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Paper: Fetal radiofrequency radiation exposure from 800-1900 MHz-rated cellular telephones affects neurodevelopment and behavior in mice.

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Introduction: There are a number of studies describing the effects of prenatal exposure of rodents and other animals to radiofrequency (RF) fields. Overall, these studies indicate that exposures to RF fields do not cause any consistent effect on behaviour of offspring in the absence of maternal hyperthermia. In an extensive study, Bornhausen and Scheingraber (2000) reported that continuous exposure of rats to low level GSM 900 MHz cellular phone signals during pregnancy had no effect on a the performance of various behavioural tasks by offspring at 3 months of age.

Few studies have examined whether cellular phone use may affect the development of children. An epidemiology study (Divan et al, 2008) reported that prenatal and postnatal use of cellular phones by mothers in Denmark is associated emotional and hyperactivity problems around the age of school entry. However, a follow-up study (Divan et al, 2011) found no evidence of an association between prenatal cell phone use and developmental delays among infants at 6 and 18 months of age.

Aldad et al investigated the effects of *in utero* RF field exposure from cellular phones. The performance of three behavioural tasks examining memory, anxiety and activity were investigated in young adult mice.

Methods: The exposure system used in this study was very simple. An ordinary cellular phone was suspended over each of the animal cages such that the animals were between 4.5 cm and 22.3 cm from the phone, depending on their location within their cage. The phone was called from a landline in order to ensure that it was radiating RF signals. Control exposure was achieved using a phone that was deactivated. The animals were exposed for 24 h per day for 17 days (behavioural tests) and 9, 15 or 24 h per day for 17 days (electrophysiology). Three female mice were exposed concurrently in each cage; a male was introduced into each cage at the beginning of the experiment, but it is not stated when these were removed.

The behaviour of the offspring was examined using three behavioural tasks. Memory was examined using an object recognition task that utilises a rodent's preference to explore previously unseen (novel) objects. Animals were allowed to explore two identical objects for 15 min per day for two days. On the third day, one of these objects was replaced with a new object and the exploration of these objects for 2 min was analysed. Memory was assessed using the ratio of the time of exploration of the new object over the combined time of exploration of both objects, multiplied by 100 (called the preference index). These tests were performed when the animals were 8, 12 or 16 weeks old

Activity and anxiety were investigated using a box with both an illuminated compartment and a dark compartment. The number of crossings between the compartments was measured to analyse activity, and anxiety by measuring the time spent in each compartment. These tests were performed when the animals were 12, 15 or 18 weeks old

Fear was assessed using a step-down test. This is the time it takes an animal to get down from a small raised platform where increased fear is associated with a longer time to step-down. These tests were performed when the animals were 12 or 40 weeks old.

Results: In the memory task, the preference index of the exposed animals was less than that of the controls on each day tested, but no statistical analysis of these individual data is reported. In the activity and anxiety task, the mean number of crossings between compartments was increased at each time point (mice at 12, 15 and 18 weeks of age) for the exposed group compared to the control group. These differences were said to be significant but no statistics were provided. The mean times the exposed group of animals spent in the dark compartment were less than the control group for all time periods but no statistics on these data are presented. However, the exposed animals spent a cumulative mean time of 207s in the dark compared to a mean of 234s for the control group; this difference was statistically significant, suggesting that exposure resulted in decreased anxiety.

In the step down task, there were no differences between treatment groups at either time point in mean times on the platform. Again, only a statistical analysis of the cumulative mean times was performed; these were not statistically different at either 12 or 40 weeks. This suggested that exposure did not affect fearfulness.

Discussion:

Using cellular phones as an exposure system is quite inappropriate for animal experiments, as the exposures cannot be controlled or described with any certainty. The extent of the dosimetry is that the active phone is described as having a specific energy absorption rate (SAR) level of 1.6 W/kg,

but this is the phone's rating when running at full power, as measured using a phantom human head in the tissues closest to the device. Without active power control the phone's emissions would not have been stable or predictable, and could be at a level very much less than those that would give rise to a SAR of 1.6 W/kg even if the phone were against the head. The paper also mentions that an additional six females were exposed to an active phone for either 9 or 15 hours per day. However, it is clear that if the phone had been running at full power for these lengths of time then the battery would have run out of power. This suggests a charger should have powered the phones; but this is not discussed in the paper.

At 4.5–22.3 cm, the SAR in a human head would be very small indeed: at the upper end of the distance range it would be a few mW/kg at most, and could be at μW/kg levels when the lack of power control of the phone is taken into account. Furthermore, the RF absorption cross section of a mouse is quite different from that of a human head; mice are very small compared to the wavelengths in the frequency range 900 – 1900 MHz and even with their bodies aligned so the maximum RF signal is absorbed, it will be a much weaker RF absorber than a human head.

Having more than one free-moving animal in the cage during exposure further complicates the determination of the dose each mouse receives, as the activity and behaviour of the animals will influence the absorbed power experienced by each. Taken together, the lack of power control, the distance between source and animals and the small absorption cross section of mice suggest that exposure levels of the exposed animals may not be significantly different from the exposures encountered by the control animals.

There is no description in the paper for control of noise, heat, magnetic field or vibration. While magnetic field and heat at the distance the exposure took place are unlikely to be significant, noise from the battery and power circuitry rather than the phone's loudspeaker, which had been silenced, may be. The authors do not describe what type of phone (3G, GSM, CDMA) was used in the study but any of these may be a source of noise audible to a mouse, with GSM arguably being the most audible to a human.

No attempt was made to standardise litter size, or to equate the sex ratio of the litters, which is common practise in teratological studies. It also appears that both male and female offspring were used, and no attempt was made to separate the results by sex. The tests applied to the animals seem appropriate and both the exposed and control animals were treated the same. However, it is not clear how many animals were used in each of the behavioural experiments, only total numbers are given for each complete test. After estimating numbers of offspring likely to be produced by about 40 pregnant female mice, some reuse of animals seems likely, so that not all animals would have been naïve during the subsequent tests. This could have affected the results.

No explanation is provided as why the particular age at testing was chosen and why the electrophysiology was performed on much younger animals than those used in the behavioural tests. The lack of statistical tests between treatments at specific ages in the behavioural tests is also of significant concern.

All the above suggests another factor in the environment may have had an influence on the behaviour of exposed animals, although it is not possible to identify what this may have been. The study did not have the correct double-blinding technique commonly used in high quality animal studies. Even though the observers for the behavioural tests were unaware of whether the animals were exposed or not, the animal handlers knew which were exposed, allowing the possibility of unconscious differences in how animals from each group were treated. A suitable exposure system should have operated such that none of the researchers knew the exposure status of the animals; with a coding regime that was only broken after the results of individual tests had been obtained.

Conclusions:

The study reports that prenatal exposure to the RF fields from a cellular phone has long lasting detrimental effects on the development of mice, with repeatable and consistent changes observed in behaviour and in electrophysiology. Further, changes in electrophysiology were seen that depended on the number of hours the animals were exposed each day.

However, the simple exposure system in this study consisted of cellular phones, and the RF fields from these phones were at an unstable and unknown level. The quoted SAR of 1.6 W/kg is a value that would be measured in a phantom human head in contact with the phone. The lack of power control, the distance of the animals from the phone and the low absorption of mice in the frequency range 900-1900 MHz together suggest that there may have been no significant difference in exposure between some or all of the exposed and control animals. Having many animals in each cage further complicates assessment of the actual exposures.

In summary, it seems implausible that the RF exposures from cell phones could have caused the effects reported.