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Cocking an eye for danger

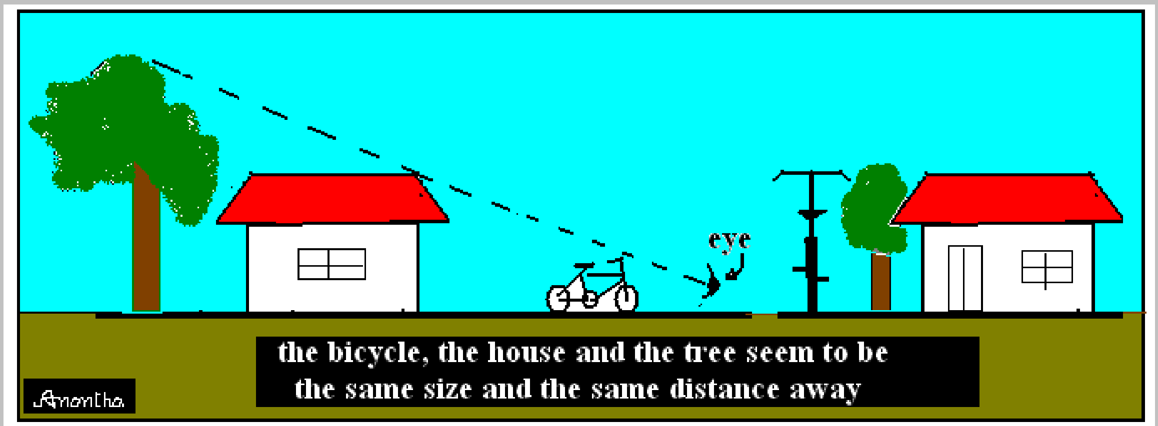
The lowly rat makes good use of its two eyes, says S.Ananthanarayanan.

Nature has provided living things with pairs of eyes, for good reason. A single eye can provide sight, but for accurate estimation of distance and depth, we need two eyes which are placed some distance apart. But not all animals use both eyes all the time, and many use their two eyes singly, to command a wider field of view.

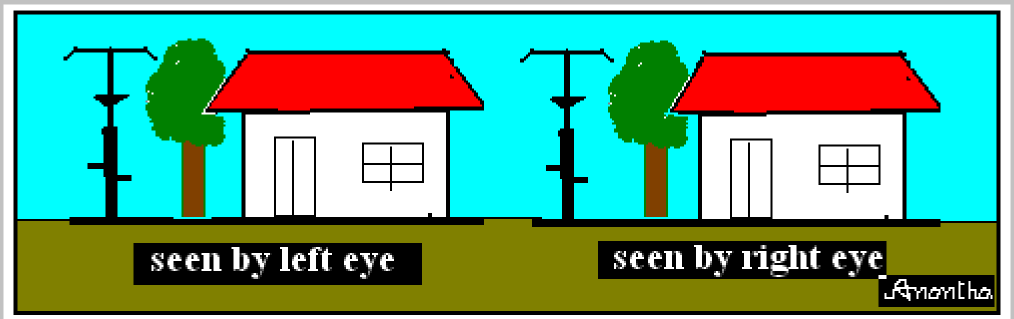
Damian J.Wallace, David S. Greenberg, Juergen Sawinski, Stefanie Rulla, Giuseppe Notaro & Jason N. D. Kerr at the Max Planck Institute for Biological Cybernetics, and the Bernstein Center for Computational Neuroscience in Germany report in the journal. ***Nature***, that rodents effectively combine both kinds of use of eyes to its best advantage.

A pair of eyes

The animal eye is noting but a biological optical camera. It focuses light that falls upon it onto the retina, which is a light sensitive screen. In other words, the world in front of the camera, which consists of objects at different distances from the eye, is captured on a flat surface, which has length and breadth, but no depth. Large objects at a distance then look the same size as a smaller object that is closer, and a single eye, or any number of eyes, by themselves, cannot make out which object is nearer or further away. This is quite noticeable in photographs of landscapes or other scenes with depth - the awareness of distances gets obscured in the picture.



But with a pair of eyes, each eye sees a different picture, each from a different point, a few inches to the side. The brain is then able to merge these two pictures and bring out the perception of distance. The views of the bicycle, house and tree, seen by each eye, one a little to the side, are shown in the second picture.



If the reader presses one eye, so that the eyes get misaligned and there are two images, and four houses, she could try to merge the two in the middle – it will spring to life, with the tree clearly behind the house. Another experiment to try is to close one eye and try to touch an object from the side. We usually miss the object, by going too far or too close – because we lose depth perception.

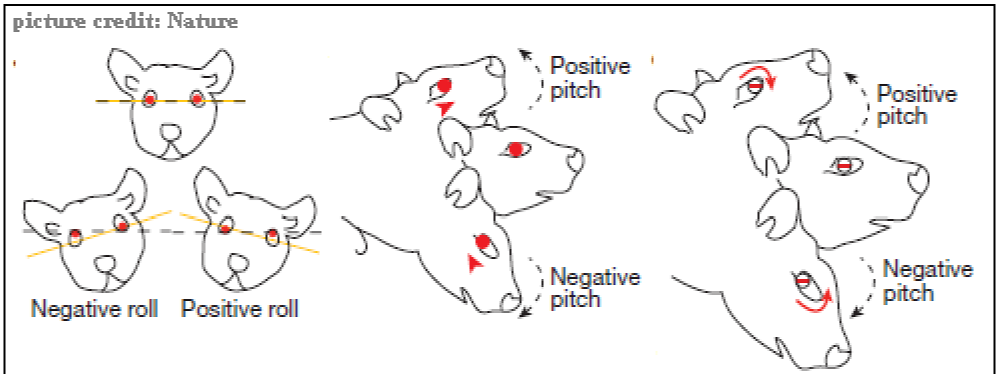
Such perception of depth, which is called ***stereoscopic vision***, is what we get thanks to our two eyes. All animals, which have two eyes, are able to correctly get to food or prey, avoid obstacles and cross barriers, thanks to this perception. But for the eyes to act in this way, there is also the need for both eyes to coordinate and align themselves to gaze at the same object at the same time, even when we move our head or shift our direction of gaze or change the focus to a different distance. This takes muscular coordination and is learnt in a few weeks by human babies, for instance, when they experiment with grasping or touching.

Using eyes singly

Coordinated use of eyes for stereoscopic vision is the rule with larger animals and certainly with primates, like the chimpanzee or humans. Keeping the eyes working together is useful for activities like leaping, hunting or using tools. But it involves a price, in limiting the field of attention. In the case of grazing birds, like the chicken, it is more useful if the bird could view all sides at once, to be able to locate things to eat. The chicken has hence evolved to have her eyes on either side of her head – difficult to coordinate, but good for surveying the whole yard at once. Once a tidbit is located, the bird could sight the morsel with both eyes, by turning her head this way and that, to capture two images which the brain could process and help the chicken to peck accurately.

The authors of the paper in ***Nature*** note that although rodents share with other mammals the key components of eye movement control, it is not known that rodents coordinate the movements of the eye even when they have not focused on an object or when they are moving freely. The group of researchers carried out a series of experiments where movement of the eyeball of freely moving rats was monitored with the help of head-mounted cameras and the position and orientation of the head itself the help of a specially designed tracking system.

The movements of the head were the roll, or tilting left and right, the pitch or looking up and down, and the yaw, which is to turn to the left or right. While the head was moving, it was found that the eyes carried out wide excursions, and markedly not coordinated. Not only did the pupils move inward, outward, up and down, they even rotated about the direction of vision. And it was found that that the movements of the pupils were dictated by the orientation of the head. Earlier studies have shown that rolling leads to raising of the eyeball on the side that goes down, or vice versa and pitching leads to the eyeballs moving to the centre for pitch up and outwards for the pitch down, And pitching motion also leads to rotation of the pupil. The movement of the pupils of free moving rats was seen to mostly follow this rule.



Changing the orientation of the head leads to movement of the eyeballs

The consequence of the finding is that the two eyes of free moving rats are often not pointed in the same direction. This led to the matching images of the two eyes only in part of the retina and at different parts every instant. This was not as much the case when the head was clamped or restrained, or when the rat held its head still, as when it had to cross a gap in the floor, but there was little evidence of coordination to keep a fixed relationship between the eyes.

The result is that the rat has a large field of view, about 200˚, in the front, above and to the rear, but most of the vision with the use of one eye only. The parts of the field where the images of the two eyes overlap are directly in front and above the head. Studies of the overlap for different orientations of the head show that the area where overlap seems to be maintained is in the area above the head. In an experiment, rats were placed in an enclosed area with a ‘shelter’, where they could retreat when threatened. It was found that showing a threat, like a shadow, from the sides of the enclosure did not result in response, but showing the threat from above led to the rats scampering into the shelter.

Despite the uncoordinated eye movements, rodents do have the capacity for stereoscopic vision and display impressive object recognition. The mechanism of combining the overlap in images may be momentary orientation of the head to match the images or a computational method to make use of the two images. But the overall object of how the rodent control of the eyes has evolved seems to be not to use both eyes to see visual targets while moving, but to have binocular vision only in the region overhead, which is where danger is most likely to lurk.

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