ARTICLES:
Why Optometry Impresses Me
Comparison of Methods of Near Lateral Associated Phoria Measurement
Some Thoughts on Empowering Patients to Learn Compliant Behaviors in Taking Medications
Overview of Potential Applications of Nanotechnology to Eye Care and Medicine

CLINICAL QUIZ: Demodex
In This Issue

This issue offers contributions from IU optometry faculty and alumni as well as from international authors. The issue starts off with profiles of two former IU optometry faculty and two present day optometry faculty. The remainder of this issue has a wide range of topics, including essays on the nature and importance of optometry and on encouraging patient compliance, articles on near associated phoria measurement methods and on potential applications of nanotechnology, and a quiz on Demodex.

David A. Goss
Editor

ON THE COVER: (clockwise) Drs. Paul Pietsch, John Levene, Patty Henderson and Khashayar Tonekaboni

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**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.

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Paul A. Pietsch, Ph.D., was a member of the Indiana University School of Optometry faculty from 1970 to 1994, and was one of its most popular and most enthusiastic instructors. Dr. Pietsch’s academic career was stellar. Over the years he was a beloved mentor to thousands of students, was the author of nearly 100 publications, and won numerous awards, including 12 awards for outstanding teaching. The Paul Pietsch Scholarship Award was endowed by Dr. Freddie Chang, a former student then colleague. Pietsch taught many courses, including: neuroanatomy, microscopic anatomy, gross anatomy, cell biology, molecular biology, embryology, ocular anatomy, comparative anatomy, and physiology. Despite these rare achievements he was anything but the stereotypical ivory tower professor.

His path to science was not a typical one. A native of Depression-era New York City, Paul Pietsch was the first of four children. His father was a taxicab driver, and his mother, who had emigrated from Ireland in 1926, worked in childcare. His father died when Paul was 6. Paul left high school when he was in the 10th grade. He joined the Army in 1946, serving until 1949 in the post-war occupation of Japan and in the Korean conflict in 1951. He always credited the G.I. Bill for providing him with the means to an education. While in the Army his love of teaching emerged, and he taught English to Japanese students. He was also a writer on military subjects. While in the Army he earned a G.E.D., and after his discharge he pursued higher education with a vengeance, earning a bachelor’s degree in zoology from Syracuse University and a Ph.D. in anatomy from the University of Pennsylvania. He supported himself and his young family at various times by working at jobs that paid the bills: journalist, science writer, bartender, construction laborer, truck driver and many others.

It was in science that Paul Pietsch found his calling. He worked as an instructor in anatomy at the Bowman Gray School of Medicine, Wake Forest University; assistant professor of anatomy at the State University of New York at Buffalo; and as a research scientist at Dow Chemical Company, where he was the author of nine patents. He came to Indiana University in 1970 as an associate professor of optometry, and his career as a neuroscientist flourished. Pietsch taught optometry students and medical students while pursuing his primary research interests in regeneration and in the relationship between the brain and the mind. He even developed coursework to teach anatomy to blind students.

Pietsch shared his research with the scientific world through publication in professional journals, and many other periodicals, such as Quest, Harper’s, and Science Digest. He believed that scientists have the obligation to share knowledge with the non-scientific public. His article “Shuffle Brain,” about brain transplants in amphibians as a test of the language of the brain and of memory, was originally published in the May, 1972, issue of Harper’s Magazine and later won the 1972 Medical Journalism Award of the American Medical Association. Popular interest in his research continued to grow, culminating in an August, 1973, interview on the television show “60 Minutes.” He also was the subject of a series of Canadian national radio broadcasts, and was interviewed on Television Francais.

A demanding but enthusiastic teacher and a rigorous and exacting scientist, Pietsch was also an intellectual in the broadest sense of the word, with interests ranging from Civil War history to the space program. He was a modest, courteous, eloquent man who loved teaching and scholarship, but he could be moved to a crackling fury by misinterpretation of science for personal gain by “crackpots” and “snake-oil salesmen.” He detested injustice in any form, which bureaucrats learned quickly during his term as president of the IU chapter of the American Federation of Teachers, when he famously advocated for those whom he believed had been treated unfairly by the institution.

Although Dr. Pietsch retired from classroom teaching in 1994, he continued to come into the office every day...
until illness made it impossible. In his retirement he
devoted himself to helping others and to the authorship
of more than ten fiction and non-fiction books.

His passion in retirement was an extension of his belief
that science should be available not just to scientists.
This passion resulted in his award-winning Web site,
Shufflebrain, (www.indiana.edu/~pietsch/home.html),
“A polycultural collection on the biology of memory,
perception and a few other items.” This site experienced
an astonishing 29.5 million hits from 1995 to 2009,
which is an enormous testament to the fact that the
world is hungry for palatable scientific information.
Ironically, in retirement, Dr. Pietsch influenced millions
of people using this new technology, while during a
lifetime of teaching, his students numbered “only” in the
thousands. He quickly embraced new Web technology
as a teaching tool.

Touching testimony to the international influence of Dr.
Pietsch’s Web site is evident in the pleas of people
afflicted with rare neurological conditions, or even more
touchingly, from the parents of children suffering from
these conditions. He was in constant communication
with people around the world who needed help
interpreting the language of science as it applied to them
in the most personal of ways. Such conditions as
agenesis of the corpus callosum (a rare condition in
which the patient lacks the bundle of nerve fibers that
connect the two hemispheres of the brain) and acute
zonal occult outer retinopathy (another rare condition
resulting in temporary or permanent vision loss) are two
of the many subjects that he researched and translated
into comprehensible lay language for sufferers
worldwide, referring them to nearby specialists for
treatment. In testimony to his efforts he received
grateful thanks from many individuals. These are only a
few examples:
“If only you were here in the Philippines I would invite
you for the baptism of my baby and for sure you’re one
of the godfathers.”
“I wish to thank you for your kind letter, about getting
out of [city] and getting the help I needed with my eye.
Dr. _____ has taken me on as a full time patient. Thank
you so very much.”
“Thank you for giving us the clue for a new life, we
have now contacted associations, other parents, etc, that
give us a lot of information and support.”
“Last year you sent me information on Lennox-Gastaut
Syndrome and the medication that our granddaughter’s
doctor had prescribed because she had 2 seizures. We
are very happy to report that she is doing very well. She
has been seizure free for over a year. She is very
healthy and happy. I wanted to thank you for your help
in finding the information we needed to make some very
difficult decisions on her health care. Our family is and
will remain very grateful to you.”
“Thanks, you could never know how much you’ve
helped. Believe me you’re our Angel.”

Despite the enormous popularity of his Web site, Dr.
Pietsch was uncomfortable with recognition, and he did
little to call it to the attention of his IU colleagues.
Many people at IU remain unaware of it despite the
priceless goodwill that it brought to the university over
the years. He modestly resisted all attempts to publicize
it among university administrators, preferring to work
quietly and tirelessly for the benefit of others. Pietsch
came to the office regularly even in retirement, until
illness prevented it. On November 26, 2009, Paul A.
Pietsch, Professor Emeritus of Optometry, lost his long
battle with end stage renal disease.

Profile: John R. Levene, D.Phil., O.D.
by David A. Goss, O.D., Ph.D.

John Reuben Levene (1929-1983) earned an M.S. in
physiological optics from Indiana University in
1961 and was a member of the optometry faculty at
IU from 1967 to 1975. Levene had a quite varied and
productive career in optometry, as well as a diverse
educational background.

Levene was born in Hull, Yorkshire, England, in 1929,
and graduated from high school in 1946. He received
training in library science at Shoreditch Library from
1946 to 1948, and completed the Library Association
Entrance Certificate in 1948. He was a signalman in
the British Army from 1948 to 1950.

Following military service, Levene undertook training in
optometry at City University, London, completing the
Diploma in Optometry in 1954. In 1955, he received
fellowship diplomas in optometry from the British
Optical Association (F.B.O.A.) and the Spectacle
Makers’ Company (F.S.M.C.). He then practiced
optometry in London for several years before
undertaking studies for his M.S. at Indiana University.
From 1956 to 1958, Levene used evenings and weekends to study music at Trinity College of Music, London University, and was awarded an Intermediate Certificate in Theory of Music.1

Levene was at IU from 1960 to 1962 before holding various research or teaching positions for short periods of time at University of Houston, University of California Berkeley, and The City University in London.3 In 1966, he received the Doctor of Philosophy degree (D.Phil.) from the Faculty of Biological Sciences at University of Oxford, England.

Returning to IU as an Associate Professor in 1967, Levene was promoted to full professor in 1971. At IU he taught courses in the areas of general and ocular disease, geriatrics, and low vision in optometry and also did some teaching in the Department of History and Philosophy of Science. In April, 1968, IU held a vision science symposium in conjunction with the dedication of the new optometry building, and John R. Pierce and Levene edited the proceedings volume resulting from that symposium.4 Levene was Director of IU’s Low Vision Clinic from 1970 to 1974.3 As Director of the low vision clinic he developed an outreach program at local retirement centers to improve student experience in low vision. Levene also served as chairman of IU’s graduate program in physiological optics from 1969 to 1975.3 With fellow IU faculty member Daniel Gerstman, he co-authored a volume of optometry review questions for study for board examinations.5

Levene was on the IU faculty during the time that efforts began to shift the optometry program from a Division of Optometry within the College of Arts and Sciences to a School of Optometry (a change which finally occurred in 1975).6 Levene was among the faculty who emphasized the importance of working toward that shift in status.7 At the request of Gordon Heath to symbolize the achievement of School status, Levene designed the sunburst patterned flag for optometry that now hangs in the IU Memorial Union Tudor Room.7 Levene also supported the idea that the school should have a clinical presence in Indianapolis, which was finally achieved in 1976 with the establishment of the Illinois Street Eye Clinic.8,9 In 1975, Levene became Dean of Faculty and Professor at Southern College of Optometry (SCO), a position he held until his death in 1983. In 1980, Levene was awarded an O.D. degree from Pennsylvania College of Optometry.10 While at SCO, he reorganized their curriculum and expanded the coverage of general and ocular disease and pharmacology.11 During that period of time, he also took most of the courses toward a Doctor of Medicine degree.

The majority of Levene’s approximately 80 professional publications were on various topics in optometry history, but he also published on low vision, contact lenses, optics, and optometric education. His book, Clinical Refraction and Visual Science,12 is well known to optometry historians. In it he presented detailed research on various aspects of the history of optometers; the study of refractive errors, accommodation, night myopia, and astigmatism; and the invention of bifocals and trifocals. One review of the book said that it was “recommended to any optometrist who would like to know more about his roots.”13 It is noteworthy that he attempted replication of some of the historical experiments that he described in his book and his papers.

Levene was the Jan Kirkaldy Prize Essayist at Oxford University in 1964. In 1968, he was a winner of a Theo E. Obrig Memorial Award for his paper “The DeLaHire 17th century contact lens, a historical discovery.”14 He was made a Fellow of the Royal Microscopical Society for his studies on the history of microscopy. Levene also won awards for his poetry. In 1985, SCO published a memorial booklet of some of his poems.15

Acknowledgments
Susan Levene, John Levene’s widow, made papers and biographical documents available. Daniel Gerstman, who worked with Levene, provided personal observations and recollections.

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8. Goss DA, Pietsch PA, Gerstman DR, Meetz RE. An
It is a pleasure to write this biographical sketch of Dr. Patty Henderson. I have been fortunate to be at the Indiana School of Optometry the entire time in which her career has flourished. What a fantastic role model she has been for our young faculty and most of all, for all the young optometry students she has taught over the years. She has always lead by example.

Let’s look at her career at the Indiana University School of Optometry. She graduated from the IU School of Optometry in 1985. She knew early on that she had a passion for teaching. To reach her goal to become an optometric educator, she prepared herself by completing a residency in hospital based optometry at the Danville VAMC in Danville, Illinois in 1986. The residency only reinforced her desire to teach. The residency also provided her with a solid background to help her pursue the dream to become an educator. She began her career when she joined the IU faculty as a visiting lecturer in 1986, and then was offered a position as a Clinical Assistant Professor in 1987. For a brief time, she worked part time as she devoted most of her time to being a mother of two children. Fortunately, Dr. Henderson returned to a full time faculty position.

She has several strengths that make her a very valuable faculty member. Dr. Henderson is an enthusiastic, caring doctor who has a great knack for translating the knowledge learned in the classroom into the clinical setting. She turns the examination into a clinical classroom for every student/patient encounter. She has great examination skills and a solid knowledge base of all aspects of primary care optometry. She is demanding of the students, but at the same time creates an environment of mutual respect among the interns, patients, staff and other doctors. She has a goal to inspire her students for a lifetime of learning. Most of all she has gained the respect of her students and colleagues by being a caring and competent doctor. She inspires her students to be inquisitive and analytical. Fortunately, we were able to arrange for Dr. Henderson to teach the Neuro-optometry course in 2002. She has always had a special interest in this area of optometry and is able to bring a wealth of clinical experience into the classroom. I have reviewed a number of her presentations over the years. She is always current and encompassing with her Power Point lectures. She has also become a popular continuing education lecturer at the school. In 1996, Dr. Henderson became the director of the IU Community Eye Care Center. The School was very fortunate to have her as its director. Her leadership skills have proven to be very much appreciated by the faculty, staff and students. Under her direction the CECC has grown tremendously in size and patient numbers, and serves a very diverse clinical population. She has reached out to a number of organizations in the community to provide vision care to underserved patients. This has been most noteworthy in the CECC’s continuing vision care involvement in the Volunteers in Medicine (VIM) program. The clinic’s reputation has grown tremendously under her leadership. This clinic provides a very valuable clinical experience that is not achieved at our main campus clinic for our students.

Dr. Henderson has received a number of awards during her career. She has been voted by her students as Consultant of the Year, received the Teaching Excellence Recognition Award by her colleagues and the Business Associate of the Year, to mention only a few areas in which she has been recognized.

Along with her community service, she has been actively involved with the School, University, IOA Optom Med 1984;3:98-102.
What has always been most impressive to me is Dr. Henderson’s attention to detail in every area of Optometry in which she becomes involved. If you ask her to do something, you know it will be done in a professional manner. Over my years, I have been fortunate to observe the maturing of a number of faculty. It has been a pleasure to watch her develop into one of our most valuable members. The school, students and our profession have, and will continue to benefit tremendously from her dedication to optometric education and our profession.

Profile: Khashayar Tonekaboni, O.D.
By Todd Peabody, O.D.

Khashayar “Khash” Tonekaboni was born in Tehran, the capital city of Iran, and grew up in a small town on the Caspian Sea. After completing his high school scholastic work, he came to America for college in 1976. His knowledge of English was limited to some reading and writing, but his vocabulary and conversational skills effected a lower than acceptable TOEFL score. Colleges in the United States required that he spend a semester in this country before allowing him to be admitted into a bachelor’s degree program. He enrolled in a semester of English as a Second Language classes at University of Kansas to spruce up his skills.

In the winter of 1976, he moved to Bloomington to study biology at Indiana University. A heavy course load and difficulties with the English language got the better of him in his first semester at IU. Homesickness and an inability to thrive academically resulted in a lowly GPA of 1.08.

Then came the summer of 1977 and there was a complete turnaround. His steadily improving English and academic performance culminated in a GPA of 3.80 and, by the end of the fall semester in 1977, he made it to the Dean’s List.

Khash continued to thrive at IU and graduated with a bachelor’s degree in Biology in 1981. Upon graduation, he headed west to Sonoma State University in Rohnert Park, CA where he pursued a master’s degree in animal physiology and immunology while he awaited admission to Southern College of Optometry. He enjoyed the program but knew his passion was in optometry. Optometry school proved to be quite a jolt for Khash due to the sheer volume and depth of the science involved, but he persevered and excelled, making it to the Dean’s List yet again at SCO by the end of his second professional year. He graduated from optometry school in 1987 and moved back to his home away from home, Bloomington. Unfortunately, he came back without an obvious career opportunity, which posed an urgent problem given the nature of his visa. Change in personnel at SCO resulted in a withdrawal of his application for Practical Training (an extension of the student visa for foreign student). This would mean he would have to leave the United States by the end of the summer of 1987.

Thankfully, Dr. Bill Somers had a position available in the BV/Peds Clinic and, with great assistance from the Indiana University International Students Office, Khash was appointed as a visiting lecturer in BV/Peds. Due to his skill and rapport with the students and patients in the clinic, Khash was kept on the faculty and eventually transferred to the Primary Care Clinic where he expertly guides students through the art of patient care.

Khash has served the school in just about every possible role over his 24 years with us. He has taught multiple classes, served on various committees, and assumed several administrative positions. His longstanding dedication and loyalty to the school has proved to be a tremendous asset to the education of thousands of optometrists worldwide.

In his spare time, Khash is a published author who has fans across the globe. He has published four books, including novels and collections of short stories, and has another dozen in development. He is also an accomplished racquet sports enthusiast and a proud oenophile.
Optometry (gr. optós = seen + metréō = to measure), according to my understanding, is a part of applied knowledge where the main area of interest is the process of seeing; especially everything related to the protection, preservation, enhancement and development of this process. Protection means the counteraction of present or possible harms; preservation means the maintenance of the current characteristics; enhancement means the improvement of perceptual and motor efficacy; and finally, development means assurance of the presence of conditions necessary for proper development. The tasks described in this way, clearly demonstrate how optometry is different from other professions interested to a lesser or greater degree in the visual system. Such professions, for example, include ophthalmology, psychology, education, and illuminating engineering. The responsibilities of our profession indicate, among others, that optometry should be interested in pathology, not only pathology of the visual system but systemic pathology, to the extent the pathology can be a reason for disturbances of the visual process.

While describing Optometry as a discipline of knowledge, it is necessary to be aware of the requirements that need to be fulfilled for any given area of knowledge to be an independent field of science. From the practical point of view, a discipline of science may be defined as a systematized set of important statements which are scientifically documented, so they may be taught at the university level. It may only be a part of a larger set, but, large enough to be a category by itself; sufficiently rich to be a subject for teaching as a separate specialty. This however, is a purely practical approach and, no doubt, optometry fulfills the formulated practical requirement as a separate discipline of science.

In turn, from the point of view of the theory of science, this definition is not complete, because it is generally accepted that the status of a separate discipline of science is reserved for a set of concepts in which basic statements are discerned and formulated. These concepts serve as a foundation for proving derivative statements. The set of ideas ordered in this way constitutes the theory of a discipline, and thus, it is an independent scientific system. This system is basic for what is considered to be the philosophy of this discipline of science.

We therefore face the question: Is optometry a separate part of science? Maybe it is only a set of practical procedures useful in vision care. If we decide to answer affirmatively, we should be able to show the theory of optometry. This is not easy but, on the other hand, if we are able to do this, it creates a very promising future for optometry.

A scientific theory is a system of logically and factually ordered statements which are connected by definite logical relations. This system exists in any given discipline of science, and it fulfils accepted criteria of scientific and methodological correctness. Scientific theories of particular disciplines have different levels of internal coherence, different levels of justification and different structures. In empirical sciences that, which is considered a scientific theory is, for example:
- a set of statements explaining a given phenomenon together with hypotheses constituting a logically compact unit of scientific knowledge; or
- a system of definitions, laws and hypotheses with such logical interrelations that all less general statements may be derived from the most general ones, and formulated in such a way that their empirical verification is possible.

Without getting too deep into the theory of science, let’s look to what extent the knowledge on the subject of our interest, as well as our methods of action, can be an inspiration in the search of a theory that is specific for optometry, and, in connection to this, a methodology appropriate for our profession. We know a lot about structures and functions of the visual system, however, our management is based on very simplified models of the system. Unfortunately, these models are very often not sufficiently connected to each other. In order to act professionally in our area, it is necessary to be aware of these simplifications and their consequences. The problem is we do not have any general theory that could, for example, allow a comparison of different dysfunctions of the visual system or could inspire a search for new methods or would become a tool to use to verify different procedures used in vision therapy.

The majority of an optometrist’s duties are based on

BY DR. BOLESŁAW KĘDZIA
using psychophysical methods to examine the visual system. In other words, the examination of the relationship between the visual stimulus and the reaction of the person being examined allows one to diagnose the status of the process of vision. Thus, even in more general terms, the relationship between input and output of the tested system carries information about the status and function of this system. This short statement already provokes questions. What do I understand by the tested system? What is an input to the visual system? How can the status of this input be described? What consequences does modification of the visual stimulus bring? To what extent are the reactions of the person being examined a clear result of the stimulus provided (or stimulus that acts)?

I am deeply convinced that not only to sustain, but also to strengthen the position of Optometry as an independent area of knowledge it is necessary to work on expanding theoretical fundamentals and not, as professor H.W. Hofstetter\(^1\) warned, taking over the areas that belong to other disciplines. This is why I am now taking a liberty to share some thoughts. They include some possible suggestions regarding directions in which potential research could be conducted in order to expand the theoretical bases of our profession.

The examined system – it is an isolated part of space that is the object of interest and interacts with its surrounding through entrance and exits. When it comes to optometry, in most cases the visual system is the examined system. The problem however, is what is understood by the visual system. It would be good to cite an expression that I heard about 50 years ago during professor W. Starkiewicz\(^2\)’s lecture to his students: “a person sees with the whole body…” The meaning for optometry, that deals with the process of vision, is that the examined system is the whole person.

Let’s consider for a moment systems in general. Mazur\(^3\) has classified systems, depending on the level of inner organization, as tools, machines, automatons and autonomous systems. The simplest example of a physical system with informative or energetic paths is a tool (e.g., a bicycle). An organizer (a cyclist) being present in the surroundings supplies it with energy and information necessary to act. A physical system which contains its own transformer of energy, an engine, is called a machine. The task of the engine is to transform energy received from the surroundings, and to collect and save it to be used at the proper time (e.g., a car). In the case of a machine, the organizer ordering its tasks is also a transformer of information. The automaton is a physical system endowed with its own transformer of information, a processor whose task is to transform information received from the engine and surroundings, storing it to be used at the proper moment (e.g., an aircraft being steered by a gyro-pilot). Although an automaton has organs serving to use information and energy, its action is performed in accordance with the interest of the organizer who is outside the system and gave it a functional structure, thus, constituting the intended activity of the system. He can also change that goal by a modification of the structure. An autonomic system is a system that creates tasks for itself and has an ability to adjust to external and internal changes in order to be able to realize these tasks.

The autonomous system chooses its own goal thus, it is its own organizer, it has a homeostat. The homeostat causes modification in the system’s own functional structure. The aim of the homeostat is counteraction of the changes, which act on the functional balance by a modification of the system’s structure such that the physical quantities describing the state of the system have their most advantageous values. The advantageous values are those, which are not close to the values that the homeostat perceives to be too high or too low to be able to control. The system prevents any internal condition which would lead to the system’s disintegration and adapts itself to changes in its surroundings.

Figure 1.
Figure 1 shows a modified schematic of an autonomous system by Mazur\(^3\). In the schematic two lenses remind us that our discussion concerns the vision system. Two yellow arrows represent two way interactions between the receptor and the processor. If we think a while about the function these two arrows represent, it is possible to understand what I was thinking when I told my students “… in these arrows the great attractiveness
of optometry is revealed”.

The quality of the achieving the aim of an autonomous system is conditioned by having sufficient energy at the disposition of the system, and by the quantity and quality of information possessed by the system. It has the possibility of affecting the efficiency of the information coming to it from the surroundings, for example, by preliminary modification of a carrier of the information in the surroundings. In the case of the vision system, the modification of the information carrier, i.e., the light, can be achieved by placing lenses and/or prisms and/or their systems in front of the eyes. In this way we may accomplish the three subsequent aims:

1. We may achieve a better fit of the carrier of information to the receptive characteristics of the receptor. This leads to increasing the number of physical states (discrete steps) of input, which could be recognized by the visual system as a result of optimal adjustment of the visual stimulus to match the perceptive capabilities of the visual system. In other words, it leads to an increase of the amount of information received by the visual system; this constitutes correction of the visual deficiencies. For example, a change of vergence of all pencils of rays occurs when corrective lenses are applied; or change of direction of all pencils when prismatic correction is used. Let us stress, that we generally call it a correction of vision, though strictly speaking, it is a correction of the light. In the case of refractive error, using prescription glasses (corrective lenses) does not cause any change in vision system, but it only adjusts the structure of the light rays to the characteristics of the eyes.

2. We can force changes in the functional structure of the system, taking advantage of its mission and possibilities of adaptation for better realization of its goal. In this case, the number of physical states (discrete steps) of input, which could be recognized by the visual system and consequently, the quantity of received information, may be temporarily diminished. After the process of adaptation, the induced changes of the perceptive capability of the system would lead to an increment of the quantity of information that can be received. Such procedures belong to the area of visual therapy, which is based on adaptability and/or learnability properties of the system. For example, in the case of monocular amblyopia, using frosted glasses in front of the better eye, one flattens relative differences of radiation intensities between various pencils of rays. Another example can be a case where the aim is to restore binocular vision as the result of temporarily applying prism.

3. We induce a change of the spatial-energetic structure of the carrier to make the reception of information about details of a given area of the surroundings possible. In this case, we obtain a desired change of spatial distribution of information density, at the cost of a decrease in the total amount. This process is called instrument - aided observation. For example, an increase of the angle between the axis of the pencil of rays and the axis of the optical system takes place when observing through magnification systems, or a relative change of radiation spectra occurs in infrared telescope-aided observation; another transformation occurs when the phase contrast is applied in a microscope.

In reviewing the three effects achieved by transformation of the information carrier, in this case realized by an optical system placed in the path of the light to our eyes, it is worthwhile to stress that often more than one of the mentioned efficiencies is achieved simultaneously. For example, when a corrective optical system is also used for restoring foveal fixation, and reactivation of that part of the retina occurs in consequence of this action or when the ocular of the microscope is used for correction of our ametropia during observation.

The above leads to the conclusion that the entrance pupils of the eyes constitute the entrance of the visual system. The structure of the light rays that enter the eyes through them includes all information, carried this way, about the surroundings. Therefore, the visual stimulus should be described in the entrance pupils of the eye, and not by describing a chosen object in the space and its position relative to the observer, since such a description does not describe fully the physical state in the pupils.

At present, unfortunately, we do not have any tool that would yield a description of the physical status at entrance pupil, thus making an understanding of the status of the visual system input, possible. This is also true for a way to describe a reaction of an observer. The word “optical illusion” is used very lightly, and somehow, in its deep meaning, it suggests some imperfection of the visual system. Yet, it is a way that
visual information is processed. This is difficult to accept, thus we use the expression “illusion”, because it is not what we know, e.g., based on measurement or other facts. However, we are not consistent. Color perception is a “pure” illusion yet we do not call it so. Through decades, even more - centuries, we have tried to understand how the visual system works to make it see in colors. It is a convincing example of searching for relationships between input and output of the visual system.

Visual Information is an expression used very often, when one describes the process of vision. Because we frequently talk about perceiving or processing visual information, this expression seems to be a very important category in optometry. Unfortunately, I have not found this term in visual science dictionaries. This could suggest that the term is commonly and univocally understood. Moreover, in these dictionaries there is no definition of the word “information” either. Maybe the use of the adjective “visual” is supposed to suggest that “information” is a basic, so not definable, term, similar to the basic terms in the international system of units (SI) that are not definable. In such a case would it be sufficient to give a unit of the measure and a way to compare it with other quantities of the same kind, as it is done in the case of basic terms in the SI system i.e., length, time, mass, etc.

What should we understand by the term “information”? At first we have to accept the following fact that may not always be cognizant, but a true one; information is not matter, i.e., it is not a substance nor is it energy. Therefore, it should not be mistaken for its carrier (in the case of the visual system, light is the carrier) or a physical stimulus affecting a system (in the case of the visual system this is a physical state in the entrance pupils of the eyes). Information is a relationship between physical states. Therefore, for information to exist, it is necessary for at least two physical states to exist. In order to distinguish one state from two possible states, the smallest amount of information is necessary and its magnitude is a unit called one bit. There is a simple formula to measure the amount of information coming into any system. It is termed the Hartley-Shannon Formula. In the simplest case, that is when all states in a set have an equal chance of occurring, the quantity (H) of information necessary to select a particular state from the set is equal to the \(\log_2 n\); where: ‘n’ is the number of states in the set, (\(H = \log_2 n\)). Therefore, in a situation where there are only two equally probable states possible, a set of 2, a stimulus that reaches a system and allows the system to recognize a state carries only one bit of information. To differentiate from four possibilities, two bits of information, from 1024 states, ten bits and from 1.3 x\(10^{30}\) states one hundred bits.

There are different assessments of the number of states possibly differentiable by the visual system. For the retina, the estimation is a huge number, projected at about 108, if expressed in bits. Taking into account the convergence in the neural system, it is accepted that this number for the human visual system equals about 100 bits. Though it does not seem much, it is true that getting information equal to 100 bits, we receive the possibility to differentiate a given state from a set \(n_1 = 1.3 \times 10^{30}\), and this is a huge set. Let us compare the number \(n_1\) with the number \(n_2\) of images possibly recognized by a human. Let’s assume that it takes a human 0.05 sec to perceive an image from the visual system. If one were to live 100 years without sleeping, one might recognize \(n_2 = 6 \times 10^{10}\) images only (!) (20 images/sec x 60 sec/min x 60 min/hr x 24 hrs/day x 365 days/year x 100 years = 6.31 x \(10^{10}\)).

I need to admit that when I first thought about the comparison of the number \(n_1\) and the number \(n_2\) I was surprised. The number of images a person can see in his or her life is very small; one could say, so small that it can be negligible part of the number of images that the visual system could distinguish. It is clear that the number \(n_1\) is over \(10^{19}\) bigger than the number \(n_2\). Therefore, a few very important questions arise: (1) How is it possible that while seeing such a relatively small number of images during the developmental period of the visual system, the system develops such huge recognition abilities? (2) Does this development depend on the variety of images seen, and if yes in what way? (3) How is one to choose which images need to be presented if one wants to enhance or alter a function of the visual system using vision therapy?

Yet, a question that seems to be fundamental for our discussion is as follows: are changes in the visual system that appear during development or during performed vision exercises, a result of the reaction to received stimuli or to information perceived? In addition, it is necessary to remember that in the visual system we deal with parainformation, i.e., receiving information while using the receiver’s memory capacity at the same time.
Informeffic\textsuperscript{6} (in the form most efficient) - a receptor system is informeffic if, in the case of the natural (not modified) information carrier, the structure of the receptor path is in the form that makes it most efficient for reception of information from the surroundings and for its transmission to the central processor. It takes place when the receptor path is adjusted optimally to the information carrier, that is, when there is no possible transformation of the carrier, which would lead to an increment in the potential for information reception. On the other hand, if it is possible to transform the information carrier to adapt it to properties of the receptor path, and in this way to increment the potential of the system to perceive and transmit information, then we can call the receptor path aformeffic.

When calculating the amount of information using Hartley-Shannon formula, an equal probability of events is assumed. There is also a formula that allows one to calculate the amount of information of a set of events that have different probabilities of occurring. However, it should be accepted that discussing the probability of the events in the case of receiving information visually is not justified. Therefore, the description “most efficient” in the definition of informeffic is accurate and is obviously not a synonym of “information maximum”. So, in addition to the quantity aspect of information it is necessary to take into account its efficiency. It is not difficult to imagine how crucial an influence the knowledge of information effectivity would have on achieving success in vision therapy.

Does a real informeffic human visual system exist or are they more or less aformeffic? It may be that today’s affirmative answer will turn out to be untrue tomorrow because a new way of transforming the carrier of information, which would enable everyone to increase the effectivity of information received through visual path will be developed (for example, a correction of higher order aberrations of the eye), or possibly that the whole population will be myopic in the future?

Observability and Controllability are two terms used in the theory of systems\textsuperscript{7} and it seems that they should be also present when optometric management is discussed. Simplifying a lot, we can say that a system is observable if based on partial observations performed in a given (limited) period of time and we can describe the state of the system at the time of the beginning of the observation. If the system consists of a large amount of elements and, in addition, the way in which the elements interact changes with time, then the full description of the initial state of the system is impossible. In such a situation the system is called a large system (complex). Also, simplifying a lot, a system is considered controllable, if by influencing its entrances within a described time period, we can transfer the system from a given state to any other state from the group of possible states for this system. A large system is not fully controllable. This means that for the large system we do not have ways to change any of its states in the way we plan, and more over, we do not even know the whole set of possible states for this system.

The idea of observability addresses the question of the possibility of the identification of the system’s initial state by measurement of its output state in a finite time interval. This is the basic question of diagnostics. Next, the concept of controllability addresses the question about the possibility of moving the system from a given initial state to a desired state in a finite period of time by application of an appropriate control. This is the basic problem of therapy.

Without doubt the visual system is a large system. Thus, it is not fully observable and not fully controllable. This fact substantiates why our reasoning, while forming a diagnosis as well as management based on this diagnosis, is always subject to some uncertainty. Both of the stages, diagnosis and therapy, have to take into consideration that the patient’s visual system for us is a gray box. Gray not black - since we know a lot about this system; on the other hand however, it is not a white box, since there is a lot about structure and especially function we have yet to learn.

This limited observability of the visual system is the reason why researchers or practitioners often focus their attention only on a part of the system and they consider the part as an independent unit, without taking into consideration all the inputs, and therefore, all the potential outputs of this unit. If we add limited controllability, we will understand why results of treatment are often so different from one another even though the same procedure was applied to similar-appearing cases.

Modeling, although we do not always realize it, is a fundamental tool in optometric management. The subject of our interest, the visual system, is a large system by definition. This is beyond dispute. A model then is an indispensable tool in diagnostics and therapy as well as in research.
A quick look into the curriculum of a health professional school delivers proof that the model is really indispensable, even if we often do not realize it. Professional health education begins with such subjects as: anatomy, physiology and, in our case, physiological optics. These subjects describe a healthy human organism. But between the textbook description of the healthy organism and the actual human presenting himself for examination exists the same differences as between the model and the real world. Now we introduce some pathology into the system. Pathology describes some undesirable changes of the model described by anatomy and physiology. Pathology also points out what should be done to restore the ill model to health.

Finally, we have a real patient, and we begin an examination procedure which is more or less detailed. Our knowledge and examination results are the basis for our diagnosis. This is nothing more than our inward projection of a patient. It is a model because our knowledge of the patient cannot possibly be complete. The model does however allow us to make a more or less detailed picture of our patient. Like any picture, it also has a finite resolving power. Therapy decisions we make are related to the model; therefore, their effectiveness depends on how close the model is to its original. Therapeutic decisions are directed to the model but they are applied to the patient. It is essential that all clinicians be aware of the differences between the model and the patient in the practitioner’s office. Therefore, the clinician should become a skilled model-maker.

The model that is formulated in such a way is an abstract object that mirrors the characteristics of the original system to the limited degree and in the restricted manner. Zeigler \(^8\) stated that a model, in its assumption, is a set of instructions to generate data about processes that take place in the system in a given time. Thus, it is easy to notice, since one has a limited number of instructions available, the possibility of formulating satisfactory models is restricted. I am going to describe it using a simple example in its design, but nicely showing the idea. John and Alice, both 12 years of age, came to an office wearing glasses OU -2.50 D. The chief complaint for both of them was: “I can not see clearly at far, again”. History revealed that reading is not their favorite activity. Let’s theoretically assume that examinations showed -0.50 D increase in myopia and both John and Alice had near stereopsis within normal limits. The practitioner thus assumed that dislike for reading is not connected to the visual system functions. Different practitioners changed the refraction correction in the same way, but also tested the phoria at near. In one’s opinion in the case of esophoria at near the prescription of bifocal lenses is indicated. It turned out that John had 10 prism diopters of exophoria at near, and Alice had 8 prism diopters of esophoria. These results showed that the first practitioner had a too limited “set of instructions”. Probably, in both cases, the reading avoidance, was the result of uncompensated phoria, and would require different approaches.

Remembering that the visual system is a large system and that the tool that allows management of such systems is modeling, the following arising questions should not be a surprise: (1) To what extent can the theoretical use of the basis of modeling support our profession, especially in building its specific theory? (2) Would application of modeling lead to an increase of effectiveness both in the education and in the practice of the optometry profession? (3) Would application of the modeling methodology result in new improved diagnostic and therapeutic methods? The example areas I am thinking of are: validity of simplification of the model, verification of models, integration of models, etc.

**Conclusion**

I am convinced that contemporary knowledge about the visual system, the methods of examination, the correction and management of this system, and the abundant set of described cases in literature of our discipline, enable us to work out and then use advanced formal descriptions in such a scope that, in extension, they will incorporate the achievements of formal science like those of logic or mathematics. Thus, it is possible and purposeful to search for formal mathematical tools for verification of diagnostic and therapeutic methods as well as instruments used in the practice of optometry. Doubtless, a formal description of not fully imaginable phenomena is very useful. We can easily imagine space and its elements if it is no more than three dimensional. However, we meet an obstacle if we make an effort to imagine a structure with four or more dimensions, but mathematically such a structure can be unequivocally described. It is worth pointing out that, for example, a full description of a visual stimulus, i.e., the physical state in the entrance pupils of the eyes, is not possible when restricted only to three dimensional space. By the term “method” we understand a set of general assumptions constituting guidelines for examination, and by “methodology” of given science a set of
investigation directions, both general and particular, resulting from a specific theoretical system. Developing the theory of optometry, its own and characteristic methodology is indeed a difficult but very exciting task. I think that we really need such studies in order to make further development of optometry as an independent profession possible. As I mentioned above, the problem seems to lie in the absence of a general theory. Such theory would allow comparison of different dysfunctions of the visual system or could inspire a search for new methods or would become a tool to use to verify different procedures used in vision therapy. Perhaps, a comprehensive description of physical state in the eyes’ entrance pupils should be a starting point. To search for and build the theory of optometry, based on over 100 years of development of our profession, is a great challenge, and for those who will undertake this challenge it will be a source of great satisfaction. I hope that my above thoughts the reader will understand as a proof of how strongly optometry has fascinated me, and a proof of my solicitude of its further development. I am conscious that optometry is not the only health care discipline for which developing its theoretical foundation is indispensable for its future.

Acknowledgments
I would like to cordially thank my daughter Dr. Grażyna M. Tondel for the help in translation of this essay. I very much appreciate friendly and useful comments and advice received from my friends Drs. D.A. Goss, G.E. Lowther, W.C. Maples, and L.L. Walls.

References

Dr. Bolesław Kędzia served as the founding Chairman of the Department of Optometry and Biology of Visual System at Poznan University of Medical Sciences in Poznan, Poland. He is recognized as the pioneer of optometric education in Poland. He has received many academic recognitions in Poland and he is a Fellow of the American Academy of Optometry.
Comparison of Methods of Near Lateral Associated Phoria Measurement

BY DAVID A. GOSS, O.D., PH.D., MONIQUE A. EMMONS, O.D. AND ERIN K. PETERSON, O.D.

Introduction
An associated phoria is defined as the amount and base direction of prism required to reduce fixation disparity to zero. Testing is done under binocular conditions with a stimulus to fusion. Polarized alignment marks are seen monocularly when Polaroid goggles are worn. Base-in prism is required for alignment of the monocularly viewed marks in cases of binocular underconvergence and base-out is required for alignment in binocular overconvergence. The resulting prism from this testing is one way to determine a prism prescription for relief of eyestrain symptoms.

Testing devices for the measurement of nearpoint associated phorias include the Mallett unit, Bernell lantern, Saladin card, and Borish card. Comparison of the associated phoria results from these four devices has not been widely studied. One study found no significant difference in the near lateral associated phoria results between Bernell lantern and Borish card testing. Another study found that there was no significant difference noted between Mallett unit and Borish card when measuring near lateral associated phorias. A comparison of all four methods has not been reported. The purpose of this study was to compare the four methods of measuring lateral associated phorias at near.

Methods
Test subjects were recruited on a volunteer basis from a population of optometry students at the IU School of Optometry. Volunteers were required to be between the ages of 18-35, have a best corrected visual acuity of at least 20/25 at 40 cm, lack of suppression such that the subject could see the monocular alignment marks on the associated phoria tests, and no strabismus. Consent forms and testing procedures were approved by the IU Human Subjects Committee. Data were collected from 65 test subjects. Each test was administered by the same examiner using the same subject instructions. The order in which the tests were performed was varied by subject.

Test subjects were seated and polarized glasses were placed over their habitual spectacle or contact lens correction. The subjects were told to look at the specified target central fusion lock, from a distance of 40 cm, and state whether the vertical lines were aligned. If the subject reported alignment, zero was recorded as the associated phoria finding. If the subject stated that there was a misalignment, a horizontal prism bar was placed in front of the left eye and the prism amount was increased until the subject reported that the top line was directly aligned with the bottom line. The prism amount and base direction of the neutralizing prism was recorded for each of the four tests. The prism bar used had prism powers increasing in steps of two prism diopters. If a step increase in prism power caused reversal in the direction of misalignment, the prism power half way between the two values on either side of the step was recorded as the power for neutralization. For statistical calculations, base-in prism powers were treated as negative numbers and base-out prism powers as positive values.

Results
A statistical summary of the data for each test is shown in Table 1. The means were all close to zero and the median was zero for all four tests. Standard deviations ranged from 2.9 to 3.8, with the highest standard deviation being for the Saladin associated phoria test. The maximum base-in finding on the four tests ranged from 4 to 8 prism diopters and the maximum base-out findings were from 12 to 16 prism diopters.

The results of paired test comparisons are shown below in Table 2. Mean differences were all close to zero, which would suggest good agreement. But other metrics should be considered. A low standard deviation of differences would suggest good agreement. The lowest standard deviations were for the Mallett-Bernell (1.5) and Bernell-Borish (1.6) comparisons. A Wilcoxon signed rank test (non-parametric) was used to test for statistical significance of differences between pairs of tests, due to the fact that the distribution of the values was not normal. None of the comparisons showed a statistically significant difference, although the difference between

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean</th>
<th>SD</th>
<th>Max. BI</th>
<th>Max. BO</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mallett</td>
<td>-0.02</td>
<td>3.3</td>
<td>6</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Bernell</td>
<td>0.29</td>
<td>3.1</td>
<td>8</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Borish</td>
<td>0.02</td>
<td>2.9</td>
<td>6</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Saladin</td>
<td>-0.05</td>
<td>3.8</td>
<td>4</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. Mean, standard deviation, range, and median for each of the four tests. Base-in associated phorias were treated as negative numbers and base-out findings as positive numbers.
Table 2. Summary of differences between tests. The mean is the mean difference between tests found by subtracting the second listed test from the first listed. SD is the standard deviation of the differences. Range is the range of differences and median is the median of the differences. The r value is the Pearson correlation coefficient of the difference of findings with the mean of findings for each subject, with * indicating statistical significance of the correlation at the 0.01 level and ** indicating the 0.001 level. The p value is the statistical significance level of the differences of tests using the Wilcoxon signed rank test.

<table>
<thead>
<tr>
<th>Test A - Test B</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Median</th>
<th>r, mean &amp; diff.</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mallett - Bernell</td>
<td>-0.31</td>
<td>1.5</td>
<td>-6 to 2</td>
<td>0</td>
<td>0.18</td>
<td>0.161</td>
</tr>
<tr>
<td>Mallett - Borish</td>
<td>-0.03</td>
<td>1.9</td>
<td>-6 to 8</td>
<td>0</td>
<td>0.23</td>
<td>0.87</td>
</tr>
<tr>
<td>Bernell - Borish</td>
<td>0.28</td>
<td>1.6</td>
<td>-4 to 6</td>
<td>0</td>
<td>0.1</td>
<td>0.145</td>
</tr>
<tr>
<td>Mallett - Saladin</td>
<td>0.03</td>
<td>2.1</td>
<td>-6 to 6</td>
<td>0</td>
<td>0.22</td>
<td>0.703</td>
</tr>
<tr>
<td>Bernell - Saladin</td>
<td>0.34</td>
<td>1.7</td>
<td>-6 to 4</td>
<td>0</td>
<td>0.41**</td>
<td>0.096</td>
</tr>
<tr>
<td>Borish - Saladin</td>
<td>0.06</td>
<td>2.3</td>
<td>-12 to 4</td>
<td>0</td>
<td>0.39*</td>
<td>0.359</td>
</tr>
</tbody>
</table>

Table 3. Counts of subjects with zero associated phoria on both tests listed, with the same non-zero associated phoria on both tests, with higher value on one test (whether it be base-in or base-out), and with opposite base direction associated phorias. Those with zero on one test and a non-zero value on another test were included in either the A>B or the B>A category.

<table>
<thead>
<tr>
<th>Column A test</th>
<th>Column B test</th>
<th>Both zero</th>
<th>Equal non-zero</th>
<th>A &gt; B</th>
<th>B &gt; A</th>
<th>Opposite base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mallett</td>
<td>Bernell</td>
<td>24</td>
<td>12</td>
<td>20</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Mallett</td>
<td>Borish</td>
<td>25</td>
<td>15</td>
<td>20</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Bernell</td>
<td>Borish</td>
<td>28</td>
<td>13</td>
<td>15</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Mallett</td>
<td>Saladin</td>
<td>17</td>
<td>11</td>
<td>12</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>Bernell</td>
<td>Saladin</td>
<td>19</td>
<td>14</td>
<td>5</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>Borish</td>
<td>Saladin</td>
<td>21</td>
<td>9</td>
<td>5</td>
<td>29</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 also shows Pearson correlation coefficients of individual differences between the two tests with the means for the two tests for each subject. Altman and Bland\(^6\) suggested that a significant correlation between differences and means would suggest poor agreement between tests because such a correlation would indicate that the differences between tests would vary depending on the magnitude of the measurement. Statistically significant correlations of differences with means were found for the Bernell-Saladin (r=0.42; p<0.001) and Borish-Saladin (r=0.39; p<0.01) comparisons.

Table 3 compares tests by counts within categories of agreement. By adding the column of both zero results and the equal non-zero results, we find that the pairs of tests that gave the same result most often were Bernell-Borish (41), Mallett-Borish (40), and Mallett-Bernell (36). Lower counts of complete agreement were found with the Saladin card: Bernell-Saladin (33), Borish-Saladin (30), and Mallett-Saladin (28).

**Discussion**

Overall, the results of the present study suggest good agreement of the Mallett, Bernell, and Borish tests. Such results are consistent with previous studies.\(^1\)-\(^2\)

The study results suggest that the Saladin card associated phorias do not agree as well with the associated phorias from the other three tests. It seems likely that the explanation for the difference between the Saladin card results and those for the other three tests is difference in the design of the targets. Included among such differences are that (1) the associated phoria alignment marks on the Saladin card are thinner than those on the other three tests and (2) the alignment marks on the Saladin card are closer to the central fusion lock than on the other three tests.

**References**

Some Thoughts on Empowering Patients to Learn Compliant Behaviors in Taking Medicine

BY SUBASH N. JANI, O.D., PH.D.

Behavioral principles teach us that we are more likely to engage in behaviors that have “relative importance” to us. We will initiate and retain behaviors if we engage in them with the right attitude. We will reinforce and maintain behaviors that are intrinsically rewarding. We need to be taught correct behaviors using chaining/paired associative learning, providing continuous reinforcement in the initial stages of a new learning behavior and continue to provide intermittent reinforcement and feedback if the behavior is to be maintained and eventually become part of our intrinsic lifestyle. Homework is less likely to be chewed by the dog if the learner has: (1) fixed location to do homework; (2) scheduled time; (3) necessary tools and accessories, e.g., pencil, paper, assignment papers; and (4) intermittent supervision and guidance and the challenge level of a learner.

I have found that adopting the following three minute conversation with my patients has improved compliance significantly enough that at follow-up or anecdotally on the street they have thanked me for suggesting the approach and that their eyes feel better following the regimen.

If the patient’s answer to the question “Do your eyes feel dry, burning, itching, watery?”, is a resounding YES, I know that the “relative importance” criterion has been met.

Then instructions to the patient can go something like the following: Now, just like bifocals past the age of 45, your eyes need tear supplements like skin lotions. So you will stop using these drops the day you stop brushing your teeth. It is visual hygiene like your oral hygiene. You should purchase drops when you get a tooth brush and hygiene supplies rather than thinking of them as medicine. It is like taking your eyes to a spa and getting your hair and nails done. (With these instructions I implanted an attitude that ”you are into wellness, not sickness”)

Place this bottle next to your toothbrush and toothpaste in the bathroom. At the last stop in the bathroom in the evening and the first stop in the morning, use one drop at the same time you do brushing and grooming. You have already used your drops twice a day without thinking. Using them at midmorning or midafternoon before lunch or reading if you can may also be helpful. You may carry a bottle in your purse or pocket and/or leave a bottle next to your computer. (Note that I used chaining/paired associative learning principles, fixed location/scheduled times, necessary tools, intrinsically rewarding when eyes feel better, and challenge level)

I believe that the principles discussed here could also be adapted to glaucoma medications and other medications.

Dr. Jani is Professor Emeritus of Special Education at Western Illinois University, Macomb, Illinois. He received an M.S. in physiological optics from IU in 1967. He is a Fellow of the American Academy of Optometry.
Overview of Potential Applications of Nanotechnology to Eye Care and Medicine

By Solani David Mathebula, B. Optom., M. Optom.

Abstract
The genesis of nanotechnology applications to medicine (nanomedicine) sprang from the visionary idea that nanoparticles could be designed, manufactured and introduced into the human body. Applications of nanotechnology imply materials and devices designed to interact with the body at subcellular (molecular) level with a high degree of specificity. The application will alter our approach to diagnosis, treatment and prevention of disease. This can be translated into targeted cellular and tissue-specific clinical application to achieve maximal therapeutic efficacy with minimal side effects. Nanotechnology in ophthalmology and optometry may play a role in both early- and late-stage intervention in the management of blinding diseases. There are likely to be many applications of nanotechnology in vision. Nanotechnology will help in making nanodevices for eye surgeries and development of new lens materials for treatment, such as for cataract.

Key words: nanotechnology, nanomedicine, nanoparticle, molecular imaging, drug delivery, vision.

Introduction
Nanotechnology can be defined as the science and engineering involved in the design, synthesis, characterization and application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale (one-billionth of a meter). The prefix “nano” derives from the Greek word for “dwarf”. One nanometer (nm) is equal to one-billionth of a meter, or about the width of 6 carbon atoms or 10 water molecules. A human hair is approximately 80,000 nm wide, while a red blood cell is approximately 7,000 nm wide. Atoms are smaller than 1 nm. Sahoo et al. define nanotechnology as the area of science and technology where dimensions and tolerances are in the range of 0.1-100 nm.

The US National Institutes of Health (NIH) reviewed the use of nanotechnology in human diseases, leading to the emergence of nanomedicine. Nanomedicine is the medical diagnosis, monitoring and applying treatment at the level of single molecule or molecular assemblies that produce structure, control, signals, homeostasis and motility in living cells. Nanomedicine may be defined as the process of diagnosing, treating, preventing disease and traumatic injury, relieving pain, and preserving and improving human health, using molecular tools and molecular knowledge of the human body. In short, nanomedicine is the application of nanotechnology to medicine.

The term “nanotechnology” was proposed by Richard Feynman for a nanomedical procedure. He said: “It would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes into the heart and looks around. It finds out which valve is the faulty one and takes a little knife and slices it out. Other small machines might be permanently incorporated in the body to assist some inadequately functioning organ.” The term “nanotechnology” was not used until 1974, when Norio Taniguchi, a researcher at the University of Tokyo, used it to refer to the ability to engineer materials precisely at the nanometer level.

Nanotechnology strives to develop and combine new materials by precisely engineering atoms and molecules to yield new molecular assemblies on the scale of individual cells, organelles or even smaller components, providing a personalized medicine. Personalized medicine is individualized or individual-based-therapy which allows the prescription of precise treatments best suited for a single patient.

Drug delivery
Nanengineered materials and devices designed to interact with cells and tissues or carry out biologically specific functions will offer a much greater degree of integration between technology and the physiological system. This will eventually translate into novel clinical applications and treatment options. This will potentially translate into targeted cellular and tissue-specific clinical applications designed to achieve maximal therapeutic effects with minimal side effects. At present, application of nanotechnology to medicine and biology is in its early stage, with most of the research at the basic science stage. The current research on the application of nanotechnology is impressive.
Most ocular diseases are treated by topical drug application in the form of solutions and ointment. These conventional dosage forms suffer from the problems of ocular bioavailability because of the inner and outer blood-retinal barriers. The use of topical eye drops is a common route of drug delivery, but the drug can be inefficient and cause systemic side effects following absorption into the bloodstream. Disposable nanoparticle contact lenses could increase efficiency and decrease systemic side effects of topical medications. There is a potential for broad application of nanoparticle contact lenses. By using nanoparticle contact lenses, absorption of medication could be enhanced and potential systemic toxicity decreased.

Even when drugs are administered topically to the eye, very little reaches the posterior segment. Tacrolimus (FK 506) has been shown to be a very effective immunosuppressive drug when delivered systemically and has suppressed uveoretinitis. However, when delivered topically it has poor ocular permeability and does not provide the effect. Researchers are developing a nanogel which could be administered by subconjunctival injection and topical instillation. Uveitis can be difficult to treat, so there is great potential for the sustained release of FK 506 and possibly other immunosuppressive drugs to treat chronic uveitis. Researchers are conducting studies to develop nanoparticles that would provide sustained drug delivery to the anterior segment and decrease the need for frequent administration of topical medications. This would possibly improve patient compliance.

With the use of nanotechnology, targeting drug molecules to the site of action will become a reality resulting in a personalized medicine. This will reduce the effect of the drug on other sites while maximizing the therapeutic effect. This nanotechnology-based drug delivery will be efficient in crossing membrane barriers (blood-retinal barrier) in the eye. The drug delivery system based on nanotechnology may prove to be the best drug delivery tool for some chronic ocular diseases.

Another area of nanomedicine involves using nanodevices to monitor diseases. One of the ocular nanodevices being researched is a 24-hour intraocular pressure sensing contact lens. Another application of the nanotechnology is the possibility of intracellular imaging.

The oral route is one of the preferred methods of drug delivery because it is non-invasive. However, the acidic condition of the stomach reduces their bioavailability. Loss of drug effect can occur because of the metabolic processes that occur before systemic circulation. As a result, some diabetic patients have to self-administer insulin by injection. Nanoparticles can improve the efficacy of drug delivery by overcoming diffusion barriers, permitting reduced dosing as well as sustained delivery.

Another application of nanotechnology could be the delivery of antigens for vaccination. Gene therapy is a new method for the treatment or prevention of genetic disorders by correcting defective genes responsible for disease development. A normal gene could be inserted within the genome to replace a non-functional gene, which would return the gene to its normal function. Nanotechnology could also have future applications in the field of dentistry.

**Potential toxicology of nanotechnology**

The growing use of nanotechnology might be another way for humans to be exposed to intentionally generated engineered nanoparticles in a negative way. Carbon in elementary form is a major component of these particles. The size of these particles is a determinant of their ability to cause respiratory and systemic cardiovascular effects.

The properties that make nanoparticles so attractive to medicine may contribute to possible toxicological effects in biological systems. The respiratory system, blood, eye, skin, central nervous system and gastrointestinal system have been shown to be targeted by nanoparticles.

**Conclusion**

Nanotechnology is a multidisciplinary field that covers a vast and diverse array of devices derived from engineering, physics, chemistry, mathematics, computer science and cell biology. This field may create opportunities for advancing medical science and disease treatment in human health care and also enhancement of normal human physiology.

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A 20-year lady with chronic anterior blepharitis and the corneal appearance shown in Figure 1 was positive for Demodex folliculorum.

1- What are different species of Demodex involved in blepharitis?

2- How do you obtain and process the specimen for the diagnosis Demodex blepharitis?

3- What are different eyelid signs of Demodex blepharitis?

4- What are conjunctival and corneal manifestations of Demodex blepharitis?

5- What are various treatment options for the condition?

6- What are diagnostic procedures to document association of Demodex in facial rosacea?

Answers:

1- The Demodex mite (class Arachnid and order Acarina) is an elongated ectoparasite that has an obvious head-neck segment with four pairs of legs and a body-tail segment. Two distinct species have been found on human skin: Demodex folliculorum and Demodex brevis. The adult D. folliculorum is 0.35 to 0.4 mm long with four pairs of well-developed legs and a stumpy body. It typically clusters at the root of eyelashes, leading to anterior blepharitis. D. brevis is 0.15 to 0.2 mm long and has an evenly distributed head-to-body ratio. It usually burrows deep into the sebaceous and meibomian glands and causes posterior blepharitis.

2- At the slit lamp, the clinician epilates two lashes from each eyelid after wiggling the lashes to loosen the cylindrical dandruff and increase the likelihood of detecting Demodex. After mounting the lashes on a glass slide, the clinician applies a cover slip and adds a drop of 0.25% Fluorescein at its edge for better visibility during an examination under a light microscope.

3- Demodex blepharitis can be classified anatomically as anterior and posterior blepharitis. The anterior form with cylindrical dandruff is pathognomonic for ocular Demodex infestation. The scales usually formed with clear cuffs collaring the lash’s root and can be easily distinguished from the greasy scales not connected with the root of the lash. Long-standing cases of Demodex infestation can cause disorders of the eyelashes such as Trichiasis and madarosis. Posterior blepharitis with meibomian gland dysfunction due to blocked orifices of the meibomian gland may lead to dry eye symptoms. Inflammation of the lid margin with variable hyperaemia, telangiectasia, thickening, and keratinisation can also occur. Granulomatous responses in the meibomian glands may lead to hordeolum or chalazion.

4- The inflammation may extend to the conjunctiva as well as the cornea, leading to superficial corneal vascularization, marginal corneal infiltration, a phlyctenule-like lesion, superficial corneal opacity, and/or a nodular corneal scar.
5- Although the life span of Demodex mites is limited (14-18 days), mating plays an important role in perpetuating infestation, and reinfestation is common. Accordingly, the aim of treatment should be to eradicate the mites, prevent their mating, and avoid reinfestation. Various approaches have been tried, including mercury oxide ointment, pilocarpine gel, sulfur ointment, and camphorated oil. The idea is to spread an ointment at the base of the eyelashes at night to trap the mites as they move from one follicle to another. *D. folliculorum* can be killed dose-dependently by tea tree oil. Lid scrubs containing 50% tea tree oil may also lure the mites out of the lash follicles, while the 5% tea tree oil ointment prevents mating and reinfestation from the skin around the eye. We therefore recommend the use of a daily lid scrub with 50% tea tree oil and lid massage with 5% tea tree oil ointment to eradicate ocular Demodex infestation.

6- Demodex infestation on the face has been implicated in causing rosacea. Nasal skin scraping helps diagnosis. It has been reported that infrared photography illustrates that temperature and skin inflammation are directly proportional to the amount of infestation resulting in “Fire-Red Demodex Face.”

References

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