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PRIMARY eye care

Newly discovered brain pathway helps to explain light's effect on mood

According to the US National Institute of Mental Health many people go through short periods of time where they feel a bit down or not like their usual selves. Sometimes, these mood changes begin and end when the seasons change with the associated daylight changes. Humans sense changes in ambient illumination, and such irradiance-dependent ("luxotonic") changes influence a wide range of functions, including circadian rhythms, visual reflexes, mood, and seemingly, cognitive processing. However, the way in which light-intensity signals reach the brain and become processed in relation to mood has not been well understood. Improved understanding of a neural pathway connecting light-sensitive cells in the retina with the cortical brain regions involved in mood and cognition has implications for the development of treatments for some mood disorders.

CAPTION: Quantity and quality of light that a person encounters can significantly impact mood.

Photo credit: Johannes Plenio

In a new study published in the Proceedings of the National Academy of Science (US), Sabbah et al. used functional MRI to reveal how light-intensity signals reach the brain, and how brain structures involved in mood process those signals. The study demonstrated that some regions of the cerebral cortex involved in cognitive processing and mood show sensitivity for light intensity.

The findings build on previous research by study co-author David Berson, a professor of neuroscience at Brown, who in 2002 discovered special light-sensing cells in the eye. Unlike rods and cones, these "intrinsically photosensitive retinal ganglion cells" are not involved in what's known as "object vision" or "form vision," but mainly function to sense light intensity, noted the lead study author Jerome Sanes, also a professor of neuroscience at Brown. Other research showed some animals have a mood-regulating neural pathway linking these photosensitive retinal cells to areas in the prefrontal cortex involved in mood disorders.

Since humans also have light-intensity-encoding, intrinsically photosensitive, retinal ganglion cells, Sabbah et al. sought to identify regions of the prefrontal cortex and other areas of the brain exhibiting light-intensity-dependent signals. This new study used functional MRI to explore whole-brain activation patterns in 20 healthy adults.

Participants viewed four different levels of light intensity through goggles that diffused light and eliminated visual shapes, colors and other objects in the environment. Light intensities ranged from dark to bright, viewed for 30 seconds each. To keep participants alert, they concurrently performed an auditory task requiring them to state the difference between two tones.

The research team found 26 human brain regions where activation either monotonically decreases or monotonically increases with light intensity. Luxotonic-related activation occurred across the cerebral cortex, in diverse subcortical structures, and in the cerebellum, encompassing regions with functions related to visual image formation, motor control, cognition, and emotion.

The results showed that light suppressed activity in the prefrontal cortex was in proportion to the light intensity. The light- evoked responses in the prefrontal cortex and their alteration by prior light exposure resembled the responses of the intrinsically photosensitive retinal ganglion cells. This study clearly showed that the prefrontal regions of the human brain have light-sensitive signals, and that these signals are similar to intrinsically photosensitive retinal ganglion cells — which together, Sanes said, may explain the effects of light intensity on complex emotional and cognitive behaviors.

“Identifying this pathway and understanding its function might directly promote development of approaches to treat depression, either by pharmacological manipulations or non-invasive brain stimulation in selected nodes of the pathway or with targeted bright-light therapy,” Sanes said.

The researchers note that while their findings offer a functional link between light exposure and prefrontal cortex-mediated cognitive and affective responses, there is more work to do investigating how light affects these same brain pathways and regions in people with mood disorders like seasonal affective disorder or major depressive disorders. Further research is needed to compare people with mood disorders with a control group of healthy people not diagnosed with these disorders.

“Does light activate the same regions, and if so, are these regions more or less sensitive to light activation? What is the magnitude of difference in the effect?” asks Sanes in the press release from Brown University which also notes that Michael Worden from Brown’s Department of Neuroscience and Carney Institute for Brain Science also contributed to this research, as did Shai Sabbah and Dimitrios Laniado, researchers from the Hebrew University of Jerusalem.

REFERENCE:

Luxotonic signals in human prefrontal cortex as a possible substrate for effects of light on mood and cognition. Shai Sabbah, Michael S. Worden, Dimitrios D. Laniado, David M. Berson, and Jerome N. Sanes. Proceedings of the National Academy of Sciences (PNAS), July 6, 2022. https://doi.org/10.1073/pnas.2118192119

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