New insights into the regulation of intuitive and reflexive body perception in insects

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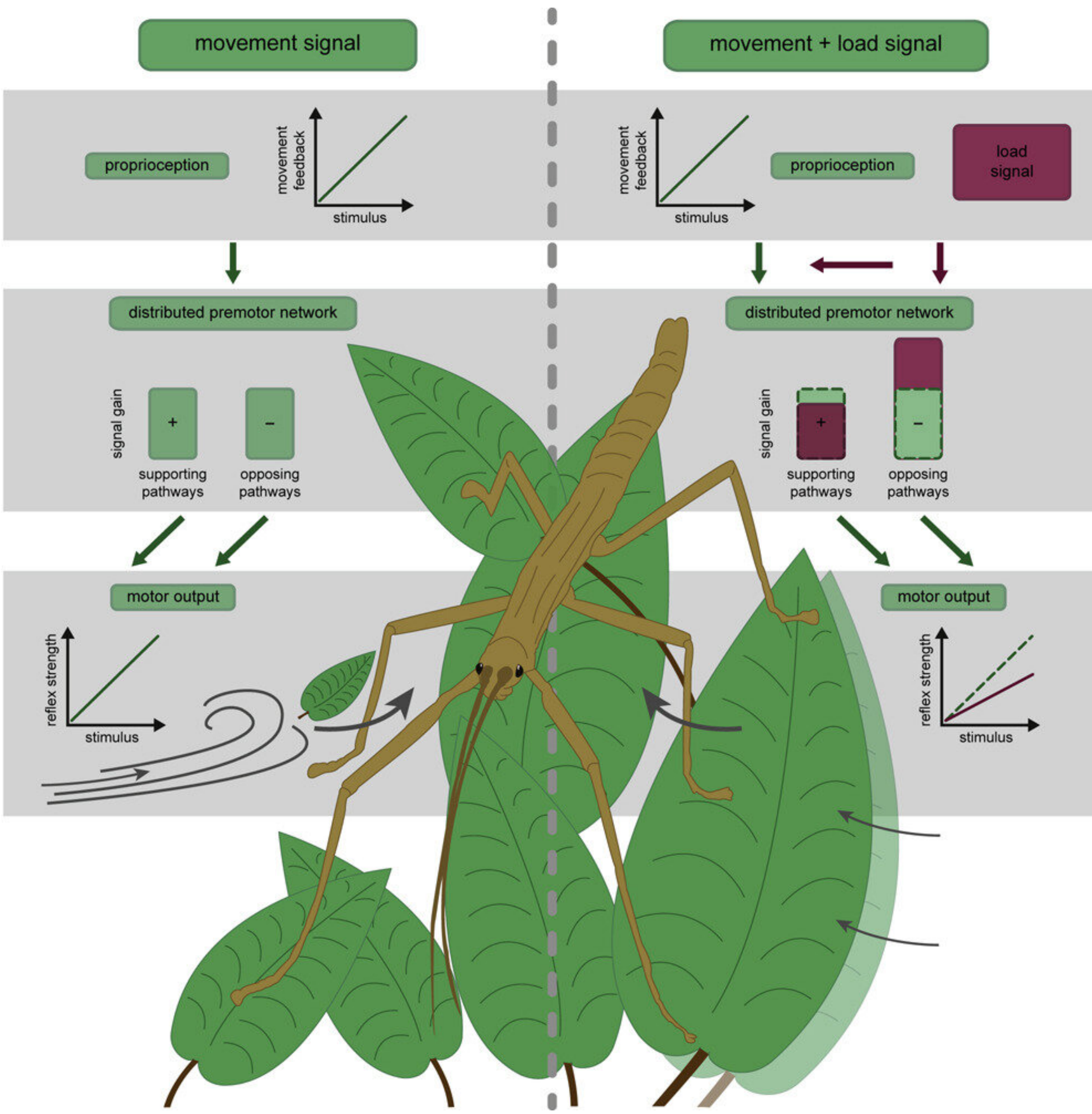

Graphical abstract. Credit: *Current Biology* (2022). DOI: 10.1016/j.cub.2022.07.005

A new study shows how movement-induced postural reflexes in stick insects are modified under different loading conditions. A team of scientists from the University of Cologne (Germany) and Ohio University (U.S.) traced the load and movement signals from the sensory organs in the insect's leg through the neuronal network to the motor neurons and muscles that generate the reflex. This allowed them to reveal a mechanism that changes the movement reflexes in the legs of stick insects depending on the load. The study was published in the journal *Current Biology*.

When asked to close the eyes and point at the foot, most people would have no trouble doing so no matter where the foot was. While this seems easy, it is an extraordinarily difficult task for the nervous system, requiring that it continually monitors, solely via internal sensory pathways, the posture and position of the body and all its limbs.

This sense of our physical self is called proprioception. Proprioception is so fundamentally a part of our existence that we are seldom consciously aware of it. One example of proprioception that most people are familiar with is the knee-jerk reflex—the tap below the kneecap by a doctor and the resulting extension of the leg. In normal behavior (e.g., walking) this reflex helps stabilize knee angle, and is one of a multitude of proprioceptive mechanisms that allow animals and humans to stand, run, swim, or ballet dance.

The response to proprioceptive inputs must be modified in a context-dependent manner. For example, the knee-jerk reflex helps stabilize the body after jumping but is suppressed during running. Context-dependent regulation requires that nervous systems integrate input from movement, load, and position sense organs. How this integration occurs on the neural level has long been an open question.

Dr. Corinna Gebehart and Professor Dr. Ansgar Büschges from the Institute of Zoology at the University of Cologne (Germany), and Professor Dr. Scott L. Hooper from the Department of Biological Sciences at Ohio University, Athens (U.S.), have recently published in *Current Biology* a mechanism by which load alters movement reflexes in stick insect legs. Similar to mammals, the "knee joint" of insect legs, the femur-tibia joint, has a stabilizing reflex. When this joint is flexed by an external perturbation, the nervous system responds by reflexively extending it. This effect is mediated by a neural network in the insect ventral nerve cord, the insect equivalent of the mammalian spinal cord.

The scientists followed load and movement proprioceptive signals from their sense organs in the stick insect leg through the neural network that combines them in the ventral nerve cord to the motor neurons and muscles that produce the reflex. "We could show that leg load decreased movement reflex strength by a neuronal mechanism called presynaptic afferent inhibition," says Dr. Corinna Gebehart, lead author of the new study. "This mechanism altered information processing in the nerve cord neural network, and thereby reduced the response of the motor neurons and muscle to movement input."

The behavioral importance of this interaction of load and movement can be appreciated by considering a light load being applied to the animal—a leaf landing on it—in which case a resistance reflex should occur to keep the leg position constant and the animal standing tall. However, if the applied load is greater than what the leg muscles can resist—a branch pressing down on the animal—the resistance reflex should be reduced, the joint should flex, and the animal's body should yield to the greater load, to prevent damage to the leg.

Proprioception, its integration by the nervous system, and the resulting motor reflexes, are surprisingly similar in mammals and insects. The findings from the stick insect thereby shed light on potentially general mechanisms by which nervous systems combine different types of proprioceptive signals to form a coherent internal picture of their body, and how these processing pathways can be adapted depending on the behavioral context of the animal.

More information: Corinna Gebehart et al, Non-linear multimodal integration in a distributed premotor network controls proprioceptive reflex gain in the insect leg, *Current Biology* (2022). DOI: 10.1016/j.cub.2022.07.005

Provided by University of Cologne

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