Researchers identify brain cells that control backward walking in fruit flies

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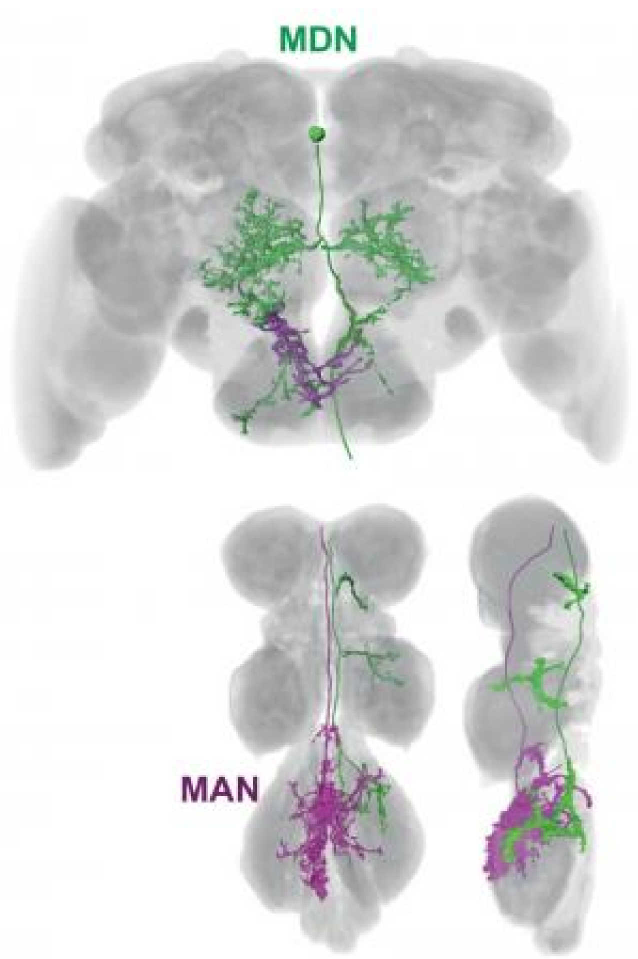

The picture depicts two neurons, MDN (Moonwalker Descending Neuron) and MAN (Moonwalker Ascending Neuron), that in the course of the study were found to be implicated in backward walking. The figure shows segmented representations of these neurons mapped onto a common template fly brain. Credit: IMP, Science/AAAS

Researchers at the Institute of Molecular Pathology (IMP) in Vienna managed to isolate "moonwalker flies" in a high-throughput screen. Screening a large collection of fruit flies, the scientists found specimens that seemed locked in reverse gear. Dickson and his co-workers were able to trace these changes in walking direction back to the activity of specific neurons in the brain. The results of the study will be published in the current issue of *Science*.

Most land animals walk forward by default, but can switch to backward walking when they sense an obstacle or danger in the path ahead. The impulse to change walking direction is likely to be transmitted by descending neurons of the brain that control local motor circuits within the central nervous system. This neuronal input can change walking direction by adjusting the order or timing of individual leg movements.

Screening for flies with altered walking patterns

In the current study, Barry Dickson and his team aimed to understand the fly's change in walking direction at the cellular level. Using a novel technology known as thermogenetics, they were able to identify the neurons in the brain that cause a change in locomotion. Their studies involved screening large numbers of flies with it which specific neurons were activated by heat, producing certain behaviors only when warmed to 30°C, but not at 24°C . Analysing several thousand flies, the researchers looked for strains that exhibited altered walking patterns compared to control animals.

Moonwalker-neurons control backward walking

Using the thermogenetic screen, the IMP-researchers isolated four lines of flies that walked backward on heat activation. They were able to track down these changes to specific nerve cells in the fly brain which they dubbed "moonwalker neurons". They could also show that silencing the activity of these neurons using tetanus toxin rendered the flies unable to walk backward.

Among the moonwalker neurons, the activity of descending MDN-neurons is required for flies to walk backward when they encounter an obstacle. Input from MDN brain cells is sufficient to induce backward walking in flies that would otherwise walk forward. Ascending moonwalker neurons (MAN) promote persistent backward walking, possibly by inhibiting forward walking.

"This is the first identification of specific neurons that carry the command for the switch in walking direction of an insect", says Salil Bidaye, lead author of the study. "Our findings provide a great entry point into the entire walking circuit of the fly. "

Although there are obvious differences in how insects and humans walk, it is likely that there are functional analogies at a neural circuit level. Insights into the neural basis of insect walking could also generate applications in the field of robotics. To date, none of the engineered robots that are used for rescue or exploration missions can walk as robustly as animals. Understanding how insects change their walking direction at a neuronal level would reveal the mechanistic basis of achieving such robust walking behavior.

More information: The paper "Neuronal Control of Drosophila Walking Direction" by Salil S. Bidaye, Christian Machacek, Yang Wu and Barry Dickson is published in *Science* on 3 April, 2014.

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