The Evaluation for two Input Methods of Cellular Phone based on User's Physiological Indices

Yanyan Zhu[1], Sufang Chen[1], Xiangshi Ren[2] and Yoshio Machi[1]

[1] Dept. of Electronic Engineering,
Graduate School, Tokyo Denki University, 2-2 Kanda-Nishiki-cho, Chiyoda-ku, Tokyo 101-8457,Japan
[2] Dept. of Information Systems Engineering, Kochi University of Technology 185 Miyanokuchi, Tosayamada-town, Kami-gun, Kochi 782-8502, Japan
Email: 01gmd12@hs.d.dendai.ac.jp , machi@d.dendai.ac.jp
Tel & Fax: 81-3-5280-3360 & 81-3-5280-3567

ABSTRACT

An experiment was conducted to measure and compare the physiological effects of two input methods on users. A common input method and an intelligent input method were tested in the experiment. The two input methods were applied to cellular phones. Thus, we designed the experiment so that we could measure and compare the physiological effects of two different input methods when the subjects were using the cellular to input email. Then we analyzed the physiological data, using ECG, GSR, respiration and oculogram four physiological indices. The evaluated results show that the intelligent input method is more efficient than the common method. The subjects found it easier to relax after using the intelligent input method.

Keywords : the intelligent input method, concentration, relaxation, fatigue, oculogram

1. INTRODUCTION

Previously, Japanese researchers used the intelligent character database in cellular phones. We call it the intelligent input method. A cellular phone with the intelligent input method has been on the Japanese market for months. The method has been applied in a Chinese character input system in China. The main characteristic of the intelligent input method is that we can find the target Chinese character even when we input only a little information. This method decreases the number of input strokes, and thus it increases the input speed. The purpose of our research is to evaluate user fatigue levels. We had evaluated output interaction in past research [1]/[3]. In this paper we evaluate the two input methods based on physiological indices. We measured the effects of both the common input method and the intelligent input method on users and, based on that data, we compared the differences between them. We concluded that the intelligent input method produces less fatigue for users.

2. METHOD

2.1. Participants

The subjects were all college students. The average age was 22.7 years old. Their input experiences were different, six subjects having had experience with the common method, two subjects having had experience using the intelligent method, and one subject not having had any experience with either method.

2.2. Apparatus

2.2.1. Cellular phone:

The size of the folded cellular phone was 50(w)×101(h)×27(d) mm^3. And its weight (including the battery) was 115g.

2.2.2. Physiological monitoring devices

The hardware used in the experiment was: an ECG monitor, a Galvanic Skin Response sensor (GSR100B module, MP100, BIOPAC system Inc.USA.), a pressure sensor with a resistance belt to measure the abdominal respiration, and a Video-Oculogram (SMI, Germany) to measure the pupil diameter [1].

2.3. Intelligent input method

On the one hand, each Japanese cellular phone key represents five or six Japanese characters. So we have to press each key up to 6 times. The intelligent input method is different from the common input method. For example, the spelling of "入力(its pronunciation is nyuryoku)" is "にゅうりょく" in Japanese. To input this word we usually have to press the '5' key two times (i.e. '5-5' brings up に), 8-8-8-8-8(ゅ), 1-1-1(う), 9-9(り), 8-8-8-8-8-8(ょ), 2-2-2(く) when using the common input method. It is at least 21 strokes plus the enter key. This means we have to input all the Japanese Characters to input each target word. But the intelligent input method displays all the words beginning with "入" when we input the first Chinese character (i.e. 5-5 (に) plus 8-8-8-8-8(ゅ) plus 1-

1-1(う)), several candidacy words appear on the screen. Then "入力", the target word, can be selected from these words. This is achieved after only 11 strokes. Furthermore, the more characters that are input, the quicker it is to find the target word. On the other hand, in the English system, each key represents three English characters. The input course is the same as it in Japanese. We can find the target word from the candidacy words even when the input information is minimal.

2.4. Procedure

The subjects were asked to follow these input steps using the two methods.

1) Open your eyes and keep your mind in a relaxed state for one minute.
2) Close your eyes and keep your mind in a relaxed state for two minutes.
3) Use Method One to input the prepared sentences into the cellular phone for five minutes.
4) Open your eyes and keep your mind in a relaxed state for one minute.
5) Close your eyes and keep your mind in a relaxed state for one minute.
6) Have a rest for twenty minutes.
7) Open your eyes and keep your mind in a relaxed state for one minute.
8) Close your eyes and keep your mind in a relaxed state for two minutes.
9) Use Method Two to input the prepared sentences into the cellular phone for five minutes.
10) Open your eyes and keep your mind in a relaxed state for one minute.
11) Close your eyes and keep your mind in a relaxed state for one minute.

The twenty minutes rest was designed to make the after effects of the first trial negligible. We used the same instructions when the subjects input using the two different input methods so that we could evaluate the methods under the same conditions. In a word, the instructions, from step (1) to step (5), are the same as the instructions from step (7) to step (11). In the experiment, the order of the two input methods was decided by random sampling before the experiment. Each subject had his or her own order.

2.5. Physiological indices

The data for each subject were recorded automatically as follow:

2.5.1. ECG, GSR and Abdominal respiration were recorded for steps 1) to 5) and for steps 7) to 12). We paid particular attention to the data in steps 2), 5), 8) and 11).

2.5.2. The Oculogram is used to measure pupil diameter, which is related to the autonomicnerve system. Data was recorded for steps 1) to 5) and steps 7) to 12). We measured the pupil data only when the subjects' eyes were open, so we paid particular attention to them in steps 1), 4), 7) and 10).

We recorded the subjects' physiological datum during the course of the experiment.

3. INDEX OF MEASUREMENT AND METHOD OF EVALUATION

On the one hand, abdominal respiration, GSR and ECG are used to evaluate the subjects' concentration levels. On the other hand, the oculogram is used to evaluate the subjects' fatigue levels. [1].

3.1. Abdominal respiration

This is respiration with abdominal movement. Here we call it Ab. When a user is concentrating on using an input method, his Ab is shallow. Conversely, if the user's respiration is deep, he is relaxed. In the experiment, we used a pressure sensor with a resistance belt to measure the abdominal respiration, and we converted the pressure data into a voltage data using collection equipment. (MP100, BIOPAC system, Inc.USA.) [1]

3.2. GSR

This is a voltage index indicating the degree of relaxation [2]. We used GSR100B to measure the resistance variations in two electrodes attached to the forefinger and the ring finger [1]. Because the GSR reflects changes in excitation of the sweat glands located in various layers of the skin [5], slight perspiration appears when the subject is under stress, causing the resistance to decrease. Conversely, it will increase when the user relaxes. The GSR100B measures skin conductance via the constant voltage technique, and employs "constant voltage" measurement techniques for determining skin conductance.

3.3. ECG

The electrocardiogram (ECG) is an electrical recording of the heart and is used in to investigate the state of the heart [3].

3.4. Oculogram

If the user's pupil is in a mydriasis state (dilated) after input, he is fatigued; conversely, if he is relaxed, the pupil will be in a state of myosis (contracted).

The Oculogram is like underwater goggles or safety glasses. It has two plastic shields, one on either side. We can fix a CCD sensor into the Oculogram from either side when the lid is taken off. Then it becomes a Video-Oculogram. The CCD sensor can record the diameter of the pupil directly into the computer. Special software for the Video-Oculogram converts this record into data, which can be recognized by Acqknowledge v 3. Then, we can analyze the data from the Video-Oculogram. In fact, because the CCD sensor is not positioned directly in front of the user's eye, it cannot take pictures directly in front of the user's eye. We can see that the lenses of the Video-Oculogram sit at and angle of about 45? to the frame (fig.1). The lenses are half mirrors. The CCD sensor takes the reflected picture from the lenses.

Fig. 1 A subject wearing the Video-Oculogram

Fig.1 is one picture that was taken during the experiment. We used the Video-Oculogram to measure the subjects' pupil diameter during the experiment. It monitors the pupil of the right eye (we can take it from either eye), after which it converts the graphic signal into an electronic signal. The subject was wearing the Video-Oculogram while inputting into the cellular phone.

3.5. Example

We will introduce our evaluation method using the following example. The example is represented by two figures, Fig.2 shows college student A's physiological data when he input using the common input method. Fig.3 shows his physiological data when he input using the intelligent input method. The subject had been inputting with the common input method for one year.

There are five channels in the following two windows. The four channels, from the top down, are different types of physiological data. The bottom channel marks the stages of the experiment. There is a border between the waveforms. The first channel represents GSR, the second represents ECG, the third represents the oculogram, and the last represents abdominal respiration.

These channels display the subject's physiological indices when he input with both the common input method (fig.2) and the intelligent input method (fig.3). These channels show the raw data in fig.2 and fig.3.

In fig.2, we can see that the level of GSR in step (5) is just a little higher than in step (2). In fact, the level of the data shows a slightly upward trend during the course of the experiment. Conversely, the level of GSR in step (11) is lower than in step (8) in fig.3.

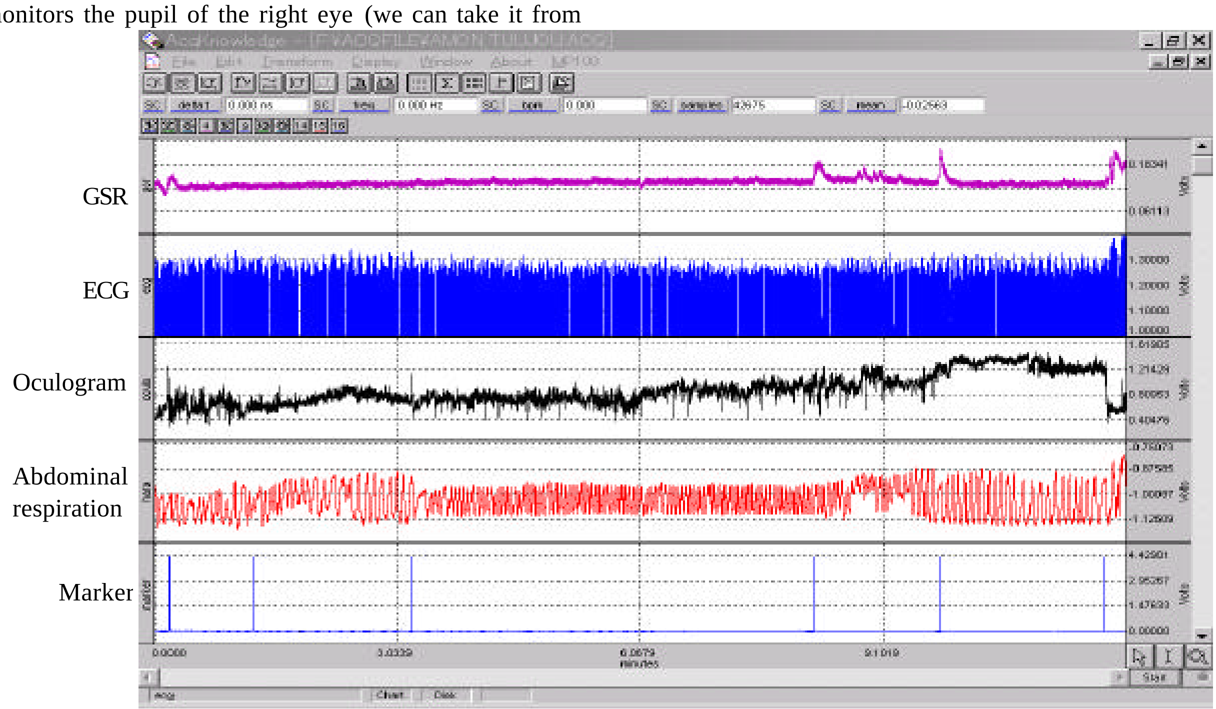

Fig.2 Subject A's physiological data when he input with the common input method

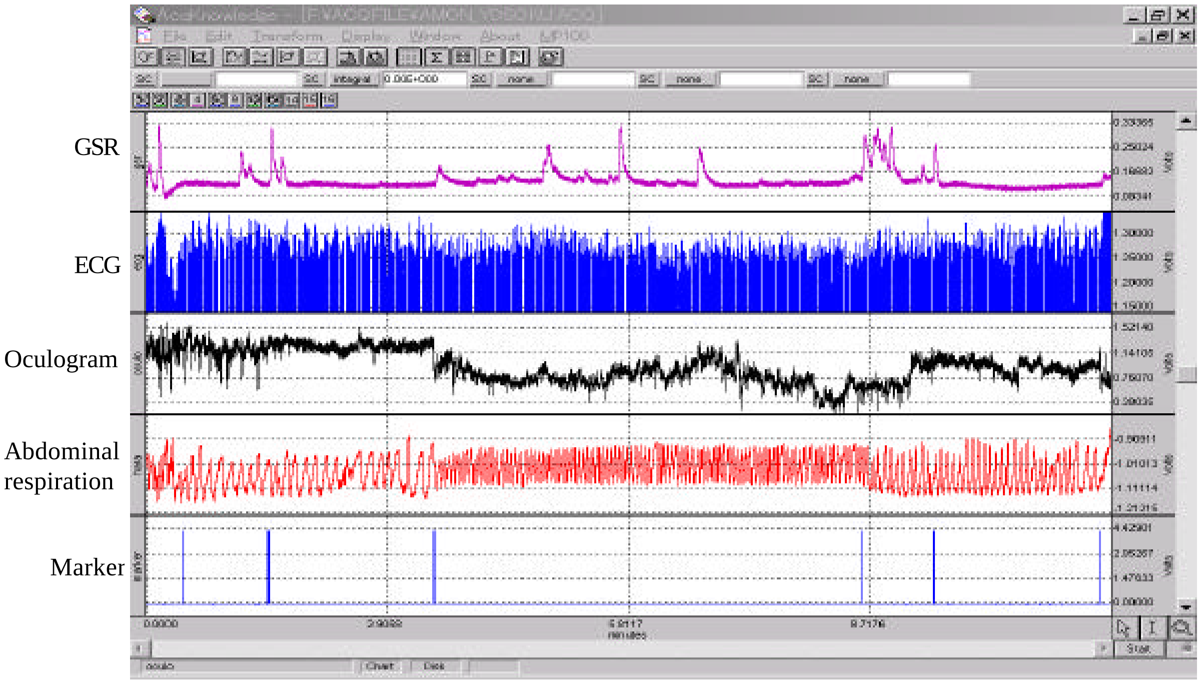

Fig.3 Subject A's physiological data when he input with intelligent input method

We used the Acqknowledge v 3 to analysis software to get these graphs and analyze the data. We calculated the mean of the GSR in different steps, and obtained the relative value between the data from the "after inputting" stage and the data from the "before inputting" stage. Then, we compared the relative values of two input methods. We used the same method to calculate the mean and get the relative values from the oculogram and abdominal respiration indices.

In fact, we are able to see the difference between the two methods even if we don't calculate it. In fig.2, the level of oculogram data in step (4) is clearly higher than in step (1), and the level of the oculogram data in step (10) is clearly lower than in step (7) in fig.3.

The level of abdominal respiration hardly changed before and after inputting with the intelligent input method. But the level of abdominal respiration in step (4) is very high. Furthermore, the level of abdominal respiration in step (9) is clearly deeper than in step (3). This means the subject was more tired when he input with common input method.

Unlike the method used to analyze the three preceding physiological indices, we used another method, CV-RR, to analyze and obtain the relative values for the ECG. We had used this method in the past.

LF/HF is a new method of analysis whereby we could have obtained more information about the subjects, but this method requires a vast amount of data. Furthermore, the experiment was too short to allow us to use this method. Therefore we chose the CV-RR method.

We had to analyze it using CV-RR. We will extend the experiment time when we do the additional experiment in the future. Then we will use the new method (LF/HF) to analyze the ECG. In fig.2, the level of ECG in step (5) is a little higher than in step (2). Conversely, the level of ECG in step (11) is lower than in step (8) in fig.3. Furthermore, it had a downward trend during the course of inputting with the intelligent input method [6].

We analyzed all the subjects' data according to the above method and we calculated the mean from their respective physiological data. The results are as follows.

4. RESULTS

4.1. Abdominal respiration results.

Common and intelligent refer to different input methods. The vertical axis shows the appearance of abdominal respiration after each input interaction. These values indicate the mean of all subjects' R_{Ab} (the relative values between Ab1, before the interaction, and Ab2, after the interaction). The two methods are represented in the graphic. The two graphic columns on the left side of fig.4 represent the abdominal respiration data for subjects inputting with the common input method. Those on the right represent the data recorded for subjects inputting with the intelligent input method.

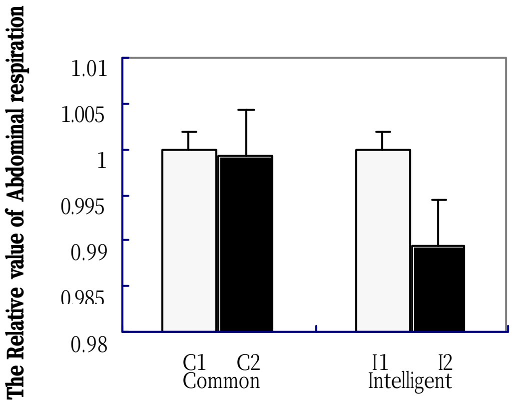

Fig.4 Abdominal respiration for two input methods

In each pair of columns, the left column represents the subjects in a relaxed state with eyes closed before inputting. Here, we call it 'relax with eyes closed Ⅰ'. This was assumed to have a value of 1.0 as the basic value. The right column represents the state of the subjects after the interaction. Here, we call it 'relax with eyes closed Ⅱ'. So we can call them C1, C2, I1, I2 from left to right, and Rc=C2/C1, Ri=I2/I1. As shown in Fig.4, C2<C1 and I2<I1, because C1=I1, Ri<Rc.

4.2. GSR results

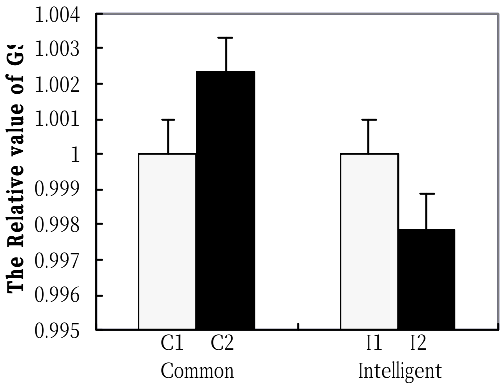

Fig.5 GSR for two input methods

Here the format and the elements are the same as in Fig.4. The vertical axis shows the appearance of a voltage on the GSR monitor after the input interaction. [2] These values indicate the mean of all subjects' R_{GSR} (the relative voltage between GSR1, before the interaction, and GSR2, after the interaction). There are four relative indices C1, C2, I1, I2. Here, C1<C2 and I1>I2, because C1=I1, C2>>I2, then $R_i<R_c$.

4.3. ECG results

Here the format and the elements are the same as in Fig.4. The vertical axis shows the appearance of the voltage on the ECG after the input interaction. These values indicate the mean of all subjects' R_{ECG} (the relative voltage between ECG1, before the interaction, and ECG2, after the interaction). There are four relative indices, C1, C2, I1, I2. Here, C1<C2 and I1>I2, because C1=I1, C2>>I2, then $R_i<R_c$.

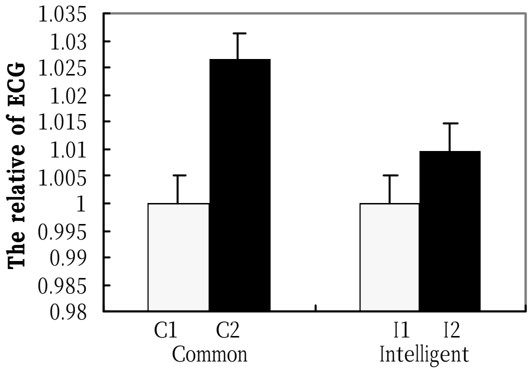

Fig.6 ECG for two input methods

4.4. Oculogram results

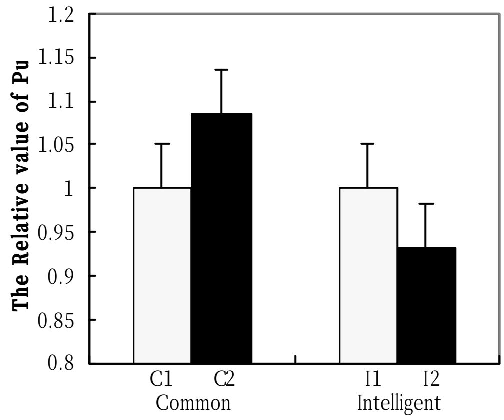

Fig.7 Oculogram for two input methods

The format and the elements are the same as Fig.4 in Fig.7. The analyzed state is different from the three preceding physiological indexes. We recorded the data during steps 1) and 7), measuring the pupil diameter when the subjects' eyes were open. The left column represents the subjects in a relaxed state with eyes open before the input interaction. We call it 'relax with eyes closed Ⅰ'. This was assumed to have a value of 1.0 as the basic value. The right column represents the state of the subjects after the interaction. Here, we call it 'relax with eyes closed Ⅱ'.

5. DISCUSSION

As shown in Fig.4, users recovered more easily after using the intelligent input method. During each input interaction, eye and hand movement and psychological stress caused the heart rate to increase.

The subjects commented that even when they closed their eyes after the interactions, the noise of the interaction seemed to continue in their minds like an echo. Thus we can understand why the ECG data (Fig.6) for both input methods shows a voltage increase after the input interactions. When the input method is not comfortable for the user, eye movement causes pupil mydriasis, and the eyes become too tired to recover quickly. We noted that the abdominal respiration recovers more quickly than the eyes. Furthermore Ab recovery was more efficient with the intelligent input method. Fig.5 and fig.7 show ideal results. They show that the intelligent input method produces not only less fatigue than the common input method, but it is also easier to recover fromthan the common input method.

Table 1. Physiological index and Subjects' states

	Fatigue strength	Relaxation
Ab	Shallow and irregular	Deep and rhythmic
GSR	High	Low
ECG	$R_{ecg} > 1$	$R_{ecg} < 1$
Pupil	Mydriasis	Myosis

Input impacted on the subjects until it was over. We used the relative values in order to isolate our results from the effects of the input interactions when we evaluated the physiological indices. These values are R_{Ab}, R_{GSR}, R_{ECG} and $R_{ocoulo.}$ Because the parasympathetic nervous system is dominant, and the user's state is relaxed, then R >1; conversely, R <1, indicates that the sympathetic nervous system is dominant, the user is in a state of concentration. [4]

In the experiment, we used the user's physiological indices to evaluate input methods. This embodies the real goal of research, which is for the benefit of human beings. This evaluation method reflects the priority of users in the input experience. In the past, researchers who studied input methods only thought about the hardware and the software with little or no regard for human physiological indices. This is not adequate. Compared with previous evaluation methods this method is no less scientific, objective and systematic. We suggest that this method should be accepted as a new and valid trend in scientific evaluation.

It is necessary for our research to add more subjects. On the one hand, the physiological data varies with the individual. For example, each subject's input experience is different. We will add more subjects and divide them according to their experience when recording and evaluating the statistical data in the near future. Furthermore, input procedures have an affect on the brain. We will also add an evaluation of the input methods effects on the brainwave index in the future.

6. CONCLUSION

Our conclusions are as follows: we proposed a physiological evaluation strategy for the two input methods of cellular phones. In the experiment we combined Abdominal Respiration Monitoring, ECG monitoring, GSR monitoring and Oculogram monitoring in order to evaluate the user's levels of relaxation. All the physiological results show that the intelligent input method is more comfortable for users. The intelligent input method is not only suitable for Japanese, but also for English and Chinese character input. Furthermore, it may be suitable for both Cellular and Compouter Keyboard input. We also suggest that our evaluation method is beneficial to research in the area of input.

ACKNOWLEDGMENTS

In the experiment, we were fortunate to have support from these volunteers who are students in our university.

REFERENCES

1. Sufang, Chen, Xiangshi, Ren, H. Kim, and Yoshio, Machi, . (2000), An evaluation of the physiological effects of CRT displays on computer users, in IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E83-A, No.8, pp.1713-1719.
2. J. L. Anddreassi, Phychophysiology: Human Behavior & Physiological Response, 3rd ed,. Lawrence Erlbaum Associates, Publishers Hove, UK, 1995.
3. H. Tamura, Human Interface, Ohm Publish Co.Ltd., Japan, 1998.
4. M. Ohsuga, "To evaluate the workload with index of autonomous nerve system," Proc. Society of Instrument and Control Engineers, 1993.

5. J.Allonson, T. Rodden, and J. Mariani, "A toolkit for Exploring Electro-physiological Human-computer Interaction," in Human-computer Interaction – INTERACT '99, eds. M. A. Sasse and C. Johnson, pp.231-237, IOS Press, IFIP TC. 13,1999.
6. Furlan R, Guzetti S, Crivellaro W et al: Continuous 24-hour assessment of the neural regulation of systemic arterial pressure and RR variabilities in am bukant subjects. Circulation 1990;81;537-547