Eye size found to account for some diversity among mammalian direction detection cells

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Ginger tabby cat. Credit: Public domain

(Phys.org)—A team of researchers affiliated with the National Institute of Neurological Disorders and Stroke in Maryland and the University of Pennsylvania, has found that eye size might have more to do with neurological differences in the retinas of mammals than has been previously thought. In their paper published in the journal *Nature*, the

team describes their studies of selective retinal neuronal circuits called starburst amacrine cells (SACs), in mice, compare them to those in rabbits and then offer some reasons for the differences they found.

Eyes are very complicated sensing organs, of that there is no doubt. Scientists still do not fully understand how some of their parts work, or in some cases why the same parts in different animals sometimes have different characteristics. In this new work, the team set out to learn more about the role SACs play in detecting movement and direction when movement is identified. They focused specifically on SACs, their characteristics, the ways they interact and differences between those that exist in mice and rabbits—two mammals that live in similar conditions.

SACs are cells with dendrites extending from a central body in a way that resembles an exploding star, hence their name. Prior research has found that individual cells as a whole are not used as a means to discern movement—that feature is left to the individual dendrites. Prior research has also shown that the dendrites have both input and output cells that allow for communication with other cells and are involved in motion detection and movement gauging. To learn more about them, the researchers focused on the arrangements of these cells as they are situated on a given dendrite.

Using an electron microscope, they were able to see that for mice, the input and output cells were clearly segregated, with the input cells located near to the cell main body, and the output cells all clustered nearer the dendrite tips. In rabbits though, the two were mixed geographically along the entire length of a given dendrite. This difference had not been noted before and caused the researchers to wonder why such a difference existed. To find an answer, they created a computer model to represent the cells and then ran them with different synaptic arrangements to see which might confer different advantages. Doing so showed that segregating the cells resulted in more robust

directional tuning, which suggested that mice eyes compute movement slower than rabbit eyes; and that the team theorized was due to the difference in eye size—rabbit eyes are much bigger than mice eyes. The differences, they suggest, allow each species to see in a way that offers the most benefit for its size.

More information: Species-specific wiring for direction selectivity in the mammalian retina, *Nature* (2016) nature.com/articles/doi:10.1038/nature18609

Abstract

Directionally tuned signalling in starburst amacrine cell (SAC) dendrites lies at the heart of the circuit that detects the direction of moving stimuli in the mammalian retina. The relative contributions of intrinsic cellular properties and network connectivity to SAC direction selectivity remain unclear. Here we present a detailed connectomic reconstruction of SAC circuitry in mouse retina and describe two previously unknown features of synapse distributions along SAC dendrites: input and output synapses are segregated, with inputs restricted to proximal dendrites; and the distribution of inhibitory inputs is fundamentally different from that observed in rabbit retina. An anatomically constrained SAC network model suggests that SAC–SAC wiring differences between mouse and rabbit retina underlie distinct contributions of synaptic inhibition to velocity and contrast tuning and receptive field structure. In particular, the model indicates that mouse connectivity enables SACs to encode lower linear velocities that account for smaller eye diameter, thereby conserving angular velocity tuning. These predictions are confirmed with calcium imaging of mouse SAC dendrites responding to directional stimuli.