Age-related sensitivity to electromagnetic fields

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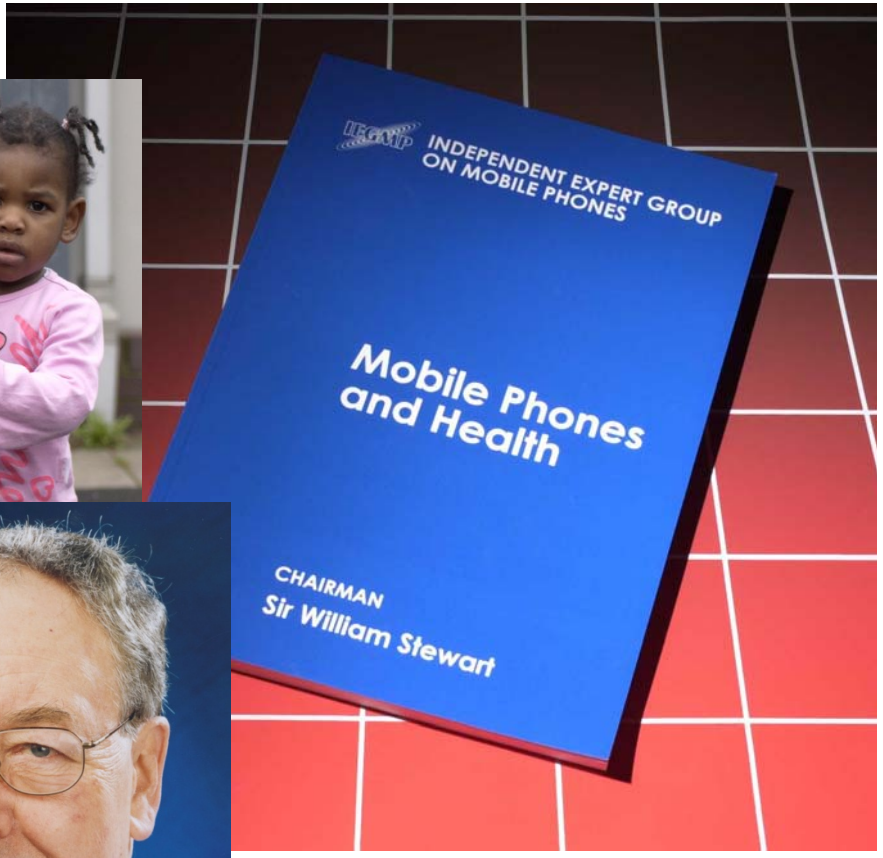


" ..*children might be especially vulnerable …*"

www.iegmp.org.uk

REASONS WHY CHILDREN COULD BE MORE SENSITIVE

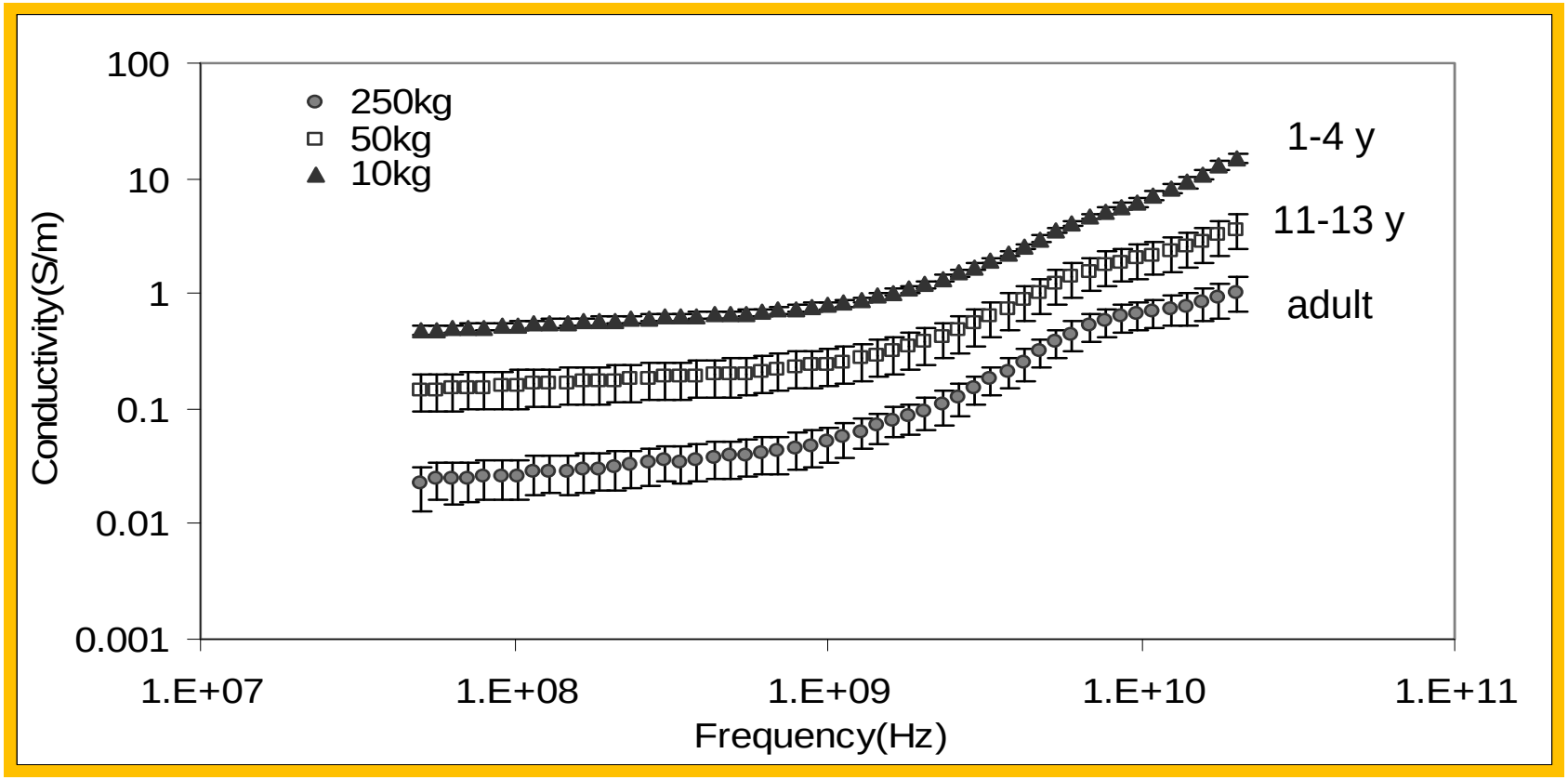
Differences with adult brain in

- morphology → greater penetration
- dielectric properties → increased absorption
- developmental processes → amplify small effects

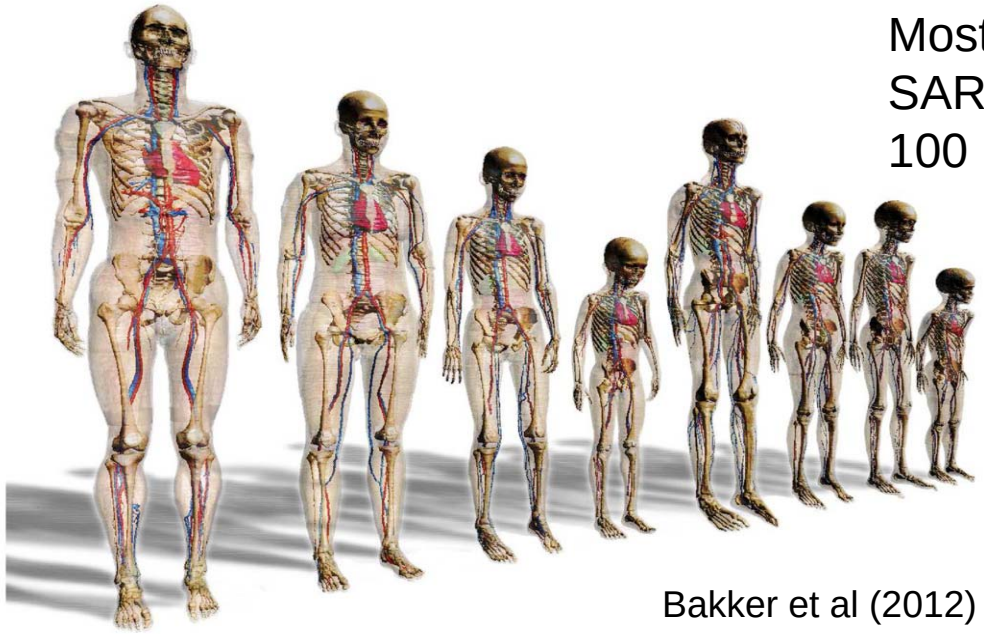
Different and prolonged pattern of handset usage

Health Council of the Netherlands (2011)

"…*data do not indicate that exposure to radiofrequency electromagnetic fields affect brain development or health in children. However, such effects cannot be ruled out*"

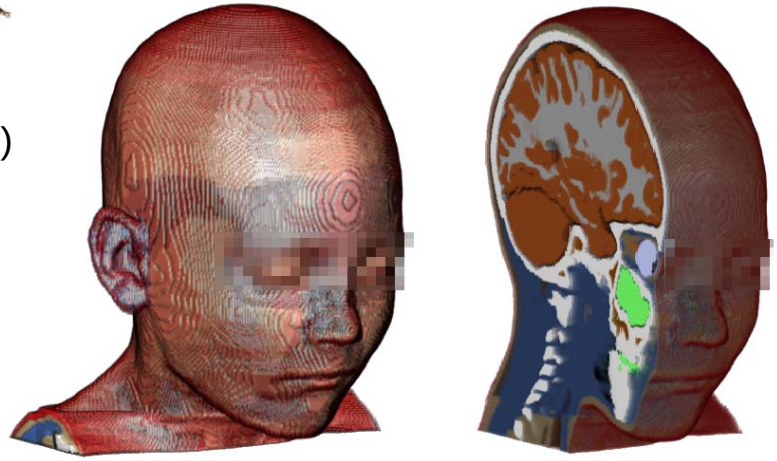


Peyman et al 2005; 2009



Bakker et al (2012)

Most studies report higher whole-body SARs in children (and small people) at 100 MHz and 1-4 GHz ⇒ body size



Some, but not all studies report higher local SARs in children ⇒ morphology

BRAIN DEVELOPMENT (Giedd 2004; Blakemore 2011)

Long-lasting and dynamic process, mainly before birth, but until maturity

- vulnerable to many agents
- critical periods exist
- sex-related differences

During early childhood and adolescence

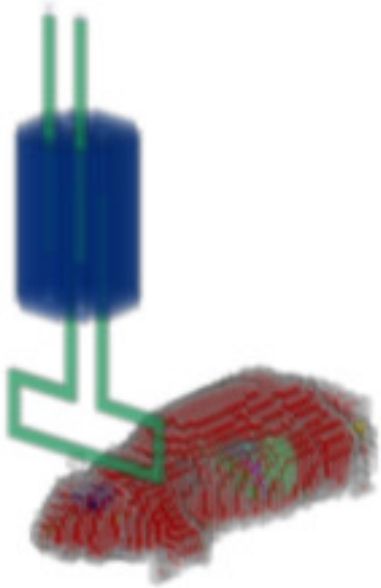
- increase in size and numbers of neurons
- increase in numbers of synapses, loss of neurons
- myelination of axons continues

Linear increase in cranial bone thickness from 1.4 mm to 6.8 mm over first 12 years, 7.7 mm at 18 years (Koenig et al 1995)

EXPERIMENTAL STUDIES with ANIMALS

Limited number of recent studies with very young or immature animals

- variety of models used, exposures, signals
- mainly rodents, no primate studies
- many good quality, but still some with inadequate exposures or dosimetry

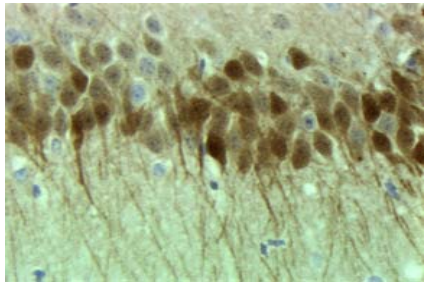


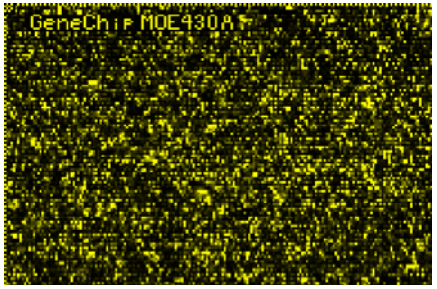
Consistent with earlier results, most evidence from recent studies does not suggest low level exposures are associated with adverse effects (Wiedemann et al 2009; Marino et al 2011)

NERVOUS SYSTEM AND BEHAVIOUR

Brain structure and function (rats)

- no effect with 900 GSM on *c-fos* or HSP (Finne et al 2006, 2009) or degeneration in hippocampus, dentate gyrus (Kumlin et al 2007) or with 1800 GSM on HSPs glial markers (Watilliaux et al 2010), or oxidative damage in rabbits (Guler et al 2010) but no SAR
- cells losses in hippocampus with CW 900 MHz (Odaci et al 2008) in dentate gyrus (Bas et al 2009) and in cerebellum (Sonmez et al 2010); *these animals considered equivalent to teenagers*
- losses in cerebellum but not in hippocampus of mice after prenatal GSM 900 MHz (Ragbetli et al 2009, 2010) but used phone in talk mode
- effects on neurogenesis reported (Orendacova et al 2009, 2010) but no shams





Blood-brain barrier

- reported effects of GSM 896 MHz in 12-26 week old rat, not replicated (McQuade et al 2009, Masuda et al 2009, Poulletier de Gannes et al 2009)
- no effects on permeability or function with PDC 1.4 GHz (Kuribayashi et al 2005) or GSM 900 MHz (Finnie 2006, 2009; Kumlin et al 2007)

Behaviour

- improved water maze performance (Kumlin et al 2007)
- stress responses with 0-25 MHz in mice (Gagnon et al 2003)
- no effect with prenatal 900 MHz (Bornhausen and Scheingraber 2000)
- no effect with pre- and early postnatal UWB or W-CDMA 2.14 GHz (Cobb et al 2000; Takahashi et al 2010)

Auditory function

- measured distortion-product otoacoustic emissions (DPOAE)
- no effects with GSM 900 MHz (Kizilay et al 2003; Aran et al 2004)
- no effects with GSM 900 or 1800 MHz (Kayabasoglu et al 2010) but no SAR
- effects with GSM 1800 MHz in rabbits (Budak et al 2009a,b,c) but no SAR

REPRODUCTION AND DEVELOPMENT (WHO1993; ICNIRP 2009)

Heat is a known teratogen in animals

- effects correlate with degree of maternal hyperthermia
- behavioural changes, low birth weight, abnormalities
- heating of the testes may cause temporary sterility

Recent studies

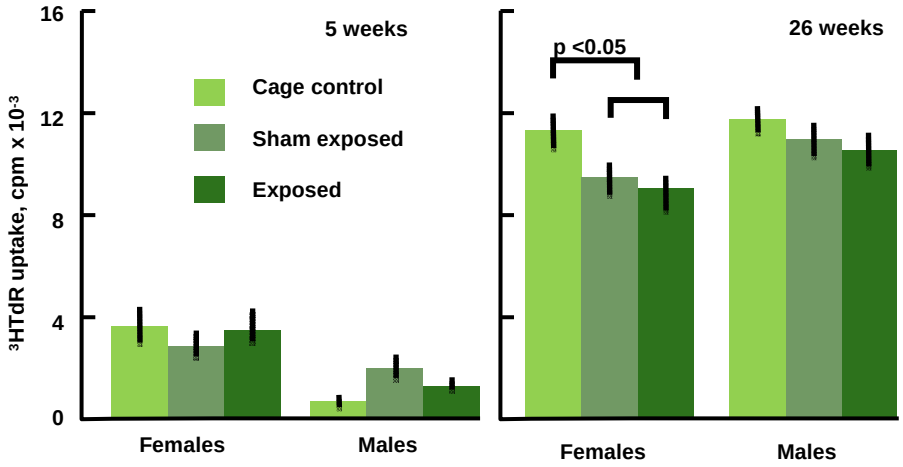
- no effects with combined CDMA 849 MHz & WCDMA 1.9 GHz (Lee et al 2009; Jin et al 2010) or W-CDMA (Ogawa et al 2009) or over 4 generations of mice with UMTS 1.966 GHz (Sommer at al 2009)
- specific effects reported on ossification in mice (Fragopoulou et al 2010) development of kidney using pulsed 9.4 GHz (Pyrpasopoulou et al 2004), litter size and numbers of ovarian follicles (Gul et al 2009) but no SAR

IMMUNE FUNCTION

Immune system is sensitive to heat, show temporary responses

Recent studies

- no field-dependent effects in mice with 2.45 GHz WiFi with prenatal exposure (Sambucci et al 2010; Laudisi et al 2012) or postnatal exposure except reduced IFN-g in male spleen cells (Sambucci et al 2011)
- changes seen attributed to stress and sex differences

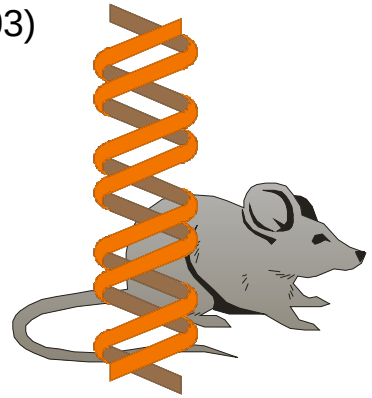


Sambucci et al 2010

CANCER STUDIES

Genotoxicity and mutagenesis

- no effects of Iridium 1.6 GHz on micronuclei (Vijayalami et al 2003)
  of CW 2.45 GHz on mutation of *lacZ* gene in Muta mice (Ono et al 2004)
- prenatal analogue 834 MHz signal increased micronuclei
  (Ferreira et al 2006)



Cancer assays

- no effects of GSM 900 MHz on skin, cerebellar or muscle tumours in *Patched1* mice (Saran et al 2007) or spontaneous tumours following combined CDMA and W-CDMA (Jin et al 2010)
- no effects of UMTS 1.966 MHz in mice, but lung tumours increased following ENU (Tillmann et al 2010)
- awaiting results of large NTP study due in 2014 (http://ntp.niehs.nih.gov)

EXPERIMENTAL STUDIES with CHILDREN

Cognitive behaviour

- no effects on 10 to14 y with GSM 902 MHz (Haarala et al 2005; Preece et al 2005)
- no effects on 15 to 16 y with UMTS base station signal (Riddervold et al 2008)

Electroencephalography

- significant changes with GSM 902 MHz in theta band (4-8 Hz) during an auditory memory task in 10 to 14 y olds (Krause et al 2006)
- no effects on spontaneous EEG with GSM 894 MHz or W-CDMA 1900 MHz in adolescents (13 to15 y) or older adults (55 to 70 years), but increase in resting alpha power (8-12 Hz) in young adults (19 to 40 y) with GSM (Croft et al 2010)

  effect on N1 component of ERP during auditory oddball detection task for all groups with GSM; accuracy reduced in N-back task with W-CDMA in adolescents (Leung et al 2011)
- no effects on auditory discrimination (mismatch negativity) with GSM 902 MHz in 11 to12 y children (Kwon et al 2010)

OBSERVATIONAL STUDIES with CHILDREN

Well being and symptoms

- MobilEe study: 24 h personal exposures of children (8 to 12 y) or adolescents (13-17 y) not associated with acute symptoms (Heinrich et al 2010) or chronic symptoms (Kuhnlein et al 2009; Heinrich et al 2011).
- also no association with electronic device use and headaches in adolescents (Milde-Busch et al 2010)

Cognition and behaviour

- improved performance in attention task by 15-16 y old self-reported heavy users (Lee et al 2001) but may reflect differences with non-users
- MoRPHEUS study: self reported phone use associated with faster, less accurate responding in battery of tests in 12 to 13 y olds (Abramson et al 2009; Thomas et al 2010) ; attributed to learning processes resulting from phone use
- MobilEe study: 24 h personal exposures associated with conduct problems in 13 to 17 y and in 8 to 12 y (Thomas et al 2010)

Behaviour in offspring from maternal phone use

- Danish National Birth Cohort (~100,000 mothers): increased prevalence of problems at 7 years (Divan et al 2008, 2010); no effect on developmental milestones at 6 and 18 months (Divan et al 2011),
- no effect on development at 14 months (Vrijheid et al 2010)

Childhood cancers

- early studies with radio and TV transmitters of ecological design
- two case control studies indicated no increased risk of childhood leukaemia with estimated exposures from transmitters (Ha et al 2007, 2008; Merzenich et al 2008)
- no association with risk of leukaemia, non-Hodgkin‘s lymphoma or brain tumours in young children (0 to 4 y) with proximity to base station during pregnancy (Elliott et al 2010)
- CEFALO study: no significant association between phone use and brain tumour risk; no exposure-response for amount of use or tumour location (Aydin et al 2011). Analysis of subset of data indicated increased risk, contrary to incidence trends
- MOBI-KIDS study: large, international case-control study of mobile phone use (and other sources, risk factors) and brain tumour risk in children and adolescents (10 to 24 y). Ongoing; data collection began in 2010

CONCLUSIONS

Is it possible that children are more sensitive to RF fields?	Yes
Is there any good evidence of this?	No, but there are few data
Is there a smoking gun?	No, except maybe changes in EEG
What about older people?	Yes, impaired thermoregulation
And what about low frequencies?	Possible, but uncertain

Thank you for your attention

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