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BCI: "Imagine playing tennis!"

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Abstract. Some patients after traumatic brain injury are not able to send any communicative signal outside the body, and it is unknown whether they are conscious or not. fMRI experiments showed that it is possible to get in contact with these minimally conscious persons. The aim of this work is to port these experiments into an EEG-based one to be used in a home environment.

Keywords: Brain-Computer Interface, minimally consciuous, electroencephalogramm EEG, fMRI

1. Introduction

Brain-Computer Interface (BCI) research is mainly devoted to severely paralyzed patients who are not able to communicate after brain stem stroke, late stage amyotrophic lateral sclerosis or muscle dystrophy. Another patients group consists of spinal cord injured persons who lost hand and arm function. Here several research teams are aiming to find solutions for providing alternative EEG-based control systems. However, another group includes non-responsive patients. Mainly, after traumatic brain injury, those people are not able to send any communicative signal outside the body, and it is unknown, whether they are conscious or not. fMRI experiments by Boly (Boly et al. 2007), Owen (Owen et al. 2006) and Monti (Monti et al. 2010) showed that it is possible to get in contact with these minimally conscious persons. In that paradigm patients were asked to imagine playing tennis vs. spatial navigation.

The aim of this work is to port this paradigm into an EEG-based paradigm with the general goal to use this kind of fMRI-based communication in a home environment based on EEG.

2. Material and Methods

Ten healthy subjects participated in this study. Nine of them were right handed and one was left-handed. All persons have had former experiences with BCI.

The EEG was recorded using sintered Ag/AgCl electrodes placed in a way that Laplacian derivatives could be obtained from the three centers C3, Cz, and C4 according to the 10-20 system. All 15 electrodes were assembled monopolarly with a left mastoid reference. Ground was taken from the right mastoid. A 16 channel amplifier (g.tec, Graz, Austria) was used with a high pass of 0.5 Hz and a low pass of 100 Hz. Notch filter (50 Hz) was on; sensitivity of 0.1 mV. The continuous signal was sampled with 512 Hz.

The participants had to perform (eyes open) two different tasks: (i) simple imagery task (SIT) and (ii) complex imagery task (CIT). During SIT, subjects had to imagine hand vs. foot movements and during CIT they had to perform "imagine playing tennis" vs. "imagine singing 'Yello Submarine (The Beatles)' loudly". Each task was repeated 4 times, the half of the group started with SIT whereas the other half of the group started with CIT. During one run a cue indicated the type of imagination. Cues were presented randomly. One trial lasted 8 s, at second 2 a beep caught the subject's attention and at second 3 the cue appeared for 1.25 s. Right after the cue, subjects were instructed to start with the indicated imagination until the trial end (second 8).

For the analysis bipolar as well as Laplacian derivations were computed. Distinction Sensitive Learning Vector Quantization (DSLVQ) (Pregenzer et al. 1996) was used to find frequency bands which discriminate best the two tasks SIT and CIT. With the selected frequency bands an LDA classifier was trained and with 10x10 cross fold validation the accuracy was determined.

3. Results

In Table 1 the best accuracy of each participant can be found. Additionally, the applied method is indicated, too. The average accuracy of 9 subjects (SIT) was 85.5% and for CIT and 8 subjects it was 75.2 %. For the SIT task, S8 had an accuracy by chance only, for CIT S1 and S3 had a random result. In Figure 1 the classification accuracies over time can be seen for each subject.

Table 1. *Accuracies (acc) for all subjects with the applied method (met,), bipolar or Laplacian derivaton, for both, SIT and CIT.*

Subject	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
SIT										
Meth	Lap	lap	bipo	lap	lap	lap	lap	na	lap	lap
Acc	87.3	68.5	77.0	89.1	85.4	87.0	77.9	-	99.4	97.5
CIT										
Meth	na	bipo	na	lap	bipo	lap	bipo	bipo	lap	bipo
Acc	-	77.6	-	86.8	67.5	78.3	70.1	69.9	69.4	81.6

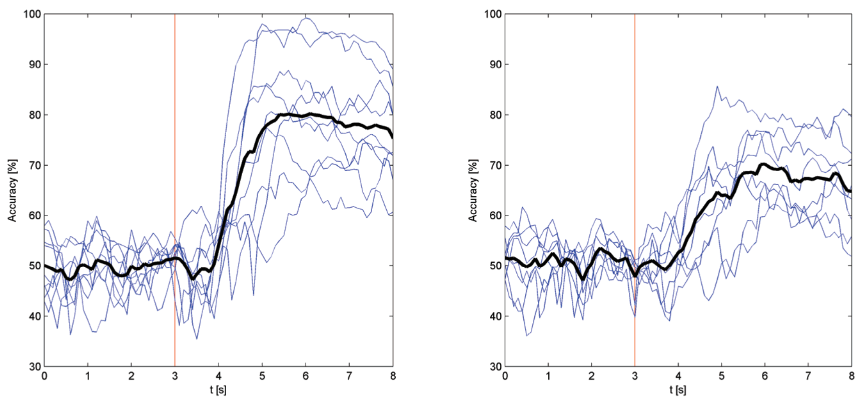

Figure 1. *Left: Average accuracy of SIT (hand vs. foot motor imagery) of 9 subjects. Right: average accuracy of CIT (tennis vs. singing imagery) of 8 subjects.*

3 Discussion

This preliminary study has shown that it is possible to transfer an important fMRI paradigm into an EEG-based paradigm. However, we exchanged the task ‘spatial navigation’ imagery with ‘singing imagination’. Still, the classic paradigm showed significantly higher results ($p>0.5$), but with the repositioning of electrodes we expect a similar result in future investigations. Overall, a first step for using this important paradigm in EEG-based communication was successfully implemented.

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