Brain 'GPS' illuminated in migratory monarch butterflies

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A new study takes a close look at the brain of the migratory monarch butterfly to better understand how these remarkable insects use an internal compass and skylight cues to navigate from eastern North America to Mexico each fall. The research, published by Cell Press in the January 27 issue of the journal *Neuron,* provides key insights into how ambiguous sensory signals can be integrated in the brain to guide complex navigation.

Previous research has shown that migrants use a time-compensated "sun compass" to maintain a southerly direction during flight. "In general, this sun compass mechanism proposes that skylight cues providing directional information are sensed by the eyes and that this sensory information is then transmitted to a sun compass system in the brain," explains senior study author, Dr. Steven Reppert from the University of Massachusetts Medical School. "There, information from both eyes is integrated and time compensated for the sun's movement by a circadian clock so that flight direction is constantly adjusted to maintain a southerly bearing over the day."

Dr. Reppert and coauthor Dr. Stanley Heinze were interested in studying exactly how skylight cues are processed by migrating monarchs and how the skylight pattern of polarized light may provide directional information on cloudy days. "The pattern of linearly polarized skylight is arranged as concentric circles of electric field vectors (E-vectors) around the sun, and they can indicate the sun's position, even when the sun itself is covered with clouds," says Dr. Reppert. "However, the symmetrical nature of the polarized skylight pattern leads to directional uncertainty unless the pattern is integrated with the horizontal position of the sun, called the solar azimuth."

Dr. Heinze compared the neuronal organization of the monarch brain sun compass network to that of the well-characterized desert locust and found it to be remarkably similar. He went on to show that individual neurons in the sun compass were tuned to specific E-vector angles of polarized light, as well as azimuth-dependent responses to unpolarized light. Interestingly, the responses of individual neurons to these two different stimuli were mediated through different parts of the monarch eye. The responses were then integrated in the sun compass part of the monarch brain to form an accurate representation of skylight cues throughout the day.

"Our results reveal the general layout of the neuronal machinery for sun compass navigation in the monarch brain and provide insights into a possible mechanism of integrating polarized skylight information and solar azimuth," conclude the authors. "More generally, our results address a fundamental problem of sensory processing by showing how seemingly contradictory skylight signals are integrated into a consistent, neural representation of the environment."

Provided by Cell Press

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