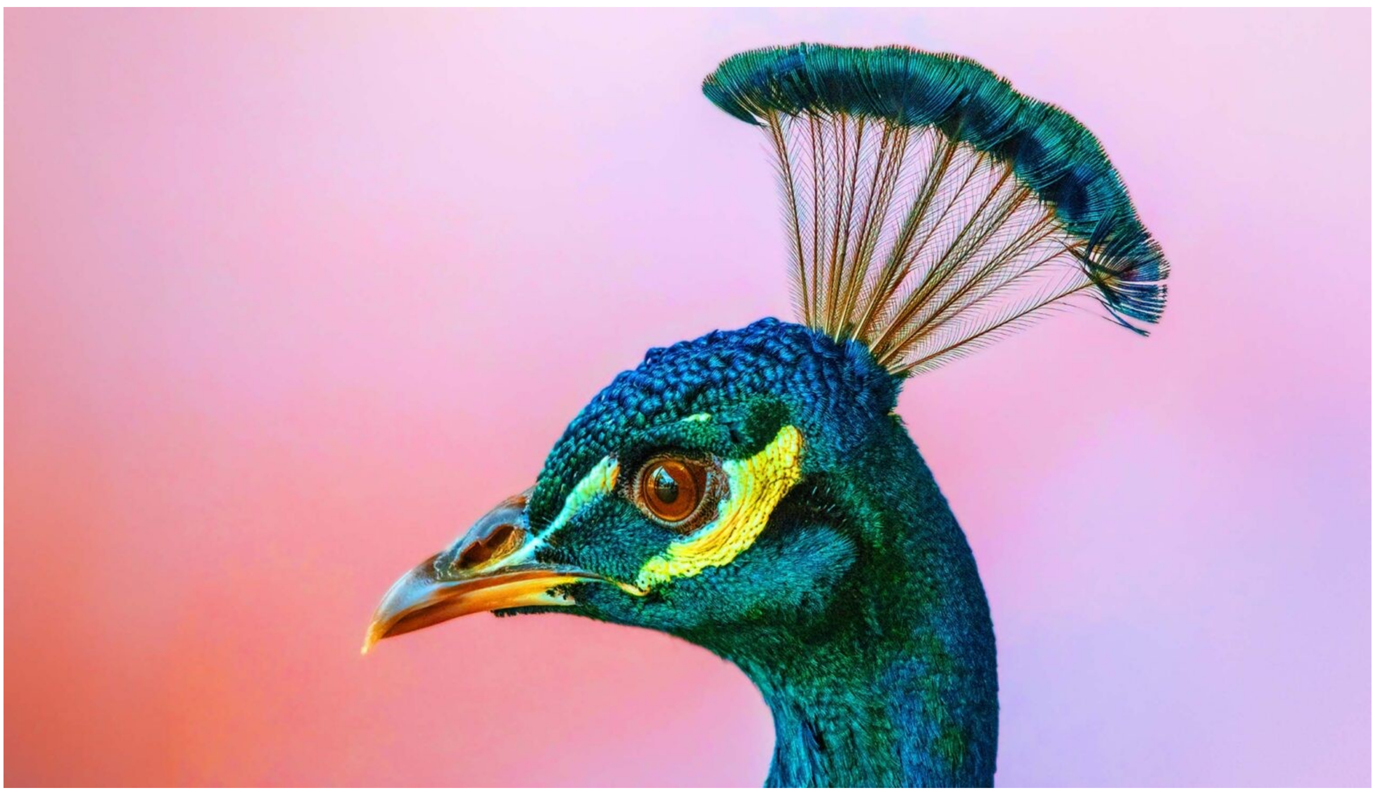
UC Berkeley

Mind & body, Research, Technology & engineering

Scientists trick the eye into seeing new color 'olo'

UC Berkeley scientists created a new platform called "Oz" that directly controls up to 1,000 photoreceptors in the eye at once, providing new insight into the nature of human sight and vision loss.

By Kara Manke



Using a new technique called "Oz," scientists at UC Berkeley can trick the eye into seeing images, videos and even a brand new color — a profoundly saturated peacock green that they named "olo."

Marissa Gutierrez/UC Berkeley (Source: Trevor McKinnon via Unsplash)

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In Frank Baum's original novel *The Wonderful Wizard of Oz*, the Emerald City is said to be such a brilliant shade of green that visitors must wear green-tinted glasses to protect their eyes from "the brightness and glory" of the city.

The glasses are one of the wizard's many deceits; the city viewed through green-tinted glasses would, of course, only look more green.

But using a new technique called "Oz," scientists at the University of California, Berkeley, have found a way to manipulate the human eye into seeing a brand-new color — a blue-green color of unparalleled saturation that the research team has named "olo."

"It was like a profoundly saturated teal … the most saturated natural color was just pale by comparison," said Austin Roorda, a professor of optometry and vision science at UC Berkeley's Herbert Wertheim School of Optometry & Vision Science, and one of the creators of Oz.

Oz works by using tiny doses of laser light to individually control up to 1,000 photoreceptors in the eye at one time. Using Oz, the team is able to show people not only a green more stunning than anything in nature, but also other colors, lines, moving dots and images of babies and fish.

The platform could also be used to answer basic questions about human sight and vision loss.

"We chose Oz to be the name because it was like we were going on a journey to the land of Oz to see this brilliant color that we'd never seen before," said James Carl Fong, a doctoral student in electrical engineering and computer sciences (EECS) at UC Berkeley.

"We've created a system that can track, target and stimulate photoreceptor cells with such high precision that we can now answer very basic, but also very thought-provoking, questions about the nature of human color vision," Fong said. "It gives us a way to study the human retina at a new scale that has never been possible in practice."

The Oz technique is described in a new study published last week in the journal *Science Advances*. The work was funded in part by federal grants from the National Institutes of Health and the Air Force Office of Scientific Research.

Hannah Doyle, a graduate student at UC Berkeley, controls the Oz system from a laptop.

Courtesy of Austin Roorda

Untapped photoreceptors

Humans are able to see in color thanks to three different types of photoreceptor "cone" cells embedded in the retina. Each type of cone is sensitive to different wavelengths of light: S cones detect shorter, bluer wavelengths;, M cones detect medium, greenish wavelengths; and L cones detect longer, reddish wavelengths.

However, due to an evolutionary quirk, the light wavelengths that activate the M and L cones are almost entirely overlapping. This means that 85% of the light that activates M cones also activates L cones.

"There's no wavelength in the world that can stimulate only the M cone," said study senior author Ren Ng, a professor of EECS at UC Berkeley, "I began wondering what it would look like if you could just stimulate all the M cone cells. Would it be like the greenest green you've ever seen?"

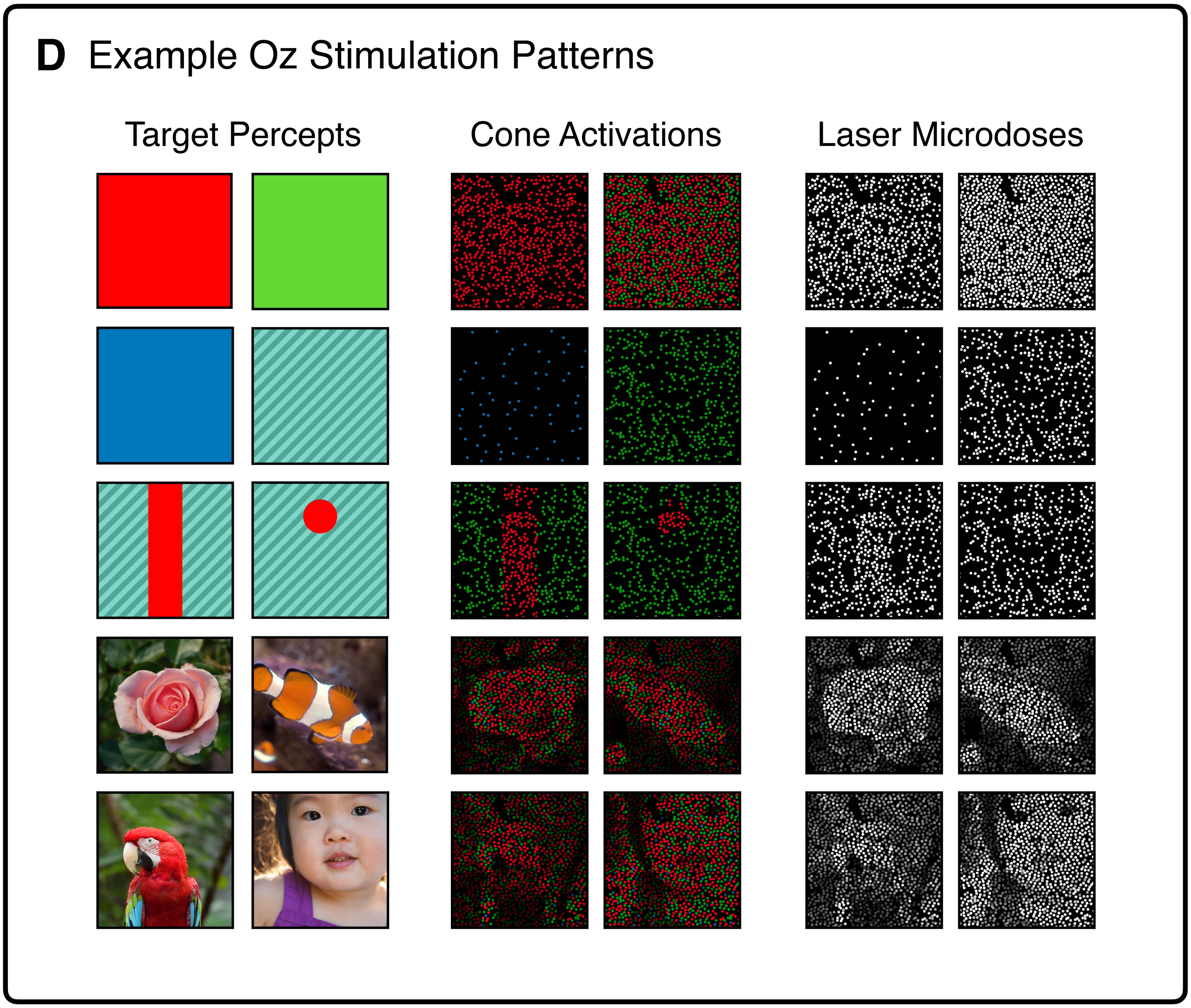
To find out, Ng teamed up with Roorda, who had created a technology that used tiny microdoses of laser light to target and activate individual photoreceptors. Roorda calls the technology “a microscope for looking at the retina,” and it is already being used by ophthalmologists to study eye disease.

But for a human to actually perceive a whole new color, Ng and Roorda would need to find a way to activate not just one cone cell, but thousands of them.

A movie screen the size of a fingernail

Fong first started working on the Oz project in 2018 as an undergraduate engineering student, and has created much of the complex software needed to translate images and colors into thousands of tiny laser pulses directed at the human retina.

“I joined after meeting this other student who was working with Ren, who told me that they were shooting lasers into people’s eyes to make them see impossible colors,” Fong said.



The Oz software takes a color image (left column) and calculates which cone cells in the retina need to be activated for a person to see that image (center). It then calculates the pattern of laser microdoses that need to be delivered to the retina to activate those cones (right).

Courtesy of James Carl Fong

For Oz to work, first you need a map of the unique arrangement of the S, M and L cone cells on an individual's retina. To get these maps, the researchers collaborated with Ramkumar Sabesan and Vimal Prahbhu Pandiyan at the University of Washington, who have developed an optical system that can image the human retina and identify each cone cell.

With an individual's cone map in hand, the Oz system can be programmed to rapidly scan a laser beam over a small patch of the retina, delivering tiny pulses of energy when the beam reaches a cone that it wants to activate, and otherwise staying off.