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A pilot study for improving the graphical user interface of P300 based BCIs

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Abstract. The graphical user interface of a BCI is an important element for user and particularly for disabled persons who need to use the BCI for a long time. While most of the effort in the last years has been dedicated to the improvement of the detection of the P300 by using advanced machine learning algorithm, many improvements are still possible for the graphical user interface. We propose to add a feedback on each cell of the P300 speller that indicates what is the current flash for spelling a character. This strategy allows knowing the current flash at any moment and if it is possible to switch to the next character.

Keywords: Brain-Computer Interface, P300, Graphical User Interface, Feedback

1. Introduction

In the last years, many advanced machine learning algorithm have been proposed for the detection of the P300 [Cecotti et. al, 2010]. These methods are usually set in relation to the subjects. To extend the user-centered approach known for signal detection, many problems should be addressed for the design of graphical user interface (GUI) [Allison, 2009]. Indeed, a poorly designed GUI can be an obstacle for an optimal detection of the P300. For a long session with the P300 paradigm, it can be quite difficult for the user to follow and count the different flashes for the selection of a character. It is particularly the case for patient suffering from severe disabilities coupled with a depression [Blackwood et .al, 1987]. The depression can involve a lack of concentration and therefore a low amplitude of the P300 wave. Usually, to spell one character with a P300-BCI, the user needs at least 12 seconds, if we consider 5 repetitions with an inter stimulus interval (ISI) of 200ms and 12 flashes for a 6x6 matrix. During this time, the subject can lost his concentration and miss some flashes. When the user does not succeed to count the expected number of flashes, he/she can get frustrated and it may change the subjects mood. We propose to add new events in the classical P300 paradigm to avoid such frustration and to keep the subject more active during the experiment.

2. Interface

The P300 interface was based on a 6x6 matrix. During each flash, the cell was intensified in green and the symbol font was larger. To keep the user active while counting the flashes, we propose to add different items around each character to specify the state of the current flash. Several states for a target

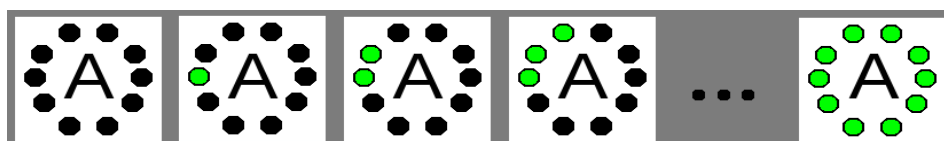


Figure 1. Cell of the matrix for the character 'A', and after different flashes (0,1,2,3 and 10).

across the different repetitions for its selection are depicted in Figure 1. As we consider 5 repetitions and 2 stimuli on the target (row/column), we have 10 events for each character.

3. Experimental protocol

The goal of the experience was to evaluate the interface subjectively, *i.e.*, to know if the change in the interface has an impact on the use of a P300-BCI. It is well known that consecutive flashes on the target impair the quality of the detection as the P300 amplitude depends on the time between flashes on the target. With two consecutive flashes, one may be missed by the user. If the user cannot reach the expected number of flashes, the user may not know when the character shall be spelt. The system was evaluated subjectively on 10 healthy subjects (7 naïve BCI users, 2 experienced P300-BCI users ; mean age=31.2, standard deviation=10.2). Subjects were sitting in front of the screen on a comfortable chair at about 60cm from the screen. They had to follow a PCI-P300 scenario where 20 characters were spelt. Under each target, there was a hand showing what symbol the user had to look at. Five repetitions, an ISI of 166ms and a pause of 5seconds and 166ms between each character and repetition, respectively, were considered. Two P300 scenarios were presented to the user: with and without the feedback for counting flashes. After each session, the subjects had to fill a questionnaire about their ability to count the flashes, to stay focused, about the effect of the flashes around the target, and about the time they could dedicate to one session while keeping their concentration. This information is relevant as if a person is not able to follow the flashes on the screen, the accuracy of the P300 speller will be poor and the user will not use the BCI. The system was also evaluated objectively on two subjects (an experienced P300-BCI subject (S1) and a new P300-BCI user (S2)) in relation to the accuracy of the speller to be sure that the proposed improvement is not an obstacle for the P300 detection. For this test, two sessions of 50 characters were considered. The EEG signal was recorded with 8 sensors (O₁,O₂,P₃,P₄,P₇,P₈,Pz,FCz). The first session was used for training the classifier (Bayesian Linear Discriminant Analysis combined with spatial filtered obtained with the xDAWN algorithm [Rivet et. al, 2009]).

4. Results

For the subjective evaluation across 10 subjects, 8 subjects considered that the interface allows to better count the flashes. 8 subjects acknowledged that the proposed interface allows to better concentrate. If the subject can chose an interface, 8 subjects would pick the proposed method for long sessions. For the question: “how much time could you use this interface?”, 4 subjects have chosen a longer time for the interface with the help for counting flashes. Among the remarks from the subjects, one major argument toward our proposition is the interest to keep a continuous visual activity. Indeed, the user is not inactive during more than 10s and she/he can follow something on the screen. Finally, the accuracy of the speller was 97% (S1) and 70% (S2) for the two subjects who have tested the speller, showing that our strategy is at least not an obstacle for the P300 detection.

5. Conclusion

When a user like a patient has to use a P300-BCI during long sessions, the interface shall be as convenient as possible. It is often difficult for the subject to focus on the requested task like counting the number of flashes. We have proposed to add a feedback on each symbol that allows the user to look and count the different flashes that correspond to one character. This improvement can be easily implemented on different interfaces and could benefit current P300-BCI users.

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