocaine). The pupils were dilated, and accommodation was paralyzed by the topical application of atropine; the nictating membranes were retracted with Neo-Synephrine. The corneas were protected and the retinas were made conjugate to a rear-projection screen 1 m from the animal with the appropriately powered contact lenses. The reflections of the area centralis and the optic discs were projected and marked on the stimulus screen by illuminating the retina via a fiber optic [R. Fernald and R. Chase, *Vision Res.* **11**, 95 (1971)].
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9 February 1979

Testosterone Reduces Refractory Period of Stria Terminalis Neurons in the Rat Brain

Abstract. *The absolute refractory period of neurons projecting from the corticomedial amygdala to the medial preoptic-anterior hypothalamic junction in rats was significantly increased by castration (from 1.01 to 1.61 milliseconds) and decreased again by testosterone (from 1.48 to 0.97 millisecond). Corticomedial amygdala neurons which projected to the capsule of the ventromedial nucleus of the hypothalamus were unaffected. These results demonstrate a specific, direct neuronal effect of testosterone.*

Steroid hormones have effects on behavior which are mediated by the central nervous system. This generalization has been confirmed repeatedly by studies of the uptake of radioactive hormones (*1*) and the effects of hormone implants in the brain (*2*). Electrophysiological investigations have shown that sex hormones alter the level of spontaneous activity in anatomically defined populations of neurons (*3*) and change the responses of peripheral and central pathways to sensory and electrical stimulation (*4*, *5*). We report here a striking effect of testosterone on the refractory period of an electrophysiologically defined group of neurons in the brain of the rat.

In the male rat, the corticomedial amygdala (CMA) and the medial preoptic-anterior hypothalamic junction (MPH) concentrate radioactive testosterone (*6*). The olfactory and accessory olfactory bulbs project to the CMA and the sense of smell is important in the control of sexual behavior in the male rat (*7*). The CMA gives rise in its turn to a large projection to the MPH via the stria terminalis (ST) (*8*). Lesions of the ST and amygdala alter the timing of sexual behavior and the number of responses to ejaculation, and lesions of the MPH abolish sexual behavior entirely (*9*). Further, electrical stimulation of the MPH increases sexual activity (*10*). It seems likely, therefore, that neurons of the CMA-ST-MPH system play a role in the control of sexual behavior in the male rat. These neurons can be distinguished electrophysiologically from other CMA neurons by stimulating them antidromically by an electrode in the MPH. Since mating is usually lost in rats 8 weeks after castration and is reinstated by testosterone propionate (TP) [200 μg/day for 16 days or more (*11*)], we examined the effect of these treatments on the physiological characteristics of CMA neurons projecting to the MPH. Another group of CMA neurons terminates in the capsule of the ventromedial nucleus of the hypothalamus and can be identified by antidromic stimulation from this site. These neurons are probably not involved in sexual behavior, since lesions of the ventromedial nucleus did not alter the sexual behavior of the male rat (*12*). As a control for nonspecific effects of castration, therefore, we also examined its effects on these neurons.

Sexually naïve, adult male Wistar rats

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