The influence of high vegetative

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1. Summary

The goal of the study (see [1]) was to investigate whether or not high frequency signals have an effect on the human vegetative nervous system. For the study 50 volunteers (probands) were exposed periodically to a multi-frequency signal consisting of a sequence of six different frequencies, in the frequency ranges of 5.8 GHz to 110 GHz. The modulation of the irradiation signals was according to equipment which is commercially available for radar and communication systems. The field strength of the signals was 15 V/m at the testing site. This is equivalent to circa 25% of the reference value of the electrical field strength according to ICNIRP.

2. Medical parameters

The best and most exact way to determine any possible non-thermal effects from micro waves on the human organism can be obtained by observing the vegetative nervous system. In order to investigate if there are any possible effects from micro wave signals on the vegetative nervous system, the following parameters were recorded during irradiation.

- electrocardiogram (ECG)
- blood pressure (systolic and diastolic)
- skin temperature
- skin conductivity

An additional blood test was dispensed with during the irradiation experiment since previous studies have shown that doing a blood test considerably influenced the parameters being recorded.

Previous investigations have illustrated the sensitivity of the parameters that are being measured: merely another person approaching the proband caused a strong alteration in the test parameters. Thus, when a possible effect on the proband occurred, it could be shown that the recorded parameters are adequate enough to detect this disturbance. In order to avoid any possible environmental effects (effects in the form of undesired electromagnetic exposition (as opposed to the desired exposition), as well as an impairment in the form of acoustic signals) the irradiation experiments were conducted in the antenna test chamber of the Institute for High Frequency Technology at the University of Stuttgart. In order to isolate the proband in the best possible way from the environment and to create identical experimental conditions, the volunteer listened to music with headphones during the experiment ("Das wohltemperierte Klavier" *The well tempered piano* by J.S. Bach)

3. The exposition experiment

Measuring procedure

In diagram 3.1 the experimental exposition procedure is shown in time segments. The 30 minute settling-in time phase at the beginning of the experiment allows the proband to get used to the new environment and facilitates an equilibrium of the recorded vegetative parameters. The settling-in time phase is followed by a first possible exposition phase of 15 minutes with an additional 15 minute recovery

GHz-signals on the nervous system

phase as well as a second possible exposition phase with another 15 minute recovery phase. Every volunteer in this experiment was exposed either in the first or in the second possible exposition phase, where 25 volunteers selected at random, were exposed in the first phase and the 25 others were exposed in the second phase.

The experiment was conducted with double blinds, the volunteers and the person conducting the experiment did not know to which irradiation group they were assigned.

Exposition signal

The exposition signal is shown in diagram 3.2. Here we are dealing with a sequence from six different frequencies in the frequency range of 5.8 GHz to 110 GHz. Each frequency was 5 ms active and the rate of repetition was 35 ms.

This selected multi-frequency makes it possible to state that none of the frequencies causes an effect on the vegetative nervous system or that at least one or several of the six frequencies have an effect on the vegetative nervous system. The advantage of the selected signals is that it is possible to simultaneously test six different frequencies, however in the case of a possible effect occurring, the disadvantage is that the frequencies causing this effect cannot be directly determined.

Test assembly

Diagram 3.3 illustrates the test assembly. The capturing and the recording of

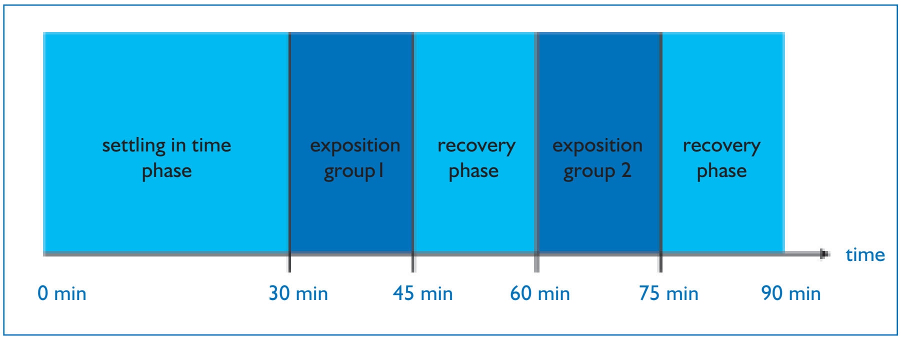

Diagram 3.1 exposition procedure

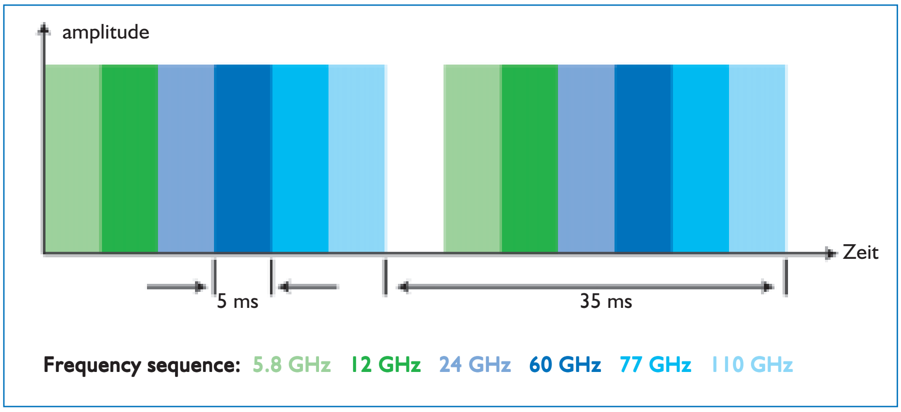

Diagram 3.2 exposition signal

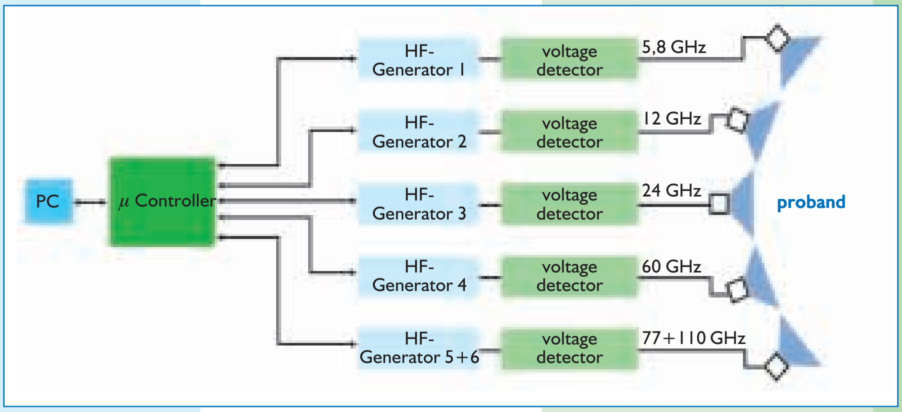

Diagram 3.3 test assembly

Figure 3.4: exposition test area

test data as well as the selection of the exposition groups was completely automated.

The RF-generators were switched on and off with a micro controller; the voltage detectors were used to monitor the signals. This made it possible to stop the test automatically if an exposition error would occur during the experiment. The recording of the test parameters were also computer controlled. The recording of the electrocardiogram as well as the measurements and the recordings of the skin temperature and skin conductivity were monitored by the controller-PC. In addition, every three minutes the test software initiated the measuring of the volunteer's blood pressure.

Exposition test area

Diagram 3.4 illustrates the exposition test area, which was set up in the antenna test chamber of the Institute for High Frequency Technology. The probands were placed 40 cm away from the horn antenna for frequencies below 77 GHz and they were placed 20 cm away for the frequencies +776 Hz and 110 GHz. Then proband's back was exposed. On the left upper arm blood pressure measurements were taken. On the middle and ring finger of the right hand skin conductivity was measured and on the back of the hand skin temperature was measured. The ECG electrodes were placed on the proband's chest.

4. Statistical evaluation

Introduction

The goal of the study was to uncover any possible effects from micro wave signals on the vegetative nervous system. The investigation was carried out on a small sample size in relation to the entire population. Therefore, the results have to be statistically well confirmed. It was expected, with regard to the signals used in the experiment, that most likely only very small effects would occur, but that on the other hand the vegetative nervous system, which responds to emotional stimuli, would show considerable variations from person to person and over time. The task is, circumstances permitting, to rule out or show very subtle effects in the presence of large variability. For this purpose the variability between probands and observation intervals is already reduced as far as possible in the planning stage of the experiment.

A model is assumed for establishing a relationship between effects, disturbances and observations; this is a usual practice in statistics. The conditions for the application of the model are checked against the data. After that parameters can be estimated, confidence intervals calculated, hypotheses checked or alternatives are decided on. The result is a statement with a certain probability.

The development and the testing of the model are important steps, in conjunction with the medical questions that are to be answered. The statistical proposition is then obtained with formal calculations. Once again what is essential is the interpretation and the evaluation of the findings, in other words the link between the statistical model and the practical application. These steps are presented in the following section of this article.

Planning of the experiment

The selected procedure for the experiment, a cross-over design, reduces variability, in comparison to a conceivable categorization of the probands into those who are exposed and those who are not. The sample size of 50 probands was determined by a physiologist according to experiences with magnitudes and variability of physiological variables.

Fatigue effect

In previous studies it has been shown that after a calming-down phase further calming-down effects still occur, which may probably overlap the exposure effects. Variations in room temperature also had effects. Since these effects and the probable irradiation effects in the experiment cannot be independently regarded, they were assumed in the model. In retrospect the occurrence of fatigue effects proved to be an advantage for the analysis, since in this way the orders of magnitude can be estimated which were still captured by the statistical model.

Statistical model

The model used is based on a linear model, i.e. it is assumed that the effects are additive. The observed value for every measurement is calculated by adding together the mean value of the fatigue effect, the influence of the room temperature, possible effects from exposition and random disturbances. Random disturbances are assumed to be normally distributed with zero expectation value. Deviations from the mean average value have to be attributed to the effects. When a disturbance is caused by many independent effects, approximate normal distribution is to be expected. However, the conditions for the application of the linear model have to be checked.

What the null hypotheses means in this case is that no exposition effects are present. What this means for the model is that for every observed variable the value differences for exposition or non-exposition is equally zero and that all deviations from zero are attributed to random disturbance.

The test variable with known distribution is constructed under the assumption of the null hypotheses with linear algebraic methods [2]. Then one can explicitly describe that the observed effects are probably caused by random variations. One can thus give the probability of a false rejection of the null hypotheses (based on the assumed model).

A vivid interpretation

For the interpretation of the findings, the example of the manufacturer and the consumer is suitable. Both desire to have a good product without "effects". The null hypothesis means, "no effects occur", i.e. certain differences are explainable with the usual variability. Both contracting parties desire that this hypothesis is correct. Deviations can occur in each specific sample. Let P be the probability that under the null hypothesis an observed effect stems from random deviations and not a real physical effect. Therefore, p is the probability of a false rejection of the null hypothesis, "no effect". The manufacturer desires that a small p is selected, in order to avoid unnecessary rejection. The consumer would rather have a big p, so a genuine effect does not go undetected. In many specific situations it happens to be that a big p stands for a slight probability that a false assumption of the null hypothesis will occur. However, these "errors of a second kind" can not be quantified within the framework of the model.

Controlling the conditions

After the measurements have been carried out, the data in ASCII files undergoes a statistical evaluation and is checked for gross mistakes and discrepancies. This automated inspection helps to detect invalid measurements, which occur when the pickup slips out of place.

Then the statistical mathematical methodology is checked, if the conditions were met for a linear model: conditions of an approximate normal distribution with a Mahalanobis-test on statistical outliers [4] and with a Shapiro-Wilk-test for every individual variable [4]. The effect of probable statistical outliers are thoroughly and individually investigated by calculating each one with and without the potential outlier, especially the homogeneity of the covariant matrix is checked [3] (satisfactory homogeneity in the entire data, very good homogeneity with elimination of outliers).

Conducting the tests

In the actual test the respective test variables are enough (fatigue effect, the influence of the room temperature, possible exposition effects) for an F-distribution with a known degree of freedom (independent of the size of the sample and the number of test variables). The possible exposition effect showed $p=0.91$(calculated with the statistics package [4]). This means that the existence of physical exposition effects can be ruled out, even when one takes into account that in about 90% of all experiments, the assumption that "there are no exposition effects" is falsely rejected. Therefore, the hypothesis is statistically well-confirmed stating that "there are no exposition effects", at a selected frequency or at selected frequencies and intensities (with regard to the measured parameters).

5. Results

A statistical evaluation of the test data could not prove that micro wave signals have an effect on the vegetative nervous system.

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[2] H. Pruscha: *Angewandte Methoden in der Mathematischen Statistik*, Teubner Verlag, Stuttgart, 1996

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