

A tactile P300 Brain-Computer Interface

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Brain-Computer Interfaces (BCI) for communication purposes are usually controlled via a P300 paradigm. There, a high number of different classes is presented to the user, thus enhancing the information transfer rate (ITR) in comparison to e.g. motor imagery based BCIs. During the last years several P300 speller, based on visual stimulation were developed. Furthermore, g.tec medical engineering created the first Patient-ready visual P300 speller that is designed to be installed and operated by caregivers or the patient's family at home. But for users suffering visual impairments or are even in minimal conscious state, the visual stimulation cannot be used any more. For this group of users a tactile stimulation can be used to elicit the evoked potential.

In this study a tactile P300 communication tool was developed and tested on a group of twelve healthy users. Three different setups were tested:

A) Stimulation with two factors: One factor was placed on the left wrist, one on the right wrist. The purpose of this setup is to test the consciousness of non-responsive patients. One factor delivers a train of standard stimuli (one stimulus is a short vibration of the factor). The factor on the other wrist produces the deviant stimulus with a probability of 12,5% to occur. If the user is able to concentrate on the deviant stimulus, a P300 response can be measured, hence the user is responsive.

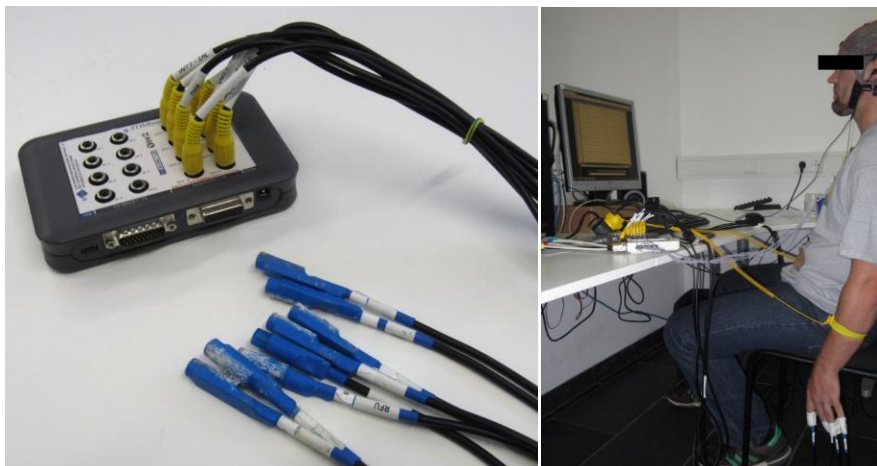


Figure 1: Left: Eight factors (blue) used for stimulation. The g.STIMbox is used to control the single factors and turn them on and off. Right: Setup of the eight factor experiment. Four factors are placed on the fingers of the left hand, the other four are placed on the fingers of the right hand. For noise suppression in the EEG signal, the user is connected to ground (yellow stripe).

B) Stimulation with three factors: This setup can be already used for a communication purpose, if only a simple yes/no response is desired. Again, one of the factors (placed on the user's back) delivers a train of standard stimuli. The deviant stimuli are now delivered on the left and right wrist,

one is the command for “yes” the other one for “no”. The user has to concentrate on the stimuli given on one of the two wrists to select the answer.

C) Stimulation with eight tactors: in this setup, tactors are placed on four fingers of each hand (see Figure 1, right). Each tactor stimulates with the same probability and hence could be translated into a control command for a BCI, if the user concentrates on the stimulations of this tactor.

The results of the study are summarized in Table 1: The classification accuracy of the two tactor experiment was 100% for all measured participants. For the three tactor experiment and the eight tactor experiment, the ITR rate was calculated additionally. The mean ITR of the eight tactor experiment was higher compared to the three tactor experiment, but also the classification accuracy decreases with increasing number of used tactors.

Table 1: Results of the three different BCI setups. The classification accuracy is best when using only two tactors but for a high ITR eight tactors or more should be considered.

Subject	two tactors	three tactors		eight tactors	
	Classification accuracy (%)	Classification accuracy (%)	ITR (bits/min)	Classification accuracy (%)	ITR (bits/min)
1	100,0	100,0	2,11	25,0	0,08
2	100,0	100,0	3,64	-	-
3	100,0	100,0	8,00	100,0	10,00
4	100,0	60,0	0,04	-	-
5	100,0	40,0	0,04	100,0	9,00
6	100,0	60,0	0,04	25,0	0,08
7	100,0	100,0	3,64	62,5	0,99
8	100,0	60,0	0,04	50,0	0,60
9	100,0	80,0	0,37	62,5	0,99
10	100,0	100,0	2,22	-	-
11	-	-	-	100,0	6,43
12	-	-	-	87,5	2,11
Mean	100,0	80,0	2,01	68,1	3,36
STD	0	22,0	2,6	26,2	3,8

The tests prove the feasibility to control the BCI via tactile stimulation. With the two tactor experiment each user reached 100% of classification accuracy, qualifying it as reliable tool to investigate consciousness in non-responsive patients. The three tactors and eight tactors settings can be used as helpful tool when other communication channels are not available.