Возможности применения нейрокомпьютерного интерфейса EmotivEPOC в научных целях

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The Use of Brain-Computer Interface Emotiv EPOC for Linguistic Studies

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Аннотация

Статья посвящена возможному применению нейрокомпьютерного интерфейса Emotiv EPOC в научных целях, в частности, для лингвистических и фонетических исследований. Данное портативное устройство, позволяющее считывать и интерпретировать актуальные сигналы головного мозга, может использоваться лингвистами при изучении процессов речепорождения и речевосприятия. Наряду с подробным описанием Emotiv EPOC представлен опыт его применения для регистрации вызванных потенциалов P300при работе с модифицированной матрицей из символов русского алфавита.

Abstract

The article deals with the possibility of using BCI Emotiv EPOC for linguistic and phonetic researches. This portable device which permits receive and interpret brain signals can be useful for linguists in studying speech perception and speech production. Along with the detailed description of the device the experiment with its use for registration of evoked potentials P300 in the process of working with the modified matrix complete with Russian letters is presented.

Ключевые слова: нейрокомпьютерный интерфейс, EmotivEPOC, вызванные потенциалы P300, речепорождение, речевосприятие.

Key words: neurocomputer interface, Emotiv EPOC, evoked potentials P300, speech perception and speech production studies.

Introduction

More and more attention has been recently paid to the theory and practice of developing neurocomputer interfaces which use registered brain activity to create and send commands to anexternaldevice using reliable and safe method of electroencephalography (EEG).

A neurocomputer interface is a device which permits its user to communicate, sending brain signals to external surroundings directly, without any intermediate sign system, such as speech or movements.

Nowadays neurocomputer interfaces are applied not only for medical purposes, where their use is quite important, but also in different kinds of industry, such as safety equipment production, entertainment industry, education and staff management.

It is obvious that the development of neurocommunication technologies permits to use portable and cheap medical equipment, doing this technology much more available. But along with this recently in response to the market demands there has been developed a new type of neurocomputer interfaces which can be used not only outside medical laboratories, but by users without special training. This type of devices is represented by NeuroSky, MindFlex, Emotiv EPOC [Stamps et al., 2010].

At the moment the main task in developing the devices is testing them on the easiest operations, such as games. The problem, however, is that such tests don't always reveal if the devices are acceptable for scientific studies.

This article is describing the experiment with the useof BCIEmotiv EPOC for simple linguistic studies.

The Approach Based on the Evoked Potentials P300 Analysis

The classical way of electro-physiological studies of brain processes is the evoked potentials P300 method, more than once described in scientific literature (for example, [Pritchard et al., 1981]). The method is based on registration of the evoked brain electric activity in response to an external stimulus or in response to some brain event, related to recognition, expectation, making decisions, initiation of a motor reaction. As it has been pointed out (for example,in [Patel et al., 2005]), P300 is only a part of a complicated potential appearing as a result of focusing a subject's attention in the course of performing a cognitive task. The process of detecting of a meaningful stimulus includes only sensory part, related to physical characteristics which are mainly reflected in the indicators of early components of evoked potential. The next task is the initial recognition and classification of stimuli, which is demonstrated essentially by the negative fluctuation (marked as N2, N200) in approximately 96-250 ms after the start of the stimulus. Then there is final stimulus recognition, which demands comparing it to the examples in the subject's memory and making decision about the subsequent action. P300 isrelatedtotheseveryevents.

P300 is usually received using so called P300-speller, which is included in the Emotiv EPOC complete set.This detector is a matrix with 36 cells, where numeric and alphabetic symbols can be used, the symbols are highlighted by flashes in random order, and a subject watches the succession of flashes. According to the instruction the subject concentrates on one symbol, and when the targeted cell (containing this very symbol) is highlighted, the speller registers the brain reaction for this stimulus. For training the speller this procedure is repeated several times. In the end the average EEG signal for targeted cells is compared to the average signal for non-targeted cells (on which the subject didn’t concentrate their attention).

One can expect that targeted cells signals will have the characteristics of evoked potentials, and non-targeted cells signals will appear as random noise. At least, this is the ideal picture; in reality, however, non-filtered EEG artefacts can considerably influence the received evoked potentials signals.

In order to test the dependence of P300-speller functioning quality the matrix was completed with Russian alphabetic symbols. It was assumed that the degree of the speller training will improve if the subject sees their native (Russian,Cyrillic) symbols instead of Latin ones.

The Description of the Experiment

The procedure recommended in the Emotiv EPOC manual was used for the experiment. The data was received for one subject. It is a man 32 years old, with higher education, right handed, without physical disabilities. For getting visual stimuli there was used free software designed for the experiments with evoked potentials P300 – OpenVibe version 1.1.0. The duration of flashes and periods between flashes was 125 ms. Brain signals were registered by Emotiv EPOC Research Edition. The received data was filtered with bandwidth 1 – 20 Hz. And then the program EEGLAB7.1.was applied.

The connection quality between Emotiv EPOC and OpenVibe software was previously tested with the use of the built-in module p300-speller-0-signal-monitoring.xml. Then the P300 speller was trained with the use of standard modules p300-speller-1-acquisition.xml (the matrix with Latin symbols), p300-speller-2-train-xDAWN.xml and p300-speller-3-train-classifier.xml. The evaluation of the precision of the trained classifier was then made: the subject was asked to fix his stare on letters and numbers; if the program recognized the symbol it was highlighted green, if it recognized the line or the column it was highlighted orange, symbolsrecognized incorrectlywere highlighted black. After the training the precision of the speller was 70.87%.

In the next step the P300 speller was trained with Russian alphabetic symbols. After this training the evaluated precision degree for the OpenVibe classifier was higher: the comparison showed that the final result for the recognition of the symbols of the Russian letters matrix was 83.45%.

The next stage of the study was detection and localization of the brain electric activity source significant for operating Emotiv EPOC during the performing of the assigned cognitive operation. For it the data received from the device was processed with EEGLAB7.1 software.

In the first step of the analysis the task was to separate the received EEG signals, detecting the signals of different brain electric activity sources, as the Emotiv EPOC sensors register the data set generated by a lot of various sources. This task was solved by the ICA (Independent component analysis) method [Comon et al., 2010], recommended by Lee Te-Won,A.J., Bell and T.J.Sejnowskias the standard method to solve the blind source separation problem[Lee Te-Won et al., 2000].This method permits to separate the observed electric signals into independent components generated by different brain structures which have a certain fixed localization each. After the application of theBasicFIR, RemoveBaselineand RunICA filters it became clear that the main brain electric activity source during the performing of the experimental task was the point F4 in the right frontal lobe.

The Results

The results of the experiment demonstrate that the neurocomputer interfaceEmotiv EPOC permits to detect the significant brain signals, and the signal detection quality depends on belonging of the presented symbols to a native subject's language or a familiar, but non-native one, in other words, on the frequency of the appearance of similar stimuli in subjects' everyday experience. The noise level in received signals can be diminished by application of the averaging and filtration techniques. However, one should bear in mind that the signal detection precision isn't as high as for professional medical EEG equipment. So, Emotiv EPOC can be used for solving not quality critical tasks.

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