Medical Xpress

It's now or never: Visual events have 100 milliseconds to hit brain target or go unnoticed

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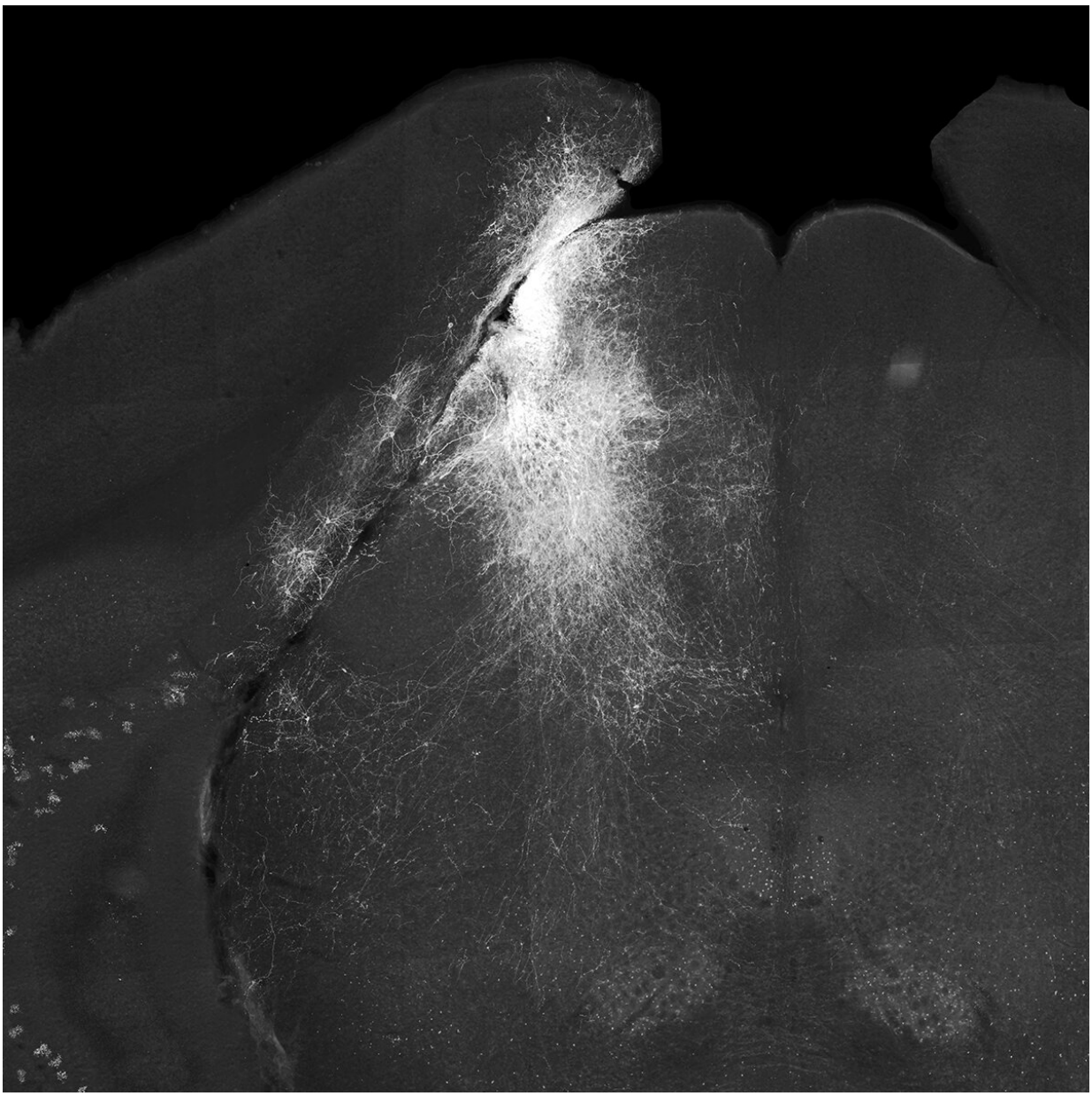

Slice of mouse brain showing neurons of the superior colliculus highlighted on one side. Credit: Lupeng Wang, Ph.D. and Charles Gerfen, Ph.D.

Researchers at the National Eye Institute (NEI) have defined a crucial window of time that mice need to key in on visual events. As the brain processes visual information, an evolutionarily conserved region known as the superior colliculus notifies other regions of the brain that an event has occurred. Inhibiting this brain region during a specific 100-millisecond window inhibited event perception in mice. Understanding these early visual processing steps could have implications for conditions that affect perception and visual attention, like schizophrenia and attention deficit hyperactivity disorder (ADHD). The study was published online in the *Journal of Neuroscience*.

"One of the most important aspects of vision is fast detection of important events, like detecting threats or the opportunity for a reward. Our result shows this depends on visual processing in the midbrain, not only the visual cortex", said Richard Krauzlis, Ph.D., chief of the Section on Eye Movements and Visual Selection at NEI and senior author of the study.

Visual perception—one's ability to know that one has seen something—depends on the eye and the brain working together. Signals generated in the retina travel via retinal ganglion cell nerve fibers to the brain. In mice, 85% of retinal ganglion cells connect to the superior colliculus. The superior colliculus provides the majority of early visual processing in these animals. In primates, a highly complex visual cortex takes over more of this visual processing load, but 10% of retinal ganglion cells still connect to the superior colliculus, which manages

basic but necessary perceptual tasks.

One of these tasks is detecting that a visual event has occurred. The superior colliculus takes in information from the retina and cortex, and when there is sufficient evidence that an event has taken place in the visual field, neurons in the superior colliculus fire. Classical experiments into perceptual decision-making involve having a subject, like a person or a monkey, look at an image of vertical grating (a series of blurry vertical black and white lines) and decide if or when the grating rotates slightly. In 2018, Krauzlis and Wang adapted these classic experiments for mice, opening up new avenues for research.

"Although we have to be cautious translating data from mice to humans, because of the difference in visual systems, mice have many of the same basic mechanisms for event detection and visual attention as humans. The genetic tools available for mice allow us to study how specific genes and neurons are involved in controlling perception," said Lupeng Wang, Ph.D., first author of the study.

In this study, Wang and colleagues used a technique called optogenetics to tightly control the activity of the superior colliculus over time. They used genetically modified mice so that they could turn neurons in the superior colliculus on or off using a beam of light. This on-off switch could be timed precisely, enabling the researchers to determine exactly when the neurons of the superior colliculus were required for detecting visual events. The researchers trained their mice to lick a spout when they'd seen a visual event (a rotation in the vertical grating), and to avoid licking the spout otherwise.

Inhibiting the cells of the superior colliculus made the mice less likely to report that they'd seen an event, and when they did, their decision took longer. The inhibition had to occur within a 100 millisecond (one-tenth of a second) interval after the visual event. If the inhibition was outside

that 100-millisecond timeframe, the mouse's decisions were mostly unaffected. The inhibition was side-specific: because the retinal cells cross over and connect to the superior colliculus on the opposite side of the head (the left eye is connected to the right superior colliculus and vice versa), inhibiting the right side of the superior colliculus depressed responses to stimuli on the left side, but not on the right.

"The ability to temporarily block the transmission of neural signals with such precise timing is one of the great advantages of using optogenetics in mice and reveals exactly when the crucial signals pass through the circuit," said Wang.

Interestingly, the researchers found that the deficits with superior colliculus inhibition were much more pronounced when the mice were forced to ignore things happening elsewhere in their visual field. Essentially, without the activity of the superior colliculus, the mice were unable to ignore distracting visual events. This ability to ignore visual events, called visual attention, is critical for navigating the complex visual environments of the real world.

"The superior colliculus is a good target for probing these functions because it has a neatly organized map of the visual world. And it is connected to less neatly organized regions, like the basal ganglia, which are directly implicated in a wide range of neuropsychiatric disorders in humans," said Krauzlis. "It's sort of like holding the hand of a friend as you reach into the unknown."

More information: Lupeng Wang et al, A causal role for mouse superior colliculus in visual perceptual decision-making, *The Journal of Neuroscience* (2020). DOI: 10.1523/JNEUROSCI.2642-19.2020

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