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3-D Vision for Tiny Eyes

by Elsa Youngsteadt on 26 January 2012, 2:15 PM | 3 Comments

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With their keen vision and deadly-accurate pounce, jumping spiders are the cats of the invertebrate world. For decades, scientists have puzzled over how the spiders' miniature nervous systems manage such sophisticated perception and hunting behavior. A new study of Adanson's jumping spider (*Hasarius adansoni*) fills in one key ingredient: an unusual form of depth perception.

ENLARGE IMAGE

Sharp. The piercing gaze of the Adanson's jumping spider relies on an unusual method of depth perception.

Credit: Science/AAAS

Like all jumping spiders, the Adanson's spider has eight eyes. The two big ones, front and center on the spider's "face," have the sharpest vision. They include a lens that projects an image onto the retina—the light-sensitive tissue at the back of the eye. That much is common in animal vision, but the jumping spider's retina takes things a step further: It consists of not one but four distinct layers of light-sensitive cells. Biologists weren't sure what all those layers were for, and research in the 1980s made them even more enigmatic. Studies showed that whenever an object is focused on the base layer, it is out of focus on the next layer up—which would seem to make the spider's vision blurrier rather than sharper.

That led to a "long-standing mystery," says Duane Harland, a biologist who studies spider vision at AgResearch in Lincoln, New Zealand, and who was not involved in the new study. "What's the point of having a retina that's out of focus?" The answer, it turns out, is that having two versions of the same scene—one crisp and one fuzzy—helps spiders gauge the distance to objects like fruit flies and other prey.

Missed! Adanson's spiders ordinarily depend on green wavelengths for depth perception. When only red light is available the spiders can still see but perceive objects as being closer than they really are. As a result, the spiders jump short of their target.
Credit: *Science*/AAAS
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A team of researchers led by biologists Akihisa Terakita, Mitsumasa Koyanagi, and Takashi Nagata of Osaka City University in Japan reached this conclusion after playing a clever trick on the spider's eyes. First, they used a combination of gene expression studies, electrophysiology, and other methods to determine that the bottom two layers of the spider's retina were the most sensitive to green light. Those two layers also responded weakly to red. The spiders are red-green colorblind, though, so to them, Harland says, a bright red object would look the same as a dim green one.

To test the spiders' depth perception, Terakita's team scooped up four Adanson's spiders from around campus. They dabbed black paint on each spider's six secondary eyes to make sure they were only testing depth perception in the two main eyes. Then, inside a tall plastic dish, each spider pounced—or tried to pounce—on several roaming fruit flies under green light or under red light. In the green light, they almost always snatched the flies with a single leap. But under red light, they fell short—sometimes by almost a centimeter, the team reports today in *Science*. Their jumps covered, on average, only 90% of the actual distance to the target fly.

That color difference was telling. In either lighting, a jumping spider's eye will focus a sharp image of a fly on the first layer of the retina. But, because the lens at the front of the eye bends green light more sharply than red, the

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image on the second layer turns out fuzzier in green light. Since the less-blurry red images tricked the spiders into thinking that objects were closer than they really were, the experiment suggests that the spiders uses the fuzziness of that secondary image to judge distance. (Ordinarily, the spiders don't get confused in nature because their sensitivity to the green wavelengths in sunlight overwhelms any input from red.)

Marie Herberstein, a behavioral ecologist at Macquarie University in Sydney, Australia, is convinced that the spiders gain a sense of depth by comparing the clear and fuzzy images projected on the different layers of their complicated retinas. The study makes a "watertight case," she says.

The results not only explain the usefulness of an out-of-focus retina, Harland says, they also provide an exciting example of how half-centimeter-long animals with brains smaller than those of house flies still manage to gather and act on complex visual information. The next step, he adds, will be figuring out how their eyes and brains actually compare those clear and fuzzy images to get a sense of distance.

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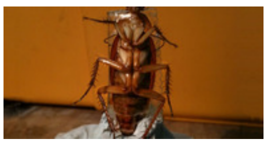

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Echo 3 Items Admin

Sanjay
OK, I see the answer to the first question in the paper: apparently those two big eyes don't have an overlapping field of view or means to focus. Which, wow -- they sure _look_ like they have more or less the same field of view. But I guess not.
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Sanjay
Also, what other cones do they have? Because as there is dispersion in the lens -- as the article points out the red and green don't focus the same -- then when green light is optimally focused on that bottom layer of cells, some other color might be in focus on the third layer or the fourth; potentially in hwite light the spider could validate the image.
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Sanjay
But then why does it need _two_ big eyes if it doesn't use the parallax? The experiment should sitill have worked if they painted over seven eyes.
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