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onderzoek

PHYSIOLOGICAL EFFECTS OF IMPULSIVE NOISES ON HUMAN BEINGS

Results of a ten-minute exposure

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PREFACE

In 1980, an investigation on the physiological effects of impulsive noises was carried out at the TNO Research Institute for Environmental Hygiene. The project was co-ordinated by mrs. drs. W. Passchier-Vermeer and carried out by ing. A.J.M. Rövekamp (project leader) and mrs. J. Dijkers (assistent).
The research, which is a joint European project, has been carried out in co-operation with laboratories in Italy (Department of Audiology of the University of Torino, project leader prof. dr. G. Rossi) and in Germany (Department of Physiology and Cybernetics of the University of Erlangen, project leader prof. dr. M. Spreng).

This report presents details of the pilot study carried out in 1980 in the laboratory at Delft. An outline of the measured physiological parameters, the organization of the research and the results of 50 experiments are presented in this report.

SUMMARY

In this report the results of a pilot study carried out in 1980 in the laboratory of the TNO Research Institute for Environmental Hygiene at Delft are presented. In the pilot study, fifty experiments were carried out with ten subjects (males and females). During an experiment a subject was exposed for ten minutes to artificial impulsive noises, constant white noise or quiet.
The aim of this study was to determine whether physiological effects result from exposure to artificial impulsive sounds and to determine the magnitude of the effects relative to effects from constant noise.
For this purpose, the effects on parameters of blood circulation and respiration were studied.

The results show small and in most cases no statistically significant differences in the measured physiological parameters of persons exposed to constant noise, impulsive noises or quiet.
Impulsive noises cause an increase in the respiration rate, whereas constant noise and quiet this rate decreases, and a larger decrease in the heart rate, less increase in the arithmia quotient and less decrease in the relative impedance plethysmogram when comparing the results with constant noise and quiet.
Therefore exposure to ten-minute impulsive noises does not cause effects, which prove that impulsive noises form a larger load on the physiological parameters measured, than ten-minute exposure to constant noise or quiet.
Perhaps the total exposure period of ten minutes was too short to show effects.

CONTENTS

1. INTRODUCTION

In this report the results of a pilot study carried out in 1980 in the laboratory of the TNO Research Institute for Environmental Hygiene at Delft are presented. This research has been carried out in co-operation with laboratories in Germany and Italy. Representatives of these three countries are members of subgroup 2: "Physiological effects of impulsive noises on human beings".
This subgroup 2 participates in a joint European research project studying "The effects of impulsive noises on human beings". The research program consists of two parts:

- a pilot study (already made in 1980),
- the actual research (depending on the results of the pilot study).

In the pilot study, fifty experiments were carried out with ten subjects (males and females). They were exposed to artificial impulsive noises, constant white noise and quiet. The exposure lasted ten minutes and the noises had an equivalent sound level of about 80 dB(A).
The purpose of this pilot study was to determine the physiological parameters most sensitive to noise exposure. Therefore, some of the physiological parameters were measured by two or all three participating laboratories, and other by only one laboratory.
This study was also made to determine whether physiological effects result from exposure to artificial impulsive sounds and to determine the magnitude of these effects relative to effects from constant noise.
For this purpose, the effects on parameters of blood circulation and respiration have been studied by the TNO Research Institute for Environmental Hygiene at Delft.

In other investigations of the Institute, the effects of a two hour exposure to constant and fluctuating white noise with sound levels varying from 70 to 100 dB(A) and traffic, aircraft, railway and impulsive noise with an equivalent level of 75 dB(A) were studied. Reports B 373E [1] and B 432 [2] and the publication P 726 [3] describe the details of this research.

Based on this experience this pilot study has been carried out. The measuring methods, physiological parameters, measuring equipment, experimental room and methods for data processing were the same as reported in the reports just mentioned [1,2]. Therefore in this report only the organization of the research, the processing of data and the results are presented. Some conclusions are given in chapter 5.

2. ORGANIZATION OF THE RESEARCH

2.1 Experimental method

In the pilot study, 50 experiments were carried out with ten young persons (5 males and 5 females). During these experiments, the effect of impulsive noise exposure on a number of parameters of blood circulation and respiration were studied. Also experiments with constant noise and silence during the exposition period were carried out. The aim was to study whether there would be any difference between these two experiments and the experiments with impulsive noise. The following physiological parameters were examined:

heart beat frequency
sinus-arithmia
absolute impedance plethysmogram
relative impedance plethysmogram
systolic and diastolic blood pressure
respiratory frequency

Five experiments were executed with each subject on five different days. The sequence of the different experiments was given at random. Only the exposure on tape number five was always given on the last day. Appendix 1 shows the details of the sequence of the experiments carried out.

All subjects were in the age of 15 to 30 years and had a good health and a hearing loss lower than 15 dB between 250 Hz and 8000 Hz, measured by means of a pure tone audiometer.

During an experiment a test subject was alone in an air-conditioned room, in a sitting position on a chair. The subject had to sit there during the whole experiment. Photograph 1 shows one of the subjects during an experiment. The background noise level in the room was about 35 dB(A).

Photo 1: Subject is sitting in the experimental room.

On the five different days the subject was exposed to noise, recorded on tape.

TAPE 1- Constant white noise (sound level of 80 dB(A))

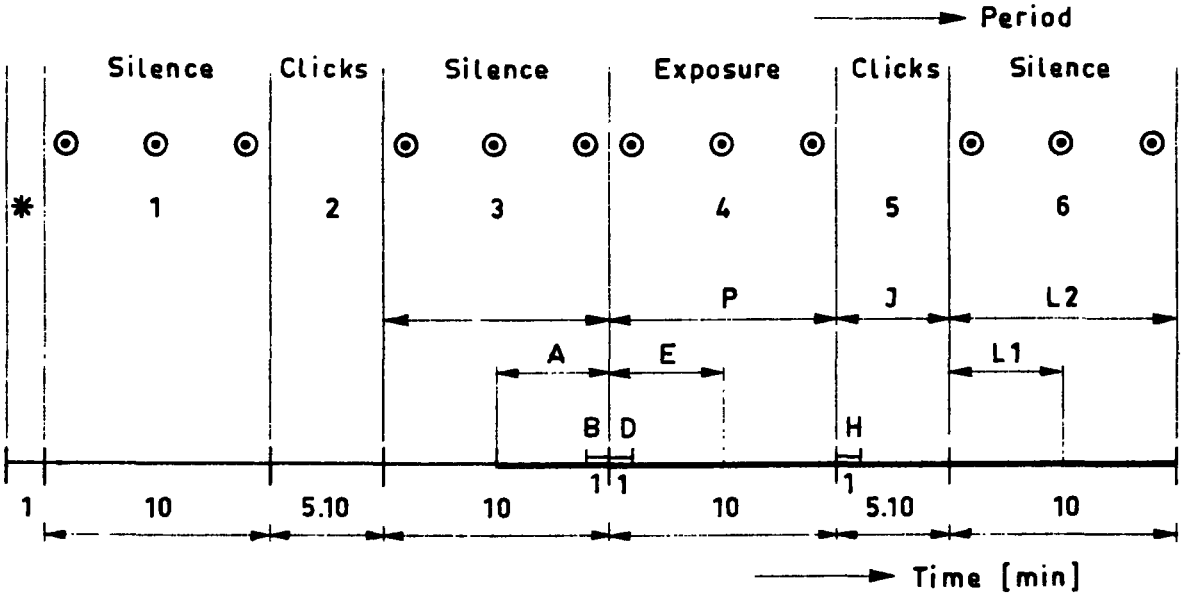
TAPE 2- White noise bursts (lasting 200 msec at 87 dB(SPL))

TAPE 3- Quiet (about 35 dB(A))

TAPE 4- Artificial regular impulsive sound (peak level at 96 dB(SPL-fast-), duration about 100 ms per impulse)

TAPE 5- Artificial irregular impulsive sound (with the same characteristics as those given for TAPE 4)

More details about these tapes are given in appendices 1,2 and 3.



⊙ Measurement of blood pressure

✱ Calibration period

Figure 1 Division of the experiments into several periods

Each experiment is divided into six periods (see figure 1):

PERIOD 1- First 10 minutes of the experiment quiet

PERIOD 2- For 5 minutes the subjects were exposed to click trains for measurement of neuro-physiological parameters

PERIOD 3- Again 10 minutes of quiet

PERIOD 4- Exposure to one of the noises recorded on the tape mentioned above

PERIOD 5- Equal to period 2

PERIOD 6- Again 10 minutes of quiet

For analysing the test results, a further division of each experiment is also given in Figure 1. Each period is defined in table 1. During all periods the subject was wearing the TDH-39 headphone. (For detail see photo 1). At the end of each experiment the subject was asked for his or her subjective experience of the noise exposure concerned.

Table 1: Definition of the periods of an experiment.

Period code (EG code:)	(IMG code:)	Definition of the period
A	3-05	5 last minutes before beginning of noise
B	3-01	last minute before beginning of noise
D	4-01	first minute after beginning of noise
E	4-05	5 first minutes after beginning of noise
P	4-10	10 first minutes after beginning of noise (identical to period 4 /*)
H	5-01	first minute after termination of noise
J	5-05	5 first minutes after termination of noise (identical to period 5 /*)
L1	6-05	5 first minutes after termination of clicks
L2	6-10	10 first minutes after termination of clicks (identical to period 6 /*)

/* See figure 1.

2.2 Processing of the physiological signals

During all periods the following physiological signals were recorded on tape. The signals are given in figure 2. They are:

-1- Respiration
-2- Blood pressure
-3- Relative and absolute impedance plethysmogram
-4- ECG

From the signals -1- and -4-, the number of respirations and heart beats per minute were counted. For calculating the arithmia quotient, the time between every two heart beats was measured by computer. The difference in interval time of every two intervals which follow after each other was calculated. As well as the absolute value of each difference, as the sign (positive or negative), if available (if a difference is zero there is no sign) was stored in memory of the computer for every 32 heart beats. If the sign changed from positive to negative or from negative to positive, it was called a sign change. To determine these sign changes the computer took the value of the first interval difference up to the last one of the 32 heart beats skipping the points of no difference. The number of sign changes was counted and the absolute value of the differences was added for every 32 heart beats. At the end of every 32 heart beats the sum of the absolute values of the differences in interval time was divided by the number of sign changes. This quotient was called the arithmia quotient.
From the relative part of the impedance plethysmogram, the maximum value of this signal, occurring as a result of a contraction of the heart, was determined and plotted, also for every 30 seconds the mean of these values was calculated by computer.

As an example, plots of subject 1 exposed to white noise and white noise bursts are given in appendix 3.

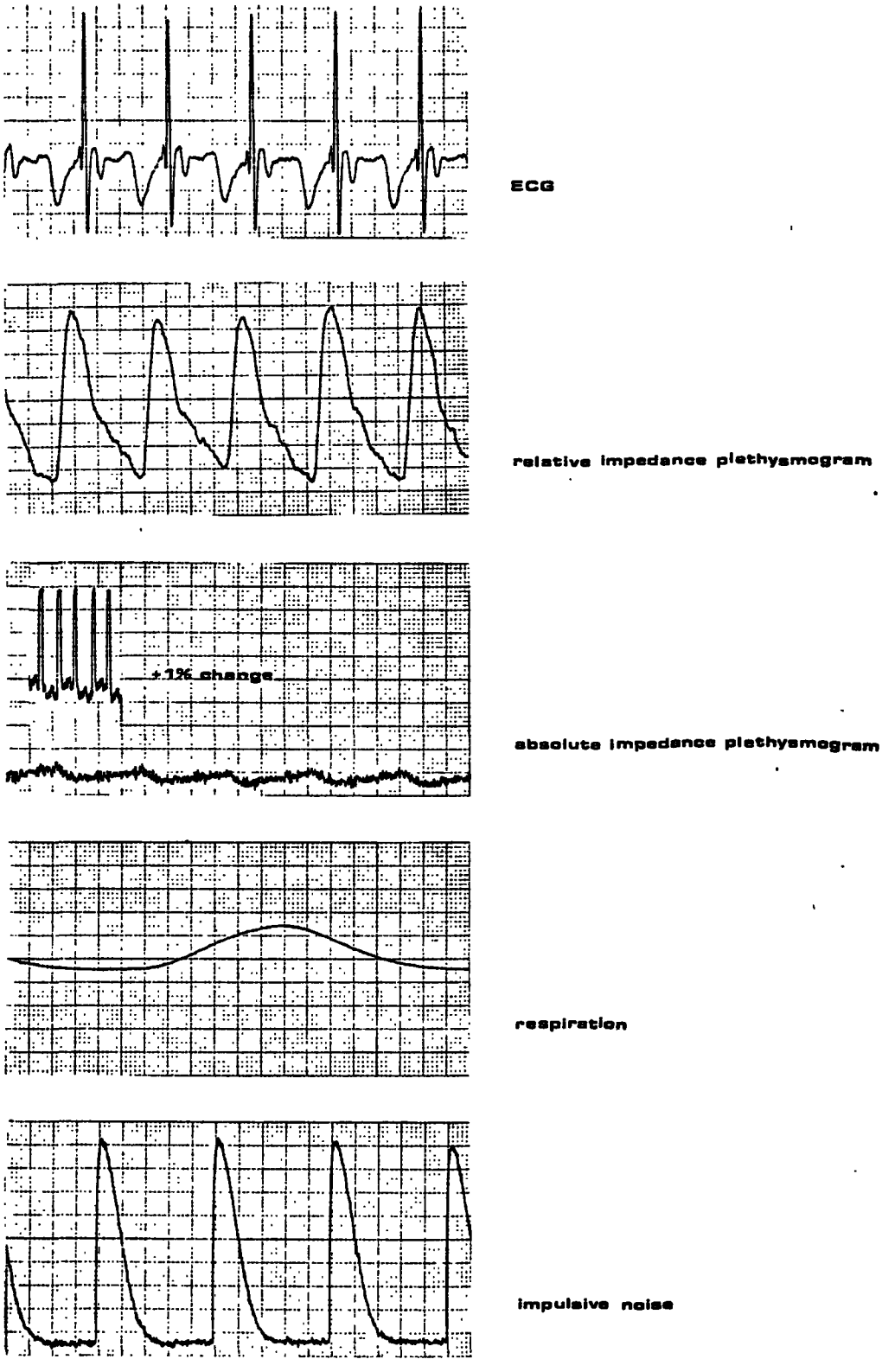


Figure 2: Measured physiological signals (above) and the sound level of impulsive noise (below).

3. PROCESSING OF DATA

3.1 Mean values and the spread of data

For each period as mentioned in table 1 of paragraph 2, the mean value of the one-minute values of the respiration rate and the heart rate, the thirty-second values of the relative impedance plethysmogram, the arithmia quotient per 32 heart beats and the systolic and diastolic blood-pressure were calculated.
Tables of all results are given in volume 2 of this report. The standard deviation of the values is also given in volume 2.

3.2 Normalized differences

To make the results of the differences between several periods more comparable, the calculated differences were divided by the mean -A- value. The results derived in this way were called "normalized differences between several periods". The results of these calculations are also given in volume 2 of this report.

3.3 Sign test

To show statistical significant effects of noise exposure, the sign test, which is suitable for a small amount of data ($N \leq 25$, $P=0.5$) was used. For this purpose, the total amount of normalized differences for each period, each exposure and all subjects together was counted.
A difference of zero was not counted. The total amount of differences was called the total number of signs (N). The positive differences were also counted in the same way. They were called the total number of positive signs (N(+)).
Under the hypothesis H0, the expected number of positive and the expected number of negative signs are equal. So, one can say:

$$H0: P(N(+))=P(N(-))=0.5 \qquad ..(1)$$

As an alternative hypothesis was taken:

$$H1: P(N(+)) \# P(N(-1)) \# 0.5 \qquad ..(2)$$

To calculate P(N(+)), the binomial test formula (3) was used:

$$P(N(+)) = \sum_{i=0}^{N(+)} \binom{N}{i} * P\left(N(+)\right)^{i} * P\left(N(-)\right)^{N-i} \qquad ..(3)$$

Based on this formula (3) the probabilities are given in table 2 associated with the number of positive signs N(+) and the total number of signs (N).

For each period and exposure, table 2 was used to find the probability P(N(+)) for the total number of signs N and P(N(+))=P(N(-))=0.5 . If this probability is larger than the usual accuracy 1-a=0.950 for a one-tailed test, the hypothesis H0 is rejected and the conclusion can be given that there is a significant difference in the number of positive signs N(+) and negative signs N(-).

The results of the above-described sign test are given in appendix 4.

Table 2 : Probabilities associated with the total number of signs (N) and the total number of positive signs N(+).

N \ N(+)	1	2	3	4	5	6	7	8	9	10
5	.188	.500	.812	.969	*					
6	.109	.344	.656	.891	.984	*				
7	.062	.227	.500	.773	.938	.992	*			
8	.035	.145	.363	.637	.855	.965	.996	*		
9	.020	.090	.254	.500	.746	.910	.980	.998	*	
10	.011	.055	.172	.377	.623	.828	.945	.989	.999	*
			1					2		

In this table one-tailed probabilities under HO are given for the binomial test, when P=Q=0.5 . On the left of line 1 and on the right of line 2, are shown the one-tailed probabilities of N(-) and N(+), respectively, with an accuracy of more than 95 % (1-a=0.950).

3.4 Mean of normalized values

To give more significance to the sign test, the mean value of the normalized values for all subjects together per exposure and per period were calculated. So, no more than than 45 values were obtained per parameter. See appendix 3 for these values.

3.5 Back to reality

In most cases it was very istructive to know the values of each parameter expressed in the specific dimension. For instance, the heart rate in beats per minute and so on for the other parameters. Realizing this, for all subjects together the mean -A period- value per exposure was calculated. In appendix 3, the product of the mean of the normalized values and the mean -A period- values is given. The physiological dimensions of each parameter are back again.

4. RESULTS AND DISCUSSION

In this chapter, a description of the results of each parameter per exposure is given for all subjects together. The normalized mean values in appendix 3 are expressed in % and are plotted in figures 2 up to 7.
The codes "E" and "D" mean:

$$E = \frac{E-A}{A} * 100\% \qquad D = \frac{D-B}{A} * 100\%$$

In the next paragraphs a description is given of possible effects of exposure with regard to period A. Minute-effects are also given in figures 2, 3, 4 and 5 as dotted points ◘ .

4.1 Respiration

Figure 3 shows the effects on the respiration rate.

-First minute-effects after exposure starts-
Exposure 5 gives the largest effect. Within the first minute of the exposure the respiration rate increases with +6 %.

-First minute-effects after the end of exposure-
Exposure 3 (experiment without noise exposure) gives an increase with +6 %. This may be caused by click series, which just started.
Exposure 5 causes a significant increase with 1.2 %.

-Effects during exposure periods E and P-
During exposures 1 and 2, there is an increase between period E and P of 2.6 % and 2.2 % (which is significant).
Exposure 5 shows a light increase during period E with 1.2 %.

-Recovery in period L2 and L1-
Except in period L1 of exposure 5 in both periods a decrease varying from 2.5 % to 7 % is seen.

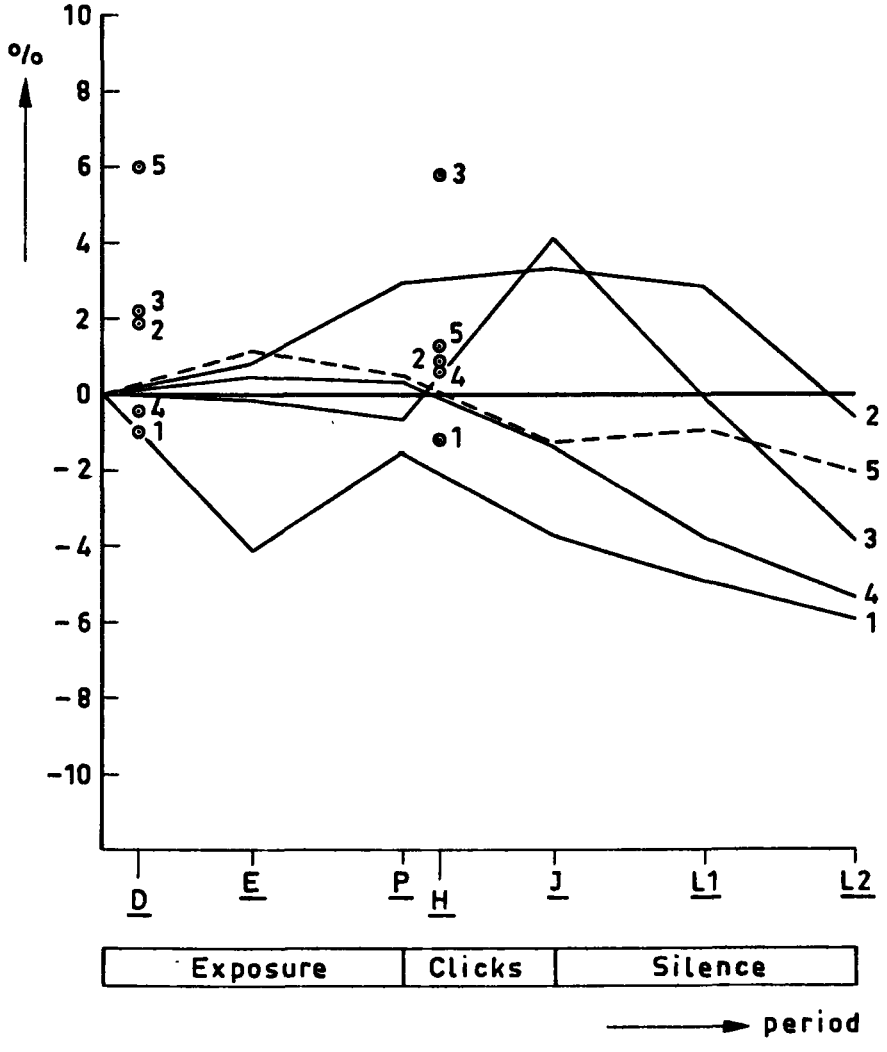


Figure 3 Respiration

4.2 Heart beat

Figure 4 shows the effect of the various exposures on the rate of the heart beat.

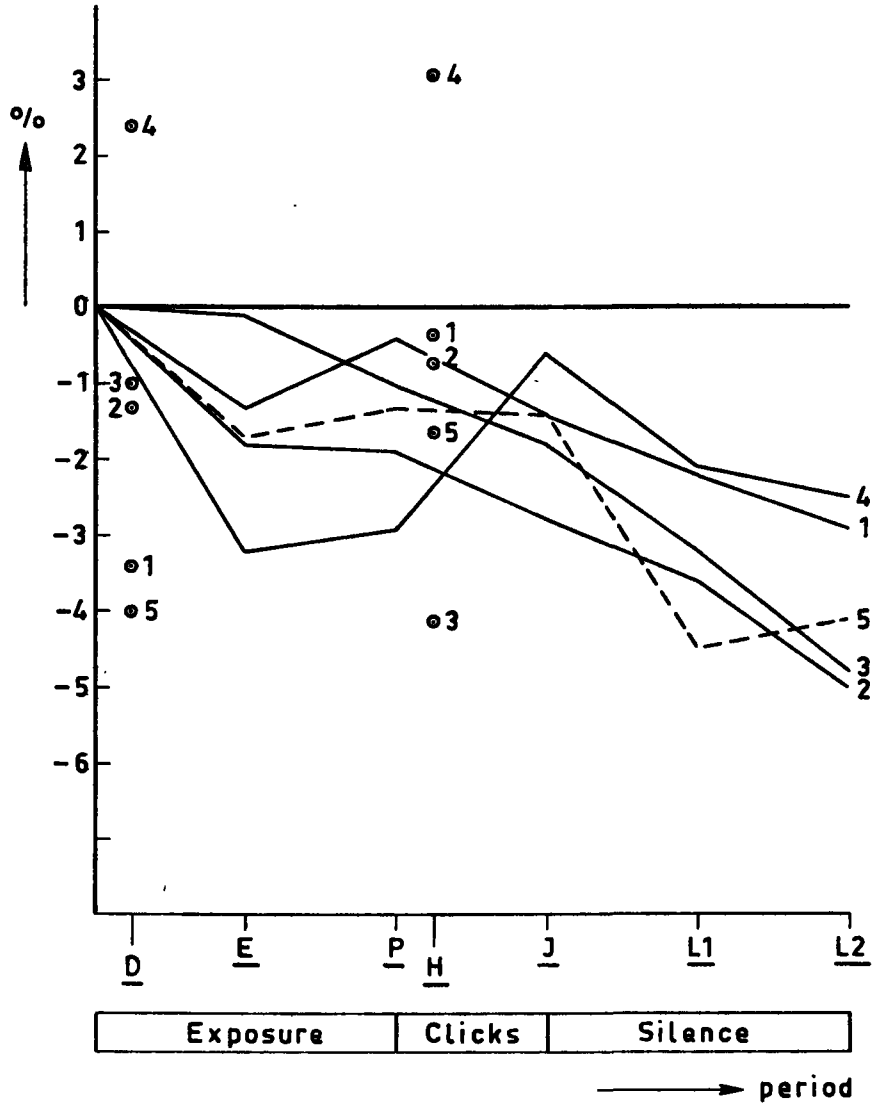


Figure 4 Heart Beat

-First minute effects after exposure starts-
Only exposure 4 shows a significant increase within the first minute with 3.2 %.
The minute values of exposures 3, 2, 1 and 5 decrease with -1 %, -1.3 %, -3.4 %, and -4 %, respectively.

-Effects after exposure ends, during click period J-
Again exposure 4 shows a significant increase with 3.1 % within the first minute (H).
This tendency is continued with an increase by 2.3 % during period J.

-Effects during exposure-
During exposure of experiments 1, 3, 4, and 5, there is a significant decrease of the heart rate.
Further this tendency continues during the periods J, L1 and L2 of experiments 2, 3, and 5.
For period L2, the values decrease to -5 %, -4.8 %, and -4.1 %, respectively.

4.3 Arithmia of the heart beat

Figure 5 shows the effects of the various exposures on the regularity of the heart beat.

-First minute effects after exposure starts-
Only exposure 1 shows a significant increase by 78.4 %.

-Effects during exposure periods E and P-
In period E, exposures 5, 1, 3, and 2 show an increase of the arithmia quotient.
Except for exposure 2 this continues within the second part of period P.

-Remarkable effects in the periods J, L1 and L2 for exposures 5 and 1-
In these experiments there is an increase with 100 % and about 80 %, respectively.

Except for period J, all effects during experiment 5 show a significant increasing tendency.

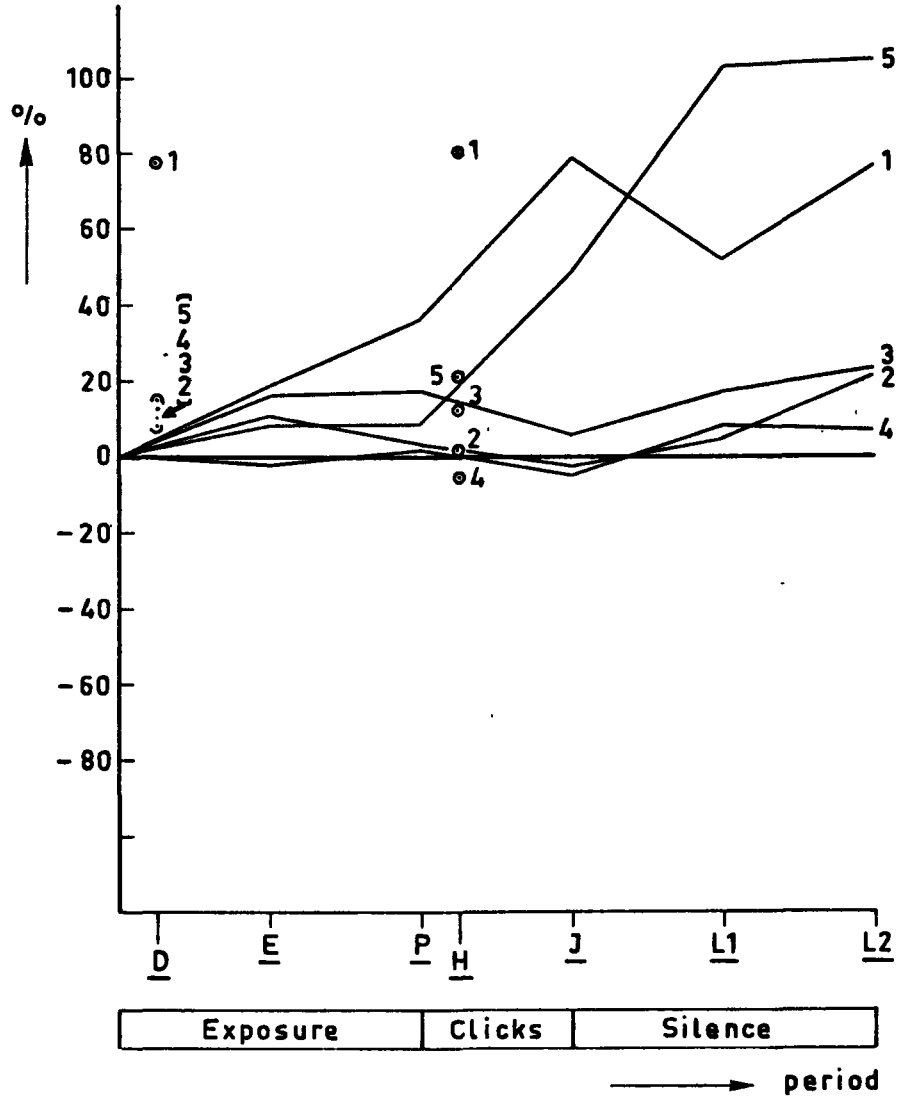


Figure 5 Arithmia

4.4 Relative impedance plethysmogram

Figure 6 shows the effect of noise exposure on the relative impedance plethysmogram.

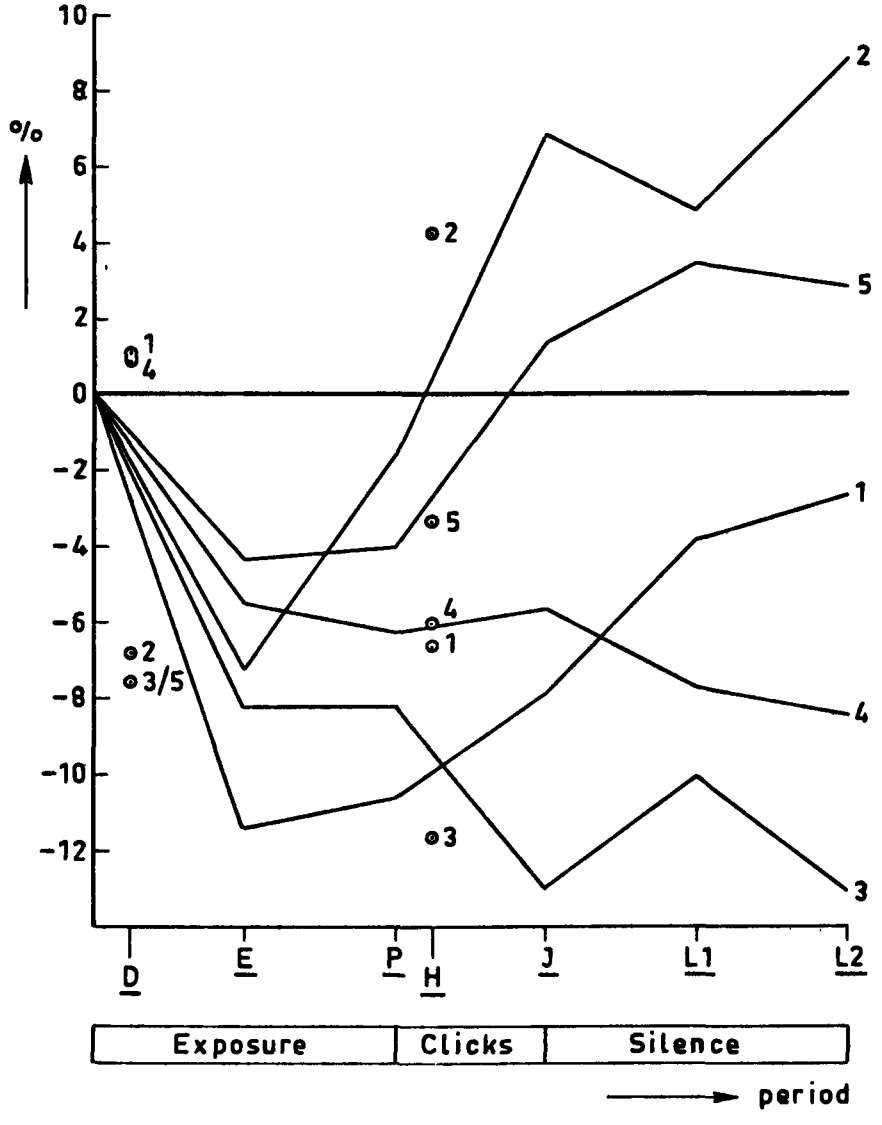


Figure 6 Relative Impedance Plethysmogram

-Effects on impedance plethysmogram during exposure period-
Within period E for all experiments there is a decreasing tendency, but in the second part of period P there is a certain increasing tendency.

-Click effects-
Within period J the largest decrease observed in experiment 3 is up to -13 % (which is statistical significant).
Also the minute value increases further to -11.6 %.

4.5 Blood pressure

The various values of periods E, P, L1, and L2 of the systolic and diastolic bloodpressure are given in figures 7 and 8, respectively.

Systolic blood pressure

Only exposure 1 causes a significant decrease up to -2.9 % in period E and up to -2.1 % in period P.
As can be seen there is no recovery during periods L1 and L2.
In all cases a decreasing tendency of the systolic blood pressure can be seen.

Diastolic blood pressure

-During the exposure period-

At the end of period P, experiments 5, 2, and 4 show an increase up to 1.5 %, 0.9 %, and 0.7 %, respectively.
Experiments 3 and 1 show a decreasing tendency.

-During recovery period-
Remarkable is the increasing tendency up to 2.5 % during experiment 3.
Experiment 1 shows a decrease in this period to -5.2 %.

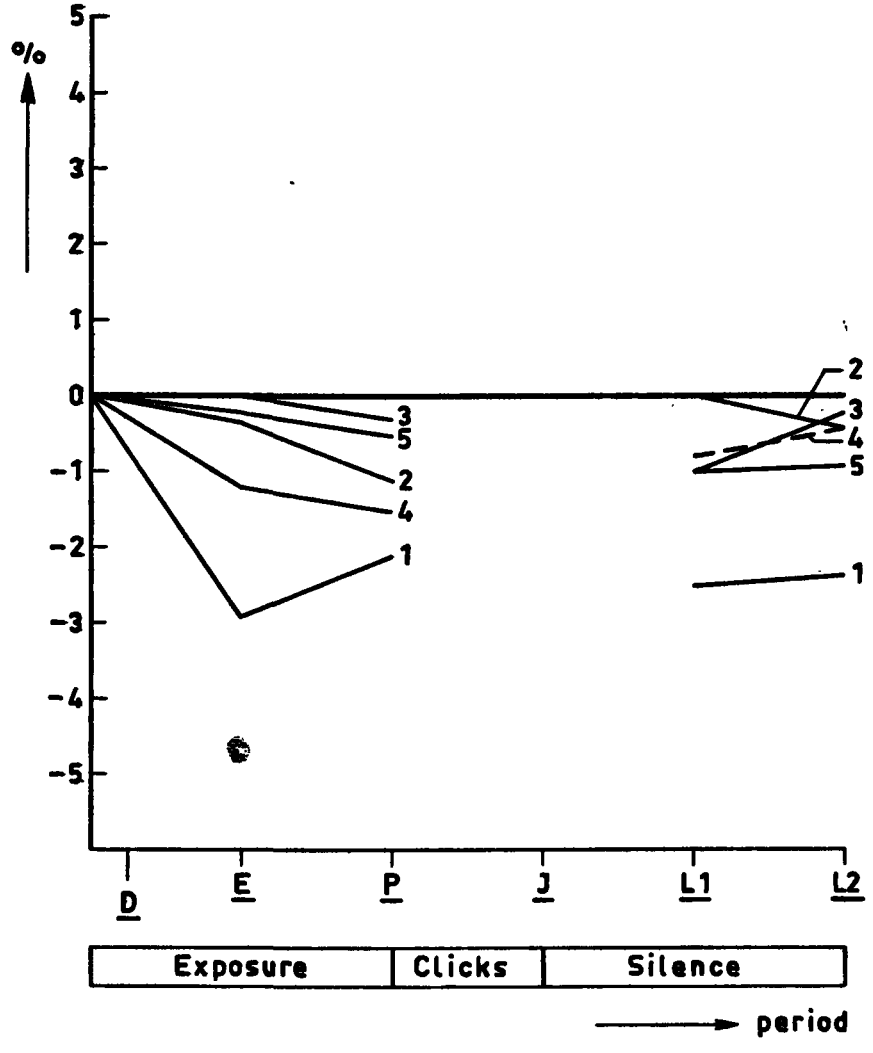


Figure 7 Systolic Bloodpressure

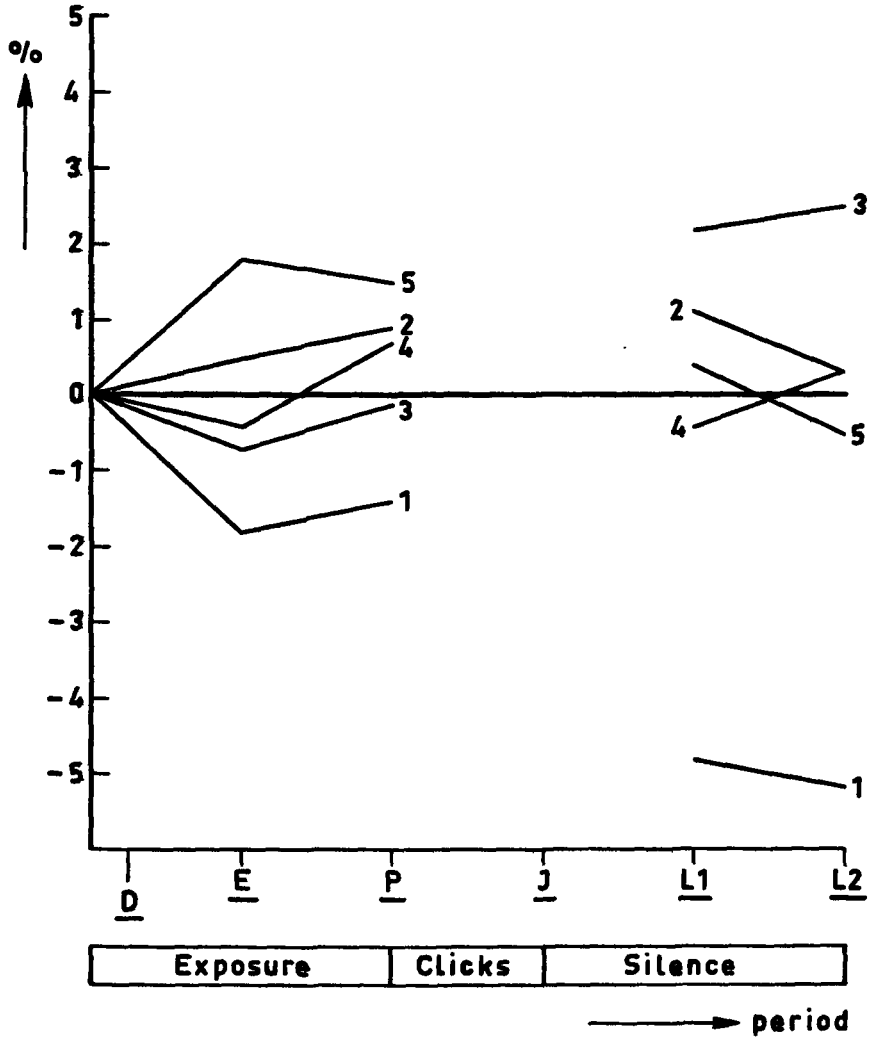


Figure 8 Diastolic Bloodpressure

5. CONCLUSIONS

In this chapter the results of chapter 4 are summarized per physiological parameter.
A difference in the effects caused by impulsive noise and constant noise or quiet is given.

5.1 Respiration rate

The respiration rate increases slightly during exposure to impulsive noises (2,4,5), whereas this rate decreases during constant noise (1) and quiet (3).
These effects are not statistically significant.
The effects of the clicks used for brainstem responses after the exposure to white noise pulses (2) and quiet (3) are comparable to the effects of the impulsive noises (2,4,5).

5.2 Heart rate

During the exposure period (P), there is a slight decrease of the heart rate. The impulsive noises (2,4,5) cause a larger decrease than constant noise (1) and quiet (3). These effects are statistically significant for the experiments 1,3,4 and 5.

5.3 Arithmia quotient

The arithmia quotient increases more during exposure to constant noise and quiet than during impulsive noise.
Only quiet and irregular impulsive noise (5) show statistically significant differences.

5.4 Relative impedance plethysmogram

During exposure to constant noise and quiet, the the parameter decreases statistically significant.
During exposure to impulsive noise, it also decreases, but not statistically significant and with smaller values.

5.5 Blood pressure

In all cases, there is a decreasing tendency of the systolic blood pressure during the exposure period.
The diastolic blood pressure slightly increases during exposure to impulsive noises (2,4,5) and decreases during quiet and constant noise exposure.

5.6 Final conclusions

The changes of the measured physiological parameters of persons exposed to constant white noise for a period of ten minutes are in most cases not statistically significant different from those due to impulsive noises. Impulsive noises cause an increase in the respiration rate, whereas during constant noise and quiet this rate decreases , and a larger decrease in the heart rate, less increase of the arithmia quotient and less decrease in the relative impedance plethysmogram compared with constant noise and quiet.
To conclude it can be said that exposure to ten minute impulsive noises does not cause effects which prove that impulsive noises form a larger load on the measured physiological parameters than ten-minute exposure to constant noise or quiet.
From former experiments [2,3] with a two-hour exposition to impulsive noise, it was concluded that impulsive noise causes larger effects than other environmental noises and quiet.
Perhaps the total exposition period of ten minutes in this pilot study reported is too short to show effects.

6. LITERATURE

[1] Rövekamp, A.J.M. and W. Passchier-Vermeer. Noise effects. Effects of noise exposure on blood circulation and respiration of man. Results of a two-hour noise exposure on groups of younger and older people. Report B 373E, Delft, IMG-TNO, 1978.

[2] Rövekamp, A.J.M. Invloed van woonomgevingsgeluid op de mens. (Effects of environmental noise on human beings -Dutch Report-) Experimenteel onderzoek naar de invloed van woonomgevingsgeluid op de bloedcirculatie en ademhaling van de mens. Report B 432, Delft, IMG-TNO, 1980.

[3] Rövekamp, A.J.M. Invloed van lawaai op de bloedcirculatie en ademhaling van de mens. (Influence of noise on blood circulation and respiration of man -Dutch Publication-) Publication P 726, Delft, IMG-TNO, 1980.

APPENDIX 1: Sequence of experiments

Listing of code numbers

EXPERIMENT	EXPOSURE	SUBJECT	SEQUENCE
1	1	1	1
2	2	1	2
3	3	1	3
4	4	1	4
5	2	2	1
6	3	3	1
7			
8	3	2	2
9	1	3	3
10	4	4	1
11	4	2	3
12	1	4	2
13	1	5	1
14	1	2	4
15	2	4	3
16	2	3	4
17	2	6	1
18	3	6	2
19	3	7	1
20	3	4	4
21	2	5	2
22	3	5	3
23	4	5	4
24	4	6	3
25	4	7	2
26	4	8	1
27	1	8	2
28	1	7	3
29	1	6	4
30	5	2	5
31	4	3	4
32	2	8	3
33	5	3	5
34	3	8	4
35	5	5	5
36	5	4	5
37	5	6	5
38	1	9	1
39	2	10	1
40	2	9	2
41	5	8	5
42	3	10	2
43	2	7	4
44	4	10	3
45	5	7	5
46	1	10	4
47	5	10	5
48	3	9	3
49	4	9	4
50	5	9	5

APPENDIX 2: More details of the tapes 1..5

Tapes no. 1,2,3.

Type of sound signal	Playing time	Tape number
Sinusoidal at 1000 Hz for calibration at 90 dB SPL	1'00".	1,2,3
Silence	10'00"	1,2,3
Four groups of 1024 clicks with a 30" silent gap between each group and the next	5'10"	1,2,3
Silence	10'00"	1,2,3
Continuous white noise at 80 dB lin. SPL	10'00"	1
Impulses of 1 Hz white noise lasting 200 msec at 87 dB lin. SPL (rise and fall time = fast)	10'00'	2
Silence	10'00"	3
Four groups of 1024 clicks with a 30" silent gap between each group and the next	5'10"	1,2,3

Fourth tape

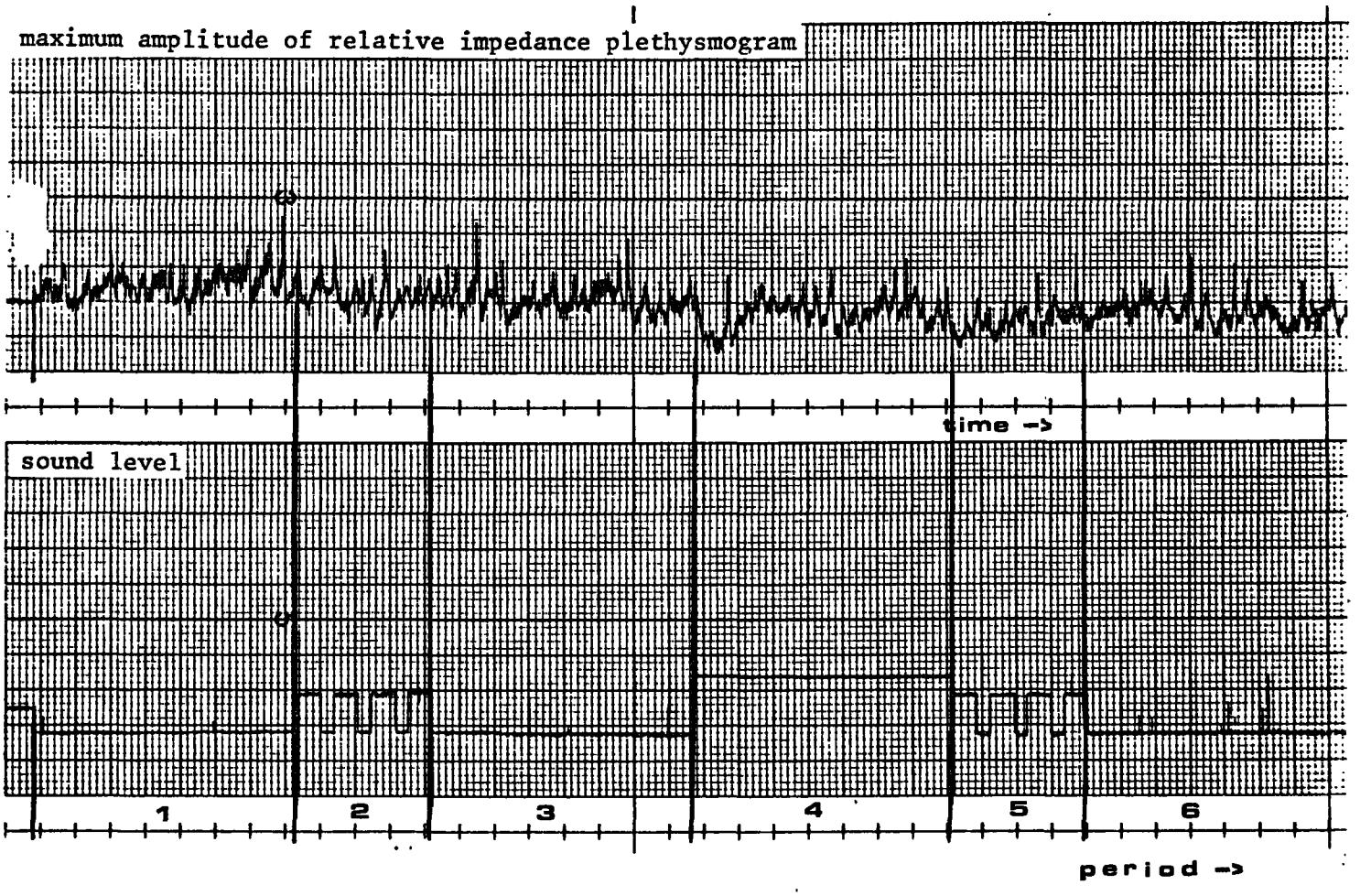
Type of signal	Playing time	Track
Sinusoidal al 1000 Hz for calibration at 84 dB (SPL)	1 m	1
Silence	10 m	
Four groups of 1024 clicks with a 30 s silent gap between each group and the next	5 m 10 s	
Stimulus		1
Trigger		2
Silence	10 m	
Impulses, repetition rate 1 per second, Rise time: 10 ms, Exponential decay time t_e=100 ms, Max Peak value 96 dB (SPL) -fast- = L_h Signal/noise Ratio 66 dB L_{eq}= 80 dB (SPL)$_{10\ m}$	10 m	1
Four groups of 1024 clicks with a 30 s silent gap between each group and the next	5 m 10 s	
Stimulus		1
Trigger		2

Fifth tape

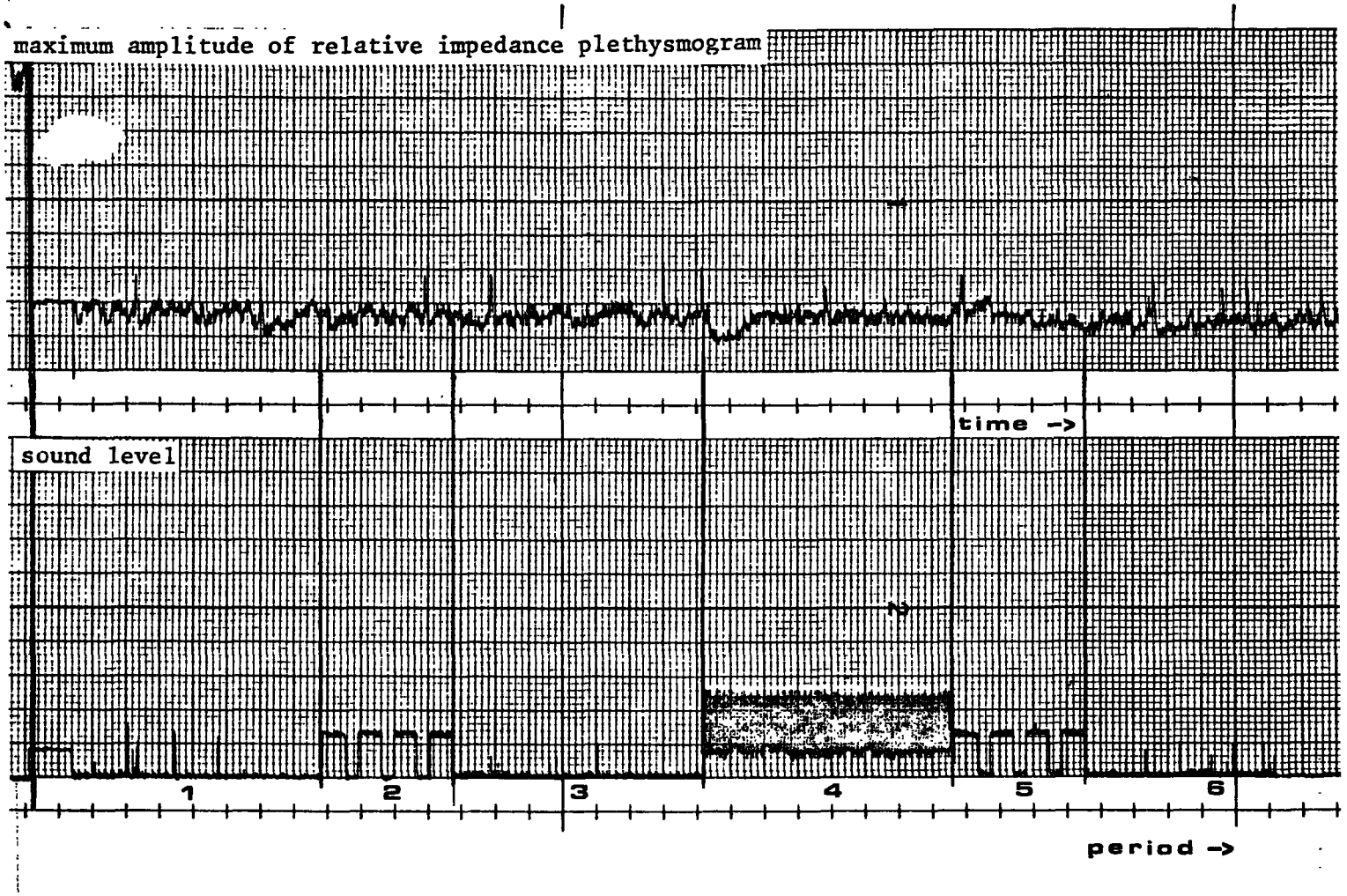
Type of signal	Playing time	Track
Sinusoidal al 1000 Hz for calibration at 84 dB (SPL)	1 m	1
Silence	10 m	
Four groups of 1024 clicks with a 30 s silent gap between each group and the next	5 m 10 s	
Stimulus		1
Trigger		2
Silence	10 m	
Impulses: 588 impulses in 10 minutes *) Rise time:<10 ms, Exponential decay time t_e=100 ms, Max Peak value 96 dB (SPL) -fast- = L_h Signal/noise Ratio 66 dB L_{eq}= 80 dB $(SPL)_{10\ m}$ *) Distance between two impulses 400 msec $< \Delta t <$ 4000 msec	10 m	1
Four groups of 1024 clicks with a 30 s silent gap between each group and the next	5 m 10 s	
Stimulus		1
Trigger		2

APPENDIX 3: Plots of two experiments

Subject 1 Exposure code 1



Subject 1 Exposure code 2



APPENDIX 4: Statistical values

TABLE: 1.1 SIGN TEST

PARAMETER :RESPIRATION CODE: 001

PERIOD CODE: EXPOSURE CODE:

	1		2		3		4		5	
	N	N(+)	N	N(+)	N	N(+)	N	N(+)	N	N(+)
(E.-A.)/A.	10	3	10	6	9	5	9	4	7	3
(P.-A.)/A.	9	4	9	7	10	5	10	5	9	4
(P.-E.)/A.	10	7	10	8	9	4	9	4	9	6
(J.-A.)/A.	10	4	8	5	6	6	10	4	7	4
(L1-A.)/A.	10	4	10	6	8	3	10	3	9	4
(L2-A.)/A.	10	2	10	4	10	4	10	3	9	2
(P.-L2)/A.	10	7	10	5	10	6	9	7	9	6
(D.-B.)/A.	6	3	5	3	8	5	7	4	8	7
(H.-B.)/A.	6	2	6	4	8	6	7	4	9	5

N : TOTAL NUMBER OF SIGNS
N(+) : NUMBER OF POSITIVE SIGNS

RESULTS OF THE BINOMIAL SIGN TEST

(E.-A.)/A.	-1		1		1		0		0	
(P.-A.)/A.	0		1	*	1		1		0	
(P.-E.)/A.	1		1	*	0		0		1	
(J.-A.)/A.	-1		1		1	*	-1		1	
(L1-A.)/A.	-1		1		-1		-1		0	
(L2-A.)/A.	-1	*	-1		-1		-1		-1	*
(P.-L2)/A.	1		1		1		1	*	1	
(D.-B.)/A.	1		1		1		1		1	*
(H.-B.)/A.	-1		1		1		1		1	

-1 : MORE NEGATIVE SIGNS THAN POSITIVE ONES

0 : NO SIGNS,
A TOO SMALL AMOUNT OF SIGNS OR,
THE CHANCE THAT THERE ARE NO MORE POSITIVE SIGNS THAN NEGATIVE ONES.

+1 : MORE POSITIVE SIGNS THAN NEGATIVE ONES

* : SIGNIFICANT DIFFERENCE BETWEEN N(+) AND N(-)
HYPOTHESIS HO REJECTED.

TABLE: 1.2 MEAN VALUE PER EXPOSURE AND PER PERIOD

PARAMETER :RESPIRATION RATE CODE: 001

PERIOD CODE: EXPOSURE CODE:

	1	2	3	4	5
MEAN OF NORMALIZED VALUES					
(E.-A.)/A.	-.041	.009	-.001	.005	.012
(P.-A.)/A.	-.015	.030	-.006	.004	.005
(P.-E.)/A.	.026	.022	-.005	-.000	-.006
(J.-A.)/A.	-.037	.034	.041	-.014	-.013
(L1-A.)/A.	-.049	.029	-.004	-.038	-.009
(L2-A.)/A.	-.059	-.006	-.039	-.053	-.021
(P.-L2)/A.	.044	.037	.033	.070	.025
(D.-B.)/A.	-.010	.019	.022	-.004	.060
(H.-B.)/A.	-.011	.009	.058	.006	.012
PRODUCT OF THE NORMALIZED, AND THE MEAN -A- VALUES IN NUMBER OF RESPIRATIONS PER MINUTE					
(E.-A.)	-.60	.13	-.01	.06	.20
(P.-A.)	-.22	.47	-.08	.06	.07
(P.-E.)	.38	.34	-.07	-.00	-.09
(J.-A.)	-.53	.51	.61	-.22	-.21
(L1-A.)	-.71	.44	-.56	-.59	-.15
(L2-A.)	-.85	-.09	-.58	-.81	-.32
(P.-L2)	.63	.56	.50	1.08	.39
(D.-B.)	-.15	.29	.33	-.08	.93
(H.-B.)	-.17	.14	.89	.08	.19

TABLE: 2.1 SIGN TEST

PARAMETER :HEART BEAT CODE: 041

PERIOD CODE: EXPOSURE CODE:

	1		2		3		4		5	
	N	N(+)	N	N(+)	N	N(+)	N	N(+)	N	N(+)
(E.-A.)/A.	9	2	10	3	9	4	9	2	9	2
(P.-A.)/A.	10	3	9	3	9	2	10	2	9	3
(P.-E.)/A.	10	8	10	7	8	1	10	7	9	7
(J.-A.)/A.	10	2	10	5	9	2	10	4	9	4
(L1-A.)/A.	10	1	9	2	9	3	10	3	8	1
(L2-A.)/A.	9	1	10	1	9	2	9	3	8	0
(P.-L2)/A.	10	7	10	8	9	7	9	5	8	6
(D.-B.)/A.	8	2	10	4	8	1	9	7	7	0
(H.-B.)/A.	9	4	9	5	8	0	9	6	6	2

N : TOTAL NUMBER OF SIGNS
N(+) : NUMBER OF POSITIVE SIGNS

RESULTS OF THE BINOMIAL SIGN TEST

(E.-A.)/A.	-1	*	-1		0		-1	*	-1	*
(P.-A.)/A.	-1		-1		-1	*	-1	*	-1	
(P.-E.)/A.	1	*	1		-1	*	1		1	*
(J.-A.)/A.	-1	*	1		-1	*	-1		0	
(L1-A.)/A.	-1	*	-1	*	-1		-1		-1	*
(L2-A.)/A.	-1	*	-1	*	-1	*	-1		-1	*
(P.-L2)/A.	1		1	*	1	*	1		1	*
(D.-B.)/A.	-1	*	-1		-1	*	1	*	-1	*
(H.-B.)/A.	0		1		-1	*	1		0	

-1 : MORE NEGATIVE SIGNS THAN POSITIVE ONES

0 : NO SIGNS,
A TOO SMALL AMOUNT OF SIGNS OR,
THE CHANCE THAT THERE ARE NO MORE POSITIVE SIGNS THAN NEGATIVE ONES.

+1 : MORE POSITIVE SIGNS THAN NEGATIVE ONES

* : SIGNIFICANT DIFFERENCE BETWEEN N(+) AND N(-),
HYPOTHESIS HO REJECTED.

TABLE: 2.2 MEAN VALUE PER EXPOSURE AND PER PERIOD

PARAMETER :HEART BEAT CODE: 041

PERIOD CODE: EXPOSURE CODE:

	1	2	3	4	5
	MEAN OF NORMALIZED VALUES				
(E.-A.)/A.	-.013	-.018	-.001	-.032	-.017
(P.-A.)/A.	.004	-.019	-.010	-.029	-.013
(P.-E.)/A.	.017	-.002	-.011	.003	.004
(J.-A.)/A.	-.014	-.028	-.018	-.006	-.014
(L1-A.)/A.	-.022	-.036	-.032	-.021	-.045
(L2-A.)/A.	-.029	-.050	-.048	-.025	-.041
(P.-L2)/A.	.023	.031	.038	-.004	.030
(D.-B.)/A.	-.034	-.013	-.010	.024	-.040
(H.-B.)/A.	-.003	-.007	-.041	.031	-.016
	PRODUCT OF THE NORMALIZED, AND THE MEAN -A- VALUES IN NUMBER OF BEATS PER MINUTE				
(E.-A.)	-.89	-1.27	.07	-2.20	-1.19
(P.-A.)	.24	-1.39	-.69	-1.97	-.88
(P.-E.)	1.14	-.12	-.76	.23	.31
(J.-A.)	-.93	-2.04	-1.24	-.39	-.98
(L1-A.)	-1.48	-2.59	-2.21	-1.44	-3.16
(L2-A.)	-1.95	-3.60	-3.31	-1.72	-2.93
(P.-L2)	1.59	2.21	+2.62	-.27	2.10
(D.-B.)	-2.55	-.91	-0.69	1.66	-2.80
(H.-B.)	-.19	-.50	-2.83	2.10	-1.08

TABLE: 3.1 SIGN TEST

PARAMETER : ARITHMIA CODE: 044

PERIOD CODE: EXPOSURE CODE:

	1		2		3		4		5	
	N	N(+)	N	N(+)	N	N(+)	N	N(+)	N	N(+)
(E.-A.)/A.	10	7	10	6	10	9	10	4	9	7
(P.-A.)/A.	10	7	10	5	10	8	10	3	9	8
(P.-E.)/A.	10	4	10	3	10	6	10	6	9	4
(J.-A.)/A.	10	7	10	3	10	6	10	4	9	6
(L1-A.)/A.	10	7	10	5	10	7	10	6	9	8
(L2-A.)/A.	10	7	10	6	10	8	10	5	9	8
(P.-L2)/A.	10	3	10	6	10	5	10	5	9	1
(D.-B.)/A.	10	6	10	5	10	8	10	7	9	5
(H.-B.)/A.	10	8	10	4	10	8	10	5	9	6

N : TOTAL NUMBER OF SIGNS
N(+) : NUMBER OF POSITIVE SIGNS

RESULTS OF THE BINOMIAL SIGN TEST

(E.-A.)/A.	1	1	1 *	-1	1 *
(P.-A.)/A.	1	1	1 *	-1	1 *
(P.-E.)/A.	-1	-1	1	1	0
(J.-A.)/A.	1	-1	1	-1	1
(L1-A.)/A.	1	1	1	1	1 *
(L2-A.)/A.	1	1	1 *	1	1 *
(P.-L2)/A.	-1	1	1	1	-1 *
(D.-B.)/A.	1	1	1 *	1	1
(H.-B.)/A.	1 *	-1	1 *	1	1

-1 : MORE NEGATIVE SIGNS THAN POSITIVE ONES

0 : NO SIGNS,
A TOO SMALL AMOUNT OF SIGNS OR,
THE CHANCE THAT THERE ARE NO MORE POSITIVE SIGNS THAN NEGATIVE ONES.

+1 : MORE POSITIVE SIGNS THAN NEGATIVE ONES

* : SIGNIFICANT DIFFERENCE BETWEEN N(+) AND N(-), HYPOTHESIS HO REJECTED.

TABLE: 3.2 MEAN VALUE PER EXPOSURE AND PER PERIOD

PARAMETER :ARITHMIA CODE: 044

PERIOD CODE: EXPOSURE CODE:

	1	2	3	4	5
MEAN OF NORMALIZED VALUES					
(E.-A.)/A.	.198	.114	.168	-.019	.088
(P.-A.)/A.	.364	.031	.188	.011	.079
(P.-E.)/A.	.166	-.083	.020	.030	-.009
(J.-A.)/A.	.783	-.024	.060	-.044	.494
(L1-A.)/A.	.524	.021	.179	.088	1.031
(L2-A.)/A.	.779	.218	.235	.069	1.056
(P.-L2)/A.	-.416	-.187	-.046	-.058	-.976
(D.-B.)/A.	.784	.087	.106	.134	.145
(H.-B.)/A.	.807	.024	.125	-.050	.215
PRODUCT OF THE NORMALIZED, AND THE MEAN -A- VALUES					
(E.-A.)	1.93	1.06	1.62	-.20	.80
(P.-A.)	3.55	.29	1.81	.12	.72
(P.-E.)	1.62	-.78	.19	.33	-.08
(J.-A.)	7.64	-.23	.58	-.48	4.48
(L1-A.)	5.11	.20	1.72	.96	9.37
(L2-A.)	7.60	2.03	2.25	.76	9.59
(P.-L2)	-4.05	-1.74	-.44	-.63	-8.87
(D.-B.)	7.65	.81	1.02	1.46	1.32
(H.-B.)	7.87	.23	1.20	-.55	1.96

TABLE: 4.1 SIGN TEST

PARAMETER :REL. IMPEDANCE PLETHYSMOGRAM CODE: 003

PERIOD CODE: EXPOSURE CODE:

	1		2		3		4		5	
	N	N(+)	N	N(+)	N	N(+)	N	N(+)	N	N(+)
(E.-A.)/A.	10	2	9	4	10	0	10	5	9	2
(P.-A.)/A.	10	2	9	3	10	2	10	3	9	3
(P.-E.)/A.	10	7	9	8	10	5	10	4	9	4
(J.-A.)/A.	10	4	9	4	10	2	10	3	9	5
(L1-A.)/A.	10	4	9	4	10	3	10	3	9	6
(L2-A.)/A.	10	6	9	5	10	2	10	3	9	4
(P.-L2)/A.	10	4	9	2	10	7	10	6	9	2
(D.-B.)/A.	10	7	9	3	10	3	10	7	9	2
(H.-B.)/A.	10	5	9	5	10	4	10	3	9	4

N : TOTAL NUMBER OF SIGNS
N(+) : NUMBER OF POSITIVE SIGNS

RESULTS OF THE BINOMIAL SIGN TEST

(E.-A.)/A.	-1	*	0		-1	*	1		-1	*
(P.-A.)/A.	-1	*	-1		-1	*	-1		-1	
(P.-E.)/A.	1		1	*	1		-1		0	
(J.-A.)/A.	-1		0		-1	*	-1		1	
(L1-A.)/A.	-1		0		-1		-1		1	
(L2-A.)/A.	1		1		-1	*	-1		0	
(P.-L2)/A.	-1		-1	*	1		1		-1	*
(D.-B.)/A.	1		-1		-1		1		-1	*
(H.-B.)/A.	1		1		-1		-1		0	

-1 : MORE NEGATIVE SIGNS THAN POSITIVE ONES

0 : NO SIGNS,
A TOO SMALL AMOUNT OF SIGNS OR,
THE CHANCE THAT THERE ARE NO MORE POSITIVE SIGNS THAN NEGATIVE ONES.

+1 : MORE POSITIVE SIGNS THAN NEGATIVE ONES

* : SIGNIFICANT DIFFERENCE BETWEEN N(+) AND N(-),
HYPOTHESIS HO REJECTED.

TABLE: 4.2 MEAN VALUE PER EXPOSURE AND PER PERIOD

PARAMETER :REL. IMPEDANCE PLETHYSMOGRAM CODE: 003

PERIOD CODE: EXPOSURE CODE:

	1	2	3	4	5
MEAN OF NORMALIZED VALUES					
(E.-A.)/A.	-.114	-.072	-.082	-.055	-.043
(P.-A.)/A.	-.106	-.016	-.082	-.062	-.040
(P.-E.)/A.	.008	.057	.000	-.007	.002
(J.-A.)/A.	-.079	.069	-.130	-.056	.014
(L1-A.)/A.	-.038	.049	-.100	-.077	.035
(L2-A.)/A.	-.026	.089	-.131	-.084	.029
(P.-L2)/A.	-.080	-.105	.049	.022	-.069
(D.-B.)/A.	.011	-.068	-.075	.009	-.076
(H.-B.)/A.	-.066	.043	-.116	-.060	-.033
PRODUCT OF THE NORMALIZED, AND THE MEAN -A- VALUES					
(E.-A.)	-2.58	-1.95	-2.42	-1.34	-1.09
(P.-A.)	-2.40	-.43	-2.42	-1.50	-1.03
(P.-E.)	.18	1.52	.00	-.16	.06
(J.-A.)	-1.79	1.85	-3.85	-1.37	.35
(L1-A.)	-.86	1.32	-2.95	-1.87	.89
(L2-A.)	-.59	2.40	-3.87	-2.04	.74
(P.-L2)	-1.81	-2.83	1.45	.54	-1.77
(D.-B.)	.24	-1.84	-2.22	.22	-1.93
(H.-B.)	-1.50	1.17	-3.44	-1.46	-.83

TABLE: 5.1 SIGN TEST

PARAMETER :SYSTOLIC BLOODPRESSURE CODE: 002

PERIOD CODE: EXPOSURE CODE:

	1		2		3		4		5	
	N	N(+)	N	N(+)	N	N(+)	N	N(+)	N	N(+)
(E.-A.)/A.	10	2	10	5	10	5	10	6	8	3
(P.-A.)/A.	9	2	10	4	10	5	10	4	8	4
(P.-E.)/A.	8	6	10	3	9	5	10	3	9	7
(J.-A.)/A.	10	0	10	0	10	0	10	0	9	0
(L1-A.)/A.	10	1	9	6	10	4	9	5	8	6
(L2-A.)/A.	9	2	9	6	10	4	10	5	9	6
(P.-L2)/A.	9	6	9	2	10	6	9	3	9	4
(D.-B.)/A.	7	2	10	3	10	4	9	3	8	4
(H.-B.)/A.	10	0	10	0	10	0	10	0	9	0

N : TOTAL NUMBER OF SIGNS
N(+) : NUMBER OF POSITIVE SIGNS

RESULTS OF THE BINOMIAL SIGN TEST

(E.-A.)/A.	-1	*	1		1	1	-1	
(P.-A.)/A.	-1	*	-1		1	-1	1	
(P.-E.)/A.	1	*	-1		1	-1	1	*
(J.-A.)/A.								
(L1-A.)/A.	-1	*	1		-1	1	1	*
(L2-A.)/A.	-1	*	1		-1	1	1	
(P.-L2)/A.	1		-1	*	1	-1	0	
(D.-B.)/A.	-1		-1		-1	-1	1	
(H.-B.)/A.								

-1 : MORE NEGATIVE SIGNS THAN POSITIVE ONES

0 : NO SIGNS,
A TOO SMALL AMOUNT OF SIGNS OR,
THE CHANCE THAT THERE ARE NO MORE POSITIVE SIGNS THAN NEGATIVE ONES.

+1 : MORE POSITIVE SIGNS THAN NEGATIVE ONES

* : SIGNIFICANT DIFFERENCE BETWEEN N(+) AND N(-), HYPOTHESIS HO REJECTED.

TABLE: 5.2 MEAN VALUE PER EXPOSURE AND PER PERIOD

PARAMETER :SYSTOLIC BLOODPRESSURE
CODE: 002

PERIOD CODE: EXPOSURE CODE:

	1	2	3	4	5
MEAN OF NORMALIZED VALUES					
(E.-A.)/A.	-.029	-.003	-.000	-.012	.002
(P.-A.)/A.	-.021	-.011	.003	-.015	.005
(P.-E.)/A.	.008	-.007	.003	-.003	.004
(J.-A.)/A.					
(L1-A.)/A.	-.025	-.000	-.010	.008	.010
(L2-A.)/A.	-.023	.004	-.002	.004	.009
(P.-L2)/A.	.003	-.014	.005	-.019	-.003
(D.-B.)/A.	-.015	-.007	-.004	-.024	.000
(H.-B.)/A.					
PRODUCT OF THE NORMALIZED, AND THE MEAN -A- VALUES IN MM-HG					
(E.-A.)	-3.33	-.37	-.01	-1.40	.22
(P.-A.)	-2.38	-1.19	.33	-1.72	.62
(P.-E.)	0.95	-.82	.34	-.32	.40
(J.-A.)					
(L1-A.)	-2.82	-.05	-1.10	.87	0.01
(L2-A.)	-2.65	.42	-.22	.46	.97
(P.-L2)	.27	-1.61	.54	-2.19	-.35
(D.-B.)	-1.65	-.90	-.43	-2.71	.04
(H.-B.)					

TABLE: 6.1 SIGN TEST

PARAMETER :DIASTOLIC BLOODPRESSURE CODE: 002

PERIOD CODE: EXPOSURE CODE:

	1		2		3		4		5	
	N	N(+)	N	N(+)	N	N(+)	N	N(+)	N	N(+)
(E.-A.)/A.	10	3	10	5	10	4	9	5	9	7
(P.-A.)/A.	10	3	10	4	10	4	9	6	9	7
(P.-E.)/A.	9	5	9	5	10	6	9	8	9	4
(J.-A.)/A.	10	0	10	0	10	0	10	0	9	0
(L1-A.)/A.	10	2	10	7	9	6	10	5	8	5
(L2-A.)/A.	10	2	10	6	10	7	10	5	9	4
(P.-L2)/A.	9	7	10	5	9	3	9	4	8	6
(D.-B.)/A.	9	3	9	6	10	3	9	5	5	3
(H.-B.)/A.	10	0	10	0	10	0	10	0	9	0

N : TOTAL NUMBER OF SIGNS
N(+) : NUMBER OF POSITIVE SIGNS

RESULTS OF THE BINOMIAL SIGN TEST

(E.-A.)/A.	-1	1	-1	1	1 *
(P.-A.)/A.	-1	-1	-1	1	1 *
(P.-E.)/A.	1	1	1	1	0
(J.-A.)/A.					
(L1-A.)/A.	-1 *	1	1	1	1
(L2-A.)/A.	-1 *	1	1	1	0
(P.-L2)/A.	1 *	1	-1	0	1 *
(D.-B.)/A.	-1	1	-1	1	1
(H.-B.)/A.					

-1 : MORE NEGATIVE SIGNS THAN POSITIVE ONES

0 : NO SIGNS,
A TOO SMALL AMOUNT OF SIGNS OR,
THE CHANCE THAT THERE ARE NO MORE POSITIVE SIGNS THAN NEGATIVE ONES.

+1 : MORE POSITIVE SIGNS THAN NEGATIVE ONES

* : SIGNIFICANT DIFFERENCE BETWEEN N(+) AND N(-), HYPOTHESIS HO REJECTED.

TABLE: 6.2 MEAN VALUE PER EXPOSURE AND PER PERIOD

PARAMETER :DIASTOLIC BLOODPRESSURE
CODE: 002

PERIOD CODE: EXPOSURE CODE:

	1	2	3	4	5
	MEAN OF NORMALIZED VALUES				
(E.-A.)/A.	-.018	.005	-.007	-.004	.018
(P.-A.)/A.	-.014	.009	-.001	.007	.015
(P.-E.)/A.	.004	.004	.006	.011	-.003
(J.-A.)/A.					
(L1-A.)/A.	-.048	.011	.022	-.004	.004
(L2-A.)/A.	-.052	.003	.025	.003	-.005
(P.-L2)/A.	.037	.006	-.025	.005	.044
(D.-B.)/A.	-.023	.043	-.004	-.003	.002
(H.-B.)/A.					
	PRODUCT OF THE NORMALIZED, AND THE MEAN -A- VALUES IN MM-HG				
(E.-A.)	-1.44	.42	-.51	-.29	1.39
(P.-A.)	-1.15	.70	-.06	.54	1.15
(P.-E.)	.30	.28	.45	.84	-.24
(J.-A.)					
(L1-A.)	-3.86	.87	1.69	-.32	.37
(L2-A.)	-4.11	.22	1.91	.22	-.39
(P.-L2)	2.97	.48	-1.97	.32	3.82
(D.-B.)	-1.84	3.38	-.30	-.23	.19
(H.-B.)					