

Neurobehavioural Effects

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Summary

Exposure to low level EMFs may only cause short-term, subtle changes in neurobehavioural function in adults

Effects on children remain unclear

Consensus of expert group reports

- AGNIR 2001, 2003
- IARC 2002
- ICNIRP 2003
- IEGMP 2000
- NRPB 2004
- Zmirou 2001

- Other reviews and papers

Extremely low frequency fields

Anecdotal evidence but database consists of many isolated studies and models

Data from studies with adult volunteers and animals

No laboratory studies with children

Human EEG studies

- **Awake EEG**

- inconsistent effects
- hint of effect with intermittent fields ?

- **Sleep EEG**

- some disturbances, intermittent fields ?

- **Evoked potentials**

- VEP affected at 60 mT, hint of dose dependency ?
- effects on later components of AEP ?

Conclusions on EEG studies

- **No well defined responses**
 - around 20 volunteer studies
 - different field and exposure conditions
 - results difficult to interpret
 - hints of subtle effects only
- **Mixed results with animals**

Human cognitive studies

- **Simple and choice reaction time**
 - mainly no field-dependent effects
 - accuracy related to task difficulty ?
- **Memory and attention**
 - decreased performance of specific working memory tasks

Animal behaviour studies

- **Many simple and complex behaviours**
 - no consistent effects
 - perception of electric fields
- **Place learning**
 - (transient) deficits in maze performance
 - exposure parameters important ?
- **Object recognition task**
 - impaired with chronic exposure ?

Neurochemistry

- **Endogenous opioids**
 - modulate analgesic effects of injected opiates
 - complex response
 - from one research group
- **Cholinergic function**
 - reduced in frontal cortex and hippocampus
 - intensity-duration relationship ?
 - mainly from one research group

Conclusions on ELF fields

- **Some evidence of subtle effects**
 - cognitive function
 - spatial memory and neurochemistry
 - relevance to health not clear
- **Further studies necessary**

Radiofrequency fields

Much anecdotal evidence, database of many isolated studies and models

Data from laboratory studies with volunteers and animals plus some studies with children

Human EEG studies

- **Spontaneous, awake**
 - variable, some effects
 - lasting slow waves in adults and children ?
- **Task dependent changes**
 - variety of effects, but not well defined
 - high attentional demands ?
- **Sleep**
 - some effects, but not replicable ?
 - intermittent or pulsed fields ?

Conclusions on EEG studies

- **No well defined responses**
 - variety of test and exposure conditions
make comparisons between studies difficult
 - effects may not replicate
 - relevance to health unclear
- **Mixed results with animals**
 - thermoregulation or heating ?

Human cognitive studies

- **Simple and choice reaction time**
 - small improvements, if anything
 - may depend on signal, SAR, other factors?
 - related to cognitive load ?
- **Memory and attention**
 - sporadic changes
 - mild facilitating effect on adolescents and students ?

Cognitive studies using children

From COST 281 Meeting, Budapest, November 2003

- **Preece study**

- 18 children, 10-12 y, double blind
- 30 min to 900 GSM at 0, 0.025 or 0.25 W
- no field-dependent effects

- **Haarala study**

- 32 children, 10-14 y, double blind
- 40-50 min to 900 GSM at 0.25 W ($\sim 1.4 \text{ W kg}^{-1}$)
- no field-dependent effects

Animal behaviour studies

- **Many innate and learned behaviours**
 - effects consistent with heating
- **Place learning**
 - 1 group reported deficits in maze performance
 - not replicated/confirmed by 4 groups

Neurochemistry

- **Cholinergic function**
 - reduced in cortex and hippocampus
 - endogenous opioid involvement ?
 - mainly from one research group

Neurophysiology

- **Hippocampal slice preparation**
 - 700 MHz, CW, $\sim 0.0030 \text{ W kg}^{-1}$
 - changes in neuronal excitability
 - reduced drug-induced epileptiform bursts
 - relevance to health ?

Conclusions on low level RF fields

- **Some evidence of subtle effects**
 - cognitive function
 - neurophysiology
- **Non-thermal or very local heating ?**
 - further study necessary

Overall summary and conclusions

No compelling support for robust detrimental effects in adults at any frequency.

But what about children ?

- assuming children are more sensitive to all/some frequencies, is there sufficient evidence to make predictions of effects ?

Possibilities for children

- **No simple answer**
 - electric fields, magnetic fields, RF fields
- **Too many unknowns to decide**
 - same effects as adults
 - additional effects
 - magnitude of effects
- **Well conducted additional research**

Draft suggestion

- **Further cognitive tests with adults**
 - acute exposure
 - replicate, validate and extend (if necessary)
- **Animal behaviour studies**
 - repeated, long-term exposure
 - acute exposure
 - over range of fields strengths

Draft suggestion

- **Longitudinal study with children**
 - repeated cognitive testing and EEG
 - power to detect field-dependent effect?
 - exposure assessment ?
- **Experimental studies with children**
 - control over exposure
 - ethical concerns

Draft suggestion

- **Mechanisms**
 - calcium ion physiology
 - neurotransmitters
 - brain slice electrophysiology
 - genome/proteome