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INFLUENCE OF EXTREME SOLAR ENERGETIC EVENTS AND GEOMAGNETIC STORMS ON THE FUNCTIONAL STATE OF THE HUMAN BRAIN

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Influence of geomagnetic storms of various intensities on the human brain functional state of practically healthy adults (females) was investigated. It is established that weak and moderate geomagnetic storms do not cause significant changes in the brain activity and exert only stimulating influence while severe strong disturbances of geomagnetic conditions having negative influence, seriously disintegrate brain's functionality, activate braking processes and amplify the negative emotional background of person.

1. INTRODUCTION. SOLAR EXTREME EVENTS' AND SEVERE GEOMAGNETIC STORMS' EFFECTS ON HUMAN HEALTH STATE

Conditions on the Sun and in the solar wind, magnetosphere, ionosphere and thermosphere can influence not only the performance and reliability of space-borne and ground-based technological systems, but can endanger all kind of human activities [1, 2]. The ecological and biological systems are also exposed to the influence of solar and geomagnetic activities and to changes in these activities [3]. There is a growing body of evidence that gradual or extremely rapid variations in the solar activity and in the geomagnetic field affect biological systems and threaten human life and health [4]. As our planet is a giant magnet, it should be no surprise that we and other life forms are sensitive to magnetism, including Earth's magnetic field and changes in this field: all biology on the planet Earth is dependant on the geomagnetic field. Since all living organisms are probably affected by magnetic fields, anything that influences those fields (gradual changes in solar activity, solar flares, solar wind variations, coronal mass ejections, geomagnetic fieled disturbances and/or storms, etc.) will indirectly or even directly perturb living organisms. It is well accepted that homing pigeons and honey bees, and probably sharks, rays and various bacteria, react to the Earth's magnetic field and its variations. Some studies indicate that biological systems, depending on their physiological state (for example, physically stressed human), may respond, by different ways, to the measurable fluctuations in the geomagnetic field. Therefore, it is very important to get more and better knowledge of solar and geomagnetic storms and their potential impacts, in order to decrease or minimize these disturbance factors. Interest and concern in this subject have led to intensive investigations on space weather (which is determined by the most varied interactions between the Sun and interplanetary space, and the Earth) influence on biological systems, particularly, on human brain physiological state.

The possibility that masses of susceptible people could be influenced during critical conditions by extremely small variations (less than 1%) of the steady-state amplitude (about 50,000nT) of the Earth's magnetic field such as during geomagnetic storms (50 to 500nT) has been discussed in [5]. Recent experimental evidence which has

shown a threshold in geomagnetic activity of about 20nT to 30nT for the report of vestibular experiences in human beings and the facilitation of limbic seizures in rodents is consistent with this hypothesis.

Study of effect of geomagnetic storms on human health and estimating of the biotropic effects have revealed that the frequency of occurrence of bursts exceeding the average number of hospitalized patients with mental and cardiovascular diseases (myocardial infarction, angina pectoris, violation of cardiac rhythm, acute violation of brain blood circulation) during magnetic storms increases significantly compared with magnetically quiet periods [6].

One of the main targets of negative influence of the disturbances of geomagnetic field on human health state is the nervous system. Geomagnetic storms, as any stress factor, influence the human health state and in this impact the main target is the central nervous (the brain and spinal cord) system being the sensitive screen, and perceiving even weak disturbance fluctuations (oscillations) in the environment [7, 8].

Results of detailed studies [9-14] show that during the period of strong geomagnetic disturbances the number of hospitalized patients with nervous diseases notably increases, the cases of myocardial infarcts and cerebral insults, different paroxysmal conditions, nervous disturbance disorders and suicidal attempts become more frequent, the psycho-neurological diseases become aggravated. During high solar activity periods, the predominance of maniacal phases in patients suffering from manic-depressive psychosis is of frequent and short-duration nature. When there is stabilization in geomagnetic conditions, the maniacal phase is replaced by the depressive stage.

The admission of mentally disturbed patients and myocardial infarction (disease) increased during the disturbed geomagnetic field conditions. Studies on deaths due to myocardial disease showed that on geomagnetically disturbed days both the morbidity and mortality were higher than on magnetically quiet days. The largest number of sudden deaths from cardiovascular disease occurred within the first twenty-four hours of a geomagnetic storm. There are reports on increase in human hallucinations with increasing geomagnetic activity. Studies of Moscow ambulance calls for brain stroke and myocardial infraction showed significant increases on geomagnetic storm days [4].

It should be noted, that during strong geomagnetic disturbances, a tolerance to mental and physical stresses is decreased; there appears a danger of disorders for the people whose professional work is connected to high-level responsibility, like surgeons, dispatchers, drivers, pilots, etc. The changes of geomagnetic conditions affect first, the activity of regulating systems, which are related to high cortical mechanisms of regulation and sub-cortical integrative apparatuses responsible for the organization of routine activity of organism, and for adaptation to environment changes.

Not only the central, but also the vegetative nervous system of human being is very sensitive (responsive) to geomagnetic disturbances. It is established that during weak and moderate magnetic storms, a tone strengthens in the field of sympathetic part (section) of a vegetative nervous system. Only in some cases and, most often for the men, the strengthening (amplification) of tone of the parasympathetic section of a vegetative nervous system is observed [12-14]. According to some investigations, an influence of electromagnetic fields on the brain has a large polymorph character. In some cases, the changes have a predominance of slow rhythms, in other cases, on the contrary, there is a predominance of fast waves, or, general depression of the bioelectrical activity.

There is an evidence that the human nervous system is a target and/or messenger at effecting fluctuations of geomagnetic field on human physiological state and, particularly, on human brain’s functional state. Investigation of bioelectric activity of the human brain, which reflects a continuum of functional conditions, is an adequate way for study of a condition of cerebral cortex (the outer layer of the cerebrum) of the big hemispheres and corticosubcortical interrelations [15]. Therefore, in our research works

the electroencephalographic (EEG) investigations are used as the most objective research method reflecting functional state of the human brain. Based on EEG researches, it is established that the nervous system of patients responds to geomagnetic disturbances by diphasic reaction [16]. During days with geomagnetic storms, the generalized reduction of indexes of spatial synchronization of EEG is marked. On the contrary, a general increase is registered in the next day in contrast to the long-lived quiet period.

It should be noted that several papers were dedicated to analysis of possible influence of space weather (especially geomagnetic disturbances) on the bioelectric activity of human brain by the help of EEG–studies [17-26].

In this original research paper we have studied the possible influence of violent Sun-Earth connection events (solar and geomagnetic storms of various strengths) on the human brain activity and its functional state.

The current solar 11-year activity cycle 23 has been relatively ordinary and with few periods of very intense space weather activity, notably, in July 2000 ("Bastille Event"), April 2001 and others. But dramatic burst of activity of the Sun during October 22 to November 4, 2003, has been noticed as one of the most violent Sun-Earth connection events on record. Fast coronal mass ejections (CMEs), X-class flares, solar energetic particles (SEPs) and interplanetary shocks were abundantly observed during these events; a few of the flares also produced gamma-rays.

The extreme solar events of October-November 2003, which was called "Halloween Events", attracted the attention of scientists, engineers, doctors and the general public all over the world. Analysis of these events offers new insight into the high-energy processes at the Sun and in the coupling mechanisms of the solar-terrestrial system. They are also of special interest in the space weather domain because of their impacts on both technological and biological systems, including human health state.

One of the major and intense geomagnetic storms of the current solar cycle 23 in October-November 2003 gave a unique chance to us to study the possible impact of extreme space weather events on the human brain state. Daily monitoring and analysis of space weather conditions, carried out by the Shamakhy Astrophysical Observatory (ShAO, Azerbaijan) using relevant Internet and other resources of the US National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), US National Oceanic and Atmospheric Administration's Space Environment Center (SEC NOAA) and SPIDR, Russian Space Weather Initiatives (RSWI), the Institute of Terrestrial Magnetism, the Ionosphere and Radio-wave Propagation (IZMIRAN, Russian Academy of Sciences) and other services, allowed to coordinate activities of astrophysicists and specialists on brain physiology, and to conduct relevant experiments within a joint research program on a subject which started several years ago [27, 28]. The relevant information about these events addressed to the public was published in daily "Space Weather Prognosis" column provided by famous Azerbaijani newspaper "Zerkalo" in Russian.

Strong disturbed geomagnetic conditions which had a place in 8-10 November 2004 and 17-19 January, 17 May, 15 June 24 August, 11-12 September 2005 were involved in our studies as well. Space weather conditions (parameters) and other available solar-geophysical data for the considered periods, were used in our continuous experiments. Special attention was paid to the days 24-25, 27 October, 29-30-31 October and, particularly, 4, 11 and 20 November 2003.

We have studied the influence of geomagnetic storms on the human brain functional state of functionally healthy adult women (permanent group) in states of relaxation, during photo-stimulation and in hyper-ventilation. Results of EEG investigations were used as the most objective method reflecting functional state of the human brain. A parallel registration of the electrocardiogram (ECG) was also conducted.

Comparison of data for days with severe geomagnetic storms (f.e., for period of October-November 2003) with other data obtained during a long-time period experiments for relatively geomagnetically quiet and moderately disturbed days as well as interpretation of the obtained results were carried out.

2. THE HUMAN BRAIN, ITS BIOELECTRIC ACTIVITY AND EXPERIMENTAL METHODS OF INVESTIGATION

There is a harmonic relationship between the Earth and human mind/bodies. Earth's low frequency isoelectric field, the geomagnetic field, and the electrostatic field which emerges from our bodies are closely interwoven. Our internal rhythms interact with external rhythms, affecting our internal "clocks", balance, sleep/dream, rapid eye movement (REM) and arousal patterns, health, and mental focus. The rhythms and pulsations of the human brain mirror those effects of the geomagnetic field changes which are, in turn, governed by space weather.

The human brain is the organ in the human body that is responsible for thought, memory, sensory interpretation, movement, etc. Cerebrum is the largest and most complex portion of the brain. It controls thought, learning, and many other complex activities. It is divided into the left and right cerebral hemispheres that are joined by the corpus callosum, which communicates between the two hemispheres. The right side of the brain controls the left side of the body, and vice versa. Each cerebral hemisphere is divided into four lobes: the frontal lobe (responsible for reasoning, emotions, judgment, and voluntary movement); the temporal lobe (contains centers of hearing, smells, and memory); the parietal lobe (responsible for touch and spoken language ability); and the occipital lobe (the region at the back of each cerebral hemisphere that contains the centers of vision and reading ability which is responsible for centers of vision and reading ability).

The brain is a massive source of extremely-low-frequency (ELF) signals that get transmitted throughout the body through the nervous system, which is sensitive to magnetic fields. Brainwaves and natural biorhythms can be affected by external factors. Brainwaves have only been studied since about the mid-1920s, and the signal form that is apparently most widely known, and identified is the alpha-rhythm.

The electroencephalograph (EEG), a graphical recorder of the electrical activity of the brain, measures brainwaves of different frequencies within the brain with the help of electrodes that are placed on the scalp to obtain information. Rhythmicity in the EEG is a key variable in the coordination of cortical activity. Electrodes are placed on specific sites on the scalp to detect and record the electrical impulses within the brain. Frequency is the number of times a wave repeats itself within a second while amplitude represents the power of electrical impulses generated by the brain. Volume or intensity of brain wave activity is measured in micro-Volts.

Raw EEG frequency bands include Gamma (higher than 30 Hz), Beta (14-30 Hz), Alpha (7.5-13 Hz), Theta (3.5-7.5 Hz) and Delta (less than 4 Hz) ones. Their ranges overlap one another along the frequency spectrum by 0.5 Hz or more. These frequencies are linked to behaviors, subjective feeling states, physiological correlates, etc. Clinical improvement with EEG biofeedback is traceable to improved neuroregulation in the basic functions by appeal to their underlying rhythmic mechanisms. In the range of human EEG, there is the Sun's electromagnetic oscillation of 10 Hz, while the Earth-ionosphere "Schumann Resonance" system is resonant at frequencies in the theta, alpha, beta1 and beta2 bands.

Human brains and bodies are "developed" in the biosphere, the electromagnetic environment conditioned by this cyclic pulse. Conversely, this pulse acts as a "driver" of human brains, and can also potentially carry information as well. Functional processes

may be altered and new patterns of behavior facilitated through the brain's web of inhibitory and excitatory feedback networks.

The brain has its own set of vibrations used to communicate with itself and the rest of the body; EEG equipment distinguishes these waves by measuring the speed with which neurons fire in cycles per second. At their boundaries these waves can overlap somewhat, merging seamlessly into one another, so different researchers may give slightly different readings for the range of cycles per second. Rate of cycling determines the type of activity, kindling wave after wave over the whole surface of the brain, by igniting more neurons.

Gamma waves (with frequencies above 30Hz) represent hyperarousal. It is believed that the 40Hz frequency may be the key to the act of cognition. Gamma appears to relate to simultaneously processing information from different brain areas: memory, learning abilities, integrated thoughts, information-rich task processing. Gamma rhythms modulate perception and consciousness, which disappears with anesthesia. Synchronous activity at about 40 Hz appears involved in binding sensory inputs into the single, unitary objects we perceive. The brain responds to inputs at a certain frequency or frequencies. The computer can create wave form patterns or certain frequencies that compare with the mind's neural signals in terms of mind patterns. If people can control their mind patterns, they can enter different states of being (mental relaxation, study, etc.).

Beta waves (14 cycles per second and above) dominate human's normal waking state of consciousness when attention is directed towards cognitive tasks and the outside world. Beta is a "fast" activity, present when we are alert or even anxious; problem-solving, judgment, decision making, processing information, mental activity and focus. The beta wave is associated with peak concentration, heightened alertness and visual acuity.

Alpha waves (7-13 cycles per second) are present during dreaming and light meditation when the eyes are closed. As more and more neurons are requited to this frequency, alpha waves cycle globally across the whole cortex. This induces of deep relaxation, but not quite meditation; alpha waves aid relaxation and overall mental coordination, calmness, alertness, inner awareness, mind/body integration and learning. In alpha, human begins to access the wealth of creativity that lies just below human's conscious awareness. It is the gateway, the entry point that leads into deeper states of consciousness. Alpha is also the home of the window frequency known also as the "Schumann Resonance", which is the resonant frequency of the Earth's electromagnetic field.

Theta waves (4-7 cycles per second) occur most often in sleep but are also dominant in the deepest state of mediation (body asleep/mind awake). The optimum level for deep thought is this realm of theta. In theta, human's senses are withdrawn from the external world and focused on the mindscape, internally originating signals. Theta waves are associated with mystery, an elusive and extraordinary realm humans can explore. It is that twilight state which we normally only experience fleetingly as we rise from the depths of delta upon waking, or drifting off to sleep. In theta we are in a waking dream, vivid imagery flashes before the mind's eye and we are receptive to information beyond our normal conscious awareness. Theta has also been identified as the gateway to learning and memory. Theta meditation increases creativity, enhances learning, reduces stress and awakens intuition and other extrasensory perception skills. Theta waves mean "slow" activity connected with intuition, daydreaming or recalling emotions and sensations. Focus is internal in this state between waking and sleep. Under stress it may manifest as distraction, lack of focus.

Delta waves range between 0-4Hz. Delta waves are the slowest but highest in amplitude and are associated with deep, dreamless sleep, non-REM sleep, trance, and

unconsciousness. In deepest meditation and dreamless sleep, delta waves are generated. Each of these brainwave frequencies serves an important function. Delta waves confer a suspension of external existence and provide the most profound feelings of peace. In addition, certain frequencies in the delta range trigger the release of growth hormone beneficial for healing and regeneration. This is why sleep, deep restorative sleep is so essential to the healing process.

In our experiments data record of bioelectric activity of the human brain was made with the help of electroencephalograph "Medicor", which is a multi-channel (16 channels) recorder intended for registration of the physiological characteristics. The digital data was recorded and subsequently subjected to reviewing and analyzing qualitatively and quantitatively.

Twenty seven healthy female persons (permanent group), aged between twenty and forty years old, selected from the same geographical area, were chosen for a long-term investigations during geomagnetically quiet (favorable) days, at days with weakly-disturbed, and strongly-disturbed (unfavorable) geomagnetic conditions. All female patients were examined in the inter-menstrual period.

Daily changes of meteorological situation during the experiments were taken into account. In order to avoid possible psychological effects prior to experiments, the persons under test were not familiarized about space weather conditions before and during experiments. The experiments were conducted in isolated rooms and in hospital conditions.

Registration of spontaneous EEG by a mono-polar way from sixteen standard leads arranged pursuant to the international system of "10-20" and a parallel registration of the electrocardiogram was conducted. The experiments were carried out in the standard system from forehead (frontal), central, parietal, occipital and temporal areas of both hemispheres of the human brain.

Investigations were carried out for quiet and active awakeners in conditions with open and closed eyes, in the states of relax, in photo-stimulation and in the process of a hyperventilation. The native records of EEG, which were obtained at different functional conditions, relevant data and registered curves, were stored. Later on, after removal of artefact segments, they were subjected to the computer analysis using the relevant software "Conan". Spectral and amplitude mapping, correlation and periodical-metric analyses were carried out. Frequency and amplitude cartograms, obtained for different functional conditions, reflect features of the human brain functioning at comparatively quiet days and at days with severe geomagnetic storm.

Experiments were conducted taking into account solar and geomagnetic storms during above-mentioned days in 2001 - 2005. As the most widely-used parameters of the geomagnetic activity for biomedical problems, daily variations of the Ap-index and Dst-index were used in our researches alongside with other space weather parameters.

Magnetic fields found in our environment are produced by both natural and artificial sources. The main natural source is the geomagnetic field which changes very slowly over time. Typically the geomagnetic field varies normally around 1 – 10nT (though changes of up to 250 nT can occur during geomagnetic storms) over a period of hours. On average the geomagnetic field is around 50,000nT (total intensity is 49,388nT in Azerbaijan, changing by 56.79nT/year); this can be altered quite substantially by the local geology. Estimated value of geomagnetic declination for Baku where experiments were conducted ($40^{\circ}22'00''$ N and $49^{\circ}53'00''$ E) is $5^{\circ}24'$E changing by $0^{\circ}4'$E/year while main field inclination is about 59°.

3. OBTAINED RESULTS AND DISCUSSIONS

Our investigations have revealed an indisposition, weakness and presence of indistinct localized headaches during days with severe geomagnetic storms for the large

majority of persons under test while there were almost no significant complaints about functional state in periods of weakly disturbed geomagnetic conditions (only in some cases a weakness were noted).

Analysis of results conducted during the periods of weak geomagnetic disturbances showed shifts, mainly seen in the frequency spectra. Some acceleration of dominating frequency was observed. Groups of synchronic alpha- and theta waves, which had amplitudes slightly exceeding the background and appearing mainly at loading, were bilaterally-synchronically registered at anterocentral areas. No pathological activity and paroxysmal phenomenon, including paroxysmal-similar signs, were registered. Inter-zonal distinctions were clearly traced. Reactivity of dominating alpha-rhythm decreased a little bit.

In days with severe geomagnetic storms, a bioelectric activity of the human brain was characterized by reduction of frequencies of dominating rhythm, by amplification (strengthening) of expressiveness of slow-wave component (mainly a theta-rhythm) and by increase in amplitude of activity. We have observed the forms of waves with pointed outlines and strengthening of process of synchronization of activity.

Flashes of pointed and sharp alpha- and theta-waves, having right cerebral hemisphere's accent (stress), were registered during our experiments. Smoothing of inter-zonal distinctions was observed as well.

Typical picture of summary EEG amplitude cartogram in the day with severe geomagnetic storm is provided in Fig.1.

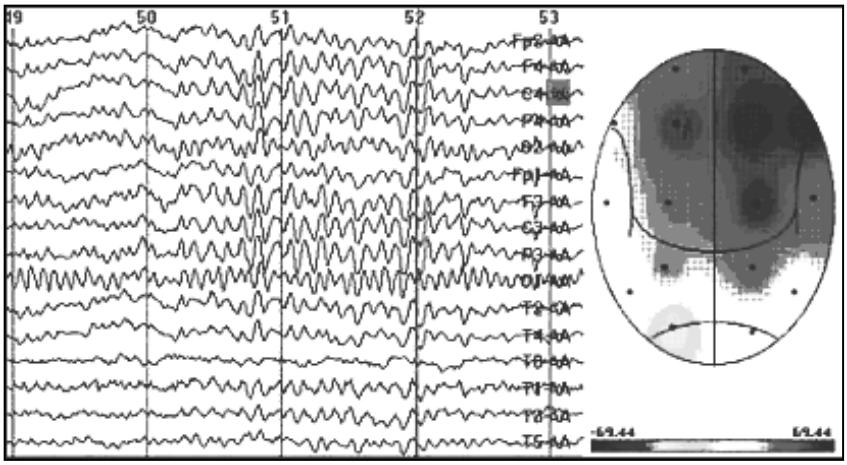

Fig.1.

Typical example of total (summary) amplitude cartogram of EEG during severe geomagnetic storm for the whole length of hyperventilation process.

During the hyperventilation process, observable flashes of both pointed and sharp alpha- and theta-rhythms were amplified, and their amplitude was increased as well.
For a part of examinees diffuse synchronization was traced on frequency ranges of alpha1 and alpha2 rhythms. Reactivity of dominating activity was weakened, and reactions of adopting a rhythm were observed on lower frequencies of the alpha-range.

Typical picture of summary amplitude cartogram through all of epochs is given in Fig.2.

Figure of correlation interrelations, inherent to various functional conditions, was broken. Inter-hemispheric asymmetry was revealed. The leading role in interrelations had temporal area of the right cerebral hemisphere. Activation of rostral-temporal and caudal-temporal connections (links) of the right hemisphere was marked.

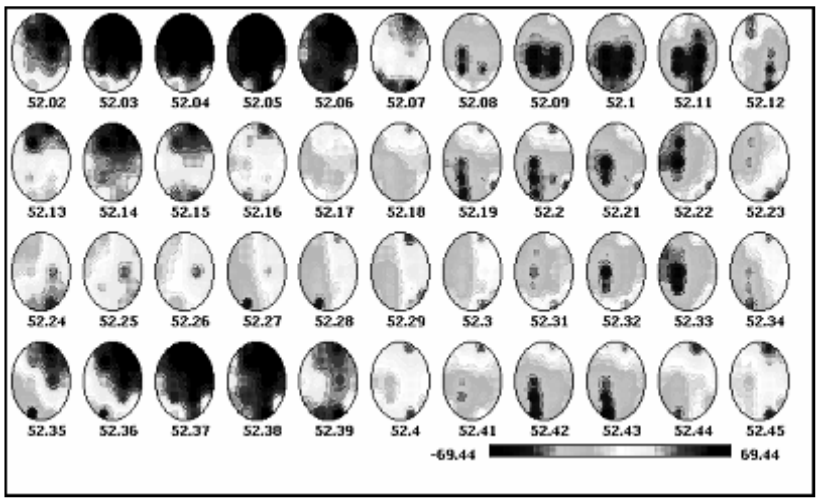

Fig.2.
Typical picture of summary amplitude cartogram through all of epochs during severe geomagnetic storms.

The obtained results prove the significant changes in activity of the human brain during the days with severe magnetic storms, reflecting infringement of functions on both central integrative mechanisms and local processes of brain regulation.

It is well known that the most sensitive sections of the human brain, influenced by negative factors of an environment, are hypothalamus (a region in the upper part of the brainstem that acts as a relay to the pituitary gland; it controls body temperature, circadian cycles, sleep, moods, hormonal body processes, hunger, and thirst) and cerebral cortex of the big hemispheres of the human brain [29].

The increase of representativity of theta- and alpha-rhythms carrying flash-like character, testifies on dysfunction of mesodiencephalitic sections within the limits of which hypothalamic nucleus are located. Considering hypothalamus as a leading part of nonspecific systems of the human brain [30, 31] and as responsible for neuroendocrinal and vegetative regulation, it should be noted that strong geomagnetic disturbances infringe normal activity of this structure, causing imbalance in ergo- and tropho-tropic interrelations. In days with weak geomagnetic storms, an order of this dysfunction was low and it was mainly traced at functional loadings, i.e., at transfer of organism from the state of rest to active state.

The dysfunction, registered on EEG at days of severe geomagnetic storms and reflecting ascending sendings of non-specific systems, undoubtedly affects descending directions as well, causing complex vegetative complaints observed in the majority of examinees. At the same time, it must be noted that pointed and sharp flashes of waves of theta- and alpha-range which are observed on some tested persons in the days with severe geomagnetic storms, testify the paroxysmal character of the infringements, specifying on reduction in a threshold of convulsive (spasmodic) readiness mesodiencephalitic formations with followed corresponding clinical-neuropsychological consequences.

Observed right cerebral hemisphere accent (stress) of changes testifies the greater “interest” of right hemisphere. According to the paper [32], activation of the right hemisphere is accompanied by negative tinge of emotional reactions. Outgoing from this fact, it is possible to assume that during significant disturbances of geomagnetic conditions the negative emotional background of the person is amplified. This assumption is also proven by results of the correlation analysis specified on strengthening cortical connections in the right cortical hemisphere and their short circuit on temporal sections, while, in geomagnetically quiet days, a profile of correlation interrelations has reflected weak internal- and inter-hemispheric connections.

Thus, results of our researches testify on different character of influence of weak and severe geomagnetic storms on the functional state of the human brain.

During days with weak geomagnetic disturbances no significant changes in the human brain activity were observed. Some negligible shifts, registered for several persons, reflected an increase of activity of mesodiencephalitic structures which is observed at activation of organism.

Comparing to the above mentioned results, in days with severe geomagnetic storms the human brain's activity is seriously disintegrated. Normal functioning of integrative nonspecific systems, located within the limits of limbric-reticular complex and responsible for creation of the corresponding level of wakefulness, which is directed on realization of optimum current activity of an organism, is broken. Imbalance of activating and deactivating mechanisms arises including also dysfunctions of ergo- and tropho-tropic over-segmentary centers.

The threshold of convulsive (spasmodic) readiness of the human brain is reduced which is especially dangerous for the persons of high risk and, as a result, this fact should be taken into account for preventive measures and therapy of paroxysmal conditions.

We suppose that geomagnetic disturbances might influence human functional state through magneto-reception mechanism. Humans and animals have been found to have a specialized set of neurological receptors containing tiny crystals of natural magnetite (iron crystals dioxide Fe_3O_4) in their brains and other tissues that allow them to "sense" magnetic field changes and navigate by the geomagnetic field. Magnetic sense in humans has been found to affect dowsing abilities and directional (spatial) orientation in the dark. These iron oxide crystals are thought to be involved in magneto-reception, the ability to sense the polarity or the inclination of the Earth's magnetic field. Possibly the most closely studied of the variable Sun's biological effects has been the degradation of homing pigeons' navigational abilities during geomagnetic storms. Pigeons and other migratory animals, such as dolphins and whales, have internal biological compasses composed of the mineral magnetite wrapped in bundles of nerve cells. Crystals of magnetite have been found in some bacteria (e.g., Aquaspirillum magnetotacticum) and in the brains of termites.

The magnetic particles (magnetite), found in some biological organisms, appeared to be surrounded by nervous tissue, suggesting the possibility of interaction between the particle and the brain. Magnetite in the ethmoid cavities of humans was discovered in 1983 [33]. The presence of biogenic magnetite in human and other animal brain tissue was also established by using magnetic and electron microscope techniques. The superconducting quantum interference device (SQUID) is generally used to measure the smallest biomagnetic fields, including those emitted by tissue and muscles. The mapping of weak magnetic fields in the human body (heart, brain, spinal cord) using SQUID-magnetometer led to a new science field called "Biomagnetism" with following major areas: magnetocardiography (MCG) which is the recording of magnetic fields produced by electrical activity in the heart, and, magnetoencephalography (MEG) which is the recording of magnetic fields produced by electrical activity in the brain.

4. SUMMARY

Conducted in this paper study on possible influence of changes of heliogeophysical conditions on human functional state showed an evident influence of solar and geomagnetic activities on the human brain. Considered problem is very complicated because of influence of many factors on human organism, which are, in turn, interconnected and are clearly reflected, at first, in human functional state.

The obtained results allowed making a conclusion that the strong disturbances of the geomagnetic conditions can negatively affect the human organism, having an effect on functional activity of a brain and changing its background state.

Based on the theory of phase transition induced by the noise and applied in biology, in our researches we consider the human being as a biological object acting as an open non-linear system being in the state of non-stable dynamic balance. Transition of this system into another state ("critical" or "disrupted rhythmical") can happen even in the case of very weak external influence having a level of noise and acting as failure of rhythm. Any changes of natural electromagnetic field (geomagnetic field) caused by solar sources can play a role of one of these external factors.

There are specific and significant changes in the functional activity of the human brain during the days with severe geomagnetic storms, which reflect infringement of functions in both central integrative mechanisms, and local processes of the human brain regulations.

It is established that, together with the detected specific changes, complex of nonspecific shifts on the EEG reflects disorganization of functional activity of the cortex of large hemispheres of the human brain at geomagnetically disturbed days, which is most likely connected with dysfunction of integrative subcortical systems, disbalance of its ascending synchronizing and desynchronizing influences. The disbalance of these mechanisms infringes the optimal functioning of the integrated brain, disorders normal level of corticosubcortical correlations, which, in turn, finally affects emotional and ideational activities.

As a rule, during periods of strong geomagnetic disturbances, indisposition, weakness and presence of indistinct localized headaches were recorded for the major part of the persons under test.

In most cases bioelectric activity of the human brain was characterized by the slow-down of frequencies of dominating rhythm, by the strengthening of expressiveness of a slow-wave component (mainly a theta-rhythm) and by an increase in amplitude of activity. The form of waves had the pointed (sharp) shape and amplification of process of synchronization of the activity as well as smoothing inter-zonal distinctions were observed.

For the part of examined patients, diffuse synchronization was traced on frequency ranges of an alpha-rhythm (clearly expressed in occipital sections and in temporal areas). Reactance of activity was weakened, reactions of mastering of a rhythm were observed on lower frequencies of an alpha-rhythm range. Flashes of both pointed and sharp alpha and theta-rhythms, exceeding on amplitude a background, were observed during hyperventilation process.

Picture of correlation relations inherent to various functional states was infringed and inter-parencephalon (inter-hemispheric) asymmetry was marked. Temporal area of the right cerebral hemisphere (parencephalon) had a leading role in interrelations. Activation of rostral-temporal and caudal-temporal links of the right hemisphere was marked.

During strong disturbances of geomagnetic conditions, the negative emotional background of the person is amplified. Strengthening cortical connections in the right cortical hemisphere and their short circuit on temporal sections during geomagnetically disturbed days were observed, while, in geomagnetically quiet days, a profile of correlation interrelations reflected weak internal- and inter-hemispheric connections. The threshold of convulsive (spasmodic) readiness of the human brain is reduced.

It is established that weak and moderate geomagnetic storms exert stimulating influence while the strong disturbances of the geomagnetic conditions activate braking (inhibiting) processes.

Great care needs to be taken collating geophysical and physiological-biological data, because it is difficult to attribute specific agents to changes in human health and behavior since we all live in a webwork of tremendous complexity. In addition to time-varied influence of geomagnetic field on us, the Earth is now also bathed in artificial electro-magnetic fields created by man and called "electro-smog". These include televisions, electric trains, microwave ovens, electrical appliances, wiring of our homes, wireless equipment, radio and television waves, radar, computers, medical equipment, our cars, their radial tires and cell phones.

Studies and researches on biological responses to geomagnetic fields by human and organisms and therapeutic/prophylactic benefits might have future applications that benefit the society.

Complex and synchronic investigation of geomagnetic storms' effects on human brain in different latitudinal and longitudinal areas of the globe could give more detailed and interesting results which are very important for understanding the influence mechanisms and preventive measures.

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FÖVQƏLADƏ GÜNƏŞ ENERGETİK HADİSƏLƏRİNİN VƏ GEOMAQNİT FIRTINALARININ İNSAN BAŞ BEYNİNİN FUNKSİONAL HALINA TƏSİRİ

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Müxtəlif intensivlikli geomaqnit fırtınalarının sağlam və yetkin yaşlı insanların (qadınların) baş beyninin funksional halına təsiri tədqiq olunmuşdur. Təyin olunmuşdur ki, zəif və orta səviyyəli geomaqnit fırtınaları insan baş beyninin fəaliyyətində ciddi dəyişikliklər yaratmır və yalnız stimullaşdırıcı təsir göstərir, lakin güclü geomaqnit həyəcanlaşmaları, mənfi təsir göstərərək, beyinin işini əhəmiyyətli dərəcədə dezinteqrasiya edir, tormozlayıcı prosesləri fəallaşdırır və şəxsiyyətin mənfi emosional fonunu gücləndirir.

ВЛИЯНИЕ ЭКСТРЕМАЛЬНЫХ СОЛНЕЧНЫХ ЭНЕРГЕТИЧЕСКИХ СОБЫТИЙ И ГЕОМАГНИТНЫХ БУРЬ НА ФУНКЦИОНАЛЬНОЕ СОСТОЯНИЕ ГОЛОВНОГО МОЗГА ЧЕЛОВЕКА

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Исследовано влияние геомагнитных бурь различной интенсивности на функциональное состояние человеческого мозга практически здоровых взрослых людей (женщин). Установлено, что слабые и умеренные геомагнитные бури не вызывают существенных изменений в деятельности мозга и оказывают только стимулирующее влияние, в то время как сильные геомагнитные возмущения, оказывая отрицательное влияние, серьезно дезинтегрируют работу мозга, активизируют тормозящие процессы и усиливают отрицательный эмоциональный фон личности.

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