Disturbing effects of short exposure to high frequency noise on the navigation of migratory bats.

Disruptive Effects of Letter Radiofrequency Noise Exposure on Migratory asked navigation.

Original Abstract

Source: Science | American Association for the Advancement of Science (AAAS)
Exposure:

Earth's magnetic field
0.01–300 MHz

EMF:data Evaluation

Introduction

A new study by the University of Oldenburg examines the effects of the same frequencies, which were recognized as disturbing in birds, on the navigation of bats. Previously, it was proven that very weak broadband signals in the range of 50 to 85 MHz interfere with the light-dependent magnetic compass of songbirds (the cryptochrome used in the retina). Although this frequency range is not in the range of mobile radio frequencies, it is present and is more widespread in urban areas (compared to wilderness areas), which is partly due to power lines and VHF broadcasting. The orientation-disturbing effects were found to be well below the current ICNIRP reference values. While it has been clearly demonstrated that the magnetic compass in the retina of birds is based on the cryptochrome CRY4, the magnetic sense of mammals is less explored. Some studies in rodents and other mammals suggest the use of CRY2. Therefore, it is important to understand whether and how wild mammals react to electromagnetic radiation, which according to the ICNIRP guidelines is considered harmless to humans. The effects of artificial electromagnetic fields on humans and animals have so far been studied mainly at direct exposure, and it remains to be clarified whether the exposure could still cause behavioral aftereffects even

after the subsidence. Bats are an ideal mammal comparison model for such research, as they have many similarities with small, nocturnal migratory birds in terms of distances traveled and the ecological challenges they face.

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Study Design and Implementation

The experiments were carried out over the course of four autumn train times on the Baltic Sea coast (2021–2024). A total of 165 adult bats of the species *Pipistrellus pygmaeus* were caught at the Pape ornithological station in Latvia. The scientists selected two sites for the exposure with a view of the Baltic Sea, with the two sites about 100 m apart. To prevent the bats from observing the sky before or after the experimental treatment, they were carefully covered and put into black linen bags, provided they were not in the exposure cages. In 2021 and 2022, exposure to electromagnetic noise occurred during the calibration phase at sunset. In the 2023 season, the EMF exposure was carried out after sunset. All bats could thus watch the sunset from the same location. In the 2024 season, EMF exposure was limited to the starting phase. In all four seasons, the same equipment was used for EMF exposure. In the first three seasons, the buildup remained the same. The bats were placed in a non-magnetic box that was 1 meter away from the transmitting antenna (double-wound magnetic loop). The transmitting antenna was connected to a signal generator that was set to cause electromagnetic noise (0.01–300 MHz, field strength 1 nT or 0.3 V/m). In the fourth season, the experimental setup was modified in such a way that the bats were exposed to the EMF noise only after their release from the orientation device – a circular arena (rebuilt Mongolian yurt). After the bat had been placed in the yurt, the test leader released the animal from outside the yurt. The attempt made it possible to capture the orientation of the animals on the basis of the traces they had left on a 360° thin layer of chalk on the edge of the round arena, i.e. on the basis of the footprints. For all groups, the intermediate orientations were analyzed using the Oriana software for circular statistics. The Rayleigh test was applied to assess whether the records in one of the tested groups deviated from a uniform circular distribution. In order to evaluate the overall effect on the navigation of the bats, an analysis of data scattering was carried out over all years of the study. Hypothesis: The authors expected that bats in the groups “Sunset” and “Departure” would have an impaired sense of orientation and would depart later at night in random directions. (The same group of researchers has shown in previous studies with the same species of bat that it has to calibrate its magnetic compass at sunset based on the position of the sun in order for the magnetic field navigation to work.) Conversely, they predicted that bats would orient themselves to the group “after sunset” in a direction similar to that

of the control animals, as they had unchanged access to environmental stimuli during the critical phase at sunset and at the later departure at night.

Results

In the first year of the study, the bats of the control group flew northward; in the second, third and fourth years, the mean direction of flight was southeast, southwest and south respectively. In each of the control groups of the four migration seasons, significant deviations from an even pattern were found, but not in the respective treated groups. In both seasons, bats that observed the natural sunset under EMF exposure then flew off in random directions (even circular distribution). Contrary to the hypothesis, the bats showed no oriented starting behavior after experiencing the sunset under natural geomagnetic field conditions, followed by EMF exposure and release within 2 to 6 hours of exposure. Their directions of flight were indistinguishable from a uniform distribution, in contrast to the control group, the distribution of which resembled a symmetrical, south-facing distribution. Over all years of the study, a clear difference was observed between the combined control and treatment groups.

Conclusions

The experiments described here show that exposure to low-performing electromagnetic noise still interferes with the orientation of bats several hours after the exposure phase. This has far-reaching consequences and raises numerous questions. The results suggest that an after-effect effect of weak broadband RF noise could play a role in the movement behaviour and in the navigational decision of animals. The fact that the orientation is disturbed regardless of whether the exposure took place during the crucial calibration phase or after, suggests that the result is based on an interaction between the effect on the magnetoreceptor and the subsequent behavioral interpretation of this effect. The exact mechanisms of how a short exposure to electromagnetic noise can cause a disturbance of the magnetic compass over several hours have not yet been clarified. After a simple, cryptochrome-based magnetic compass with radical pairs, this should not actually be possible. Therefore, this discovery illustrates a gap between the predictions of quantum mechanics and animal behavior, between theory and experiment. At least in the case of bats, the effects of exposure are still almost unexplored, but could play a role in some phenomena, such as the so-called invasions of dwarf bats, which since the late 20. Century are increasingly observed in European cities. As a limitation, the authors point out that they have tested migratory bats in a flying room without guidance, i.e. without access to other navigational instructions such as stars or the natural soundscape. Therefore, it

could be that additional orientation indications in a natural environment mitigate the disorientation caused by high-frequency radiation. Irrespective of the concrete reason for the observed carryover effect, the potential ecological consequences of the disorder shown here are worrying, since the current exposure limits relate exclusively to humans, which puts wildlife itself at risk within the limits of these guidelines. (AT)

Editor's comments:

A magnetic compass based on cryptochrome is usually only useful during the day (and in dry weather) because CRY must be activated by the blue light of sunlight. Some insects have a mechanism to circumvent this restriction, with the details still unknown [1]. Since the Earth's magnetic field has often changed catastrophically over the course of geological periods, and since solar flares and associated phenomena can severely disrupt the natural Earth's magnetic field (and the Schumann resonance) on average on a few days per year, most animals generally appear to have two types of magnetic sensors: those based on cryptochrome and those based on magnetite, as well as various other (sensory) ways This new study in bats finds very similar findings to previous studies in migratory birds – this increases the likelihood that bats also use cryptochrome (but CRY2, not CRY4, which only have birds) for their magnetic compass, with several species known (tortoises, termites [2], also humans [3, 4]) that possess both a cryptochrome and magnetite It is worrying that the disturbance of the magnetic sense in migratory birds, and as here, bats, takes place even at very low field strengths – 1 nT, i.e. 0.3 V/m or about 240 µW/m2 for radio waves in the VHF band and long-wave low frequencies. It is also of concern that the disorder persists for several hours after EMF exposure. It would certainly be worthwhile to specifically examine the magnetic sense of bats and other mammals, since humans also belong to this animal group. (AT)

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