Mobile phones and Cognition in Children

Report on studies by Alan W. Preece and Christian Haarala

Gerd Friedrich
Forschungsgemeinschaft Funk e.V.
Istanbul, 10th of June 2004
Starting points

Assumption:
- Effects have been identified in adults
- Effect in Children may be greater
  - Children may be a sensitive subset of humans (measles for example is mild in adults, serious in children)
  - In the past: ethic concerns about research with children
  - ...

First media awareness:
Reasons for such research

- Concerns of public in general
- Lack of existing knowledge, no known studies on children
- Children are Power-User!
  - 88% of children 11 – 15 y.o. own a phone
  - 66% in possession for > 1 year
  - 10% had used > 45 mins of calls per day

Pupil researcher Initiative (Sheffield Hallam University)
Concerns of public in general

- **Dielectric properties of the brain**
  (higher water content – both $\varepsilon'$ and $\varepsilon''$ are higher therefore the initial SAR will be higher)

- **Less muscle, skin and bone between phone and brain**

- **Young tissues are more susceptible?**
  (Cf. ionising radiation)

- **More years to collect and suffer detriment**

- **development**
  (functional and physiological development of head/brain not at the same level as adults, therefore e.g. conductivity might be different)

- **long term effects**
  (children of today will be exposed to mobile phones for a longer period of time over life-span than previous generations)
Comparision of proportions

An 11-year old is almost exactly intermediate
Concerns of size under the loupe

- Assumption: Children are more vulnerable than adults to EMF emitted by mobile phones due to differences in head geometry – children have smaller heads

<table>
<thead>
<tr>
<th>Age 5</th>
<th>Age 8</th>
<th>Age 11</th>
<th>Age 15</th>
<th>Age 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain weight (g) Girls</td>
<td>1150</td>
<td>1200</td>
<td>1250</td>
<td>1300</td>
</tr>
<tr>
<td>Brain weight (g) Boys</td>
<td>1100</td>
<td>1150</td>
<td>1200</td>
<td>1250</td>
</tr>
</tbody>
</table>

Head circumference (cm)

<table>
<thead>
<tr>
<th>Age 5</th>
<th>Age 8</th>
<th>Age 11</th>
<th>Age 15</th>
<th>Age 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>19</td>
<td>19,5</td>
<td>20</td>
<td>20,5</td>
</tr>
<tr>
<td>Boys</td>
<td>19</td>
<td>19,5</td>
<td>20</td>
<td>20,5</td>
</tr>
</tbody>
</table>
What health effects should research consider?

- Harmful effects – short term, long term
- Other effects – i.e. within a physiological range

<table>
<thead>
<tr>
<th>Health</th>
<th>or</th>
<th>Physiological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td></td>
<td>Cognition*</td>
</tr>
<tr>
<td>Ageing</td>
<td></td>
<td>Behaviour*</td>
</tr>
<tr>
<td>Neuro-degeneration</td>
<td></td>
<td>Blood flow*</td>
</tr>
<tr>
<td>Stress</td>
<td></td>
<td>Blood pressure*</td>
</tr>
<tr>
<td>Epilepsy</td>
<td></td>
<td>Evoked potentials</td>
</tr>
<tr>
<td>High temperature</td>
<td></td>
<td>Mild temperature</td>
</tr>
</tbody>
</table>

*within physiological ranges
Human cognitive studies (1)

   **Effect of a 915-MHz simulated mobile phone signal on cognitive function in man**

   **Effects of 902 MHz electromagnetic field emitted by cellular telephones on response times in humans**
   Neuroreport 2000 Feb 7;11(2):413-5

   **Effects of electromagnetic field emitted by cellular phones on the EEG during a memory task**

Studies including youngish subjects

5. Lee T.M.C. et al 2001 Effect on human attention of exposure to EM fields emitted by mobile phones Neuroreport (12) 729-731


7. Edelsteyn & Oldershaw 2002 The acute effects of exposure to the EM fields emitted by mobile phones on human attention Neuroreport 13 119-121
A brief literature review on EMF & cognitive functions (behavioural)

<table>
<thead>
<tr>
<th>Study</th>
<th>Result(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preece et al., 1999</td>
<td>↓ reaction time (1/15)</td>
</tr>
<tr>
<td>Koivisto et al., 2000a</td>
<td>↓ reaction time (1/14)</td>
</tr>
<tr>
<td>Koivisto et al., 2000b</td>
<td>↓ reaction time (1/4)</td>
</tr>
<tr>
<td>Lee et al., 2001</td>
<td>↓ reaction time (2/4) (b/w S’s design; Bonferroni?)</td>
</tr>
<tr>
<td>Edelstyn &amp; Oldershaw, 2002</td>
<td>Improved performance (5/6) (b/w-S’s design; phone position; Bonferroni?)</td>
</tr>
<tr>
<td>Haarala et al., 2003</td>
<td>No effect</td>
</tr>
<tr>
<td>Lee et al., 2003</td>
<td>↓ reaction time (1/4) (Bonferroni?)</td>
</tr>
<tr>
<td>Smythe &amp; Costall, 2002</td>
<td>improved memory but only in men 1/2</td>
</tr>
</tbody>
</table>
Results from the seven studies

- Speeding up in Simple reaction time
- Speeding of vigilance response
- Effect enhanced by “workload”
- Improvement in accuracy (except one study)
- Effect appears to persist after exposure (users are “smarter” than non-users)
  - Keetley
  - Lee et al
  - Bristol study
Experiments in Children?

How to proceed?

Are ethic aspects against this?

Having the same testing methods?

Presentation of two different independent studies carried out by A. Preece and C. Haarala
Power deposition levels from phones

- Highest brain SAR from GSM (0.25 W) = 0.44 W/kg
- Lowest SAR from GSM model = 0.02 W/kg
- Range of SAR from analogue = 0.9 - 1.76 W/kg

Thermal estimates

Worst case for head:
4 W/kg for 30 min = 1.7°

Worst case for brain:
0.44 W/kg for 30 min - 0.2° (GSM)
1.6 W/kg for 30 min - 0.7° (Analogue)

Measured or estimated (for GSM)
Anderson and Joyner (‘95) 0.03°
Van Leeuwen (‘99) 0.11° (time constant 6 min)
Wainwright (‘00) 0.1°
Distance between measurement position and the inner surface of the skull [cm]
Set-up of the Bristol Experiment as Example

To Coding switch

217 Hz

915 MHz
Used Equipment in Bristol experiment
Human cognitive function tests (Bristol experiments)

Standard tests used to assess effects of drugs e.g. opiates, psychotropics for medico-legal purposes (Cognitive Drug Research, Ltd.)

1. Immediate Word Recall  
2. Picture Presentation  
3. Simple Reaction Time  
4. Digit Vigilance Task  
5. Choice Reaction Time  
6. Spatial Working Memory  
7. Numeric Working Memory  
8. Delayed Word Recall  
9. Delayed Word Recognition  
10. Delayed Picture Recognition

10 specific tasks

15 derived parameters (speed and accuracy)
Preece: Subjects of Bristol Test

- **Hospital staff (18)**
  - Age range 21-49
  - Mean age 31.4 years
  - 9 male/9 female
  - Mean phone use **53.4** min/month

- **Medical students (18)**
  - Age range 20-24
  - Mean age 21.7 years
  - 9 male/9 female
  - Mean phone use **372** min/month (one outlier)

Tea, coffee, alcohol, sleep, medicines monitored
Comparision of the two independent studies

<table>
<thead>
<tr>
<th></th>
<th>Haarala et al.</th>
<th>Preece et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td>10-14 year olds</td>
<td>10-12 year olds</td>
</tr>
<tr>
<td>n</td>
<td>32 (16 boys)</td>
<td>18 (9 boys)</td>
</tr>
<tr>
<td>Exposure</td>
<td>Nokia 6110 with speaker removed</td>
<td>Nokia 3110 with speaker removed</td>
</tr>
<tr>
<td>SAR</td>
<td>1.44 W/Kg (1g)</td>
<td>Near the top of the range of commonly available phones</td>
</tr>
<tr>
<td>Mounting</td>
<td>The phone in an acrylic cradle mounted on a plastic ear defender, replacing the earmuff on the left side.</td>
<td></td>
</tr>
</tbody>
</table>
## Two independent studies

<table>
<thead>
<tr>
<th></th>
<th>Haarala et al.</th>
<th>Preece et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td>Off vs. On (0.25 W), double-blind, within-subject</td>
<td>Off vs. 0.025 W vs. 0.25 W, double-blind, within-subject</td>
</tr>
<tr>
<td><strong>Exposure time</strong></td>
<td>40-50 min</td>
<td>30-35 min</td>
</tr>
<tr>
<td><strong>Testing sessions</strong></td>
<td>Sequential days (24 +/- 1 hr)</td>
<td>Sequential days, ~same time of the day</td>
</tr>
</tbody>
</table>
Two independent studies

<table>
<thead>
<tr>
<th>Cognitive tests</th>
<th>Haarala et al.</th>
<th>Preece et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CogniSpeed</td>
<td>Simple reaction time, 2-choice reaction time, 10-choice reaction time, Vigilance task</td>
<td>Cognitive Drug Research Word recognition I, Simple reaction time, Number vigilance, Choice reaction time, Spatial memory, memory scanning, Word recognition II, Picture recognition, Dual attention task</td>
</tr>
<tr>
<td>N-back</td>
<td>0-back, 1-back, 2-back, 3-back</td>
<td></td>
</tr>
</tbody>
</table>
Reaction times, Haarala et al.

Cognitive task

Phone Off

Phone On

Reaction time (ms)

[Bar chart showing reaction times for different cognitive tasks with and without a phone.]
Reaction times, Preece et al.

Cognitive task

- Phone Off
- Phone On, 0.025W
- Phone On, 0.25W
Indices, Preece et al.

Cognitive task

Reaction time (ms)

Phone Off  Phone On, 0.025W  Phone On, 0.25W

(RECSI)  (SPMSI)  (NWMSI)  (DRECSI)  (DPICS)}
Two comparable tasks* in the present studies

*SRT in Preece et al. had the word ‘yes’ as a stimulus, and number ’0’ in Haarala et al.
Results out of the experiments

- There were no significant differences between sham, 0.025 W, and 0.25W exposures in either study.
- Mobile phone did not affect the children’s cognitive performance as measured by response speed and accuracy.
- The discrepancy in results of existing literature may be due to methodological differences (design, exposure set-up):
  - Double-blind conditions essential: Haarala et al. (2003; double-blind) unable to replicate the results of Koivisto et al. (2000a, 2000b; single-blind) with same exposure set-up and tests.
  - When same exposure set-up is used, results more systematic: Haarala et al. (2003) found same results in two independent laboratories; the two present studies.
Some general observations (1)

- Children were very much slower at some of the reaction tasks
  - There are other observations that support this
  - If age/maturity is important then likely to introduce large variability
- It seems likely that we may only detect an effect twice as large (35 msec) as that seen in adults
Some general observations (2)

- It is probably not surprising that results will be variable
  - Penetration of RF into the head is marginal – and even more so with later phone models
  - Phone design can alter SAR by a large factor
  - So can positioning
  - Clever electronics to save battery life can confuse
Future research

- Are children more vulnerable?
  - Dielectric properties of human tissue as a function of age
  - Other relevant physiological differences between children and adults?
  - SAR distribution in children as opposed to adults

- Do mobile phones affect children?
  - Replication of current studies
  - Subjective symptoms
  - Different parameters: age, exposure set-up, intensity, duration & location (ethical considerations).
COST 281 - Potential Health Implications from Mobile Communication Systems

**COST 281 Newsflash**

- **May 10th, 2004:**
  - **Workshop Presentations**
    - **NEW!** All the documents and presentations which were presented at the CDST/FOR workshops are now available:
      - **Workshop Helsinki:** "Influence of RF Fields on the Expression of Stress Proteins" [Go to download]
      - **Workshop Thessaloniki:** "Potential bioeffects of new technologies, in particular in the UHF range (300 MHz – 3 GHz)." [Go to download]
      - **Workshop Immensand:** "Can electromagnetic fields used in mobile communications provoke sleep disorders and other cognitive changes?" [Go to download]
      - **Workshop Budapest:** "Mobile Telecommunication and the Brain" [Go to download]
      - **Workshop Reisenburg:** "The Blood-Brain Barrier (BBB) - Can it be influenced by RF-field interactions?" [Go to download]

- **May 4th, 2004:**
  - **Workshop in Helsinki, Finland on April 28-29, 2004**
    - "Influence of RF Fields on the Expression of Stress Proteins"

Aim of this workshop was to evaluate and discuss current available experimental data on protein expression under the influence of RF fields. Results from the workshop will be collected and presented in a documentation accepted by the participating experts.

The Workshop was organized by the Forschungsgemeinschaft Funk (Research Association for Radio Applications), in