SHORT PHOTOESSAY: Krachmer’s Spots

COMMENTARY: A Complete Refractive Education

CLINICAL REVIEWS AND RESEARCH:
Studies on the Relationship of Lag of Accommodation with Dissociated Phoria
Refractive Error Changes in Patients with Amblyopia

BOOK REVIEWS:
Renaissance Vision from Spectacles to Telescopes
A Brief Tour of Human Consciousness
The Wisdom Paradox
Ophthalmology Made Ridiculously Simple
This issue offers items on a variety of topics. It leads off with a short photoessay on Krachmer’s spots. In a commentary piece, IU grad John Potter offers some opinions regarding the profession’s obligations in the area of refractive surgery.

Clinical reviews examine the relationship of lag of accommodation with dissociated phoria and the refractive changes characteristic of amblyopia. The issue closes with four book reviews, one on a book on the history of spectacles in Renaissance Italy, two on books examining aspects of neurology, and one small book emphasizing major points in ophthalmology.

David A. Goss
Editor

ON THE COVER: Krachmer’s spots. See the photoessay on page 2

Correspondence and manuscripts submitted for publication should be sent to the Editor: David A. Goss, School of Optometry, Indiana University, Bloomington, IN 47405 USA (or dgoss@indiana.edu). Business correspondence should be addressed to the Production Manager: J. Craig Combs, School of Optometry, Indiana University, Bloomington, IN 47405 USA (or jocombs@indiana.edu). Address changes or subscription requests should be sent to Sue Gilmore, School of Optometry, Indiana University, Bloomington, IN 47405 USA (or sgilmore@indiana.edu).

Our appreciation is extended to Essilor of America for financial support of this publication.

Varilux® is a registered trademark of Essilor International, S.A
TABLE OF CONTENTS

SHORT PHOTOESSAY:
KRACHMER’S SPOTS, BY M.Y. SHAIKH AND H.S. DUA......................2

COMMENTARY:
A COMPLETE REFRACTIVE EDUCATION, BY JOHN POTTER..............3

CLINICAL REVIEWS AND RESEARCH:
STUDIES ON THE RELATIONSHIP OF LAG OF ACCOMMODATION WITH DISASSOCIATED PHORIA, BY DAVID A. GOSS AND BILL B. RAINEY ......5

REFRACTIVE ERROR CHANGES IN PATIENTS WITH AMBLYOPIA:
LITERATURE REVIEW AND CASE REPORTS, BY DAVID A. GOSS, KRISTEN RABAUT, AND JILLIAN LOEBACH .............9

BOOK REVIEWS:
RENAISSANCE VISION FROM SPECTACLES TO TELESCOPES,
REVIEWED BY DAVID A. GOSS ..................................................14

A BRIEF TOUR OF HUMAN CONSCIOUSNESS,
REVIEWED BY PAUL A. HARRIS .............................................16

THE WISDOM PARADOX, REVIEWED BY DAVID A. GOSS .............19

OPHTHALMOLOGY MADE RIDICULOUSLY SIMPLE,
REVIEWED BY SUBHASH N. JANI ..........................................20

Statement of Purpose: The Indiana Journal of Optometry is published by the Indiana University School of Optometry to provide members of the Indiana Optometric Association, Alumni of the Indiana University School of Optometry, and other interested persons with information on the research and clinical expertise at the Indiana University School of Optometry, and on new developments in optometry/vision care.

The Indiana Journal of Optometry and Indiana University are not responsible for the opinions and statements of the contributors to this journal. The authors and Indiana University have taken care that the information and recommendations contained herein are accurate and compatible with the standards generally accepted at the time of publication. Nevertheless, it is impossible to ensure that all the information given is entirely applicable for all circumstances. Indiana University disclaims any liability, loss, or damage incurred as a consequence, directly or indirectly, of the use and application of any of the contents of this journal. This journal is also available on the world wide web at: http://www.opt.indiana.edu/IndJOpt/home.html
A 29-year-old gentleman who had undergone penetrating keratoplasty two years ago presented with subtle decrease in vision of one month duration. Examination revealed subepithelial infiltrates in the graft, suggestive of a form of epithelial graft rejection. These lesions are described as Krachmer’s spots after an American ophthalmologist who described it. These subepithelial infiltrates are small, discrete opacities located immediately beneath the Bowman’s membrane, diffusely scattered across the graft. The lesions can be subtle and are often missed with a narrow slit-lamp beam; they are best seen with a broad beam casting diffuse side illumination. They very closely resemble infiltrates of epidemic adenoviral keratoconjunctivitis. In the latter condition, however, the lesions are present both on graft and host cornea. Krachmer’s spots can herald an episode of the more serious type of corneal endothelial transplant rejection. They require treatment with topical corticosteroids. Their timely recognition and prompt treatment can be sight saving.

References
I am going to make an argument that refractive surgery should be a part of clinical care, education, and research in our profession. To me these three areas are all equal in significance, and when integrated into the art and science of optometric practice completely, we are all better for it, especially our patients.

It is fair to say that refractive surgery is already a part of optometric clinical care. Last year, more than 8,000 optometrists trusted TLC Laser Eye Centers alone with at least one patient from their practice. Certainly, there are optometrists who have been more active or less active in refractive surgery, but it is an undisputed fact that there are more optometrists who have trusted a refractive surgeon to care for one of their patients than there are ophthalmologists who have trusted a refractive surgeon to care for one of their patients. And, to the benefit of our patients, optometrists and ophthalmologists who do trust their patients to refractive surgeons are nearly always involved intimately in the patients’ pre-operative and post-operative care. And, in my opinion, this makes the continuing eye and vision care for a refractive surgery patient better overall and more vital. The broad optometric education that includes a curriculum with both clinical and vision sciences has made the understanding of eye and vision care in refractive surgery a more meaningful transition for clinicians, which may or may not be the case for ophthalmologists. And, this in part, may explain why optometrists are so much more involved with refractive surgery than ophthalmologists who do not perform refractive surgery themselves.

Education in refractive surgery is a different matter. Yes, there are continuing education opportunities for optometrists to learn more about refractive surgery and how it might benefit their patients. However, it is apparent that the schools and colleges of optometry are unclear on how to integrate refractive surgery into the refractive curriculum. And, this is not an issue for schools and colleges of optometry in isolation. Residency programs in ophthalmology have similar challenges with the integration of refractive surgery into their programs. And, even the role of refractive surgery in fellowship training is unclear.

Looking at optometric education in isolation for a moment, some of the issues seem to be as much related to contact lens care as anything else. A conservative view might be that no patient should be considered for refractive surgery unless they are absolutely contact lens intolerant. Indeed, someone might argue that even a patient who utilizes eyeglasses as their refractive treatment should first try contact lenses before pursuing refractive surgery. This thinking, of course, makes refractive surgery and contact lens care competitive, which I will argue they are not. And, the aforementioned reasoning is clearly not parallel to the thinking of the overwhelming majority of practitioners of the art and science of optometry as it is practiced today. Indeed, since the inception of TLC Laser Eye Centers more than a decade ago, the percentage of contact lens wearing patients has neither increased nor decreased significantly. If contact lens utilization increases or decreases, it is simply on the merits of that form of treatment for refractive errors alone. In fact, many successful optometrists tell me that when they added refractive surgery to their practice, their contact lens practice increased also as patients had and considered more options for the treatment of the refractive status than eyeglasses alone.

There are few courses in refractive surgery in the schools and colleges of optometry, even though there are laser eye surgery centers associated with many schools and colleges. In residencies in optometry, refractive surgery is usually a sideline of a cornea and contact lens residency, and I am not aware of accredited programs that are just refractive surgery, even though there are hundreds of optometrists who practice in the field of refractive surgery on a full-time basis and have made it a career choice. The Indiana University School of Optometry does offer an affiliated residency in Refractive and Ocular Surgery.

Research in refractive surgery is not as meaningful as it should be. Yes, it is true that there is good work done in the vision sciences,
although I would argue not enough. In the clinical sciences, the research in refractive surgery is much more limited, which is not good for refractive surgery or for patients. I will argue that optometrists have a unique perspective on vision and the eye that should be brought to bear on refractive surgery to make the experience better for the patient. Here is but one example: there is still not a clear consensus by anybody of authority in optometry regarding the cessation of contact lenses before refractive surgery. This is an important contribution to refractive surgery that could and should be addressed. Every clinical trial in refractive surgery addresses how long contact lenses should be removed before surgery, but where is the opinion of the optometric profession? There are postoperative issues that could and should be addressed, too. Recently, one of my colleagues and his associates completed research to be presented at the Association for Research in Vision and Ophthalmology (ARVO) meeting that shows that cyclosporine ophthalmic emulsion 0.5% (Restasis) use postoperatively may reduce enhancement rates following refractive surgery, and this is a great step forward. It is, however, not enough. There are many issues that could be addressed and they are not. What is the best approach to monovision treatments in refractive surgery? How can postoperative night vision problems be addressed better? Where and how to contact lenses play a role postoperatively in refractive surgery? What is the best progressive lens design for presbyopic correction following refractive surgery? And, there are many more.

Optometrists include refractive surgery in the care they provide their patients. It makes sense that optometric education, along with clinical and basic science research in the field of refractive surgery, should increase their roles in support of practitioners and their patients. It is in all our best interests to do so, especially for our patients.

John Potter, O.D., is Vice President for Patient Services for TLC Laser Eye Centers. He is an alumnus of the School of Optometry at Indiana University (1973). He can be reached by email at john.potter@tlcvision.com.
It is well known that increases in either accommodation or convergence are accompanied by increases in the other function and likewise that decreases in accommodation or convergence are associated with decreases in the other. As a consequence there may be correlations of dissociated phoria and lag of accommodation. This article discusses three studies on the relationship of those two variables. The first is a study of the relationship of monocular accommodative response and phoria which has previously only appeared in abstract form. The second is a study correlating binocular accommodative response with dissociated phoria. The third study to be discussed reported on the change in accommodative response from monocular to binocular conditions as a function of phoria. Some of the clinical implications of these studies will be discussed.

**Relationship of Dissociated Phoria and Monocular Accommodative Response**

Fifty-one non-presbyopic adults served as subjects in this study. Monocular accommodative response was measured with a Canon Autoref R-1 infrared autorefractor. This autorefractor has an open view of the environment made possible by an infrared reflecting mirror through which the subject views. Accommodative response measurements were taken while subjects viewed a Bernell Corporation Muscle Imbalance Measure (MIM) card placed at 50 cm from the spectacle plane. Dissociated phorias were taken with the modified Thorington test procedure using the MIM card. The Maddox rod used for taking the modified Thorington phoria was in place also during the accommodative response measurements, thus making those determinations under monocular conditions. Further details on testing phoria and accommodative response with these procedures are given in another publication.

Accommodative response and dissociated phoria were measured using five trial lens conditions over the habitual prescription, +2 D, +1 D, 0, -1 D, and -2 D. It was assumed that the habitual prescription exactly corrected the subjects’ refractive errors, so that in combination with the 50 cm working distance, the added lenses resulted in accommodative stimuli of 0, 1, 2, 3, and 4 D. Lag of accommodation was calculated by subtracting the accommodative response from the accommodative stimulus. A lead of accommodation was treated as a negative number. In calculations exophoria was treated as a negative number and esophoria as a positive number.

The range of lags of accommodation with the habitual prescription was -0.4 D (lead) to 1.4 D, with a median of 0.5 D. The range of dissociated phorias with the habitual was 13 prism diopters exo to 6 prism diopters eso. The Pearson coefficient of correlation of lag of accommodation with dissociated phoria with the habitual prescription was -0.20. The negative sign indicates that the lag had a tendency to decrease as the near phoria became more eso or less exo; but because the correlation coefficient was so low, it was only a slight trend. The correlation coefficients for other accommodative stimulus levels were quite low (Table 1). None of these correlation coefficients were statistically significant at the 0.05 level.

Subjects were also grouped into three dissociated phoria categories. Mean lags of accommodation for these phoria groupings are shown in Table 2. It appeared that the largest lags tended to be in the higher exo group, but the differences in lag between phoria groups were all less than 0.2 D. Those phoria groupings were made to yield roughly equal numbers of subjects in

**Table 1. Pearson coefficients of correlation of dissociated phoria with monocular lag of accommodation in the first study.**

<table>
<thead>
<tr>
<th>Accommodative stimulus (D)</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.05</td>
</tr>
<tr>
<td>1</td>
<td>-0.14</td>
</tr>
<tr>
<td>2</td>
<td>-0.20</td>
</tr>
<tr>
<td>3</td>
<td>-0.15</td>
</tr>
<tr>
<td>4</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

Table 2. Mean lags of accommodation for three phoria groups and five accommodative stimulus (AS) levels in the first study. Negative numbers indicate a lead of accommodation.

<table>
<thead>
<tr>
<th>Dissociated Phoria</th>
<th>Lag of Accommodation (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exo&gt;3 prism diopters (n=17)</td>
<td>-0.66 0.11 0.57 0.88 1.41</td>
</tr>
<tr>
<td>0.5-3 prism diopters exo (n=20)</td>
<td>-0.66 -0.01 0.47 0.69 1.36</td>
</tr>
<tr>
<td>Ortho and eso (n=14)</td>
<td>-0.70 -0.03 0.42 0.79 1.23</td>
</tr>
</tbody>
</table>
each group. When the subjects were categorized by the familiar Morgan’s norms, the mean lags of accommodation with the habitual prescription were: greater than 6 prism diopters exo, 0.58 D (n=7), ortho to 6 prism diopters exo, 0.47 D (n=38), and eso, 0.46 D (n=6).

**Relationship of Dissociated Phoria and Binocular Accommodative Response**

In this study, accommodative response and dissociated phoria were measured for a 40 cm viewing distance in 73 children with myopia. The subjects ranged in age from 7.2 to 14.7 years. Accommodative response was determined with a Canon Autoref R-1 autorefractor under binocular conditions. Dissociated phoria was measured with the von Graefe method. The sign conventions were the same as in the previous study. The range of dissociated phorias was 20 prism diopters exo to 16 prism diopters eso.

The Pearson coefficient of correlation for a linear relation of accommodative response and dissociated phoria was -0.32, indicating a decrease in accommodative response (or an increase in lag of accommodation) with a change in phoria toward eso. The correlation coefficient was statistically significant (p<0.01). When calculation of the correlation coefficient was repeated using an exponential equation fitted to the data, the correlation coefficient increased to -0.39. The relation between accommodative response and phoria appeared to be stronger for esophores than for exophores, so the correlation was calculated for subjects with esophoria only. For the 44 esophoric subjects, the correlation coefficient for a linear relation was -0.59, which was statistically significant (p<0.001).

The mean accommodative responses and lags of accommodation for phoria groups are given in Table 3. The difference in accommodative response between the eso group and the exo and ortho group was not statistically significant (p=0.43), but the difference between the 5 or more eso group and the exo and ortho group was statistically significant (p=0.0259).

<table>
<thead>
<tr>
<th>N</th>
<th>Mean lag of accommodation</th>
<th>Mean accommodative response (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exo and ortho</td>
<td>29</td>
<td>0.70 D</td>
</tr>
<tr>
<td>Eso</td>
<td>44</td>
<td>0.76 D</td>
</tr>
<tr>
<td>5 prism diopters or more eso</td>
<td>21</td>
<td>0.93D</td>
</tr>
</tbody>
</table>

Table 3. Mean binocular lags of accommodation and mean binocular accommodative responses in diopters for different phoria groups in the second study.

**Relationship of Dissociated Phoria and Change in Accommodative Response from Monocular to Binocular Conditions**

A study conducted in Japan measured accommodative response with a Grand Seiko WV-500 infrared autorefractor. Like the Canon Autoref R-1, it provides an open view for the subject by using an infrared reflecting mirror for the refractive measurement. Subjects were 99 patients, ages 6 to 39 years, in the Strabismus Clinic at the hospital of the Okayama University Medical School plus ten subjects, ages 8 to 40 years, selected as normal controls. The 99 patients had either intermittent exotropia, exophoria, or esophoria and had stereopsis of at least 120 seconds on the TNO stereo test. Nine of the 99 patients had esophoria, the remainder having exophoria or intermittent exotropia. Phorias were measured by prism neutralized cover test.

The eso subjects had a mean age of 15.3 years, 5 m phorias ranging from 0 to 23 prism diopters eso, and 40 cm phorias ranging from 0 to 14 prism diopters eso. The exo group subjects had a mean age of 12.9 years, and cover test results ranging from 0 to 50 prism diopters exo at 5 m and from 0 to 48 prism diopters exo at 40 cm. The normal group had a mean age of 25.1 years, 5 m phorias which ranged from 0 to 6 prism diopters exo and 40 cm phorias that ranged from 15 prism diopters exo to 3 prism diopters eso.

Subjects viewed a Maltese cross pattern at 40 cm while the accommodative response measurements were taken. Subjects wore their habitual spectacles or contact lenses during the measurements. Accommodative response was determined under both monocular and binocular conditions. Lags of accommodation were calculated by subtracting the accommodative response from the accommodative stimulus.

The mean lags of accommodation in the three groups are shown in Table 4. The coefficient of correlation of distance phoria with lag of accommodation was -0.22, which was statistically significant (p<0.05). The negative sign of the correlation indicates that the lag increased as the amount of exo increased or eso decreased. The coefficient of correlation of distance phoria with binocular lag of accommodation was 0.17, which was not statistically significant (p=0.10). The positive sign of the correlation would indicate an
increase in lag as the amount of eso increased or exo decreased. It would be interesting to know if these correlations would have been greater if the near phorias would have been used instead of the distance phorias because the near phorias would likely have a closer relation to the lag of accommodation than the distance phoria.

Comparing the monocular and binocular lags in Table 4, it may be noted that the lag decreased from monocular to binocular conditions in the exo group (p<0.05) and the lag increased from monocular to binocular conditions in the eso group (p<0.05). These changes would be expected. In esophoria, the use of negative fusional vergence for fusion would result in a decrease in accommodation and thus an increase in the lag. In exophoria, the use of positive fusional vergence would be associated with an increase in accommodation, thus decreasing the lag.

The coefficient of correlation of the distance phoria with the difference in lags from monocular to binocular conditions was -0.49 (p<0.01). The negative sign of the correlation indicates that the decrease in lag became greater as the amount of exo became greater and that the increase in lag became greater as the amount of the eso became greater.

**Discussion**

The results of the third study are consistent with the results of the first and second studies. Under monocular conditions there appears to be a trend toward greater lags in exophoria, and under binocular conditions the trend is in the direction of higher lags in esophoria.

The trend observed under monocular conditions can be observed clinically in cases where an abnormally low accommodative response drives the near phoria toward exo. This case is often referred to as pseudo convergence insufficiency because the high exophoria at near is secondary to the high lag of accommodation. Some optometrists think of pseudo convergence insufficiency as both a convergence insufficiency and an accommodative insufficiency because the treatment can include elements of the treatment of the both of those conditions. The treatment can include either plus adds for near or vision therapy or both. The plus add would seem to be an unusual treatment in the case of a high exophoria, but it may be useful because of the high lag of accommodation. Many optometrists have observed a paradoxical improvement in the near point of convergence with plus adds in pseudo convergence insufficiency.6,7

The trend of increasing lag under binocular conditions with more convergent phoria is seen clinically in cases where the vergence effort for fusion affects accommodative response. Cases of convergence excess and basic esophoria are often accompanied by a high lag of accommodation. The tendency toward decreased lag in cases with more divergent phorias is due to the increase in accommodation associated with the use of positive fusional vergence. Minimal lag of accommodation or a lead of accommodation is often found in basic exophoria.

The relationship of high lag and esophoria has implications for control of childhood myopia progression with multifocal lenses. One of the leading theories of myopia etiology is the defocus theory, which holds that eye growth and thus axial elongation is accelerated when the point of best focus is significantly behind the retina.8-12 In other words, the eye grows longer to move the retina closer to a position where it would receive a clearer image. With a high lag of accommodation during near viewing, the point of best focus is behind the retina. A plus add would move the point of focus anteriorly toward the retina. Several studies have found that the rate of childhood myopia progression tends to be greater in children with nearpoint esophoria than in children with esophoria at near and that bifocals and progressive addition lenses can slow the rate of progression in children with nearpoint esophoria but are unlikely to do so in exophoria.13-19 Perhaps those findings are partially explained by the fact that there tends to be higher binocular lags in esophoria than in exophoria.

A computer simulation of the relationship between dissociated phoria and lag of accommodation predicted that the high lag of accommodation associated with esophoria would be more pronounced when the AC/A ratio or the CA/C ratio was high and particularly when they

<table>
<thead>
<tr>
<th>Group</th>
<th>Monocular Lag</th>
<th>Binocular Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exo (n=90)</td>
<td>0.64 D (0.06)</td>
<td>0.14 D (0.06)</td>
</tr>
<tr>
<td>Eso (n=9)</td>
<td>0.37 D (0.09)</td>
<td>0.77 D (0.16)</td>
</tr>
<tr>
<td>Normal (n=10)</td>
<td>0.54 D (0.08)</td>
<td>0.40 D (0.10)</td>
</tr>
</tbody>
</table>

*Table 4. Mean lags of accommodation in the third study with standard errors in parentheses.*

Indiana Journal of Optometry ... Spring 2008 ... Vol. 11, No. 1... page 7
both were high.\textsuperscript{20} The third study discussed here\textsuperscript{3} confirmed that for high AC/A ratios.

References
The association of amblyopia and anisometropia is well known. Because sensory deprivation is a known cause of amblyopia, it has been assumed that anisometropia causes amblyopia. But it has also been suggested that amblyopia could cause anisometropia. This paper reviews studies on refractive error changes in persons with amblyopia and presents some case reports illustrating the variability in refractive error changes in amblyopes.

Literature Review

Lepard presented data on refractive changes in 55 patients with strabismus and amblyopia. These patients all had esotropia and had decimal visual acuity of at least 0.8 in one eye and 0.4 or less in the other eye. A group of 55 patients without strabismus and with decimal visual acuity of at least 0.8 in both eyes served as a control group. The ages at first examination ranged from less than one year to nine years for both groups. The time interval between the first and last refractions ranged from 5 to 29 years and averaged 14 years for the amblyopic group and 13 years for the control group. The mean changes in spherical equivalent cycloplegic refraction between the first and last refractions for the control group were -2.50 D (SD=1.92) in the right eye and -2.48 D (SD=1.92) in the left eye. For the group of patients with strabismus and amblyopia, the mean changes were -2.35 D (SD=1.93) in the fixating eye and -0.47 D (SD=1.70) in the deviating amblyopic eye. In 37 of the 55 patients with strabismus and amblyopia, the difference in refractive change between the two eyes was more than 1 D.

A paper by Leffertstra reported refractive error changes in 329 comitant esotropes. They were followed for at least ten years starting at 12 years of age or less. The author stated that the refractive error changes in the 84 patients in the sample with alternating strabismus were generally about the same in the two eyes. The remaining 245 patients with unilateral strabismus were divided into a group which was emmetropic after the period of follow-up (n=190) and a group which was myopic after the period of follow-up (n=55). In the emmetropic group, the spherical equivalent refractive error changed more than 2 D in 23% of the fixating eyes and in 15% of the deviating amblyopic eyes. In the group with myopia, refractive changes of more than 2 D were found in 96% of the fixating eyes and 26% of the deviating amblyopic eyes.

Bielik et al. discussed refractive error changes in 212 Israeli children with strabismus. They were first seen at one to two and a half years of age and followed for periods of three to five years. They did not distinguish between changes in fixating and deviating eyes, but they did state that there was a difference in refractive change between the two eyes of individuals of 1.5 D or more in 14% of the cases.

Nastri et al. described the refractive error changes in 61 children with amblyopia who were followed for at least ten years at Naples University. Refractive error data were expressed as the spherical equivalents of cycloplegic refractions. At the initial exam the patients were three to five years of age, had decimal visual acuities of 0.8 or better in one eye and 0.3 or lower in the other eye, and had refractive errors of +2 to +6 D in the amblyopic eye and +1 to +4 D in the other eye. Almost all of the patients had more hyperopia in the amblyopic eye than in the non-amblyopic eye. After ten years, refractive errors ranged from 0 to +5 D in the amblyopic eyes and -5 to +2 D in the non-amblyopic eyes. In ten years, the average refractive error changes were -0.61 D in the amblyopic eyes and -1.67 D in the non-amblyopic eyes.

Like Lepard, Nastri et al. found more minus change in refractive error in the non-amblyopic eyes than in the amblyopic eyes. In the Nastri et al. study, all of the patients initially had hyperopia. In the Lepard study, all of the patients had esotropia, so we might suspect that most had hyperopia. We might then ask whether the trends would be any different in patients with myopia. A study by Burtolo et al. presented separate data for myopic and hyperopic amblyopes. In the Burtolo et al. study, there were 30 patients with strabismus and amblyopia who had cycloplegic retinoscopy and ultrasound measurements taken three years apart. Twenty patients with hyperopia averaged 5.1 years of age at the first exam. Ten patients with myopia averaged 5.9 years of age at the first exam. The patients wore a full correction for their ametropia.
and some underwent treatment with orthoptics or occlusion. For the patients with hyperopia, the average refractive errors went from +3.25 to +1.93 D in the fixating eye and from +5.10 to +4.70 D in the deviating eye in the three years of the study. The axial length changes were consistent with the refractive error changes in that the axial length increased more in the fixating eye than in the deviating eye. In the patients with myopia, the average refractive errors changed from -1.90 to -2.40 D in the fixating eyes and from -2.90 to -5.70 D in the deviating eyes. Here also the axial length changes were consistent with the changes in refractive error. For the patients with myopia, axial length increased more in the deviating eyes than in the fixating eyes.

The mean changes in the Burtolo et al. study were -1.32 D in the fixating eye and -0.40 D in the deviating eye for hyperopes and -0.50 D in the fixating eye and -2.80 D in the deviating eye for myopes. There was more minus change in the fixating eye of hyperopes and in the deviating eye of myopes. Another way to state this is that hyperopes changed less away from hyperopia in the deviating eye and myopes changed more into increasing myopia in the deviating eye. Perhaps the emmetropization mechanism is faulty in amblyopic eyes. The studies reviewed here mostly involved patients that had both strabismus and amblyopia. One could wonder whether the possibly faulty emmetropization mechanism is due to the presence of amblyopia, strabismus, or both.

Case Reports

Charts were obtained from two clinics of the Indiana University School of Optometry, Community Eye Care Center and Atwater Eye Care Center in Bloomington, Indiana. The charts all contained signed information release consent forms in which the patient granted the university permission to use information from their charts for research purposes. Additional permission to use patient information was granted by the Indiana University Human Subjects Committee prior to beginning the project.

A search was conducted for charts with at least four exams between the ages of 5 and 18 years. Patients were selected if they had no better than 20/25 visual acuity in one eye throughout the time span covered by the chart and at least 20/20 visual acuity at some time in the other eye. For selection of cases, there were no treatment restrictions either prior to or during the period of time covered by the chart. Patients with ocular disease were excluded from the study. We used spherical equivalents from either subjective refraction or retinoscopic refraction obtained under either cycloplegic or mydriatic conditions. All of the refractive data presented for each individual subject are either retinoscopy or subjective refraction, whichever provided the most complete data through the period of follow-up.

Case #1

A myopic male was followed from age 7 to age 18. He presented with right eye amblyopia and anisometropia. Treatment included spectacle correction and occlusion therapy with best corrected visual acuities of 20/30 in the right eye and 20/20 in the left eye at the last recorded examination. Refractive error was measured by subjective refraction five times in eleven years. The spherical equivalent results are given in Table 1. The fixating eye was found to increase in myopia by 3.50 diopters over the 11 year period, while the amblyopic eye underwent a hyperopic shift of 1.50 diopters. These results do not agree with the results of Burtolo et al., where the deviating eye increased more in myopia. This patient did not have strabismus as did the patients in the Burtolo et al. study. This case may not be representative of the refractive changes in most cases of amblyopia because of the high amount of myopia in one eye.

Case #2

A boy followed from age 5 to age 9 had right eye amblyopia, hyperopic anisometropia, and right esotropia. Treatment received was spectacle prescription only, resulting in best corrected visual acuities of 20/30 in the right eye and 20/20 in the left eye recorded at the last examination. No vision therapy, patching, or surgery was performed. Refractive error was measured a total of four times, using retinoscopy and one drop of 1% cyclopentolate in each eye. Spherical equivalent

<table>
<thead>
<tr>
<th>Age  (years)</th>
<th>Refractive error, OD (amblyopic eye)</th>
<th>Visual acuity, OD</th>
<th>Refractive error, OS (non-amblyopic eye)</th>
<th>Visual acuity, OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>-13.75 D</td>
<td>20/100</td>
<td>-0.50 D</td>
<td>20/25</td>
</tr>
<tr>
<td>11</td>
<td>-13.00 D</td>
<td>20/30</td>
<td>-2.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>12</td>
<td>-13.00 D</td>
<td>20/30</td>
<td>-2.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>13</td>
<td>-12.25 D</td>
<td>20/30</td>
<td>-3.75 D</td>
<td>20/20</td>
</tr>
<tr>
<td>15</td>
<td>-12.25 D</td>
<td>20/30</td>
<td>-4.00 D</td>
<td>20/20</td>
</tr>
</tbody>
</table>

Table 1. Refractive errors and visual acuities for case #1.
refractive errors are recorded in Table 2. Neither eye showed a large refractive change over the four years. The fixating eye remained somewhat stable, only losing about 0.25 D of total plus power while the amblyopic eye showed an increase of about 1.00 D of plus power.

**Case #3**

A hyperopic female was followed from age 5 to age 13. The patient presented with right eye amblyopia and right esotropia at distance and near. Treatment received was through spectacle lenses, with a plus add included for near work. Best corrected visual acuities were 20/25 in the right eye and 20/20 in the left eye at the last recorded examination. No vision therapy, patching or surgery was performed. Refractive error was measured a total of seven times by retinoscopy, using one drop of either 1% tropicamide or 1% cyclopentolate in each eye. Spherical equivalent refractive errors are given in Table 3. Neither eye showed much change in refractive error.

**Case #4**

A hyperopic female was followed from age 10 to age 17. The patient presented with anisometric hyperopia and left eye amblyopia and was treated with spectacle prescription only. No vision therapy, patching or surgery was performed. Best corrected visual acuities were found to be 20/20 in the right eye and 20/30 in the left eye at the last examination. Refractive error was measured a total of six times over the seven years using retinoscopy and one drop of either 1% tropicamide or 1% cyclopentolate in each eye. Looking from the first to last examinations, there was minimal change in the amblyopic eye (+0.25 D) and a shift from low hyperopia to low myopia (-1.25 D total change) in the non-amblyopic eye.

**Case #5**

A hyperopic male was followed from the age of 5 to age 18. The patient presented with high hyperopia in both eyes. The patient was corrected with spectacles only. No vision therapy, patching or surgery was performed. Best corrected visual acuities were 20/15 in the right eye and 20/30 in the left eye at the last recorded examination. Refractive error was measured ten times over the period of thirteen years using retinoscopy and one drop of 1% tropicamide in each eye. Spherical equivalent refractive errors are recorded in Table 5. Over a thirteen year period, the patient’s net refractive error decreased in a nearly equal amount in the two eyes, although the time course of the refractive changes appeared to differ in the two eyes.

**Case #6**

A hyperopic female was followed from age 11 to age 18. The patient presented with right eye amblyopia and right esotropia. The patient was managed with spectacles alone. Best corrected visual acuities were 20/25 in the right eye and

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Refractive error, OD (amblyopic eye)</th>
<th>Visual acuity, OD</th>
<th>Refractive error, OS (non-amblyopic eye)</th>
<th>Visual acuity, OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>+2.75 D</td>
<td>20/25</td>
<td>+1.25 D</td>
<td>20/25</td>
</tr>
<tr>
<td>6</td>
<td>+3.25 D</td>
<td>20/40</td>
<td>+2.50 D</td>
<td>20/30</td>
</tr>
<tr>
<td>8</td>
<td>+3.50 D</td>
<td>20/40</td>
<td>+1.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>9</td>
<td>+3.75 D</td>
<td>20/30</td>
<td>+1.00 D</td>
<td>20/20</td>
</tr>
</tbody>
</table>

**Table 2. Refractive errors and visual acuities for case #2.**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Refractive error, OD (amblyopic eye)</th>
<th>Visual acuity, OD</th>
<th>Refractive error, OS (non-amblyopic eye)</th>
<th>Visual acuity, OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>+3.00 D</td>
<td>--</td>
<td>+3.25 D</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>+3.25 D</td>
<td>20/50</td>
<td>+3.00 D</td>
<td>20/40</td>
</tr>
<tr>
<td>8</td>
<td>+3.00 D</td>
<td>20/25</td>
<td>+3.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>9</td>
<td>+3.00 D</td>
<td>20/25</td>
<td>+2.75 D</td>
<td>20/20</td>
</tr>
<tr>
<td>10</td>
<td>+3.25 D</td>
<td>20/25</td>
<td>+3.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>12</td>
<td>+3.75 D</td>
<td>20/25</td>
<td>+4.00 D</td>
<td>20/20</td>
</tr>
<tr>
<td>13</td>
<td>+2.50 D</td>
<td>--</td>
<td>+3.25 D</td>
<td>--</td>
</tr>
</tbody>
</table>

**Table 3. Refractive errors and visual acuities for case #3.**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Refractive error, OD (amblyopic eye)</th>
<th>Visual acuity, OD</th>
<th>Refractive error, OS (non-amblyopic eye)</th>
<th>Visual acuity, OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>+0.50 D</td>
<td>20/25</td>
<td>+3.50 D</td>
<td>20/60</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>20/25</td>
<td>+3.75 D</td>
<td>--</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>20/20</td>
<td>+4.00 D</td>
<td>20/40</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>20/20</td>
<td>+2.25 D</td>
<td>20/25</td>
</tr>
<tr>
<td>16</td>
<td>-0.50 D</td>
<td>20/20</td>
<td>+3.00 D</td>
<td>20/25</td>
</tr>
<tr>
<td>17</td>
<td>-0.75 D</td>
<td>20/20</td>
<td>+3.75 D</td>
<td>20/30</td>
</tr>
</tbody>
</table>

**Table 4. Refractive errors and visual acuities for case #4.**
20/20 in the left eye at the last recorded examination. Refractive error was measured seven times using retinoscopy and one drop of either 1% cyclopentolate or 1% tropicamide in each eye. Spherical equivalent refractive errors are given in Table 6. The patient showed a shift toward myopia in both eyes.

**Case #7**

An anisometropic female with right eye amblyopia was followed from age 9 to age 19. The patient was corrected with spectacles alone. Best corrected visual acuities were 20/30 in the right eye and 20/15 in the left eye at the last recorded examination. Refractive error was measured nine times using retinoscopy and one drop of 1% tropicamide in each eye. See Table 7 for the spherical equivalent refractive errors at each examination. In a ten year period the patient's refractive error showed a myopic shift in both eyes, with the amblyopic eye showing a greater increase in myopia. This result correlates with the research by Burtolo et al., which found the fixating eye to undergo little axial elongation and the non-fixating eye to undergo a larger amount of elongation in myopes. This patient's amblyopic eye had a myopia increase of -7.50 D versus -2.75 D in the non-amblyopic eye.

**Case #8**

A hyperopic female with right esotropia was followed from the age of 2 to age 25. The patient was initially treated with single vision spectacles and later with bifocal spectacles and surgery. After the surgery, the patient's hyperopia began to decrease at the same rate in both eyes. By the late teen years, the patient was myopic in both eyes. Best corrected visual acuities were 20/30 in the right eye and 20/20 in the left eye, as recorded at the last examination.

**Discussion**

The refractive trends in some of the case reports follow the findings of the published studies and some do not. The published studies mostly involved patients with both amblyopia and strabismus. Some of the patients in the case reports did not have strabismus. The patients in the case reports had mild amblyopia judging from the level of the visual acuities. We selected cases in which the visual acuity of the ambylopic eye never improved to better than 20/25, so these were cases in which the amblyopia apparently was not completely resolved.

From the literature and from some of these case reports, it appears that refractive changes and emmetropization may be affected by amblyopia,
but there could be numerous variables which might modify that effect. Some of the variables could include: (1) whether strabismus is also present, (2) whether treatment included vision therapy, occlusion, or surgery, (3) level of success of treatment, (4) whether the patient is initially myopic or hyperopic, (5) whether anisometropia is fully or partially corrected, (6) whether myopia or hyperopia is fully or partially corrected, (7) whether nearpoint plus adds are prescribed, (8) how much near work the patient does, (9) inheritance, (10) ages and possible sensitive periods for various effects, and (11) unknown other factors. We did not attempt to assess these variables in the case reports, but we acknowledge that some of the differences in the cases from the published literature may be related to these or other variables.

Answering some of the questions concerning the relation of amblyopia and anisometropia has implications for the prescription of lenses in anisometropia. Some practitioners prefer to fully correct anisometropia in order to optimize retinal imagery in each eye and possibly prevent or improve amblyopia. Some practitioners note that anisometropia is variable over time and suggest that fully correcting anisometropia may make it more permanent, preferring instead to give similar lens powers in the two eyes. This is clearly an area where there are perplexing questions in need of answers.

References

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Refractive error, OD (amblyopic eye)</th>
<th>Visual acuity, OD</th>
<th>Refractive error, OS (non-amblyopic eye)</th>
<th>Visual acuity, OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>+3.00 D</td>
<td>20/80</td>
<td>+3.00 D</td>
<td>20/30</td>
</tr>
<tr>
<td>3</td>
<td>+3.00 D</td>
<td>20/40</td>
<td>+3.00 D</td>
<td>20/30</td>
</tr>
<tr>
<td>3</td>
<td>+4.00 D</td>
<td>20/40</td>
<td>+4.00 D</td>
<td>20/30</td>
</tr>
<tr>
<td>4</td>
<td>+4.00 D</td>
<td>20/40</td>
<td>+4.00 D</td>
<td>20/30</td>
</tr>
<tr>
<td>4</td>
<td>+4.75 D</td>
<td>20/30</td>
<td>+5.00 D</td>
<td>20/30</td>
</tr>
<tr>
<td>5</td>
<td>+5.50 D</td>
<td>20/30</td>
<td>+5.00 D</td>
<td>20/30</td>
</tr>
<tr>
<td>6</td>
<td>+5.50 D</td>
<td>20/70</td>
<td>+5.25 D</td>
<td>20/30</td>
</tr>
<tr>
<td>7</td>
<td>+5.00 D</td>
<td>20/30</td>
<td>+4.25 D</td>
<td>20/25</td>
</tr>
<tr>
<td>9</td>
<td>+4.25 D</td>
<td>20/30</td>
<td>+4.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>10</td>
<td>+2.50 D</td>
<td>--</td>
<td>+2.00 D</td>
<td>--</td>
</tr>
<tr>
<td>11</td>
<td>+2.50 D</td>
<td>20/50</td>
<td>+2.00 D</td>
<td>20/20</td>
</tr>
<tr>
<td>12</td>
<td>+1.50 D</td>
<td>20/40</td>
<td>+1.00 D</td>
<td>20/25</td>
</tr>
<tr>
<td>14</td>
<td>+0.75 D</td>
<td>--</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>17</td>
<td>+0.25 D</td>
<td>20/50</td>
<td>0</td>
<td>20/25</td>
</tr>
<tr>
<td>19</td>
<td>-0.50 D</td>
<td>20/30</td>
<td>0</td>
<td>20/25</td>
</tr>
<tr>
<td>21</td>
<td>-1.25 D</td>
<td>20/30</td>
<td>-1.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>23</td>
<td>-1.75 D</td>
<td>20/30</td>
<td>-2.50 D</td>
<td>20/20</td>
</tr>
<tr>
<td>25</td>
<td>-1.75 D</td>
<td>20/30</td>
<td>-2.75 D</td>
<td>20/20</td>
</tr>
</tbody>
</table>

Table 8. Refractive errors and visual acuities for case #8.

Changes in refraction over a period of 3-5 years in 212 strabismic children aged one to two and a half. Metabolic Ophthalmol 1978;2:115-117.

Kristen Rabaut and Jillian Loebach are members of the Indiana University School of Optometry Doctor of Optometry Class of 2007.
Book Review: Renaissance Vision from Spectacles to Telescopes

Reviewed by David A. Goss, O.D., Ph.D.


The early development of spectacles as an economic entity has received little study. That is the main emphasis of this well researched book, but it also ranges broadly over a number of topics from the invention of spectacles to their production over the next three centuries to the development of the telescope. The author, Vincent Ilardi, is Professor Emeritus of History at the University of Massachusetts, Amherst. His particular area of expertise is history of the fifteenth century, especially diplomatic history. His interest in the topic of this book stems from his discovery of two large orders of eyeglasses from dukes of Milan placed with spectacle makers in Florence between 1462 and 1466. He subsequently found a flourishing spectacle making and exportation industry in fifteenth century Florence. The author states that "by the end of the fifteenth century, Florence and similar urban areas were awash with eyeglasses in varying degrees." (pages 178-179) Some of the other discoveries and observations made by the author are discussed below.

Ilardi noted that optical science didn’t take up the question of the optics of spectacle lenses in the early years of spectacles. The optical writings of Peckham, Bacon, and Witelo in the thirteenth century dealt with natural philosophy (basic science) rather than applied science. Even though spectacles were invented in the late thirteenth century, it wasn’t until Francesco Maurolico in the mid sixteenth century and Johannes Kepler in the early seventeenth century that the optics of spectacle lenses were seriously examined.

Medical prejudice against spectacles started early. In a small book published in 1361 as part of a medical and surgical manual and entitled Prescriptions for the Eyes, Maestro Piero Ubertini da Brescia recommended herbal pills rather than eyeglasses for clear vision. Some of the components of the pills were chamomile, colocynth, quince, and leeks. Spectacles were mentioned as a last resort if potions such as fennel seeds didn’t work by French surgeon and professor of medicine Guy de Chauliac (c.1300-1368) in his 1363 book Chirurgia magna.

The opposition of medical authorities to eyeglasses is also illustrated by the book Ophthalmomouleia, a treatise on eye diseases and ocular surgery by George Bartisch (1535-1606). To avoid the weak vision of old age, Bartisch recommended various potions, purges, pills, eye powders, head washes, and charms to be worn around the neck. Some of these had to be applied at a particular phase of the moon. Ilardi quoted Bartisch as saying the following about the use of spectacles: "It is natural to be sure, that a person should see and recognize something better when he had nothing in front of his eyes than when he has something in front of his eyes, however subtle, clear, or thin it may be. It is much better for a person to preserve two eyes than one should have four. When however it happens that some people say they see better through spectacles and eye glasses, better than otherwise, consider this more as a habit, than as an affliction or deficiency of the eyes...." (page 250)

The 1462 order of spectacles discovered by Ilardi was placed by Duke Francesco Sforza of Milan through his ambassador in Florence to Florentine spectacle makers. The order specified that there should be a dozen pairs of eyeglasses "apt and suitable for distant vision, that is for the young," a dozen "suitable for near vision, that is for the elderly," and another dozen for more "common vision." (page 82) It is likely that the spectacles for common vision contained plus lenses for beginning presbyopes. The distant vision spectacles for the young probably contained minus lenses. This appears to be the first documented use of minus lenses. The first use of spectacles following their invention in about 1286 was plus lenses for presbyopia. It is thought that the spectacles were ordered in large numbers to be presented as gifts.

Another order for spectacles from Milan to Florence was placed in 1466 by Sforza’s son and successor, Galeazzo Maria. This order specified certain numbers of spectacles for ages in five year intervals from 30 to 70 years, along with eyeglasses for medium vision and distant vision for
the young. Thus there were by this time, several powers of plus lenses used for presbyopia and at least two powers of minus lenses for myopia. Ilardi also uncovered a 1488 diary of a Florentine ambassador to Egypt and the Holy Land in which was mentioned the age levels of the spectacles that the ambassador had promised to friars in Jerusalem. Thus it is evident that by the mid fifteenth century it was known that presbyopia advanced, requiring increasing plus lens powers.

Early spectacles that have been discovered often have the lenses missing or in such poor shape that power determinations are difficult. One example from the early or mid sixteenth century found in an Italian archives had biconvex lenses with powers of +1.50 D on each surface for a lens power of about +3 D. Another pair of Italian spectacles from the late sixteenth or early seventeenth century contained plus lenses of about +3 D. Ilardi also cites a finding of 300 pairs of spectacles in a shipwreck off the coast of Croatia. Those spectacles are thought to have been of German origin and date to the late sixteenth century. The powers of ones preserved well enough to make a power determination were +3 to +3.5 D. So even though the correspondence from the fifteenth century suggests a somewhat wide range of powers for presbyopia, the lenses which have been discovered from around the sixteenth century show a fairly narrow range of powers. A 1585 book by Tommaso Garzoni discussed the occupation of spectacle maker and described “the various iron forms used to grind convex and concave lenses for various ages in decades from 30 to 100 and for cataracts already removed. The curvature (power) of the lenses for each decade was measured on a scale from ½ to 15 punti (points or degrees), presumably ‘inches’ to the foot as understood in Venice.” (page 226) Ilardi also noted that the famous 1623 book by Daza de Valdes of Spain, often recognized as the first book that could be considered a book on optometric procedure and analysis, presented measuring units for lens power corresponding to age decades.

Early spectacle frames were made from bone, leather, horn, wood, and other materials and had a bridge that could rest on the nose, but no temples. The bone frames were typically made with circular rims with handles extending from the rims and the handles connected with a rivet. The lenses could be held with one over each eye or they could be rotated at the rivet so that the lenses were superimposed for looking at finer objects with one eye. When not in use, the spectacles could be folded up and placed in a bag suspended by a string from the belt. It is thought that the first use of a “temple” to help hold spectacles in place was the use of cords or strings wrapped around the ears in late sixteenth century Spain.

The first five chapters of the book contain a great amount of detail on the history of spectacles, particularly in Italy. The sixth and final chapter discusses the development of telescopes and lens making and touches on the early history of the study of retinal imagery. Contributions by Della Porta, Manzini, Bacon, Maurolico, da Vinci, Kepler, and others are discussed. The book contains three appendices. The first is a list of 48 artisans known to have worked as spectacle makers in Florence between 1413 and 1562. The second appendix discusses four friars in Florence who were also spectacle makers. The third, and by far the largest appendix, is an extensive section on spectacles in art. It lists paintings that contain depictions of early spectacles. This appendix includes 77 figures, mostly color reproductions of paintings, but also a few photographs of fifteenth to seventeenth century spectacles.

Anyone wishing to learn extensive details about the history of eyeglasses should consult this book. One disappointment I had with this book didn’t concern Ilardi’s writing at all, but rather what one of his statements in the preface indicated about the current interests of optometrists and optometric educators. He mentioned that he published an article in 1976 on the fifteenth century orders of spectacles by the dukes of Milan, and that he was encouraged to write this book by “the many requests for offprints of the article by ophthalmologists, opticians, and medical schools…” (page ix) Mention of optometrists and optometry schools was conspicuously absent from that statement. We should do a better job of getting involved in the study of the history of our profession.

In a review of this book in the October, 2007 issue of Hindsight: Journal of Optometry History, Jay Enoch states that Ilardi’s book “contributes critical new knowledge to the history of optics, to spectacle lens and frame developments, …and to the history of provision of ophthalmic care and practice” and that the book “is a truly brilliant scholarly work.” I heartily agree.
Book Review: A Brief Tour of Human Consciousness
Reviewed by Paul A. Harris, O.D.


V. S. Ramachandran is a noted neurologist whose highly praised previous book, Phantoms in the Brain, was reviewed in the Spring, 2006 issue of this journal. Those of you who have read or had the good fortune to hear Rama, as he likes to be called, speak, as he did a few years ago at the College of Optometrists in Vision Development annual meeting, have come to expect great insights into human behavior presented in an engaging style interlaced with humor. His latest, A Brief Tour of Human Consciousness, does not disappoint. The following are some of the aspects that I found particularly relevant to my understanding of vision.

In the preface, Rama attacks head-on the critique that dogs those of us who provide optometric care from the behavioral perspective, namely the weakness of case studies: “The criticism is sometimes made that it is easy to be misled by single strange cases, but this is nonsense. Most of the syndromes in neurology that have stood the test of time – for example, the major aphasias (language disturbances), amnesia, cortical color blindness, neglect, blindsight, ‘split brain’ syndrome, etc. – were initially discovered by a careful study of single cases, and I don’t know of even one that was discovered by averaging results from a large sample. The best strategy, in fact, is to begin by studying individual cases and then to make sure that the observations are reliably repeatable in other patients.” (page xi) One can almost feel Rama calling on us, pioneers in our profession, to continue to follow the paths that each of our patients takes us, applying the underlying foundation principles that derive from our insights into the visual process and working to help our patients. We should then be taking the time to document our “most interesting” patients in ways that our colleagues can know what we have done. Only over time may patterns emerge that could later lead to a large scale study.

He continues, “By studying neurological syndromes which have been largely ignored as curiosities or mere anomalies we can sometimes acquire novel insights into the functions of the normal brain – how the normal brain works. Many of the functions of the brain are best understood from an evolutionary vantage point.” (page 2) This statement really touched a nerve in me as I read it. For those interested in following this thread, understanding the evolution of the brain from a functional perspective, I highly recommend the book, The Evolution of the Brain – Creation of the Self, by John C. Eccles (1989, Routledge, ISBN 0-415-03224-5).

Cortical plasticity is one of the foundations on which stands much of what we do in vision therapy. “There is a tremendous amount of plasticity or malleability even in the adult brain, and this can be demonstrated in a five-minute experiment on a patient with phantom limb.” (page 15) Much of Rama’s research has been in the area of phantom limbs and the lessons we learn from the way the architecture of the brain is reorganized and used differently following the loss of a limb. These lessons apply to functional redistributions of the use of the brain following extensive practice in a particular domain and are the basis for change following vision therapy.

Rama brings in something that for me has been interesting and which has triggered a new way of understanding how yoked prisms may affect autism spectrum patients, namely synesthesia. “Synesthesia is surprisingly common, affecting about one in two hundred people.” (page 19) This condition, that I learned so much about from the book, The Man Who Tasted Shapes, by Richard Cytowic (1993, Putnam, ISBN 0-87477-738-0), is not just an odd curiosity but is functioning below levels of consciousness in all of us and helps us make the cross modal associations we do.

Rama touces briefly on the subject of laughter, where it fits into communication and why it evolved. I have been interested in this ever since reading the book, Laughter – A Scientific Investigation, by Robert Provine (2000, Viking, ISBN 0-670-89375-7). “…laughter is nature’s way of signaling that ‘it’s a false alarm.’ Why is this
useful from an evolutionary standpoint? I suggest that the rhythmic staccato sound of laughter evolved to inform our kin who share our genes: don’t waste your precious resources on this situation; it’s a false alarm. Laughter is nature’s OK signal.” (page 22) In interpersonal communication laughter is also a form of communication, particularly when tickling is occurring in play to let the tickler know that it’s OK to continue.

Rama speaks a bit on how much of the brain is involved in the visual process leading up to insights into blindsight. “We primates are highly visual creatures. We have not just one visual area, the visual cortex, but thirty areas in the back of our brains which enable us to see the world.” (page 25)

The following section has changed forever how I view certain events that occur throughout my day. In reference to blindsight: “Imagine you are driving your car and having an animated conversation with your friend sitting next to you. Your attention is entirely on the conversation, it’s what you’re conscious of. But in parallel you are negotiating traffic, avoiding the pavement, avoiding pedestrians, obeying red lights and performing all these very complex elaborate computations without being really conscious of any of it unless something strange happens, such as a leopard crossing the road….you have blindsight for driving and negotiating traffic.” (page 31) I often go a certain food establishment to get my Caesar salad with chicken. In this place you first wait in line to order and pay and then slide down to await the pick up of your food. Then I walk towards the tables to find a place to sit. While walking to find a table one of the ways is to walk back through where the first line is. I love watching how as I walk through people, they move forward or backward clearing a path for me, while never directly looking at me or altering for a second anything that they are doing: talking with someone else in line, talking on their cell phone, looking at the menu posted on the wall, etc. They are all functioning by using their blindsight pathways throughout all of that. I have found this a much easier way to explain to a patient or family member what we are working with in vision therapy following a stroke.

Rama addresses the subject of neglect. Interestingly, he still addresses neglect as occurring purely on the left side of space and the body only with right side hemisphere strokes. “A patient with a right hemisphere stroke (left side paralyzed) sending a command to move his arm receives a visual feedback signal saying it is not moving, so there is a discrepancy. His right hemisphere is damaged, but his intact left hemisphere goes about its job of denial and confabulation, smoothing over the discrepancy and saying, all is fine, don’t worry. On the other hand, if the left hemisphere is damaged and the right side is paralyzed, the right hemisphere is functioning as it should, so it notices the discrepancy between the motor command and the lack of visual feedback and recognized the paralysis.” (page 36) For useful information, I recommend reviewing an article entitled “A primer for the optometric management of unilateral spatial inattention,” by Suchoff and Ciuffreda in the May, 2004 issue of Optometry, Journal of the American Optometric Association (volume 75, number 5).

Rama has a theory of rationalizing neglect as being a left-sided phenomenon, based on his understanding of the spotlight of attention, which goes something like this. Because the left side of the brain is so involved in speech and language, and speech and language evolved to use some of the correlate parts in the right brain that are used for global processing, the left brain’s attention mechanisms only see the right side of the world internally and externally. The right sides of the brain’s attention centers are global in function and view the whole world internally and externally. Thus, if the left side of the brain is affected, the right side of the brain can see the whole world and the entire person. If, however, it is the right side of the brain that is affected, then the remaining attention mechanisms in the left side of the brain only see the right side of the world and the right side of the person. Suchoff and Ciuffreda’s article call some of this into question or at least create a tension that may be resolved with further discoveries.

Rama then moves into areas in which he has particular interest such as how an artist can exploit aspects of how our visual processing occurs to stimulate our interest in what they produce. He first talks about how there is an economy in the use of our visual process: “the goal of vision is to do as little processing or computation as is necessary for the job on hand...” (page 46) I am surprised over and over about how in directing movement we seem to follow the least action principle, nearly always selecting from the infinite set of potential movement patterns that which bring about the expected results while using the least amount of effort and energy. Not only are we lazy in using our visual process but also in performing the myriad of tasks we do throughout the day.

Rama uses Richard Gregory’s Dalmatian dog puzzle picture to illustrate aspects of visual processing. “Even looking at a simple scene
involves a complex hierarchy, a stage-by-stage processing. At each stage in the hierarchy of processing, when a partial solution is achieved – when a part of the dog is identified – there is a reward signal 'a-ha,' a partial 'a-ha,' and a small bias is sent back to earlier stages to facilitate the further binding of the features of the dog. And through such progressive bootstrapping the final dog clicks into place to create the final big 'A-HA!' Vision had much more in common with problem solving – like a twenty-questions game – than we usually realize." (page 49) An interesting perspective as to the evolutionary advantage which results from a visual process that possesses these abilities is, "Vision evolved mainly to discover objects and defeat camouflage." (page 50)

What an artist tries to do is generate as many of the "a-ha" signals in as many visual areas as possible. This is accomplished by more optimally exciting these areas with painting or sculpture as could be achieved with natural visual scenes or realistic images. What comes to mind here for me are the works of Escher. As I solve something in one part of a picture and then scan along, my interpretation is challenged and the search for meaning and the “a-ha” continues, getting turned upside down each time my scan falls onto another part of the picture. I continue scanning, problem solving, getting “a-ha’s” but never the final resolution. I can return over and over and continue to enjoy.

Who do some of us enjoy this searching so much? “…the wiring of your visual centers to your emotional centers ensures that the very act of searching for the solution is pleasing, just as struggling with a jigsaw puzzle is pleasing long before the final “a-ha.” (page 51) Think of optical illusions for a moment. “There cannot be two overlapping patterns of neural activity simultaneously….There is a bottle-neck of attention. Attention resources may be allocated to only one entity at a time.” (page 52)

Fellow Optometric Extension Program Board member Greg Kitchener has emphasized analogy and metaphor in understanding the visual process. Douglas Hofstadter has explored this in his series of books, most notably in his book, Fluid Concepts and Creative Analogies – Computer Models of the Fundamental Mechanisms of Thought. (1995, Basic Books, ISBN 0-465-05154-5) Rama comments on synesthesia being the underlying basis of metaphors, “I would conjecture that the TPO [temporal parietal occipital] junction – especially the angular gyri – in the two hemispheres may have also evolved complementary roles in mediating somewhat different types of metaphor: the left one for cross-modal ones (e.g., ‘loud shirt,’ ‘sharp cheese’) and the right for spatial metaphors (he ‘stepped down’ from his post).” (page 75)

In a later section Rama takes on the subject of free will, asking the question, is there any such thing as free will? Subjects were instructed to wiggle a finger at any time of their own choosing within a ten-minute period. A full three-quarters of a second before the finger movement the researchers picked up a scalp EEG potential, which they called the “readiness potential,” even though the subject’s sensation of consciously willing the action coincided almost exactly with the actual onset of finger movement. “It’s almost as though your brain is really in charge and your ‘free will’ is just a post-hoc rationalization – a delusion...” (page 87)

Finally, this comment from Rama: “Our brains are essentially model-making machines. We need to construct useful, virtual reality simulations of the world that we can act on. Within the simulation, we need to also to construct models of other people’s minds because we primates are intensely social creatures….We need to do this so we can predict their behavior….for this internal simulation to be complete it needs to contain not only models of other people’s minds but also a model of itself, of its own stable attributes, its personality traits and the limits of its abilities – what it can and cannot do.” (page 105)

This book is a fast read and I highly recommend adding it to your personal library.

This review consists of excerpts of Dr. Harris’s review in the February, 2007 issue of OEP Clinical Curriculum News. Paul Harris, O.D., is a practicing optometrist specializing in vision therapy in Cockeysville, Maryland. He is a Fellow of the College of Optometrists in Vision Development and is a member of the Board of Directors of the Optometric Extension Program.
The author defines wisdom as "an extreme form of expertise or competence." (page 78). The wisdom paradox that he discusses in this book is that wisdom can increase as we get older even as the brain anatomically shows aging changes. The author has a private practice in neuropsychology and is a clinical professor of neurology at New York University School of Medicine. His first book, published in 2001, was “The Executive Brain: Frontal Lobes and the Civilized Mind.” In this book, he uses knowledge gained from his private practice, information from brain research, and examples from history and culture to build a framework for his theory. He speaks of the three seasons of the brain being development, maturity, and aging. All of the brain is affected by aging, but the phylogenetically newest areas of the brain are affected most.

A major theme of the book is that as we gain life experience, we no longer have to solve each problem we face as if it were a completely new and unique problem: "With age, the number of real-life cognitive tasks requiring a painfully effortful, deliberate creation of new mental constructs seems to be diminishing. Instead, problem-solving (in the broadest sense) takes increasingly the form of pattern recognition. This means that with age we accumulate an increasing number of cognitive templates. Consequently, a growing number of future cognitive challenges is increasingly likely to be relatively readily covered by a preexisting template, or will require only a slight modification of a previously formed mental template. Increasingly, decision-making takes the form of pattern recognition rather than of problem-solving….pattern recognition is the most powerful mechanism of successful cognition.” (page 20)

The author devotes one chapter (Aging and Powerful Minds in History) to discussing “late and luminous bloomers,” persons who showed great creative abilities or were powerful political leaders in their seventh decades of life and later. Because of the importance of pattern recognition, some remained creative or effective even though they exhibited signs of early dementia. In a later chapter, Goldberg notes that mental faculties such as memory and attention, which are evaluated in formal neuropsychological tests, are affected more by aging than procedural knowledge. Consequently, persons of advanced age may continue to perform well in their jobs, even though declines in memory and attention can be demonstrated.

Goldberg argues that the popular concept of right brain and left brain divisions of labor is incorrect. He presents arguments that the right brain processes new tasks and is involved in solving novel problems, while the left brain stores the templates that develop from experience and act in pattern recognition. One of the bits of evidence he presents is that children are affected more by injuries to the right side of the brain, while adults are handicapped more by injuries to the left side of the brain. In addition, the left hemisphere is affected more adversely by aging than the right hemisphere. Goldberg also argues that there are no separate memory storage areas in the brain: “the perception of a certain thing and the memory of that same thing share the same cortical territory; in fact they share the same neuronal networks.”

The author discusses at length how the brain can be modified by mental activity. Cognitive exercise can stimulate neuronal growth in areas of the brain specific to the type of activity being performed. As a result, cognitive exercise forms a sort of protection against detrimental effects of aging on the brain. In the last chapter, Goldberg talks about the remarkable positive effects his “cognitive enhancement” or “cognitive fitness” program has had on some of its participants. In an epilogue, he recaps some of the points made in the book. He notes, for example, that “the scope and quality of one’s mental lifetime will shape the quality of its final stages….A life of the mind rich in experiences, faced with mental challenges….rewards us with a generous arsenal of cognitive tools.” (page 289)

I found the material in this book to be clearly and logically presented. I feel that I learned quite a bit about brain function and the effects of aging on the brain from the book. Even though he did not explain what procedures were used in his cognitive exercise program, the book can be recommended to persons interested in brain function, cognition, and effects of aging. The book includes 27 pages of reference notes and an index.
Book Review: Ophthalmology Made Ridiculously Simple  
Reviewed by Subhash N. Jani, O.D., M.S., Ph.D.


I would like to share with the Indiana Journal of Optometry readership an informative and sometimes humorous book, Ophthalmology Made Ridiculously Simple. Directed toward the primary care physician, it claims to contain all the ophthalmology necessary to the non-opthalmologist, and in it resides plenty of folk wisdom for the primary care optometrist too.

The first author, Stephen Goldberg, is a Professor Emeritus at University of Miami School of Medicine. He combined his family physician, neurology, and ophthalmology experiences to target this book for non-ophthalmologists. The second author, William Trattler, served a cornea fellowship and practices ophthalmology, while also teaching at Bascom Palmer Eye Institute.

In keeping with the digital era, the fourth edition has a CD-ROM with an atlas of ophthalmological conditions and includes movies of ophthalmological surgical procedures viewable with appropriate software download. Altogether there are 209 photos of tests, procedures, and ocular pathologies of the external eye, conjunctiva/sclera, cornea/anterior chamber, retina, iris, and lens. Arrows highlight the critical features of specific disease entities. Also included are movies depicting five surgeries, namely cataract, Lasik, Lasek, Intacts, and lens implantation. Internet search for multitudes of ocular conditions is only a click away by the categories of diagnosis, prescription, definition, literature, and images.

The anatomy chapter of the book (chapter 1) begins, “It is difficult to play billiards using eyeballs, as the eye is not perfectly spherical.” (page 1) Talking of the cornea, the authors say, “The ‘poor’ minerals (calcium; iron from foreign bodies) settle in the ‘Bowery’ (Bowman’s membrane). The ‘rich’ minerals (copper, in Wilson’s disease; gold, in gold poisoning, as in arthritis treatment…) tend to deposit deeper, in Descemet’s membrane.” (pages 2-3) They use various memory aids, such as noting that Cranial Nerve III – the “three pillars” – serves to keep the eyes open. It is Cranial Nerve 7 – “a hook” – which closes the eye.

In chapter 2, Visual Disorders, the authors explain how a pinhole would be a remedy if you lost your glasses in the woods as long as you didn’t care for peripheral vision, illumination and, of course, cosmesis! In this chapter there was an amusing anecdote concerning a conversation between an intern and the attending. A cataract patient had 20/100 on Snellen distance chart and Rosenbaum near card. The intern, knowing that Snellen and Rosenbaum were “equivalent”, thought something was wrong with the charts because his own distance visual acuity (VA) without Rx was 20/100 (Snellen) but an excellent 20/20 at near. The attending, noted for his keen judgment, tried himself. To his amazement, without his glasses, he was 20/20 at far but only 20/100 at near. They concluded: These charts only work on patients.

Chapter 3, The Red Eye, notes that if discomfort disappears with the use of proparacaine, the disorder is superficial, contrasted with the deep, intense aching pain of glaucoma, uveitis, neuritis, sinusitis or vascular etiologies. The two highly painful corneal conditions that commonly occur late at night and can be readily diagnosed even by a half-awake physician, are contact lens overwear and UV exposure with sun lamp or welding arc. A chart of red eye causes, symptoms & treatment is included after the book’s index.

Chapter 4, Ocular Trauma, begins with blunt trauma and the chorus “Don’t press on the eye” or else with a perforated globe you might see a “squashed grape” extrusion! The authors note that a pupil size difference greater than 20% is abnormal. Crepitus-cracking sound on gentle palpation of swollen lids (not globe) may indicate an ethmoid fracture. For traumas they suggest applying the rule “ice the first day and heat the next.” Alkali (e.g., lye) is more damaging than acids and resultant stromal damage is usually irreversible, necessitating transplant. Profuse irrigation for 15 to 20 minutes is the initial treatment. Neutralizing alkali with acid or vice-versa are ill-advised due to damaging heat reactions. Pupil constriction may be a tell tale sign for intraocular inflammation, and a cycloplegic may relieve discomfort and prevent glaucoma.

Chapter 5, Retinal Disease, is filled with several differential diagnoses one-liners. The authors contrast hypertension and diabetes by summarizing how hemorrhages, exudates, A/V nicking, occur in both but for opposite reasons. Hypertension affects the arteriolar end of the capillary bed, and diabetes affects the venous side of the capillary bed. They
also point out how the appearance of the papilledematous disc is the reverse of that in a glaucomatous one. In papilledema, the pressure is elevated outside (intracranial) the eye, unlike in glaucoma.

The papilledematous disc is “angry,” red, elevated, with a small cup. The glaucomatous disc is pale, depressed and has a large cup. The hemorrhages and exudates cluster around the optic nerve head in papilledema. The hypertensive/diabetes hemorrhage pattern is more distributed across the posterior pole. Venous pulsation in the disc area is normal, but it is difficult to detect. So the absence of venous pulsation has limited diagnostic value. But its presence is diagnostic that papilledema is absent. Localized blur around disc margins may indicate papilledema, but a generalized blur possibly is indicative of cataracts. Visual acuity is more likely diminished in papillitis (a less common condition) than it is in papilledema. The leading cause of blindness in the United States is diabetic retinopathy; among elderly it is AMD, and around the world it is trachoma.

Chapter 6, Neuro-ophthalmology, is rich with schematics in its seven pages. It covers field plots of glaucoma, and lesions across the visual pathways. The authors remind us that bitemporal hemianopia depicts chiasmal lesion suggestive of pituitary tumor, right homonymous hemianopia is indicative of stroke, and that a unilateral central scotoma may be indicative of optic neuritis in multiple sclerosis. Also, the authors note that in visual-motor cortex lesions, patient “looks at the lesion.” For example, the eyes deviate left because patient cannot look to right, due to left visual-motor cortex involvement. In multiple sclerosis, convergence is intact. However, the medial longitudinal fasciculus (MLF) is damaged, so conjugately looking left, the right eye stops straight ahead, and looking right, the left eye stops straight ahead. Parinaud’s syndrome involves vertical gaze paralysis due to lesions proximal to the pineal gland/superior colliculus. Horizontal jerk nystagmus can be indicative of vestibular and brain stem disorders. Vertical nystagmus is always abnormal, secondary to brainstem dysfunction.

Discussing the cranial nerves, the authors note that Cranial Nerve 5 trigeminal lesions affect touch, pain and blink reflex resulting in corneal erosions and dry eyes. Associated with distribution of the CN5 ophthalmic division, in herpetic lesions one sees the classic midline-respecting lid and forehead rash. Cranial Nerve 7 lesion is related with Bell’s palsy. Other branches of Cranial Nerve 7 lesions may result in hyperacusis and “crocodile tears,” i.e., tearing rather than salivating when eating.

Migraine often is familial. Its prodromal visual aura phase is due to vasoconstriction, showing symptoms of wavy ripples, field defects, and dizziness. The subsequent vasodilation and arterial wall edema result in headaches. Transient ischemic attacks (TIAs), in contrast, are neurological deficits due to micro-embolisms, and have shorter duration. Cluster headaches, variants of migraine, occur in clusters of several times daily over several weeks and then stop for weeks or months. With these, the eyes are red and headaches excruciating and often exacerbated with alcohol. With temporal arteritis, patients are typically elderly, have a unilateral headache, the temporal artery is tender to touch – a response to inflammation, and an ESR of 50+ mm/hr. Blindness resulting from thrombosis of central retinal artery may be averted with steroids.

Chapter 7 is entitled Ocular Findings in Systemic Disease. Seventy systemic disease entities are presented alphabetically identifying their key ocular signs/symptoms – all in three pages. Also added is a half-page section on drug effects. Chapter 8, Ophthalmologic Techniques, is mostly old hat for optometrists. However, the authors’ strategy of applying drops to patients afraid of eye drops is notable. They suggest telling patients to close their eyes. Then you place the drop in the area between nose and nasal aspect of lids. Then you instruct patients to open their eyes. As the eyes open, drops enter between the eyelids.

The final chapter 9, Clinical Review, has a two page table of eye symptoms and the corresponding most common diagnoses, followed by 35 black and white schematic figures depicting common lid and ocular surface conditions, anterior and posterior segment diagnoses, and systemic associations. At the end of the book there are three pages of glossary and four pages of index, followed by a table of red eye signs, symptoms, and diagnoses. I recommend this book for those interested in a fun, quick, read/review of ophthalmology made ridiculously simple!

Subhash N. Jani is Professor Emeritus at Western Illinois University, Macomb, IL 61455, and a practicing optometrist. He obtained an M.S. degree in physiological optics from Indiana University in 1967. He is a Fellow of the American Academy of Optometry.