



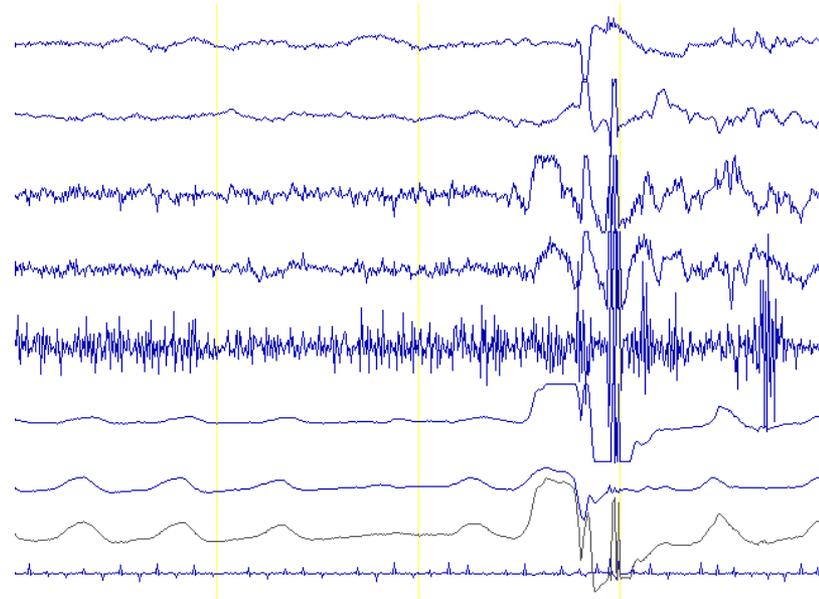
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Current assessment of the human volunteer laboratory studies

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EEG recording electrodes and spectra



EEG (Electroencephalogram)

- Records collective activity of cortical neurons (amplitudes in microvolts)
- Produces important data for studying sleep pattern, arousal, epilepsy etc
- Frequency bands:
 - delta (1.5 - 4 Hz)
 - theta (4 - 7 Hz)
 - alpha (8 - 12 Hz)
 - beta (13 - 35 Hz)

Resting EEG and well-being

- Kleinlogel et al., 2008
 - 15 healthy male subjects, mean age 26.6 +/- 4.6 years
 - GSM 900 MHz and UMTS 1950 MHz exposure
 - Exposure of the subjects' head:
 - 0.1 W/kg (UMTS weak)
 - 1 W/kg (GSM and UMTS high)
 - Test methods
 - vigilance controlled resting EEG
 - subjectively felt somatic and general discomfort
 - Results
 - no effects on resting EEG or well-being by 30 min exposure
 - no evidence for deleterious effects on normal healthy mobile phone users

Effects of Weak Mobile Phone Electromagnetic Fields (GSM, UMTS) on Well-Being and Resting EEG by Kleinlogel H et al, BEMSJ Sept 2008

Sleep disturbances

- Huber et al. 2002
 - 16 men (20-25 y)
 - 30 min exposure (900 MHz, SAR 1 W/kg)
 - PET scans after 30 min head exposure
 - Night-time sleep recorded after exposure
 - Findings:
 - alterations in regional cerebral blood flow during waking
 - pulse modulation necessary to induce EEG changes
- Huber et al. 2003
 - Extended analysis of previous studies:
 - RF fields have an effect on the sleep EEG
 - no consistent effect on the waking EEG

Common cognitive performance tests

Test	Task	Description
Working memory	visual/spatial working memory; short term recall; immediate word and picture recognition	testing ability of keeping information “in mind” in short-term period (minutes) and identify or relay back that information
Long-term memory	long-term recall; delayed word/picture recognition	requires generation of learned information at >10 min onwards
Attention/ working memory	forward and backward digit/spatial span; time estimation; visual and auditory discrimination; auditory-verbal learning	need of subject to concentrate on task and also need to keep information “in mind” simultaneously
Attention/ reaction speed	simple/choice/10 choice reaction time; trail making test; flexibility task;	requires concentration on target stimulus with emphasis on reaction speed to the target
Executive function	verbal fluency; serial subtraction	requires spontaneous generation of words or solutions to calculations

Reaction time and well-being

- Zwamborn et al. 2003
 - Whole body exposure to GSM and UMTS signals
 - Subjects
 - persons with complaints linked to RF signals
 - control group without symptoms
 - Methods
 - 4 cognitive function tests, questionnaire
 - Results
 - significant increase in reaction times (slower)
 - effects on subjective well-being linked with UMTS signal, not with GSM

Working memory

- Croft et al. 2008
 - Testing of working memory in different age-groups
 - Mobile phone 2G, 3G exposure, and sham conditions
 - 3 groups studied:
 - 38 children (13-15 y)
 - 42 young adults (19-40 y)
 - 20 elderly (55-70 y)
 - Results
 - no effect of MP exposure observed in adults
 - no effect of MP exposure found for reaction time in any group
 - reduced accuracy was found in children during the 3G exposure (no effect during 2G exposure)
 - Requires replication before it can be concluded whether the finding is real or chance

Do 2G and 3G Mobile Phone Exposures Affect Working Memory in Children, Adults and Elderly? by Croft RJ, et al, Proceedings of URSI 08

Cardiovascular tests

- Braune et al. 1998
 - Subjects: 7 male and 3 female volunteers
 - GSM 900 MHz exposure
 - Test methods:
 - 35 min exposure, 5 times on different days
 - blood pressure, heart rate, capillary perfusion, subjective well-being
 - Results:
 - resting blood pressure increased during exposure

Cardiovascular replication study

- Braune et al. 2002
 - Replication study with 40 subjects
 - GSM-like signal, 900 MHz, 2W
 - Results:
 - systolic and diastolic BP increased
 - changes independent and not linked to RF exposure

Cardiophysiological study

Tahvanainen, Lindholm, Hietanen et al. BEMS 2003

- Replication of Braune studies
- 32 healthy subjects
- 900 MHz and 1800 MHz mobile phone exposure
- Cardiophysiological recordings during and after 35 min
- RF exposure and sham session
- No changes in arterial blood pressure or heart rate



Limitations of human studies

- Only immediate or short-term effects identified
- EEG refers only to limited part of cerebral functions
- Study population contains mostly young healthy subjects
- Experimental conditions limited by ethical considerations
- Experimental design and statistical power depending on volunteer compliance

Benefits of human studies

- Exposure conditions can be accurately controlled and varied (frequency, modulation, SAR)
- The test environment can be standardized and monitored
- Various categorized groups of volunteers can be studied (gender, age)
- High priority at ICNIRP guideline developing process

New methodologies

- Near –Infrared Spectroscopy (NIRS) is a new sensitive method to investigate effects of small temperature increases on blood circulation
- Promising method in brain studies is functional imaging using Positron Emission Tomography (PET)
 - PET can assist in providing detailed information on changes in regional cerebral blood flow (rCBF) and also on metabolism
 - Until now 3 rCBF EMF studies completed using PET, no definitive findings yet available

Conclusions

Exposure setups for human volunteer studies require substantial engineering efforts to provide data useful for risk evaluation

Exposure should represent the worst case with respect to the exposed tissues, exposure strength, and signal characteristics of the tested technology

Health-directed human volunteer research important to detect potential health risks from emerging EMF technologies

No evidence of adverse health effects on volunteers until now



Thank you for your attention!