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Editorial

Is electromagnetic hypersensitivity entirely ascribable to nocebo effects?

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Electromagnetic fields (EMFs) are force fields composed of an electrical component and a magnetic component oriented perpendicularly to each other. The main sources of EMFs are high- and low-voltage power lines, home electrical wiring, motorized devices, microwave ovens, computer monitors, radio and television transmitters, and mobile phones. Electrical field intensity is usually measured in volts per meter (V/m) and magnetic field intensity (which decreases very rapidly as distance from the source increases) in microtesla (μT). Table 1 shows examples of field intensities. Electromagnetic waves have been shown to disrupt orientation in migrating robins [1]. Whether they also exert objective effects on other animals or on humans is therefore a legitimate question.

1. Scientific studies have found no adverse effects of usual magnetic fields

Although many studies have been conducted, none showed lasting adverse effects in mammals, including humans, of the exposure levels considered acceptable (100 μT for the public and 500 μT for workers) [1]. Using a mobile phone for a prolonged period produces a measurable increase in external auditory canal temperature, but the variation is less than 0.2 °C. Furthermore, the temperature decreases with intermittent as opposed to prolonged exposure. Far stronger magnetic fields are required to induce symptoms. In a double-blind randomized trial of 31 healthy volunteers, exposure to a 1 T static magnetic field (in front of a 7 T magnetic resonance imaging scanner) decreased attention by 5% and concentration by 21% during tasks requiring a strong contribution of working memory. A temporary impairment in orientation to time and place has also been reported (of 47% per T). Nevertheless, these transient adverse neurocognitive effects occurred only when the static magnetic field was combined with a magnetic field induced by head movements and equal to 2.4 T/s [2]. Magnetic fields encountered in everyday life are nearly always less than 100 μT in strength (Table 1).

2. Some people who perceive themselves as hypersensitive to electromagnetic fields may be chiefly hypersensitive to nocebo effects

Although the weakest magnetic fields shown to induce biological or cognitive effects are 25 (or even 50) times stronger than the magnetic fields encountered in everyday life, debate continues about possible pathogenic effects. This apparent paradox is ascribable to reports by some individuals of electromagnetic hypersensitivity (EMH), now known as idiopathic environmental intolerance attributed to EMFs (IEI-EMF) [3]. IEI-EMF manifests as the development within 24 h after exposure of a variety of symptoms such as headaches, dizziness, fatigue [4], and insomnia [5]. In a double-blind randomized study of 700 students in Iran, 28 (4%) reported IEI-EMF [6]. The results of sham versus real exposures suggested nocebo effects as the source of the symptoms. Two arguments support this possibility.

2.1. The symptoms are not reproduced reliably by real exposures in double-blind studies

Double-blind studies in adults and teenagers failed to demonstrate any link between the various symptoms reported by the participants and EMF exposure [4,7], even in individuals having self-perceived IEI-EMF. One such study compared 231 controls to 88 individuals with IEI-EMF who reported significant adverse effects on well-being during open-label exposure to EMFs [8]. No difference in symptoms was detected between exposure to EMFs from mobile phone base stations and sham exposure, in either group. Similarly, studies of objective measures such as heart rate or autonomic nervous system activity found no significant difference between sham and real exposures [3,6]. Another study focused on the use of a handheld TETRA transmitter emitting 385-Hz signals (a professional mobile digital radio system and two-way transceiver similar to a sophisticated walkie-talkie and specifically designed for public services and the military) [9]. Short-term exposures of 1.5 or 6.0 W/kg produced no significant adverse effects. Finally, potential effects of real EMF exposure simulating the use of a mobile phone for 3 consecutive hours before bedtime on 3 consecutive

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Table 1
Examples of intensities of electrical and magnetic fields.

Electrical fields	
Computer monitor	1 to 10 V/m
Home	Up to 20 V/m
1 m from a mobile phone base station	50 V/m
100 m from a 400,000 V line	40 V/m
A few meters from an FM transmitter	50 V/m
1 cm from a mobile phone antenna	90 V/m
Meadow during quiet weather conditions	100 to 200 V/m
Carpet (at 5 mm), without rubbing	200 V/m
Electrical train or tramway car	300 V/m
30 m from a 400,000 V line	1.2 kV/m
Under a from a 400,000 V line	4.5 kV/m
Carpet after rubbing	Up to 20 kV/m
Meadow during stormy weather conditions	Up to 100 kV/m
Magnetic fields	
1 m from household appliances	0.002 μT
Mobile phone antenna	0.3 μT
In a subway train	20 μT
Earth's magnetic field	30 μT
In an electrical train or tramway car	30 to 70 μT
Metal detector (airports)	50 to 100 μT
Under a high-voltage power line	Up to 200 μT

days were compared to those of sham exposure in 19 volunteers [10]. Sleep parameters including subjective sleep quality and EEG recordings showed no significant differences between the real and sham exposures.

2.2. Individuals with self-perceived IEI-EMF are usually unable to discriminate between real and sham EMF exposures

In a double-blind trial, 48 individuals with self-perceived IEI-EMF were unable to differentiate real and sham exposures and did not report more symptoms compared to 132 controls [11]. Similar findings were obtained in smaller studies of 37 [12], 52 [3], or 60 [13] participants. A comprehensive metaanalysis reported in 2010 included 46 studies with 1175 individuals reporting IEI-EMF [14]. The results showed that individuals with IEI-EMF were unable to detect EMF exposure.

3. The symptoms reported by individuals with IEI-EMF seem frequently ascribable to nocebo effects

The influence on sleep quality of a mobile phone base station was tested in a double-blind study of 397 residents of 10 villages in various parts of Germany [15]. Sleep parameters were recorded at home during five nights with sham exposure and five nights with real exposure. No differences in subjective or objective sleep quality were found between the sham and real exposures. Sleep quality was slightly lower in participants who were concerned about potential adverse health effects compared to other participants, but this difference was already present at baseline. These findings suggest that any impact on sleep may be related to a nocebo effect. Support for this possibility was provided by a metaanalysis showing a strong correlation between a belief in adverse effects of EMFs and subsequent reports of untoward symptoms, even in the placebo arms of double-blind trials [15].

Although nocebo effects are not the exact opposites of placebo effects, reports that EMFs can also induce benefits further support a role for nonspecific mechanisms in the impact of EMF exposure. Thus, in a randomized controlled trial performed in Italy in 110 patients with diabetic neuropathy, 10 sessions of EMF exposure induced small and transient decreases in pain intensity, although the primary endpoint (change in electromyographic parameters) was not achieved [16]. In addition, both real and sham EMF exposures were associated with a decrease in weight circumference in 28 obese patients [17]. These "benefits" are probably ascribable to a combination of placebo and Hawthorne effects and, as with studies of "adverse" effects, to the small sample sizes (in studies of knee osteoarthritis, depression, fibromyalgia, or immobility-induced bone loss) and imperfect blinding. Publication bias in favor of these positive results will probably be detected by higher-powered studies or metaanalyses with funnel plots to identify unpublished negative studies [18].

4. Nocebo effects are potentiated by actions by the media (and even some industrials) that support a belief in the adverse effects of EMFs

The nonexistence of supernatural phenomena (such as ghosts) cannot be demonstrated scientifically. On the other hand, an appealing strategy for the media is to increase their audience by focusing people's anxiety or resentment toward modern life on an environmental factor [19].

A random sample of 60 articles on EMF effects published in British newspapers was analyzed recently [20]. Among them, 72% encouraged the readers to believe in adverse EMF effects and 40% suggested possible remedial measures such as alternative therapies. Articles based on an interview of a patient reporting IEI-EMF were significantly more likely to report deleterious health effects of EMFs. Few articles contained information provided by a scientist. The ability of media warnings to induce belief in deleterious EMF effects was assessed by having 147 volunteers watch either a film on supposed adverse health effects of Wi-Fi or a control film [19]. The participants were then exposed to a sham Wi-Fi signal for 15 mins. Among them, 57% reported symptoms after the exposure, and this proportion was significantly higher in the group shown the health-warning film, in those with high preexisting anxiety, and in those who believed they had IEI-EMF. The pseudo-scientific messages delivered by industrials who sell products claimed to protect against EMFs probably also contribute to perpetuate the nocebo effects that are the true source of the symptoms experienced by these individuals.

5. Other industrials might throw out the baby with the bathwater

The possibility that a minority of individuals may experience idiosyncratic effects of EMFs, particularly of high intensity, cannot be completely ruled out. Some of the double-blind studies were funded by telecommunications companies, and some tested only low-intensity EMFs. Furthermore, mean values may fail to detect individuals who have true IEI-EMF if their numbers are very small compared to the population of individuals with personality traits that predispose to nocebo effects.

6. Some individuals may derive secondary benefits from claiming they have IEI-EMF

Individuals with self-perceived IEI-EMF have come together in "victims" groups, thereby further strengthening their beliefs. Some have gone as far as to live in caves to escape from the supposed adverse effects of EMFs. These extreme behaviors have probably cast discredit on the topic of EMF sensitivity. Attempting to restore premodern living conditions is unlikely to provide lasting symptom relief, since Earth itself induces a magnetic field of 30 μT (Table 1). Although sensitivity to EMFs is probably not the Legend of the Centuries, this escape from civilization might be akin to a phobic behavior that calls to mind the end of the poem *Conscience* by Victor Hugo:

"In the middle of a stone tower, they set him,
And he remained gloomy and worn. "Oh, my sire,

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Is the Eye gone?" asked Zillah, trembling.
But Cain replied: "No, it is still there."
Then added: "I will live beneath the earth,
As a solitary man in his sepulcher.
I will see nothing and will be seen of no one."
They dug a deep pit, until Cain said: "Tis enough,"
As he lowered himself alone into the tomb.
But when he sank, ghost-like, into his chair,
And they had sealed the dungeon over his head,
The Eye was in the tomb and staring at Cain."

Disclosure of interest

The author declares that he has no competing interest.

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