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Training Effects of Multiple Auditory BCI Sessions

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Abstract. Most P300 brain-computer interfaces (BCIs) rely on visual stimulation. This is problematic for patients who have lost gaze control. One alternative P300 BCI design is to use auditory stimuli. We investigated the possibility of improving spelling accuracy by performing multiple sessions per participant. Online accuracy increased from 4 bits/min in the first session to between 5.5 to 5.9 bits/min in the following sessions.

Keywords: EEG, auditory P300, spelling, training effects, spatial cues

1. Introduction

Visual P300 brain-computer interfaces (BCIs) provide a robust and fast communication method using electroencephalography (EEG) signals [Farwell and Donchin, 1988; Kaufmann et al., 2012]. Due to the fact that many severely motor impaired people also experience loss of gaze control, P300 BCIs with non-visual stimuli have to be explored. Among others, auditory stimuli are a promising alternative [Furdea et al., 2009; Schreuder et al., 2010; Käthner et al., 2012]. We investigated possible training effects with a sample of healthy participants when using an auditory P300 BCI for spelling.

2. Material and Methods

2.1. Participants

Eight healthy participants took part in the study. All participants performed five sessions which were between two and five days apart.

2.2. Data acquisition

The EEG was recorded with 16 active Ag/AgCl electrodes. These were located at positions F3, Fz, F4, T7, C3, Cz, C4, T8, Cp3, Cp4, P3, Pz, P4, PO7, PO8, and Oz. The signal was sampled with 256 Hz and filtered between 0.1 and 30 Hz. Stimulus presentation and data recording was performed using the BCI2000 framework [Schalk et al., 2004].

2.3. Auditory speller

A matrix with 25 elements was used (all letters of the latin alphabet except Z). Each column and row was coded with a specific auditory stimulus (five animal sounds (duck, bird, frog, seagull, and pigeon) with an additional spatial component ranging from left, diagonal left, center, diagonal right to right). Each sound had a duration of 187.5 ms followed by an inter-stimulus interval of 250 ms.
The classifier was trained anew for each session using three runs with ten stimulus repetitions in which the participant had to select the symbols from the diagonal of the matrix ("AGSMY"). These runs were also used to set the number of repetitions for the following copy spelling task to the number of sequences needed to reach 70 % accuracy plus two sequences. The calibration was followed by nine copy spelling runs in which a total of 48 selections had to be made. Stepwise linear discriminant analysis (SWLDA) was used for online classification.

3. Results

The eight participants achieved the following average information transfer rates (ITRs) in sessions one to five: 3.95, 5.92, 5.68, 5.52 and 5.58 bits/min (see Figure 1). The average ITR across all sessions and participants was 5.33 bits/min. The highest ITR achieved was 9.76 bits/min and the lowest 1.2 bits/min. The average letter selection accuracy across all participants and sessions was 79 %. Note that the accuracies are not comparable between participants due to a varying number of stimulus repetitions (on average 5.35).

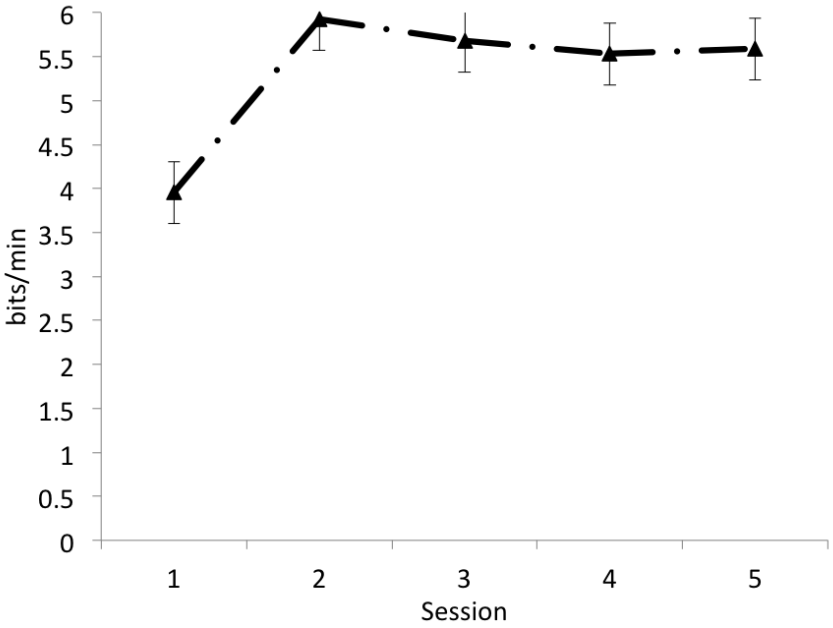

Figure 1: *The figure shows the information transfer rate achieved on average by all participants per session.*

4. Discussion

Online ITRs of on average 5.33 bits/min and letter selection accuracies of 79 % are sufficient to operate an online spelling system. In particular, considering that the number of stimulus repetitions was set individually for each participate to minimize selection accuracy saturation. By performing multiple sessions, thus giving the user an opportunity to adapt to the system, and using natural sounds as stimuli, the ITR increased from 2.76 bits/min in [Käthner et al., 2012] to 5.33 bits/min. We assume that the training effect is due to an increased ability of the participant to focus on the task of attending the target stimuli. It seems that the training effects using an auditory P300 BCI are much larger than during usage of a visual P300 BCI. This should be taken into account when designing and testing new auditory P300 BCI paradigms for and with severely motor impaired people.

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