Introduction

In general, steady-state evoked potentials (SSSEPs) have already been well explored in the electrophysiology literature, and are often used in brain-computer interfaces (BCIs). Steady-state somatosensory evoked potentials (SSSEPs) [1, 2] can be used in BCIs for communication and control without any movement, purely by focusing on tactile stimuli applied e.g. to the index finger of the left and right hand [3]. The aim of this work is to investigate the stability of such signals to ensure constant results over longer time periods. Vibro-tactile stimulation of five fingers on the right hand is used for generating SSSEPs, using a self-made stimulation device. We also explored the emergence of a person independent tuning curve based on SSSEPs.

Methods

A 200 Hz sine wave was modulated with a rectangular signal to stimulate Pacinian corpuscles. The frequency range of the modulation signal was between 17 and 35 Hz. Stimulation was applied in 2 Hz steps, resulting in 10 different frequencies. Fingers were never stimulated consecutively and every stimulation frequency was applied at every finger 40 times.

The study was divided in two sessions with at least two weeks between the two sessions. Every session was separated into 20 runs to reduce the burden on the subjects.

A visual distraction on a screen (subjects were told to count red marked characters) was presented to the subjects to prevent focusing on a specific finger. EEG was recorded using three bipolar channels over C3, Cz and C4. Trials with EMG artifacts were removed manually before data processing. Discrete Fourier transform computations were performed to check data for amplitude increases during stimulation in the respective frequency range. Bandpower computations were made to describe a bandpower increase compared to a given reference period. Nine subjects participated in the study with an average of 28 days between the measurements to investigate a possible change in their SSSEPs over time.

Results

Six out of nine subjects showed a significant bandpower increase, independent of the stimulated finger. The emergence of a tuning curve, similar at all five fingers, could be shown. Resonance frequencies were person dependent. A significant increase only arose over C3, whereas all subjects showed a good stability of bandpower increase over time.

![Figure 1: 200 Hz sine modulated with a 25 Hz rectangular signal (50% duty cycle).](image)

The right picture makes a comparison between stimulation and reference period. A visual distraction on a screen (subjects were told to count red marked characters) was presented to the subjects to prevent focusing on a specified finger. EEG was recorded using three bipolar channels over C3, Cz and C4. Trials with EMG artifacts were removed manually before data processing. Discrete Fourier transform computations were performed to check data for amplitude increases during stimulation in the respective frequency range. Bandpower computations were made to describe a bandpower increase compared to a given reference period. Nine subjects participated in the study with an average of 28 days between the measurements to investigate a possible change in their SSSEPs over time.

![Figure 2: Graphical illustration of the distraction paradigm at measurement start.](image)

To avoid external auditory influences, all subjects listened to white noise during the whole experiment.

Discussion

Vibro-tactile stimulation elicited significant EEG changes in most subjects. Due to the simple design of the experiment, finger pressure on the stimulator could not be measured, and inadequate finger pressure may explain why three subjects did not show significant B changes. Because of the long duration of the experiment, only two sessions were performed. A single screening session is enough to determine optimal frequencies for each subject, since they can be considered stable over time.

References


Acknowledgements

This work is supported by the European ICT Programme Project FP7-224631. This paper only reflects the authors’ views and funding agencies are not liable for any use that may be made of the information contained herein.