How birds unlock their super-sense, ultraviolet vision

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A first-year Penn State College of Information Sciences and Technology doctoral student spent four months observing birds in an effort to learn what it would mean to design technologies from a more-than-human perspective. Her autoethnographic study contributes to addressing the challenging research problem of how to operationalize posthuman concepts into practice for human-computer interaction. House finchnigel. Credit: Wikimedia Commons

The ability of finches, sparrows, and many other birds to see a visual world hidden to us is explained in a study published in the journal *eLife*.

Birds can be divided into those that can see ultraviolet (UV) light and those that cannot. Those that can live in a sensory world apart, able to transmit and receive signals between each other in a way that is invisible to many other species. How they unlock this extra dimension to their sight is revealed in new findings from the Washington University School of Medicine in St. Louis.

The study reveals two essential adaptions that enable birds to expand their vision into the UV range: chemical changes in light-filtering pigments called carotenoids and the tuning of light-sensitive proteins called opsins.

Birds acquire carotenoids through their diets and process them in a variety of ways to shift their light absorption toward longer or shorter wavelengths. The researchers characterized the carotenoid pigments from birds with violet vision and from those with UV vision and used computational models to see how the pigments affect the number of colors they can see.

"There are two types of light-sensitive cells, called photoreceptors, in the eye: rods and cones. Cone photoreceptors are responsible for color vision. While humans have blue, green, and red-sensitive cones only, birds have a fourth cone type which is either violet or UV-sensitive, depending on the species," says senior author Joseph Corbo, MD, PhD, Associate Professor of Pathology and Immunology.

"Our approach showed that blue-cone sensitivity is fine-tuned through a change in the chemical structure of carotenoid pigments within the photoreceptor, allowing both violet and UV-sighted birds to maximize how many colors they can see."

The study also revealed that sensitivity of the violet/UV cone and the blue cone in birds must move in sync to allow for optimum vision. Among bird species, there is a strong relationship between the light sensitivity of opsins within the violet/UV cone and mechanisms within the blue cone, which coordinate to ensure even UV vision.

Taken together, these results suggest that both blue and violet cone cells have adapted during evolution to enhance color vision in birds.

"The majority of bird species rely on vision as their primary sense, and color discrimination plays a crucial role in their essential behaviors, such as choosing mates and foraging for food. This explains why birds have evolved one of the most richly endowed color vision systems among vertebrates," says first author Matthew Toomey, a postdoctoral fellow at the Washington University School of Medicine.

"The precise coordination of sensitivity and filtering in the visual system may, for example, help female birds discriminate very fine differences in the elaborate coloration of their suitors and choose the fittest mates. This refinement of visual sensitivity could also facilitate the search for hidden seeds, fruits, and other food items in the environment."

The team now plans to investigate the underlying molecular mechanisms that help modify the carotenoid pigments and light-sensitive protein tuning in a wide range of bird species, to gather further insights into the evolution of UV vision.

More information: Matthew B Toomey et al, Complementary shifts in photoreceptor spectral tuning unlock the full adaptive potential of ultraviolet vision in birds, *eLife* (2016). DOI: 10.7554/eLife.15675

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