Development of new method of drug abuse detection based brain computer interface

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Abstract. A methods of drugs abuse detection is urgently needed. Currently a conventional method such as urine test, hair test, Functional Magnetic Resonance Imaging, Positron Emission Tomography, and others are used. Those methods, instead of expensive and complicated, it is require a medical experts. Furthermore, this tool cannot be used to detect new variations of drug. In this study, a new method of drugs abuse detection based brain computer interface (BCI) which recorded with an electroencephalogram is developed. In principle, as long as the subject is still be able to remember, then the tool will be able to detect whether ever use a drug or not. In the experiment 15 subjects are tested. In the signal processing, the EEG signal is filtered with baseline correction and band-pass filter and extracted using wavelet symlet method. The brain maps of damaged brains are in sharp contrast to those of brains which have not been subjected to drug abuse. This studies could be used to identify drug abusers and alternative tool for rehabilitation.

1. Introduction

Electroencephalography (EEG) equipment is now becoming more accessible in the general market, allowing a variety of research related to brain activity easier and wider. The brain computer interface (BCI) is a user method to communicate their brain signal activity with the external device without any help of muscle contraction [1]. The brain signal activity used in BCI can be measured using invasive or noninvasive techniques. The EEG equipment is one of the noninvasive techniques. When many neurons which produce a small electrical voltage become active in the brain, their combination can be detected on the scalp surface with the help of electrode sensors or EEG. These very small electrical signals are amplified and recorded for the latter known as brain waves (represent brain activity that occurs in different areas of the brain). The BCI-based technology developers strive to make BCI more user-friendly, real-time with high accuracy, suitable for voluntary general users such as clinical patients and those with disabilities. Also it must be noted that the current use of BCI is not only used by patients but also by healthy users with various applications [2-12]. Thus, the researcher will do the best to provide an improvement until the tool can be easily found in the market and is expected to operate well with just one channel. In the end anyone who developed the BCI should be really useful for those who need it. In this paper, a medical instrument based BCI for early detection of drug abuse is developed.
Consumption of drugs causes losses in various things including economic and social for human. Furthermore, it is harmful to health both physically and physically. Drug effects on life in particular on brain activity have already been reported [13-19]. Weakness and health abnormalities due to drug abuse will persist for a long time and tend to increase the consumption dose. In addition, it can cause accidents while driving a vehicle and even cause bad behavior in the community. Interesting evidence is found that drug abuse can cause dysfunction of cortical orbitals, altering the frontal and temporal areas, and tend to make users more addicted. Generally, it is associated with a cognitive deficits which directly effecting the user in the emotional and motivation regulations, concentration, working and learning ability, and a respons to make decision. Therefore, needed a tool that is able to detect early drug users so the family can do early treatment before it gets worse. So far, very rare research on the development of early detection of drugs is done.

In this paper, an application of signal processing before the brain mapping is proposed. The Brain mapping highly important for the neurophysiological evaluation such as caused by drug abuser. It is used to discriminate the drug effects on the brain and also to evaluate the relationship between the brain and behavior. All involved subjects in the experiment were provided with a complete brain map analysis. The analysis results indicated that there are an enhancement of brain disturbances in the drug abusers compare with the control subjects. The dependents can be measured and detected using the proposed developed EEG tools. This kind of disturbances are not obtain in as great a number of normal subjects with similar psychiatric problems. It is found that the drug abuser had the greatest number of total brain abnormalities. Moreover, the higher abnormalities were detected in the more severe drug abuser than the normal subjects.

2. Experiment Method

An EEG is a test that measures and records the electrical activity of the brain subject. An electrode sensors are attached to subject head and connected by wires to a computer. While the computer records, the brain's electrical activity is displayed on the screen. In the experiment, 10 male rehabilitation subjects were hired from Hasan Sadikin General Hospital (HSGH) of Bandung-Indonesia[20-24]. For control 5 male subject were hired from Indonesian Institute of sciences. Before the experiment, all subject was interviewed by the medical doctor according to their personal data and time period information of the drug abuse. Then the subject completed the questionnaires. Also, urine tests were performed on all subjects. During the experimental period it has been determined that no subjects are taking prescription. The experiment was supported by the Ethical clearance from RSHS Committee to make sure that the conducted experiment was based on the clinical ethic. Moreover, all subject was provided by written informed consent and rewarded with IDR 150.000 for transport compensation.

Participants (i.e., has been informed about the entire experiment procedure) were requested to contribute in an experiment of the EEG signals record of the brain activities. The experiment consist of three session which are before, ten minutes and one hours after methadone consumption, respectively. The EEG technologist will attach several flat metal discs (electrodes) to different places on the head, using a sticky paste to keep contact between the electrodes and the scalp. During the experiment, the electrodes impedance was retained under 5 KΩ such that a high-quality of the EEG data is obtained. After preparation, each subject were sitting relaxed on a chair while concentrate to the flashed stimuli on the monitor. They were asked to count how many time the drug picture was appear. The sequence appearance of the flashed picture (shown in Fig. 1) were randomly displayed at the separate but sequential experiment. In this paper, we are only considering the channels of Fp1, Fp2, F7, F3, Fz, F4, F8, P3, and P4. The recorded EEG signals were amplified and preprocessed with embended softwares on WinEEG system with sampling rate about 500 Hz. The experiment process is shown in Fig. 2 (from the top to the right: interview by the docter, explanation by experimenter, the EEG setup, and experiment start up). The stimuli was run on a different computer with the EEG machine was attached to record and save the data.
3. Results and Discussions
The raw data, filtered, and extracted of the EEG signals of the rehabilitation subjects from 10 channels (Fp1, Fp2, F7, F3, Fz, F4, F8, P3, Pz, P4) is described in figure 3. Before feature extraction and brain maps is started, a 6th-order band pass filter (BPF) with cutoff frequencies of 3 Hz and 30 Hz was applied. The filtered EEG signals then decomposed by the decomposition of the signal with noise on wavelet bases where the wavelet coefficient hold an information. Denoising (separating the wavelet coefficients with the download threshold) is obtained by applying the thresholding wavelet coefficients technique. The wavelet group is used to pass the signal through wavelet transform blocks for the decomposition process into wavelet coefficients (i.e., in the thresholding and denoising). The thresholding technique is applied to reduce the noise and keep the information in the maximum signal. After rearrange each trial, the peak amplitude and the latency of P300 component for each considered channels is obtained. The average maximum amplitudes and latencies before and after one hours of the methadone consumption is provided in figure 4. Figure 4 shows the extraction results of the P300 signal: (a) at the craving condition (shortly before taking methadone) and (b) after one hour of taking methadone, respectively.

The maximum amplitude of about 4 micro volts when craving condition tends to be higher when compared with the amplitude after one hour of drinking methadone which is about 1.25 micro volts. The high amplitude of the target is also followed by high amplitude of the nontarget, which means that the brain activity is much higher overall and tend to not focus. The differences can be seen in the post-
drinking methadone (figure 4(b)) where the target amplitude is significantly higher than nontarget. The high amplitude of the target are triggered by the flashed image of the drug, while the high nontarget is suspected to be triggered by the craving condition. Latency also looks significantly different before and after taking methadone i.e each about 390 ms and 240 ms. This difference can be interpreted as a change in the condition of the subject body including brain as a whole that is subject conditions become more comfortable after taking the drug. Moreover, subjects tend to be more focused and especially more responsive to stimuli inputs. The difference between these two features seems to be sufficient to describe the effect of drugs on brain activity.

Figure 5 shows brain activity maps which obtained from the P300 signal from two of the 10 methadone subjects when before taking the drug or methadone (craving condition) and after one hour of taking the drug. Red color indicates more dominant the brain activity than other areas. The first that can be seen from figure 5 is that in the craving condition the brain activity tends to spread rather than after taking the drug (more active in the frontal lobe area). The spread of brain activity occurs in subject 1 which is the second line of the condition after taking the drug. These area is an occipital lobe and the increase in activity is thought to be due to visual effects of the stimuli. For both subjects, changes in brain activity in the frontal lobe appear to change from the outer layer to the deeper layers. This pattern of change is most clearly seen in subject 1 i.e., the third line craving condition and the second line after taking the drug.

Similar to the P300 signal occurs in the brain map of the beta wave before and after taking the drug, the concentration of brain activity occurs in the second row for each subject as shown in figure 6. The brain activity at 10 minutes after taking the drug is not significantly change compared with craving conditions. It can be concluded that the drug is very decisive to the dynamics changes of the brain activity. The reasons why the results may not be helpful caused by movement of the subject during experiment, consuming some medicines, coffee, soda, tea, or other foods that contain caffeine before the test which affected the recorded brain activity. The limitation of the used algorithm for processing also support the final results of the extraction. The EEG records changes in the brain waves that may not be in just one area of the brain. A case affecting the entire brain such as drug intoxication or metabolic disorders that change the chemical balance in the body and the brain may cause these kinds of changes.

![Figure 3](image_url)
Figure 4. The average maximum amplitudes and latencies before (a) and after one hours (b) methadone consumption.

Figure 5. The P300 brain activity maps of the two subjects before (a) and after one hours (b) of taking methadone.
Figure 6. The beta brain activity maps of the three subjects before (a), and after ten minute (b), and after one hours (b) of taking methadone.

4. Conclusions
The comparison effect of the drug abuse to the brain activities before (craving condition) and after taking the drug or methadone is provided. It is obtained that the maximum average amplitudes is highly higher in craving condition than after taking the drug. The abnormality of the brain activity in the craving condition is highly related with the drug abuse. The drug abusing subjects had the greatest number of total brain abnormalities. Moreover, increasing abnormalities were observed in the more severe drug abuser or dependents compared to the normal controls.

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