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ANALYSIS OF BRAIN ACTIVITY PERIOD IN VARIOUS HUMAN ACTIVITIES BY VIBRAIMAGE TECHNOLOGY

Viktor Minkin, Andrey Kachalin
ELSYS Corp., St. Petersburg, Russia (minkin@elsys.ru).

Abstract: *An experimental study of the brain activity period of a person in the very low frequency (VLF) range during the occupation of three different activities was conducted. It is shown how the period of brain activity varies with different work. A hypothesis is proposed explaining the dependence of brain activity period on the load on the brain.*

Keywords: *vibraimage, psychophysiology, brain activity period (BAP), natural regulation of brain activity, response to stimuli, VLF.*

In the study of psychophysiological mechanisms of brain activity period formation [Minkin, Blank, 2019], a hypothesis was proposed that the period of brain activity in the VLF frequency range (very low frequency, period of 30–60 seconds) [Fleishman, 1999, 2014, 2015] is the function from the mind load on the brain. The purpose of this work was to test the proposed hypothesis and to conduct statistically reliable measurements of the brain activity period of a testee solving various mental problems.

Methods and Materials

Measurements of the period of brain activity were carried out on one testee, a 29-year-old man, a programmer by profession, who holds the title of CMS in chess. The measurements were carried out during working hours and when the person performed production tasks from 11.00 to 18.00 in March 2019 with the consent of the person. The production activity of the testee consisted in programming and working with documentation. As a rest between solving production problems, the testee was playing chess (blitz) over the Internet with time control 1 minute per game (1 move about 2 seconds). The measurement of the period of brain activity was carried out by the vibraimage technology [Minkin, 2000, 2007, 2018] while controlling the vestibular-emotional reflex [Minkin, Nikolaenko, 2008, Blank et al., 2012].

Microsoft LifeCam Studio web camera with a resolution of 640 × 480 elements, frame rate of 30 Hz was installed infront programmer and fixed on the monitor. The image of the testee head was on the photodetector of the webcam, was not less than 200 elements horizontally. Video processing and determination of data on the current value of the psycho-physiological state (PPS) of the subject was determined by the VibraMed10 program [VibraMed10, 2019], the program settings were set by default except for the PPS measurement time, which was set 380 s.

Statistical processing of measurement results was carried out by VibraStat program [VibraStat, 2019], which carried out the summation and averaging of the current PPS using the Fourier fast transformation (FFT) algorithm [Heideman et al., 1984]. 78 PPS measurement results were sent to the processing, when the testee was operating in the documentation processing, 38 results of programming process and 38 results when he was playing chess. Each result of PPS measuring by VibraMED10 measuring included 380 × 5 = 1900 counts of the PPS, since the frequency of PPS measuring was 5 counts per second.

Results

The results of FFT processing and averaging of 78 PPS spectrograms when testee was operating documents and reading the technical literature are given in figure 1.

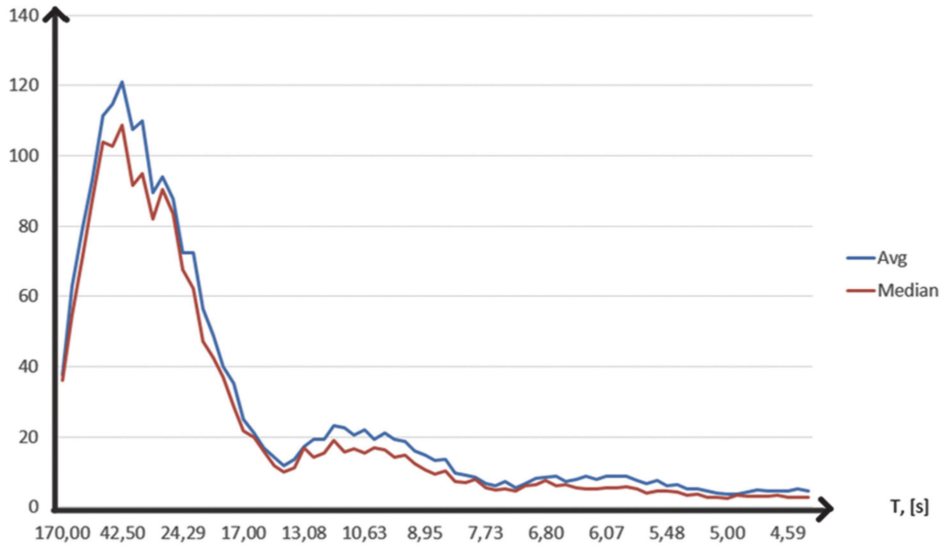

Fig. 1. Averaged FFT spectrogram of PPS changes for testee brain activity in documentation

The averaged spectrogram obtained in figure 1 has a maximum of 48.5 seconds. The maximum, determined by the mean and median value when averaging the Fourier spectrograms coincides.

The results of the FFT spectrograms averaging when measuring the PPS of the testee who was programming shown in figure 2.

The spectrogram obtained in figure 2 has a maximum of 42.5 seconds. In this case, the maximum determined by the mean and median values when averaging the Fourier spectrograms coincided.

The results of averaging the FFT spectrograms when measuring PPS of the testee who was playing the chess shown in figure 3.

During the measurements, the testee was engaged in playing chess. The spectrogram obtained in figure 3 has a maximum equal 34 seconds so that means the period of maximum brain activity was 34 seconds.

Figure 4 shows the dependence of the maximum value (brain activity periods) of the averaged spectrograms of the data in figures 1–3 on the type of activity of the programmer being tested.

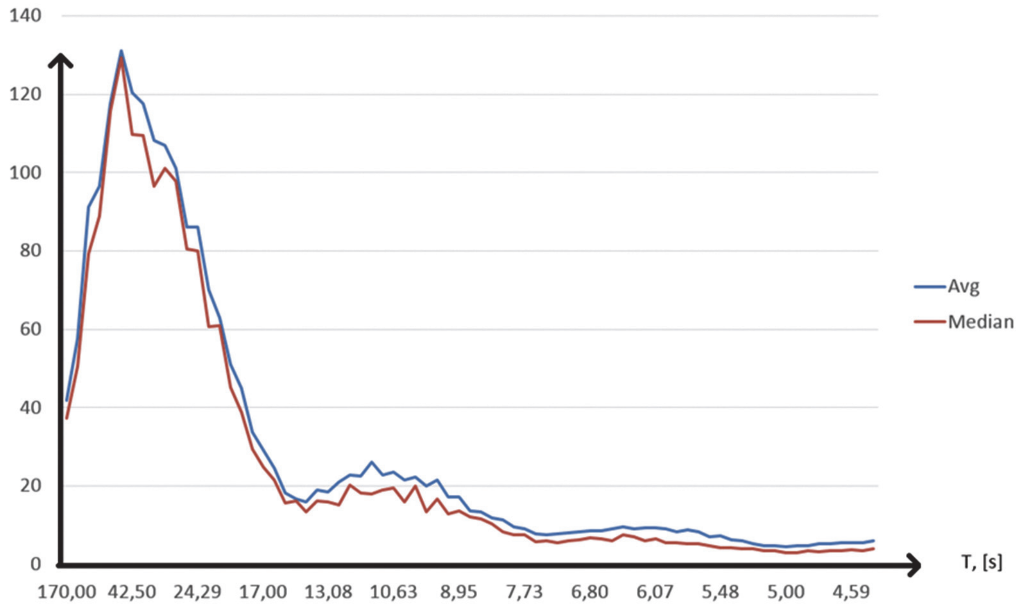

Fig. 2. Averaged FFT spectrogram of PPS changes for testee brain activity in programing

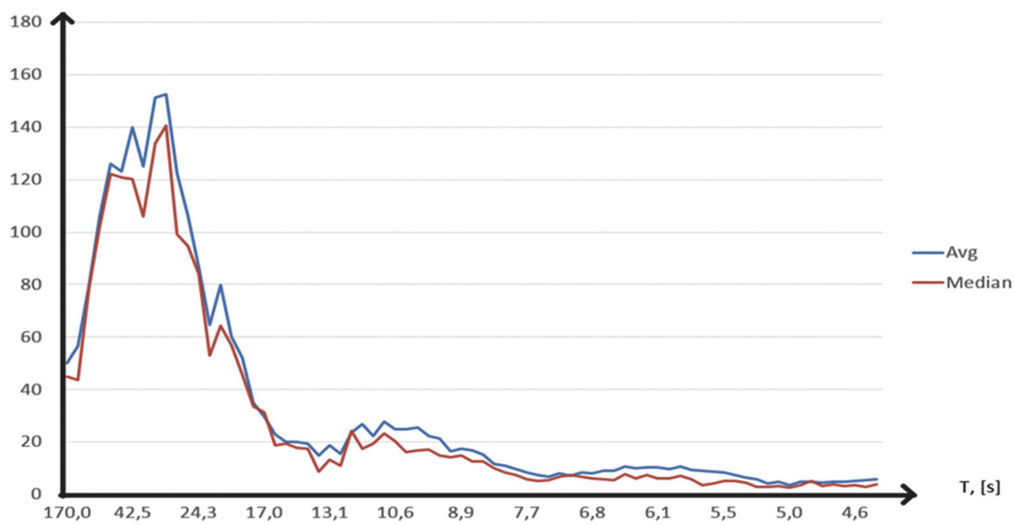

Fig. 3. Averaged FFT spectrogram of PPS changes for testee brain activity in chess playing

The number of tests for different types of activity turned out to be different due to the current production load of the testee, since one of the objectives of the study was the lack of influence of this study on the standard production process of the testee. At the same time, the identity of the maximum estimates for the arithmetic mean and median average confirms the reliability of the estimates obtained [Novitsky, 1975].

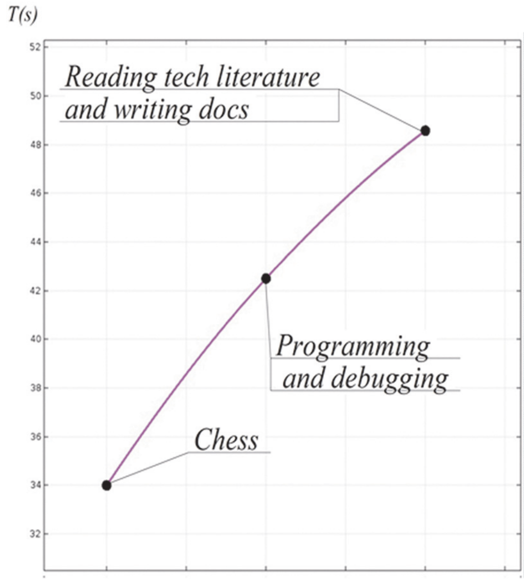

Fig. 4. Dependence of brain activity period (in seconds) from occupation type

Discussion of the results

Studies have shown a clear dependence of the period of change in the PPS from the type of activity of the programmer being tested. Since the testee was not engaged in physical labor during this testing, earlier in the work [Minkin, 2019] it was proposed to associate the change in the PPS of the testee with a load on the brain. Consequently, it is logical to assume that a different load on the brain leads to a change in the period of brain activity, just as an increase in the physical load on the human body leads to an increase in heart rate [Fleischman, 1999].

Since the period is an inverse function of frequency, then, by analogy with the heart rate, it turns out that the testee spends the maximum energy when playing chess, is slightly less when programming and the minimum mental costs occur when working with documents. It is interesting to note that, according to the testimony of the testee, he considers himself as a good expert in chess, an average in programming and weak in working with documentation. If we summarize the data, it turns out that the brain activity that is pleasant for a person is a greater burden on the brain and requires a large amount of energy from it. While the activity is unpleasant for a person, it requires less brain activity.

Let us clarify what we mean precisely the physical expenditure of energy on brain activity. Physically, the assumption looks logical enough, because if a person is an expert in a certain kind of activity, then naturally his brain works as efficiently as possible, that is, it performs the maximum number of operations and the maximum number of information transfers between brain neurons occurs. Human activity, which is unpleasant to him, is characterized by low efficiency and low transmission of information between the neurons of the brain, which means less energy is spent on it. Opponents may argue that it is nothing new, that all this known from the works of Wiener and Bernstein [Wiener, 1948; Bernstein, 1967] and they will be partially right. What is new in this study is only that experimental confirmation of the human cybernetic model has been obtained, and it has been obtained using the vibraimage technology that analyzes the work of the vestibular system.

Analysis of the vestibular system functions turned out to be more effective psychophysiological testing than the EEG, heart rate and MRT studies [Standards, 2014], most likely due to the following reasons. The function of the vestibular system in the micro-movements control of the head automatically filters high-frequency oscillations due to mechanical inertia. Namely, high-frequency processes are the main subject of the study of EEG and heart rate. MRT equipment during the study does not contribute to normal human activity, so it is quite difficult to conduct similar studies and collect statistics in hundreds of measurements during MRT studies.

Of course, this study needs independent confirmations, which is quite simple to do as the VibraMed10 program used has a DEMO mode, which allows all interested parties to conduct similar studies.

Conclusion

The results of this study confirm the hypothesis put forward that the brain activity period measured by the vibraimage technology depends on the type of activity and brain load of a person.

References:

1. *Bernstein N. A.* (1967). The co-ordination and regulation of movements. Oxford: Pergamon Press.
2. *Heideman et al.* (1984). Gauss and the history of the fast Fourier transform (PDF) // IEEE ASSP Magazine. Vol. 1 (4). P. 14–21. DOI: 10.1109/MASSP.1984.1162257.
3. *Fleishman A. N.* (1999). Slow hemodynamic oscillations. Novosibirsk.
4. *Fleishman A. N. et al.* (2014 *a*). The Complicated Structure and Nonlinear Behavior of VLF Heart Rate Variability: Analysis Models and Practical Applications // PND. Vol. 22, No. 1. P. 55–68.
5. *Fleishman A. N. et al.* (2014 *b*). Orthostatic tachycardia: diagnostic and prognostic value of VLF heart rate variability // Bulletin of Siberian Medicine. Vol. 13, No. 4. C. 136–149.
6. *Minkin V. A., Nikolaenko N. N.* (2008). Application of Vibraimage Technology and System for Analysis of Motor Activity and Study of Functional State of the Human Body. Biomedical Engineering. Vol. 42, No. 4. P. 196–200. DOI: 10.1007/s10527-008-9045-9.
7. *Minkin V. A.* (2017). Vibraimage. St. Petersburg: Renome. DOI: 10.25696/ELSYS.B.EN.VI.2017.
8. *Minkin V., Blank M.* (2019). Psychophysiological formation of brain activity period // Modern Psychophysiology. The Vibraimage Technology: Proceedings of the 2nd International Open Science Conference, June 25–26, 2019, Saint Petersburg, Russia. St. Petersburg: ELSYS Corp. P. 232–239.
9. *Novitsky P. V.* (1975). Electrical measurement of non-electrical values. Leningrad: Energy. (In Russian)

10. Patent US 7346227, IPC G06K 9/36. Method and device for image transformation / *V. A. Minkin, A. I. Shtam*, ELSYS Corp. Filed 19.12.2000; Publ. 18.03.2008.
11. Patent RU 2515149, IPC A61B 5/11. Method for Screening Diagnosing of Prostate Cancer / *M. A. Blank, O. A. Blank, V. A. Minkin*, ELSYS Corp. Filed 06.02.2012; Publ. 10.05.2014, Bul. № 13.
12. Patent RU 2017109920, IPC A61B 5/11. A method for assessing a person's psychophysiological state / *V. A. Minkin*, ELSYS Corp. Filed 24.03.2017; Publ. 24.09.2018, Bul. № 27.
13. Standards for Educational and Psychological Testing (2014) / Edition Developed jointly by: American Educational Research Association (AERA), American Psychological Association (APA), National Council on Measurement in Education (NCME).
14. VibraMed (2019). Emotion Recognition and Behavior Detection system. Version 10 [Electronic resource]. St. Petersburg: ELSYS Corp. URL: http://www.psymaker.com/downloads/Vibra-MedEng10.pdf (access date: 06.06.05.2019).
15. VibraStat (2019). VibraStat Manual. Vibraimaging analysis of MED psychophysiological parameters statistics [Electronic resource]. St. Petersburg: ELSYS Corp. URL: http://www.psymaker.com/downloads/VibraStatAdvEng.pdf (access date: 06.06.05.2019).
16. *Wiener N.* (1948). Cybernetics: Or Control and Communication in the Animal and the Machine. Paris: Hermann & Cie; Cambridge, Mass.: MIT Press. (2nd revised ed. 1961).