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# Technical artifacts in QEEG research - results of own research

***Abstract.*** *The paper presents the method of QEEG electroencephalographic research in the assessment of brain activity. In the Laboratory of Experimental Biofeedback at the Jan Długosz of Univercity in Częstochowa, research is carried out on the assessment of cognitive activity in engineering students with the use of deterministic computer simulations.Technical artifacts in QEEG research - results of own research)*

***Streszczenie.*** *W pracy przedstawiona zostanie metoda badań elektroencefalograficznych QEEG w ocenie aktywności pracy mózgu. W Laboratorium Badań Eksperymentalnych Biofeedback funkcjonującej na Uniwersytecie Humianistyczno-Przyrodnicznym im. Jana Długosza w Częstochowie prowadzone są badania związane z oceną aktywności poznawczej u studentów na kierunku inżynierskim z wykorzystaniem deterministycznych symulacji komputerowych.* ***(Artefakty techniczne w badaniach QEEG - wyniki badań własnych)***

**Keywords:** electroencephalographic studies, QEEG, artifacts
**Słowa kluczowe:** badania elektroencefalograficzne, QEEG, artefakty

## Introduction

The QEEG research uses the Mitsar-202 measuring apparatus and specialized computer software to analyze the obtained data. In studies of measuring the brain's electrical activity, I use the quantitative electroencephalography (QEEG) method. The QEEG method allows us to record EEG not only as waves, their shapes and amplitudes as a function of time. The raw EEG signal is transformed quantitatively using a mathematical Fourier function (FFT - fast fourier Transform), which facilitates diagnostics for the clinician and significantly helps in observing deviations from the norm. This technique is often called "brain mapping". The QEEG method is a non-invasive examination of the brain. It can be used in many fields of science, including the assessment of brain activity during work, learning, etc. In simple terms, measurement consists in reading electrical impulses with electrodes placed on the human head. Of course, their location is not accidental. For this purpose, the so-called a cap with electrodes arranged in them, which is put on the head of the examined person. These electrodes read signals flowing from the surface of the scalp to the reading apparatus. In order to minimize the impedance of conductivity between the electrode and the scalp, special conductive gels are used to facilitate skin contact. Read pulses are sent to the Mistar apparatus and then to a computer with the appropriate WinEEG software installed. The obtained data can be individually interpreted by the researcher or compared with available normative databases. Normative reference databases play an important and important role in the assessment of the respondents using the QEEG method. It was noticed that the accuracy of the tests depends on many factors, including the conditions in which the tests are conducted. The article will indicate, first of all, factors of external origin in the form of disturbances from electromagnetic fields accompanying the research. In order to eliminate these disturbances, the so-called artifacts, they can be limited by innovations in the operation of the device thanks to the use of simple design solutions of the device. For this purpose, innovations have been applied in the form of introducing additional device shielding, and more specifically the cables responsible for connecting the probes with the Mitsar recording device.

## Protection against electromagnetic interference

The measurement of the brain's electrical activity is accompanied by numerous disturbances of amplitude often several times greater than the QEEG signal itself. The accuracy of the measurements depends, among other things, on the environmental conditions in which they are carried out. One of the causes may be interference from external magnetic and electromagnetic fields. One of the methods of minimizing such disturbances are properly constructed devices, both at the level of their internal construction, implemented by manufacturers, but also by observing the care of their implementation by the operator. In metrology, the so-called screens for the elimination or attenuation of currents. These currents can be induced by point or distributed charge sources that generate electric fields. For example, a moving person carries with him the static charge with which he is charged. The alternating field of the power grid in laboratories or production rooms, as well as outdoors, can induce disturbing alternating electric fields. An additional element of the interfering circuits is the insulation capacitance between the transformer windings in the meter power supply [1]. The screening effectiveness is the result of three parameters: screen thickness, coverage density and conductivity of the screen material. As the screens of the cables to ensure electromagnetic compatibility are made of copper, the third parameter is the same for all cables of this type. It is difficult to predict at the design stage what screen will be sufficient, what the screening effectiveness must be, so it is always worth considering the best screening [2]. The measuring device also uses built-in filters, high-pass and network.

The main disturbances accompanying the recording of the QEEG signal include:

– physical and chemical phenomena between the skin, electrolyte and electrode;

– generators of electrical activity located in the human body. The strongest disturbances include the signal from the heart muscle, signals from the muscles responsible for facial expressions, movement and keeping the head in an upright position, etc. The source of a very strong disturbance is also the electrically polarized eyeball;

– electric fields created by nearby electrical appliances and the mains. The last source of interference has a major influence on the construction of the enhancement block in the electroencephalograph. Of course, the QEEG test can be performed in an environment free of electrical disturbances, e.g. in a Faraday cage.

**QEEG test stand**

Figure 1 shows the stand for electroencephalographic tests using the QEEG method. The Mitsar 202 device is connected to the so-called cap with probes using a visible multi-core cable without shielding.

Fig.1 Mitsar 202 recording equipment with a computer [source: own]


Fig.2 Mitsar 202 recording apparatus [source: own]

Figure 2 shows the way of connecting the cables to the recording device in more detail. The horizontal arrow marks the set of cables included in the standard equipment of the apparatus. The vertical arrow shows the place where the above-mentioned cables were interchangeably connected using individual places with the use of shielded cables directly to the probes on the cap. Then, the recording equipment was started in both configurations in order to compare the obtained readout results. Identical configuration parameters of the device have been kept. The registration of signals was not intended to determine the activity of the brain, but only to show the differences in the readings of the apparatus. The results of the readings are shown in Figures 3 and 4.

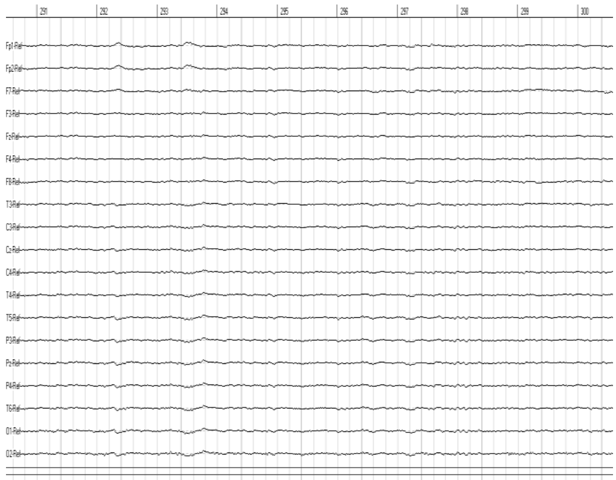

Fig. 3 Reading with unshielded cables [source: own]

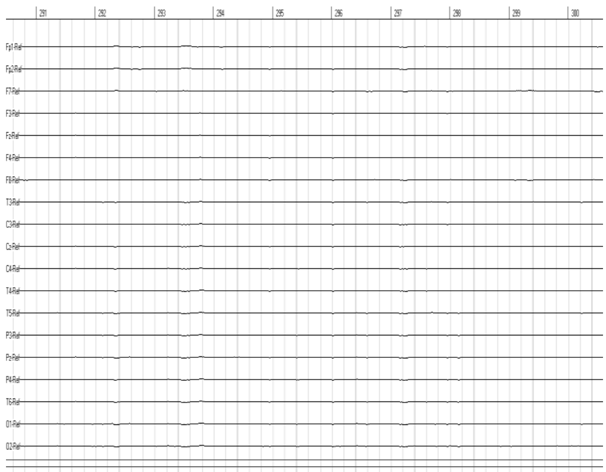

Fig.4 Reading with shielded cables [source: own]

The results of the measurements were compared with and without changes to the design of the device (Figures 3 and 4). As indicated by the obtained data, there are slight differences, however, in terms of the accuracy of the research, they are extremely important. The results are also presented in a graphic form illustrating the recorded measurement signals (Figs. 5 and 6).

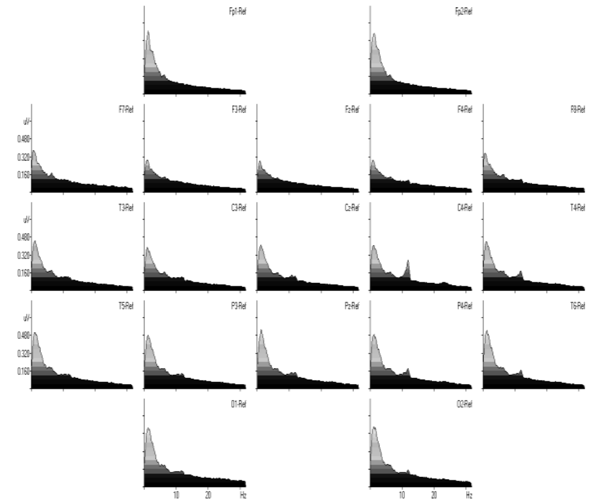

Fig.5 Graphical interpretation of signal amplitudes obtained with the use of shielded cables [source: own]

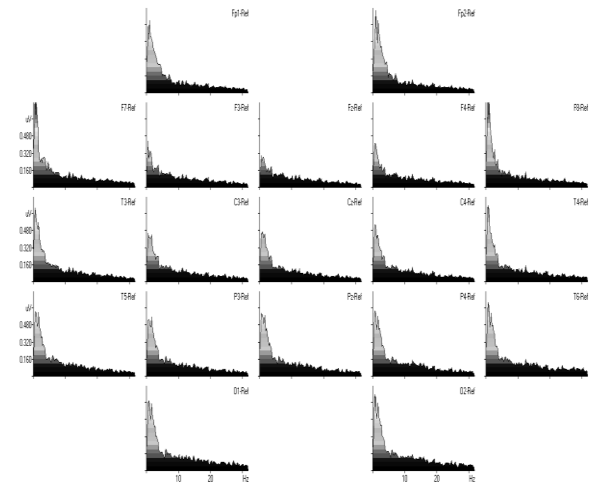

Fig.6 Graphical interpretation of signal amplitudes obtained with the use of unshielded cables [source: own]

**Conlusions**

In the author's research, this method was used to measure the activity of the brain during the learning process with the use of deterministic computer simulations in polytechnic education. Therefore, the accuracy of reading the data is extremely important. Repeated errors as a result of their registration could completely change the frequency characteristics of the recorded signals, which in effect would indicate a misinterpretation of the test results. The following wave frequencies were taken as the observation element: Beta waves in the frequency range 12-36 Hz. They illustrate the involvement of the cerebral cortex in cognitive activity. Generating a Beta wave is associated with a state of wakefulness, vigilance, external orientation, and logical thinking, problem solving and attention. The wide range of Beta can be broken down into smaller frequency ranges that better correspond to the different ways in which the cerebral cortex functions [4]. Waves 12–15 Hz, the so-called SMRs arise from receiving information from the five senses. They are responsible for relaxing with external attention and solving problems. Man is relaxed in this state, but ready to observe the world. Too low SMR level accompanies attention deficits. Beta1 waves, 16–20 Hz, are associated with concentration on one issue, with an external orientation. If a person is faced with the need to solve, for example, a mathematical problem (intense mental effort), we will notice that first the amplitude of the activity around 17 Hz will increase and the exact amplitude of the Theta and Alpha (8-10 Hz) will decrease at the same time. This bandwidth correlates with the cognitive activity characteristic of active problem solving (intense mental effort). Low Beta1 level is associated with intellectual deficits, concentration and attention disorders. Too high Beta wave in the non-dominant (genetically non-dominant) hemisphere disturbs the emission of the SMR wave, which in turn is associated with emotional disturbance and attention deficit Waves 18-36H, the so-called Beta2 - a stressful wave of anxiety, accompanies us during intense mental work. It is associated with increased emotional tension, because its emission accompanies the release of adrenaline responsible for the state of readiness of the body. For the above studies, it was assessed as undesirable [4]. The higher the frequency, the greater the creative stimulation and abstract thinking. We are aware of external stimuli. We can also control our emotions and our attention is focused. We focus on performing tasks, then new ideas are born.

The differences shown on the basis of the waveforms indicate that there are visible differences in the range of practically full frequencies. The obtained results indicate that the accuracy of the tests is influenced, among others, by capacitive disturbances caused by the variable electric fields of the system in the vicinity of the device itself. The reason is that the cables are laid in parallel over a longer distance, acting as two opposite capacitor plates and therefore short-circuiting high-frequency signals. The solution to this problem is to avoid or minimize the parallel routing of cables and the greatest possible separation between the source of noise and the cable. In addition, the use of shielded signal cables and the use of so-called twisted pair is one way to eliminate interference. Another cause of disturbances are inductive disturbances, ie those caused by an alternating magnetic field from the environment. A magnetic field is created around the conductor, which also passes through adjacent conductors. The change in current causes the magnetic field to change, which then induces voltage in adjacent conductors. In this case, one way to limit the influence of this field is, as before, to keep the distance between the conductors and to avoid parallelism of the conductors. Moreover, the use of shielded cables has an influence on the accuracy of the measurements. The method of screen connection depends primarily on the expected interference. One-sided grounding of the shield is necessary to eliminate electric fields. The elimination of interferences resulting from the influence of an alternating magnetic field is possible only when the shield is connected on both sides [3]. In the standard connection of the Mitsar apparatus, the so-called a tape of parallel cables, which in terms of the discussed issues may be of minor importance, however, taking into account the extremely small amplitudes and a wide frequency band of the recorded and then amplified signals, it is the cause of interference. The use of a screen allows, inter alia, to protect the recording equipment against the fields coming from the device and vice versa - it protects the device against the effects of magnetic or electric fields present in its environment. First of all, in order for the screen to fulfill its function, it must be grounded. Therefore, the standard connection of the probes to the recording device in the form of a tape composed of unshielded wires has been abandoned in favor of free shielded connections. The test results are presented in graphs taking into account the full range of recorded frequencies. The article omits the detailed stages of preparation for QEEG tests, because they are extensive and require specific preparatory procedures in order to avoid the occurrence of the so-called artifacts not caused by electromagnetic interference [4,5-7].

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