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Microwaves and Behavior

DON R. JUSTESEN

Laboratories of Experimental Neuropsychology, Veterans Administration Hospital, Kansas City, Missouri

Victor Frankenstein surgically fathered the famous fictional monster, but the fiend was conceptually mothered if not physically spawned by electricity in the form of lightning from the heavens. Perhaps unwittingly, perhaps intuitively, author Mary Shelley (1831) touched a deep truth in the maternal metaphor: Life did originate from electrical discharges into the primeval fog. Indeed, life continues to preserve in all of its earthly forms from the most primitive cell to the most complex organism an elemental dependence on electrical phenomena. Understandably, the curiosity of the scientist about the electrobiological goings-on of the earth's flora and fauna is shared by the layman. A large popular literature is accumulating and embraces experiments and anecdotes that range from the ostensibly respectable to the seemingly bizarre. Recently published texts by Tompkins and Bird (1973) and by Burr (1972, 1973) are not only exemplars of the literature but are rich sources of reference materials. One reads, for example, that plants have nervous systems that yield differing electrical signals on "stimulation" by ***kind*** or ***malevolent thoughts*** of human beings (Backster, 1968). One also reads that many Soviet scientists are giving credence and careful study to ESP and related phenomena, not in defiance of Marxian dictates of materialism but quite in keeping with them. The Soviets are championing earlier theoretical notions of Georges Lakhovsky (1934) to the effect that each plant or animal cell is an oscillatory system capable of transmitting and receiving high-frequency electromagnetic energy over a distance. While affirming that electrical events are intin[illegible] yet [illegible] hum[illegible] billi[illegible] its c[illegible]

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Requests for reprints should be sent to Don R. Justesen, Laboratories of Experimental Neuropsychology, Veterans Administration Hospital, Kansas City, Missouri 64128. The author is also at the Department of Psychiatry, Kansas University Medical Center, Kansas City, Kansas 66103.

University Medical Center, Kansas City, Kansas 66103.

water, for example, in carbon-impregnated plastic and in crumpled sheets of aluminum foil. Even subjects who cannot hear microwaves when directly radiated by them can readily perceive clicking sounds when a piece of energy-absorbing material is interposed between the head and a radiator of pulsed microwave energy. Oddly enough, the mass of the interposed material does not seem to be too critical; I successively used smaller and smaller pieces of material as sonic transducers until it was necessary to impale tiny pieces on a toothpick, yet the clicking sounds induced in the material by microwave pulses were clearly audible to me.

The demonstration of sonic transduction of microwave energy by materials lacking in water lessens the likelihood that a thermohydraulic principle is operating in human perception of the energy. Nonetheless, some form of thermoacoustic transduction probably underlies perception. If so, it is clear that simple heating as such is not a sufficient basis for the Frey effect; the requirement for pulsing of radiations appears to implicate a thermodynamic principle. Frey and Messenger (1973) demonstrated and Guy, Chou, Lin, and Christensen (1975) confirmed that a microwave pulse with a slow rise time is ineffective in producing an auditory response; only if the rise time is short, resulting in effect in a square wave with respect to the leading edge of the envelope of radiated radio-frequency energy, does the auditory response occur. Thus, the rate of change (the first derivative) of the wave form of the pulse is a critical factor in perception. Given a thermodynamic interpretation, it would follow that information can be encoded in the energy and "communicated" to the "listener." Communication has in fact been demonstrated. A. Guy (Note 1), a skilled telegrapher, arranged for his father, a retired railroad telegrapher, to operate a key, each closure and opening of which resulted in radiation of a pulse of microwave energy. By directing the radiations at his own head, complex messages via the Continental Morse Code were readily received by Guy. Sharp and Grove (Note 2) found that appropriate modulation of microwave energy can result in direct "wireless" and "receiverless" communication of speech. They recorded by voice on tape each of the single-syllable words for digits between 1 and 10. The electrical sine-wave analogs of each word were then processed so that each time a sine wave crossed zero reference in the negative direction, a brief pulse of microwave energy was triggered. By radiating themselves with these "voice-modulated" microwaves, Sharp and Grove were readily able to hear, identify, and distinguish among the 9 words. The sounds heard were not unlike those emitted by persons with artificial larynxes. Communication of more complex words and of sentences was not attempted because the averaged densities of energy required to transmit longer messages would approach the current 10 mW/cm^2 limit of safe exposure. The capability of communicating directly with a human being by "receiverless radio" has obvious potentialities both within and without the clinic. But the hotly debated and unresolved question of how much microwave radiation a human being can safely be exposed to will probably forestall applications within the near future.

The U.S. limit of 10 mW/cm^2 is actually an order of magnitude below the density that many investigators believe to be near the threshold for thermal hazards (Schwan, 1970). There are two camps of investigators in the United States, however, who believe that the limit is not sufficiently stringent. In the first camp of conservatives are those who accept the Soviet's belief that there are hazardous effects unrelated to heating from chronic exposures to fields of low density (< 1 mW/cm^2); some agree with Milton Zaret (1974), a New York ophthalmologist, who holds that severely debilitating subcapsular lesions of the eyes may develop years, even decades, after exposure to weak microwave fields. Others tend to reject the notion that weak microwave fields produce this anomalous cataract, because of lack of substantiating evidence from the clinic or the laboratory (Appleton & Hirsch, 1975). But these conservatives are possessed of a vague unease simply because the Soviet's limit of continuous permissible exposure is three orders of magnitude below that of the United States.[3]

The other camp of conservatives tends to reject the possibility of hazardous nonthermal effects,

[3] The Soviet's exposure limit of 10 $\mu W/cm^2$ is three orders of magnitude below the exposure limit in the United States, but a different, that is, *emission*, limit holds for microwave ovens purchased for use in the American kitchen. In the United States at the present time, a newly purchased microwave oven may not emit radiation at a density greater than 5 mW/cm^2 as measured at a distance of 5 cm from the oven's surface. A user who stands 1 m from an oven that emits energy at the maximum permissible quantity would probably be exposed to a density of only a few microwatts per square centimeter—this is because electromagnetic energy when radiated from a point source attenuates markedly as it propagates through space.