human inner-retinal disease. Thus, the results are consistent with an inner retinal origin for the PERR signal, when it is stimulated by low-contrast gratings. Dawson, Rubin, and Maida have pointed out that this signal has attributes so different that the application of the term "ERG" or "PERG" is probably inappropriate at this time.

Rate-dependent inhibition of the PERR is probably highly dependent on the amacrine cells and may become a useful, noninvasive tool for the further understanding of both complex image processing and pathology.

Key words: retina, inhibition, amacrine cells, ganglion cells, movement, pattern

From the Department of Ophthalmology, College of Medicine, University of Florida, Gainesville, Florida. Supported by NEI grant 1-RO1-EY-04460 and an unrestricted departmental grant from Research to Prevent Blindness, Inc. Some of these data were presented at the 1983 ISCERV Symposium, Budapest. Submitted for publication: November 2, 1983. Reprint requests: Dr. William W. Dawson, Department of Ophthalmology, Box J-284, JHMHC, University of Florida, Gainesville, FL 32610.

References


Effects on Stereopsis of Monocular versus Binocular Degradation of Image Contrast

Effects on Stereopsis of Monocular versus Binocular Degradation of Image Contrast

Kurt Simons

Stereacuity on a number of common clinical tests was reduced twice as much by degradation of the contrast of one eye's image as by an equal reduction of contrast of the image in both eyes. This finding, in conjunction with related clinical and animal study results, emphasizes the need for early detection of conditions causing interocular contrast asymmetry in infants and children, if normal binocular visual development is to be achieved. It also raises question about the effect of monocular occlusion therapy on the binocular potential of amblyopic patients. Invest Ophthalmol Vis Sci 25:987-989, 1984

Microelectrode studies of animal visual development suggest that loss of contrast information in one eye's image produces more serious binocular visual deficits than results from an equivalent reduction of image contrast in both eyes. The monocular contrast loss deficit seems to arise from competition in synaptic development of geniculate projections from the two eyes to binocular cells in the cortex. Is the developing human visual system also more susceptible to deficits from interocular contrast asymmetries than from binocularly balanced loss?

Amblyopia may be associated with relatively small amounts (1 D) of anisometropia. However, the same amount of refractive error present symmetrically as myopia or hyperopia produces no such deficit. Clinical studies of amblyopia in patients with contrast-reducing visual obstacles such as cataract, corneal opacity, and lid hemangioma indicate that the visual prognosis fol-
Table 1. Stereoacuity thresholds in seconds of arc for subjects fogged to 20/100 visual acuity.

<table>
<thead>
<tr>
<th>Name of stereo test</th>
<th>Monocularly fogged threshold</th>
<th>Binocularly fogged threshold</th>
<th>Mean monocular/binocular threshold ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Frisby</td>
<td>652</td>
<td>298</td>
<td>250</td>
</tr>
<tr>
<td>Randot</td>
<td>358</td>
<td>98</td>
<td>120</td>
</tr>
<tr>
<td>TNO</td>
<td>1770</td>
<td>398</td>
<td>640</td>
</tr>
</tbody>
</table>

lowing treatment is poorer when the obstacle is present in one eye than when it is present symmetrically in both eyes.4-7 However, these studies do not provide adequate information for discriminating between the monocular (ie, visual acuity) and uniquely binocular (stereoscopic) effects of such conditions. I hoped to obtain more clear-cut evidence of such a difference by modeling the effect in adult normal humans.

One pertinent model is to demonstrate that monocular contrast loss degrades stereopsis more than equivalent binocular loss. There are reports that stereocuity for line targets is reduced more by lens-induced anisometropia than by lens-induced myopia,8 but this finding is not conclusive. Since the lenses that accomplished the blurring also magnified the image, reduced performance from the monocular blurring may, thus, have been caused by image size differences between eyes (aniseikonia)9 rather than by contrast loss. The present report demonstrates that contrast effects, alone, can account for the greater degradation from monocular fogging.

**Materials and Methods.** Aniseikonia-free contrast reduction filters were made from the slightly hazy film used in plastic bags. Pilot studies indicated that three adjacent sheets of this material reduced visual acuity to approximately 20/100 and produced a clear-cut difference between monocular and binocular fogging thresholds. Therefore, three sheets were used for the main experiment.

Three commercially available stereotests, the Frisby, Randot Circles, and TNO tests were used. The Frisby and TNO are random element stereograms and the Randot Circles is a test with monocularly visible target contours.10 The plastic film filters were placed in a frame that could either be mounted on the polaroid or red-green anaglyph glasses used to view the Randot and TNO stereograms, or be used as a frame by itself to view the Frisby test. In the case of polaroid glasses, the filter frame was mounted on the eye side of the polaroid, not on the optical path between the test plate and glasses, in order to avoid the depolarizing effect of the plastic films.

On the Randot and TNO tests, the stereo targets are grouped in fixed locations on the test plate and booklet, respectively. To eliminate any potential location cue artifact when presenting the targets repeatedly for threshold determination, the TNO plates were removed from their test booklet, and the individual Randot Circle targets were mounted on slides for random-order presentation. The Randot test was obtained in the form of a transparency and presented in front of a light box to avoid reflections from the test's shiny front surface. The Frisby test also was presented in front of the light box since reflections may provide artifactual monocular cues on this test.10 Fixation distance on the Randot test targets was reduced from the standard 40 cm to 20 cm, and on the TNOs, from 40 to 30, 20, or 10 cm, as necessary, to increase the range of large-disparity stimuli. With the exception of the TNO test,* two monocular thresholds were obtained for every subject, one with each eye fogged, to control for eye dominance effects.

Six normal adult observers were used. Informed consent was obtained from each of them.

**Results.** Table 1 lists the results for the six observers. Monocular figures are an average of left and right fogging thresholds. A monocular:binocular threshold ratio was calculated for each subject on each test. The lowest ratio of any subject was 1.7 and the overall mean ratio was 2.75, indicating that the binocularly fogged threshold was, on average, less than one-half the monocular threshold.

**Discussion.** The average threshold difference between the monocular and binocular contrast reduction conditions was more than 2:1. This difference is apparent for both the random element stereotests (Frisby, TNO) and the test with monocularly visible target contours (Randot). The latter test produced finer absolute thresholds, apparently because such targets provide vergence cues that aid fusion under reduced stimulus conditions.10 Since the plastic film filters used to reduce contrast do not cause aniseikonia in the monocular fogging condition, the difference between the monocular and binocular thresholds seems due solely to contrast effects.

The Randot plate contains a clinical test for interocular suppression, and all subjects reported suppression of the fogged eye's image on this test during monocular fogging. No such suppression was reported for either eye during binocular fogging. This finding sug-

* We found on the TNO test that monocular fogging of the eye viewing through the red lens reduced stereocuity more than fogging of the green-viewing eye, apparently because the image contrast for the red-viewing eye was lower than that for the green-viewing eye in the test plate printing. Fogging the green-viewing eye compensated to some extent for the red-viewing eye's reduced image contrast, resulting in a stimulus more analogous to binocular than monocular fogging. Consequently, only the red-viewing eye was fogged in the experiment.
suggests that the interocular inhibition or “competition” mechanism postulated to occur in the cortex during visual development may be responsible for the difference between the monocularly and binocularly fogged stereoscopic acuity decrements in the main experiment. As in the animal studies, contrast difference between the eyes’ images seems to trigger inhibition of the contrast-deprived eye, while binocularly symmetric contrast loss does not.

The present results, together with related animal studies that demonstrate the extreme vulnerability of the developing visual system to contrast imbalance between the two eyes, hold a number of important clinical implications. First, they emphasize the need for early detection and treatment in infants and children of any condition leading to interocular contrast imbalance if normal binocular vision is to develop. Second, they add weight to the question of whether monocular occlusion therapy for amblyopia improves visual acuity at the price of degrading binocular vision potential. Findings in the cat suggest that such occlusion during the “sensitive period” (ie, the neural plasticity interval when an amblyope would be treated) causes an irreversible loss of stereopsis.

Alternative amblyopia therapies aimed at better maintenance of binocular vision have been proposed, such as graded vision reduction rather than total occlusion of the sound eye or binocular occlusion. Successful results with some patients are reported. However, clinical experience has found graded occlusion ineffective at treating deep amblyopia, and animal experiments indicate that prolonged binocular occlusion may lead to deprivation effects (though it also may extend the sensitive period). Thus, whether these or other techniques will succeed in maintaining binocular vision in most amblyopes while improving monocular visual acuity remains to be determined.

Key words: amblyopia, image contrast, interocular inhibition, stereoscopic acuity


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Proptosis and Increase of Intraocular Pressure in Voluntary Lid Fissure Widening

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The eyeball proptoses about 0.5 mM and increases in intraocular pressure (IOP) about 2 mmHg with voluntary widening of the lid fissure. The findings probably result from the retraction of the upper lid into the orbit, thus increasing the volume of orbit contents and forcing the eyelid forward. Decrease in IOP with repeated tonometry may result, in part, from decay of the increased pressure induced by lid fissure widening. Invest Ophthalmol Vis Sci 25:989-992, 1984

When the eyelids voluntarily are opened widely, the eyeball moves forward perceptibly and downward slightly. No proptosis is seen, however, if the lids are opened passively, as by retractors.

The mechanism of the globe movement with voluntary lid fissure widening has been attributed variously to relief of lid pressure on the eyeball or to displace-