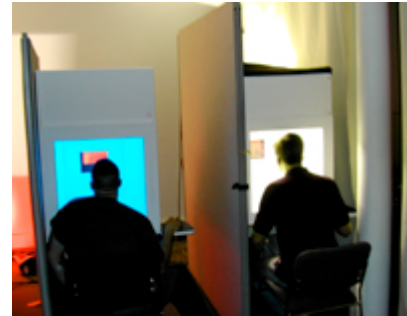


LRC Studies Human Response to Light, Discovers Evidence of Mechanism Leading to Melatonin Suppression

Scientists have long known that light plays an important role in regulating the human body's daily biological rhythms — also known as circadian rhythms — including the sleep-wake cycle, alertness, and hormone production. At night and under conditions of darkness, the pineal gland produces melatonin, a hormone closely related to the body's master clock. Using techniques from visual psychophysics, LRC researchers are gaining a better understanding of the mechanisms that convert light into neural signals in the human circadian system. A recently published LRC study is the first to show evidence of a “color” mechanism in the circadian system that controls melatonin suppression when humans are exposed to light.



Experimental setup used to evaluate light exposure from blue LEDs and clear mercury white lamps.

Effects of light on melatonin

Normally, melatonin levels rise in the evening, remain high for most of the night while we sleep, then drop in the morning as we awaken. In recent years, researchers have learned that bright white light suppresses melatonin. Previous studies have also suggested that melatonin suppression reacts differently to light of varying wavelengths, specifically showing a maximum sensitivity to short-wavelength (“blue”) light. Further research has shown that the cones and rods of the eye, which receive and transmit signals about light to the brain and body, get help from a photoactive substance named melanopsin when it comes to melatonin suppression in humans. Melanopsin is found in a subset of retinal ganglion cells.

A recent study published in *NeuroReport* by LRC researchers, with Professor Robert Parsons of Rensselaer's biology department, shows that 18 lux of blue light from light-emitting diodes is more effective at suppressing melatonin levels than 450 lux of clear mercury white light because a “spectral opponent mechanism” likely contributes to the circadian system's response to light, also known as circadian phototransduction.

“Our preliminary evidence shows that opponency of some kind is involved in the suppression of melatonin by light in humans, making white light found in buildings much less effective at suppressing melatonin than was previously thought,” said Dr. Mariana Figueiro, LRC Light and Health researcher.

Opponency explained

For color vision, three types of cones (short, middle and long wavelength) process color

information in the retina. The visual system separates cone responses into color information processed by two opponent channels, the red vs. green and the blue vs. yellow channels.

In these opponent channels, light in one wavelength region (e.g., blue) increases a neural response, while light in the opposing region (e.g., yellow) decreases it. The right balance of energy in the opposing wavelength regions will result in a null response in that channel, signaling that there is no color, and indeed that there is no light at all.

Though biologists understand how opponency works for color vision, the LRC study is the first to find the existence of spectral opponency in circadian phototransduction. Figueiro explains the concept of opponency for the circadian system: “Similarly, in the case of the circadian system, it seems that a sufficient balance of light in each wavelength region results in a null response by the circadian system, just as if there is no light at all.” As part of their study, Figueiro, Parsons, and LRC researchers John Bullough and Mark Rea showed that a spectral opponent mechanism was consistent with their data, as well as with other previously published data on the suppression of melatonin by light in humans.

“In the past, we thought the human circadian system was additive, meaning if a certain amount of blue light and a certain amount of yellow light each produced the same level of melatonin suppression, then half of these amounts of blue and yellow added together would produce the same level of melatonin suppression,” said Figueiro. However, this theory is contradicted by study results showing a small amount of blue light producing a stronger suppression than a much greater amount of white light (blue plus yellow), suggesting the existence of spectral opponency in the human circadian system.

“It seems that the circadian system in diurnal (active during the day) humans is preferentially sensitive to blue light, presumably the blue sky,” said Mark Rea, LRC director.

New study compares findings in mice

LRC researchers also are conducting parallel investigations, in collaboration with Skidmore College biology professor Bernard Possidente, using mice in cages equipped with running wheels. Mice are nocturnal animals that are active during dark periods and still when lights are on. “Even in constant darkness, mice maintain circadian activity rhythms, alternating about 12 hours of rest with about 12 hours of wheel-running activity,” said Bullough of the LRC. “Exposure to light a few hours after activity normally begins will cause the next burst of activity to be delayed,” he added. Using the length of this delay as a measure, Bullough compared different wavelengths of light, alone and in combination, to delay activity in mice. In contrast to humans, the circadian responses of mice to light appear to be additive, says Bullough. “It seems that the circadian system of the nocturnal mouse is not preferentially sensitive to any particular color like it is in humans,” he said. Bullough notes that this seeming contradiction might be explained by the fact that unlike humans, mice have at best very weak color vision, emphasizing the potential perils in generalizing across different species.

Putting these findings to practical use

LRC researchers note that these findings show promise for a number of practical applications, including improving sleep quality in patients with Alzheimer's disease, advancing treatments for seasonal affective disorder, and studying effects of light on night-shift workers and premature infants.

The paper, "Preliminary Evidence for Spectral Opponency in the Suppression of Melatonin by Light in Humans" by Figueiro, Bullough, Parsons and Rea, is published in the February 9, 2004 issue (Volume 15, Number 2) of *NeuroReport*.

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