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EDITORIAL

Eyes: The Gateway to Brain Health—Advancing Disease Detection and Patient Accessibility

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In a recent article published in *The Lancet Global Health,* an international group of healthcare professionals called for a global digital eye health task force to facilitate and coordinate funding, infrastructural development, and democratization along with artificial intelligence (AI) and digital health to drive progress in eye health forward for those living in rural and underserved communities.[1]

From a medical perspective, eye health is defined as the degree to which vision, ocular health, and function are maximized to optimize overall well-being and quality of life.[2] The contribution of telehealth in democratization, that is, to extend the accessibility and benefits of eye health technologies to all populations, including remote populations, seems obvious. But what is the status of eye health technologies, with emphasis on AI, that healthcare providers can now or hopefully someday offer to their patients through telehealth? In this editorial, the authors present a topline view of the state-of-the-art of health technology in eye health, the contributions of AI, and the application to telehealth now and in the future.

There has long existed a connection between the eyes and brain health.[3] Eye tracking technology—a non-invasive and cost-effective way to quantitatively measure eye movements during different activities[4]—can help healthcare providers identify ocular biomarkers that point to several serious conditions, including Alzheimer's and other neurodegenerative diseases.

Especially in the last 5 years, much of what has been accomplished using AI has transformed the way healthcare providers diagnose and treat diseases.[5] This, in tandem with a rise in digital medicine, has brought a boon in the application of tele-ophthalmology. As a result, building AI tools that utilize metrics that can be calculated using solely a laptop has become crucial in leveraging the growing popularity of telehealth.

While the technology is not new, the accessibility of the technology has been an ongoing issue due to the cost and complexity of the science behind the technology. With a rise in the utilization of AI technology and consistent innovation in the space, a "gateway to brain health" through eye-tracking is becoming more available globally.

Revealing Brain Health Through the Eyes

Scientists have identified a significant connection between deficits in eye movements and disorders of the brain or brain injuries. This discovery has led to earlier detection of several conditions, leading to earlier treatment and sometimes longer, healthier patient lives.

Eye tracking tests are employed to measure the brain's ability to perform or suppress reflexive eye movements—movements patients may not even be aware that they are performing. These tests include saccade tests, anti-saccade tests, and smooth pursuit tasks.

Saccades are rapid eye movements that shift the center of gaze from one part of the visual field to another. Examining saccades gauges the patient's ability to perform this function in a single, rapid movement, while anti-saccade tests measure a patient's ability to suppress those reflexive movements. Smooth pursuit tasks test a patient's ability to follow an object smoothly while keeping that object in full view. It is considered voluntary, and a patient's inability to perform well in them may point to deeper issues inside the brain.

In addition, pupillary responses can point to issues with emotional response or a brain's cognitive load.

Neurology, as a discipline, has largely relied on in-person assessment, but developing at-home solutions using these eye-movement tests can help physicians better understand what might be occurring inside a patient's brain without necessitating an in-person visit.

Individualizing Care

Eye-movement testing has been revolutionized by pivoting from bulky, expensive equipment to a smartphone or laptop camera, allowing easier access to testing capabilities and a more affordable option for providers and patients. With better detection and diagnosis, patients can begin to receive tailored, individualized care early on, leading to better chances of treatment success.

Eye-movement tests have been used to pinpoint degenerative disorders (e.g., Huntington's disease or Parkinson's disease), neuropsychiatric disorders (e.g., schizophrenia and anxiety), as well as brain injuries (e.g., concussions). Innovations in the eye-movement test space have also leveraged advances in telehealth[6] and remote healthcare capabilities.

Today's rapidly aging population[7] has led providers to seek alternative care options while keeping in mind quick detection and diagnosis of serious conditions, such as Alzheimer's disease and other forms of dementia. Newer gaze-tracking tools can bring remote detection to more providers and, therefore, more patients.

Advancements in technology are also standardizing the mode of care, allowing patients the freedom to compare test outcomes from several providers consistently. Telehealth has consistently been seen as inferior—a "Plan B" option for a physical visit—and reserved for times of duress. However, technological advancements can help eradicate the disparity in diagnostic capabilities between a physical and telehealth visit.

Advancing the Study of Brain Health

The positive patient outcomes expected from advanced gaze tracking tools are the "why" behind the further development of the technology. What the advancements can do for the study of brain health, however, could be the "icing on the cake."

Even though conditions such as Alzheimer's disease and Parkinson's disease negatively affect the lifespan of millions worldwide, too little is known about the cause of those conditions and conditions like them. Brain health evaluation tools, such as eye-tracking, can help researchers delve deeper into neurology, neurological treatment efficacy and effectiveness, and develop wider-reaching scientific evidence to support theories of cause for neurodegenerative diseases. Such research would be pivotal in generating more widespread support for integrating similar technology on a telemedical scale.

Future Potential

Gaze tracking is not a new concept, but the vast improvements and innovations being brought forth in the healthcare space have made gaze tracking a more accessible option. New gaze tracking systems are non-invasive, have remote capabilities, and come at significant cost savings over older methods.

The plight of those with neurodegenerative diseases will likely benefit most from the increased accessibility of eye-tracking technology. Research[8] shows that over 50% of people with dementia worldwide are never properly diagnosed. For those who do receive a proper diagnosis, it typically comes far too late to slow the progression of the disease.

With advances in gaze tracking, neurodegenerative diseases can be caught earlier than ever, allowing providers to treat patients earlier and possibly slow disease progression. Groundbreaking work in gaze tracking has often failed to "see" real-world applications reach enough people who could benefit from the technology. Now, with advancements in gaze tracking and the enhanced reliance on telehealth in the post-COVID environment, that gap is being bridged.

It has been said the eyes are the windows to the soul. While that may remain true, science is showing us that the eyes can also be the gateway to the brain.

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Contributors

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