# Influence of electromagnetic fields of mobile radio systems TETRA, GSM and UMTS on the behaviour of humans in different demand situations

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## Background and motivation

Current high frequency radiation exposure limit values are based on well-established thermal effects. As the use of mobile phones involves an extreme near-field exposure of the user's head there are still concerns about an influence of high-frequency electromagnetic fields electromagnetic fields (EMF) on the central nervous system affecting mental performance. Several single studies were already conducted to investigate this issue. Our studies should help to tackle the lack of comparable single studies conducted so far.

## Aim of the investigations

The aim of this project was to assess a potential health risk related to the use of the mobile radio systems TETRA, GSM or UMTS. Hence, comparable studies with human male volunteers were conducted in a shielded laboratory to find possible differences related to the properties of frequency ranges of the three systems. Standards TETRA, GSM and UMTS use frequencies in of 400, 900 and 2000 MHz, respectively. The following facts have to be considered: higher penetration of the energy of TETRA fields compared to GSM and UMTS exposure, different frame repetition rates of TETRA and GSM signals respectively no frame repletion rate of the UMTS signal.

To allow for comparison the subjects had to work on the same computer-based tasks during the exposure to of one of these systems. Five studies were carried out using generic antennas and/or with modified commercial handsets of TETRA, GSM and UMTS communication systems. In order to compare the results of the studies they were conducted in the same Faraday room, identical tasks were fulfilled by the volunteers and the same procedures were kept in all experiments.

## Material and methods

For preliminary aptitude experiments about 60 male healthy volunteers aged between 20 to 30 years were acquired for each study. All subjects had to be of generally good mental disposition and were not allowed to have any extreme psychological characteristics. These requirements presupposed a monitoring of stress and psychological rating methods. Each volunteer completed preliminary investigations of reaction behavior and performance level prior to the main experiments in order to select a homogeneous sample with at least 24 persons for each of the five studies. The reason was to ensure a homogeneous sample as a very important pre-condition for precise statistical results especially for possibly very small effects.




Fig. 1 Volunteers with similar helmets, handsets of GSM and TETRA or antennas of UMTS mobile system

All studies were performed under the same conditions In a (3 x 4)-m Faraday room to have the possibility of checking the results of one mobile system against the results of the other systems.

Data were collected from groups of 24 or 36 volunteers, age between 20 to 30 years. The test persons were exposed to the field of generic antennas or to TETRA, GSM or UMTS handsets fitted on the right and the left side of the head at a helmet in "intended use position", see fig 1.

Tab. 1 shows the investigated signals, transmission powers and measured values of the specific absorption rate (SAR).

For the commercially used transmission powers all SAR values were found to be below the exposure limit values (head) recommended by ICNIRP for occupational exposure (10 W/kg) and for general public (2 W/kg). The measured SAR values of the second GSM study were found to be above the general public limits because of the high transmitting power (5.8 W) used in this study, however the values were below those for occupational exposure.

Each experiment started with a 20 minutes medical check-up and a questionnaire about health and well-being.

In double-blind-tests the reaction behavior of the volunteers has been analysed while the antenna or the handset was either switched on or off (sham exposure).

According to a balanced experimental design the subjects had to solve different visual demands for three periods of 30 minutes (each right, lift side and non-field exposure). These demands (computer-based cognitive tasks) were aimed at different cognitive performances. The first test period was used as an exercise and has not been evaluated. Using the Vienna Test System the volunteers had to absolve a vigilance test (duration 10 minutes), a signal detection test (7.5 minutes) and a reaction test (duration 1.5 minutes). These tests of performance were followed by a test without any performance, a 10 minute "autokinetic illusion" test in order to investigate possible effects in a rest situation (see. fig. 3).

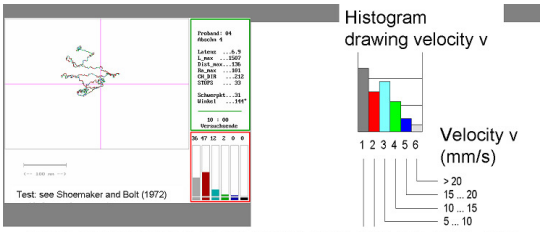


Fig. 3 Example of a pattern of TETRA 25 experiments. Measured parameters: latency period (s), overall length in the track (mm), max. span of the track (mm), max. distance from starting point (mm), number of changes of direction, number of stops, speed of drawing (mm/s)

We wanted to investigate aspects of psychological basic activity because it could be possible that very small effects of the high frequency fields are superposed by the efforts of the volunteers necessary to fulfil the cognitive tests. If we would find significant effects when the subject is in a situation without a demand of performance then it would be necessary to perform further research at this special field.

We carried out a survey about subjective parameters and possible perception of the TETRA, GSM or UMTS field after each test period. The total time of each single experiment was three hours, with little breaks between the tasks.

| Mobile radio system | Test Frequency (MHz) | Special technical characteristics of the test signal | Transmitting Power (W) | Measured SAR maximum values head phantom W/kg |
|---|---|---|---|---|
| TETRA 25 | Study 1: 380<br>Study2: 380.25 | Frame repetition rate<br>Study 1: 17 Hz<br>Study 2: 17.65 Hz | 2 | 1,35 W/kg (1 g)<br>0,83 W/kg (10 g) |
| GSM | 916.2 | Frame repetition rate<br>217 Hz | Study 1: 2.8<br>Study 2: 5.8 | Study 1:<br>1,42 W/kg (1 g)<br>0,88 W/kg (10 g)<br>Study 2:<br>6,95 W/kg (1 g)<br>4,25 W/kg (10 g) |
| UMTS | 1966 | No frame repetition rate (the signal is like a noise) | 1 | 2.46 W/kg (1 g)<br>1.42 W/kg (10 g) |

Tab. 1 Investigated signals, transmission powers and measured values of the specific absorption rate (SAR) of the TETRA, GSM and UMTS generic antennas or handsets

Before starting the experiments the SAR for the used maximum transmission power was measured with a head phantom to guarantee the safety and the health of the participants of the studies (example see fig. 2).

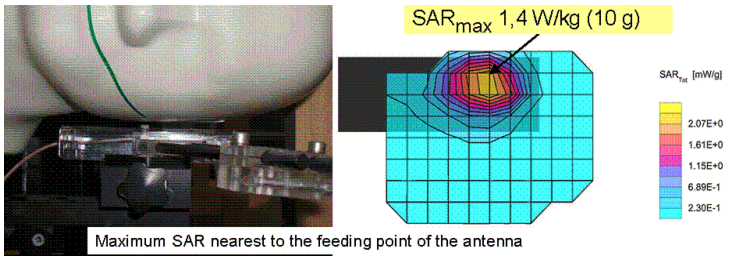


Fig. 2 Example of measurement specific absorption rate (SAR), generic UMTS antenna in intended use position (here left side of head), frequency 1966 MHz, RF-power fed 1 W

## Statistical analysis of data

Both time and exposure effects on the dispersion about the mean of the sample have been evaluated by analysis of multifactorial variance using the statistical systems SPSS and SYSTAT with regard to the response time values, the errors and the parameters of the "autokinetic illusion". The results of the second study of GSM and TETRA investigations verified the results of the corresponding first investigation.

The total analysis revealed no statistically significant differences between field exposures and sham conditions ($p < 0.05$).

## Results and conclusion

We did not find any health relevant field influence with respect to each of the investigated parameters of the TETRA, GSM and UMTS fields. None of the variances of the average values between the different exposure conditions showed significant effects. The switching on and off of the electromagnetic fields of the different mobile radio systems was not perceived by the volunteers. The questionnaires related to the subjective well-being at the end of the experiments revealed that changes of the well-being were not correlated with the particular mode of exposure but were explained with the high cognitive requirements in performing the tasks,

Our analysis did not show any influence on the visual information processing or the subjective experience in a special rest situation as a result of the exposure to an electromagnetic field of TETRA, GSM or UMTS handset.

Thus, the coupled studies with homogenous groups of volunteers showed no significant harmful effects on cognitive processes and the subjective experience due to a short exposure to electromagnetic fields of the mobile radio systems TETRA, GSM and UMTS. The investigations shall contribute to the prevention of concerns and associated psychological discomfort and, consequently, to the safe and reliable use of handsets.

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