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# The influence of environmental conditions on the accuracy of QEEG electroencephalography

***Abstract.*** *The article presents the results of investigations of selected factors interfering the QEEG electroencephalography performed with the Mitsar EEG 202 apparatus and the LZ-643 magnetic field strength meter. The accuracy of QEEG research depends on the occurrence of so-called artifacts, which are the source of magnetic fields occurring in the environment and disturbances in the power supply for measuring apparatus. The research was carried out in the Laboratory of Experimental Research Biofeedback of the Jan Dlugosz University in Czestochowa.*

***Streszczenie.*** W *artykule przedstawiono wyniki badań wybranych czynników zakłócających prowadzonych badań elektroencefalograficznych QEEG za pomocą aparatury Mitsar EEG 202 oraz miernika natężenia pola magnetycznego typu LZ-643. Dokładność badań QEEG jest uzależniona od występowania tzw. artefaktów, których źródłem są występujące w otoczeniu pola magnetyczne oraz zakłócenia w sieci zasilającej aparaturę pomiarową. Badania przeprowadzono w Laboratorium Badań Eksperymentalnych Biofeedback Uniwersytetu Humanistyczno-Przyrodniczego im. Jana Długosza w Częstochowie.* ***(Wpływ warunków otoczenia na dokładność badań elektroencefalograficznych QEEG)***

**Keywords:** magnetic field investigation, Biofeedback, artifacts, EEG
**Słowa kluczowe:** badanie pola magnetycznego, Biofeedback, artefakty, EEG

## Introduction

EEG electroencephalography is a non-invasive method for measuring the activity of the nervous system in humans. Brain mapping (QEEG -quantitative - or "quantitative" EEG), and thus the quantitative measurement of electrical impulses on the surface of the human scalp, allows for more accurate observation of any changes in brain activity including their location [1,2]. The registration of brain activity by measuring the extremely small amplitudes of the tensions recorded on the surface of human skin also has its drawbacks. This method makes it possible to register changes in small voltage potentials due to placed sensors. The signal is recorded at the sensor location, which often does not reflect the origin of the signal. It may originate from a completely different location (eg cerebral lobes), and the place of its registration is most often the result of the accumulation of many factors, for example related to skin conductance, etc. In addition, the accuracy of the obtained results is also burdened with other external interfering signals. In the analysis of EEG / QEEG research results, the so-called artifacts, i.e. observed undesirable changes in the signal course. The source of their creation are not impulses measured for the brain activity itself, but only these are disturbances originating, for example, from numerous motor activities of the examined person and from external sources, e.g. mains disruptions, magnetic fields, apparatus vibrations, etc. this is an extremely important and serious problem, because the interpretation of waveforms of registered waves may consequently lead to incorrect conclusions and subsequent medical recommendations.

EEG / QEEG research in the field of neurodidactics and broadly understood research on cognitive processes are conducted in the Laboratory of Experimental Research Biofeedback of the University of Humanities and Natural Sciences Jan Długosz in Częstochowa [3]. The laboratory is equipped with a number of research stands equipped with various types of test equipment and simulation stations. In the field of QEEG testing, stands equipped with Mitstar 201 (202) apparatus and IT infrastructure (Figures 1 ,2,3,4,5) are used.

Fig. 1. A separate lab for QEEG research

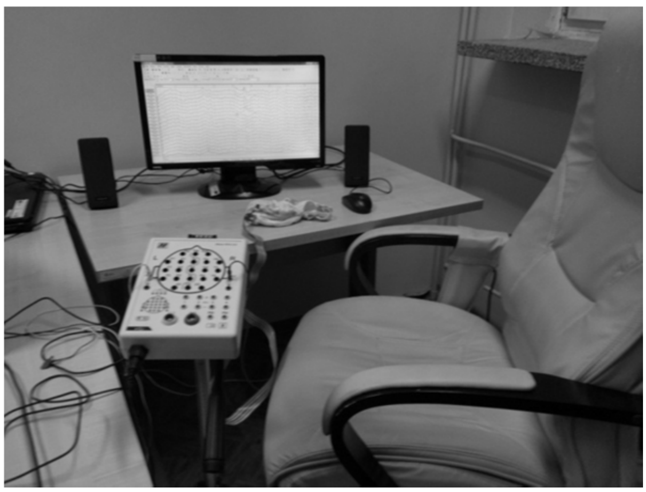

Fig. 2. View of the QEEG electroencephalographic site using Mitstar 201.

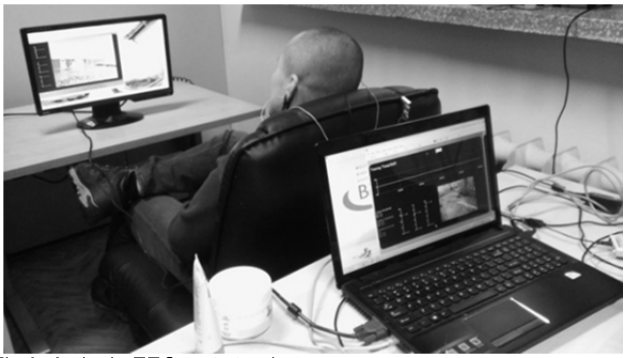

Fig 3. A single EEG test stand.

Fig. 4. Others EEG test stands.

Fig. 5. Simulation station for the group of " transport drivers".

As one can see in numerous photos, the studio has enormous potential in conducting large-scale EEG, QEEG and derivative studies. However, a fundamental question arises about the accuracy of conducted research, often performed on behalf of external institutions as well as academic and medical centers. Research is conducted by highly specialized people in this area of knowledge, which issue appropriate certificates confirming the reliability of the measurements carried out [4]. Therefore, the problem of occurring artifacts during research is a big challenge for the reliability of research. In this article, this problem has been included in relation to the most important factors, and more specifically to external magnetic fields and disturbances coming from the power grid (for low and high frequencies).

**Laboratory tests**

In such a spacious room, located in the vicinity of other laboratory rooms in the building there is a suspicion that disturbing magnetic fields may appear in the EEG / QEEG laboratory, which may affect the operation of the apparatus itself, additional instrumentation of the recording apparatus, sensors, etc. To verify the correctness of the hypothesis, an available magnetic field meter was used (teslomierz) symbol LZ-683 along with additional measuring probes (Fig.6). After the meter was calibrated, measurements were taken for the characteristic spaces around the apparatus and other devices to determine whether there is a risk of disruption of the workplace. During multiple QEEG tests, numerous disturbances in the operation of the recording equipment have been observed. An example of emerging artefacts is shown in Figure 7.

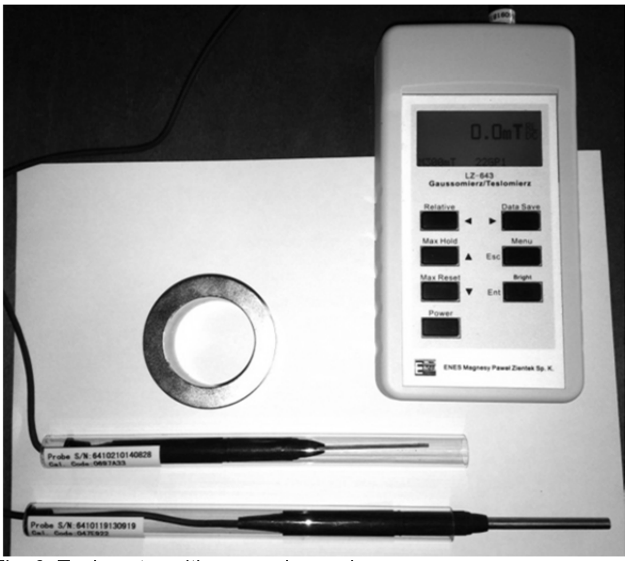


Fig. 6. Teslometer with measuring probes.

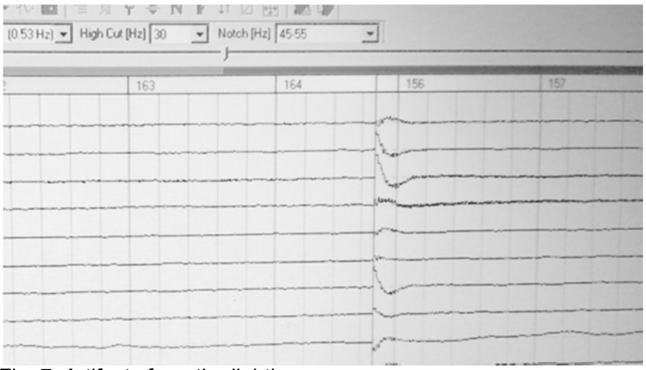


Fig. 7. Artifacts from the lighting source

**The formation of EEG and QEEG**

The basic questions that arise in a person joining an encephalographic examination are questions about typically medical nature, where do these signals come from, what is their source etc.? The basics of medical knowledge in this area are necessary for the proper conduct of a laboratory test and then the correct interpretation of the results of the test results. The EEG or QEEG record is nothing more than the recording of electrical signals that arise on the surface of the human skin. Their source is the activity primarily of nerve cells that function in the brain called neurons. It is thanks to them that the phenomenon of conversion in the synaptic connections of the electrical impulse to the chemical signal takes place. Generally, it can be assumed that it is neurons that are the source of recorded electrical impulses. Unfortunately, the recorded electrical impulses have different sources of electrical activity. These can be action potentials, postsynaptic or long-term depolarization of neurons. The recorded signal by the device can be an extremely complex signal, when it comes to the natural source of their creation. Functional potentials are pulses lasting about 10 ms, additionally they are signals with a very small electric field. It seems that they will not be detected by the device, however, they should be kept in mind when analysing the obtained results. The Mitstar device primarily registers postsynaptic potentials, with a duration of 50 to 200 ms and a larger electric field. However, in the recorded signal through the device one can also receive signals from the so-called prolonged depolarization of the neuron or glial cell. Their source is in the case of damage to the brain tissue. The neurotransmitter causes the postsynaptic membrane to change the conductivity, and thus change the polarization in the cell membrane. Then it is created in dendrite, the so-called Post-synaptic potential (EPSP), which causes local hyperpolarization, and in the body of the cell there is the potential of IPSP (postsynaptic potential inhibitors) so-called. brake potential postsynaptic. The mutual combination of these potentials is the source of the creation of recorded currents in the neuron and its surroundings. It is these currents that are recorded on the skin of the time in the form of different waves (frequencies). These currents must, of course, be amplified several times for the recording of the apparatus to microvolts and then recorded either in the raw EEG record or depicted in QEEG due to the mathematical function called the fast Fourier transform. By raising the Fourier series coefficient to a square, we get a power spectrum, which expresses the power measured in puntats (pW) for given real-time waves. It is worth noting here that in this case, we strengthen not only the source of the signal we are interested in, but also all other derivatives recorded by the apparatus, and thus signals to us unnecessary and disruptive to the final result, so-called artefacts.

Apart from the electronic part, the Mitstar device uses simple passive elements in the form of electrodes and cabling. Electrodes are nothing but small bowls made of metal that come into contact with the skin. Appropriate placement and adherence to the skin is extremely important in the registration of these currents. The impedance decreases at the metal-to-skin interface due to the use of appropriate gels or conductive pastes that improve the contact of the electrodes with the skin. Mitstar has a function of preliminary impedance analysis before testing. Any conductance in the chairmanship are recorded and displayed on the computer screen in numerical and graphic form. When performing a series of tests, it is at this point that the researcher encounters a number of problems with their correct placement. The shape of the skull is somewhat different for each subject, this tolerance requires proper selection of the size of the cap in QEEG studies. Each person also has different skin properties, so proper cleansing of the epidermis requires the use of so-called pastes that rub the epidermis. The problem is also the hair, their density, the amount and hence the hairstyle that the incoming people have. They are elements independent of the researcher, and with which he must manage during the preparation phase for research. The correctness of performing these activities has a climactic effect on the quality of the results obtained. What's more, during the tests, the subject performs continuous movements, often uncontrolled, which introduce repeated interferences in the electrode connections. QEEG studies use a standardized arrangement of electrodes, so-called System 10-20, which assumes the most effective measurement. The arrangement of electrodes in a certain topology makes it easier to compare records made in different places. It has been developed by scientists from the Institute of Neurology in Montreal and is practiced all over the world. It is based on an accurate measurement of time with the use of several points characteristic of the human head. [8].

**Research results**

The measurements were taken in several places and in the conditions of preparation and operation of the test apparatus. The observation was made with the electrodes removed from the head surface.

**Option I**. Mitstar 201 device connected (powered) via a USB port with a laptop, whose operation is supported only by its own battery (without connecting the power supply to the 220V grid), a laboratory illuminated by commonly used combined in a casing with fluorescent tubes in the amount of six pieces, a teslable meter at the same Mitstar device. The measurement of the magnetic induction value was 0.38-0.49mT in the immediate vicinity of the recording equipment.

**Option II**. Mitstar 201 device connected (powered) via a USB port with a laptop, which operation is supported only by its own battery (without connecting the power supply to the 220V network), unlit lab, teslometer measurement at the Mitstar device itself. The measurement of the magnetic induction value was within 0.05 mT.

**Option III**.. Mitstar 201 device connected (powered) by a USB port with a laptop, which operation is additionally supported by a 220V mains power supply, a laboratory illuminated by commonly used fluorescent in a housing with a total of six pieces, registration of artefacts as a result of the attachmentand turning off the room lighting. The result of the observations is presented in Figure 7. At the moment of switching on the laboratory lighting, fast descending peaks of the waveform were observed on practically all waveforms from the electrodes. However, at the moment of turning off the lighting, there was a rapid increase in the waveform and then return to the equilibrium (flat characteristics)

**Conlusions**

The Voltage potentials measured on the surface of the skin resulting from accumulations of pulses as a result of brain activity as well as from other external sources. The ratio of the signal coming from the brain to the background noise is very small, however the background for EEG measurements is both the bioelectric activity of other parts of the body's work, electromagnetic interference, originating from the external environment Measurement of the magnetic induction value is small in virtually all variants of testing, however, one should bear in mind the high degree of amplification of Mitstar signals. Regarding the recorded signals from the surface of the skin during the examination, it is important, so that the amplified signal can consequently affect the accuracy of the reading. The research did not take into account other elements that may affect the accuracy of reading, eg impedance of conductive gels, bioelectrical activity of the whole organism, etc. It should also be borne in mind that all elements of the measurement system are interconnected and there may be various interactions between them. example of gain noise. The wires connecting the components of the measuring apparatus may act as an antenna for electromagnetic waves present in the environment. Not without significance are also noises, which may be caused by various types of radio and television transmitters, mobile telephony, radiation of building materials. The registered artifacts (Fig. 7) seem so clear that they should be marked and removed, in addition to the automatic cleansing function via the WinEEG computer program. They are also an indication that during the EEG / QEEG tests, different types of switching on and operation of unnecessary electrical devices should be avoided in the surroundings of the measuring equipment. The information provided is also an innovative concept for the development of scientific research, using the latest equipment for electroencephalographic research in the field of neurodidactics. This is currently the latest trend in research in cognitive psychology and widely understood pedagogy. It is assumed that the QEEG method will help to deepen the knowledge also in the field of didactic activity assessment, but not from the level of the work of the examined person, and during his intellectual effort [5]. It will also allow to explain differences in cognitive activity in the didactic process using deterministic computer simulations in technical education, but also from interpersonal differences resulting from the different structure and operation of the brain. Simulation programs are also now widely used in engineering in the field of solving complex research problems [6,7]. Observation of the work environment by means of electroencephalographic research and the accompanying interfering signals is a key issue aimed at clarifying the importance of ensuring proper preparation of the test stand.

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