MIND

Could certain frequencies of electromagnetic waves or radiation interfere with brain function?

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Amir Raz, assistant professor of clinical neuroscience at Columbia University, offers the following answer.

Definitely. Radiation is energy and research findings provide at least some information concerning how specific types may influence biological tissue, including that of the brain. In some cases the effect may be therapeutic. For example, transcranial magnetic stimulation (TMS) is a technique used to induce a short-term interruption of normal activity in a relatively restricted area of the brain by rapidly changing a strong magnetic field near the area of interest. Mark George provided a nice account of TMS in the September 2003 issue of *Scientific American*. In it he described how head-mounted wire coils can deliver powerful yet evanescent magnetic pulses directly into focal brain regions to painlessly modulate neural activity by inducing minute electric currents. Clinically, TMS may be helpful in alleviating certain symptoms, including those of depression.

Researchers typically differentiate between the effects of ionizing radiation (such as far-ultraviolet, X-ray and gamma ray) and nonionizing radiation (including visible light, microwave and radio). The ionizing variety may be undesirable because it can cause DNA damage and mutations, thus we should all limit our exposure to its sources--radioactive materials and solar radiation among them. However, given modern technology, nonionizing radiation from power lines, personal wireless devices, cell phone towers and other sources is practically unavoidable. Extremely low frequency electromagnetic fields (EMF) surround home appliances as well as high-voltage electrical transmission lines and transformers.

Evidence of health effects from EMF, including their influence on the brain, is inconclusive, and the probability that EMF exposure is a genuine health hazard is currently small. Nevertheless, exposure to high levels of nonionizing energy, such as at

radio wave frequencies, can damage the structure and function of the nervous system. For example, microwave frequencies below 3,000 megahertz can penetrate the outer layers of the skin, be absorbed in the underlying tissues, and result in all of the known biological effects of heating, including burns, cataracts, and possibly death. Indeed, government regulators set most exposure limits to ensure that the amount of tissue heated by the absorption of energy is not in excess of what the body can take.

It is possible that heating is not the only effect of radiation. Some scientists claim that human tissue, including the brain, may be affected nonthermally. Regrettably, many exposure parameters, such as frequency, orientation, modulation, power density and duration, make it difficult to directly compare experiments and draw specific conclusions at nonthermal levels. Also, it is important to remember that, perhaps expectedly, interpretations of findings in this area of investigation are shrouded in controversy, particularly because special interests may influence some of the research. The publication of findings does not necessarily scientifically validate a study.

At lower levels of exposure, evidence for specific effects that may occur as a result of direct neural interactions with radio frequency fields is sparse. In addition, many of the studies that claim provocative results have yet to be replicated by independent

laboratories. Other studies describe potential associations. For example, a recent report suggests that the low-intensity electromagnetic field of geomagnetic storms--disturbances in the earths magnetic field caused by gusts of solar wind--may have a subtle but measurable influence on suicide incidence in women.

In recent years, cell phones, which transmit and receive at radio frequencies, have become ubiquitous. Researchers have investigated whether these low-intensity radio waves influence the central nervous system and cognitive performance. A few studies concluded that cell phone exposure enhanced certain aspects of cognitive performance as measured by reaction time and accuracy; others showed no difference, and a few, including a very recent investigation, showed that such exposure had detrimental effects in specific contexts such as attention span. Replication of either the negative or positive effects of exposure on cognition is sorely lacking in the scientific literature and more work is required to verify and reconcile differences between studies reporting either contradictory or no effects.

Unfortunately, at least some of these studies fail to meet many of the criteria for good research, thus weakening their scientific value further. Therefore, more well-controlled studies are required to validate conclusions as to whether exposure to cell phones influences cognition, especially in the long term. Nevertheless, most of the reported effects are small as long as the radiation intensity is within the reasonable nonthermal range and its duration does not exceed common exposure for users.

In 2002 the U.K. published a brochure recommending that children and young people should use cell phones as little as possible. A year later Thailands interior minister considered a ban on their use by children. But in 2004 the Health Council of the Netherlands, unable to find convincing scientific data demonstrating a difference between children and adults in the absorption of electromagnetic energy, found no reason to recommend limiting child use.

I was unaware of solid scientific evidence to support such concerns, but given that my cell phone was one of my infant sons favorite toys, I let him play with it only after I made sure it had been switched off. A precautionary approach remains justifiable because detrimental effects cannot be ruled out completely. Now that my son has learned how to turn my phone back on, however, I remind myself that when these phones are used in public, the indirect health effects sustained by vexed passersby may well outweigh the direct neural disturbances on their users.

Still, a very recent report associates increased risk of malignant brain tumor with long-term cell phone use. This report does not represent a new study but is instead a combined analysis of two population-based case control studies published in 2003 and 2005. The findings from this report are difficult to interpret because the experimental design is notably different from that of previous studies of long-term cell phone use and brain cancer. For example, the exposure assessment was mostly performed using mailed questionnaires; multiple confounding factors were not addressed, and a single statistical adjustment corrected for the year of diagnosis only. In addition, a compelling mechanism of action is absent and it is unclear what physiological process could explain such a decisive correlation. Finally, the results are incongruent with most animal studies, which show no relationship between cell phone exposure and brain cancer.

Of course, cell phones are not the only form of radiation exposure, simply an example of popular technology. And, as with TMS, some exposures may actually be helpful in certain contexts. Magnetic resonance imaging (MRI) of the living brain uses an externally imposed magnetic field. Preliminary findings suggest that bipolar-disorder patients moods improve immediately after they undergo a specific MRI procedure. It is possible that this effect works in a way similar to that of TMS on symptoms of depression, but further investigation is warranted.