

Feasibility of BMI improvement applying a Stroop effect

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Abstract— The author considers that applying a Stroop effect to the extracting method of the event related potential (ERP) by presenting the characters as a visual stimulus contributes to the development of the reactive brain machine interface. In order to investigate the influence of the Stroop effect on the brain wave, one of the two Chinese characters “red” and “blue” is turned into red or blue periodically and these characters are taken as the visual stimuli. The subject counts silently every time when the Chinese character as the targeted stimulus is presented on the display. As a result, when the test data was of the subject A, the percentages of correct answers were 86.0% and 83.0% for the cases in which the character “blue” printed in red and the character “red” printed in blue were presented on the display as the targeted stimuli. On the other hand, the percentages of correct answers were obtained as 79.0% and 69.0% for the cases in which the character “red” printed in red and the character “blue” printed in blue were as the targeted stimuli.

Keywords— EEG, ERP, Stroop effect, SVM, Chinese character

I. INTRODUCTION

A. BACKGROUND

Brain Machine Interface (BMI) is attracting attention as an interface between the brain and the machine directly, and is actively studied recently. BMI using Electroencephalogram (EEG) is suitable for practical use because EEG can be measured by a non-invasive method with a high time resolution. BMI equipment may be compact and low cost as compared to the other equipment such as MEG, PET and fMRI [1], [2].

A P300 speller is a typical presentation method of a flash stimulus and is often used in the reactive BMI [3]. It is reported that there are differences in the measured EEG of a subject when a stimulus is changed from a flash stimulus to others [4], [5]. Therefore, the stimulus that is applying a Stroop effect is adopted in the present paper. The Stroop effect is a psychological phenomenon. That is to say, the reaction time of the subject's brain task when the letter "blue" printed in red color is presented on the display as the stimulus takes longer, than that when the letter "red" printed in red color is presented [6]. The specified stimulus is called as the targeted one, otherwise non-targeted one herein.

The authors consider that the difference might arise between the decision percentages of correct answers when the subject decides whether the stimulus is targeted one or non-

targeted one. The present paper uses the Chinese characters “blue” and “red” as the stimuli. The characters, that are “blue” printed in blue color and “red” printed in red color, are assumed to be the congruent stimuli. On the other hand, the “blue” printed in red color and the “red” printed in blue color are assumed to be the incongruent ones. The electrodes P3, P4 and Pz are used in the measurement of EEG. When the stimulus are presented on the display, the subject counts silently how many times the targeted stimuli have been presented on the display.

B. OBJECTIVE

The present paper shows that the decision percentages of correct answers with respect to the incongruent stimulus become higher than these with respect to the congruent stimulus, and discusses the influence of the Stroop effect on the percentage of correct answers and also the applicability of the results to the reactive BMI.

II. METHOD

A. EXPERIMENT

Figure 1 shows the picture displayed in every interval between stimuli. The left hand side Chinese character means red in English. The right hand side one means blue. Hereafter, the Chinese characters are written in the form of Red and Blue in which the first letter is the capital one. The two characters are printed in gray color. The size of Picture as visual stimulus is 15cm x 32cm. Figure 2 (a) and (b) shows the congruent visual stimuli. The character Red is printed in red color in (a). In (b), the Blue is printed in blue color. Figure 3 (a) and (b) shows the incongruent visual stimuli. The Red is printed in blue color in (a). In (b), the Blue is printed in red color. These five kinds of pictures are presented periodically on the display. Namely, the picture in Figure 1 is presented on the display for 1000ms, then any of the visual stimuli in Figure 2 and 3 is chosen randomly and presented on the display for 500ms. This process is iteratively repeated. The subject is noticed what the targeted stimulus is in advance. He counts silently the number of the targeted stimulus every time when it is presented on the display. The EEGs are measured and preprocessed. Especially the brain waves from P3, P4, and Pz electrodes are processed using a support vector machine.

The subjects were two males and one female in twenties who voluntarily participated in the measurement. They were

healthy and didn't take medicine. They don't have histories of current or past neurological or psychiatric illness. Informed consent was obtained from all the subjects before the experiment. The color visions of every subject is confirmed all right. The targeted stimulus is noticed to the subject.



Figure 1. Picture displayed in the interval between stimuli



Figure 2. Congruent stimuli



Figure 3. Incongruent stimuli

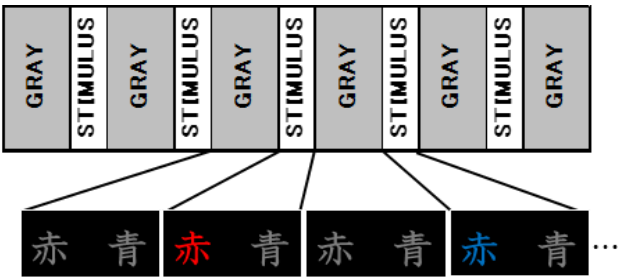


Figure 4. Presentation of stimuli

Figure 4 shows an example of the presentation of the stimuli in time series on the computer display. Figure 5 shows the measurement system block diagram. A subject with an electrode helmet looks at the display at a distance of one meter away. The electrode helmet with the international standard of 10-20 is used. EEG is measured by the electroencephalograph in which the low cut filter frequency is set to 1.5Hz and high cut filter frequency is set to 30Hz. EEGs are converted by the A/D converter with the sampling frequency of 1000Hz and with 12bit resolution. The digitally converted signals are received by the PC and recorded using the software called

VitalRecorder. The software program that presents the visual stimulus is made using JAVA language.

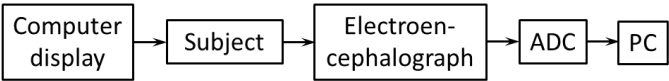


Figure 5. EEG measurement system

B. PREPROCESSING

Figure 6 shows the preprocessing procedures of EEGs from P3, P4 and Pz electrodes. The event related potentials (ERP) appear at these electrodes much larger than the other electrodes and are normally extracted by averaging. ERP arises generally the time of 100ms the moment after the visual stimulus is presented. Thus, EEGs from 200ms to 600ms is extracted and processed through the processors of down sampling, lowpass filter (LPF) and normalization. After the processors, 40 samples of EEGs from the electrodes P3, P4, and Pz are serially arranged in line. The 120 samples of EEG in line make up one vector for processing using a support vector machine. Artifacts which arises from the blink and myoelectricity are often included in the EEG measured in the experiment. They are not removed here in the processing procedure.

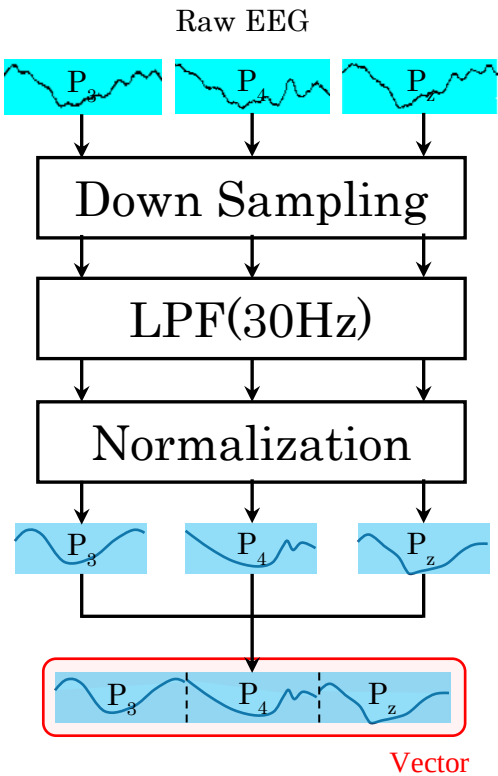


Figure 6. Preprocessing

Figure 7 (a) and (b) shows preprocessed some vectors. Each color of plots show one vector. Figure7. (a) shows five vectors from subject A when targeted stimuli are presented and (b) shows five vectors when non-targeted stimuli are presented respectively.

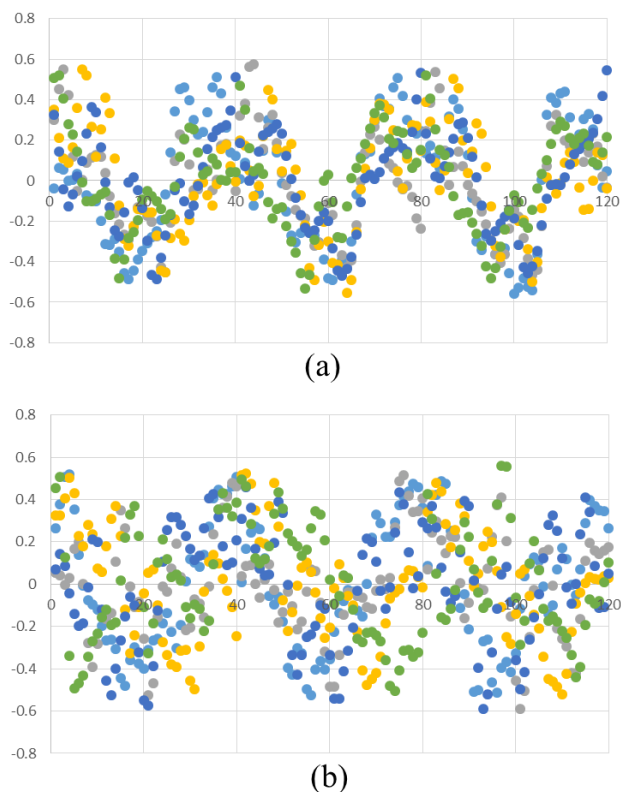


Figure 7. Preprocessed vectors

C. SUPPORT VECTOR MACHINE

There are differences between ERPs detected from the electrode such as P3 arranged on the left hand side scalp and the electrode such as P4 on the right hand side scalp [9]. The support vector machine (SVM) is a classification method based on statistical learning theory and is shown to provide higher performance than traditional learning machines and is introduced as powerful tools to solve the classification problems including EEG classification [10].

The authors grasp that the SVM makes a decision whether the stimulus is targeted or non-targeted. The correct answer is considered for the cases in which the subject counts silently in the case of targeted stimulus and he doesn't count in the case of non-targeted stimulus.

Learning data consists of 400 vectors. These vectors are obtained with subject A, when the targeted stimuli are presented 200 times, and the non-target ones are presented 200 times.

III.RESULTS

TABLE 1 shows the decision percentages of correct answers for three subjects. The test data “Red” and “Blue” are the congruent stimuli and “Red” and “Blue” are the incongruent stimuli. For the subject A, 86.0% and 83.0% for the incongruent stimuli were obtained as the percentage of correct answers. 79.0% and 69.0% for the congruent stimuli were obtained. For the subject B, 80.0% for the incongruent stimuli were obtained. 70.2% and 75.0% for the congruent stimuli were obtained. For the subject C, 77.0% and 83.0% for the incongruent stimuli were obtained. 62.0% and 54.0% for the congruent stimuli were obtained. Judging from the results shown in TABLE 1, the decision percentages of correct answers for the incongruent stimuli are estimated to be higher than these for the congruent stimuli.

TABLE 1. Percentage of correct answer

test data	subject A	subject B	subject C
“Red”	79.0%	70.2%	62.0%
“Blue”	86.0%	80.0%	77.0%
“Red”	83.0%	80.0%	83.0%
“Blue”	69.0%	75.0%	54.0%

IV.DISCUSSION

The number of electrode used in a conventional BMI are 8 [1], [7], [8]. According to the authors' method, it is feasible to be only 3 electrodes, which is advantageous from the point of the practical use.

Because the EEGs taking the Stroop effects on the alphabet word and on the Chinese character are assumed to be different, it cannot be compared readily. The differences between EEGs measured from the electrodes P3 and P4 involves the differences of ERPs that are affected by the Stroop effect. Therefore the Stroop effects on EEGs from the electrodes P3, P4, and Pz should be discussed independently in future. It is required to know concretely how the decision percentage of correct answer is affected by the Stroop effect through the processing method using the SVM. The larger number of subjects are necessary to verify the influence of the Stroop effect on the percentage of correct answers appropriately. By doing so, the applicability of the Stroop effect to the BMI is increased.

V. CONCLUSION

The authors presented the decision percentages of correct answers for the incongruent visual stimulus and congruent stimulus. As a result, for the case of the incongruent stimulus, the decision percentage of correct answers tend to be higher than that for the case of the congruent visual stimulus. To verify accurately, a lot of the future subjects are left.

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