



ICNIRP 7th International NIR Workshop

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NON-CANCER RF EFFECTS IN HUMANS

Eric van Rongen

ICNIRP MEMBER, CHAIR ICNIRP SC II Biology

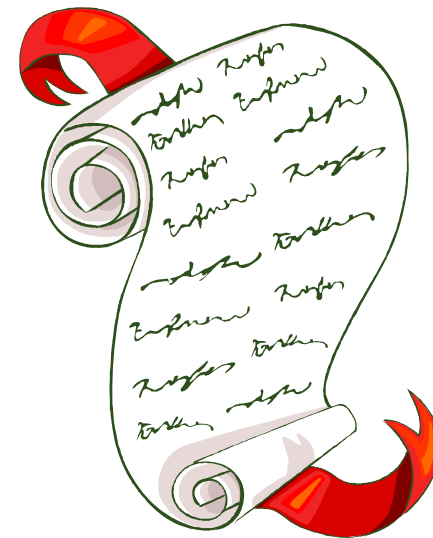
Health Council of the Netherlands, The Hague, The Netherlands



Overview – a long list...

- Cardiovascular system and thermoregulation
- Auditory and vestibular function
- Neuroendocrine system (melatonin, other hormones)
- Fertility, reproduction
- Symptoms and well-being
- Cognitive performance
- Electroencephalogram (EEG)
- Brain metabolism
- Immune system

- Basis: ICNIRP blue book review (2009), closed June 2007





Cardiovascular system and thermoregulation

- Whole-body metabolic heat production: ~1 W/kg (rest)
- ~10 W/kg (heavy exercise)
- At work: core temperatures maximum 38°C
- Heat stroke: most serious, often fatal consequence of excessive heat exposure; occurs at core temperatures >40°C
- SAR 1-6 W/kg for short periods in passive adult volunteers:
 - increased skin blood flow, sweating, small changes (< 0.5°C), if any, in core temperature





Cardiovascular system and thermoregulation

- Whole-body resonance frequencies: less well perceived than more superficial RF, less effective in initiating thermoregulation
- Children: thermoregulation ~ adults, more vulnerable to dehydration (smaller body mass)
- Elderly (>75 y): less thermoregulation (↓ sweating, blood flow responses)





Auditory and vestibular function

- Hearing:
 - No effects short term GSM exposure
 - Hearing loss frequent mob phone users
 - >8 h/d (Kerekhanjanarong 2005)
 - (Oktay 2006)
 - Work in broadcast station
 - (Oktay 2004)
 - Decreased inner ear function mobile phone users
 - >3 y (Panda 2011)
 - Microwave hearing
 - Pulsed microwaves induce clicking, buzzing sound
 - Thermoelastic expansion (temp increase of $0.5 \times 10^{-6} \text{ }^{\circ}\text{C}$ per pulse)
- Sense of balance
 - No effects short & long term





Neuroendocrine system: melatonin

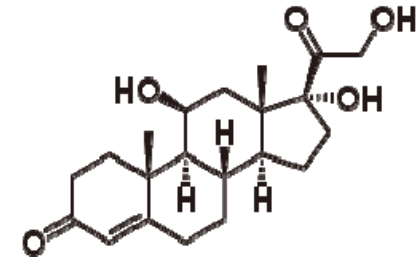
- Controlled GSM 900 MHz: no effect
 - 8 h during sleep (Mann 1998)
 - 30 min (Wood 2006) or 1 h before sleep (Bortkiewicz 2002)
 - 4 h at night or day (Radon 2001)
 - 2 h/d, 5 d/wk, 4 wk (De Sèze 1999)
- (Analog) cell phone users (Burch 2002)
 - Male electric utility workers
 - Study 1: no effect in 3 subj >25 min call time/d
 - Study 2: lower nocturnal melatonin in 5 subj >25 min call time/d
- 1900 MHz personal handy phone (Jarupat 2003)
 - 6 x 30 min before sleep
 - Slightly lower melatonin 1 h after last exposure
- Better/larger studies overall: no effect





Neuroendocrine system: other hormones

- Controlled GSM 900 MHz
 - 8 h during sleep (Mann 1998)
 - Small increase cortisol for 1 h after start exp
 - No effect growth hormone (GH), luteinizing hormone (LH)
 - 50 min (Braune 2002)
 - No effect norepinephrine, epinephrine, cortisol, endothelin
 - 4 h at night or day (Radon 2001)
 - No effect cortisol
 - 2 h/d, 5 d/wk, 4 wk (De Sèze 1998)
 - No effect adrenocorticotropin, thyrotropin, GH, prolactin, LH, FSH
 - 2 h/d, 5 d/wk, 4 wk (Djeridane 2008)
 - Lower GH at 2&4 wk; return to normal after exposure
 - Lower cortisol at 2 wk; return to normal after exposure
 - No effect testosterone, TSH, prolactin, adrenocorticotropin





Fertility, reproduction

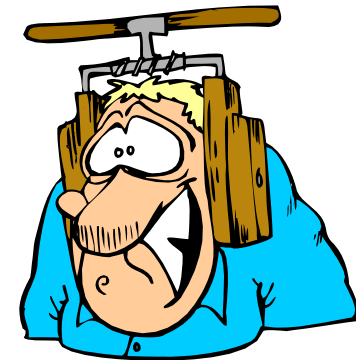
- Animals: heating testis 3-5°C:
 - Prolonged reduction sperm count
- Humans: ex vivo exposure sperm
 - Decreased motility
 - Reduced zona binding
 - Increased ROS
 - Increased DNA breaks
 - Inconsistent results; often unrealistically high exposure
- Epidemiology (mobile phone users, RF welders, radar operators, etc):
 - Altered sex ratio offspring
 - Reduced fertility
 - Low / unclear exposure
 - Causal explanation not possible





Symptoms and well-being

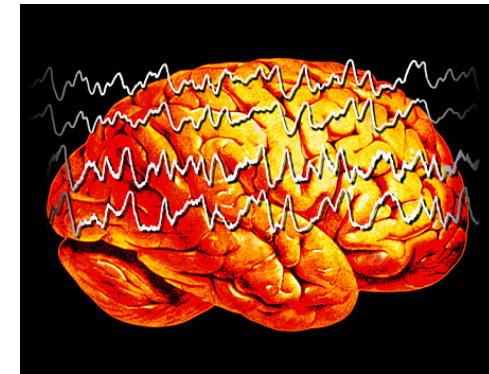
- Attribution of subjective symptoms to EMF (electrosensitivity):
 - No effect EMF exposure
 - No perception of EMF
 - No changes in physiological functions
 - Effect of belief to be exposed (nocebo)
- But:
 - Short term lab studies might be less suitable
 - Long term studies in home / work environment needed





Cognitive performance

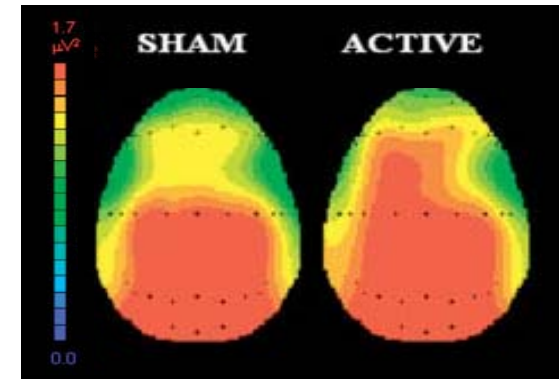
- Memory, reaction speed, etc.
 - Effects observed in some studies
 - Only with relatively high fields strengths (using mobile phone)
 - Not observed with environmental field strengths (living near mast)
 - Small, reversible effects
 - No adverse health effects
- No significant effect on cognition in adults or children





Electroencephalogram (EEG)

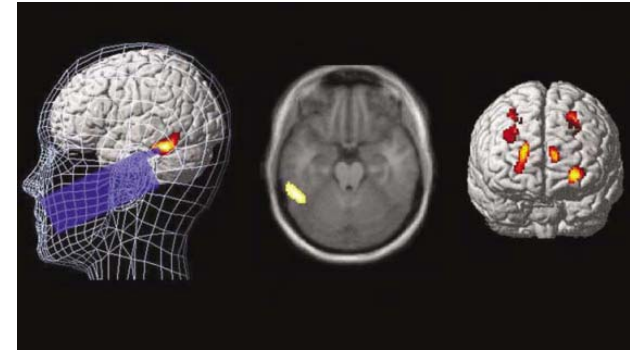
- Electrical activity from large ensembles of neurons measured from scalp
- Resting EEG ('alpha' activity):
 - Increased activity (e.g. Curcio 2005, Regel 2007, Croft 2008/2010)
 - GSM 900 but not CDMA (Croft 2010)
 - No clear ipsilateral/contralateral distinction
- Sleep EEG ('Sleep spindle' activity – non-REM sleep)
 - Increased activity (e.g. Borbély 1999, Huber 2000/2002, Loughran 2005)
 - Pulse-modulated only (Regel 2007, Schmid 2011)
 - Dose-dependent (Regel 2007)
 - Replicated within-individual (Loughran 2012)
- No evidence of behavioural or health impairment





Brain metabolism

- Regional cerebral blood flow (rCBF) by positron emission tomography (PET)
- GSM 900 (pulsed):
 - Increased activity close to phone (Huber 2002, 2005)
 - Increased activity at distance (Haarala 2003; Aalto 2006)
 - Decreased activity ipsilateral (Kwon 2010)
- GSM 900 (base station):
 - No effect (Huber 2005)
- CDMA (UMTS-like):
 - No effect during, after exposure (Mizuno 2010)
 - Increased activity close to phone (Volkow 2011)
- Contradictory data
 - Possible influence noise, temperature





Immune system

- **Healthy and allergic women living near broadcast stations** (Del Signore 2000, Boscolo 2001, Boscolo 2006)
 - Decreased immune parameters
 - Influence lifestyle parameters cannot be excluded
- **Mobile phone** (Kimata 2002, 2005)
 - Decreased immune parameters in allergic patients
- **GSM signal (8 x 4 h)** (Radon 2001)
 - No effect salivary immunoglobulin A
- **Workers exceeding exposure limits** (Tuschi 1999, 2000)
 - Physiotherapists, diathermy: no difference with controls
 - Operators induction heaters: increased immune parameters
- **Data not consistent**





Conclusions

- Cardiovascular effects:
 - Very unlikely below SAR limits, also for potentially sensitive groups
- Hearing
 - No effects short-term mobile phone use
 - Some indications effects after longterm exposure
- Sence of balance:
 - No effects short & longterm exposure
- Melatonin:
 - Better/larger studies overall: no effect
- Other hormones:
 - Temporary increase growth hormone, cortisol during prolonged daily exposure
 - No effect other regimes / other hormones



Conclusions (cont.)

- Fertility, reproduction:
 - Ex vivo exposure sperm: inconsistent results, high exposures
 - Epidemiology: indication for effects, but unclear exposure
- Symptoms:
 - No effect short-term exposure
 - Nocebo
- Cognition:
 - No significant effect in adults or children
- Sleep & Resting EEG
 - Effects, but no evidence of impairment
- Brain metabolism:
 - Contradictory data
- Immune system:
 - Some effects, but inconsistent data



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Thank you!

