

Report SAM-TR-75-28

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EFFECT OF 19 MHz RF RADIATION ON NEUROTRANSMITTERS IN MOUSE BRAIN

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Interim Report for Period November 1974 - February 1975

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
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NOTICES

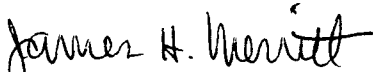
This interim report was submitted by personnel of the Radiation Physics Branch, Radiobiology Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7757-01-48.

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The animals involved in this study were procured, maintained, and used in accordance with the Animal Welfare Act of 1970 and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources - National Research Council.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

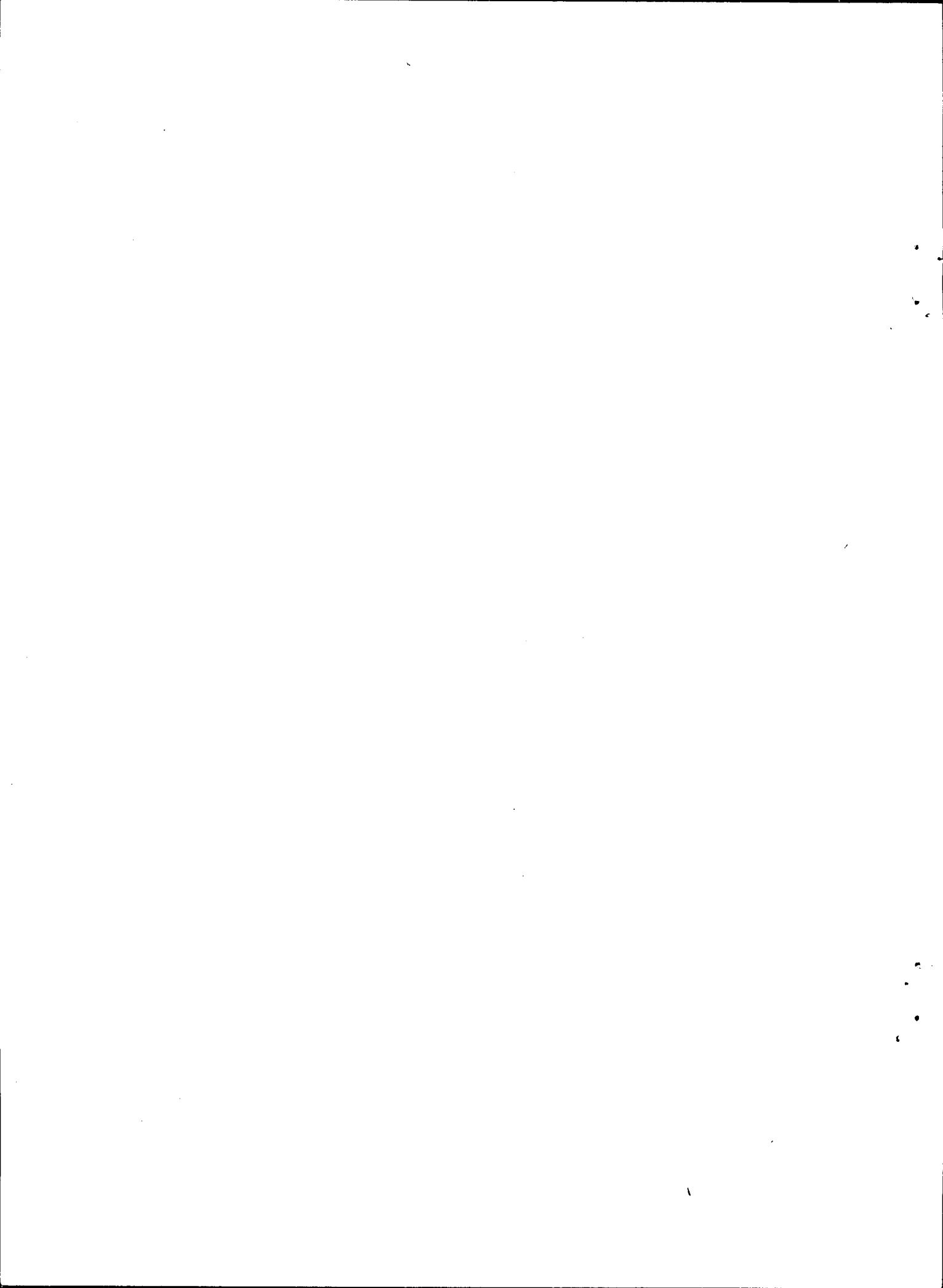
This technical report has been reviewed and is approved for publication.


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Mice were exposed to 19 MHz radiofrequency radiation and then euthanized by microwave-heating brain inactivation. Brain levels of 5-hydroxyindole acetic acid (5HIAA), homovanillic acid (HVA), serotonin (5HT), norepinephrine (NE), and dopamine (DA) were not altered by this radiation. Brain concentration of 5HIAA, 5 HT, NE, and DA was higher when control animals were euthanized by microwave inactivation than by cervical dislocation.		



EFFECT OF 19 MHZ RF RADIATION ON NEUROTRANSMITTERS IN MOUSE BRAIN

INTRODUCTION

Electromagnetic radiation safety standards for Air Force personnel must be based on the biological consequences of exposure to radiofrequency (RF) radiation environments. In order to do this, knowledge of the radiation insult must be developed. Much literature from Eastern European countries has implicated RF radiation in central nervous system (CNS) changes; for example, RF radiation has been reported to activate hypothalamic neurosecretion (8).

Since CNS neurotransmission is mediated by small molecules, electromagnetic perturbations of the vibrational modes of these molecular species could possibly alter nerve transmission. Furthermore, since brain levels of the putative neurotransmitter substances are in homeostatic balance regulated by feedback mechanisms, the CNS content of these substances may also be altered by such perturbations in their molecular vibrational modes.

This study was undertaken to determine if high-frequency (19 MHz) radiation alters the whole brain level of serotonin or its metabolite, 5-hydroxyindole acetic acid; dopamine or its metabolite, homovanillic acid; and/or norepinephrine in the mouse.

METHODS AND MATERIALS

Male Swiss Webster mice, 25-30 g, were exposed in the near-field synthesizer, a simulator which can generate nearly pure E- and H-fields at frequencies from 10 to 30 MHz (1). The H-field (magnetic) is generated in a multiple feed ring, and the E-field (electric) is generated by capacitor plates. The exposure frequency was 19 MHz; and the electromagnetic fields were measured with dipole and loop antenna probes calibrated by National Bureau of Standards to measure E- and H-field components respectively (2). With an input power of 400 watts, the E-field was measured at 6000 volts/meter, and associated with this E-field was an H-field of 6.4 amps/meter. The H-field was measured at 41 amps/meter, and the associated E-field was 2000 volts/meter. The animals were confined in adequately ventilated 8 x 20 cm plastic cages, which were placed inside the ring of the simulator so that the long axes of the mice were perpendicular to the E-field. With separate groups in the H-field only and the E-field only, the mice were irradiated for 10 minutes. The amount of

incident radiation did not produce a rise in their rectal temperature as measured by a thermistor probe. Control animals were placed in cages and the cages placed inside the ring with the power off.

Fifteen minutes after irradiation, the animals were euthanized by inactivation of brain enzymes in a Raytheon industrial microwave oven modified with a waveguide. The system consists of a shorted line with a 5.08-cm hole cut one wavelength from the shorted stub so that the animal's head is extended across the waveguide and parallel to the maximum electric field. The unit operates at 2450 MHz driven by a 5 kW magnetron. Absorption tests show that the animal's head absorbs about 60% of the forward power, which produces a 40°-50° C temperature increase in the brain tissue in 1 second. Controls were euthanized in the same manner 15 minutes after removal from the cages. Also, a group of control animals was conventionally euthanized by cervical dislocation to compare this with the rapid inactivation method. The brains were quickly removed and immediately frozen in liquid nitrogen. The frozen brains were homogenized in cold acidified (10 mM HCl) butanol, and assayed for 5-hydroxyindole acetic acid, homovanillic acid, norepinephrine, serotonin, and dopamine by a modification of Haubrich and Denzer's method (4). The modification involves using ninhydrin to produce a serotonin fluorophore instead of o-phthaldehyde.

RESULTS AND DISCUSSION

The results of exposure of mice to 19 MHz radiation are shown in Table 1. There were no significant differences in any of the neurotransmitters or metabolites when microwave controls were compared to either the E- or H-field groups. When compared to the conventional controls, however, the microwave controls had significantly higher ($P < .02$ at least) brain content of 5-hydroxyindole acetic acid, serotonin, norepinephrine, and dopamine. This difference may represent a pool of neurotransmitters with a very rapid turnover (5).

Variable effects of RF radiation on neurotransmitters were reported for rats by Stavinoha et al. (6). They showed that there was no effect of RF radiation on whole brain serotonin or serotonin turnover in discrete brain areas of irradiated rats. The brain areas examined were cerebellum, cortex, medulla, thalamus, hippocampus, midbrain, and corpus striatum. In addition, in these brain areas, the uptake of intraventricularly administered ^3H -norepinephrine and ^3H -epinephrine was examined. Differences observed were decreases in uptake of ^3H -epinephrine in the midbrain and of ^3H -norepinephrine in the cerebellum of the irradiated rats. No differences were seen in any other of the brain areas of the irradiated animals

TABLE 1. EFFECT OF E- AND H-FIELD RF RADIATION ON NEUROCHEMICALS

	<u>5HIAA</u>	<u>HVA</u>	<u>5HT</u>	<u>NE</u>	<u>DA</u>
Microwave control	742 ± 121 (13)	184 ± 62 (13)	774 ± 50 (12)	468 ± 88 (14)	1355 ± 287 (12)
Conventional control	621 ± 75 (8)	184 ± 62 (8)	582 ± 86 (10)	367 ± 38 (10)	1025 ± 108 (10)
H-field	752 ± 62 (13)	182 ± 44 (13)	770 ± 79 (12)	533 ± 123 (12)	1487 ± 374 (12)
E-field	780 ± 113 (5)	172 ± 61 (5)	745 ± 132 (5)	402 ± 167 (5)	1318 ± 362 (5)

Note: The values for 5-hydroxyindole acetic acid (5HIAA) homovanillic acid (HVA), serotonin (5HT), norepinephrine (NE), and dopamine (DA) are given in ng/g brain ± SD. Numbers in parentheses are number of determinations. Microwave controls were euthanized by microwave-heating inactivation of brain enzymes; conventional controls, by cervical dislocation.

compared to the controls. These data indicate that RF radiation under such experimental conditions apparently does not result in major disturbances of the uptake mechanisms of catecholamines in the brain. Recently, Stavinoha and Medina (7) reported that no change in the norepinephrine or serotonin content of discrete brain areas occurred after irradiation at 19 MHz; however, they did show an increase in ³H-norepinephrine in the cerebellum and thalamus of rats irradiated in the near-field synthesizer.

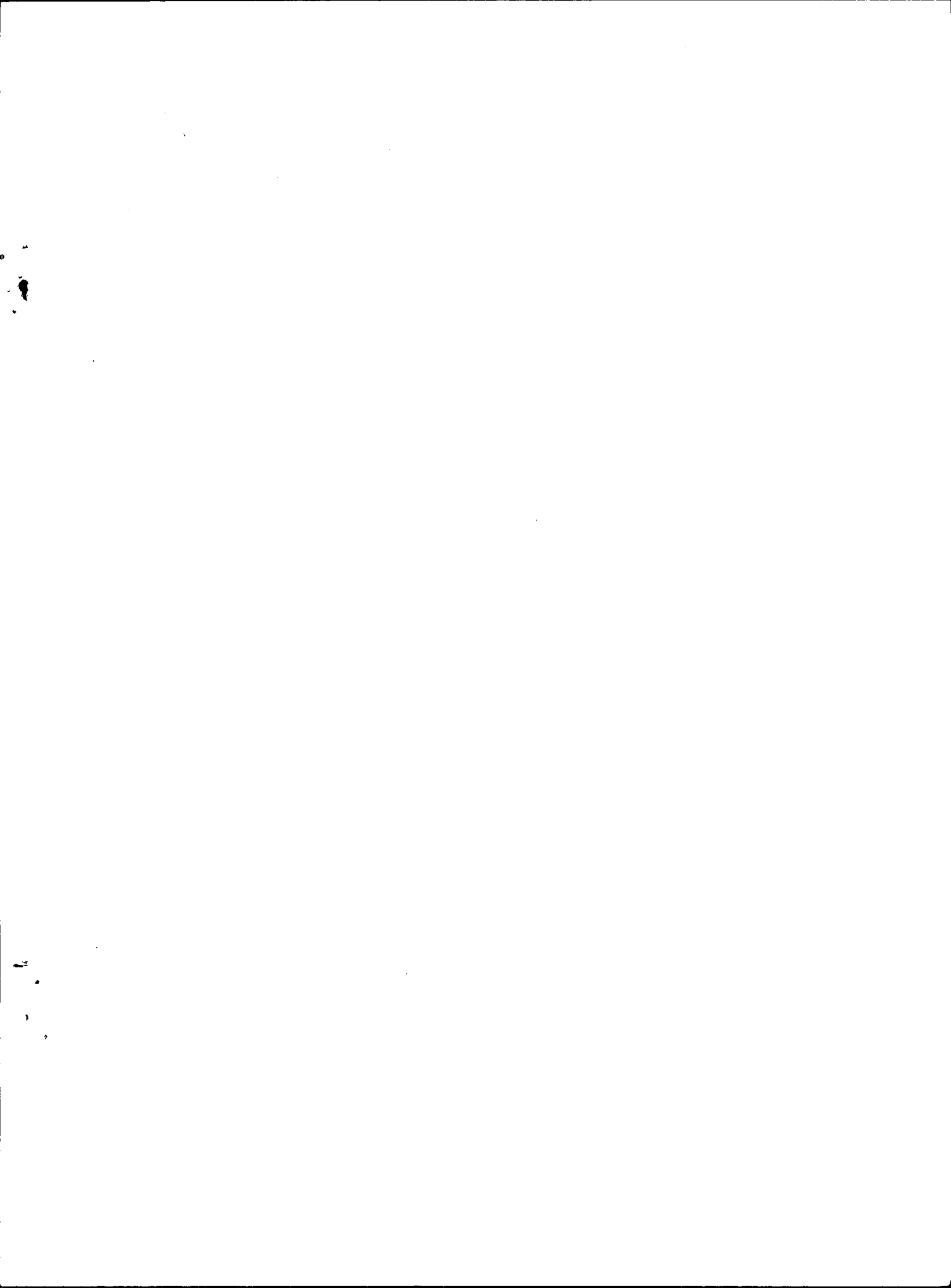
Guy et al. (3) predicted power absorption in models of a variety of organisms, including mice. At or below 30 MHz, power absorption was shown to vary as the square of the frequency, and thus to be dependent on the size of the absorbing object. Power absorption then can be reasonably extrapolated to man from animal data. For a mouse exposure, approximately 30-40 times more incident power density is required at 19 MHz than for an equivalent human exposure. Since the mouse represents a much smaller aperture than a rat, differences are to be expected between the two regarding power absorption and bioeffects of RF radiation at the same power. In our study with mice, no increase in core temperature was noted; while in the investigations with rats reported

by Stavinoha and Medina (7), an increase of 1° C was noted. This difference in power absorption could also explain the differences in the neurochemical alterations seen in the two species.

From the data reported here, and assuming that power absorption can be extrapolated from mouse to man, we feel reasonably safe in concluding that an equivalent exposure in man would not result in alterations of neurotransmitters in the human nervous system.

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