More light shed on how pigeons navigate

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Feral Pigeon (Columba livia domestica) in flight. Credit: Alan D. Wilson/Wikipedia.

(Phys.org) -- Pigeons are renowned for their ability to find their way home from a release point hundreds of miles away, but scientists have never fully understood how they are able to achieve the feat. Now a new study has shed more light on this perennial puzzle.

It has long been known that many animals use the Earth's magnetic field for navigation but little is understood about how the brain receives and interprets information about the magnetic field. Now a new study in the US has shown how newly-discovered neurons within pigeons' brains are sensitive to the strength and direction of the Earth's magnetic field, and together with magnetic receptors feeding the brain magnetic information, form a global positioning system for the birds.

Scientists have known that magnetic receptors must exist in pigeons and other birds, but the new study from the US reveals for the first time which parts of the brain translate magnetic information into directional cues the birds can use.

The researchers, led by Le-Qing Wu and J. David Dickman, of the Department of Neuroscience at Baylor College of Medicine, Houston, Texas, took seven pigeons and placed them into an unlit room and canceled out the Earth's magnetic field using a three-dimensional coil system, which they could also use to generate an artificial field within the room that they could manipulate. They recorded the neuronal activity within the birds' brains while they adjusted the magnitude and elevation and angles of the artificial magnetic field.

The study, published in *Science*, showed that single cells within the birds' brainstems were able to encode information on the magnetic field direction and its intensity and polarity. This information is needed if the brain is to develop a model of the bird's direction and heading in relation to the Earth's surface.

Previous theories have proposed that pigeons and other birds were able to navigate because their beaks contained cells rich in magnetite (a form of iron), but another international study suggested this is not the case and that the iron-rich cells are actually macrophages (specialized white blood cells) involved in recycling iron of a less magnetic form than magnetite, and have no involvement in the navigation system.

The present study examined the activity in 329 neurons in the brain and identified 53 that were most sensitive to changes in the artificial magnetic field, and identified those most sensitive to the parameters of the Earth's natural magnetic field. Wu and Dickman suggested these neurons would enable the pigeons to determine their position and direction of travel, and could even differentiate between the Northern

and Southern Hemispheres.

Some puzzles still remain—for example confirming which cells detect the magnetic fields—but Dickman said working backward from the neurons in the brain will help to determine if these cells are in the inner ear rather than in the beak or eyes, as other scientists have suggested.

More information: Neural Correlates of a Magnetic Sense, *Science*, DOI: 10.1126/science.1216567

ABSTRACT

Many animals rely on the Earth's magnetic field for spatial orientation and navigation. However, how the brain receives and interprets magnetic field information is unknown. Support for the existence of magnetic receptors in the vertebrate retina, beak, nose, and inner ear has been proposed and immediate gene expression markers have identified several brain regions activated by magnetic stimulation, but the central neural mechanisms underlying magnetoreception remain unknown. Here, we describe neuronal responses in the pigeon's brainstem that show how single cells encode magnetic field direction, intensity, and polarity—qualities that are necessary to derive an internal model representing directional heading and geosurface location. Our findings demonstrate a neural substrate for a vertebrate magnetic sense.

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