Brain Mapping of Low and High Impulsivity based P300 Signals

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Abstract. Impulsiveness is defined as action without good planning and with little consideration the consequences. Impulsive actions are typically poorly conceived, prematurely expressed, or inappropriate to the undesirable situation such as abuse of drugs. Instead of taking treatment for an addiction subject, it is better take prevention. In this paper, an impulsivity detection based EEG-P300 potential is proposed. Twenty four subjects consist of three groups (addiction, methadone, and control) are involved in the experiment. Five different pictures (one picture related drug is used as a target) were randomly flashed to the subjects. The subject is asked to comfortably sit in a chair and to silently count the appearance number of the target. The high amplitude of the P300 component with shortest latency and dominant brain activity are indicated by high impulsive group.

1. Introduction
Impulsiveness is a drive based on consciously or unconsciously desire. Acting impulsively is an action based on the impulse to express a desire [1, 2]. Acting impulsively also means acting without thinking about the action first, a behavior that wants to get immediate feedback from the environment, or impatient behavior to delay its desire. The cause of a person behaving impulsively is a case related to attention and active behavior, so there is no definite cause. According to experts, there are many factors that encourage a person to behave impulsively, such as the nature that tends to hyperactive, temperamental, family environment influences, gender, and characteristics of parents also play a role.

Impulsivity has widely contributed to a psychopathology, including bipolar disorder [3], attention deficit hyperactivity disorder [4], borderline personality disorder [5], pathological behaviors associated with Parkinson's disease [6], and substance addictions [7]. Impulsivity is a multidimensional concept which can be represented into at least three distinct forms: trait impulsivity, impulsive action, and impulsive choice [1, 8]. Behavioral tendencies or personality traits, such as impulsivity and sensation-seeking, have been associated with various substance-use disorders relating to alcohol [9], tobacco [10], opiates [11], and cocaine [12]. The relationships between behavioral impulsivity and substance-related attentional biases were significantly stronger than the relationships between self-reported impulsivity and substance-related attentional biases [13]. Measuring of the impulsivity behavioral will also be critical for understanding of the relationships between impulsivity and drug abuse. This findings will help the development method for prevention and treatment of the drug abuse.
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 method of communication between the user through brain signaling activity with the external device without any help of muscle contraction [14]. 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 [15-25]. 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, an analysis of recorded EEG signals and brain mapping for early detection of impulsivity is developed. All involved subjects received total brain map analysis. This study demonstrated that there are increased brain disturbances in drug abusers and dependents which can be identified and measured using the EEG tools.

2. Experiment Method

Acquisition is the process of taking data from each subject with the preparation and recording stages. The recording process is conducted using Mitsar EEG-202 equipment which consists of 31 channels. The 10 channels used in the experiment are Fp1, Fp2, F7, F3, Fz, F4, F8, P3, Pz, and P4. The channels of P3, Pz, and P4 are located in the central part of the brain (parietal lobe) which is responsible for the subject feels of stimulation. The others channels are used as a drug-related channels (located in the frontal lobe that acts on the control center of the feeling while the drugs attack). In the process of brain signals recording the given stimulus in the form of flashed images (similar drugs that expected to produce higher impulse) is used. In the experiment things to note are the installation of EEG sensors, tool calibration, and the selection of channels to be used. In the experiment, 16 male rehabilitation subjects (8 subjects with high impulsivity and 8 subjects with low impulsive) were hired from Hasan Sadikin General Hospital (HSGH) of Bandung-Indonesia. Before the experiment, all subject were 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 were provided by written informed consent and rewarded with IDR 150.000 for transport compensation.

Before recording begins, subjects are given an explanation of the recording steps and some rules that the subject must perform. During the recording process, subjects are required to do little movement because the movement of the subject can be read by the instrument that will signal the noise and greatly affect the results of the recording. Signal recording using software compatible with mitsar is WinEEG. The visual stimulus already in video form is activated simultaneously with the WinEEG program, so the subject can respond to the stimulus and the recorded EEG signal. Estimated recording time of each session is 2 seconds. Each subject must pass through 10 sessions already available, so each subject will perform the recording process for 20 seconds. 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, during, and 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, Pz 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. The stimuli was run on a different computer with the EEG machine was attached to record and save the data.

![Figure 1. Flashed similar stimuli with (e) as a target [24].](image1)

![Figure 2. Experiment setup.](image2)

3. Results and Discussions
Raw data is the result of recording EEG signals that have not experienced signal processing or still contain noise and artifact. It is characterized by an irregular waveform signal. Raw data of EEG signals for subject A3 and B3 can be seen in Fig. 3(a) and (b) to indicate the low and high impulsive group of subjects. The raw data of EEG signal is filtered using bandpass filter with frequency range
0.5 Hz to 30 Hz because in EEG signal research, the frequency with information is in the range of 0.5 Hz - 30 Hz. So the signal that is outside the frequency will be categorized as an artifact or noise. The bandpass filter results in the EEG signal shown in Fig. 4(a) and (b) which low and high impulsive subjects. Figs. 5 – 7 are the extracted signals using wavelet method. Each target for each channels are average from Fig. 5 as shown Fig. 6. Each target and nontarget trial in the extracted signals in Fig. 5 are average in as shown Fig. 7. The average method is is used to shows the general form of extracted P300 component.

![Figure 3](image-url)

**Figure 3.** Raw data of (a) low (b) high impulsive subjects.
Figure 4. Filtered signals (a) low and (b) high impulsive signals.

Figure 5. Extracted signal using Wavelet (a) low and (b) high impulsive.
Figure 6. P300 component of each selected channels: (a) low (b) high implusive subjects.
**Figure 7.** The average P300 component of the target and nontarget: (a) low and (b) high implusive subjects.

The maximum amplitude (Fig. 7(a)) of about 6 and 1.5 micro volts for the target of low and high implusive, respectively. The latency is about 600 ms and 250 ms for the target of low and high implusive, respectively. The higher amplitude is obtained for the low implusive but longer latency by mean the responds to the given stimulus is slower compare with the high implusive subject. The high amplitude of the target may triggered by the high desire of the subject. Latency also looks significantly different for low and high implusive subject. This difference can be conclude that the subject is impulsively express their desire. Moreover, subjects tend to be more focused and especially more responsive to stimuli inputs. The difference between these two features seems to be easier to describe the identification of the implusiveness.

Fig. 8 shows brain activity maps (left is low implusive and right is high implusive) which obtained from the P300 signal from two out of the 16 experimenter subjects of channels of Fp1, Fp2, F7, F3, Fz, F4, F8, P3, Pz and P4, respectively. Red color indicates more dominant activity of the brain than other areas. Since the experiment is based on the visual stimuli, the higher brain activity is provided in the optical area for most of the channels. For low implusive, the higher brain activity is obtained from channels F8 and Pz whilst for high implusive is obtained from channels F3, Fz, F8 and Pz.

**Figure 8.** Brain Mapping of (left) low and (right) high implusive subject: channels of Fp1, Fp2, F7, F3, Fz, F4, F8, P3, Pz and P4.

**4. Conclusions**

In this paper, an implusivity detection based EEG-P300 potential is proposed. Sixteen subjects consist of two groups (low and high implusive) are involved in the experiment. The subject is asked to comfortably sit in a chair and to silently count the appearance number of the target. Based on the extracted P300 component and the mapping of the brain activity, the low and high implusive subject is successfully identified. The high amplitude of the P300 component with shortest latency and dominant brain activity are indicated by high implusive group.

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