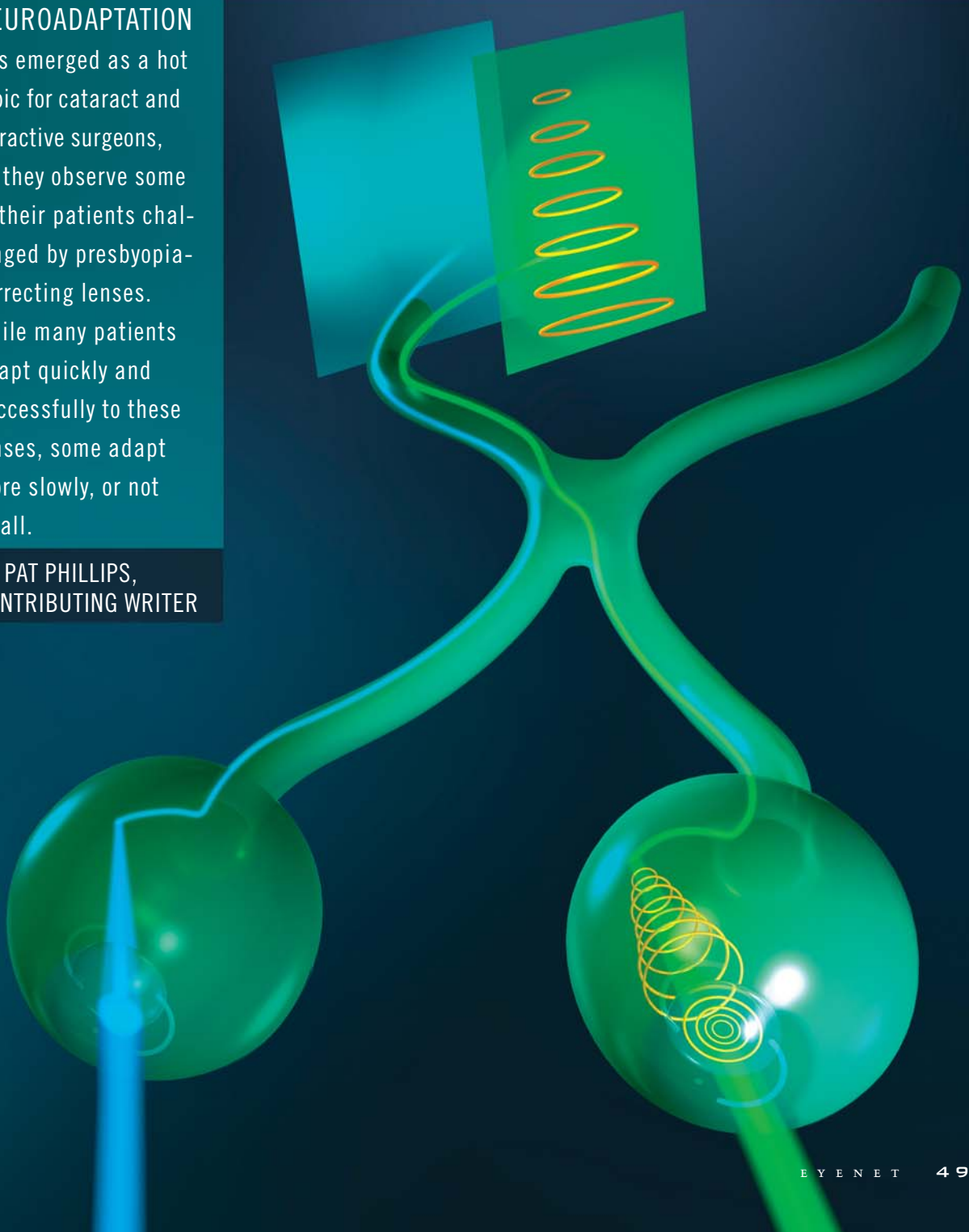
THE IMPORTANCE OF NEUROADAPTATION

new Lens same Brain

NEUROADAPTATION has emerged as a hot topic for cataract and refractive surgeons, as they observe some of their patients challenged by presbyopia-correcting lenses. While many patients adapt quickly and successfully to these lenses, some adapt more slowly, or not at all.

BY PAT PHILLIPS, CONTRIBUTING WRITER



Stereopsis is a crowning glory of visual evolution. The brains of binocular animals, like humans, manage to combine disparate images from two eyes in order to achieve a single unified picture, rich with depth perception.

Ophthalmologists have unwittingly made that picture a bit more complicated, however. More and more cataract surgeons are turning to multifocal intraocular lenses to compensate for presbyopia in their patients. By their very design, lenses like the ReStor and the ReZoom override the "one eye, one image" construct of physiologic binocular vision by allowing for multiple foci, thus producing an image that is variously focused and defocused within a single eye. And since the visual cortex has no prewired circuitry with which to digest the information from multifocality, the brain requires a period of adjustment.

"Multifocality has no precedent whatsoever in the natural human visual experience," said William F. Maloney, MD, associate clinical professor of ophthalmology at the University of California, Irvine. Consequently, "neuroadaptation is the process by which the necessary neurocircuitry is put in place to mediate this new type of visual challenge," Dr. Maloney said. "The word adaptation is quite fitting in this context. It means the circuitry that is in place is not sufficient to deal with this new challenge. New circuitry has to be laid down." As millions of Americans enter their presbyopic years, ophthalmologists will be asked to assess and select patients who will easily adapt to multifocal IOLs, said Dr. Maloney, making neuroadaptation a "very important and timely topic."

Its importance, in fact, may not yet be fully realized. "Neuroadaptation plays an important role in ophthalmology and is a highly underestimated brain phenomenon not yet fully understood," said Robert M. Kershner, MD, clinical professor of ophthalmology at the University of Utah in Salt Lake City.

ANATOMY OF AN IMAGE

Pictures of the external world that seem so effortlessly beamed to consciousness are actually constructed on a neural assembly line:

1. Every point along the hierarchical visual pathway contributes to the interpretation of an image.

2. The most critical action, however, takes place in the sixth-order neurons, where binocularity is consolidated, according to Dr. Maloney. Prior to the sixth-order, the lateral geniculate nucleus and all of the cortical nuclei organized into alternating ocular dominance columns are monocular.

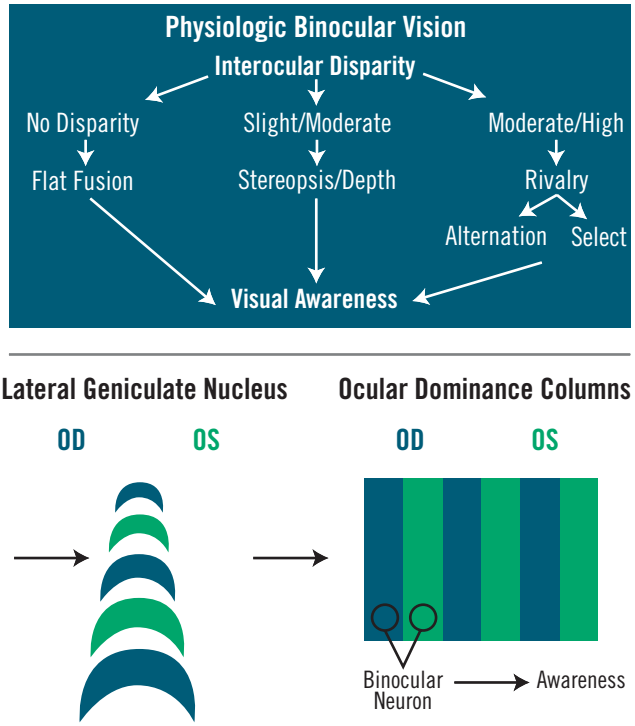
3. It is thought that binocular vision takes shape when the images from the two eyes meet at the cellular level and can be fused; otherwise some type of binocular rivalry will occur. The visual cortex is well equipped to mediate most interocular rivalry, including the focus disparity resulting from anisometropia.

4. With multifocal lenses, focal multiplicity is introduced to the visual system long before the sixth order, and presents the visual cortex with an unprecedented challenge. Established neural circuits are not wired to process a monocular image that is partially focused and defocused. "With multifocality, we create *intra*ocular rivalry," Dr. Maloney said. "We know what takes place within the binocular neurons as they mediate binocular focus disparity. What we don't know is what alternative is laid down during neuroadaptation to process intraocular focus disparity." But a successful result means that a useful visual percept is ultimately passed into awareness.

This does not typically happen easily or immediately. "It's a testament to the astonishing plasticity of the visual cortex that neuroadaptation can take place at all in the face of multifocality, let alone within six to 12 months," Dr. Maloney said.

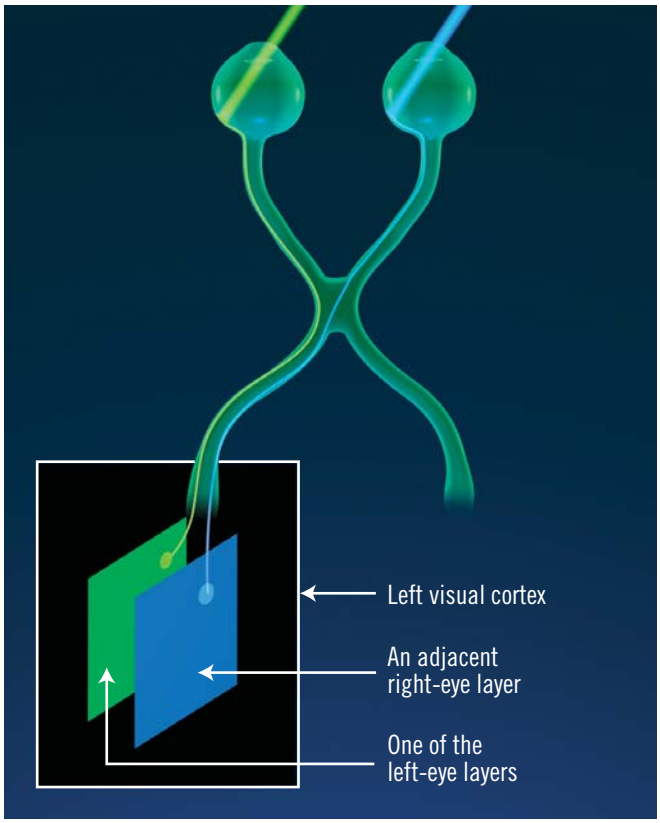
The cradle of adaptability. From Dr. Kershner's perspective, neuroadaptation begins at the start of life and remains an encompassing, ongoing phenomenon.

"When light first hits a baby's retina at birth, the startled look in the baby's opened eyes reflects a dramatic flood of information to the occipital cortex," he said. "The hardware is there, but the software has not yet been developed." And when a baby first registers an image, the physics of optics predict that the image will be inverted. Neuroadaptation flips it cortically so that up is down and down is up, according to Dr. Kershner.



Algorithm (top) developed by Dr. Maloney describes the alternative outcomes of physiologic binocular vision. The degree of interocular disparity determines the outcome. **The images from each eye** (bottom) do not meet until they reach the sixth-order of neurons in the hierarchical visual cortex. Within these specialized binocular neurons the two images are either fused or they compete for access to awareness. The winning percept is granted immediate admission to visual awareness while the loser is suppressed and remains unnoticed.

SOURCE: WILLIAM F. MALONEY, MD



With anisometropia, the images from each eye have a different focus. The winner in the binocular competition is that which contributes more to the task at hand. There is typically a clear winner-take-all outcome. But with the unprecedented *intra*-ocular difference presented by multifocality, binocular rivalry cannot delineate a winning percept without a period of neuroadaptation to establish the necessary new neural pathways.

SOURCE: WILLIAM F. MALONEY, MD

"The brain has incredible power to adapt," he said. "The brain is continuously processing visual stimuli and making sense of images the retina recognizes. When there is a change in the optical system, the brain will prefer the better image, the clearer image."

From heroin to hemiplegia. Neuroadaptation is an issue in several different medical disciplines, from addiction medicine to rehabilitation after cerebrovascular injury. "In patients with chemical dependencies, neuroadaptation is the mechanism that explains how they got accustomed to certain substances," said Thomas R. Mizen, MD, associate professor of ophthalmology, neurology and neurosurgery at Rush University in Chicago. "Neuroadaptation to alcohol and stronger drugs promotes a response in the cortex to which people adapt."

In stroke rehabilitation, patients are dealing with a changed optical input, according to Dr. Mizen. Therapy then encourages the patient's occipital lobe to accept new images as normal. "Vision therapy in stroke rehabilitation involves helping expand the visual field after stroke. This occurs at the cortical level and means recruiting cells to pick up the slack from the cells that were damaged," he said. "There is a neuronal basis for vision recovery after cellular damage."

ENTER THE IOLS

Dr. Mizen considers neuroadaptation with multifocal IOLs "extremely important because we're asking patients now to adapt cortically to images different from what they have experienced before." For some patients it may be easy to neuroadapt to a disparity of images, while for other patients any disparity at all produces significant discomfort, he said. Dr. Mizen, along with other surgeons, said the key problem is that there is not yet a methodical way to determine which patients will be able to tolerate the image disparity.

Picture gets more complicated. Dr. Maloney regards the practice of mixing and matching lenses as a "manifestation of the fact that none of these multifocal lenses are an across-the-board solution. There are gaps in the range of vision delivered by each of these lenses."

In addition, astigmatism induced by cataract surgery is a significant and difficult optical aberration, according to Dr. Kershner. He cites astigmatism as a result of shifting meridians, with different images from one axis to another. "Even with 20/20 vision, the patient can be miserable and will say, 'I hate my vision without glasses,' because a new meridian has been induced that is significant enough to make neuroadaptation impossible."

Lisa B. Arbisser, MD, clinical adjunct associate professor at the University of Utah agreed, adding that although "neuroadaptation is a topic whose time has come," astigmatism is the most difficult issue that surgeons have to address. She believes that the eyes seek harmony, which is why she does not typically mix and match IOLs. She finds the outcome is better when the same visual technology system is used in both eyes.

The eye, the brain and the calendar. Depending on the lens and the patient, neuroadaptation may happen sooner, later or not at all. The majority of patients will adapt to multifocal IOLs within six to 12 months, according to Dr. Maloney. But about 10 percent of patients never will adapt. "There are times when a patient who is having serious vision problems during the six to 12-month postop period will say, 'I'm not willing to endure this any longer, I want these lenses removed.'"

It's a long time to ask patients to hold their confidence, Dr. Maloney added. "There is almost nobody who adapts to this challenge of intraocular image disparity automatically or quickly, and when a patient fails neuroadaptation, the only option the surgeon has is explantation."

Some specialists report that 100 percent of their patients neuroadapt with these IOLs, while others report such discouraging experiences postoperatively that they no longer offer these lenses to patients.

"This is art, not cookbook science," Dr. Arbisser said. "With multifocal IOLs, most of these patients neuroadapt within three months or even three weeks, with successful outcomes."

What about a reshaped cornea? Corneal refractive corrections also require some neuroadaptation. "There may be aberrations created by the corneal refractive surgery that present the patient with a visual percept not encountered before," said Dr. Maloney. But, he said, "This neuroadaptation usually

is quite rapid, much like adjusting to a new spectacle prescription." Dr. Kershner noted that most refractive surgery patients can neuroadapt, and young patients adapt quickly.

MEASURING EXPECTATIONS

Some patients may have understandable, yet unrealistic, expectations about what visual acuity will be after multifocal lens implantation. They may have had very good vision without spectacles and expect the same or better after multifocal lens implantation. Dr. Mizen cited the example of an engineer who expected precise, focused images all the time everywhere, from the grocery store to the computer to reading a newspaper with fine print. "This patient might as well be asking for the fountain of youth," Dr. Mizen said. "He wanted something that wasn't going to happen." The gift of youth is to go from 20 feet to 20 inches instantaneously, with everything in between precisely in focus, he said. As patients become older, their focusing plane starts to collapse, and then patients search for perfect vision with implants.

But patients need to be fully informed about the benefits and risks of their multifocal IOL options, according to Dr. Arbisser. "There is no technology that is perfect." (See "The Value of Thorough Consent.")

Good sight may have a price tag. The expense of premium IOLs can also have an impact on patient expectations. Even with Medicare partial coverage, the cost to the patient is about $2,000 per eye. "Paying for premium IOLs contributes to the expectation of perfection," Dr. Mizen said. "A patient may say that he could tolerate some blurring vision or other aberration, if he weren't paying for it himself." Counseling patients preoperatively about what to expect with IOLs is essential.

Patient profiling. Personality, lifestyle and the anatomy of the eye provide what Dr. Arbisser calls clues and Dr. Maloney calls "soft identifiers" to patient selection. "There are only clues, not definitive answers," said Dr. Arbisser. She says it's helpful to take into account the patient's individual history with glasses or other previous experiences. Someone who has been wearing glasses for years and has been gradually losing visual acuity is more likely to be an accepting candidate.

"We have a technology that we know works, but recommendations are difficult to make when there is no way to know in advance if a patient will be able to neuroadapt," said Dr. Maloney. In general, if a person is a rigid, type "A" personality who tends to notice or hold on to every visual detail, that person is probably less able to adapt than a patient who is more easygoing, according to Dr. Maloney. "We need to be the devil's advocate here and explain loud and clear to the patient what to expect and how long to expect it, and get a sense from the patient if he or she can handle the limitations. If the patient cannot, I don't go any further with the multifocality option. There are very good alternatives such as the Crystalens and pseudophakic monovision that do not require this particular compromise," he said.

Dr. Mizen said that if a patient has an accepting attitude and is not expecting to be free of spectacles 100 percent of the time—perhaps only 80 percent of the time—that patient is likely to be a good candidate. Patients need to be counseled to consider the trade-offs they are willing to make to be free of spectacles for reading and other activities during the day, while tolerating some abnormalities at night, such as seeing halos, glares or starburst patterns around headlights.

Yet some analyses have found improved patient satisfaction with multifocal IOLs in comparison to monofocal lenses. One study concluded that success of both types of lenses was dependent on preoperative patient expectations and postoperative quality of near vision.[1]

Neuroadaptation itself will continue to be a focus of research, expanding an understanding of the visual cortex and the process by which a grocery list or a stop sign is carried from the eye into visual awareness. This research will gather data and experts from a wide variety of disciplines, including physics, neurophysiology, psychology and, of course, ophthalmology.

THE VALUE OF THOROUGH CONSENT

Complaints to the Academy Ethics Committee suggest that the current pace of patient education on new IOLs may be lagging. The committee has received a number of complaints from disappointed and angry patients, suggesting the promised efficacy of new multifocal, accommodative and toric intraocular lenses may not match outcomes.

Informed consent for these new IOLs could possibly be given greater attention. The Academy has online resources to assist you in providing truly informed consent. Visit www.aao.org/about/ethics/informed_consent.cfm.

1 Javitt, J. *Ophthalmology*;107(11):2040–2048.

MEET THE EXPERTS

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