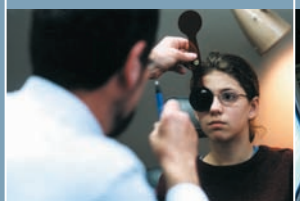
RESEARCH

The New England College of Optometry

Vision in Focus

research
knowledge
discovery
vision

CONTENTS



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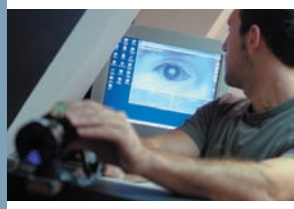
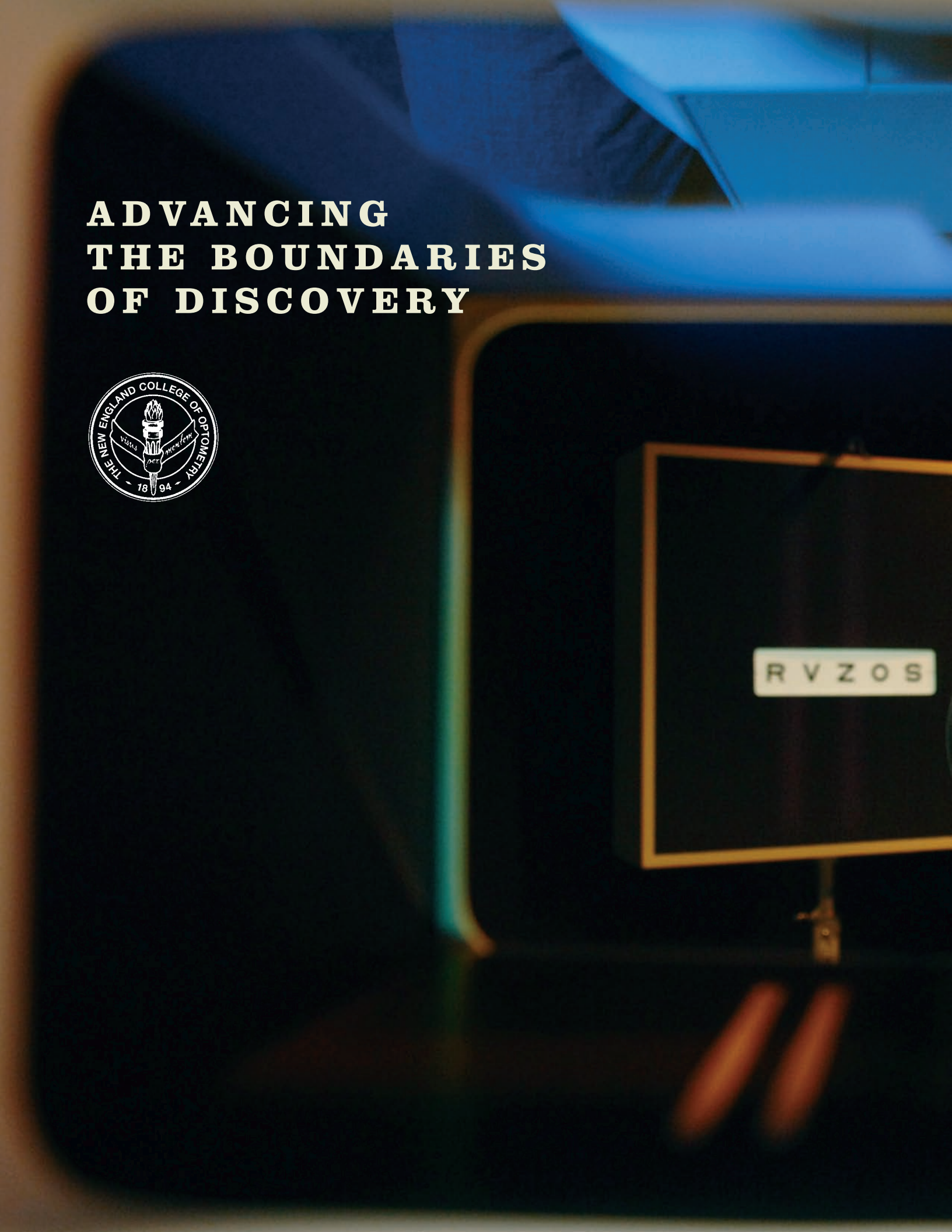


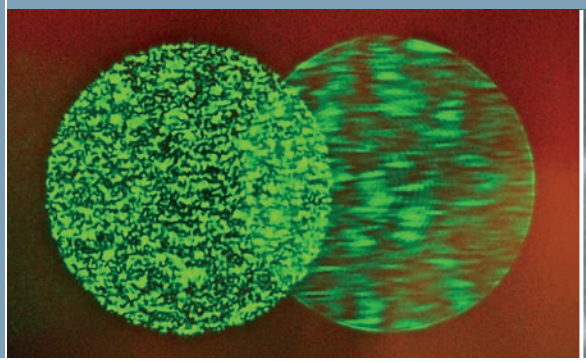
ADVANCING THE BOUNDARIES OF DISCOVERY

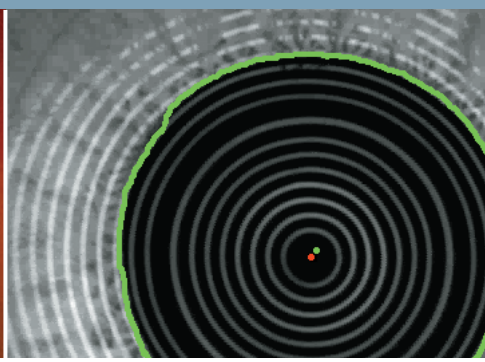


"While myopia research is still an important focus, there has been a strategic shift to encompass a broader range of research areas. This is bringing new researchers, new grants, and new energy to the overall program at the College."

—Dr. Jane Gwiazda, Director of Research

ADVANCING THE BOUNDARIES OF DISCOVERY



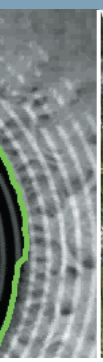


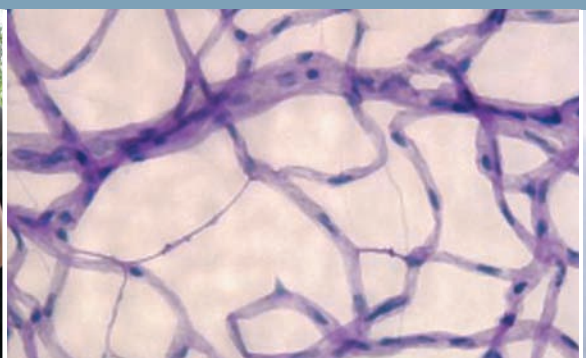
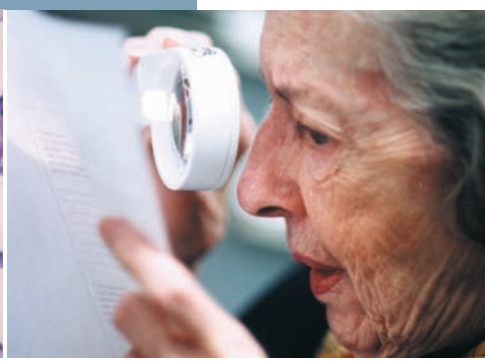
Only a few strategies can effect major changes within a college and enhance its reputation nationally and internationally. Building a research program is such a strategy. About twenty years ago the New England College of Optometry broadened its focus to build a strong research program that could contribute new knowledge, lead the optometry profession into new directions, strengthen its faculty, and enhance its reputation. This publication highlights the research that is now a central core of its mission.

The College reached a major milestone with the establishment of the Myopia Research Center in 1995. This was the first center of research that adopted a multidisciplinary approach to the understanding, treatment and prevention of myopia. Its recognition reached new levels when the College was selected to host the International Myopia Conference in 2000, which was attended by myopia researchers from around the world, representing 17 countries.

The focus on myopia was timely. Some parts of the world such as the urban centers of Asia are experiencing dramatic increases in myopia. Myopia is an intriguing and important topic to study: the eye grows too long for its optical power and an image falls in front of the retina, causing blurred distance vision. The factors causing abnormal eye growth and what can be done to control them are a central focus for myopia research at the College: clinical, biological and optical research as well as ultrahigh imaging of retinal structures all take place at The New England College of Optometry.

As more research-oriented faculty members joined the College, they set up laboratories and became mentors to students who wanted to study basic and clinical research to supplement their optometric education. This has culminated in a formal Master of Science in Vision Science degree that became available in 2003.



The next phase in the College's research program occurred about five years ago when there was a strategic shift to expand the program to include a broader range of research areas. This phase has brought in new researchers, new grants, and new energy to the overall program.

The growth is now reflected in the range of vision research topics being investigated at the College:

- Biomedical research
- Visual optics and advanced imaging
- Human vision
- Epidemiology and clinical trials of treatments for myopia

The coming years will see the College's research expand in established areas of strength—biological science, vision science, and clinical research, with myopia an overarching field of study—and the implementation of goals that will propel programs forward in new directions. At the same time, students earning degrees in the College's graduate programs will join the next generation of vision researchers.

RETINAL PHYSIOLOGY, STRUCTURE AND FUNCTION IN BOTH NORMAL AND DISEASED RETINAS

Stacey S. Choi

AREAS OF INTEREST: RETINAL IMAGING, ADAPTIVE OPTICS, RETINAL DISEASES, OPTIC NERVE DISEASES, AND RETINAL FUNCTION

Associate Professor of Vision Science
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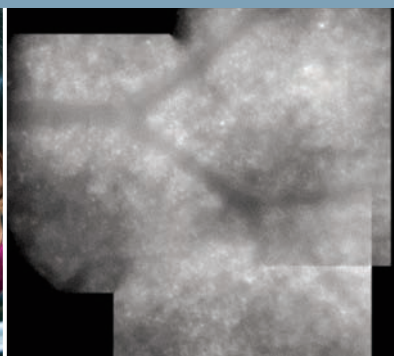


Above, right: In vivo image of human cone receptors acquired with an adaptive optics flood-illuminated fundus camera. Blood vessels are clearly apparent.

COLLABORATOR: Nathan Doble

FUNDING: Department of Defense, US Army

SELECTED PUBLICATIONS:

Choi SS, Zawadzki RJ, Keltner JL, Werner JS. Changes in cellular structure revealed by ultra-high resolution retinal imaging in optic neuropathies. *Investigative Ophthalmology and Visual Science*, 49:2103-2119 (2008).

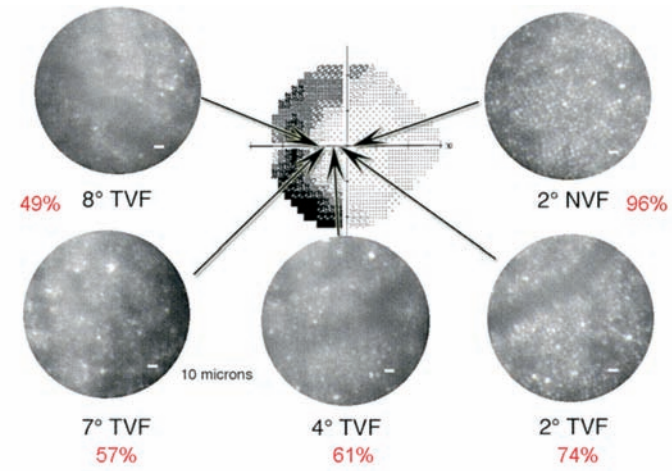
Choi SS, Zawadzki RJ, Greiner MA, Werner JS, Keltner JL. High-resolution retinal imaging of optic nerve head drusen showing nerve fiber layer loss and photoreceptor changes. *Journal of Neuro-ophthalmology*, 28(2):120-125 (2008).

Choi SS, Doble N, Hardy JL, Jones SM, Keltner JL, Oliver SS, Werner JS. In-vivo imaging of the photoreceptor mosaic in retinal dystrophies and correlations with retinal functioning. *Investigative Ophthalmology and Visual Science*, 47:2080-2092 (2006).

Dr. Choi investigates various types of retinal and optic nerve diseases at the cellular level in living eyes of patients by employing ultrahigh resolution retinal imaging instruments such as the adaptive optics (AO) fundus camera and optical coherence tomography (OCT). One of her main research interests is to understand the retinal physiology and function in both normal and diseased retinas, which will enable us to advance our understanding of various disease mechanisms by combining in vivo retinal images and function. The ultimate goal is to be able to detect changes in the retina even before they start to cause visual defects.

One of her studies includes an extensive investigation of photoreceptor geometry in various retinal dystrophy patients. The results show a significant correlation between the reduction of cone density and the loss of visual function measured at the same retinal locations. The measurements include visual field sensitivity, multifocal electroretinography (mfERG) and contrast sensitivity. These results clearly demonstrate the potential of AO fundus cameras in diagnosing and monitoring the health of the retina at a sensitivity level that cannot be achieved with conventional clinical and research instruments.

Dr. Choi's ongoing research is the application of this powerful imaging modality to study various retinal and optic nerve diseases.



Cone photoreceptor mosaic of a cone-rod dystrophy patient as a function of retinal eccentricity.

HIGH RESOLUTION RETINAL IMAGING

Nathan Doble

AREAS OF INTEREST: **OPHTHALMIC INSTRUMENT DESIGN, ADVANCED IMAGING, RETINAL STRUCTURE**

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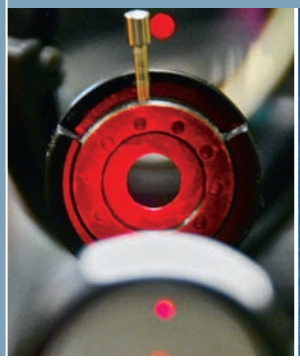

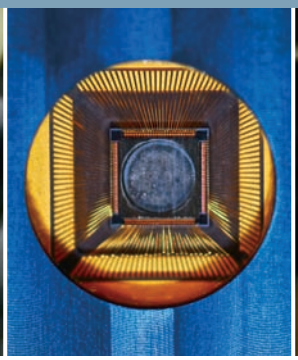

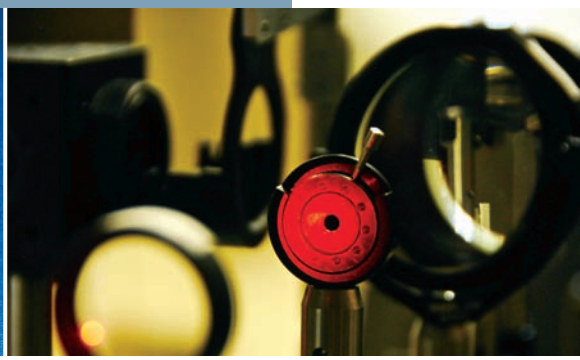

Above: Sections of an adaptive optics flood-illuminated fundus camera.

COLLABORATORS: Stacey Choi, Elise Harb, Debora Nickla, Erik Weissberg

FUNDING: Department of Defense, US Army

SELECTED PUBLICATIONS:

Doble N, Miller DT, Yoon G, Williams DR. Deformable Mirror Requirements for Adaptive Corrections in a Population of Normal Human Eyes. *Applied Optics.* 46:4501-4514 (2007).

Doble N, Miller DT. Wavefront Corrections for Vision Science. In: *Adaptive Optics for Vision Science: Principles, Practices, Design and Applications.* Wiley Series in Microwave and Optical Engineering, Wiley Interscience (2006).

Doble N. High Resolution, In-Vivo Retinal Imaging using Adaptive Optics and its Future Role in Ophthalmology. *Expert Review of Medical Devices*, 2(2):205-216 (2005).

Dr. Doble is developing and constructing next-generation ophthalmic retinal imaging systems that provide single cell resolution within the living human eye. His ultrahigh resolution fundus cameras and optical coherence tomography systems (OCT) use adaptive optics to increase resolution by an order of magnitude. He has designed advanced optical systems for the College and for many leading laboratories around the country. The heart of any adaptive optics system is a deformable mirror that can be instantaneously shaped to compensate for the irregularities or aberrations within the living eye. Dr. Doble is now using his adaptive optics fundus camera to study the distribution of cones in normal human eyes and in patients with different retinal diseases.

He has also adjusted the camera so that he can see the cone mosaic in the retina of the tiny eyes of normal and myopic young chicks and genetically altered mice. His most ambitious challenge is to try to enhance the resolution of his ultrahigh resolution fundus camera even further so that he can identify the slender outer segments of individual rods. This has never been accomplished. If we can count the loss of individual rods in patients with retinitis pigmentosa and other retinal dystrophies it could marshal in a whole new era of precisely quantifying the effects of the diseases and the potential positive effects of new treatments.

Dr. Doble's next major project is to build an optical coherence tomography system with such high resolution that he will be able to picture individual cones in 3-D.

"The eye is a very complex and dynamic system. The same distortions that can make it impossible to see clearly without corrective lenses make it difficult to accurately image the inside of the eye."

DEVELOPMENT OF MYOPIA IN CHILDREN

Jane Gwiazda

AREAS OF INTEREST: **LENS INTERVENTIONS TO SLOW THE PROGRESSION OF MYOPIA**

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COLLABORATORS: Li Deng, Elise Harb, Ji Chang He, Leslie Hyman (State University of New York at Stony Brook), Ruth Manny (University of Houston Optometry), Wendy Marsh-Tootle and Tom Norton (University of Alabama at Birmingham Optometry), Mitch Scheiman (Pennsylvania College of Optometry), Frank Thorn, Erik Weissberg

FUNDING: National Eye Institute

SELECTED PUBLICATIONS:

Gwiazda J, Hyman L, Dong L, Everett D, Norton T, Kurtz D, Manny R, Marsh-Tootle W, Scheiman M and the COMET group. Factors associated with high myopia after 7 years of follow-up in the Correction of Myopia Evaluation Trial (COMET) cohort. *Ophthalmologic Epidemiology*, 14:230-237 (2007).

Gwiazda J, Thorn F, Held R. Accommodation, accommodative convergences, and response AC/A ratios before and at the onset of myopia in children. *Optometry and Vision Science*, 82:273-278 (2005).

Gwiazda J, Hyman L, Hussein M, Everett E, and the COMET group. A randomized clinical trial of progressive additional lenses versus single vision lenses on the progression of myopia in children. Investigative *Ophthalmology and Visual Science,* 44:1492-1500 (2003).

Dr. Jane Gwiazda brings 30 years of experience as a vision scientist to her current positions as director of research and professor of vision science at the College. Although she previously conducted many studies on infant vision development, Dr. Gwiazda's research interests in the past two decades shifted to include both the risk factors for myopia development and the evaluation of treatments for slowing myopia. Dr. Gwiazda is principal investigator and chair of the Correction of Myopia Evaluation Trial (COMET), a national, multi-site randomized clinical trial that evaluated whether progressive addition lenses were more effective than traditional single vision lenses in slowing the progression of juvenile-onset myopia. The COMET study, which began in 1996, was the first clinical trial in optometry and is still ongoing, although its focus is now a longitudinal study of risk factors for myopia progression.

Dr. Gwiazda is also the protocol chair for COMET2, a randomized trial comparing the relative effectiveness of the two types of lenses investigated in COMET, but only within a subset of children with poor accommodative responses and near esophoria. She is also principal investigator on the NEI-funded T35 Training Grant, an initiative through which promising optometry students are recruited each year to participate in an intensive 10-week summer research program to interest them in pursuing careers in vision research and academia.

"Available treatments for myopia correct the problem but do not represent a cure, since they do nothing to stop the underlying eye growth that can lead to problems later in life."

PROGRESSION OF JUVENILE-ONSET MYOPIA

Erik Weissberg

AREAS OF INTEREST: MYOPIA, EYE CARE IN THE DEVELOPING WORLD, STRABISMUS, AMBLYOPIA

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COLLABORATORS: Jane Gwiazda, Elise Harb, Bruce Moore

FUNDING: National Eye Institute

SELECTED PUBLICATIONS:

Smith K, Weissberg E, Travison T. Alternative Methods of Refraction: A Comparison of Three Techniques. *Optometry and Vision Science*, 87(3):176-182 (2010).

Correction of Myopia Evaluation Trial 2 Study Group. Accommodative lag by autorefraction and two dynamic retinoscopy methods. *Optometry and Vision Science*, 86(3):233-43 (2009).

Chan K, Weissberg E, Deng L. Detectability of Socially Significant Strabismus. Presented at the annual meeting of the Association for Research in Vision and Ophthalmology (2009).

"If we can train local health care workers in Nicaragua to provide basic eye care, then our work continues long after we leave. Projects like this will improve access to eye care in countries where there are not enough eye care professionals to meet the needs of the local people."

Dr. Weissberg's main research focus is the progression of juvenile-onset myopia. Specifically, he has been involved in the Correction of Myopia Evaluation Trial (COMET) with Dr. Jane Gwiazda and is currently the Principal Investigator for the Collaborative Observational Study of Myopia in COMET Children 2 (COSMICC2), a follow-up of the original COMET study. COMET was a multi-center, randomized, double-masked clinical trial to evaluate whether progressive addition lenses slow the progression of juvenile-onset myopia when compared to conventional single vision lenses, as measured by cycloplegic autorefraction. The original clinical trial phase ended after 5 years of follow-up with children in their original lens assignments. COSMICC, a longitudinal study of myopia progression in the same cohort followed, and at present COSMICC2 is ongoing. One of the major aims of COSMICC2 is to use mathematical functions to model myopia progression and to develop predictive models and test hypotheses based on previously identified risk factors.

Dr. Weissberg is also interested in developing systems and testing tools to improve the delivery of eye care in the developing world. Along with Principle Investigator Dr. Bruce Moore, he has been involved in the VERAS project since 2005. VERAS is an acronym for the services provided and means "now I see" in Spanish. Among other things, the project is attempting to bring pediatric vision screening to Central America with multi-national cooperation. He has also worked throughout Nicaragua addressing several other problems, such as the lack of eye care in rural territories. He has trained local health care workers in northern Nicaragua to provide basic eye care services and tested tools that can be used to determine refractive error in the absence of eye care professionals.

COMMON VISUAL DEFECTS IN CHILDREN

Elise Harb

AREAS OF INTEREST: **PEDIATRIC OPTOMETRY, MYOPIA DEVELOPMENT, PEDIATRIC VISUAL ACUITY TESTING, TREATMENT OF AMBLYOPIA AND STRABISMUS**

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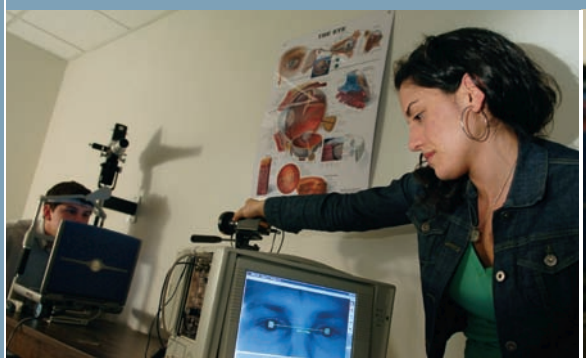


COLLABORATORS: Stephen Christiansen and Jean Ramsey (Boston Medical Center), Li Deng, Jane Gwiazda, Luisa Mayer, Bruce Moore, Erik Weissberg

SELECTED PUBLICATIONS:

Mallios J, Harb E, Moore B, Mayer L, Deng L. Comparison of Pediatric Computerized Visual Acuity Systems to a Pediatric 'Gold-Standard'. Presented at the annual meeting of the American Academy of Optometry (2009).

Troilo D, Totonelly K, Harb E. Imposed anisometropia, accommodation, and regulation of refractive state. *Optometry and Vision Science*, 86(1):E31-39 (2009).

Harb E, Thorn F, Troilo D. Characteristics of accommodative behavior during sustained reading in emmetropes and myopes. *Vision Research*, 46(16):2581-2592 (2006).

Dr. Harb studies issues related to pediatric optometry. In her clinical research, she assesses the instruments and clinical strategies used to provide eye care for the pediatric population. The development of myopia in children is a major interest and she is part of a team that is performing a multi-site clinical study.

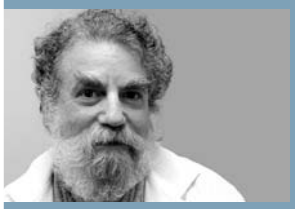
She works with Drs. Jane Gwiazda and Erik Weissberg on a follow-up of the myopia progression project (COMET). In the current study, COSMICC2, they are assessing other factors that may be related to the progression of juvenile-onset myopia. These parameters include central corneal thickness, intraocular pressure, retinal measurements using optical coherence tomography, and the assessment of environmental risk factors. A parallel study, MOONS, will assess these ocular parameters in a normal population and will be used for comparison to the COSMICC2 group.

In other work, Dr. Harb is assessing computerized systems for testing visual acuity and comparing these results with traditional vision screening tests. She is also a co-investigator on a series of studies with the Pediatric Eye Disease Investigator Group (PEDIG) at Boston Medical Center that are assessing the treatment strategies used for common childhood visual anomalies.

VISION SCREENING AND VISION CARE IN SPECIAL POPULATIONS

Bruce Moore

AREAS OF INTEREST: VISION SCREENING, HYPEROPIA IN CHILDREN, DEVELOPMENT OF VISUAL ACUITY AND VISUAL ACUITY TESTING IN INFANTS AND YOUNG CHILDREN



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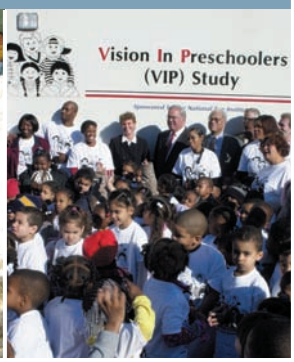


Above, right: Dr. Moore with children participating in the vision screening program.

COLLABORATORS: Catherine Johnson, Stacey Lyons, Nicole Quinn and Joshua Silver (Oxford University), Leon Ellwein (former Associate Director of the National Institutes of Health), Nathan Congdon (Hong Kong), Ming Guang He (Guangzhou, China)

FUNDING: The World Bank through Oxford University, UNESCO, Lions Eye Research Foundation, Massachusetts Department of Public Health, Prevent Blindness America

SELECTED PUBLICATIONS:

Vision in Preschoolers (VIP) Study Group. Impact of confidence number on the accuracy of the SureSight Vision Screener. *Optometry and Vision Science*, 87:2, In Press.

Vision in Preschoolers (VIP) Study Group. Children unable to perform screening tests in Vision in Preschoolers Study: proportion with ocular conditions and impact on measures of test accuracy. *Investigative Ophthalmology and Visual Science,* 48:83-87 (2007).

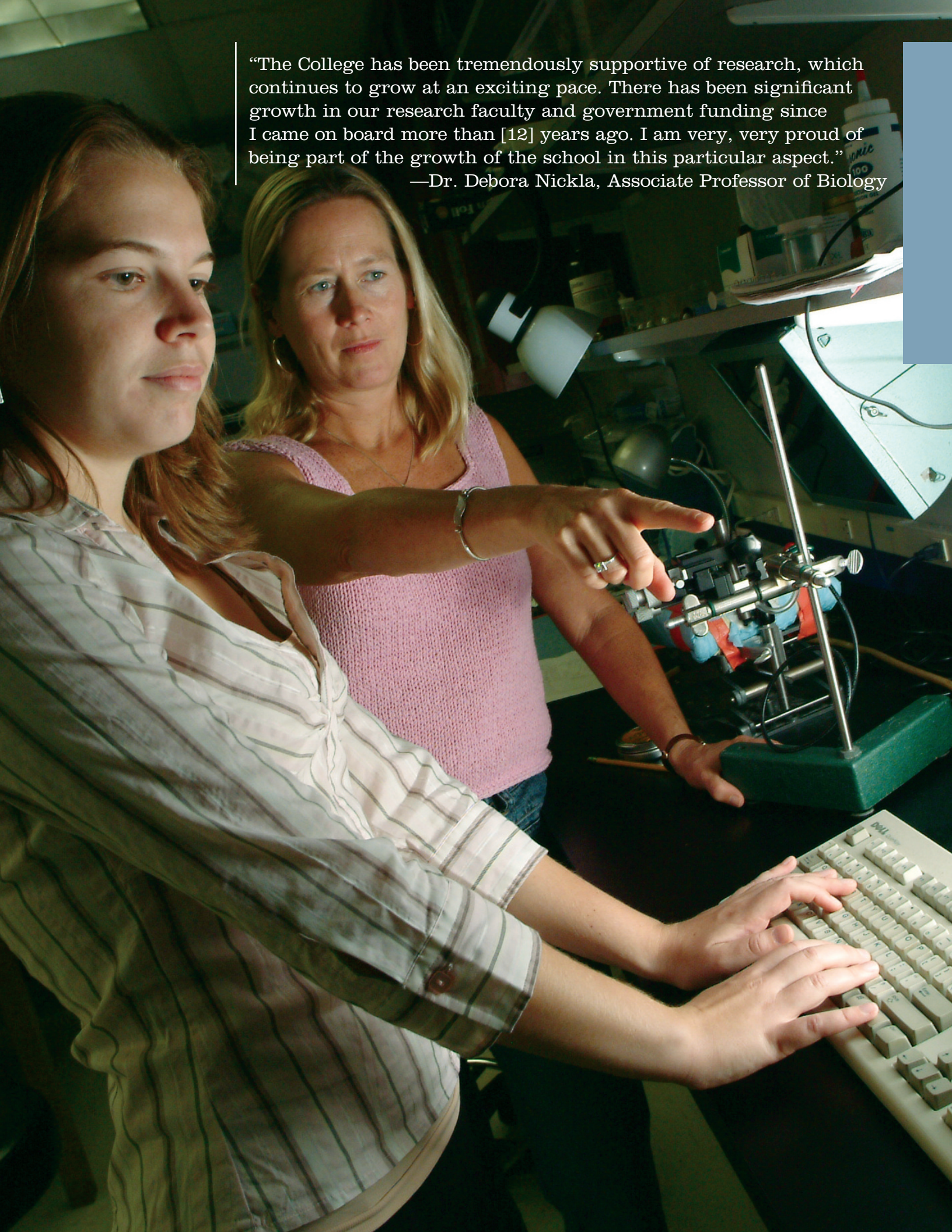
Schmidt PP, Maguire MG, Moore B, Cyert L for the Vision in Preschoolers Study Group. Testability of preschoolers on stereotests used to screen vision disorders. *Optometry and Vision Science*, 80:753-757 (2003).

Dr. Moore's career as a pediatric optometrist has been devoted to studying the visual problems and therapeutic options for infants and young children with ocular anomalies. He is active in research and policy efforts to design effective screening programs for infants and young children. And he is involved in efforts to develop a broader and more effective program of vision care for young children on the local, state and national levels.

He is a principal investigator for the federally funded multi-center study of vision screening in children, the Vision in Preschoolers (VIP) Study. This project aims to develop a battery of screening procedures for broad use in the preschool population in the U.S. and beyond. He is also a leader in the next phase of this project: the Vision in Preschoolers—Hyperopia in Preschoolers (HIP) epidemiological study to answer the following question: Do uncorrected hyperopic (far-sighted) children without other major vision problems perform worse on educational tests than do comparable children with normal vision? This will resolve a question that has resisted easy resolution: Does a significant refractive error play an important role in a child's early education?

Dr. Moore is also a scientific advisor and clinical participant in international research projects funded by the World Bank, Oxford University in the UK, and UNESCO. These projects are focused on providing vision care to children in the developing world, in places where access to eye care is limited or absent.

Dr. Moore uses a slit lamp biomicroscope to examine the anterior segment of a patient's eye.



"The College has been tremendously supportive of research, which continues to grow at an exciting pace. There has been significant growth in our research faculty and government funding since I came on board more than [12] years ago. I am very, very proud of being part of the growth of the school in this particular aspect."

—Dr. Debora Nickla, Associate Professor of Biology

THE OPTICS OF THE EYE

Nancy Coletta

AREAS OF INTEREST: VISUAL OPTICS, REFRACTIVE ERROR, NIGHT VISION

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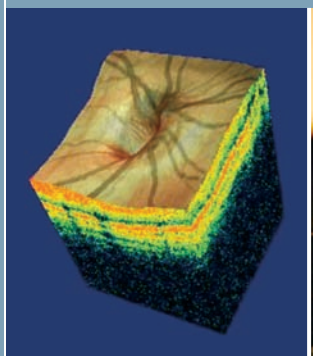
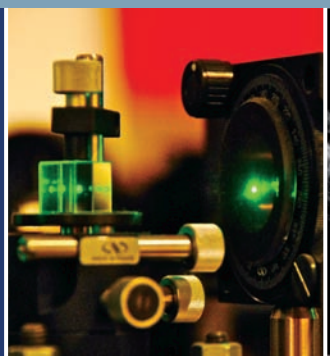
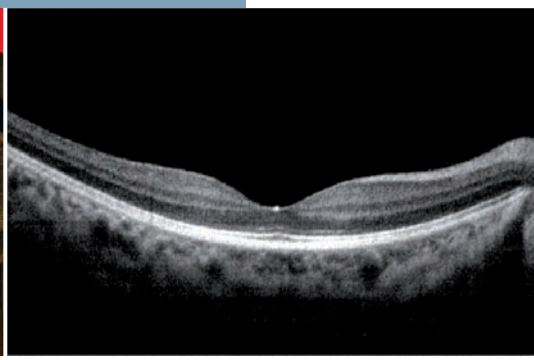






Above, left to right: OCT volumetric image of an optic nerve head; laser interferometer; OCT section through the central retina.

COLLABORATORS: Jane Gwiazda, Anne Fulton (Children's Hospital), Anne Moskowitz (Children's Hospital), Susana Marcos (Instituto de Optica, Madrid, Spain), David Troilo (State University of New York)

SELECTED PUBLICATIONS:

Coletta NJ, Johnson L, Raghuram A, Rondon M. Foveal pit depth and visual acuity in myopia. *Investigative Ophthalmology and Visual Science*, 50 (2009) (ARVO E-abstract 357).

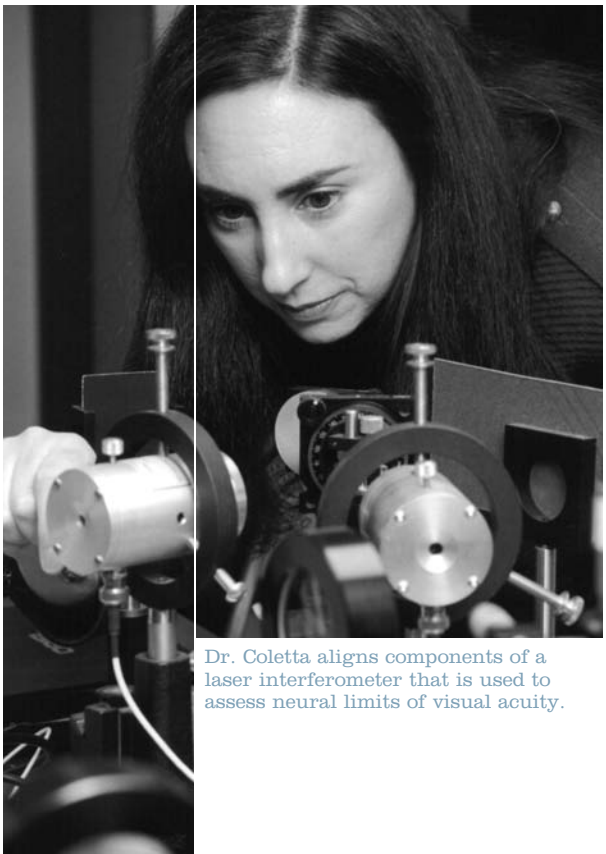
Coletta N, Watson T. Effect of myopia on visual acuity measured with laser interference fringes. *Vision Research*, 46(5):636-51 (2006) Epub 2005 Jul 19.

Coletta NJ. Visual psychophysics: Temporal factors in vision. Chapter 7 in Norton T, Corliss D. Bailey J (Eds). *Fundamentals of Visual Psychophysics*. Butterworth-Heinemann: Boston (2002).

Dr. Coletta studies the interaction between the optics of the human eye and neural factors in the human visual system, with emphasis on how these factors affect night vision. Subjects with corrected myopia, who have otherwise healthy eyes, have reduced visual acuity. Dr. Coletta has shown that this visual deficit becomes more evident at low light levels and is now examining the possible retinal contributions to this effect. The focus of her current myopia project is to correlate visual performance with retinal morphology as imaged by high-resolution optical coherence tomography (OCT). She is also collaborating with Dr. Anne Fulton's group at Children's Hospital of Boston on adaptive-optics retinal imaging and electroretinogram studies related to her own work. Studies of visual performance, retinal function and retinal imaging in the same eyes may contribute to a greater understanding of retinal architecture and function in myopia and other conditions.

Dr. Coletta's other recent and current projects with students in the Master's program at the College concern retinal imaging in subjects at risk for Alzheimer's disease, changes in peripheral aberrations with accommodation, estimating peripheral retinal contour from off-axis refractions, and demonstrating the effects of soft contact lens wear on corneal swelling and visual performance.

Dr. Coletta also works with Drs. Troilo and Marcos to examine various high-resolution images and wavefront aberration measurements from the eyes of small animals raised under conditions that induce a variety of refractive errors. They are trying to quantify the exact changes in the eyes during refractive development so they can define exactly how an eye grows to produce a specific refractive error.



Dr. Coletta aligns components of a laser interferometer that is used to assess neural limits of visual acuity.

VISUAL PERFORMANCE OF CHILDREN

Frank Thorn

Professor of Vision Science
Chair, Department of Vision Science
PhD (1967), Physiological Psychology, University of Rochester
OD (1979), The New England College of Optometry
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AREAS OF INTEREST: READING, REFRACTION, EFFECTS OF BLUR

COLLABORATORS: James Comerford, Li Deng, Jane Gwiazda, Ji-Chang He and Lu Fan, Jinhua Bao, Chen Jie (Wenzhou Medical College, China), Pawan Sinha (MIT)

SELECTED PUBLICATIONS:

Deng L, Gwiazda J, Thorn F. Children's refractions and visual activities in the school year and summer. *Optometry and Vision Science*, 87, In Press.

Thorn F, Gwiazda J, Held R. Myopia progression is specified by a double exponential growth function. *Optometry and Vision Science*, 82:286-297 (2005).

Thorn F, Cruz AAV, Machado AJ, Carvalho RAC. Refractive status of indigenous people of the northwestern Amazon region of Brazil. *Optometry and Vision Science*, 82:267-272 (2005).

Dr. Thorn studies the development of myopia and the underlying factors that influence it. Experiments with young animals have demonstrated that refraction is under the control of visual feedback as the retina analyzes the images projected onto it in order to control eye growth. But researchers cannot intentionally induce refractive errors in people or directly study many of the biological changes that take place in the human eye.

Dr. Thorn is primarily interested in how visual feedback works in children to control their refractive errors. The challenge is to perform experiments that create a model of the retina's response to an image, especially the image of text during reading, to show how the retina interprets this signal to induce the posterior part of the eye to grow faster or slower. If researchers can understand how a blurred signal influences eye growth, then measures can be taken to control the development of myopia.

This work is being performed with colleagues in the College's Children's Vision Lab and in the National Research Center of Optometry and Vision Science in Wenzhou, China. The quality of the retinal image during reading depends on a combination of factors: reading distance, sustained reading, illumination, accommodative accuracy, pupil size, and aberrations in the optics of the eye. Dr. Thorn is presently studying the natural ergonomics of recreational and textbook reading along with measurements of accommodation, pupil size, and optical aberrations to mathematically simulate the retinal image under normal reading conditions.

In other lines of research he has created a mathematical model of the progression of myopia in individual children and hopes to use this to create a formula that will allow clinicians to predict future refractive changes in children. He has also studied the development of myopia in illiterate populations. He and his colleagues ventured into the upper Amazon and other areas of Brazil to study the refractive errors of illiterate people. They found that myopia is rare in these populations presumably because their visual feedback is not disrupted by reading and confinement to the indoors.

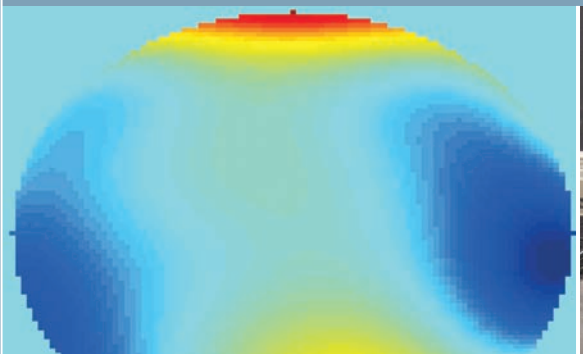
Dr. Thorn and his Brazilian ophthalmology colleagues with leaders of a Tukano indian village in the Amazon.

PHYSIOLOGICAL OPTICS AND VISUAL PERFORMANCE OF THE EYE

Ji Chang He, PhD

AREAS OF INTEREST: WAVEFRONT ABERRATIONS, COLOR VISION, RETINAL IMAGING

Associate Professor of Physiological Optics
PhD (1995), Biopsychology, University of Chicago
email: hej@neco.edu



Above, left: Corneal topography showing surface irregularities.

COLLABORATORS: Jane Gwiazda, Frank Thorn. In China: Fan Lu and Jia Qu (Wenzhou Medical College), Renyuan Chu and Xinghuai Sun (Shanghai Eye & ENT Hospital, Fudan University), Ningli Wang (Tongren Hospital, Capital Medical University), Peiying Xie (Beijing University)

SELECTED PUBLICATIONS:

He JC, Fang YW. A Method of Scheimpflug Image Processing for Accurate Measurement of Ocular Surfaces. *Journal of Cataract and Refractive Surgery*, 36, In Press.

Li SM, Xiong Y, Wang NL, Li J, Dai Y, Xue LX, Zhou HX, Ziang WH, Zhang YD, He JC. Effects of monochromatic aberration correction on visual acuity using adaptive optics system. *Optometry and Vision Science*, 86:868-876 (2009).

Bao JH, Le RR, Wu JX, Shen Y, Lu F, He JC. Higher-order wavefront aberrations in populations of young emmetropes and myopes. *Journal of Optometry*, 2:51-58 (2009).

Dr. He is an expert in color vision and physiological optics. He is currently investigating human wavefront aberrations, which degrade retinal image clarity. The aberrations are irregularities in the eye's optics. As beams pass through different parts of the pupil, the irregularities cause the beams to bend in different directions and to focus on different planes in front of or behind the retina rather than on the retina for clarity. Dr. He specifically focuses on the characteristics and sources of aberrations in the human eye and their relationship to accommodation, peripheral visual field positions and subjective vision. He uses various techniques including a wavefront aberrometer, corneal topography system and a Scheimpflug imaging system to measure ocular aberrations of the entire eye and relate aberrations to the surfaces of the cornea and lens.

A thorough knowledge of wavefront aberrations enhances the overall understanding of the optics of the eye and aids practitioners in their attempts to provide an accurate treatment of aberration-related vision problems. Dr. He hopes that his research will provide ophthalmologists and optometrists with comprehensive and effective information for wavefront-related vision treatments such as refractive surgery, cataract surgery and contact lenses.

Dr. He also studies color vision, myopia development, retinal imaging and visual performance of the eye. He has been actively engaged in collaborations with vision scientists and ophthalmologists in China covering a broad range of eye research during the last few years.

OCULAR GROWTH RHYTHMS

Debora Nickla

AREAS OF INTEREST: OCULAR GROWTH REGULATION, SCLERAL AND CHOROIDAL BIOCHEMISTRY, CIRCADIAN RHYTHMS

Associate Professor of Biology
PhD (1996), Biology, City College of The City University of New York
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COLLABORATORS: Josh Wallman and Xiao Ying Zhu (City College of The City University of New York), Falk Schroedl (Paracelsus University, Austria)

FUNDING: National Eye Institute

SELECTED PUBLICATIONS:

Nickla D, Wallman J. The Multifunctional Choroid. *Progress in Retinal and Eye Research*, 29(2):144-168 (2010).

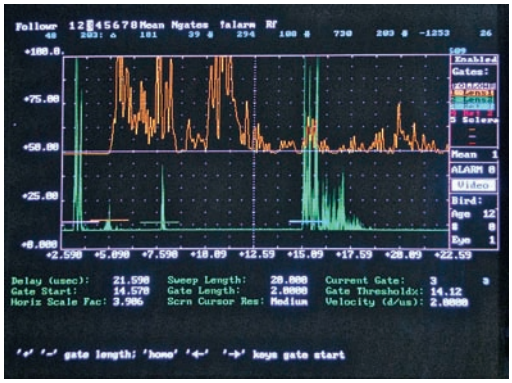
Nickla D, Damyanova P, Lytle G. Inhibiting the neuronal form of nitric oxide synthase has similar effects on the compensatory choroidal and axial responses to myopic defocus in chicks as does the non-specific inhibitor L-NAME. *Experimental Eye Research*, 88:1092-1099 (2009).

Nickla DL. Transient increases in choroidal thickness are consistently associated with brief daily visual stimuli that inhibit ocular growth in chicks. *Experimental Eye Research*. 84:951-959 (2007).

Animal models have shown that the growth of the eye is regulated by visual experience, however, the cellular and molecular pathways that mediate this "emmetropization" are as yet unknown. The changes that occur in the sclera and choroid in the posterior part of the eye are responsible for the ocular growth that can lead to myopia. One of the focuses of Dr. Nickla's research is to investigate the effects of specific drugs on both the choroidal and scleral responses to defocus in an effort to address the question of why some people become myopic while others do not.

Dr. Nickla's latest research shows evidence that muscarinic antagonists such as atropine and pirenzepine have effects on the choroid that, in turn, act on the sclera to mediate ocular growth changes in chickens. Specifically, these drugs produce a transient thickening of the choroid, which is associated with ocular growth inhibition. Muscarinic agonists, on the other hand, produce the opposite changes: choroidal thinning and growth stimulation. She has been studying these effects both in vivo and in eyecup preparations. She believes that acetylcholine might play a role in the changes in choroidal thickness by affecting the tonus of the non-vascular smooth muscles in the stromal layer of the choroid, which in turn may mediate changes in eye growth.

Another molecule of interest in eye growth regulation is the gaseous neurotransmitter nitric oxide. Dr. Nickla has studied the effects of the nitric oxide synthase inhibitor L-NAME and found that this inhibits the transient choroidal thickening normally seen in response to myopic defocus. This in turn dis-inhibits ocular growth, linking the two responses, and supporting nitric oxide as a candidate molecule in eye growth regulation.



High-frequency ultrasonography recordings from the eye of a small animal.

TOPICAL OCULAR DRUG DELIVERY

Steven Koevary

AREAS OF INTEREST: **DIABETIC RETINOPATHY, NON-INVASIVE TREATMENT STRATEGIES**

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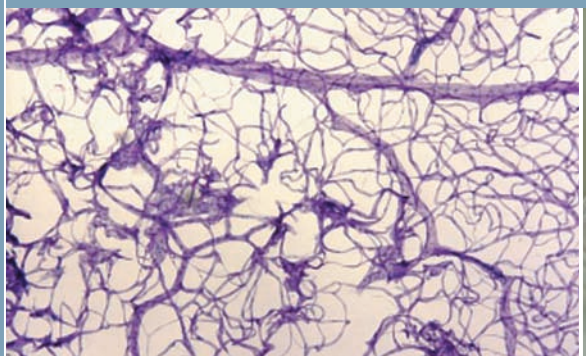
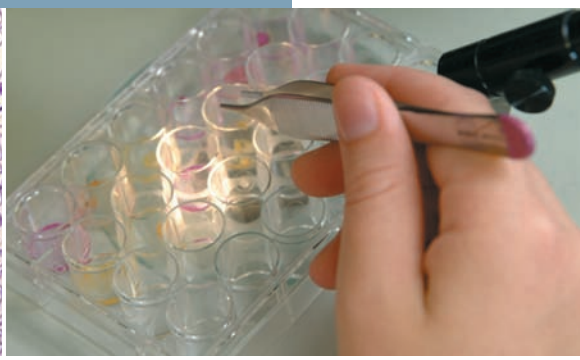
The City University of New York
email: koevarys@neco.edu





Above, left: Vascular changes indicative of early diabetic retinopathy are assessed using retinal trypsin digests.

FUNDING: OneSight Foundation; Pharmalight, Inc.

SELECTED PUBLICATIONS:

Skarbez K, Priestley Y, Hoepf M, Koevary SB. Comprehensive review of the effects of diabetes on ocular health. *Expert Review of Ophthalmology*, In Press.

Koevary SB, Nussey J, Kern TS. Long-term, topical insulin administration increases the severity of retinal vascular pathology in streptozotocin-induced diabetic rats. *Optometry*, 78:574-581 (2007).

Koevary SB, Lam V, Patsiopoulos G. Pharmacokinetics of insulin uptake by ocular tissues and the role of cerebrospinal fluid in optic nerve insulin accumulation following topical application. *Optometry*, 75:183-188 (2004).

Dr. Koevary is examining the efficacy of using topically applied drugs to treat posterior segment eye diseases in rat models. He has previously shown that topically applied insulin can reach the retina and optic nerve. His group is now examining whether the topical application of insulin can prevent diabetic retinopathy in the rat. Diabetic retinopathy is a common, potentially blinding complication of diabetes. His published findings to date support the feasibility of this approach.

While the above studies involve the use of topical drops which can be wasteful and uneconomical, Dr. Koevary, in partnership with Pharmalight, Inc., is also working to develop an alternative, efficient, non-invasive system for the delivery of peptide drugs to the back of the eye. He is specifically targeting the use of the device for the treatment of age-related macular degeneration and optic nerve changes in glaucoma. In light of the restrictions placed on optometrists in Massachusetts, a non-invasive alternative drug delivery system would allow optometrists to treat these conditions. The ophthalmic drug delivery system being investigated consists of a variable-frequency, piezoelectric, ultrasound nebulizer that has been adapted to produce nano-sized droplets containing drugs with unique formulations. Currently, Dr. Koevary is testing the efficacy of the device in delivering steroids and antibodies to the retina in rats and rabbits.

The ELISA assay is one of the main assays Dr. Koevary uses in his research to quantify peptide levels.

COLOR AND MYOPIA DEVELOPMENT

Frances Rucker

AREAS OF INTEREST: **EMMETROPIZATION, MYOPIA, COLOR, ACCOMMODATION**

Assistant Professor of Bioscience and Disease
PhD (2004), Vision Science, State University of New York College of Optometry
MSc (1999), Vision Science, State University of New York College of Optometry
MCOptom (1981), Optometry Diploma, British College of Optometrists
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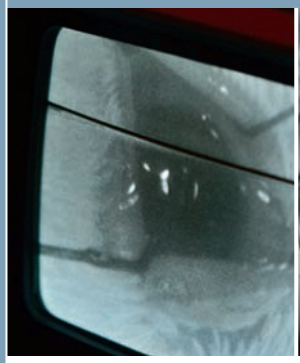

COLLABORATORS: Josh Wallman (City College of New York), Philip Kruger (State University of New York), Lawrence Stark (Southern California College of Optometry)

SELECTED PUBLICATIONS:

Rucker FJ, Wallman J. Chick eyes compensate for chromatic simulations of hyperopic and myopic defocus: Evidence that the eye uses longitudinal chromatic aberration to guide eye-growth. *Vision Research*, 49:1775-1783 (2009).

Rucker FJ, Wallman J. Cone signals for spectacle-lens compensation: Differential responses to short and long wavelengths. *Vision Research*, 48(19):1980-1991 (2008).

Rucker FJ, Osorio D. The effects of longitudinal chromatic aberration and a shift in the peak of the middle-wavelength sensitive cone fundamental on cone contrast. *Vision Research*, 48(19):1929-1939 (2008).

Dr. Rucker is interested in the signals that provide cues for focusing the eye. It is important to understand how the eye determines when it is in focus because of the association with eye growth and the development of myopia. Once the focusing mechanism is understood, the environmental triggers for excessive growth can be regulated and treatments developed for the control of eye growth and refractive errors.

There are several ways that the eye could determine when it is in focus. The eye could maximize contrast, use color cues from irregularities caused by chromatic aberration, or use other asymmetries in the retinal image. In the last few years Dr. Rucker has been looking at the color irregularities caused by chromatic aberration to see if the eye can use color signals to determine focus.

Chromatic aberration causes a lens to focus blue light in front of green light while red light is focused furthest away. The difference in the focus of the different colors could be used to guide the eye to focus on an object more accurately. Her recent experiments have shown that the chick uses color cues to control eye growth.

Dr. Rucker also studies the signals that provide cues for focusing the eye during ocular accommodation that occurs while looking at near objects. She has studied the color signals that are used in this process by depriving the eye of color information and by simulating the effects of chromatic aberration on the retinal image. In addition, she has investigated how near-sighted and far-sighted people differ in their use of these signals.

While Dr. Rucker was working on the focusing cues for accommodation at the SUNY College of Optometry in New York, she worked on identifying signals that could arise from asymmetries in the retinal image such as the Stiles Crawford Effect and other achromatic aberrations. This work is important because poor accommodation while reading may result in changes in eye growth that affect refraction.

CLINICAL TRIALS AND PUBLIC HEALTH

Li Deng

AREAS OF INTEREST: CLINICAL TRIALS, JUVENILE MYOPIA, PUBLIC HEALTH METHODOLOGY

Associate Professor of Biostatistics
PhD (2006), Statistics, Rice University
MA (2004), Statistics, Rice University
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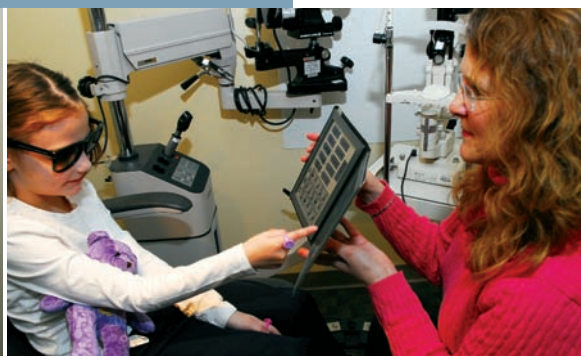


COLLABORATORS: Stacey Choi, Jane Gwiazda, Elise Harb, Catherine Johnson, Chea-su Kee (Hong Kong Polytechnic University, School of Optometry), Luisa Mayer, Bruce Moore, Frank Thorn

SELECTED PUBLICATIONS:

Deng L, Gwiazda J, Thorn F. Children's refractions and visual activities in the school year and summer. *Optometry and Vision Science*, In Press.

Deng L, Kimmel M, Foy M, Qing W, Spitz M, Gorlova O. Estimation of the effects of smoking and DNA-repair capacity on coefficient of a carcinogenesis model of lung cancer. *International Journal of Cancer*, 124(9):2152-2158 (2009).

Kee C, Deng L. Astigmatism associated with Experimentally-Induced Myopia or Hyperopia in Chickens. *Investigative Ophthalmology and Visual Science*, 49:858-867 (2008).

Dr. Deng's research focuses on statistical methods that analyze clinical and public health data. Her main interest is identifying risk factors for juvenile myopia development. As a complex trait, juvenile myopia is driven by multiple factors. For instance, children with both myopic parents have a higher risk of developing myopia and Asian children tend to be more myopic than other ethnic groups. A basic problem in research lies in identifying significant risk/protective factors, their relative contributions and interactions.

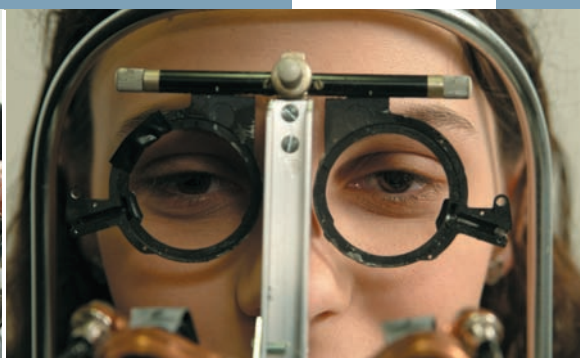
She also works with researchers to use information from retinal imaging data to unveil the association of myopia development and dynamic changes in retinal structure. Dr. Deng is involved in projects that apply public health methodology to real-world studies of glaucoma prevalence, preschool vision screening and collaborates with researchers at the College to design and evaluate the validity of visual acuity measurements.

ACCOMMODATION AND VERGENCE

Glen McCormack

AREAS OF INTEREST: **BINOCULAR VISION, OCULAR MOTILITY**

Professor of Optometry and Physiological Optics
PhD (1977), Physiological Optics,
University of California, Berkeley
OD (1971), Indiana University
email: mccormackg@neco.edu



Above, middle: Very small video cameras near the observer's head rest measure eye movements. Above, right: An observer views visual targets through ophthalmic lenses while the head is supported by a head rest.

COLLABORATORS: Li Deng, Catherine Johnson, Nicole Quinn, Frank Thorn

SELECTED PUBLICATIONS:

McCormack GL, Fisher SK. The source of disparity vergence innervation determines prism adaptation. *Ophthalmic and Physiological Optics*, 16(1):73-82 (1996).

McCormack G, Peli E, Stone P. Differences in tests of aniseikonia. *Investigative Ophthalmology and Visual Science*, 33:2063-2067 (1992).

McCormack G, Fisher SK, Wolf K. Retinal eccentricity of fusion detail affects vergence adaptation. *Optometry and Vision Science*, 68:711-717 (1991).

Dr. McCormack studies the influence of ocular convergence on measures of nearness perception. Convergence is the inward turning of the eyes induced by looking at near objects.

He has found that some measures of nearness perception, such as verbal reporting of nearness, are less affected by convergence than motor-dependent measures, such as pointing an unseen index finger at a near object.

Work in his laboratory has also shown that the influence of convergence on nearness perception is much stronger when observers look at objects moving in depth. This means that convergence may not be important for perceiving the nearness of stationary objects.

He is currently using his knowledge of convergence and nearness perception to test whether nearness perception causes abnormally strong convergence in patients with Divergence Excess Intermittent Exotropia. This condition is characterized by an outward turning of one eye that causes a cosmetic disfigurement of the patient as well as the loss of binocular vision.

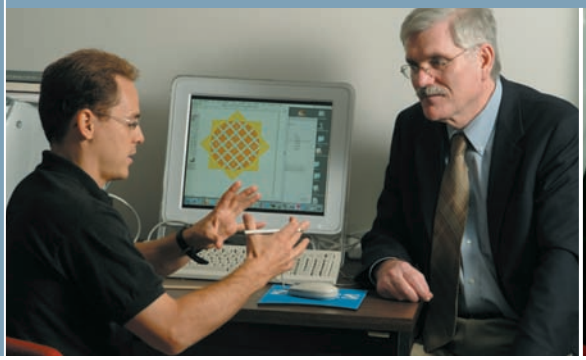
His research also has implications for future studies of vision and performance in some sports, and suggests how to augment visual training procedures used on patients with convergence disorders.

NEUROPHARMACOLOGY AND VISUAL PSYCHOPHYSICS

James P. Comerford

AREAS OF INTEREST: SENSORY PROCESSES, PERCEPTION, CLINICAL PSYCHOPHYSICS, COLOR VISION, ENVIRONMENTAL VISION

Professor of Vision Science
OD (1978), The New England College of Optometry
PhD (1972), Experimental Psychology,
University of California, Santa Barbara
email: comerfordj@neco.edu



COLLABORATOR: Frank Thorn

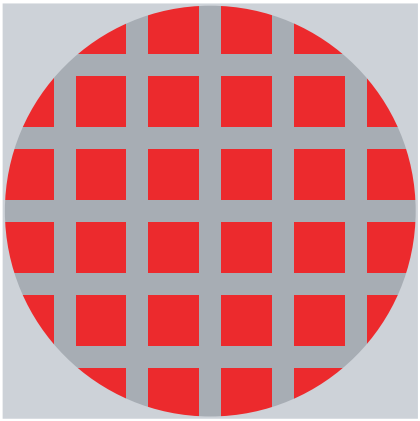
SELECTED PUBLICATIONS:

Comerford JP, Thorn F, Garland EM. S cone input to the chromatic Hermann grid illusion. Presented at the annual meeting of the Vision Science Society (2007).

Comerford JP, Thorn F, Garland E. Chromatic grid illusions occur with isoluminant stimuli. Presented at the annual meeting of the Vision Science Society (2006).

Comerford JP. Visual Psychophysics: Intensity Discrimination. In Norton T, Corliss D, Bailey J (Eds). *Fundamentals of Visual Psychophysics.* Butterworth-Heinemann: Boston (2002).

Above, left and right: Dr. Comerford and a student research assistant discuss the mechanisms of the Hermann Grid illusion. Below: A Hermann Grid used for assessing visual function. Disease may affect the response of visual neurons to different portions of the pattern.



Dr. Comerford uses sophisticated testing procedures to understand the mechanisms of loss that affect the visual system. In his work he attempts to relate specific visual performance deficits to defects of neurotransmission (a chemical messenger system). His main effort is devoted to developing tests that uncover the basic visual functions subserved by dopamine, a neurotransmitter that is responsible for neural interaction in many parts of the brain and retina. His research could have important implications for clinical pathologies such as Parkinson's disease, diabetes and myopia.

Parkinson's disease results when neurons that use dopamine degenerate in the brain. This disease also affects dopamine-dependent neurons in the retina. Since the retina is very sensitive to the loss of dopamine, certain types of psychophysical tests can detect very specific changes in retinal function. Parkinson's disease could then be detected in its early stages, which is essential for developing an effective course of treatment.

Based on his previous work using specialized techniques of visual perimetry, Dr. Comerford speculated that the Hermann Grid illusion could be an ideal instrument for efficient assessment of dopamine-mediated visual function. He and his colleagues demonstrated that patients with Parkinson's disease and those with diabetes have difficulty seeing this illusion.

Since other work has indicated that patients with Parkinson's disease have anomalies of color vision, Dr. Comerford has also been investigating the role of color in generating grid illusions.

AFFILIATED LABORATORIES

The researchers featured in this section are adjunct faculty at the College who bring their expertise to the classroom. They also make their laboratories available to students interested in their research.

LOW VISION

Eli Peli

Adjunct Professor of Optometry
Major Affiliation: Schepens Eye Research Institute, Harvard Medical School
OD (1983), New England College of Optometry
MSc (1978), Biomedical Engineering, Technion-Israel Institute of Technology
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AREAS OF INTEREST: **IMAGE ENHANCEMENT, TEXT READING, CONTRAST PERCEPTION**

Above, left: Driving simulator; right: Magnified TV.

FUNDING: Multiple grants from the National Eye Institute

SELECTED PUBLICATIONS:

Luo G, Woods RL, Peli E. Collision judgment when using an augmented-vision head-mounted display device. *Investigative Ophthalmology and Visual Science*, 50(9):4509-4515 (2009).

Peli E, Woods RL. Image enhancement for impaired vision: the challenge of evaluation. *International Journal on Artificial Intelligence Tools*, 18(3):415-438 (2009).

Peli E, Vargas-Martin F. In-the-spectacle-lens telescopic device. *Journal of Biomedical Optics*, 13:034027 (2008).

Dr. Peli is developing image enhancement techniques and devices to improve the television perception for people with impaired vision. He uses psychophysical methods to determine the dynamics of normal and impaired visual functions to guide the development of prototype image enhancement devices.

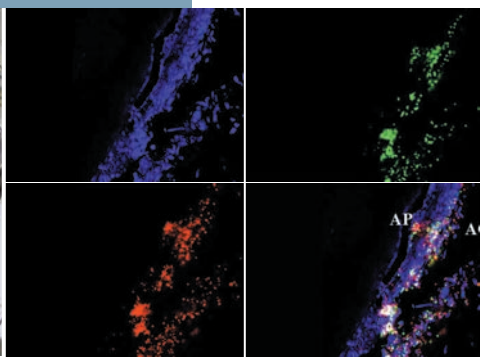
He and his team of optometrists, psychologists, and engineers are also developing and testing optical and electronic devices that can partially restore a combination of central (high-resolution) and peripheral (wide-field) vision. They test these approaches in virtual environments and determine their usefulness in real-world situations including multicenter clinical trials.

OUTFLOW RESISTANCE IN NORMAL AND GLAUCOMATOUS EYES

Haiyan Gong

AREAS OF INTEREST: MECHANISMS OF GLAUCOMA, TREATMENT STRATEGIES

Adjunct Associate Professor of Biology
Major Affiliation: Boston University School of Medicine and MIT
PhD (1991), Anatomy and Neurobiology, Boston University School of Medicine
MD (1977), Medicine, Jiangxi Medical College
MS (1982), Ophthalmology, Peking Union Medical College
email: hgong@bu.edu



COLLABORATORS: Thomas Freddo (University of Waterloo, Canada), Mark Johnson (Northwestern University), Roger Kamm (MIT), Douglas Rhee (Massachusetts Eye and Ear Infirmary, Harvard University), Joel Schuman (University of Pittsburgh)

FUNDING: National Institutes of Health, Glaucoma Research Foundation, American Health Assistance Foundation

SELECTED PUBLICATIONS:

Gong H, Freddo TF. The Washout Phenomenon in Aqueous Outflow – Why Does It Matter? *Experimental Eye Research*, 88:729–737 (2009).

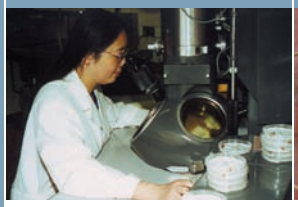
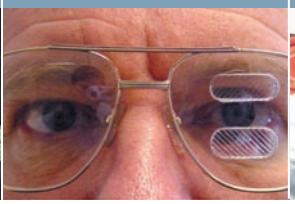
Zhang Y, Toris CB, Ye Liu, Ye W, Gong H. Morphological and Hydrodynamic Correlates in Monkey Eyes with Laser-Induced Glaucoma. *Experimental Eye Research*, 89:748-756 (2009).

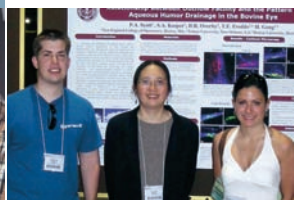
Scott PA, Lu Z, Ye Liu, Gong H. Relationships between increased aqueous outflow facility during washout with the changes in hydrodynamic pattern and morphology in bovine aqueous outflow pathways. *Experimental Eye Research*, 89:942-949 (2009).

Dr. Gong seeks to understand the mechanism of aqueous humor outflow resistance in the normal eye, how it is modulated, and the causes of increased outflow resistance in open angle glaucoma (POAG), a disease which is the second leading cause of blindness worldwide. Her team is also trying to develop new strategies for the treatment of glaucoma. One of her research projects is aimed at a better understanding of how the connectivity between the inner wall of Schlemm's canal (SC) and its underlying juxtacanalicular connective tissue (JCT) plays a role in the regulation of outflow resistance. One goal is to determine whether the inner wall and JCT separation can be induced in human eyes to decrease outflow resistance and thus intraocular pressure in glaucoma. Another project is aimed at understanding how SC and its distal drainage system contribute to increased outflow resistance in POAG.

She collaborates with scientists at other institutions in studies that examine the JCT and inner wall cells of SC where most of the outflow resistance is thought to occur. These studies include real-time imaging of SC cell dynamics using a three-dimensional cell culture device; whether increased stiffness of the inner wall cells of SC leads to a decrease in inner wall porosity, contributing to POAG; the role of matricellular proteins and how the dysregulation of these proteins leads to glaucoma. A comparative study is assessing the relationship between spectral domain OCT imaging of the aqueous outflow pathway and its morphology in the same tissue using light and electron microscopy.

RESEARCH EDUCATION



The best reflection on an educational institution is the quality of its curriculum and the caliber of its graduates. When the faculty are actively involved in research, they bring the latest ideas to the classroom and clinic. This offers the students an education infused with exciting discoveries and theories within the framework of optometry and vision science. Those students who take advantage of research education programs have the potential to make a unique contribution to their chosen profession, and they graduate with a background that gives them more career options.

Master of Science in Vision Science

The New England College of Optometry offers a graduate program leading to a Master of Science in Vision Science. This program is available to qualified candidates who are interested in doing original research in vision science. Select students can earn an MS degree at no additional cost while enrolled in the College's four-year OD program. A dual MS/OD degree is awarded upon graduation.

This program is also available to candidates who wish to earn a Master's degree without enrolling in the OD program. This tuition-based degree program is usually completed in two years. Qualified candidates must have a college-level background in science or a professional degree.

OD/PhD Dual Degree Program

The New England College of Optometry and the Division of Graduate Medical Sciences at the Boston University School of Medicine have established a combined Doctor of Optometry and PhD program. This is a seven-year course of study, with both degrees awarded after the satisfactory completion of all dual-degree requirements.

Summer Research Traineeships

Through a grant from The National Eye Institute, summer research fellowships are available for first- and second-year optometry students from around the country who want to participate in basic or clinical research. Through hands-on experience, the summer research fellows learn how to acquire data in the laboratory or the field, develop and test theories, and prepare their work for presentation at scientific meetings and in publications. Stipends are available for study during the three summer months.

Research Lecture Series

Under this program, recognized vision and clinical scientists from a wide range of disciplines are invited to the College to present their work. These presentations are followed by lively discussions and informal receptions so the College community can become better acquainted with the work of other researchers. Guest speakers come from American colleges and universities as well as from educational institutions in other countries.

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