

COMPUTERS AND HEALTH IN THE WORKPLACE

Derek J. Clements-Croome¹, John Jukes²

¹Department of Construction Management and Engineering, University of Reading, UK

²Jukes Association, Old Coulsdon, UK

ABSTRACT

This paper describes research on the extremely low frequency (ELF) end of the electromagnetic spectrum from VDUs, because this is very close to the frequencies of the brain when it is concentrating. Our most recent experiments involve the use of an alpha oscillator which when stimulated with magnetic radiation from VDU's emits frequencies which peak around 12 Hz. The oscillator neutralises ELF emissions from the VDU by resonance thus acting like a tuning fork. A recent experiment carried out at a Health Authority office building involved 100 people who were given either active or dummy devices over a period of two months. It was a double blind crossover experiment because neither of the occupants of the building nor the researchers knew which devices were active and which ones were dummies until the end of the experiment. Each subject then answered 19 questions concerned with building sickness syndrome and ergonomic factors. Everyone answered the questionnaire three times, once at the beginning, once after the first experiment and once after the second experiment, having swapped over the activity and dummy devices. The statistical analysis of the results showed that there was a highly significant effect in the reduction of building sickness symptoms by a third when using the alpha oscillator, thus leaving scope for a further reduction of nearly 70% due to other factors than radiation.

KEYWORDS: electromagnetic fields, VDT-work, SBS

INTRODUCTION

Television, Personal Computers Video Display Units and Mobile Phones

Televisions and computers are broad band radiating sources which emit a wide spectrum of frequencies from 20 Hz --200 MHz. Pictures on the screen are made up of separate lines each being constantly generated from left to right. There is also a fly-back circuit that returns the line of sweep to the left side of the screen at the end of each line. Flyback circuits operate in the VLF range generally at about 17 kHz. The electromagnetic radiation is generated from the circuits within the equipment. The radiation pattern from a computer is similar to that from television but people are sitting much closer to the screen in the former case.

[15] reports the effect of VDUs and mobile telephones on chicken hatching patterns. Embryo mortality rates exposed to these electromagnetic sources increased from around 15% to about 60% with significant reductions in the hormonal and immune responses as well as body weight. Using an alpha oscillator it was possible to restore these levels of responses although the embryo mortality still remained some 10% above the control levels. [8] reports work of the Avignon Teaching Hospital in France which shows that VDUs have an effect on the brain using EEG measurements as the source of data.

[8] reports on several studies which have placed an alpha oscillator on a VDU. Most of the experiments involve testing a number of subjects with and without the alpha oscillator. Research at the University of Luton used mood tests and found that by using an alpha oscillator people were more relaxed, less tense and more alert. This result is supported by previous work [9,14,16].

[8] goes on to describe further work carried out at the Tecnosphere Research Centre, at Sampigny in association with the Cochin Hospital in Paris in which VDU workers at several French and Swiss companies were tested using a Stroop colour word test for assessing the degree of stress. By using the alpha oscillator peoples concentration was improved, especially for individuals who were more stressed. There were also improvements in speed and alertness reactions as well as a significant improvement in stress resistance.

[5] shows that the electromagnetic fields emitted by mobile phones influence slow brain potentials which represent some stage of information processing but no conclusions were reached regarding health and well-being.

Electromagnetic Radiation and VDUs

[6] in the USA reports that women who use VDU's for more than 20 hours a week had more than twice as many miscarriages as women doing other types of office work. A survey was carried out among 1583 pregnant women and showed that the risk of early or late miscarriages increased approximately 80% for all women who worked on VDUs for more than 20 hours a week.

An extensive source of references on VDUs are given by Bentham [4] who describes evidence from another twenty-three studies in Canada, Denmark, UK, Finland, Sweden, Japan, Poland as well as the USA and she concludes that the results show that unsuccessful pregnancies among VDU users are on an average of around 75% more common than for non-users. In other words VDU's increase the risk, but like most environmental issues, there are a number of confounding factors which can cause a particular outcome.

Clearly VDUs can give rise to problems in a number of ways for people who are using them continuously. They can cause various muscle aches, repetitive strain injury, sore eyes, skin complaints as well as the possible effects of electromagnetic radiation. VDUs emit extremely low frequency radiation (15 – 60 Hz), very low frequencies (up to 20 kHz), radio frequencies (100 kHz up to 300 MHz), microwaves (300 MHz – 20 GHz) and to complete the non-ionising radiation range, infrared and ultraviolet radiation. VDUs also emit soft x-rays in the ionising radiation range. The spectrum for mobile phones is similar.

The extremely low frequency emissions (ELF) result from the input electrical power and the vertical sweep circuits which put together emit electric and magnetic fields of up to 60 Hz frequency and associated harmonics. The major source of the magnetic field is the magnetic deflection coil. The human body is conductive to magnetic and electric fields hence there is the possibility of disturbance with the body's natural electromagnetic systems.

The International Telecommunications Union (ITU) recommend the following electromagnetic spectrum definitions as shown in Table 1.

Table 1. Electromagnetic spectrum definitions by ITU [2]

| | Frequency range |
|-------------------------|------------------------|
| Extremely low frequency | range 30 – 300 Hz* |
| Voice frequency | range 300 – 3000 Hz |
| Very low frequency | range 3 – 30 kHz |
| Low frequency | range 30 – 300 kHz |
| Mean frequency | range 300 – 3000 kHz |
| High frequency | range 3 – 30 MHz |
| Very high frequency | range 30 – 300 Hz |
| Ultra high frequency | range 300 – 3000 Hz |
| Super high frequency | range 3 – 30 GHz |
| Extra high frequency | greater than 30 GHz |

* This will also include sub harmonic below 30 Hz and harmonics above 30 Hz.

Biological Effects of ELF fields

Magnetic fields can pass through most materials and when they enter the human body they can induce small electric currents. [3] and [4] provide many references referring to the impact of these fields on protein synthesis, activity of enzymes, changes in the immune system and other effects. "Add on screens" to VDUs can eliminate the static and alternating electric fields but they do not affect magnetic field components. In addition these screens usually reduce glare and reflections from the screen. Bentham [3] reviews evidence from surveys of VDU for VLF fields which give magnetic flux densities ranging from 69 – 1150 nT (screens with electric field strengths ranging from 1 – 165 Vm⁻¹). For ELF fields the magnetic flux density ranges from 6 - 200 nT (0.05 – 10 Vm⁻¹).

The Swedish National Board for Technical Accreditation (SWEEDAC) pioneered and introduced the first ergonomic studies for VDU screens in 1990, known as NPR 11 (SEEDAC 1990). This limits the emissions of the VLF (25 nT, 2.5 Vm⁻¹) and ELF (250 nT, 25 Vm⁻¹) magnetic and electric fields measured at 50 cm from the VDU in three planes.

Graham [7] reports changes in the body's fundamental processes when people are exposed to low frequency magnetic fields which resulted in the slowing down of the heartbeat and reduced ability to concentrate. He concluded that lower frequencies may be more harmful than the higher ones. Aday [1] reports that cells in the body communicate with each other by passing signals and chemicals from one cell to the other and if there is interference with this process then the cells can behave in a cancerous way. Electromagnetic fields can be one source which can disrupt this inter cellular communication process. Some of his earlier work showed that cells exposed to 15 Hz resulted in a loss of calcium ions from body cells. Electromagnetic radiation plays a vital role in different parts of the cellular processes including the transmission of nerve impulses.

More recently the work [11] at the National Radiological Protection Board reports on the effect of 50 Hz magnetic fields on a spatial learning task by mice. The magnetic field had a flux density of 0.75 nT and lasted for forty five minutes. The conclusion from these studies was that power frequency magnetic fields *may* affect the processing of spatial information in rodents. Other studies have identified that acute exposure to high field strengths can cause a transient and reversible effect on learning behaviour. Sienkiewics [12] suggests that the behavioral changes reported for mice may have implications of effects in humans, but

extrapolating data obtained with animals to humans is notoriously difficult. Behaviour changes noted so far are not large and do not appear to last but nevertheless there could be implications for people working with VDUs in their workplace over several hours. Research is needed to resolve these questions.

Sienkiewicz [13] gives a review about the biological effects of electromagnetic fields. Earlier reviews by the National Radiological Protection Board are referred to. Whilst acknowledge that there have been well established perceptual effects and a few subtle responses have been observed with low frequency electromagnetic fields, these effects remain small in magnitude, short in duration and are reversible.

Some recent work [10] at the University of Bristol on the effect of 50 Hz magnetic fields as regards to cognitive functions in humans concludes that power frequency magnetic fields of 0.6 nT can lead to some temporary deterioration in attention whilst working due to a loss of some memory performance. There does not appear to be any effect on the speed of carrying out a task. There does not appear to be any evidence with regard to these effects from a static magnetic field of the same magnitude.

ELECTROMAGNETIC RADIATION AND SBS – A CASE STUDY

Electromagnetic radiation can be reduced at source, by distance or by the introduction of various tuning fork resonance devices between the source and the person. This experiment uses an alpha oscillator* and compares the building sickness syndrome scores for people with and without the oscillator attached to the VDU.

METHOD

A double blind crossover study was conducted among 107 office workers in the South West Health Authority, UK. The building sickness symptom scores were ascertained using a 19 item questionnaire covering general stress, environmental and ergonomic factors. 46 subjects answered the questionnaire by interview (stage 1). Active and dummy alpha oscillator devices were given randomly to the 46 subjects situated in two wings. Neither the subjects nor the researchers knew the colour coding which was an active or dummy device (stage 2).

After a month the subjects answered the questions again then swapped active for dummy devices and vice versa (stage 3). After a further month the subjects answered the question again (stage 4).

An analysis of the findings took place after identifying the colour coding for the active, dummy devices. Stage 2 used active oscillators in the South Wing and dummies in the North Wing; in Stage 3 this situation was reversed.

Thus the only difference between the stages, apart from the day, was the introduction of an alpha oscillator which interacts with magnetic ELF's.

* Tecno AO (electromagneto-bioprotective technology; international patent) device is a magnetic oscillator (AO for alpha oscillator, peak of 8-12 Hz; at ultra low magnetic intensity: 100-150 fT) made of a double antenna filled with an electromagnetically treated saline solution.

Table 2. Factors included in the questionnaire on stress, environment and ergonomics

| SBS symptoms | Stage | 1 | 2 | 3 | 4 | Comments |
|--|-------|---|---|---|---|----------|
| 1. Headache | | | | | | |
| 2. Cough/sneezing | | | | | | |
| 3. Dry, itchy or tired eyes | | | | | | |
| 4. Blocked or runny nose | | | | | | |
| 5. Tiredness/fatigue | | | | | | |
| 6. Rashes, itches, dry skin | | | | | | |
| 7. Cold or flue symptoms | | | | | | |
| 8. Dry throat, thirsty | | | | | | |
| 9. Sore throat | | | | | | |
| 10. Breathing difficulties | | | | | | |
| Pain stiffness or discomfort in | | | | | | |
| 11. Lower back | | | | | | |
| 12. Shoulders | | | | | | |
| 13. Neck | | | | | | |
| 14. Arms & elbows | | | | | | |
| 15. Hands, wrists & fingers | | | | | | |
| Occasionally feeling | | | | | | |
| 16. Irritable, tense | | | | | | |
| 17. Depressed/pessimistic | | | | | | |
| Occasional problems with | | | | | | |
| 18. Concentration | | | | | | |
| 19. Short term memory | | | | | | |

Single paired t-tests were used in the statistical analysis thus eliminating any variation due to location of subjects. The average readings at Stage 1 was 6.652 symptoms per subject and at Stage 2 and 3 the average for active antennae was 4.457 (33% reduction from Stage 1) and 6.152 for dummies (7.5% reduction from Stage 1).

Comparing *Active* with Stage 1 gives
 $t = 6.00$ $p < 0.001$ highly significant (1)

Comparing *Dummy* with Stage 1 gives
 $t = 1.64$ $p = 0.054$ not significant at 5% level (placebo effect) (2)

The differences were normally distributed but non-parametric tests (Wilcoxon Signed Rank Test) was applied and similar conclusions were drawn. Power tests checks revealed there is almost 100% certainty that the conclusions are correct.

CONCLUSIONS

Subjects in this office experience building sickness syndrome due to general stress, environmental and ergonomic factors. Healthy buildings usually report 4 or less symptoms per person. This building has an average score of over 6 per person (based on 20 symptoms). By the use of an alpha oscillator on the VDU the symptoms of building sickness were reduced by an average of 33% (t-tests analysis). Thus these symptoms are partly due to the low frequency radiation (1/3), which reacts with the alpha oscillator and prevents its transmission through the head to the brain, and to other factors (2/3).

Building sickness syndrome arises from various combinations of environmental factors. There is usually a principal factor which triggers a chain of events by initially lowering the immune system and hence increasing the likelihood of other factors affecting the body.

VDU's can provide three sources of trigger reactions; those derived from posture, eyestrain and extremely low frequency radiation. In this experiment it has been shown that the latter can be highly significant.

ACKNOWLEDGEMENTS

The authors wish to thank Dr P. Bowtell (formerly Department of Applied Statistics, University of Reading), South West Health Authority and Tecno AO, for their contribution in this research project.

REFERENCES

1. Adey, W.R., 1988, *Cell Membranes: The Electromagnetic Environment and Cancer Promotion*, Neuro Chemistry Research, 12, 671.
2. Allen, S.G., et al., 1994, *Review of Occupation Exposures to Optical Radiation and Electromagnetic Fields with regard to the proposed CEC Physical Agents Directive*, National Radiological Protection Board, Chiltern, Didcot, Oxon. January.
3. Becker, R.O., 1990, *Cross Currents*, Published by Tarcher Putnam: New York, ISBN. No. 8744 776090.
4. Bentham, P., 1995, *The Development of a New Classification System for Identifying and Managing Risks to Health and Safety in VDU Environments*, Mphil. Thesis, Manchester Metropolitan University.
5. Freude, G., et al., 1998, *Effects of Microwaves Emitted by Cellular Phones on Human Slow Brain Potentials*, Bioelectromagnetics, 19, 384-387.
6. Goldharbar, G., Poland, N., Hiatt, R., 1988, *Risk of Miscarriage and Birth Defects Among Women who use Video Display Units*, American Journal of Industrial Medicine, 13, 695-706.
7. Graham, C., 1990, Report issued by Midwest Institute, Kansas, USA. Originally summarised in an interview with T Mangold, in *Electricity a Shock Instore*, BBC Panorama, March 21, 1988.
8. Hyland, G.J., 1999, *Electromagnetic Bio Compatibility of the Workplace: Protection Principals, Assessment and Test*, Proceedings of the Non Ionising Radiation Conference, 27 September to 1 October, Volume 1, 13 – 240.
9. Johansson, G., 1984, *Stress Reactions in Computerised Initiative Work*, Journal of Occupational Behaviour, 5, 159-181.
10. Preece, 1998, *The Effect of a 50 Hz Magnetic Field on Cognitive Function in Humans*, Int.J.Rad.Biology, 74, (4), 463-470.
11. Sienkiewicz, J., et al., 1998a, *Deficits in Spatial Learning after Exposure of Mice to a 50 Hz Magnetic Field*, Bioelectromagnetics, 79 – 84.
12. Sienkiewicz, J., et al., 1998b, *Deficits in Spatial Learning after Exposure of Mice to a 50 Hz Magnetic Field*, *ibid*, 486-493.
13. Sienkiewicz, J., 1998c, *Biological Effects of Electromagnetic Fields and Radiation*, The Journal of Radiological Protection, 18, 3, 185-193.
14. Smith, M.J., et al., 1981, *An Investigation of Health Complaints and Job Stress in Video Display Operations*, Human Factors, 23, 389-400.
15. Youbicier – Simo, B.J., et al., 1997, *Biological Effects of Continuous Exposure of Embryos and Young Chickens to Electromagnetic Fields Emitted by Video Display Units*, 1990, Bioelectromagnetics, 18, 514-523.
16. Zavala, A., 1984, *Stress and Factors of Productivity Amongst Software Development Workers*, Human Computer Interaction, edited by Salvendy (Elsevier), 365-370.