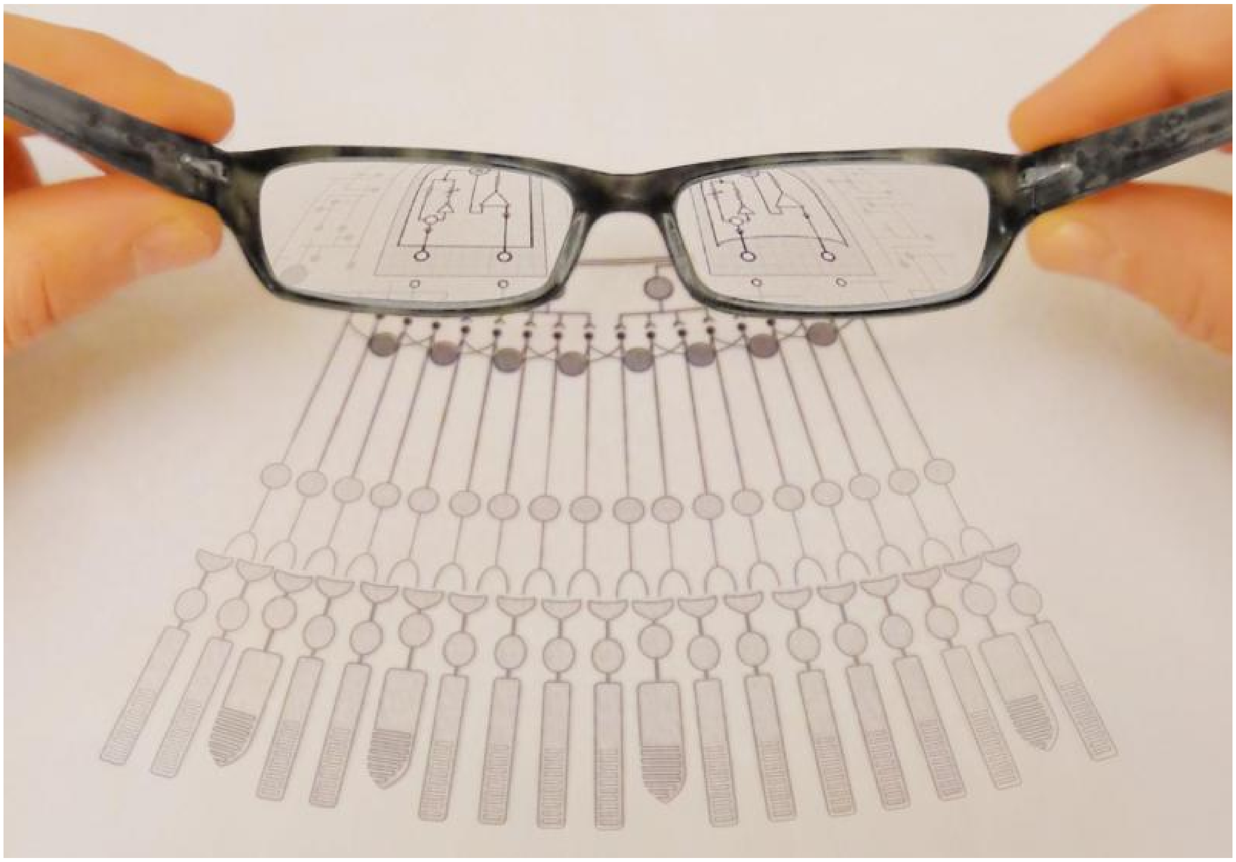
Medical Xpress

Eye cells may use math to detect motion

March 7 2016



NIH scientists uncovered how neurons in the eye may use math to distinguish moving objects. Credit: Diamond lab, NIH/NINDS, Bethesda, MD

Our eyes constantly send bits of information about the world around us to our brains where the information is assembled into objects we recognize. Along the way, a series of neurons in the eye uses electrical and chemical signals to relay the information. In a study of mice, National Institutes of Health (NIH) scientists showed how one type of neuron may do this to distinguish moving objects. The study suggests that the NMDA receptor, a protein normally associated with learning and memory, may help neurons in the eye and the brain relay that information.

"The eye is a window onto the outside world and the inner workings of the brain," said Jeffrey S. Diamond, Ph.D., senior scientist at the NIH's National Institute of Neurological Disorders and Stroke (NINDS), and the senior author of the study published in *Neuron*. "Our results show how neurons in the eye and the brain may use NMDA receptors to help them detect motion in a complex visual world."

Vision begins when light enters the eye and hits the retina, which lines the back of the eyeball. Neurons in the retina convert light into nerve signals which are then sent to the brain. Using retinas isolated from mice, Dr. Alon Poleg-Polsky, Ph.D. a postdoctoral fellow in Dr. Diamond's lab, studied neurons called directionally selective retinal ganglion cells (DSGCs), which are known to fire and send signals to the brain in response to objects moving in specific directions across the eye.

Electrical recordings showed that some of these cells fired when a bar of light passed across the retina from left to right, whereas others responded to light crossing in the opposite direction. Previous studies suggested these unique responses are controlled by incoming signals sent from neighboring cells at chemical communication points called synapses. In this study, Dr. Poleg-Polsky discovered that the activity of NMDA receptors at one set of synapses may regulate whether DSGCs sent direction-sensitive information to the brain.

NMDA receptors are proteins that generate electrical signals in response to the neurochemicals glutamate and glycine. When activated, they allow electrically charged ions to flow in and out of cells like water through an unlocked canal. In the early 1980s, studies in France and at the NIH showed that magnesium blocks the flow until the neuron is strongly activated and its electrical state rises above a certain voltage. This regulation is thought to be critical for certain types of learning and memory, and in amplifying signals in neurons.

Further experiments by Dr. Poleg-Polsky examined how magnesium's control of NMDA receptors may regulate the firing of DSGCs. To mimic realistic conditions, Dr. Poleg-Polsky passed bars of light across retinas while exposing them to various background lights. The results suggested that the variable magnesium block that ensured the cells consistently sent information to the brain in response to the passing bars of light despite the distracting incoming stream of signals generated by the background lights. The NMDA receptors did this by amplifying the cells' responses to the bars in a process called multiplicative scaling.

"Cells in the eye can multiply," said Dr. Poleg-Polsky. "The process may help these cells determine whether a tiger is sauntering by, or fast approaching as it's looking for dinner."

Neurons in the eye and brain receive a constant stream of information. The results of this study support a growing body of evidence suggesting that NMDA receptors play in critical role in how neurons relay information.

"Our results suggest that NMDA receptors help neurons distinguish relevant information from irrelevant background noise," said Dr. Diamond. "In the future we plan to examine whether this process contributes to other aspects of vision."

More information: Alon Poleg-Polsky et al. NMDA Receptors Multiplicatively Scale Visual Signals and Enhance Directional Motion

Discrimination in Retinal Ganglion Cells, *Neuron* (2016). DOI: 10.1016/j.neuron.2016.02.013

Provided by National Institutes of Health