Light switch: Study finds increased light may moderate fearful reactions

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Biologists and psychologists know that light affects mood, but a new University of Virginia study indicates that light may also play a role in modulating fear and anxiety.

Psychologist Brian Wiltgen and biologists Ignacio Provencio and Daniel Warthen of U.Va.'s College of Arts & Sciences worked together to combine studies of fear with research on how light affects physiology and behavior.

Using mice as models, they learned that intense light enhances fear or anxiety in mice, which are nocturnal, in much the same way that darkness can intensify fear or anxiety in diurnal humans.

The finding is published in the Aug. 1 issue of the journal *Proceedings of the National Academy of Sciences*.

"We looked at the effect of light on learned fear, because light is a pervasive feature of the environment that has profound effects on behavior and physiology," said Wiltgen, an assistant professor of psychology and an expert on learning. "Light plays an important role in modulating heart rate, circadian rhythms, sleep/wake cycles, digestion, hormones, mood and other processes of the body. In our study we wanted to see how it affects learned fear."

Fear is a natural mechanism for survival. Some fears – such as of loud noise, sudden movements and heights – appear to be innate. Humans and

other mammals also learn from their experiences, which include dangerous or bad situations. This "learned fear" can protect us from dangers.

That fear also can become abnormally enhanced in some cases, sometimes leading to debilitating phobias. About 40 million people in the United States suffer from dysregulated fear and heightened states of anxiety.

"Studies show that light influences learning, memory and anxiety," Wiltgen said. "We have now shown that light also can modulate conditioned fear responses."

"In this work we describe the modulation of learned fear by ambient light," said Provencio, an expert on light and photoreception. "The dysregulation of fear is an important component of many disorders, including generalized anxiety disorder, panic disorder, specific phobias and post-traumatic stress disorder. Understanding how light regulates learned fear may inform therapies aimed at treating some of these fear-based disorders."

The researchers used a common method for studying learned fear. They cued their mice with a minute-long tone that was followed two seconds later by a quick, mild electrical shock. The mice learned to associate the tone with the shock and quickly became conditioned to duck down and remain motionless when they heard the tone, in the same way they would if a predator appeared.

The researchers discovered that by intensifying the ambient light, the mice showed a greater fear reaction to the tone than when the light was dimmer. This makes sense Wiltgen said, because mice naturally avoid detection by predators by hunkering down motionless as a defense mechanism. In a natural habitat they likewise would become particularly

anxious in the presence of a predator in bright light where they would be more easily detected.

"We showed that light itself does not necessarily enhance fear, but more light enhances learned fear," Wiltgen said. "It may be similar to a person learning to be more fearful in the dark."

The researchers wanted to understand what visual pathways to the brain in mammals may be responsible for this behavior in the presence of more light. The eye has two pathways that begin in the retina and end in the brain: one is image-forming and made up of rods and cones; the other is the non-image-forming retinal ganglion cells where melanopsin, a circadian rhythm-regulating photo-pigment, is located.

Using two types of mutant mice, ones without rods and cones but with the melanopsin retinal ganglion cells, the others without functioning melanopsin ganglion cells but with rods and cones, the researchers were able to determine that the visual pathway affecting light behavior was in the rods and cones – the image-forming pathway.

"Both pathways have connections to the emotional circuitry of the brain," Wiltgen said. "The two types of mice are a nice tool for figuring out which pathway controls the light effect."

By indexing the two types of fear reactions in the presence of increased light, the researchers learned that the image-forming pathway of the rods and cones had the modulating effect on fear.

"The implications of this in humans is this: that being diurnal, the absence of light can be a source of fear," Wiltgen said. "But increased light can be used to reduce fear and anxiety and to treat depression. If we can come to understand the cellular mechanisms that affect this, then eventually abnormal anxiety and fear might be treated with improved

pharmaceuticals to mimic or augment light therapy."

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