Birds evolved compass 'head up display'

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Illustration merging migrating birds and HUD. Credit: Diane Constable.

(PhysOrg.com) -- Certain birds may have compass information mapped directly onto their vision, much as fighter pilots have ‘head up displays’ overlaying flight information on their view of the skies.

It’s well known that birds, such as the European Robin, can detect the Earth's magnetic field in order to help them navigate on long migratory flights.

This ‘compass’ sense must be associated with the eyeball, because the birds cannot detect magnetic fields in darkness.

But now Oxford University and National University of Singapore scientists have shown that birds may really ‘see’ the invisible force of magnetism, giving them a compass on top of their normal vision: rather

like aircraft ‘head up displays’ which overlay crucial navigation information on a transparent screen in front of the pilot.

According to the new model, when a photon of light from the Sun is absorbed by a special molecule in the bird's eye, it can cause an electron to be kicked from its normal state into an alternative location a few nanometres away. Until the electron eventually relaxes back, it creates an ‘electric dipole field’ which can augment the bird's vision - for example altering colours or brightness.

Crucially, the alignment of the molecule compared to the Earth's magnetic field controls the time it takes for the electron to relax back, and so controls the strength of the effect on the bird's vision.

There are many such molecules spread throughout the eye, with different orientations. So from the patterns on top of its vision, and the change of these patterns as it moves its head, the bird learns about the direction of Earth's magnetic field.

A report of the research is published in Biophysical Journal.

An important consequence of the new research is that this process ‘piggybacks’ on normal vision and so could evolve quite easily - it does not require the evolution of a whole new sensory organ.

"We can imagine that in an ancestral bird’s eye this disturbance to vision, oriented to the Earth’s magnetic field, gave some individuals an advantage when it came to navigating vast distances," Simon Benjamin of Oxford University’s Department of Materials and National University of Singapore, an author of the report, told me.

"Natural selection would then favour those individuals so that the effect became stronger and stronger over many generations resulting in the

powerful magnetic sense birds have today."

The research shows that, in an ancestral bird's eye, just a few molecules could have absorbed photons, creating electric dipoles that made the very weak magnetic field of the Earth faintly visible.

If this effect gave individuals an evolutionary advantage, the number, ordering, and characteristics of those special molecules is likely to have increased over millions of years, creating the compass used by modern birds.

Erik Gauger, of Oxford University's Department of Materials and National University of Singapore, adds: "Further experiments will verify whether the mechanism we have proposed correctly describes the bird's compass.

"However, even if it doesn't, our idea could be a powerful blueprint for engineered magnetometers; for instance a compass that is integrated into a contact lens."

Provided by Oxford University