

# From Eye<sup>2</sup> to Eyecare

## How wearables and eye tracking are adding new dimensions to ocular health

BY ANDREW KARP / GROUP EDITOR, LENSES + TECHNOLOGY

NEW YORK—From smart glasses with heads-up displays, internet connectivity and high definition video cameras to goggles that deliver a fully immersive, 3D experience for playing games or watching movies, wearable technology in the form of eyewear offers powerful new ways of “seeing” both the real and virtual worlds.

As the market for eyewear wearables grows among consumers and enterprise users, a highly specialized segment of that market is also emerging: people with vision impairments. To serve their needs, a growing number of technology companies are harnessing the power of augmented reality and virtual reality as well as technologies such as eye tracking to develop new tools for diagnosing and treating ocular conditions such as strabismus,

amblyopia and low vision, as well as for studying oculomotor behavior, cognitive visual function and other physiological aspects of vision. These new ophthalmic technologies are already having a significant impact on patient outcomes, and have the potential for even greater treatment possibilities.

Because eyecare wearables are a newly emerging area of technology, they represent only a tiny segment of the global eyeglass wearable tech market, which is predicted to reach shipments of 10 million units per year by 2018, according to market research firm Juniper Research. However, the eyecare wearables segment could quickly balloon as a result of the sharp increase predicted for age-related eye disease.

According to a 2012 report by Prevent Blindness America, the number of Americans at risk for age-

related eye diseases is increasing as the Baby Boomer generation ages. These conditions, including age-related macular degeneration, cataract, diabetic retinopathy and glaucoma, affect more Americans than ever before. PBA predicts that the number of Americans with age-related eye disease and the vision impairment that results is expected to double within the next three decades. As of 2010, more than 142 million people in the U.S. were age 40 and older; about 62 percent of them had impaired vision, PBA estimates.

These aging Boomers may create an unprecedented demand for vision care products and services, including eyecare wearables and other technologies designed to preserve sight and enhance vision.

**Continued on page 26**

## New Technologies for Diagnosing and Treating Vision Impairments

Continued from page 25

### AMBLYOPIA TREATMENTS AND DIAGNOSIS

One of the most promising uses for eyecare wearables is the diagnosis and treatment of amblyopia, or lazy eye. A major cause of visual impairment in children, amblyopia occurs when an ocular pathology such as strabismus, anisometropia, high refractive error, or deprivation interferes with normal cortical visual development. Approximately 3 percent to 5 percent of children worldwide are affected by amblyopia, according to the American Academy of Ophthalmology.

A conventional technique for treating amblyopia is to put an adhesive patch on the patient's good eye for set periods of time in order to strengthen their weak eye. Although this method of occlusion can be effective, treatment is ineffective if the child resists wearing the eyepatch because it is uncomfortable or draws unwanted attention from other children.

Seeking a more effective therapeutic approach, several companies have developed wearables designed to improve upon the old school eye patch. One of the first products introduced into the market is Amblyz. It was created by XPand

3D, a major supplier of active shutter, 3D eyewear for cinema, home entertainment and gaming, in conjunction with ophthalmologists and optometrists. Amblyz look like normal prescription glasses, but feature an electronic shutter controlled by a preprogrammed

microchip incorporated into the frame. The microprocessor controls the shutter, creating short, intermittent occlusions of the strong eye in order to treat the lazy eye.

"As pioneers in active 3D vision (cinema, home theater and professional applications) we grew up with the active shutter LCD technology and we know how to modify and apply it like no other," said Karel van Gorp, director of XPand's medical division.

"This expertise is manifest in Amblyz by the high quality LCD lenses, the low weight of the frame, the ergonomics and the design. After manufacturing and selling hundreds of thousands of electronic eyeglasses for the cinema market, we know how to make comfortable, durable, aesthetic electronic eyewear that people like to use."

*XPand's Amblyz glasses use electronic shuttering to treat amblyopia.*

XPand has also applied its active-shutter technology to create glasses that prevent motion sickness (see sidebar on page 34).

Made of durable, flexible plastic, the colorful, one-size

fits all glasses have a fun, techy look that appeals to children. "No kid wants to be different, and patching can lead to them being ostracized," noted Bianca Granado, marketing manager for Good-Lite, which distributes Amblyz in the U.S.

"Amblyz gives them a normal play or school experience. They look like real glasses, and children can have their own prescription put into them."

Since launching Amblyz internationally several years ago, XPand has been working with researchers such as pediatric ophthalmologist Daniel E. Neely, MD.

"These glasses are predominately used to treat children under age seven," said Neely, a professor at Indiana University's School of Medicine Glick Eye Institute. "It's the first therapeutic advancement in amblyopia other than sensors that lets us monitor patients to see what they're doing."

"One reason we have treatment failures [with patches] is that patients usually have to wear the patch for a minimum of two hours. If a kid can't see through the eye that's being occluded, it's tough for them to comply with the treatment," said Dr. Neely. "The attractiveness of Amblyz to me is that the occlusion is intermittent. It's 30 seconds, so they're only occluded for half the time, then they can see normally for the next 30 seconds."

Dr. Neely and his colleagues have been using Amblyz for about a year in a study of 50 children who have amblyopia. The preliminary results of the three-month pilot study, which the team presented recently at the American Association for Pediatric Ophthalmology and Strabismus meeting, showed that most of the children gained two LogMAR lines, a mild to moderate increase in vision. Although similar results were achieved with patching, Dr. Neely said patient compliance was greater with Amblyz, a factor that may yield better results in future studies.

Continued on page 28



*Dr. Neely with a patient wearing Amblyz.*



## Diagnostic and Therapeutic Benefits of Wearable Technology

Continued from page 26

“A lot of the families participating in the study will be interested from a technology standpoint for the same reasons people are interested in Google Glass,” said Dr. Neely. “It’s more engaging for the family. In this group, it may not be changing the outcome, but it’s changing the experience.”

Dr. Neely said he would like to try Amblyz with children who have severe vision loss, as much as 20/200. “Those kids are always patch failures,” he noted. “But if compliance is better with the glasses, then that group may have achieved more treatment times, and hopefully, better results.”

A different approach to amblyopia treatment that also uses electronic occlusion is being pioneered by Eyetronix, a Silicon Valley start-up headed by Grace Sheen, a former John-

son & Johnson executive with a background in consumer medical devices. The company describes its Eyetronix Flicker Glass, as “a simple, wearable tool for binocular therapy that integrates known principles of the visual system and flicker, combined with the clinical experience of practicing eyecare professionals.” It is priced at \$399 for ECPs.

Flicker Glass is designed to combat suppression, the partial loss of vision in one eye that occurs when the images from the two eyes are so different that they cannot be fused into a single

image. According to Eyetronix, the key to breaking suppression is to “wake up” that sensory pathway and encourage the brain to accept visual sensory signals from both eyes. The company said its Flicker Technology uses advanced liquid crystal technology to deliver “precisely controlled, rapid alternating occlusion at flicker rates shown in vision science research to effectively break sup-

pression. Instead of occluding to penalize one eye and forcing the signal from the other eye, the theory is that using flicker can gently stimulate the visual system and encourage both eyes to naturally work together, ultimately aiding in the restoration of binocular vision and depth perception.”

“We’re in the process of commercializing Flicker Glass,” said Sheen. “We’ve been focusing on current efforts to provide an investigational use device for research and case studies.”

In a recent clinical study conducted with Flicker Glass, results showed significant improvement in both visual acuity and stereopsis—even into older age ranges typically considered more challenging to treat. Study investigators were impressed with the levels of compliance, and patients and parents rated Flicker Glass highly on ease of use, comfort and preference over traditional monocular therapies. From a quality of life perspective, reports of improved reading and sports performance sup-

ported the overall positive evaluation of the Flicker Glass experience, according to Eyetronix, which has reported the findings at the 2014 annual meetings of COVD (College of Optometrists in Vision Development), ARVO (Association for Research in Vision and Ophthalmology), and the American Academy of Optometry.

Ongoing clinical evaluation is in progress to further advance Flicker Glass binocular therapy. “Although Eyetronix is initially focused on amblyopia, we believe Flicker Glass has applications that go well beyond amblyopia, including strabismus and accommodative disorder,” Sheen added.

Another company to enter the market recently is Vivid Vision, a San Francisco Bay area start-up that has developed a complete virtual reality system for eye clinics to treat and assess amblyopia and strabismus. Patients using the system are immersed in a 360-degree, 3D virtual environment where they can use their hands naturally to interact with the games and tests. The doctor or vision therapist can see what they are seeing and control their experience through the touchscreen interface.

Vivid Vision was founded by James Blaha, a software programmer who has amblyopia and strabismus. “I did all of the patching and vision therapy exercise as a kid,” he said. “I hated doing patching, and I took off the patch when my par-



Child reading with Eyetronix Flicker glasses.



Eyetronix Flicker glasses are designed to combat suppression.



*Vivid Vision is a complete virtual reality system for treating and assessing amblyopia and strabismus, including Oculus Rift goggles.*

ents weren't looking. Those things never really worked for me. I wanted to make something for kids that was more fun than that."

The system Blaha developed consists of proprietary software, a desktop computer custom-built for virtual reality, a 21.5 inch touchscreen monitor for live control of the system and an Oculus Rift DK2 head mounted display. The system contains games, tools, and tests to measure and help treat suppression, stereo acuity, acuity, contrast sensitivity, fusion and other visual abilities. Vivid Vision launched the system at this year's COVD meeting, and some clinics across the U.S. have already begun using the software in their practices, according to Blaha.

Ben Backus, PhD, a science advisor to Vivid Vision who is also an associate professor at the Graduate Center for Vision Research at SUNY College of Optometry, said he is impressed with Vivid Vision's performance.

"Vivid Vision can overcome dynamic or clinical suppression. It retrains the brain to better utilize information from the amblyopic eye," explained Backus. "The product has shown promise in people who suppress by reducing their suppression. I like it because it has a large field of view. It's connected through the internet so you can collect data for both safety and efficacy measures. It's well suit-

ed for providing a wide variety of vision tests in clinics and at-home situations."

Backus added that Vivid Vision is particularly useful for displaying images of different contrast to the two eyes. "Kids can't cheat by taking off their red/green glasses and getting the answers right. The immersive quality of the game play seems to be valuable in engaging people of all ages." He also likes that the system gives

patients immediate feedback, so they know how well they're doing when playing a game.

"Moment to moment, you have a goal you want to achieve. It's inherent in the game, such as shooting asteroids."

### ASSISTIVE DEVICES FOR LOW VISION

Technology plays an important role in helping people who suffer from low vision or legal blindness. Among the most commonly used assistive devices are electronic magnifiers, both hand held and desktop models. Patients rely on such tools to help them read printed materials, view computer screens and navigate their surroundings.

Recently, new types of low vision aids that use eyewear as a platform are starting to emerge. One of the first products on the market is eSight, a hands-free, mobile system consisting of a headset that houses a camera and display technology coupled with a processing unit. The system, which combines augmented reality and virtual reality features, delivers real-time video images which users can enhance, magnify and adjust to ensure their eyes can best interpret their surroundings. It was developed by eSight Corp.,

which is based in Toronto, Ontario and conducts research and development in Ottawa, Ontario.

eSight is currently available throughout the U.S. and Canada. Even with its \$15,000 price tag, it is attracting a growing user base.

"We're now up to over 250 users across North America, and the diversity within our user community is incredible," said Taylor West, eSight's director of outreach. "Our youngest eSight user is six years old and our oldest is 95." According to eSight, the most common causes of vision loss among users are macular degeneration, diabetic retinopathy, Stargardt's Disease, ocular albinism, Leber's Hereditary Optic Neuropathy, cone-rod dystrophy and some forms of glaucoma and retinitis pigmentosa.

West said that eSight is working to develop relationships with independent eyecare professionals,



*eSight eyewear delivers real-time video images which users can enhance, magnify and adjust to ensure their eyes can best interpret their surroundings.*

**Continued on page 30**

## Eye Tracking Provides New Tool for Vision Research

Continued from page 29

low vision clinics, and community-focused low vision organizations. These groups work closely with their communities and have the local connections to ensure that eSight users can achieve success with their eyewear.”

eSight recently added some new features to its glasses. The most significant hardware change has been the addition of HDMI-in capability, which expands and improves the utility of eSight with computers and televisions. “This new capability has proven to be particularly effective in work and school settings where technology has become essential to the everyday needs of users,” said West. He added that the company has also made a variety of software improvements, including expanded user controls for advanced tasks and upgrades to its image processing software, which has improved how the glasses represent color and contrast.

Essilor International is also developing eyewear that uses augmented reality to assist people with low vision. The company began researching the

and appropriate human-machine interfaces for visual aid devices.

More recently, a clinical trial, approved by the French National Drug and Medical Device Agency and by an ethics committee is aiming to demonstrate the benefits of augmented reality eyewear for visually-impaired individuals by having them perform visual tasks in simulated life conditions. This clinical trial conducted by Essilor on an opto-electronic device is organized for people affected by low-vision pathologies such as age-related macular degeneration, retinitis pigmentosa, diabetic retinopathy or other ocular diseases.

“Essilor’s augmented reality eyewear prototype is a nomadic device including the projection of a virtual image, with text or video content, transmitted toward the retina through the corrective lens,” explained Eric Perrier, Essilor International’s corporate senior vice president, research and development. “The virtual image is superimposed to the natural scene, ‘inside’ the corrective lens, which allows the wearer to maintain access to the complete environment through the lens. The prototype allows people with visual disabilities the opportunity to apply personalized magnification and image processing (such as contrast improvement and brightness enhancement) to the natural scenery filmed with a miniature camera.”

Thanks to a remote control, the wearer can process the picture in real time and adapt the visual information displayed to perceive the whole environment better,

Perrier said. As a result, their residual vision can be improved.

“The lenses of course provide the wearers the visual correction they need, according to their ametropia, as well as enhanced comfort of vision

thanks to Essilor’s innovative lens treatments,” he noted.

At Oxford University in the U.K., researchers have developed another type of smartglass for low vision users. The glasses consist of a video camera mounted on the frame of the glasses; a computer processing unit that is small enough to fit in a pocket; and software that provides images of objects close-by to the see-through displays in the eyepieces of the glasses. Transparent electronic displays, where the glasses’ lenses would be, give a simple image of nearby people and obstacles. The camera with specially designed software interprets the nearby surroundings allowing people to see important things much more distinctly than before, such as curbs, tables and chairs, or groups of people.

“The idea of the smart glasses is to give people with poor vision an aid that boosts their awareness of what’s around them—allowing greater freedom, independence and confidence to get about, and a much improved quality of life,” said Stephen Hicks, PhD, of the Nuffield Department of Clinical Neurosciences at the University of Oxford, who is leading the development of the glasses. “We eventually want to have a product that will look like a regular pair of glasses and cost no more than a few hundred pounds—about the same as a smartphone,” he added.

### EYE TRACKING

Eye-tracking technology, which is used in fields as varied as gaming, computing, automotive, medical devices and virtual reality, is also being used in ophthalmology. Eye tracking helps vision researchers to better understand eye movements and eye movement problems, and to develop means to prevent, diagnose and treat abnormalities or ocular disease in clinical situations. Clinical areas where eye tracking can improve existing methods for screening and diagnostics are align-



*Prototypes of augmented reality glasses that Essilor has been developing since 2011.*

technology in 2009, and is currently participating in a clinical trial led by the Paris Vision Institute and the Clinical Investigation Center (CIC) of the Quinze-Vingts national hospital of Ophthalmology in Paris with the goal of developing effective tools





*Tobii's eye-tracking technology being used in an ophthalmology office.*

ment such as strabismus or amblyopia, fixation stability, smooth pursuit and saccadic movements, visual field testing and pediatric vision testing.

Tobii, a leading eye tracking company based in Sweden, has developed technology that is used by vision researchers to study oculomotor behavior, cognitive visual function and vision deficiencies. Its Tobii Pro business unit markets eye trackers that measure both the direction of gaze as well as the position of the eyes in space with high accuracy. This enables the calculation of head movements and, by extension, true eye movements within the orbit of the eye, according to Tobii Pro.

Tobii Pro offers eye trackers mounted in an eyeglass-like frame, as well as vision research solutions as stand-alone cameras or cameras integrated into computer monitors. In this case, patients look at a sensor-equipped screen that registers their eye and head movements, which are then analyzed to determine preferential looking in an objective and automatic way. This technique is used to study acuity, contrast, color, stereovision and visual fields in pre-verbal children,

for example.

Maggie Woodhouse and Jon Erichsen, senior lecturers at the School of Optometry & Vision Sciences at Cardiff University in Wales, have used the Tobii T60 XL Eye Tracker to study the eye movements of people with an early onset nystagmus, a continuous oscillation of their eyes that impairs their vision. Eye tracking has allowed the researchers to quantify the dynamics of

these eye movements and how they are affected by environmental influences such as stressful situations.

T60 XL offers several advantages, according to Tobii Pro. The system does not require wearing anything potentially intrusive and is easy to calibrate. The unit's wide screen makes it easier to present eccentric stimuli to investigate size and frequency of eye movements in people with nystagmus affected by the orientation of the eyes in the head. The system noninvasively measures vertical and horizontal eye movements, and includes stimulus presentation and analysis software that easily allow experiments studying everyday tasks like reading or looking at complex images.

"We are finding the Tobii systems very easy to use and very patient friendly. The Tobii T60 XL is going to allow us to extend our research to hard-to-test groups such as children, and to explore avenues of research that were simply not open to us beforehand, such as non-invasive recording of eye movements in all directions simultaneously," said Woodhouse and Erichsen.

In addition to the T60 XL, Tobii Pro has another solution more appropriate for studies requiring a higher sampling rate, the TX300 Eye Tracker. This tool allows researcher to more easily study eye movements such as saccades and correctives saccades and saccade trajectories, as well as fixations, pupil size changes and blinks. The sophisticated technology in the TX300 allows head movements to be subtracted from gaze direction data, thus measuring real eye movements.

A different therapeutic application of eye tracking is being offered by RightEye, a start-up that has developed patent-pending software to improve visual performance improvement. The company is launching its first product, RightEye VATS (Visual Assessment & Training Solution), this fall.

Initially targeted to optometrists, RightEye VATS is designed to be part of a patient's pre-testing protocol. It uses a computer and monitor



*Tobii's TX300 Eye Tracker allows researcher to more easily study eye movements such as saccades and correctives saccades and saccade trajectories, as well as fixations, pupil size changes and blinks.*

**Continued on page 34**

## Eye Tracking as a Diagnostic Tool

Continued from page 31

powered by RightEye's software to perform a two-minute, non-intrusive pre-test that measures visual performance, partly through playing games. Patients control the computer using gaze interaction.

The test identifies up to 30 different parameters, including visual acuity, eye dominance and convergence. The test results are then delivered in a detailed report that specifies if the patient requires training to improve their visual performance or if they need further clinical evaluation by their doctor.

"The beautiful thing about our approach is that it's very involving for the patient," explained RightEye's president Barbara Barclay, a veteran executive who was formerly general manager of Tobii North America. "When patients get the report, they want to know how they're doing. In every case there will be training that incorporates eye tracking. The training uses gamification with

*RightEye eye-tracking vision performance solutions will offer the vision health care community the opportunity to create customized interfaces for information sharing around vision metrics and tracking improvement with patients, similar to this example.*

direct and specific feedback. It keeps the patient in closer contact with their optometrist, because they want to go back and get checked again to see how their performance is improving."

Barclay said RightEye will charge optometrists a small monthly fee for the VATS system and a pay-per-use fee that includes access to RightEye's portal and training solutions. ■



## Using Technology to Combat Motion Sickness

**X**Pand, which makes active shutter glasses for viewing 3D movies, TV and games as well as for vision care, has put its technology to a novel use: fighting motion sickness. The company's X105-MS-1 Anti Motion Sickness Glasses, which are sold online to consumers for \$179, use shuttering lenses to reduce severity of motion sickness while traveling by airplane, boat or driving.

When the motion sickness mode is enabled on the glasses, the electro-optical system is engaged and the electronic lenses start to strobe. Both of the UV-blocking sun lenses quickly become clear. By creating longer pauses between what the person sees XPand's Anti Motion Sickness Glasses create better



*XPand Anti Motion Sickness Glasses.*

perception of movement and thus minimize the disagreement between perception and vestibular interpretation of movement, according to the company's sales literature. Unlike XPand's Amblyz glasses, which are used to treat amblyopia, the Anti Motion

Sickness Glasses are set to strobe at fixed intervals and cannot be programmed by the user.

The glasses are currently available with only non-prescription lenses, although XPand can potentially make an Rx version if there is sufficient demand, according to David Chechelashvili, XPand's executive vice president of business development. However, they can be worn over prescription glasses, he noted.

"XPand is distributing the glasses via Amazon, yacht club stores, and catalogues, but not through optical retailers or eyecare professionals. "We are not convinced that it is the right way to distribute through eyecare professionals, but we are open to possibilities," Chechelashvili said. ■