 DOI:10.3217/978-3-85125-260-6-98

A Tactile P300-Based BCI

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Abstract. In this publication a tactile P300-based Brain-Computer Interface (BCI) is presented. It can be used for communication, but is also aimed for testing the consciousness in nonresponsive patients. Three different settings were evaluated: two tactors for testing if a P300 could be detected; three tactors that could be used for simple communication, and a setup with eight tactors that provides more classes and is hence suitable for advanced communication. The BCI was evaluated on 12 healthy users showing a mean accuracy of 100% for classification in the two tactor approach, 80% in the three tactor approach and 69.4% in the eight tactor approach.

Keywords: EEG, P300, vibrotactile Stimulation, minimal conscious state

1. Introduction

Brain-Computer Interfaces (BCIs) for communication are usually controlled via a P300 paradigm. During the last 25 years, several P300 spellers based on visual stimulation have been developed. But for users suffering visual impairments or even in a minimally conscious state, visual stimulation cannot be used any more. For this group of users, a tactile stimulation can be used to elicit the evoked potential. Hence, one can use this way of stimulation for communication and also for assessment of the level of consciousness in patients classified as non-responsive. Kotchoubey et al. tested event related responses to stimuli of different complexity levels in patients with persistent vegetative state (PVS) and minimal conscious state [Kotchoubey et al., 2005]. They found a P300 also in PVS patients although it was associated more frequent to patients with lower level of disability. Therefore, after testing the general appearance of P300, one should present certain command to the patient, like e.g. counting the number of stimuli appearing on the left hand. If the user is able to follow a sequence of commands, the patient could be classified as responsive. For a visual P300 speller, it was shown that healthy users reach an average control accuracy of 91% [Guger et al., 2009] and a group of fifteen people suffering motor impairments reached 70.1% [Ortner et al., 2011] In this paper, the accuracy of a tactile P300 speller is evaluated on twelve healthy users.

2. Material and Methods

Three different scenarios were tested. In the first paradigm, two stimulators were placed on the user's wrists. One tactor delivered a train of standard stimuli (one stimulus was a short vibration of the tactor). The tactor on the other wrist produced the deviant stimulus with a probability of 12.5%. If the user was asked to concentrate on the deviant stimulus, one could evaluate if this person has a P300 reponse. The second paradigm used three tactors. Again, one of the tactors (placed on the user's back) delivered a train of standard stimuli. The deviant stimuli were now delivered on the left and right wrist, one of which conveyed "yes" the other of which conveyed "no". The user had to concentrate on the stimuli given on one of the two wrists to select the answer. This setup could be used for communication if only a simple yes/no response is desired. In the third paradigm, eight tactors were used instead of three. They were placed on the fingers (little finger, ring finger, middle finger, index finger) of the left and right hand. Each tactor flashed with the same probability (12.5%). During one run, the user had to concentrate on each finger in a random order, the commands on which tactor the user should concentrate actually were give via voice.

In each session of the three paradigms, two runs were performed: one to set up a classifier and a second run to test the classifier. Each run of the two-tactor and three-tactor paradigm consisted of 5 sequences, with 15 target events per sequence. The runs of the eight tactor experiment consisted of eight sequences, again with 15 target events per sequence. For each session the accuracy was calculated.

3. Results

Table 1 summarizes the results of the twelve persons. The mean accuracy was at 100% for the two tactors, 80% in the three tactor approach and 69.4% in the eight tactor experiment. Not all persons had enough time to process all of the three approaches, hence some field in the table are empty. When looking at the mean accuracy of the people participating to all three approaches (S1, S3, S5, S6, S7, S8, S9) the mean accuracy was: 100%, 77.1% and 73.2%.

Table 1. *Accuracy (%) of the single sessions.*

User	*two-tactor*	*three-tactor*	*eight-tactor*
1	100	100	50
2	100	100	-
3	100	100	100
4	100	60	-
5	100	40	100
6	100	60	75
7	100	100	62.5
8	100	60	25
9	100	80	100
10	100	100	-
11	-	-	100
12	-	-	12.5
mean	100	80.0	69.4
STD	0	23.1	34.3

4. Discussion

Patients with visual impairments or unknown levels of consciousness need new ways to present the stimuli that will elicit the P300 response, since visual P300 BCIs are not practical for such users. The presented tool could be used for both: for communication and for detection of consciousness in nonresponsive persons. The accuracy in the three tactor experiment was higher than in the eight tactor experiment, but with the higher number of classes the Information transfer rate would be higher in the eight tactor experiment.

Details such as the exact duration of the stimuli or the best location of the stimulator are grounds for further investigation. Also, the methods used in this study, and the potential applications and users, will be expanded. Promising tests on people suffering Locked in Syndrome were already performed and will be published soon [Lugo et al., 2013].

Acknowledgements

This work was funded by the EC projects Decoder and Brainable.

References

Guger C, Daban S, Sellers E, Holzner C, Krausz G, Carabalona R, Gramatica F, Edlinger G. How many people are able to control a P300-based brain–computer interface (BCI)? *Neurosci Lett*, 462:94-98, 2009.

Kotchoubey B, Lang S, Mezger G, Schmalohr D, Schnecke M, Semmler A, Bostanova V, Birbaumer N. Information processing in severe disorders of consciousness: vegetative state and minimally conscious state. *Clin Neurophysiol*, 116:2441-2453, 2005.

Lugo ZR, Rodriguez J, Lechner A, Ortner R, Gantner IS, Kübler A, Laureys S, Noirhomme Q, Guger C. A vibrotactile P300-based BCI for consciousness detection and communication. *Clin Neurophysiol*, under review.

Ortner R, Aloise F, Prückl R, Schettini F, Putz V, Scharinger J, Opisso E, Costa U, Guger C. Accuracy of a P300 Speller for People with Motor Impairments: a Comparison. *Clin EEG Neurosci*, 42(4):214-218, 2011.