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Cracking Mystery Reveals How Electronics Affect Bird Migration

From a glitch in a bird experiment, scientists gain startling insight into the effects of weak broadband waves.

Susan McGrath

for National Geographic

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In the spring of 2005 Henrik Mouritsen was stumped. Mouritsen, a professor of neurosensory sciences at Germany's University of Oldenburg, had just launched an ambitious investigation into what part of the brain a migratory bird uses in orienting to the Earth's magnetic compass.

The animal navigation expert had all his ducks in a row: funding, lab space, graduate students, sophisticated instruments. But to Mouritsen's dismay, the birds themselves (not actually ducks, but European robins) refused to cooperate.

The birds' innate migratory behavior -- well documented, fundamental to the research design, and the least of Mouritsen's concerns going into this project -- had gone haywire.

It took Mouritsen and his team three years to get to the bottom of the birds' seemingly anomalous behavior. But in doing so the scientists made a startling discovery -- one with important implications both for songbird conservation and for human health. The results are published in the current issue of *Nature*, released today.

Here's how the mystery was unraveled.

Birds, and Scientists, Baffled

Mouritsen's research centers on two wooden huts and two sets of night-migrating European robins already restless to fly north. One set of birds serves as the control population; the other is subject to various manipulations once the experiment gets under way.

Inside the huts, robins are released in special cages called Emlen funnels. Thermal paper linings in the funnels record the scratches the birds' feet make as they scrabble upward. In the absence of other navigational cues, namely sun and stars, the birds will orient to the Earth's magnetic field, which is detectable through the wooden walls of the huts. They will take off toward the north, marking the paper in their attempt to escape.

Or so they had in thousands of previous experiments, including Mouritsen's own Ph.D. research conducted in rural Denmark. But this time the exercise went immediately awry.

The robins seemed to have no idea where north was. "The birds basically jumped in random directions every spring and autumn for three years," Mouritsen says.

Puzzlement gave way to desperation. The scientists changed the robins' food, their cages, the shape of their cages, the light, the daylight cycle. Nothing affected the randomness of the scribbles inside the funnels.

Then a graduate student, Nils-Lasse Schneider, suggested using aluminum Faraday cages. A Faraday cage is basically a grounded metal box. It doesn't screen out the Earth's powerful, static magnetic field but it would shield against weaker, time-dependent electromagnetic fields such as those generated by electric appliances and electronics.

"I would have laughed the suggestion off three years earlier," Mouritsen admits. Instead, they installed aluminum Faraday cages in the huts, grounding them to wires screwed to the outside. Once again, the scientists released the robins in the Emlen funnels. Miraculously, it seemed to Mouritsen, the robins flew north.

Three years behind schedule at this point, the scientists threw themselves into conducting the brain experiment. They identified "cluster N," a part of the robin's forebrain, as the site where magnetic compass information is processed in the bird's brain. They published that finding in *Nature* in 2009.

But the weird behavioral hitch resolved by the Faraday cages still had the scientists scratching their heads.

The Simple Turn of a Screw

Though the effect of weak electromagnetic fields has been a hotly contested issue -- related to the safety of cell phones and the like -- there existed no reliable scientific evidence of weak electromagnetic fields affecting behavioral processes.

Furthermore, if the cages worked because they screened out confounding sources of weak electromagnetic activity, why had unscreened huts worked without Faraday cages elsewhere in the past? Had something changed?

Finished with their brain experiment, Schneider and Mouritsen decided to run a quick test. They assigned students to release robins in both huts over subsequent days. Without letting the students know, the scientists repeatedly disconnected and connected the cages' grounding screws in each hut.

As the students observed the robins, they saw no discernible pattern in the birds' ability to orient to north at some moments but not at others. Then Schneider and Mouritsen revealed the schedule on which they'd been grounding and ungrounding the shielding cages, and the patterns aligned perfectly. The simple turn of a screw turned on and off the birds' orientation mechanism.

Intrigued, the team next measured electromagnetic disturbances inside the huts, grounded and ungrounded. The noise detected in the ungrounded huts was broadband in frequency, in the range of AM radio, and it was low -- a hundred to a thousand times below the guidelines adopted by the World Health Organization to protect human health. Yet mystifyingly it proved enough to disable the birds' magnetic compass.

Then came the clincher, one more layer of proof. The scientists intentionally added broadband, low-level noise inside the screened huts. Disturbances no stronger than those equivalent to AM radio frequencies were enough to switch off the birds' magnetic compasses.

"Powerful Effects on Songbirds"

The scientists were astonished. "We were seeing powerful effects on songbirds, yet billions of migratory songbirds nevertheless do arrive at their destinations every season," says Mouritsen. "And you can listen to AM radio everywhere. So how could these signals be disturbing birds?"

The scientists took their experiment out of town. In the middle of a field outside of Oldenburg, far from any electric and electronic equipment, they reran their experiment. The level of noise in the unscreened hut in the field approximated that in the screened hut in Oldenburg. Birds took off toward the north.

Though they could hardly believe it themselves, the scientists had their answer. Low-level, broadband electromagnetic noise -- the kind that urban areas are now awash in -- can disable a critical tool migratory songbirds use in finding their way between seasonal destinations.

This finding that urban areas can handicap navigation may help explain the disturbing decline in migratory songbird populations, Mouritsen says.

It also provides the first ever, scientifically sound evidence of weak, anthropogenic electromagnetic fields affecting a biological process.

What devices are contributing to the noise? Given the measured frequencies, Mouritsen can say that these are not from cell phones or power lines, but other than that, he can't specify. The possible sources are almost endless: The Oldenburg campus alone houses everything from toaster ovens to scanning electron microscopes.

Because of this finding, it might eventually be possible to phase out use of those frequencies found to disturb birds' navigation. It pleases Mouritsen that his team made this contribution to avian science.

As to the implications for human health: "Not my area of interest," Mouritsen declares flatly. "We stumbled upon these effects by chance. I won't pursue this finding, though others may."

http://www.nature.com/nature/journal/v509/n7500/full/nature13290.html

Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird

- Svenja Engels,
- Nils-Lasse Schneider,
- Nele Lefeldt,
- Christine Maira Hein,
- Manuela Zapka,
- Andreas Michalik,
- Dana Elbers,
- Achim Kittel,
- P. J. Hore
- & Henrik Mouritsen

- Affiliations
- Contributions
- Corresponding author

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Electromagnetic noise is emitted everywhere humans use electronic devices. For decades, it has been hotly debated whether man-made electric and magnetic fields affect biological processes, including human health[1, 2, 3, 4, 5]. So far, no putative effect of anthropogenic electromagnetic noise at intensities below the guidelines adopted by the World Health Organization[1, 2] has withstood the test of independent replication under truly blinded experimental conditions. No effect has therefore been widely accepted as scientifically proven[1, 2, 3, 4, 5, 6]. Here we show that migratory birds are unable to use their magnetic compass in the presence of urban electromagnetic noise. When European robins, *Erithacus rubecula*, were exposed to the background electromagnetic noise present in unscreened wooden huts at the University of Oldenburg campus, they could not orient using their magnetic compass. Their magnetic orientation capabilities reappeared in electrically grounded, aluminium-screened huts, which attenuated electromagnetic noise in the frequency range from 50â€‰kHz to 5â€‰MHz by approximately two orders of magnitude. When the grounding was removed or when broadband electromagnetic noise was deliberately generated inside the screened and grounded huts, the birds again lost their magnetic orientation capabilities. The disruptive effect of radiofrequency electromagnetic fields is not confined to a narrow frequency band and birds tested far from sources of electromagnetic noise required no screening to orient with their magnetic compass. These fully double-blinded tests document a reproducible effect of anthropogenic electromagnetic noise on the behaviour of an intact vertebrate.

http://www.uni-oldenburg.de/en/news-single/art/electrosmog-disrupts-orientation-in-migrato ry-birds-948/

Electrosmog Disrupts Orientation in Migratory Birds

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European robin. Foto: Robjem/istockphoto

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Henrik Mouritsen: "Clear and reproducible effect of human-made electromagnetic fields on a vertebrate."

For the first time, a research team led by Prof. Dr. Henrik Mouritsen, a biologist and Lichtenberg Professor at the University of Oldenburg, has been able to prove that the magnetic compass of robins fails entirely when the birds are exposed to AM radio waveband electromagnetic interference.

Below a certain threshold value, electrosmog has no impact on biological processes or even human health â€“ that was the state of scientific knowledge up to now. But for the first time, a research team led by Prof. Dr. Henrik Mouritsen, a biologist and Lichtenberg Professor at the University of Oldenburg, has been able to prove that the magnetic compass of robins fails entirely when the birds are exposed to AM radio waveband electromagnetic interference â€“ even if the signals are just a thousandth of the limit value defined by the World Health Organization (WHO) as harmless.

The findings based on seven years of research by nine Oldenburg scientists, in cooperation with Prof. Dr. Peter J. Hore of Oxford University, are now available in a paper entitled "Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird", published in the latest issue of the renowned scientific journal Nature. Nature underlines the importance of this study by making it the cover story of its May 15th issue.

"In our experiments we were able to document a clear and reproducible effect of human-made electromagnetic fields on a vertebrate. This interference does not stem from power lines or mobile phone networks", Mouritsen stresses, explaining that electromagnetic interference within the two kilohertz to five megahertz frequency range is mainly generated by electronic devices. "The effects of these weak electromagnetic fields are remarkable: they disrupt the functioning of an entire sensory system in a healthy higher vertebrate."

It all started with a stroke of luck. For around 50 years it has been known that migratory birds use the Earth's magnetic field to determine their migratory direction. Biologists have proven this in numerous experiments in which they tested the birds' navigation abilities in so-called orientation cages. "So we were surprised when robins kept in wooden huts on the Oldenburg University campus were unable to use their magnetic compass", Mouritsen recounts. Dr. Nils-Lasse Schneider, an electrophysiologist and researcher in Mouritsen's work group, then came up with the idea that set things in motion: he proposed covering the wooden huts, along with the orientation cages they contained, with sheets of aluminium.

This did not affect the Earth's magnetic field, which is vital for the birds to navigate, but it strongly attenuated the time-dependent electromagnetic interference â€“ the electrosmog â€“ inside the huts. The effect was astounding: suddenly the birds' orientation problems disappeared. "Our measurements of the interferences indicated that we had accidentally discovered a biological system that is sensitive to anthropogenic electromagnetic noise generated by humans in the frequency range up to five megahertz", Mouritsen says. The surprising thing here, the biologist adds, was that the intensity of the interference was far below the limits defined by the International Commission on Non-Ionizing Radiation Protection and the WHO.

Considering the potential importance of the finding, Mouritsen and his team performed a large number of experiments to provide evidence of the effect they observed: â€œOver the course of seven years we carried out numerous experiments and collected reliable evidence, in order to be absolutely certain that the effect actually exists.â€ Under the leadership of Svenja Engels, Mourtisen's doctorate students conducted numerous so-called double-blind studies. Several generations of students repeated the experiments independently of one another on the Oldenburg campus. What they found was that as soon the grounding of the screens was disconnected or electromagnetic broadband interference was deliberately created inside the aluminium-clad and earthed wooden huts, the birds' magnetic orientation ability was immediately lost again.

Furthermore, the scientists were able to show that the disruptive effects were generated by electromagnetic fields that cover a much broader frequency range at a much lower intensity than previous studies had suggested. This electromagnetic broadband interference is omnipresent in urban environments. It is created wherever people use electronic devices. As expected, it is significantly weaker in rural areas. And indeed, unlike on the University campus, the magnetic compass of the robin did function in orientation cages placed one to two kilometres outside city limits, even without any screening. â€œThus, the effect of anthropogenic electromagnetic noise on bird migration is localised. However these findings should make us think â€“ both about the survival of migratory birds as well as about the potential effects for human beings, which have yet to be investigatedâ€ , Mouritsen concludes.

PROFILE

Prof. Dr. Henrik Mouritsen has been teaching and conducting research at the University of Oldenburg since 2002, and obtained his habilitation there in 2005. The Danish biologist has held a Lichtenberg Professorship from the VolkswagenStiftung since 2007. Through its “Lichtenberg Professorships” initiative the foundation funds outstanding scientists in innovative fields of teaching and research. Mouritsen researches the behavioural, molecular, physiological and cognitive mechanisms underlying long-distance navigational abilities in migratory birds. As head of the international research group “Neurosensorik/Animal Navigation” he has contributed substantially to the current state of the art suggesting that the birds use the Earth's magnetic field for orientation in two different ways. Light-sensitive molecules in their eyes enable them to visually detect the compass direction of the magnetic field. Furthermore, the birds seem to have magnetic sensors associated with the ophthalmic branch of the trigeminal nerve, which are connected via neural pathways to the brainstem. Mouritsen's group identified for the first time the areas in the birds' brains involved in both these orientation systems.

“Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird” by Svenja Engels, Nils-Lasse Schneider, Nele Lefeldt, Christine Maira Hein, Manuela Zapka, Andreas Michalik, Dana Elbers, Achim Kittel, P.J. Hore, Henrik Mouritsen, Nature.

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