NEURO-AMEA

Method

The Neuro-Metabolic Activity Mapper (NMAM) is currently used in various medical and research facilities. The instrument has received highest appraisal from the researches that work with it. Data received from NMM allows detecting pathologies that require further medical investigations with PET and/or Functional MRI.

The method is based on functional dependency of a certain spectrum of DC potentials and metabolic activity of the brain. Therefore, the NMAM method is somewhat similar to PET tomography though based on electro-physiological properties of the brain.

The method NMAM is implemented as a hardware-software system. There are two models available: 12-channel and 5-channel. The software component for the 12-channel model system is also compatible with the hardware for the 5 channel model.

General Provisions

DC potentials are measured on the skin surface using non-polarizable sensors. The obtained values then are amplified using a DC amplifier with 10M impedance. The sensors should be tested before they could be used on a patient. For testing sensors are placed in hypertonic (having higher concentration) salt solution (NaCl) then potential difference (PD) and resistance between sensors are measured. The PD between sensors should not exceed 30 mV and impedance between them should be around 15 – 20 kOhm. The PD drift between the sensors should not exceed 1 – 2 mV in 10 minutes.

Now the instrument is ready for patient examination. One of the sensors, the reference sensor, is placed on a wrist. The other sensors, active sensors, are placed on the scalp along the sagittal line.

If a 12 channel version of instrument is used, then sensors are placed on the scalp in the following areas: central forehead area (Fpz), right forehead area (Fd), left forehead area (Fs), central right area (Cd), central area (Cz), central left area (Cs), vertex right area (Pd), vertex area (Pz), vertex left area (Ps), back head area (Oz), right temple area (Td), and left temple area (Ts).

If a 5 channel version of instrument is used, then sensors are placed on the scalp in the following areas: forehead area (Fz), central area (Cz), back head area (Oz), left (Tz) and right (Td) temple areas.

Contact pads of the sensors should be moistened with hypertonic NaCl solution. This reduces skin impedance. The data reading begins after 5-7 minutes after placing the sensors on the scalp. This, 5 to 7 minute delay, allows transient processes to complete and triboelectrical (inducted due to friction between two surfaces) currents to subside.

The skin impedance at the points of sensor contacts is also measured during data acquisition. This impedance should not exceed 30 kOhm. The magnitude of static electricity on the scalp, which distorts DC potential reading, correlates with the skin impedance. The artifacts due to static electricity could be minimized by reducing skin/scalp impedance, stabilizing skin/scalp impedance during whole acquisition process, and equalizing skin impedance at the points of sensor contacts The absolute values of DC potentials are calculated as difference of DC potentials between the sensors attached to the scalp and the reference sensor attached to the wrist. Acquired data are processed automatically during neuro-activity map computing. In certain cases, however, difference between a DC potential obtained from at a given sensor and the average value of DC potentials obtained from all the sensors attached to the scalp is used. Doing so gives an ability to estimate DC potentials obtained from sensors in each area without taking into consideration the DC potential values obtained from the reference sensor. This approach is especially advantageous when a local damage to the brain is examined, for example, after a stroke. The results are also presented in tabulated form and as a color coded brain map of DC potentials.

There is also an option to enter DC potential values manually from the computer keyboard.

The software has a database with reference DC potentials. These data were obtained from healthy individuals of both genders and various ages. The results could be compared with the reference data after the patient's demographics is entered into the software. The results were averaged within each age group for given gender. The color coded map of DC potentials gives up an opportunity to visually estimate differences between the patient and reference maps.

Statistical analysis of the obtained data is provided in the Medical Assessment section. In this section, deviation from median value is calculated and differences between acquired and reference data are analyzed.

The final result of DC-potential analysis is a assessment based on the latest knowledge of the DC potential origin and on the evaluated rate of metabolism in different areas of the brain.

Method description

The electro-physiological method for estimation of the acid-base balance in human brain was devised in the Brain Research Centre, Russian Academy of Medical Sciences, Moscow, in the 1980s. The method is based on evaluation of the Direct Current (DC) in the brain followed by analysis of acquired data using computer.

Direct Current potentials (DC) of the brain are slow voltage changes in millivolt range. These potentials represent membrane neurons' DC potentials, glia (the tissue between neurons that maintain homeostasis) DC potentials, and blood-brain barrier DC potentials. This approach measures the DC potentials mostly on the blood-brain barrier membrane. These DC potentials depend on difference of hydrogen ion number on each side of the membrane. The blood-vessel potentials are defined by the difference in number of hydrogen ions of each side of the blood-vessel wall or the endothelial membrane. The acids are the final product of the energetic metabolism. Therefore, the concentration of the hydrogen ions in the blood flowing from the brain allows estimating metabolic rate. The higher metabolic rate, the higher hydrogen ions concentration and thus higher measured DC potential values are. For example, relative increase in the DC voltage on the dominant hemisphere of the brain means higher glucose utilization rate in this hemisphere. On the contrary, decrease in the DC voltage on a brain hemisphere indicates slow-down in the functional brain activity in this hemisphere. This may happen, for example, in the presence of acute circulatory problems.

Due to its origin, the DC potentials correlate with numerous biochemical and immunological processes that linked to cerebral metabolic rate and functional state of human adaptation systems. In the presence of cerebral damage, the DC potentials show stage and severity of pathological processes, which affect the brain metabolism, and therefore can be used as a marker, for example, of therapeutic treatment.

Numerous researches conducted in medical clinics (in the departments of psychiatry, psychology, and neurology), occupational medicine (air craft pilot tests), and sport medicine have proved the DC potentials as a reliable marker of brain metabolic rate.

Areas of Application

This instrument could be used in healthy people such as: pilots, software developers/engineers, athletes, students, etc. in order to estimate:

- Functional activity (just like in functional MRI).
- Metabolic reserves .

- Psychentonia.
- Fatigue.
- Stress level or stage of general adaptation syndrome (described by Hans Selye).
- Diagnosis of monotony and satiety and their differentiation.
- Efficiency studies.
- Fitness level of athletes.
- Observation of recovery processes.
- Observation and control over learning processes in students.
- Forecasting of life expectancy.

In patients with vascular or atrophic brain damage, for example, as a result of stroke, Parkinson's disease, Alzheimer disease, epilepsy, etc. for:

- Differential diagnostics .
- Estimation of damage.
- Localization of affected area.
- Observation and control of treatment plan efficiency (medication or psychotherapy).

In patients with neuroses and depressions for:

- Differential diagnostics.
- Observation and control of treatment plan efficiency (medication or psychotherapy).

In patients with general diseases for:

- Estimation of stage and rate of the degenerative processes.
- Observation and control of treatment plan.

In patients with drug abuse, alcoholism, and other addictions for:

- Estimation of stage and rate of the degenerative processes.
- Observation and control of treatment plan.

The instrument can also be used in:

Physiology, psycho-physiology, and neurology

- To study functions of the brain.
- To study connection between psychological and physiological processes.

Neuropathalogy, psychiatry, and narcology

- For diagnostics.

- For studies of etiology, course, and the nature of nervous and mental diseases.
- For medicine selection and development of new treatment plans.

Psychotherapy

- For treatment plan evaluation.
- For personal treatment plan selection and correction.
- For new treatment plan development.

Therapy

- Estimation of stage and rate of the degenerative processes.

Spa treatment

- For optimization of the recovery plan.
- For treatment plan selection and its efficiency evaluation.

Hypnology

- For influence methodology selection.
- For trance induction method selection.

Pediatrics

- Diagnostics of birth injury consequences, cerebral palsy, mental retardation, encephalopathy.
- Forecasting such diseases development, treatment plan development.

Psychology and neuro-psychology

- Diagnostics of learning disabilities, attention, perception, logical and creative thinking, memory, and imagination together with the traditional methods.
- Evaluation of brain metabolic rate for the above-mentioned process.
- Monitor rehabilitation and training of mental and psychomotor functions.
- Development of proper techniques for psycho correction and psycho training.
- Training for self-control using natural biological feedback of the human body.

Gerontology

- Screening and diagnostics of degenerative brain diseases such as: dementia, Alzheimer disease, and atherosclerosis.

Juvenology

- General health screening.
- Screening of SPA treatment efficiency and safety.

Sports medicine

- Evaluation of body physical reserves, stress resistance, training level, stamina, and ability and speed of recovery after physical training.
- Performance forecast, efficiency evaluation, and optimization of dietary supplements.

Pharmacology

- Assessment of drugs effects on the brain acid-base balance, metabolism, brain functional activity and blood circulation.

The method advantages

1. Pain-free, safe, and non-invasive application.
2. Produces very low number of biological and physiological artifacts.
3. Short analysis time (one measurement could be completed in 5 – 7 minutes).
4. Possibility of long-term dynamic observations.
5. Medical and biological significance of the results.
6. Small size.
7. Simple, user friendly interface.
8. Could be used as a medical diagnostic or research tool.

Technical requirements

The hardware:

The UNEK software would run on any PC-compatible computer.

Peripheral equipment:

The UNEK software is designed to work with the “NMAM” microcontroller based system. The software communicates with NMAM via USB 2.0 port connected to the AK-80XX device, which is included in NMAM distribution.

Software requirements:

- The Windows OS.
- The UNEK software.

Capabilities of Neuro-methabolic Activity Mapper, a software and hardware system for visualization, registration, and analysis of low frequency electrical activity of the human brain

Data acquisition:

- Non-polarisable sensors used.
- Programmable DC current amplifier used.
- Simultaneous acquisition on 5 independent channels.
- Automatic estimation and compensation for residual DC potentials and resistance of the sensors.
- Variable time lapse in the recording of DC potentials.
- Option to enter data manually from the keyboard.

Data analysis:

- Automatic computation of local DC potentials.
- Representation of DC potentials as topographic brain map with color coded DC values.
- Option to compare map of obtained DC values with the reference values for the given gender and age.
- Differences measured between map of the obtained DC values and the reference map.
- Estimation of energy level and metabolic rate in the brain tissues.

Data interpretation and storage:

- Data output as graphs and tabulated data to printer.
- Patients' data (DC Potentials) as graphics and numerical values are stored in data base.

Clinical cases overview. 5-Channel version of NMAM.

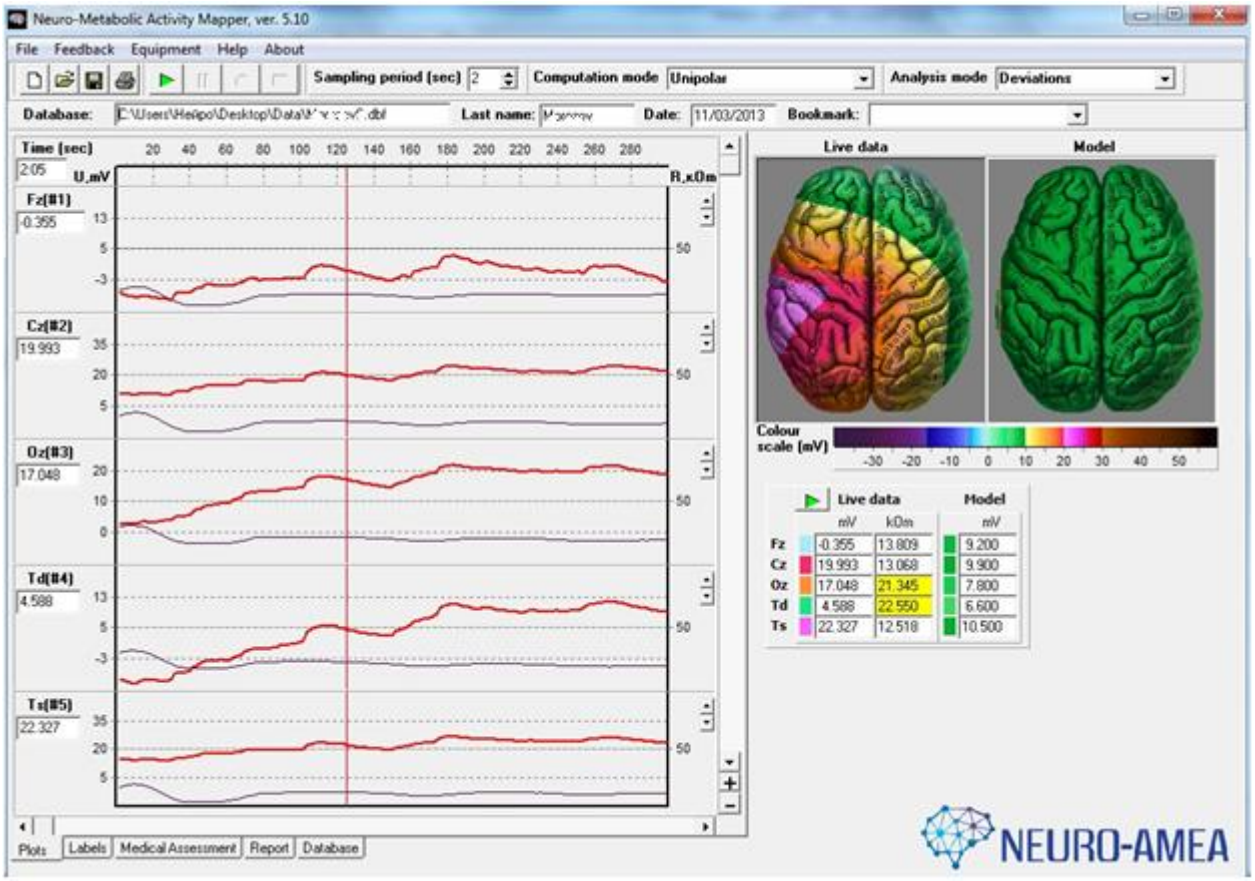

Figure 1. The main window of NMAM Software (5-channel version).

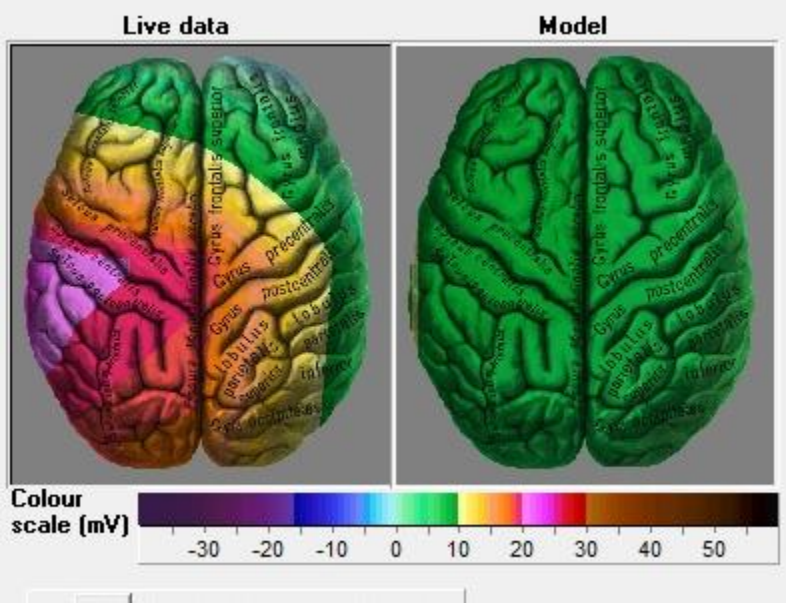

Figure 2. Ischemic stroke in the left hemisphere. Discirculatory encephalopathy, ipsilateral increase in the DC potentials.

In Figure 2. Ischemic stroke in the left hemisphere. Discirculatory encephalopathy, ipsilateral increase in the DC potentials., a DC map of a 78 years old patient is presented. The examination was conducted 8 months before ischemic stroke happened in the vicinity of the left middle cerebral artery. Discirculatory encephalopathy, ipsilateral increase DC potentials in the left hemisphere of the brain present.

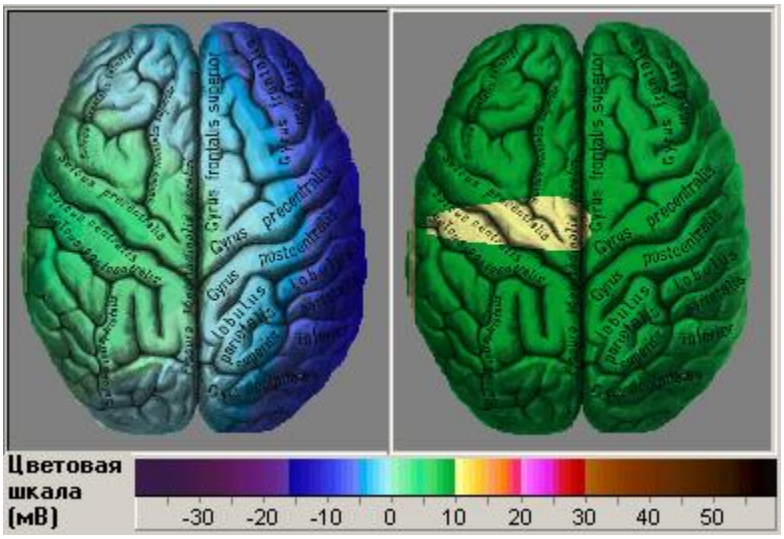

Figure 3. Ischemic stroke in the vicinity of the right brain artery. Ipsilateral decrease in the DC potentials.

In Figure 3, a DC potential map of a 56 years old patient is given. Diagnosis: Ischemic stroke in the vicinity of right brain artery. Ipsilateral decrease in DC potentials in the right hemisphere.

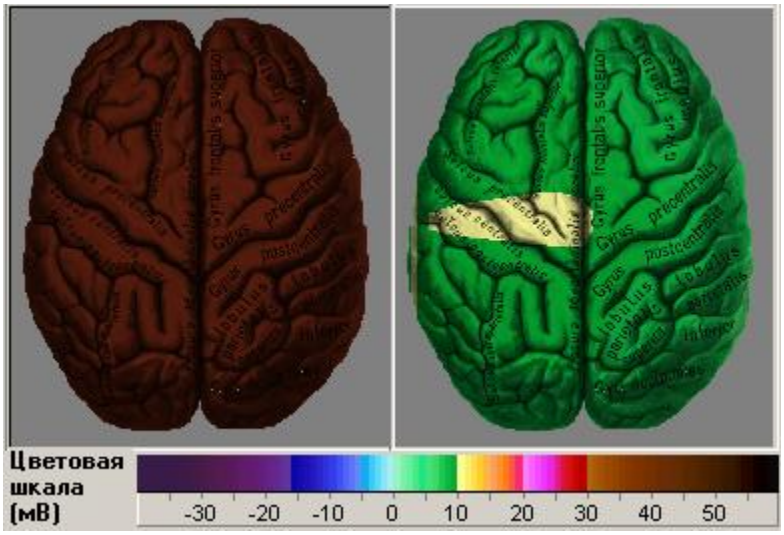

Figure 4. Hemorrhagic stroke. One hour before patient's death.

In Figure 4, a DC potentials map of a 40 year old patient. Non specific generalized increase in the DC potentials. Diagnosis: hemorrhagic stroke. The examination was done one hour before patient's death.

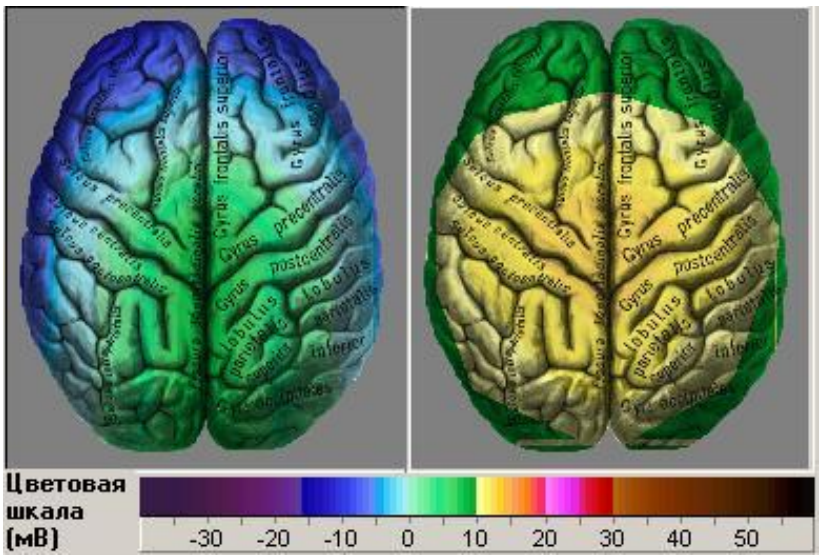

Figure 5. Decrease in DC potentials in the front and temporal lobes of the brain.

In Figure 5, a DC potential map of a 12 year old patient. Diagnosis: ADHD, specific decrease of the DC potentials in front and temporal lobes.

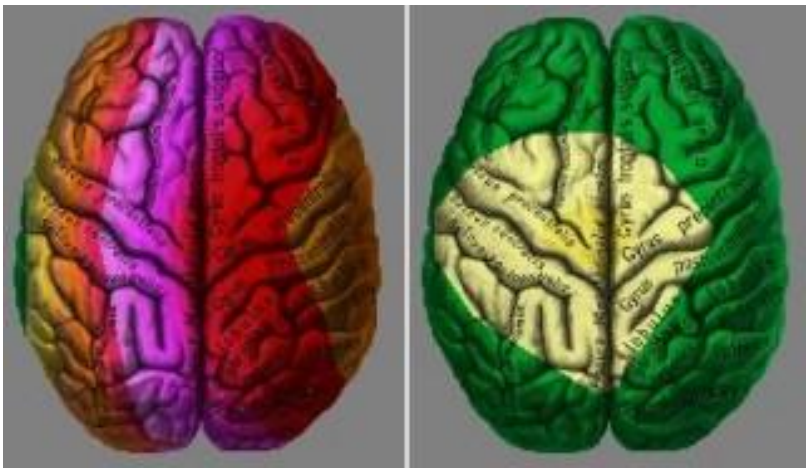

Figure 6. Sharp headache.

Figure 7. 40 minutes after administration of Baralgin.

In Figure 6, a DC potentials map of a 26 years old patient. Sharp headache. Specific increase in the DC potentials in the left hemisphere, ipsilateral to cephalalgia localization. In Figure 7, the DC potential map of the same patient 40 minutes after administration of the Baralgin pain killer, the headache is relieved.

Clinical cases overview. 12-Channel version of NMAM

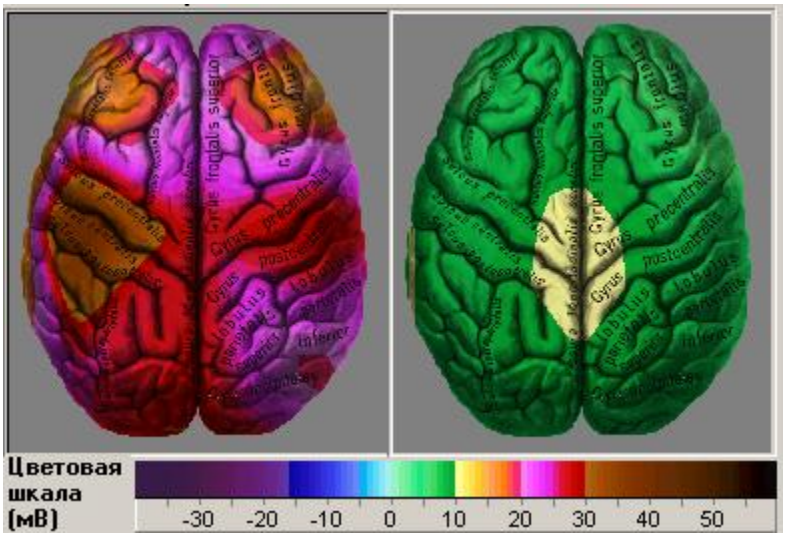

Figure 8. Metabolically active tumor in the left hemisphere.

In Figure 8, a DC potential map of a 55 year old patient. There is a metabolically active tumor in the left hemisphere, ipsilateral to area of increased DC potentials.