Orientational Anisotropy in Infant Vision

Susan Cohen Leehey; Anne Moskowitz Cook; Sarah Brill; Richard Held


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biosynthesis and deposition of collagen in rat brain vessels and in testicular arteries as it does in other peripheral large blood vessels. In preliminary studies it has been shown that epinephrine-thyroxine treated rabbits, which exhibit increased collagen synthesis in peripheral blood vessels (7), also show increases in prolyl hydroxylase activity as it does in other peripheral large blood vessels and in the in vitro synthesis of collagen in brain microvessels.

Pathologic examination of the rats showed that after 6 weeks of treatment with DOCA-salt, there was only occasional and mild fibrinoid necrosis in arteries and arterioles of the brain. pial membrane, also show increases in prolyl hydroxylase activity as it does in other peripheral large blood vessels and in the in vitro synthesis of collagen in brain microvessels.

The findings reported here indicate that there is increased collagen biosynthesis in arterioles and arteries in the periphery and in the central nervous system of DOCA-salt hypertensive rats and provide an early biochemical indication that fibrogenesis is involved in the production of hypertensive vascular damage (arteriosclerosis). It was previously shown (1) that the increase in prolyl hydroxylase activity is the result of increased production of the enzyme. We have calculated that DOCA-salt treatment increases synthesis of vascular collagen and prolyl hydroxylase to a far greater extent than it does total protein. These observations lend further biochemical support to the findings of Freis and co-workers (12) and of Hollander (13) that hypertension shortens life and produces pathologic lesions and that these changes are prevented by antihypertensive drugs. It is also likely that the structural hypertrophy of the resistance vessels induced by hypertension (14) is, at least in part, due to collagen deposition. As far as the brain microvessels are concerned, it is interesting to consider the possibility that in untreated hypertensive hypertension, deposition of small amounts of collagen, in quantities insufficient to be observed by standard pathologic techniques as frank arteriosclerosis, could nevertheless alter vascular permeability and transport mechanisms and thereby diminish mental function.

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Abstract. Infants prefer to look at horizontal and vertical gratings rather than at oblique gratings only when they are at or near threshold spatial frequencies, as would be expected if acuity for oblique edges is lower than that for horizontal and vertical edges. That such a bias exists as early as 6 weeks of age suggests that the orientational asymmetry of the visual system depends on endogenous maturation rather than exposure to a carpentered world.

Under a wide variety of conditions, the visual acuity of adult human observers is greater for horizontal and vertical edges than for oblique edges (1, 2). This “oblique effect” has been attributed to early visual experience in our carpentered environment, with its preponderance of vertical and horizontal contours (3). The notion that the sensitivity of the visual system to contours of various orientations is shaped at an early stage of development by the prevalence and clarity of the edges to which the eye is exposed implies a form of neural plasticity. This viewpoint is supported by claims that the distribution of orientation-sensitive single units in the visual cortices of kittens is altered by rearing the kittens in orientationally biased environments (4) and by reports that astigmatic human observers suffer a residual loss of acuity for edges along the blurred axis even when optical factors are eliminated (5).

If environmental exposure were responsible for the orientational asymmetries in the visual system, then these asymmetries should not be evident prior to an appropriate period of exposure. Evidence for an oblique effect has been described in 2-year-old children (6), but in the only study of infant acuity as a function of edge orientation, no meridional differences in sensitivity were observed (7). However, using a similar but more sensitive technique, we have found that the oblique effect is present in human infants as young as 6 weeks of age. Our result casts doubt upon explanations of the oblique effect solely in terms of environmental biasing.

We investigated the development of orientational differences in the acuity of infants using a modification of Teller et al.’s two-alternative preferential looking technique (7). It has been demonstrated that infants preferentially fixate patterned over homogeneous stimuli (8). Teller et al. paired a grating of a given orientation with a homogeneous gray larger than equal luminance. We simultaneously presented two gratings of the same spatial frequency (one cycle consists of one bar and one space of equal width) but of different orientations. Our technique is based on the premise that an infant will preferentially fixate the more ly hydroxylase in tissues other than blood vessels, as might be expected from its effect on rat growth (Table 1). However, reserpine lowers vascular prolyl hydroxylase far more than it does prolyl hydroxylase in other tissues. Both chlorothiazide and reserpine were found to reverse the effects of hypertension on vascular collagen synthesis (1). It was noted that the response treated animals yielded values that were even lower than the normotensive controls, indicating that this drug has an effect over and above its effect on blood pressure.

References and Notes
5. N. 2-Hydroxystyrylpyrazine-N-2 ethansulfonic acid.
10. Reserpine, in the doses given here, also lowers prolyl hydroxylase in tissues other than blood vessels, as might be expected from its effect on rat growth (Table 1). However, reserpine lowers vascular prolyl hydroxylase far more than it does prolyl hydroxylase in other tissues. Both chlorothiazide and reserpine were found to reverse the effects of hypertension on vascular collagen synthesis (1). It was noted that the response treated animals yielded values that were even lower than the normotensive controls, indicating that this drug has an effect over and above its effect on blood pressure.
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clearly visible of two simultaneously presented target gratings. At a given spatial frequency, a vertical (or horizontal) and an oblique grating may both be visible, and therefore both be preferentially fixated over a gray target; but one of the orientations may, in fact, appear clearer than the other. While such a difference in orientational visibility could go undetected by the pattern versus gray technique; the pattern versus pattern technique might detect the difference.

Full-term infants ranging from 6 to 50 weeks of age were tested. Each infant was refracted by retinoscopy, and only infants showing no appreciable astigmatism were included in the sample (9). Subjects were placed in one of four age groups (6 to 13 weeks, 14 to 22 weeks, 23 to 36 weeks, and 37 to 50 weeks); there were six infants in each group.

The apparatus consisted of a wooden partition with two circular screens, one to the right and one to the left of a fixation light; each subtended 11° of visual angle, and they were separated by 25° of visual angle. Black and white square wave gratings of 93 percent contrast (10) were projected onto the rear of the screens to yield a mean luminance of 34 cd/m². Stimuli consisted of four orientations (0°, 45°, 90°, and 135°) at five frequencies (0.75, 1.5, 3.0, 6.0, and 12.0 cycles per degree) and horizontal patterns over obliques at the lowest frequency tested (0.75 cycle per degree). The 14- to 22-week age group showed a peak frequency at 3.0 cycles per degree, while the 23- to 36-week group peaked at 6.0 cycles per degree. For the oldest group (37 to 50 weeks), the peak preference for vertical and horizontal patterns over obliques at the lowest frequency tested (0.75 cycle per degree). The 14- to 22-week age group showed a peak preference at 3.0 cycles per degree, while the 23- to 36-week group peaked at 6.0 cycles per degree. For the oldest group (37 to 50 weeks), the peak preference for vertical and horizontal patterns over obliques at the lowest frequency tested (0.75 cycle per degree). The 14- to 22-week age group showed a peak preference at 3.0 cycles per degree, while the 23- to 36-week group peaked at 6.0 cycles per degree. For the oldest group (37 to 50 weeks), the peak preference for vertical and horizontal patterns over obliques at the lowest frequency tested (0.75 cycle per degree). The 14- to 22-week age group showed a peak preference at 3.0 cycles per degree, while the 23- to 36-week group peaked at 6.0 cycles per degree.

In summary, our results indicate the existence of an oblique effect as early as 6 weeks of age. It is unlikely that during the first 6 weeks of life, the infant's retina is exposed to more vertical and horizontal than oblique edges, since such young infants spend much of their waking time in prone or supine positions. Thus, the occurrence of an oblique effect by 6 weeks of age argues against an interpretation of this form of meridional anisotropy as resulting solely from prolonged exposure to an asymmetrical distribution of edges on the retina.

SUSAN COHEN LEEHEY

ANNE MOSKOWITZ-COOK

SARAH BRILL, RICHARD HELD

Department of Psychology,
Massachusetts Institute of Technology,
Cambridge 02139

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1. For a review of these findings, see S. Appelle, Psychol. Bull. 78, 226 (1972).


3. The electroretinogram does not exhibit the oblique effect, which indicates that the effect is mediated by neural structures more central than the site of the electroretinogram [L. Maffei and F. W. Campbell, Science 167, 386 (1970)].


Cortical Effect of Early Selective Exposure to Diagonal Lines

Abstract. Neurons in the visual cortex that respond preferentially to diagonal contours are present only in cats exposed to diagonal lines early in life. In contrast, cells that prefer horizontal or vertical contours are found following exposure to horizontal, to vertical, and to diagonal lines. Such cells do not require a specific visual input for maintenance or for development; neurons responding preferentially to diagonal lines do.

Most neurons in the visual cortex of the cat and the monkey respond maximally to line-shaped stimuli presented at a given orientation and position on the retina (1). The particular stimulus orientation that elicits a maximum response varies from cell to cell. If an animal's early postnatal visual experience is restricted, the distribution of the preferred stimulus orientations of these neurons, and to some extent the animal's behavioral capabilities, are modified (2, 3). The precise conditions necessary for the development of orientation specificity, however, remain unclear (4, 5).

In a wide range of animals, including man, behavioral and physiological evidence indicates that the visual system responds preferentially to horizontal and vertical patterns (6). To determine whether this bias is a consequence of an animal's early visual experience, we compared the effects of early selective exposure to diagonal lines and to horizontal and vertical lines. In cats exposed only to horizontal and vertical patterns, nearly all orientation-sensitive cells studied responded most strongly to lines oriented either horizontally or vertically (2). In contrast, in cats exposed to diagonal patterns alone, we found more cortical cells responding preferentially to horizontal or vertical lines than to diagonal lines (7). Since, with our techniques, the cat's visual system cannot be made to respond preferentially to diagonal lines, we suggest that the preferential response of the visual system to horizontal and vertical lines reflects its inherent organization and is not simply the response to an early visual environment dominated by horizontal and vertical contours.

Eight cats born in a laboratory colony served as experimental subjects. They were housed with their mother in total darkness for approximately 100 hours. By 2 months of age, the infant's accommodative capacity is sufficiently developed to allow sharp focusing of targets at a distance (4). We thank Dr. S. Wittenberg and Dr. I. Mohindra, Massachusetts College of Ophthalmology, for performing the retinosecopy.

Contrast was calculated from the following formula: (L - Ld)/(L + Ld), where L is the luminance of the light area and Ld the luminance of the dark area.

In accordance with previously determined differences in acuity as a function of age (7, 8), the youngest group was tested with gratings of 0.5, 1.5, 3.0, and 6.0 cycle/degree, while 1.5, 3.0, and 6.0 cycle/degree gratings were used for the older age groups.

Two experimental sessions were run on most subjects. Approximately 64 trials were obtained on each subject in the youngest age group (6 to 13 weeks) and approximately 109 trials for each subject in the three older groups (14 to 22 weeks, 23 to 36 weeks, and 37 to 50 weeks). For infants in the youngest group, we often obtained fewer than 48 trials per session because of lack of subject cooperation.

There were no appreciable differences between results obtained with the parents facing toward or away from the stimulus targets; this makes it unlikely that the parents were biasing the infant's looking behavior. Furthermore, the possibility that the few parents who had any knowledge of the oblique effect could have predicted its interaction with spatial frequency is slight.

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15. Subjects showed an elevated fixation percentage for vertical and horizontal patterns at more than one spatial frequency. This dispersion in the data can be explained either if the actual threshold for subjects in a given age group lies between two of the spatial frequencies tested or if subjects in a given group have two different thresholds.

16. The possibility exists that instead of measuring the infant's limit of resolution (his threshold), the preferential looking technique is a measure of the spatial frequency beyond which the infant no longer attends to visual stimuli. But, even if this were the case, our finding of differential responses to vertical and horizontal versus oblique gratings would imply an underlying disparity in orientational visibility.

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