LIE DETECTION USING BRAIN P300 SIGNAL: PRELIMINARY RESULTS

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ABSTRACT

The traditional lie detector called "polygraph" monitors several subject physiological activities during a question-answer interview to observe how they change in comparison to normal levels. However, because the subject can control his/her physiological reactions or show anxiety for other reasons than lying, the polygraph result is not reliable and acceptable legally. In this study, we will look into a method which does not directly depend on emotional reactions of the suspect. In this technique, the key is one of the significant brain signal's components called P300. The P300, a positive peak in EEG signals, occurs about 300 msec after the subject is confronted by a sequence of stimuli which one of them is rarely presented. In this method, EEG signals are recorded while the sequence of words, pictures or sounds (oddball paradigm) is displayed to the suspect and analyzed afterward to indicate whether or not the subject has some information about the relevant stimulus. In this study, we precisely designed an interface including series of random pictures and ask subjects to press a key immediately after observing particular images. On the other hand, we have placed our lie-related picture in this sequence and observe the user's EEG response. Using this technique, users have no control on their P300 and so it is more reliable and accurate than polygraph. In this paper, preliminary results on lie detection using the brain P300 signal have been presented.

INTRODUCTION

The fact that lying alters some physiological variables has long been declared and so it can be employed to detect lies. The best known device uses this phenomenon is "polygraph". A polygraph is a combination of medical devices used to measure and record several body activities such as blood pressure, heart rate, respiration and skin conductivity during a question-answer interview. After the experiment, the examiner compares the measured values with expected normal ones to indicate the level of subject's honesty. Even though it has been claimed by "American Polygraph Association" that polygraph examination is a scientific test, there are some evidences illustrate its unreliability. Moreover it is imaginable that subjects show anxiety for reasons but lying or even they beat the test by controlling their anxiety and produces no noticeable clue. Consequently, the polygraph test result is not always reliable and acceptable legally. However, during the past decade, some new technologies have been studied and developed to bring the lie detection beyond the polygraph. Among current lie-detection techniques, we studied a method which is based on brain electrical activities to spot a liar pioneered by Farwell in 2001 [1]. In this technique, one of the most significant brain EEG's components called P300 is used. The P300 is a positive peak about 300 msec elicited by a rare stimulus in an oddball series [2]. In the other word, the P300 is evoked from a subject's brain after he/she is confronted with a stimulus which has meaning to him/her. As a result, if the subject had previous knowledge about the stimulus, the P300 will be reflected on the EEG signal and could be detected [1]. In this paper, we will study lie-detection technique based on the P300 wave. In this method a sequence of pictures and sounds is shown to the subject whose EEG is recorded from the surface of his/her scalp simultaneously. Within the sequence, any picture – or sound – that seems unexpected to the subject may elicit the P300; thus any detection of the P300 possibly will give us a clue to detect the associated stimulus. Note that the more surprising the stimulus, the higher the P300 amplitude. For the lie detection purpose, our goal is to determine whether specific picture, e.g. crime scene, or sound, e.g. murdered voice, evokes the P300 with the high amplitude.

METHOD

The P300 and source of errors

One of the most significant elements in our lie detector is detection of the P300, a major even related potential in EEG. Detection of the P300 is directly linked to identifying a lie. However, the P300 detection is not as easy as it sounds due to the characteristics of the P300 and various types of

errors. Besides experimental errors, there are some other source of errors which mostly take place due to some perceptual phenomena such as attentional blink, repetition blindness and habituation [3]. They are most effective phenomena during a Rapid Serial Visual Presentation (RSVP). Attentional blink occurs when a stimulus follows a previous one with a short delay (up to 500 ms) [4] and as a result the subject cannot catch the second target. Nonetheless, by properly setting the time intervals between targets this error will be simply eliminated. Repetition blindness is the inability to detect repeated stimuli (letter, digit, color [5] or picture [6]) in Rapid Serial Visual Presentation [5]. For reducing errors caused by RB, targets have been carefully selected to prevent repetition. Habituation is decrease in strength of a brain response due to representing a stimulus repeatedly and may affect the P300 by decreasing its amplitude [7]. In 1998, Polich et al. measured the P300 elicits form oddball task and clearly proved that after 10 (sufficient) trial blocks, P300 amplitude decreased specially at Fz and Cz electrode site [8]. User habituation error can be reduced by considering a task oriented experiment.

Experiment Protocol

In our experiment, a sequence of stimuli was shown to the subject whose EEG is recorded simultaneously. There were three different types of stimuli: "Target", "Probe", and "Irrelevant" [1]. Targets are referred to particular type of stimuli the subject is assumed to respond to, while there is no task defined as response to Probes and Irrelevants. However, Probes must be placed in the sequence to unmask a lie. Comparing P300 amplitude in response to Probes, Targets and Irrelevants confirms whether or not the subject is lying. Besides, irrelevant stimuli have no relation to the situation under analysis. In our case the subject was considered as a liar and so we selected unexpected pictures and sounds as Probes which would be replaced with lie-related stimuli in real application. The associated task for Targets was pressing a key immediately after observing the particular type of images.

Before experiment started, volunteer was asked to sit on a chair in front of monitor. Shortly after he felt comfortable the experiment was initialized by attaching the electrodes to the subject's scalp using conductive paste. EEG signals were collected and recorded at five channels of Cz, C3, C4, Fz, Pz, O1, O2 using "Brain Products GmbH" instruments. During the experiment, some random simple images were shown to the user on the monitor and he was supposed to follow the pictures to carry out the task mentioned before. Three types of images were used in this sequence: an unexpected face as Probe, a collection of bus-photo as Targets, and a collection of flower-photo as Irrelevants. Overall, 150 photos randomly displayed on the screen including 9 Probe, 31 Target, and 120 irrelevant. Each photo was represented about 400 msec on the screen. Meanwhile, the volunteer's brain signals are captured and transferred to the computer for further analysis. The test was carried on up to the time which the last image in sequence appeared on the screen.

RESULT

The P300 wave amplitude is too small to be detectable within regular EEG signal. On the other hand, the assumption here is the brain response to a particular stimulus such as the P300 is similar from trial to trial. Consequently, taking average on Targets, Probes and Irrelevants individually would cancel out random variations and as a result the P300 wave will be visible in the final plot. Figure 1 presents the average of subject's brain signal at Cz and Fz in response to Targets, Probes and Irrelevants stimuli about 600 ms.

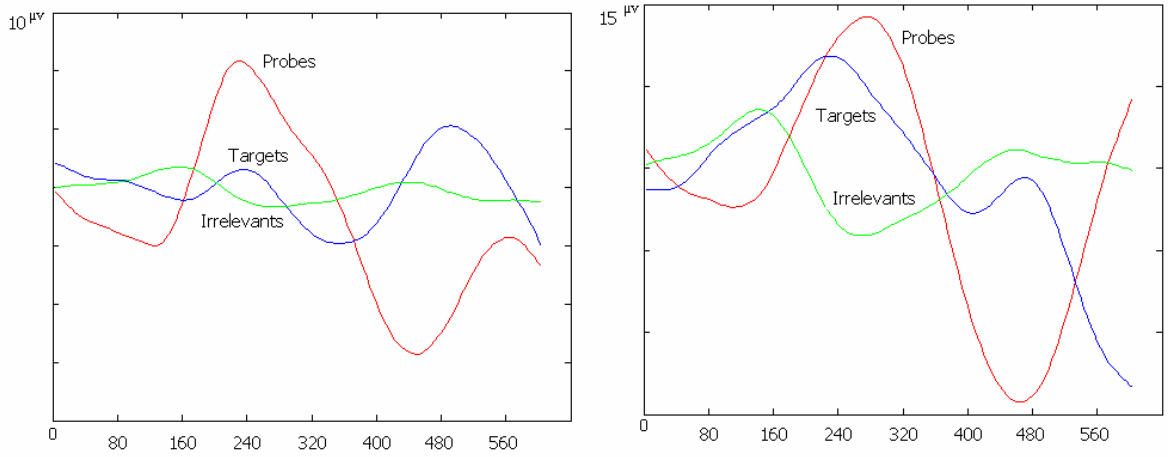

Figure 1: Brain response on Probes, Targets, and Irrelevants at Cz (left) and Fz (right)

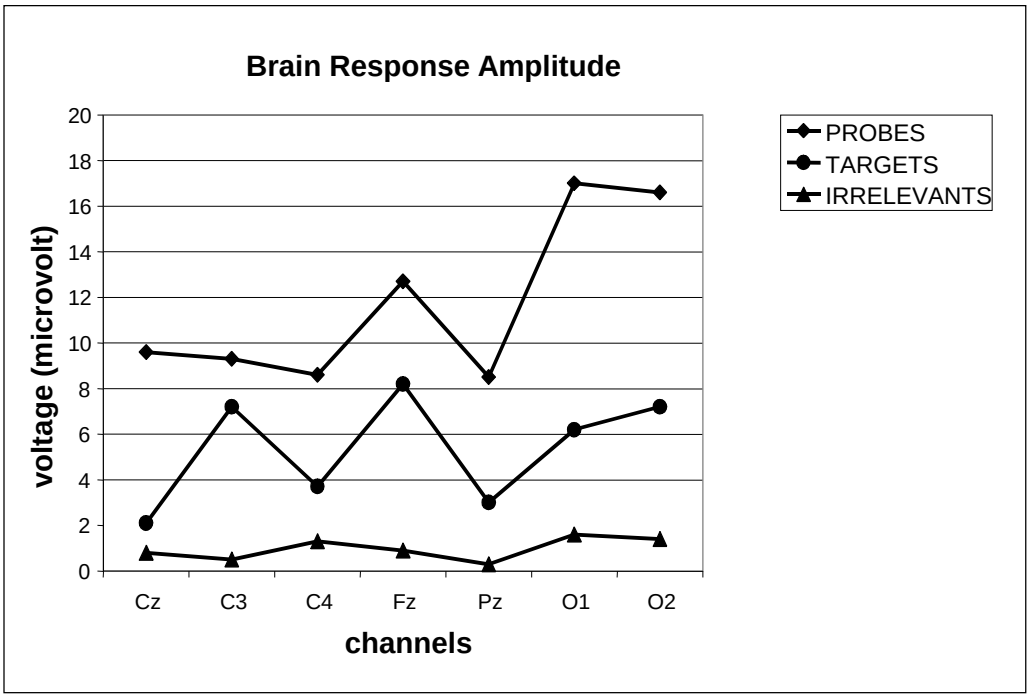

Figure 2: Brain response amplitude in Probes, Targets, and Irrelevants at different channels

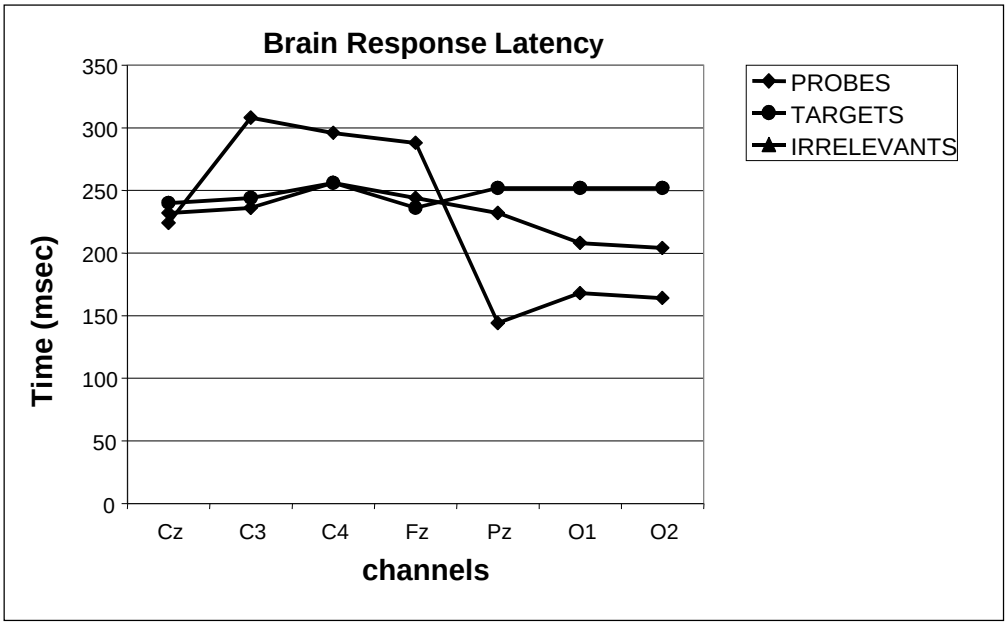

Figure 3: Brain response latency in Probes, Targets, and Irrelevants at different channels

A moving average filter with 40ms window length was chosen to eliminate phase distortions. However, the P300 wave with high amplitude is clearly visible in response to Probes in all of the channels while brain response amplitude in response to Targets is lower than Probes and more than Irrelevants as it is expected. As an example, the P300 amplitude is about 13μv and 10μv with latency of 284 msec and 216 msec at channels Cz and Fz respectively in response to Probes and is about 3.1μv and 2.6μv in response to Targets while is almost zero in response to Irrelevants. Figure 2 and Figure 3 show brain response amplitude and latency on different stimuli at all of the channels. Obviously, Probes have made higher P300 amplitude compares to Targets and Irrelevants; therefore, we can conclude that if suspect confronted by a stimulus which is unanticipated to him/her it will be clearly visible in recorded brain signal. However, it should be noted that the brain response to Probes will be similar to Irrelevants if Probes remind nothing from the subject's point of view. Therefore, Targets amplitude will be higher than other stimuli and certainly it confirms the subject is innocent.

CONCLUSION

In this paper, it has been tried to put the lie-detection system into operation to identify a liar using a specific feature in the brain signals. Since the current lie-detectors (polygraphs) are unreliable, there is a need to to develop a robust lie detector. Despite the fact that small sample of subjects participated in our experiment, results show great promise in developing and improving the lie detector system based on the P300. It has been claimed, in some way, that the p300-based lie detector offers 100-percent accuracy and high confidence level of the results [1]. Therefore, it potentially can save innocent people and recognize liars from truth-tellers.

ACKNOWLEDGEMENT

Financial support from the University (of Manitoba) Research Grant Program is greatefully is acknowledged.

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