LOW-LIGHT DETECTION

Olivucci studies thermal noise effects on night vision

Human sight depends on an organized choreography of the retina with its cone and rods cells, the optic nerve, the brain's visual cortex and light – be it a sunny day or a dark, star-studded night.

Remarkably, in extremely poor illumination conditions, the retina can still perceive intensities corresponding to only a few photons. Rod rhodopsins enable this high sensitivity.

"Night vision represents the last frontier of light detection," said Massimo Olivucci, Ph.D., director of the Laboratory for Computational Photochemistry and Photobiology (LCPP) at the Center for Photochemical Sciences, Bowling Green State University. "If we can understand the mechanism for low-light detection, we will open new pathways that could shed light on the molecular basis of currently incurable diseases such as night blindness or tell us how to build extremely efficient light detectors approaching the sensitivity of a single-photon."

For this reason, the research group at LCPP has been investigating thermal noise, one of the main factors reducing the sensitivity of dim-light vision. Thermal noise is due to a thermal, rather than photochemical, activation of rod rhodopsins; it can be thought of as the number of activation events triggered by ambient body heat in the absence of light.

The highly sensitive rods depend on extremely low levels of thermal noise. British neuroscientist Horace Barlow first proposed in 1957 that the ubiquitous bluish color perceived during night vision – the Purkinje effect – is determined by the need to minimize thermal noise in dim light.

Through a series of sophisticated computer simulations of the thermal activation of a set of rod rhodopsins, the LCPP research group has provided a first-principle explanation for the Purkinje effect and a molecular level understanding of thermal noise. Their results appeared in the September 7 issue of *Science Magazine.* The simulations successfully explain the existence of a link between the color of light perceived by the sensor and its thermal noise and establishes that the minimum possible noise is achieved when the absorbing light has a wavelength that corresponds to blue light.

Using the powerful computation and storage resources of the Ohio Supercomputer Center, the work was directed by Olivucci, and completed by Nicolas Ferré, Ph.D., at the Université d'Aix-Marseille, France, BGSU graduate student Samer Gozem and BGSU research assistant Igor Schapiro, Ph.D.

(top) Photographic reconstruction of the Purkinje effect, a blue-shift of perceived color under diminishing levels of illumination.

(bottom) Tube representation of the molecular structure of the dim-light visual receptor rhodopsin. The frame shows the location of the molecular fragment capable of absorbing light (in red).

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