

# CONTRAST SENSITIVITY 8-04

Thank you for your interest in contrast sensitivity in general and in the Stereo Optical's vision testing products in specific. A list of abstracts on a wide variety of subjects relating to contrast sensitivity is attached for your consideration. If you would like to receive a complete copy of any of these papers, please circle the corresponding number, fill out your name and address, and return this form to us.

- GENERAL:** Contrast Sensitivity & Glare Research and Techniques:  
A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8, A-9, A-11, A-15, A-16, A-17, A-18, A-19,  
A-20, A-21
- CATARACTS:** B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-8, B-9, B-10, B-11, B-12, B-13, B-14, B-15, B-16,  
B-17, B-18, B-19, B-20, B-21, B-22, B-23, B-24, B-25
- GLAUCOMA:** C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9
- LOW VISION:** D-1, D-2, D-3, D-4, D-5, D-6, D-7
- DIABETES:** E-1, E-2
- PITUITARY ADENOMA:** F-1
- MACULAR DEGENERATION:** G-1,
- CONTACT LENSES:** H-1, H-2, H-3, H-4, H-5
- ALZHEIMER'S DISEASE:** I-1, I-2, I-3
- OPTIC NEURITIS:** J-1
- KERATOCONUS:** K-1, K-2
- AMBLYOPIA:** L-1, L-2, L-3, L-4, L-5, L-6, L-7
- NEUROLOGICAL:** M-1, M-2, M-3
- RETINITIS PIGMENTOSA:** N-1
- HIV:** O-1, O-2
- REFRACTIVE SURGERY:** P-1, P-2, P-3, P-4, P-5, P6, P7, P8
- SPORTS VISION:** Q-1, Q-2, Q-3, Q-4, Q-5, Q-6, Q-7
- NEUROTOXICOLOGY:** R-1, R-2, R-3, R-4, R-5, R-6, R-7, R-8, R-9, R10

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## **GENERAL: CONTRAST SENSITIVITY AND GLARE RESEARCH AND TECHNIQUES**

A-1) Ginsburg, A.P., *A New Contrast Sensitivity Vision Test Chart*, Am. J. Opt. Physiol. Opt., 61(6), 1984, 403-407

Abstract:

A new contrast sensitivity vision chart has been tested and compared to an automated video-based vision tester on 83 observers whose ages ranged from 9 to 75 years. Good agreement was found between the contrast sensitivity measurements obtained with the vision chart and the automated tester for similar population and age variations. These results suggest that vision test charts can be developed to provide useful contrast sensitivity psychometric functions and yet be as simple to use as present eye charts.

A-2) Ginsburg, A.P., Evans, D., Cannon, M., and Mulvanny, P, *Large Sample Norms for Contrast Sensitivity*, Am. J. Opt. Physiol. Opt., 61(2), 1984, 80-84.

Abstract:

A portable microprocessor-controlled instrument automatically measured the static and dynamic contrast sensitivity functions (CSFs) of 265 observers for a normal population at the Dayton Air Fair and Air Force Museum. Repeat measures for six observers taken six months later show small, nonsystematic differences from original measurements. Median values of contrast sensitivity and regions encompassing 75% and 90% of our sample are shown.

A-3) Woo, G.C. and Bohnsack, H., *Comparison of the Distance and Near Vistech Vision Contrast Test Systems (VCTS)*, Can. J. Opt., 48(1), 1986, 12.

Abstract:

This paper describes the essential principles associated with the clinical use of a contrast sensitivity function (CSF) test to document vision loss or improvement. Some advantages of the CSF over the more conventional visual acuity test are described as well as the type of CSF losses associated with several ocular and neurological conditions. Contrast sensitivity was measured on each of 12 normal subjects ages 21 to 27 years on two separate occasions using both the Vistech Vision Contrast Test System charts (VCTS). Analysis of the variance showed that the results obtained using the distance and near chart were not significantly different. The contrast sensitivity scores elicited on the second trial, as compared to the first, were found to be consistently higher at all frequencies. This improvement associated with repeated testing is clinically evident among a great percentage of subjects tested but not statistically significant at the .05 level.

A-4) Greene, H. and Madden, D., *Adult Age Differences in Visual Acuity, Stereopsis, and Contrast Sensitivity*, Am. J. Ophthal. Physiol. Opt., 64(10) 1987, 749-753

Abstract:

We investigated adult age differences in four measures of visual function: distance acuity, near acuity, stereopsis and contrast sensitivity. Twenty-four young adults (mean age 19.5 years) and 24 older adults (mean age 68.4 years) participated. Age differences were present in each of the four measures. A step-wise discriminant analysis performed on the four measures revealed that, when the correlations among the measures were taken into account, only contrast sensitivity significantly discriminated young and older adults' performance. The strength of the correlations among the four measures was greater for older adults than for young adults. The results indicated that contrast sensitivity is a useful measure for detecting age-related changes in visual function and that a common mechanism may underlie age differences on various visual tests.

**GENERAL: CONTRAST SENSITIVITY AND GLARE RESEARCH AND TECHNIQUES** Continued

- A-5) Rogers, G.L., Bremer, D.L., and Leguire, L.E., *Contrast Sensitivity Functions in Normal Children With The Vistech Method*, J. Ped. Ophthal. Strab., 24, 1987, 216-219

Abstract:

The Vistech CSF tester (VCTS 6500-1) for distance was evaluated to determine the minimum age of children that could complete the test and to determine changes in the CSF as a function of age. A total of 72 normal children between the ages of 24 and 84 months were tested twice with each eye. The results revealed that no child below 36 months of age could complete the test and by 48 months of age 50% could complete the test. By 60 months all children could complete the test. It was also found that as age increased the CSF increased equally at all spatial frequencies. A comparison between the eyes of the CSFs revealed a highly statistically significant correlation of 0.78, which showed that the eyes were very similar. Test-retest correlations (0.78) also were highly statistically significant, which demonstrated that the test was very reliable. The results are discussed within the context of screening young children for visual disorders and the evaluation of patching therapy for amblyopia.

- A-6) Bosse, J.C. and Lederer, P.J., *Visual Acuity, Are You Getting the Whole Picture?* Rev. Opt., 125(6), 1988, 59-67

Abstract:

While the Snellen chart has historically been an effective way to measure visual capacity, it can't provide the whole picture. The Snellen chart only measures a piece of the visual spectrum - small objects viewed at high contrast. On the other hand, contrast sensitivity testing provides a look at the full visual spectrum - small and large objects, viewed at high and low contrast. Most stimuli in the visual world are larger and of lower contrast than visual acuity thresholds. With contrast sensitivity testing, you can gather comprehensive data in just a few minutes. The data are an extremely valuable diagnostic tool which will enable you to manage your patient the best way possible. This article describes how contrast sensitivity testing can benefit your practice.

- A-7) Bosse, J.C., *An Argument for the Inclusion of Contrast Sensitivity Testing into the Routine Optometric Regimen*. New England Journal of Optometry., April 1990, 6-10

Abstract:

Many researchers have stated that contrast sensitivity testing is superior to visual acuity testing for assessing visual function. Test systems to measure contrast sensitivity have been commercially available for several years. This paper offers an argument to accelerate the inclusion of contrast sensitivity testing into the routine optometric regimen. A brief description and definition of contrast sensitivity is offered. A discussion of how this test is used in general optometric practice is followed by clinical examples.

- A-8) Carmean, S.L., and Regeth, R.A., *Optimum Level of Visual Contrast Optimum Level of Visual Contrast Sensitivity for Reading Comprehension*. Perceptual and Motor Skills, 1990, 71, 755-762.

Abstract:

Reading comprehension scores were curvilinearly related to a visual contrast sensitivity measure of 155 elementary school children. Moderate contrast sensitivity for fine detail appeared to be optimal for reading; both low and high sensitivity were associated with lower reading comprehension.

- A-9) Sadun A.A., *Contrast Sensitivity and Other New Methods of Visual Assessment*. 20/20 Focus/Winter 1990 3-3-4.

Abstract:

Review of specific uses and interpretation of Contrast Sensitivity.

**GENERAL: CONTRAST SENSITIVITY AND GLARE RESEARCH AND TECHNIQUES**Continued

- A-11) Jindra, L.F., Zemon, V., *Contrast Sensitivity Testing: A more complete Assessment of Vision.*  
Jo Cataract Refract Surgical, Volume 15, March 1989.

Abstract:

Contrast sensitivity testing is a powerful tool for determining the capability of the visual system to process spatial and temporal information about the everyday objects we see. The current gold standard in the assessment of vision, visual acuity, provides only a limited amount of information, obtained under artificial conditions. Contrast sensitivity testing measures a range of visual performance under real-life conditions. It measures the least amount of contrast needed to detect a visual stimulus and gives us a more complete quantization of patients' visual capabilities. Many instances in which losses in contrast sensitivity were detected when visual acuity (one point on the contrast sensitivity function) was normal have been reported. These include amblyopia, neuro-ophthalmology, retina, anterior segment disease and glaucoma. Therefore, contrast sensitivity testing enables the clinician to diagnose selective deficits in visual processing at an earlier stage than is possible with conventional testing methods.

- A-15) Lederer, P.J., Bosse, J.C., *Clinical Use of Contrast Sensitivity Evaluation for General practice of Optometry,*  
Practical Optometry, 3:1, 1992

Abstract:

Historically, visual acuity has been the standard measure of vision. As optometrists, we recognize the limitation of this measurement. We know that to truly understand a patient's visual capabilities, we must supplement visual acuity with visual fields, color testing, and other vision tests. Although attempts have been made to improve, standardize, and scrutinize the visual acuity testing procedure, the test has remained more or less the same for over a century. Due to its simplicity and wide-range acceptance, it will no doubt remain the standard description of an individual's visual ability.

As clinicians, we need to know much more about vision than the minimal recognizable print at 20 feet under optimum, high contrast conditions -- 20/20 is not enough. Just as the audiologist probes hearing sensitivity through a wide range of tonal frequencies, the vision specialist should probe the patient's visual capabilities through low- and mid- spatial frequencies, in addition to the high-spatial frequency offered by visual acuity testing. We should also assess the visual function at less than optimum contrast conditions. In daily living, our vision is subject to these conditions much more so than seeing in high resolution under optimum high contrast conditions.

- A-16) Wall, M. *Contrast Sensitivity Testing,* Mediguide to Ophthalmology, 1990, 1-5.

Abstract:

This article provides a brief overview of the history and methodology of contrast sensitivity, and gives examples of several clinical findings using contrast sensitivity.

The article concludes that contrast sensitivity test results better correlate with visual performance than does Snellen acuity, and that it may be better at assessing development and change in some eye disorders, such as glaucoma and optic neuritis. The article also concludes that the contrast sensitivity is a beneficial test to use to measure visual loss that is not revealed by traditional methods.

**GENERAL: CONTRAST SENSITIVITY AND GLARE RESEARCH AND TECHNIQUES** Continued

A-17) Emigh Scharre, J., Cotter, S.A., Stein Block, S., and Kelly, S.A. *Normative Contrast Sensitivity Data for Young Children*, Optometry & Vision Science, Vol. 67, No. 11, PP. 826-832.

Abstract:

Contrast Sensitivity (CS) was measured in children ages 3 to 7 years using the Vistech Contrast Sensitivity distance chart (VCTS 6500). The purpose of the study was to determine how effectively the technique could be used with young children and to establish normative data for this age group. Of 286 children participating in a vision screening, the contrast sensitivity function (CSF) was measurable on 241 (84%) under binocular conditions and 229 (80%) under both binocular and monocular conditions. The 219 binocular CSF's and 208 monocular CSF's obtained from visually normal children were used to establish normative data and then compared to similar data from 50 visually normal young adults. The results indicated that there is an effect of age between 3 and 7 years, children are significantly less sensitive than adults, and adult-like levels of CS are not yet reached at 7 years of age. In addition, although the children's mean contrast thresholds fell within the norms provided with the VCTS 6500, the variability in the children's CSF's precludes using the Vistech data for diagnostic purposes in the young. The normative data are presented to assist the clinician in evaluating CS in young children when using the VCTS 6500.

A-18) Ginsburg, A.P., *Next Generation Contrast Sensitivity Testing*. In Rosenthal B., Cole R (ed): *Functional Assessment of Low Vision*, St. Louis, 1996, Mosby-Year Book, Inc., PP. 77-88.

Abstract:

Contrast Sensitivity is gaining increased recognition as a valuable tool for measuring functional vision. It can detect vision loss often caused by early eye disease and has been proven to provide a more sensitive and comprehensive measurement of visual capability and performance than is provided by Snellen visual acuity. This review discusses the advantages and disadvantages of each approach to contrast sensitivity and the differences between them. Also discussed are methods of displaying test results. Both curves and pictures are discussed which allow one to "see" the world through the eyes of the patient and methodologies discussed are; Arden Grating, Vision Contrast Test System (VCTS, Vistech Consultants), Sine Wave Acuity Test (SWCT, Stereo Optical Co.), Functional Acuity Contrast Test (FACT Stereo Optical Co.) Regan Chart, Pelli-Robson Chart, CVS-1000 (Vector Vision), MCT8000 (Vistech Consultants), Optec Vision Testers with and without glare (Stereo Optical Co.) and Eyeview (Visumetrics, Corp).

A-19) Kirkner, R. *Using Contrast Sensitivity Testing in Practice*. Rev. of Opt #139 315/96

Abstract:

Contrast sensitivity can be used to explain many ocular disorders. This article defines contrast sensitivity, how to use it, score your patients, and what contrast sensitivity can tell you about certain ocular disorders.

## **GENERAL: CONTRAST SENSITIVITY AND GLARE RESEARCH AND TECHNIQUES** Continued

A-20) Provines WF, Harville B and Block M., *Effects of Yellow Filters On Contrast Sensitivity Function of Albino Patients*. Jo of Amer Optometric Asctn. Vol 68/#6/June 97

Abstract:

*Background:* Yellow ophthalmic filters are often prescribed for albino patients in an effort to enhance visual performance. The effects of a moderate- and a high-excitation purity yellow filter on the contrast sensitivity function (CSF) of ten albino patients were investigated. Hue discrimination loss induced by each filter was also evaluated.

*Methods:* Three monocular CSF curves (best-corrected eye) were determined for each subject: one while viewing through a #3 Kodak Wratten filter, one through a #12 filter, and one used no filter. Panel D-15 color tests were administered to five albino patients viewing through each filter.

*Results:* Using an analysis of variance (ANOVA) and a Student-Newman-Keuls Analysis, no statistical difference at the 0.05 levels of confidence was found between using no filter, the #3 filter, or the #12 filter CSF curves. A statistically significant blue-yellow hue confusion was induced by the #12 filter.

*Conclusion:* While neither filter was shown to enhance nor degrade the CSF among these subjects, a more extensive investigation may reveal that subtle but real contrast enhancement occurs with yellow filter use. High-purity filters should be avoided to minimize hue recognition losses.

A-21) Boxer Wachler, B.S. MD, Krueger, R.R., MD, MSE *Normalized Contrast Sensitivity Values*, Jo. Of Refractive Surgery, Vol. 14, July/August 1998.

Abstract:

Introduction to a new method by which to generate a normalized notation (reporting method) of contrast sensitivity.

## **CATARACTS**

B-1) Committee on Ophthalmic Procedures Assessment approved by the Academy's Board of Directors, *Contrast Sensitivity and Glare Testing in the Evaluation of Anterior Segment Disease*, Ophthalmology, September 1990, 1233-1237

Abstract:

The purpose of the Committee on Ophthalmic Procedures Assessment is to evaluate on a scientific basis new and existing ophthalmic tests, devices, and procedures for their safety, efficacy, clinical effectiveness and appropriate uses. Evaluation include examination of available literature, epidemiological analyses when appropriate, and compilation of opinions from recognized experts and other interested parties. After appropriate review by all contributors, including legal counsel, assessments are submitted to the Academy's Board of Directors for consideration as official academy policy.

B-2) Ginsburg, A.P., *Why Contrast Sensitivity and Glare Testing Are Needed*, Oclr Srgry News, Jan 15, 1988, 18.

Abstract:

Although Snellen acuity has worked well for over 125 years, some cataract patients who experience severe vision loss exhibit good visual acuity. More accurate and complete evaluation of cataract-related vision loss is needed to provide relevant regulatory standards for the patient's health and safety. This article describes the problem of cataract evaluation and why contrast sensitivity and glare are needed to supplant the inadequacies of standard Snellen acuity testing.

## **CATARACTS** Continued

B-3) Ginsburg, A.P., *What Are Contrast Sensitivity and Glare Testing?*, Oclr Srgry News, February 15, 1988, 30-37.

### Abstract:

This article describes what constitutes appropriate contrast sensitivity and glare tests to document cataract-caused patient complaints. Contrast sensitivity and glare testing are explained and useful properties of those tests discussed.

B-4) Ginsburg, A.P., *Need for Standard Glare, Contrast Sensitivity Tests*, Oclr Srgry News, March 15, 1988, 25-31.

### Abstract:

The major aspects of developing new contrast sensitivity and glare tests that provide scientific and standardized documentation, which indicate significant functional vision losses of cataract patients, are discussed in this article. While this article focuses on target selection, size and contrast range, and luminance for both contrast sensitivity and glare tests, glare configuration and illuminance for proper glare tests are also discussed.

B-5) Ginsburg, A.P., *Evaluating Functional Vision Loss: Proposed Standards*, Oclr Srgry News, May 15, 1988, 8-20.

### Abstract:

Standardized contrast sensitivity testing methods provide quantitative data about the functional vision of the patient regardless of who performs the test or when and where the test is performed. Standardization allows repeatable test results for tracking and treatment of eye disease through the use of common notation and should be the goal of all vision tests. Accordingly, this article discusses test method, the benefits of using a standardized test, and the clinical, statistical, and functional relevance of contrast sensitivity and glare tests. Also discussed and illustrated are examples and explanations of significant vision losses and how to tell if a loss is significant.

B-6) Ginsburg, A.P., *Proposed Basis for Evaluating Functional Vision Loss*, Oclr Srgry News, June 15, 1988, 6-8.

### Abstract:

This article proposes standards based upon the contrast sensitivity and glare tests discussed in the previous Ocular Surgery News articles to aid in the clinical and governmental decisions of when cataract surgery is indicated. Creating these standards involves consideration of the underlying science, standardization of test methods, and the statistical, clinical, and functional relevance of contrast sensitivity and glare testing. The resulting standards quantify decreased functional vision due to a cataract in percent contrast sensitivity loss as well as Snellen notation.

B-7) Donshik, P.C., *Case Study: Results of Glare, Contrast Testing Substantiate Patient Complaints*, Oclr Srgry News, 6(8), April 15, 1988, 30-31.

### Abstract:

While on the job, a 23-year-old male with no history of eye problems was injured in the right eye with a nail. The injury resulted in a keyhole-type pupil with a large defect in the inferior iris between 5:30 and 7:30. Following the injury and subsequent surgery, the patient complained about his vision in the presence of glare although his visual acuity was 20/20. A complete eye examination including auto-refraction, keratometry, and measurement of intraocular pressure, stereovision, and color vision was completed. Refraction in the right eye yielded +0.75 while the left eye was +0.75 - 0.25 at 40. Keratometry readings were 42 x 42.25 in the right eye and 42.25 x 42.37 in the left eye, the intra-ocular pressures were 15 mmHg, and stereovision and color tests were normal.

Testing with the Multivision Contrast Tester (MCT 8000), however, revealed a substantial loss of functional vision in the injured right eye. A significant decrease in the patient's vision for the right eye under both normal conditions and in the presence of glare were found for the injured right eye but not for the left. The findings from this contrast sensitivity and glare testing verified the patient's complaints about his vision in the presence of glare.

## **CATARACTS** Continued

- B-8) Ginsburg, A., Osher, R., Blauvelt, K., and Blosser, E., *The Assessment of Contrast and Glare Sensitivity in Patients Having Cataracts*, Presented at the American Academy of Ophthalmology Annual Meeting, 1987.

### Abstract:

Contrast and glare sensitivity were measured in thirty-one patients referred for cataract surgery using the Multivision Contrast Tester (MCT 8000). Corrected visual acuity and contrast sensitivity were measured using the Snellen letter chart slide and VCTS slides included in the MCT. Contrast Sensitivity was found to be reduced in the cataract patients. Unlike visual acuity, contrast sensitivity measures the functional loss of vision described by cataract patients under both daytime and nighttime conditions. Contrast sensitivity of cataract patients under either daytime or nighttime levels is more severely reduced under peripheral, radial, and central glare conditions.

- B-9) Ginsburg, A.P., and Tedesco, J., *Evaluation of Functional Vision of Cataract and YAG Posterior Capsulotomy Patients Using the Vistech Contrast Sensitivity Chart*, Invest. Ophthalm. Vis. Sci. (Suppl.), 27(3), 1986, 107.

### Abstract:

Standard Snellen visual acuity is not an adequate test to evaluate the functional vision loss of cataract patients. Visual acuity is an adequate measure of optical blur but not of contrast loss due to light scattering from a cataractous lens. Contrast sensitivity tests can measure the loss of contrast due to cataracts. Compared here are the contrast sensitivity losses to visual acuity losses in 66 pre-operative cataract patients. Snellen visual acuity greatly underestimated the functional vision loss of the cataract patients. It is recommended that contrast sensitivity be measured to determine the true functional loss of vision due to cataracts. A contrast sensitivity curve based on this data is suggested as an appropriate indication for cataract surgery.

- B-10) Hess, R. and Woo, G., *Vision Through Cataracts*, Invest. Ophthalm. Vis. Sci. 17, 1978, 438.

### Abstract:

Contrast thresholds for a range of different spatial frequencies were compared with acuity tests for ten subjects with unocular senile cataract. The results indicate that the magnitude and extent of the intra-resolution limit abnormality vary dramatically in cataract patients and that, for some patients, vision is abnormal for objects of all sizes. This finding indicates that the present acuity evaluation of vision with cataracts is inadequate because, in some cases, it grossly overestimates the nature of the visual world of the cataract patient.

- B-11) Sweeney, C. and Steen, W., *Contrast Sensitivity as Cataract Practice Builder*, Ophthl. Mngmnt, May 1987, 32-36.

### Abstract:

The VCTS home test screening was an effective vehicle for us in increasing practice awareness, developing a better working relationship with the optometrists in our area and generally achieving an additional level of exposure through the various aspects of the campaign. The responses gathered by the Shreveport Research Foundation were used to increase the mailing list for our quarterly newsletter and to report a summary of the campaign to sponsors. The television station has done one follow-up story, plans another, and is interested in sponsoring the home test as an annual event.

## **CATARACTS** Continued

- B-12) Ginsburg, A.P., and McIntyre, D., *Evaluation of Visual Functional Loss Related to Cataract Development*, In Dollars and Disease: The True Cost of Cataract, L.M. McDonald, ed., O.O.S.S. Foundation, San Diego, CA, February 1988, 29-35.

### Abstract:

Snellen acuity has been an important tool in vision assessment for more than 126 years. However, it is well known by vision scientists and clinicians that Snellen acuity does not identify the many cataract patients who complain of "hazy" vision and are disabled by glare. Accordingly, a more accurate and complete way to evaluate functional vision loss is necessary to meet the current medical, insurance, and government needs of the cataract patients and their surgeons. To understand why Snellen acuity is inadequate for comprehensive vision assessment and to define what type of test is required, one must first understand what the visual system is and how it works. Visual function is the total mechanism of perceptual objects in the visual field. Various components of visual function include resolution or spatial frequency, contrast sensitivity, color perception, visual field, motion perception, pattern perception, and stereopsis. Because different types of cataracts can cause many different types of disturbances in visual function, improved methods of measuring the functional vision loss due to a cataract are needed not only to meet the scientific, clinical, and regulatory needs of ophthalmology but also to best treat the patient.

- B-13) Lasa, M.M., Datiles III, M.B., Podgor, M.J. and Magno, D.V. *Contrast and Glare Sensitivity: Association with the Type and Severity of the Cataract Development*, Ophthalmology, (99) 7, 1992.

### Abstract:

*Purpose:* Contrast and glare sensitivity tests are now being used as adjuncts to visual acuity in the assessment of visual function. Limited data are available on the associations of the former tests with cataract type and severity. The aim of the study is to assess these associations using standardized techniques.

*Methods:* Contrast sensitivity tests (using the Pelli-Robson chart) and glare sensitivity tests (using the Vistech MCT 8000) were done on 128 patients with cataracts and no other ocular disease and on 29 control volunteers. The cataracts were graded using the Lens Opacities Classification System II (LOCS II). Data from the left eyes were analyzed using logistic regression models.

*Results:* Contrast sensitivity loss was associated with cataract severity for cortical ( $P < 0.0001$ ) and posterior subcapsular ( $P = 0.0001$ ) cataracts and with decreased visual acuity ( $P = 0.0001$ ). Night and day glare sensitivity were each associated only with increased severity of posterior subcapsular cataracts ( $P \leq 0.003$ ) and with decreased visual acuity ( $P < 0.001$ ). Additional analyses showed that contrast and glare sensitivity were similar in eyes with no cataracts and early cataracts.

*Conclusion:* These results suggest that the Pelli-Robson Chart and the Vistech MCT 8000 are good techniques for evaluating visual function in moderate to advanced cataracts. However, for early cataracts, other techniques need to be explored to assess visual function loss. Ophthalmology 1992;99:1045-1049.

- B-14) Drews-Bankiewicz, M.A., Caruso, R.C., Datiles, M.B., and Kaiser-Kupfer, M.I. *Contrast Sensitivity in Patients with Nuclear Cataracts*, Arch Ophthalmology, (110), 1992.

### Abstract:

Spatial contrast sensitivity and lens density were measured in 30 subjects (18 patients with pure nuclear cataracts and 12 age-matched controls). Contrast sensitivity was assessed using two techniques: a conventional monitor method in which gratings were viewed through the cataract (overall spatial contrast sensitivity) and a laser interferometer method in which gratings were formed directly on the retina (interferometric spatial contrast sensitivity), thus reducing the effect of an opaque lens on grating contrast. The degree of lens nuclear opacity was measured by assessing the density of Zeiss Scheimpflug slit-lamp video camera images. A contrast sensitivity loss was found by using both methods; this reduction reached statistical significance only when monitor stimuli were used. There was a significant correlation between lens nuclear density and sensitivity loss at spatial frequencies from 4 to 16 cycles/degree ( $r = .56$  to  $.79$  and  $P < .05$  to  $< .001$ ). A correlation coefficient of  $.82$  ( $P < .001$ ) characterized the relationship between visual acuity (log of the minimal angle of resolution) and lens density. Nuclear lens opacity significantly affects contrast sensitivity; pure nuclear cataracts produce spatial visual losses at intermediate and high spatial frequencies.

## **CATARACTS** Continued

- B-15) Morrill, K., *Study refutes guidelines panel: Glare and Contrast Sensitivity tests documented visual disability that was relieved by cataract surgery in patients whose Snellen acuity alone did not justify surgery.* Oclr Srgry News, (10), 17, 1992

DENVER-Contrary to the findings of the cataract practice guidelines panel, glare and contrast sensitivity testing are useful indicators of the need for surgery, according to a study here.

David S. Pfoff, MD, evaluated the tests in 109 patients in his Denver practice, and found the tests to be good indicators of the need for cataract removal. "We all have seen a number of patients who come in with relatively good visual acuity and who are complaining of glare symptoms," Pfoff said. "Yet we can't, on a Snellen basis, justify surgery."

In Pfoff's study, the average preop Snellen visual acuity was less than 20/50, but the contrast and glare acuity was 20/128. The major symptom of the study group was discontinuation of night time driving. Postoperatively, the patients had an average contrast and glare acuity improvement of 5.3 lines.

- B-16) Ravalico, G., Baccara, F., and Rinaldi, G., *Contrast Sensitivity in Multifocal Intraocular Lenses*, Jo. Cataract Rfrctv Srg, Vol 19, January 1993.

Abstract:

Contrast sensitivity was measured in two groups of 20 patients each implanted with refractive and diffractive multifocal intraocular lenses and in two control groups of 20 patients each - the first group implanted with a monofocal IOL and the second phakic subjects. All cases had a postoperative follow-up of at least one year and a corrected visual acuity of 20/20 or better. We used two psychophysical tests, Pelli Robson test chart and Vistech 6500 test chart, and an objective test, visual evoked potentials (VEPs). There were no statistically significant differences in contrast sensitivity in the psychophysical tests between the two groups implanted with multifocal IOLs. The situation was different, however, when they were compared with the control group with monofocal IOLs and the group with phakic eyes: the Pelli-Robson test results were not significantly different, but the Vistech 6500 test showed a significant reduction in contrast sensitivity in both groups. The pattern VEPs objective test confirmed these results: no differences were noted between the two different multifocal IOLs, while there was a drop in contrast sensitivity when their results were compared with those of the control groups; the intermediate frequencies were particularly affected by this phenomenon. The contrast sensitivity in patients with multifocal IOLs is reduced despite high visual acuity and this can affect the quality of vision.

- B-17) Winther-Nielsen, A., Corydon, L., and Olsen, T., *Contrast Sensitivity and Glare In Patients with a Diffractive Multifocal Intraocular Lens* Jo. Cataract Rfrctv Srg, Vol 19, March 1993.

Abstract:

Contrast sensitivity was measured in 25 patients who had a multifocal diffractive intraocular lens and in 23 control patients with a monofocal lens in four simulated light conditions: (1) daylight, (2) daylight with peripheral glare, (3) twilight, (4) twilight with central glare. In normal daylight and twilight, contrast sensitivity of the multifocal group was significantly lower than the control group's ( $P < .05$ ). The difference was 0.13 log units for the multifocal group and 0.17 log units for the control group (mean value across the tested frequency from 1.5 to 18 cycles/deg). Peripheral glare reduced contrast sensitivity under daylight conditions in both groups ( $P < .05$ ), but the loss did not differ significantly between the two ( $P > .05$ ). Central glare reduced contrast sensitivity under twilight conditions in both groups ( $P < .05$ ) with the greatest loss in the multifocal patients ( $P < .001$ ). We conclude that the most significant loss of contrast sensitivity in patients with the diffractive multifocal intraocular lens is found with central glare under twilight conditions.

## **CATARACTS** Continued

- B-18) Masket, S., *Glare Disability And Contrast Sensitivity Function In The Evaluation Of Symptomatic Cataract*, Ophthalmology Clinics Of North America, Volume 4, No. 2, June 1991.

### Abstract:

Glare disability testing and contrast sensitivity evaluation appear to have definite value in the assessment of the visual status and symptoms of the cataractous patient. Wider acceptance of these relatively new testing parameters, however, will require that clear standards for testing equipment be established and implemented for clinical practice so that test, retest, and interest results are comparable. Although the addition of glare and contrast testing to our battery of information about patients with cataract formation aids in the determination of appropriate indication for surgery, no single test of visual function is sufficient to mandate surgery. Rather, the visual needs of the patient in combination with careful estimation of the potential for the return of visual function after surgery should dictate the need for surgery.

- B-19) Kattouf, R.S., *Glare Testing, Contrast Sensitivity, & Potential Acuity: Giving Your Patients The Best Possible Vision*, Optometry Today, Jan/Feb 1992.

### Abstract:

Primary care of the aging patient is the obligation of optometry. It requires some investment in instrumentation and additional people skills in managing aging patients.

- B-20) Superstein, R., Boyaner, D., Overbury, O., Starkman, L.T., *Functional Complaints, Visual Acuity, Spatial Contrast Sensitivity and Glare Disability in Pre- and Post-Operative Cataract Patients*. Cataract/Cataract Surgery Poster Presentation 2692-B537 April 1996.

### Abstract:

Many cataract patients have good visual acuity, yet have functional visual complaints. This study attempts to quantify cataract patients' functional visual complaints and correlate them with their objective glare disability and spatial contrast sensitivity scores.

- B-21) Superstein, R., Boyaner, D., Overbury, O., Collin, C., *Glare Disability and Contrast Sensitivity Before and After Cataract Surgery*. J Cataract Refract Surg, Vol 23, March 1997

### Abstract:

*Purpose:* To determine whether brightness-induced glare decreases spatial contrast sensitivity and visual acuity in preoperative cataract patients with functional visual complaints and to compare preoperative with postoperative results.

*Setting:* Sir Mortimer B. Davis Jewish General Hospital, Montreal, Quebec, Canada.

*Methods:* Twenty patients with a visual acuity of 20/70 or better at the time of chart selection and no other ocular pathology who were referred for cataract surgery were evaluated with the Optec 3000 vision tester to assess contrast sensitivity and visual acuity in the presence and absence of glare. Testing was done preoperatively and 1 and 3 months postoperatively.

*Results:* An analysis of variance indicated that there were statistically significant double interactions between the preoperative/postoperative and glare/no-glare variables and between the preoperative/postoperative and spatial frequency variables. Postoperatively, visual acuity and contrast sensitivity improved to within normal limits.

There were no statistically significant differences in visual acuity and spatial contrast sensitivity between 1 and 3 months postoperatively.

*Conclusion:* Spatial contrast sensitivity and glare testing provided objective assessment of patients who had good visual acuity yet also had functional complaints.

**CATARACTS** Continued

B-22) American Academy of Ophthalmology and American Society of Cataract and Refractive Surgery White Paper on Cataract Surgery, April 1996

Abstract:

The purpose of the white paper is to help bridge the gap between the AHCPDR guideline which was published in 1993, and more recent knowledge about practices in cataract surgery. The Academy and the American Society of Cataract and Refractive Surgery have jointly developed this paper. It is intended to clarify specific interpretations of the AHCPDR guideline which have proven to be most controversial, and to outline briefly more recent relevant clinical developments, which have significantly changed the practice of cataract surgery in the past few years. More detailed and thorough explanation of relevant clinical developments in the field of cataract surgery will be discussed in the Academy's PPP revision.

B-23) Packer, M MD, Fine, I.H. MD, Hoffman, R.S. MD, Piers and P.A. MSc, *Prospective Randomized Trial of an Anterior Surface Modified Prolate Intraocular Lens*, J Refract Surg. Vol 18 November/December 2002

Abstract:

*Purpose:* We compare the contrast sensitivity obtained with an anterior surface modified prolate intraocular lens with the contrast sensitivity obtained with a standard spherical intraocular lens.

*Methods:* Patients presenting for cataract surgery in one eye were randomized to receive either the Tecnis Z9000 intraocular lens (Pharmacia) or the AMO AR40e Opti-Edge intraocular lens (AMO). Sine wave grating contrast sensitivity testing under mesopic and photopic conditions served as the principal outcome measure.

*Results:* The Tecnis Z9000 intraocular lens provided statistically significantly better contrast sensitivity at 1.5 and 3 cycles per degree under mesopic conditions and at 6, 12 and 18 cycles per degree under photopic conditions

*Conclusion:* The use of a modified prolate intraocular lens during cataract surgery has the potential to improve contrast sensitivity under both mesopic and photopic conditions. (J Refract Surg 2002; 18:692-696)

B-24) Packer, M MD, Fine, I.H. MD and Hoffman, R.S. MD, *Wavefront Sensing, IOLs Contribute to Functional Vision, Contrast sensitivity testing emerging as a more comprehensive measure of visual acuity.* Visual Performance, Ophthalmology Times. November 1, 2002 Pages 65-67, 2002

Abstract:

Today, contrast sensitivity testing emerging as a more comprehensive measure of vision that will probably replace Snellen letter acuity testing, just as audiometric testing replaced the "click" and spoken-word tests used prior to the 1940's.

B-25) Montes-Mico, R OD, Mphil, Espana, E, MD, PhD, Bueno, I, OD, Charman, W N PhD, DSc and Menezo, J L MD, PhD, *Visual Performance with Multifocal Intraocular Lenses: Mesopic Contrast Sensitivity under Distance and Near Conditions*. *Ophthalmology* 2004;111:85-96.

Abstract:

*Objective:* To evaluate distance and near visual performance under bright (photopic) and dim (mesopic) conditions in patients who had undergone uncomplicated cataract extraction with multifocal or monofocal intraocular lens (IOL) implantation.

*Design:* Prospective, nonrandomized, masked, comparative, observational case series.

*Participants:* Thirty-two eyes of 32 patients after zonal-progressive multifocal IOL implantation (Allergan Medical Optics Array SA-40N) and 32 eyes of 32 age-matched patients after monofocal IOL implantation (Allergan medical Optics SI-40NB).

*Intervention:* All eyes underwent phacoemulsification and IOL implantation.

*Main Outcome Measures:* At 18 months after surgery, the monocular contrast sensitivity (CS) function was measured with sinusoidal grating charts at distance and near, at one photopic luminance level and 2 mesopic luminance levels (85, 5, and 2.5 candelas per square meter).

*Results:* Under bright conditions, CS at distance in the multifocal group was not statistically different ( $P>0.01$ ) from that in the monofocal group at any tested grating spatial frequency (1.5, 3, 6, 12, and 18 cycles per degree [cpd]). At low luminances, distance CS for the multifocal group was worse than that for the monofocal group at the highest test spatial frequencies (12 and 18 cpd;  $P<0.01$ ). At near, photopic CS in the multifocal group was lower than at distance; patients with only a monofocal distance correction, however, could not detect the test gratings, even at the highest available contrast. With optimal near spectacle additions (i.e., using the distance correction of the multifocal IOL), there were no significant differences between the photopic near CS values for the multifocal and monofocal groups. When the luminance was decreased, near CS at all spatial frequencies was reduced in both groups. Contrast sensitivity in the near-corrected, multifocal group was significantly worse than in the near-corrected, monofocal group at high spatial frequencies (12 and 18 cpd).

*Conclusions:* This work supports the findings of earlier authors that the Array multifocal IOL, with its center-distance design, is distance biased. Distance CS is within normal limits under bright photopic conditions but shows deficits at higher spatial frequencies (more than approximately 12 cpd) under dim mesopic conditions. Near CS obtained with the multifocal IOL is below that which can be achieved by an appropriate monofocal near correction, for all spatial frequencies and illumination conditions.

## **GLAUCOMA**

- C-1) Ross, J.E., Bron, A.J., Reeves, B.L., and Emmerson, P.G., *Detection of Optic Nerve Damage in Ocular Hypertension*, Br. J. Ophthalmol., 69, 1985 897-903.

Abstract:

Thirty patients with ocular hypertension were tested for contrast sensitivity loss. Seventeen were not on treatment, and thirteen were receiving some form of pressure-reducing therapy. The contrast sensitivity results of 63% of ocular hypertensive eyes were abnormal (greater than 2 SDs from the age-matched norm). Thus it appears that contrast sensitivity can detect early visual loss in patients who have normal visual fields and it is suggested that this test might be used as a criterion for therapy in ocular hypertension. There was no significant difference in the intraocular pressure between patients who gave abnormal contrast sensitivity results and those who did not in the untreated group ( $p > 0.05$ ), suggesting that intraocular pressure level is a poor indicator of optic nerve fiber damage in patients with ocular hypertension.

- C-2) Minckler, D.C. Heijl, A., and Bron, A.J., *Panelists Review Histologic, Functional Indicators of Early Glaucoma*, New Vistas in the Detection and Management of Glaucoma, Sept. 3-4, 1987, 2.

Abstract:

The opening session of the symposium focused on a description of the basic anatomic and physiologic features characteristic of the early stages of glaucoma and a review of the functional changes that occur, such as alterations in visual field status and contrast sensitivity. Changes in contrast sensitivity seen in ocular hypertension and early glaucoma were described by Dr. Anthony J. Bron, Margaret Ogilvie Reader in Ophthalmology at the University of Oxford. Dr. Bron also reviewed the results of several studies in which contrast sensitivity was measured in patients with ocular hypertension. The percentage of such patients showing contrast sensitivity losses ranged from 20% to 67% in studies that employed static tests and from 53% to 83% when dynamic tests were used. Contrast sensitivity losses appeared to be irreversible in glaucoma patients; however, he noted in one recent report that lowering of IOP was associated with a reversal of contrast sensitivity losses in 56% of a series of patients with ocular hypertension. One method of measuring contrast sensitivity is the Vistech chart, a test of spatial contrast sensitivity using five spatial frequencies presented over a range of contrasts. In a study conducted by Dr. Bron and his colleagues in 24 ocular hypertensive and 24 glaucoma patients, the Vistech chart was compared with an oscilloscopic technique of measuring contrast sensitivity. Dr. Bron reported that "In general, both tests discriminated equally well between ocular hypertension and glaucoma."

- C-3) Kearns, L.A., *Contrast Sensitivity Used in Following Glaucoma*, Ocul. Surg. News, 6(15), August 1, 1988, 1-39.

Abstract:

A quick and simple contrast sensitivity test is providing physicians with a new tool for early detection and management of glaucoma. By mapping a patient's drop on contrast sensitivity charts, physicians are detecting early and subtle glaucoma differences. Dr. Eleanor E. Faye of the Lighthouse of the Blind in New York and Dr. Rick Sponsel of the University of Wisconsin discuss the importance of using contrast sensitivity in conjunction with other tests to test for and evaluate glaucoma. Case histories and the merits of the vision Contrast Test System (VCTS) are also discussed.

- C-4) Blanchard, D.L., *Contrast Sensitivity: A Useful Tool in Glaucoma*, Glaucoma, 10, 1988, 151-153.

Abstract:

Contrast Sensitivity using the Vistech model was done in a group of glaucoma and suspected glaucoma patients and compared with normal data. Midfrequency loss (6 cycles/degree of visual angle) was noted in 82% of glaucoma eyes, 41% of suspected glaucoma eyes, and 5% of normal eyes. This test was found to be a useful adjunct in the evaluation of glaucoma patients and should be more widely utilized.

## **GLAUCOMA** Continued

- C-5) Bron, A.J., *Contrast Sensitivity Changes in Ocular Hypertension and Early Glaucoma* (Summary), Survey of Ophthalmology., Vol. 33, Supplement, April 1989, 405-406.

### Abstract:

The visual system is organized to distinguish spatial and temporal elements at various levels of contrast. This ability depends on the neural subsystems including the small X and larger Y ganglion cells of the retina. X cells have high spatial contrast sensitivity, but low temporal contrast sensitivity. Just the opposite is true for Y cells. Patients with glaucoma show reductions in both spatial and temporal contrast sensitivity, which suggests that both the X and Y systems are damaged by this disease.

Static and dynamic tests are used to assess contrast sensitivity. Static contrast sensitivity tests measure the threshold contrast at which gratings of varying spatial frequency become visible. Dynamic or temporally modulated tests utilizing diffuse and counterphase flicker measure the threshold of visibility of a stimulus whose contrast varies cyclically, alternating between light and dark. Age, refractive error, pupil and stimulus size, and retinal eccentricity all affect the outcome of contrast sensitivity testing. The values obtained are also dependent on the psychophysical technique used to determine sensitivity.

Early studies of contrast sensitivity in patients with chronic simple glaucoma (CSG) and ocular hypertension (OHT) have demonstrated spatial and temporal sensitivity losses.

- C-6) Ginsburg, A.P., *Contrast Sensitivity Holds Promise for Early Glaucoma Detection.* Oclr Srgry News, 1991, 8-11.

### Abstract:

Review of research and clinical experience on the use of contrast to detect Glaucoma.

- C-7) Guttman, C., *Contrast Sensitivity Testing Might Detect Glaucoma Early*, Ophth. Times, July 1, 1991, 19.

### Abstract:

A review by E. Faye, M.D. of the Manhattan Eye, Ear and Throat Hospital of the indications for and benefits of Contrast Sensitivity for early detection of Glaucoma.

- C-8) Sample, P.A., Pascal, S.C., Juang, B.S., and Weinreb, R.N., *Isolating The Effects Of Primary Open-Angle Glaucoma On The Contrast Sensitivity Function*, Amrcn Jo of Ophthalmology 112:308-316, Sept. 1991.

### Abstract:

We evaluated spatial Contrast Sensitivity functions in age-matched and lens density-matched healthy eyes, eyes with primary open-angle glaucoma, and eyes with ocular hypertension. We also controlled for refraction, visual acuity, pupil size, and previous ocular history. We found an overall reduction in Contrast Sensitivity for the glaucomatous eyes with a significant difference at 12 cycles per degree ( $P < .012$ ). Eyes with ocular hypertension were not significantly different from normal eyes. Significant differences were noted at several spatial frequencies with less careful controls for age and lens effects. We concluded that spatial Contrast Sensitivity may be a useful adjunctive diagnostic test for glaucoma, but interpreting the results without other clinical data may lead to errors in diagnosis.

## **GLAUCOMA** Continued

C-9) Hawks, T., *Managing The Glaucoma Suspect In Your Practice* Optometry Today, Jan/Feb 1992.

Abstract:

Thorough assessment of the glaucoma suspect involves a lot of baseline testing. It can prove disruptive to patient flow unless you prepared the glaucoma suspect and worked him or her into the schedule properly. I believe that it is in everyone's best interest to perform a comprehensive work-up. Glaucoma patients can add a new dimension to the way that you practice, both professionally and financially. And the thorough primary-care testing that you do will provide the necessary data to properly manage this patient.

## **LOW VISION**

D-1) Faye, E.E., *VCTS 6000 and Low Vision*, J. Vis. Rehab., 1, 1987, 40.

Abstract:

The Vistech VCTS 6000 is a valuable addition to the psychophysical tests developed to provide information formerly available only from a research institution. Glaucoma suspects can easily be followed at 6 month to 1 year intervals with maximum compliance.

D-2) Faye, E.E., *Low Vision Management in Selected Eye Diseases*, G. Woo, ed., *Low Vision: Principles and Applications*, New York: Springer-Verlag, 1987, 96-107.

Abstract:

One of the greatest challenges in doing low vision work is the opportunity to combine an interest in medicine with rehabilitation, psychology, optics and psychophysics. In this paper, some of these interests are combined in discussing the effect on patient management of the eye diagnosis. Contrast sensitivity tests may help to confirm suspects who already have field defects on automated perimeters, but may have presented with normal visual acuity and borderline/normal intraocular pressures. Following patients' response to medication with CSF as well as perimetry may ultimately improve therapeutic management.

D-3) Porter, F.I. and Demer, J., *Magnification Efficiency in the Low Vision Patient*, G. Wood, ed., *Low Vision: Principles and Applications*, New York: Springer-Verlag, 1987, 249-261.

Abstract:

Visual impairment, or the loss of visual acuity and/or visual field due to some pathology of the eye or brain, afflicts an estimated 6 million people in the United States. In the State of Texas, more than 392,000 people are said to have a best corrected visual acuity of less than 6/21 (20/70). One method of maximizing visual functioning in such persons is through the use of the unique services available at low vision rehabilitation clinics. Employing specialized refracting techniques and using optical devices such as telescopes and microscopes, the low vision clinician strives to maximize remaining residual vision. Improvement of visual acuity can be attained by enlarging the object size, as by magnification; accenting definition, as by emphasizing functionally significant spatial frequencies; or varying the illumination, as by altering the contrast. Telescopes have long been used in visual rehabilitation. These devices enlarge distant objects; with modification telescopes will magnify near objects as well. The telescopes may be prescribed for academic, vocational, recreational, and mobility uses.

**LOW VISION** Continued

- D-4) Eldred K.B., Jose R.T., *Binocular Contrast Sensitivity Testing for Low Vision Patients. Jo of the Amrcn Optmtrc Assn 1991;62:766-9.*

Abstract:

Contrast Sensitivity testing is often included in primary care and low vision examinations. This test is designed to provide information regarding the quality of a patient's vision. This clinical study provides a method to assess the binocularity of a low vision patient with Contrast Sensitivity testing. The method allows the practitioner to determine if monocular or binocular conditions are optimal for the use of a near low-vision device.

- D-5) Ginsburg, A.P., Rosenthal, B., Cohen, J., *The Evaluation Of The Reading Capability Of Low Vision Patients Using The Vision Contrast Test System (VCTS)*

Abstract:

In this study we report the use of the VCTS to measure the contrast sensitivity of 55 low vision patients having a wide variety of eye diseases. This initial study was designed to determine if contrast sensitivity as measured by the VCTS could provide more information than visual acuity in predicting patient performance using aids for a continuous reading task. A secondary goal was to determine if contrast sensitivity could predict the preferred eye of the low vision patient more accurately than acuity, an important part of helping to treat the low vision patient. Comparison of the contrast sensitivity of the low vision population to that of a normal population was an additional goal.

- D-6) Faye, E.E., *Managing Low Vision Patients. Jo of Ophth. Nursing & Tech. 1998; Vol 17, No. 6.*

Abstract:

The use of contrast sensitivity in identifying, evaluating and treating low vision patients.

- D-7) Leat, S.J., Legge, G.E., and Bullimore, M.A., *What is Low Vision? A Re-evaluation of Definitions Optom & Vis Sci. Vol. 76, No. 4, April 1999*

Abstract:

Purpose: To re-evaluate definitions of low vision, visual impairment, and disability.

Methods. We review current definitions of legal blindness and low vision and how these definitions are variably based on disability or impairment. We argue for a definite distinction being made between criteria for visual impairment and visual disability, low vision being defined as the presence of a visual impairment that results in a disability. Visual impairment is defined according to population norms and a statistical cut-off is used. Visual disability is defined by consideration of the level of visual measures which result in measurable or reportable disability. We consider the evidence that contrast sensitivity should be a criterion for visual disability in addition to visual acuity and visual field.

Conclusions. According to the current information, we define visual impairment as best monocular or binocular visual acuity <(worse than) 6/7.5, total horizontal visual field <146° (Goldmann III-4e) or <109° (iii-3e), and contrast sensitivity <1.5 (PellipRobson); we define visual disability as best monocular or binocular visual acuity <6/12 or contrast sensitivity <1.05. (Optom Vis Sci 1999;76:198-211).

## **DIABETES**

- E-1) Sokol, S., Moskowitz, A., Skarf, B., Evans, R., Molitch, M., and Senior, B., *Contrast Sensitivity in Diabetics With and Without Background Retinopathy*. Arch. Ophthalm., 103, 1985, 51-54.

Abstract:

Contrast sensitivity measurements were obtained from 64 patients with insulin-dependent (IDDM) and non-insulin dependent (NIDDM) diabetes mellitus who had normal Snellen acuity and minimal or no visible diabetic retinopathy. Contrast thresholds were determined for stationary gratings at six spatial frequencies, ranging from 0.5 to 22.8 cycles/degrees (c/deg), and for 1.0-c/deg gratings phase-alternated at 15Hz. Data from each group of diabetic patients were compared with data from age-matched normal subjects. We found that (1) patients with IDDM and no retinopathy had normal contrast sensitivity, (2) patients with NIDDM and no retinopathy had abnormal contrast sensitivity at only one spatial frequency (22.8 c/deg), and (3) patients with NIDDM and background retinopathy had abnormal contrast sensitivity at all spatial frequencies tested. We also found a dissociation of Snellen acuity and contrast sensitivity, indicating that contrast sensitivity can be used as an early index of changes in the retina not demonstrated by measurements of visual acuity.

- E-2) Trick, G.L., Burde, R.M., Gordon, M.O., Santiago, J.V., and Kilo, C., *The Relationship Between Hue Discrimination and Contrast Sensitivity Deficits in Patients with Diabetes Mellitus*, Ophthalm., 95(5), 1988, 693-698.

Abstract:

In an attempt to elucidate more fully the pathophysiologic basis of early visual dysfunction in patients with diabetes mellitus, color vision (hue discrimination), and spatial resolution (contrast sensitivity) were tested in diabetic patients with little or no retinopathy (n = 57) and age-matched visual normals (n = 35). Some evidence of visual dysfunction was observed in 37.8% of the diabetics with no retinopathy and 60.0% of the diabetics with background retinopathy. Although significant hue discrimination and contrast sensitivity deficits were observed in both groups of diabetic patients, contrast sensitivity was abnormal more frequently than hue discrimination. However, only 5.4% of the diabetics with no retinopathy and 10.0% of the diabetics with background retinopathy exhibited both abnormal hue discrimination and abnormal contrast sensitivity. Contrary to previous reports, blue-yellow (B-Y) and red-green (R-G) hue discrimination deficits were observed with approximately equal frequency. In the diabetic group, contrast sensitivity was reduced at all spatial frequencies tested, but for individual diabetic patients, significant deficits were only evident for the mid-range spatial frequencies. Among diabetic patients, the hue discrimination deficits, but not the contrast sensitivity abnormalities, were correlated with the patients' hemoglobin A(1) level. A negative correlation between contrast sensitivity at 6.0 cpd and the duration of diabetes also was observed.

## **PITUITARY ADENOMA**

- F-1) Kurzer, A.R., *Contrast Sensitivity Signals Pituitary Adenoma*, Rev. of Opt., 123(4), 1986. 119.

Abstract:

A 30-year-old man complained of hazy vision with his left eye and headaches on the left side of the front of his head. None of his visual tests had abnormal results except the contrast sensitivity test. Further outside testing revealed a very early pituitary adenoma. After removal of the tumor, the patient's vision and contrast sensitivity returned to normal.

## **MACULAR DEGENERATION**

- G-1) Loshin, D.S. and White, J., *Contrast Sensitivity: The Visual Rehabilitation of the Patient with Macular Degeneration*, Arch. Ophthalm., 102, 1984, 1303-1306.

Abstract:

Contrast sensitivity functions (CSFs) were determined on a large group of patients with macular degeneration to better assess qualitative aspects of their residual vision. Contrast sensitivity was also determined through the telescopic low-vision aids of selected patients. In general, the patients have a substantial loss of contrast sensitivity for all spatial frequencies. The preferred eye of these patients appeared to be related to the peak of the CSF more so than to the Snellen visual or resolution acuity. Through the low-vision aid, not only was there the predictable increase in resolution acuity but also a notable increase in peak contrast sensitivity. These findings indicate that contrast sensitivity testing provides useful information that should be considered in the visual rehabilitation of the patient with macular degeneration.

## **CONTACT LENSES**

- H-1) Ginsburg, A.P. and Turner, M.W., *Contrast Sensitivity: A Practical Tool for Contact Lens Fit and Management*, Contact Lens Forum, July 1987, 67-70.

Abstract:

Contrast Sensitivity testing provides early detection of a wide variety of visual eye disease and provides the contact lens practitioner with an objective measure for replacement of contact lenses due to haze, deposits, or improper care, even when acuity is unchanged. This allows the doctor to measure losses in visual quality due to subtle changes over time, changes which may not even be noticed by the patient. Contrast sensitivity testing also allows better patient management by aiding the practitioner in choosing the most appropriate type and material of contact lens for the individual patient, by giving the practitioner an objective measure to demonstrate to the patient when contaminated or damaged lenses must be replaced. Reliable, quick, easy, and inexpensive, the VCTS can give the contact lens practitioner the solution to those common and difficult to solve complaints of poor vision, even with 20/20 acuity.

- H-2) Edwards, K. and Haig Brown, G., *An Evaluation of Bifocal Lens Performance and the Design of a New Fitting Protocol*, Transactions of the British Contact Lens Association Conference, 1987, 30-34.

Abstract:

As the application of contact lenses increases with new lens technology and fitting techniques, manufacturers' and practitioners' interest is turning to the potential presbyopic wearer. Despite a plethora of new lens types (especially in soft materials) and the expectancy of the holographic diffraction lens becoming a clinical reality, there are still serious limitations to the successful application of bifocal contact lenses. Most new lenses are of the simultaneous (concentric) type and can produce a demonstrable adverse effect on contrast. Indeed, clinical experience already indicates this when adequate V/A is measured in a patient who is nonetheless complaining of unacceptable vision. This study assesses the contrast sensitivity function as a means to predict satisfied bifocal lens wearers and attempts to identify the maximum disruption consistent with successful wear through a retrospective study. The evaluation of this data is then applied as a basis for fitting new patients, attempting to predict in advance the likely success.

H-3) Kurzer, A.R., Contrast Sensitivity Builds Your Contact Lens Practice, Opt. Management, January 1988, 46-49.

Abstract:

Each day we encounter contact lens patients who complain about the quality of their vision, but nevertheless test 20/20 or better on the Snellen acuity chart. Contrast sensitivity has emerged as an effective and more accurate tool for diagnosing and assessing visual deficits and performance, and is especially suitable for contact lens patients. Discussed here are uses for contrast sensitivity testing in a contact lens practice, how to incorporate contrast sensitivity into your practice, and how to use contrast sensitivity to build your practice.

H-4) Gundel, R.E., Kirshen, S.A., and DiVergillo, D., *Changes in Contrast Sensitivity Induced by Spherical Hydrogel Lenses on Low Astigmats*, Jo. Am. Opt. Assoc., 59(8), 1988, 636-640.

Abstract:

Contrast sensitivity values were taken on seven astigmatic (cylinder correction under 1.00 diopter) and eight spherical myopes using the Vistech VCTS 6500 System. For the astigmatic group, no significant difference in contrast sensitivity was found between the full subjective correction and an equivalent spherical spectacle prescription, despite the absence of cylinder correction. However, comparing the full subjective correction with an equivalent spherical hydrogel lens, we found a significant decrease in contrast sensitivity while wearing lenses for all but the highest spatial frequency tested. Using a group of spherical myopes, we were unable to demonstrate a decrease in contrast sensitivity as a product of hydrogel lens wear alone. Our findings suggest that there is a measurable decrease in contrast sensitivity as a result of fitting low astigmats with spherical hydrogel lenses which cannot be attributed solely to hydrogel lens wear or the absence of cylinder correction.

H-5) Ziel, C. J., Gussler, J.R., Van Meter, W. S., Schmeisser, E., Litteral, G., *Contrast Sensitivity in Extended Wear of the Boston IV Lens*, CLAO Journal, October 1990, Volume 16, Number 4

Abstract:

Over a one-year period we evaluated subjective and objective factors associated with extended wear of Boston IV rigid gas permeable contact lenses. Patients wore the lens on an extended wear schedule, with removal at 2-week intervals for cleaning. We performed keratometry and endothelial cell counts and measured visual acuity, contrast sensitivity, refraction, and corneal thickness at the initial visit (with patients wearing their former glasses or soft or hard lenses) and again at 6 and 12 months (with patients wearing the Boston IV lens). Twenty-four of 31 patients (77%) completed the study. All measured parameters were checked for statistically significant change over time. Contrast sensitivity increased at all spatial frequencies tested, with the largest meters showed no significant changes ( $P > .05$ ). Our data support the use of contrast sensitivity for qualitative assessment of visual function among contact lens wearers and suggest that contrast sensitivity testing may prove to be a more effective means of evaluating visual acuity in contact lens wearers over time than Snellen acuity.

## **ALZHEIMER'S DISEASE**

I-1) Sadun, A.A., Borchert, M., DeVita, E., Hinton, D., and Bassi, C., *Assessment of Visual Impairment in Patients With Alzheimer's Disease*, Am. J. Ophthal., 104(2), 1987, 113-120.

Abstract:

We have examined five patients with Alzheimer's disease who complained of poor vision. Two patients had mild Alzheimer's disease; they complained of problems with reading and of "bumping into things", yet both had normal visual acuities.

One patient with moderate Alzheimer's disease had abnormal eye movements, visual-evoked potentials, and contrast sensitivity. The other two patients had severe Alzheimer's disease. Despite difficulties in performing the examination, we were able to see moderate impairments in visual acuity and visual fields, as well as marked dyschromatopsia, severe deficits in contrast sensitivity, and markedly abnormal eye movements and visual-evoked potentials.

**ALZHEIMER'S DISEASE** Continued

- I-2) Cronin-Golomb, A., Corkin, S., Rizzo, J.F., Cohen, J., Growdon, J.H. and Banks, K.S., *Visual Dysfunction in Alzheimer's Disease: Relation to Normal Aging*, Annals of Neurology Vol. 29 No. 1

Abstract:

In patients with Alzheimer's disease (AD), compared with age-matched and young healthy control subjects, visual deficits in the following functions were observed: color, stereoacuity, contrast sensitivity, and backward masking (homogeneous and pattern). Critical flicker fusion thresholds were normal, relative to age-matched healthy subjects. For color, the majority of the errors were tritanomalous (blue axis). Color and stereoacuity deficits were unrelated to severity of dementia, in accordance with models of vision that describe these functions as modular rather than diffuse for cortical localization. Although contrast sensitivity was depressed throughout the frequency range in AD, more patients were impaired at low than at high spatial frequencies, contrasting with the observed normal aging pattern of high-frequency loss. Healthy elderly subjects showed depressed critical flicker fusion thresholds and reduced contrast sensitivity at high frequencies, relative to the young group; differences between these groups were not found for the other vision tests. A subset of the AD group received detailed neuro-ophthalmological examination, and no abnormalities were found. This finding, taken together with normal thresholds for critical flicker fusion, suggests that the widespread visual dysfunction reported here is more likely to be related to known pathological changes in primary visual and association cortex in AD than to changes in the retina or optic nerve.

- I-3) Gilmore, G.C., Levy, J.A., *Spatial Contrast Sensitivity in Alzheimer's Disease: A Comparison of Two Methods*, Optometry & Vision Science, 1991, Vol. 68, No. 10, pp. 790-794.

Abstract:

The present study was designed to compare the contrast sensitivity function (CSF) obtained with the Nicolet CS2000 and the Vistech VCTS6500 for a sample (N = 25) of patients diagnosed with probable Alzheimer's disease (AD) and a sample (N = 25) of healthy elderly adults. With the Nicolet, CSF were determined for gratings presented under static and rapidly counterphased (7.5 Hz) conditions. All research participants were able to complete the Vistech test. However, 13.7 and 7.4% of the original samples of Alzheimer patients and healthy adults, respectively, did not yield usable data. Both test instruments showed uniformly low contrast sensitivities for the AD group. The results support the proposition that AD involves a primary visual disturbance and suggest that the Vistech chart can be used with a broader range of patients for initial screening.

## **OPTIC NEURITIS**

- J-1) Fleishman, J.A., Beck, R.W., Linares, O.A., and Klein, J.W., *Deficits in Visual Function after Resolution of Optic Neuritis*, Ophthalmol., 94(8), 1987, 1029-1035.

Abstract:

A study was done to systematically characterize visual function in eyes with recovered optic neuritis. Thirty-five eyes from 27 patients, all of whom had recovered at least 20/30 Snellen acuity after resolution of the neuritis, were included. Minimum recovery period was 6 months. Abnormalities were found in color vision (57%), contrast sensitivity (72%), perimetry (26%), stereoacuity (80%), light brightness (89%), pupillary reaction (89%), and optic disc appearance (77%). Eighty-five percent of patients complained of at least some subjective disturbance in vision. Subjective visual complaints correlated better with deficits in contrast sensitivity than they did with other measures. The results of the study indicate that deficits in visual function are common after resolution of optic neuritis.

## **KERATOCONUS**

- K-1) Zadnik, K., Mannis, M., Johnson, C., and Rich, D., *Rapid Contrast Sensitivity Assessment in Keratoconus*, Am. J. Opt. Physiol. Opt., 64(9), 1987, 693-697.

Abstract:

Contrast sensitivity derangement may accompany keratoconus even in the presence of normal or near normal Snellen visual acuity. This has been demonstrated with computer-driven contrast sensitivity test devices. The purpose of this study was to evaluate the utility and efficacy of rapid screening devices for contrast sensitivity testing. However, such devices are often cumbersome and difficult to use clinically. We tested 12 patients with keratoconus on two simple chart systems designed to test contrast sensitivity in a rapid and clinically useful manner: the Vistech chart and the Regan multi-contrast visual acuity charts. Both devices detected the contrast sensitivity abnormalities present in early keratoconus, but some patients [with  $\geq 6/12$  (20/40) visual acuity] were unable to respond to areas of the charts corresponding to high spatial frequency and/or low contrast tasks. Such simple wall charts may be useful in measuring the visual abnormalities in early keratoconus, in monitoring the progression of the disease, and in evaluating various treatment options.

- K-2) Mannis, M., Zadnik, K., and Johnson, C., *The effect of Penetrating Keratoplasty on Contrast Sensitivity in Keratoconus*, Arch. Ophthalmol., 102, 1984, 1513-1516.

Abstract:

Complaints of visual distortion often precede a decrement in visual acuity in keratoconus. We studied seven patients with keratoconus who had undergone keratoplasty in one eye and whose Snellen visual acuity measurements were equal in the grafted and nongrafted eyes. Subjects were examined clinically; we then measured contrast thresholds for seven spatial frequencies of computer-generated sinusoidal gratings after optimal contact lens correction. Results indicate that nongrafted keratoconic eyes demonstrate abnormal contrast sensitivity, even with good visual acuity measurements. Eyes with clear corneal grafts and with visual acuities comparable to nongrafted eyes fell within 95% confidence limits of the normal contrast sensitivity curve. The findings confirm that corneal distortion or opacity in the optimally corrected keratoconic eye may account for notable visual dysfunction and that keratoplasty improves not only Snellen visual acuity but contrast sensitivity as well.

## **AMBLYOPIA**

- L-1) Leguire, L.E., Rogers, G.L., and Bremer, D.L., *Functional Amblyopia is a Single Continuum of Visual Impairment on Contrast Sensitivity Functions*, Bin. Vis., 2(4), 1987, 199-208.

Abstract:

Contrast sensitivity functions (CSFs) were measured on six children with strabismic and/or anisometric amblyopia during the course of full-time patching therapy. At the start of patching, acuity averaged 20/100 and the CSF of the amblyopic eye was depressed at lower and higher spatial frequencies compared to the nonamblyopic normal eye (type II amblyopia). During the course of patching therapy, when acuity improved to an average of 20/40, the CSF of the amblyopic eye matched that of the nonamblyopic normal eye at the lower spatial frequencies (type I amblyopia). In other words, patching improved acuity and changed the basic shape of the CSF. When contrast sensitivity of the amblyopic eye was averaged across spatial frequency so that each subject's CSF could be described by a single mean contrast sensitivity value, a statistically significant correlation was found between mean contrast sensitivity and acuity. Based on these results, we hypothesize that amblyopia may reflect a single continuum of visual impairment which varies in severity, with severity being determined, in part, by visual acuity. These results argue against the current hypothesis that amblyopia reflects two distinct functional types of visual impairment.

## **AMBLYOPIA** Continued

- L-2) Rogers, G.L., Bremer, D.L., and Leguire, L.E., *The Contrast Sensitivity Function and Childhood Amblyopia*, Am. J. Ophthalm., 104, 1987, 64-68.

### Abstract:

We measured contrast sensitivity function and visual acuity in both eyes of strabismic and anisometropic amblyopic patients. There was a linear relationship between contrast sensitivity function and visual acuity in the amblyopic eye. As visual acuity decreased, the contrast sensitivity function decreased along the contrast sensitivity axis, and peak sensitivity shifted to lower spatial frequencies. After patching therapy, when visual acuity reached 20/20 in each eye, suggesting that the amblyopia was cured, there continued to be a statistically significant difference in the contrast sensitivity functions between the eyes. The contrast sensitivity function from the previously amblyopic eye was depressed compared to the nonamblyopic eye. A comparison between patients with strabismic and anisometropic amblyopia showed that, when matched for visual acuity, the contrast sensitivity functions were similar for both the nonamblyopic and amblyopic eyes. However, a large difference was found between the amblyopic and nonamblyopic eyes of each group.

- L-3) Bosse, J.C., *Clinical Use of Contrast Sensitivity Test Plates for Amblyopia*, Jo. of Opt. Vision Development, Vol. XVII/December 1985, 24-27

### Abstract:

Clinical use of contrast sensitivity testing is increasing - primarily for its value in early pathology detection. Another potential use is with amblyopia. Amblyopic eyes show a depression in contrast sensitivity, most consistently for the higher spatial frequencies. When the mid and low spatial frequencies are affected, amblyopia is typically more severe. Research has shown correlations for mid and low frequency deficits with degree of visual acuity impairment, amount of anisometropia, and severity of fixation anomaly. Clinical use of contrast sensitivity test plates will detect these abnormalities. Use of contrast sensitivity assessment is suggested for evaluation of amblyopia to augment visual acuity and other standard tests. This article discusses advantages and clinical application of contrast sensitivity data.

- L-4) Bosse, J.C., and Lederer, P.J., *Contrast Sensitivity Used For Detection of Shallow Amblyopia*, Jo. of Opt. Vision Development, Vol. XVIII/December 1987, 10-15

### Abstract:

Contrast Sensitivity function is an extremely sensitive and complete measure of the visual loss present in amblyopia. Because contrast sensitivity function (CSF) is evaluated at threshold levels of contrast rather than high contrast, it is a far more sensitive tool in evaluating the early changes in sight loss associated with amblyopia. Contrast sensitivity function analysis represents a new and exciting tool in the assessment of amblyopia.

- L-5) Leguire, L.E., Rogers, G.L., and Bremer, D.L., and Wali, N. *A Comparison of Contrast Sensitivity Functions (CSF) Between Strabismic and Anisometropic Amblyopia in children*, Bin. Vis., Fall 4(4), 1989, 179-186.

### Abstract:

Contrast Sensitivity Functions (CSFs) were measured on the VCTS 6500 board in two groups of children; 20 strabismic amblyopes and 31 anisometropic amblyopes. In general, the strabismic group exhibited a greater loss of contrast sensitivity at the lower spatial frequencies (type II pattern of CSF loss) while the anisometropic group had a greater loss of contrast sensitivity at the higher spatial frequencies (type I). However, in both strabismic and anisometropic amblyopes the type of CSF loss also depended on the depth of amblyopia, as measured by visual acuity. Mild amblyopes tended to have a type I pattern and moderate amblyopes a type II (loss at all frequencies) pattern, whether anisometropic or strabismic. Testing compliance is enhanced using a three-alternative forced-choice procedure when CSF is measured with the VCTS 6500. This study supports the testing of CSF's in the evaluation of childhood amblyopia and the differentiation of pathology.

## **AMBLYOPIA** Continued

- L-6) Leguire, L.E. *Case Report-CSF and Visual Impairment: When in Doubt, Correct.* J. of Vision Rehab. 2(2) 61-63.

Case report describing 12 year old boy with congenital nystagmus, myopia and astigmatism using contrast sensitivity.

- L-7) Rogers, G.L., Bremer, D.L., and Leguire, L.E., *Contrast Sensitivity Functions in Normal Children With The Vistech Method*, J. Ped. Ophthal. Strab., 24, 1987, 216-219

Abstract:

The Vistech CSF tester (VCTS 6500-1) for distance was evaluated to determine the minimum age of children that could complete the test and to determine changes in the CSF as a function of age. A total of 72 normal children between the ages of 24 and 84 months were tested twice with each eye. The results revealed that no child below 36 months of age could complete the test and by 48 months of age 50% could complete the test. By 60 months all children could complete the test. It was also found that as age increased the CSF increased equally at all spatial frequencies. A comparison between the eyes of the CSFs revealed a highly statistically significant correlation of 0.78, which showed that the eyes were very similar. Test-retest correlations (0.78) also were highly statistically significant, which demonstrated that the test was very reliable. The results are discussed within the context of screening young children for visual disorders and the evaluation of patching therapy for amblyopia.

## **NEUROLOGICAL**

- M-1) Kupersmith, M.J., Siegel, I., and Carr, R.E., *Subtle Disturbances of Vision with Compressive Lesions of the Anterior Visual Pathway Measured by Contrast Sensitivity*, Ophthal. (Rochester), 89(1), 1982, 68-72.

Abstract:

Contrast thresholds were determined for patients with compressive lesions of the chiasm or optic nerve but whose visual acuity was 20/20 on the Snellen scale. A generalized loss of contrast sensitivity for spatial frequencies ranging from 0.2 to 6.4 cycles per degree was found even in patients with normal color vision and full visual fields. After surgery was performed, improvements in the fields and color vision were seen in those patients who also showed a significant increase in their postoperative contrast sensitivity scores. Contrast sensitivity is shown to be a useful procedure for evaluating very mild visual complaints as well as for establishing early diagnosis and evaluation of surgical therapy in patients with compressive lesions of the anterior visual pathway.

- M-2) Leguire, L.E., Pappa, K.S., Kachmer, M.L., Rogers, G.L., Bremer, D.L., *Loss of Contrast Sensitivity in Cystic Fibrosis*, Amrcn Jo of Ophthalmology, April, 1991, 111:427-429.

Abstract:

We measured the contrast sensitivity function in a 16-year-old boy with cystic fibrosis, before and during vitamin A supplementation. Before vitamin A supplementation, serum levels of vitamin A were abnormally low, the electroretinogram was reduced, and contrast sensitivity was abnormally low at all spatial frequencies. During vitamin A supplementation (25,000 IU/day), serum levels of vitamin A became low normal, and the overall contrast sensitivity function improved by 94%. We propose that the contrast sensitivity function may be abnormal in patients with cystic fibrosis who have reduced retinal function secondary to vitamin A deficiency.

M-3) Nordmann, J.P., Roncin, J.P., Denis, P.D., Blein, J.P., and Saraux, H., *Contrast Sensitivity as an Early Indicator of Acute Mountain Sickness*, American Journal of Ophthalmology, May, 1991, 111:651-653

Abstract:

Acute Mountain sickness is a debilitating illness of travelers who rapidly ascent to altitudes above 3,000m. The disease is characterized by headache, lassitude, anorexia, nausea, and vomiting. Visual function is likely to be impaired by this disease, but simple tests, such as visual acuity, are usually not included in the evaluation of this illness because they are not sensitive enough to detect early signs of hypoxia and alkalosis caused by the low level of oxygen pressure in high altitudes. To find an early indicator of these disturbances, we tested contrast sensitivity at high altitude.

## **RETINITIS PIGMENTOSA**

N-1) Gawande, A.A., Donovan, W.J., Ginsburg, A.P., and Marmor, M.F., *Photophobia in Retinitis Pigmentosa*, Submitted for publication, 1987.

Abstract:

Light-induced impairment of visual function, or photophobia, has been a recognized but poorly documented symptom in retinitis pigmentosa. We found, in a survey of retinitis pigmentosa and normal patients, that photophobia is a significant complaint in a majority of retinitis pigmentosa patients even in the absence of cataract. Psychophysical tests showed that retinitis pigmentosa patients had reduced contrast sensitivity relative to normals, but the decrement in their visual performance as a result of glare or photostress was only slightly worse than that of normal controls. Retinitis pigmentosa patients had elevated short-term adaptation or increment threshold levels, but their rate of short-term or photopic adaptation was normal. Photophobia in retinitis pigmentosa may result because elevated adaptation and contrast sensitivity thresholds allow even a minimal, or normally acceptable, decrement of function to place patients in a range of functional disability. Photophobia may also be multifactorial and derive from a complex of minor disabilities.

## **AIDS**

O-1) Morrill, K., *Contrast Sensitivity and AIDS*, Ocular Surgery News November 1, 1991

Abstract:

Vision screening at a Houston clinic is finding that almost half of HIV-positive people have Contrast Sensitivity deficits, most from various neuro-ophthalmological pathologies.

O-2) Quiceno, J.I., Capparelli, E., Pharm, D., Sadun, A.A., Munguia, D., Grant, I., Listhaus, A., Crapotta, J., Lambert, B., and Freeman, W.R. *Visual Dysfunction Without Retinitis In Patients With Acquired Immunodeficiency Syndrome*, American Journal Of Ophthalmology 113:8-13, January, 1992.

Abstract:

Patients with human immunodeficiency virus infection may have noninfectious and infectious retinopathies, as well as clinical symptoms consistent with optic nerve dysfunction. Noninfectious acquired immunodeficiency syndrome-related retinopathy is seen in most patients with AIDS. Morphologic studies have shown that the number of retrobulbar optic nerve fibers in patients with AIDS is decreased compared to the number of optic nerve fibers in normal control eyes. To determine whether these patients had a visual dysfunction consistent with damage to the macula and optic nerve, 78 subjects (156 eyes) were studied using color-vision and contrast sensitivity testing. The Farnsworth-Munsell 100-Hue color-vision test was performed on all subjects and age-corrected color-vision scores for all groups were compared. A significant decrease in color discrimination was found in the patients with AIDS ( $P < .001$ ). Contrast-sensitivity testing disclosed a deficit of contrast threshold in patients with AIDS at four of five spatial frequencies and in patients with AIDS related complex at three of the five spatial frequencies examined. This study demonstrated a functional visual deficit in eyes without retinitis consistent with dysfunction of the macula or optic nerve in patients with AIDS.

## **REFRACTIVE SURGERY**

- P-1) Esente, S., Passarelli, N., Falco, L., Passani, F., and Guidi, D., Contrast Sensitivity Under Photopic Conditions in Photorefractive Keratectomy: A Preliminary Study, Splmnt to Rfrctv & Corneal Srgry Volume 9 March/April 1993

Abstract:

In order to control and quantify the quality of vision after photorefractive keratectomy (PRK) we tested 21 treated eyes with contrast sensitivity. (Refract Corneal Surg (suppl) 1993;9:S70-S72.

- P-2) Ambrosio, MD Gennaro, Cennamo, MD, Giovanni, De Marco, MD, Rocco, Loffredo, MD Luciano, Rosa, MD, Nicola, Sebastiani, MD, Adolfo Visual Function Before and After Photorefractive Keratectomy for Myopia. Journal of Refractive & Corneal Surgery Volume 10 March/April 1994

Abstract:

**BACKGROUND:** To date, Snellen visual acuity and postoperative refraction have been used to evaluate the results of photorefractive keratectomy. However, other parameters, such as contrast sensitivity function and glare, may be affected by refractive surgery and lead to unsatisfactory visual performance. This prospective study is aimed at evaluating the effect of photorefractive keratectomy on contrast sensitivity function and glare.

**SUBJECTS AND METHODS:** Static contrast sensitivity function, dynamic contrast sensitivity function, and glare Sensitivity were evaluated in 22 myopic eyes before as well as 1, 3, and 6 months after photorefractive keratectomy. The eyes tested were divided into three groups, according to the amount of myopia: group I, from -4.00 to -8.00 diopters (D); group II, from -8.25 to -11.00 D; group III, from -11.25 to -20.00 D.

**RESULTS:** Both static and dynamic contrast sensitivity function at the intermediate spatial frequencies were altered at 1 month after photorefractive keratectomy, with a trend toward recovery at 3 and 6 months postoperatively. Glare sensitivity was not significantly affected by surgery.

**CONCLUSIONS:** Contrast sensitivity function and glare testing may show abnormalities in the presence of optimal visual and refractive results. These tests may result especially important for the evaluation of new refractive surgical procedures. [J Refract Corneal Surg. 1994;10:129-136.]

- P-3) Shimizu, MD, Kimiya, Amano, MD, Shiro, Tanaka, MD, Shunichi Photorefractive Keratectomy for Myopia: One-year Follow-Up in 97 Eyes. Splmnt. to Jo. Refractive & Corneal Surgery Volume 10 March/April 1994

Abstract:

We made a comprehensive study of 97 eyes that received photorefractive keratectomy (PRK) for myopia and followed them for one year. In 95 eyes, uncorrected visual acuity improved and best corrected acuity remained unchanged. In eyes with myopia of more than -3.0 diopters (D), the postoperative refraction was within -1.0 D of attempted correction. Predictability decreased with the higher myopia. We also examined the changes of both epithelium and endothelium with the specular microscope and found no significant changes after photorefractive keratectomy.

Videokeratography showed an average of inferior decentration in most eyes by 0.51 m +/- 0.31 (n-60); only one clinical problem was noted-one eye experienced monocular diplopia for seven months. Pachometry showed a small percentage had corneal thinning-the amount depended on the degree of myopia. A rise in intraocular pressure over 21 mm Hg was observed in 8.9% of eyes but it was controlled without surgery. Haze was observed in most eyes, but faded gradually without significant problems. Reduced contrast sensitivity in night vision was noted and some patients experienced glare. Day vision contrast sensitivity was related to corneal haze. [J Refract Corneal Surg. 1994;10:S178-S187.]

**REFRACTIVE SURGERY** Continued

- P-4) Schallhorn, S.D., Blanton, C.L., Kaupp, S.E., Sutphin, J., Gordon, M., Goforth Jr., H. and Butler, Jr. F.K. *Preliminary Results of Photorefractive Keratectomy in Active-duty United States Navy Personnel.* Ophthalmology. Vol 103, No 1, January 1996

Abstract:

To evaluate the safety, efficacy, and quality of vision after photorefractive keratectomy (PRK) in active-duty military personnel.

- P-5) Guimaraes, R., M.D., Staar Surgical Company: *Study: ICL Shows Good Results* Ocular Surgery News July 2000

Abstract:

ICL Surgeries in Latin America results of the top ten surgeons. STAAR ICL

- P-6) Montes-Mico, R., and Charman, W. N., *Mesopic Contrast Sensitivity Function After Excimer Laser Photorefractive Keratectomy.* Journal of Refractive Surgery. Vol 18, January/February 2002:18:9-13

Abstract:

**PURPOSE:** To evaluate contrast sensitivity under mesopic conditions in patients who had undergone uncomplicated excimer laser photorefractive keratectomy (PRK) for myopia.

**METHODS:** Monocular contrast sensitivity function was measured with the Stereo Optical F.A.C.T. chart in 26 patients who had received PRK using the Nidek EC-5000 excimer laser system. Mean preoperative refractive error was  $-6.23 \pm 1.69$  D (range, -4.00 to  $-8.25$  D); postoperatively, mean refractive error was  $-0.36 \pm 0.58$  D (range, -0.75 to + 0.50 D) Contrast sensitivity function was measured 6 months after surgery using four different chart luminances: 85, 5.0, 2.5 and  $0.1 \text{ cd/m}^2$ , the first being a photopic level and the rest mesopic. A control group of eight emmetropic subjects was also studied to allow comparison of results for statistical purposes.

**RESULTS:** Logarithmic values of contrast sensitivity at each spatial frequency were used for statistical analysis and normalize values were used for graphical representation. The results showed a statistically significant reduction ( $P < .01$ ) in contrast sensitivity for the PRK patients in comparison with the control group under mesopic conditions for each spatial frequency tested (1.5, 3, 6, 12 and 18 c/deg, although no significant contrast sensitivity differences were observed between PRK and control groups at the photopic ( $85 \text{ cd/m}^2$ ) level ( $P > .01$  for all frequencies)...

**CONCLUSION:** Photorefractive keratectomy can induce significant reductions in contrast sensitivity under mesopic conditions, even though the photopic contrast sensitivity function is normal.

- P-7) Kaiserman, I, MD, MSc, Hazarbassanov, R MD, Varssano, D, MD and Grinbaum,

Abstract:

**PURPOSE:** To Compare the effects on contrast sensitivity of wave front-guided (WFG) versus standard LASIK.

**DESIGN:** Prospective, nonrandomized, comparative clinical study.

**PARTICIPANTS:** Twenty-four eyes of 13 consecutive patients (mean age,  $25.2 \pm 8.4$  years; spherical equivalent, -0.5 to -4.25 diopters [D]) treated with WFG LASIK (WaveLight-Allegretto scanning-spot laser and wave front analyzer) and 22 eyes of 12 consecutive patients (mean age,  $28.4 \pm 9.1$  years; spherical equivalent, -0.75 to -4.5 D) treated with standard LASIK (WaveLight-Allegretto scanning-spot laser).

**METHODS:** Best-corrected contrast sensitivity was measured before and 1 month after surgery in both the WFG LASIK group and the standard LASIK group. A sine-wave contrast sensitivity test (functional acuity contrast test) was used to measure contrast sensitivity at 5 spatial frequencies (1.5, 3, 6, 12, and 18 cycles/degree). We compared the LASIK-induced changes in contrast sensitivity in each group at each spatial frequency.

**MAIN OUTCOME MEASURE:** The effect on contrast sensitivity of WFG LASIK versus standard LASIK.

**RESULTS:** Uncorrected visual acuity of 20/20 or better was achieved by 72% of eyes treated with WFG LASIK and by 70% of the eyes treated with standard LASIK. One month after LASIK, 88% of the contrast sensitivity measurements improved in the WFG LASIK group, whereas in the standard LASIK group, only 40% of the contrast sensitivity measurements improved. The contrast sensitivity improvement was significantly larger in the WFG LASIK group at all spatial frequencies ( $<0.05$ ). The WFG LASIK patients had a negative correlation between the changes in contrast sensitivity and the preoperative refractive error.

**CONCLUSIONS:** The ability of WFG LASIK to correct optical aberrations results in significantly improved contrast sensitivity compared with standard LASIK 1 month after surgery.

P-8) Perez-Carrasco MJ, Sanchez-Ramos C, Puell-Marín MC, Langa-Moraga A, Perez-Perez JM  
Ageing and Mesopic Pupil Diameter in Drivers *Dept Optics, Optic and Optometry School, UCM (Spain)*

**Abstract:** The rising mean age of the population has meant an increased need for understanding the physiologic consequences of ageing on visual function. Optical changes in the aged eye, such as pupillary miosis, increased lens density and impaired dark adaptation may contribute to older drivers having serious difficulty in mesopic visual performance, even in the absence of eye disease. In large populations of drivers, poor vision has been correlated with accident rates.

After the age of 45 years, the eye shows a more rapid increase in forward scatter and a reduction in contrast sensitivity. Photopic pupil diameter was found to diminish with age, but the difference was not significant.

It is known that pupil size does not affect photopic contrast sensitivity. In a recent study, photopic contrast sensitivity in subjects of all age groups did not differ significantly according to their pupil diameters.

In adult-drivers, a negative effect of age was observed on mesopic contrast sensitivity with and without glare.

Our aim was to determine, under mesopic conditions, the effect of age on pupil diameter, visual acuity and contrast sensitivity in a large sample of adult-drivers.

## **SPORTS VISION**

Q-1) Love, P.A. Ph.D. and Kluka, D.A., Ph.D. *Contrast Sensitivity Function in Elite Women and Men Softball Players*, Intl J of Sports Vision December, 1992

Abstract:

Of particular importance to elite softball success are visual abilities. One set of such abilities is contrast sensitivity function (CSF). The purpose of this investigation was three-fold: (1) to determine if significant differences in CSF scores occurred between the left and right eyes of elite men and women softball players; (2) to determine if significant differences in CSF scores occurred between elite men and women softball players; and (3) to determine if significant differences in CSF scores occurred between those selected for the 1991 men's and women's Pan American Games softball teams and those who were not. A total of 72 subjects qualified to participate in the investigation. Thirty six elite men and 36 elite women softball players were assessed at the 1991 Pan American Games softball team tryouts held at the USOTC-CS. Subjects ranged between the ages of 17 and 47 years. Each subject was preliminarily screened for SVA-distance, lateral/vertical phorias, stereopsis, and color perception. CSF was assessed at 1.5, 3, 6, 12, and 18 cpd using the Stereo Optical Company's Optec 2000 Vision Tester. Each subject was assessed monocularly; eye initially assessed was randomly determined. A 3 X 2 factorial analysis of variance ( $\alpha = .05$ ) was used to analyze data. No significant differences were noted between left and right eyes of elite softball players. Additionally, elite women softball players displayed significantly higher CSF at lower and higher spatial frequencies than elite male softball players. Finally, those elite softball players selected for the 1991 Pan American softball teams had significantly higher CSF at the lowest spatial frequency assessed.

Q-2) Kluka, D.A., Ph.D., and Love, P.A. Ph.D. *The Effects of Daily-Wear Contact Lenses on Contrast Sensitivity in Selected Professional and Collegiate Female Tennis Players*, Jo Am Optom Assn 1993; 64:182-6

Abstract:

Contrast sensitivity (CS) has recently emerged as an important predictor of visual performance. Few studies, however, have been published involving CA and its role in vision for sport. The purpose of this investigation was to determine if significant differences occurred in CS between female professional and collegiate tennis players who wore daily-wear soft contact lenses (N=10) and those players who wore no corrective lenses (N=10) in competition as measured by the stereo Optical Optec 2000 Vision Tester. Subjects were between the ages of 18 and 37 years. Mean ages were 21.76 ( $\pm 4.018$ ) and 25.40 ( $\pm 5.379$ ) years for those wearing lenses and those not, respectively. Each subject was preliminarily screened for SVA-distance, lateral/vertical phorias, stereopsis and color perception. All subjects were within accepted limits. CS was assessed at 1.5, 3, 6, 12, and 18 cycles per degree (cpd). Each subject was assessed monocularly; eye initially assessed with determined randomly. A 2x2 factorial analysis of variance ( $\alpha=.05$ ) was used to analyze data. No significant differences were found at 3, 6, 12, and 18 cpd. It may be concluded that those female professional and collegiate tennis players wearing no corrective lenses were significantly higher in CS at intermittent and high spatial frequencies than those who wore daily-wear soft contact lenses in competition.

## **SPORTS VISION** Continued

Q-3) Teig, D.S., O.D. *Building A Sports Vision Practice*, Optom Economics April 1993

Abstract:

In my travels around the country, lecturing to colleagues about the virtues of sports vision, I am often confronted with a question: "Sports vision is a lot of fun, but can you make a living from it?" In our practice the answer is a resounding "yes". From humble beginnings 19 years ago, in a 750-square-foot storefront office, sports vision has allowed my practice to grow to a 3,500-square-foot office in a beautiful new professional building. From a one-doctor, one-assistant setting, The Institute for Sports Vision is now a three-doctor, two-trainer, four-office-staff facility.

Either directly or indirectly, approximately 50 percent of our practice earnings derive from sports and recreationally active patients. With the addition of our new Mobile Eye Gym we have "taken our show on the road," providing comprehensive sports vision performance evaluations to athletes on-site.

Q-4) Christenson, G.N., Winkelstein, A.M., *Visual Skills of Athletes Versus Nonathletes: Development of a Sports Vision Testing Battery*, Jo of The Amrcn Optm Assn. Volume 59, Number 9, 9/88.

Abstract:

The field of sports vision has a fundamental premise that athletes require superior visual abilities to succeed in their sporting activity. This study takes a scientific look at what appear to be sports related visual abilities using a clinical battery of vision tests to compare the visual performances of athletes to nonathletes. Significantly better visual performances were found to exist in the athletic population for certain visual skills, vergence facility, saccades, visual reaction time, peripheral awareness and near point of convergence. The tests for accommodative facility, visual proaction time, span of recognition distance phoria and distance stereopsis did not yield a statistically significant difference between the groups. These results provide a foundation for the development of a research based sports vision testing battery.

Q-5) Kluka, D.A., Love, P.A., *Contrast Sensitivity in Elementary and College-Aged Females Participating in Daily Physical Education Programs*.

Abstract:

For over a century, the Snellen Eye Chart has been used to measure static visual acuity. Designed as an assessment tool for an individual's ability to resolve fine spatial detail through graduated letter recognition, it alone seems to be a poor predictor of visual performance for sport (Burg, et. al, 1966; Owsley, et. al, 1982). Contrast Sensitivity Function (CSF) has recently emerged as an important predictor in the assessment of visual performance (Ginsburg, 1983; Jindra, et. al, 1989). Nearly one thousand investigations have been published involving CSF. Few studies, however, have been published involving CSF and its role in vision for sport. The purpose of this investigation was to determine whether differences existed in Contrast Sensitivity Function between elementary and college-aged females who participated in daily indoor and outdoor physical activity which included striking activities.

Q-6) Kluka, D.A., Ph.D., Love, P.A. Ph.D., Kuhlman, J., Ph.D., Hammock G, O.D., and Wesson, M.D., O.D., M.S., *The Effects of a Visual Skills Training Program on Selected Female Intercollegiate Volleyball Athletes* Intl Jo Sports Vision 1996; 3,1

Abstract:

The purpose of this investigation was three-fold: (1) to develop a test battery which assessed necessary visual skills specific to volleyball; (2) to develop a visual skills training program specific to volleyball for use in this investigation; and (3) to determine the effect of the training program upon selected intercollegiate women volleyball athletes.

## **SPORTS VISION** Continued

- Q-7) Love, P.A. Ph.D., Kluka, D.A., Ph.D., Cobb, T.D., M.S., *The Effects of Blood Glucose Levels of Contrast Sensitivity Function In Female Athletes*, Intl Jo Sports Vision 1996; 3,1

### Abstract:

The purpose of this investigation was two-fold: (a) to determine the impact of time upon blood glucose levels and contrast sensitivity function (CSF) and (b) to determine the best linear combination of CSF scores and glucose levels of female athletes during aerobic exercise. Subjects were 10 female athletes between the ages of 18 and 30 years ( $M = 22.10$ ;  $SD = 3.70$ ). Work protocol for the aerobic exercise involved pedaling a bicycle ergometer for 60 minutes at a workload which elicited a heart rate equal to 65% of each subject's maximum heart rate reserve (Karvonen et al., 1957). The subject's CSF and blood glucose levels were assessed pre-exercise, at 15 minutes, 30 minutes, 45 minutes and postexercise (60 minutes). a multivariate analysis of variance for repeated measures with one within subject factor (time) and two dependent variables (CSF and glucose) was used as the statistical method of choice for the glucose and CSF tests. Time had a statistically significant impact ( $p < .05$ ) on CSF scores at 6.0 cpd. Time had no significant impact upon glucose levels.

## **NEUROTOXICOLOGY**

- R-1) Hudnell, H.K. and Benignus, V.A., *Carbon Monoxide Exposure and Human Visual Detection Thresholds* Neurotoxicology and Teratology, Vol. 11, pp. 363-371 1989

### Abstract:

In order to test for CO exposure effects on vision, a battery of visual tests was administered to male college students. All subject completed the battery of tests both before and during an exposure period in a double-blind study. Experimental subject received CO during the exposure period, whereas control subjects received only room air. The battery of visual tests was designed for the assessment of scotopic (dark adapted, rod mediated) detection, photopic (light adapted, cone Mediated) detection, the pattern detection process and the motion detection process. Contrast thresholds for the detection of stimulus pattern and for the detection of stimulus motion were measured under both photopic and scotopic viewing conditions, and sensitivity was monitored throughout the course of dark adaptation by measuring luminance thresholds. The results indicated that visual function in healthy, young-adult males was not affected by a COHb level of about 17% which was maintained for over 2 hours.

- R-2) Hudnell, H.K., Skalik, I., Otto, D., House, D., Subrt, P., and Sram, R. *Visual Contrast Sensitivity Deficits in Bohemian Children* Neurotoxicology and Teratology, Vol. 17, pp. 615-628, 1996

### Abstract:

Visual contrast sensitivity (VCS) tests have been used successfully in medical diagnosis and subclinical neurotoxicity detection. This paper reports VCS measurements in three studies of children in the Czech Republic. Study 1 compared children in standard schools and schools for the learning disabled. Studies 2 and 3 compared children in Teplice, an area in which soft-brown coal combustion produced high levels of pollutants (e.g. Hg, As, SO<sub>2</sub>, NO<sub>x</sub>, and aromatic hydrocarbons), with children in areas of low air pollution, Znojmo and/or Prachatice. It was hypothesized that in utero exposure to the combustion products disrupted neurological development (Sram 1991). The VCS test (Stereo Optical Co.) consisted of circular field containing sinusoidal gratings at 5 spatial frequencies (1.5 - 18 cycles/degree) and various levels of contrast. Subjects indicated orientation of the gratings by pointing left, up, or right. Visual acuity and VCS were measured in each eye of 74 children in Study 1, 327 second-grade children in Study 2, and 426 fourth-grade children in Study 3. Hair samples were collected in Studies 2 and 3 and analyzed for Hg and As content. Children attending schools for the learning disabled scored significantly lower than controls on VCS, whereas visual acuity was normal. The deficit was greatest at mid- to high spatial frequency, even though visual acuity was slightly above control level. Regression analyses showed that VCS had no relationship to As, but a significant negative correlation with hair Hg was observed in the exposed district. However, current Hg levels were higher in Prachatice. VCS deficits were not observed in the fourth-grade students of Teplice in Study 3. The results of Study 1 indicated that behavioral VCS testing in field studies is practical in young, non-English speaking children, and suggested that vision may be compromised in learning-disabled children. Studies 2 and 3 indicated that at these levels, current Hg body-burdens are poor predictors of VCS. If the VCS deficits seen in Study 2 were related to prenatal exposures, the results of Study 3 suggest that they represent a

developmental delay. a longitudinal-study design is needed to address this issue.

## **NEUROTOXICOLOGY** Continued

R-3) Broadwell, D.K., Darcey, D. J., Hudnell, H.K., Otto, D.A., and Boyes, W.K., *Work-Site Clinical and Neurobehavioral Assessment of Solvent-Exposed Microelectronics Workers. American Journal of Industrial Medicine* Vol. 27, pp. 677-698 1995

### Abstract:

Twenty-five workers, five currently and 20 formerly involved in the manufacture of hybrid microcircuits, underwent clinical evaluations at the request of a management-union committee concerned about chronic solvent exposures in a research and development laboratory. A battery of neurobehavioral tests was administered to compare the solvent-exposed group with 32 age-, gender-, ethnicity-, and education-matched controls. The tests included: MMPI-I, hand grip strength, tactile sensitivity, dexterity, color discrimination, visual acuity and contrast sensitivity, and tests selected from the computerized Neurobehavioral Evaluation System (NES2). Clinical narratives and retrospective exposure assessments in the study group suggested chronic low-level exposure to solvents, with intermittent acute excursions. Work-related diagnoses included upper respiratory mucosal irritation and sinusitis (44%), lower respiratory reactive airway disease (12%), and dermatitis (5%). Three workers (12%) had findings consistent with a solvent-induced encephalopathy. Significant differences (after Bonferroni correction) were found between the two groups on 5 of 11 NES subtests: symptom scale, mood scale, finger tapping, simple reaction time, and symbol-digit substitution. Differences also reached significance for overall vibration sensitivity thresholds, visual contrast sensitivity, and grip strength. The MMPI average clinical scale elevation was significantly higher in the exposed group than controls. These results support an association between chronic low-dose solvent exposure and measurable neurobehavioral changes.

R-4) Hudnell, H.K., Boyes, W.K., Otto, D.A., House, D.E., Creason, J.P., Geller, A.M., Darcey, D.J., Broadwell, D.K. *Battery of Neurobehavioral Tests Recommended To ATSDR: Solvent-Induced Deficits in Microelectronic Workers. Toxicology and Industrial Health* Vol. 12, No. 2 1996

### Abstract:

The Agency for Toxic Substance and Disease Registry (ATSDR) convened a workshop (Anger et al. In press) to recommend a battery of neurobehavioral tests for use in environmental health field studies of adults. The proposed battery included 14 core tests, as well as secondary tests, for assessing sensory, motor, and cognitive function and effect. Acting on the recommendation, ATSDR published a description of the Adult Environmental Neurobehavioral Test Battery (AENTB), which included 13 core and secondary tests (ATSDR 1992). We implemented 12 core, 2 secondary, and 4 other tests in a study of microelectronic workers (MEW) chronically exposed to low-level solvent mixtures (Broadwell et al. In press).

Our test battery resulted in 92 variables that could be used in statistical analyses to test for differences in exposure groups. Although many studies of solvent-induced neurotoxicity have produced large numbers of variables (bibliography in Cranmer and Goldberg 1986), no systematic and comprehensive data-analysis plan has been proposed. an analysis plan is needed to strike an appropriate balance between two opposing factors: false-positive and false-negative results.

The probability of obtaining false-positive results increases with both the number of variables and the significance level (alpha) of each test. In our study, for example, analysis of each of the 92 variables at an alpha level of 0.05 would lead to about five false-positive results on average. Conclusions drawn from false-positive results could cause unnecessary concern among the public. However, the use of conservative statistical procedures to guard against false-positive results, such as Bonferroni corrections, lead to an inordinate loss of statistical power. The result is a loss of sensitivity for detecting subclinical neurologic deficits, or an increased probability of false-negative results.

We have begun to develop a data-analysis plan that addresses this issue and is appropriate for use with the AENTB and similar batteries of tests. The plan is based on the premise that the optimal balance of false-positive and false-negative result probabilities can be achieved by reducing the number of group comparisons in the first level of statistical analysis while using as many of the data as possible. Statistical methods that have been used thus far and their results are reported. The influence of vision on the computerized test results, which are generally considered to reflect cognitive and motor function, is also discussed.

## **NEUROTOXICOLOGY** Continued

- R-5) Hudnell, H.K., Otto, D.A., and Sizemore, O.J., Neurobehavioral Tests Of Visual, Cognitive, and Motoric Functions in Relationship to Neurotoxicant-Induced, Neurodegenerative Disease *Ntnl Hlth & Nutrition Examination Survey*, 1998

Abstract:

The National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency proposes the administration of neurobehavioral tests of visual, cognitive, and motoric function in NHANES IV participants. The goals are to establish national population parameters for these tests, and to assess relationships between neurological function, neurotoxicant exposures, neurodegenerative diseases, and other factors. In conjunction with blood and urinary measures proposed by CDC, the proposed tests would allow assessments of relationships between functions in the three domains of the central nervous system and exposures to volatile organic compounds, pesticides, and selected metals. One emphasis is on susceptible populations, children and the elderly, who are considered to be particularly susceptible subsets of the general population to adverse-health effects of chemical exposure. The young are thought to be particularly at risk to neurotoxicant exposures due to the decline in reserve-neurological capacity and protective/compensatory mechanisms. Another emphasis is solvent-induced effects. An emerging body of evidence suggests that neurobehavioral tests of vision may reveal some of the earliest, subclinical, adverse-health effects of solvent exposure in humans.

all of the recommended tests are in the battery of tests which were recommended to the Agency for Toxic Substances and Disease Registry for use in field studies of health effects in humans living near toxic waste sites (Anger, et al. 1994), ultimately included in the ATSDR battery (ATSDR, 1995), and shown to be highly sensitive to low-level, solvent-induced effects (Hudnell et al., 1996). Measurement of visual acuity and visual-contrast Sensitivity (VCS) are requested in all subjects of 7 years or greater in age. The cost of one set of equipment is approximately \$600.00, and the time needed for testing is approximately 8 minutes. It is further proposed that color-discrimination data be collected from all subjects of 10 years or greater in age. The cost of one set of equipment is approximately \$259.50, and the time needed for testing is approximately 7 minutes. Three computerized-neurobehavioral tests of cognitive and motoric functions (Symbol-digit substitution, simple-reaction time, and finger tapping tests) from the Neurobehavioral Evaluation System 2 (NES) are requested for all individuals from the ages of 7 to 19 years, and individuals older than 60 years of age. NES data was collected from the intermediate age range in NHANES III, obviating the need for this data in NHANES IV. The cost of one set of computerized-equipment is approximately \$2,500.00 (equipment used in NHANES III may be reusable), and the time needed for the computerized testing is approximately 15 minutes. The entire battery of tests will require 30 for completion.

The proposed research addresses the priority research areas in EPA's Strategic Plan for the Office of Research and Development of Human Health Protection and Indoor Air in the project categories of susceptible populations, hazard identification, chemical-specific data, and volatile organic compounds. The complimentary Public Health Significance Issues of NCHS which are addressed include surveillance, prevention, untreated disease, health promotion/disease prevention, research for public health policy, and standardization.

- R-6) Dahr, R., White, R.F., Weihe, P., Sorensen, N., Letz, R., Hudnell, H.K., Otto, D. A., and Grandjean, P., *Feasibility and Validity of Three Computer-Assisted Neurobehavioral Tests in 7-Year Old Children* *Neurotoxicology and Teratology*, Vol. 18, No. 3, pp. 1-8, 1996

Abstract:

Three tests from the computerized Neurobehavioral Examination System (NES) were administered to a group of 917 Faroese children at approximately 7 years of age. The NES Continuous Performance Test (CPT) was modified to use animal silhouettes as stimuli instead of letters. Almost all children completed Finger Tapping (FT), the modified CPT, and Hand-Eye Coordination (HE). However, 18% of the children missed at least 25% of the stimuli on the CPT (full test period), and 27% of the children did not improve their HE performance by at least 10%, as compared to the first trial. Boys obtained better results than girls, and older children performed better than younger ones. However, both factors were confounded by acquaintance with computer games. Children who used glasses, who had strabismus, or who had decreased contrast sensitivity obtained less satisfactory scores, especially on CPT and HE. The NES performance was significantly associated with functional neurological performance, including catching a ball, diadochokinesia, and finger agnosia. Slight, though statistically significant, decrements were seen with increased levels of prenatal exposure to neurotoxicants, as indicated by the mercury concentrations in cord blood obtained at the time of birth. In conclusion, the

tests were feasible in this age group after slight modifications, and the test results showed meaningful associations with major predictors, thus supporting the validity of the data.

## **NEUROTOXICOLOGY** Continued

- R-7) Hudnell, H.K., Otto, D.A., and House, D.E., *The Influence of Vision on Computerized Neurobehavioral Test Scores: A Proposal for Improving Test Protocols* Neurotoxicology and Teratology, Vol. 18, No. 4, pp. 1-11, 1996

### Abstract:

Computerized tests of neurobehavioral function are frequently administered in neurotoxicological studies with little attention given to the optical properties of test stimuli or to the vision of subject. Yet many test stimuli are small or briefly presented, and tests endpoints often involve short reaction times. Stimulus detection and reaction time are known to be strongly dependent upon stimulus luminance, contrast, and size, as well as on the subject's visual abilities. The current study assessed the influence of visual contrast sensitivity on Neurobehavioral Evaluation System 2 (NES2) test results in three data sets. Analyses indicated that vision was associated with up to 24% of the variance (Hand-Eye Coordination test0 in NES2 scores, even when visual acuity was normal, and that vision often influenced the significance of group differences. It is suggested that researchers measure the luminance, contrast, and size of test stimuli, the distance from the subject's eyes to the monitor, and the subject's visual contrast sensitivity. The measurement and control of stimulus parameters and the inclusion of visual function scores in analysis models could reduce the variability among computerized test scores both within and between studies. Models that assess the influence of vision on computerized test results may help to identify the CNS domains and specialized functions adversely affected by neurotoxicant exposures.

- R-8) Kronemeyer, Bob, Visual Contrast Sensitivity Test Helps Screen for Ciguatera, Infectious Disease News, March 2001,42.

### Abstract:

F.A.C.T. Contrast Sensitivity was used to diagnose and monitor a double-blind placebo-controlled cholestyramine clinical trial for patients with possible chronic ciguatera. For the patients treated with cholestyramine, contrast sensitivity function improved along with their symptoms.

- R-9) Shoemaker, R., Hudnell, H.K., *Possible Estuary-Associated Syndrome: Symptoms, Vision and Treatment* Grand Rounds: Environmental Health Perspectives Volume 19, No. 5, May 2001

### Abstract:

The human illness designated as possible estuarine-associated syndrome (PEAS) by the Centers for Disease Control and Prevention (CDC) has been associated with exposure to estuaries inhabited by toxin-forming dinoflagellates, including members of the fish-killing toxin *Pfiesteria* complex (TPC), *Pfiesteria piscicida* and *Pfiesteria shumwayae*. Humans may be exposed through direct contact with estuarine water or by inhalation of aerosolized or volatilized toxin(s).

The five cases reported here demonstrate the full spectrum of symptoms experienced during acute and chronic stages of this suspected neurotoxin-mediated illness. The nonspecific symptoms most commonly reported are cough, secretory diarrhea, headache, fatigue, memory impairment, rash, difficulty in concentrating, light sensitivity, burning skin upon water contact, muscle ache, and abdominal pain. Less frequently encountered symptoms are upper airway obstruction, shortness of breath, confusion, red or tearing eyes, weakness and vertigo. Some patients experience as few as four of these symptoms. The discovery that an indicator of visual pattern-detection ability, visual contrast sensitivity (VCS), is sharply reduced in affected individuals has provided an objective indicator that is useful in diagnosing and monitoring PEAS. VCS deficits are present in both acute and chronic PEAS, and VCS recovers during cholestyramine treatment coincident with symptom abatement. Although PEAS cannot yet be definitively associated with TPC exposure, resolution with cholestyramine treatment suggests a neurotoxin-mediated illness. Key words: cholestyramine, chronic neurotoxic illness, harmful algal blooms. *Pfiesteria*, possible estuary-associated syndrome, visual contrast sensitivity, Environ Health Perspect 109: 539-545 (2001)

## **NEUROTOXICOLOGY** Continued

R-10) Shoemaker, R., *Residential and Recreational Acquisition of Possible Estuary-Associated Syndrome: A New Approach to Successful Diagnosis and Treatment*  
*Environmental Health Perspectives* Volume 109, No. 5, October 2001

### Abstract:

Evidence suggests that the estuarine dinoflagellates, *Pfiesteria piscicida* Steidinger & Burkholder and *P. shumwayae* Glasgow & Burkholder, members of the toxic *Pfiesteria* complex (TPC), may release one or more toxins that kill fish and adversely affect human health. In the current study we investigated the potential for undiagnosed cases of possible estuary-associated syndrome (PEAS), as termed by the Centers for Disease Control and Prevention (CDC), in a population that had residential and/or recreational exposure to TPC-affected estuaries, but that did not have direct contact with fish kills or lesioned fish. Age-adjusted visual contrast sensitivity (VCS) was significantly lower and the presence of PEAS-associated symptoms was much higher in the estuary cohort (n = 77) than in combined-control cohorts (n = 87), one without exposure to bodies of water (n = 53) and one with exposure to marine waters (n = 34). In the estuary cohort, 37 individuals met the CDC case definition for PEAS and had significantly lower VCS than non-PEAS cases. The VCS improved and symptoms abated after 2 weeks of treatment with cholestyramine. Cholestyramine, the original drug approved for treatment of hypercholesterolemia, has previously been reported to enhance the elimination rates of a variety of toxins, presumably by interruption of enterohepatic recirculation through toxin entrapment in its polymeric structure and/or anion-exchange process. Control studies showed that repeated VCS testing alone did not improve VCS scores and that cholestyramine treatment did not affect VCS in patients with elevated cholesterol levels. These results suggested that a) susceptible individuals may acquire PEAS through residential and/or recreational contact with TPC-affected estuaries in the absence of an active fish kill; b) VCS is a useful indicator in PEAS diagnosis and treatment monitoring; and c) PEAS can be effectively treated with cholestyramine. Because the study did not use population sampling techniques, the results do not indicate PEAS prevalence. Furthermore, definitive diagnosis of PEAS and association with TPC toxin(s) must await identification of, and a serologic test for, the putative TPC toxin(s). key word: cholestyramine, chronic neurotoxic illness, harmful algal blooms, *Pfiesteria*, possible estuary-associated syndrome, visual contrast sensitivity.